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RNP APCH

07-10 April 2015

Air Navigation Service Provider (ANSP) Considerations

- **Navaid infrastructure**
  - GNSS is the primary navigation system to support RNP APCH procedures
  - Missed approach segment may be based upon conventional navaid (e.g., DME)
- **Communication and ATS Surveillance**
  - RNP APCH does not include specific requirements

System Performance

Accuracy

- **Initial & Intermediate Approach Segments →**
  - *Lateral Total System Error (TSE)*: 1.0 NM, 95%
  - *Along-Track Error*: 1.0 NM, 95%
- **Final Approach Segment →**
  - *Lateral TSE*: 0.30 NM, 95%
  - *Along-Track Error*: 0.3 NM, 95%
- **Flight Technical Error (FTE) Limits →**
  - *Initial, Intermediate & Missed Approach*: FTE < 0.50 NM, 95%
  - *Final Approach Segment*: FTE < 0.25 NM, 95%
  - May drive equipment requirements for RNP APCH operations
    - Navigation data displayed on a lateral deviation display (CDI, (E)HSI, and/or navigation map display)

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System Performance

Integrity

- ***Major*** **failure conditions can result in significant reduction in safety and significant increase in pilot workload**
- **RNP APCH criteria protects for *major* failure conditions**
- **Probability of *major* failure condition < 1×10^{-5}**

Continuity

- **Protects for *minor* failure condition → *if* operator can revert to an alternate navigation system**
- **If the procedure contains a conventional missed approach:**
  - The necessary navigation equipment must be installed & operable
  - Required ground-based navigation must be available

Signal-In-Space Monitoring & Alerting

- ***During initial, intermediate and missed approach segments, navigation system shall alert:***
  - Probability of SIS error causing a lateral position error greater than 2.0 NM exceeds 1×10^{-7}, or
- ***During the final approach segment:***
  - Probability of SIS error causing a lateral position error greater than 0.6 NM exceeds 1×10^{-7}

Performance Monitoring & Alerting

- ***During initial, intermediate and missed approach segments, the RNP system (or RNP system and pilot in combination) shall alert:***
  - When the accuracy requirement is not met, or
  - When the probability that lateral Total System Error (TSE) exceeds 2.0 NM is greater than 1×10^{-5}
- ***During the final approach segment, the RNP system (or RNP system and pilot in combination) shall alert:***
  - When the accuracy requirement is not met, or
  - When the probability that lateral Total System Error (TSE) exceeds 0.6 NM is greater than 1×10^{-5}

On-Board Performance Monitoring & Alerting Function

- **On-board performance monitoring and alerting should comprise:**
  - Navigation System Error monitoring and alerting, and
  - Automatic monitoring of flight technical error (FTE) or Lateral Deviation Display enabling the flight crew to monitor FTE

Systems Meeting Accuracy, Integrity and Continuity Requirements

- **GNSS stand-alone systems approved IAW 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 approved IAW FAA 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**

- GNSS receiver approved IAW E/TSO-C129() → capability for satellite Fault Detection and Exclusion (FDE) is recommended

Key Aircraft Functional Requirements

- **Lateral deviation display should agree with alerting and annunciation limits**
- **Lateral deviation display must have full-scale deflection suitable to phase of flight**
  - Scale set automatically or from navigation database
  - Must be known or displayed to the flight crew
  - As previously stated, navigation map display *may* meet the requirement

More Key Aircraft Functions

- **Continuous display to pilot flying, on primary flight instruments for navigation, RNAV-computed desired path and aircraft's position relative to the path**
- **Capability to load the entire approach, by name, from the on-board navigation database**
- **Display of RNAV system failure, including sensor failures, in pilot's primary field of view**
- **Alert when Navigation System Error (NSE) exceeds limits → provided by on-board monitoring & alerting**

RNP APCH Operational Approval Overview

- **RNP APCH Pre-Flight Planning**
- **General Operating Procedures**
- **Contingency Procedures**
- **Pilot Knowledge & Training**
- **Navigation Database Requirements**

RNP APCH Pre-flight Planning

- **Flight plan suffixes should reflect the navigation capability of the aircraft**
- **Flight crew must confirm the aircraft navigation database is current and contains desired procedures**
- **Navigation data must be current for flight duration**
  - Operator and pilot procedures must ensure data integrity and accuracy when the AIRAC cycle changes during flight

