

Advisory Circular

OPERATIONAL APPROVAL FOR BAROMETRIC VERTICAL NAVIGATION (BAROVNAV)

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GENERAL

Advisory Circulars (ACs) are issued by the Director-General of Civil Aviation (DGCA) from time to time to provide practical guidance or certainty in respect of the statutory requirements for aviation safety. ACs contain information about standards, practices and procedures acceptable to CAAS. An AC may be used, in accordance with section 3C of the Air Navigation Act (Cap. 6) (ANA), to demonstrate compliance with a statutory requirement. The revision number of the AC is indicated in parenthesis in the suffix of the AC number.

PURPOSE

This AC provides guidance to demonstrate compliance with the requirements regarding, and information related to an application for, an approval for specified navigation performance operations in accordance with ANR-98.

APPLICABILITY

This AC is applicable to the operator seeking an approval for BaroVNAV operations.

RELATED REGULATIONS

This AC relates specifically to Division 2 in Part 2 of ANR-98.

RELATED ADVISORY CIRCULARS

- AC 98-1-1 Application for an Approval to Conduct a Special Operation

CANCELLATION

This AC supersedes AC AOC-27.

EFFECTIVE DATE

This AC is from 1 October 2018.

OTHER REFERENCES

- ICAO Doc 4444 Procedures for Air Navigation Services – Air Traffic Management
- EASA AMC 20-27 Airworthiness approval and operational criteria for RNP APPROACH (RNP APCH) operations including APV BAROVNAV operations
- EASA AMC 20-28 Airworthiness approval and operational criteria related to Area Navigation for Global Navigation Satellite System approach operation to Localiser Performance with Vertical guidance minima using Satellite Based Augmentation System
- FAA AC 20-138D Airworthiness approval of positioning and navigation systems

1 DEFINITIONS

For the purpose of this AC, the following terms will have the following definitions:

APV (approved approach procedure with vertical guidance) is an instrument approach procedure with both lateral and vertical guidance but does not meet the criteria for precision approach classification.

BaroVNAV (barometric vertical navigation), as the name suggests, is the vertical flight path computed using barometric altitude derived from the onboard altimetry system. The vertical flight path guidance is referenced to specific flight path angle (FPA) nominally set at 3 degrees.

APV BaroVNAV is an APV using RNP APCH (RNP approach) to provide the lateral (and longitudinal) guidance and BaroVNAV for the vertical component.

2 INTRODUCTION TO CHARTING AND OBSTACLE CLEARANCE

- 2.1 Charting standards are based on ICAO Annex 4 promulgations for RNAV procedure where the vertical flight path is specified by a glide path angle and the charting designation remain consistent with the current convention, e.g. if the lateral procedure is predicated on GNSS, the charting will indicate RNAV (GNSS).
- 2.2 The RNP APCH ends at the DA(H) or MAP, the missed approach segment may be based on GNSS, ground nav aids or even dead-reckoning navigation. These airborne nav aids necessary to conduct the missed approach will be identified on the approach charts.
- 2.3 All APV BaroVNAV procedures are based upon WGS 84 coordinates and provisions for obstacle clearance are as promulgated in PANSOPS (Doc 8168, Volume II).

3 SUPPORTING DOCUMENTATION

- 3.1 The operator has to submit evidence as part of his application to CAAS attesting to the aircraft VNAV system capability by statement in AFM, TC, STC, TCDS or manufacturer's Service Letter.

4 ALTIMETER SENSOR REQUIREMENTS

- 4.1 In order for an aircraft to be deployed for BaroVNAV approach operations, the aircraft has to be equipped such that, based on the RNAV system, the aircraft FPA can be automatically determined using inputs from any of the following equipment:
 - (a) TSO-C106 / ETSO-C106 Air Data Computer; or
 - (b) ARINC 706 Mark 5 or ARINC 738 Air Data and Inertial Reference system; or
 - (c) Barometric altimeter compliant with RTCA DO-88 (Altimetry) and/or EUROCAE ED-26 (Minimum performance specifications for airborne altitude measurements and coding systems); or
 - (d) Type certified integrated system providing an Air Data System capability comparable to (b).

