APPENDIX F-1

ADVISORY CIRCULAR

AC	**:**	**91-009**
DATE	**:**	**12/10/09**
REVISION	**:**	**1**
ISSUED BY	**:**	**SRVSOP**

SUBJECT: AIRCRAFT AND OPERATORS APPROVAL FOR RNP AUTHORIZATION REQUIRED APPROACH (RNP AR APCH) OPERATIONS

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1. PURPOSE

This advisory circular (AC) provides acceptable means of compliance (AMC) concerning aircraft and operators approval for RNP authorization required approach (RNP AR APCH) operations.

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 applicant or operator that chooses to meet the criteria established in this AC.

2. RELATED SECTIONS OF 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 9905	Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual (final draft)
Doc 8168	Aircraft Operations
	Volume I: Flight Procedures
	Volume II: Construction of Visual and Instrument Flight Procedures
AMC 20-26	Airworthiness Approval and Operational Criteria for RNP Authorization Required (RNP AR) Operations
FAA AC 90-101	Approval Guidance for RNP Procedures with SAAAR
IFFP/2 WP/5	Instrument flight procedure panel (IFPP) – PBN working group meeting - Working paper 5: Flight operational safety assessment (FOSA) prepared by Dave Nakamura.

4. DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

a) **Area navigation (RNAV)**.- Navigation method that permits aircraft operations in any desired flight path within the coverage of ground-based or space-based navigation aids, or within the capability limits of autonomous aids, or through a combination of the two.

Area navigation includes performance-based navigation as well as other operations not contemplated in the performance-based navigation definition.

b) **Authorization required (AR).-** Specific authorization required by the CAA for an operator to be able to conduct RNP approach operations that need mandatory authorization (RNP AR APCH).

c) **Barometric vertical navigation (baro-VNAV).-** A function of some RNAV systems that displays an estimated vertical guide to the pilot, referred to as a specific vertical path. The estimated vertical guide is based on barometric altitude information and is commonly estimated as a geometric path between two waypoints or as an angle based on a single waypoint.

d) **Estimated position uncertainty (EPU)**.- A measure in nautical miles (NM) based on a defined scale that indicates the estimated performance of the current position of the aircraft, also known as navigation performance (ANP) or estimated position error (EPE) in some aircraft. The EPU is not an estimate of the actual error, but a defined statistical indication.

e) **Flight management system (FMS)**.- Integrated system made up by an on-board sensor, a receiver, and a computer with navigation and aircraft performance databases, capable of providing performance values and RNAV guidance to a display and automatic flight control system.

f) **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.

g) **Global navigation satellite system (GNSS)**.- Generic term used by ICAO to define any global positioning and timing system made up by one or more main satellite constellations, such as the GPS and the global navigation satellite system (GLONASS), aircraft receivers, and several integrity surveillance 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).

h) **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”.

i) **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 contex 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).

j) **Performance-based navigation (PBN)**.- Performance-based area navigation requirements applicable to aircraft conducting operations on an ATS route, in an instrument approach procedure, or a designated airspace.

Performance requirements are expressed in the navigation specifications (RNAV and RNP specifications) in terms of the precision, integrity, continuity, availability, and functionality required for the intended operation within the context of a particular airspace concept.

k) **Primary field of view.-** For purposes of this AC, the primary field of view is within 15 degrees of the primary line of sight of the pilot.

l) **Radius to fix (RF) leg.-** An RF leg is defined as any circular path (an arc) with a constant radius around a defined turn centre that starts and ends in a fix.

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 enhanced GPS signals with barometric altitude data. This determination is achieved by a consistency check between redundant pseudo-range measurements. At least one satellite in addition to those required must be available to obtain the navigation solution.

n) **RNP operations**.- Aircraft operations that use an RNP system for RNP applications.

o) **RNP system**.- Area navigation system that provides on-board performance control and alert.

p) **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.

q) **Way-point (WPT).-** A specified geographical location used to define an area navigation route or the flight path of an aircraft employing area navigation. Way-points are identified as either:

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

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

4.2 Abbreviations

a)	CAA	Civil aviation administration
b)	ABAS	Aircraft-based augmentation system
c)	AGL	Above ground level
d)	AP	Automatic pilot
e)	APCH	Approach
f)	APQ	Advance qualification program
g)	APV	Approach procedure with vertical guide
h)	AR	Authorization required
i)	AIP	Aeronautical information publication
j)	AIRAC	Aeronautical information regulation and control
k)	AC	Advisory circular (FAA)
l)	AFM	Aircraft flight manual
m)	AIM	Aeronautical information manual

n)	AMC	Acceptable means of compliance
o)	ANP	Navigation performance
p)	ANSP	Air navigation service provider
q)	ATC	Air traffic control
r)	ATS	Air traffic service
s)	baro-VNAV	Barometric vertical navigation
t)	AC	Advisory circular (SRVSOP)
u)	CDI	Course deviation indicator
v)	CDU	Control display unit
w)	CF	Course to a fix
x)	DA/H	Decision altitude/height
y)	DF	Direct to a fix
z)	DME	Distance-measuring equipment
aa)	EASA	European Aviation Safety Agency
bb)	EGPWS	Enhanced ground proximity warning system
cc)	EPE	Estimated position error
dd)	EPU	Estimated position uncertainty
ee)	EUROCAE	European Organization for Civil Aviation Equipage
ff)	FA	Course from a fix to an altitude
gg)	FAA	United States Federal Aviation Administration
hh)	FAF	Final approach fix
ii)	FD	Flight director
jj)	FMS	Flight management system
kk)	FOSA	Flight operational safety assessment
ll)	FSD	Maximum deflection
mm)	FTD	Flight training devices
nn)	FTE	Flight technical error
oo)	GBAS	Ground-based augmentation system
pp)	GNSS	Global navigation satellite system
qq)	GLONASS	Global navigation satellite system
rr)	GP	Glide path
ss)	GPS	Global positioning system
tt)	GS	Ground speed
uu)	HAL	Horizontal alert limit
vv)	HIL	Horizontal integrity limit
ww)	HPL	Horizontal protection level
xx)	IAC	Instrument approach chart

yy)	IAF	Initial approach fix
zz)	IFR	Instrument flight rules
aaa)	INS	Inertial navigation system
bbb)	ILS	Instrument landing system
ccc)	IRS	Inertial reference system
ddd)	IRU	Inertial reference unit
eee)	ISA	International standard atmosphere
fff)	LAAS	Local area augmentation system
ggg)	LAR	Latin American Aeronautical Regulations
hhh)	LNAV	Lateral navigation
iii)	LOA	Letter of authorization
jjj)	LOE	Line-oriented evaluation
kkk)	LOFT	Line-oriented flight training
lll)	MEL	Minimum equipment list
mmm)	NAVAIDS	Navigation aids
nnn)	NOTAM	Notice to airmen
ooo)	OACI	International Civil Aviation Organization
ppp)	OEM	Original equipment manufacturer
qqq)	OM	Operations Manual
rrr)	PBN	Performance-based navigation
sss)	PC	Proficiency check
ttt)	PDE	Path definition error
uuu)	PF	Pilot flying the aircraft
vvv)	POH	Pilot operations manual
www)	POI	Principal operations inspector
xxx)	PM	Pilot monitoring the aircraft
yyy)	PT	Proficiency training
zzz)	RA	Radio altimeter
aaaa)	RAIM	Receiver autonomous integrity monitoring
bbbb)	RF	Constant radius arc to a fix
cccc)	RF leg	Constant radius to fix arc leg
dddd)	RF turn	Constant radius to fix turn
eeee)	RNAV	Area navigation
ffff)	RNP	Required navigation performance
gggg)	RNP APCH	Required navigation performance approach
hhhh)	RNP AR APCH	Required navigation performance authorization required approach
iiii)	RTCA	Requirements and technical concepts for aviation

jjjj)	SBAS	Satellite-based augmentation system
kkkk)	SET	Selected event training
llll)	SPOT	Special-purpose operational training
mmmm)	TF	Track to a fix
nnnn)	TLS	Target level of safety
oooo)	TOGA	Take-Off/Go-Around
pppp)	VDI	Vertical deviation indicator
qqqq)	VNAV	Vertical navigation
rrrr)	VOR	VHF omnidirectional radio range
ssss)	VPA	Vertical path angle
tttt)	WAAS	Wide area augmentation system
uuuu)	WPT	Waypoint

5. INTRODUCTION

5.1 ICAO Document 9613 - Manual on Required Navigation Performance (PBN), currently establishes two types of RNP navigation specifications for approach operations: RNP approach (RNP APCH) and RNP approach with authorization required (RNP AR APCH).

5.2 RNP AR APCH operations permit a high level of navigation performance and require that the operator meet additional aircraft and flight crew requirements in order to obtain an operational authorization from the CAA.

5.3 These operations can offer significant operational and safety advantages compared to other RNAV procedures, since they introduce additional navigation capabilities in terms of precision, integrity and functions allowing for operations with reduced obstacle clearance allowances that permit approach and departure procedures under circumstances in which other approach and departure procedures are neither possible nor satisfactory from the operational point of view.

5.4 RNP AR APCH operations include particular capabilities that require a special and mandatory authorization similar to that for ILS CAT II and CAT III operations.

5.5 All RNP AR APCH operations have reduced lateral obstacle evaluation areas and vertical obstacle clearance surfaces, based on aircraft and crew performance requirements stated in this AC.

5.6 RNP AR APCH operations are classified as vertical guide approach procedures (APV) according to Annex 6. In addition to lateral guide, this type of operation requires a positive vertical navigation guidance system for the final approach segment.

5.7 An RNP AR APCH procedure is designed when a direct approach is not operationally possible.

5.8 There are three features in procedure design criteria that must only be used when there is a specific operational need or a benefit. Accordingly, an operator may be authorized to any or all of the following sub-sets of these types of procedures:

- ✓ ability to fly a published arc, also referred to as a *radius to fix leg (RF leg)*
- ✓ *reduced obstacle evaluation area on the missed approach, also referred to as a missed approach requiring RNP less than 1.0*
- ✓ *an RNP AR APCH that employs a line of minima less than RNP 0.3 and/or a missed approach requiring an RNP less than 1.0*

5.9 An operator conducting an RNP AR APCH operation using a line of minima less than RNP 0.3 and/or a missed approach that requires an RNP less than 1.0 shall comply with paragraphs 5 and/or 6 of Appendix 2 to this AC.

5.10 The criteria in this AC are based on the use of multi-sensor navigation systems and barometric vertical navigation (baro-VNAV) systems.

5.11 The RNP AR APCH approches are use for operations with a final approach segment of RNP 0.3 o lower and are designed with straight and/or fixed radius (constant radius arc to a fix) segments.

5.12 According to ICAO Doc 9613, navigation precision associated with flight phases of RNP AR APCH approach are the following:

a)	Initial segment:	RNP 1.0 to 0.1
b)	Middle segment:	RNP 1.0 to 0.1
c)	Final segment:	RNP 0.3 to 0.1
d)	Unsuccessful approach segment:	RNP 1.0 to 0.1

5.13 Procedures RNP AR APCH are named as $RNAV_{(RNP)}$. Through Aeronautical Information Publication (AIP) and aeronautical letters will be specified permitted sensors or required RNP value.

5.14 The procedures to be implemented pursuant to this AC will permit the use of high-quality lateral and vertical navigation capabilities to improve safety and reduce the risks of controlled flight into terrain (CFIT).

5.15 The material described in this AC has been developed based on the following documents:

- ✓ ICAO Doc 9613, Volume II, Part C, Chapter 6 – Implementing RNP AR APCH; and
- ✓ Working Paper IFPP/2 WP/5 – Flight operational safety assessment (FOSA) submitted to the ICAO PBN Working Group meeting (22 September to 3 October 2008).

5.16 Where possible, this AC has been harmonized with the following documents:

- ✓ EASA AMC 20-26 - Airworthiness approval and operational criteria for RNP authorization required (RNP AR) operations; and
- ✓ FAA AC 90-101 – Approval guidance for RNP procedures with SAAR.

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

6. DESCRIPTION OF THE NAVIGATION SYSTEM

6.1 Lateral Navigation (LNAV)

a) In LNAV, RNP equipment enables the aircraft to navigate in accordance with appropriate routing instructions along a path defined by waypoints maintained in an on-board navigation database.

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

b) For purposes of this AC, RNP AR APCH operations are based on the use of RNP equipment that automatically determines aircraft position on the horizontal plane using data inputs from the following types of position sensors (listed in no specific order of priority or combination), but whose primary basis for positioning is the GNSS.

1) Global navigation satellite system (GNSS).

2) Inertial navigation system (INS) or inertial reference system (IRS), with automatic position updating from suitable radio-based navigation equipment.

