PBN Operational Approval

RNP APCH Navigation Specifications
Introduction

- RNP APCH is the designator for all PBN approaches except AR operations
- All RNP approach operations require GNSS
  - RNP APCH Type A - ABAS
  - RNP APCH Type B - SBAS
RNP APCH Type A

RNP APCH LNAV

• No change from previous operations
  • Charted as RNAV RWxx
  • Based on GA stand-alone receivers
  • May be flown by GNSS equipped FMS aircraft
    • Provided RNP 0.3 capable

RNP APCH LNAV/VNAV

• VNAV minima published
• Satisfies minimum requirements for APV
• Requires FMS integrating GNSS lateral nav and Barometric VNAV
# Navigation Application by Phase of Flight

<table>
<thead>
<tr>
<th>NAVIGATION SPECIFICATION</th>
<th>FLIGHT PHASE</th>
<th>APPROACH</th>
</tr>
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<tr>
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<td>En Route Oceanic / Remote</td>
<td>En Route Continental</td>
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</tr>
<tr>
<td>RNP APCH PART B</td>
<td>1</td>
<td>1</td>
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</tbody>
</table>
RNP APCH (LNAV)

Procedure design tolerances

½AW IF/IAF/Missed Approach < 56km (30NM)

2.5NM

0.95NM

2NM

½AW FAF

½AW MAPt

½AW IF/IF

FAF

MAPt

RNP

1NM

0.3NM

1NM
RNAV Approach (LNAV)

Changes to RNAV RWY 28 in 2014

Procedure entry may be facilitated by T or Y bar. Not required where STAR used.
Applicable Systems

- GNSS stand-alone systems (FAA AC 20-138A or equivalent):
  - TSO-C129a / ETSO-C129a Class A1, or
  - E/TSO-C146() Class Gamma & Operations Class 1, 2 or 3.

- Multi-sensor systems using GNSS (AC 20-130A)*:
  - TSO-C115b*
  - TSO-C129( ) / ETSO-C129( ) Class B1, C1, B3, C3; or
  - E/TSO-C145() class 1, 2 or 3 (with equivalent integration guidance)

*Must demonstrate RNP APCH capability

Almost ALL GNSS receivers either stand-alone or incorporated in an FMS are capable of RNP APCH LNAV
Minimum Equipment

- Single GNSS approach qualified system
- Alternate approach using conventional aids
  - Should be planned
  - GNSS availability cannot be guaranteed
  - Even with multiple GNSS systems

Note: Australia has implemented a system based entirely on carriage of duplicated GNSS with FDE subject to specific operational conditions
Standard Functionality

- Navigation database
- Load whole approach from database
- Direct to function
- Automatic leg sequencing with fly-by or fly-over
- Track consistent with:
  - TF
  - DF (often used in missed approach)
- Display RNAV system failure, including sensor failure
- Indicate when NSE alert limit is exceeded
Lateral Deviation Displays

- Lateral deviation display scaling automatically compatible with alerting and annunciation limits
- Full scale deflection suitable for phase of flight
- Course selector automatically slaved to computed path unless map shows flight path and deviation

Consistent with standard functionality for stand-alone receivers with automatic transition to +/- 0.3 CDI deflection and HAL 0.3 alerting in approach mode.

Typically FMS equipped aircraft do NOT provide this functionality and alternative means need to be evaluated.
Functionality

• Display
  • Distance + Bearing to active (To) Waypoint
  • Ground Speed or time to active (To) Waypoint
  • Distance between waypoints
  • Distance to go
  • Active navigation sensor type

Distance is typically displayed only to the next waypoint and **NOT** to the runway threshold.