5 SYSTEM ACCURACY

5.1 VNAV Equipment Error

- 5.1.1 For instrument approach operations, the VNAV equipment error, excluding altimetry, horizontal coupling and flight technical error on a 99.7% probability basis should be less than the following:

	Level flight segments and climb/descent intercept altitude region of specified altitudes	Climb/Descent along specified vertical Profile (angle)
At or below 5000 ft (MSL)	15m / 50ft	30m / 100 ft
5000 ft to 10000 ft (MSL)	15m / 50ft	45m / 150 ft
10000 ft to 15000 ft (MSL)	15m / 50ft	67m / 220 ft

5.2 Horizontal Coupling Error (HCE)

- 5.2.1 HCE is a component of a vertical error component of along track position error and is assumed to be 24ft on a 99.7% probability basis using longitudinal accuracy of 0.05nm at 95% and vertical path of 3 degrees.

5.3 Vertical Flight Technical Error (FTE)

- 5.3.1 The vertical FTE based on 99.7% probability should be less than:

	Level flight segments and climb/descent intercept altitude region of specified altitudes	Climb/Descent along specified vertical Profile (angle)
At or below 5000 ft (MSL)	45m / 150ft	60m / 200 ft
5000 ft to 10000 ft (MSL)	73m / 240ft	91m / 300 ft
10000 ft to 15000 ft (MSL)	73m / 240ft	91m / 300 ft

Note: The above figures are promulgated in ICAO Doc 9613. These figures are acceptable to CAAS provided flight director and autopilot are used to fly the profile.

5.4 Vertical Total System Error (TSE)

5.4.1 The vertical TSE made up the root-sum-square of all error components described this paragraph 11 on 99.7% probability is as follows:

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

Note: An acceptable means of complying with the above accuracy requirements is to have the VNAV system approved for RNAV in accordance with FAA AC 20-138C.

5.5 Vertical Path Error at FAP due to vertical fly-by transition

5.5.1 The error due to the capture of the vertical path starting from the FAP altitude causing momentary deviation below the published minimum procedure altitude is acceptable provided it is no more than 50 ft.

6 FUNCTIONAL CRITERIA

6.1 Continuity of Function

For operations predicated on use of BaroVNAV, at least one RNAV system has to be serviceable.

6.2 Path definition

The navigation system has to be capable of defining a vertical path angle to a fix. The system should also be capable of defining altitude constraints as follows:

- (a) "AT" altitude constraint, e.g. 2400
- (b) "AT or ABOVE" altitude constraint, e.g. 2400A
- (c) "AT or BELOW" altitude constraint, e.g. 2400B
- (d) "WINDOW" constraint, e.g. 2400A3400B

6.3 Vertical Constraints

All altitude and/or speeds associated with published procedures should be automatically extracted from the navigation database upon selecting the approach procedure.

6.4 Path Construction

The system should be able to construct a path to provide guidance from the current position to a vertically constrained fix.

6.5 Capability to load procedure from the navigation database

The navigation system should have the capability to load and modify the entire procedure(s) to be flown, based upon ATC instructions, into the RNAV system from the on-board navigation database. This includes the approach (including vertical angle), the missed approach and the approach transitions for the selected airport and runway. The navigation system should preclude modification of the procedure data contained in the navigation database.

6.6 Temperature limits

6.6.1 For aircraft using Barometric VNAV without temperature compensation to conduct the approach, low 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 glide path angle, while high temperatures increase the actual glide path angle.

6.6.2 Aircraft using Barometric VNAV with temperature compensation or aircraft using an alternate means for vertical guidance (e.g. SBAS) may disregard the temperature restrictions.

6.7 Guidance and control

For the vertical performance requirements, the path steering error budget has to reflect altitude reference as well as other factors, such as roll compensation and speed protection, as applicable.

6.8 User Interface (Displays and Control)

The display readout and entry resolution for vertical navigation information should be as follow:

Parameter	Display resolution (readout)	Entry resolution
Altitude	Flight Level or (1 ft)	Flight Level or (1 ft)
Vertical Path Deviation	10 feet	Not Applicable
Flight Path Angle	0.1 degree (*)	0.1 degree
Temperature	1 degree	1 degree

6.9 Path deviation and monitoring

The navigation system should 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 vertically defined path. The display has to allow the pilot to readily distinguish if the vertical deviation exceeds +30 m/-15 m (+100 ft/-50 ft). The deviation should be monitored, and action taken to minimise errors.

