Transport Canada Transports Canada

Advisory Circular

Subject: **Required Navigation Performance Approach (RNP APCH)**

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1.0 INTRODUCTION

(1) This Advisory Circular (AC) is provided for information and guidance purposes. It describes an example of an acceptable means, but not the only means, of demonstrating compliance with regulations and standards. This AC on its own does not change, create, amend or permit deviations from regulatory requirements, nor does it establish minimum standards.

1.1 Purpose

(1) The content of this AC is based on the guidance contained in the International Civil Aviation Organization (ICAO) Doc. 9613 *Performance Based Navigation Manual*. Adhering to the content of this AC will assure compliance with the ICAO specification for the conduct of RNP approaches to Lateral Navigation (LNAV), Lateral Navigation / Vertical Navigation (LNAV/VNAV), Localizer Performance with Vertical Guidance (LPV) and Localizer Performance without Vertical Guidance (LP) minima. Authorization through the issuance of Operations Specification (Ops Spec) 620 to Canadian air operators or private operators will constitute their operational approval to conduct instrument approaches designated as RNP APCH, subject to the applicable requirements of the Country in which the approach is conducted.

***Note**: Air operators and private operators who wish to perform RNP APCH procedures which contain a Radius to Fix transition, must also meet the criteria of, and receive, Ops Spec 623 – Radius to Fix Transition Segments.*

(2) This AC does not address Required Navigation Performance Approach – Authorization Required (RNP AR APCH) operations, nor the requirements to obtain the associated authorization, Ops Spec 621 - *Required Navigation Performance Approach – Authorization Required (RNP AR APCH)*.

(3) This authorization will also form the basis upon which a foreign National Aviation Authority (NAA) may authorize, within their jurisdiction, a Canadian air operator or private operator to conduct instrument approaches designated as RNP APCH.

(4) Aircraft are certified by their State of manufacture. Operators are approved in accordance with the *Canadian Aviation Regulations* (CARs). The navigation specification provides the technical and operational criteria, and does not imply a need for recertification of the aircraft or its equipment.

1.2 Applicability

(1) This AC applies to Canadian air operators holding an Air Operator Certificate issued under Part VII of the CARs or to private operators holding a Private Operator Certificate issued under Subpart 604 of the CARs, who wish to conduct instrument approaches requiring RNP APCH navigation performance. These will be commonly referred to as “operator” in this AC.

(2) This document is also applicable to all Transport Canada Civil Aviation (TCCA) employees, and to individuals and organizations when they are exercising privileges granted to them under an External Ministerial Delegation of Authority. The content of this document is also available to the aviation industry at large for information purposes.

1.3 Description of Changes

(1) Not applicable.

1.4 Approval Process

(1) The following steps must be completed before conducting RNP APCH operations:

(a) aircraft equipment eligibility must be determined, documented and be acceptable to TCCA;

(b) operating procedures for the navigation systems to be used and the operator navigation database process must be documented in the Company Operations Manual (COM);

(c) the operator's training program must be amended to include the training requirements of this AC; and

(d) operational approval must then be obtained in accordance with the CARs.

(2) Operators may be restricted in the type of RNP approach they can conduct. Such a restriction would be indicated on the Ops Spec 620 as "Restricted to LNAV Minima Only", "Restricted to LNAV and LNAV/VNAV Minima Only" or "Restricted to LP and LPV Minima Only", and would be based on the operator's equipment capability.

2.0 REFERENCES AND REQUIREMENTS

2.1 Reference Documents

(1) It is intended that the following reference materials be used in conjunction with this document:

(a) Part V of the *Canadian Aviation Regulations* (CARs)—*Airworthiness*;

(b) Part VI, subpart IV of the CARs—*Private Operator Passenger Transportation;*

(c) Part VII, subpart II of the CARs—*Aerial Work*;

(d) Part VII, subpart III of the CARs – *Air Taxi Operations*;

(e) Part VII, subpart IV of the CARs—*Commuter Operations*;

(f) Part VII, subpart V of the CARs—*Airline Operations*;

(g) Standard 722 of the *Commercial Air Services Standards* (CASS)—*Aerial Work*;

(h) Standard 723 of the CASS – *Air Taxi*;

(i) Standard 724 of the CASS—*Commuter Operations*;

(j) Standard 725 of the CASS—*Airline Operations*;

(k) Operations Specification (Ops Spec) 623 – *Radius to Fix (RF) Path Terminator*;

(l) Operations Specification 620 – *Required Navigation Performance – Approach (RNP APCH)*;

(m) Advisory Circular 700-027 - *Radius to Fix (RF) Path Terminator*;

(n) Transport Canada Publication (TP) 14371 – *Aeronautical Information Manual*;

(o) TP 308 - *Criteria for the Development of Instrument Approaches*;

(p) Federal Aviation Administration Advisory Circular (FAA AC) 90-105 - *Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System*;

(q) FAA AC 90-107 - *Guidance for Localizer Performance With Vertical Guidance and Localizer Performance Without Vertical Guidance Approach Operations in the U.S. National Airspace System*;

(r) International Civil Aviation Organization (ICAO) Doc. 9613 *Performance Based Navigation (PBN) Manual*, Volume II Part C Implementing RNP APCH; and

(s) ICAO Doc. 7030 *Regional Supplementary Procedures*.

2.2 Cancelled Documents

(1) Not applicable.

(2) By default, it is understood that the publication of a new issue of a document automatically renders any earlier issues of the same document null and void.

2.3 Definitions and Abbreviations

(1) The following **definitions** are used in this document:

(a) **Advisory Circular:** A document providing an example of an acceptable means, but not the only means, of demonstrating compliance with regulations and standards.

(b) **Advisory Vertical Guidance:** Vertical path deviation guidance indication that is generated by any means, but is only an aid provided by some manufacturers to help pilots meet altitude restrictions. Advisory vertical guidance is an optional capability implemented at the manufacturer's discretion; not a requirement for positioning and navigation equipment.

Note. *It is the flight crew member's responsibility to use the barometric altimeter to ensure compliance with altitude restrictions, particularly during approach operations. Advisory vertical guidance is not approved vertical guidance like that found on approaches with LNAV/VNAV, LPV or instrument landing system (ILS) lines of minima.*

(c) **Air navigation services**: This term includes air traffic management (ATM), communications, navigation and surveillance systems (CNS); meteorological services for air navigation (MET); search and rescue (SAR); and aeronautical information services (AIS). These services are provided to air traffic during all phases of operations (approach, terminal and en route).

(d) **Air navigation services provider**: An independent entity established for the purpose of operating and managing air navigation services, and empowered to manage and use the revenues it generates to cover its costs. In Canada, this function is normally performed by NAV CANADA.

(e) **Aircraft-based Augmentation System:** A system which augments and/or integrates the information obtained from other Global Navigation Satellite System (GNSS) elements with information available on board the aircraft. The most common form of Aircraft-based Augmentation System (ABAS) is the receiver autonomous integrity monitoring (RAIM).

(f) **Approach with Vertical Guidance:** An instrument approach procedure that utilizes lateral and vertical guidance that does not meet the requirements established for a precision approach.

(g) **Approved Vertical Guidance:** Actual vertical path deviation guidance indications generated by a certified means for charted approach procedures that contain a protected glidepath (e.g. approaches with LNAV/VNAV, LPV or ILS lines of minima).

(h) **Area Navigation**: A navigation system that allows aircraft to operate on any desired flight track within the coverage of ground or space-based navigation aids, or within the limits of the capability of self-contained aids, or a combination of both methods. Area navigation includes performance-based navigation as well as other operations that are not contemplated in the definition of performance-based navigation.

(i) **Required Navigation Performance System:** Area navigation system that includes the requirement for on-board performance monitoring and alerting, designated by the prefix RNP (e.g. RNP 4, RNP APCH).

(ii) **Area Navigation System:** Area navigation system that does not include the requirement for on-board performance monitoring and alerting, designated by the prefix RNAV (e.g. RNAV 5, RNAV 1).

(i) **Barometric Aiding (Baro-Aiding):** A method of augmenting the GPS integrity solution in RAIM by using a barometric altitude input source. Baro-aiding requires four satellites and a barometric altimeter to detect an integrity anomaly (the current altimeter setting may need to be entered into the receiver as described in the operating manual). Baro-aiding satisfies the RAIM requirement in lieu of a fifth satellite.

(j) **Barometric Vertical Navigation (baro-VNAV):** A function of certain RNAV systems which presents computed vertical guidance to the pilot referenced to a specified vertical path. The computed vertical guidance is based on barometric altitude information and is typically computed as a geometric path between two waypoints or an angle based on a single waypoint. Baro-VNAV may generate advisory or approved vertical guidance, depending on the type of approach.

(k) **Decision Altitude:** In an approach with approved vertical guidance, Decision Attitude (DA) is a specified altitude expressed in feet above mean sea level (MSL) at which a missed approach must be initiated if the required visual references to continue the approach have not been established.

(l) **Fault Detection and Exclusion:** A RAIM algorithm that can automatically detect and exclude a faulty satellite from the position solution when measurements from six or more satellites are available. The wide area augmentation systems (WAAS) equipment uses FDE for integrity whenever a WAAS signal is not available to permit continued operation from en route through approach operations.

(m) **Global Navigation Satellite System:** A generic term used by the International Civil Aviation Organization (ICAO) to define any global position, speed, and time determination system that includes one or more main satellite constellations, such as GPS and the global navigation satellite system (GLONASS); aircraft receivers; and several integrity monitoring systems, including aircraft-based augmentation systems (ABAS), satellite-based augmentation systems (SBAS), such as the WAAS, and ground-based augmentation systems (GBAS), such as the local area augmentation system (LAAS).

(n) **Global Positioning System:** The GNSS of the United States is a satellite-based radio navigation system that uses precise distance measurements to determine the position, speed, and time in any part of the world. The GPS is made up by three elements: the spatial, the control, and the user elements. The GPS spatial segment nominally consists of at least 24 satellites in 6 orbital planes. The control element consists of 5 monitoring stations, 3 ground antennas, and one main control station. The user element consists of antennas and receivers that provide the user with position, speed and precise time.

(o) **Integrity:** A measure of the trust that can be placed in the correctness of the information supplied by the total system. Integrity includes the ability of a system to provide timely and valid warnings to the user (alerts).

(p) **Lateral Navigation:** An RNAV function that computes, displays, and provides horizontal approach navigation without approved vertical guidance.

(q) **Lateral Navigation/Vertical Navigation:** An APV using a final approach segment (FAS) data block that computes, displays and provides both horizontal and approved vertical approach navigation. Both WAAS vertical guidance and baro-VNAV support approaches to LNAV/VNAV lines of minima.

(r) **Localizer Performance with Vertical Guidance:** An APV requiring WAAS, using a FAS data block, which computes, displays and provides both horizontal and approved vertical approach navigation to minimums as low as 200 foot ceiling and ½ mile visibility.

(s) **Localizer Performance without Vertical Guidance:** A non-precision approach requiring WAAS, using a FAS data block that computes, displays, and provides horizontal

approach navigation using the horizontal accuracy and integrity of LPV without the approved vertical guidance. The LP line of minima is provided at locations where issues prevent the use of LPV vertical guidance, and provides a higher probability of achieving the lowest minimum at these locations.

(t) **Navigation specification:** A set of requirements needed to implement and support performance based navigation within a defined airspace.

(u) **Performance Based Navigation:** Area navigation based on performance requirements for aircraft operating along an Air Traffic Service (ATS) route, on an instrument approach procedure or in a designated airspace.

Note. *Performance requirements are expressed in the navigation specification (RNAV specification or RNP specification) in terms of accuracy, integrity, continuity, availability and functionality needed for the proposed operation in the context of a particular airspace concept.*

(v) **Radius to Fix Path Terminator:** Also known as RF legs. A specific fixed-radius curved path in a terminal or approach procedure intended to be applied where an accurate, repeatable and predictable ground path is required.

(w) **Receiver Autonomous Integrity Monitoring:** A form of ABAS whereby a GNSS receiver processor determines the integrity of the GNSS navigation signals using only GPS signals or GPS signals augmented with altitude (baro-aiding). This determination is achieved by a consistency check among redundant pseudo-range measurements. At least one additional satellite needs to be available with the correct geometry over and above that needed for the position estimation for the receiver to perform the RAIM function.

(x) **Required Navigation Performance Approach:** RNP APCH is a navigation specification based on area navigation that includes the requirement for on-board performance monitoring and alerting features to notify the pilot when the RNP for the approach phase of flight is not being met. RNP APCH does not include approach operations classified as RNP Authorization Required (RNP AR).

(y) **Satellite-Based Augmentation System:** SBAS is a wide area coverage augmentation system. The user receives GPS constellation augmentation information from a geostationary satellite-based transmitter. SBAS complements the core GPS satellite constellation by increasing navigation accuracy, integrity, continuity and availability provided within a service area. The SBAS which works with GPS is the WAAS.

