

**AMC 20-27 Effective: 23/12/2009**

Annex III to ED Decision 2009/019/R of 16/12/2009

**AMC 20-27 Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BARO-VNAV Operations****1. PURPOSE**

This AMC provides an acceptable means that can be used to obtain airworthiness approval of an Area Navigation (RNAV) system based on a Global Navigation Satellite System (GNSS) stand-alone receiver or multi-sensor system including at least one GNSS sensor in order to conduct RNP Approach (RNP APCH) operations.

RNP APCH procedures are characterised by existing charted RNAV (GNSS) approach procedures designed with straight final approach segments.

This AMC also defines operational criteria necessary to conduct safely RNP APCH operations in designated European airspace.

This AMC addresses RNP APCH operation without vertical guidance (Non Precision Approach operation) and with vertical guidance based on barometric vertical navigation (APV BARO-VNAV operation). Final approaches utilising SBAS (Localiser Performance with Vertical guidance (LPV) operation) are addressed in separate AMC material.

APV BARO-VNAV systems are based on barometric altimetry for the determination of the aircraft position in the vertical axis. The final approach segment of VNAV instrument flight procedures are performed using vertical guidance to a vertical path computed by the on-board RNAV system. The vertical path is contained in the specification of the instrument procedure within the RNAV system navigation database. For other phases of flight, barometric VNAV provides vertical path information that can be defined by altitudes at fixes in the procedure. It should be noted that there is no vertical requirement in this AMC associated to the use of VNAV guidance outside of the final approach segment. Vertical navigation on the initial or intermediate segment can be conducted without VNAV guidance.

An applicant may elect to use an alternative means of compliance. However, those alternative means of compliance must meet safety objectives that are acceptable to the Agency or the competent authority. Compliance with this AMC is not mandatory. Use of the terms *shall* and *must* apply only to an applicant who elects to comply with this AMC in order to obtain airworthiness approval or to demonstrate compliance with the operational criteria.

**2. BACKGROUND**

This document addresses and defines airworthiness and operational criteria related to RNAV systems approved for RNP APCH based on GNSS with or without vertical guidance based on BARO-VNAV. It relates to the implementation of area navigation within the context of the Single European Sky<sup>1</sup>, in particular in relation to the verification of conformity of the airborne constituents, per Article 5 of EC Regulation 552/2004<sup>2</sup>. It addresses general certification considerations of stand-alone and multi-sensor systems

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<sup>1</sup> Regulation (EC) No 549/2004 of the European Parliament and of the Council of 10 March 2004 laying down the framework for the creation of the single European sky (the framework Regulation) (O J L 096 , 31/03/2004, p. 01).

<sup>2</sup> Regulation (EC) No 552/2004 of the European Parliament and of the Council of 10 March 2004 on the interoperability of the European Air Traffic Management network (O J L 096, 31.3.2004, p. 26).

on-board aircraft, including their functional requirements, accuracy, integrity, continuity of function, and limitations, together with operational considerations.

This document is applicable to RNP APCH operations only. It does not address RNP AR APCH operations (see AMC 20-26).

This AMC identifies the airworthiness and operational requirements for RNP APCH operations including APV BARO-VNAV operation. Operational compliance with these requirements must be addressed through national operational regulations, and may require a specific operational approval in some cases.

Use of BARO-VNAV information for RNP APCH with LNAV minima only is possible using the CDFA (Continuous Descent Final Approach) concept. This use is possible provided the navigation system is able to compute a vertical continuous descent path on the Final Approach segment and operator complies with EU OPS 1.430 section. It should be noted that this AMC does not address such operational approval authorisation.

### **3. SCOPE**

This AMC includes airworthiness and operational criteria related to RNAV systems based on a GNSS stand-alone receiver, or multi-sensor systems including at least one GNSS sensor, intended to be used under Instrument Flight Rules, including Instrument Meteorological Conditions, in designated European airspace. It contains also airworthiness and operational criteria related to systems based upon the use of barometric altitude and RNAV information in the definition of vertical paths and vertical tracking to a path to conduct APV BARO-VNAV operation.

Section 4.2 of this AMC refers to documents which contribute to the understanding of the RNP APCH concept and which may support an application for approval. However, it is important that an operator evaluates his aircraft system and the proposed operational procedures against the criteria of this AMC.

Compliance with this AMC does not, by itself, constitute an operational authorisation to conduct RNP APCH operations. Aircraft operators should apply to their national authority. Since this AMC has been harmonised with other RNP implementation and operational criteria outside of Europe, i.e. USA/FAA, it is expected to facilitate interoperability and ease the effort in obtaining operational authorisation by operators.

This AMC does not cover RNP approaches where special authorisation is required (RNP AR APCH). RNP AR APCH is addressed in a separate AMC.

### **4. REFERENCE DOCUMENTS**

#### **4.1 Related Requirements**

- CS 25.1301, 25.1302, 25.1307, 25.1309, 25.1316, 25.1321, 25.1322, 25.1325, 25.1329, 25.1431, 25.1581.
- CS 23.1301, 23.1309, 23.1311, 23.1321, 23.1322, 23.1325, 23.1329, 23.1335, 23.1431, 23.1581.
- Equivalent requirements of CS/FAR 27 and 29 if applicable.
- EU-OPS<sup>3</sup> 1.035, 1.220, 225, 1.243, 1.290, 1.295, 1.297, 1.400, 1.420, 1.845, 1.865, 1.870, 1.873 and 1.975.
- JAR-OPS 3.243, 3.845, 3.865.
- National operational regulations.

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<sup>3</sup> Council Regulation (EEC) No 3922/91 on the harmonisation of technical requirements and administrative procedures in the field of civil aviation. Regulation as last amended by Regulation (EC) No 1899/2006 of the European Parliament and of the Council of 12 December 2006 (O L J 377, 27.12.2006, p. 1).

**4.2 Related Material**

**4.2.1 ICAO**

ICAO Annex 10	International Standards and Recommended Practices- Aeronautical Telecommunications
ICAO Doc 7030/4	Regional Supplementary Procedures
ICAO Doc 9613	Performance Based Navigation Manual (PBN)
ICAO Doc 8168	PANS OPS (Procedures for Air Navigation Services- Aircraft Operations)

**4.2.2 EASA**

AMC 25-11	Electronic Flight Deck Display
AMC 20-5	Airworthiness Approval and Operational Criteria for the use of the Navstar Global Positioning System (GPS)
ETSO-C115( )	Airborne Area Navigation Equipment using Multi-Sensor Inputs
ETSO-C129( )	Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)
ETSO-C145( )	Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
ETSO-C146( )	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
ETSO-C106( )	Air Data Computer
EASA OPINION Nr. 01/2005	Conditions for Issuance of Letters of Acceptance for Navigation Database Suppliers by the Agency (i.e. an EASA Type 2 LoA). EASA OPINION Nr. 01/2005 on "The Acceptance of Navigation Database Suppliers" dated 14 Jan 05

**4.2.3 FAA**

AC 25-4	Inertial Navigation Systems (INS)
AC 25-11( )	Electronic Display Systems
AC 20-129	Airworthiness Approval of Vertical Navigation (VNAV) Systems or use in the U.S. National Airspace System (NAS) and Alaska
AC 20-138( )	Airworthiness Approval of GNSS equipment
AC 20-130A	Airworthiness approval of navigation or flight management systems integrating multiple navigation sensors
AC 23-1309-1C	Equipment, systems, and installation in Part-23 airplanes
AC 20-153	Acceptance of data processes and associated navigation data bases

**4.2.4 Technical Standard Orders**

FAA TSO-C115( )	Airborne Area Navigation Equipment using Multi-Sensor Inputs
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FAA TSO-C129( )	Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)
FAA TSO-C145( )	Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
FAA TSO-C146( )	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
FAA TSO-C106( )	Air Data Computer

**4.2.5 EUROCAE/RTCA, SAE and ARINC**

ED 26	MPS for airborne Altitude measurements and coding systems
ED 72A	Minimum Operational Performance Specification for Airborne GPS Receiving Equipment
ED-75( )/DO-236( )	Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation
ED-76/DO-200A	Standards for Processing Aeronautical Data
ED-12( )/DO-178( )	Software considerations in airborne systems and equipment certification
ED-77/DO-201A	Standards for Aeronautical Information
DO 88	Altimetry
DO 187	Minimum operational performances standards for airborne area navigation equipments using multi-sensor inputs
DO 208	Minimum Operational Performance Standards for Airborne Supplemental Navigation Equipment Using Global Positioning System (GPS)
DO-229( )	Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne equipment
ARINC 424	Navigation System Data Base
ARINC 706	Mark 5 Air Data System

**5. ASSUMPTIONS**

Applicants should note that this AMC is based on the following assumptions:

**5.1 Navaid infrastructure**

GNSS is the primary navigation system to support RNP APCH procedures.

The acceptability of the risk of loss of RNP APCH capability for multiple aircraft due to satellite failure, loss of the on board monitoring, alerting function (e.g. RAIM holes) and radio frequency interference, will be considered by the responsible airspace authority.

**5.2 Obstacle clearance**

**5.2.1 RNP APCH without BARO-VNAV guidance**

Detailed guidance on obstacle clearance is provided in PANS-OPS (Doc 8168, Volume II). Missed approach procedure may be supported by either RNAV or conventional (e.g. based on NDB, VOR, DME) segments.

Procedures design will take account of the absence of a VNAV capability on the aircraft.

### 5.2.2 APV BARO-VNAV

BARO-VNAV is applied where vertical guidance and information is provided to the flight crew on instrument approach procedures containing a vertical path defined by a vertical path angle.

Detailed guidance on obstacle clearance is provided in PANS-OPS (Doc 8168, Volume II). Missed approach procedure may be supported by either RNAV or conventional (e.g. based on NDB, VOR, DME) segments.

