Australian Government
Civil Aviation Safety Authority

DRAFT

Advisory Circular

AC 91U-II-Attachment (0) JULY 2011

NAVIGATION AUTHORISATIONS – APV BARO-VNAV

CONTENTS

1. REFERENCES

- ICAO Doc 9613 Performance-based Navigation Manual Volume II Part C Attachment Barometric VNAV.
- CAO 20.91 Navigation Authorisations, Appendix 8, Requirements for use of APV Baro-VNAV.
- AC 91U-II-C-5 (0) Navigation Authorisations – RNP APCH
- FAA AC 20-129 Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the U.S. National Airspace system (NAS) and Alaska.
- FAA AC 90-105 Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System
- FAA AC 20-138B Airworthiness Approval of Positioning and Navigation Systems
- EASA AMC 20-27 Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BARO-VNAV Operations
- CASA Form 1307: *Reduced Vertical Separation Minimum and Required Navigation Performance* Application Form.

Advisory Circulars are intended to provide advice and guidance to illustrate a means, but not necessarily the only means, of complying with the Regulations, or to explain certain regulatory requirements by providing informative, interpretative and explanatory material.

Where an AC is referred to in a 'Note' below the regulation, the AC remains as guidance material.

ACs should always be read in conjunction with the referenced regulations.

This AC has been approved for release by the Executive Manager Standards Development and Future Technology Division.

2. PURPOSE

2.1 This Advisory Circular (AC) provides information for operators of Australian, or foreign registered aircraft, who wish to gain approval to conduct Performance Based Navigation (PBN) operations in Australian airspace. These operations are consistent with the navigation specifications described in International Civil Aviation Organization (ICAO) Document 9613 Performance-based Navigation Manual (ICAO Doc 9613 PBN Manual) and include area navigation (RNAV) and Required Navigation Performance (RNP) navigation specifications.

3. STATUS OF THIS AC

3.1 This is the first AC relating to Approach with Vertical Guidance (APV) Barometric Vertical Navigation (Baro-VNAV) navigation authorisations and is based on information contained in Volume II, Attachment, Barometric VNAV of ICAO Doc 9613 PBN Manual and Appendix 6, Requirements for use of APV Baro-VNAV *Civil Aviation Order (CAO) 20.91 Navigation Authorisations*. The numbering convention used in the title of this AC is also aligned to the relevant part of the PBN manual.

4. ACRONYMS

AC	Advisory Circular
AFM	Aircraft Flight Manual
APV	Approach with Vertical Guidance
Baro-VNAV	Barometric Vertical Navigation
CAO	Civil Aviation Order
CASA	Civil Aviation Safety Authority
CASR	Civil Aviation Safety Regulations 1998
DA	Decision Altitude
EASA	European Aviation Safety Agency
FAA	Federal Aviation Administration
FAF	Final Approach Fix
GNSS	Global Navigation Satellite System
ICAO	International Civil Aviation Organization
LNAV	Lateral Navigation
LOA	Letter of Acceptance
MDA	Minimum Decision Altitude
MEL	Minimum Equipment List
OEM	Original Equipment Manufacturer
Ops Specs	Operational Specifications
PBN	Performance Based Navigation
RNAV	Area Navigation
RNP	Required Navigation Performance

RNP APCH	RNP Approach
RNP AR APCH	RNP Authorisation Required Approach
RVSM	Reduced Vertical Separation Minimum
TSE	Total System Error
VNAV	Vertical Navigation
VPA	Vertical Path Angle

5. BACKGROUND

5.1 Baro-VNAV is a navigation system that enables a vertical path to be defined by on-board computers based on information derived from air data sensors and a suitable lateral navigation system.

5.2 An instrument approach procedure utilising Baro-VNAV is one method that may be used to enable an approach and landing operation with vertical guidance. Such an approach is classified as an APV.

5.3 When Baro-VNAV is used, the lateral navigation guidance is based on RNP APCH and RNP AR APCH navigation specifications.

