GENERAL ADVISORY CIRCULAR

CIVIL AVIATION AUTHORITY OF BOTSWANA

CAAB Document GAC-021

GUIDANCE ON THE APPLICATION FOR AIRCRAFT AND OPERATORS RNAV 5 AND RNP APPROVAL

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Chapter 1

1. Purpose

This advisory circular (AC) provides acceptable means of compliance (AMC) concerning aircraft and operator's approval for RNAV 5 operations. An operator may use alternative means of compliance, as far as those means are acceptable for Civil Aviation Authority of Botswana (CAAB). The use of the verb in future or the word "must", is applied to an applicant or operator choosing to fulfil the criteria described in this AC. This AC also provides guidelines to operators when the stand-alone global positioning system (GPS) is used as the means of navigation in RNAV 5 operations (where the stand-alone GPS equipment provides the only RNAV capability installed on board the aircraft).

2. Related Documents

- ICAO Doc 9613 Performance-based navigation (PBN) manual
- Civil Aviation Regulations

3. Definitions and Abbreviations

3.1 Definitions

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

Note. - *Area navigation includes performance-based navigation as well as other operations that do not meet the definition of performance-based navigation.*

b) **Area navigation route**. - An Air traffic services (ATS) route established for the use of aircraft capable of employing area navigation.

c) **Global positioning system (GPS)**.- The United States Global navigation Satellite System (GNSS) is a satellite-based radio navigation system which utilizes precise range measurements to determine position, velocity and time in anywhere in the world. The GPS is composed by three elements: space, control, and user. The space element is formed of at least 24 satellites in 6 orbital planes. The control element consists of 5 monitor stations, 3 ground antennas, and a master control station. The user element consists of antennas and receivers that provide positioning, velocity and precise timing to the user.

d) **Navigation specifications**. - A set of aircraft and air crew requirements, needed to support performance based navigation operations within a defined airspace. There are two kinds of navigation specifications: RNAV and RNP. A RNAV specification does not include requirements for on-board performance monitoring and alerting. A RNP specification includes requirements for on-board performance monitoring and alerting.

e) **Performance based navigation (PBN)**. - Area navigation based on performance requirements for aircraft operating along an ATS route, on an instrument approach procedure or in a designated airspace.

Note. - *Performance requirements are expressed in navigation specifications (RNAV specification, RNP specification) in terms of accuracy, integrity, continuity, availability and functionality needed for the proposed operation in the context of a particular airspace concept.*

f) **Receiver autonomous integrity monitoring (RAIM)**.- A technique used within a GPS receiver/processor to determine the integrity of its navigation signals using only GPS signals, or GPS signals augmented with barometrical altitude data. This determination is achieved by a consistency check among redundant pseudo-orange measurements. At least one additional satellite needs to be available in respect to the number of satellites that are needed to obtain the navigation solution.

g) **RNAV operations**. - Aircraft operations using area navigation for RNAV applications. RNAV operations include the use of area navigation for operations which are not developed in accordance with the PBN manual.

h) **RNAV system**.- Area navigation system, which permits aircraft operation on any desired flight path within the coverage of ground or space-based navigation aids, or within the limits of the capability of self-contained aids, or a combination of both. A RNAV system may be included as part of the Flight Management System (FMS)

3.2 Abbreviations

a) AC Advisory circular
b) ADF Automatic direction finder
c) AFM Aircraft flight manual
d) AIP Aeronautical information publication
e) AIRAC Aeronautical information regulation and control
f) AMC Acceptable means of compliance
g) ANSP Air navigation services provider
h) ATC Air traffic control
i) ATS Air traffic services
j) B-RNAV Basic area navigation
k) CAA Civil Aviation Authority
l) CDI Course deviation indicator
m) CDU Control display unit
n) DME Distance measuring equipment
o) DOP Dilution of precision
p) FDE Fault detection and exclusion
q) FMS Flight management system
r) FTE Flight technical error
s) GNSS Global navigation satellite system
t) GPS Global positioning system
u) HSI Horizontal situation indicator
v) IFR Instrument flight rules

w) INS Inertial navigation system
x) IRS Inertial reference system
y) IRU Inertial reference unit
z) LOA Letter of authorization/Letter of acceptance
aa) MEL Minimum equipment list
bb) ii) NAVAIDS Navigation aids
cc) NDB Non-directional beacon
dd) ND Navigation display
ee) NOTAM Notice to airmen
ff) ICAO International Civil Aviation Organization
gg) OM Operations manual
hh) PBN Performance based navigation
ii) PF Pilot flying
jj) PNF Pilot not flying
kk) POH Pilot operating handbook
ll) RAIM Receiver autonomous integrity monitoring
mm) P-RNAV Precision area navigation
nn) RAIM Receiver autonomous integrity monitoring
oo) RNAV Area navigation
pp) SA Selective availability
qq) SB Service bulletin
rr) STC Supplemental type certificate
ss) TCDS Type certificate data sheet
tt) TLS Target level of safety
uu) TSO Technical standard order
vv) VOR Very high frequency (VHF) Omni-directional radio range
ww) WGS World geodetic system
xx) WPT Waypoint

4. INTRODUCTION

4.1 In the context of the terminology adopted in the Performance based navigation manual (PBN manual) of the International Civil Aviation Organization (ICAO), B-RNAV requirements are termed RNAV 5.

4.2 While RNAV operation requirements are addressed primarily in an ATS surveillance environment, RNAV 5 implementation has occurred in areas where there is no surveillance. This has required an increase in route spacing to ensure compliance with the desired level of safety (TLS).

4.3 RNAV 5 specification does not require an alert to the pilot in the event of excessive navigation errors; neither requires two RNAV Systems, thus, the potential for loss of RNAV capability requires the aircraft to be provided of an alternative navigation source.

4.4 The performance level selected for RNAV operations allows a wide range of RNAV systems to be approved for these operations, including INS with a two hour limit after its last alignment/position update performed on the ground, when they do not have a function for automatic radio updating of aircraft position.

4.5 Although RNAV 5 specification does not include requirements for on-board performance monitoring and alerting, it does require that the on-board equipment keeps a lateral and longitudinal navigation accuracy on route of + 5 NM or better during 95% of the total flight time.

5. GENERAL CONSIDERATIONS

5.1 Nav-aid infrastructure

i) The CAA may prescribe RNAV 5 navigation specification for specific routes or for specific areas or flight levels of airspace.

j) RNAV 5 systems permit aircraft navigation along any desired flight path within the coverage of ground or space-base navigation aids (NAVAIDS) or within the limits of the capability of self-contained aids or a combination of both methods.

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

1) VOR/DME;
2) ME/DME;
3) INS or IRS; and
4) GNSS.

Note. - *The application of the sensors is subject to the limitations contained in this AC.*

l) The Air navigation services providers (ANSP) must assess the NAVAID infrastructure in order to ensure that it is sufficient for the proposed operations, including reversionary modes.

m) It is acceptable for gaps in NAVAIDS coverage to be present; when this occurs, route spacing and obstacle clearance surfaces must be consider due to the expected increase in lateral track keeping errors during the “dead reckoning” phase of flight.

5.2 Communication and air traffic services (ATS) surveillance

a) Direct pilot to ATC voice communication is required.

b) When reliance is placed on the use of ATS surveillance to assist contingency procedures, its performance should be adequate for that purpose.

c) Radar monitoring by the ATS may be used to mitigate the risk of gross navigation errors, provided the route lies within the ATS surveillance and communications service volumes and the ATS resources are sufficient for the task.

5.3 Obstacle clearance and route spacing

a) Detailed guidance on obstacle clearance is provided in PANS-OPS (Doc 8168), Volume II; the general criteria in Parts I and III apply.

b) The ANSP is responsible for route spacing and should have ATS surveillance and monitoring tools to support detection and correction of navigation errors.

c) In an ATC surveillance environment, the route spacing will depend on acceptable ATC workload and availability of controller tools.

d) The route design should account for the navigation performance achievable using the available NAVAID infrastructure, as well as the functional capabilities required by this document. Two aspects are of particular importance:

1) Spacing between routes in turns

(a) Automatic leg sequencing and associated turn anticipation is only are commended function for RNAV 5. The track followed in executing turns depends upon the true airspeed, applied bank angle limits and wind. These factors, together with the different turn initiation criteria used by manufacturers, result in a large spread of turn performance. Studies have shown that for a track change of as little as 20 degrees, the actual path flown can vary by as much as 2 NM. This variability of turn performance must be considered in the design of the route structure where closely spaced routes are proposed.

2) Along track distance between leg changes

(a) A turn can start as early as 20 NM before the waypoint in the case of a large track angle change. Manually initiated turns may overshoot the following track.

(b) The track structure design has to ensure leg changes do not occur too closely together. The required track length between turns shall depend upon the required turn angle.

5.4 Publication

a) The AIP shall clearly indicate the navigation application is RNAV 5. The requirement for the carriage of RNAV 5 equipment in specific airspace or on identified routes should be published in the AIP.
b) The route must rely on normal descent profiles and identify minimum segment altitude requirements.
c) The navigation data published in the AIP for the routes and supporting navigation aids must meet the requirements of Chicago Convention Annex 15 - Aeronautical Information Services.
d) All routes must be based upon WGS-84 coordinates.
e) The available NAVAID infrastructure must be clearly designated on all appropriate charts (e.g. GNSS, DME/DME,VOR/DME). Any navigation facilities that are critical to RNAV 5 operations shall be identified in the relevant publications.
f) A navigation database does not form part of the required functionality of RNAV 5. The absence of such a database necessitates manual waypoint entry, which significantly increases the potential for waypoint errors. En-route charts should support gross error checking by the flight crew by publishing fix data for selected waypoints on RNAV 5 routes.

5.5 Additional considerations

a) Many aircraft have the capability to fly a path parallel to, but offset left or right from, the original active route. The purpose of this function is to enable offsets for tactical operations authorized by ATC.
b) In the same way, many aircraft have the capability to execute a holding pattern manoeuvre using their RNAV system; this capability can provide flexibility to ATC in designing RNAV 5 operations.

6. AIRWORTHINESS AND OPERATIONAL APPROVAL

6.1 In order to the operator receives an RNAV 5 authorization, this must comply with two types of approval:
a) Airworthiness approval in charge of the State of registry; (See Art. 31, Chicago Convention, Paragraph 5.2.3 and 8.1.1 of Annex 6, Part I; and
b) Operational approval required by the State of the operator (See Paragraph 4.2.1 and Attachment F of Annex 6 Part I).

6.2 For general aviation operators, the State of registration (See Paragraph 2.5.2.2 of Annex 6 Part II) will submit a Letter of Acceptance (LOA) once determined that the aircraft accomplishes all applicable requirements of this document for RNAV 5 operations.

6.3 Compliance with airworthiness requirements by themselves does not constitute the operational approval.

7. AIRWORTHINESS APPROVAL

7.1 Aircraft equipment

a) An aircraft may be considered eligible for an RNAV 5 approval if it is equipped with one or more navigation systems approved and installed in accordance with the guide included in this document.
b) An aircraft capacity to perform RNAV 5 operations can be demonstrated or reached in the following cases
   1) First case: Demonstrated capacity in the manufacturing process and declared in the Aircraft flight manual (AFM) or in the AFM supplement or in the Type certificate data sheet (TCDS) or in the Pilot operating handbook (POH).
   2) Second case: Capacity reached in-service:
      (a) By applying the service bulletin or supplemental type certificate or service letter or equivalent document and inclusion of the supplement in the AFM; or
      (b) Through aircraft navigation system approval.

7.2 Eligibility based on AFM or AFM supplement or TCDS or POH.

To determine eligibility of the aircraft in function of AFM or AFM supplement, TCDS or POH, aircraft RNAV 5 capacity must have been demonstrated in production (aircraft in manufacturing process or new construction).

a) **Aircraft RNAV 5 systems eligibility.**

   1) An aircraft may be considered eligible for RNAV 5 operations, if AFM or AFM supplement or TCDS or POH shows the appropriate instruments flight rules (IFR) navigation system installation has received airworthiness approval.