Operators must be alert to the significant human factors associated with loss of situational awareness.
Pre-Flight

• Check GNSS availability at destination airport

• Check database currency and availability of approach

• Check availability of conventional navaids, if required

• Review contingency procedures

• File ‘R’ in FPL field 10, ‘PBN/S1’ in remarks
Operating Procedures (1)

• Retrieve procedure from on-board database by name
• Pay particular attention to procedure subscript where used
  • e.g. RNAV Z RWY 20R
  • Review significant data elements
• Use lateral deviation indicator, flight director and/or autopilot in LNAV
• Lateral deviation scaling:
  • 1.0NM for the initial & intermediate approach segments,
  • 0.3NM for the final approach segment, and
  • 1.0NM for the missed approach segment
Stand-alone systems

- Prior to FAF approach is armed
- At FAF procedure is active and in approach mode

FMS Systems

- Ensure RNP 0.3 selected prior to FAF

Maintain XTK tolerances

- ± 0.5NM initial, intermediate and miss, ±0.15NM on final

Go-around if XTK exceeds tolerance on straight segments.

Operating procedures for stand-alone receivers is based on automatic mode switching and significantly different to FMS operations. Missed approach sequencing must be initiated by the pilot.
Operating Procedures (3)

- GNSS must be available to begin the approach
- Check availability prediction
- If an alert occurs execute the missed approach
- Fly the published missed approach procedure

Note: Some aircraft do not alert when GNSS updating is lost provided the navigation system can continue to satisfy the selected RNP conditions. Typically such systems revert to IRS navigation and approach navigation may be available for a considerable period after loss of GNSS updating.
Contingency Procedures

- Notify ATC of any loss of RNP APCH navigation capability
  - Propose an alternate course of action
  - Operator’s contingency procedures should enable a safe response to the loss of RNP APCH capability

An integrity alert does not normally result in a loss of navigation and the missed approach can be flown without loss of accuracy
Pilot Knowledge and Training

Navigation equipment operating procedures including:

- GNSS principles
- GNSS/FMS operations
- Limitations on intercepting approach
- Enter and fly holding pattern
- Missed approach and re-programming subsequent approach

Operation of stand-alone receivers is considerably more complex than FMS systems. Thorough flight crew training and checking is necessary.
Navigation Database

Supplier should hold Letter of Acceptance (LOA)

- Transport Canada Letter of an Aeronautical Data Process,
- FAA AC 20-153, Acceptance of Data Processes and Associated Navigation Databases or
- EASA IR 21 subpart G and Opinion Letter dated 01/2005

Supplier should comply with RTCA DO-200A / EUROCAE document ED 76, Standards for Processing Aeronautical Data

Particular attention should be paid to GA operators who may find the expense of database updates considerable. Operators should be regularly audited to ensure operators maintain current data-cards
Database Errors

• If an operator or flight crew discovers database discrepancies that invalidate a procedure:
  • Immediately report the discrepancy to the supplier
  • Prohibit the procedure use by the operator’s flight crews through an advisory notice until corrected
• Operators should consider conducting cyclic checks

CAAs should consider regulating the mandatory report of significant database errors as the safety of all operators may be compromised
RNP APCH (LNAV/VNAV)

- LNAV operations are unchanged
- Operators must demonstrate LNAV capability
- Barometric VNAV provides vertical course guidance
- Applicable to final approach segment
- May also be used in other segments
  - But procedure design ONLY relies on VNAV in the FAS
- Constitutes an Approach with Vertical Guidance APV
- ICAO Assembly Resolution requires all APV by 2016
Equipment

- Air Data Computer (TSO-C106/ETSO-C106)
- Mark 5 Air Data System (ARINC 706)
- Barometric altimeter system (DO-88/ED-26)
- Type certified integrated systems providing an Air Data System capability (FAR/CS 25.1325)
Temperature Effects

- Cold temperatures reduce actual VNAV path angle
- High temperatures increase actual VNAV path angle
- Procedure design provides obstacle clearance
  - At the minimum operating temperature
  - Minimum operating temperature published on approach chart
  - VNAV operations not permitted in lower temps
  - LNAV operations may be flown
- Aircraft equipped with temperature compensation or using other VNAV systems (e.g., SBAS) may disregard temperature restrictions
Mis-set Altimeter

- If altimeter subscale setting is in error, VNAV flight path by 30 ft per Hpa.
- Significant safety risk.
- Flight crew procedures and knowledge must be thorough.

The aircraft flies a descent path which is 390 ft (13 x 30 ft) below the required path. The barometric information displayed to the crew is incorrect. All distance and barometric altitude checks during the approach will be as per the chart, except the altimeter is 390 ft in error.