(z) **Technical Standard Order:** A minimum performance standard for specified materials, parts, and appliances used on civil aircraft.

(aa) **Total System Error:** The difference between the true position and the desired position. This error is equal to the sum of the vectors of the path definition error (PDE), the flight technical error (FTE) and the navigation system error (NSE).

(i) Flight Technical Error (FTE): The FTE is the accuracy with which an aircraft is controlled as measured by the indicated aircraft position with respect to the indicated command or desired position. It does not include blunder errors.

(ii) Navigation System Error (NSE): The difference between the true position and the estimated position.

(iii) Path Definition Error (PDE): The difference between the defined path and the desired path at a given place and time.

(ab) **World Geodetic System 1984 (WGS 84):** The most recent geocentric reference system definition developed by the United States Department of Defence (World Geodetic System Committee).

(2) The following **abbreviations** are used in this document:

(a) **AC:** Advisory Circular;

(b) **ABAS:** Aircraft-based Augmentation System;

(c) **ANSP:** Air Navigation Service Provider;

(d) **APV:** Approach with Vertical Guidance;

(e) **CRC:** Cyclic Redundancy Check;

(f) **DA:** Decision Attitude;

(g) **FAS:** Final Approach Segment;

(h) **FDE:** Fault Detection and Exclusion;

(i) **FTE:** Flight Technical Error;

(j) **GNSS:** Global Navigation Satellite System;

(k) **GPS:** Global Positioning System;

(l) **LNAV:** Lateral Navigation;

(m) **LNAV/VNAV:** Lateral Navigation/Vertical Navigation;

(n) **LP:** Localizer Performance without Vertical Guidance;

(o) **LPV:** Localizer Performance with Vertical Guidance;

(p) **NPA:** Non-Precision Approach;

(q) **NSE:** Navigation System Error;

(r) **OCS:** Obstacle Clearance Surface;

(s) **PBN:** Performance Based Navigation;

(t) **PDE:** Path Definition Error;

(u) **RAIM:** Receiver Autonomous Integrity Monitoring;

(v) **RF:** Radius to Fix;

(w) **RNAV:** Area Navigation;

(x) **RNP:** Required Navigation Performance;

(y) **RNP APCH:** Required Navigation Performance Approach;

(z) **ROC:** Required Obstacle Clearance;

aa) **SBAS:** Satellite-Based Augmentation System;

ab) **TCCA:** Transport Canada Civil Aviation;

ac) **TSE:** Total System Error;

ad) **TSO:** Technical Standard Order;

ae) **VPA:** Vertical Path Angle;

af) **WAAS:** Wide Area Augmentation System; and

ag) **WGS 48:** World Geodetic System 1984.

3.0 BACKGROUND

(1) The material described in this Advisory Circular (AC) has been developed based on International Civil Aviation Organization (ICAO) Doc 9613 *Performance Based Navigation (PBN) Manual*, Vol. II Part C Implementing RNP APCH. And TP 308 *Criteria for the Development of Instrument Approaches*. Additional information may be found in TP 14371 *Aeronautical Information Manual*.

(2) This AC does not establish all the requirements that may be specified for a given Required Navigation Performance Approach (RNP APCH). Some of these requirements are established in other documents, such as the Transport Canada Publication (TP) 308 *Criteria for the Development of Instrument Procedures*. Although operational approval is normally related to equipment, procedures and training requirements, operators must consider other regulatory requirements before conducting RNP APCH procedures.

3.1 RNP Approach Operations – General

(1) RNP APCH operations:

(a) are based on the Global Navigation Satellite System (GNSS);

(b) include existing RNAV (GNSS) and RNAV Global Positioning System (GPS) approach procedures;

(c) rely on conventional compliance with descent profiles and altitude requirements;

(d) use the World Geodetic System 1984 (WGS 84) coordinates in the creation of procedures;

(e) meet the requirements of Annex 15 to the Convention on International Civil Aviation in the navigation data published for the routes and procedures;

(f) will clearly indicate the required navigation standard (e.g. RNP APCH) on all the appropriate charts;

(g) may contain a missed approach segment based upon a conventional Navigation Aid (NAVAID) (e.g. VHF Omni-Directional Radio (VOR), Distance Measuring Equipment (DME), Non-Directional Beacon (NDB));

(h) may contain a Radius-to-Fix Path Terminator leg (RF leg). Additional authorization in the form of Operations Specification (Ops Spec) 623 is required to perform RF legs contained in RNP APCH operations.

3.2 Wide Area Augmentation System

(1) Wide Area Augmentation System (WAAS) essentially meets the same navigation performance requirements (accuracy, integrity and continuity) as Instrument Landing System (ILS), and provides similar guidance. WAAS avionics continually calculate integrity levels during an approach and will provide a message to the crew if alert limits are exceeded. Although the WAAS integrity monitor is very reliable, good airmanship nevertheless dictates that pilots verify the final approach waypoint (FAWP) crossing altitude depicted on approach plates with Lateral Navigation/Vertical Navigation (LNAV/VNAV) and Localizer Performance with Vertical Guidance (LPV) minima, in the same way that the beacon crossing altitude is checked when flying an ILS approach. Large altitude deviations could be an indication of a database error or otherwise undetectable incorrect signal.

3.3 Ops Spec 100 – Instrument Flight Rules Instrument Approaches Global Positioning System

(1) Ops Spec 100 authorizes an operator to perform RNAV (GNSS) approach procedures;

(2) Ops Spec 100 does not authorize an operator to perform RNP APCH procedures due to the additional equipment functions and personnel training required for RNP operations;

(3) Effective immediately, Ops Spec 100 will only be issued to operators of aircraft unable to meet the RNP equipment requirements contained in this AC. The intention is to allow such operators to benefit from the use of existing RNAV (GNSS) approaches. Operators of RNP-capable aircraft not already in possession of Ops Spec 100 will require Ops Spec 620 for the same activity.

4.0 RNP APPROACH MINIMA

4.1 Lateral Navigation Minima

(1) LNAV minima depict a Minimum Descent Altitude (MDA).

(2) GNSS-based approaches to LNAV minima are non-precision approaches which do not define a vertical path through space. As such, each approach segment has a minimum step-down altitude below which the pilot may not descend.

(3) Aircraft equipment must comply with the criteria of Appendix A, as a minimum. The avionics may provide advisory vertical guidance during an LNAV approach but barometric altimeter information remains the primary altitude reference for complying with any altitude restrictions.

(4) To conduct RNP APCH operations to LNAV minima, operators must have a restricted or unrestricted Ops Spec 620.

4.2 Lateral Navigation/Vertical Navigation Minima

(1) The LNAV/VNAV minima depict a decision altitude (DA).

(2) RNP approaches to LNAV/VNAV minima are a form of Approach with Vertical Guidance (APV) which define both a lateral and vertical path through space.

(3) Aircraft equipment must meet the criteria of Appendix A and C; or of Appendix B.

(4) To conduct RNP APCH operations to LNAV/VNAV minima, operators must be authorized by the issuance of an Ops Spec 620 restricted to LNAV and LNAV/VNAV minima only or an unrestricted Ops Spec 620.

4.3 Localizer Performance with Vertical Guidance Minima

(1) The LPV minima depict a DA.

(2) RNP approaches to LPV minima are a form of APV which define both a lateral and vertical path through space.

Note. *At the time of writing this document, ICAO was considering the possibility of including this type of approach in the category of Precision Approach, instead of APV*.

(3) Aircraft equipment must meet the criteria of Appendix B.

(4) To conduct RNP APCH operations to LPV minima, operators must be authorized by the issuance of an unrestricted Ops Spec 620.

4.4 Localizer Performance without Vertical Guidance Minima

(1) LP minima depict a MDA, unlike LPV minima.

(2) RNP approaches to LP minima are non-precision approaches which do not define a vertical path through space. As such, each approach segment has a minimum step-down altitude below which the pilot may not descend.

(3) LP minima will not be published on approach procedures with approved vertical guidance (LNAV/VNAV or LPV) minima. Publishing a LP line of minima will only occur if terrain, obstructions or some other reason prevent publishing a vertically guided procedure. It is possible to have LP and LNAV minima published on the same approach chart, but a LP minimum will only be published if it provides a lower minimum than the associated LNAV line of minima. LP is not a fail-down mode for LPV.

(4) The aircraft equipment must meet the criteria of Appendix B. The avionics may provide advisory vertical guidance during an LP approach but barometric altimeter information remains the primary altitude reference for complying with any altitude restrictions.

(5) To conduct RNP APCH operations to LP minima, operators must be authorized by the issuance of an unrestricted Ops Spec 620.

4.5 Required Navigation for RNP Approach Minima Types

Table 1 – GNSS-Based approach minima

Approach Minima	Lateral Navigation	Vertical Navigation	Vertical Guidance
LNAV	GPS or WAAS	Altitude-based NPA techniques*, Baro-VNAV or WAAS	Advisory
LNAV/VNAV	GPS or WAAS	Baro-VNAV or WAAS	Approved
LPV	WAAS	WAAS	Approved
LP	WAAS	Altitude-based NPA techniques*, Baro-VNAV or WAAS	Advisory

* “Altitude-based NPA techniques” refers to the step down technique and the constant descent angle technique (e.g. Stabilized Constant Descent Angle (SCDA)).

5.0 RNP APPROACH VERTICAL NAVIGATION

(1) Prior to the advent of GNSS, ICAO defined only two types of approach and landing operations - precision approach (PA) and non-precision approach (NPA). It has now added a definition for APV to cover approaches that use lateral and vertical guidance, but that do not meet the requirements established for precision approach. The vertical guidance of an APV is referred to as approved vertical guidance.

(2) RNP approaches to LNAV/VNAV and LPV minima are considered APV types of approaches. The LNAV/VNAV and LPV minima depict a DA, which requires the pilot to initiate a missed approach at the DA if the visual reference to continue the approach has not been established. Since the LNAV/VNAV and LPV approach designs use a sloped vertical obstacle clearance surface, the DA associated with LNAV/VNAV or LPV approaches will be lower than the LNAV MDA in most cases.

(3) The nominal final approach course vertical flight path angle for LNAV/VNAV and LPV approaches is 3°, avoiding the step-down minimum altitudes associated with traditional non-precision approaches.

(4) The vertical profile of an APV may be flown using baro-VNAV (LNAV/VNAV minima) or WAAS (LPV minima). Refer to Appendix C for more information on baro-VNAV.

5.1 Advisory and Approved Vertical Guidance

(1) *Advisory Vertical Guidance.* RNP approach procedures with a MDA (i.e. LNAV and LP minima) have been assessed for obstacles based on a level obstacle clearance surface (OCS). Although designed for a dive-and-drive type of vertical navigation technique, flight crew members may use a stabilized descent technique as a safer option. To facilitate the stabilized descent, some avionics, such as baro-VNAV and WAAS capable systems, generate a calculated vertical profile and the guidance to follow this profile. The vertical guidance generated by the navigation system when conducting an approach to an MDA is advisory only. Flight crew members must use the barometric altimeter as the primary altitude reference to ensure compliance with any and all altitude restrictions during such instrument approach operations. LPV capable equipment requires special considerations when using advisory vertical guidance, and operators should refer to the manufacturer's operating guides or limitations section in the Aircraft Flight Manual (AFM), Rotorcraft Flight Manual (RFM) or Aircraft Flight Manual Supplement (AFMS).

(2) *Approved Vertical Guidance.* RNP approach procedures to a DA (i.e. LNAV/VNAV and LPV minima) have been assessed for obstacles using a sloping OCS. These approaches have been designed for a stabilized constant descent vertical navigation technique and require the aircraft to be equipped with a certified means of providing vertical guidance to the flight crew. The aircraft navigation system must be capable of generating the vertical guidance to follow the approved vertical profile stored in the navigation database.

(3) An RNP approach to LNAV/VNAV minima requires the approved vertical guidance to be generated by a baro-VNAV or WAAS navigation system.

(4) An RNP approach to LPV minima requires the approved vertical guidance to be generated by a WAAS navigation system.

6.0 AIRCRAFT ELIGIBILITY REQUIREMENTS

(1) Relevant documentation acceptable to Transport Canada Civil (TCCA) Aviation must be available in order to establish that the aircraft is equipped with an RNAV system meeting RNP APCH requirements. To avoid unnecessary regulatory activity, the determination of eligibility for existing systems may consider acceptance of manufacturer documentation of compliance.

6.1 Aircraft Requirements

(1) The aircraft systems must be shown to meet the requirements defined in this AC as it relates to RNP APCH operations.

(2) For aircraft requirement details associated with:

(a) Ops Spec 620 restricted to LNAV minima only, refer to Appendix A of this AC.

(b) Ops Spec 620 restricted to LNAV and LNAV/VNAV minima only, refer to Appendix A and Appendix C of this AC.