   2) Once aircraft eligibility has been established, operator approval will proceed, according to paragraph 8 of this AC.

b) **General aviation aircraft approval**

   1) General aviation operators should revise the AFM or AFM supplement or TCDS or POH to assure that the aircraft navigation system is eligible to perform RNAV 5 operations, according to describe on paragraph 7.2 a) 1) of this AC.
   2) After having determined eligibility of the navigation system, general aviation operators will present respective documents to the CAAB.
   3) In case general aviation operators are not able to determine, based on the AFM or AFM supplement or TCDS or POH, whether the Aircraft system has been installed and approved according with an appropriate CA or AC or AMC, they will proceed according to paragraph 7.3 of this document.

c) **Air operator certificate aircraft approval**

   1) Air Operator Certificate holder operators will present the following documents to CAAB:

(a) Sections of the AFM or AFM supplement or TCDS that document airworthiness approval in accordance with this AC or with guidance materials mentioned in Paragraph 7.2 a) 1) of the this document.

2) These operators will ensure that the aircraft navigation system will meet the functions required in paragraph 7.6 of this AC.

3) In case an air operator certificate holder is not able to determine, based on the AFM or AFM supplement or TCDS, whether the system has been installed and approved, it will proceed in accordance with to the steps established in the following paragraph.

7.3 Eligibility not based on AFM or TCDS or AFM Supplement or POH –

RNAV 5 capacity reached during service.

a) Determination of the aircraft eligibility through evaluation of its navigation equipment.

1) The operator makes a request for assessment of aircraft RNAV equipment for eligibility to the airworthiness inspection Direction or equivalent CAA entity. The operator, together with the request, will provide the following:

(a) RNAV system make, model and part number;

(b) Evidence that the equipment meets lateral and longitudinal navigation accuracy on route of + 5 NM or better during 95% of the total flight time. This can be determined through the evaluation of system design. Evidence of meeting the requirements of another AC can be used for this purpose.

(c) Proof that the system meets the required functions for RNAV 5 operations described in this CA on paragraph 7.6.

(d) Crew operating procedures and bulletins; and

(e) Any other pertinent information required by the CAA.

2) In case the airworthiness inspection Direction or CAA equivalent entity is not able to determine RNAV equipment eligibility, evaluation request together with supporting documents will be forward to the aircraft certification Direction or equivalent entity from the State of registry. In any case, aircraft certification Division or equivalent will inform to airworthiness inspection Direction or CAA equivalent entity about the eligibility of the proposed equipment to perform RNAV 5 operations.

3) *General Aviation Operators*.- Once the CAAB has determined the aircraft equipment is eligible for RNAV 5 operations, the airworthiness inspection Direction or CAA equivalent entity will issue a letter of finding documenting that the aircraft RNAV equipment is eligible to perform those operations.

4) *Air Operator Certificate Holder*.- The CAAB will verify aircraft RNAV system eligibility including the required functions on paragraph 7.6 of this AC.

7.4 Limitations on the design and/or use of navigation systems.-

Although the following navigation systems offer RNAV capability, these present limitations for their use in RNAV 5 operations.

a) **Inertial navigation systems/Inertial reference systems (INS/IRS)**

1) Inertial systems may be used either as a standalone inertial navigation system (INS) or as an inertial reference (IRS) acting as part of a multi-sensor RNAV system where inertial sensors provides augmentation to the basic position sensors as well as a reversionary position data source when out of cover of radio navigation sources.

2) INS without a function for automatic radio updating of aircraft position and approved in accordance with CAAB requirements when complying with the functional criteria of paragraph 7.6 of this AC, may be used only for a maximum of two (2) hours from the last alignment/position update performed on ground. Consideration may be given to specific INS configurations (e.g. triple mix) where either equipment or aircraft manufacturer's data justifies extended use from the last position update.

3) INS without automatic radio updating of aircraft position, including those systems where manual selection of radio channels is performed in accordance with flight crew procedures, must be approved in accordance with CAAB requirements or any other equivalent document.

b) **VHF Omni-directional radio range (VOR)**

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

c) **Distance measuring equipment (DME)**

1) DME signals are considered sufficient to meet requirements of RNAV 5 wherever the signals are received and there is no closer DME on the same channel, regardless of the published coverage volume. Where the RNAV 5 system does not take account of published "Designated operational coverage" of the DME, the RNAV system must execute data integrity checks to confirm that the correct DME signal is being received.

d) **Global navigation satellite system (GNSS)**

1) **Global positioning system (GPS)**

(a) The use of GPS to perform RNAV 5 operations is limited to equipment approved in accordance with the TSO-C 129(), TSO-C-145() and TSO-C-146() from FAA or ETSO-129(), ETSO-145() and ETSO-146() from EASA or equivalent documents which include the minimum systems functions specified in the present AC on Paragraph 7.6.

(b) The integrity of GPS system must be provided by the receiver autonomous integrity monitoring (RAIM) or an equivalent means within a multi-sensor

navigation system. In addition, stand-alone GPS equipment must include the following functions according to the TSO-C 129a or ETSO-129a criteria:
 Pseudo range step detection; and
 Health word checking

(c) Compliance with these two requirements can be determined the following way:

(1) a statement in the AFM or POH indicating the GPS equipment meets the criteria for primary means of navigation in oceanic and remote airspace; or
(2) A placard on the GPS receiver certifying it meets TSO-C 129 (), TSO-C-145 () and TSO-C-146 () from FAA or ETSO-129 (), ESTO-145 () and ESTO-146 () from EASA; or
(3) A CAA letter of design approval for the applicable equipment. Operators should contact the avionic equipment's manufacturer to determine if the equipment complies with these requirements and ask if a letter of design approval is available. Manufacturers may obtain this letter by submitting documentation to the certifications offices of the States of aircraft design or manufacturer. Operators will keep the letter of design approval within the AFM or POH as evidence of the RNAV 5 eligibility. Any limitations included in the letter of design approval should be reflected in a letter of finding to General Aviation operators or in the operations specifications (OpSpecs) for Air Operator Certificate holder.

(d) Traditional navigation equipment (e.g., VOR, DME or automatic direction finder (ADF)) must be installed and operative, so as to provide an alternative navigation means of navigation.

(e) Where approval for RNAV 5 requires the use of traditional navigation equipment as a backup in the event of loss of GPS, the required navigation aids as defined in the approval (e.g. VOR, DME or ADF) must be installed and serviceable.

2) **Stand-alone GPS equipment**

(a) Stand-alone GPS equipment approved in accordance with guidance provided in this AC may be used in RNAV 5 operations, subject to the limitations included in this document. Such equipment must be operated in accordance with procedures acceptable to the CAAB. The flight crew must receive appropriate training for use the stand-alone GPS equipment regarding normal and contingency procedures detailed in the Paragraph 9 of this AC.

7.5 RNAV-5 system requirements

a) Accuracy

1) The navigation performance of aircraft approved for RNAV 5 requires a track keeping accuracy equal to or better than + 5 NM during the 95% of the flight

time. This value includes signal source error, airborne receiver error, display system error and flight technical error (FTE).

2) This navigation performance assumes the necessary coverage provided by satellite or ground based navigation aids are available for the intended route to be flown.

b) Availability and integrity

The minimum level of availability and integrity required for RNAV 5 systems can be met by a single installed system comprising by:

1) one sensor or a combination of the following sensors: VOR/DME, DME/DME, INS or IRS and GNSS or GPS;
2) RNAV computer;
3) Control display unit (CDU); and
4) Navigation display(s) [(e.g. navigation display (ND), horizontal situation indicator (HSI) or course indicator deviation (CDI)]provided that the system is monitored by the flight crew and that in the event of a system failure the aircraft retains the capability to navigate relative to ground based navigation aids (e.g. VOR, DME or Non-directional beacon (NDB)).

7.6 Functional requirements

a) *Required Functions* - The following system functions are the minimum required to conduct RNAV 5 operations:

1) Continuous indication of the aircraft position relative to track to be displayed to the pilot flying (PF) on a navigation display situated in his primary field of view;
2) In addition, where the minimum flight crew is two pilots, indication of the aircraft position relative to track to be displayed to the pilot not flying (PNF) on a navigation display situated in his primary field of view.
3) Display of distance and bearing to the active (To) waypoint;
4) Display of ground speed or time to active (To) waypoint;
5) Storage of a minimum of 4 waypoints; and
6) Appropriate failure indication of the RNAV system, including the sensors failure.

b) RNAV 5 navigation displays

1) Navigation data must be available for display either on a display forming part of the RNAV equipment or on a lateral deviation display (e.g. CDI, (E) HSI, or a navigation map display).
2) These displays must be used as primary flight instruments for the navigation of the aircraft, for manoeuvre anticipation and for failure/status/integrity indication. They should meet the following requirements:
   (a) The displays must be visible to the pilot when looking forward along the flight path.
   (b) The lateral deviation display scaling should be compatible with any alerting and annunciation limits, where implemented.
   (c) The lateral deviation display must have a scaling and full-scale deflection suitable for the RNAV 5 operation.

7.7 Continued airworthiness

a) The operators of aircraft approved to perform RNAV 5 operations, must ensure the continuity of the technical capacity of them, in order to meet technical requirements established in this AC.
b) Each operator who applies for RNAV-5 operational approval shall submit to the CAA of State of registry, a maintenance and inspection program that includes all those requirements of maintenance necessary to ensure that navigation systems continue fulfilling the RNAV 5 approval criteria.
c) The following maintenance documents must be revised, as appropriate, to incorporate RNAV 5 aspects:
   1) Maintenance control manual (MCM);
   2) Illustrated parts catalogues (IPC)
   3) Minimum Equipment List; and
   4) Maintenance program.

d) The approved maintenance program for the affected aircraft should include maintenance practices listed in maintenance manuals of the aircraft manufacturer and its components, and must consider:
   1) that equipment involved in the RNAV 5 operation should be maintained according to directions given by manufacturer's components;
   2) that any amendment or change of navigation system affecting in any way RNAV 5 initial approval, must be forwarded and reviewed by the CAAB for its acceptance or approval of such changes prior to its implementation; and
   3) That any repair that is not included in the approved/accepted maintenance documentation, and that could affect the integrity of navigation performance, should be forwarded to the CAAB for acceptance or approval thereof.

e) Within the RNAV maintenance documentation should be presented the training program of maintenance personnel, which inter alia, should include:

   1) PBN concept;
   2) RNAV 5 application;
   3) Equipment involved in a RNAV 5 operation; and
   4) MEL use.

8. OPERATIONAL APPROVAL

8.1 *Requirements to obtain the operational approval*. - To obtain the operational approval, the operator will comply with the following steps considering the operational procedures established in Paragraph 9 of this AC.

a) *Airworthiness approval*. - The Aircraft must have the corresponding airworthiness approvals as in Paragraph 7 of this AC.

b) *Documentation* - The operator will present to the CAAB the following documents:

   1) The application to obtain RNAV 5 authorization;

2) Amendments to the operations manual (OM) which must include operations procedures according to what is described in Paragraph 9 of this AC, for crews and dispatchers, if applicable;
3) Amendments, when applicable, of maintenance manuals and programs which must have the maintenance procedures for the new equipment, as well as the training of the maintenance associated personnel, in accordance with Paragraph 7.7 e);
4) A copy of the AFM parts, or AFM supplement or TCDS or POH, to verify the airworthiness approval for RNAV 5 for each affected aircraft;
5) The amendments to the Minimum Equipment List (MEL), which must identify the minimum necessary equipment to comply with RNAV 5; and
6) Training programs or amendments to the operator's training program for crews and flight dispatchers, if applicable, according to what is described in Paragraph 10 of this document;

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

d) *Validation flights*. - The CAAB may perform a validation flight, if determines it is necessary in the interest of safety.

8.2 *Authorization issuance to perform RNAV 5 operations*. - Once the operator has successfully completed the operational approval process, the CAAB will issue the operator, when applicable, the corresponding authorization to perform RNAV 5 operations.

a) *General Aviation operators*. - For General aviation operators, the CAAB will issue a letter of authorization (LOA).
b) Air Operator Certificate Holder. - For Air Operator Certificate holder, the CAAB will issue the corresponding OpSpecs, which will show RNAV 5 authorization.

9. OPERATION PROCEDURES

9.1 Flight planning.

a) Before operating on a RNAV 5 route, the operator will ensure that:

1) The aircraft counts on a RNAV 5 approval;
2) Routes correspond to the authorization;
3) The necessary equipment to operate RNAV 5 work correctly and are not degraded;
4) The availability of the navaid infrastructure, required for the intended routes, including any non-RNAV contingencies, must be confirmed for the period of intended operations using all available information;
5) The crews check the contingency procedures.

b) *Stand-alone GPS equipment.* During the planning phase the following procedures must be accomplish in regard to the stand-alone GPS equipment:

1) An aircraft can depart without further action in the following cases, when:

(a) All satellites are scheduled to be in service; or
(b) One satellite is scheduled to be out of service in case of GPS equipment that includes barometrical altitude.