3) Distance measuring equipment (DME) that provides measurements from two or more ground

stations (DME/DME)

Note.- *Depending on DME infrastructure, an operator may use DME/DME position updating as a means of reversal. This function must be assessed on a case-by-case basis and approved at the operational level.*

6.2 **Vertical Navigation (VNAV)**

a) In VNAV, the system enables the aircraft to fly level and descend relative to a linear, point-to-point vertical path that is maintained in an on-board navigation database. The vertical profile will be based on altitude constraints or vertical path angles (VPA) where appropriate, associated with the vertical navigation path waypoints.

Note.- *Normally, VNAV is a mode of flight guidance systems, where RNP equipment with VNAV capability provides path steering commands to the flight guidance system that controls the flight technical error (FTE) through either manual pilot control with vertical deviation display or through FD or AP coupling.*

7. AIRCRAFT EQUIPMENT REQUIREMENTS

7.1 The operator must establish and have a configuration list available describing in detail the components and equipment to be used for RNP AR APCH operations.

7.2 The required equipment list shall be established during the operational approval process, taking into account the AFM and available operational mitigation methods. This list shall be used to update the MEL of each type of aircraft for which the operator submits an operational application.

7.3 The details of the equipment and its use in accordance with the characteristic(s) of each approach are described in the appendices to this AC.

8. AIRWORTHINESS AND OPERATIONAL APPROVAL

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

a) an airworthiness approval from the State of Registry; (see Article 31 of the Chicago Convention and paragraphs 5.2.3 and 8.1.1 of Annex 6, Part I); and

b) an operational approval from the State of the Operator (see paragraph 4.2.1 and Attachment F to Annex 6, Part I).

8.2 For general aviation operators, the State of Registry (See paragraph 2.5.2.2 of Annex 6 Part II) will determine if the aircraft meets the applicable RNP AR APCH requirements and will issue the operational authorization (*e.g.,* a letter of authorization – LOA).

8.3 An operator that has obtained operational approval can conduct RNP AR APCH operations in the same way as an operator that has been authorized to conduct ILS CAT II and III operations.

8.4 Before submitting the application, manufacturers and operators shall review all the performance requirements. Compliance with airworthiness requirements or the installation of the equipment, by itself, does not constitute operational approval.

8.5 Appendix 1 to this AC contains the RNP AR APCH procedure characteristics that must be taken into account by operators when conducting this type of operations.

8.6 In order to get operational approval, operators shall meet the requirements contained in Appendices 2 to 6 to this AC.

8.7 Appendix 7 contains a summarized list of requirements to obtain RNP AR APCH authorization, including the documents to be included in the application.

8.8 Appendix 8 contains a summarized guide on the approval process to get an RNP AR APCH authorization.

8.9 Appendix 9 provides guidance on the flight operational safety assessment (FOSA).

9. AIRWORTHINESS APPROVAL

9.1 Aircraft Qualification Documentation

a) Manufactures should develop aircraft qualification documentation showing compliance with Appendix 2 of this AC. This documentation shall identify the optional capabilities (*e.g.,* RF legs and RNP missed approaches), the RNP capability of each aircraft configuration, and the characteristics that may alleviate the need for operational mitigation. This documentation shall also define the recommended RNP maintenance procedures.

9.2 Aircraft Acceptability

a) *For new aircraft*.- the aircraft qualification documentation can be approved by the CAA as part of an aircraft certification project, and will be reflected in the AFM and related documents.

b) *For aircraft in service*.- The operator shall submit the aircraft qualification documentation produced by the manufacturers to the corresponding CAA bodies (*e.g.*, aircraft certification division, or airworthiness inspection division, or equivalents). These bodies shall accept, as appropriate, the data package for RNP AR APCH operations. This acceptance will be documented in a letter addressed to the operator.

9.3 Aircraft Modification

a) If any aircraft system required for RNP AR APCH operations is instaled or modified (e.g., software or hadware change), the aircraft installation or modification must be approved.

b) The operator must obtain a new operational approval supported by the manufacturer´s updated aircraft qualification and operational documentation.

10. OPERATIONAL APPROVAL

10.1 In order to obtain RNP AR APCH authorization, the operator must meet the criteria set forth in this paragraph and in Appendix 7 - Requirements to obtain RNP AR APCH authorization.

10.2 RNP AR APCH Operational Documentation

a) The operator will submit operational documentation for RNP AR APCH operations in accordance with the following appendices to this AC: Appendix 3 – Navigation data validation program; Appendix 4 – Operational considerations; Appendix 5 – Training programs; and Appendix 6 – RNP monitoring programs.

b) *For new aircraft*.- The RNP AR APCH operational documentation submitted by the operator will be accepted by the relevant CAA body (for example, the aircraft certification division or flight standard body or equivalent).

c) *For aircraft in service*.- The operator shall send the RNP AR APCH operational documentation to the corresponding CAA bodies (for example, the aircraft certification division or flight standard body or equivalent). These entities will accept, as appropriate, the RNP AR APCH operational documentation. This acceptance will be documented in a letter addressed to the aircraft operator.

10.1 Operator Approval

a) LAR 91, 121, and 135 operators shall submit to the flight standard body or equivalent evidence of compliance with the aircraft operational or qualification documentation accepted by the CAA as described in Annex 7 to this AC. This documentation will indicate compliance with Appendices 2 to 9 and will be specific to aircraft equipment and procedures. Once the operator has met the requirements of this AC or equivalent, the CAA will issue the operational specifications (OpSpecs) for LAR 121 or 135 operators or a letter of authorization (LOA) for LAR 91 operators, authorizing RNP AR APCH operations.

b) **Provisional Authorization**

1) The operator will be authorized to conduct RNP AR APCH operations using RNP 0.3 minima during the first 90 days of operation or the period stipulated by the CAA, and at least during the first 100 approaches in each type of aircraft.

2) For approaches without a line of minima associated with RNP 0.3 (minima under 0.3), the procedure shall be conducted under visual meteorological conditions (VMC).

3) The provisional authorization will be withdrawn once the operator has completed the applicable period of time and the required number of approaches and once the CAA has reviewed the RNP AR APCH monitoring program reports.

Note 1.- *Operators with experience in equivalent RNP AR APCH operations may receive credit to reduce provisional authorization requirements.*

Note 2.*- Operators with experience in RNP AR APCH operations that are applying for new or modified system or aircraft operations, variations of the aircraft type or different aircraft types with identical crew procedures and interface may use reduced periods or approaches in the provisional authorization (for example, periods of less than 90 days and approaches of less than 50), as determined by the CAA.*

Note 3.*- In particular circumstances in which compliance with 50 successful approaches could take a long time due to factors such as the small number of aircraft in the fleet, limited opportunities to use aerodromes with the appropriate procedures, and when an equivalent level of reliability can be obtained, consideration can be given, on a case-by-case basis, to a reduction in the required number of approaches.*

c) **Final Authorization**

1) The CAA will issue the OpSpecs or the LOA authorizing the use of the lowest applicable minima once the operators have successfully completed the time period and the number of approaches required by the CAA, as established in paragraph b) above.

APPENDIX 1

RNP AR APCH INSTRUMENT APPROACH PROCEDURES

1. INTRODUCTION

a) ICAO Doc 9905 - *Manual for the design of RNP procedures with authorization required (RNP AR)*, provides RNP AR APCH procedure design criteria.

b) This appendix provides a summary of the key characteristics of approach procedures, and introduces the types of RNP approach operations.

2. PARTICULAR CHARACTERISTICS OF RNP AR APCH APPROACHES

a) **RNP value**.- Each line of minima published has an associated RNP value; for example, RNP 0.3 or RNP 0.15. A minimum RNP value is documented as part of an RNP AR APCH authorization for each operator, and it may vary depending on aircraft configuration or operational procedures (for example, inoperative GPS, use of FD with or without AP).

b) **Procedures that include *radius to fix legs* (RF legs)**.- Some RNP procedures have curved paths, known as *radius to fix legs (RF legs).* Since not all aircraft can fly this type of legs, pilots are responsible for knowing if they can conduct an RNP AR APCH procedure with an RF leg. RNP requirements for RF legs will be indicated in the note section of instrument approach charts (IAC) or in the applicable initial approach fix (IAF).

c) **Missed approaches that require RNP values of less than 1.0**.- In designated locations, the airspace or the obstacle area will require an RNP capability of less than 1.0 during a missed approach from any location in the procedure. Navigation system reliability must be very high in these locations. These approaches will normally require redundant equipment since no single point-of-failure can cause a loss of RNP capability.

d) **Non-standard speeds or climb gradients**.- RNP AR APCH procedures are developed on the basis of standard approach speeds and a with climb gradient of 200 ft/NM in the missed approach. Any exception to these standards will be stated in the approach procedure and the operator will ensure compliance with any published limitation before conducting the operation.

e) **Temperature limits**.-

1) High and low temperature limits are identified in RNP AR APCH procedures for aircraft using barometric vertical navigation (baro-VNAV) without temperature compensation on the approach.

2) Aircraft using baro-VNAV with temperature compensation, or an alternate means of vertical guidance (*e.g.,* SBAS) can ignore temperature restrictions.

3) Since temperature limits established in the charts are assessed only for obstacle clearance in the final approach segment, and taking into account that temperature compensation affects only vertical guidance, the pilot may need to adjust the minimum altitude in the initial and intermediate approach segments and in the decision altitude/height (DA/H)).

Note 1.- *Temperature affects the indicated altitude. The effect is similar to having high and low pressure changes, but not as significant as those changes. When the temperature is higher than the standard (ISA), the aircraft will be flying above the indicated altitude. When the temperature is lower than the standard, the aircraft will be flying below the altitude indicated in the altimeter. For further information, refer to altimeter errors in the aeronautical information manual (AIM).*

Note 2.- *Pilots are responsible for all low (cold) temperature corrections required at all minimum altitudes/heights published. This includes:*

- the altitudes/heights for the initial and intermediate segments;
- the DA/H; and
- the subsequent missed approach altitudes/heights.

Note 2.- *The final approach path VPA is protected against the effects of low temperatures by the procedure design.*

f) **Aircraft size**.- The minima to be obtained may depend on the size of the aircraft. Large aircraft may require higher minima due to the height of the landing gear and/or aircraft wingspan. When appropriate, aircraft size restrictions will be reflected in RNP AR APCH procedure charts.

APPENDIX 2

AIRCRAFT QUALIFICATION

1. INTRODUCTION

a) This appendix describes aircraft performance and the functional criteria for qualifying an aircraft for RNP AR APCH operations.

b) Applicants may establish compliance with this appendix based on the type certification or supplementary type certification, and document said compliance in the AFM (supplement).

c) The operator of a previously certified aircraft may document compliance with this aircraft certification criterion without a new airworthiness project (for example, without a change in the AFM) and must report to the aircraft certification division or equivalent any new performance not covered by the original airworthiness approval.

d) The AFM or other proof of aircraft qualification shall indicate the normal and non-normal flight crew procedures, responses to failure alerts, and any other limitation, including information on the operation modes required for flying an RNP AR APCH procedure.

e) In addition to the specific RNP AR APCH guide presented in this AC, the aircraft must comply with AC 20-129 – Airworthiness approval of vertical navigation (VNAV) systems for use in the U.S. National Airspace System (NAS) and Alaska and either with AC 20-130 () – Airworthiness approval of navigation or flight management systems integrating multiple navigation sensors or AC 20-138 () – Airworthiness approval of NAVSTAR Global Positioning System (GPS) for use as a VFR and IFR supplemental navigation system, or equivalent documents.

2. PERFORMANCE REQUIREMENTS

This paragraph defines the general performance requirements for aircraft qualification. Paragraphs 3, 4, and 5 of this appendix provide guidance material on acceptable methods of compliance to meet such requirements.

a) **Path definition.-** Aircraft performance is assessed around the path defined by the published procedure and by Section 3.2 of document RTCA/DO.236B. All flight paths used in conjunction with the final approach segment will be defined by the flight path angle (VPA) (RTCA/DO-236B, Section 3.2.8.4.3) as a straight line to a fix and altitude.

b) **Lateral precision.-** Any aircraft conducting RNP AR APCH procedures must have a cross-track navigation error not greater than the precision value (0.1 NM to 0.3 NM) applicable to 95% of the flight time. This error includes the position error, the flight technical error (PTE), and the display system error. Likewise, the along-path position error must not be greater than the precision value applicable to 95 % of the flight time.

c) **Vertical precision.-** The vertical system error includes the altimeter error (assuming international standard atmosphere (ISA) temperature and lapse rates), the along-path effect of the error, the system calculation error, and the flight technical error. 99.7% of the system error in the vertical direction must not be less than (in feet):

$$\sqrt{((6076.115)(1.225)\mathbf{RNP}\cdot tan\boldsymbol{\theta})^2+(60\,tan\boldsymbol{\theta})^2+75^2+\left(\left(-8.8\cdot10^{-8}\right)(\mathbf{h}+\boldsymbol{\Delta h})^2+\left(6.5\cdot10^{-3}\right)(\mathbf{h}+\boldsymbol{\Delta h})+50\right)^2}$$

Where θ is the vertical navigation path angle, h is the height of the local altimeter reporting station, and Δh is the height of the aircraft over the reporting station.

d) **Airspace containment.-** RNP AR APCH approaches are published as performance-based approaches; therefore, they do not require any specific procedure or technology, but rather a

performance level.

