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)
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 $< 1 \times 10^{-5}$

**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 $1 \times 10^{-7}$, or

• *During the final approach segment:*
  – Probability of SIS error causing a lateral position error greater than 0.6 NM exceeds $1 \times 10^{-7}$
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 $1 \times 10^{-5}$

• **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 $1 \times 10^{-5}$
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
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)
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
- 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

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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**