(c) Ops Spec 620 unrestricted; refer to Appendix B of this AC.

6.2 Continued Airworthiness

(1) The operators of aircraft approved to perform RNP APCH operations must ensure that the navigation system is maintained according to the design approval holder's instructions for continuing airworthiness (ICAs), including any software updates.

(2) Each operator who applies for RNP APCH operational approval is required to incorporate the RNP APCH equipment inspection requirements, specified by the design approval holder, and amend the aircraft maintenance schedule as required. This requirement is designed to ensure that navigation systems continue to meet the RNP APCH approval criteria.

Note. *If the aircraft was delivered by the aircraft manufacturer with RNP APCH capability, the maintenance requirements may already exist in the maintenance schedule*.

(3) Maintenance for the affected aircraft is required to include the maintenance practices listed in the maintenance manuals of the aircraft manufacturer and its components, and must consider:

(a) that the equipment involved in the RNP APCH operation is required to be maintained according to the ICA from the component design approval holder;

(b) that any amendment or change of navigation system affecting in any way RNP APCH initial approval, must be submitted to the Principle Maintenance Inspector (PMI) and reviewed for acceptance or approval of such changes prior to its implementation; and

(c) that any repair that is not included in the approved/accepted maintenance documentation, and that could affect the integrity of navigation performance, is required to be forwarded to the PMI or regional airworthiness office for acceptance or approval thereof.

7.0 NAVIGATION DATABASE

(1) The operator must obtain the navigation database from a supplier that complies with Radio Technical Commission for Aeronautics (RTCA) DO 200A/EUROCAE document ED 76, Standards for Processing Aeronautical Data. An acceptable method of compliance is a Type 2 Letter of Acceptance (LoA) given to the supplier by the supplier's regulatory authority. An EASA Type 2 LoA is issued by European Aviation Safety Agency (EASA) in accordance with EASA OPINION Nr. 01/2005 on "The Acceptance of Navigation Database Suppliers" dated 14 January 2005. The Federal Aviation Administration (FAA) issues a Type 2 LoA in accordance with AC 20-153(), while TCCA issues an Acknowledgement Letter of an Aeronautical Data Process using the same basis.

(2) The operator must have a system where if a discrepancy is discovered that may invalidate a procedure, it is reported to the navigation database supplier and the affected procedure is prohibited by an operator's notice to its flight crew until the discrepancy is resolved.

(3) The operator should consider the need to conduct ongoing checks of the operational navigation databases in order to confirm the existing quality system requirements are met.

(4) The following conditions apply to aircraft not capable of Radius to Fix Legs:

(a) The navigation system should not permit, either manually or automatically, the flight crew to select a procedure that is not supported by the equipment (e.g. a procedure is not supported if it incorporates an RF leg and the equipment does not provide RF leg capability).

(b) The navigation system should also prohibit flight crew access to procedures requiring RF leg capability if the system can select the procedure, but the aircraft is not otherwise equipped (e.g. the aircraft does not have the required roll steering autopilot or flight director installed).

(c) Examples of an acceptable means to meet these requirements are:

(i) screening the aircraft's onboard navigation database to remove any routes or procedures that the aircraft is not eligible to execute;

(ii) flight crew training to identify and prohibit the use of procedures containing RF legs.

8.0 RNP APPROACH PROCEDURES

(1) Operational approval will confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation. Information that indicates the potential for repeated errors may require modification of an operator's training program. Information that attributes multiple errors to a particular flight crew member may necessitate remedial training.

(2) For detailed procedure requirements associated with:

(a) Ops Spec 620 restricted to LNAV minima only, refer to Appendix A of this AC.

(b) Ops Spec 620 restricted to LNAV and LNAV/VNAV minima only, refer to Appendix A and Appendix C of this AC.

(c) Ops Spec 620 unrestricted; refer to Appendix B of this AC.

8.1 Flight Planning

(1) With GPS and WAAS, the knowledge of a satellite outage by way of Notice to Airmen (NOTAM) does not equate to a direct knowledge of service availability. The procedures for determining service availability are different for GPS (Technical Standard Order TSO C129/C129a) and WAAS (TSO C145a/C146a) avionics, and are explained in the next sections. Additional Flight Planning requirements are detailed in the applicable Appendices.

8.2 Global Positioning System Notice to Airmen

(1) This section is applicable only to operators using TSO C129/ C129a avionics. Research has shown minor differences among avionics' computations of RAIM availability, making it impractical to develop a GPS RAIM NOTAM system that will work reliably for all receivers. Because of this, and since the Instrument Flight Rules (IFR) GPS approval requires aircraft to be equipped with traditional avionics to be used when RAIM is unavailable, NOTAM information on GPS RAIM availability is not provided in Canada.

(2) Canadian flight information centres (FIC) can supply NOTAM on GPS satellite outages by querying the international NOTAM identifier KNMH (This information is also available at <https://www.notams.jcs.mil>). The availability of RAIM can then be computed from the satellite availability information by entering the expected outages into PC-based RAIM prediction software provided by some avionics manufacturers or through direct entry into Flight Management System (FMS) computers that support this function.

(3) GNSS avionics also contain such a model, and this allows pilots to determine if approach-level RAIM will be available) upon arrival at destination or an alternate. The calculation typically uses current information, broadcast by the satellites, identifying which satellites are in service at that time. However, unlike the software that is based on the NOTAM data, this prediction does not take into account scheduled satellite outages.

(4) Operators using TSO C129/C129a avionics who wish to take advantage of an RNP approach when specifying an alternate airport must check KNMH NOTAM to verify the status of the constellation.

8.3 Wide Area Augmentation System Notice to Airmen

(1) NAV CANADA has implemented a NOTAM system for users of WAAS avionics (TSO C145a/C146a). It makes use of a service volume model (SVM) that considers current and anticipated GPS constellation status and geometry, along with the availability of WAAS GEO satellites, and computes estimates of the availability of service where GNSS-based approach procedures are published.

(2) The SVM runs twice daily, at 0000Z and 1200Z. It computes the expected availability of LPV, and WAAS-based LNAV/VNAV and LNAV for a period of eighteen hours for all aerodromes in its

database. When a service is predicted not to be available for a duration of more than fifteen minutes, an aerodrome NOTAM will be issued. In the event that two outages of less than fifteen minutes each are predicted, and are separated by a period of less than fifteen minutes during which the service is available, a NOTAM will be issued for a single outage covering the entire period.

(3) The SVM is also run in response to an unscheduled change in the GPS constellation status. This typically implies a satellite failure.

(4) Flight planning should be based on the assumption that the services referred to in a NOTAM will not be available. However, once the flight arrives at the aerodrome, the service may, in fact, be available because of the conservative nature of the prediction. In this case, the approach may be used. When LPV and WAAS-based LNAV/VNAV are not available, pilots may fly the LNAV procedure to the published MDA. Since LNAV procedures will be used when LPV and LNAV/VNAV is not available, flight crew members should ensure that they maintain their skills in flying these approaches.

Note. *Operators and flight crew members must be familiar with the aircraft's approach capability in the event of no Satellite-Based Augmentation System (SBAS) (WAAS) service. Not all SBAS-equipped aircraft are capable of LNAV or LNAV/VNAV operations without SBAS service.*

(5) Because of the high availability of services supporting en-route and terminal operations, no NOTAMs are issued for these phases of flight.

Note. *WAAS NOTAM information is not applicable to users of TSO C129a avionics.*

8.4 Negative W Notation

(1) Normally, WAAS-based approaches will only be designed and published where the nominal availability of the required service is greater than 99%. This policy avoids issuing a large number of NOTAM for sites where the availability is low. However, there may be aerodromes for which an LNAV/VNAV approach is published because of a local demand by operators flying baro-VNAV-equipped aircraft. These procedures will appear in the database of WAAS receivers, and will be flyable by them. In the event that such an aerodrome is located in a region of poor WAAS availability, NOTAMs will not be issued when WAAS-based LNAV/VNAV is expected to be unavailable. Pilots will be alerted to this fact by a negative "W" (white on a black background) on the approach plate. Flight planning should be conducted as though WAAS-based LNAV/VNAV will not be available at these aerodromes. However, if the service is available upon arrival, it may be used safely.

9.0 KNOWLEDGE AND TRAINING REQUIREMENTS

Note. *If the operator is not authorized to conduct RF legs (Ops Spec 623), operators must prevent their flight crew members from inadvertently attempting to perform RF legs contained in RNP APCH procedures. Refer to Advisory Circular 700-027 for more information.*

(1) Flight crew members must be trained as required by the applicable Regulation or Standard:

(a) Section 604.24 of the *Canadian Aviation Regulations* (CARs);

(b) Subsection 722.76(15) of the *Commercial Air Services Standards* (CASS);

(c) Subsection 723.98(21) of the CASS;

(d) Subsection 724.115(22) of the CASS;

(e) Subsection 725.124(27) of the CASS;

(2) For training requirements associated with:

(a) Ops Spec 620 Restricted to LNAV Minima Only, refer to Appendix A of this AC.

(b) Ops Spec 620 Restricted to LNAV and LNAV/VNAV Minima Only, refer to Appendix A and Appendix C of this AC.

(c) Ops Spec 620 Unrestricted; refer to Appendix B of this AC.

(3) Maintenance personnel involved in the routine or detailed checks of RNP APCH avionics should be familiar with the Performance Based Navigation concept.

(4) The dispatchers' training must address how to determine:

(a) RNP APCH availability (considering aircraft equipment capabilities);

(b) MEL requirements; and

(c) navigation signal availability (e.g. GPS RAIM/predictive RNP capability tool, WAAS NOTAMS, GPS NOTAMs) for destination and alternate airports.

(5) Operators wishing to receive credit for elements of the required training already conducted as part of an existing training program (e.g. elements of a training curriculum already in place to satisfy a foreign state's approval requirements) must receive approval from their principal operations inspector or equivalent. In such a case, the operator must include training on the differences between RNP APCH procedures and the operation(s) associated with the common training elements.

10.0 OPERATIONAL APPROVAL

(1) The requirements for authorization to conduct RNP approach procedures are as follows:

(a) The equipment must meet the certification and installation requirements of Part V of the CARs, and the criteria of this AC;

(b) The operator must ensure the quality of the navigation database as per this AC;

(c) The operator must establish procedures in its COM, or private operator equivalent, for the guidance of its personnel related to the conduct of RNP APCH operations;

(d) If a MEL has been approved in respect of an operator by the Minister, the operator must establish guidance, restrictions and procedures (as required) in the MEL for use in the event of RNP approach equipment unavailability;

(e) The operator must amend its Maintenance Program in accordance with the maintenance requirements of this AC; and

(f) The operator must amend its training program to provide training to operational control personnel, each flight crew member and, when applicable, maintenance personnel involved with RNP approach operations. Updates to the operator's Training Program should be done in accordance with the requirements of this AC, as well as Section 604.05 of the CARs or the guidance in Sections 722.76, 723.98, 724.115, 725.124 of the CASS, as applicable;

(2) The operator must receive Ops Spec 620 Required Navigation Performance – Approach (RNP APCH) prior to performing the RNP APCH procedures.

11.0 CONCLUSION

(1) Operators intending to apply for Ops Spec 620 should review the referenced documents and then contact their Principal Operations Inspector (POI), or private operator equivalent, for more information. In order to minimize the workload for the operator (e.g. Training Program development, aircraft eligibility), it is recommended that operators who wish to conduct RF legs apply for Operations Specification 623 – *Radius to Fix Transition Segments* simultaneously with the application for Ops Spec 620.

(2) As a summary of the privileges associated with Ops Spec 620:

(a) Restricted to LNAV minima only:

(i) May conduct RNAV and RNP approaches to LNAV minima;

(ii) May **not** conduct RNAV and RNP approaches to LNAV/VNAV, LP or LPV minima;

(b) Restricted to LNAV and LNAV/VNAV minima only:

(i) May conduct RNAV and RNP approaches to LNAV and LNAV/VNAV minima;

(ii) May **not** conduct RNAV and RNP approaches to LP or LPV minima;

(c) Unrestricted:

(i) May conduct RNAV and RNP approaches to LNAV, LNAV/VNAV, LP and LPV minima;

Note: *An unrestricted Ops Spec 620 requires the aircraft to be equipped with SBAS equipment. The operator must clearly identify the fail-down capability of the navigation system in the event of the loss of SBAS coverage or capability. Some SBAS systems may not have a baro-VNAV capability which would result in an inability to perform LNAV/VNAV operations with the loss of SBAS. Such a limitation must be clearly captured in the Company Operations Manual (COM) documentation and the flight crew member training. This will not result in a restricted Ops Spec 620 since the aircraft is capable of conducting all types of RNP APCH procedures when SBAS capability and coverage are operational.*

(3) The POI, with the assistance of the PMI or Regional Airworthiness office, should confirm that all of the above requirements are satisfied. Once all of the applicable conditions of this AC have been met, Ops Spec 620, restricted if required, may be issued to the operator.