RNP APCH Pre-flight Planning

- **Operators and pilots must confirm:**
  - Availability of GNSS required for the intended RNP APCH operation
    - May be a prediction service offered by the State or private service
    - A prediction tool may be integrated into the aircraft's avionics
    - Pilots should follow guidance per their State operating authority
  - Availability of any conventional ground-based navigation aids for non-RNAV contingencies

General Operating Procedures (1)

- **The flight crew must retrieve the RNP APCH procedure from the on-board database by procedure name**
- **Before the initial approach fix (IAF), the flight crew must verify the correct RNP APCH procedure is displayed**
- **As a minimum, the flight crew must:**
  - Check the waypoint sequence loaded by the navigation database & system
  - Compare avionics display with available charts (paper or electronic)
  - Ensure the path complies with the ATC clearance (when assigned)

General Operating Procedures (2)

During the RNP APCH operation:

- **If the aircraft does not meet the criteria for the RNP APCH operation → pilot must inform ATC and request an alternate clearance**
- **Pilots must use a lateral deviation indicator, flight director and/or autopilot in the lateral navigation (LNAV) mode**
- **If using barometric-VNAV → the flight crew must confirm the current, local altimeter setting**
- **If using multi-sensor systems → the flight crew must confirm GNSS is available and being used by the navigation system**

General Operating Procedures (3)

During the RNP APCH operation:

- **Lateral deviation scaling should match required navigation accuracy for each approach segment:**
  - 1.0 nm for the initial & intermediate approach segments,
  - 0.3 nm for the final approach segment, and
  - 1.0 nm for the missed approach segment
- **All pilots are expected to maintain path centerline at all times**

General Operating Procedures (4)

During the RNP APCH operation:

Cross-track deviation limited to:

- **±½ times the required navigation accuracy → example: 0.15 nm during the final approach segment (½ × 0.30 = 0.15)**
- **1 times the required navigation accuracy during and after turns → up to maximum of 1.0 nm during and immediately after turns**

General Operating Procedures (5)

During the RNP APCH operation:

- **When using barometric vertical navigation (baro-VNAV) for vertical path guidance, vertical deviations must not exceed:**
  - +100 feet above the depicted vertical path
  - -50 feet below the depicted vertical path
- **If deviation exceeds a lateral or vertical limit, the pilot must initiate a missed approach procedure**
  - Pilot may continue visually if the required visual references are available

General Operating Procedures (6)

During an RNP APCH missed approach operation:

- **Fly the published missed approach procedure, and**
- **If available, use the RNAV path extracted from the on-board navigation database**
- **Interim Summary:**
  - GNSS is needed to begin the approach.
  - If GNSS is lost, execute the missed approach.
    - If appropriate, pilot may continue visually if required visual references are available

RNP APCH Contingency Procedures

- **The flight crew must notify ATC of any loss of RNP APCH navigation capability**
  - Flight crew should propose an alternate course of action
  - The operator's contingency procedures should enable a safe response to the loss of RNP APCH capability
- **In event of lost communication, the flight crew should comply with published lost communication procedure (general or procedure-specific)**

RNP APCH

Pilot Knowledge and Training (1)

Pilot knowledge and training should include:

- **Characteristics of RNP APCH procedures**
- **Depiction of waypoint types and path terminators**
- **The required navigation equipment → at least 1 (one) GNSS-based RNP system**
- **Compliance with the operator-recommended levels of automation for phase of flight**
- **Phraseology for RNP APCH applications**
- **The ability to conduct contingency procedures when facing RNP system failures and alerts**

RNP APCH

Pilot Knowledge and Training (2)

Knowledge of RNAV equipment operating procedures:

- **How to verify the currency of navigation database and retrieve an RNP APCH in its entirety**
- **How to complete RNP system self-tests and initialize aircraft position**
- **How to verify waypoints and program the flight plan**
- **How to intercept an initial or intermediate approach segment of an RNP APCH**
- **How to monitor lateral and vertical deviations within operational tolerances**

RNP APCH
Pilot Knowledge and Training (3)

RNP system-specific knowledge and training:

- **Levels of automation, mode annunciations, alerts, interactions, reversions, and systems degradation**
- **Functional integration with other aircraft systems**
- **Knowledge of the meaning of route discontinuities**
- **Pilot monitoring procedures and interpretation of electronic displays**
- **Types of navigation sensors used for RNP and their operation**

Navigation Database Requirements for RNP APCH Operations

- **Operators should obtain the navigation database from a supplier complying with public criteria**
  - RTCA DO-200A / EUROCAE document ED 76, *Standards for Processing Aeronautical Data*
- **The supplier should hold a database integrity Letter of Acceptance (LOA) (for example, Transport Canada, FAA or EASA)**

Navigation Database Requirements for RNP APCH Operations

Descriptions of Letters of Acceptance can be found in:

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

Navigation Database Requirements for RNP APCH Operations

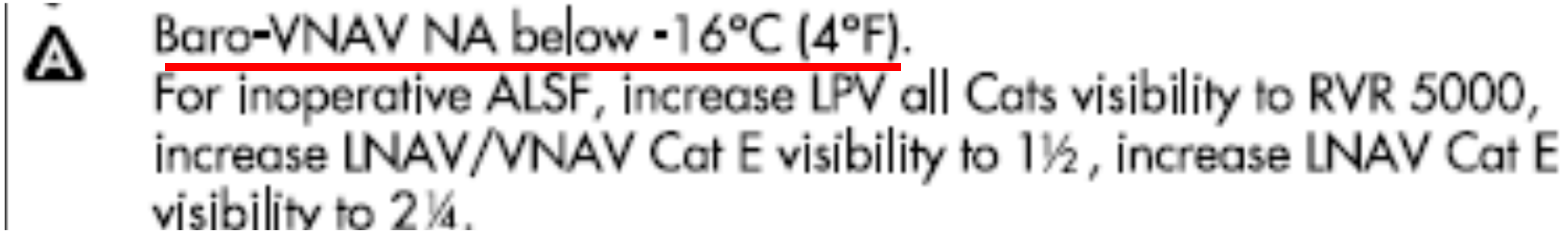
- **If an operator or flight crew discovers database discrepancies that invalidate a procedure:**
  - Immediately report the discrepancy to the supplier
  - Prohibit the procedure's use by the operator's flight crews through an advisory notice until corrected
- **Operators should consider employing ongoing checks of database to ensure data quality**
  - Automated tools may be available to assist in this task

Baro-VNAV Systems

- **Background**
  - RNP APCH final approach segment: vertical path guidance computed by the on-board RNAV system
  - Other flight phases: vertical path information that can be defined by vertical angles or altitudes at procedure fixes
- **Reference PANS-OPS**
  - Application: Doc 8168, Volume I
  - Obstacle Clearance: Doc 8168, Volume II

Key Vertical Navigation Functions

- **Temperature limits:**
  - Cold temperatures reduce actual glidepath angle
  - High temperatures increase actual glidepath angle
  - Aircraft using temperature compensation or alternate means (e.g., SBAS) may disregard temperature



Baro-VNAV NA below -16°C (4°F).
For inoperative ALSF, increase LPV all Cats visibility to RVR 5000, increase LNAV/VNAV Cat E visibility to 1½, increase LNAV Cat E visibility to 2¼.

Operating Procedures

- **Altimeter setting**
  - Flight crews obtain current setting, particularly during times of rapid change. Remote settings not allowed.
- **Cold temperature**
  - Check chart, or use AFM-approved temp comp system
- **Contingency procedures**
  - Consistent with operator practices
- **Pilot knowledge and training**
- **Database**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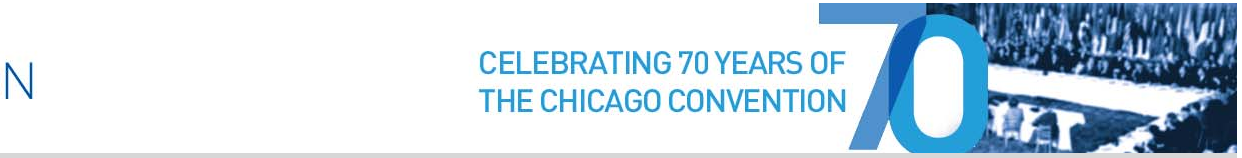

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