1) **RNP and baro-VNAV aircraft.-** This AC provides acceptable methods of compliance for aircraft using an RNP system based mainly on GNSS, and a vertical navigation system (VNAV) based on a barometric altimeter. Paragraphs 3, 4, and 5 of this appendix, together with the guide established in Appendices 3 and 4, describe an acceptable method of acceptance to obtain the required navigation performance. Aircraft and procedures that comply with these paragraphs and appendices meet the airspace containment requirement.

2) **Other alternate systems or methods of compliance.-** For other alternate systems or methods of compliance, the likelihood of the aircraft exceeding the lateral and vertical limits of the obstacle clearance volume must not exceed 10^{-7} per approach (Doc 9905 - *Manual for the design of navigation required performance procedures with authorization required (RNP AR)*, including approach and missed approach. This requirement can be met through a safety assessment, applying:

- ✓ appropriate quantitative numerical methods;
- ✓ operational and procedural qualitative considerations and mitigations; or
- ✓ an appropriate combination of both quantitative and qualitative methods.

Note 1.- *This requirement applies to the total likelihood of excursions outside of the obstacle clearance volume, including events caused by latent conditions (integrity) and detected conditions (continuity) if the aircraft does not remain within the obstacle clearance volume after the failure is announced. The alert control limit, the latent status of the alert, the crew response time, and the aircraft response shall be taken into account when ensuring that the aircraft will not go outside the obstacle clearance volume. The requirement applies to a single procedure, considering the exposure time of the operation, the radio aid (NAVAID) geometry, and the navigation performance available for each published approach.*

Note 2.- *This containment requirement is derived from the operational requirement and is particularly different from the requirement specified in Document RTCA/DO-236B. The requirement in Document RTCA/DO-236B was developed to expedite airspace design and is not directly equivalent to obstacle clearance.*

e) **System control.-** A critical component of RNP during approach is the capability of the aircraft navigation system to control the navigation performance obtained and identify for the flight crew whether or not the operational requirement is being met during the operation.

3. GENERAL RNP AR APCH REQUIREMENTS

a) **Navigation Sensors.-** This section identifies the particular features of navigation sensors within the context of RNP AR APCH operations.

1) **Global Positioning System (GPS).-**

(a) The sensor must meet the criteria of FAA AC 20-138 (). For systems that comply with this AC, the following sensor precisions can be used in the total system precision analysis without any additional justification:

(1) GPS sensor precision better than 36 m (95%); and

(2) augmented GPS (GBAS or SBAS) sensor precision better than 2 m (95%).

(b) In case of latent failure of the GPS satellite and marginal geometry of said satellite (*e.g.,* horizontal integrity limit (HIL) equal to the horizontal alert limit (HAL)), the likelihood of the aircraft remaining within the obstacle clearance volume used to assess the procedure must be greater than 95% (both laterally and vertically).

Note.- *GNSS-based sensors produce an HIL, also known as horizontal protection level (HPL) (see AC 20-138A, Appendix 1 and document RTCA/DO-229C for an explanation of these terms). The HIL is a measure of the estimated position error, assuming a latent failure is present. Instead of a detailed analysis of the effects of latent failures on the total system error, an acceptable means of compliance for GNSS-based systems is to ensure the HIL remains twice as low as the navigation precision, minus 95% of the flight technical error (FTE), during RNP AR APCH operations.*

2) **Inertial reference system (IRS).-** An IRS must meet the criteria of LAR 121 Appendix G or

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

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

3) **Distance measuring equipment (DME).-** Initiation of all RNP AR APCH procedures is based on GNSS updating. Except where the use of DME in a procedure is specifically designated as "not authorized", DME/DME updating can be used as a reversal mode during the approach and missed approach when the system complies with the navigation precision. The manufacturer and the operator shall identify any DME infrastructure or procedure limitation preventing an aircraft type from meeting this requirement.

4) **VHF omnidirectional radio range (VOR).-** For initial RNP AR APCH implementation, the RNP system may not use VOR updating. The manufacturer and the operator shall identify any constraints on the VOR infrastructure or the procedure for a given aircraft to comply with this requirement.

Note.- *This requirement does not prohibit the capability of the VOR equipment, provided there is a direct means to inhibit its update. A procedure that allows the flight crew to inhibit VOR updating or to execute a missed approach if the system reverts to VOR updating may meet this requirement.*

5) **Multi-sensor systems**.- For multi-sensor systems, there must be automatic reversal to an alternate RNAV sensor if the primary RNAV sensor fails. Automatic reversal from one multi-sensor system to another multi-sensor system is not required.

6) **Altimetry system error**.- 99.7% of the altimetry system error for each aircraft (assuming international standard atmosphere temperature and lapse rate) must be less or equal to the following, with the aircraft in the approach configuration:

$$\mathbf{ASE} = -8.8 \cdot 10^{-8} \cdot \mathbf{H}^2 + 6.5 \cdot 10^{-3} \cdot \mathbf{H} + 50$$

Where H is the true altitude of the aircraft

7) **Temperature compensation systems.-** Systems that provide temperature-based corrections to the barometric VNAV guidance must comply with RTCA/DO-236 Appendix H.2. This applies to the final approach segment. Compliance with this requirement shall be documented to enable the operator to conduct RNP AR APCH approaches when the actual temperature is above or below the published procedure design limit. Appendix H.2 also provides guidance on operational aspects related to temperature compensation systems, such as intercepting compensated paths from non-compensated procedure altitudes.

b) **Flight path definition and flight planning**

1) **Track-keeping and transition legs.-** The aircraft must be capable of executing transition legs and maintain tracks consistent with the following paths:

(a) a geodetic line between two fixes;

(b) a direct to fix path;

(c) a specific track to a fix, defined by a course; and

(d) a specific track to an altitude.

Note 1.- *The standards for these paths may be found in documents EUROCAE ED-75 / RTCA DO-236B and in ARINC Specification 424 – Navigation database. These standards refer to these paths as path terminators: Track to a fix (TF), Direct to a fix (DF), Course to a fix (CF), Course from a fix to an altitude (FA). Likewise, some procedures require radius to a fix (RF) legs as described in paragraph 4 of this appendix. Documents EUROCAE ED-75A/RTCA DO-236B and ED-77/DO-201A describe in more detail the application of these paths.*

Note 2.- *Navigation systems can accommodate other ARINC 424 path terminators (e.g., heading to a manual terminator (VM)). Missed approach procedures may use these types of paths when there is no requirement for RNP containment.*

2) **Fly-By and Flyover Fixes**.- The aircraft navigation system must be capable of executing fly-by and flyover fixes. For fly-by turns, the navigation system must limit the path definition within the theoretical transition area defined in document EUROCAE ED-75B/RTCA DO-236B under the wind conditions identified in ICAO Doc 9905. The flyover turn is not compatible with RNP flight tracks and will only be used when there is no repetitive path requirement.

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

4) **"Direct to" function capability** - The navigation system must have a "direct to" function that the flight crew can activate at any time. This function must be available for any fix. The navigation system must also be capable of generating a geodetic path "to" the designated fix, without turns and undue delays.

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

   (a) an AT or ABOVE altitude constraint (for example, 2400A) may be appropriate for situations where it is not necessary to limit the vertical path;

   (b) an AT or BELOW altitude constraint (for example, 4800B) may be appropriate for situations where it is not necessary to limit the vertical path;

   (c) an AT altitude constraint (for example, 5200); or

   (d) a WINDOW-type altitude constraint (for example, 2400A3400B).

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

6) **Altitudes and/or speeds.-** Altitudes and speeds associated with published procedures must be extracted from the navigation database.

7) **Path construction.**- The system must be capable of constructing a path to provide guidance from current position to a constrained fix.

8) **Ability to load procedures from the navigation database.-** The navigation system must be capable of loading the entire procedure(s) to be flown into the RNP system from an on-board database. This includes the approach (including a vertical angle), the missed approach, and the approach transitions for the selected aerodrome and runway.

9) **Means to retrieve and display navigation data.-** The navigation system must provide the flight crew the ability to verify the procedures to be flown through a review of the data stored in the on-board navigation database. This includes the ability to review the data for individual waypoints and navigation aids.

10) **Magnetic variation.**- For paths defined by a course (path terminators: Course to a fix (CF) and Course from a fix to an altitude (FA)), the navigation system must use the magnetic variation value for the procedure loaded on the navigation database.

11) **Changes in the RNP value.**- Changes to lower RNP values must be completed at the fix that defines the leg with the lowest RNP value. Any operational procedure necessary to accomplish this must be identified.

12) **Automatic leg sequencing.**- The navigation system must provide the ability to automatically sequence to the next leg and display the sequencing to the flight crew in a readily visible manner.

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

c) **Demonstration of path steering performance.**- When the RNP demonstration includes a path steering performance demonstration (flight technical error), the applicant must complete such demonstration in accordance with paragraphs 5.19.2.2 and 5.19.3.1 of FAA AC 120-29A.

d) **Displays.-**

1) **Continuous display of deviation.-** The navigation system must provide the ability to continuously display the aircraft position relative to the defined RNP path (both lateral and vertical deviation) to the pilot flying the aircraft, on the primary flight navigation instruments. The display must allow the pilot to readily distinguish if the cross-track deviation exceeds the navigation precision (or a smaller value) or if the vertical deviation exceeds 75 ft (or a smaller value).

(a) It is advisable that a appropriately-scaled non-numeric deviation display (*e.g.,* the lateral deviation indicator or the vertical deviation indicator) be located in the primary field of view of the pilot. A course deviation indicator (CDI) is acceptable provided it demonstrates an appropriate scaling and sensitivity for the intended navigation precision and operation. With a scalable CDI, the scale should be derived from the RNP selection, and does not require a separate selection of the CDI scale. Alerting and annunciation limits must also match the scaling values. If the equipment uses a pre-established navigation precision to describe the operational mode (*e.g.,* en route, terminal area, and approach), then displaying the operational mode is an acceptable means from which the flight crew can derive the CDI scale sensitivity.

(b) Normally, a numeric deviation display or the display of a graph on a map without a properly regulated deviation indicator is not acceptable. The use of a numeric display or a map display may be possible depending on the flight crew workload, display characteristics, flight crew procedures and training. Furthermore, initial and recurrent training or on-line experience must be provided to the flight crew, but this solution increases flight crew workload during approach, and imposes additional costs to the operator due to training requirements.

2) **Identification of the active (to) waypoint.-** The navigation system must provide a display identifying the active waypoint, either in the primary field of view of the pilot or on a display that is visible to, and of ready access by the flight crew.

3) **Display of distance and heading.-** The navigation system must provide a display of distance and heading to the active (to) waypoint in the primary field of view of the pilot. Where not viable, an easily accessible page on the control display unit (CDU), readily visible to the flight crew, may display the information.

4) **Display of groundspeed (GS) and time.-** The navigation system must provide a display of groundspeed and time to the active (to) waypoint in the primary field of view of the pilot. Where not viable, an easily accessible page on the control display unit, readily visible to the flight crew, may display the information.

5) **Display of to/from the active fix.-** The navigation system must provide a to/from display in the primary field of view of the pilot.

6) **Desired track display.-** The navigation system must be capable of continuously displaying the desired RNP track to the pilot flying the aircraft. The display must be on the primary flight instruments for aircraft navigation.

7) **Display of aircraft track.**- The navigation system must provide a display of the actual aircraft track (or track angle error), either in the primary field of view of the pilot, or on a display that is visible to, and readily accessible by the flight crew.

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

9) **Enslaved course selector.-** The navigation system must provide a course selector automatically enslaved to the computed RNP path.

10) **RNP path display.-** When the minimum flight crew is two pilots, the navigation system must provide a readily visible means for the pilot monitoring the aircraft to verify the defined RNP path and the aircraft position relative to said path.

11) **Display of distance to go.-** The navigation system must provide the ability to display distance to go to any waypoint selected by the flight crew.

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

13) **Display of deviation.** The navigation system must provide a numeric display of vertical deviation with a resolution of 10 ft or less, and a lateral deviation with a resolution of 0.01 NM or less.

14) **Display of barometric altitude.**- The aircraft must display barometric altitude from two independent sources, one in the primary field of view of each pilot.