12.0 INFORMATION MANAGEMENT

(1) Not applicable.

13.0 DOCUMENT HISTORY

(1) Not applicable.

14.0 CONTACT OFFICE

For more information, please contact:

Commercial Flight Standards Division (AARTF)

E-mail: **AARTInfoDoc@tc.gc.ca**

Suggestions for amendment to this document are invited, and should be submitted via:
AARTInfoDoc@tc.gc.ca

Original signed by Arlo Speer on September 25, 2013

Aaron McCrorie
Director, Standards
Civil Aviation
Transport Canada

Transport Canada documents or intranet pages mentioned in this document are available upon request through the Contact Office.

APPENDIX A — CRITERIA SPECIFIC TO: OPS SPEC 620 *REQUIRED NAVIGATION PERFORMANCE APPROACH (RNP APCH) – RESTRICTED TO LNAV MINIMA ONLY* AND OPS SPEC 620 *REQUIRED NAVIGATION PERFORMANCE APPROACH (RNP APCH) – RESTRICTED TO LNAV AND LNAV/VNAV MINIMA ONLY*

1.0 AIRCRAFT REQUIREMENTS

(1) Operators may demonstrate the qualification of their aircraft navigation system by satisfying one of the following criteria:

(a) The design approval holder will demonstrate compliance, and the approval will be documented in manufacturer documentation. Such documentation indicates that the aircraft and equipment meet the technical requirements of this Advisory Circular (AC), and no further assessment of aircraft eligibility need be made. Acceptable documentation for this purpose is:

(i) The aircraft manufacturer has included a statement in the Aircraft Flight Manual (AFM) indicating that the aircraft is approved to conduct Required Navigation Performance Approach (RNP APCH) operations, and that this approval is based on Global Navigation Satellite System (GNSS) and Global Positioning System (GPS) navigation.; or

(ii) The aircraft manufacturer has included a statement in the AFM that the aircraft meets the requirements of both Federal Aviation Administration (FAA) Advisory Circular (AC) 20-138A, FAA AC 20-130A or Technical Standard Order (TSO) C115b; and European Aviation Safety Agency (EASA) Acceptable Means of Compliance (AMC) 20-27 (or subsequent versions of these documents), and that this approval is based on GNSS (GPS) navigation.

(b) If aircraft approval to conduct RNP APCH operations using GNSS (GPS) navigation has not been documented, the operator may demonstrate aircraft eligibility by meeting the criteria described below in this section.

1.1 On Board Performance Monitoring and Alerting

(1) *Accuracy*: During operations on the initial and intermediate segments and for the RNAV missed approach, of an RNP APCH, the lateral total system error must be within ±1 nautical mile (nm) for at least 95 per cent of the total flight time. The along-track error must also be within ±1 nm for at least 95 per cent of the total flight time. During operations on the final approach segment of an RNP APCH to Lateral Navigation (LNAV) or Lateral Navigation/Vertical Navigation (LNAV/VNAV) minima, the lateral total system error must be within ±0.3 nm for at least 95 per cent of the total flight time. The along-track error must also be within ±0.3 nm for at least 95 per cent of the total flight time. To satisfy the accuracy requirement, the 95 per cent Flight Technical Error (FTE) should not exceed 0.5 nm on the initial and intermediate segments, and for the Area Navigation (RNAV) missed approach, of an RNP APCH. The 95 per cent FTE should not exceed 0.25 nm on the final approach segment of an RNP APCH.

Note. *The use of a deviation indicator with 1 nm full-scale deflection on the initial and intermediate segments, and for the RNAV missed approach and 0.3 nm full-scale deflection on the final approach segment, has been found to be an acceptable means of compliance. The use of an autopilot or flight director has been found to be an acceptable means of compliance (roll stabilization systems do not qualify).*

(2) *Integrity*: Malfunction of the aircraft navigation equipment is classified as a major failure condition under airworthiness regulations (i.e. $1x10^{-5}$ per hour).

(3) *Continuity*: Loss of function is classified as a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport.

(4) *On-Board performance monitoring and alerting*: During operations on the initial and intermediate segments and for the RNAV missed approach of an RNP APCH, the RNP system shall provide an alert if the accuracy requirement is not met, or if the probability that the lateral TSE exceeds 2 nm is greater than $1x10^{-5}$. During operations on the final approach segment of an RNP APCH to LNAV or LNAV/VNAV minima, the RNP system shall provide an alert if the accuracy requirement is not met, or if the probability that the lateral total system error (TSE) exceeds 0.6 nm is greater than $1x10^{-5}$.

(5) *Signal-in-space*: During operations on the initial and intermediate segments and for the RNAV missed approach of an RNP APCH, the aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 2 nm exceeds 10^{-7} per hour. During operations on the final approach segment of an RNP APCH to LNAV or LNAV/VNAV minima, the aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 0.6 nm exceeds $1x10^{-7}$ per hour.

Note. *There are no RNP APCH requirements for the missed approach if it is based on conventional means (Omni-directional radio (VOR), Distance Measuring Equipment (DME), NDB) or on dead reckoning. Compliance with the performance monitoring and alerting requirement does not imply automatic monitoring of a flight technical error. The on-board monitoring and alerting function should consist at least of a navigation system error (NSE) monitoring and alerting algorithm and a lateral deviation display enabling the crew to monitor the flight technical error (FTE). Path definition error (PDE) is considered negligible due to the quality assurance process and crew procedures.*

1.2 Equipment Eligibility

(1) The following systems meet the accuracy, integrity and continuity requirements, but must be shown to meet the Functional Requirements of this section as well:

(a) GNSS Stand-alone systems: Equipment should be approved in accordance with TSO-C129a/ETSO-C129a Class A; E/TSO-C146() Class Gamma and operational class 1, 2 or 3; or TSO C-196().This equipment must be installed and certified as per Part V of the *Canadian Aviation regulations* (CARs).

(b) GNSS Multi-sensor systems (e.g. FMS): Equipment should be approved in accordance with TSO-C129()/ETSO-C129() Class B1, C1, B3, C3; E/TSO C145() class 1, 2 or 3; or TSO C-196(). For GNSS receivers approved in accordance with E/TSO-C129(), capability for satellite fault detection and exclusion (FDE) is recommended to improve continuity of function. These systems should be approved in accordance with FAA AC 20-130A or TSO-C115b (or subsequent versions of these documents), as well as having been demonstrated for RNP APCH capability. All equipment must be installed and certified as per Part V of the CARs; or

1.3 Criteria for specific navigation systems

(1) RNP APCH is based on augmented GNSS positioning. Positioning data from other types of navigation sensors may be integrated with the GNSS data provided it does not cause position errors exceeding the TSE budget, or if means are provided to deselect the other navigation sensor types.

1.4 Functional Requirements - Navigation Displays

(1) Navigation data, including a “to/from” indication, and a failure indication, must be displayed on a lateral deviation display (Course Deviation Indicator (CDI), Electronic Horizontal Situation Indicator (EHSI) and/or a navigation map display. These must be used as primary flight instruments for the navigation of the aircraft, for manoeuvre anticipation and for failure/status/integrity indication:

(a) the displays must be visible to the pilot and located in the primary field of view (±15 degrees from the pilot's normal line of sight) when looking forward along the flight path;

(b) the lateral deviation display scaling should agree with any alerting and annunciation limits;

(c) the lateral deviation display must also have a full-scale deflection suitable for the current phase of flight and must be based on the TSE requirement. Scaling is ±1 nm for the initial and intermediate segments and ±0.3 nm for the final segment;

(d) the display scaling may be set automatically by default logic or set to a value obtained from a navigation database. The full-scale deflection value must be known or must be available for display to the pilot commensurate with approach values;

(e) as an alternate means, a navigation map display must give equivalent functionality to a lateral deviation display with appropriate map scales (scaling may be set manually by the pilot). To be approved, the navigation map display must be shown to meet the TSE requirements;

(f) it is highly recommended that the course selector of the deviation display is automatically slaved to the RNAV computed path;

Note. *This does not apply for installations where an electronic map display contains a graphical display of the flight path and path deviation.*

(g) a flight director and/or autopilot is not required for this type of operation, however, if the lateral TSE cannot be demonstrated without these systems, it becomes mandatory. In this case, coupling to the flight director and/or automatic pilot from the RNP system must be clearly indicated at the cockpit level; and

(h) enhanced navigation display (e.g. electronic map display or enhanced EHSI) to improve lateral situational awareness, navigation monitoring and approach verification (flight plan verification) is mandatory if the RNAV installation doesn't support the display of information necessary for the accomplishment of these crew tasks (dependent on the type of equipment installed).

1.5 Functional Requirements - Capabilities

(1) The following system functions are required as a minimum:

(a) The capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft (primary navigation display), the RNAV computed desired path and aircraft position relative to the path. For aircraft where the minimum flight crew is two pilots, the means for the pilot not flying to verify the desired path and the aircraft position relative to the path must also be provided.

(b) A navigation database, containing current navigation data officially promulgated for civil aviation, which can be updated in accordance with the aeronautical information regulation and control (AIRAC) cycle and from which approach procedures can be retrieved and loaded into the RNP system. The stored resolution of the data must be sufficient to achieve the required track-keeping accuracy. The database must be protected against pilot modification of the stored data.

(c) The means to display the validity period of the navigation data to the pilot.

(d) The means to retrieve and display data stored in the navigation database relating to individual waypoints and navigation aids, to enable the pilot to verify the procedure to be flown.

(e) Capacity to load from the database into the RNP system the whole approach to be flown. The approach must be loaded by its name from the database into the RNP system.

(f) The means to display the following items, either in the pilot's primary field of view, or on a readily accessible display page:

(i) the identification of the active (To) waypoint;

(ii) the distance and bearing to the active (To) waypoint; and

(iii) the ground speed or time to the active (To) waypoint.

(g) The means to display the following items on a readily accessible display page:

(i) the display of distance between flight plan waypoints;

(ii) the display of distance to go;

(iii) the display of along-track distances; and

(iv) the active navigation sensor type, if there is another sensor in addition to the GNSS sensor.

(h) The capability to execute a "Direct to" function.

(i) The capability for automatic leg sequencing with the display of sequencing to the pilot.

(j) The capability to execute procedures extracted from the on-board database, including the capability to execute flyover and fly-by turns.

(k) The capability to automatically execute leg transitions and maintain tracks consistent with the following ARINC 424 path terminators, or their equivalent:

(i) ARINC 424 path terminators;

(ii) Initial fix (IF);

(iii) Track to fix (TF);

(iv) Direct to fix (DF).

Note. *Path terminators are defined in ARINC Specification 424, and their application is described in more detail in Radio Technical Commission for Aeronautics (RTCA)/European Organisation for Civil Aviation Equipment (EUROCAE) documents DO 236B/ED-75B and DO-201A/ED-77.*

(l) The capability to display an indication of the RNP system failure, including the associated sensors, in the pilot's primary field of view.

(m) The capability to indicate to the flight crew when NSE alert limit is exceeded (alert provided by the "on-board performance monitoring and alerting function").

(n) The capability to automatically load numeric values for courses and tracks from the RNP system database.

2.0 OPERATING PROCEDURES

(1) Airworthiness certification alone does not authorize an operator to conduct RNP APCH operations to LNAV or LNAV/VNAV minima. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

2.1 Pre-flight planning

(1) Operators and pilots intending to conduct operations using an RNP APCH procedure must file the appropriate flight plan suffixes, and the on-board navigation data must be current and include appropriate procedures.

Note. *Navigation databases are expected to be current for the duration of the flight. If the AIRAC cycle is due to change during flight, operators and pilots should establish procedures to ensure the accuracy of navigation data, including the suitability of navigation facilities used to define the routes and procedures for the flight.*

(2) In addition to the normal pre-flight planning checks, the following must be included:

(a) the flight crew member must ensure that approaches which may be used for the intended flight (including alternate aerodromes) are selected from a valid navigation database (current AIRAC cycle), have been verified by the appropriate process (navigation database integrity process) and are not prohibited by a company instruction or Notice to Airmen (NOTAM);

(b) during the pre-flight phase, the flight crew members should ensure sufficient means are available to navigate and land at the destination or at an alternate aerodrome in the case of loss of RNP APCH airborne capability;

(c) operators and flight crew members must take account of any NOTAMs or operator briefing material that could adversely affect the aircraft system operation, or the availability or suitability of the procedures at the airport of landing, or any alternate airport; and

(d) for missed approach procedures based on conventional means (VOR, NDB), operators and flight crew members must ensure that the appropriate airborne equipment required for this procedure is installed in the aircraft and is operational; and that the associated ground-based Navigation Aids (NAVAIDs) are operational.