5.4 When combined with an RNP APCH - LNAV navigation authorisation or endorsement an APV Baro-VNAV navigation authorisation/endorsement permits the conduct of an APV instrument approach procedure for which LNAV/VNAV minima are published. In such approaches lateral guidance is provided by the Global Navigation Satellite System (GNSS) and vertical guidance is provided by a Baro-VNAV system. Obstacle clearance is assured through the use of Minimum Obstacle Clearance methodology for both the approach and missed approach segments in the procedure design.

5.5 The final approach vertical flight path is defined by a vertical path angle (VPA) originating at a specified waypoint (normally the runway threshold or RWY waypoint) and extending back along the flight path to a final approach point. The VPA is contained in the specification of the instrument procedure within the RNAV system navigation database.

5.6 An APV Baro-VNAV instrument approach is a 3-dimensional approach and is flown to a Decision Altitude (DA).

5.7 Baro-VNAV standards in this chapter do not apply to RNP AR APCH operations however an operator who holds an RNP AR Terminal navigation authorisation meets the standards applicable to APV Baro-VNAV.

6. APPLICABILITY

6.1 This AC is applicable to operators of Australian and foreign registered aircraft and their flight crews. An APV Baro-VNAV navigation authorisation (or equivalent approval from another State) is not mandatory in order to gain access to Australian 'PBN airspace'. However, an APV Baro-VNAV *and* an RNP APCH - LNAV navigation authorisation/endorsement (or equivalent approval from another State) must be obtained from CASA in order to conduct an RNP APCH – LNAV/VNAV procedure in Australia.

Note: *The terms APV Baro-VNAV and RNP APCH – LNAV/VNAV are synonymous.*

7. RELATED PUBLICATIONS

7.1 For further information on this topic, operators are advised to view the following regulations/publications:

- ICAO Doc 8168 Procedures for Air Navigation Services – Aircraft Operations Volume I, Part 2, Section 4, Chapter 1.
- Draft AC 173-4(0) Instrument Procedures Design Clarification of RNAV and Baro-VNAV criteria.
- CASA AC 21-37(0) Airworthiness Approval of Navigation or Flight Management Systems Integrating Multiple Navigation Sensors.
- CASA AC 21-36(0) Global Navigation Satellite System (GNSS) Equipment: Airworthiness Guidelines.
- Civil Aviation Orders (CAO) 40.2.1 Instrument Ratings.

8. NAVIGATION AUTHORISATION

8.1 An operator should carry out the following steps so that the Civil Aviation Safety Authority (CASA) has sufficient information to issue a RNP APCH navigation authorisation:

- Demonstrate Aircraft Eligibility:
  - Aircraft equipment eligibility requirements for APV Baro-VNAV are described in the PBN Manual and may be demonstrated through an Aircraft Flight Manual (AFM) compliance statement, AFM supplement or Original Equipment Manufacturer (OEM) service letter; however where aircraft equipment varies from these requirements subsequent eligibility will be determined by CASA;
- Describe Training and Operating Procedures:
  - Flight crew training and operating procedures for the navigation systems to be used must be described by the operator in a syllabus of training and an aid memoir e.g. Quick Reference Handbook, checklist etc.; and
- Document Training and Operating Procedures:
  - Methods of control for flight crew training, operational procedures and data base management must be identified in the operations manual.

9. NAVIGATION AUTHORISATION PROCESS

9.1 Navigation authorisations for all PBN navigation specifications and Reduced Vertical Separation Minimum (RVSM) operations are as follows:

- An aircraft operator applies for a navigation authorisation through the CASA Permission Application Centre using Form 1307 Reduced Vertical Separation Minimum and Required Navigation Performance Application Form;
- The CASA Permission Application Centre registers the Form 1307 and forwards it to the relevant Certificate Management Team for assessment;
- The Certificate Management Team conducts the navigation authorisation assessment and:
  - Where the application meets the criteria listed in the PBN Manual and this AC, the Certificate Management Team approves the application and returns it to the Permission Application Centre; or

- Where the application does not meet the criteria listed in the PBN Manual and this AC (e.g. a non-standard application due to specific aircraft equipment functionality or training requirements) the Certificate Management Team seeks further information from the applicant. Once sufficient information has been received such that CASA may assess the application as 'equivalent' to the requirements of the PBN Manual and this AC the Certificate Management Team approves the application and returns it to the Permission Application Centre; and

- The CASA Permission Application Centre registers the approved navigation authorisation application in the operator's Operational Specifications (Ops Specs) and issues an updated Ops Specs to the operator.