2) The availability of GPS integrity RAIM shall be confirmed for the intended flight (route and time) through the use of a prediction program either ground-based or incorporated in the on-board system, following the criteria established in Appendix 1 of this AC, when:

(a) Any satellite is scheduled to be out of service; or
(b) More than one satellite is scheduled to be out of service in case of GPS equipment that includes barometric altitude.

3) This prediction is required for any route and route segment RNAV 5 based upon the use of GPS.

4) The specified route of flight, including trajectory to any alternative aerodrome will be defined by a series of waypoints and by the estimated time of pass over them for a speed or series of speed, which at the same time will be in function of the intensity and previous wind direction.

5) Taking in consideration that during flight may occur deviations in regards to the specified ground speedy, prediction must be done using different speeds within the predictable margin for them.

6) Prediction program must be executed with a maximum anticipation of two hours preview to the flight departure. The operator will confirm that data about the state of the constellation and GPS ephemerides have been updated with the latest information distributed by notice to airmen (NOTAM).

7) In order to get exact prediction, the program will allow manual de-selection of satellites considered non operative, as well as selection of those back to service condition during the flight time.

8) The operator will not dispatch or release a flight in case of continuous prediction loss of RAM higher than 5 minutes to any part of the previewed route. In this event, flight can be delayed, cancelled or re-routed in which RAM requirements may be accomplished.

c) *ATS – ICAO flight plan*.- At the time to file the ATS flight plan, authorized aircraft operators on RNAV 5 route, will insert corresponding code (R) on flight plan form's box 10 (equipment), as defined within ICAO Doc 7030 for these operations and PBN/B1-B5 (as appropriate) in field 18.

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

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

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

9.2 Preview flight procedures at the aircraft.-

The crew will perform on the aircraft the following procedures preview to the flight:

a) Check registrations and forms to be sure that maintenance actions have been taken in order to correct defects in the equipment; and
b) Check data base validation (current AIRAC cycle), if it is installed.
c) Flight crews should cross-check the cleared flight plan by comparing charts or other applicable resources with the navigation system textual display and the aircraft map display, if applicable. If required, the exclusion of specific navigation aids should be confirmed.

9.3 En-route operations.

a) The crew will assure the aircraft correct functioning of its navigation system during its operation in a RNAV 5 route, confirming that:

1) necessary RNAV 5 equipment have not degraded during flight;
2) route corresponds to the authorization;
3) aircraft navigation accuracy is pertinent for RNAV 5, assuring this through pertinent cross check; and
4) others navigation aids (for example VOR, DME ADF) must be selected in a way to permit a cross check or immediate reversion in the event of a RNAV capacity loss.
5) flight crews should cross-check the cleared flight plan by comparing charts or other applicable resources with the navigation system textual display and the aircraft map display, if applicable. If required, the exclusion of specific navigation aids should be confirmed.
6) During the flight, where feasible, the flight progress should be monitored for navigational reasonableness, by cross-checks with conventional navigation aids using the primary displays in conjunction with the RNAV control and display unit (CDU).
7) All pilots are expected to maintain route centrelines, as depicted by on-board lateral deviation indicators and/or flight guidance, during all RNAV operations described in this manual, unless authorized to deviate by ATC or under emergency conditions. For normal operations, cross-track error/deviation (the difference between the RNAV system-computed path and the aircraft position relative to the path) should be limited to +/-0.5 the navigation accuracy associated with the procedure or route (i.e. 2.5NM). brief deviations from this standard (e.g. overshoots) during and immediately after procedure/route turns,

up to a maximum of one-times the navigation accuracy (i.e. 5NM), are allowable.

Note: *Some aircraft do not display or compute a path during turns; pilots of these aircraft may not be able to adhere to the +/-0.5 accuracy standard during route turns but are still expected to satisfy the standard during intercepts of the final track following the turn and on straight segments.*

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

9.4 Contingency procedures.

a) Flight crews must familiarize with the following general provisions:

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

2) An aircraft must not enter or continue the operations in airspace designated as RNAV 5, according to the present ATC authorization, if because of a failure or degradation the navigation systems falls under RNAV 5 requirements, the pilot will obtain as soon as possible an amended authorization;

3) According to ATC instructions, operations will continue in regards to the present ATC authorization, or when not possible, will be requested a revised authorization to return to the VOR/DME conventional navigation;

4) In the event of communications failure, the flight crew should continue with the flight plan, in accordance with the published lost communication procedures; and
5) In any case, the crew must follow contingency procedures established for every operation region and obtain an ATC authorization as soon as possible.

b) Stand-alone GPS equipment.

1) The operating procedures must identify the flight crew actions required in the event of RAIM function loss or exceedance of integrity alarm limit (erroneous position). This procedures must include:

(a) in case of loss of the RAIM detection function. - The flight crew may continue navigating with the GPS equipment. The flight crew should attempt to crosscheck the aircraft position with the information provided for the ICAO conventional navaids: VOR, DME and ADF, in order to confirm the existence of a required level of precision. In other case, the crew must revert to an alternative navigation means;

(b) In the event of an observed failure (including the failure of a satellite impacting the performance of the navigation systems based on GPS), the flight crew must revert to an alternative means of navigation.

(c) In case of exceedance of the alarm limit. - The flight crew must revert to an alternative means of navigation.

2) *On-board equipment availability VOR, DME or ADF;* The operator must have installed on the aircraft the VOR, DME or ADF on-board equipment capacity according to the applied operational rules for general aviation and/or commercial operators. This capacity must be available along the intended route of flight to assure the availability of navigation alternative means in case of a GPS/RNAV system failure.

c) Any incidence registered in flight must be notified to the CAAB in a maximum time of seventy-two hours, unless justified cause.

10. NAVIGATION ERROR REPORTS FOLLOW UP PROCESS

a) The operator will establish a process to receive, analyse and do a follow up of the navigation error reports which allows to determine the appropriate corrective action.
b) Repetitive navigation error occurrences attributed to a specific part of the navigation equipment must be analysed in order to correct its cause.
c) The nature and severity of the error may result in temporary withdrawal of the authorization to use the navigation equipment until the cause of the problem has been identified and rectified.

11. TRAINING PROGRAM

a) The training programs for flight crews and flight dispatchers, if applicable, must be reviewed and approved by the CAAB. The operator should include at least the following modules:

1) Required equipment's, capacities, limitations and operation of these equipment's in RNAV 5 airspace.
2) The routes and airspace for which the RNAV system is approved to operate.
3) The NAVAID limitations in respect of the operation of the RNAV system to be used for the RNAV 5 operation.
4) Contingency procedures for RNAV failures.
5) The Radio/Telephony Phraseology for the airspace in accordance to ICAO Doc 4444 and Doc 7030 as appropriate.
6) The flight planning requirements for the RNAV operation.
7) RNAV requirements as determined from chart depiction and textual description.
8) RNAV 5 en-route procedures;
9) Methods to reduce navigation errors through dead-reckoning techniques.
10) RNAV system-specific information, including:

(a) Levels of automation, mode annunciations, changes, alerts, interactions, reversions and degradation.
(b) Functional integration with other aircraft systems.

(c) Monitoring procedures for each phase of flight (for example, monitor PROG or LEGS page).
(d) Types of navigation sensors (for example, DME, IRU, GNSS) utilized by the RNAV system and associated system prioritization/weighting/logic.
(e) Turn anticipation with consideration to speed and altitude effects.
(f) Interpretation of electronic displays and symbols.

11) RNAV equipment operating procedures, as applicable, including how to perform the following actions:

(a) Verify currency of aircraft navigation data.
(b) Verify successful completion of RNAV system self-tests.
(c) Initialize RNAV system position.
(d) Fly direct to a waypoint.
(e) Intercept a course/track.
(f) Be vectored off and rejoin procedure.
(g) Determine cross-track error/deviation.
(h) Remove and reselect navigation sensor input.
(i) When required, confirm exclusion of a specific navigation aid or navigation aid type.
(j) Perform gross navigation error check using conventional navigation aids.

b) Training program on the GPS as a primary means of navigation.

1) Besides the training modules describe on the previous paragraphs, operators' training programs which use RNAV systems based on GPS as a primary navigation means will include modules described in Appendix 2.

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Appendix 1

GPS integrity monitoring (RAIM) prediction program

Where a GPS integrity monitoring (RAIM) prediction program is used as a means of compliance with paragraph 4.2 (a) of this document, it should meet the following criteria:

a) The program should provide prediction of availability of the integrity monitoring (RAIM) function of the GPS equipment, suitable for conducting RNAV 5 operations in designated airspace.
b) The program should use either a RAIM algorithm identical to that used in the airborne equipment or an algorithm based on assumptions for RAIM prediction that give a conservative result.
c) The program should calculate RAIM availability based on a satellite mask angle of no less than 5 degrees, except where use of lower mask angle has been demonstrated to be acceptable to the authority.
d) The program should have the capability to manually designate GPS satellites which have been notified as being out of service for the intended flight.
e) The program should allow the user to select:

    1) the intended route and declared alternates; and
    2) the time and duration of the intended flight.

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Appendix 2

Training program on the GPS as a primary means of navigation

The training programs for flight crews that use RNAV 5 systems based on the GPS as a primary means of navigation will include a segment with the following training modules:

a) GPS system components and operating principles.- Understanding of the GPS system and its operating principles:

1) GPS system components: control segment, user segment, and space segment;
2) on-board equipment requirements;
3) GPS satellite signals and pseudo-random code;
4) positioning principle;
5) receiver clock error;
6) masking function;
7) performance limitations of the different types of equipment;
8) WGS84 coordinate system;

b) Navigation system performance requirements.- Define the following terms in relation to the navigation system and evaluate the degree of compliance by the GPS system of the requirements associated with the following terms:

1) precision;
2) integrity;
   (a) Means to improve GPS integrity: RAIM and fault detection and exclusion (FDE)
3) availability;
4) service continuity

c) Authorizations and documentation.- Requirements applicable to pilots and navigation equipment for GPS operation:

1) pilot training requirements;
2) aircraft equipment requirements;
3) AFM system certification criteria and limitations;
4) GPS-related NOTAMs.

d) GPS system errors and limitations.- Cause and magnitude of typical GPS errors:

1) ephemerides;
2) clock;
3) receiver;
4) atmospheric/ionosphere;
5) multi-reflection;
6) selective availability (SA);
7) total typical error associated to the C/A code;
8) effect of the dilution of precision (DOP) on the position;
9) susceptibility to interference;
10) comparison of vertical and horizontal errors; and
11) Path-tracking precision. Collision avoidance.

e) Human factors and GPS. - Limitations on the use of GPS equipment due to human factors. Operating procedures that offer protection against navigation errors and loss of awareness of the real situation due to the following causes:

1) Mode errors;
2) Data entry errors;
3) Data checks and validation, including independent cross-checking procedures;
4) Automation-induced relaxation;
5) Lack of standardization of GPS equipment;
6) Information processing by humans and situational awareness.

f) GPS equipment – Specific navigation procedures.- Knowledge of the appropriate operating procedures for GPS in the typical navigation tasks for each specific type of equipment in each type of aircraft that includes:

1) selection of the appropriate operating mode;
2) review of the different types of information contained in the navigation database;
3) forecast of the availability of the RAIM function;
4) procedure for entering and checking the waypoints defined by the user;
5) procedure for entering, retrieving and checking flight plan data;
6) interpretation of the typical information shown on the GPS navigation display: LAT/LONG, distance and heading to the waypoint, CDI;
7) interception and maintenance of the GPS-defined routes;
8) in-flight determination of ground speed (GS), estimated time of arrival (ETA), time and distance to the waypoint;
9) indication of waypoints over flight;
10) use of the “DIRECT TO” function;
11) use of the “NEAREST AIRPORT” function;
12) Use of the GPS in GPS or DME/GPS arrival procedures.

g) Verification of GPS equipment.- For each type of equipment in each aircraft, the following operational and start-up checks must be conducted at the appropriate time:

1) constellation status;
2) RAIM and FDE functional status;
3) dilution of precision (DOP) status;
4) currency of the instrument flight rules (IFR) database;
5) receiver operating condition;
6) CDI sensitivity;
7) Position indication.

h) GPS messages and warnings.- For each type of equipment in each aircraft, timely action must be recognized and taken in face of GPS messages and warnings, including the following:

1) loss of RAIM function;
2) 2D/3D navigation;
3) dead-reckoning navigation mode;
4) database not updated;

5) loss of the database;
6) GPS equipment failure;
7) barometric data entry failure;
8) power failure;
9) prolonged parallel displacement; and
10) Satellite failure.