Note.- *This display supports an operational cross-check of altitude sources. If the aircraft altitude sources are automatically compared, the output of the independent altimetry sources, including independent aircraft static air pressure systems, must be analyzed to ensure that they can provide an alert in the primary field of view of the pilot when deviations exceed 75 ft. Such comparator monitor function shall be documented so that it may eliminate the need for an operational mitigation.*

15) **Display of active sensors.-** The aircraft must display the navigation sensor(s) in use. It is recommended that this display be provided in the primary field of view of the pilot.

Note.- *This display is used to support operational contingency procedures. If such display is not provided in the primary field of view of the pilot, flight crew procedures can mitigate the need for this display if the workload is designated as acceptable.*

e) **Design assurance**.- The system design assurance must be consistent with at least a major failure condition with respect to false lateral or vertical guidance during an RNP AR APCH.

Note.- *The false vertical or lateral RNP guidance display is considered to be a (severe or major) hazardous failure condition for RNP AR APCH with an RNP value of less than 0.3. Systems designated as consistent with this effect should be documented since they can eliminate the need for some aircraft operational mitigation.*

f) **Navigation database**

1) **Navigation database.-** The aircraft navigation system must use a navigation database that:

(a) can receive updates in accordance with the AIRAC cycle; and

(b) permits the retrieval and loading of RNP AR APCH procedures from and into the RNP system.

2) **Database protection.-** The on-board navigation database must be protected against flight crew modification of stored data.

Note.- *When a procedure is loaded into the database, the RNP system must fly the published procedure. This does not prevent the flight crew from having the means to modify a procedure or route that has been loaded into the RNP system. However, the procedures stored in the navigation database must not be modified and must remain intact in the navigation database for reference and future use.*

3) **Validity period display.-** The aircraft must provide a means to display the validity period of the on-board navigation database to the flight crew.

4. REQUIREMENTS FOR RNP AR APCH PROCEDURES WITH RF LEGS

This section defines the additional requirements for executing approaches with RF legs. The AFM or the aircraft qualification guidance shall state whether or not this capability is provided.

a) The navigation system must be capable of executing transition legs and maintaining tracks that are consistent with the RF legs between two fixes.

b) The aircraft must have an electronic map displaying the procedure selected.

c) The FMC, the flight management system, and the autopilot must be capable of commanding a bank angle of 25º above 400 ft AGL and up to 8º below 400 ft AGL.

d) Once a missed approach or go-around (through the activation of TOGA of other means) has been initiated, the flight guidance mode must remain in LNAV to enable continuous track guidance during an RF leg.

5. REQUIREMENTS FOR APPROACHES WITH AN RNP OF LESS THAN 0.3

The AFM or aircraft qualification guidance must state whether or not the ability of executing approaches with an RNP of less than 0.3 is provided for each aircraft configuration (*e.g.,* two APs may achieve an RNP capability that is lower to that achieved with two flight directors).

a) **Single point of failure.-** No single point of failure can cause the loss of guidance compatible with the RNP value of the approach. Typically, the aircraft must have at least the following equipment:

   1) two GNSS sensors;

   2) two FMS;

   3) two air information systems;

   4) two AP; and

   5) one inertial reference unit (IRU).

b) **Design assurance.-** The system design assurance must be consistent with at least a severe or major failure condition due to loss of lateral or vertical guidance during an RNP AR APCH where an RNP value of less than 0.3 is required to avoid obstacles and terrain while executing an approach.

   Note.- *The loss of lateral guidance display during RNP AR APCH operations that require an RNP value of less than 0.3 to avoid obstacles or terrain is considered as a hazardous (severe or major) failure condition. The AFM shall document designated systems that are consistent with this effect. This documentation shall describe the specific configuration of the aircraft or the mode of operation to obtain RNP values of less than 0.3. Compliance with this requirement may replace the general requirement for the two pieces of equipment described above.*

c) **Go-around guidance**.- Once a missed approach or go-around maneuver has been initiated (through activation of TOGA or other means), the flight guidance mode must remain in LNAV to enable continuous track guidance during an RF leg. If the aircraft does not provide this capability, the following requirements apply:

   1) If the aircraft provides RF leg capability, the lateral path after initiating a go-around maneuver (TOGA) (taking into account a straight segment of at least 50 seconds between the point where the RF leg ends and the decision altitude (DA)) must fall within 1º of the track defined by the straight segment through the DA point. The previous turn may have an arbitrary angular extension and a turn radius as small as 1 NM, with speeds consistent with the approach conditions and the turn radius.

   2) The flight crew must be capable of coupling the AP or DF to the RNP system (connect LNAV) at 400 ft AGL.

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

6. REQUIREMENTS FOR MISSED APPROACHES WITH RNP LESS THAN 1.0

The AFM or the aircraft qualification guidance shall identify if the aircraft can achieve an RNP value of less than 1.0 in a missed approach. The AFM or the aircraft qualification guidance shall also specify the aircraft configuration or operating mode required to obtain RNP values of less than 1.0 (*e.g.,* two APs may achieve an RNP capability that is lower than that achieved with two FDs).

a) **Single point of failure**.- No single point of failure can cause the loss of guidance compliant with an RNP value associated to a missed approach procedure. Typically, the aircraft must have at least the following equipment:

1) two GNSS sensors;

2) dual FMS;

3) two air information systems;

4) two APs; and

5) one IRU.

b) **Design assurance**.- The system design assurance must be consistent with at least one severe or major failure condition due to loss of lateral or vertical guidance during an RNP AR APCH where an RNP value of less than 1.0 is required to avoid obstacles and terrain while executing a missed approach.

Note.- *The loss of lateral guidance display during RNP AR APCH missed approach operations that require an RNP value of less than 1.0 to avoid obstacles or terrain is considered as a hazardous (severe or major) failure condition. The AFM shall document designated systems that are consistent with this effect. This documentation shall describe the specific aircraft configuration or operation mode to obtain RNP values of less than 1.0. Compliance with this requirement may substitute the general requirement for two pieces of equipment described above.*

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

1) If the aircraft provides the ability for RF legs, the lateral path after initiating a go-around (TOGA) (taking into account a straight segment of at least 50 seconds between the point where the RF leg ends and the decision altitude (DA)), must be within 1º of the track defined by the straight segment through the DA point. The previous turn may have an arbitrary angular extension and a turn radius as small as 1 NM, with speeds consistent with approach conditions and turn radius.

2) The flight crew must be capable of coupling the AP or DF to the RNP system (connect LNAV) at 400 ft AGL.

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

APPENDIX 3

NAVIGATION DATA VALIDATION PROGRAM

1. INTRODUCTION

The procedure stored in the navigation database defines the aircraft lateral and vertical guidance. Navigation database updates are done every 28 days. The navigation data used in each update are critical for the integrity of each RNP AR APCH procedure. Taking into account the reduced obstacle clearance associated with these approaches, navigation data validation requires special consideration. This appendix provides guidance on operator procedures to validate navigation data associated with RNP AR APCH operations.

2. DATA PROCESSING

a) In its procedures, the operator shall identify the person responsible for the navigation data updating process.

b) The operator must document a process to accept, verify, and load the navigation data into the aircraft.

c) The operator must place its documented data process under configuration control.

3. INITIAL DATA VALIDATION

The operator must validate each RNP AR APCH procedure before flying the procedure under instrument meteorological conditions (IMC) to ensure compatibility with the aircraft and make sure that the resulting paths correspond to the published procedure. The operator must at least:

a) compare the navigation data of the procedure to be loaded into the FMS with a published procedure.

b) validate the navigation data of the loaded procedure, either in the flight simulator or in the aircraft under visual meteorological conditions (VMC). The procedure outlined in a map display must be compared to the published procedure. The complete procedure must be flown to make sure that the path can be used, has no apparent lateral or vertical path inconsistencies, 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 for comparison with subsequent data updates.

4. DATA UPDATES

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

5. NAVIGATION DATA SUPPLIERS

Navigation data providers must have a letter of acceptance (LOA) in order to process these data (*e.g.,* FAA AC 20-153, Conditions for issuance of letters of acceptance for navigation data suppliers by the European Aviation Safety Agency – EASA or equivalent document). An LOA recognizes the data of a supplier as those where the quality of the information, the integrity and quality management practices are consistent with the criteria of document DO-200A/ED-76. An operator supplier (for example, an FMS

company) must have an LOA Type 2 and its respective suppliers must have an LOA Type 1 or 2. AAC may accept a LOA submitted by navigation data providers or submit its own LOA.

6. AIRCRAFT MODIFICATIONS (DATA BASE UP TO DATE)

If an aircraft system required for RNP AR APCH operations is modified (*e.g.*, software change), the operator is responsible for validating the RNP AR 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 there is no such verification by the manufacturer, the operator must conduct an initial navigation data validation with the modified system.

APPENDIX 4

OPERATING PROCEDURES

1. GENERAL

This appendix provides guidance on the execution of RNP AR APCH operations. In addition to the guidelines provided in this appendix, the operator must ensure continuous compliance with the general RNP AR APCH operating procedures and verification of notices to airmen (NOTAMs), NAVAID availability, aircraft system airworthiness, and flight crew qualification.

2. PRE-FLIGHT CONSIDERATIONS

a) **Minimum equipment list (MEL).-** The operator MEL must be developed or revised to indicate equipment requirements for instrument RNP AR APCH procedures. Guidance on these equipment requirements is available in the documents of the aircraft manufacturer. The required equipment may depend on the intended navigation precision and whether the missed approach requires an RNP value of less than 1.0. For example, GNSS and AP are normally required for a low navigation precision. Normally, dual equipment is required for approaches when using a line of minima of less than RNP 0.3 and/or when the missed approach has an RNP value of less than 1.0. An operable enhanced ground proximity warning system (EGPWS/TAWS) is required for all RNP AR APCH procedures. It is advisable that the EGPWS/TAWS use local pressure- and temperature-compensated altitudes (*e.g.,* a corrected GNSS and barometric altitude) and that it includes data on significant obstacles and terrain. The flight crew must be aware of the equipment requirement.

b) **Autopilot (AP) and flight director (FD).-** For procedures with a navigation precision of less than RNP 0.3 or with RF legs, the use of AP and FD driven by the aircraft RNP system is required in all cases. Therefore, the AP and FD must operate with a suitable precision to track the lateral and vertical paths required by a specific RNP AR APCH procedure. When the dispatch or release of a flight is predicated on flying an RNP AR APCH approach that requires the use of AP at the destination and/or alternate aerodrome, the flight dispatcher or pilot in command must make sure that the AP is installed and operational.

c) **Assessment of an RNP AR APCH dispatch or release.-** The operator must have a predictive performance capability to forecast whether the specific RNP will be available at the location and time of a desired RNP AR APCH operation. This capability can be provided through a ground service and does not need to reside in the aircraft avionic equipment. The operator must establish procedures requiring the use of this capability as a dispatch or release tool and as a flight-tracking tool in case of reported failures. RNP assessment must consider the specific combination of aircraft capabilities (sensors and integration).

   1) **Assessment of RNP AR APCH with GNSS updating**.- The predictive capability must take into account known and predicted temporary suspension of GNSS satellite service or other negative effects on navigation system sensors. The prediction program shall not use a masking angle of less than 5º, as operational experience indicates that satellite signals at low elevations are not reliable. The prediction must use the current GPS constellation with an algorithm identical to that used in the on-board equipment. For RNP AR APCH procedures in high terrain, the operator must use a masking angle appropriate to the terrain.

   2) From the initiation of the approach, RNP AR APCH procedures require GNSS updating.

d) **NAVAID exclusion**.- The operator must establish procedures to exclude air navigation facilities in accordance with published NOTAMs (*e.g.,* DMEs, VORs, and localizers). Rationality checks of the internal avionic equipment may not be appropriate for RNP AR APCH operations.

e) **Validity of the navigation database**.- Upon initiating the system, the pilots of aircraft equipped with certified RNP systems must confirm that the navigation database is valid. The databases are expected to be current for the duration of the flight. If the AIRAC cycle changes during the flight, the operators and pilots must establish procedures to ensure the precision of navigation data,

including the suitability of navigation facilities used for defining routes and flight procedures. Traditionally, this has been accomplished by verifying electronic data against paper documents. One acceptable means is to compare aeronautical charts (new and old) to verify navigation fixes prior to flight dispatch or release. If an amended chart has been published for the procedure, the navigation database must not be used to conduct the operation.