Correct DA using QNH = 1000 hPa.

Aircraft will fly to a DA which is 390 ft (13 x 30 ft) below the correct DA.
Functionality

- Vertical deviation display resolution 10ft
- If AP mode indication
  - VNAV Path (Boeing)
  - FINAL APP (Airbus)
- Path definition:
  - Vertical path defined by a flight path angle to a fix
  - Angle derived from the nav database
Functionality Recommended

- Automatic temperature compensation
  - Altimeter source temperature input
  - Clear display of temperature adjustment
- Automatic intercept of vertical path at FAP using vertical fly-by technique
Pre-Flight

• As for RNP APCH LNAV
• File ‘R’ in FPL field 10, ‘PBN/S2’ in remarks
Prior to Commencing

- Confirm correct altimeter setting
- Remote altimeter setting not permitted
- Airport temperature at or above the published minimum
During Procedure

- Before FAF check:
  - Altimeter setting
  - Difference between altimeters <100ft
- After established on vertical path check:
  - Correct VNAV mode
  - Vertical deviations must not exceed:
    - -75 feet below the vertical path
    - +75 feet above the depicted vertical path not sustained
- If deviation exceeds vertical limit, initiate a missed approach procedure
Approval Documentation

• FAA AC 20-129
  • Airworthiness Approval of Vertical Navigation (VNAV) Systems for Use in the US National Airspace System (NAS) and Alaska

• FAA Order AC 90-105
  • RNP Operations and Barometric Vertical Navigation in the US National Aerospace System

• EASA AMC 20-27
  • Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BARO-VNAV Operations

Advisory Circular

Subject: Approval Guidance for RNP Operations and Barometric Vertical Navigation in the U.S. National Airspace System

Date: 1/23/2009
AC No: 90-105
Initiated by: AFS-400
Change:

1. PURPOSE. This advisory circular (AC) provides system and operational approval guidance for operators to conduct Title 14 of the Code of Federal Regulations (14 CFR) part 97, Required Navigation Performance (RNP) instrument approach procedures (IAP). This AC provides system and operational approval guidance for the conduct of RNP Instrument Departure Procedures (RNP 1 DPs), Standard Terminal Arrival Routes (STAR) (RNP 1 STARs), and RNP 2 routes within the U.S. National Airspace System (NAS) where domestic air traffic control (ATC)...

AMC 20-27

Airworthiness Approval and Operational Criteria for RNP APPROACH (RNP APCH) Operations Including APV BARO-VNAV Operations

1. PURPOSE
This AMC provides an acceptable means that can be used to obtain airworthiness approval of an RNAV system based on a GNSS stand-alone receiver or multi-sensor system including at least one GNSS sensor in order to conduct RNP Approach (RNP APCH) operations.

RNP APCH procedures are characterised by existing charted RNAV (GNSS) approach procedures designed with straight segment.
RNP APCH Type B

- SBAS approach
- LPV minimum
  - Lowest authorised 200ft HAT
- Based on ILS emulation
- Supported by WAAS in US, EGNOS in Europe
- Other systems under development
- Requires geo-stationary satellite
- Widely spaced ground monitoring stations
- Air transport aircraft typically not equipped
- GA TSO C145/145 receivers capable
# Navigation Application by Phase of Flight

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<td>RNP APCH PART B</td>
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</table>
RNP APCH (LPV & LP)

Availability of SBAS performance determines level of service

- **LPV**
  - Lateral position error ≤ 40m
  - Vertical position error ≤ 50m or 35m (Cat I)
- **LP**
  - Lateral position error ≤ 40m
  - No vertical positioning available

An LPV is an APV flown to a DA
An LP is a NPA flown to an MDA
RNP APCH (LPV)

Changes to RNAV RWY 08 in 2014
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### Output Data

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| Calculated CRC Value                        | BA52CF4F                    |
Required Systems

• GNSS stand-alone systems:
  • E/TSO-C146() Class Gamma & Operations Class 3.

