

ADVISORY CIRCULAR

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REVIEW : **1**
ISSUED BY : **SRVSOP**

SUBJECT: AIRCRAFT AND OPERATORS APPROVAL FOR APPROACH OPERATIONS WITH VERTICAL GUIDANCE/BAROMETRIC VERTICAL NAVIGATION (APV/baro-VNAV)

1. PURPOSE

This advisory circular (AC) establishes APV/baro-VNAV approval requirements (barometric vertical navigation only) for aircraft and operators. Barometric vertical navigation may be included together with lateral navigation in a RNP APCH approach, as established in CA 91-008. Criteria of this AC together with criteria of AC 91-008, establish requirements for RNP APCH approach with baro-VNAV.

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

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

2. RELATED SECTIONS OF THE LATIN AMERICAN AERONAUTICAL REGULATIONS (LARs) OR EQUIVALENT

LAR 91: Sections 91.1015 and 91.1640 or equivalents

LAR 121: Section 121.995 (b) or equivalent

LAR 135: Section 135.565 (c) or equivalent

3. RELATED DOCUMENTS

| | |
|---------------|---|
| Annex 6 | Operation of aircraft |
| Doc 9613 | Performance-based navigation (PBN) manual Attachment A – Barometric VNAV |
| Doc 9905 | Required navigation performance authorization required (RNP AR) procedure design manual (final draft) |
| Doc 8168 | Aircraft operations Volume I: Flight procedures Part II, Section 4, Chapter 1 – APV/baro-VNAV approach procedures Volume II: Construction of visual and instrument flight procedures Part III, Section 3, Chapter 4 – APV/baro-VNAV |
| AMC 20-27 | Airworthiness approval and operational criteria for RNP APPROACH (RNP APCH) operations including APV BARO-VNAV operations |
| FAA AC 90-105 | Approval guidance for RNP operations and barometric vertical navigation in the U.S. National Airspace System – Appendix 4 – Use of barometric VNAV |

4. DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

- a) **Approach procedure with vertical guidance (APV).**- An instrument approach procedure which utilizes lateral and vertical guidance but does not meet the requirements established for precision approach and landing operations.
- b) **Barometric vertical navigation (baro-VNAV).**- Is a navigation system that presents to the pilot computed vertical guidance referenced to a specified vertical path angle (VPA), nominally 3°. The computer-resolved vertical guidance is based on barometric altitude and is specified as a VPA from reference datum height (RDH).
- c) **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.

Note 1.- The decision altitude (DA) is referenced to mean sea level and the decision height (DH) is referenced to the threshold elevation.

Note 2.- The required visual reference means that section of the visual aids or of the approach area which should have been in view for sufficient time for the pilot to have made an assessment of the aircraft position and rate of change of position, in relation to the desired flight path. In Category III operations with a decision height the required visual reference is that specified for the particular procedure and operation.

Note 3.- For convenience where both expressions are used they may be written in the form "decision altitude/height" and abbreviated "DA/H".

- d) **Flight management system (FMS).**- Integrated system made up by an on-board sensor, a receiver, and a computer with navigation and aircraft performance databases, capable of providing performance values and RNAV guidance to a display and automatic flight control system.
- e) **Initial approach fix (IAF).**- Fix that marks the beginning of the initial segment and the end of the arrival segment, if applicable. In RNAV application, this fix is normally defined as a "fly-by waypoint".
- f) **Non-precision approach (NPA) procedure.**- An instrument approach procedure which utilizes lateral guidance but does not utilize vertical guidance.
- g) **Precision approach (PA) procedure.**- An instrument approach procedure using precision lateral and vertical guidance with minima as determined by the category of operation.
- Note.- Lateral and vertical guidance refers to the guidance provided either by:*
- a ground-based navigation aid; or
 - computer-generated navigation data.
- h) **Primary field of view.**- For purposes of this AC, the primary field of view is within 15 degrees of the primary line of sight of the pilot.
- i) **Reference datum height (RDH).**- The height of the extended glide path or a nominal vertical path at the runway threshold.
- j) **RNAV system.**- Area navigation system that allows the aircraft to operate on any desired flight path within the coverage of ground or airspace-based navigation aids or within the limits of the capability of self-contained navigation aids or a combination of both. An RNAV system may be included as part of a flight management system (FMS).
- k) **RNP system.**- Area navigation system which supports on-board performance monitoring and alerting.
- l) **Vertical navigation.**- A navigation method that allows the aircraft to operate on a vertical flight profile using altimetry sources, external flight path references, or a combination of these.

- m) **Vertical path angle (VPA).**- Angle of the published final approach descent in baro-VNAV procedures.
- n) **Waypoint (WPT).** A specified geographical location used to define an area navigation route or the flight path of an aircraft employing area navigation. Way-points are identified as either:
- Fly-by waypoint (fly-by WPT).*- A waypoint which requires turn anticipation to allow tangential interception of the next segment of a route or procedure, or
- Flyover waypoint (flyover WPT).*- A waypoint at which a turn is initiated in order to join the next segment of a route or procedure.