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Appendix 3

RNAV 5 approval process

a) The RNAV 5 approval process is comprised of two types of approvals: the airworthiness approval and the operational approval, even though, they have different requirements, both must be considered under one process only.

b) This process constitutes a well-arrange method, which is used by the CAAB to ensure the applicants comply with the established requirements.

c) The approval process is conformed by the following phases:

1) Phase one: Pre-application
2) Phase two: Formal application
3) Phase three: Analysis of the documentation
4) Phase four: Demonstration and inspection
5) Phase five: Approval

d) *In Phase One - Pre-application*, CAAB holds a meeting with the operator (the pre-application meeting), in which the operator will be informed about all the requirements that he needs to comply with during the approval process.

e) *In Phase Two - Formal application*, the operator submits the formal application with all applicable documents.

f) *In Phase Three - Analysis of the documentation*, CAAB reviews the submission and evaluates the navigation equipment in order to determine the method of approval (aircraft equipment eligibility). As a result of this evaluation, CAAB may accept or return the Formal Application with the documentation.

g) *In Phase Four - Demonstration and inspection*, the operator will accomplish the training program and the validation flight if this is required by CAAB, otherwise the process will advance to the next phase.

h) *In phase Five - Approval*, CAAB issues the RNAV 5 authorization, once the operator has completed the airworthiness and operations requirements. For operators who holds AOC will be issued with OpSpecs and for general aviation will be issued with a LOA.

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Chapter 2 Basic RNP 1

1. Purpose

1.1. Basic RNP 1 is based on GNSS positioning. The navigation specification is intended to support arrival and departure procedures without the dependence on a DME/DME infrastructure.

1.1.1. Other than the requirement for GNSS there is no significant difference between the RNAV 1 and 2 navigation specification and basic RNP 1.

1.2. Operational Approval

1.2.1. Operators of GNSS equipped aircraft holding an RNAV 1 and 2 operational approvals qualify for Basic RNP 1 subject to the following conditions:

1.2.1.1. Manual entry of SID/STAR waypoints is not permitted

1.2.1.2. Pilots of aircraft with RNP input selection capability (typically equipped FMS aircraft)

1.2.1.3. Shall select RNP 1 or lower for Basic RNP 1 SIDs and STARs

1.2.1.4. If a Basic RNP 1 SID or STAR extends beyond 30NM from the ARP in some cases the CDI scale may need to be set manually to maintain FTE within limits (see below)

1.2.1.5. If a MAP display is used, scaling must be suitable for Basic RNP 1 and a FD or AP used.

1.2.2. Operators of GNSS equipped aircraft holding both P-RNAV and US RNAV approvals also meet the requirements for RNAV 1 and 2 and therefore also qualify for Basic RNP 1 subject to the additional conditions listed in the previous paragraph.

1.2.3. Applicants without previous relevant approvals will need to be assessed against the requirements of the Basic RNP 1 navigation specification.

2. Summary

2.1. A single RNAV system only is required.

2.2. GNSS is required.

2.3. A navigation database is required.

2.3.1. Navigation displays in the pilot's forward view must be sufficient to permit track following and maneuvering.

2.3.2. MAP display (without CDI) is acceptable provided FD or AP is used.

2.3.3. The maximum cross-track error deviation permitted is 0.5NM.

3. Stand-alone GNSS systems

3.1. The most basic qualifying system is a stand-alone GNSS receiver (TSO C129(a)) which shall be coupled to a CDI or HSI display providing course guidance and cross-track deviation indications. This type of system may also be integrated with a map display, however primary guidance is provided by the CDI/HSI. The receiver normally incorporates a self-contained control and display unit but the interface may also be provided by a separate CDU.

3.1.1. In this arrangement Basic RNP 1 capability is provided when in terminal mode. In terminal mode:

3.1.1.1. CDI scaling is automatically set at +/- 1NM full scale deflection

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

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

3.1.3. For departure, provided the current flight plan includes the departure airport (usually the ARP) terminal mode will be active and annunciated. (An annunciator panel shall be installed in accordance with the manufacturer's recommendations and State airworthiness regulations). In the general case terminal mode will automatically switch to en-route mode at 30NM from the departure ARP. If the Basic RNP 1 SID extends past 30NM, the CDI scaling will no longer be adequate to support the required FTE limit (+/- 0.5NM), and flight crew action is necessary to manually select +/-1NM CDI scaling.

3.1.4. On arrival, provided the current flight plan route includes the destination airport (ARP) the receiver will automatically switch from en-route to terminal mode at 30NM from the ARP. If the STAR commences at a distance greater

than 30NM radius from the destination, then en-route CDI scaling of +/-5NM is inadequate for Basic RNP 1 and must be manually selected to +/-1NM.

Note: Manual selection of +/- 1NM CDI scale (terminal scaling) does not change the mode, and en- route RAIM alert limits apply RNP Systems;

3.2. Aircraft equipped with a flight management system, normally integrate positioning from several sources (radio navaids, GNSS) often using a multi-mode receiver (MMR) with IRS.

3.3. In such systems the navigation capability, alerting and other functions are based upon an RNP capability, and the RNP for a particular operation may be a default value, a pilot selected value or a value extracted from the navigation database.

3.3.1. There is normally no automatic mode switching (as in the case of a stand-alone receiver), although the default RNP may vary with the phase of flight.

3.3.2. For this type of operation it is necessary for the flight crew to select either RNP 1 or accept a lesser default value before commencement of a Basic RNP 1 SID or STAR.

4. Integrity availability

4.1. GNSS based operations require prediction that a service (with integrity) will be available for the route. Most GNSS availability prediction programs are computed for a specific location (normally the destination airport) and are unable to provide predictions over a route or large area. However for Basic RNP 1 the probability of a loss of GNSS integrity is remote and the prediction requirement can normally be met by determining that sufficient satellites are available to provide adequate continuity of service.

5. De-selection of radio updating

5.1. The PBN Manual makes reference to the possibility of position errors caused by the integration of GNSS data and other positioning data and the potential need for de- selection of other navigation sensors. This method of updating is commonly associated with IRS/GNSS systems and the weighting given to radio updating is such that it is unlikely that any potential reduction in positioning accuracy will be significant in proportion to Basic RNP 1 navigation accuracy.

6. Functionality

6.1. The PBN MANUAL lists the functional requirements for Basic RNP 1 which are identical to RNAV 1 and 2.

6.1.1. For the majority of air transport aircraft equipped with FMS, the required functionalities, with the exception of the provision of a non-numeric lateral deviation display are normally available. For this category of aircraft lateral deviation is displayed on a map display, usually with a numeric indication of cross-track error in 1/10th NM. In some cases a numeric indication of cross-track error may be provided outside the primary field of view (e.g. CDU). Acceptable lateral tracking accuracy for Basic RNP 1 routes is adequate provided the autopilot is engaged or flight director is used.

6.1.2. Aircraft equipped with stand-alone GNSS navigation systems, shall be installed to provide track guidance via a CDI or HSI. A lateral deviation display is often incorporated in the unit, and may be suitable if of sufficient size and position to allow either pilot to maneuver and monitor cross-track deviation.

6.1.3. Caution shall be exercised in regard to the limitations of stand-alone GNSS systems with respect to ARINC 424 path terminators. Path terminators involving an altitude termination are not normally supported due to a lack of integration of the lateral navigation system and the altimetry system. For example, a departure procedure commonly specifies a course after takeoff until reaching a specified altitude (CA path terminator). Using a basic GNSS navigation system it is necessary for the flight crew to manually terminate the leg on reaching the specified altitude and then navigate to the next waypoint, ensuring that the flight path is consistent with the departure procedure. This type of limitation does not preclude operational approval (as stated in the PBN MANUAL functional requirements) provided the operator's procedures and crew training are adequate to ensure that the intended flight path and other requirements can be met for all SID and STAR procedures.

7. Operating procedures

7.1. Operators with en-route RNAV experience will generally meet the basic requirements of Basic RNP 1 and the operational approval shall focus on procedures associated with SIDs and STARs.

7.2. Particular attention shall be placed on selection of the correct procedure from the database, review of the procedures, connection with the en-route phase of flight and the management of discontinuities. Similarly an evaluation shall be made of procedures manage selection of a new procedures, including change of runway, and any crew amendments such as insertion or deletion of waypoints.

8. Pilot Knowledge and Training

8.1. During the operational approval, particular attention shall be placed on the application of the pilot knowledge and training to the conduct of Basic RNP 1 SIDs and STARs. Most crews will already have some experience RNAV operations, and many of the knowledge and training items will have previously been covered in past training.

8.2. Execution of SIDs and STARs, connection with the en-route structure and transition to approach procedures require a thorough understanding of the airborne equipment, and its functionality and management. Particular attention shall be placed on:

8.2.1. The ability of the airborne equipment to fly the designed flight path. This may involve pilot intervention where the equipment functionality is limited,

8.2.2. Management of changes (procedure, runway, track),

8.2.3. Turn management (turn indications, airspeed & bank angle, lack of guidance in turns),

8.2.4. Route modification (insertion/deletion of waypoints, direct to waypoint),

8.2.5. Intercepting route, radar vectors

8.3. Where GNSS is used, flight crews must be trained in GNSS principles related to en-route navigation.

8.4. Flight training for Basic RNP 1 is not normally required, and the required level of competence can normally be achieved by classroom briefing, computer-based training, desktop simulator training, or a combination of these methods. Computer based simulator programs are available from a number of GPS manufacturers which provide a convenient method for familiarity with programming and operation of stand-alone systems.

8.5. Although not specifically mentioned in the PBN MANUAL Basic RNP 1 navigation specification, where VNAV is used for SIDs and STARs attention shall be given to the management of VNAV and specifically the potential for altitude constraints to be compromised in cases where the lateral flight path is changed or intercepted.

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Chapter 3: AIRCRAFT AND OPERATORS APPROVAL FOR RNP APPROACH (RNP APCH) OPERATIONS

1. PURPOSE

This advisory circular (AC) establishes RNP APCH approval requirements (lateral navigation only) for aircraft and operators. The requirements for barometric vertical navigation (baro-VNAV) of a RNP APCH approach are detailed on CA 91-010 (APV/baro-VNAV). Criteria of this AC together with criteria of AC 91010 establish the requirements for RNP APCH with baro-VNAV 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 operator that chooses to meet the criteria established in this AC.

2. SECTIONS RELATED TO THE BOTSWANA AERONAUTICAL REGULATIONS (CARs) OR EQUIVALENT

Civil Aviation Regulations

3. RELATED DOCUMENTS

Annex 6:	Aircraft operations
Annex 10:	Aeronautical telecommunications
	Volume I: Radio navigation aids
Doc 9613:	Performance-based navigation manual (PBN)
Doc 8168:	Aircraft operations
	Volume I: Flight procedures
	Volume II: Construction of visual and instrument flight procedures

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

4. DEFINITIONS AND ABBREVIATIONS

4.1. Definitions

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

b) **Navigation specifications.** - A set of aircraft and flight crew requirements needed to support performance-based navigation operations within a defined airspace. There are two kinds of navigation specifications:
Required navigation performance (RNP) specification. - A navigation specification based on area navigation that includes the requirement for on-board performance monitoring and alerting, designated by the prefix RNP, e.g., RNP 4, RNP APCH, RNP AR APCH.
Area navigation (RNAV) specification. - A navigation specification based on area navigation that does not include the requirement for on-board performance monitoring and alerting, designated by the prefix RNAV, e.g., RNAV 5, RNAV 2, RNAV 1.

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

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

c) **Performance based navigation (PBN).** - Performance based navigation specifies system performance requirements for aircraft operating along an ATS route, on an instrument approach procedure, or in a designated airspace. Performance requirements are defined in terms of accuracy, integrity, continuity, availability, and functionality needed for the proposed operation in the context of a particular airspace concept.

d) **Area navigation (RNAV).** - A method of navigation which permits aircraft operation on any desired flight path within the coverage of ground or space-based navigation aids or within the limits of the capabilities of self-contained navigation aids, or a combination of these.

