AMC 20-26 Effective: 23/12/2009
Annex II to ED Decision 2009/019/R of 16/12/2009

AMC 20-26 Airworthiness Approval and Operational Criteria for RNP Authorisation Required (RNP AR) Operations

This AMC provides a means of compliance for applicants for an airworthiness approval to conduct Required Navigation Performance Authorisation Required (RNP AR) Operations and the applicable criteria to obtain an operational approval. It relates to the implementation of area navigation within the context of the Single European Sky[1], in particular in relation to the verification of conformity of the airborne constituents, per Article 5 of EC Regulation 552/2004. Additional guidance material can be found in the ICAO Performance Based Navigation Manual, Document 9613, Volume II, Chapter 6, as contained in ICAO State Letter AN 11/45-07/22.

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[1] 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).

1 PREAMBLE

In order to ensure an increased availability, enhanced safety and reduced operating minima over and above that provided from traditional non-precision and conventional Area Navigation (RNAV) approaches, the concept of area navigation within the European Region, RNP should be implemented on instrument approach procedures

This AMC provides a means of compliance for the airworthiness approval of area navigation systems and their use for RNP AR operations that range from nominal (i.e. where general aircraft qualification is matched to standard AR procedure design) to those more demanding in operational and performance requirements. The assurance of consistency with and conformance to the target level of safety (TLS) objectives for RNP AR operations results from the specific compliance criteria of this AMC and the associated standard RNP AR procedure design.

This AMC is generally consistent with the Single European Sky legislation and with material in the ICAO Performance-Based Navigation Manual, as well as in EUROCONTROL publications dealing with related operational and functional requirements for area navigation. The material contained in this AMC reflects the fundamental change associated with RNP in the roles, responsibilities and requirements for the regulator, manufacturer, operator and procedure designer.

This AMC is based on barometric-vertical navigation (BARO-VNAV) and RNAV multi-sensor navigation systems, as well as the system concepts, guidance and standards defined in the RTCA DO-236()/EUROCAE ED-75() MASPS. RNP AR builds on the RNP concept that requires the ability of the aircraft navigation system to monitor its achieved navigation performance, and to identify to the pilot whether the operational requirement is or is not being met during an operation.

This AMC addresses general certification considerations, including functional requirements, accuracy, integrity, continuity of function and system limitations.

This AMC introduces some provisions for aircraft qualification to RNP AR Departure protected with customised procedure design criteria. These provisions will be completed in a next issue of the AMC, once ICAO has published public procedure design criteria for departures.

This AMC is based on the criteria developed in FAA AC 90-101, with inclusion of more stringent criteria (see Appendix 6), including notably a focus on aircraft performance in Non-Normal conditions.

Compliance with this AMC provides, but by itself does not constitute, a basis for an operational approval to conduct RNP operations. The special procedure design criteria contained in the RNP AR procedure design manual may necessitate additional operational evaluation depending upon the operator needs or operating conditions.

Aircraft operators should apply to their competent authority for such an approval. Since this AMC has been harmonised with other RNP implementation and operations approval criteria outside of Europe i.e. USA/FAA, it is expected to facilitate interoperability and ease the effort in obtaining operational approval by airline operators.

1.1 PURPOSE

This AMC establishes an acceptable means of compliance for an applicant to obtain airworthiness approval of an RNP system and the operational criteria for use in designated European airspace blocks where RNP AR operations have been implemented by the competent aviation authority. 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. Compliance with this AMC is not mandatory hence the 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.

1.2 BACKGROUND

The application of RNP AR to terminal area and approach operations provides an opportunity to utilise modern aircraft capability and performance to improve safety, efficiency and capacity. Safety is improved when RNP AR procedures replace visual procedures or non-precision approaches, and efficiency is improved through more repeatable and optimum flight paths. Capacity can be improved by de-conflicting traffic during instrument conditions.

RNP AR includes unique capabilities that require aircraft and aircrew authorisation similar to Category (CAT) II/III ILS operations. All RNP AR procedures have reduced lateral obstacle evaluation areas and vertical obstacle clearance surfaces predicated on the aircraft and aircrew performance requirements of this AMC. In general, RNP AR procedures are expected to be developed to not only address specific operational needs or requirements but also to enable benefits to the broadest segment of the RNP AR aircraft population possible. As a result, there are some aspects of RNP AR approach procedure design that will be used only as necessary.

A critical component of RNP is the ability of the aircraft navigation system to monitor its achieved navigation performance, and to identify to the pilot whether the operational requirement is or is not being met during an operation.

The criteria (both procedure design and certification) may take account of the fact that aircraft with different flight guidance capabilities will be used to fly the procedures. However, the procedure design criteria do reflect specific levels of aircraft performance and capability for the barometric VNAV aspects of the operation. The operator authorisation may be extended where the operational requirements can be met by aircraft but require more stringent performance criteria.

2 SCOPE

This material provides airworthiness approval criteria related to RNAV systems with lateral navigation (LNAV) and BRAO-VNAV capabilities, intended to be used under Instrument Flight Rules, including Instrument Meteorological Conditions, in designated European airspace blocks where RNP Authorisation Required (AR) operations have been implemented per a decision of the competent aviation authorities. It addresses general certification requirements, including functional requirements, accuracy, integrity, continuity of function, and system limitations.

The material contained in this AMC is unique and represents the fundamental change associated with RNP in the roles, responsibilities and requirements for the regulator, manufacturer, air operator and procedure designer. The assurance of consistency with and conformance to the target level of safety (TLS) objectives for RNP AR operations results from the specific compliance criteria of this AMC, a flight operational safety assessment and the associated standard RNP AR procedure design.

The material and criteria contained herein also provide a means for development and approval of an RNP AR capability consistent with the RNP AR procedures implemented using the ICAO PBN RNP AR Procedure Design Manual. However, it should be recognised that in order to perform RNP AR operations there are three key aspects of this AMC that must be considered. The first is that where an operator/manufacturer satisfies all criteria contained herein, they should be considered operationally ready to conduct RNP AR operations using procedure design and alternatives defined by the ICAO PBN RNP AR Procedure Design Manual. The second is that there are three elements of the procedure design criteria that will only be used on the occasions where there is a specific operational need or benefit. As a result, operators can be authorised for all or any subset of these types of procedures:

- Reduced lateral obstacle evaluation area on the missed approach or departure (also referred to as a procedure requiring RNP less than 1.0) or

- When conducting a RNP AR approach using a line of minima less than RNP 0.3 and/or a missed approach or departure that requires RNP less than 1.0. and
- Ability to fly a published ARC (also referred to as a RF leg)

These aspects of instrument procedures are reflected in the guidance and criteria of the ICAO PBN RNP AR procedure design manual. Therefore, an operator/manufacturer with aircraft lacking some or all of these capabilities should recognise that this will result in operational limitations, i.e. the more complex or demanding operations using these procedure criteria may not be performed. The third aspect is that there will be specific situations where even full compliance to the AMC may be insufficient to conduct procedures that are tailored to aircraft specific performance

This AMC recognises that published criteria for demonstrated aircraft performance may be insufficient to enable RNP AR operations where the performance required is less than 0.3 NM. Consequently, this AMC provides the criteria necessary to support airworthiness approval to these lower values and criteria including guidance for the assessment of:

- Training and Crew Qualification (see APPENDIX 2)
- RNP Operational Considerations (see APPENDIX 3)
- Flight Technical Error (see APPENDIX 4)
- Flight Operation Safety Assessment (see APPENDIX 5)

This AMC also contains criteria reflecting the Agency's opinion that parts of the ICAO PBN Navigation Specification for RNP AR APCH are not appropriate for the RNP AR operations that the Agency will authorise. As a result, select criteria in the AMC are different and are clearly noted as such.

Section 3.2 of this AMC refers to documents which contribute to the understanding of the RNP concept and which may support an application for approval. However, it is important that an applicant evaluates his aircraft system against the criteria of this AMC.

Compliance with this AMC provides, but by itself does not constitute, a basis for, an operational approval to conduct RNP operations. Aircraft operators should apply to their national authority for such an approval. While an objective of this AMC is interoperability and to ease operator operational approvals, some operators and manufacturers will need to consider the noted differences in requirements from the ICAO PBN Manual and FAA AC 90-101 to determine what additional aircraft or system changes are necessary, or what operational limitations must be implemented.

A glossary of terms and acronyms used in this AMC is given in APPENDIX 1.

3 REFERENCE DOCUMENTS

3.1 RELATED REQUIREMENTS

CS 25.1301, 25.1302, 25.1307, 25.1309, 25.1316, 25.1321, 25.1322, 25.1329, 25.1431, 25.1581.
CS 23.1301, 23.1309, 23.1311, 23.1321, 23.1322, 23.1329, 23.1335, 23.1431, 23.1581.
EU-OPS[2] 1.243, 1.420, 1.845, 1.865, 1.873
National operational regulations

[2] REGULATION (EC) No 1899/2006 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 12 December 2006 amending Council Regulation (EEC) No 3922/91 on the harmonisation of technical requirements and administrative procedures in the field of civil aviation.

3.2 RELATED MATERIAL

3.2.1 ICAO

Doc 8168-OPS/611	Aircraft Operations (PANS OPS)
Doc 9613	Performance Based Navigation Manual
Doc 9881	Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information
Doc 9905	Required Navigation Performance Authorization Required (RNP AR) Procedure Design Manual

3.2.2 EASA

AMC 20-5	Airworthiness Approval and Operational Criteria for the use of the Navstar Global Positioning System (GPS)
AMC 25-11	Electronic Display Systems
AMC 20-27	AMC 20-27 Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BARO-VNAV Operations
EASA Opinion Nr. 01/2005	The Acceptance of Navigation Database Suppliers

3.2.3 EUROCONTROL

NAV.ET1.ST16-001( )	Navigation Strategy for ECAC
Document 003-93( )	Area Navigation Equipment: Operational Requirements and Functional Requirements

3.2.4 FAA

AC 25-11( )	Electronic Display Systems
AC 20-129	Airworthiness Approval of Vertical Navigation (VNAV) Systems for Use in the U.S. National Airspace System (NAS) and Alaska
AC 20-130( )	Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors
AC 20-138( )	Airworthiness Approval of NAVSTAR Global Positioning System (GPS) for use as a VFR and IFR Supplemental Navigation System
AC 25-4	Inertial Navigation Systems (INS)
AC 25-15	Approval of Flight Management Systems in Transport Category Airplanes
AC 90-97	Use of Barometric Vertical Navigation (VNAV) for Instrument Approach Operations using Decision Altitude
Order 8260.52	United States Standard for Required Navigation Performance (RNP) Approach Procedures with Special Aircraft and Aircrew Authorization Required (SAAAR)

AC 90-101	Approval for Required Navigation Performance (RNP) Procedures with Special Aircraft and Aircrew Authorisation Required (SAAAR)
AC 120-29A	Criteria for Approval of Category I and Category II Weather Minima for Approach
AC 20-153	Acceptance of Data Processes and Associated Navigation Databases

3.2.5 Technical Standard Orders

ETSO-C115( )/TSO-C115( )	Airborne Area Navigation Equipment Using Multi-sensor Inputs.
ETSO-C129( )/TSO-C129( )	Airborne Supplemental Navigation Equipment Using the Global Positioning System (GPS)
ETSO-C145( )/TSO-C145( )	Airborne Navigation Sensors Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
ETSO-C146( )/TSO-C146( )	Stand-Alone Airborne Navigation Equipment Using the Global Positioning System (GPS) Augmented by the Wide Area Augmentation System (WAAS)
ETSO-C151( )/TSO-C151( )	Terrain Awareness and Warning System (TAWS)

3.2.6 EUROCAE/RTCA and ARINC

ED-75( )/DO-236( )	Minimum Aviation System Performance Standards: Required Navigation Performance for Area Navigation
DO-283A	Minimum Operational Performance Standards for Required Navigation Performance for Area Navigation
ED-76 / DO-200A	Standards for Processing Aeronautical Data
ED-77 / DO-201A	Standards for Aeronautical Information
DO-229( )	Minimum Operational Performance Standards for Global Positioning System/Wide Area Augmentation System Airborne equipment
ARINC 424	Navigation System Data Base

4 ASSUMPTIONS

Applicants should note that this AMC is based on the following assumptions concerning the measures taken by the responsible airspace authorities and service providers to safeguard RNP AR operations in the European region:

4.1 NAVAID INFRASTRUCTURE CONSIDERATIONS

RNP AR approaches are only authorised based on GNSS as the primary Navaid infrastructure. The use of DME/DME as a reversionary capability (e.g. extraction when on an approach or continuation for departures) is only authorised for individual operators where the infrastructure supports the required performance. RNP AR operations should not be used in areas of known navigation signal (GNSS) interference.

Note 1: Most modern RNAV systems will prioritise inputs from GNSS and then DME/DME positioning. Although VOR/DME positioning is usually performed within a flight management computer when DME/DME positioning criteria do not exist, avionics and infrastructure variability pose serious challenges to standardisation.

Note 2: Procedure validation will entail use of an infrastructure navigation performance tool that is capable of analysing the flight procedure path and profile relative to the ground navigation aid infrastructure. This type of tool is likely to only approximate results for the actual procedure. However, due to the cost of flight checking, increased efficiency is anticipated in flight checking when augmented with an infrastructure navigation performance tool.

Note 3: With or without an infrastructure navigation performance tool, a flight check aircraft is expected to be used. Where State flight check aircraft systems do not reflect the types of aircraft or systems intending to conduct the RNP AR procedure, use of operator aircraft with systems that also provides real time calculations of their achieved performance along the procedure flight path and profile should also be used to evaluate a procedure. The selected aircraft are intended to provide confidence in the interoperability of differing systems and implementations.

Note 4: For procedures that allow aircraft to rely only on GNSS, (see paragraph 8.3), the acceptability of the risk of degraded navigation performance beyond the requirements for the operation for multiple aircraft due to satellite failure or RAIM holes, has been considered by the responsible airspace authority.

4.2 COMMUNICATION & ATS SURVEILLANCE CONSIDERATIONS

RNP AR operations described herein do not require any unique communication or ATS Surveillance considerations.

4.3 OBSTACLE CLEARANCE AND ROUTE SPACING

All RNP AR procedures:

(1) are published by an Aeronautical Information Service Provider certified according to article 7 of Regulation 550/2004[3]; or

(2) are consistent with the relevant parts of ICAO Doc 8168 PANS OPS and ICAO PBN RNP AR Procedure Design Manual;

(3) take account of the functional and performance capabilities of RNP systems and their safety levels as detailed in this AMC;

Note: Particular attention should be given to the constraints implied by the Airworthiness Certification objectives of paragraph 6.

(4) require that barometric vertical navigation capability be used;

(5) support reasonableness checking by the flight crew by including, on the charts, fix data (e.g. range and bearing to navigational aids or waypoint to waypoint);

(6) terrain and obstacle data in the vicinity of the approach is published in accordance with ICAO Annex 15 to the Convention on International Civil Aviation and Doc 9881, Guidelines for Electronic Terrain, Obstacle and Aerodrome Mapping Information;

(7) if the contingency procedure allows a reversion in aircraft use of navigation infrastructure, e.g. GNSS to DME/DME, the obstacle clearance assessment is based on an RNP that allows either infrastructure;

(8) barometric altitude compensation for low temperature effects is accounted for in the procedure design, and any necessary limitations are specified in the AIP;

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[3] Regulation (EC) No 550/2004 of the European Parliament and of the Council of 10 March 2004 on the provision of air navigation services in the single European sky (the service provision Regulation).