4.2 Abbreviations

| | | |
|----|---------------|--|
| a) | AAC | Civil Aviation Administration |
| b) | AC | Advisory circular (FAA) |
| c) | AFM | Airplane flight manual |
| d) | AIM | Aeronautical information manual |
| e) | AMC | Acceptable means of compliance |
| f) | AP | Autopilot |
| g) | APCH | Approach |
| h) | APV | Approach procedure with vertical guidance |
| i) | APV/baro-VNAV | Approach procedure with vertical guidance/Barometric vertical navigation |
| j) | AR | Authorization required |
| k) | ARINC | Aeronautical radio, Incorporated |
| l) | ASE | Altimetry system error |
| m) | ATC | Air traffic control |
| n) | baro-VNAV | Barometric vertical navigation |
| o) | CA/AC | Advisory circular (SRVSOP) |
| p) | CFIT | Controlled flight into terrain |
| q) | CFR | US Code of Federal Regulations |
| r) | CS | Certification specifications (EASA) |
| s) | DA/H | Decision altitude/height |
| t) | DME | Distance measuring equipment |
| u) | EASA | European Aviation Safety Agency |
| v) | EHSI | Enhanced horizontal situation indicator |
| w) | FAA | US Federal Aviation Administration |
| x) | FAF | Final approach fix |
| y) | FAP | Final approach point |
| z) | FD | Flight director |

| | | |
|------|-----------|---|
| aa) | FMS | Flight management system |
| bb) | FTD | Flight training devices |
| cc) | FTE | Flight technical error |
| dd) | GNSS | Global navigation satellite system |
| ee) | Hg | Inches of mercury |
| ff) | hPa | Hectopascals |
| gg) | HSI | Horizontal situation indicator |
| hh) | IAF | Initial approach fix |
| ii) | IRU | Inertial reference unit |
| jj) | ISA | International standard atmosphere |
| kk) | KIAS | Indicated airspeed |
| ll) | LAR | Latin American Aeronautical Regulations |
| mm) | LNAV | Lateral navigation |
| nn) | LNAV FAF | final approach fix for lateral navigation |
| oo) | LNAV MDA | Lateral navigation minimum descent altitude |
| pp) | LOA | Letter of authorization/acceptance |
| qq) | MAPt | Missed approach point |
| rr) | MAPt LNAV | Missed approach point for lateral navigation |
| ss) | MDA/MDH | Minimum descent altitude/height |
| tt) | MEL | Minimum equipment list |
| uu) | NPA | Non-precision approach |
| vv) | ICAO | International Civil Aviation Organization |
| ww) | OCA/H | Obstacle clearance altitude/height |
| xx) | OM | Operations Manual |
| yy) | PANS-OPS | Procedures for air navigation services - Aircraft operations |
| zz) | PBN | Performance-base navigation |
| aaa) | PA | Precision approach |
| bbb) | PDE | Path definition error |
| ccc) | PF | Pilot flying |
| ddd) | PM | Pilot monitoring |
| eee) | PNF | Pilot not flying |
| fff) | QNE | Standard atmosphere that corresponds to 1013 hPa or 29.92" Hg. This setting indicates the altitude above the isobaric surface of 1013 hPa, if temperature is standard |
| ggg) | QNH | Pressure at mean sea level. This setting indicates the altitude above the means sea level (MSL), if temperature is standard. |

| | | |
|------|-------------|--|
| hhh) | RDH | Reference datum height |
| iii) | RNAV | Area navigation |
| jjj) | RNP | Required navigation performance |
| kkk) | RNP APCH | Required navigation performance approach |
| lll) | RNP AR APCH | Required navigation performance approach with authorization required |
| mmm) | SBAS | Satellite-based augmentation system |
| nnn) | TCH | Obstacle clearance height |
| ooo) | TSO | Standard technical order |
| ppp) | VDI | Vertical deviation indicator |
| qqq) | VNAV | Vertical navigation |
| rrr) | VNAV DA | Vertical navigation decision altitude |
| sss) | VPA | Vertical path angle |
| ttt) | WPT | Waypoint |

5. INTRODUCTION

5.1 The acceptable means of compliance of this AC are based on the use of barometric vertical navigation (baro-VNAV).

5.2 The baro-VNAV navigation system presents the pilot with estimated vertical guidance referenced to a specified vertical path angle (VPA), nominally of 3°. The computed vertical guide is based on the barometric altitude and is specified as a VPA from the reference datum height (RDH).

5.3 The calculated vertical path is stored in the instrument flight procedure specification in the database of the area navigation (RNAV) system or of the required navigation performance (RNP) system.

5.4 For other flight phases, barometric VNAV offers vertical guidance path information that can be defined by vertical angles or altitudes at the procedure fixes.

5.5 It should be noted that there is no vertical requirement in this AC associated with the use of vertical guidance outside of the final approach segment. Therefore, vertical navigation can be performed without VNAV guidance in the initial and intermediate segments of an instrument procedure.

5.6 Aircraft authorised to conduct RNP authorization required approach (RNP AR APCH) operations are considered eligible for the baro-VNAV operations described in this AC. In this sense, there is no need for a new approval according to the criteria established in this document.

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

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

- ✓ ICAO Doc 9613, Volume II, Attachment A – Barometric VNAV; and
- ✓ ICAO Doc 8168, Volume I, Part II, Section 4, Chapter 1 – APV/baro-VNAV approach procedures.

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

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

- ✓ FAA AC 90-105 Approval guidance for RNP operations and barometric vertical navigation in the U.S. national airspace system - Appendix 4 – Use of barometric VNAV.

Note.- Notwithstanding harmonisation efforts, operators shall note the differences that exist between this AC and the aforementioned documents when applying for an authorization from the corresponding Administrations.

6. GENERAL CONSIDERATIONS

6.1 Navaid infrastructure

The procedure design does not have unique infrastructure requirements. This criteria is based upon the use of barometric altimetry by an airborne RNAV/RNP system whose performance capability supports the required operation. The procedure design will have to take into account the functional capabilities required by this document.

6.2 Publications

Charting must follow the standards of Annex 4 for the designation of an RNAV procedure where the vertical flight path is specific by a glide path angle. The charting designation will remain consistent with the current convention (for example if the lateral procedures are predicated on GNSS, the charting will indicate RNAV_(GNSS)).