3. FLIGHT CONSIDERATIONS

a) **Flight plan modification**.- Pilots are not authorized to fly a published RNP AR APCH procedure unless it can be retrieved by its name from the navigation database and conforms to the published procedure. The lateral path must not be modified, except that the pilot may accept a clearance to fly direct to a fix located prior the FAF in the approach procedure, and that does not immediately precede an RF leg. The only other acceptable modification to the loaded procedure is to change speed and/or altitude waypoint constraints on the initial, intermediate, or missed approach segments (for example, corrections applied due to cold temperature or to comply with an ATC clearance/instruction).

b) **Required equipment list**.- The flight crew must have a list of the equipment required to conduct RNP AR APCH procedures or alternate methods for addressing, during the flight, equipment failures that hinder the execution of an RNP AR APCH procedure (*e.g.,* the quick reference handbook - QRH).

c) **RNP AR APCH management**.- Flight crew operating procedures must ensure that the navigation system uses the appropriate navigation precision during the approach. If the approach chart shows several minima associated to different navigation precision values, the flight crew must confirm that the desired navigation precision has been entered in the RNP system. If the RNP system does not extract and set the navigation precision from the on-board database for each leg of the procedure, then the flight crew operating procedures must ensure that the lowest navigation precision required to complete the approach or missed approach has been selected before starting the approach.

d) **GNSS updating**.- From the beginning of the approach, all instrument RNP AR APCH procedures require GNSS updating of the navigation position solution. The flight crew must verify that GNSS updating is available before starting the RNP AR APCH procedure. If at any time during the approach GNSS updating is lost and the navigation system does not have the performance to continue the approach, the flight crew must abandon the RNP AR APCH procedure, unless the pilot has in sight the visual references required to continue such approach.

e) **Radio updating**.- The initiation of any RNP AR APCH procedure is based on GNSS updating. Except where specifically designated in a procedure as not authorized, DME/DME updating can be used as a reversal mode during the approach or missed approach when the system complies with the navigation precision. VOR updating is not authorized at this time. Consequently, the flight crew must follow operator procedures to inhibit specific facilities (see paragraph 2.d) of this appendix).

f) **Approach procedure confirmation**.- The flight crew must confirm that the correct procedure has been selected. This procedure includes the confirmation of waypoint sequence, the rationality of track angles and distances, and any other parameter that can be modified by the pilot, such as altitude and speed constraints. A procedure must not be used if validity of the navigation database is in doubt. A navigation system text display or a navigation map display can be used.

g) **Track deviation monitoring**.- Pilots must use a lateral deviation indicator, an FD and/or an AP in lateral navigation mode during RNP AR APCH procedures. Pilots of aircraft with lateral deviation indicators must ensure that indicator scaling (full-scale deflection) is suitable for the navigation precision associated with the various segments of the RNP AR APCH procedure.

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

For normal operations, the cross-track error/deviation (the difference between the path estimated by the RNP system and the aircraft position relative to the path) shall be limited to $\pm$ ½ the

navigation precision associated with the procedure segment.

Small lateral deviations from this requirement (*e.g.,* overshooting or undershooting the limit) during or immediately after a turn are allowed, up to a maximum of 1 times (1xRNP) the navigation precision of the procedure segment.

The vertical deviation must be within 75 ft during the final approach segment. Lateral deviations shall be monitored above and below the glide path (GP). While being above the glide path provides a margin over the obstacles during the final approach, it can result in the pilot deciding to do a go-around closer to the runway, which reduces obstacle clearance during the missed approach.

Pilots must execute a missed approach if lateral deviation exceeds 1xRNP or if vertical deviation exceeds 75 ft, unless the pilot has in sight the visual references required to continue the approach.

1) Some aircraft navigation displays do not incorporate lateral and vertical deviations scaled for each RNP AR APCH operation in the primary field of view of the pilot. When using a moving map, a low-resolution vertical deviation indicator (VDI), or a numeric deviation display, flight crew training and procedures must ensure the effectiveness of these displays. Normally, this implies a demonstration of the procedure with a number of trained crews and the inclusion of this monitoring procedure in the recurrent training program for RNP AR APCH.

2) For aircraft using a CDI for lateral path tracking, the AFM or the aircraft qualification guidance shall indicate which navigation precision (RNP value) and operations the aircraft supports and the effects of the operation on CDI scale. The flight crew must know the CDI full-scale deflection (FSD) value. The avionics system can automatically adjust the CDI scale (depending on the flight phase) or the flight crew can manually adjust such scale. If the flight crew manually selects the CDI scale, the operator must have procedures in place and provide training to ensure that the CDI scale selection is appropriate for the intended RNP AR APCH operation. The deviation limit must be readily visible, considering CDI scale (*e.g.,* full-scale deflection).

h) **System cross-check**.- For RNP AR APCH procedures with a navigation precision of less than 0.3, the flight crew must monitor the lateral and vertical guidance provided by the RNP navigation system to ensure that this guidance is consistent with other available data and displays provided by an independent means.

Note.- *This cross-check may not be necessary if lateral and vertical guidance systems have been developed taking into account a hazardous (severe or major) failure condition due to false information (see Appendix 2, paragraph 3.e) and if normal system performance supports airspace containment (see Appendix 2, paragraph 2.d).*

i) **Procedures with RF legs**.- An RNP AR APCH procedure may require that aircraft be capable of executing an RF leg to avoid terrain and obstacles. Since not all aircraft have this capability, flight crews must know whether or not they can conduct these procedures. When flying an RF leg, flight crew compliance with the flight path is essential to maintain the track defined on the ground.

1) If a go-around maneuver is initiated during or immediately after an RF leg, the flight crew must be aware of the importance of maintaining the published path as closely as possible. The operator must develop and establish operating procedures for aircraft that do not stay in LNAV when a go-around maneuver is initiated, to ensure that the RNP AR APCH track defined on the ground is maintained.

2) Pilots must not exceed the maximum speeds shown in Table 4-1 during the RF leg. For example, an A 320 Category C must slow down to 160 KIAS at the final approach fix (FAF) or can fly as fast as 185 KIAS if using Category D minima. A missed approach prior to the decision altitude (DA) may require a segment speed for that segment to be maintained.

Table 4-1 – Maximum speed by segment and category

Indicated Airspeed (Knots)					
Segment	Indicated airspeed by aircraft category				
	Cat A	Cat B	Cat C	Cat D	Cat E
Initial and intermediate (IAF to FAF)	150	180	240	250	250
Final (FAF to DA)	100	130	160	185	As specified in the IAC
Missed approach (DA to MAHP)	110	150	240	265	As specified in the IAC
Airspeed restriction*	As specified in the IAC				

* Airspeed restrictions may be used to reduce turn radius regardless of aircraft category.

j) **Temperature compensation**.- For aircraft with temperature compensation capability as per paragraph 3.a)7) of Appendix 2 to this CA, flight crews may disregard temperature limits for RNP AR APCH procedures if the operator provides flight crews with training on the use of this capability. Temperature compensation through the aircraft system is applicable to VNAV guidance and is no substitute for flight crew compensating for cold temperature effects at minimum altitudes or the decision altitude. Flight crews must be familiar with the effects of temperature compensation when intercepting the compensated path described in documents EUROCAE ED-75B/RTCA DO-236B Appendix H.

k) **Altimeter setting**.- Due to reduced obstacle clearance inherent to instrument RNP AR APCH procedures, the flight crew must verify that the current local altimeter is set prior to the FAF but not prior to the IAF. The execution of an instrument RNP AR APCH procedure requires that the current altimeter be set for the aerodrome of intended landing. Remote altimeter settings are not allowed.

l) **Altimeter cross-check**.- Prior to the FAF, but not before the IAF, the flight crew must carry out a cross-check of both pilot altimeters to make sure they agree within $\pm$ 100 ft. If the cross-check fails, the crew must not continue with the approach. If the avionics system provides an automatic altitude comparison warning system for pilot altimeters, flight crew procedures shall indicate the action to be taken in the event of an altimeter comparator warning while executing an RNP AR APCH.

Note.- *This operational cross-check is not required if the aircraft system automatically compares altitudes to within 100 ft (see paragraph 3. d)15) of Appendix 2).*

m) **VNAV altitude transitions**.- The aircraft VNAV barometric system provides fly-by vertical guidance to ensure a smooth transition when intercepting the glide path prior to the FAF. Small vertical shifts, which may occur in a vertical constraint (*e.g.,* in the FAF), are considered operationally acceptable and desirable since they allow for the capture of a new or the next vertical segment. This temporary deviation below the published minima is acceptable as long as the deviation is limited to no more than 100 ft and is the result of a normal VNAV capture. This applies to both “leveling” and “altitude capture” segments that follow a climb or descent or vertical climb or beginning of a segment with descent, or when climb and descent paths with different slopes come together.

n) **Non-standard climb gradient**.- When the operator intends to use a DA associated with a missed approach non-standard climb gradient, it must ensure that the aircraft will be able to comply with the climb gradient published for the expected weight (mass) of the aircraft, atmospheric conditions, and operating procedures before conducting the operation. When the operator has performance personnel available to determine whether its aircraft can meet the published climb gradients, such personnel must provide information to pilots about the climb gradients that they must comply with.

o) **Engine-out procedures**.- Aircraft may demonstrate an acceptable flight technical error (FTE) with one engine inoperative when conducting RNP AR APCH procedures. Otherwise, flight crews are expected to take appropriate action in case of an engine failure during an approach, so no specific aircraft qualification is required in this case. The aircraft qualification must identify any performance limitation in case of engine failure to support the definition of the appropriate flight crew procedures. Operators must pay special attention to published procedures with non-standard climb gradients.

p) **Missed approach or go-around**

1) **Missed approach procedure requiring RNP 1.0**.- Where possible, the missed approach will require RNP 1.0. The missed approach of these procedures is similar to the missed approach of an RNP APCH operation.

2) **Missed approach procedures requiring RNP of less than 1.0**.- When necessary, RNP values of less than 1.0 will be used in the missed approach. For an operator to be approved to execute these approaches, the equipage and procedures must meet the criteria established in paragraph 6 of Appendix 2 (Requirements for missed approaches with an RNP of less than 1.0).

3) In many aircraft, a change may occur in lateral navigation when TOGA is activated during a missed approach or go-around. Also, in many aircraft, TOGA activation disconnects the AP and FD from LNAV guidance, and the FD reverts to track-hold derived from the inertial system. LNAV guidance to the AP and FD shall be re-engaged as quickly as possible.

4) Flight crew procedures and training programs must address the impact on navigation capability and flight guidance if the pilot initiates a go-around during a turn. In the event an early missed approach is initiated, the flight crew must follow the approach and missed approach tracks unless otherwise cleared by the ATC. The flight crew shall also be aware that RF legs are designated based on the maximum true speed at normal altitudes, and initiating an early missed approach will reduce the maneuverability margin, and will potentially make it impractical to hold the turn at missed approach speeds.

5) Upon loss of GNSS updating, the RNP guidance may begin to navigate on IRU, if installed on the aircraft, but the aircraft will begin to drift, degrading the navigation position solution. Therefore, when RNP AR APCH missed approach operations are based on IRU autonomous navigation, the inertial guidance can only provide RNP guidance for a specific amount of time.

q) **Contingency procedures**

1) **Failure while en route**.- The aircraft RNP capability is dependent upon operational equipment and GNSS satellites. Before initiating the approach, the flight crew must be capable of assessing the impact of equipment failure on the RNP AR APCH procedure and take the appropriate corrective action. As stated in paragraph 2.c) of this appendix, the flight crew must also be capable of assessing the impact of changes in GNSS constellation and take appropriate corrective action.

2) **Failure on approach**.- The operator contingency procedures must cover at least the following conditions:

(a) RNP system components failures, including those affecting lateral and vertical deviation performance (*e.g.,* failures of GPS sensors, AP or FD).

(b) Loss of navigation signal-in-space (loss or degradation of external signal).

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APPENDIX 5

TRAINING PROGRAM

1. INTRODUCTION

The operator must provide training for key personnel on the use and application of RNP AR APCH procedures (for example, flight crews, flight dispatchers, performance engineers, and maintenance personnel). A full understanding of operating procedures and best practices is crucial for safe aircraft operation during RNP AR APCH procedures. The training program must provide sufficient detail on aircraft navigation and flight control systems to enable the flight crew to identify failures affecting their RNP capability and apply the appropriate normal, non-normal, and emergency procedures. The required training must include both knowledge and evaluation of skills acquired by flight crews, flight dispatchers, performance engineers, and maintenance personnel.

a) **Flight crew training**

1) Each operator is responsible for providing flight crews with training on the specific RNP AR APCH operations it conducts. The operator must include training on the various types of RNP AR APCH procedures and the equipment required. Training must include a discussion of regulatory requirements. The operator must include these requirements and procedures in its operating and training manuals as applicable. This material must address all aspects of RNP AR APCH procedures conducted by the operator, including the applicable operational authorization (*e.g.,* operational specifications (OpSpecs)). An individual must have completed the appropriate ground and/or flight training segments before participating in RNP AR APCH procedures.