### 5.3 Publication

The instrument approach chart will clearly identify the RNP APCH application as RNAV<sub>(GNSS)</sub>.

For non APV BARO-VNAV operation, the procedure design will rely on normal descent profiles and the chart will identify minimum altitude requirements for each segment, including an LNAV OCA(H).

For APV BARO-VNAV operation, charting will follow the standards of ICAO 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 charting designation will remain consistent with the current convention and will promulgate a LNAV/VNAV OCA(H).

If the missed approach segment is based on conventional means, the navaid facilities or airborne navigation means that are necessary to conduct the missed approach will be identified in the relevant publications (e.g. approach charts).

The navigation data published in the applicable AIP for the procedures and supporting navigation aids will meet the requirements of ICAO Annex 15 and Annex 4 to the Convention on International Civil Aviation. The chart will provide sufficient data to support navigation data base checking by the crew (including waypoint name, track, distance for each segment and vertical path angle).

All procedures will be based upon WGS 84 coordinates.

### 5.4 Communication, ATS surveillance and ATC coordination

RNP APCH does not include specific requirements for communication or ATS surveillance. Adequate obstacle clearance is achieved through aircraft performance, operating procedures and procedure design. Where reliance is placed on the use of radar to assist contingency procedures, its performance will be shown to be adequate for that purpose, and the requirement for a radar service will be identified in the AIP.

RT phraseology appropriate to RNP APCH operations will be promulgated.

It is expected that ATC will be familiar with aircraft VNAV capability, as well as issues associated with altimeter setting and temperature effect potentially affecting the integrity of the APV BARO-VNAV operation.

The particular hazards of a terminal and approach area and the impact of contingency procedures following multiple loss of RNP APCH capability will be assessed.

ATC may use radar vectoring techniques to place aircraft onto final approach axis when the RNAV system supports this function. Air Navigation Service Providers implementing such operation in their airspace should inform airspace users of this operational possibility in the relevant AIP.

### 5.5 Service provider assumption for APV BARO-VNAV operation.

It is expected that air navigation service provision will include data and information to enable correct and accurate altimeter setting on-board the aircraft, as well as local temperature. This data will be from measurement equipment at the airport where the approach is to take place (remote or regional pressure setting are not authorised).

The specific medium for transmission of this data and information to the aircraft may include voice communication, ATIS or other media. In support of this, it is also expected that MET service providers will assure the accuracy, currency and availability of meteorological data supporting APV BARO-VNAV operations. In order to minimise the potential for miss-setting of barometric reference, Air Traffic Controllers will confirm QNH with flight crews prior to commencement of the approach.

**6. RNP APCH AIRWORTHINESS CRITERIA**

**6.1 General**

The following airworthiness criteria are applicable to the installation of RNAV system intended for IFR approach operation, certified according to CS-23, -25, -27 and -29

This AMC uses FAA Advisory Circulars AC 20-138/AC 20-138A (GPS stand-alone system) or AC 20-130A (Multi-sensors systems) as the basis for the airworthiness approval of an RNAV system based on GNSS. For APV BARO-VNAV operation, this AMC uses FAA Advisory Circular AC 20-129 as the airworthiness basis with additional requirements.

This AMC is to be used as Interpretative Material to show compliance with the applicable CS codes on each application, e.g. xx.1301 and xx.1309.

**6.2 Equipment qualification**

**6.2.1 General**

If the RNAV installation is based on GNSS stand-alone system, the equipment shall be approved in accordance with TSO-C129a/ETSO-C129a Class A1 or ETSO-C146()/TSO-C146() Class Gamma, operational class 1, 2 or 3.

If the RNAV installation is based on GNSS sensor equipment used in a multi-sensor system (e.g. FMS), the GNSS sensor shall be approved in accordance with TSO-C129( )/ETSO-C129( ) Class B1, C1, B3, C3 or ETSO-C145( )/TSO-C145( ) class Beta, operational class 1, 2 or 3.

Multi-sensor systems using GNSS should be approved in accordance with AC20-130A or ETSO-C115b/TSO-C115b, as well as having been demonstrated for RNP capability.

Note 1: For GNSS receiver approved in accordance with ETSO-C129()/TSO-C129(), capability for satellite Fault detection and Exclusion (FDE) is recommended, to improve Continuity of function.

Note 2: GNSS receivers approved in accordance with ETSO-145/TSO-C145a or ETSO-C146/TSO-C146a (DO 229C) and used outside SBAS coverage area may trigger inappropriate Loss of Integrity (LOI) warning. DO229D paragraph 2.1.1.6 provides a correct satellite selection scheme requirement to address this issue. Although most of the ETSO-C145/TSO-C145a or ETSO-146/TSO-C146a approved receivers comply with this satellite selection scheme, a confirmatory statement from the equipment manufacturer is still necessary. It should be noted that such confirmatory statement is not necessary for equipment compliant with TSO-C145b or TSO-C146b.

**6.2.2 Altimeter sensor requirement for APV BARO-VNAV operation**

In addition to requirements of paragraph 6.2.1 above, the RNAV equipment that automatically determines aircraft position in the vertical plane should use inputs from equipment that can include:

- a) ETSO-C106/TSO-C106, Air Data Computer; or
- b) Air data system, ARINC 706, Mark 5 Air Data System, ARINC 738 (Air Data and Inertial Reference System); or
- c) Barometric altimeter system compliant with DO-88 "Altimetry" and/or ED-26 "MPS for Airborne Altitude Measurements and Coding Systems"; or

- d) Type certified integrated systems providing an Air Data System capability comparable to item b).

**6.3 Accuracy**

**6.3.1 Horizontal**

The Lateral and Longitudinal Total System Error (TSE) of the on-board navigation system must be equal to or better than:

- a)  $\pm 1$  NM for 95% of the flight time for the initial and intermediate approach segments and for the RNAV missed approach.

Note: There is no specific RNAV accuracy requirement for the missed approach if this segment is based on conventional means (VOR, DME, NDB) or on dead reckoning.

- b)  $\pm 0.3$  NM for 95% of the flight time for the final approach segment.

The Lateral Total System Error (TSE) is dependent on the Navigation System Error (NSE), Path Definition Error (PDE) and Flight Technical Error (FTE).

In order to satisfy the  $\pm 0.3$  NM TSE accuracy for the final approach segment, FTE (95%) should not exceed  $\pm 0.25$  NM whatever the operating mode (manual, flight director or Autopilot):

- a) A demonstrated FTE (95%) of  $\pm 0.25$  NM is assumed for manual mode if a standardised CDI is installed (compliant with the full-scale deflection sensitivity requirement of TSO-C129a paragraph (a).3.(viii) or RTCA/DO-229() paragraph 2.2.1.4.2.1) Otherwise, it should be demonstrated that an FTE of  $\pm 0.25$  NM can be maintained under all foreseeable conditions through a dedicated flight test evaluation.
- b) A demonstrated FTE (95%) of  $\pm 0.25$  NM is assumed when coupled to a flight director.
- c) A demonstrated FTE (95%) of  $\pm 0.125$  NM is assumed when coupled to an autopilot.

Outside of the Final Approach Segment, a demonstrated FTE of  $\pm 0.5$  NM may be assumed.

Positioning data from other types of navigation sensors may be integrated with the GNSS data provided it does not cause position errors to exceed the Total System Error (TSE) budget, otherwise a means must be provided to deselect the other navigation sensor types.

Note: The horizontal positioning error component of TSE is assumed to be equal to the 2D navigation accuracy of systems/sensors qualified to AC20-138, 20-138A, and 20-130A

An acceptable means of complying with these accuracy requirements is to have an RNAV system approved for RNAV approaches in accordance with 2D navigation accuracy criteria of FAA AC 20-138, AC 20-138A or AC 20-130A.

**6.3.2 Vertical accuracy for APV BARO-VNAV operation.**

**a) Altimetry System Error (ASE)**

Altimetry system performance is demonstrated separately from the APV BARO-VNAV certification through the static pressure system certification process. With such approval (e.g. CS 25.1325), each system must be designed and installed so that the error in indicated pressure altitude, at sea-level, with a standard atmosphere, excluding instrument calibration error, does not result in an error of more than  $\pm 9$  m ( $\pm 30$  ft) per 185 km/hr (100 knots) speed for the appropriate configuration in the speed range between 1.23 VSR0 with wing-flaps extended and 1.7 VSR1 with wing-flaps retracted. However, the error need not be less than  $\pm 9$  m ( $\pm 30$  ft).

Altimetry systems meeting such a requirement will satisfy the Altimetry System Error (ASE) requirements for APV BARO-VNAV operation. No further demonstration or compliance is necessary.

Note 1: Altimetry Error refers to the electrical output and includes all errors attributable to the aircraft altimetry installation including position effects resulting from normal aircraft flight attitudes. In high performance aircraft, it is expected that altimetry correction will be provided. Such correction should be done automatically. In lower performance aircraft, upgrading of the altimetry system may be necessary.

Note 2: Positioning data from other sources may be integrated with the barometric altitude information provided it does not cause position errors exceeding the vertical accuracy requirement.

**b) VNAV Equipment Error**

The error of the airborne VNAV equipment (excluding altimetry, horizontal coupling and flight technical error) on a 99.7 per cent probability basis should be demonstrated to be less than:

	Descent Along Specified Vertical Profile (angle) (ft)
At or below 5000 ft (MSL)	100
5000 ft to 10000 ft (MSL)	150
10000 ft to 15000 ft (MSL)	220

Note 1: VNAV Equipment Error is the error associated to the vertical path computation. It includes path definition error (PDE) and approximation made by the VNAV equipment for the vertical path construction if any.

**c) Horizontal Coupling Error**

The Horizontal coupling error (vertical error component of along track positioning error) is a function of the horizontal NSE (see 6.3.1) and is directly reflected in the along track tolerance offset used in APV BARO-VNAV procedure design criteria.