Note. *- Area navigation includes performance based navigation as well as other RNAV operations that do not meet the definition of performance based navigation.*

e) **RNP operations**. - Aircraft operations using a RNP system for RNP applications.

f) **Waypoint (WPT).** - A specified geographical location used to define an area navigation route or the flight path of an aircraft employing area navigation. Waypoints are identified as either:
Fly-by waypoint. - A waypoint that requires turn anticipation to allow tangential interception of the next segment of a route or procedure.
Flyover waypoint. - A waypoint at which a turn is initiated in order to join the next segment of a route or procedure.

g) **Initial approach fix (IAF).** - Fix that marks the beginning of the initial segment and the end of the arrival segment, if applicable. In RNAV application, this fix is normally defined as a “fly-by fix”.

h) **Flight management system (FMS).** - An integrated system, consisting of an airborne sensor, receiver and computer with both navigation and aircraft performance databases, which provides performance and RNAV guidance to a display and automatic flight control system.

i) **Global positioning system (GPS).** - The U.S. global navigation satellite system (GNSS) is a satellite-based radio navigation system that uses precise distance measurements to determine the position, velocity and time anywhere in the world. The GPS is composed of space, control and user elements. The space element consists of at least 24 satellites in 6 orbiting planes. The control element consists of 5 monitoring stations, 3 ground antennas, and one main control station. The user element consists of antennas and receivers that provide the user with position, speed, and precise time information.

j) **Global navigation satellite system (GNSS).-** Generic term used by ICAO to define any worldwide position, velocity and time determination system, which consists of one or more main satellite constellations, such as the GPS and the global navigation satellite system (GLONASS), aircraft receivers, and several integrity monitoring systems, including aircraft-based augmentation systems (ABAS), satellite-based augmentation systems (SBAS), such as the wide area augmentation system (WAAS) and ground-based augmentation systems (GBAS), such as the local area augmentation system (LAAS).
Distance information will be provided, at least in the immediate future, by GPS and GLONASS.

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

l) **RNP value.** - The RNP value designates the lateral performance requirement associated with a procedure. Examples of RNP values are: RNP 0.3 and RNP 0.15.

m) **Receiver autonomous integrity monitoring (RAIM).** - Technique used in a GPS receiver/processor to determine the integrity of its navigation signals, using only GPS signals or GPS signals augmented with barometric altitude data. This determination is achieved by a consistency check among redundant pseudo-range measurements. At least one additionally satellite to those required must be available to obtain the navigation solution.

4.2. Abbreviations

a) CAA- Civil Aviation Administration
b) ABAS- Aircraft-based augmentation system
c) AIP- Aeronautical information publication
d) AP- Autopilot
e) APCH- Approach
f) APV- Approach procedure with vertical guidance
g) APV/baro-VNAV- Approach operations with vertical guidance/Barometric vertical navigation
h) AR- Authorisation required
i) AIRAC- Aeronautical information regulation and control
j) AC- Advisory circular (CAAB)
k) AFM- Aircraft flight manual
l) AMC- Acceptable means of compliance
m) ANSP- Air navigation service provider
n) ATC- Air traffic control
o) ATS- Air traffic service
p) Baro VNAV- Barometric vertical navigation
q) AC- Advisory circular
r) CDI- Course deviation indicator
s) CDU- Control display unit
t) DME- Distance measuring equipment
u) DME/DME- Distance measuring equipment/distance measuring equipment
v) DME/DME/IRU- Distance measuring equipment/distance measuring equipment/inertial reference unit
w) DTK- Desired track
x) EASA- European Aviation Safety Agency
y) EHSI- Enhanced horizontal situation indicator
z) ETA- Estimated time of arrival
aa) FAA- United States Federal Aviation Administration
bb) FAF- Final approach fix
cc) FD- Flight director

dd) FDE- Fault detection and exclusion
ee) FMS- Flight management system
ff) Fly-by WPT- Fly-by waypoint
gg) Flyover WPT- Flyover waypoint
hh) FSD- Maximum deflection
ii) FTE- Flight technical error
jj) GBAS- Ground-based augmentation system
kk) GNSS- Global navigation satellite system
ll) GLONAS- Global navigation satellite system
mm) GPS- Global positioning system
nn) IAF- Initial approach fix
oo) IAP- Instrument approach procedure
pp) IFR- Instrument flight rules
qq) IRU- Inertial reference unit
rr) LAAS- Local area augmentation system
ss) CAR- Civil Aviation Aeronautical Regulations
tt) LNAV- Lateral navigation
uu) LOA- Letter of authorisation/letter of acceptance
vv) LP- Localizer performance
ww) LPV- Localizer performance with vertical guidance
xx) MAPt- Missed approach point
yy) MEL- Minimum equipment list
zz) NAVAIDS- Navigation aids
aaa) 2D navigation- 2D area navigation that only uses the capabilities on the horizontal plane
bbb) NDB- Non-directional beacon
ccc) NPA- Non-precision approach
ddd) NSE- Navigation system error
eee) NOTAM- Notice to airmen
fff) OACI- International Civil Aviation Organization
ggg) OCA/H- Obstacle clearance altitude/height
hhh) OEM- Original equipment manufacturer
iii) OM- Operations manual
jjj) OpSpecs- Operational specifications
kkk) PANS-OPS- Procedures for air navigation services – Aircraft operations
lll) PBN- Performance-based navigation
mmm) PDE- Path definition error
nnn) PF- Pilot flying the aircraft
ooo) PFD- Primary flight display
ppp) POH- Pilot operations handbook
qqq) PM- Pilot monitoring the aircraft
rrr) PNF- Pilot not flying the aircraft
sss) RAIM- Receiver autonomous integrity monitoring
ttt) RF- Constant radius arc to a fix

uuu) RNAV- Area navigation
vvv) RNAV(GNSS) GNSS (GPS)-based RNP APCH approaches
www) RNP- Required navigation performance
xxx) RNP APCH- Required navigation performance approach
yyy) RNP AR APCH- Required navigation performance authorization required approach SBAS- Satellite-based augmentation system
zzz) SL- Service letters
aaaa) SOP- Standard operating procedures
bbbb) SRVSOP- Regional Safety Oversight Cooperation System
cccc) STC- Supplemental type certificate
dddd) TCDS- Type certificate data sheet
eeee) TSE- Total system error
ffff) TSO- Technical standard order
gggg) VMC- Visual flight meteorological conditions
hhhh) VNAV- Vertical navigation
iiii) VOR VHF- omnidirectional radio range
jjjj) VPA- Vertical path angle
kkkk) WAAS- Wide area augmentation system
llll) WGS- World geodetic system
mmmm) WPT- Waypoint
nnnn) XTK- Cross-track

5. INTRODUCTION

5.1. According to Doc 9613 of the International Civil Aviation Organization (ICAO) – Performance-based navigation manual (PBN), there are two types of navigation specifications for approach operations: RNP approach (RNP APCH) and RNP authorisation required approach (RNP AR APCH).

5.2. This AC establishes only the requirements for lateral navigation (2D navigation) of RNP APCH approaches designed with straight segments. This navigation specification includes present RNAV(GNSS) or GNSS approaches.

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

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

5.5. According to Annex 6 to the Convention on International Civil Aviation (also known as Chicago Convention), when RNP APCH approaches do not include barometric vertical guidance, they are classified as non-precision approach (NPA) operations. On the other hand, when RNP APCH operations include barometric vertical guidance, they are classified as approach procedures with vertical guidance (APV).

5.6. Baro-VNAV systems are optional capabilities that do not constitute a minimum requirement for flying RNAV(GNSS) or GNSS approaches using the LNAV line of minima.

5.7. Operations with localizer performance (LP) and localizer performance with vertical guidance (LPV) are not covered by this AC and will be the subject of another SRVSOP AC.

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

5.9. Stand-alone and multi-sensor RNP systems that use GNSS (GPS) and that comply with AMC 20-27 of the European Aviation Safety Agency (EASA) and with the advisory circulars (AC) of the United States Federal Aviation Administration

(FAA): AC 90-105, AC 20-138A, AC 20-130A or TSO C 115b/ETSO C 115b, meet the ICAO RNP APCH navigation specification.

***Note**.- The multi-sensor systems may use other sensors combinations, such as distance measuring equipment/distance measuring equipment (DME/DME) or distance measuring equipment/distance measuring equipment/inertial reference unit (DME/DME/IRU), that provide the navigation performance acceptable for RNP APCH operations; however, such cases are limited due to the increased complexity in the navigation aid (NAVAID) infrastructure requirements and assessment, and are not practical or cost effective for widespread application*.

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

ICAO Doc 9613, Volume II, Part C, Chapter 5 – Implementing RNP APCH.

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

EASA AMC 20-27 - Airworthiness approval and operational criteria for RNP APPROACH (RNP APCH) operations including APV BARO-VNAV operations; and

FAA AC 90-105 - Approval guidance for RNP operations and barometric vertical navigation in the U.S. National Airspace System.

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

6. GENERAL CONSIDERATIONS

6.1. Navaid infrastructure

a) The global navigation satellite system (GNSS) is the primary navigation system to support RNP APCH procedures.
b) For baro-VNAV RNP APCH operations, the procedure design is based upon the use of a barometric altimetry by an airborne RNP system whose capabilities support the required operation. The procedure design must take into account the performance and functional capabilities required in SRVSOP AC 91-010 – Aircraft and operators approval for APV/baro-VNAV operations or in equivalent documents.
c) The acceptability of the risk of loss of RNP APCH capability for multiple aircraft due to satellite failure or loss of on-board monitoring and alerting function (for example, spaces with no receiver autonomous integrity monitoring (RAIM) coverage), must be considered by the responsible airspace authority.

6.2. Obstacle clearance

6.2.1. RNP APCH operations without baro-VNAV guidance

a) Detailed guidance on obstacle clearance is provided by ICAO Doc 8168 (PANS-OPS), Volume II – Construction of visual and instrument flight procedures. The missed approach procedure may be supported by either RNAV or by conventional segments (e.g., segments based on VHF onmidirectional radio range (VOR), distance measuring equipment (DME), or non-directional radio beacon (NDB)).
b) Procedure designs must take into account of the absence of the vertical navigation (VNAV) capability of the aircraft

6.2.2. RNP APCH operations with baro-VNAV guidance

a) Baro-VNAV is applied where vertical guidance and information is provided to the flight crew during instrument approach procedures containing a vertical path defined by a vertical path angle (VPA).
b) Detailed guidance on obstacle clearance is provided in Doc 8168 (PANS-OPS), Volume II – Construction of visual and instrument flight procedures. The missed approach procedure may be supported by either RNAV or conventional segments (e.g., segments based on VOR, DME, NDB).

6.3. Publications

a) The instrument approach charts will clearly identify the RNP APCH application as RNAV(GNSS).
b) For RNP APCH operations without baro-VNAV, the procedure design will be based on normal descent profiles, and the charts will identify minimum altitude requirements for each segment, including a lateral navigation obstacle clearance altitude/height (LNAV OCA/H).
c) For RNP APCH operations with baro-VNAV, the charts will follow the standards of Annex 4 to the Convention on International Civil Aviation for the designation of an RNAV procedure where the vertical path is specified by a glide path angle. The chart designation will be consistent with said Annex and a lateral and vertical navigation obstacle clearance altitude/height will be issued (LNAV/VNAV OCA/H).
d) When the missed approach segment is based on conventional means, the navaid facilities or the airborne navigation means that are necessary to conduct the missed approach will be identified in the relevant publications.
e) The navigation information published in the applicable aeronautical information publication (AIP) for the procedures and the supporting NAVAIDs will meet the requirements of Annexes 15 and 4 to the Convention on International Civil Aviation (as appropriate). Procedure charts will provide sufficient data to support navigation data base checking by the flight crew (including waypoint names (WPT), tracks, distances for each segment and the VPA).

f) All procedures will be based on the 1984 World Geodetic Coordinates (WGS 84).

6.4. Air traffic service (ATS) communication and surveillance

a) RNP APCH operations do not include specific requirements for communication and ATS surveillance. Adequate obstacle clearance is achieved through aircraft performance and operating procedures. Where reliance is placed on the use of radar to assist contingency procedures, it must be demonstrated that its performance is adequate for this purpose. The radar service requirement will be identified in the AIP.
b) Appropriate radio phraseology will be published for RNP APCH operations.
c) It is expected that Air traffic control (ATC) to be familiar with aircraft VNAV capabilities, as well as with aspects concerning altimetry setting and the effect of temperature that could potentially affect the integrity of baro-VNAV RNP APCH operations.
d) The particular hazards of a terminal and approach area and the impact of contingency procedures following a multiple loss of RNP APCH capability must be assessed.