(3) The availability of the NAVAID infrastructure required for the intended routes, including any non-RNAV contingencies, must be confirmed for the period of intended operations using all available information. Since GNSS integrity (Receiver Autonomous Integrity Monitoring (RAIM) or Satellite-Based Augmentation System (SBAS) signal) is required, the availability of these should also be determined as appropriate. For aircraft navigating with SBAS receivers (all TSO-C145()/C146()), operators should check appropriate GPS RAIM availability in areas where the SBAS signal is unavailable.

2.2 Aircraft-based Augmentation System (ABAS) (RAIM) availability

(1) RAIM levels required for RNP APCH to LNAV or LNAV/VNAV minima can be verified either through NOTAMs (where available) or through prediction services. Operators should be familiar with the prediction information available for the intended route.

(2) RAIM availability prediction should take into account the latest GPS constellation NOTAMs and avionics model (when available). The service may be provided by the Air Navigation Service Provider (ANSP), avionics manufacturer, and other entities, or through an airborne receiver RAIM prediction capability.

(3) In the event of a predicted, continuous loss of appropriate level of fault detection of more than five minutes for any part of the RNP APCH operation, the flight planning should be revised (e.g. delaying the departure or planning a different departure procedure).

(4) RAIM availability prediction software does not guarantee the service. Rather, they are tools to assess the expected capability of meeting the required navigation performance. Because of unplanned failure of some GNSS elements, flight crew members should realize that RAIM or GPS navigation altogether may be lost while airborne which may require reversion to an alternative

means of navigation. Therefore, flight crew members should assess their capability to navigate, potentially to an alternate destination, in case of failure of GPS navigation.

2.3 SBAS and other Augmented GNSS availability

(1) If the aircraft uses other GNSS augmentations, or enhancements to a basic GNSS capability (i.e. use of multiple constellations, dual frequency), the RNP APCH operation must be supported by a prediction capability based on the specific characteristics of these other augmentations.

2.4 Prior to Commencing the Procedure

(1) In addition to the normal procedure prior to commencing the approach (before the Initial Approach Fix (IAF) and in compatibility with flight crew workload), the flight crew member must verify the correct procedure was loaded by comparison with the approach charts. This check must include:

(a) the waypoint sequence; and

(b) reasonableness of the tracks and distances of the approach legs, and the accuracy of the inbound course and length of the final approach segment.

Note. *As a minimum, this check could be a simple inspection of a suitable map display that achieves the objectives of this paragraph.*

(2) The flight crew members must also check which waypoints are fly-by and which are flyover, using the published charts, the map display or control display unit (CDU).

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

(4) For an RNP system with ABAS requiring barometric corrected altitude, the current airport barometric altimeter setting should be input at the appropriate time and location, consistent with the performance of the flight operation.

(5) When the operation is predicated on the availability of ABAS, the pilot should perform a new RAIM availability check if ETA is more than 15 minutes different from the Estimated Time of Arrival (ETA) used during the pre-flight planning. This check is also processed automatically 2 nm before the Final Approached Fix (FAF) for an E/TSO-C129a Class A1 receiver.

(6) Air Traffic Control (ATC) tactical interventions in the terminal area may include radar headings, “direct to” clearances which bypass the initial legs of an approach, interception of an initial or intermediate segment of an approach, or the insertion of waypoints loaded from the database. In complying with ATC instructions, the flight crew member should be aware of the implications for the RNP system:

(a) the manual entry of coordinates into the RNP system by the flight crew member for operation within the terminal area is not permitted; and

(b) “direct to” clearances may be accepted to the intermediate fix (IF) provided that the resulting track change at the IF does not exceed 45 degrees.

Note. *“Direct to” clearance to FAF is not acceptable.*

(7) The lateral definition of the flight path between the FAF and the missed approach point (MAPt) must not be revised by the pilot under any circumstances.

2.5 During the Procedure

(1) To ensure terrain and obstacle clearance, the aircraft must be established on the final approach course no later than the FAF before starting the descent.

(2) The flight crew members must check the approach mode annunciator, or equivalent, is properly indicating approach mode integrity within 2 nm before the FAF.

Note. *This will not apply for certain RNP systems (e.g. aircraft already approved with demonstrated RNP capability). For such systems, other means are available which clearly indicate to the crew that the approach mode is activated.*

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

(a) the RNAV-computed desired path (DTK); and

(b) the aircraft position relative to the path (cross-track deviation) for FTE monitoring.

(4) The procedure must be discontinued:

(a) if the navigation display is flagged invalid; or

(b) in case of loss of integrity alerting function; or

(c) if integrity alerting function is annunciated not available before passing the FAF; or

(d) if FTE is excessive.

(5) The missed approach must be flown in accordance with the published procedure. Use of the RNP system during the missed approach is acceptable, provided:

(a) the RNP system is operational (e.g. no loss of function, no NSE alert, no failure indication); and

(b) the whole procedure, including the missed approach, is loaded from the navigation database.

(6) During the RNP APCH procedure, flight crew members must use a lateral deviation indicator, flight director and/or autopilot in lateral navigation mode. In aircraft with a lateral deviation indicator (e.g. CDI), flight crew members must ensure that lateral deviation indicator scaling (full-scale deflection) is suitable for the navigation accuracy associated with the various segments of the procedure (i.e. ±1.0 nm for the initial and intermediate segments, ±0.3 nm for the final approach segment to LNAV or LNAV/VNAV minima, and ±1.0 nm for the missed approach segment). All flight crew members are expected to maintain procedure centrelines, as depicted by on-board lateral deviation indicators and/or flight guidance during the whole approach procedure, unless authorized to deviate by ATC or under emergency conditions. For normal operations, cross-track error/deviation (the difference between the RNP system computed path and the aircraft position relative to the path) should be limited to ±½ nm the navigation accuracy associated with the procedure (i.e. 0.5 nm for the initial and intermediate segments, 0.15 nm for the final approach segment, and 0.5 nm for the missed approach segment). Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after turns, up to a maximum of one-times the navigation accuracy (i.e. 1.0 nm for the initial and intermediate segments), are allowable.

Note. *Some aircraft do not display or compute a path during turns, but are still expected to satisfy the above standard during intercepts following turns and on straight segments.*

(7) When baro-VNAV is used for vertical path guidance during the final approach segment, deviations above and below the baro-VNAV path must not exceed +22 m/–22 m (+75 ft/–75 ft), respectively.

(8) Flight crew members must execute a missed approach if the lateral deviations or vertical deviations, if provided, exceed the criteria above, unless the pilot has in sight the visual references required to continue the approach.

2.6 General operating procedures

(1) Operators and flight crew members must not request, or accept a clearance to conduct, an RNP APCH procedure unless they satisfy all the criteria.

(2) The flight crew members must comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements in this navigation specification.

(3) If the missed approach procedure is based on conventional means (e.g. NDB, VOR, DME), related navigation equipment must be installed and be serviceable.

(4) Flight crew members are encouraged to use flight director and/or autopilot in lateral navigation mode, if available.

2.7 Contingency procedures

(1) The flight crew members must notify ATC of any loss of the RNP APCH capability, together with the proposed course of action. If unable to comply with the requirements of an RNP APCH procedure, flight crew members must advise Air Traffic Services (ATS) as soon as possible. The loss of RNP APCH capability includes any failure or event causing the aircraft to no longer satisfy the RNP APCH requirements of the procedure. The operator should develop contingency procedures in order to react safely following the loss of the RNP APCH capability during the approach.

3.0 FLIGHT CREW MEMBER KNOWLEDGE AND TRAINING

(1) The training programme must provide sufficient training (e.g. simulator, training device, or aircraft) on the aircraft's RNP system to the extent that the pilots are not just task oriented. This includes:

- (a) the information in this AC;
- (b) the meaning and proper use of RNP systems;
- (c) procedure characteristics as determined from chart depiction and textual description;
- (d) knowledge regarding depiction of waypoint types (flyover and fly-by), required path terminators (IF, TF, DF) and any other types used by the operator as well as associated aircraft flight paths;
- (e) knowledge on the required navigation equipment in order to conduct RNP APCH operations (at least one RNP system based on GNSS);
- (f) knowledge of RNP system-specific information:
  - (i) levels of automation, mode annunciations, changes, alerts, interactions, reversions, and degradation;
  - (ii) functional integration with other aircraft systems;
  - (iii) the meaning and appropriateness of route discontinuities as well as related pilot procedures;
  - (iv) monitoring procedures for each phase of flight;
  - (v) types of navigation sensors utilized by the RNP system and associated system prioritization/weighting/logic;
  - (vi) turn anticipation with consideration to speed and altitude effects; and
  - (vii) interpretation of electronic displays and symbols;
- (g) knowledge of RNAV equipment operating procedures, as applicable, including how to perform the following actions:
  - (i) verify currency of the aircraft navigation data;

(ii) verify the successful completion of RNP system self-tests;

(iii) initialize RNP system position;

(iv) retrieve and fly an RNP APCH;

(v) adhere to speed and/or altitude constraints associated with an approach procedure;

(vi) fly interception of an initial or intermediate segment of an approach following ATC notification;

(vii) verify waypoints and flight plan programming;

(viii) fly direct to a waypoint;

(ix) determine cross-track error/deviation;

(x) insert and delete route discontinuity;

(xi) perform gross navigation error check using conventional NAVAIDs; and

(xii) change arrival airport and alternate airport;

(h) knowledge of operator-recommended levels of automation for phase of flight and workload, including methods to minimize cross-track error to maintain procedure centreline;

(i) knowledge of radio telephony phraseology for RNP applications;

(j) ability to conduct contingency procedures following RNP system failures;

(k) an understanding of the restrictions associated with Ops Spec 620.

APPENDIX B – CRITERIA SPECIFIC TO OPS SPEC 620 *REQUIRED NAVIGATION PERFORMANCE APPROACH (RNP APCH)* (UNRESTRICTED)

1.0 AIRCRAFT REQUIREMENTS

(1) Operators may demonstrate the qualification of their aircraft navigation system by satisfying one of the following criteria:

(a) The design approval holder will demonstrate compliance, and the approval will be documented in manufacturer documentation. Such documentation indicates that the aircraft and equipment meet the technical requirements of this Advisory Circular (AC), and no further assessment of aircraft eligibility need be made. Acceptable documentation for this purpose is:

(i) The aircraft manufacturer has included a statement in the Aircraft Flight Manual (AFM) indicating that the aircraft is approved to conduct Required Navigation Performance Approach (RNP APCH) operations using augmented Global Navigation Satellite System (GNSS) and Global Positioning System (GPS) navigation Wide Area Augmentation System (WAAS);

(ii) The aircraft manufacturer has included a statement in the AFM that the aircraft meets the requirements of both Federal Aviation Administration (FAA) Advisory Circular (AC) 20-138A, FAA AC 20-130A or Technical Standard Order (TSO) C115b; and European Aviation Safety Agency (EASA) Acceptable Means of Compliance (AMC) 20-28 (or subsequent versions of these documents), and that this approval is based on augmented GNSS (GPS) navigation (WAAS);

(b) If aircraft approval to conduct RNP APCH operations using augmented GNSS (GPS) navigation (WAAS) has not been documented, the operator may demonstrate aircraft eligibility by meeting the criteria described below in this section.

1.1 On-Board Performance monitoring and alerting

(1) Accuracy: Along the final approach segment and the straight continuation of the final approach in the missed approach, the lateral and vertical Total System Error is dependent on the Navigation System Error (NSE), Path Definition Error (PDE) and Flight Technical Error (FTE).

(a) NSE: the accuracy itself (the error bound with 95 per cent probability) changes due to different satellite geometries. NSE is the error between the true position of the aircraft and that estimated by the on-board navigation system.

(b) FTE: FTE performance is considered acceptable if the lateral and vertical display full scale deflection is compliant with the non-numeric lateral cross-track and vertical deviation requirements of Radio Technical Commission for Aeronautics (RTCA) DO 229 C (or subsequent version) and if the crew maintain the aircraft within 1/3 the full scale deflection for the lateral deviation and within 1/2 the full scale deflection for the vertical deviation.

(c) PDE: PDE is considered negligible based upon the process of path specification to data specification and associated quality assurance that is included in the final approach segment (FAS) data-block generation process which is a standardized process. The responsibilities for FAS data block generation lies with the Air Navigation Service Provider.

Note. *FTE performance is considered acceptable if the approach mode of the Flight Guidance System is used during such approach.*

(2) Integrity: Simultaneously presenting misleading lateral and vertical guidance with misleading distance data during an RNP APCH operation down to Localizer performance with vertical navigation (LPV) minima is considered a hazardous failure condition (extremely remote). Simultaneously presenting misleading lateral guidance with misleading distance data during an RNP APCH operation down to Localizer Performance without Vertical Guidance (LP) minima is considered a hazardous failure condition (extremely remote).

(3) Continuity: Loss of approach capability is considered a minor failure condition if the operator can revert to a different navigation system and proceed to a suitable airport. For RNP APCH operation down to LP or LPV minima at least one system is required.