6.3 Air traffic control (ATC) coordination

It is expected that ATC will be familiar with aircraft VNAV capability, as well as issues associated with altimeter setting and temperature data required by the aircraft.

7. APV/baro-VNAV APPROACH PROCEDURES CLASSIFICATION

7.1 Approach procedures with vertical guidance/barometric vertical navigation (APV/baro-VNAV) are classified as instrument approach procedures for approach and landing operations with vertical guidance (see the definition in Annex 6, Part I, to the Chicago Convention). These procedures are published with a decision altitude/height (DA/H) and must not be confused with non-precision approach procedures (NPA), which specify a minimum descent altitude/height (MDA/H) below which the aircraft must not descend.

7.2 The use of APV/baro-VNAV procedures improves the safety of NPA procedures, providing a guided and stabilized descent for landing, thus avoiding an early descent to minimum altitudes.

7.3 Notwithstanding the above, the inherent inaccuracy of barometric altimeters and the certified performance of the specific RNAV/RNP mode used, prevent the systems of these procedures from emulating the accuracy of the systems used in a precision approach (PA). In particular, with some systems it might not be possible to keep the aircraft within the obstacle-free surfaces of Annex 14 to the Chicago Convention. Thus, the pilot must keep this possibility in mind when making the decision to land at the decision altitude/height (DA/H).

7.4 In APV/baro-VNAV approach procedures no final approach fix (FAF) or missed approach fix (MAPt) is identified.

7.5 The lateral part of APV/baro-VNAV criteria is based on non-precision RNAV criteria. However, the FAF is not part of the APV/baro-VNAV procedure and is replaced by a final approach point (FAP), although the RNAV FAF may be used as a final approach course fix in database design. Likewise, the MAPt is replaced by a DA/H, which depends upon the category of the aircraft.

7.6 The LNAV FAF and MAPt are used for coding purposes in the baro-VNAV procedure and are not aimed at inhibiting the descent in the FAP or restricting the DA/H.

7.7 The minimum DH for APV/baro-VNAV is 75 m (246 ft) plus the height loss margin. However, the operator may increase this minimum DH limit to at least 90 m (295 ft) plus a height loss margin, when

the lateral navigation system is not certified to ensure that the aircraft will be within the inner approach, inner transitional, and balked landing surfaces indicated in Annex 14 to the Chicago Convention (extended as necessary above the inner horizontal surface to the obstacle clearance altitude/height (OCA/H)) with a high degree of probability.

8. NAVIGATION SYSTEM DESCRIPTION

8.1 Vertical navigation (VNAV)

- a) In VNAV, the system allows the aircraft to fly level and descent point to point in a vertical linear profile path that is kept in an on board navigation database. The vertical profile will be based upon altitude constraints or VPAs, where appropriate, associated with the lateral navigation (LNAV) path waypoints (WPT).

Note.- Normally, VNAV is a flight guidance systems mode, where the RNAV/RNP equipment containing the VNAV capability provides path steering commands to the flight guidance system, which controls the flight technical error (FTE) by means of the pilot manual control in the vertical deviation display or through flight director (FD) or autopilot (AP) coupling.

9. AIRWORTHINESS AND OPERATIONAL APPROVAL

9.1 In order to get an APV/baro-VNAV authorization, a commercial air transport operator shall obtain two types of approval:

- a) an airworthiness approval from the State of registry; (see Article 31 of the Chicago Convention and Paragraphs 5.2.3 and 8.1.1 of Annex 6, Part I); and
- b) the operational approval from the State of the operator (see Paragraph 4.2.1 and Attachment F to Annex 6, Part I).

9.2 For general aviation operators, the State of registry will determine if the aircraft meets the applicable APV/baro-VNAV requirements (see Paragraph 2.5.2.2 of Annex 6, Part II).

10. AIRWORTHINESS APPROVAL

10.1 Equipment requirements

10.1.1 APV/baro-VNAV procedures are to be used by aircraft equipped with flight management systems (FMS) or other RNAV or RNP systems capable of calculating barometric VNAV paths and, based on these, display deviations on the instrument visual indicator.

10.1.2 Aircraft equipped with APV/baro-VNAV systems that have been approved by the State of registry for the corresponding level of lateral navigation operations (LNAV)/VNAV may use these systems to conduct APV/baro-VNAV approaches, provided:

- a) the navigation system has a certified performance of 0.3 NM or lower, with a 95% probability. This includes:
- 1) global navigation satellite systems (GNSS) certified for approach operations; o
 - 2) multiple-sensor systems that use inertial reference units (IRU) in combination with dual distance measuring equipment (DME/DME) or certified GNSS systems; o
 - 3) RNP systems approved for operations with RNP 0.3 or lower.
- b) the APV/baro-VNAV equipment is operational;
- c) the aircraft and the aircraft systems are properly certified for the planned APV/baro-VNAV approach operations;
- d) the aircraft is equipped with an integrated LNAV/VNAV system with an accurate source of

barometric altitude; and

- e) VNAV altitudes and all the relevant procedural and navigation information are obtained from a navigation database whose integrity is supported by appropriate quality assurance measures.

10.1.3 In cases where LNAV/baro-VNAV procedures have been published, the approach area will be assessed in order to identify obstacles invading the inner approach surfaces, the inner transitional surfaces, and the balked landing surface defined of Annex 14 to the Chicago Convention. If obstacles invade these surfaces, a restriction amounting to the minimum value of the allowed OCA/H will be imposed.