2) Flight training segments must include training and verification modules representative of the type of RNP AR APCH operations the operator conducts during airline activities. Many operators can provide training in RNP AR APCH procedures in accordance with the training provisions and standards established by advanced qualification programs (AQP). Operators can also do assessments in line-oriented flight training (LOFT) and selected-event training (SET) scenarios or in a combination of both. The required flight training modules can be conducted in flight training devices (FTD), flight simulators, and other enhanced training devices, as long as these training media accurately replicate operator equipment and RNP AR APCH operations, and are CAA-approved.

b) **Qualification training for LAR 91, 121, and 135 flight crews**

1) Operators must refer to RNP AR APCH training and qualification modules during initial, transition, upgrade, recurrent, discrepancy, re-qualification, and autonomous (self-teaching) training, in accordance with the approved training programs. The skill of each pilot to understand and properly use RNP AR APCH procedures will be assessed based on qualification standards (initial RNP AR APCH assessment). The operator must also develop recurrent qualification standards to ensure its flight crews properly maintain their knowledge of, and proficiency in RNP AR APCH operations (RNP AR APCH recurrent qualification).

2) Operators may address RNP AR APCH topics separately or integrated with other curriculum elements. For example, a flight crew qualification may focus on a specific aircraft during transition, upgrade, or discrepancy courses. General training must also address RNP AR APCH qualification (*e.g.,* during recurrent training or verification events such as proficiency checks (PC), proficiency training (PT), line-oriented evaluations (LOE), or special-purpose operational training (SPOT)). A separate, independent RNP AR APCH qualification program can also address RNP AR APCH training (*e.g.,* by completion of a special RNP AR APCH curriculum at an operator training centre or designated crew bases).

3) **Credit for using the approved RNP training program of an operator in service**.- Operators intending to receive credit for RNP training, when their proposed program relies on previous RNP training (for example, special instrument approach procedures (IAPs)), must

receive specific authorization from their principal operations inspector (POI). In addition to the current RNP training program, the operator must provide training on discrepancies between the existing training program and RNP AR APCH training requirements.

4) **Flight dispatcher training**

(a) Training for flight dispatchers must include:

(1) training on the different types of RNP AR APCH procedures;

(2) the importance of specific navigation and other equipment during RNP AR APCH operations, and regulatory RNP AR APCH procedures and requirements.

(b) Flight dispatcher procedures and training manuals must include the requirements of paragraph (a) above.

(c) Training must also cover all aspects of RNP AR APCH operations conducted by the operator, including applicable authorizations (*e.g.,* OpSpecs, operations manual, LOA).

(d) A dispatcher must have completed the appropriate training course before participating in RNP AR APCH operations.

(e) Additionally, dispatcher training must address how to determine:

(1) RNP AR APCH availability (taking into account equipment capabilities);

(2) MEL requirements;

(3) aircraft performance; and

(4) navigation signal availability (*e.g.,* GPS RAIM, RNP capability predictive tools) for destination and alternate aerodromes.

2. GROUND TRAINING SEGMENTS

The ground segment of the RNP AR APCH training program must include modules addressing the following subjects during the initial introduction of RNP AR APCH operations and systems for flight crews. For recurrent training programs, the training curriculum needs only to review the initial curriculum requirements and address new, revised, or emphasized aspects of RNP AR APCH operations.

a) **General concepts of RNP AR APCH operations**.- RNP AR APCH academic training must address the theory behind RNP AR APCH systems to the extent appropriate to ensure proper operational use. Flight crews must understand the basic operational concepts of RNP AR APCH systems, its classifications and limitations. Training must include general knowledge and operational application of instrument RNP AR APCH procedures. This training module must address the following specific elements:

1) definition of RNAV, RNP, RNP AR APCH;

2) the difference between RNAV and RNP;

3) the types of RNP AR APCH procedures and familiarity with the charts for these procedures;

4) RNP programming and display and aircraft-specific displays (*e.g.,* current navigation performance);

5) how to enable and disable RNP-related navigation updating modes;

6) the appropriate navigation precision for the different flight phases and RNP AR APCH procedures, and how to select it (if required);

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

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

9) how to determine database validity and whether it contains the required navigation data for using waypoints;

10) explanation of the different components that contribute to the total system error and their characteristics (*e.g.,* the effect of temperature on barometric vertical navigation (baro-VNAV), drift characteristics when using IRU with no radio updating);

11) Temperature compensation. Flight crews operating avionics systems with a compensation function may disregard temperature limits on RNP AR APCH procedures if the operator provides flight crew training on the operation of such function and crews use the function. The training must indicate that temperature compensation through the aircraft system is applicable to VNAV guidance and is not a substitute for flight crew compensating for cold temperature effects on minimum altitudes or the decision altitude.

Note 1.- *Pilots are responsible for all low (cold) temperature corrections required at all published minimum altitudes/heights. This includes:*

- altitudes/heights for initial and intermediate legs;
- the DA/H; and
- subsequent missed approach altitudes/heights.

Note 2.- *The VPA of the final approach path is protected against the effect of low temperatures by the procedure design.*

b) **ATC communications and coordination for conducting RNP AR APCH operations**.- Ground training must instruct the flight crew on flight plan classification, any ATC procedure applicable to RNP AR APCH operations, and the need to advise ATC immediately when the performance of the aircraft navigation system is no longer suitable to support continuation of an RNP AR APCH procedure. The flight crew must know that navigation sensors are part of the basis for RNP AR APCH compliance, and must be capable of assessing the impact of failure of any avionics equipment or ground navigation systems and services on flight plan compliance.

c) **RNP AR APCH equipment components, controls, displays, and alerts**.- Academic training must cover RNP terminology, symbols, operation, optional controls, and display features, including aspects that are specific to the operator implementation or systems. Training must address applicable alerts and limitations. Flight crews and dispatchers should achieve full understanding of the equipment used in RNP operations and any limitations on the use of the equipment during these operations.

d) **AFM operating procedures and information**.- The AFM or other evidence of aircraft eligibility must address normal and non-normal flight crew operating procedures, responses to failure alerts, and any limitation, including information related to RNP modes of operation. Training must also address contingency procedures for loss or degradation of RNP capability. The accepted or approved operations manuals, including the aircraft operations manual (AOM/FCOM) and the pilot operations handbook (POH), must contain this information in the corresponding sections.

e) **MEL provisions**.- Flight crews must have a full understanding of MEL requirements supporting RNP AR APCH operations.

3. FLIGHT TRAINING SEGMENTS

In addition to academic training, flight crews must receive appropriate operational training. Training programs must address the proper execution of RNP AR APCH procedures according to the documentation of the original equipment manufacturer (OEM). The operational training must include RNP AR APCH procedures and limitations, standardization of cockpit electronic display configuration during an RNP AR APCH procedure, recognition of aural warning signals, alerts, and other annunciations that can affect compliance of an RNP AR APCH procedure, and timely and effective responses to loss of RNP AR APCH capability in a variety of scenarios embracing the breadth of RNP AR APCH procedures that the operator plans to execute. Flight training may use approved FTDs or flight simulators. This training must include the following specific elements:

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

b) use of RADAR, EGPWS (TAWS), or other avionics systems to support track monitoring and avoidance of obstacles and adverse weather by the flight crew;

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

d) the effect of ground speed on compliance with RNP AR APCH procedures, and bank angle constraints that hinder the ability to remain on the centre line of the course;

e) the relationship between RNP and the appropriate line of approach minima on a published RNP AR APCH procedure, and any operational limitation if the available RNP degrades o is not available prior to the approach (this includes flight crew procedures outside the FAF *versus* inside the FAF);

f) complete and concise flight crew briefings on all RNP AR APCH procedures and the important role cockpit resource management (CRM) plays on successfully completion of an RNP AR APCH procedure;

g) data insertion alerts and use of a wrong navigation precision for a desired segment of an RNP AR APCH procedure;

h) performance requirements for coupling the AP/FD to the navigation system lateral guidance on RNP AR APCH procedures requiring an RNP of less than 0.3;

i) the importance of aircraft configuration to ensure that it maintains any required speed during RNP AR APCH procedures;

j) the events that trigger a missed approach when using aircraft RNP capability;

k) any bank angle constraint or limitation on RNP AR APCH procedures;

l) the potentially detrimental effect of reducing flap setting, reducing the bank angle, and increasing airspeed on the ability to comply with an RNP AR APCH procedure.

m) the knowledge and skills required by the flight crew to properly conduct RNP AR APCH operations;

n) the programming and operation of the FMC, AP, auto-throttles, RADAR, GPS, INS, EFIS (including a moving map), and EGPWS (TAWS) in support of RNP AR APCH procedures;

o) the effect of activating TOGA during a turn;

p) FTE monitoring and its effect on go-around decision and execution;

q) loss of GNSS during a procedure;

r) performance aspects associated with reversal to radio position updating, and limitations on the use of DME and VOR updating;

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

t) as a minimum, each pilot must complete two RNP AR APCH procedures using the unique characteristics of the approved procedures of the operator (*e.g.,* RF legs, loss of RNP). One procedure must culminate in a transition to landing and another procedure must culminate in the execution of an RNP missed approach procedure.

4. EVALUATION MODULE

a) **Initial evaluation of RNP AR APCH procedures and knowledge**.- The operator will evaluate the knowledge that each member of the flight crew has with respect to RNP AR APCH procedures before they use these procedures. As a minimum, this must include a complete evaluation of pilot procedures and the specific performance requirements for RNP AR APCH operations. An acceptable means for this initial evaluation includes one of the following:

1) An evaluation by an authorized instructor evaluator or an operator inspector, using an simulator or training device.

2) An evaluation by an authorized instructor evaluator or an operator inspector during on-line operations, training flights, proficiency check (PC) or proficiency training (PT) events, operational experience (OE), en-route checks and/or on-line checks.

3) Line-oriented flight training (LOFT)/line-oriented evaluation (LOE).- LOFT/LOE training programs using an approved simulator that incorporates RNP operations with the unique RNP AR APCH characteristics (*e.g.,* RF legs, loss of RNP) of the approved procedures of the operator.

b) **Specific elements of the evaluation module.-** The specific elements that must be included in the evaluation module are:

1) Demonstrate the use of any RNP limits/minima that might affect various RNP AR APCH operations.

2) Demonstrate the application of position radio updating procedures, such as enabling and disabling FMC ground-based radio updating (*e.g.,* DME/DME and VOR/DME updating), and knowledge of when to use this feature. If aircraft avionics does not include the capability of disabling radio updating of the position, then training must ensure the flight crew is capable of adopting operational measures to mitigate the lack of this feature.

3) Demonstrate the ability to monitor the lateral and vertical flight paths relative to the programmed flight path, and complete the appropriate flight crew procedures when exceeding an FTE lateral or vertical limit.

4) Demonstrate the ability to read and interpret a RAIM (or equivalent) forecast, including forecasts predicting RAIM unavailability.

5) Demonstrate how to properly configure the FMC, the weather RADAR, EGPWS (TAWS), and the moving map for the various RNP AR APCH operations and scenarios that the operator intends to implement.

6) Demonstrate the use of flight crew briefings and checklists for RNP AR APCH operations, with emphasis on CRM.

7) Demonstrate knowledge and skills to conduct an RNP AR APCH missed approach procedure in a variety of operating scenarios (*e.g.,* loss of navigation or failure to obtain visual conditions).

8) Demonstrate speed control during segments requiring speed restrictions to ensure compliance with the RNP AR APCH procedure.

9) Demonstrate proficient use of instrument approach charts (IAC), briefing cards, and checklists.

10) Demonstrate the ability to complete a stable RNP AR APCH procedure: bank angle, speed control, and staying on the centre line of the procedure.

11) Know the operational limit for deviations below the desired flight path on an RNP AR APCH procedure and how to precisely monitor the aircraft position relative to the vertical path.

5. RECURRENT TRAINING ON RNP AR APCH KNOWLEDGE AND PROCEDURES

a) **RNP AR APCH recurrent training**.- In its training program, the operator must incorporate

recurrent RNP training and evaluation covering the unique characteristics of RNP AR APCH operations with respect to the approved procedures.

b) Each pilot must fly a minimum of two RNP AR APCH procedures in each duty position (pilot flying the aircraft (PF) and pilot monitoring the aircraft (PM)), with one approach culminating in a complete landing and one culminating in a missed approach.

Note.- *Equivalent RNP approaches may be credited toward compliance of the requirement for two RNP AR APCH procedures.*

APPENDIX 6

RNP AR APCH MONITORING PROGRAM

1. The operator must have an RNP AR APCH monitoring program to ensure continued compliance with the guidelines of this AC and to identify any negative performance trends. As a minimum, the monitoring program will include the following activities: During the provisional approval, the operator must submit the following information every 30 days to the authority that issued the authorization. Subsequently, it will continue collecting information and periodically reviewing it to identify potential safety risks. It will also maintain a summary of the processed information.

a) Total number of RNP AR APCH procedures executed.

b) Number of satisfactory approaches per aircraft and system (they are considered satisfactory if completed as planned without any anomalies in the navigation or guidance system).

c) Reasons for unsatisfactory approaches, such as:

   1) UNABLE REQ NAV PERF, NAV ACCUR DOWNGRAD, or other messages activated during the approach;

   2) Excessive lateral or vertical deviation;

   3) EGPWS (TAWS) warning;

   4) Disconnection of the AP system;

   5) Navigation data errors; and

   6) Reports of anomalies by the pilot.

d) Comments by the crew.