(4) On-board performance monitoring and alerting: During operations on the final approach segment of an RNP APCH operation down to LP and LPV minima, the on-board performance monitoring and alerting function is fulfilled by:

(a) NSE monitoring and alerting (see Signal-in-space section).

(b) FTE monitoring and alerting: LPV approach guidance must be displayed on a lateral and vertical deviation display (Horizontal Situation Indicator (HSI), Electronic Horizontal Situation Indicator (EHSI), Course Deviation Indicator (CDI) / Vertical deviation indicator (VDI)) including a failure indicator. The deviation display must have a suitable full-scale deflection based on the required track keeping accuracy. The lateral and vertical full scale deflections are angular and associated to the lateral and vertical definitions of the final approach segment contained in the FAS data block.

(5) Navigation database: Once the FAS data block has been decoded, the equipment shall apply the cyclic redundancy code (CRC) to the data block to determine if the data is valid. If the FAS data block does not pass the CRC test, the equipment shall not allow activation of the LP or LPV approach operation.

(6) Aircraft requirements - Signal-in-space

(a) Between 2 Nautical Mile(s) (nm) from the final approach point (FAP) and the FAP, the aircraft navigation equipment shall provide an alert within 10 seconds if the signal-in-space error causing a lateral position error is greater than 0.6 nm, with a probability of $1x10^{-7}$ per hour.

(b) After sequencing the FAP and during operations on the final approach segment of an RNP APCH operation down to LP or LPV minima:

(i) the aircraft navigation equipment shall provide an alert within 6 seconds if the signal-in-space errors causing a lateral position error is greater than 40 m, with a probability of $1x10^{-7}$ in any approach (International Civil Aviation Organization (ICAO) Annex 10, Volume I, Table 3.7.2.4-1); and

(ii) the aircraft navigation equipment shall provide an alert within 6 seconds if the signal-in-space errors causing a vertical position error is greater than 50 m (or 35 m for LPV minima down to 200 ft); with a probability of $1x10^{-7}$ in any approach (ICAO ISARP Annex 10, Volume I, Table 3.7.2.4-1).

Notes:

(1) *There are no RNP APCH requirements for the missed approach if it is based on conventional means (Omni-directional radio (VOR), Distance Measuring Equipment (DME), Non-Directional Beacon (NDB)) or on dead reckoning. The requirements for the straight continuation of the final approach, in the missed approach, are in accordance with RTCA DO 229C (or subsequent version).*

(2) *Compliance with the performance monitoring and alerting requirement does not imply an automatic monitor of flight technical error (FTE). The on-board*

monitoring and alerting function should consist at least of a navigation system error (NSE) monitoring and alerting algorithm and a lateral and vertical deviation display enabling the crew to monitor the FTE. To the extent operational procedures are used to monitor FTE, the crew procedure, equipment characteristics, and installation are evaluated for their effectiveness and equivalence as described in the functional requirements and operating procedures. Path definition error (PDE) is considered negligible.

1.2 Equipment Eligibility

(1) The following systems meet the accuracy, integrity and continuity requirements but must be shown to meet the Functional Requirements of this section as well:

(a) GNSS Satellite-based augmentation systems (SBAS) stand-alone equipment approved in accordance with E/TSO C146a (or subsequent version). Application of this standard guarantees that the equipment is at least compliant with RTCA DO 229C. The equipment should be a Class Gamma, operational class 3;

(b) For integrated navigation system (e.g. Flight Management System (FMS)) incorporating a GNSS SBAS sensor, E/TSO C115b and AC 20-130A (or subsequent versions of these documents) provide an acceptable means of compliance for the approval of this navigation system when augmented by the following guidelines:

(i) the performance requirements of E/TSO-C146a (or subsequent version) that apply to the functional class gamma, operational class 3 or delta 4 is demonstrated; and

(ii) The GNSS SBAS sensor is approved in accordance with E/TSO C145a class Beta, operational class 3;

(c) Approach system incorporating a class Delta GNSS SBAS equipment approved in accordance with E/TSO C146a (or subsequent version). This standard guarantees that the equipment is at least compliant with RTCA DO 229C. The equipment should be a Class Delta 4; and

(d) Future augmented GNSS systems are also expected to meet these requirements.

1.3 Criteria for specific navigation systems

(1) RNP APCH operation down to LP or LPV minima is based on augmented GNSS positioning. Positioning data from other types of navigation sensors may be integrated with the GNSS data provided it does not cause position errors exceeding the total system error (TSE) budget, or if means are provided to deselect the other navigation sensor types.

1.4 Functional Requirements - Navigation Displays

(1) Approach guidance must be displayed on a lateral and vertical deviation display (Horizontal Situation Indicator (HSI), Electronic Horizontal Situation Indicator (EHSI), CDI/ Vertical deviation indicator (VDI)) including a failure indicator, and must meet the following requirements:

(a) must be used as primary flight instruments for the approach;

(b) must be visible to the pilot and located in the primary field of view (± 15 degrees from pilot's normal line of sight) when looking forward along the flight path; and

(c) the deviation display must have a suitable full-scale deflection based on the required track keeping accuracy.

(2) The lateral and vertical full-scale deflections are angular and associated to the lateral and vertical definitions of the final approach segment contained in the FAS data block.

Note. *Where the minimum flight crew is two pilots, it should be possible for the pilot not flying to verify the desired path and the aircraft position relative to the path. For more details on lateral and vertical deviation displays scales, see the non-numeric lateral cross-track and vertical deviation requirements of DO 229C (or subsequent version).*

1.5 Functional Requirements - Capabilities

(1) The capability to display the GNSS approach mode (e.g. LP, LPV, Lateral Navigation / Vertical Navigation (LNAV/VNAV), Lateral Navigation (LNAV)) in the primary field of view. This annunciation indicates to the crew the active approach mode in order to correlate it with the corresponding line of minima on the approach chart. It can also detect a level of service degradation (e.g. downgrade from LPV to LNAV). The airborne system should automatically provide the highest "level of service" available for the annunciation of the GNSS approach mode when the approach is selected.

(2) The capability to continuously display the distance to the landing threshold point/fictitious threshold point (LTP/FTP).

(3) The navigation database must contain all the necessary data/information to fly the published approach procedure (final approach segment). Although data may be stored or transmitted in different ways, the data has to be organized in data blocks for the purpose of computing the CRC. This format provides integrity protection for the data it contains. Consequently, each final approach segment is defined by a specific "FAS data block" containing the necessary lateral and vertical parameters depicting the approach to be flown. Once the FAS data block has been decoded, the equipment shall apply the CRC to the data block to determine if the data is valid. If the FAS data block does not pass the CRC test, the equipment shall not allow activation of the approach operation.

(4) The capacity to select from the data base into the installed system the whole approach procedure to be flown (SBAS channel number and/or approach name).

(5) The indication of the loss of navigation (e.g. system failure) in the pilot's primary field of view by means of a navigation warning flag or equivalent indicator on the vertical and/or lateral navigation display.

(6) The indication of the loss of integrity (LOI) function in the pilot's normal field of view (e.g. by means of an appropriately located annunciator).

(7) The capability to immediately provide track deviation indications relative to the extended final approach segment, in order to facilitate the interception of the extended final approach segment from a radar vector (e.g. vector to final (VTF) function).

Note. *These requirements are limited to the final approach segment, the straight continuation of the final approach in the missed approach, and to the interception of the extended final approach segment. If the installed system is also able to fly the initial, intermediate and missed approach segments of the approach, the corresponding requirement applies.*

2.0 OPERATING PROCEDURES

(1) Airworthiness certification alone does not authorize operator to conduct RNP APCH operation down to LP or LPV minima. Operational approval is also required to confirm the adequacy of the operator's normal and contingency procedures for the particular equipment installation.

2.1 Pre-flight Planning

(1) Operators and pilots intending to conduct RNP APCH operation down to LP or LPV minima must file the appropriate Air Traffic Control (ATC) flight plan suffixes. The on board navigation data must be current and must include the appropriate procedures.

Note. *Navigation databases are expected to be current for the duration of the flight. If the Aeronautical Information Regulation and Control (AIRAC) cycle is due to change during flight, operators and pilots should establish procedures to ensure the accuracy of navigation data, including suitability of navigation facilities used to define the routes and procedures for flight.*

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

(a) The pilot must ensure that approach procedures which may be used for the intended flight (including alternates aerodromes) are selectable from a valid navigation data base (current AIRAC cycle), have been verified by the appropriate process and are not prohibited by a company instruction or Notice to Airmen (NOTAM).

(b) During the pre-flight phase, the pilot should ensure sufficient means are available to navigate and land at the destination or at an alternate aerodrome in the case of loss of LP or LPV airborne capability.

(c) Operators and flight-crews must take account of any NOTAMs (including SBAS NOTAMs) or operator briefing material that could adversely affect the aircraft system operation, or the availability or suitability of the procedures at the airport of landing, or any alternate airport.

(d) If the missed approach procedure is based on conventional means (e.g. VOR, NDB), the appropriate airborne equipment required to fly this procedure must be installed in the aircraft and must be operational. The associated ground-based NAVAIDs must also be operational. If the missed approach procedure is based on RNAV (no conventional or dead reckoning missed approach available) the appropriate airborne equipment required to fly this procedure must be installed in the aircraft and must be operational.

(3) The availability of the NAVAID infrastructure, required for the intended routes, including GNSS integrity and any non-RNAV contingencies, must be confirmed for the period of intended operations using all available information.

2.2 Augmented GNSS Availability

(1) Service levels required for RNP APCH operations down to LP or LPV minima can be verified either through NOTAMs (where available) or through prediction services. Operators should be familiar with the prediction information available for the intended route.

(2) LP or LPV service availability prediction should take into account the latest GPS constellation and SBAS system status NOTAMs and avionics model (when available). The service may be provided by the Air Navigation Service Provider (ANSP), avionics manufacturer, other entities or through an airborne receiver LP or LPV service prediction capability.

(3) In the event of a predicted, continuous loss of appropriate level of fault detection of more than five minutes for any part of the RNP APCH operation, the flight planning should be revised (e.g. delaying the departure or planning a different departure procedure).

(4) Service availability prediction software does not guarantee the service. They are tools to assess the expected capability to meet the required navigation performances. Because of unplanned failure of some GNSS or SBAS elements, flight crew members should realize that GPS or SBAS navigation may be lost while airborne, which may require reversion to an alternative means of navigation. Therefore, flight crew members should assess their capability to navigate, potentially to an alternate destination, in case of failure of GPS plus SBAS navigation.

(5) These availability prediction services are expected to be developed also for future GNSS systems with performances equivalent to SBAS.

2.3 Prior To Commencing The Procedure

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

(a) the waypoint sequence;

(b) reasonableness of the tracks and distances of the approach legs, the accuracy of the inbound course and mileage of the final approach segment; and

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

(c) the vertical path angle.

(2) ATC tactical interventions in the terminal area may include radar headings, 'direct to' clearances which by-pass the initial legs of an approach, interception of an initial or intermediate segment of an approach or the insertion of waypoints loaded from the database. In complying with ATC instructions, the flight crew members should be aware of the implications for the navigation system.

(a) The manual entry of coordinates into the navigation system by the flight crew member for operation within the terminal area is not permitted.

(b) A 'Direct to' clearance may be accepted to the intermediate fix (IF) provided that the resulting track change at the IF does not exceed 45°.

Note. *Direct to clearance to FAP is not acceptable.*

(3) The approach system provides the capability for the flight crew member to intercept the final approach track well before the FAP (vector to final (VTF) function or equivalent). This function should be used to respect a given ATC clearance.

2.4 During The Procedure

(1) The approach mode will be activated automatically by the RNP system. When a direct transition to the approach procedure is conducted (e.g. when the aircraft is vectored by the ATC to the extended final approach segment and the flight crew member selects the VTF function or an equivalent function), the LP or LPV approach mode is also immediately activated.

(2) The system provides lateral and/or vertical guidance relative to the LP or LPV final approach segment or to the extended final approach segment (for the direct transition).

(3) The flight crew members must check that the GNSS approach mode indicates LP or LPV (or an equivalent annunciation) 2 nm before the FAP.

(4) To ensure terrain and obstacle clearance, the final approach segment should be intercepted no later than the FAP in order for the aircraft to be correctly established on the final approach course before starting the descent.

(5) The appropriate displays should be selected so that the following information can be monitored:

(a) aircraft position relative to the lateral path;

(b) aircraft position relative to the vertical path; and

(c) absence of LOI (loss of integrity) alert.

(6) The flight crew members should respect all published altitude and speed constraints.

(7) Prior to sequencing the FAP, the flight crew members should abort the approach procedure if there is:

(a) loss of navigation indicated by a warning flag (e.g. absence of power, equipment failure);

(b) loss of integrity monitoring (LOI), annunciated locally, or equivalent; and

(c) low altitude alert (if applicable).

