







# Approach Specifications Part II


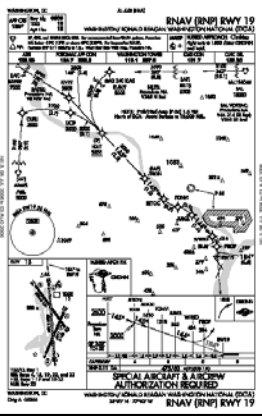

## RNP Authorization Required Approach (RNP AR APCH)









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- ## Overview
- Learning Objectives: After this briefing, you should:
    - Understand the background and foundation for RNP AR APCH operations
    - Understand unique RNP AR APCH characteristics and how it is different than RNP APCH
    - Recognize the close relationship between procedure design, aircraft qualification and operation
    - Understand aircraft qualification and eligibility
    - Understand the operational qualification for RNP AR APCH
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- ## Background on ICAO Guidance for RNP AR APCH Procedures
- Developed based on operational experience in implementing unique approach procedures in multiple States
    - United States (Alaska Airlines), Canada (West Jet), New Zealand, Australia (Qantas)
  - Developed to take advantage of navigation capabilities in existing RNP-certified aircraft
  - “AR” = “Authorization Required”
    - Similar to how CAT III Instrument Landing System (ILS) is approved by Civil Aviation Authorities (CAA)
    - RNP AR APCH capabilities are available in a limited number of current aircraft and for which current operators have limited experience
    - Specific authorization ensures adequate CAA oversight of aircraft and operator to safely conduct these procedures
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- ## Capabilities
- Reduced Lateral & Vertical Obstacle Clearance
    - Takes advantage of improved aircraft performance
  - Curved Paths
    - Use Radius-to-Fix (RF) legs where & when appropriate
  - RNP AR Missed Approach Guidance
    - Enable lower minima where extraction requires precise guidance
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- ## Applications (1)
- RNP AR APCH can be used to increase safety and access where conventional approach cannot be aligned to runway
  - US Honolulu procedure provides stabilized approach with final segment aligned to runway
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- ## Applications (2)
- RNP AR APCH can be used to improve safety and increase access in mountainous terrain
  - US: Palm Springs procedure provides approach through mountainous terrain
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### Applications (3)

- RNP AR APCH can be used to increase access in congested airspace
- US Chicago Midway (MDW) procedure provides approach without conflicting with Chicago O'Hare (ORD) traffic

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### Successful RNP Implementation Requires All The Elements Be Put In Place

Regulatory Capability + Airport & Facility Capability + Air Traffic Capability + Airline Capability + Airplane Capability

= safe and efficient RNP AR operations

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### Key Elements of Operational Approval: RNP AR APCH

Operational Approval

Procedure Design Criteria

Operational Procedures and Standards

Equipment/System Standards

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### Types of Procedures

- RNP AR APCH provides several types of procedures to accommodate different aircraft capabilities
  - Varying accuracy values (RNP 0.3, RNP 0.1)
  - Straight segments only or curved segments (RF)
  - RNP APCH or RNP AR APCH missed approach
- These characteristics are indicated on each published approach

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### RNP (AR) Approach: RNP Segment Width

PLAN VIEW

PROFILE VIEW

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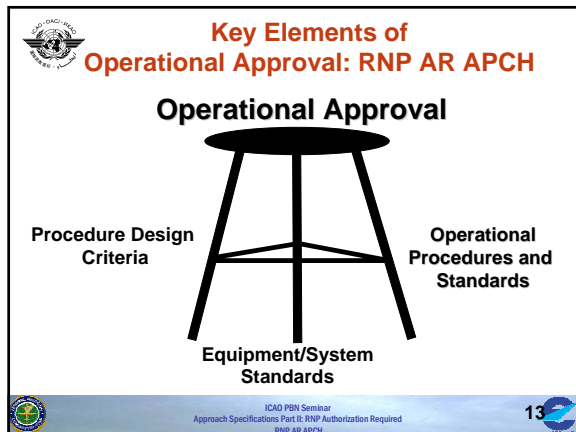
### RNP (AR) Approach Radius to Fix (RF) Turns