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APPENDIX 7

REQUIREMENTS FOR OBTAINING RNP AR APCH AUTHORIZATION

In order to obtain operational approval, the operator will take the following steps, taking into account the criteria established in paragraphs 7, 8, 9, and 10 and in Appendices 2, 3, 4, 5, 6, 8, and 9 to this AC.

a) *Airworthiness approval*.- Aircraft shall have the corresponding airworthiness approvals as established in paragraphs 8 and 9 of this AC.

b) *Application*.- The operator shall submit the following documentation to the CAA:

1) *The application for RNP AR APCH operational approval*.

2) *Aircraft qualification documentation*.- The documentation of the manufacturer demonstrating that the proposed aircraft equipment meets the requirements of this AC as described in Appendix 2. This documentation shall contain hardware and software requirements, procedural requirements, and limitations.

3) *Type of aircraft and description of aircraft equipment to be used*.- The operator will provide a configuration list with details of the relevant components and the equipment to be used in the operation. The list shall include each manufacturer, model, and version of software installed in the FMS.

4) *Operational procedures and practices*.- The operator manuals must properly describe the characteristics of the intended area of operation and operational (navigation) practices and procedures identified in Appendix 4 to this AC. LAR 91 operators shall confirm that they will operate using identified practices and procedures.

5) *Navigation data validation program*.- The details of the navigation data validation program are described in Appendix 3 to this AC.

6) *Flight crew training program*.- According to Appendix 5 to this AC, operators must submit the training syllabi and other appropriate teaching material to demonstrate that operations have been incorporated into their programs. Training programs must properly address the special characteristics of the intended area of operation and (navigation) operational practices and procedures identified in Appendix 4 to this AC.

7) *Flight simulator training*.- Operators must submit a description of the training to be provided using simulation, the credits to be granted to simulation, the simulator qualification, and how this training will be used for on-line pilot qualification. Normally, this training will be included in the flight crew training program.

8) *Training programs for dispatchers and flight trackers*.- Operators will submit the training syllabi and other appropriate teaching material to demonstrate that this personnel has been incorporated into its programs as established in Appendix 5 to this AC.

9) *Instruction program for maintenance program.*- Operators will submit instruction syllabus corresponding to maintenance personnel.

10) *Operation manuals and checklists*.- Operators will submit the operation manuals and checklists containing information and guidance for the operations requested.

11) *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. The operator will provide a procedure for withdrawing and then restoring RNP AR APCH operational capability on the aircraft.

12) *RNP AR APCH monitoring program*.- The operator must submit a program for collecting data on executed RNP AR APCH procedures. Each operation must be recorded and unsatisfactory attempts must include the factors that prevented the successful completion of an operation.

13) *MEL*.- The operator will submit any revision to the MEL that is required for the conduction of

operations.

14) *Validation*.- The operator will submit a validation test plan to demonstrate its ability to conduct the intended operation (see Chapter 13 of Volume II, Part II, of the SRVSOP Operations Inspector Manual (OIM)). The validation plan shall at least include the following:

(a) a statement that the validation plan has been designated to demonstrate the capability of the aircraft to execute RNP AR APCH procedures;

(b) the operational and dispatch procedures of the operator;

(c) the effectiveness of the operator training program;

(d) the effectiveness of maintenance procedures; and

(e) MEL procedures.

Note 1.- *The validation plan shall benefit from ground training devices, flight simulators, and aircraft demonstrations. If validation is done on board an aircraft, it must be done during in daytime and in VMC.*

Note 2.- *Validations may be required for each manufacturer, model and version of software installed in the FMS.*

15) *Conditions or limitations necessary or required for authorizations*.- The operator will submit any condition or limitation necessary or required for the authorizations.

16) *Flight operational safety assessment (FOSA).*- The operator will submit the methodology and process developed.

c) *Training*.- Once the amendments to the manuals, programs, and documents submitted have been accepted or approved, the operator will provide the required training to its personnel.

d) *Validation flights*.- Validation flights will be conducted in accordance with paragraph b) 13) above.

e) *Issuance of provisional authorization to conduct RNP AR APCH operations*.- Once the operator has completed the operational approval process, the CAA will issue the provisional authorization for the operator to conduct RNP AR APCH operations.

1) *LAR 91 operators*.- For LAR 91 operators, the CAA will issue a letter of acceptance (LOA) containing a provisional authorization to conduct RNP AR APCH operations according to the guidelines of this AC.

2) LAR 121 and/or 135 operators.- For LAR 121 and/or LAR 135 operators, the CAA will issue the corresponding OpSpecs reflecting the RNP AR APCH provisional authorization.

f) *Issuance of final approval*.- The CAA will issue the amended OpSpecs or the amended LOA authorizing the use of the lowest applicable minima, once the operators have satisfactorily completed the time period and the number of approaches required by the CAA, in accordance with paragraph 9.1 of this AC.

APPENDIX 8

RNP AR APCH Approval Process

a) The RNP AR APCH approval process encompasses the airworthiness and the operational approval. Although the two have different requirements, they must be considered within the same process.

b) This process constitutes an orderly method used by CAAs to ensure that 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:	Review of 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, in accordance with Appendix 7 to this AC.

f) In *Phase three - Review of documentation*, the CAA evaluates the documentation and the navigation system to determine their admissibility 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 implement the validation plan.

h) In *Phase five - Approval*, the CAA issues the RNP AR APCH provisional authorization 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 an LOA.

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APPENDIX 9

FLIGHT OPERATIONAL SAFETY ASSESSMENT (FOSA)

1. INTRODUCTION

The objective of RNP AR APCH procedures is to provide safe flight operations. Traditionally, safety has been defined by a target level of safety (TLS) and specified as a collision risk of 10^{-7} per approach. For RNP AR APCH operations, a different methodology, known as flight operational safety assessment (FOSA) is used. The FOSA is intended to provide a safety level that is equivalent to the traditional TLS.

With the FOSA, the safety objective is met by taking into account more than just the aircraft navigation system. The FOSA combines quantitative and qualitative analyses and evaluations of the navigation systems, aircraft systems, operational procedures, hazards, failure mitigations, normal, rare-normal and non-normal conditions, and the operational environment.

The FOSA relies on aircraft qualification, operational approval, and instrument procedure design criteria to address mostly the general technique, procedures and factors of the process. Additionally, operational expertise, technique and experience are required to conduct and complete the FOSA.

This appendix provides an overview of hazards and mitigations to assist States in applying these criteria. Safety of RNP AR APCH operations rests with the operator and the air navigation service provider (ANSP), as described in this appendix.

A FOSA must be conducted for RNP AR APCH procedures when the specific aircraft characteristics, operational environment, obstacles, etc., warrant the conduction of an additional assessment to ensure that safety objectives are met. This assessment must give proper attention to the inter-dependence of design, aircraft capability, crew procedure, and operational environment elements.

The FOSA is a key part of the operational authorization for RNP AR APCH procedures. This methodology is associated with a specific type of aircraft or a specific performance, and may be applied to a demanding environment.

2. BACKGROUND

a) La FOSA is used to make a safety case for RNP AR APCH operations. This methodology was developed in response to the following factors:

   1) System and aircraft certification and demonstration to determine their performance and capabilities are related to rules and criteria in force at a given point in time. This condition establishes a safety basis for aircraft operations. As a result, the aircraft is known to be safe if related to known airspace types, operations, and infrastructures.

   2) Throughout time, operators and ANSPs have developed new and novel operational solutions to the problems or limitations encountered in general flight operations.

   3) The implementation of new and novel procedures allows aircraft and systems to operate in a way that varies from the original design and aircraft capability approvals.

   4) In some cases, a new application or operational procedure exposes the aircraft to failures and hazards that were not considered in the basic system design and in the approval.

   5) Normally, airworthiness guidelines cannot keep pace with the new and original operational applications. The FOSA helps to address this issue.

b) The significant difference between the FOSA and other safety analysis tools is that this methodology applies a technical judgment based on combined qualitative and quantitative assessments of aircraft and flight operations. This means that the FOSA is not a safety analysis, or a risk analysis, or a risk model.

c) While the FOSA must consider risk estimates and exposures due to specific hazards and failures,

the main aspect of the assessment is confidence on the technical judgment to determine acceptable mitigations for hazards or failures.

d) Although the FOSA has recently been formalized as a process in connection with RNP AR APCH operations, it has been extensively applied to assess particular cases, like the operations of a customer whose procedure design may significantly differ from the standard, and where there is a significant dependence on aircraft capability and performance. What the FOSA really offers is a process that repeats itself and a high level of standardization of case considerations and conditions.

3. DOCUMENTATION RELATED TO THE FOSA AND RNP AR APCH OPERATIONS

The FOSA is part of the total data package that must be compiled or created when an operator wishes to obtain an operational approval for RNP AR APCH procedures. Most of the aspects of the following RNP AR APCH package must be compiled or at least defined before conducting the FOSA.

a) *Aircraft capability and qualification;

b) Design of procedures, airspace, and intended operations;

c) Identification of non-standard aspects of procedure design;

d) *Identification of any special aircraft capability or performance requirements;

e) Description of the aerodrome and operation in the airspace;

f) Air traffic environment and operations;

g) *Maintenance process and procedures;

h) *Dispatch guidance and procedures;

i) *Training (flight crews, operations, air traffic, dispatch, recurrent training);

j) *Flight crew procedures;

k) *AR operations monitoring program; and

l) *Minimum equipment list

Most of the material with an asterisk (*) may have been developed to support aircraft type design or as part of the operational approval. In any case, specific acceptable means of compliance have been developed in this AC or in equivalent documents, like FAA AC 90-101 and AMC 20-26.

4. THE FOSA PROCESS

The FOSA process depends on the following factors:

a) a group of experts that includes;

   1) the operator (flight operations, dispatch, maintenance, inspectors, safety, quality system, etc.),

   2) air traffic services (ATC controller, airspace planner, principal operations inspectors, safety management, etc.);

   3) regulators; and

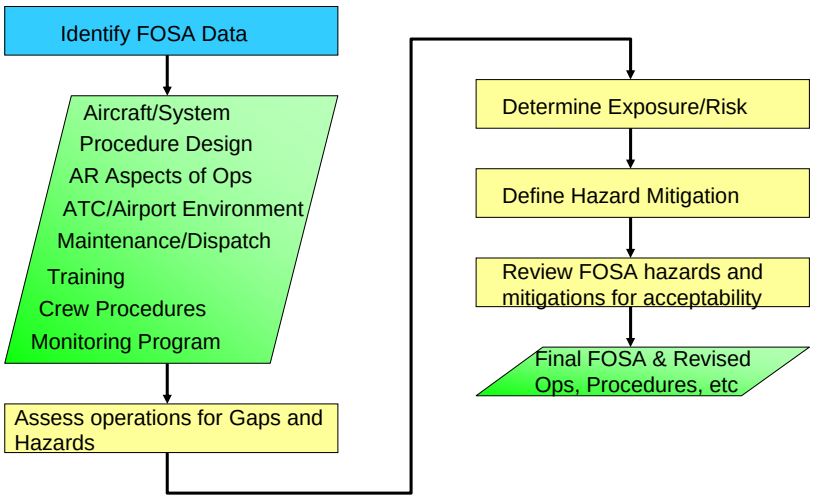
   4) experts on aircraft and system technical support.

b) a process leader capable of facilitating the guiding the review;

c) access to, or direct knowledge of the information required in paragraph 3; and

d) the process steps described in Table 9-1 – FOSA Process Steps:

Table 9-1 – FOSA Process Steps



5. FOSA PREPARATION

As documents and the data package are being organized and developed, the operator must review specific data or relevant information for the FOSA, including some of the following aspects:

a) What are the operational requirements or objectives?

b) What is the operational environment?

c) How do the aircraft operational and functional capabilities conform to procedure design requirements?

d) What specific system performance assessments and analyses have been performed to support aircraft qualification?

e) Are services and infrastructure suitable for the RNP AR APCH operation?

f) What RNP training is currently provided to flight crews and ATC?

g) What are the flight crew procedures for RNP operations?

h) How are RNP navigation specifications incorporated into ATS operations?

6. FLIGHT OPERATIONAL SAFETY ASSESSMENT (FOSA)

6.1 General.-

As part of the application package of the operator for RNP AR APCH operations, the FOSA shall contain:

a) An introduction or overview;

b) A description of the safety assessment process and criteria used;

c) A description of the system and of the RNP AR APCH operation assessed;

d) The identification of risk areas, hazards and severity;

e) Mitigation of risks; and

f) Conclusions and recommendations.