(8) After sequencing the FAP, unless the flight crew members have the visual references required to continue the approach in sight, the procedure must be discontinued if:

(a) loss of navigation is indicated by a warning flag (e.g. lateral flag, vertical flag or both flags);

Note: *Loss of integrity monitoring (LOI) after sequencing the FAP leads to a loss of navigation (warning flag).*

(b) loss of vertical guidance is indicated (even if lateral guidance is already displayed); and

(c) FTE is excessive and cannot be corrected in a timely manner.

(9) Flight crew members must execute a missed approach if excessive lateral and/or vertical deviations are encountered and cannot be timely corrected, unless the flight crew members have the visual references required to continue the approach. The missed approach must be flown in accordance with the published procedure (e.g. conventional or RNAV).

2.5 General Operating Procedures

(1) Operators and flight crew members must not request, nor accept a clearance to conduct, an RNP APCH operation down to LP or LPV minima unless they satisfy all the criteria.

(2) The flight crew members must comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements in this chapter.

(3) If the missed approach procedure is based on conventional means (e.g. NDB, VOR, DME), related navigation equipment must be installed and be serviceable.

(4) Flight crew members are encouraged to use the flight director and/or autopilot in lateral navigation mode, if available.

2.6 Contingency Procedures

(1) The operator should develop contingency procedure in order to react safely following the loss of the approach capability during the approach.

(2) The operator and flight crew members must have a clear understating of the aircraft's approach capability in the event of the loss of WAAS service or capability. WAAS-equipped aircraft without a baro-VNAV capability will not be able to perform RNP APCH procedures to LNAV/VNAV minima if the aircraft has lost its WAAS capability (e.g. poor WAAS service level).

(3) The flight crew members must notify ATC of any loss of the RNP APCH capability, together with the proposed course of action. If unable to comply with the requirements of an RNP APCH procedure, flight crew members must advise Air Traffic Service (ATS) as soon as possible. The loss of RNP APCH capability includes any failure or event causing the aircraft to no longer satisfy the RNP APCH requirements of the procedure.

3.0 FLIGHT CREW MEMBER KNOWLEDGE AND TRAINING

(1) The pilot training programme should be structured to provide sufficient theoretical and practical training, using a simulator, training device, or line training in an aircraft, on the use of the aircraft's approach system to ensure that flight crew members are not just task oriented. The following syllabus should be considered as a minimum amendment to the training programme to support these operations:

(a) The content of this AC;

(b) RNP approach concept containing LP or LPV minima:

(i) theory of approach operations;

(ii) approach charting;

(iii) use of the approach system including:

(A) selection of the LP or LPV approach procedure;

(B) Instrument Landing System (ILS) look alike principle;

(iv) use of lateral navigation mode(s) and associated lateral control techniques;

(v) use of vertical navigation mode(s) and associated vertical control techniques;

(vi) radiotelephony (R/T) phraseology for LP or LPV approach operations; and

(vii) the implication for LP or LPV approach operations of systems malfunctions which are not related to the approach system (e.g. hydraulic failure).

(c) RNP approach operation containing LP or LPV minima:

(i) definition of LP or LPV approach operations and its direct relationship with RNAV (GNSS) procedures;

(ii) regulatory requirements for LP or LPV approach operations;

(iii) required navigation equipment for LP or LPV approach operations:

(A) GPS concepts and characteristics;

(B) augmented GNSS characteristics; and

(C) minimum equipment list (MEL);

(iv) procedure characteristics:

(A) chart depiction;

(B) aircraft display depiction;

(C) minima;

(v) retrieving a LP or LPV approach procedure from the database (e.g. using its name or the SBAS channel number);

(vi) change arrival airport and alternate airport;

(vii) flying the procedure:

(A) use of autopilot, autothrottle and flight director;

(B) flight guidance(FG) mode behaviour;

(C) lateral and vertical path management;

(D) adherence to speed and/or altitude constraints;

(E) fly interception of an initial or intermediate segment of an approach following ATC notification;

(F) fly interception of the extended final approach segment (e.g. using the VTF function);

(G) consideration of the GNSS approach mode indication (e.g. LP, LPV, LNAV/VNAV, LNAV); and

(H) the use of other aircraft equipment to support track monitoring, weather and obstacle avoidance;

(viii) ATC procedures;

(ix) abnormal procedures;

(x) contingency procedures; and

(xi) the operator and flight crew members must have a clear understating of the aircraft's approach capability in the event of the loss of WAAS service. Not all SBAS-equipped aircraft have a fail-down to LNAV or LNAV/VNAV approach capability.

APPENDIX C – BAROMETRIC VNAV (BARO-VNAV)

1.0 INTRODUCTION

1.1 Purpose

(1) The purpose of this appendix is to provide air operators and private operators with the requirements that need to be met to obtain authorization to conduct barometric VNAV (baro-VNAV) operations for the purpose of Required Navigation Performance – Approach (RNP APCH) instrument procedures to Lateral Navigation / Vertical Navigation (LNAV/VNAV) minima. Final authorization will be granted by the annotation of Operations Specification (Ops Spec) 620 - *Required Navigation Performance Approach (RNP APCH)* restricted to LNAV and LNAV/VNAV minima.

(2) The content of this appendix is based on the Attachment A to Volume II Part C of International Civil Aviation Organization (ICAO) Doc 9613 *Performance Based Navigation (PBN) Manual* and the content found in TP 14371 *Aeronautical Information Manual*. Until a Standard on baro-VNAV is published in the *Commercial Air Services Standards* (CASS), the content of this appendix will constitute the conditions to be met to obtain the authorization for baro-VNAV.

2.0 BACKGROUND

(1) This document addresses those systems based upon the use of barometric altitude and RNAV information in the definition of vertical flight paths, and vertical tracking to a path. The final approach segment of VNAV instrument flight procedures can be performed using vertical guidance to a glide path generated by the on-board RNP system. The glide path is contained in the coding of the instrument procedure within the RNP system navigation database. For other phases of flight, baro-VNAV provides vertical path information that can be defined by vertical angles or altitudes at fixes in the procedure.

(2) The vertical guidance for baro-VNAV systems has been derived from a barometric altitude input. The information provided by these systems during a non-precision approach (NPA) is advisory only. Flight crew members are required to respect all minimum altitudes, including step-down altitudes, since non-precision approaches are not specifically designed to take advantage of the constant descent angle technique facilitated by baro-VNAV capability.

(3) NPAs are typically based on a descent and level off obstacle clearance criteria. The minimum descent altitude is based on a set clearance above the highest obstacle. This results in a very high margin of safety as the minimum altitude is applied to the entire segment of the approach, but results in high Minimum Descent Altitudes (MDA).

(4) The requirement for authorization to conduct baro-VNAV operations associated with RNP Approaches to LNAV/VNAV minima, and consequently additional flight crew knowledge and training, results from the vertical profile of an Approach Procedure with Vertical guidance (APV) approach being based on a sloped design. This is the product of the Required Obstacle Clearance (ROC) being based on a ratio rather than a fixed amount of clearance. The result is a vertical profile design very similar to that of an Instrument Landing System (ILS) approach, and allows for the publication of lower approach minima.

(5) Consequently, the flight crew must be aware of the approach procedure design differences between an RNP approach to LNAV/VNAV minima, and an RNP approach to LNAV minima.

2.1 Approach Operations Utilizing Baro-VNAV equipment

(1) Baro-VNAV equipment can be applied to two different approach and landing operations:

(a) *Approach and landing operations with vertical guidance*. In this case, the use of a VNAV system such as baro-VNAV is required. When baro-VNAV is used to conduct an RNP approach to LNAV/VNAV minima, the lateral navigation guidance is based on the RNP APCH specifications, and authorization is required.

(b) *Non-precision approach and landing operations*. In this case, the use of a baro-VNAV system is not required but auxiliary to facilitate a constant descent technique. This means that advisory VNAV guidance is being overlaid on a non-precision approach. The lateral navigation guidance is predicated on the navigation system designated on the chart, and authorization to use baro-VNAV is not required.

(2) Approach and landing operations with approved vertical guidance provide significant benefits over advisory VNAV guidance being overlaid on a NPA, as they are based on specific procedure design criteria, avoiding the requirement for cross-checking the NPA procedure constraints such as step-down fixes. These criteria furthermore address:

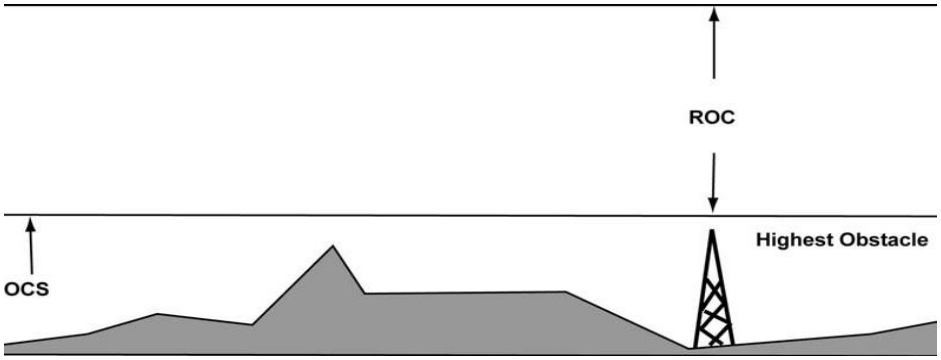
(a) height loss after initiating a missed approach allowing the use of a decision altitude (DA) instead of an MDA, thereby standardizing flight techniques for vertically guided approach operations;

(b) obstacle clearance throughout the approach and landing phase taking into account temperature constraints down to the DA, therefore resulting in better obstacle protection compared to a NPA procedure.

2.2 Procedure Design – LNAV vs. LNAV/VNAV

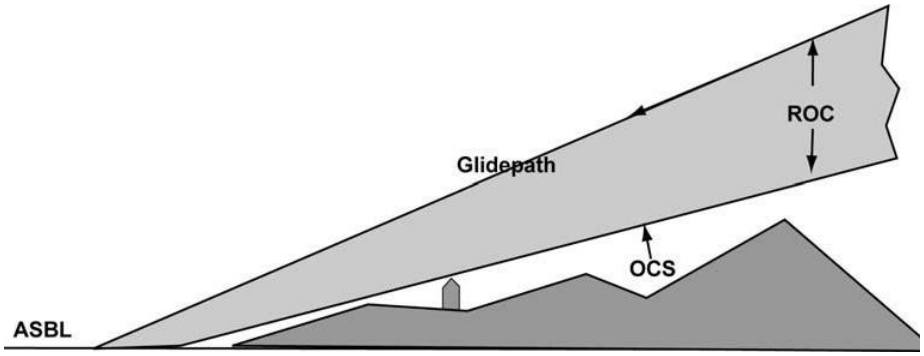
(1) *LNAV.* The level obstacle clearance surface (OCS) concept is applicable to “level flight” segments. These segments are level flight operations intended for non-precision final approaches, as well as other types of operations. A single required obstacle clearance (ROC) value is applied over the length of the segment.

Figure 1 – Obstacle clearance criteria for an RNP approach to LNAV minima



(2) *LNAV/VNAV*. The method of applying the ROC in segments dedicated to descending on a glidepath requires a different obstacle clearance concept than the level OCS because the ROC value must vary throughout the segment. The value of ROC near the runway is relatively small, and the value at the opposite end of the segment is sufficient to satisfy a level OCS.

Figure 2 – Obstacle clearance criteria for an RNP approach to LNAV/VNAV minima



(3) *Descending on a Precision Glidepath*. The obstacle evaluation method for descent on a glidepath is the application of a descending OCS below the glidepath. The vertical distance between the glidepath and the OCS is ROC. The ROC decreases with distance from the Final Approached Fix (FAF) as the OCS and glidepath converge on the approach surface baseline (ASBL) height.

(4) The procedure design does not have unique infrastructure requirements. These criteria are based upon the use of barometric altimetry by an airborne RNAV system whose performance capability supports the required operation.

3.0 AIRCRAFT ELIGIBILITY REQUIREMENTS

3.1 Documentation

(1) Relevant documentation acceptable to Transport Canada must be available to establish that the aircraft is equipped with an RNAV system with a demonstrated VNAV capability. Eligibility may be established in two steps, one recognizing the qualities and qualifications of the aircraft and equipment, and the second determining the acceptability for operations. The determination of eligibility for existing systems should consider acceptance of manufacturer documentation of compliance.

Note: *RNP systems demonstrated and qualified for RNP AR operations including VNAV are considered qualified with recognition that the RNP approaches are expected to be performed consistent with the operators RNP AR (Authorization Required) approval. No further examination of aircraft capability, operator training, maintenance, operating procedures, databases, etc. is necessary.*

3.2 Baro-VNAV System

(1) For operations predicated on the use of barometric VNAV capability, at least one RNP system is required.