10.1.4 APV/baro-VNAV operations are based on RNAV/RNP systems that receive inputs from equipment that may include:

- a) an air data computer: FAA Technical Standard Order (TSO)-C 106.
- b) an air data system: Aeronautical Radio, Incorporated (ARINC) 706, Mark 5 Air Data System.
- c) a barometric altimetry system of the following types: DO-88 altimetry, ED-26 MPS for airborne altitude measurements and coding systems, ARP-942 pressure altimeter systems, ARP-920 design and installation of pitot static systems for transport aircraft.
- d) integrated type-certified systems providing the capabilities of an air data system comparable to the one described in paragraph b).

Note 1.- Position data from other sources may be integrated with the barometric altitude information, provided they do not cause position errors exceeding the path-keeping precision requirements.

Note 2.- The altimetry system performance will be demonstrated separately through the certification of static pressure systems (e.g., *14 CFR 25.1325 or *CS 25.1325 or equivalent sections), where performance must be 30 ft by 100 knots of indicated airspeed (KIAS). Altimetry systems that meet this requirement will meet the altimetry system error (ASE) requirements for baro-VNAV operations. Additional compliance or demonstration is not required.

*14 CFR 25.1325: Section 1325 of Part 25 of Title 14 of the United States Code of Federal Regulations (CFR).

*CS 25.1325: Certification Specification (CS) 25.1325 of EASA certification specifications for large aircraft (CS 25).

10.1.5 Continuity of function.- At least one RNAV system is required to conduct baro-VNAV operations.

10.2 System accuracy

10.2.1 For instrument approach operations, it must be demonstrated that the on board VNAV equipment error, excluding altimetry, is lower than the values described in Table 10-1, with a probability of 99.7%.

Table 10-1

| | Level flight segments and climb/descent intercept altitude region of specified altitudes (ft) | Climbs/descents along the specified vertical profile (angle) (ft) |
|-----------------------|---|---|
| At or below 5 000 ft | 50 | 100 |
| 5 000 ft to 10 000 ft | 50 | 150 |
| Above 10 000 ft | 50 | 220 |

Note 1.- The VNAV equipment error is the error associated with the calculation of the vertical path. This includes the path definition error (PDE) and an approach performed by the VNAV equipment from the construction of the vertical path, if any.

10.2.2 Vertical flight technical errors (FTE).- Using satisfactory displays of vertical guidance information, it must be demonstrated that the flight technical errors are below the values shown in Table 10-2, on a three-sigma basis:

Table 10-2

| | Level flight segments and climb/descent intercept altitude region of specified altitudes (ft) | Climbs/descents along the specified vertical profile (angle) (ft) |
|-----------------------|---|---|
| At or below 5 000 ft | 150 | 200 |
| 5 000 ft to 10 000 ft | 240 | 300 |
| Above 10 000 ft | 240 | 300 |

10.2.3 Regarding the facility, a sufficient number of test flights should be conducted to verify that these values could be maintained. Lower FTE values can be achieved, especially when the VNAV system is coupled to an AP or FD. However, at least the total system vertical precision shown in Table 10-3 must be maintained.

10.2.4 If a facility produces higher FTEs, the total vertical error of the system (excluding altimetry) can be determined by combining the FTEs with the equipment errors using the root sum square method. The result shall be lower than the values listed in Table 10-3:

Table 10-3

| | Level flight segments and climb/descent intercept altitude region of specified altitudes (ft) | Climbs/descents along specified vertical profile (angle) (ft) |
|-----------------------|---|---|
| At or below 5 000 ft | 158 | 224 |
| 5 000 ft to 10 000 ft | 245 | 335 |
| Above 10 000 ft | 245 | 372 |

10.2.5 The approval of the VNAV system in accordance with FAA AC 20-129, and the approval of the altimetry system in accordance with FAR/CS/LAR 25.1325 or equivalent, constitutes acceptable means of compliance with the aforementioned precision requirements.

10.3 functional requirements for APV/baro-VNAV operations

10.3.1 Required functions

- a) **Displays.**- APV/baro-VNAV deviations must be shown on a vertical deviation display (e.g., the horizontal situation indicator (HSI), the enhanced horizontal situation indicator (EHSI), and the vertical deviation indicator (VDI)).

This display must be used as primary flight instrument during the approach. The display must be visible to the pilot and be located in the primary field of view of the pilot.

The deviation display must have a suitable full-scale deflection based on the required vertical track error.

- b) **Continuous deviation display.**- The navigation display must provide the capacity of continuously showing the aircraft position relative to the defined vertical path to the pilot flying the aircraft (PF), on the primary navigation flight instruments. The display must permit the pilot to readily note if the vertical deviation exceeds +100/-50 ft. The deviation shall be monitored and the pilot will take the appropriate action to minimise errors.

Note.- When the minimum crew consists of two pilots, a means shall be provided for the pilot not flying the aircraft (PNF) (pilot monitoring (PM)) to check the desired path and the aircraft position relative to the path.

- 1) It is recommended that a properly graduated non-numerical deviation display (e.g., the vertical deviation indicator) be located on the primary field of view of the pilot. A fixed-scale deviation indicator is acceptable, provided said indicator demonstrates the proper setting and

sensitivity for the planned operation. Alert and annunciation limits must also correspond to scale values.

Note.- Current systems incorporate vertical deviation scales in the range of ± 500 ft. These deviation scales shall be assessed based on the aforementioned requirements.