(9) the Safety Case assessment for RNP AR operations accounts for the regulatory determination and documentation of compliance to the AMC~~s~~ detailed requirements for the navigation system, aircraft operational capability, crew procedures and continuing airworthiness, as meeting or exceeding their TLS objectives for the procedure and/or spacing;

(10) are designated RNAV e.g. RNAV$_{(RNP)}$ and throughout the AIP and on aeronautical charts, will specify either the sensors allowed or the RNP value required;

(11) may have attributes that depart from the standard applications of procedures described in the ICAO RNP AR Procedure Design Manual.

4.4 ADDITIONAL CONSIDERATIONS

a) Guidance in this chapter does not supersede the applicable operational requirements for equipage.

b) Current local pressure setting must be provided to support RNP AR approaches, where the aircraft's achieved vertical path is dependent on that setting. Failure to report a correct setting can lead to aircraft leaving the obstacle clearance area.

4.5 FLIGHT EVALUATION

a) As RNP AR approaches do not have a specific underlying navigation facility, there is no requirement for flight inspection of navigation signals. However, due to the importance of publishing correct data, it is recommended that flight evaluation be used prior to publication for procedure validation and obstacle validation. Flight evaluation can be accomplished through ground evaluation (e.g. simulator assessment) and actual flight.

b) Procedure validation includes confirmation of the basic flyability of the procedure in accordance with the procedure design. A thorough flyability assessment is not required prior to publication, since flyability is individually assessed by the operator as part of their database updating and maintenance process due to the unique nature of RNP AR approaches. The flight evaluation prior to publication should confirm track lengths, bank angles, descent gradients, runway alignment and compatibility with predictive terrain hazard warning functions (e.g. ETSO-C151( )/TSO-C151( ) compliant Terrain Awareness and Warning Systems). A Flight Inspection Truth System is typically not required. Due to variations in aircraft speeds, flight control system design, and navigation system design this flight evaluation does not confirm flyability for all of the various aircraft conducting RNP AR approaches.

c) Obstacle validation through flight evaluation may be used to validate the obstacle data used to design the procedure. An obstacle flight evaluation may not be necessary if obstacle validation can be accomplished through ground inspection or validated survey techniques to the appropriate accuracy.

4.6 PUBLICATION

a) The AIP clearly indicates the navigation application is RNP AR approach and specific authorisation is required.

b) All procedures are based upon WGS 84 coordinates.

c) The navigation data published in the relevant AIP for the procedures and supporting navigation aids must meet the requirements of Annex 15 and Annex 4 to the Convention on International Civil Aviation (as appropriate). The original data defining the procedure should be available to the operators in a manner suitable to enable the operator to verify their navigation data.

d) The navigation accuracy for all RNP AR approach procedures is clearly published in the AIP.

e) The navigation data for the procedure(s) to be loaded into the flight management system is from database supplier holds a Type 2 Letter of Acceptance (LoA) or equivalent and has been independently validated by the operator.

f) Where reliance is placed on the use of radar to assist contingency procedures, its performance has been shown to be adequate for that purpose, and the requirement for a radar service is identified in the AIP.

4.7 CONTROLLER TRAINING

Air traffic controllers, who will provide control services at airports where RNP approaches have been implemented, have completed the appropriate training

4.8 STATUS MONITORING

The Navaid infrastructure is monitored and, where appropriate, maintained by a service provider certified for navigation services according to article 7 of EC regulation 550/2004. For the use of non EU navigation service providers, timely warnings of outages (NOTAM) should be issued. Also status information should be provided to Air Traffic Services in accordance with ICAO Annex 11 to the Convention on International Civil Aviation for navigation facilities or services that may be used to support the operation.

4.9 ATS SYSTEM MONITORING

When available, radar observations of each aircraft's proximity to track and altitude are typically noted by Air Traffic Service (ATS) facilities and aircraft track-keeping capabilities are analysed. If an observation/analysis indicates that a loss of separation or obstacle clearance has occurred, the reason for the apparent deviation from track or altitude should be determined and steps taken to prevent a recurrence.

5 SYSTEM DESCRIPTION

5.1 LATERAL NAVIGATION (LNAV)

5.1.1 For lateral navigation, the RNAV equipment enables the aircraft to be navigated in accordance with appropriate routing instructions along a path defined by waypoints held in an on-board navigation database.

Note: LNAV is typically a flight guidance systems mode, where the RNAV equipment provides path steering commands to the flight guidance system, which then controls flight technical error through either manual pilot control with a path deviation display or through coupling to the flight director or autopilot.

5.1.2 For the purposes of this AMC, RNP AR operations are based upon the use of RNAV equipment that automatically determines aircraft position in the horizontal plane using inputs from the following types of positioning sensor (in no specific order of priority or combination) but whose primary basis for positioning is GNSS:

(a) Global Navigation Satellite System (GNSS).
(b) Inertial Navigation System (INS) or Inertial Reference System (IRS).
(c) Distance Measuring Equipment giving measurements from two or more ground stations (DME/DME).

Additional information and requirements are in paragraphs 8.3 through 8.5.

5.2 VERTICAL NAVIGATION

5.2.1 For Vertical Navigation, the system enables the aircraft to fly level and descend relative to a linear, point to point vertical profile path that is held in an on-board navigation database. The vertical profile will be based upon altitude constraints or vertical path angles where appropriate, associated with the LNAV path waypoints.

Note 1: VNAV is typically a flight guidance systems mode, where the RNAV equipment containing VNAV capability provides path steering commands to the flight guidance system, which then controls flight technical error through either manual pilot control with a vertical deviation display or through coupling to the flight director or autopilot.

Note 2: The ARINC 424 specification data allows the definition of a vertical angle, however some system implementations preclude the specification of a vertical angle on a flight leg. In such a case it may be necessary to examine the leg types available that do and determine if the resulting lateral path is acceptable for the surrounding airspace.

Note 3: The specification of vertical angles on multiple path fixes in descent may lead to possible vertical path discontinuities (e.g. temperature effect). This type of procedure should be assessed to determine if the system response and performance can be accommodated in this situation and for other systems, or if the procedure must be changed. Climb paths are typically not included in a vertical profile e.g. departure or missed approach.

Note 4: Additionally, some system implementations may allow the manual specification of a vertical angle for a path or path segment. This capability may need to be evaluated to determine if it has the potential to alter or impact a VNAV procedure and the possible means of mitigating the potential condition e.g. design change or operational procedure.

Note 5: The system may provide the capability to determine performance optimised paths. A performance optimised path is defined by a series of straight line path segments that are designed to hold an aircraft at a specified speed while holding thrust to a constant value (e.g. typically near idle for descent) and guiding to the series of straight line paths. The elements required for the determination of the performance optimised path include gross weight, lift, drag and speed. This path capability and aircraft operation may be acceptable where the vertical path is specified with flexibility (e.g. altitude windows, AT/ABOVE). However, in the case where a linear point to point path, or flight path angle is specified, this type of systems capability with its associated vertical path errors may be unacceptable for the required operations.

Note 6: Systems may implement vertical profiles specified by AT/ABOVE constraints as a point to point path defined by AT constraints. This type of characteristic in system path definition may be acceptable.

Note 7: Systems that allow vertical paths to be defined by a combination of altitude constraints, and flight path angles, may be subject to vertical discontinuities, where a smooth or continuous vertical path is not possible. System responses to this condition may vary from possible level off manoeuvres to vertical speed captures of the flight path. The aircraft system performance must be assessed on a case by case basis for its acceptability for the required operation, and still may not be acceptable.

5.2.2 Temperature Compensation Systems: Systems that provide temperature-based corrections to the barometric VNAV guidance must comply with EUROCAE ED-75B, Appendix H.2. This applies to the final approach segment. Compliance to this standard should be documented to enable the operator to conduct RNP approaches when the actual temperature is below or above the published procedure design limit.

6 AIRWORTHINESS CERTIFICATION OBJECTIVES

The following performance certification criteria are defined for the airborne systems on the basis that the Assumptions of Section 4 are valid.

6.1 ACCURACY

Aircraft performance is evaluated around the path defined by the published procedure and EUROCAE/ED-75B, Section 3.2. All vertical paths used in conjunction with the final approach segment will be defined by a Flight Path Angle (EUROCAE/ED-75B, Section 3.2.8.4.3) as a straight line emanating from a fix and altitude.

6.1.1 Lateral

During operations on approaches notified exclusively for RNP equipped aircraft, the lateral track keeping accuracy and along-track positioning error of the on-board navigation system shall be equal to or better than the RNP for 95% of the flight time.

Note 1: The lateral track keeping accuracy is dependent on the navigation total system error (a combination of path definition error, position estimation error, display error and Flight Technical Error (FTE)).

a) Refer to APPENDIX 4 for the assessment of FTE for RNP AR operations authorised with RF legs, reduced lateral obstacle evaluation, e.g. less than 0.3 NM in final approach, less than 1.0 NM for missed approach.

Note 2: Provided that paragraph 8.3(b) has been shown to be valid in respect of typical GNSS performance, then, for RNAV systems that have been declared (e.g. in the Aircraft Flight Manual) to be compliant with the navigation accuracy criteria of FAA AC 20-130(), or FAA AC 20-138() or AMC20-5 or AMC20-27 and the accuracy requirements of this AMC including a statement of the operational RNP capability, the intent of this paragraph is considered as satisfied and no further accuracy demonstration is required. However, such a Flight Manual statement, by itself, does not constitute an airworthiness approval for RNP AR operations and compliance with all other criteria of this AMC will need to be shown.

Note 3: Some RNP system implementations may provide for multi-sensor mixing in the calculation of aircraft position. While this is not required, it provides for smoothing when positioning sources change and a means to optimise the calculation of aircraft position that is not possible for single source systems. Manufacturers should consider the effects of sensor failure or errors on lateral position during the conduct of RNP AR operations, and the potential departure, approach and missed approach RNP, in implementing system architecture, sensor switching, and redundancy.

6.1.2 Vertical

During operations on instrument approach procedures notified exclusively for RNP aircraft and where the Vertical Error Budget(VEB) applies, the vertical system error includes altimetry error (assuming the temperature and lapse rates of the International Standard Atmosphere), the effect of along-track error, system computation error, data resolution error, and flight technical error. The 99.7% of system error in the vertical direction during the stabilised constant descent path must be less than the following (in feet):

$$\sqrt{\left((6076.115)(1.225)\mathbf{RNP}\cdot tan\theta\right)^2 + (60\,tan\theta)^2 + 75^2 + \left(\left(-8.8\cdot 10^{-8}\right)(\mathbf{h}+\Delta\mathbf{h})^2 + \left(6.5\cdot 10^{-3}\right)(\mathbf{h}+\Delta\mathbf{h}) + 50\right)^2}$$

Where θ the vertical navigation (VNAV) path angle, h is the height of the local altimetry reporting station and Δh is the height of the aircraft above the reporting station.

The 99.7% altimetry system error for each aircraft (assuming the temperature and lapse rates of the ISA) shall be less or equal to than the following with the aircraft in the approach configuration:

ASE = $-8.8\cdot10^{-8}\cdot H^2\cdot + 6.5\cdot10^{-3}\cdot H + 50$ (ft)

Where H is the true altitude of the aircraft.

Note 1: Current guidance for VNAV such as AC20-129, and AC90-97 has less stringent performance requirements. A supplemental analysis, assessment and regulatory approval (i.e. airworthiness) will be necessary in meeting the requirements.

Note 2: For the vertical system error above, vertical angle error is not included and is not considered since data and database processes associated with DO-200A and DO-201A are required. In addition ATIS, automatic terminal information service temperature error is not included and is accounted for in the procedure design.

6.1.3 RNP System Performance

The required demonstration of RNP system performance, including lateral and vertical path steering performance (FTE), will vary according to the type of AR operation being considered e.g. low RNP for obstacle clearance or separation in an obstacle rich environment or high density air traffic environment. It will be for the competent Authority, responsible for the approval of the procedure, to assess the RNP level for the considered operation in accordance with the Flight Operations Safety Assessment (FOSA) see APPENDIX 5.

In supporting the FOSA exercise, the applicant will be required to demonstrated the aircraft capability in terms of RNP system performance under a variety of operational conditions, rare normal conditions and non-normal conditions – see also APPENDIX 4. For the non-normal conditions the applicant should conduct a safety impact assessment, which identifies from the existing aircraft System Safety Assessments (SSA), those Failure Conditions that have an impact on the RNP system performance. This safety assessment process should encompass the additional Failure Conditions introduced by any specific feature designed and implemented as mitigation for RNP AR operations (e.g. lateral deviation display) and also identify and document any additional flight crew procedures and training, necessary to support the overall safety of the operation.

Specific evaluations should be conducted to assess the path excursions upon failures and the resulting RNP levels. Results should be documented in the Aircraft Flight Manual (AFM), AFM Supplement or appropriate aircraft operational support document and made available to the operator, thereby alleviating the need for similar operational evaluations.

Acceptable criterion to be used for assessing RNP significant failures under limit performance conditions (see Appendix 4 Para 4) is as follows:

a) The lateral excursions observed as a result of Probable failures should be documented against an objective of containment within 1xRNP.

Note 1: The System Safety Assessment of the aircraft systems supporting RNP AR operations (RNAV systems, Flight Controls Systems, Flight Guidance Systems, etc.) should therefore be revisited to identify these Probable failures. Probable failures are failures with a probability greater than 10^{-5} per operation.

Note 2: This demonstration can rely on crew action to intervene and place the aircraft back on the target track, or apply a contingency procedure when the guidance is lost.

b) The lateral excursions observed as a result of One Engine Inoperative (OEI) should be documented against an objective of containment within 1xRNP.

Note 1: This demonstration can rely on crew action to intervene and place the aircraft back on the target track.

c) The lateral excursions observed as a result of Remote failures should be documented against an objective of containment within 2xRNP.

Note 1: The demonstration should evaluate the contributions of:

(i) Remote systems failures that may impact the RNP capability

(ii) GNSS satellite outages

Note 2: Remote system failures should include latent failures (integrity) and detected failures (continuity). For the detected failures, the monitor limit of the alert, the time to alert, the crew reaction time, and the aircraft response should all be considered when ensuring that the aircraft does not exit the obstacle clearance volume. Remote failures are failures with a probability between 10^{-5} and 10^{-7} per operation.

d) A demonstration should be made that the aircraft remains manoeuvrable and a safe extraction may be flown for all Extremely Remote failures.

Note 1: Extremely Remote failures are failures with a probability between 10^{-7} and 10^{-9}.

For conditions a, b and c above, the vertical excursion should not exceed 75 feet below the desired path.