This Horizontal Coupling error in this context is assumed to be 24 ft on a 99.7 per cent probability basis using a longitudinal positioning accuracy of 0.05 NM at 95% and a vertical path of 3°.

Note: For straight approaches, it is assumed that longitudinal accuracy does not include an FTE component. An arbitrary TSE (based on NSE) of 0.2NM is applied instead of 0.3NM.

**d) Vertical Flight Technical Error (FTE)**

The vertical FTE on a 99.7 per cent probability basis should be demonstrated to be less than

	Descent Along Specified Vertical Profile (angle) (ft)
At or below 5000 ft (MSL)	150
5000 ft to 10000 ft (MSL)	150
10000 ft to 15000 ft (MSL)	150

Note 1: FTE performance requirements are more stringent compared with AC 20-129 and the ICAO PBN manual where 200 ft (at or below 5000 ft MSL) and 300 ft (from 5000 ft to 15000 ft MSL) are required.

Note 2: Use of a flight director or autopilot may be required to support such an FTE requirement.

**e) Vertical Total System Error (TSE)**

The Vertical Total System Error (using the Root Sum Square (RSS) of all errors components described above) on a 99.7 per cent probability basis is as follow:

	Altimeter System Error <sup>4</sup>	VNAV Equipment Error	Horizontal coupling Error	Flight Technical Error	<b>Vertical Total System Error</b>
At or below 5000 ft (MSL)	80 ft	100 ft	24 ft	150 ft	<b>199 ft</b>
5000 ft to 10000 ft (MSL)	106 ft	150 ft	24 ft	150 ft	<b>238 ft</b>
10000 ft to 15000 ft (MSL)	127 ft	220 ft	24 ft	150 ft	<b>296 ft</b>

Note 1: If an installation results in larger Fight Technical Errors, the Total Vertical Error for the system should be determined by combining the demonstrated errors using the root sum square (RSS) method. The result should be less than the values listed.

Note 2: The manual monitoring of the altimeters to comply with the DA/DH is independent of the BARO-VNAV system and provides additional mitigation.

An acceptable means of complying with the above accuracy requirements is to have the VNAV system approved for RNAV approaches in accordance with FAA AC 20-129 and to provide evidence that the FTE, or VTSE, or operation procedures to bound the FTE are within the required limits.

**f) Vertical Path Error at FAP due to the vertical fly-by transition**

Error due to the capture of the vertical path starting from the FAP altitude should be limited. This momentary deviation below the published minimum procedure altitude at the FAP is acceptable provided the deviation is limited to no more than 50 feet (assuming no VNAV equipment error).

Note: ED-75 B paragraphs 1.5.7.2 and 3.2.8.5 provides guidance regarding the VNAV path transitions and, in particular, the vertical fly-by transition

**6.4 Integrity**

During operations on instrument approach procedures, the probability of displaying misleading navigational or positional information to the flight crew during the approach, including the final segment, shall be remote.

In the horizontal plane and during operations on the initial, intermediate segment and for the RNAV missed approach of an RNP APCH, the system, or the system and pilot in combination, shall provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 2 NM is greater than 10<sup>-5</sup>. During operations on the final approach segment of an RNP APCH, the system, or the system and pilot in

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<sup>4</sup> The ASE value has been computed using the following formula:

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

where h is the height of the local altimetry reporting station and Δh is the height of the aircraft above the reporting station.

combination, shall provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 0.6 NM is greater than  $10^{-5}$ .

For APV BARO-VNAV operation, in the vertical plane the integrity is relying on system development assurance, crew procedures and use of airborne systems independent from the VNAV computer system (e.g. primary altimeter system). The integrity requirement is satisfied by applying appropriate quantitative numerical methods, qualitative operational and procedural considerations and mitigations. The airborne VNAV system must be designed in accordance with the major failure condition regarding the computation of an erroneous vertical guidance. Two independent altimetry systems (sources and displays) must be operational and crew must cross-check the displayed altitude during the approach and, in particular, when determining the Decision Altitude (DA). Operator procedures and crew training should highlight the importance of having the current altimeter setting for the selected instrument procedure and runway and the respect of temperature limitation if the VNAV system does not compensate automatically.

Note 1: An airborne safety objective of Remote recognises that not only is the navigation system design evaluated consistent with known industry and regulatory system safety assessment views, but is now augmented with a comprehensive assessment of system performance assurance, system features/functions, human interface, flight crew procedures, maintenance and training, that is unique for RNP. The result is that the safety assurance provided greatly exceeds that of conventional navigation systems.

Note 2: An airborne objective of Remote is applicable to an instrument approach in particular on the final segment, i.e. from the FAF down to the runway. It is possible to satisfy this objective when considering the RNP system's unique requirements for RNP monitoring and integrity alerting, situational awareness information, error checking via the human machine interface and cockpit displays of independent flight information. Furthermore, the pilot should respect all vertical constraints associated to the procedure (start of descent, step-down fix,...) in order to respect obstacle clearance.

Note 3: The probability to fail to detect a GPS-induced position error larger than 0.3 NM is less than  $10^{-7}/Fh$  if the receiver is compliant with ETSO-C129( )/TSO-C129( ), ETSO-C145/TSO-C145a or ETSO-C146/TSO-C146a. This  $10^{-7}/Fh$  criterion is the combined probability of the missed detection probability (less than or equal to  $10^{-3}/Fh$ ) and the probability of receiving an erroneous satellite signal (less than or equal to  $10^{-4}/Fh$ ).

Note 4: Traditionally, this requirement has not specifically addressed the airborne system operational software or airborne system databases (e.g. navigation database). However, it is expected that where the RNAV airborne software has been previously shown compliant with the criteria of ED-12B/DO-178B, Level C, as a minimum, it is acceptable for the operations associated with this AMC.

Note 5: Probability terms are defined in CS AMC 25.1309, AC 23.1309-1() AC 27-1B or AC 29-2C.

Note 6: For RNP APCH operation, the on-board monitoring and alerting function is provided through the use of ABAS (RAIM or an equivalent algorithm) in conjunction with crew monitoring of the FTE.

Note 7: For aircraft and systems approved for RNP AR operations, per AMC 20-26, the crew alerting based upon RNP is an acceptable alternative.

## 6.5 Continuity of function

It shall be demonstrated that:

- (a) The probability of loss of all navigation information is Remote.
- (b) The probability of non-restorable loss of all navigation and communication functions

is Extremely Improbable.

Loss of the RNP APCH functions with or without BARO-VNAV guidance is considered a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport. For RNP APCH operations at least one RNAV system is required.

Note 1 From an operational point of view, the operator should develop contingency procedure for the loss of the RNP APCH capability during the approach.

Note 2: Probability terms are defined in CS AMC 25.1309, AC 23.1309-1() AC 27-1B or AC 29-2C.

**7. FUNCTIONAL CRITERIA**

**7.1 Required Function for RNP APCH**

Item	Functional Description
1	<p>Navigation data, including a to/from indication and a failure indicator, must be displayed on a lateral deviation display (CDI, (E)HSI) and/or a navigation map display. These must be used as primary flight instruments for the navigation of the aircraft, for manoeuvre anticipation and for failure/status/integrity indication. They must meet the following requirements:</p> <ol style="list-style-type: none"> <li>1) The displays must be visible to the pilot and located in the primary field of view (<math>\pm 15</math> degrees from pilot's normal line of sight) when looking forward along the flight path.</li> <li>2) The lateral deviation display scaling must agree with any alerting and annunciation limits, if implemented.</li> <li>3) The lateral deviation display must also have a full-scale deflection suitable for the current phase of flight and must be based on the required total system accuracy. For installations having a lateral deviation display, its full-scale deflection must be suitable for the phase of flight and based on the required track-keeping accuracy. Scaling is <math>\pm 1</math> NM for the initial and intermediate segments and <math>\pm 0.3</math> NM for the final segment.</li> <li>4) The display scaling may be set automatically by default logic or set to a value obtained from a navigation database. The full-scale deflection value must be known or made available for display to the flight crew.</li> </ol> <p>Enhanced navigation display (e.g. electronic map display or enhanced EHSI) to improve lateral situational awareness, navigation monitoring and approach (flight plan) verification could become mandatory if the RNAV installation does not support the display of information necessary for the accomplishment of these crew tasks.</p>
2	<p>Capability to continuously display, to the pilot flying, the RNAV computed desired path (DTK), and the aircraft position relative to the path (XTK), on the primary flight instruments for navigation of the aircraft.</p> <p>Note: Where the minimum flight crew is two pilots, it shall be possible for the pilot not flying to verify the desired path and the aircraft position relative to the path.</p>
3	<p>A navigation database, containing current navigation data officially promulgated for civil aviation;</p> <ol style="list-style-type: none"> <li>a) which can be updated in accordance with the AIRAC cycle and</li> <li>b) from which approach procedures can be retrieved in their entirety and loaded into the RNAV system.</li> </ol> <p>The resolution to which the data is stored must be sufficient to ensure that the</p>