- 2) Instead of duly graduated vertical deviation indicators, it may be acceptable to have a numeric vertical deviation display, depending on the flight crew workload and display characteristics. The use of a numerical display may require initial and recurrent training for the flight crew.
 - 3) Since the vertical deviation scale and sensitivity vary significantly, an eligible aircraft may also be equipped with an operational FD or AP capable of following a vertical path.
- c) **Definition of the vertical path.-** The navigation system must be capable of defining a vertical path in accordance with the published vertical path. It must also be capable of specifying a vertical path within the altitude constraints at two fixes in the flight plan. Altitude constraints at fixes must be defined as one of the following:
- 1) an AT or ABOVE altitude constraint (for example, 2400A may be appropriate when there is no need to limit the vertical path);
 - 2) an AT or BELOW altitude constraint (for example, 4800B may be appropriate when there is a need to limit the vertical path);
 - 3) an AT altitude limitation (for example, 5200); or
 - 4) a WINDOW-type altitude constraint (for example, 2400A3400B).

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

- d) **Path construction.-** The system must be capable to construct a path to provide guidance from current position to a vertically constrained fix.
- e) **Capability to load procedures from the navigation database.-** The navigation system must have the capability to load and modify the entire procedures to be flown, based upon ATC instruction, into the RNAV/RNP system from onboard navigation database. This includes the approach (including vertical angle), the missed approach, and the approach transitions for the selected aerodrome and runway. The RNAV/RNP system shall preclude modification of the procedure data contained in the navigation database.
- f) **User interface (control and displays)-** the display readout and entry resolution for vertical navigation information shall be as follows:

Table 10-4

| Parameters | | Display resolution | Entry resolution |
|-------------------------|-------------------------------------|--------------------|------------------|
| Altitude | Above the transition level altitude | Flight level | Flight level |
| | Below the transition level altitude | 1 ft | 1 ft |
| Vertical path deviation | | 10 ft | Not applicable |
| Flight path angle | | 0.1° | 0.1° |
| Temperature | | 1° | 1° |

- g) The navigation database must contain the necessary information to fly the APV/baro-VNAV approach. This database must contain the Wets and associated vertical information (obstacle clearance height (TCH) and flight path angle (VPA)) for the procedure.

Vertical constraints (altitudes and airspeeds) associated with published procedures must be automatically retrieved from the navigation database once the approach procedure has been selected.

- h) The navigation system must be capable of indicating the navigation loss (e.g., system failure) in the pilot's primary field of view through a warning signal (flag) or equivalent indicator on the vertical navigation display.
- i) The aircraft must show barometric altitude from two independent altimetry sources, one in each pilot's primary field of view. When single pilot operation is permitted, the two displays must be visible from the pilot position.

10.3.2 Recommended functions

- a) **Temperature compensation** The baro-VNAV navigation system should be capable of automatically adjusting 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.
- b) Capability to automatically intercept the vertical path at the final approach point (FAP), using a vertical fly-by technique.

10.4 Aircraft eligibility

- a) **RNP system capability.-** An aircraft is eligible for RNP operations when it meets the RNP performance and functional requirements described in SRVSOP AC 91-008 (RNP APCH) or AC 91-009 (RNP AR APCH) or equivalents.
- b) **Barometric VNAV capability.-** An aircraft is eligible when it has a flight manual (AFM) or AFM supplement which clearly states that the VNAV system is approved for approach operations in accordance with FAA AC 20-129 or AC 20-138 or equivalent documents. In addition, for a VNAV system to be approved for approach operations according to AC 20-129 or AC 20-138 or equivalent documents, it must have a vertical deviation indicator (VDI). Since VDI sensitivity and setting vary significantly, an eligible aircraft must also be equipped and use either a flight director (FD) or an autopilot (AP) capable of following the vertical path. Pilot deviation of +100/-50 ft is considered acceptable on a published VNAV path.

Note.- An aircraft with RNP AR APCH authorisation is considered eligible for conducting baro-VNAV operations in accordance with this AC. No further evaluation is required.

- c) **Database requirements.-** The aircraft database must include the WPTs and the associated VNAV information, e.g., altitudes and vertical angles for the procedure to be flown.

10.5 Aircraft approval

a) Eligibility based on the AFM or AFM supplement

1) LAR 91 operators

LAR 91 operators must review the aircraft AFM or AFM supplement in order to establish the eligibility of the navigation system as described in Paragraph 10.4.

2) LAR 121 y 135 operators

(a) LAR 121 and 135 operators must present the following documentation to the CAA:

- (1) the sections of the AFM or AFM supplement that document the RNAV/RNP airworthiness approval for APV/baro-VNAV approach procedures in accordance with Paragraph 10.4 of this AC.

b) Eligibility that is not based on the AFM or AFM supplement

- 1) An operator may not be in a position to determine the eligibility of the equipment for conducting APV/baro-VNAV approaches based on the AFM or AFM supplement. In this case, LAR 91, LAR 121 and 135 operators must request that the Airworthiness inspection division of the CAA or equivalent, assess the baro-VNAV equipment to determine its eligibility.
- 2) Together with the request, the operator will provide to the Airworthiness inspection division or equivalent the following information:
 - (a) name of the manufacturer, model, and part number of the RNAV/RNP system;
 - (b) any evidence of IFR approval of the navigation system; and
 - (c) relevant information about flight crew operating procedures.
- 3) If the Airworthiness inspection division or equivalent is not in a position of determining the eligibility of the equipment, it shall send the request, together with the supporting data, to the Aircraft certification division or equivalent.
- 4) The Aircraft certification division or equivalent will verify that the aircraft and the RNAV/RNP system meet the baro-VNAV criteria and that the system can safely fly VNAV paths associated to instrument approach procedures, applying a DA instead of an MDA. The Aircraft certification division or equivalent will provide written documentation (e.g., a report of an amended flight standard bulletin or other official document) to verify the eligibility of the equipment.
- 5) **For LAR 91 operators.**- If the CAA determines that the navigation equipment is eligible for baro-VNAV instrument approach operations, the Airworthiness inspection division or equivalent will provide documentation showing that the aircraft equipment is approved for said operations.
- 6) **For LAR 121 and 135 operators.**- The CAA will try to establish the eligibility of the system and will make sure that training and operation manuals reflect the operational policies of Paragraphs 12, 13 and 14 of this AC.
- 7) Compliance with airworthiness or equipment installation requirements, by itself, does not constitute operational approval.