6.2 INTEGRITY

6.2.1 System

a) RNP and Barometric VNAV aircraft (e.g. FMS RNAV/VNAV equipped). This AMC provides a detailed acceptable means of compliance for aircraft that use an RNP system based primarily on GNSS and a VNAV system based on barometric altimetry. Aircraft complying with this AMC provide the requisite airspace containment (i.e. satisfactory assurance that the aircraft will remain within the obstacle clearance volume) through a variety of monitoring and alerting (e.g. 'Unable RNP', GNSS alert limit, path deviation monitoring).

b) Other systems or alternate means of compliance. For other systems or alternate means of compliance, the probability of the aircraft exiting the lateral and vertical extent of the obstacle clearance volume (defined in ICAO PBN RNP AR Procedure Design Manual) must not exceed 10^{-7} per operation, including the departure, approach and missed approach. The use of such alternatives may be satisfied by the flight operational safety assessment (see APPENDIX 5).

Note 1: The 10^{-7} requirement applies to the total probability of excursion outside the obstacle clearance volume, including events caused by latent conditions (integrity) and by detected conditions (continuity) if the aircraft does not remain within the obstacle clearance volume after annunciation of the failure. The monitor limit of the alert, the latency of the alert, the crew reaction time, and the aircraft response should all be considered when ensuring that the aircraft does not exit the obstacle clearance volume. The requirement applies to a single approach, considering the exposure time of the operation and the Navaid geometry and navigation performance available for each published approach.

Note 2: This containment requirement derives from the operational requirement. This requirement is notably different than the containment requirement specified in RTCA/DO-236B (EUROCAE ED-75B). The requirement in RTCA/DO-236B (EUROCAE ED-75B) was developed to facilitate airspace design and does not directly equate to obstacle clearance.

6.2.2 Display

The system design must be consistent with at least a major failure condition for the display of misleading lateral or vertical guidance on an RNP AR approach.

Note: The display of misleading lateral or vertical RNP guidance is considered a hazardous (severe-major) failure condition for RNP AR approaches with an RNP value less than RNP 0.3. Systems designed consistent with this effect should be documented as it may eliminate the need for some operational mitigations for the aircraft.

6.3 CONTINUITY OF FUNCTION

With respect to the airborne systems, it shall be shown 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.

Note 1: In addition to the equipment required by EU-OPS 1, Sub-part L for IFR flight (or equivalent national requirements), at least one area navigation system is required. Where continued operation is required for a procedure with RNP on either the approach or missed approach, dual systems will be needed (see 7.2).

Note 2: Systems approved for RNP operations may have to comply with additional continuity requirements to ensure that the RNP capability is available for a specified RNP and operational environment e.g. dual equipage, independent systems for cross checking, etc.

Note 3: 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 MINIMUM REQUIRED FUNCTIONS FOR RNP AR OPERATIONS

Table 1 lists and describes the system functions and features required where RNP AR operations are predicated on nominal RNP AR procedure design criteria e.g. FAA Notice 8260.52, ICAO RNP AR Procedure Design Manual.

Item	Function/Feature
	Displays
1	Continuous Display of Deviation. The navigation system must provide the capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft, the aircraft position relative to the defined lateral and vertical path (both lateral and vertical deviation) and manoeuvre anticipation. The display must allow the pilot to readily distinguish if the cross-track deviation exceeds the RNP (or a smaller value) or if the vertical deviation exceeds 75 feet (or a smaller value). Where the minimum flight crew is two pilots, means for the pilot not flying must be provided to verify the desired path and the aircraft position relative to the path. To achieve this, an appropriately scaled non-numeric deviation display (i.e. lateral deviation indicator and vertical deviation indicator) located in the pilot's primary field of view may be provided. Alternatively: For lateral data presentation only For RNP 0.3 and above, • a navigation map display, readily visible to the flight crew, with appropriate map scales, giving equivalent functionality to an appropriately scaled non-numeric lateral deviation display, except that scaling may be set manually by the flight crew or • a numeric display of the lateral deviation , readily visible to the flight crew, with a minimum resolution of 0.1 NM and direction relative to the track For RNP <0.3 • a numeric display of the lateral deviation, in the primary field of view, with a resolution of 0.01 NM and direction relative to the track Note 1: A fixed-scale CDI is acceptable as long as the CDI demonstrates appropriate scaling and sensitivity for the intended navigation accuracy and operation. With a scalable CDI, the scale should be derived from the selection of RNP, and shall not require the separate selection of a CDI scale. Where a CDI is relied upon, alerting and annunciation limits must also match the scaling values. If the equipment uses default navigation accuracy to describe the operational mode (e.g. en-route, terminal area and approach), then displaying the operational mode is an acceptable means from which the flight crew may derive the CDI scale sensitivity.
2	Identification of the Active (To) Waypoint. The navigation system must provide a display identifying the active waypoint either in the pilot's primary field of view, or on a readily accessible and visible display to the flight crew.
3	Display of Distance and Bearing. The navigation system should provide a display of distance and bearing to the active (To) waypoint in the pilot's primary field of view. Where not viable, a readily accessible page on a control display unit, readily visible to the flight crew, may display the data.

Item	Function/Feature
4	Display of Groundspeed and Time. The navigation system should provide the display of groundspeed and either estimated time of arrival or time to the active (To) waypoint in the pilot's primary field of view. Where not viable, a readily accessible page on a control display unit, readily visible to the flight crew, may display the data.
5	Display of To/From the active fix. The navigation system must provide a To/From display in the pilot's primary field of view. Systems with electronic map display in the pilot's primary field of view having designation of the active waypoint fulfil this requirement.
6	Desired Track Display. The navigation system must have the capability to continuously display to the pilot flying the aircraft the RNAV desired track. This display must be on the primary flight instruments for navigation of the aircraft.
7	Display of Aircraft Track. The navigation system must provide a display of the actual aircraft track (or track angle error) either in the pilot's primary field of view, or on a readily accessible and visible display to the flight crew.
8	Slaved Course Selector. The navigation system must provide a course selector automatically slaved to the RNAV computed path. As an acceptable alternative is an integral navigation map display.
9	RNAV Path Display. Where the minimum flight crew is two pilots, the navigation system must provide a readily visible means for the pilot not flying to verify the aircraft's RNAV defined path and the aircraft's position relative to the defined path.
10	Display of Distance to Go. The navigation system must provide the ability to display distance to go to any waypoint selected by the flight crew.
11	Display of Distance Between Flight Plan Waypoints. The navigation system must provide the ability to display the distance between flight plan waypoints.
12	Display of Barometric Altitude. The aircraft must display barometric altitude from two independent altimetry sources, one in each pilots' primary field of view. The altimeter setting input must be used simultaneously by the aircraft altimetry system and by the RNAV system. Note 1: This display supports an operational cross-check (comparator monitor) of altitude sources. If the aircraft altitude sources are automatically compared, the output of the independent altimetry sources, including independent aircraft static air pressure systems, must be analysed to ensure that they can provide an alert in the pilot's primary field of view when deviations between the sources exceed ±75 feet. Such comparator monitor function should be documented as it may eliminate the need for an operational mitigation. Note 2: A single input is necessary to prevent possible crew error. Separate altimeter setting for the RNAV system is prohibited.
13	Display of Active Sensors. The aircraft must display the current navigation sensor(s) in use that are readily accessible to the flight crew.

Item	Function/Feature
	Performance, Monitoring and Alerting
14	Navigation performance: The system should include a capability to monitor for its achieved lateral navigation performance (e.g. EPU, EPE, ACTUAL or equivalent), and to identify for the flight crew whether the operational requirement is or is not being met during an operation (e.g. 'UNABLE RNP', 'Nav Accur Downgrad', path deviation monitoring, GNSS alert limit). For vertical navigation, this may be achieved by system vertical monitoring and alerting or by a combination of indications such as barometric altitude display and vertical deviation display in combination with procedural crosschecks. Signals radiated by GNSS augmentation systems managed by certified navigation service providers may be taken into account.
15	For multi-sensor systems, automatic reversion to an alternate navigation sensor if the primary navigation sensor fails. Note: This does not preclude means for manual navigation source selection.
16	When DME is used in RNP AR operations, automatic tuning of DME navigation aids used for position updating together with the capability to inhibit individual navigation aids from the automatic selection process. Note: Further guidance may be found in EUROCAE ED-75B / RTCA DO-236B, Section 3.7.3.1.
17	Capability for the RNAV system to perform automatic selection (or de-selection) of navigation sources, a reasonableness check, an integrity check, and a manual override or deselect. Note 1: The reasonableness and integrity checks are intended to prevent navigation aids being used for navigation update in areas where the data can lead to radio position fixing errors due to co-channel interference, multipath, stations in test, changes in station location and direct signal screening. In lieu of using radio navigation aid designated operational coverage (DOC), the navigation system should provide checks which preclude use of duplicate frequency navaids within range, over-the-horizon navaids, and use of navaids with poor geometry. Note 2: Further guidance may be found in EUROCAE ED-75B/RTCA DO-236B, Section 3.7.3.1.
18	Failure Annunciation. The aircraft must provide a means to annunciate failures of any aircraft component of the RNAV system, including navigation sensors. The annunciation must be visible to the pilot and located in the primary field of view.
19	Navigation Database status: The system should provide the means to display the validity period of the navigation database to the flight crew.

Item	Function/Feature
	Path Definition and Flight Planning
20	Maintaining Track and Leg Transitions. The aircraft must have the capability to execute leg transitions and maintain tracks consistent with the following paths: i) A geodesic line between two fixes (TF) ii) A direct path to a fix (DF) iii) A specified track to a fix, defined by a course (CF) Note 1: Industry standards for these paths can be found in RTCA DO-236B and ARINC Specification 424, which refer to them as TF, DF, CF path terminators. EUROCAE ED-75A/RTCA DO-236B and EUROCAE ED-77/RTCA DO-201A describe the application of these paths in more detail. *Note 2: Use of CF may be acceptable in missed approach only, subject to local approval.*
21	Fly-By and Fly-Over Fixes. The aircraft must have the capability to execute fly-by and fly-over fixes. The fly-over turn does not provide for repeatable paths, and is not compatible with RNP flight tracks. The fly-by turn may be used for limited RNP AR path changes under TF-TF or DF-TF transitions subject to procedure design requirements. When fly-by turns are required for specific RNP AR operations, the navigation system must limit the path definition within the theoretical transition area defined in RTCA DO-236B under the wind conditions identified in the ICAO PBN RNP AR Procedure Design Manual Doc 9905.
22	Waypoint Resolution Error. The navigation database must provide sufficient data resolution to ensure the navigation system achieves the required accuracy. Waypoint resolution error must be less than or equal to 60 feet, including both the data storage resolution and the RNAV system computational resolution used internally for construction of flight plan waypoints. The navigation database must contain vertical angles (flight path angles) stored to a resolution of hundredths of a degree, with equivalent computational resolution.
23	Capability for a "Direct-To" Function. The navigation system must have a "Direct-To" function the flight crew can activate at any time. This function must be available to any fix. The navigation system must also be capable of generating a geodesic path to the designated "To" fix, without "S-turning" and without undue delay.
24	Capability to define a vertical path. The navigation system must be capable of defining a vertical path by a flight path angle to a fix. The system must also be capable of specifying a vertical path between altitude constraints at two fixes in the flight plan. Fix altitude constraints must be defined as one of the following: i) An "AT or ABOVE" altitude constraint (for example, 2400A, may be appropriate for situations where bounding the vertical path is not required); ii) An "AT or BELOW" altitude constraint (for example, 4800B, may be appropriate for situations where bounding the vertical path is not required); iii) An "AT" altitude constraint (for example, 5200); or iv) A "WINDOW" constraint (for example, 2400A3400B); Note: For RNP AR procedures, any segment with a published vertical path will define that path based on an angle to the fix and altitude.

Item	Function/Feature
25	Altitudes and/or speeds associated with published terminal procedures must be extracted from the navigation database.
26	The system must be able to construct a path to provide guidance from current position to a vertically constrained fix.
27	Capability to Load Procedures from the Navigation Database. The navigation system must have the capability to load the entire procedure(s) to be flown into the RNAV system from the onboard navigation database. This includes the approach (including vertical angle), the missed approach and the approach transitions for the selected airport and runway.
28	Means to Retrieve and Display Navigation Data. The navigation system must provide the ability for the flight crew to verify the procedure to be flown through review of the data stored in the onboard navigation database. This includes the ability to review the data for individual waypoints and for navigation aids.
29	Magnetic Variation. For paths defined by a course (CF path terminator), the navigation system must use the magnetic variation value for the procedure in the navigation database.
30	Changes in Navigation accuracy. RNP changes to lower navigation accuracy must be complete by the fix defining the leg with the lower navigation accuracy, considering the alerting latency of the navigation system. Any operational procedures necessary to accomplish this must be identified.
31	Automatic Leg Sequencing. The navigation system must provide the capability to automatically sequence to the next leg and display the sequencing to the flight crew in a readily visible manner.
32	A display of the altitude restrictions associated with flight plan fixes must be available to the pilot. If there is a specified navigation database procedure with a flight path angle associated with any flight plan leg, the equipment must display the flight path angle for that leg.
	Navigation Database
33	The aircraft navigation system must use an on-board navigation database containing current navigation data officially promulgated for civil aviation by a certified AIS provider, which can: a) be updated in accordance with the AIRAC cycle and b) from which terminal airspace procedures can be retrieved and loaded into the RNAV system. The resolution to which the data is stored must be sufficient to ensure that the assumption of no path definition error is satisfied. The database must be protected against flight crew modification of the stored data. 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 system. However, the procedure stored in the database must not be modified and must remain intact within the database for future use and reference.

Table 1: Required Functions

7.2 ADDITIONAL REQUIRED FUNCTIONS SUPPORTING RNP AR OPERATIONS

Table 2 lists and describes the system functions and features required for more demanding operations e.g. where RNP AR operations are predicated on use of RF legs, RNP less than 0.3 or RNP less than 1.0 on missed approach.

Item	Operation/Function
	Where RNP AR Operations use RF Legs:
1	(1) The navigation system must have the capability to execute leg transitions and maintain tracks consistent with an RF leg between two fixes. (2) The aircraft must have an electronic map display of the selected procedure. (3) The navigation system, the flight director system and autopilot must be capable of commanding a bank angle up to 25 degrees at or above 400 feet AGL and up to 8 degrees below 400 feet AGL. (These values are consistent with those published in the ICAO Doc 9905). (4) Upon initiating a go-around or missed approach (through activation of TOGA or other means), the flight guidance mode should remain in LNAV to enable continuous track guidance during an RF leg. Other means or mitigations may be acceptable depending on the aircraft, demonstrated path tracking performance, procedures and associated FOSA for go-around and missed approach procedures that require an RNP 0.3 or greater. (5) When evaluating flight technical error on RF legs, the effect of rolling into and out of the turn should be considered. The procedure is designed to provide 5 degrees of manoeuvrability margin, to enable the aircraft to get back on the desired track after a slight overshoot at the start of the turn. Note: It should be noted that a radius to fix (RF) leg is considered a procedure design tool that is available to solve a specific operational requirement or problem. As such it may be considered a highly desired option for select RNP AR operations. In some instances, the RF will be applied in the final or missed approach, requiring additional consideration in a FOSA. Systems lacking such capability should have sufficient means to ensure that operators are aware of this limitation and that it precludes the conduct of RNP AR procedures containing an RF leg.