Item	Functional Description
	<p>assumption of no path definition error is satisfied.</p> <p>The database shall be protected against flight crew modification of the stored data.</p> <p>Note: When a procedure is loaded from the database, the RNAV system is required to fly it as published. This does not preclude the flight crew from having the means to modify a procedure or route already loaded into the RNAV/GNSS system as permitted by paragraph 10. However, the procedure stored in the database must not be modified and must remain intact within the database for future use and reference.</p>
4	Means to display the validity period of the navigation database to the flight crew.
5	Means to retrieve and display data stored in the navigation database relating to individual waypoints and navigation aids, to enable the flight crew to verify the procedure to be flown.
6	Capacity to load from the database into the RNAV system the whole approach procedure to be flown.
7	Display of the identification of the active (To) waypoint, either in the pilot's primary field of view, or on a readily accessible page on the RNAV CDU, readily visible to the flight crew.
8	Display of distance and bearing to the active (To) waypoint in the pilot's primary field of view. Where impracticable, the data may be displayed on a readily accessible page on the RNAV CDU, readily visible to the flight crew.
9	Display of distance between flight plan waypoints. The navigation system must provide the ability to display the distance between flight plan waypoints.
10	Display of distance from present position to any selected waypoint. The navigation system must provide the ability to display the distance to any waypoint selected by the flight crew. Such selection should not impact the active flight plan.
11	Display of ground speed or time to the active (To) waypoint, either in the pilot's primary field of view, or on a readily accessible page on the RNAV CDU, readily visible to the flight crew.
12	Capability for the "Direct to" function.
13	Capability for automatic leg sequencing with display of sequencing to the flight crew.
14	<p>Capability to execute database procedures including:</p> <p>a) fly-over and</p> <p>b) fly-by turns.</p>
15	<p>Capability to execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators (automatic capability), or their equivalent:</p> <p>Initial Fix (IF),</p> <p>Track to Fix (TF),</p> <p>Direct to Fix (DF)</p> <p>Note: Path terminators are defined in ARINC Specification 424, and their application is described in more detail in documents PANS-OPS, EUROCAE ED-75()/RTCA DO-236(), ED-77/RTCA DO-201A, and EUROCONTROL Document NAV.ET1.ST10.</p>

Item	Functional Description
16	Capability to automatically execute leg transitions consistent with ARINC 424 FA path terminators, or the RNAV system must permit the pilot to fly a course and turn at a designated altitude. If manual intervention is necessary to turn at the designated altitude, the associated crew workload shall be assessed
17	Indication of the RNAV system failure leading to the loss of navigation function in the pilot's primary field of view (e.g. by means of a navigation warning flag on the navigation display).
18	Indication of the Loss Of Integrity (LOI) function (e.g. loss of RAIM) in the pilot's normal field of view (e.g. by means of an appropriately located annunciator). Note: Systems providing RNP alerts that reflect loss of GNSS integrity are considered acceptable.
19	Capability for the accomplishment of holding patterns and procedure turns. Activation of this function shall at least: <ul style="list-style-type: none"> <li>a) Change automatic waypoint sequencing to manual.</li> <li>b) Permit the pilot to readily designate a waypoint and select a desired course (by means of a numerical keypad entry, HSI course pointer, CDI omni-bearing selector, etc.) to or from the designated waypoint (TO/FROM mode operation is acceptable).</li> <li>c) Retain all subsequent waypoints in the active flight plan in the same sequence.</li> <li>d) Permit the pilot to readily return to automatic waypoint sequencing at any time prior to the designated fix ("TO" waypoint) and continue with the existing flight plan.</li> </ul>

**7.2 Additional required function for APV BARO-VNAV operation**

In addition to the required function specified in paragraph 7.1, the system shall meet the following requirements:

Item	Functional Description
1	<p>APV BARO-VNAV deviation must be displayed on a vertical deviation display (HSI, EHSI, VDI).</p> <p>This display must be used as primary flight instruments for the approach. The display must be visible to the pilot and located in the primary field of view (<math>\pm 15</math> degrees from pilot's normal line of sight) when looking forward along the flight path.</p> <p>The deviation display shall have a suitable full-scale deflection based on the required vertical track error.</p> <p>The non-numeric display must allow the flight crew to readily distinguish if the vertical deviation exceeds <math>\pm 75</math> feet.</p> <p>If the non-numeric display does not permit the flight crew to readily distinguish excessive vertical deviations, the approach must be conducted with the flight director and/or the autopilot and a numeric display should allow the pilot to readily distinguish if the vertical deviation exceeds <math>\pm 75</math> feet</p>

Item	Functional Description																													
2	<p>Capability to continuously display, to the pilot flying, the vertical deviation relative to the Final approach segment on the primary flight instruments for navigation of the aircraft.</p> <p>Note: Where the minimum flight crew is two pilots, a means for the pilot not flying to verify the desired path and the aircraft position relative to the path shall be provided.</p>																													
3	<p>The navigation system must be capable of defining a vertical path in accordance with the published vertical path.</p> <p>Note: The VNAV equipment error budget (see 6.3.2.b) includes the path approximation error.</p>																													
4	<p>User Interface (Displays and Control) The display readout and entry resolution for vertical navigation information shall be as follow:</p> <table border="1" data-bbox="304 745 1398 1081"> <thead> <tr> <th data-bbox="304 745 459 779"></th> <th data-bbox="459 745 775 779">Parameter</th> <th data-bbox="775 745 1054 779">Display resolution</th> <th data-bbox="1054 745 1398 779">Entry resolution</th> </tr> </thead> <tbody> <tr> <td data-bbox="304 779 459 913" rowspan="2">Altitude</td> <td data-bbox="459 779 775 846">Above altitude transition level</td> <td data-bbox="775 779 1054 846">Flight Level</td> <td data-bbox="1054 779 1398 846">Flight Level</td> </tr> <tr> <td data-bbox="459 846 775 913">Below altitude transition level</td> <td data-bbox="775 846 1054 913">1 foot</td> <td data-bbox="1054 846 1398 913">1 foot</td> </tr> <tr> <td data-bbox="304 913 459 947"></td> <td data-bbox="459 913 775 947">Vertical Path Deviation</td> <td data-bbox="775 913 1054 947">10 feet</td> <td data-bbox="1054 913 1398 947">Not applicable</td> </tr> <tr> <td data-bbox="304 947 459 981"></td> <td data-bbox="459 947 775 981">Flight Path Angle</td> <td data-bbox="775 947 1054 981">0.1 degree (*)</td> <td data-bbox="1054 947 1398 981">0.1 degree</td> </tr> <tr> <td data-bbox="304 981 459 1014"></td> <td data-bbox="459 981 775 1014">Temperature</td> <td data-bbox="775 981 1054 1014">1 degree</td> <td data-bbox="1054 981 1398 1014">1 degree</td> </tr> <tr> <td data-bbox="304 1014 459 1081"></td> <td colspan="3" data-bbox="459 1014 1398 1081">(*) A Display resolution of 0.01 degree is recommended</td> </tr> </tbody> </table>				Parameter	Display resolution	Entry resolution	Altitude	Above altitude transition level	Flight Level	Flight Level	Below altitude transition level	1 foot	1 foot		Vertical Path Deviation	10 feet	Not applicable		Flight Path Angle	0.1 degree (*)	0.1 degree		Temperature	1 degree	1 degree		(*) A Display resolution of 0.01 degree is recommended		
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	Temperature	1 degree	1 degree																											
	(*) A Display resolution of 0.01 degree is recommended																													
5	<p>The navigation database must contain all the necessary data/information to fly the published APV BARO-VNAV approach. The navigation database must contain the waypoints and associated vertical information (e.g. VPA) for the procedure. Vertical Constraints associated with published procedures must be automatically extracted from the navigation database upon selecting the approach procedure.</p>																													
6	<p>Indication of loss of navigation (e.g. system failure) in the pilot's primary field of view by means of a navigation warning flag or equivalent indicator on the vertical navigation display.</p>																													
7	<p>The aircraft must display barometric altitude from two independent altimetry sources, one in each pilots' primary field of view. When single pilot operation is permitted, the two displays must be visible from the pilot position.</p>																													

**7.3 Recommended Function for RNP APCH**

Item	Functional Description		
1	<p>Capability, following ATC instructions, to immediately provide horizontal track deviation indications relative to the extended final approach segment, in order to facilitate the interception of this extended final approach segment from a radar vector.</p>		
2	<p>Course selector of the deviation display automatically slaved to the RNAV computed path.</p> <p>Note: Systems with electronic map display in the pilot's primary field of view having a depiction of the active route are sufficient.</p>		

**7.4 Recommended Function for APV BARO-VNAV operation**

Item	Functional Description
1	Temperature compensation: Capability to automatically adjust the vertical flight path for temperature effects. The equipment should provide the capability for entry of altimeter source temperature to compute temperature compensation for the vertical flight path angle. The system should provide clear and distinct indication to the flight crew of this compensation/adjustment.
2	Capability to automatically intercept the vertical path at FAP using a vertical fly by technique. Note: Vertical Fly By performance is described in ED-75 B paragraphs 1.5.7.2 and 3.2.8.5

**8. AIRWORTHINESS COMPLIANCE**

**8.1 General**

This section details a means of airworthiness compliance for new or modified installations (Para 8.2) and for existing installations (Para 8.3). It also details specific points that should be considered during these approval processes (Para 8.4).

Relevant documentation demonstrating airworthiness compliance should be available to establish that the aircraft is equipped with an RNAV systems meeting RNP APCH requirements without or with vertical guidance (APV BARO-VNAV).

**8.2 New or Modified Installations**

In demonstrating compliance with this AMC, the following specific points should be noted:

The applicant will need to submit to the Agency a compliance statement which shows how the criteria of this AMC have been satisfied. The statement should be based on a plan, agreed by the Agency at an early stage of the implementation programme. The plan should identify the certification data to be submitted which should include, as appropriate, a system description together with evidence resulting from the activities defined in the following paragraphs.

Compliance with the airworthiness requirements for intended function and safety may be demonstrated by equipment qualification, system safety analysis, confirmation of appropriate software design assurance level (i.e. consistent with paragraph 6.4), performance analyses, and a combination of ground and flight tests. To support the approval application, design data will need to be submitted showing that the objectives and criteria of Sections 6 and 7 of this AMC have been satisfied.

Use of the RNAV systems and the manner of presentation of lateral and vertical (if provided) guidance information on the flight deck should be evaluated to show that the risk of flight crew error has been minimised.

**8.2.1 Specific Installation criteria**

The following points need to be taken into consideration during the airworthiness approval process.