• Multi-sensor systems using GNSS:
  • E/TSO-C145() Class Beta 3
  • E/TSO-C146() Class Gamma 3 or Delta 4
Equipment

• At least one system
• If operator can revert to alternative system and proceed to suitable airport, loss of navigation system is minor.
• Conventional navaid receivers appropriate to the missed approach.
Functionality

• Lateral deviation display scaling automatically compatible with alerting and annunciation limits

• Full scale deflection suitable for phase of flight

• Display
  • Active approach mode (LPV, LNAV/VNAV, LNAV)
  • Distance to landing threshold

• Select whole procedure by channel number/approach name

• Indicate system failure or loss of integrity

• Support VTF function
Pre-Flight

- Check SBAS NOTAMs
- Check database currency and availability of approach
- Check availability of conventional navaids, if required
- Review contingency procedures
- File ‘BR’ in FPL field 10, ‘PBN/S2’ in remarks
Operating Procedures (1)

- Retrieve procedure from on-board database by name
- Before the IAF, verify correct procedure is displayed
- Ensure path complies with ATC clearance (when assigned)
- Direct to clearance to IF acceptable if final approach intercept ≤45°.
- Direct to FAP is not permitted.
- Use VTF function if required
Operating Procedures (2)

- Confirm GNSS mode is LP or LPV, as appropriate, 2NM before FAP
- Intercept final approach prior to FAP
- Monitor:
  - Aircraft position relative to lateral path
  - Aircraft position relative to vertical path
  - Absence of ‘Loss of Integrity’ alert
- Respect altitude and speed restrictions
- LOI alert, low altitude alert, loss of nav, loss of vertical guidance, excessive FTE – missed approach
Operating Procedures (3)

- GNSS is needed to begin the approach.
- If Alert annunciated execute the missed approach.
- Fly the published missed approach procedure
  - If available, use the LNAV path from the on-board navigation database
Pilot Knowledge and Training

Knowledge of RNAV equipment operating procedures including, in particular:

- Selection of LP/LPV procedure
- Use of LNAV and VNAV modes and displays
- R/T phraseology
- Implications of system malfunctions
- Procedure characteristics
- Flying the procedure
- ATC procedures
- Contingency procedures
Supplier must hold a Database Integrity Letter of Acceptance (LOA)

- Transport Canada Acknowledgement Letter of an Aeronautical Data Process,
- FAA AC 20-153, Acceptance of Data Processes and Associated Navigation Databases or
- EASA IR 21 subpart G and Opinion Letter dated 01/2005

*Supplier should comply with RTCA DO-200A / EUROCAE document ED 76, Standards for Processing Aeronautical Data*
Approval Documentation

- FAA Order AC 90-107
  - Guidance for LPV and LP approach operations in the US national airspace

- EASA AMC 20-28
  - Airworthiness Approval and Operational Criteria related to RNAV for GNSS approach operations to LPV minima using SBAS

Advisory Circular

**Subject:** Guidance for Localizer Performance with Vertical Guidance and Localizer Performance without Vertical Guidance Approach Operations in the U.S. National Airspace System

**Date:** 2/11/11
**Initiated by:** AFS-400
**AC No:** 90-107
**Change:**

**FOREWORD**

This advisory circular (AC) provides guidance for operators to conduct Title 14 of the Code of Federal Regulations (14 CFR) part 97 instrument flight rules (IFR) Area Navigation (RNAV) Global Positioning System (GPS) instrument approach procedures (IAP) with Localizer Performance with Vertical guidance (LPV) and Localizer Performance without vertical guidance (LP) lines of minima using the wide area augmentation system (WAAS). This AC applies to all

**AMC 20-28**

**AMC 20-28 Effective:** 24/09/2012
**Annex II to ED Decision 2012/014/R of 17/09/2012**

**AMC 20-28** Airworthiness Approval and Operational Criteria related to Area Navigation for Global Navigation Satellite System approach operation to Localiser Performance with Vertical guidance minima using Satellite Based Augmentation System

This AMC provides an acceptable means that can be used to obtain airworthiness approval for an Area Navigation (RNAV) approach system based on Global Navigation Satellite System (GNSS) augmented by a Satellite Based Augmentation System (SBAS) in order to conduct approach operations to Localiser Performance with Vertical guidance (LPV) minima. This AMC also defines the operational criteria necessary to conduct safely such approach operations in designated European airspace.
Questions?