	Where RNP AR Operations are less than RNP 0.3:
2	(1) *No single-point-of-failure*. No single-point-of-failure can cause the total loss of guidance compliant with the navigation accuracy associated with the approach. Typically, the aircraft must have at least the following equipment: dual GNSS sensors, dual flight management systems, dual air data systems, dual autopilots, and a single inertial reference unit (IRU). A single autopilot is acceptable provided dual independent flight directors are available and the approach permits use of the flight directors to either continue the approach or execute a missed approach. Note: If automatic switching is not available, it must be demonstrated that the time required to switch to an alternate system does not result in the aircraft exceeding the RNP value. (2) *Hazardous Failure*. The system design must be consistent with at least a hazardous failure condition (as per AMC 25-1309) for the loss or display of misleading of lateral or vertical guidance. (3) *Go-around guidance*. Upon initiating a go-around or missed approach (through activation of TOGA or other means), the flight guidance mode should remain in LNAV to enable continuous track guidance during an RF leg. (4) *Loss of GNSS.* After initiating a go-around or missed approach following loss of GNSS, the aircraft must automatically revert to another means of navigation that complies with the navigation accuracy for the time necessary to fly the go-around or the missed approach.
	Where Missed Approach are less than RNP 1.0
3	(1) *Single-point-of-failure*. No single-point-of-failure can cause the total loss of guidance compliant with the navigation accuracy associated with a missed approach procedure. Typically, the aircraft must have at least the following equipment: dual GNSS sensors, dual flight management systems, dual air data systems, dual autopilots, and a single inertial reference unit (IRU). A single autopilot is acceptable provided dual independent flight directors are available and the approach permits use of the flight directors to either continue the approach or execute a missed approach. Note: If automatic switching is not available, it must be demonstrated that the time required to switch to an alternate system does not result in the aircraft exceeding the RNP value. (2) *Major Failure.* The system design assurance must be consistent with at least a major failure condition (as per AMC 25.1309) for the loss of lateral or vertical guidance. (3) *Go-Around Guidance*. Upon initiating a go-around or missed approach (through activation of TOGA or other means), the flight guidance mode should remain in LNAV to enable continuous track guidance during an RF leg. For go-around and missed approach procedures that require an RNP 0.3 or greater other means and/or mitigations may be acceptable depending on the aircraft, demonstrated path tracking performance, procedures and associated FOSA. (4) *Loss of GNSS.* After initiating a go-around or missed approach following loss of GNSS, the aircraft must automatically revert to another means of navigation that complies with the navigation accuracy for the time necessary to fly the go-around or the missed approach.

Table 2: Procedure Specific Required Functions

8 AIRWORTHINESS COMPLIANCE

8.1 GENERAL

The following compliance guidelines assume that the aircraft is equipped in accordance with EU-OPS 1 Sub-part L for IFR flight for aeroplanes involved in commercial air transportation, or equivalent national requirements for aircraft outside the scope of EU-OPS.

Due to the unique requirements for RNP AR operations and the need for crew procedures that are specific to each particular aircraft and navigation system, RNP AR operational support documentation is required from the manufacturer. The document(s) should describe the navigation capabilities of applicant's aircraft in the context of RNP AR operations, and provide all the assumptions, limitations and supporting information necessary for the safe conduct of RNP AR operations.

It is expected that operators will use the manufacturer recommendations when developing their procedures and application for approval. Installation of equipment is not sufficient by itself to obtain approval for use on RNP AR.

8.1.1 New or Modified Installations

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

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

b) Aircraft Qualification

(1) 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 6.2.2 and if applicable paragraph 7.2), 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.

(2) Use of the RNAV systems and the manner of presentation of lateral and vertical guidance information on the flight deck must be evaluated to show that the risk of flight crew error has been minimised. In particular, during the transition to the final approach, the display of ILS or other approved landing system information simultaneously with RNAV information to a flight crew member will need careful consideration.

(3) Equipment failure scenarios involving conventional navigation sensors and the RNAV system(s) must be evaluated to demonstrate that adequate alternative means of navigation are available following failure of the RNAV system, and that reversionary switching arrangements do not lead to misleading or unsafe display configurations. The evaluation must consider also the probability of failures within the switching arrangements.

(4) The coupling arrangements for the RNAV system to flight director/automatic pilot must be evaluated to show compatibility and that operating modes, including RNAV system failures modes and RNP alerts, are clearly and unambiguously indicated to the flight crew.

(5) To comply with Section 7, Table 1, item 20. (in particular when intercepting a CF leg) must be shown to be possible without the need for manual intervention,

i.e. without disengaging the RNAV mode, and then a manual course selection. This does not preclude means for manual intervention when needed.

(6) MEL requirements and maintenance procedures should be consistent with the aircraft RNP systems availability and performance requirements.

8.1.2 Existing Installations

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 Section 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 will be required. Paragraph 9 addresses Aircraft Flight Manual changes that might be necessary.

8.2 DATABASE INTEGRITY

The navigation database should be shown to comply with EUROCAE ED-76/RTCA DO-200A, or equivalent approved procedures.

8.3 USE OF GPS

a) The sensor must comply with the guidelines in AC 20-138(). For systems that comply with AC 20-138(), the following sensor accuracies can be used in the total system accuracy analysis without additional substantiation: GPS sensor accuracy is better than 36 meters (95%), and augmented GPS (GBAS or SBAS) sensor accuracy is better than 2 meters (95%).

b) In the event of a latent GPS satellite failure and marginal GPS satellite geometry (e.g. Horizontal Integrity Limit (HIL) equal to the horizontal alert limit), the probability that the aircraft remains within the obstacle clearance volume used to evaluate the procedure must be greater than 95% (both laterally and vertically).

Note: GNSS-based sensors output a HIL, also known as a Horizontal Protection Level (HPL) (see FAA AC 20-138A Appendix 1 and RTCA/DO-229C for an explanation of these terms). The HIL is a measure of the position estimation error assuming a latent failure is present. In lieu of a detailed analysis of the effects of latent failures on the total system error, an acceptable means of compliance for GNSS-based systems is to ensure the HIL remains less than twice the navigation accuracy, minus the 95% of FTE, during the RNP AR operation.

8.4 USE OF INERTIAL REFERENCE SYSTEM (IRS)

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

Note 1: Integrated GPS/INS position solutions reduce the rate of degradation after loss of position updating. For "tightly coupled" GPS/IRUs, RTCA/DO-229C, Appendix R, provides additional guidance.

Note 2: INS/IRS by itself is not considered suitable for the types of RNP applications described herein. However, it is recognised that many multi-sensor navigation systems utilise INS/IRS within their navigation calculations to provide continuity when the other higher accuracy sensor(s) are momentarily unavailable.

8.5 USE OF DISTANCE MEASURING EQUIPMENT (DME).

Initiation of all RNP AR procedures is based on GNSS updating. Except where specifically designated on a procedure as Not Authorised, DME/DME updating can be used as a reversionary mode during the approach or missed approach when the system complies with the RNP. Aircraft manufacturer and applicants should identify any constraints on the DME infrastructure or the procedure for a given aircraft to comply with this requirement.

Note 1: In general, Distance Measurement Equipment (DME) (i.e. position updating from two or more ground stations, DME/DME) will not be sufficient to achieve RNP AR operations where the performance required is less than 0.3 NM. However, where DME is sufficient, it is expected that they meet ICAO Annex 10 to the Convention on International Civil Aviation and are listed in the AIP.

8.6 USE OF VHF OMNI-DIRECTIONAL RANGE STATION (VOR)

For the initial RNP AR implementation, the RNAV system may not use VOR updating. The manufacturer should identify any constraints on the VOR infrastructure or the procedure for a given aircraft to comply with this requirement.

Note: This requirement does not imply an equipment capability must exist providing a direct means of inhibiting VOR updating. A procedural means for the flight crew to inhibit VOR updating or executing a missed approach if reverting to VOR updating may meet this requirement.

8.7 INTERMIXING OF EQUIPMENT

Installation of area navigation 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. There can be problems even when intermixing different versions of the same equipment. For approach operations, intermixing of RNAV equipment will only be permitted when specific factors have been addressed satisfactorily. As a minimum, consideration must be given to the following potential incompatibilities particularly where the flight deck architecture includes cross coupling capabilities (e.g. GNSS-2 switched to drive the number 1 displays).

a) Data entry: The two systems must have consistent methods of data entry, and similar pilot procedures for accomplishing common tasks. Any differences should be evaluated for pilot workload. If the wrong procedures are used, (for example, the data entry procedures for the offside system are used by mistake for the onside), there must be no misleading information and it must be easy to identify and recover from the mistake.

b) CDI scaling: Sensitivity must be consistent or annunciated.

c) Display symbology and mode annunciation: There must be no conflicting symbols or annunciation (e.g. a common symbol used for two different purposes), and differences should be specifically evaluated to evaluate the potential confusion they may cause.

d) Mode logic: The modes internal to the equipment and their interface to the rest of the aircraft must be consistent.

e) Equipment failure: The effect of failure of one unit must not result in misleading information.

f) Displayed data: The display of primary navigation parameters must use consistent units and a consistent notation.

g) Database differences: Due to the inherent data conflict, differences in the area navigation database will not be 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 operation or having specific statement of RNP capability. 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 RNP operations.

b) Appropriate amendments or supplements to cover RNP operations in the following sections:

- Limitations – including use of 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 or 'UNABLE REQ NAV PERF', 'NAV ACCUR DOWNGRAD', (or equivalent) or other RNP messages).

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 OPERATIONAL CRITERIA

10.1 GENERAL

This section plus the considerations provided in APPENDIX 3 are provided to assist an operator in developing the necessary processes and materials supporting their application for an operational approval to conduct RNP AR operations. This includes standard operating procedures, flight operations documentation and training package. The operational criteria assume that the corresponding installation/airworthiness approval has been granted by the Agency.

Operations of the RNAV system should be in accordance with the AFM or AFM supplement. The (Master) Minimum Equipment List (MMEL/MEL) should be amended to identify the minimum equipment necessary to satisfy operations using the RNAV system.

10.2 FLIGHT OPERATIONS DOCUMENTATION

The relevant parts and sections of the Operations Manual and check lists must be revised to take account of the operating procedures detailed below (Normal Procedures and Abnormal Procedures). The operator must make timely amendments to the Operations Manual to reflect relevant RNAV AR procedure and database checking strategies. Manuals and check lists need to be submitted for review by the responsible authority as part of the approval process.

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

10.3 QUALIFICATION AND TRAINING

Each pilot should receive appropriate training, briefings and guidance material in order to safely conduct RNP AR procedures. The material and training should cover the normal and abnormal procedures. Standard training and checking such as recurrent training and proficiency checks should include RNP procedures. Based on this, the operator should determine what constitutes a qualified crew.

The operator should ensure that effective methods are used to implement applicable RNP AR procedures to ensure that in line operations each pilot can perform assigned duties reliably and expeditiously for each procedure to be flown, both in normal circumstances, and for probable non-normal circumstances. Additional guidance is provided in APPENDIX 2 and 3, as well as the RNP AR APCH navigation specification contained in the ICAO Performance Based Navigation Manual, Volume II.

10.4 Navigation Database Management

10.4.1 Initial Data Validation

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

a) Compare the navigation data for the procedure(s) to be loaded into the flight management system with the published procedure.

b) Validate the loaded navigation data for the procedure, either in a simulator or in the actual aircraft in visual meteorological conditions (VMC). The depicted procedure on the map display must be compared to the published procedure. The entire procedure must be flown to ensure the path is flyable, does not have any apparent lateral or vertical path disconnects, and is consistent with the published procedure.

c) Once the procedure is validated, retain and maintain a copy of the validated navigation data for comparison to subsequent data updates.

10.4.2 Operator involved in the operation of aeroplanes for commercial air transportation

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

10.4.3 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) is 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.

10.4.3.1 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.

10.4.3.2 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.

10.4.3.3 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.

10.4.4 Aircraft Modifications

If an aircraft system required for RNP AR operations is modified (e.g. software change), the operator is responsible for validation of RNP AR procedures with the navigation database and the modified system. This may be accomplished without any direct evaluation if the manufacturer verifies that the modification has no effect on the navigation database or path computation. If no such assurance from the manufacturer is available, the operator must conduct initial data validation with the modified system.

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, 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 database 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.

10.6 FLEET APPROVALS

Normally, operational approvals for RNAV AR Procedures will be fleet specific.

10.7 RNP MONITORING PROGRAMME

The operator should have an RNP monitoring programme to ensure continued compliance with the guidance of this AMC and to identify any negative trends in performance. At a minimum, this programme must address the following information.

During the initial 90 day interim approval period, the operator must submit the following information every 30 days to the authority granting their authorisation. Thereafter, the operator must continue to collect and periodically review this data to identify potential safety concerns, and maintain summaries of this data.

a) Total number of RNP AR procedures conducted

b) Number of satisfactory approaches by aircraft/system (Satisfactory if completed as planned without any navigation or guidance system anomalies)

c) Reasons for unsatisfactory approaches, such as:

   1) UNABLE REQ NAV PERF, NAV ACCUR DOWNGRAD, or other RNP messages during approaches

   2) Excessive lateral or vertical deviation

   3) TAWS warning

   4) Autopilot system disconnect

   5) Nav data errors

   6) Pilot report of any anomaly

d) Crew comments

APPENDIX 1 GLOSSARY

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

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.

Note: RNAV functional capability is typically viewed as navigation operations in the horizontal plane, which is known also as Lateral Navigation Mode. However, an RNAV system may include functional capabilities for operations in the vertical plane, known as Vertical Navigation Mode.

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.

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.

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.

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

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

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.

The following acronyms are used in the document:

AFM	Aircraft Flight Manual
AGL	Above Ground level
AIP	Aeronautical Information Publication
AIRAC	Aeronautical information regulation and control
AP	Autopilot
APCH	Approach
AR	Authorisation Required
ATC	Air Traffic Control
ATS	Air Traffic Service
BARO	Barometric
CAT	Category
CDI	Course Deviation Indicator
CF	Course to Fix
CRM	Collision risk model
CRM	Crew resource management
DA/H	Descent Altitude/Height
DF	Direct to Fix
DME	Distance Measuring Equipment
EC	European Commission
EFIS	Electronic flight instrument system
EGNOS	European Geostationary Navigation Overlay Service
ETA	Estimated Time of Arrival
EU	European Union
FAF	Final Approach Fix
FD	Flight Director
FOM	Flight Operations Manual
FMC	Flight Management Computer
FMS	Flight Management System
F/O	First Officer
FOSA	Flight Operations Safety Assessment
FTE	Flight Technical Error
GBAS	Ground-based augmentation system
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GPWS	Ground Proximity Warning System
HIL	Horizontal Integrity Limit
HSI	Horizontal situation indicator
IAF	Initial Approach Fix
IAP	Instrument approach procedure
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument meteorological conditions
INS	Inertial Navigation System
IRS	Inertial Reference System
IRU	Inertial Reference Unit
ISA	International standard atmosphere
KIAS	Knots indicated airspeed
LoA	Letter of Acceptance
LOE	Line Oriented Evaluation
LOFT	Line Oriented Flight Training
LNAV	Lateral Navigation
MASPS	Minimum Aviation System Performance Standards
MEL	Minimum Equipment List
MMEL	Master Minimum Equipment List
NAV	Navigation

NM	Nautical Mile
NOTAM	Notice to Airmen
OEI	One Engine Inoperative
OEM	Original Equipment Manufacture
PBN	Performance Based Navigation
PC	Proficiency Check
POH	Pilot Operating Handbook
PT	Proficiency Training
RAIM	Receiver Autonomous Integrity Monitoring
RF	Radius to Fix
RNAV	Area Navigation
RNP	Required Navigation Performance
RTA	Required Time of Arrival
SBAS	Satellite-based augmentation system
SSA	System Safety Assessments
STC	Supplemental Type Certificates
TAWS	Terrain Awareness Warning System
TC	Type Certificates
TERPS	Terminal Instrument Procedures
TF	Track to Fix
TLS	Target Level Of Safety
TOGA	Take off/Go around
VDI	Vertical Deviation Indicator
VEB	Vertical Error Budget
VMC	visual meteorological conditions
VNAV	Vertical Navigation
VOR	VHF Omni-directional Range
WGS	World Geodetic System

APPENDIX 2 TRAINING AND CREW QUALIFICATION ISSUES

1 INTRODUCTION

The operator must provide training for key personnel (e.g. flight crewmembers and dispatchers) in the use and application of RNP AR procedures. A thorough understanding of the operational procedures and best practices is critical to the safe operation of aircraft during RNP AR operations. This programme must provide sufficient detail on the aircraft's navigation and flight control systems to enable the pilots to identify failures affecting the aircrafts RNP capability and the appropriate abnormal/emergency procedures. Required training must include both knowledge and skill assessments of the crewmembers and dispatchers duties.