10.6 Aircraft modification

- a) If any system required for baro-VNAV operations is modified (e.g., change in the software or hardware), the aircraft modification must be approved.
- b) The operator must obtain a new operational approval that is supported by operational and aircraft qualification documentation presented by the operator.

11. OPERATIONAL APPROVAL

11.1 To obtain the operational approval, the operator will take the following steps:

- a) *Airworthiness approval.*- aircraft shall have the corresponding airworthiness approvals as established in Paragraph 10.
- b) *Application.*- The operator will submit the following documentation to the CAA:
 - 1) *the application to obtain the APV/baro-VNAV authorization;*
 - 2) *aircraft qualification documentation.*- Documentation showing that the equipment of the proposed aircraft meets the requirements described in Paragraph 10 of this AC.
 - 3) *Type of aircraft and description of the aircraft equipment to be used.*- The operator will

provide a configuration list describing in detail the relevant components and the equipment to be used in the APV/baro-VNAV operation. The list shall include each manufacturer, model and version of the FMS software installed.

Note. - Barometric altimetry and the associated equipment, such as air data systems, are basic capabilities required for flight operations.

- 4) *Operational procedures.*- Operator manuals shall properly indicate the navigation procedures identified in Paragraphs 12 and 13 of this AC. LAR 91 operators shall confirm that they will operate applying identified practices and procedures.
- 5) *Training programmes.*- LAR 121 and 135 operators will submit the training curriculums in accordance with Paragraph 14 of this AC, which describe the operational and maintenance practices and procedures and training aspects related to VNAV approach operations (e.g., initial, promotion, and recurrent training for flight crews, flight dispatchers, and maintenance personnel).

Note. - A separate training programme is not required if RNAV and VNAV training is already part of the training programme of the operator. However, it should be possible to identify the practices and procedures concerning VNAV aspects covered in the training programme. LAR 91 operators should be familiar with the practices and procedures identified in Paragraph 14 of this AC.

- 6) *Operations manual (OM) and checklists.*- Operators will submit the operations manuals and checklists containing information and guidance on APV/baro-VNAV operations.
- 7) *Maintenance procedures.*- The operator will submit the maintenance procedures containing airworthiness and maintenance instructions concerning the systems and equipment to be used in the operation. The operator will provide a procedure to remove and restore the APV/baro-VNAV operational capacity of the aircraft.
- 8) *MEL.*- The operator will submit any revision to the MEL needed to conduct APV/baro-VNAV operations.
- 9) *Validation.*- The CAA will determine the need to conduct validation tests based on the type of operation and operator experience. If validation tests are necessary, the operator will submit a validation test plan to show its capacity to conduct the proposed operation (see Chapter 13 of Volume II, Part II of the SRVSOP Operations Inspector Manual). The validation plan must at least include the following:
 - (a) a statement indicating that the validation plan has been designated to demonstrate the capacity of the aircraft to execute APV/baro-VNAV procedures;
 - (b) operational and dispatch procedures; and
 - (c) MEL procedures.

Note 1. - the validation plan shall make use of ground training devices, flight simulators, and aircraft demonstrations. If the demonstration will be conducted in an aircraft, it must be completed during the day and under VMC.

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

- 10) *Navigation data validation program.*- The operator shall submit the details of the navigation data validation program as described in Appendix 1 of this AC.
- c) *Training.*- Once the CAA has accepted or approved the amendments to the manuals, programmes and documents submitted, the operator will provide the respective training to its personnel.
 - d) *Validation flights.*- Validation flights, if required, will be conducted according to Paragraph 11.1 b) 9).
 - e) *Issuance of the authorisation.*- Once all the aforementioned steps have been completed satisfactorily, the CAA will issue the OpSpecs for LAR 121 and 135 operators, or a LOA for LAR 91.

12. OPERATIONAL PROCEDURES

12.1 For APV/baro-VNAV operations, the crews must be familiar with the following procedures:

- a) **Corrections for cold temperatures.**- Pilots are responsible for any cold temperature correction required at all minimum altitudes/heights published. This includes:
- The altitudes/heights for initial and intermediate segments;
 - The DA/H; and
 - Subsequent missed approach altitudes/heights.

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

- b) **Altimeter setting.**- APV/baro-VNAV operations will only be conducted when:

- a current and local source for altimeter setting is available; and
- the *QNH/*QFE is properly selected in the aircraft altimeter.

*QNH: Pressure at mean sea level. This setting indicates the altitude above mean sea level, (MSL) with standard temperature.

*QFE: Standard atmosphere that corresponds to 1013 hPa or 29.92" Hg. This setting indicates the altitude above the isobaric surface of 1013 hPa, with standard temperature.

Note.- A remote source for altimetry setting shall not be used.