- a) Where other conventional navigation systems, apart from the RNAV system, provide display and/or guidance to a flight director/Autopilot, means should be provided for:
  - a navigation system source selector as the only means of selection;
  - clear annunciation of the selected navigation system on or near the navigation display;
  - display of guidance information appropriate to the selected navigation system; and

- delivery of guidance information to a flight director/autopilot appropriate to the selected navigation system.
- b) Annunciation for flight director, autopilot and selected navigation system should be consistent, and compatible with the original design philosophy of the cockpit.
- c) Loss of navigation capability should be indicated to the flight crew.
- d) Equipment failure scenarios involving conventional navigation systems and the RNAV system(s) should be evaluated to demonstrate that:
- adequate alternative means of navigation are available following failure of the RNAV system; and
  - reversionary switching arrangements, e.g. VOR/GPS#2 on HSI#1, do not lead to misleading or unsafe display configurations.
- The evaluation should consider also the probability of failures within the switching arrangements.
- e) If barometric altitude input is used by the RNAV system (e.g. Baro aiding for RAIM function), loss of altitude information should be indicated by the RNAV system.
- f) The coupling arrangements between the RNAV system and the flight director/automatic pilot should be evaluated to show compatibility and to demonstrate that operating modes, including RNAV system failures modes, are clearly and unambiguously indicated to the flight crew.
- g) The use of the RNAV system and the manner of presentation of lateral and vertical (if provided) guidance information on the flight deck should be evaluated to show that the risk of flight crew error has been minimised. The crew should be aware, at any time, of the system used for navigation.
- h) The installation configuration features provided by the RNAV system which affect airworthiness approval or operational criteria, such as: external CDI selection; external CDI calibration; entering of GPS antenna height above ground; serial Input/Output port configuration; reference datum, should not be selectable by the pilot. Instructions on how to configure the RNAV system for the particular installation should be listed in the appropriate manual.
- i) Controls, displays, operating characteristics and pilot interface to RNAV system should be assessed in relation to flight crew workload, particularly in the approach environment. Essential design considerations include:
- Minimising reliance on flight crew memory for any system operating procedure or task. Developing a clear and unambiguous display of system modes/sub-modes and navigational data with emphasis on enhanced situational awareness requirements for any automatic mode changes, if provided.
  - Use of context sensitive helps capability and error messages (for example, invalid inputs or invalid data entry messages should provide a simple means to determine how to enter "valid" data).
  - Placing particular emphasis on the number of steps and minimising the time required to accomplish flight plan modifications to accommodate ATS clearances, holding procedures, runway and instrument approach changes, missed approaches and diversions to alternate destinations.
  - Minimising the number of nuisance alerts so the flight crew will recognise and react appropriately when required.

### **8.3 Existing Installations**

Aircraft that are approved for RNP AR APCH operations are considered compliant with this AMC.

An existing statement in the AFM that indicates the aircraft is approved:

- to perform RNP 0.3 GNSS approaches or,

- for instrument approaches including a specification of RNP GNSS capability that meets RNP 0.3

is considered acceptable for lateral performance.

If this is not the case, the applicant will need to submit to the Agency a compliance statement which shows how the criteria of this AMC have been satisfied for existing installations. Compliance may be established by inspection of the installed system to confirm the availability of required features and functionality. The performance and integrity criteria of Sections 6 and 7 may be confirmed by reference to statements in the Aircraft Flight Manual or to other applicable approvals and supporting certification data. In the absence of such evidence, supplementary analyses and/or tests may be required.

To avoid unnecessary regulatory activity, the determination of eligibility for existing systems should consider acceptance of manufacturer documentation. In this specific case, an AFM amendment is recommended to reflect the RNP APCH aircraft capability. The addition of this aircraft capability in the AFM without any technical modification applied to the aircraft could be considered as a Minor change by the Agency.

## **8.4 Specific Installation assessment**

### **8.4.1 Lateral and vertical Fly-By transition mechanism**

The applicant should demonstrate that the turn indication during lateral fly-by transitions is accurate enough to keep the aircraft within the theoretical transition area as described in ED-75 B paragraph 3.2.5.4. Lateral Fly-by transition assessment should be evaluated in manual and in autopilot mode. If the equipment provides positive course guidance through the turn (during the fly-by transition), then no specific flight test is required.

The applicant should demonstrate that the vertical indication during vertical fly-by transitions is accurate enough to keep the aircraft within the profile described in ED-75 B paragraph 3.2.8.5. Vertical Fly-by transition assessment should be evaluated in manual and in autopilot mode. It is recalled that momentary deviation below the published minimum procedure altitude at the FAP is acceptable provided the deviation is limited to no more than 50 feet assuming no VNAV equipment error.

### **8.4.2 Enhanced navigation displays**

It is recognised that enhanced navigation display (such as IFR approved electronic moving map or enhanced EHSI) improves crew lateral situational awareness and navigation monitoring. It is strongly recommended that the RNAV installation incorporates an IFR approved moving map display. This may be a stand-alone display or may be integrated within the aircraft electronic display system or directly integrated within the GNSS stand-alone receiver. For certain cases an enhanced navigation display is required (see Para 7.1 Item 1).

The graphical map display should incorporate at least the active flight plan, map ranges consistent with the flight operation, available navigation aids, and airports. Design and installation of enhanced navigation display should be approved during the approval process; in particular the evaluation of the man-machine interface (colour, symbol, cluttering aspect, display location, display size, etc.).

Enhanced navigational display is considered an essential function for the crew to verify the approach procedure loaded from the navigational database. This display is also a key element for the navigation crew monitoring (e.g. flight plan progress).

### **8.4.3 Intermixing of equipment**

Simultaneous use of RNAV systems with different crew interfaces can be very confusing and can lead to problems when they have conflicting methods of operation and conflicting display formats. For approach operations, simultaneous use of RNAV equipment which is not identical or compatible is not permitted.

## 9. AIRCRAFT FLIGHT MANUAL/PILOT OPERATING HANDBOOK

For new or modified aircraft, the Aircraft Flight Manual (AFM) or the Pilot's Operating Handbook (POH), whichever is applicable, should provide at least the following information:

- a) A statement which identifies the equipment and aircraft build or modification standard certificated for RNP APCH operation with or without vertical guidance (APV BARO-VNAV). This may include a very brief description of the RNAV/GNSS system, including the RNAV/GNSS airborne equipment software version, CDI/HSI equipment and installation and a statement that it is suitable for RNAV operations. A brief introduction to the RNAV(GNSS) approach concept using ICAO RNP APCH terminology may also be included.
- b) Appropriate amendments or supplements to cover RNP APCH approach operations in the following sections:
  - Limitations – including use of VNAV, FD and AP; currency of navigation database; crew verification of navigation data; availability of RAIM or equivalent function; restrictions on use of GNSS for conventional Non Precision Approaches.
  - Normal Procedures
  - Abnormal Procedures – including actions in response to a Loss of Integrity (e.g. 'RAIM Position Warning', (or equivalent) message or a 'RAIM not available', (or equivalent) message).

Note: This limited set assumes that a detailed description of the installed system and related operating instructions and procedures are available in other approved operational or training manuals.

## 10. RNP APCH OPERATIONAL CRITERIA

This section describes acceptable operational criteria for approach operations, subject to the limitations given below. The operational criteria assume that the corresponding installation/airworthiness approval has been granted by the Agency.

Operational criteria apply to the use of the RNAV system for RNP APCH operations on any aircraft operated under IFR in accordance with EU legislation or the applicable operational regulations in the fields for which the EU legislation has not yet been established.

Operations of the RNAV system should be in accordance with the AFM or AFM supplement. The operational procedures to be addressed by the operator are detailed in APPENDIX 4. The (Master) Minimum Equipment List (MMEL/MEL) should be amended to identify the minimum equipment necessary to satisfy operations using the RNAV system.

The operator should determine the operational characteristics of the procedure to be flown. It is recommended that the process described in paragraph 10.3 and APPENDIX 2 of this AMC should be followed to validate its operational use by the crew.

Depending on the aircraft capability and the approach procedure, RNP APCH procedures may be conducted with lateral (LNAV), lateral/vertical (LNAV/VNAV) or equivalent mode engaged, and coupling with either a flight director or autopilot.

Prior to the operation, the operator needs to be authorised by his/her competent authority for such operations.

### 10.1 Flight Operations Documentation

The relevant parts and sections of the Operations Manual (e.g., Aircraft Operations Manual, check lists, training of crew) should be revised to take account of the operating procedures detailed in this section and, in particular those in APPENDIX 4. The operator should make timely amendments to the Operations Manual to reflect relevant RNP APCH procedure without or with vertical guidance (APV BARO-VNAV) and database checking

strategies. Manuals and check lists need to be submitted for review by the responsible authority as part of the authorisation process.

The aircraft operator should propose an amendment to the Minimum Equipment List (MEL) appropriate to RNP APCH operations.

## **10.2 Flight Crew Training**

Each pilot should receive appropriate training, briefings and guidance material in order to safely conduct RNP APCH operations without or with vertical guidance (APV BARO-VNAV). This material and training should cover both normal and abnormal procedures. Standard training and checking, such as recurrent aeroplane/STD training and proficiency checks, should include RNP APCH procedures. Based on this, the operator should determine what constitutes a qualified crew.

The operator should ensure that during line operations each pilot can perform assigned duties reliably and expeditiously for each procedure to be flown in:

- a) normal operations and
- b) abnormal operations

The operator should ensure that altimeter settings procedures and cold temperature limitations during APV BARO-VNAV operation are respected.

- a) Altimeter setting

Flight Crews should take precautions to switch altimeter settings at appropriate times or locations and request a current altimeter setting if the reported setting is not recent, particularly at times when pressure is reported or is expected to be rapidly decreasing. Remote (regional) altimeter settings are not allowed.