1.1 FLIGHT CREW TRAINING

a) Each operator is responsible for the training of flight crews for the specific RNP AR operations exercised by the operator. The operator must include training on the different types of RNP AR procedures and required equipment. Training must include discussion of RNP AR regulatory requirements. The operator must include these requirements and procedures in their flight operations and training manuals (as applicable). This material must cover all aspects of the operator's RNP AR operations including the applicable AR authorisation. An individual must have completed the appropriate ground and or flight training segment before engaging in RNP AR operations.

b) Flight training segments must include training and checking modules representative of the type of RNP AR operations the operator conducts during line flying activities. Many operators may train for RNP AR procedures under the established training standards and provisions for any advanced qualification programmes. They may conduct evaluations in Line Oriented Flight Training (LOFT) scenarios, selected event training scenarios or in a combination of both. The operator may conduct required flight-training modules in Flight Training Devices, Aircraft Simulators, and other enhanced training devices as long as these training mediums accurately replicate the operator's equipment and RNP AR operations.

1.2 FLIGHT CREW QUALIFICATION TRAINING

a) Operators must address initial RNP AR training and qualifications during initial, transition, upgrade, recurrent, differences, or stand-alone training and qualification programmes in a respective qualification category. The qualification standards assess each pilot's ability to properly understand and use RNP AR procedures. The operator must also develop recurrent qualification standards to ensure their flight crews maintain appropriate RNP AR knowledge and skills (RNP AR Recurrent Qualification).

b) Operators may address RNP AR operation topics separately or integrate them with other curriculum elements. For example, an RNP AR flight crew qualification may key on a specific aircraft during transition, upgrade, or differences courses. General training may also address RNP AR qualification (e.g. during recurrent training or checking events such as recurrent proficiency check/proficiency training (PC/PT), line oriented evaluation (LOE) or special purpose operational training. A separate, independent RNP AR qualification programme may also address RNP AR training (e.g. by completion of a special RNP AR curriculum at an operator's training centre or at designated crew bases).

c) Operators intending to receive credit for RNP training, when their proposed programme relies on previous training (e.g. Special RNP IAP's) must receive specific authorisation from their approving authority. In addition to the current RNP training programme, the operator will need to provide differences training between existing training programme and the RNP AR training requirements.

1.3 FLIGHT DISPATCHER TRAINING

Training for flight dispatchers must include: training on the different types of RNP AR procedures, the importance of specific navigation equipment and other equipment during RNP AR operations and discuss RNP AR regulatory requirements and procedures. Dispatcher procedure and training manuals must include these requirements (as applicable). This material must cover all aspects of the operator's RNP AR operations including the applicable authorisation. An individual must have completed the appropriate training course before engaging in RNP AR operations. Additionally, the dispatchers' training must address how to determine: RNP AR availability (considering aircraft equipment capabilities), MEL requirements, aircraft performance, and navigation signal availability (e.g. GPS RAIM/predictive RNP capability tool) for destination and alternate airports.

2 GROUND TRAINING SEGMENTS

Ground training segments must address the following subjects as training modules in approved RNP AR academic training during the initial introduction of a crewmember to RNP AR systems and operations. For recurrent programmes, the curriculum need only review initial curriculum requirements and address new, revised, or emphasised items.

2.1 GENERAL CONCEPTS OF RNP AR OPERATION

RNP AR academic training must cover RNP AR systems theory to the extent appropriate to ensure proper operational use. Flight crews must understand basic concepts of RNP AR systems operation, classifications, and limitations. The training must include general knowledge and operational application of RNP AR instrument approach procedures. This training module must address the following specific elements:

a) Definitions of RNAV, RNAV (GPS), RNP, RNP AR, RAIM, and containment areas.

b) The differences between RNAV and RNP.

c) The types of RNP AR approach procedures and familiarity with the charting of these procedures.

d) The programming and display of RNP and aircraft specific displays (e.g. Actual Navigation Performance).

e) How to enable and disable the navigation updating modes related to RNP.

f) RNP values appropriate for different phases of flight and RNP AR instrument procedures and how to select (if required).

g) The use of GPS RAIM (or equivalent) forecasts and the effects of RAIM "holes" on RNP AR procedures (flight crew and dispatchers).

h) When and how to terminate RNP navigation and transfer to traditional navigation due to loss of RNP and/or required equipment.

i) How to determine if the FMC database is current and contains required navigational data.

j) Explanation of the different components that contribute to the total system error and their characteristics (e.g. effect of temperature on BARO-VNAV, drift characteristics when using IRU with no radio updating, considerations in making suitable temperature corrections for altimeter systems).

k) Temperature Compensation. Flight crews operating avionics systems with compensation for altimetry errors introduced by deviations from ISA may disregard the temperature limits on RNP AR procedures, if pilot training on use of the temperature compensation function is provided by the operator and the compensation function is utilised by the crew. However the training must also recognise the temperature compensation by the system is applicable to the VNAV guidance and is not a substitute for the flight crew compensating for the cold temperature effects on minimum altitudes or the decision altitude.

l) The effect of wind on aircraft performance during RNP AR procedures and the need to positively remain within RNP containment area, including any operational wind limitation and aircraft configuration essential to safely complete an RNP AR procedure.

m) The effect of groundspeed on compliance with RNP AR procedures and bank angle restrictions that may impact the ability to remain on the course centreline. For RNP procedures aircraft are expected to maintain the standard speeds associated with applicable category.

n) Relationship between RNP and the appropriate approach minima line on an approved published RNP AR procedure and any operational limitations if the available RNP degrades or is not available prior to an approach (this should include flight crew procedures outside the FAF versus inside the FAF).

o) Understanding alerts that may occur from the loading and use of improper RNP values for a desired segment of an RNP AR procedure.

p) Understanding the performance requirement to couple the autopilot/flight director to the navigation system's lateral guidance on RNP AR procedures requiring an RNP of less than RNP 0.3.

q) The events that trigger a missed approach when using the aircraft's RNP capability to complete an RNP AR procedure.

r) Any bank angle restrictions or limitations on RNP AR procedures.

s) Ensuring flight crews understand the performance issues associated with reversion to radio updating, know any limitations on the use of DME and VOR updating.

2.2 ATC COMMUNICATION AND COORDINATION FOR USE OF RNP AR

Ground training must instruct the flight crews on proper flight plan classifications and any Air Traffic Control (ATC) procedures applicable to RNP AR operations. The flight crews must receive instruction on the need to advise ATC immediately when the performance of the aircraft's navigation system is no longer suitable to support continuation of an RNP AR procedure. Flight crews must also know what navigation sensors form the basis for their RNP AR compliance, and they must be able to assess the impact of failure of any avionics or a known loss of ground systems on the remainder of the flight plan.

2.3 RNP AR EQUIPMENT COMPONENTS, CONTROLS, DISPLAYS, AND ALERTS

Academic training must include discussion of RNP terminology, symbology, operation, optional controls, and display features including any items unique to an operator's implementation or systems. The training must address applicable failure alerts and limitations. The flight crews and dispatchers should achieve a thorough understanding of the equipment used in RNP operations and any limitations on the use of the equipment during those operations.

2.4 AFM INFORMATION AND OPERATING PROCEDURES

The AFM or other aircraft eligibility evidence must address normal and abnormal flight crew operating procedures, responses to failure alerts, and any limitations, including related information on RNP modes of operation. Training must also address contingency procedures for loss or degradation of RNP capability. The flight operations manuals approved for use by the flight crews (e.g. Flight Operations Manual (FOM) or Pilot Operating Handbook (POH)) should contain this information.

a) Temporary Limitations on Minima. Where Operators are new to RNP operations and whose initial application is for RNP < 0.3, it is appropriate to establish a temporary limitation for minima consistent with RNP 0.3, until operational experience is gained. This period could be based upon time (i.e. 90 days) and/or number of conducted operations (e.g. 100 RNP approaches), as agreed upon by the regulator and operator.

2.5 MEL OPERATING PROVISIONS

Flight crews must have a thorough understanding of the MEL requirements supporting RNP AR operations.

3 FLIGHT TRAINING SEGMENTS

In addition to the academic training, the flight crews must receive appropriate operational use training. Training programmes must cover the proper execution of RNP AR procedures in concert with the OEM's documentation. The operational training must include RNP AR procedures and limitations; standardisation of the set-up of the cockpit's electronic displays during an RNP AR procedure; recognition of the aural advisories, alerts and other annunciations that can impact compliance with an RNP AR procedure; and the timely and correct responses to loss of RNP AR capability in a variety of scenarios embracing the breadth of the RNP AR procedures the operator plans to complete. Such training may also use approved flight training devices or simulators. This training must address the following specific elements:

a) Procedures for verifying that each pilot's altimeter has the current setting before beginning the final approach of an RNP AR procedure, including any operational limitations associated with the source(s) for the altimeter setting and the latency of checking and setting the altimeters for landing.

b) Use of aircraft RADAR, TAWS, GPWS, or other avionics systems to support the flight crew's track monitoring and weather and obstacle avoidance.

c) Concise and complete flight crew briefings for all RNP AR procedures and the important role Cockpit Resource Management (CRM) plays in successfully completing an RNP AR procedure.

d) The importance of aircraft configuration to ensure the aircraft maintains any required speeds during RNP AR procedures.

e) The potentially detrimental effect of reducing the flap setting, reducing the bank angle or increasing airspeeds may have on the ability to comply with an RNP AR procedure.

f) Develop flight crew knowledge and skills necessary to properly conduct RNP AR operations (RNP AR Procedure Training).

g) Ensure flight crews understand and are capable of programming and operating the FMC, autopilot, autothrottles, RADAR, GPS, INS, EFIS (including the moving map), and TAWS in support of RNP AR procedures.

h) Handling of TOGA while in a turn.

i) Monitoring of FTE and related go-around operation.

j) Handling of loss of GPS during a procedure.

k) Flight crew contingency procedures for a loss of RNP capability during a missed approach. Due to the lack of navigation guidance, the training should emphasise the flight crew contingency actions that achieve separation from terrain and obstacles. The operator should tailor these contingency procedures to their specific, approved AR procedures.

l) As a minimum, each pilot must complete two RNP approach procedures that employ the unique AR characteristics of the operator’s approved procedures (i.e., RF legs, RNP missed). One procedure must culminate in a transition to landing and one procedure must culminate in execution of an RNP missed approach procedure.

4 EVALUATION

4.1 INITIAL EVALUATION OF RNP AR KNOWLEDGE AND PROCEDURES

The operator must evaluate each individual flight crewmember on their knowledge of RNP AR procedures prior to employing RNP AR procedures. As a minimum, the review must include a thorough evaluation of pilot procedures and specific aircraft performance requirements for RNP AR operations. An acceptable means for this initial assessment includes one of the following:

a) An evaluation by an examiner using an approved simulator or training device.

b) An evaluation by an authorised instructor evaluator or check airman during line operations, training flights, PC/PT events, operating experience, route checks, and/or line checks.

c) Line Oriented Flight Training (LOFT)/Line Oriented Evaluation (LOE). LOFT/LOE programmes using an approved simulator that incorporates RNP AR operations that employ the unique AR characteristics (i.e., RF legs, RNP missed) of the operator’s approved procedures.

4.2 SPECIFIC ELEMENTS THAT MUST BE ADDRESSED IN THIS EVALUATION MODULE ARE:

a) Demonstrate the use of any RNP AR limits/minimums that may impact various RNP AR operations.

b) Demonstrate the application of radio-updating procedures, such as enabling and disabling ground-based radio updating of the FMC (i.e., DME/DME and VOR/DME updating) and knowledge of when to use this feature. If the aircraft's avionics do not include the capability to disable radio updating, then the training must ensure the flight crew is able to accomplish the operational actions that mitigate the lack of this feature.

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

d) Demonstrate the ability to read and adapt to a RAIM (or equivalent) forecast including forecasts predicting a lack of RAIM availability.

e) Demonstrate the proper setup of the FMC, the weather RADAR, TAWS, and moving map for the various RNP AR operations and scenarios the operator plans to implement.

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

g) Demonstrate knowledge of and ability to perform an RNP AR missed approach procedure in a variety of operational scenarios (i.e., loss of navigation or failure to acquire visual conditions).

h) Demonstrate speed control during segments requiring speed restrictions to ensure compliance with an RNP AR procedure.

i) Demonstrate competent use of RNP AR approach plates, briefing cards, and checklists.

j) Demonstrate the ability to complete a stable RNP AR approach: bank angle, speed control, and remaining on the procedure's centreline.

k) Know the operational limit for deviation below the desired flight path on an RNP AR approach and how to accurately monitor the aircraft's position relative to vertical flight path.

5 RECURRENT TRAINING OF RNP AR KNOWLEDGE AND PROCEDURES

5.1 RNP AR Recurrent Training. The operator should incorporate recurrent RNP training that employs the unique AR characteristics of the operator's approved procedures as part of the overall programme.

5.2 A minimum of two RNP AR approaches must be flown by each pilot for each duty position (pilot flying and pilot monitoring), with one culminating in a landing and one culminating in a missed approach, and may be substituted for any required "precision-like" approach.

NOTE: Equivalent RNP approaches may be credited toward this requirement

APPENDIX 3 RNP OPERATIONAL CONSIDERATIONS

1 GENERAL

This appendix provides an acceptable means to conduct of RNP operations where authorisation is required (AR). In addition, the operator must continue to ensure they comply with the general RNAV operating requirements; checking Notices to Airmen (NOTAMS), availability of Navigational Aids (NAVAID), airworthiness of aircraft systems, and aircrew qualification.