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

a) According to ICAO Doc 9613, navigation accuracies associated with the flight phases of a RNP APCH approach are the following:
   1) initial segment: RNP 1.0
   2) middle segment: RNP 1.0
   3) final segment: RNP 0.3
   4) missed approach segment: RNP 1.0

6.6. Additional considerations

a) It will be considered that many aircraft have the capability to execute a holding pattern maneuver using an RNP system.

7. DESCRIPTION OF THE NAVIGATION SYSTEM

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

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

8. AIRWORTHINESS AND OPERATIONAL APPROVAL

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

a) an airworthiness approval from the State of registry; (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 will determine if the aircraft meets the applicable RNP APCH requirements and will issue the operational authorisation (e.g., a letter of authorization – LOA) (see paragraph 2.5.2.2 of Annex 6, Part II).

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

9. AIRWORTHINESS APPROVAL

9.1. General

a) The following airworthiness criteria are applicable to the installation of RNP systems required for RNP APCH operations:

1) This AC uses FAA AC 20-138/AC 20-138A (GPS stand-alone system) or AC 20-130A (multisensors systems) as a basis for the airworthiness approval of an RNP system based on GNSS.

2) For APV/baro-VNAV operations, AC 20-129 will be used, as established in SRVSOP AC 91-010.

9.2. Aircraft and system requirements

a) Aircraft approved to conduct RNAV(GNNS) or GNSS approaches meet the performance and functional requirements of this AC for RNP APCH instrument approaches without radius to fix segments (without RF segments).

b) Aircraft that have a statement of compliance with respect to the criteria contained in this AC or equivalent documents in their flight manual (AFM), AFM supplement, pilot operations handbook (POH), or the operating manual for their avionics meet the performance and functional requirements of this AC.

c) Aircraft that have a statement from the manufacturer documenting compliance with the criteria of this AC or equivalent documents meet the performance and functional requirements of this document. This statement will include the airworthiness basis for such compliance. Compliance with the sensor

requirements will have to be determined by the equipment or aircraft manufacturer, while compliance with the functional requirements may be determined by the manufacturer or through an inspection by the operator.

d) If the RNP installation is based on GNSS stand-alone system, the equipment must be approved in accordance with technical standard order (TSO) C129a/ETSO-C129a Class A1 (or subsequent revisions) or with TSO-C146a/ETSO-C146a Class Gamma, Operational Class 1, 2, or 3 (or subsequent revisions) and meet the functionality requirements of this document.

e) If the RNP installation is based on GNSS sensor equipment used in a multi-sensor system (e.g., flight management system (FMS)), the GNSS sensor must be approved in accordance with TSO-C129 ()/ETSO-C129 () Class B1, C1, B3, C3 (or subsequent revisions) or TSO-C145 ()/ETSO-C145 () Class Beta, Operational Class 1, 2 or 3 (or subsequent revisions) and meet the functionality requirements of this document.

f) Multi-sensor systems using GNSS must be approved in accordance with AC 20-130A or TSOC115b/ETSO-C115b and meet the functionality requirements of this document.

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

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

9.3. Performance and functional requirements for RNP APCH systems

a) Accuracy

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

(a) ± 1 NM for at least 95 percent of the total flight time in the initial and intermediate approach segments and for the missed approach of a RNP APCH procedure.

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

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

2) To satisfy the accuracy requirement, the flight technical error (FTE) (95%) shall not exceed:

(a) 0.5 NM in the initial, intermediate, and missed approach segments of a RNP APCH procedure; and
(b) 0.25 NM in the final approach segment of the procedure.

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

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

b) **Integrity.** - Malfunction of the aircraft navigation equipment that causes the TSE to exceed 2 times the RNP value is classified as a major failure condition under airworthiness regulations (e.g., 10-5 per hour). In the horizontal plane (lateral and longitudinal), the system must provide an alert if the accuracy requirement is not met, or if the probability that the TSE exceeds 2 NM for initial, intermediate and missed approach segments or 0.6 NM for the final approach segment is greater than 10-5 per hour.

c) **Continuity.** - Loss of the RNP APCH functions is classified as a minor failure condition if the operator can revert to a different navigation system and safely proceed to a suitable airport. If the missed approach procedure is based on conventional NAVAIDs (e.g., VOR, DME, NDB), the associated navigation equipment must be installed and operational. For RNP APCH operations, at least one RNP navigation system is required.

Note. - *From an operational point of view, the operator must develop contingency procedures in case of loss of the RNP APCH capability during approach.*

d) **Performance monitoring and alerting**. - During operations in the initial, intermediate and the missed approach segments of a RNP APCH procedure, the RNP system or the RNP system in combination with the pilot, shall provide an alert if the accuracy requirement is not met or if the probability that the lateral TSE exceeds 2 NM is greater than 10-5. During operations on the final approach segment, the RNP system or the RNP system in combination with the pilot shall provide an alert if the accuracy requirement is not met or if the probability that the lateral TSE exceeds 0.6 NM is greater than 10-5.

e) **Signal-in-space.** - During operations in the initial, intermediate, and missed approach segments of an RNP APCH procedure, the aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 2 NM exceeds 10-7 per hour (Chicago Convention Annex 10, Table

3.7.2.4-1). During operations in the final approach segment of a RNP APCH procedure, the aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 0.6 NM exceeds 10-7 per hour (Chicago Convention Annex 10, Table 3.7.2.4-1).

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

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

g) **Functional requirements of navigation displays.** - The following navigation displays and functions are required, according to FAA AC 20-130 and AC 20-138 or equivalent advisory material. Navigation data, including a to/from indication and a failure indicator must be displayed on a lateral deviation display (course deviation indicator (CDI), enhanced horizontal situation indicator (EHSI)) and/or a navigation map display. These displays must be used as primary flight instruments for the navigation of the aircraft, maneuver anticipation and for failure/status/integrity indication. The aforementioned non-numerical lateral deviation displays must have the following attributes:

1) the displays must be visible to the pilot and located in the primary field of view when looking forward along the flight path

2) the lateral deviation display scaling must agree with any alerting and annunciation limits

3) the lateral deviation display must also have an FSD suitable for the current phase of flight and must be based on the TSE requirement. Scales of ± 1 NM for the initial, intermediate, and missed approach segments and ± 0.3 NM for the final segment are acceptable.

4) the scale of the display may be set automatically by default logic or set to a value obtained from a navigation database. The FSD value must be known or must be available for display to the pilot commensurate with approach values

5) as an alternate means, a navigation map display must provide equivalent functionality to a lateral deviation display with appropriate map scales (scales may be set manually by the pilot) and provide equivalent functionality to a lateral deviation display. To be approved, the navigation map display must show compliance with TSE requirements and be located in the primary field of view of the pilot.

6) the lateral deviation display must be automatically slaved to the RNP computed path. It is recommended that the course selector of the deviation display be automatically slewed to the RNP computed path.

Note. *- This does not apply for installations where an electronic map display contains a graphical display of the flight path and path deviation.*

7) Enhanced navigation displays (e.g., electronic map displays or enhanced HSI) to improve lateral situational awareness, navigation monitoring and approach verification (flight plan verification) could become mandatory if the RNP installation does not support the display of information necessary for the accomplishment of these crew tasks.

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

1) the capability to continuously display to the pilot flying (PF) the aircraft, on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNP computed desired path and aircraft position relative to the path. For operations where the required minimum flight crew is two pilots, a means for the pilot not flying (PNF) the aircraft (pilot monitoring (PM)) to verify the desired path and the aircraft position relative to the path must also be provided.

2) a navigation database, containing current navigation data officially promulgated by the CAA, which can be updated in accordance with the aeronautical information regulation and control (AIRAC) cycle and from/into which approach procedures can be retrieved and entered in the RNP system. The stored resolution of the data must be sufficient to achieve the required track keeping accuracy. The database must be protected against pilot modification of the stored data

3) the means to display the validity period of navigation data to the pilot.

4) the means to retrieve and display data stored in the navigation database relating to individual waypoints and NAVAIDs, to enable the pilot to verify the route to be flown

5) the capability to load from the database into the RNP system, the whole approach to be flown. The approach must be loaded by its name from the database to the RNP system.

6) the means to display the following items, either in the primary field of view of the pilot or on a readily accessible display page:
   a) the identification of the active (to) WPT;
   b) the distance and bearing to the active (to) WPT; and
   c) the ground speed or time to the active (to) WPT.

7) the means to display the following items on a readily accessible display page:
   a) the display of distance between the operational flight plan WPTs;
   b) the display of distance to go;
   c) the display of along track distances; and
   d) the active navigation sensor type, if there is another type of sensor in addition to the GNSS sensor.

8) the capability to execute the “direct to” function.

9) the capability for automatic leg sequencing with the display of sequencing to the pilot.

10) the capability to execute RNP instrument approach procedures (IAP) extracted from the on-board aircraft database, including the capability to execute flyover and fly-by turns.

11) the capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators or their equivalent:
   a) initial fix (IF)
   b) track to fix (TF)
   c) direct to fix (DF)

Note. *- Path terminators are defined in ARINC Specification 424 and their application is described in more detail in RTCA documents DO-236B and DO-201A.*

Note. *- Numerical values for tracks must be automatically entered from the RNP system database.*

12) the capability to display an indication of the RNP system failure, including the associated sensors, in the primary field of view of the pilot.

13) the capability to indicate to the flight crew when the NSE alert limit is exceeded (alert provided by the on-board performance monitoring and alerting function).

i) **Flight director/autopilot**. - It is recommended that the flight director (FD) and/or autopilot (AP) remain coupled for RNP approaches. FD or AP coupling is mandatory when lateral TSE cannot be demonstrated without these systems. In this case,

operational procedures must indicate that FD and/or AP coupling from the RNP system is mandatory for RNP APCH approaches.

j) **Database integrity.** - the navigation database suppliers must comply with RTCA DO-200A. A letter of acceptance (LOA), issued by the appropriate regulatory authority to each one of the participants in the data chain, demonstrates compliance with this requirement. Positive compliance with this requirement will be considered for those Laos Type 2 issued prior to the publication of this AC.

9.4. System eligibility and approval of RNP APCH operations

a) **Introduction.** - The original equipment manufacturer (OEM) or the holder of installation approval for the aircraft (e.g., the holder of the supplementary type certificate (STC)), must demonstrate to the CAA of State of registry or manufacture that it complies with the appropriate provisions of this AC. The approval can be recorded in the documentation of the manufacturer (e.g., service letters (SL), etc.). Provided the CAA accepts manufacturer documentation, need not be recorded in the AFM.

b) **Eligibility for RNP APCH operations.** - Systems that meet the requirements of Paragraph 9.2 of this AC are eligible for RNP APCH operations. Aircraft qualified in accordance with SRVSOP AC 91-009 or equivalent, e.g., FAA AC 90-101 or EASA AMC 20-26 are considered qualified for RNP APCH operations without further examination.

c) **System eligibility for RNP APCH operations**

1) LNAV Line of minima qualification

(a) **Stand-alone systems.-** Stand-alone systems that comply with TSO-C129/ETSOC129 Class A1 or TSO-C146/ETSO-C146 Classes 1, 2, or 3 meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided the IFR equipment installations have been performed in accordance with FAA AC 20-138. RNP systems must be approved in accordance with AC 20-138 or equivalent.

Note. - *it is considered that these systems meet the functional and performance requirements set out in Paragraph 9.3 of this AC in the aspects that correspond.*

(b) **Multi-sensor systems. –**

(1) Multi-sensor systems that use TSO-C129/ETSO-C129 Classes B1, B3, C1, or C3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided:

- the equipment installations meet the criteria of this AC; and
- the associated flight management system (FMS) complies with TSO-C115b/ETSO-C115b and are installed in accordance with FAA AC 20-130.

(2) Multi-sensor systems that use TSO-C145/ETSO-C145 Classes 1, 2, or 3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV line of minima, provided:

- the equipment installations meet the criteria of this AC; and are installed in accordance with FAA AC 20-138.

Note. - *it is considered that these systems meet the functional and performance requirements set out in Paragraph 9.3 of this AC in the aspects that correspond.*

2) LNAV/VNAV Line of minima qualification

(a) Stand-alone systems

(1) Stand-alone TSO-C146/ETSO-C146 Classes 2 or 3 systems meet the aircraft qualification requirements for RNP APCH operations using the LNAV/VNAV line of minima, provided that the installations meet at least the performance and functional requirements of this AC and AC 91-010 or equivalent.