Note: The operational crosscheck between altimeter read-out and charted altitude values at FAF or other profile fixes does not protect against altimeter setting errors.

- b) Cold Temperature

When cold weather temperatures exist, the pilot should check the chart for the instrument approach procedure to determine the limiting temperature for the use of BARO-VNAV capability. If the airborne system contains a temperature compensation capability, manufacturer instructions should be followed for use of the BARO-VNAV function, and the operational use of the temperature compensation function must be authorised by the Air Navigation Service Provider.

A training programme should be structured to provide sufficient theoretical and practical training. An example of training syllabus is described in APPENDIX 5.

## **10.3 Aerodrome competence and Operator verification**

Before planning a flight to an aerodrome (destination or alternate) with the intent to use an RNAV procedure contained in the Navigation Database, the operator should determine the operational characteristics of the procedure in accordance with EU OPS 1.975 or the applicable operational regulations. Further details are provided in APPENDIX 2.

Based on this assessment, the appropriate information should be given to the crew. If the aerodrome access requires a specific competence, the designated crew shall have a validated competence.

Note: This AMC addresses only RNP APCH procedures which are designed with straight segment (e.g. T or Y approach). It is therefore anticipated that in most cases no specific competence should be required to fly such approach procedure.

## **10.4 Navigation Database Management**

### **10.4.1 Operator involved in the operation of aeroplanes for commercial air transportation**

EU-OPS 1.873 for the management of navigation database applies.

### **10.4.2 Operator not involved in the operation of aeroplanes for commercial air transportation**

The operators should not use a navigation database for RNP APCH operations unless the navigation database supplier holds a Type 2 Letter of Acceptance (LoA) or equivalent.

An EASA Type 2 LoA is issued by EASA in accordance with EASA OPINION Nr. 01/2005 on "The Acceptance of Navigation Database Suppliers" dated 14 Jan 05. The FAA issues a Type 2 LoA in accordance with AC 20-153, while Transport Canada (TCCA) issues an Acknowledgement Letter of an Aeronautical Data Process using the same basis. Both the FAA LoA and the TCCA Acknowledgement Letter are seen to be equivalent to the EASA LoA.

EUROCAE/RTCA document ED-76/DO-200A Standards for Processing Aeronautical Data contains guidance relating to the processes that the supplier may follow. The LoA demonstrates compliance with this standard.

#### **10.4.2.1 Non-approved Suppliers**

If the operator's supplier does not hold a Type 2 LoA or equivalent, the operator should not use the electronic navigation data products unless the Authority has approved the operator's procedures for ensuring that the process applied and the delivered products have met equivalent standards of integrity. An acceptable methodology is described in APPENDIX 3 of this AMC.

#### **10.4.2.3 Quality Monitoring**

The operator should continue to monitor both the process and the products in accordance with the quality system required by the applicable operational regulations.

#### **10.4.2.4 Data Distribution**

The operator should implement procedures that ensure timely distribution and insertion of current and unaltered electronic navigation data to all aircraft that require it.

## **10.5 Reportable Events**

A reportable event is one that adversely affects the safety of the operation and may be caused by actions/events external to the operation of the aircraft navigation system. The operator should have in place a system for investigating such an event to determine if it is due to an improperly coded procedure, or a navigation data base error. Responsibility for initiating corrective action rests with the operator.

For those operators for whom approval is granted under EU OPS 1, the following events should be the subject of Occurrence Reports (see EU-OPS 1.420):

Technical defects and the exceeding of technical limitations, including:

- a) Significant navigation errors attributed to incorrect data or a data base coding error.
- b) Unexpected deviations in lateral/vertical flight path not caused by pilot input or erroneous operation of equipment.
- c) Significant misleading information without a failure warning.
- d) Total loss or multiple navigation equipment failure.
- e) Loss of integrity (e.g. RAIM) function whereas integrity was predicted to be available during the pre-flight planning.

**11. AVAILABILITY OF DOCUMENTS**

JAA documents are available from the JAA publisher Information Handling Services (IHS). Information on prices, where and how to order is available on the JAA website and at [www.jaa.nl](http://www.jaa.nl).

EASA documents may be obtained from EASA (European Aviation Safety Agency), 101253, D-50452 Koln, Germany. Website: [www.easa.europa.eu](http://www.easa.europa.eu)

EUROCAE documents may be purchased from EUROCAE, 102 rue Etienne Dolet, 92240 MALAKOFF, France (Fax: 33 1 46 55 62 65). Website: <http://boutique.eurocae.net/catalog/>.

FAA documents may be obtained from Superintendent of Documents, Government Printing Office, Washington, DC 20402-9325, USA. Website: <http://www.gpoaccess.gov/>.

RTCA documents may be obtained from RTCA Inc, 1828 L Street, NW., Suite 805, Washington, DC 20036, USA (Tel: 1 202 833 9339; Fax 1 202 833 9434). Website: [www.rtca.org](http://www.rtca.org).

ICAO documents may be purchased from Document Sales Unit, International Civil Aviation Organisation, 999 University Street, Montreal, Quebec, Canada H3C 5H7, (Fax: 1 514 954 6769, e-mail: [sales\\_unit@icao.org](mailto:sales_unit@icao.org)) or through national agencies.

## APPENDIX 1: GLOSSARY

The following are definitions of key terms used throughout this AMC.

**Aircraft-Based Augmentation System (ABAS):** An augmentation system that augments and/or integrates the information obtained from the other GNSS elements with information available on board the aircraft.

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

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

**Accuracy:** The degree of conformance between the estimated, measured, or desired position and/or the velocity of a platform at a given time, and its true position or velocity. Navigation performance accuracy is usually presented as a statistical measure of system error and is specified as predictable, repeatable and relative.

**ASE (Altimetry System error):** Altimetry error refers to the electrical output and includes all errors attributable to the aircraft altimetry installation including position effects resulting from normal aircraft flight attitudes.

**Availability:** An indication of the ability of the system to provide usable service within the specified coverage area and is defined as the portion of time during which the system is to be used for navigation during which reliable navigation information is presented to the crew, automatic pilot, or other system managing the flight of the aircraft.

**BARO-VNAV (Barometric Vertical NAVigation)** is a navigation system that presents to the pilot a computed vertical guidance based on barometric altitude.

**Basic GNSS operation:** Operation that are based on GNSS Aircraft Based Augmentation System (ABAS). An ABAS system is typically a GNSS receiver with fault detection compliant to E/TSO C 129a, E/TSO-C145() or E/TSO-C146().

**Continuity of Function:** The capability of the total system (comprising all elements necessary to maintain aircraft position within the defined airspace) to perform its function without non-scheduled interruptions during the intended operation.

**DA(H):** Decision altitude (DA) or Decision height (DH). A specified altitude or height in the precision approach or approach with vertical guidance at which a missed approach must be initiated if the required visual reference to continue the approach has not been established.

**FAP:** Final Approach Point.

**Fault Detection and Exclusion (FDE):** FDE is a receiver processing scheme that autonomously provides integrity monitoring for the position solution, using redundant range measurements. The FDE consist of two distinct parts: fault detection and fault exclusion. The fault detection part detects the presence of an unacceptably large position error for a given mode of flight. Upon the detection, fault exclusion follows and excludes the source of the unacceptably large position error, thereby allowing navigation to return to normal performance without an interruption in service.

**GNSS stand-alone receiver:** A GNSS system incorporating the GNSS sensor, the navigation capability and the navigation data base.

**GNSS sensor:** A GNSS system incorporating only the GNSS receiving and positioning part. It doesn't incorporate the navigation capability and the navigation data base.

**HCE (Horizontal Coupling Error):** The vertical error component of an along track positioning error

**Integrity:** The ability of a system to provide timely warnings to users when the system should not be used for navigation.

**MDA(H):** Minimum descent altitude (MDA) or minimum descent height (MDH). A specified altitude or height in a non-precision approach or circling approach, below which, descent should not be made without the required visual reference.

**NSE (Navigation System Error):** The difference between true position and estimated position

**OCA/H:** In a precision approach procedure (or APV), the OCA/H is defined as the lowest altitude/height at which a missed approach must be initiated to ensure compliance with the appropriate obstacle clearance design criteria.

**On board Monitoring and Alerting function:** This function is the main element which determines if the navigation system complies with the necessary safety level associated to a RNP application; it relates to both lateral and longitudinal navigation performance. On-board performance monitoring and alerting allows the flight crew to detect that the RNAV system is not achieving the navigation performance required. On-board performance monitoring and alerting is concerned with the monitoring of all type of errors which may affect the aircraft ability to follow the desired flight path.

**TCH:** Threshold Crossing Height. The height of the Glide Path above the threshold.

**TSE (Total System Error):** The difference between true position and desired position. This error is equal to the root sum square (RSS) of the Flight Technical Error (FTE), Path Definition Error (PDE), and Navigation System Error (NSE).

**PDE (Path Definition Error):** The difference between the defined path and the desired path.

**Receiver Autonomous Integrity Monitoring (RAIM):** A technique whereby a GNSS receiver/processor determines the integrity of the GNSS navigation signals using only GPS signals or GPS signals augmented with altitude. This determination is achieved by a consistency check among redundant pseudorange measurements. At least one satellite in addition to those required for navigation should be in view for the receiver to perform the RAIM function.

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

**RNAV(GNSS) approach:** A GNSS RNAV approach promulgated by a State and designed in accordance with PANS-OPS Criteria Doc 8168, Volume II, Part III, Section 1, Chapter 2 and Section 3, Chapter 3 (Basic GNSS). Such approach should be flown by using an airborne RNAV system approved for RNP APCH operations.

**SBAS:** Satellite Based Augmentation System. SBAS augments core satellite constellation by providing ranging, integrity and correction information via geostationary satellites. This system comprises a network of ground reference stations that observe satellites signals, and master stations that process observed data and generate SBAS messages for uplink to the geostationary satellites, which broadcast the SBAS message to the users.