2 OPERATIONAL CONSIDERATIONS

a) Minimum Equipment List. Operators minimum equipment list should be developed/revised to address the equipment requirements for RNP instrument approaches. Guidance for these equipment requirements is available from the aircraft manufacturer. The required equipment may depend on the intended navigation accuracy and whether or not the missed approach requires RNP less than 1.0. For example, GNSS and autopilot are typically required for small navigation accuracy. Dual equipment is typically required for approaches when using a line of minima less than RNP-0.3 and/or where the missed approach has an RNP less than 1.0. An operable Class A Terrain Awareness Warning System (TAWS) is required for all RNP AR approach procedures. It is recommended that the TAWS use altitude that is compensated for local pressure and temperature effects (e.g. corrected barometric and GNSS altitude), and include significant terrain and obstacle data. The flight crew must be cognisant of the required equipment.

b) Autopilot and Flight Director. RNP procedures with RNP values less than RNP 0.3 or with RF legs require the use of autopilot or flight director driven by the RNAV system in all cases. Thus, the autopilot/flight director must operate with suitable accuracy to track the lateral and vertical paths required by a specific RNP AR approach procedure. When the dispatch of a flight is predicated on flying an RNP AR approach requiring the autopilot at the destination and/or alternate, the flight crew must determine that the autopilot is installed and operational.

c) Dispatch RNP Assessment. The operator should have a predictive performance capability, which can determine whether or not the specified RNP will be available at the time and location of a desired RNP operation. This capability can be a ground service and need not be resident in the aircraft's avionics equipment. The operator should establish procedures requiring use of this capability as both a pre-flight dispatch tool and as a flight-following tool in the event of reported failures. The RNP assessment should consider the specific combination of the aircraft capability (sensors and integration), as well as their availability.

(1) RNP assessment when GNSS updating. This predictive capability must account for known and predicted outages of GNSS satellites or other impacts on the navigation system's sensors. The prediction programme should not use a mask angle below 5 degrees, as operational experience indicates that satellite signals at low elevations are not reliable. The prediction must use the actual GPS constellation with the (RAIM) (or equivalent) algorithm identical to that used in the actual equipment. For RNP AR approaches with high terrain, use a mask angle appropriate to the terrain.

(2) Initially, RNP AR approach procedures require GNSS updating.

d) NAVAID Exclusion. The operator should establish procedures to exclude NAVAID facilities in accordance with NOTAMs (e.g. DMEs, VORs, localisers). Internal avionics reasonableness checks may not be adequate for RNP operations.

e) Navigation Database Currency. During system initialisation, pilots of aircraft equipped with an RNP-certified system, must confirm that the navigation database is current. Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle will change during flight, operators and pilots must establish procedures to ensure the accuracy of navigation data, including suitability of navigation facilities used to define the routes and procedures for flight. Traditionally, this has been accomplished by verifying electronic data against paper products. One acceptable means is to compare aeronautical charts (new and old) to verify navigation fixes prior to dispatch. If an amended chart is published for the procedure, the database must not be used to conduct the operation.

3 FLIGHT CONSIDERATIONS

a) Modification of Flight Plan. Pilots should not be authorised to fly a published RNP procedure unless it is retrievable by the procedure name from the aircraft navigation database and conforms to the charted procedure. The lateral path must not be modified; with the exception of accepting a clearance to go direct to a fix in the approach procedure that is before the FAF and that does not immediately precede an RF leg. The only other acceptable modification to the loaded procedure is to change altitude and/or airspeed waypoint constraints on the initial, intermediate, or missed approach segments flight plan fixes (e.g. to apply cold temperature corrections or comply with an ATC clearance/instruction).

b) Required Equipment. The flight crew should have either a required list of equipment for conducting RNP approaches or alternate methods to address in flight equipment failures that would prohibit RNP approaches (e.g. crew warning systems, quick reference handbook).

c) RNP Management. The flight crew's operating procedures should ensure the navigation system uses the appropriate RNP values throughout the approach. If the navigation system does not extract and set the navigation accuracy from the on-board navigation database for each leg of the procedure, then the flight crew's operating procedures must ensure that the smallest navigation accuracy required to complete the approach or the missed approach is selected before initiating the approach (e.g. before the initial approach fix (IAF)). Different IAF's may have different navigation accuracy, which are annotated on the approach chart.

d) Loss of RNP The flight crew must ensure that no loss of RNP annunciation is received prior to commencing the RNP AR approach. During the approach, if at any time a loss of RNP annunciation is received, the flight crew must abandon the RNP AR approach unless the pilot has in sight the visual references required to continue the approach.

e) Radio Updating. Initiation of all RNP AR procedures is based on GNSS updating. Except where specifically designated on a procedure as Not Authorised, DME/DME updating can be used as a reversionary mode during the approach or missed approach when the system complies with the navigation accuracy. VOR updating is not authorised at this time. The flight crew must comply with the operator's procedures for inhibiting specific facilities.

f) Approach Procedure Confirmation. The flight crew must confirm that the correct procedure has been selected. This process includes confirmation of the waypoint sequence, reasonableness of track angles and distances, and any other parameters that can be altered by the flight crew, such as altitude or speed constraints. A procedure must not be used if validity of the navigation database is in doubt. A navigation system textual display or navigation map display must be used.

g) Track Deviation Monitoring. The flight crew must use a lateral deviation indicator, flight director and/or autopilot in lateral navigation mode on RNP AR approach procedures. The flight crew of aircraft with a lateral deviation indicator must ensure that lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the various segments of the RNP AR approach procedure. All flight crew are expected to maintain procedure centrelines, as depicted by onboard lateral deviation indicators and/or flight guidance during all RNP operations described in this manual unless authorised to deviate by ATC or under emergency conditions. For normal operations, cross-track error/deviation (the difference between the RNP system computed path and the aircraft position relative to the path) should be limited to the navigation accuracy (RNP) associated with the procedure segment.

Vertical deviation should be monitored above and below the glide-path; The vertical deviation must be within ±75 feet of the glide-path during the final approach segment.

Flight crew must execute a Missed Approach if the lateral deviation exceeds 1xRNP or the vertical deviation exceeds 75 feet, unless the pilot has in sight the visual references required to continue the approach.

(1) Where a moving map, low-resolution vertical deviation indicator (VDI), or numeric display of deviations are to be used, flight crew training and procedures must ensure the effectiveness of these displays. Typically, this involves demonstration of the procedure with a number of trained crews and inclusion of this monitoring procedure in the recurrent RNP AR approach training programme.

(2) For installations that use a CDI for lateral path tracking, the aircraft flight manual (AFM) or aircraft qualification guidance should state which navigation accuracy and operations the aircraft supports and the operational effects on the CDI scale. The flight crew must know the CDI full-scale deflection value. The avionics may automatically set the CDI scale (dependent on phase of flight) or the flight crew may manually set the scale. If the flight crew manually selects the CDI scale, the operator must have procedures and training in place to assure the selected CDI scale is appropriate for the intended RNP operation. The deviation limit must be readily apparent given the scale (e.g. full-scale deflection).

h) System Cross-check. For approaches with RNP value less than RNP 0.3, the flight crew should ensure the lateral and vertical guidance provided by the navigation system is consistent with other available data and displays provided by an independent means.

Note: This cross-check may not be necessary if the lateral and vertical guidance systems have been developed and/or evaluated consistent with extremely remote failure conditions and if the normal system performance supports 1xRNP containment.

i) Procedures with RF Legs. An RNP procedure may require the ability to execute an RF leg to avoid terrain or obstacles. As not all aircraft have this capability, flight crews should be aware of whether or not they can conduct these procedures.

(1) If initiating a go-around during or shortly after the RF leg, the flight crew must be aware of the importance of maintaining the published path as closely as possible. Operational procedures are required for aircraft that do not stay in LNAV when a go-around is initiated to ensure the RNP AR APCH ground track is maintained.

(2) Pilots must not exceed the maximum airspeeds shown in Table 1 throughout the RF leg segment. For example, a Category C A320 must slow to 160 KIAS at the FAF or may fly as fast as 185 KIAS if using Category D minima. A missed approach prior to DA may require the segment speed for that segment be maintained.

Table 1: Maximum Airspeed by Segment and Category

Indicated Airspeed (Knots)					
Segment	Indicated Airspeed by Aircraft Category				
	Cat A	Cat B	Cat C	Cat D	Cat E
Initial & Intermediate (IAF to FAF)	150	180	240	250	250
Final (FAF to DA)	100	130	160	185	As Specified
Missed Approach (DA to MAHP)	110	150	240	265	As Specified
Airspeed Restriction*	As Specified				

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

j) Temperature Compensation. For aircraft with temperature compensation, flight crews may disregard the temperature limits on RNP procedures if the operator provides pilot training on the use of the temperature compensation function. Temperature compensation by the system is applicable to the VNAV guidance and is not a substitute for the flight crew compensating for the cold temperature effects on minimum altitudes or the decision altitude. Flight crews should be familiar with the effects of the temperature compensation on intercepting the compensated path described in EUROCAE ED-75B/RTCA DO-236B Appendix H.

k) Altimeter Setting. Due to the performance based obstruction clearance inherent in RNP instrument procedures, the flight crew should verify the most current airport altimeter is set prior to the final approach fix (FAF). Operators should take precautions to switch altimeter settings at appropriate times or locations and request a current altimeter setting if the reported setting may not be recent, particularly at times when pressure is reported or is expected to be rapidly decreasing. Execution of an RNP instrument procedure requires the current altimeter setting for the airport of intended landing. Remote altimeter settings are not allowed.

l) Altimeter Cross-check. The flight crew should complete an altimetry crosscheck ensuring both pilots' altimeters agree within ±100 feet prior to the final approach fix (FAF) but no earlier than when the altimeters are set for the airport of intended landing. If the altimetry cross-check fails then the procedure must not be continued.

Note: This operational cross-check is not necessary if the aircraft systems automatically compare the altitudes to within 75 feet.

m) Go-Around or Missed Approach. Where possible, the missed approach will require RNP 1.0. The missed approach portion of these procedures is similar to a missed approach of an RNP APCH procedure. Where necessary, navigation accuracy less than RNP 1.0 will be used in the missed approach. To be approved to conduct these approaches, equipage and procedures must meet criteria in paragraph 7, Table 2 (Requirements for Approaches with Missed Approach less than RNP 1.0).

(1) In many aircraft when executing a go-around or missed approach activating Take-off/Go-around (TOGA) may cause a change in lateral navigation. In many aircraft, activating TOGA disengages the autopilot and flight director from LNAV guidance, and the flight director reverts to track-hold derived from the inertial system. LNAV guidance to the autopilot and flight director should be re-engaged as quickly as possible.

(2) The flight crew procedures and training must address the impact on navigation capability and flight guidance if the pilot initiates a go-around while the aircraft is in a turn. When initiating an early go-around, the flight crew should follow the rest of the approach track and missed approach track unless issued a different clearance by ATC. The flight crew should also be aware that RF legs are designed based on the maximum true airspeed at normal altitudes, and initiating an early go-around will reduce the manoeuvrability margin and potentially even make holding the turn impractical at missed approach speeds.

(3) Upon loss of GNSS updates, the RNAV guidance may begin to "coast" on IRU, if installed, and drift, degrading the navigation position solution. Thus, when the RNP AR APCH missed approach operations rely on IRU "coasting" the inertial guidance can only provide acceptable navigation performance for a specified amount of time.

n) Contingency Procedures

(1) Failure while En Route. The aircraft RNP capability is dependent on operational aircraft equipment and GNSS satellites. The flight crew should be able to assess the impact of equipment failure on the anticipated RNP approach and take appropriate action.

(2) Failure on Approach. The operator's contingency procedures should address at least the following conditions:

a) Failure of the RNP system components, including those affecting lateral and vertical deviation performance (e.g. failures of a GPS sensor, the flight director or automatic pilot)

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

o) Engine-Out Procedures. Aircraft may demonstrate acceptable flight technical error with one engine inoperative to conduct RNP AR operations. Otherwise, flight crews are expected to take appropriate action in event of engine failure during an approach so that no specific aircraft qualification is required. The aircraft qualification should identify any performance limits in event of engine failure to support definition of appropriate flight crew procedures.

APPENDIX 4 ACCEPTABLE METHODS FOR FLIGHT TECHNICAL ERROR ASSESSMENT FOR RNP

This appendix outlines criteria for assessment of "Flight Technical Error" (FTE) related to RNP capability and other navigation applications (e.g. instrument approach capability, etc.). These criteria are available for use for FMS/EFIS based applications, RNP applications, or other navigation applications related to this AMC or as otherwise determined to be acceptable by the appropriate regulatory authority. It may be used in lieu of FTE assumptions referenced in other Advisory Circulars.

1 BACKGROUND

For RNPs of 0.3 NM or greater, industry standard default values for FTE e.g. RTCA DO-208, AC20-130, etc are used and present a convenience to an operator or applicant in enabling a quick determination of what combinations of systems, capabilities, features and performance are allowable for the conduct of operations. However, the default value is the dominant error as RNP values are reduced below 0.3 NM. As a result, use of the standard defaults limit the extent that a system may be utilised, i.e. for RNP 0.15 an FTE of 0.125 NM is assumed when coupled to an autopilot. For RNP less than 0.15 NM, the standard FTE values are insufficient such that an aircraft may not be used even with a precision source such as GNSS, until there is a reduction in FTE.

FTE estimates or assumptions are typically added to navigation system error characteristics to permit specification of "protected airspace" for obstacle clearance or aircraft-to-aircraft separation (using various mathematical statistical methods such as "Root Sum Squared"). Protected airspace may pertain to procedure obstacle clearance surfaces, establishing route or airway widths, setting oceanic track separation values, definition of ICAO Obstacle Clearance Limits, or other similar applications.

Previous FTE assessments were based on very limited samples of normal performance of a population of aircraft that included "worst case aircraft types and least capable systems" and is not representative of modern, advanced aircraft. This penalises, or does not appropriately credit, modern systems which have resulted in improved FTE performance.

Further, some assessments of FTE usually consider only "normal performance", and do not appropriately assess path displacements for "rare normal performance" (e.g. strong winds), or "non-normal performance" (e.g. flight path performance related to failures - engine failure while on RF turn, extraction, etc).

2 OBJECTIVES

A major element of aircraft and navigation system performance assessment is the proper characterisation of FTE. This appendix provides uniform criteria for assessing FTE to be used in conjunction with AC120-29A, and other relevant regulatory and industry references.

This FTE method:

a) Establishes FTE for modern aircraft in a way that provides improved pilot situation information over that provided in previous generation aircraft,

b) Comprehensively considers the factors which affect FTE,

c) Establishes a means to provide credit to an aircraft and navigation system design which includes features which provide for significantly reduced FTE,

d) Permits improved partitioning of the application and use of FTE between airworthiness assessment, operational authorisation, and procedure development and implementation (e.g. for definition of RNP routes, use of PANS-OPS or TERPS applications etc.),

e) Provides operational incentives, and consequential design incentives for good FTE performance,

f) Allows proactive rather than reactive applications (e.g. eliminate the need for lengthy and costly in service data collection)

g) Properly addresses "real" safety factors related to functional hazard assessments,

h) Establishes consistent application with the desired navigation evolution to RNP, 4D, MASPS, etc.

i) Permits the eventual introduction of new methods of risk assessment (i.e. performance based design) as alternatives to the traditional, conservative methods such as "Collision Risk Model (CRM)", and

j) Facilitates the transition to GPS, GNSS, and other modern navigation techniques.