(a) It is recommended that an appropriately-scaled non-numeric deviation display (i.e. vertical deviation indicator) be located in the pilot's primary optimum field of view. A fixed-scale deviation indicator is acceptable as long as it

demonstrates appropriate scaling and sensitivity for the intended operation. Any alerting and annunciation limits should also match the scaling values.

Note: Existing systems provide for vertical deviation scaling with a range of ± 500 ft. Such deviation scaling should be assessed consistent with the above requirement on discern ability.

- (b) In lieu of appropriately scaled vertical deviation indicators in the pilot's primary optimum field of view, a numeric display of deviation may be acceptable depending on the flight crew workload and the numeric display characteristics. A numeric display may require additional initial and recurrent flight crew training.
- (c) Since vertical deviation scaling and sensitivity varies widely, eligible aircraft should be equipped with and operationally using either a flight director or autopilot capable of following the vertical path.

6.10 Barometric altitude

The aircraft has to display barometric altitude from two independent altimetry sources, one in each pilot's primary optimum field of view. Operator procedures should ensure current altimeter settings for the selected instrument procedure and runway.

7 OPERATING PROCEDURES

7.1 Manufacturer's instructions or procedures

The operator has to ensure that the flight crew comply with all instructions or procedures identified by the manufacturer as necessary for safe operation.

7.2 Altimeter Setting

The operator has to ensure that the flight crew pay particularly attention when reading back to ATC as well as setting of aircraft altimeters, especially during period of high workload.

7.3 Cold Temperature

The flight crew have to be aware of the limiting temperature for the use of BaroVNAV. During cold weather operations, the flight crew have to check for temperature limit and temperature correction on the instrument approach chart. If the airborne system contains a temperature compensation capability, the manufacturer's instructions have to be followed.

7.4 Contingency procedures

The operator has to ensure that the flight crew are aware that where the contingency procedure requires reversion to a conventional procedure, the necessary preparations should be completed before commencing the RNAV procedure.

8 PILOT KNOWLEDGE AND TRAINING

- 8.1 The list below describes the scope of training necessary for proficiency of VNAV operations. Subject to CAAS's discretion, an operator who is RNAV experienced may submit a truncated version for approval.
- (a) the concept of PBN operation and contents of this BaroVNAV AC;
 - (b) the meaning and proper use of aircraft systems;
 - (c) ICAO Doc 8168 Vol 1 Chapter 1 Table I-4-1-2 Speeds for procedures calculations.
 - (d) procedure characteristics, as determined from chart depiction and textual description:
 - (i) depiction of waypoint types (flyover and fly-by) and path terminators used by the operator) as well as associated aircraft flight paths;
 - (ii) RNAV system-specific information;
 - (iii) levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
 - (iv) functional integration with other aircraft systems;
 - (v) the meaning and appropriateness of vertical path discontinuities as well as related flight crew procedures;
 - (vi) monitoring procedures for each phase of flight (e.g. monitor "PROGRESS" or "LEGS" page in the FMC);
 - (vii) turn anticipation with consideration to speed and altitude effects; and
 - (viii) interpretation of electronic displays and symbols.
- 8.2 Procedures for operating VNAV equipment including the following actions:
- (a) adhere to speed and/or altitude constraints associated with an approach procedure;
 - (b) verify waypoints and flight plan programming;
 - (c) fly direct to a waypoint;
 - (d) determine vertical-track error/deviation;
 - (e) insert and delete route discontinuity;
 - (f) change arrival airport and alternate airport;
 - (g) contingency procedures for VNAV failures;
 - (h) crew requirements for altimeter cross-checks, checking for temperature limitations and procedures for altimeter settings for approach; and
 - (i) discontinuation of a procedure based upon loss of systems or performance and flight conditions, e.g. inability to maintain required path tracking or loss of required guidance, etc.
- 8.3 Additional operations guidance related to the considerations reflected in the procedure design are included in PANS-OPS, (Doc 8168), Volume I.

9 NAVIGATION DATABASE INTEGRITY

- 9.1 The navigation database integrity should comply with RTCA DO-200A / EUROCAE ED-76 standards. The operator has to ensure that the navigation database supplier or vendor to the operator hold valid Type LOA (Letter of Approval) issued in accordance with FAA AC 20-153B or EASA Part DAT.
- 9.2 The operator should also conduct additional navdata check of any new or changed procedure. Reports on navigation error has to be acted upon promptly. Repeated navigation error occurrences attributed to a specific piece of navigation equipment may result in cancellation of the approval for use of that equipment.