Note: *Ops Specs are yet to be provided with a legislative head of power through Subpart 91U of the Civil Aviation Safety Regulations 1998 (CASR 1998). This will occur in the future through the Subpart 91U of CASR 1998 update and rewrite process which will align all navigation authorisations with the ICAO PBN Manual. Until such time, APV Baro-VNAV navigation authorisations will be issued under CAO 20.91.*

10. APPLICATION

10.1 The contents of an operator's application for an APV Baro-VNAV navigation authorisation include the following technical, operational and training information:

- aircraft airworthiness documents:
  - the AFM, an AFM Supplement, OEM service letters etc. that establish that the aircraft is equipped to meet the requirements for LNAV and Baro-VNAV operations (i.e.: APV Baro-VNAV or RNP APCH - LNAV/VNAV); or
  - where it is not possible to determine an aircraft's equipment eligibility from airworthiness documentation, a detailed description of the equipment proposed to be used, evidence of suitable performance, bulletins and any other pertinent information, including any relevant crew operating procedures that is sufficient to allow CASA to make a determination of aircraft eligibility;
- a description of pertinent aircraft equipment including a configuration list which details components and equipment to be used;
- a description of the proposed training programmes including:
  - training provided by the operator;
  - training conducted by a CASA approved training organisation;
  - evidence of other training and/or qualifications that is sufficient for CASA to determine that personnel have appropriate knowledge and skills for APV Baro-VNAV operations; and
  - training provided personnel employed by the organisation responsible for the maintenance of the operator's aircraft;
- a description of operating procedures, including:
  - a statement of any operating procedures applicable to APV Baro-VNAV; and
  - any changes to checklists with regard to APV Baro-VNAV operations.
- a description of the method that is to be used to monitor APV Baro-VNAV operations to identify, report and investigate any failure or potential failure in the Baro-VNAV system or operating procedures;
- revisions to the Minimum Equipment List (MEL);

- a description of the maintenance programme including any provisions necessary to ensure the continuing airworthiness of relevant navigation equipment; and
- a compliance statement that identifies how the operator's application conforms to each individual paragraph in this AC and the associated Regulation under Part 91 of CASR 1998.

Note: *Course material, lesson plans and other training products are subject to CASA approval of the operator's Regulation 217 Training and Checking organisation of the Civil Aviation Regulations 1988 (CAR 1988).*

11. AIRCRAFT ELIGIBILITY

11.1 Eligible aircraft will be equipped with:

- a Baro-VNAV system;
- a navigational database that permits the vertical path to be defined;
- navigation displays which enable vertical deviation from the defined VNAV path to be determined; and
- a GNSS RNAV system approved for IFR approach operations in accordance with an RNP APCH navigation authorisation.

11.2 An aircraft is eligible for an APV Baro-VNAV navigation authorisation if:

- It is equipped with a barometric VNAV system that meets the requirements of:
  - FAA AC 20-129 Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the U.S. National Airspace system (NAS) and Alaska;
  - FAA AC 90-105 Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System;
  - EASA AMC 20-27 Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BARO-VNAV Operations;
  - An approval issued in the aircraft state of operation or registry, and which is assessed by CASA as conforming to this AC; or
  - CASA has made an assessment of the aircraft and determines that the aircraft meets the standards for eligibility.

12. SYSTEM PERFORMANCE, MONITORING AND ALERTING

12.1 The performance standards for a Baro-VNAV system used in APV Baro-VNAV operations are met if:

- The Baro-VNAV system satisfies the requirements of FAA AC 20-129 Airworthiness Approval of Vertical Navigation (VNAV) Systems for use in the United States National Airspace System (NAS) and Alaska; or
- It is demonstrated that the VNAV Total System Error (TSE), including altimetry errors, is less than 75 m (246 ft) for a probability of 99.99%. For the purpose of this demonstration, the VNAV TSE analysis includes:
  - altimetry errors including allowance for accuracy of reported barometric pressure (ATIS error);
  - VNAV system error, including VPA resolution error;
  - waypoint resolution error; and

- flight technical error.