(2) The systems that meet TSO-C129/ETSO-C129 can be used for RNP APCH operations using the LNAV/VNAV line of minima if they meet the criteria of this AC and AC 91-010 or equivalent.

(3) RNP systems must be approved in accordance with FAA AC 20-138 or equivalent, and those systems that utilize conventional baro-VNAV must provide vertical navigation system performance that meets or exceeds the criteria of AC 91-010 or equivalent.

(b) Multi-sensor systems

(1) Multi-sensor systems that use TSO-C129/ETSO-C129 Classes B1, B3, C1, or C3 sensors or TSO-C145/ETSO-C145 Classes 1, 2, or 3 sensors meet the aircraft qualification requirements for RNP APCH operations using the LNAV/VNAV line of minima, provided the installations meet the requirements of this AC and AC 91-010 or equivalents.

(2) RNP systems that utilize conventional baro-VNAV must provide a vertical navigation system performance that meets or exceeds the criteria of AC 91-010 or equivalent.

(3) RNP systems must be installed in accordance with FAA AC 20-138 or equivalent and/or the associated FMS must comply with TSO-C115b/ETSO-C115b and must be installed in accordance with AC 20-130 or equivalent.

9.5. Aircraft modification

a) If any system required for RNP APCH operations is modified (e.g., changes in the software or hardware), the aircraft modification must be approved.

b) The operator must obtain a new operational approval that is supported by updated aircraft operational and qualification documentation.

9.6. Continued airworthiness

a) The operators of aircraft approved to perform RNR APCH operations, must ensure the continuity of the technical capacity of them, in order to meet technical requirements established in this AC.

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

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

c) Each operator who applies for RNP APCH operational approval shall submit to the CAA of State of registry, a maintenance and inspection program that includes all those requirements of maintenance necessary to ensure that navigation systems continue fulfilling the RNP APCH approval criteria.

d) The following maintenance documents must be revised, as appropriate, to incorporate RNP APCH aspects:
   1) Maintenance control manual (MCM);
   2) Illustrated parts catalogues (IPC); and
   3) Maintenance program.

e) The approved maintenance program for the affected aircrafts should include maintenance practices listed in maintenance manuals of the aircraft manufacturer and its components, and must consider:

   1) that equipment involved in the RNP APCH operation should be maintained according to directions given by manufacturer's components;
   2) that any amendment or change of navigation system affecting in any way RNP APCH initial approval, must be forwarded and reviewed by the CAA for its acceptance or approval of such changes prior to its implementation; and

   3) that any repair that is not included in the approved/accepted maintenance documentation, and that could affect the integrity of navigation performance, should be forwarded to the CAA for acceptance or approval thereof.

f) Within the RNP APCH maintenance documentation should be presented the training program of maintenance personnel, which inter alia, should include:

   1) PBN concept;
   2) RNP APCH application;
   3) equipment involved in a RNP APCH operation; and
   4) MEL use.

10. OPERATIONAL APPROVAL

The airworthiness approval, by itself, does not authorise the operator to conduct RNP APCH operations. In addition to the airworthiness approval, the operator must obtain an operational approval confirming that the installation of the specific equipment is consistent with normal and contingency procedures.

10.1. Operational approval requirements

To obtain the RNP APCH authorisation, the operator will take the following steps, taking into account the criteria established in this paragraph and in Paragraphs 10.2 to 10.10 of this AC.

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

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

1) The application to obtain the RNP APCH authorization;

2) Aircraft eligibility and qualification documentation. - Airworthiness documentation showing that the aircraft and system proposed meet the requirements of this AC, as described in Paragraphs 9 and 10.3. To avoid unnecessarily regulatory activity, the determination of eligibility for existing systems should consider acceptance of manufacturer documentation of compliance. Systems qualified for RNP AR APCH operations are considered qualified for RNP APCH operations without further examination.

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

4) Operational procedures and practices. - Operator manuals shall properly indicate the navigation operating practices and procedures identified in Paragraphs 10.4, 10.6, and 10.7 of this AC. General Aviation operators shall confirm that they will operate using identified practices and procedures.

5) Navigation data validation programme. - Details of the navigation data validation programme are provided in Appendix 1 to this AC.

6) Training programmes for the flight crew and flight dispatchers

(a) Commercial operators must provide a training programme addressing the operational practices, procedures and training items related to RNP APCH

operations (e.g. initial, upgrade or recurrent training for flight crew and dispatchers).

Note. - *It is not required to establish a separate training program or regime if RNP APCH training, identified in Paragraph 10.8, is already integrated in the operator's training program. However, it must be possible to identify what aspects of RNP APCH are covered within a training program.*

(b) Private operators (e.g. BCAR 91 operators) must be familiar with the practices and procedures identified in Paragraph 10.8 "training program" of this AC.

7) Training programme for maintenance personnel. - Operators will send instruction syllabus corresponding to maintenance personnel.

8) Operations manual (OM) and checklists

(a) Operations manual and checklists of commercial operators must address information and guidance on the standard operating procedures (SOP) detailed in Paragraph 10.6. The appropriate manuals should contain navigation operating instructions and contingency procedures described in Paragraph 10.7 of this AC, where specified. Manuals and checklists must be submitted for review as part of the approval process.

(b) Private operators (General Aviation) must operate using the practices and procedures identified in Paragraphs 10.6 and 10.7 "operating procedures and contingency procedures" of this AC.

9) Maintenance procedures. - The operator will submit the maintenance procedures containing airworthiness and maintenance instructions for the systems and equipment to be used in the operation. The operator will provide a procedure to remove and restore RNP APCH operational capability in the aircraft.

10) Minimum equipment list (MEL). - The operator will submit any revision to the MEL needed to conduct RNP APCH operations for approval.

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

d) Validation flights. - The CAA may conduct validation flights if it deems it necessary for safety purposes. Validation flights will be conducted according to Chapter 13, Volume II, Part II of the SRVSOP Operation Inspector Manual (MIO).

e) Issuance of the authorisation to conduct RNP APCH operations. - Once the operator has successfully completed the operational approval process, the CAA will issue, as appropriate, the authorisation to the operator to conduct RNP APCH operations.

1) General operators. - the CAA will issue a letter of authorisation (LOA).

2) AOC Holders. - the CAA will issue the corresponding operational specifications (OpSpecs) reflecting the RNP APCH authorisation.

10.2. Description of the aircraft equipment

a) The operator must establish and have available a configuration list detailing the components and equipment to be used for RNP APCH operations.
b) The list of required equipment shall be established during the operational approval process, taking into account the AFM. This list shall be used for updating the MEL for each type of aircraft that the operator intends to operate.
c) The details of the equipment and its use in accordance with the approach characteristics appear in this AC and in AC 91-010.

10.3. Aircraft qualification documentation

a) For aircraft currently conducting RNAV (GPS) or GPS approaches under FAA AC 90-94 or equivalent. - Documentation is not required for aircraft that have an AFM or AFM supplement which states the aircraft is approved to fly RNAV (GPS) or GPS approaches, to the LNAV line of minima.
b) For aircraft without approval to fly RNAV (GPS) or GPS instrument approach procedures. - Operators will submit to the CAA the RNP qualification documentation showing compliance with this AC, provided the equipment is properly installed and operated.

Note. - *Before requesting an RNP APCH authorisation, operators shall review all equipment performance requirements. Equipment installation by itself does not guarantee operational approval nor permit its operational use.*

10.4. RNP APCH operational documentation

a) The operator will develop RNP APCH operational documentation for using the equipment, based on the aircraft or avionics manufacturer documentation.
b) The operational documentation of the aircraft or avionics manufacturer will consist of recommended operational procedures and training programmes for the flight crew, in order to assist operators meet the requirements of this AC.

10.5. Acceptance of documentation

a) New aircraft/equipment (aircraft/equipment in the process of being manufactured or recently manufactured). - The aircraft/equipment qualification documentation can be approved as part of an aircraft certification project and be reflected in the AFM and related documents.
b) Aircraft/equipment in service (capacity achieved in service). - Previous approvals issued to conduct RNAV (GPS) or GPS instrument approaches according to AC 90-94 or equivalent do not require further evaluations. For

installations/equipment not eligible to conduct RNAV (GPS) or GPS instrument approaches, the operator will submit aircraft or avionics qualification documentation to the CAA.

c) The relevant CAA organisation will review the RNP APCH application package. Acceptance will be documented by means of a letter to the operator.

10.6. Operating procedures

a) Pre-flight planning

1) Operators and pilots planning to conduct RNP APCH operations must file the appropriate flight plan suffixes. “R” and “B” (LVP only) should appear in field 10 and PBN/S1 or PBN/S2 (LNAV/VNAV only) in field 18.

2) At system initialization, pilots must confirm the navigation database is current and includes appropriate procedures. Likewise, pilots must also verify that the aircraft position is correct.

Note. *- Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle changes during the flight (becomes due), the operators and pilots shall establish procedures to ensure the precision of navigation data, including the capacity of navigation facilities to define routes and flight procedures. Traditionally, this has been done by comparing electronic data with printed documents. An acceptable method is to compare aeronautical charts (new and old) in order to verify navigation fixes before dispatch. If an amended letter for the procedure is published, the database must not be used for conducting the operation.*

3) Airworthiness certification alone does not authorize an operator to conduct an RNP APCH operation down to LNAV or LNAV/VNAV minima. Operational approval is also required to confirm the adequacy of the operator’s normal and contingency procedures for the particular equipment installation

4) Pilots must verify the proper entry of their ATC assigned route once they have received the initial clearance and following any subsequent changes of the route. Likewise, pilots must ensure the WPT sequence depicted by their navigation system matches their assigned route and the route depicted on the appropriate charts.

Note. - *Pilots may notice a slight difference between the navigation information portrayed on the chart and the heading shown on the primary navigation display. A difference of 3 degrees or less may be due to a magnetic variation applied by the equipment manufacturer and may be operationally acceptable.*

Note. - *Manual selection of functions that limit the aircraft bank angle can reduce the aircraft’s ability to maintain the desired track and is not recommended.*

5) The aircraft RNP capability depends on the aircraft operational equipment. The flight crew must be able to assess the impact of equipment failure on the anticipated RNP APCH operation and take appropriate action. When a flight dispatch is predicated on flying an RNP APCH procedure that requires the use of the AP or FD at the destination and/or alternate aerodrome, the operator must determine that the AP and/or FD are installed and operational.

6) Pilots must ensure that the approaches which may be used for the intended flight (including the approaches in alternates aerodromes):
   (a) can be selected from a valid navigation data base (current AIRAC cycle);
   (b) have been verified through an appropriate process (navigation database integrity process); and
   (c) have not been prohibited by any NOTAM issued by the CAA or by the air navigation service providers or by an operational instruction of the company.

7) Pilots must ensure that there are sufficient means available to fly and land at the destination or alternate aerodrome in case of loss of RNP APCH capability.

8) Operators and flight crews must take account of any NOTAM issued by the CAA or by the ANSP, or by an operational instruction of the company that might adversely affect aircraft system operation or the availability or suitability of the procedures at the destination aerodrome or at any alternate aerodromes.

9) For missed approach procedures based on conventional NAVAIDs (VOR, NDB), pilots must verify that the appropriate airborne equipment required to fly such procedures is installed and operational in the aircraft. Likewise, they must verify that the associated ground-based NAVAIDs are operational.

10) The availability of the NAVAID infrastructure, required for the intended routes and RNP APCH operations, including any non-RNP contingency, must be confirmed for the period of intended operations, using all available information. Since GNSS integrity (receiver autonomous integrity monitoring (RAIM) or satellite-based augmentation system (SBAS) signal) is required by Annex 10, the availability of such signals must also be determined as appropriate. For aircraft navigating with SBAS receivers (all TSO-C145()/C146()/ETSO-C145()/C146()), operators must check appropriate GPS RAIM availability in areas where SBAS signal is unavailable.

11) RAIM prediction must be performed prior to departure.
   (a) The predictive capability must account for known and predicted outages of GPS satellites or other impacts on the navigation system's sensors. The prediction programme should not use a mask angle below 5 degrees, as operational experience indicates that satellite signals at low elevations are not reliable. RAIM availability prediction should take into account the latest GPS constellation

notices to airmen (NOTAMs issue by CAAB and/or ANSP) and avionics model (when available) and use the identical algorithm to that used in the airborne equipment, or an algorithm based on assumptions for RAIM prediction that give a more conservative result. The service may be providing by the ANSP, avionics manufacturer, other entities or through an airborne receiver RAIM prediction capability. RAIM availability may be confirmed by using a model-specific RAIM prediction software.