6.2 Assessment criteria.-

a) The FOSA shall identify the specific conditions or hazards associated with the aircraft, aircraft performance, navigation services, ATC, flight crew, operations of the operator, procedures, etc. In

many cases, the total package of identified potential hazards will include many of the hazards already identified through aircraft certification, operator procedures, and air traffic operations.

b) Some times, the FOSA may contain several of the hazards contemplated in the aircraft system safety analysis. In this case, the assessment helps to make the safety case rather than to re-analyze aircraft airworthiness. Additionally, this reduces the probability of multiple mitigations for a risk that requires a single mitigation.

c) The FOSA applies the qualitative technique and operational experience, as well as technical judgment and relevant data availability. The assessment of findings regarding risk severity and likelihood shall follow the criteria contained in Table 9-2 – Risk severity and likelihood of success, which is based on ICAO Doc 9859 – Safety Management Manual.

Table 9-2 – Risk Severity and Likelihood of Occurrence

Risk Severity		**Likelihood of Occurrence**	
Level		**Probability**	
Catastrophic	Equipment destroyed Multiple casualties	Frequent	Likelihood of occurring many times
Hazardous	Significant reduction of safety margins, physical suffering or workload such that there can be no confidence in the operators precisely or fully performing their tasks. Several casualties or seriously injured. Significant damage to the equipment.	Occasional	Likelihood of occurring some times
Significant (Major)	Significant reduction of safety margins, reduction of operator ability to face adverse operational conditions due to an increased workload or conditions hindering efficiency. Serious incident. Injured individuals.	Remote	Not very likely, but possible.
Of little importance (Minor)	Nuisance. Operational limitations. Use of emergency procedures. Minor incident.	Unlikely	Its occurrence is very unlikely.
Negligible	Of little consequence.	Extremely unlikely	Its occurrence is almost unconceivable.

d) It is important to note that a risk assessment cannot be assumed to be always the same in each FOSA. A failure or condition considered as “major/unlikely” for an aircraft, procedure, and operational environment could be easily considered as “hazardous/remote” for another aircraft, procedure, and operational environment.

6.3 The following conditions are examples of the most significant hazards and mitigations associated to a specific aircraft, operational criterion, and RNP AR APCH operational procedures.

a) **Aircraft**

1) This area of the FOSA is derived from the safety analysis of aircraft systems, the documentation describing the system, and operational experience. The aspects to consider are as follows:

   (a) Failure of the following systems:

   - navigation;
   - flight guidance;
   - flight instruments for approach, missed approach or departure (for example, loss of GNSS updating, receiver failure, auto-pilot disconnect, FMS failure, etc.).

   Note.- *Depending on the aircraft, this may be addressed in the aircraft design and operational procedures as cross-check guidance (e.g., dual equipment for lateral errors, use of EGPWS/TAWS).*

   (b) Malfunction of altimetry or air data systems.- The risk can be mitigated through a cross-check procedure between two independent systems.

2) The FOSA must also consider normal, rare-normal, and non-normal conditions.

   (a) Normal performance.- Lateral and vertical precision and RNP performance are addressed in aircraft requirements, in the aircraft itself, and in the systems normally operated in standard configurations and operating modes, while individual error components are monitored through the design system and crew procedures.

   (b) Rare-normal and non-normal performance.- RNP lateral and vertical precision is assessed through system failures, as part of aircraft qualification. Additionally, other rare-normal and non-normal conditions, as well as ATC operating conditions, flight crew procedures, NAVAID infrastructure, and the operational environment are also assessed with respect to RNP or 2xRNP, as appropriate. When the results of a failure or condition are not acceptable for continued operations, mitigations must be developed or limitations established for the aircraft, flight crew and/or operation.

b) **Aircraft performance**

1) The RNP AR APCH procedure design criteria are linked to general aircraft performance. The result may be conservative in terms of performance margins, depending on the aircraft and the systems that have been assessed. These are the specific parameters that shall be assessed for the deviation as they relate to those in the procedure design, such as bank angle limit, climb, high altitude performance, etc.

2) *Inadequate performance to conduct the approach*.- The initial aircraft qualification and operational procedures ensure an adequate performance on each approach, as part of flight planning and to initiate or continue the approach. Consideration shall be given to aircraft configuration and any configuration change associated with a go-around (*e.g.,* engine failure, flap retraction).

3) *Loss of engine*.- Loss of an engine while conducting an RNP AR APCH procedure is a rare occurrence due to high engine reliability and the short exposure time during the approach. Operators are expected to develop flight procedures and training allowing them to take appropriate action to mitigate the effects of a loss of engine through a go-around and taking manual control of the aircraft, if necessary.

c) **Navigation services**

1) The use and availability of navigation services are critical in RNP AR APCH applications, where small RNP values are required for the approach and possible extraction maneuvers. Multi-sensor navigation systems must be assessed as to use and selection of sensors. The following must be considered:

   (a) *Use of NAVAIDs outside of their designated coverage or in test mode*. Aircraft requirements and operational procedures have been developed to mitigate this risk.

(b) *Navigation database errors*.- Procedures must be validated through a validation flight specific to the operator and aircraft, and the operator must have a process defined to maintain validated data through navigation database updates.

Note.- *Navigation database assurance is covered by the letters of authorization issued by the CAAs to database manufacturers, which must be combined with operator procedures to ensure that the correct and updated databases are installed on the aircraft.*

d) **ATC operations**

1) Frequently, the ATC is not involved in the implementation of RNP AR APCH operations until it is too late. An early revision of ATC operational aspects is critical to enable RNP AR APCH procedures. In this sense, the following must be considered:

(a) Procedures assigned to an aircraft that is not RNP AR APCH capable: Operators are responsible for not accepting the authorization.

(b) The ATC provides vector guidance onto an approach whose performance cannot be achieved by the aircraft: ATC procedures and training must ensure obstacle clearance until the aircraft is established on the procedure. The aircraft shall not be guided by the ATC over or towards a point too close to the curved segments of the procedure.

e) **Flight crew operations**

1) Human factors in RNP AR APCH operations are related to an increased reliance on ground and air automation to reduce human error exposure and incidents. However, since human action and interaction are required, at least the following must be considered:

(a) Incorrect barometric altimeter setting: Is there a flight crew entry and check procedure to mitigate this risk?

(b) Incorrect procedure selection or loading.- Is there a flight crew procedure to verify that the loaded approach corresponds to the published procedure? Is there an on board display requirement?

(c) Incorrect flight control mode selection: Is there any training on the importance of the flight control mode, and an independent procedure to monitor an excessive path deviation?

(d) Incorrect RNP selection: Is there a flight procedure to check if the RNP loaded on the system corresponds to the published value?

(e) Go-around and missed approach: Assess the risk of a balked approach at or below the DA (H). Note that this does not respond to procedure design criteria.

(f) Unfavorable meteorological conditions: What is the risk of losing or significantly reducing visual reference that might result in, or require a go-around, and what would be the effect?

f) **Infrastructure**

1) Support infrastructure and services are an integral part of aircraft performance: Some aspects are already addressed in the aircraft system risk and safety analyses.

2) GNSS satellite failure: This condition is assessed during aircraft qualification to ensure that it is possible to maintain obstacle clearance, considering the low probability of failure occurrence.

3) Loss of GNSS signals: Relevant independent equipment (*e.g.,* IRU) is required for RNP AR APCH operations with RF legs and approaches where missed approach precision is less than 1 NM. Other approaches use operational procedures to approach a published track or climb over obstacles.

4) Testing of ground NAVAIDs in the vicinity of the approach: Aircraft and operational procedures are required to detect and mitigate this event.

g) **Operating conditions**

1) Certain aspects of the aerodrome and the airspace environment are reflected on the RNP AR APCH procedure design criteria. In this sense, the following must be considered:

(a) Tailwind conditions: Excessive speed on RF legs will result in inability to maintain the track. This must be addressed in the aircraft requirements for command guidance limits, inclusion of a banking maneuverability margin of 5 degrees, consideration of the effect of speed and flight crew procedures on maintenance of speeds below the maximum authorized speed.

(b) Crossed wind conditions and the effect of flight technical error: Consider that a nominal flight technical error is assessed under a variety of wind conditions, and that a flight crew procedure to monitor and limit deviations, ensures a reliable operation.

(c) Effects of extreme temperature on barometric altitude (*e.g.,* extreme cold temperatures, knowledge of local meteorological or atmospheric phenomena, upper winds, severe turbulence, etc.): The effect of this error on vertical path is mitigated by procedure design and flight crew procedures. Aircraft that have a temperature compensation system can conduct procedures regardless of the published temperature limit. The effect of this error on minimum altitude segments and on the decision altitude is addressed in an equivalent manner for all other approach procedures.

6.4 Repercussions on the proposed solutions/mitigations

a) When assessing different conditions and risks, some may fall on a range where risk or probability is not acceptable. When reviewed by the team of FOSA experts, a range of possible solutions (*e.g.,* system design, procedures, processes, etc.) may be identified, which, turned into mitigations, reduce the level of risk and/or risk incidence in such a way that risks can be considered acceptably safe for RNP AR APCH operations. The following aspects must be considered:

1) **Operations**

(a) What are the repercussions/changes for ATC, dispatch, maintenance, flight procedures (*e.g.,* knowledge of aircraft capability, RNP equipment prediction, equipment required, and specific checks, respectively).

2) **Safety/risk**

(a) How do main differences in procedure design or operational requirements associated with aircraft or operator qualification compare (*e.g.,* what aircraft or operator exceptions or limitations compare to operational or procedural requirements)?

(b) How does the certification basis apply to intended operations? For example, are the demonstrated performance (RNP), functionality, and capabilities, together with safety and risk assessments equivalent or better than that required for the operation?

(c) How are rare-normal and non-normal conditions, failures or hazards considered in the procedure design criteria, aircraft and operator qualifications, or in the added procedures or system checks?

(d) How is the safe termination of the procedure or extraction affected?

3) General applicability in RNP AR APCH operations

(a) RNP AR APCH procedures and operational requirements differ and, thus, an applicant must consider the effect of possible mitigations on the general use of RNP aircraft regarding crew training, procedures, equipment, ATC interfaces, etc.

(b) The different hazards considered in the FOSA must be summarized, together with the associated hazards and their frequency, mitigations, and the level of the mitigated hazard and its frequency. Significant factors and aspects shall be highlighted in the final recommendations (see the attached example in Table 9-3 – Example of a FOSA work sheet).

Note.- *While many aspects and questions in this appendix must be considered in the FOSA methodology, this material does not need to be included in the FOSA if reference is made in the package of the applicant.*

Table 9-3 – Example of a FOSA work sheet

Hazard identification	ID	Name	Severity	Likelihood	Description	Mitigation	Severity of the mitigation	Frequency of the mitigation	Ref. Doc.
Aircraft/system failure	A1	Engine failure	Significant	Remote	The engine failure can cause loss of separation from the ground.	A performance assessment has been done with a single engine to determine the specific performance conditions for ABC company. The crews must conduct the existing single-engine failure procedures.	Minor	Remote	PBN Manual Ch 5; 5.1
	A2	Failure of one GNSS receiver	Minor	Remote	The failure of one GPS receiver results in loss of navigation capability redundancy.	For RNP AR APCH procedures, two GNSS receivers are required. Flight crew procedures require a go-around upon failure of one GPS within the FAF. Crew procedures require a go-around for all failures within the FAF,	Insignificant	Remote	PBN Manual Ch 5; 5.5

Hazard identification	ID	Name	Severity	Likelihood	Description	Mitigation	Severity of the mitigation	Frequency of the mitigation	Ref. Doc.
						except under visual conditions.			
	A3	Incorrect flap retraction							
	A4	FMC/CDU dual failure under IMC conditions							
	A5	Degradation or loss of GPS signal							
	A6	Loss of all APs/ control mode							
	A7	Failure of two GNSS receivers							
	A8	AP disconnect							
	A9	Loss of equipment, resulting in single-system operation							
	A10	Air data/altimeter failure, resulting in display differences							
Operational environment (*e.g.,* physical conditions, airspace, and route design)	E1	Performance limited by tailwind							
	E2	Environmental temperature							
	E3	Strong cross-winds							
Operators	H1	Incorrect pilot response							
	H2	Poor pilot response or pilot error							
Human-	I1	Incorrect altimeter							

Hazard identification	ID	Name	Severity	Likelihood	Description	Mitigation	Severity of the mitigation	Frequency of the mitigation	Ref. Doc.
machine interface		setting due to error in ATC-to-aircraft communications							
Operational procedures	P1	Temperature compensation							
	P2	Balked or rejected landing							
Maintenance procedure	M1	Incorrect navigation database							
External services	S1	Source-altimeter error							
	S2	ATC							
	S3	NAVAID out of coverage or in test mode							
	S4	Lack of GNSS satellite							

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