Note: *Provision for RNAV along-track system error is not included.*

13. SYSTEM FUNCTIONALITY

13.1 The functions applicable to the Baro-VNAV system used in APV/Baro-VNAV operations are:

- the capability to load the entire procedure(s) to be flown into the RNAV system from the on-board navigation database, including the approach, the missed approach and the approach transitions for the selected airport and runway;
- flight crew modification of instrument approach procedure data is not possible;
- the resolution of VPA entry (from the navigation database) and display is 0.1° or smaller;
- the vertical path is defined by a waypoint and a vertical angle;
- vertical deviation from the defined VNAV path is continuously displayed;
- in the pilot's primary field of view;
- vertical deviation resolution is 10 ft;
- where the crew is two pilots, barometric altitude from two independent sources is displayed, one in each pilot's primary field of view; and
- a means for the crew to readily determine the VNAV mode of operation, including establishment/capture of the vertical path, and any mode change or reversion.

13.2 An alternative standard for the display and monitoring of vertical deviation is met where an operational assessment enables CASA to determine that the pilot flying is able to readily distinguish vertical deviation not exceeding +100 ft/-50 ft such that timely corrective action (including a go-round) can be initiated. The assessment will include the following;

- digital display of vertical deviation;
- displays not in the primary field of view;
- aural or other warnings or annunciations;
- crew procedures and training;
- use of flight director and/or autopilot; and
- flight trials and/or other performance indicators.

14. OPERATING STANDARDS

14.1 The standards for the conduct of APV Baro-VNAV operations are:

- Operations are conducted using an approved local barometric pressure source;
- Procedures are applied to ensure that the correct barometric pressure is set and a method of cross-checking is applied prior to the commencement of an approach;
- A stabilized approach is flown to a DA indicated on an approach chart by a LNAV/VNAV minima;
- Deviations below the defined vertical path are limited by the flight crew to 75 ft;
- A missed approach procedure is conducted if the vertical deviation exceeds 75 ft below the defined vertical path;
- Procedures are applied to limit any sustained deviations above the VNAV path to 75 ft or less;

- For aircraft operating under a navigation authorisation that is applicable to an aircraft equipped with a Baro-VNAV system that does provide temperature compensation in the derivation of the vertical path operations are conducted within the temperature limitations published on the approach chart;
- For aircraft operating under a navigation authorisation that is applicable to an aircraft equipped with Baro-VNAV systems that provide temperature compensation in the determination of the vertical path temperature limitations do not apply;
- The aircraft is established on the vertical path no later than the final approach fix (FAF);
- If Baro-VNAV guidance is intended for use prior to the FAF operating procedures ensures that any minimum altitudes are displayed and the computed vertical flight path does not permit descent below any minimum altitude; and
- A means for the flight crew to determine that the aircraft configuration and serviceability for APV Baro-VNAV operations.

15. FLIGHT CREW KNOWLEDGE AND TRAINING

15.1 Minimum flight crew knowledge and training elements for the conduct of APV/Baro-VNAV operations are:

- APV Baro-VNAV instrument approach charts, including LNAV/VNAV minima, temperature limitations, and vertical flight path angle;
- Principles of Baro-VNAV vertical guidance including path construction and the effect of temperature;
- Basic APV Baro-VNAV instrument approach procedure design;
- Use of Minimum Decision Altitude and DA for LNAV and LNAV/VNAV minima respectively;
- Approach procedure selection;
- Barometric datum selection (altimeter subscale setting), and cross-checking/verification procedures including effect of incorrect setting;
- VNAV mode selection and monitoring;
- VNAV failure modes and mode reversions; and
- VNAV flight tolerances.

16. MINIMUM EQUIPMENT LIST

16.1 The MEL will identify any equipment specifically required for the conduct of APV Baro-VNAV operations.

17. CONTINUING AIRWORTHINESS

17.1 The operator is required to implement procedures to ensure the continuing airworthiness of the aircraft for APV Baro-VNAV operations.