3 CRITERIA

The criteria in the following sections provide a means for applicants to demonstrate improved FTE performance which may be used in lieu of previous standard FTE assumptions that may not be appropriate for certain modern aircraft and systems.

Items in section 4 address FTE demonstration criteria. Items in section 5 address acceptable methods for data collection and presentation of results.

4 FTE Demonstration Criteria

a) USE OF REALISTIC TASKS

Tasks selected should address relevant flight phases applicable to the FTE measurements sought (e.g. takeoff, climb, cruise, descent, approach, landing, and missed approach.). Tasks should be realistic in providing appropriate lateral, vertical, and longitudinal elements, even though capability in only one or several dimensions is being assessed. Realistic and representative procedures should be used (e.g., number of waypoints, placement of waypoints, segment geometry, leg types, etc.).

b) REPRESENTATIVE TEST METHODS AND TEST SUBJECTS

(1) TEST METHODS

An acceptable combination of analysis, simulation, and flight verification should be used to establish alternative FTE performance. A plan acceptable to the appropriate regulatory authority should be provided by the applicant prior to testing.

(2) TEST SUBJECTS

Test crews should represent an appropriate mix of flight experience, currency, and qualification (Captain, F/O, etc.).

c) PERFORMANCE ASSESSMENT

Normal performance (straight and turning flight), Rare Normal Performance (e.g. strong winds and wind gradient effects), and Non-Normal Performance (e.g. engine failure, remote and extremely remote effects) should each be considered. Functional hazard assessments should be the basis for deciding how to assess non-normal performance. Characterisation of performance should address "95%" and "limit performance" for a suitable sample size.

Emphasis should be on practical and realistic flight scenarios rather than on rigorous statistical demonstrations that may not be representative of "in service" conditions.

Successful demonstration of procedures intended for terminal area applications (e.g. approach, missed approach) may generally be considered to also cover en-route applications.

Note: Probable failures are in accordance with AMC 25-1309, and 10^{-5} per operation.

The demonstration of Flight Technical Error must be completed in a variety of operational conditions; rare-normal conditions and non-normal conditions. This should be documented in the appropriate aircraft operational support document. Realistic and representative procedures should be used (e.g. Number of waypoints, placement of waypoints, segment geometry, leg types, wind etc.). The non-normal assessment should consider the following:

(1) Acceptable criteria to be used for assessing probable failures and engine failure during the aircraft qualification is to demonstrate that the aircraft trajectory is maintained within a 1xRNP corridor laterally and 75 feet vertically.

(2) Acceptable criteria to be used for assessing remote failures during the aircraft qualification is to demonstrate that the aircraft trajectory is maintained within a 2xRNP corridor laterally and 75 feet vertically.

(3) Extremely remote failure cases should be assessed to show that under these conditions the aircraft can be safely extracted from the procedure. Failure cases might include dual system resets, flight control surface runaway and complete loss of flight guidance function while in NAV.

(4) The aircraft performance demonstration during the operational evaluations can be based on a mix of analysis and flight technical evaluation using expert judgment.

RNP AR procedures with navigation accuracy less than RNP 0.3 or with RF legs require the use of autopilot or flight director driven by the RNAV system in all cases. Thus, the autopilot/flight director must operate with suitable accuracy to track the lateral and vertical paths required by a specific RNP AR approach procedure.

d) REFERENCE PATH SELECTION

For FTE assessments a nominal path may be used (magenta line) that does not include consideration of specific navigation sensor/system anomalies (e.g. DME updating anomaly characteristics etc.). The applicant should, however, indicate how any FTE effects related to navigation system anomalies, if any, should be operationally addressed.

5 PARAMETERS TO BE MEASURED AND PRESENTATION OF RESULTS

a) FTE ASSESSMENT PARAMETER MEASUREMENT

Parameters measured should include:

(1) Pertinent lateral and vertical path displacements,

(2) Longitudinal performance as applicable (speed errors, ETA/RTA errors, etc.),

(3) Other parameters as necessary to assure realistic operational performance (bank angles, pitch attitudes, thrust changes, track/heading variation, G loading, etc.).

b) FTE ASSESSMENT METHODS

Unless otherwise agreed by the regulator, demonstrations should be based on appropriate simulations, and be verified by flight trials.

c) FTE ASSESSMENT RESULT PRESENTATION

Data may be presented in various AFM provisions related to demonstrated performance for levels of "RNP", instrument approach and landing capability, etc.

6 EXAMPLES OF REGULATORY RESPONSIBILITY FOR ASSESSMENT OF FTE AND USE OF FTE EVALUATION RESULTS

The Agency will:

a) typically conduct assessments of FTE in conjunction with Type Certification/Supplemental Type Certification (TC/STC) projects, when a TC/STC applicant has made such a request. Special circumstances may exist where assessments acceptable to the Agency will be conducted by other organisations (FAA, etc.),

b) participate in FTE assessments in conjunction with aircraft certification projects, and assure that appropriate flight standardisation provisions are identified,

c) assure proper application of FTE as specified in AFMs for particular applications (e.g. RNP authorisations),

d) address crew qualification requirements necessary to achieve the intended FTE performance.

7 FTE ASSESSMENT PROCESS

Applicants apply through normal channels to the Agency. The Agency will evaluate the application for applicable criteria and specific evaluation plans.

APPENDIX 5 FLIGHT OPERATION SAFETY ASSESSMENTS

1 SAFETY ASSESSMENT

The safety objective for RNP AR operations is to provide for safe flight operations. Traditionally, operational safety has been defined by a target level of safety and specified as a risk of collision of 10^{-7} per approach. For RNP AR approaches a flight operational safety assessment (FOSA) methodology may be used. The FOSA is intended to provide a level of flight safety that is equivalent to the traditional TLS, but using methodology oriented to performance-based flight operations. Using the FOSA, the operational safety objective is met by considering more than the aircraft navigation system alone. The FOSA blends quantitative and qualitative analyses and assessments for navigation systems, aircraft systems, operational procedures, hazards, failure mitigations, normal, rare-normal and abnormal conditions, hazards, and the operational environment. The FOSA relies on the detailed criteria for aircraft qualification, operator approval and instrument procedure design to address the majority of general technical, procedure and process factors. Additionally, technical and operational expertise and experience are essential to the conduct and conclusion of the FOSA.

An overview of the hazards and mitigations is provided to assist States in applying these criteria. Safety of RNP AR approach operations rests with the operator and the air navigation service provider as described in this chapter.

A FOSA should conducted for each RNP AR approach procedure where more stringent aspects of the nominal procedure design criteria are applied (e.g. RNP 0.1 missed approach, RF legs, and RNP missed approaches less than 1.0) or where the application of the default procedure design criteria is in an operating environment with special challenges or demands to ensure that for each specific set of operating conditions, aircraft, and environment that all failure conditions are assessed and where necessary mitigations implemented to meet the operational safety objective. The assessment should give proper attention to the inter-dependence of the elements of design, aircraft capability, crew procedures and operating environment.

The following hazard conditions are examples of some of the more significant hazards and mitigations addressed in the aircraft, operational and procedure criteria:

Normal performance: Lateral and vertical accuracy are addressed in the aircraft requirements, aircraft and systems operate normally in standard configurations and operating modes, and individual error components are monitored/truncated through system design or crew procedure.

Rare-Normal and Abnormal Performance: Lateral and vertical accuracy are evaluated for aircraft failures as part of the determination of aircraft qualification. Additionally, other rare-normal and abnormal failures and conditions for ATC operations, crew procedures, infrastructure and operating environment are also assessed. Where the failure or condition results are not acceptable for continued operation, mitigations are developed or limitations established for the aircraft, crew and/or operation.

2 AIRCRAFT FAILURES

a) System Failure: Failure of a navigation system, flight guidance system, flight instrument system for the approach, or missed approach (e.g. loss of GNSS updating, receiver failure, autopilot disconnect, FMS failure etc.). Depending on the aircraft, this may be addressed through aircraft design or operational procedure to cross-check guidance (e.g. dual equipage for lateral errors, use of terrain awareness and warning system).

b) Malfunction of air data system or altimetry: Crew procedure cross-check between two independent systems mitigates this risk.

3 AIRCRAFT PERFORMANCE

a) Inadequate performance to conduct the approach: the aircraft qualification and operational procedures ensure the performance is adequate on each approach, as part of flight planning and in order to begin or continue the approach. Consideration should be given to aircraft configuration during approach and any configuration changes associated with a go-around (e.g. engine failure, flap retraction, re-engagement of LNAV mode).

b) Loss of engine: Loss of an engine while on an RNP AR approach is a rare occurrence due to high engine reliability and the short exposure time. Operators will take appropriate action to mitigate the effects of loss of engine, initiating a go-around and manually taking control of the aircraft if necessary.

4 NAVIGATION SERVICES

a) Use of a navigation aid outside of designated coverage or in test mode: Aircraft requirements and operational procedures have been developed to address this risk.

b) Navigation database errors: Procedures are validated through flight validation specific to the operator and aircraft, and the operator is required to have a process defined to maintain validated data through updates to the navigation database.

5 ATC OPERATIONS

a) Procedure assigned to incapable aircraft: Operators are responsible for declining the clearance.

b) ATC vectors aircraft onto approach such that performance cannot be achieved: ATC training and procedures must ensure obstacle clearance until aircraft is established on the procedure, and ATC should not intercept on or just prior to a curved segments of the procedure.

6 FLIGHT CREW OPERATIONS

a) Erroneous barometric altimeter setting: Crew entry and cross-check procedures mitigate this risk.

b) Incorrect procedure selection or loading: crew procedure to verify loaded procedure matches published procedure, aircraft requirement for map display.

c) Incorrect flight control mode selected: training on importance of flight control mode, independent procedure to monitor for excessive path deviation.

d) Incorrect RNP entry: crew procedure to verify RNP loaded in system matches the published value.

e) Go-Around/Missed Approach: Balked landing or rejected landing at or below DA (H).

f) Poor meteorological conditions: Loss or significant reduction of visual reference that may result in or require a go-around.

7 INFRASTRUCTURE

a) GNSS satellite failure: This condition is evaluated during aircraft qualification to ensure obstacle clearance can be maintained, considering the low likelihood of this failure occurring.

b) Loss of GNSS signals: Relevant independent equipage (e.g. IRU) is required for RNP AR approaches with RF legs and approaches where the accuracy for the missed approach is less than 1 NM. For other approaches, operational procedures are used to approximate the published track and climb above obstacles.

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

8 OPERATING CONDITIONS

a) Tailwind conditions: Excessive speed on RF legs will result in inability to maintain track. This is addressed through aircraft requirements on the limits of command guidance, inclusion of 5 degrees of bank manoeuvrability margin, consideration of speed effect and crew procedure to maintain speeds below the maximum authorised.

b) Wind conditions and effect on flight technical error: nominal flight technical error is evaluated under a variety of wind conditions, and crew procedures to monitor and limit deviations ensure safe operation.

c) Extreme temperature effects of barometric altitude (e.g. extreme cold temperatures, known local atmospheric or weather phenomena, high winds, severe turbulence etc.): The effect of this error on the vertical path is mitigated through the procedure design and crew procedures, with an allowance for aircraft that compensate for this effect to conduct procedures regardless of the published temperature limit. The effect of this error on minimum segment altitudes and the decision altitude are addressed in an equivalent manner to all other approach operations.

APPENDIX 6 AMC 20-26/PBN Manual/AC90-101 Comparison

This appendix contains a comparison of this AMC relative to the ICAO Performance Based Navigation Manual and the US AC90-101. In general, the AC is the same as the PBN Manual Navigation Specification for RNP AR APCH. The AMC contains some differences that are noted as follows.

The matrix does not highlight the unique requirements introduced by AC 90-101 and not contained within this AMC.

Regular = Same/Comparable
Italic = areas where AMC provides additional information, guidance or criteria
ALL CAP = areas where PBN Manual is more extensive
Bold = areas where AMC is more stringent than PBN Manual and/or AC90-101 criteria

Section	AMC 20-26	Para	PBN Vol II, Chap 6	Section	AC90-101	Comment
1	Preamble					NC
1.2	Purpose	6.1.2	Purpose	1	Purpose	NC
1.2	Background	--	--	--	--	NC
2	Scope	--	--	--	--	NC
3	Reference Documents	--	--	4	Related Documents	NC
3.1	Related Requirements	--	--	--	--	NC
3.2	Related Material	--	--	2	Related CFR Sections	NC
3.2.1	ICAO	--	--	--	--	NC
3.2.2	EASA	--	--	--	--	NC
3.2.3	Eurocontrol	--	--	--	--	NC
3.2.4	FAA	--	--			NC
3.2.5	ETSO	--	--			NC
3.2.6	EUROCAE /RTCA, ARINC	--	--	--	--	NC
4	*Assumptions*	*6.2*	*ANSP Considerations*	--	--	*AMC expands assumptions for procedure design, infrastructure, publication, status monitoring, controller training, flight evaluation.*
5	System Description	--	--	--	--	NC
5.1	LNAV			--	--	NC
5.1.1		--	--	--	--	AMC descriptive info
5.1.2	*Position Determination and Sensors*	*6.3.3.2*	*Criteria for Specific Navigation Services*	*App 2, 3.a*	*Position Estimation*	*AMC has more explicit description, PBN implies more*
5.2	VNAV	--	--	--	--	AMC provides descriptive info

Section	AMC 20-26	Para	PBN Vol II, Chap 6	Section	AC90-101	Comment
5.2.2	Temperature Compensation Systems	6.3.3.2	Criteria for Specific Navigation Services, Temperature Compensation Systems	App 2, 3.a(7)	Temperature Compensation Systems	Same
6	Airworthiness Certification Objectives	--	--	--	--	AMC ties criteria to assumptions
6.1	Accuracy	6.3.3.1	System Performance, Monitoring and Alerting, Path Definition	App 2, 2.a	Path Definition	Same
6.1.1	Lateral	6.3.3.1	System Performance, Monitoring and Alerting, Lateral Accuracy	App 2, 2.b	Lateral Accuracy	More notes of clarification and expanded considerations
6.1.2	Vertical	6.3.3.1	System Performance, Monitoring and Alerting, Airspace Containment	App 2, 2.c	Vertical Accuracy	More notes of clarification and expanded considerations
6.1.2	Vertical	6.3.3.2	Criteria for Specific Navigation Services, Altimetry System Error	App 2, 3.a(6)	99.7% ASE	Same
6.1.3	**RNP System Performance**	**6.3.3.3**	**Functional Requirements, Demonstration of Path Steering Performance**	**App 2, 3.c**	**Path Steering Performance**	**AMC has More Stringent Requirements**
6.2	Integrity	--	--	--	--	--
6.2.1, a)	System	6.3.3.1	System Performance, Monitoring and Alerting, Airspace Containment	App 2, 2.d(1)	RNP and BARO-VNAV	Same
6.2.1, b)	System	6.3.3.1	System Performance, Monitoring and Alerting, Airspace Containment	App 2, 2.d(2)	Other Systems or Alternate Means of Compliance	Same
6.2.2	Display	6.3.3.3	Functional Requirements, Design Assurance	App 2, 3.e	Design Assurance	Same