**RNP APCH:** RNP AProaCH. A RNP approach defined in the ICAO Performance Based Manual (PBN) manual. An approach equivalent to the RNAV (GNSS) one.

**TSO-C129()/ ETSO- C129a GPS Class A equipment:** Equipment incorporating both the GNSS sensor and navigation capability. This equipment incorporates RAIM as defined by TSO/ETSO-C129( ).

**TSO-C129()/ ETSO-C129 a GPS Class B and C equipment:** GNSS sensor providing GNSS data (position, integrity,..) to an integrated navigation system (e.g. FMS).

**TSO-C146() Class GAMMA:** This functional class corresponds to equipment consisting of both the GNSS/SBAS position sensor and a navigation function, so that the equipment provides path deviations relative to a selected path. The equipment provides the navigation function required of a stand-alone navigation system. This equipment also provides integrity in the absence of SBAS signal through the use of FDE. In addition, this class of equipment requires a data base, display outputs and pilot controls.

**TSO-C145() class BETA:** Equipment consisting of a GNSS/SBAS sensor that determines position (with integrity) and provides position and integrity to an integrated navigation system (e.g. flight management system, multi-sensor navigation system). This equipment also provides integrity in the absence of the SBAS signal through the use of fault detection and exclusion (FDE).

**TSO-C146( ) or TSO-C145( ) Operational Class 1:** This operational class supports oceanic and domestic en-route, terminal and non precision approach, and departure operation.

**TSO- C146( ) or TSO-C145( ) Operational Class 2:** This operational class supports oceanic and domestic en-route, terminal and non precision approach, LNAV/VNAV and departure operation.

**TSO-C146( ) or TSO-C145 ( ) Operational Class 3:** This operational class supports oceanic and domestic en-route, terminal and non precision approach, LNAV/VNAV, LPV and departure operation.

**"T" approach:** T approach is defined in ICAO document 8168 and in RTCA/EUROCAE DO 201A/ED 77. "T" approach is composed of two initial approach segments perpendicular to the intermediate approach segment.

**Vertical Navigation:** A method of navigation which permits aircraft operation on a vertical flight profile using altimetry sources, external flight path references, or a combination of these.

**VPA (Vertical Path Angle):** Angle of the published final approach descent.

**VTF:** Vector To Final.

**VSR:** Reference Stall Speed.

**"Y" approach:** Y approach is defined in ICAO document 8168 and in RTCA/EUROCAE DO 201A/ED 77. "Y" approach is derived from the "T" approach but the initial segments are establishing at 70° to the intermediate segment rather than 90°.

**APPENDIX 2: OPERATIONAL CHARACTERISTICS OF THE PROCEDURE AND ITS OPERATIONAL USE**

The operator should show evidence that consideration has been given to the evaluation of any new or modified RNP APCH procedures.

RNP APCH procedure should be designed using straight segments; the operator should check that the selected procedure fulfils this requirement.

Particular attention should be paid to procedures:

- in mountainous environments,
- within the proximity of well-known obstacles,
- that may require adequate knowledge for the aerodrome access or aerodrome competence qualification, as specified in EU-OPS 1.975 or the applicable operational requirements.

Competence may be required specifically for this RNAV procedure or the procedure may be published for an aerodrome already listed as requiring an aerodrome competence. This may be aircraft type related and subject to periodic revalidation.

- In the absence of radar coverage,
- When missed approach trajectory involve turns, especially at low altitudes,
- Subject to a declared exemption to the procedure design rules specified by the ICAO PANS OPS,
- Every other case considered necessary to be evaluated by the operator.

The operator may develop an internal process (e.g. filtering methods or tools covering the AIP review) to detect RNP APCH procedure(s) showing one or more of the above-listed characteristics.

The operational evaluation of a RNP APCH procedure showing evidence of the above-mentioned operational characteristics may include, at operator discretion, an approach conducted with the aircraft in VMC or the use of a full flight simulator (FFS) in order to evaluate if the procedure is correctly executed by the RNAV system and fly-able with the aircraft type.

**APPENDIX 3: ALTERNATE NAVIGATION DATABASE INTEGRITY CHECK**

If operator's navigation data base supplier has no Type 2 LOA, the operator should develop and describe a method to demonstrate an acceptable level of integrity of the navigation data base content used by the RNAV system on board the aircraft.

The operator should implement navigation data base integrity checks for all RNP APCH procedures they wish to operate, using manual verification procedures or appropriate software tools, at each AIRAC Cycle.

The objective of this integrity check is to identify any significant discrepancies between the published charts/procedures and the navigation database content.

Integrity checks may be conducted by a designated third party, under the operator responsibility.

**1 Elements to be verified**

At least the following elements of an RNP APCH should be verified:

- Coordinates/location verification of IAF, IF, FAF, MAPt, and other waypoints between IAF and MAPt (if any)
- Tracks between these waypoints
- Distance between these waypoints
- Vertical path angle (for APV BARO-VNAV operation)

**2 Means to verify those elements**

**2.1 The Operator verification process**

The operator should, at the very least, verify the information listed in paragraph 1 of this Appendix, by comparison with the official published data.

As the data may evolve at each AIRAC Cycle, this verification should be done at every AIRAC cycle using comparison with source documents or a reference data base (gold standard).

The operator should describe the method used to verify the navigation data base integrity which can be based on a:

- a) manual method, with or without software support, whereby the airborne data base is compared with the original published data, or
- b) recurrent method with a reference database, whereby any changes identified between the latest data base and the reference data base are checked against the original published data. Once the latest data base has been verified, it becomes the reference data base for the next AIRAC cycle.

The recurrent method relies on the integrity of the initial data base, and requires that the check of every RNP APCH procedure has been properly conducted and validated at the very first time. It also relies on the assumption that every change in the data base is properly identified and checked. It is recommended that software tools are used to compare the contents of one (N) AIRAC cycle data base with the contents of the previous (N-1) AIRAC cycle data base.

Whatever the method, data to be checked must come from the final source to be loaded on the aircraft.

## **2.2 The means to enable this verification**

In many cases, the RNAV system and an enhanced navigation display are necessary to access the data (on the aircraft or on a flight simulator).

An RNAV system comparable to the one installed on the aircraft (i.e. using the same algorithms) may also be used, as well as appropriate simulation software tools. The RNAV system manufacturer should be consulted on the adequacy of specific software for this purpose.

Data may also be acquired through a tool able of unpacking the data encoded on the files (e.g. decompactor) developed by the RNAV system manufacturer.

Whatever software tool is used, it should be validated for its intended use by the operator.

## **3 Feed back and reporting errors found**

In case of errors found, the operator should take appropriate actions.

In particular, significant errors (i.e. those that would affect the flight path of the aircraft) should be reported to the database supplier and the competent authority and affected procedures should be prohibited by a company instruction or NOTAM.

Note: Integrity checks could be conducted for several operators by a same designated third party. In this case, it is strongly recommended that any problem recorded by this third party be reported to all its client operators.

## **APPENDIX 4: OPERATIONAL PROCEDURES**

This Appendix should be used by the operator to amend the relevant parts and sections of the Operations Manual as described in 10.1 to support these types of operations.

### **1 Normal Procedures**

#### **1.1 Pre-flight Planning**

Operators and flight crew intending to conduct operations on RNP APCH procedures must file the appropriate flight plan suffixes. The on-board navigation data must be current and must include the appropriate procedures.

In addition to the normal pre-flight planning, the following additional checks must be carried out:

- a) The instrument approach chart should clearly identify the RNP APCH operation as RNAV<sub>(GNSS)</sub> or equivalent (e.g.: RNAV<sub>(GNSS)</sub> RWY 27,...). The operator should determine in accordance with the promulgated OCA(H) and the operational requirement (e.g. EU-OPS 1.430) the Minimum Descent Altitude/Height (MDA(H)) for LNAV approaches or the Decision Altitude/Height (DA(H)) for APV BARO-VNAV operation.
- b) Flight crew must ensure that RNP APCH procedures which may be used for the intended flight (including alternates aerodromes) are selectable from a valid navigation data base (current AIRAC cycle) and are not prohibited by a company instruction or NOTAM.

Flight crew could check approach procedures (including alternate aerodromes) as extracted by the system (e.g. CDU flight plan page) or presented graphically on the moving map, in order to confirm the correct loading and the reasonableness of the procedure content. The vertical path of the APV BARO-VNAV procedure could be checked as extracted from the navigation data base on the RNAV Man Machine Interface (e.g. MCDU).

If above verification is not satisfactory, the flight crew should not use the procedure, and not consider this approach(es) during the selection of aerodromes for the intended flight.

- c) Flight crew should ensure sufficient means are available to navigate and land at the destination or at an alternate aerodrome in the case of loss of RNP APCH airborne capability.

In particular, the pilot should check that:

- a non-RNP APCH procedure is available at the alternate, where a destination alternate is required
- at least one non-RNP APCH procedure is available at the destination aerodrome, where a destination alternate is not required

- d) Operators and flight crews must take account of any NOTAMs or operator briefing material that could adversely affect the aircraft system operation, or the availability or suitability of the procedures at the airport of landing, or any alternate airport.
- e) If the missed approach procedures are based on conventional means (VOR, NDB), the appropriate airborne equipment required to fly this procedure must be installed in the aircraft and must be operational. The associated ground-based nav aids must also be operational.

If the missed approach procedure is based on RNAV (no conventional or dead reckoning missed approach available), the appropriate airborne equipment required to fly this procedure must be available and serviceable on board the aircraft.

- f) For those GNSS systems relying on RAIM, its availability 15 min before Estimated Time of Arrival (ETA) until 15 min after ETA should be verified during the pre-flight

planning. In the event of a predicted continuous loss of fault detection of more than five (5) minutes, the flight planning should be revised (e.g. delaying the departure or planning a different approach procedure).