(2) Baro-VNAV approach operations are based upon the use of RNAV equipment that automatically determines aircraft position in the vertical plane using inputs from equipment that can include:

(a) FAA TSO-C106, Air Data Computer;

(b) air data system, ARINC 706, Mark 5 Air Data System;

(c) barometric altimeter system, 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; and

(d) type certified integrated systems providing an air data system capability comparable to an air data system, ARINC 706, Mark 5 Air Data System.

(3) Positioning data from other sources may be integrated with the barometric altitude information provided it does not cause position errors exceeding the track keeping accuracy requirements.

(4) Altimetry system performance is demonstrated separately through the static pressure systems certification where performance must be 30 feet (ft) per 100 Knots Indicated Air Speed (KIAS). Altimetry systems meeting such a requirement will satisfy the altimetry system error (ASE) requirements for baro-VNAV.

(5) The 99.7 per cent aircraft altimetry system error for each aircraft (assuming the temperature and lapse rates of the International Standard Atmosphere) must be less than or equal to the following with the aircraft in the approach configuration:

$ASE=-8.8\cdot10^{-8}\cdot H^2 + 6.5\cdot10^{-3}\cdot H+50$ (ft) where H is the true altitude of the aircraft

Note. *Barometric altimetry and related equipment such as air data systems are a required basic capability and already subject to minimum equipment requirements for flight operations.*

3.3 System accuracy

(1) For instrument approach operations, the error of the airborne VNAV equipment, excluding altimetry, should have been demonstrated to be less than that shown below on a 99.7 per cent probability basis:

Table 2 – VNAV equipment error excluding altimetry

	Level flight segments and climb/descent intercept altitude region of specified altitudes	Climb/descent along specified vertical profile (angle)
At or below 1,500 m (5,000 ft.)	15 m (50 ft.)	30 m (100 ft.)
1,500 m to 3,000 m (5,000 ft. to 10,000 ft.)	15 m (50 ft.)	45 m (150 ft.)
Above 3,000 m (10,000 ft.)	15 m (50 ft.)	67 m (220 ft.)

Note. *Maximum operating altitudes are to be predicated on a compliance with total accuracy tolerance.*

(2) VNAV guidance may be used in level flight en route as in the case of altitude hold control laws, which are integrated with speed control laws to provide an energy trade. The incremental error component contributed by the VNAV equivalent must be offset by a corresponding reduction in other error components, such as flight technical error, to ensure that the total error budget is not exceeded.

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

(4) VNAV equipment error includes all errors resulting from the vertical guidance equipment installation. It does not include errors of the altimeter system, but does include any additional

errors resulting from the addition of the VNAV equipment. This error component may be zero in level en-route flight if the operation is limited to guidance by means of the altimeter only. It should not be disregarded in terminal and approach operations where the pilot is expected to follow the VNAV indications.

(5) The vertical error component of an along track positioning error is bounded by the following equipment qualification requirements for Barometric VNAV, and is directly reflected in the along-track tolerance offset used in Barometric VNAV procedure design criteria:

(a) GNSS navigation systems certified for approach or multi-sensor systems using inertial reference unit (IRU) in combination with GNSS; or

(b) RNP systems approved for RNP 0.3 or less;

(c) serviceable VNAV equipment;

(d) VNAV system certified for baro-VNAV approach operations;

(e) integrated LNAV/VNAV system with accurate source of barometric altitude; and

(f) VNAV altitudes and procedure information from a navigation database with integrity through quality assurance.

(6) Flight technical (pilotage) errors. With satisfactory displays of vertical guidance information, flight technical errors should have been demonstrated to be less than the values shown below on a three-sigma basis.

Table 3 – Flight Technical Error

	Level flight segments and climb/descent intercept altitude region of specified altitudes	Climb/descent along specified vertical profile (angle)
At or below 1,500 m (5,000 ft.)	45 m (150 ft.)	60 m (200 ft.)
1,500 m to 3,000 m (5,000 ft. to 10,000 ft.)	73 m (240 ft.)	91 m (300 ft.)
Above 3,000 m (10,000 ft.)	73 m (240 ft.)	91 m (300 ft.)

(7) Sufficient flight tests of the installation should have been conducted to verify that these values can be maintained. Smaller values for flight technical errors may be achieved especially in the cases where the VNAV system is to be used only when coupled to an autopilot or flight director. However, at least the total system vertical accuracy shown below should be maintained.

(8) If an installation results in larger flight technical errors, the total vertical error of the system (excluding altimetry) may be determined by combining equipment and flight technical errors using the root sum square (RSS) method. The result should be less than the values listed below.

Table 4 – Total Vertical Error

	Level flight segments and climb/descent intercept altitude region of specified altitudes	Climb/descent along specified vertical profile (angle)
At or below 1,500 m (5,000 ft.)	48 m (158 ft.)	68 m (224 ft.)
1,500 m to 3,000 m (5,000 ft. to 10,000 ft.)	74 m (245 ft.)	102 m (335 ft.)
Above 3,000 m (10,000 ft.)	74 m (245 ft.)	113 m (372 ft.)

(9) An acceptable means of complying with these accuracy requirements is to have an RNAV system approved for VNAV approaches in accordance with the criteria of FAA AC20-129 () and an altimetry system approved in accordance with Federal Aviation Regulations FAR/CS 25.1325 or equivalent.

3.4 Vertical Navigation Functions – Path Definition

(1) The requirements for defining the vertical path are governed by the two general requirements for operation:

(a) allowance for aircraft performance; and

(b) repeatability and predictability in path definition.

(2) This operational relationship leads to the specifications in the following sections that are based upon specific phases of flight and flight operations.

(3) The navigation system must be capable of defining a vertical path by a flight path angle to a fix. The system must also be capable of specifying a vertical path between altitude constraints at two fixes in the flight plan. Fix altitude constraints must be defined as one of the following:

(a) An “AT or ABOVE” altitude constraint (e.g. 2400A, may be appropriate for situations where bounding the vertical path is not required);

(b) An “AT or BELOW” altitude constraint (e.g. 4800B, may be appropriate for situations where bounding the vertical path is not required);

(c) An “AT” altitude constraint (e.g. 5200); or

(d) A “WINDOW” constraint (e.g. 2400A3400B).

3.5 Vertical constraints

(1) Altitudes and/or speeds restrictions associated with published procedures must be automatically extracted from the navigation database upon selecting the approach procedure.

3.6 Path construction

(1) The system must be able to construct a path to provide guidance from the current position to a vertically constrained fix.

3.7 Capability to load procedures from the navigation database

(1) The navigation system must 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.

3.8 Guidance and control

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

3.9 User interface - Displays and control

(1) The display resolution (readout) and entry resolution for vertical navigation information should be as follows:

Table 5 – Display and entry resolution

Parameter	Display Resolution (readout)	Entry resolution
Altitude	Flight level or (1 ft.)	Flight level or (1 ft.)
Vertical path deviation	10 ft.	Not applicable
Flight path angle	0.1°	0.1°
Temperature	1°	1°

3.10 Path deviation and monitoring

(1) Due to the sloped OCS, it is essential that the flight crew members are able to accurately monitor the aircraft's position relative to the vertically defined path so that a missed approach may be performed as required without delay.

(2) The navigation system must provide the capability to continuously display to the pilot flying, on the primary flight instruments for navigation of the aircraft, the aircraft position relative to the vertically defined path. The display must allow the pilot to readily distinguish if the vertical deviation exceeds +22 m/–22 m (+75 ft/–75 ft). The deviation should be monitored, and action taken to minimize errors.

(3) It is recommended that an appropriately-scaled non-numeric deviation display (i.e. vertical deviation indicator) be located in the pilot's primary field of view. A fixed-scale deviation indicator is acceptable as long as it demonstrates appropriate scaling and sensitivity sufficient to meet the above requirements. Any alerting and annunciation limits must also match the scaling values.

(4) In lieu of appropriately scaled vertical deviation indicators in the pilot's primary 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.

(5) Since vertical deviation scaling and sensitivity varies widely, eligible aircraft must be equipped with either a flight director or autopilot capable of following the vertical path.

3.11 Barometric altitude

(1) The aircraft must 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.

4.0 OPERATING PROCEDURES

(1) Airworthiness certification alone does not authorize operators to utilize baro-VNAV during the conduct of RNP approaches to LNAV/VNAV minima. Operational approval to conduct baro-VNAV procedures as part of RNP APCH operations is required to confirm the adequacy of the operator's procedures and training program.

4.1 General operating procedures

(1) Flight crew members should comply with any instructions or procedures identified by the manufacturer as necessary to comply with the performance requirements.

(2) Flight crew members must execute a missed approach if the vertical deviations exceed 22 m (75 ft) below the vertically defined path, unless the pilot has the visual references in sight required to continue the approach.

4.2 Altimeter setting

(1) The vertical path defined by baro-VNAV is affected by altimeter setting errors. For this reason, baro-VNAV is not authorized unless a local field altimeter setting is available.

(2) Flight crew members should make altimeter settings at appropriate times or locations, and use a current altimeter setting, particularly at times when pressure is reported or is expected to be rapidly decreasing.

4.3 Effect of Temperature on the Vertical Profile

(1) For aircraft using baro-VNAV without temperature compensation to conduct the approach, low and, possibly, high temperature limits published on the charted procedure. Aircraft using baro-VNAV with temperature compensation may disregard the temperature restrictions.

(2) When cold weather temperatures exist, the pilot should check the instrument approach procedure chart to determine the limiting temperature for the use of baro-VNAV capability. If the airborne system contains a temperature compensation capability, the manufacturer's instructions should be followed for the use of the baro-VNAV function.

(3) Non-standard atmospheric conditions, particularly temperature, induce errors in the baro-VNAV vertical path. For example, a nominal 3° glide path may be closer to 2.5° at very low temperatures. Similarly, at above International Standard Atmosphere (ISA) temperatures, a baro-VNAV vertical path would be steeper than normal. To compensate for these temperature effects, some avionics allow input of the temperature at the airport, and apply temperature compensation so that the baro-VNAV vertical path is not biased as a function of temperature. Unfortunately, not all systems have the capability to compensate for temperature effects. The sample vertical path angle (VPA) deviation chart, (Table 6), indicates the effect of temperature on the uncorrected baro-VNAV VPA, for an aerodrome at sea level.

Table 6 – Effect of Cold Weather on VPA

VPA Deviations	
Aerodrome Temp	Uncorrected VPA
+30˚C	3.2˚
+15˚C	3.0˚
0˚C	2.8˚
-15˚C	2.7˚
-31˚C	2.5˚

(4) When temperature compensation is not, or cannot be, applied through the FMS, pilots shall refer to a temperature limit, referred to as T_{Lim}, published on the approach chart. Below this temperature, the uncompensated vertical path generated by the FMS will not provide the required obstacle protection. Therefore, when the temperature is below the published T_{Lim}, an aircraft with an uncompensated baro-VNAV system shall not fly an RNAV approach to LNAV/VNAV minima. T_{Lim} will be a function of the reduced obstacle clearance resulting from flying an uncompensated VPA, and will vary from approach to approach. For avionics systems that have the capability to correctly compensate the VPA for temperature deviations, the published T_{Lim} does not apply if the pilots enable the temperature compensation.

(5) Regardless of whether the FMS provides temperature compensation of the vertical path or not, all altitudes on the approach, including DA, should still be temperature corrected.

5.0 FLIGHT CREW MEMBER KNOWLEDGE AND TRAINING

(1) The training programme should provide sufficient training (e.g. simulator, training device, or aircraft) on the aircraft's VNAV capability to the extent that the flight crew members are not just task-oriented, including:

- (a) the information in this Advisory Circular;
- (b) the effect of non-standard temperatures on the baro-VNAV path;
- (c) procedure characteristics, as determined from chart depiction and textual description:
  - (i) depiction of waypoint types (fly-over vs. fly-by, path terminators and any other types used by the operator) as well as associated aircraft flight paths;
  - (ii) RNP 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);
  - (vii) turn anticipation with consideration to speed and altitude effects; and
  - (viii) interpretation of electronic displays and symbols.
- (d) Baro-VNAV equipment operating procedures, as applicable, including how to perform the following actions:
  - (i) adhere to speed and/or altitude constraints associated with an approach procedure;
  - (ii) verify waypoints and flight plan programming;
  - (iii) fly direct to a waypoint;
  - (iv) determine vertical-track error/deviation;
  - (v) insert and delete route discontinuity;
  - (vi) change arrival airport and alternate airport;
  - (vii) contingency procedures for baro-VNAV failures;

(viii) there should be a clear understanding of crew requirements for comparisons to primary altimeter information, altitude cross-checks (e.g. altimetry comparisons of 30 m (100 ft)), temperature limitations for instrument procedures using VNAV, and procedures for altimeter settings for approach; and

(ix) discontinuation of a procedure based upon loss of systems or performance and flight conditions (e.g. inability to maintain required path tracking, loss of required guidance).