(b) The RAIM availability prediction software does not guarantee the service. The software is rather a tool to assess the expected capability to meet the required navigation performance. Because of unplanned failures of some GPS elements, pilots must realize that RAIM or GPS navigation may be lost while in flight which may require reversion to an alternative means of navigation. Therefore, pilots must assess their capability to navigate to an alternate aerodrome in case of failure of GPS navigation.

(c) In the event of a predicted, continuous loss of RAIM of more than 5 minutes for any part of the intended RNP APCH operation, the flight should be revised (delayed, cancelled, or re-routed) where RAIM requirements can be met.

12) For aircraft navigating with SBAS receivers (all TSO-C145/C146/ ETSO-C145/C146 systems), operators shall take into account the latest GPS constellation and SBAS NOTAMs issued by the CAA or ANSP. If the NOTAMs indicate the SBAS signal is not available over the intended flight route, operators should check appropriate GPS RAIM availability.

b) Prior to commencing the procedure

1) In addition to normal procedures, prior to commencing the approach (before the initial approach fix (IAF)), the flight crew must verify the correct procedure has been loaded, by comparing said procedure with the approach charts. This check must include:
   (a) the WPT sequence;
   (b) the integrity of the tracks and distances of the approach legs, the accuracy of the inbound course and the length of the final approach segment.

Note. - *As a minimum, this check could be a simple inspection of a map display that permits the achievement of the objectives of this paragraph.*

2) The flight crew must also check from the publish charts, map display or control display unit (CDU), which WPT are fly-by, and which are flyover.

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

4) For a RNP system with aircraft-based augmentation system (ABAS) requiring barometric corrected altitude, the current aerodrome barometric altimeter setting,

must be set at the appropriate time and location, consistent with the performance of the flight operation.

5) When the operation is based on ABAS availability, the flight crew must perform a new RAIM availability check if the estimated time of arrival (ETA) is more than 15 minutes different from the ETA used during the flight planning. This check is also processed automatically 2 NM before the final approach fix (FAF) for a TSO-C129a/ ETSO-C129a Class A1 receiver.

6) In the terminal area, ATC tactical interventions may include radar headings, "direct to" clearances which by-pass the initial approach legs, interception of an initial or intermediate approach segment, or the insertion of WPT loaded from the database. In complying with ATC instructions, the flight crew must be aware of the implications for the RNP system.
   (a) The manual entry of coordinates into the RNP system by the flight crew for operations within the terminal area is not permitted.
   (b) "Direct to" clearances may be accepted up to the intermediate fix (IF), provided that the resulting track change at the IF does not exceed 45º.

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

7) The lateral definition of the flight path between the FAF and the missed approach point (MAPt) must not be revised by the flight crew under no circumstances.

8) The approach system provides the capability for the pilot to intercept the final approach track well before the FAP (VTF function or equivalent). This function should be used to respect a given ATC clearance.

c) During the procedure

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

2) Before starting the descent, the aircraft must be established on the final approach course no later than the FAF to ensure obstacle and terrain clearance.

3) Pilots must check that the navigation system is in approach mode within 2 NM prior to the FAF.

Note. - *This check does not apply for certain RNP systems (e.g., for aircraft that have been approved with a demonstrated RNP capability). For such systems, other means are available, including electronic map display, flight guidance mode indications, etc., which clearly indicate to the flight crew that the approach mode is activated.*

4) The appropriate displays must be selected so that the following information can be monitored by the flight crew:

(a) the RNP computed desired track (DTK); and
(b) the aircraft position relative to the path cross track deviation (XTK) for the flight technical error (FTE) monitoring.

5) A RNP APCH procedure must be discontinued:
   (a) if the navigation display is announcing a failure (flagged invalid): or
   (b) in case of loss of the integrity alerting function; or
   (c) if the integrity alerting function is annunciate not available before passing the FAF; or if the FTE is excessive.

6) A missed approach must be flown in accordance with the published procedure. Use of the RNP system during the missed approach is acceptable, provided:
   (a) the RNP system is operational (e.g., there is no loss of function, no NSE alert, no failure indication, etc.).
   (b) the whole procedure (including the missed approach) is loaded from the navigation data base.

7) During the RNP APCH procedure, pilots must use a lateral deviation indicator, FD and/or AP in the lateral navigation mode. Pilots of aircraft with lateral deviation indicator (e.g., CDI) must ensure that lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the different procedure segments (e.g., ± 1.0 NM for the initial, intermediate, and missed approach segments, and ± 0.3 NM for the final approach segment).

8) All pilots are expected to maintain procedure centerlines, as depicted by onboard lateral deviation indicators and/or flight guidance during all the approach procedure unless authorized to deviate by ATC or in emergency conditions.

9) For normal operations, the cross-track error/deviation (the difference between the RNP system computed path and the aircraft position relative to the path) must be limited to ± ½ of the navigation accuracy associated with the procedure (e.g., 0.5 NM for the initial, intermediate and missed approach segments and 0.15 NM for the final approach segment). Brief deviations from this standard (e.g., overshoots or undershoots) during and immediately after turns, up to a maximum of one (1) time the navigation accuracy (e.g., 1.0 NM for the initial and intermediate segments), are allowable.

10) When baro-VNAV is used for vertical path guidance during the final approach segment, deviations above and below the baro-VNAV path must not respectively exceed +-22 m (+-75 ft).
11) Pilots must execute a missed approach if the lateral or vertical deviations exceed the criteria of the previous paragraph, unless the pilot has in sight the visual references required to continue the approach.

12) For aircraft requiring two pilots, the flight crew must verify that each pilot's altimeter has the current setting before beginning the final approach of a RNP APCH approach procedure. The flight crew must also observe any operational limitations associated with altimeter setting sources and the latency of checking and setting the altimeters when approaching the FAF.

13) Although the scale should change automatically, the pilots of an aircraft with lateral deviation indicator (e.g., CDI) must make sure that the scale of the lateral deviation indicator (maximum deflection) is consistent with the different segments of the procedure (e.g., ± 1.0 NM for the initial, intermediate, and missed approach segments, and ± 0.3 NM for the final approach segment).

14) RNP APCH procedures require flight crew monitoring of lateral and, if installed, vertical track deviations on the pilot's primary flight displays (PFD) to ensure the aircraft remains within the bounds defined by the procedure.

15) Pilots must execute a missed approach if the lateral deviations or vertical deviations, if provided, exceed the criteria above in item 10, unless the pilot has in sight the visual references required to continue the approach.

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

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

10.7. Contingency procedures

a) The pilots must notify ATC of any loss of the RNP APCH capability, together with the proposed course of action.
b) If the pilots cannot meet the requirements of a RNP APCH procedure, they must notify the air traffic service (ATS) as soon as possible.
c) The loss of RNP APCH capability includes any failure or event causing the aircraft to no longer satisfy the RNP APCH requirements of the procedure.
d) The operators must develop contingency procedures in order to react safely following the loss of the RNP APCH capability during the approach.
e) In the event of communication failure, the flight crew must continue with the RNP APCH procedure in accordance with the published lost communication procedure.
f) The operator's contingency procedures must address at least the following conditions:

1) failure of the RNP system components, including those affecting lateral or vertical deviation performances (e.g., failures of a GPS sensor, FD or AP); and
2) loss of navigation signal-in-space (loss or degradation of the external signal).

g) The pilot must ensure the capability to navigate and land at an alternate aerodrome if loss of RNP APCH capacity occurs.

10.8. Training programme

a) The training programme must provide sufficient training on the aircraft's RNP systems (e.g., training in flight simulators, flight training devices or in the aircraft). The training programme will cover at least the following aspects:

1) the information about this AC.

2) the meaning and proper use of RNP systems.

3) the characteristics of the procedures, as determined from chart depiction and textual description.

4) depiction of WPT types (fly-by and flyover waypoints), required path terminators (IF, TF, and DF) and any other types used by the operator as well as associated aircraft flight paths.

5) navigation equipment required to conduct a RNP APCH operation (at least one RNP system based on GNSS).

6) specific information on RNP systems:
   (a) automation levels, annunciation modes, changes, alerts, interactions, reversions and degradation;
   (b) functional integration with other aircraft systems;
   (c) the meaning and appropriateness of route discontinuities, as well as related flight crew procedures;
   (d) monitoring procedures for each flight phase;
   (e) types of navigation sensors utilized by the RNP and associated systems, prioritization/weighting/logic;
   (f) turn anticipation, taking into account the effect of speed and altitude; and
   (g) interpretation of electronic displays and symbols.

7) the operating procedures for RNP equipment, as applicable, including how to perform the following actions:
   (a) verify currency of aircraft navigation data;
   (b) verify successful completion of RNP system self-tests;
   (c) initialize RNP system position;
   (d) retrieve and fly an RNP APCH procedure;

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

8) The automation levels recommended for the flight phases and workload, including methods to minimize cross-track error to maintain procedure centreline

9) radio communication phraseology for RNP applications.

10) Ability to conduct contingency procedures following RNP system failures.

10.9. Navigation database

a) The operator must obtain the navigation databases from a qualified supplier.
b) Navigation data suppliers must have a letter of acceptance (LOA) in order to process the navigation information (e.g., FAA AC 20-153 or document on the conditions for the issuance of letters of acceptance for navigation data suppliers by the European Aviation Safety Agency – EASA (EASA IR 21 Sub-part G) or equivalent documents). A LOA recognises the data supplier as one whose data quality, integrity, and quality management practices are consistent with the criteria of document DO-200A/ED-76. The database supplier of an operator must have a Type 2 LOA and their respective suppliers must have a Type 1 or 2 LOA. The CAA may accept a LOA issued to the navigation data suppliers or issue its own LOA.
c) Discrepancies that invalidate a procedure must be reported to the navigation database supplier and affected procedures must be prohibited by an operator's notice to its pilots.
d) The operator should continue to monitor both the process and the products in accordance with the quality system required by the applicable operational regulations.
e) The operator should implement procedures that ensure timely distribution and insertion of current and unaltered electronic navigation data to all aircraft that require it.

10.10. Follow-up of navigation error reports

a) The operator will establish a process to receive, analyse, and do the follow-up of navigation error reports that will help him determine the appropriate corrective action.
b) Repetitive occurrences of navigation errors attributed to a specific part of the navigation equipment may result in the cancellation of the approval for using the equipment.
c) The information that indicates the potential for repetitive errors may require the modification of the operator's training programme.
d) The information that attributes multiple errors to a particular pilot may require additional training or licence review.

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APPENDIX 1

NAVIGATION DATA VALIDATION PROGRAMME

1. INTRODUCTION

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

2. DATA PROCESSING

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

3. INITIAL DATA VALIDATION

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

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

4. DATA UPDATING

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

5. NAVIGATION DATA SUPLIERS

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

6. AIRCRAFT MODIFICATIONS (UPDATE OF THE DATA BASE)

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

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APPENDIX 2

RNP APCH APPROVAL PROCESS

a) The RNP APCH approval process consists of two types of approvals: the airworthiness and the operational approval. Although the two have different requirements, they must be considered within a single process.
b) This process constitutes an orderly method used by the CAAs to ensure that applicants meet the established requirements.
c) The approval process consists of the following phases:

1) Phase one: Pre-application
2) Phase two: Formal application
3) Phase three: Analysis of the documentation
4) Phase four: Inspection and demonstration
5) Phase five: Approval

1) 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.

2) In Phase two - Formal application, the applicant or operator submits the formal application, accompanied by all the relevant documentation, as established in Paragraph 10.1 of this AC.

3) In Phase three – Analysis of the documentation, the CAA evaluates the documentation and the navigation system to determine their eligibility and the approval method to be applied with respect to the aircraft. As a result of this review and evaluation, the CAA may accept or reject the formal application together with the documentation.

4) In Phase four - Inspection and demonstration, the operator will train its personnel and conduct validation flights, if required.

5) In Phase five - Approval, the CAA issues the RNP APCH authorisation once the operator has met the airworthiness and operational requirements. For AOC Holders, the CAA will issue the OpSpecs, and for General Aviation operators, it will issue a LOA.

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For/Civil Aviation Authority

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