17.2 Aircraft equipment and configuration control consistent with the APV Baro-VNAV capability and minimum equipment requirements is required.

17.3 Engineering personnel are to be provided with training where required to ensure that they are familiar with APV Baro-VNAV airworthiness requirements.

18. NAVIGATION DATA BASE

18.1 A navigation database should be obtained from a supplier that complies with Radio technical Commission for Aeronautics (RTCA) DO 200A/ European Organisation for Civil Aircraft Equipment (EUROCAE) document ED-76, Standards for Processing Aeronautical Data and should be compatible with the intended function of the equipment (see ICAO Annex 6, Part 1, Chapter 7). A Letter of Acceptance (LOA), issued by an appropriate regulatory authority to each of the participants in the data chain, demonstrates compliance with this requirement (e.g. Federal Aviation Administration (FAA) LOA issued in accordance with FAA AC 20-153 or European Aviation Safety Agency (EASA) LOA issued in accordance with EASA Implementing Rule (IR) 21 subpart G).

18.2 An operator who uses a navigation database supplier that does not meet these standards must implement navigation database integrity checks using appropriate software tools or approved manual procedures to verify data relating to all waypoints in airspace or routes where APV Baro-VNAV operations are conducted. These checks are in addition to any checks performed by the Aeronautical Information Services, unapproved navigation database suppliers or navigation equipment manufacturers.

Note: *While a LOA provides assurance of minimum standards for the supply of a navigation data, errors may still occur and all operators should consider the need to conduct periodic checks to ensure database integrity.*

18.3 Any discrepancy in data is to be reported to the navigation database supplier and resolved prior to operational use by:

- re-issue of the navigation database;
- prohibition of the route; or
- instructions to flight crew.

Note: *Typically, airline operators will contract with a navigation database supplier to provide a customised database and will establish procedures to validate the navigation data at each 28 day cycle. Other operators may rely on a generic database and may not have the capability to independently validate the data. In such cases procedures may need to be implemented to validate navigation data using a simulator or desk-top device, or additional cockpit procedures applied to validate each procedure before commencement of an approach.*

18.4 The data used to compute the APV/Baro-VNAV vertical navigation path:

- is extracted from the aircraft electronic database associated with the RNAV system;
- defines VPA and runway and other waypoints necessary to compute the vertical path; and
- is not able to be modified by the flight crew.

19. IMPLEMENTATION PROGRAMME

19.1 The implementation of APV/Baro-VNAV operations is to be managed in accordance with a programme developed by the operator in consultation with CASA.

19.2 For an operator that has not previously conducted Baro-VNAV approach operations or has not previously conducted Baro-VNAV approach operations using a particular aircraft type, the implementation programme will include limits on operating minima until the operator has demonstrated the capability to safely conduct APV/Baro-VNAV operations.

Note: *The initial operating period is determined after consideration of all relevant factors including operator RNAV and VNAV operating experience, the number and frequency of APV Baro-VNAV operations conducted and the number of non-compliant incidents recorded.*

19.3 The implementation programme will include the monitoring of operations and the collection of data to enable any negative trend in performance or operations to be identified.

19.4 At intervals as specified in the operator's implementation programme, the operator will submit to CASA a report containing a review of operations including the following elements:

- total number of procedures conducted;
- number of satisfactory approaches by aircraft/system (satisfactory if completed as planned without any navigation or guidance system anomalies);
- reasons for unsatisfactory operations, such as:
  - UNABLE REQ NAV PERF, PRI GPS LOST, or other RNP related messages;
  - excessive lateral or vertical deviation;
  - Terrain Awareness and Warning System warning;
  - autopilot system disconnect;
  - navigation data errors; and
  - pilot report of any anomaly;
- crew comments.

Note: *The structure of the implementation programme, including limited operating minima or the number or duration of operations applicable to any particular phase of the operator's programme are subject to many variables and is not specified. Factors such as the operator's previous experience in RNAV and RNP approach and departure operations, the frequency of RNP AR operations, the number of qualified crews available should be considered and a suitable programme developed in consultation with CASA. A phased implementation programme which provides for goals to be met at the conclusion of each phase is recommended.*

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