Note 1: For certain systems, prediction is not systematic but is only required in specific cases and shall be detailed in the relevant section of the AFM

Note 2: RAIM availability prediction services may be provided to users by the air navigation service provider (ANSP), an avionics manufacturer or other entities.

g) Any MEL restriction should be observed

## **1.2 Prior to Commencing the Procedure**

In addition to normal procedure prior to commencing the approach (before the IAF and in compatibility with crew workload), the flight crew must verify the correctness of the loaded procedure by comparison with the appropriate approach charts. This check must include:

- a) The waypoint sequence.
- b) Reasonableness of the tracks and distances of the approach legs, and the accuracy of the inbound course and mileage of the final approach segment.

Note: As a minimum, this check could be a simple inspection of a suitable map display.

- c) The vertical path angle.

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

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

For those GNSS systems relying on RAIM and necessitating a check of its availability for RNP APCH, the flight crew should perform a new RAIM availability check if ETA is more than 15 minutes different from the ETA used during the pre-flight planning. This check is also performed automatically for ETSO/TSO-C129a Class A1 receiver, 2 NM before the FAF.

Note: Systems providing RNP alerts that reflect loss of GNSS integrity are considered acceptable and no flight crew RAIM availability check is required.

For APV BARO-VNAV operation, the crew must confirm the correct altimeter setting. The procedure must only be flown with:

- a) a current local altimeter setting source available; and
- b) the QNH/QFE, as appropriate, set on the aircraft's altimeters.

Procedures using a remote (regional) altimeter setting source cannot support APV BARO-VNAV approach.

For APV BARO-VNAV operation, pilots are responsible for any necessary cold temperature compensations to all published minimum altitudes/heights. This includes:

- a) the altitudes/heights for the initial and intermediate segment(s);
- b) the DA/H; and
- c) subsequent missed approach altitudes/heights.

APV BARO-VNAV procedures are not permitted when the aerodrome temperature is below the promulgated minimum aerodrome temperature for the procedure, unless the RNAV system is equipped with approved cold temperature compensation for the final approach.

ATC tactical interventions in the terminal area may include radar headings, 'direct to' clearances which by-pass the initial legs of an approach, interceptions of an initial or intermediate segments of an approach or the insertion of additional waypoints loaded from the data base. In complying with ATC instructions, the flight crew should be aware of the implications for the RNAV system.

- a) The manual entry of coordinates into the RNAV system by the flight crew for operation within the terminal area is not permitted.
- b) 'Direct to' clearances may be accepted to the Intermediate Fix (IF) provided that the resulting track change at the IF does not exceed 45°.

Note: Direct to clearance to FAF is not acceptable. Modifying the procedure to intercept the final approach course prior to the FAF is acceptable for radar vectored arrivals or at other times with ATC approval.

The lateral and vertical (for APV BARO-VNAV operation) definition of the flight path between the FAF and the Missed Approach Point (MAPt) must not be revised by the flight-crew under any circumstances.

### **1.3 During the Procedure**

The final approach trajectory must be intercepted no later than the FAF in order for the aircraft to be correctly established on the final approach course before starting the descent (to ensure terrain and obstacle clearance).

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

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

For APV BARO-VNAV operation, the crew should check that the two altimeters provide equivalent altitude (difference of 100 feet max) at or before FAF. This check must be made after the crew has set the correct altimeter setting.

The crew should also check the consistency between the VNAV guidance and the primary altimeters indications commensurate with pilot workload (e.g. after the aircraft is established on the vertical path).

During the descent, crew should check that the vertical speed is consistent with the VNAV angle to be flown.

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

- a) The RNAV computed desired path (DTK), and
- b) Aircraft position relative to the lateral path (Cross-Track Deviation) for FTE monitoring
- c) Aircraft position relative to the vertical path (for APV BARO-VNAV operation)

The crew should respect all published altitude and speed constraints.

The procedure must be discontinued:

- a) If RNAV failure is annunciated (e.g. warning flag),
- b) If the NSE alarm is triggered (e.g. RAIM alert),
- c) In case of loss of the NSE alerting function (e.g. RAIM loss),
- d) If lateral or vertical (if provided) FTE is excessive,
- e) If VNAV trajectory is not consistent with aircraft altimetry system information or vertical speed information.

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

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

- a) The RNAV system is operational (e.g. no loss of function, no RAIM alert, no failure indication, etc.).
- b) The whole procedure (including the missed approach) is loaded from the navigation data base.

During the RNP APCH procedure, pilots must use a lateral deviation indicator, flight director and/or autopilot in lateral navigation mode.

Pilots of aircraft with a lateral deviation indicator (e.g. CDI) must ensure that lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the various segments of the procedure (i.e.,  $\pm 1.0$  nm for the Initial and Intermediate segments,  $\pm 0.3$  nm for the Final Approach segment, and  $\pm 1.0$  nm for the Missed Approach segment).

All pilots are expected to maintain procedure centrelines, as depicted by on board lateral deviation indicators and/or flight guidance during all the approach procedure unless authorised 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  $\pm \frac{1}{2}$  the navigation accuracy associated with the procedure (i.e., 0.5 nm for the Initial and Intermediate segments, 0.15 nm for the Final Approach segment, and 0.5 nm for the Missed Approach segment).

Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after turns, up to a maximum of 1 times the navigation accuracy (i.e., 1.0 nm for the Initial and Intermediate segments), are allowable.

In addition, during APV BARO-VNAV procedures pilots must use a vertical deviation indicator, flight director and/or autopilot in vertical navigation mode.

Deviations above and below the vertical path must not exceed  $\pm 75$  feet. Pilots must execute a Missed Approach if the vertical deviation exceeds the criteria above, unless the pilot has in sight the visual references required to continue the approach.

In the event of failure of one RNAV system during a procedure where two systems are necessary, the crew should abort the procedure if the failure occurs before FAF but could continue the approach if the failure occurs after FAF.

Use of GNSS altitude information by the crew is prohibited.

## **2 Abnormal Procedures**

Abnormal procedures to address Cautions and Warnings resulting from the following conditions should be developed:

- a) Failure of the RNAV system components, including those affecting Flight Technical Error (e.g. failures of the flight director or automatic pilot).
- b) RAIM (or equivalent) alert or loss of integrity function.

In the event of communications failure, the flight crew should continue with the procedure in accordance with published lost communication procedures.

The flight crew should notify ATC of any problem with the RNAV system that results in the loss of the approach capability.

**APPENDIX 5: FLIGHT CREW TRAINING SYLLABUS**

The flight crew training programme should be structured to provide sufficient theoretical and practical training, using a simulator, training device, or line training in an aircraft, in the concept of RNP APCH operations without or with vertical guidance (APV BARO-VNAV) and the use of the aircraft's RNAV system in such operations to ensure that pilots are not just task-oriented. The following syllabus should be considered as minimum amendment to the training programme to support RNP APCH including APV BARO-VNAV operations:

Note: Operators who are already using procedures to fly other types of approaches, may receive appropriate credit for common training and procedural elements.

**1 GENERAL RNAV CONCEPTS INCLUDING:**

1. Theory of RNAV including differences between types of RNAV operations
2. Limitations of RNAV
3. Limitations of BARO-VNAV
4. Charting and database issues including:
  - i. Waypoint naming concepts
  - ii. Vertical path angle
  - iii. Fly-by and fly-over waypoints
5. Use of RNAV equipment including:
  - i. Verification and sensor management
  - ii. Tactically modifying the flight plan
  - iii. Addressing discontinuities
  - iv. Entering associated data such as:
    - Wind
    - Altitude/speed constraints
    - Vertical profile/vertical speed
6. Use of lateral navigation mode(s) and associated lateral control techniques
7. Use of vertical navigation mode(s) and associated vertical control techniques
8. R/T phraseology for RNAV operations
9. The implication for RNAV operations of systems malfunctions which are not RNAV related (e.g. hydraulic or engine failure)

**2 RNP APCH concepts including:**

1. Definition of RNP APCH operations and its direct relationship with RNAV (GNSS) procedures.
2. Regulatory requirements for RNP APCH operations
3. Required navigation equipment for RNP APCH operations:
  - i. GPS concepts and characteristics
  - ii. RNP/ANP requirements
  - iii. RAIM
  - iv. BARO-VNAV
  - v. MEL
4. Procedure characteristics
  - i. Chart depiction
  - ii. Aircraft display depiction
  - iii. Minima
5. Retrieving a RNP APCH(or a RNAV(GNSS)) approach procedure from the data base
6. Procedure change at destination airport, change arrival airport and alternate airport
7. Flying the procedure:
  - i. Use of autopilot, auto throttle and flight director
  - ii. Flight Guidance(FG) mode behaviour
  - iii. Lateral and vertical path management
  - iv. Adherence to speed and/or altitude constraints

- v. Fly direct to a waypoint
  - vi. Determine lateral and vertical-track error/deviation
  - vii. Fly interception of an initial or intermediate segment of an approach following ATC notification
  - viii. Where the RNAV system supports interception of the extended final approach segment then flight crew should be trained in use of the function.
  - ix. The use of other aircraft equipment to support track monitoring, weather and obstacle avoidance
  - x. Contingency procedures in case of lateral mode failure ( LNAV) and/or vertical mode failure (VNAV)
8. For APV BARO-VNAV operation, a clear understanding of specific crew requirements:
- i. for comparisons of VNAV guidance with primary altimeter information
  - ii. for altitude crosschecks between primary altimeters (e.g. altimetry comparisons of 100 feet),
  - iii. for temperature limitations on instrument procedures
  - iv. for altimeter settings in term of currency, accuracy and integrity.
9. The effect of temperature deviation and its compensation
10. ATC procedures
11. Abnormal procedures
12. Contingency procedures