Section	AMC 20-26	Para	PBN Vol II, Chap 6	Section	AC90-101	Comment
6.3	*Continuity*	--	--	--	--	*AMC contains explicit requirements. AC requirement is implied through airspace containment and predetermined through MEL requirements*
7	Functional Criteria			--	--	NC
7.1, 1	Lateral/Vertical Deviation	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(1)	Lateral/Vertical Deviation	Same
7.1, 1	For RNP < 0.3, Fixed CDI or Scaled to RNP	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(1)(a)		Unique to AMC
7.1, 1	For RNP < 0.3, Fixed CDI or Scaled to RNP	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(1)(b)		Unique to AMC
7.1, 1	Navigation Map display alternative	6.3.3.3	Functional Requirements, Displays	App 4, 3.g(1)	Moving map, VDI or numeric display of deviation	Same
7.1, 2	Identification of the Active (To) Waypoint.	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(2)	Identification of the Active (To) Waypoint.	Same
7.1, 3	Display of Distance and Bearing.	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(3)	Display of Distance and Bearing.	Same
7.1, 4	Display of Groundspeed or Time	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(4)	Display of Groundspeed or Time	Same
7.1, 5	Display of To/From the active fix.	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(5)	Display of To/From the active fix.	Same
7.1, 6	Desired Track Display	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(6)	Desired Track Display	Same
7.1, 7	Display of Aircraft Track.	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(7)	Display of Aircraft Track.	Same
7.1, 8	Slaved Course Selector	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(9)	Slaved Course Selector	Same
7.1, 9	RNAV Path Display	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(10)	RNAV Path Display	Same
7.1, 10	Display of Distance to Go.	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(11)	Display of Distance to Go.	Same
7.1, 11	Display of Distance Between Flight Plan Waypoints.	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(12)	Display of Distance Between Flight Plan Waypoints.	Same

Section	AMC 20-26	Para	PBN Vol II, Chap 6	Section	AC90-101	Comment
7.1, 12	Display of Barometric Altitude	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(14)	Display of Barometric Altitude	Same
7.1, 13	Display of Active Sensors	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(15)	Display of Active Sensors	Same
7.1, 14	*Navigation Performance*	*6.3.3.1*	*System Performance, Monitoring and Alerting*	*App 2, 2.e*	*System Monitoring.*	*AMC provides additional guidance for vertical*
7.1, 15	Multi-Sensor Systems	6.3.3.2	Criteria for Specific Navigation Services	App 2, 3.a(5)	Multi-Sensor Systems	Same
7.1, 16	*Auto tuning of DME*	--	--	--	--	*More explicit guidance for reversion capability in AMC. PBN/AC implies through position estimation criteria for DME*
7.1, 17	*Auto selection/ de-selection of navigation sources*	--	--	--	--	*More explicit guidance in AMC. PBN/AC are implies through position estimation criteria*
7.1, 18	Failure Annunciation	6.3.3.3	Functional Requirements, Displays	App 2, 3.d(8)	Failure Annunciation	Same
7.1, 19	Navigation Database Status	6.3.3.3	Functional Requirements, Displays	App 2, 3.f(3)	Display the Validity Period	Same
7.1, 20	Maintain Track and Leg Transitions	6.3.3.3	Functional Requirements, Path Definition and Flight Planning	App 2, 3.b(1)	Maintain Track and Leg Transitions	less stringent
7.1, 21	Fly-by and Fly-over Fixes	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(2)	Fly-by and Fly-over Fixes	Same
7.1, 22	Waypoint Resolution Error	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(3)	Waypoint Resolution Error	Same
7.1, 23	*Capability for a "Direct-To" Function*	*6.3.3.3*	*Functional Requirements, Path Definition & Flight Planning*	*App 2, 3.b(4)*	*Capability for a "Direct-To" Function*	*AMC contains additional guidance for VNAV, not in AC*
7.1, 24	Capability to define a vertical path	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(5)	Capability to define a vertical path	Same

Section	AMC 20-26	Para	PBN Vol II, Chap 6	Section	AC90-101	Comment
7.1, 25	Altitudes and/or Speeds	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(6)	Altitudes and/or Speeds	Same
7.1, 26	Construct a Path	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(7)	Construct a Path	Same
7.1, 27	Capacity to Load Procedures from the Navigation Database.	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(8)	Capacity to Load Procedures from the Navigation Database.	Same
7.1, 28	Means to Retrieve and Display Navigation Data.	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(9)	Means to Retrieve and Display Navigation Data.	Same
7.1, 29	Magnetic Variation	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(10)	Magnetic Variation	Same
7.1, 30	Changes in Navigation Accuracy	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(11)	Changes in RNP Value	Same
7.1, 31	Automatic Leg Sequencing.	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(12)	Automatic Leg Sequencing.	Same
7.1, 32	Display of Altitude Restrictions	6.3.3.3	Functional Requirements, Path Definition & Flight Planning	App 2, 3.b(13)	Display of Altitude Restrictions	Same
7.1, 33	Navigation Database	6.3.3.3	Functional Requirements	App 2, 3.f(1)	Navigation Database	Same
7.1, 33	Navigation Database	6.3.3.3	Functional Requirements	App 2, 3.f(2)	Database Protection	Same
7.2, 1	Where RNP AR operations use RF Legs	6.3.3.3	Functional Requirements, Requirements for RNP AR Approaches with RF Legs	App 2, 4	Requirements for RNP SAAAR Approaches with RF Legs	Conditional requirements tied to RF, RNP less than procedure defaults for approach and missed approach.
7.2, 2	**Where RNP AR operations are less than RNP 0.3**	**6.3.3.3**	**Functional Requirements, Requirements for RNP AR Approaches to less than RNP 0.3**	**App 2, 5**	**Requirements for Using Lines of Minima less than RNP 0.3**	**AMC is more stringent by removing the alternative for when aircraft lacks continuous LNAV capability**

Section	AMC 20-26	Para	PBN Vol II, Chap 6	Section	AC90-101	Comment
7.2, 3	**Where Missed Approach are less than RNP 1.0**	**6.3.3.3**	**Functional Requirements, Requirements for Approaches with Missed Approach less than RNP 1.0**	**App 2, 6**	**Requirement s for Approaches with Missed Approach less than RNP 1.0**	**AMC is more stringent by removing the alternative for when aircraft lacks continuous LNAV capability**
8	Airworthiness Compliance	--	--	--	--	NC
8.1	General	6.3.2	Approval Process	6.a	Overview	Comparable
8.1.1(a)	New or Modified Installations – Compliance Statement	6.3.2	Approval Process	6.b(1)	Aircraft Qualification Documentation	Comparable
8.1.1(b)(1)	Design data to support compliance	6.3.2	Approval Process	6.b(1)	Aircraft Qualification Documentation	Comparable
8.1.1(b)(2)	RISK OF FLIGHT CREW ERROR	6.3.4	OPERATING PROCEDURES, TRACK DEVIATION MONITORING	APP 4, 3.G	TRACK DEVIATION MONITORING	PBN MANUAL/AC PROVIDE MORE EXPLICIT GUIDANCE
8.1.1(b)(3)	Equipment failures and reversion	6.3.4	Operating Procedures, Contingency Procedures	App 4, 3.p	Contingency Procedures	Comparable
8.1.1(b)(4)	Coupling arrangements	6.3.4	Operating Procedures, Autopilot & Flight Director	App 4, 2.b	Autopilot & Flight Director	Comparable
8.1.1(b)(5)	*Intercepting CF*	--	--	--	--	*AMC is more explicit for this condition*
8.1.1(b)(6)	MEL & maintenance	6.3.2.2.4	MEL Considerations	App 4, 2.a	MEL	Comparable
8.1.2	*Existing Installations*	--	--	--	--	*AMC unique*
8.2	Database Integrity	6.3.6	Navigation Database	6.b(2)	RNP SAAAR Operational Documentation	Same
8.3	Use of GPS	6.3.3.2	Criteria for Specific Navigation Services	App 2, 3.a(1)	GPS	Same
8.4	Use of IRS	6.3.3.2	Criteria for Specific Navigation Services	App 2, 3.a(2)	IRS	Same
8.5	Use of DME	6.3.3.2	Criteria for Specific Navigation Services	App 2, 3.a(3)	DME	Same

Section	AMC 20-26	Para	PBN Vol II, Chap 6	Section	AC90-101	Comment
8.6	Use of VOR	6.3.3.2	Criteria for Specific Navigation Services	App 2, 3.a(4)	VOR	Same
8.7	*Intermixing of Equipment*	--	--	--	--	*AMC contains additional guidance and criteria*
9	Aircraft Flight Manual	6.3.5	Pilot/Dispatch/Operator Knowledge and Training	6.b(3)	FAA Acceptance	Comparable
10	Operational Criteria	--	--	--	--	NC
10.1	*General*					*AMC general info*
10.2	*Flight Operations Documentation*	*6.3.2*	*Approval Process*	*6.b*	*FAA Acceptance*	*AC provides more guidance*
10.3	*Qualification and Training*	*6.3.5*	*Pilot/Dispatch/Operator Knowledge and Training*	*App 5*	*Training*	*AC is more extensive*
10.4	Navigation Database Management	6.3.6	Navigation Database	App 3	Navigation Data Validation Programme	Comparable
10.5	*Reportable Events*	--	--	--	--	*AMC is more extensive*
10.6	*Fleet Approvals*	--	--	--	--	*AMC unique*
10.7	RNP Monitoring Programme	6.3.7	Oversight Of Operators	App 6	RNP Monitoring Programme	Comparable
Appendix 1	Glossary	--	--	3	Definitions	NC
Appendix 2	Training and Crew Qualification Issues	6.3.5	Pilot/Dispatch/Operator Knowledge and Training	App 5	Training	Comparable
Appendix 3	Operational Considerations	6.3.4	Operating Procedures	App 4	Operational Considerations	Comparable
Appendix 4	*Acceptable Methods for FTE Assessment for RNP*	--	--	--	--	*AMC unique*
Appendix 5	*FOSA*	*6.4*	*Safety Assessment*	*App 2, 2.d(2)*		*AMC guidance consistent with PBN manual. AC contains a mention to OSA only.*

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[1], in particular in relation to the verification of conformity of the airborne constituents, per Article 5 of EC Regulation 552/2004[2]. It addresses general certification considerations of stand-alone and multi-sensor systems

[1] 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).

[2] 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[3] 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.

[3] 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

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 $\text{RNAV}_{\text{(GNSS)}}$.

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) ±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) ±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 ±0.3 NM TSE accuracy for the final approach segment, FTE (95%) should not exceed ±0.25 NM whatever the operating mode (manual, flight director or Autopilot):

a) A demonstrated FTE (95%) of ±0.25NM 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 ±0.25 NM can be maintained under all foreseeable conditions through a dedicated flight test evaluation.

b) A demonstrated FTE (95%) of ±0.25NM is assumed when coupled to a flight director.

c) A demonstrated FTE (95%) of ±0.125 NM is assumed when coupled to an autopilot.

Outside of the Final Approach Segment, a demonstrated FTE of ±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 ±9 m (±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 ±9 m (±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[4]	VNAV Equipment Error	Horizontal coupling Error	Flight Technical Error	**Vertical Total System Error**
At or below 5000 ft (MSL)	80 ft	100 ft	24 ft	150 ft	**199 ft**
5000 ft to 10000 ft MSL)	106 ft	150 ft	24 ft	150 ft	**238 ft**
10000 ft to 15000 ft MSL)	127 ft	220 ft	24 ft	150 ft	**296 ft**

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^{-5}. During operations on the final approach segment of an RNP APCH, the system, or the system and pilot in

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[4] The ASE value has been computed using the following formula:

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

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 to10^{-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	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: 1) The displays must be visible to the pilot and located in the primary field of view (±15 degrees from pilot's normal line of sight) when looking forward along the flight path. 2) The lateral deviation display scaling must agree with any alerting and annunciation limits, if implemented. 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 ±1NM for the initial and intermediate segments and ±0.3 NM for the final segment. 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. 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.
2	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. 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.
3	A navigation database, containing current navigation data officially promulgated for civil aviation; a) which can be updated in accordance with the AIRAC cycle and b) from which approach procedures can be retrieved in their entirety and loaded into the RNAV system. The resolution to which the data is stored must be sufficient to ensure that the

Item	Functional Description
	assumption of no path definition error is satisfied. The database shall be protected against flight crew modification of the stored data. 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.
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	Capability to execute database procedures including: a) fly-over and b) fly-by turns.
15	Capability to execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators (automatic capability), or their equivalent: Initial Fix (IF), Track to Fix (TF), Direct to Fix (DF) 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.

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: a) Change automatic waypoint sequencing to manual. 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). c) Retain all subsequent waypoints in the active flight plan in the same sequence. 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.

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	APV BARO-VNAV deviation must be displayed on a vertical deviation display (HSI, EHSI, VDI). 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 (±15 degrees from pilot's normal line of sight) when looking forward along the flight path. The deviation display shall have a suitable full-scale deflection based on the required vertical track error. The non-numeric display must allow the fight crew to readily distinguish if the vertical deviation exceeds ±75 feet. If the non-numeric display does not permit the fight 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 ±75 feet

<table>
<tr><th>Item</th><th>Functional Description</th></tr>
<tr><td>2</td><td>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.
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.</td></tr>
<tr><td>3</td><td>The navigation system must be capable of defining a vertical path in accordance with the published vertical path.
Note: The VNAV equipment error budget (see 6.3.2.b) includes the path approximation error.</td></tr>
<tr><td>4</td><td>User Interface (Displays and Control)
The display readout and entry resolution for vertical navigation information shall be as follow:
<table>
<tr><th colspan="2">Parameter</th><th>Display resolution</th><th>Entry resolution</th></tr>
<tr><td rowspan="2">Altitude</td><td>Above altitude transition level</td><td>Flight Level</td><td>Flight Level</td></tr>
<tr><td>Below altitude transition level</td><td>1 foot</td><td>1 foot</td></tr>
<tr><td colspan="2">Vertical Path Deviation</td><td>10 feet</td><td>Not applicable</td></tr>
<tr><td colspan="2">Flight Path Angle</td><td>0.1 degree (*)</td><td>0.1 degree</td></tr>
<tr><td colspan="2">Temperature</td><td>1 degree</td><td>1 degree</td></tr>
<tr><td colspan="2">(*) A Display resolution of 0.01 degree is recommended</td><td></td><td></td></tr>
</table>
</td></tr>
<tr><td>5</td><td>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.</td></tr>
<tr><td>6</td><td>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.</td></tr>
<tr><td>7</td><td>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.</td></tr>
</table>

7.3 Recommended Function for RNP APCH

Item	Functional Description
1	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.
2	Course selector of the deviation display automatically slaved to the RNAV computed path. Note: Systems with electronic map display in the pilot's primary field of view having a depiction of the active route are sufficient.

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 .

EASA documents may be obtained from EASA (European Aviation Safety Agency), 101253, D-50452 Koln, Germany. Website: 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.

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) 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 $RNAV_{(GNSS)}$ or equivalent (e.g.: $RNAV_{(GNSS)}$ 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. ~~M~~CDU).

   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 navaids must also be operational.

   If the missed approach procedure is based on RNAV (no conventional or dead reckoning missed approach available), the appropriate airborne equipment required to fly this procedure must be 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., ±1.0 nm for the Initial and Intermediate segments, ±0.3 nm for the Final Approach segment, and ±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 ± ½ 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 ±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