- c) **Actions to be taken at the DA.**- The flight crew is expected to operate the aircraft along the published vertical path, and to execute a missed approach procedure once it reaches the DA, unless the required visual references to continue with the approach are in sight.
- d) **Temperature limitation.**- Because of the pronounced effect of nonstandard temperature on baro-VNAV operations, instrument approach procedures will contain a temperature limitation below which the use of a vertical navigation decision altitude (VNAV DA) based on baro-VNAV is not authorized. The temperature limitation will be shown through a note in the instrument approach procedure. If the aircraft system is capable of temperature compensation, the crew must follow the operator procedures based on the manufacturer instructions.
- e) **VNAV path mode selection.**- The flight crew must know the correct selection of the vertical mode(s) that command vertical navigation via the published flight path. Other vertical modes, such as vertical speed are not applicable to baro-VNAV approach.
- f) **Restriction to using a remote source for altimeter setting.**- The use of baro-VNAV up to a DA is not authorised if the altimeter setting is issued from a remote source. For APV/baro-VNAV operations, a current altimetry setting is required for the landing aerodrome. When minima related to a remote altimetry setting are shown, the VNAV function can be used, but only up to the published lateral navigation minimum descent altitude (LNAV MDA).
- g) **Manual adjustments.**- If manual adjustments to stored altitude information are necessary, e.g., cold temperature adjustments, the flight crew must make appropriate adjustments to the procedure altitudes and revert to use of the temperature adjusted LNAV MDA.

13. TEMPERATURE LIMITATIONS

- a) For aircraft using barometric vertical navigation without temperature compensation to conduct the approach, cold temperature limits are reflected in the procedure design and identified along with any high temperature limits on the charted procedure. Cold temperatures reduce the actual glidepath angle, while high temperatures increase the glidepath angle. Aircraft using barometric vertical navigation with temperature compensation or aircraft using an alternate means of vertical guidance (e.g., satellite-based augmentation system (SBAS)) may disregard the temperature

restrictions.

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

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

Note 2.- *The ISA standard conditions at sea level are:*

- *The standard temperature is defined as 15° Celsius (centigrade's) or 288.15° Kelvin;*
- *The standard pressure is defined as 29.92126 inches of mercury (Hg) or 1013.2 hectopascals (hPa); and*
- *The standard density for these conditions is 1.225 kg/m³ or 0.002377 slugs/cubic ft.*

14. TRAINING PROGRAMME

14.1 The training programme of the operator shall include sufficient training on aircraft VNAV capabilities for flight crews and flight dispatchers (e.g., ground training, flight simulators, flight training devices (FTD) or aircraft). Training will cover the following areas:

- a) information about this AC;
- b) the meaning and proper use of aircraft systems;
- c) the characteristics of APV/baro-VNAV procedures, as determined from chart depiction and textual description;
 - 1) description of WPT types (fly-by and flyover WPTs), path terminators, and any other type of terminator used by the operator, as well as the associated flight paths of the aircraft;
 - 2) information about the specific RNAV/RNP system;
 - 3) automation levels, annunciation modes, changes, alerts, interactions, reversions, and degradation;
 - 4) functional integration with other aircraft systems;
 - 5) the meaning of vertical path discontinuities and related flight crew procedures;
 - 6) monitoring procedures for each flight phase (e.g., monitoring of "PROGRESS" or "LEGS" pages);
 - 7) turn anticipations, taking into account the effect of airspeed and altitude; and
 - 8) interpretation of electronic displays and symbols.
- d) VNAV equipment operating procedures, where applicable, including how to perform the following actions:
 - 1) adhere to speed and/or altitude constraints associated with an approach procedure;
 - 2) verify WPTs and flight plan programming;
 - 3) fly direct to a WPT;
 - 4) determine vertical track error/deviation;
 - 5) insert and delete route discontinuity;
 - 6) change destination and alternate aerodromes;

- 7) contingency procedures for VNAV failures;
- e) the functioning of barometric altimeters.- Barometric altimeters are calibrated to indicate the true altitude under ISA atmospheric conditions. If, on a given day, the temperature is warmer than ISA, the true altitude will be higher than indicated altitude. Conversely, on a day colder than ISA, the true altitude will be lower than indicated altitude. These errors increase in magnitude as the altitude above the altimeter setting source increases.
- f) altimetry setting procedures and cold temperatures.
 - 1) Altimeter setting.- Flight crews must take precautions when changing the altimeter setting and will request a current altimeter setting if the reported setting may not be recent, especially when pressure tends to drop quickly. Remote altimeter setting is not permitted for APV/baro-VNAV operations.
 - 2) Cold temperatures.- In case of cold temperatures, the pilot shall verify the instrument approach procedure chart to determine the temperature limit for using the baro-VNAV capability. If the aircraft system has temperature compensation capability, the crew shall follow the procedures established by the operator based on the manufacturer instructions for using the baro-VNAV function.
- g) Knowledge of failures and reversal modes.- The flight crew shall have knowledge of failures and reversal modes that adversely impact the aircraft's ability to conduct baro-VNAV approach operations. In addition, the flight crew must be aware of contingency procedures (e.g., reversal to LNAV MDA following a VNAV failure).
- h) Operational verification of altimeters.- When two pilots are required on an aircraft, the flight crew must complete an altimetry crosscheck ensuring both pilots' altimeters agree within ± 100 ft prior to the FAF. If the altimeter crosscheck fails, the instrument approach procedure must not be executed, or, if said procedure is in progress, it must not be continued. If the avionics system provides a warning system that compares the pilots' altimeters, flight crew procedures shall indicate the action to be taken in the event of a warning from the pilot altimeter comparator when executing an APV/baro-VNAV operation.

Note.- This operational crosscheck of the altimeters is not necessary if the aircraft automatically compares the altitudes within 100 ft.

15. NAVIGATION DATABASE

- a) The operator must obtain the navigation database from a qualified supplier that complies with RTCA document DO-200A / EUROCAE ED- 76, Standards for processing aeronautical data.
- b) Navigation data suppliers must have a letter of acceptance (LOA) in order to process the navigation information (e.g., FAA AC 20-153 or European aviation safety agency (EASA) document on the conditions for the issuance of letters of acceptance for navigation database suppliers by the Agency (EASA IR 21 Sub-part G) or equivalent documents). A LOA recognizes the data of a supplier as those in which information quality, integrity, and quality management practices are consistent with the criteria of document DO-200A/ED-76. The operator's database supplier (e.g., an FMS company) must have a Type 2 LOA and their respective suppliers must have a Type 1 or 2 LOA.
- c) The operator must report to the navigation data provider any discrepancy that invalidates a procedure, and prohibit the use of the affected procedures by means of a notice to flight crews.
- d) Operators should consider the need to periodically verify the navigation databases, in order to maintain the existing requirements of the quality system or safety management system.

16. OVERSIGHT, INVESTIGATION OF NAVIGATION ERRORS AND WITHDRAWAL OF APV/baro-VNAV AUTHORISATION

- a) The operator will establish a procedure to receive, analyse, and follow up on navigation error reports in order to determine appropriate corrective actions.
- b) Information that indicates the potential of repeated errors may require modification of an operator's training programme.
- c) Information that attributes multiple errors to a particular pilot may required remedial training or license review.
- d) Repeated navigation errors attributed to a piece of equipment or a specific part of that piece of equipment or to operational procedures can entail the cancellation of an operational approval (withdrawal of APV/baro-VNAV authorisation from the OpSpecs or withdrawal of the LOA in the case of private operators).

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APPENDIX 1

NAVIGATION DATA VALIDATION PROGRAMME

1. INTRODUCTION

The procedure stored in the navigation database defines the aircraft lateral and vertical guidance. The navigation database is updated every 28 days. The navigation data used in each update are critical for the integrity of each APV/baro-VNAV approach. Taking into account the reduced obstacle clearance associated with these approaches, navigation data validation requires special consideration. This appendix provides guidance on the operator procedures to validate the navigation data associated with APV/baro-VNAV approaches.

2. DATA PROCESSING

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

3. INITIAL DATA VALIDATION

3.1 The operator must validate every APV/baro-VNAV procedure before flying the procedure in instrument meteorological conditions (IMC) to ensure compatibility with their aircraft and to ensure the resulting path correspond to the published procedure. As a minimum, the operator must:

- a) compare the navigation data of the procedure to be loaded on the FMS with a published procedure.
- b) validate the navigation data of the loaded procedure, either in the flight simulator or in the actual aircraft under 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 that the path can be used, that it has no apparent lateral or vertical path disconnections, and is consistent with the published procedure.
- c) once the procedure is validated, a copy of the validated navigation data must be kept and maintained to be compared with subsequent data updates.

4. DATA UPDATING

Whenever the operator receives a navigation data update and before using such data on the aircraft, the update must be compared with the validated procedure. This comparison must identify and resolve any discrepancy in the navigation data. If there are any significant changes (any change affecting the approach path or performance) to any part of the procedure, the operator must validate the amended procedure in accordance with the initial data validation (Paragraph 3 of this AC).

5. NAVIGATION DATA SUPPLIERS

Navigation data suppliers must have a letter of acceptance (LOA) to process these data (e.g., FAA AC 20-153 or EASA document on the conditions for the issuance of letters of acceptance for navigation data suppliers (EASA IR 21 Sub-part G) or equivalent document). An LOA recognizes the data of a supplier as having an information quality; integrity and quality management practices that are consistent with the criteria of document DO-200A/ED-76. The operator's database supplier must have a Type 2

LOA and their respective suppliers must have a Type 1 or 2 LOA. The AAC may accept a LOA submitted by navigation data suppliers or issues its own LOA.

6. AIRCRAFT MODIFICATIONS (DATA BASE UP TO DATE)

If an aircraft system required for APV/baro-VNAV operations is modified (*e.g.*, a change in the software), the operator is responsible for validation of APV/baro-VNAV 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 on path computation. If this verification is not accomplished by the manufacturer, the operator must carry out an initial navigation data validation with the modified system.

APPENDIX 1**APV/baro-VNAV APPROVAL PROCESS**

- a) The APV/baro-VNAV approval process consists of two types of approvals: the airworthiness and operational approvals. Although the two have different requirements, they must be considered under a single process.
- b) This process constitutes an orderly method used by the CAAs to ensure that applicants meet the established requirements.
- c) The approval process consists of the following phases:
 - 1) Phase one: Pre-application
 - 2) Phase two: Formal application
 - 3) Phase three: Review of the documentation
 - 4) Phase four: Inspection and demonstration
 - 5) Phase five: Approval
- d) In *Phase one - Pre-application*, the CAA meets with the applicant or operator (pre-application meeting), who is advised of all the requirements it must meet during the approval process.
- e) In *Phase two - Formal application*, the applicant or operator submits the formal application, accompanied by all the relevant documentation, as established in Paragraph 11 of this AC.
- f) In *Phase three - Review of documentation*, the CAA evaluates the documentation and the navigation system to determine their eligibility and the approval method to be applied with respect to the aircraft. As a result of this review and evaluation, the CAA may accept or reject the formal application together with the documentation.
- g) In *Phase four - Inspection and demonstration*, the operator will train its personnel and conduct validation flights, if required.
- h) In *Phase five - Approval*, the CAA issues the APV/baro-VNAV authorization once the operator has met the airworthiness and operational requirements. For LAR 121 and 135 operators, the CAA will issue the corresponding OpSpecs, and for LAR 91 operators, it will issue a LOA.

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