Cross Section

ROC/MOC

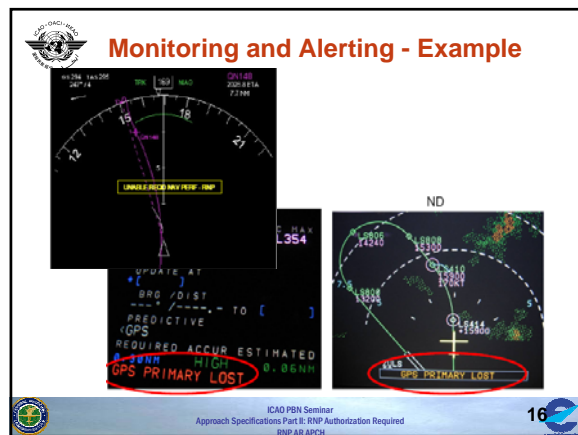
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- ### Aircraft Eligibility for RNP AR APCH
- Aircraft eligibility must be determined through demonstration of compliance against the relevant aircraft qualification criteria
    - Typically documented by Aircraft Manufacturer and accepted by CAA
    - May not require new Aircraft Flight Manual (AFM) entries if previous systems and equipment are adequate
  - Aircraft equipment eligibility includes:
    - Aircraft qualification
    - Maintenance procedures
    - Minimum Equipment List (MEL) revisions
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- ### RNP AR APCH System Performance Monitoring and Alerting
- Different from other Navigation Specifications
    - Unique vertical accuracy requirements
    - Unique monitoring and alerting due to reduced obstacle clearance
  - Lateral Accuracy:
    - Range of accuracy values (0.1 to 0.3 NM)
  - Vertical Accuracy:
    - Defines 99.7% of system error in vertical direction
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- ### RNP AR APCH System Monitoring and Alerting
- Alerting relates to:
    - Lateral and vertical performance
      - Vertical addressed through several operational mitigations
    - Fault-free and faulted performance consistent with safety objective
  - Aircraft and operational requirements work together to meet the requirements for the approach
    - GNSS and Baro-VNAV equipped aircraft can comply when the aircraft operation is in harmony with the guidance
    - May require new pilot training and procedures
  - Alternate means of compliance for the aircraft can help the operator achieve operational approval
    - Probability of exceeding the lateral and vertical obstacle clearance volume must be less than  $1 \times 10^{-7}$  per approach
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- ### RNP AR APCH Specific Navigation Service Requirements
- Global Navigation Satellite System (GNSS)
    - Required to begin any RNP AR APCH
  - Inertial Reference Unit (IRU)
    - Required for any RNP AR APCH with accuracy value less than 0.3 NM or missed approach with RNP less than 1.0 NM
  - Distance Measuring Equipment (DME)
    - DME/DME updating may serve as reversionary mode where infrastructure and aircraft can provide required missed approach performance
  - VHF Omni-Directional Range (VOR) Stations
    - The RNAV system may not use VOR updating
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## Key Altimetry Functions for RNP AR APCH

- Altimetry performance is a key component of RNP AR APCH
- Criteria requires two, independent altimetry sources in the pilots' primary field of view
- Requires a flight crew altimeter crosscheck within  $\pm 100'$ 
  - Confirms satisfactory input to FMC providing the vertical path
  - Requirement may be met by automated comparator monitor function
  - Absence of automated function requires procedural mitigation → flight crew procedures
- When the flight crew sets the altimeter, this must also set the RNP system's (FMC) altimeter input through a single action

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## Key Aircraft Functions: Display

Displays that support flight crew monitoring of lateral and vertical deviation

FTE Monitoring: Airbus L/DEV

FTE Monitoring: Boeing NPS

Operational procedure: Numeric display

FMC CDU

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## Requirements for RNP AR APCH with RF Legs

- For approaches where RF legs are used (indicated on chart):
  - Navigation system *must* have the capability to execute RF legs between two fixes
  - Aircraft *must* have an electronic map
  - The FMC, flight director and Autopilot *must* be capable of commanding 25° of bank at or above 400' AGL and 8° of bank below 400' AGL
    - 5° maneuverability margin over the 20° used in procedure

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## Example: Radius to Fix (RF) Turns

Turn Radius (Min)

Maneuverability Margin

Bank angle to hold turn (Max)

Automatic Flight Control Command Authority

Max Airspeed + Tailwind

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## Key Requirements for RNP AR APCH Less Than RNP-0.3

- No single point of failure can cause loss of guidance required for the approach
  - Aircraft typically require: dual GNSS sensors, dual FMS, dual air data systems, dual autopilots and a single IRS
  - Loss of display of lateral guidance is *hazardous*
- System performance, monitoring and alerting of vertical errors consistent with safety objective
  - Vertical obstacle clearance reduced with increased lateral accuracy
  - System crosscheck can provide operational mitigation

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## Key Requirements for RNP AR Missed Approach Less than RNP-1.0

- When possible, missed approach will use RNAV or conventional criteria
  - Enables participation by more aircraft
- When missed approach requires accuracy value < 1.0 NM (RNP AR missed approach):
  - No single point of failure can cause loss of guidance → dual equipage (same as RNP AR APCH < 0.3)
  - Loss of display of lateral guidance is *hazardous*
  - *Must* be able to couple Autopilot/Flight Director by 400' AGL
  - Upon loss of GNSS, aircraft *must* revert to another means of navigation complying with the navigation accuracy requirement

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**Example: Missed Approach with Inertial**

Loss of GNSS updating is considered (e.g., interference): Immediate effect is to revert to inertial navigation.

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**Key Requirements for RNP AR**

- Flight guidance *should* remain in LNAV upon TOGA or other means of go-around/missed approach
  - Navigation system may revert to 'track-hold' or 'heading hold', and if followed, drive aircraft off procedure path

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**Example: Go-Around Alignment**

Criteria ensures straight alignment segment for procedures where precision guidance is required in missed approach (accuracy values less than 1.0 NM)

Actual guided track is average of prior track

Decision Altitude Point

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**Key Elements of Operational Approval: RNP AR APCH**

**Operational Approval**

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**Preflight Planning for RNP AR APCH**

- Minimum Equipment List (MEL)
  - Varies depending on the RNP AR APCH operation & the required navigation accuracy for the procedure
    - May require dual equipment
  - RNP AR APCH operations requires operable Class A TAWS
  - RNP < 0.3, or RF legs, require flight director or autopilot
- RNP Prediction
  - Each operator must have a predictive capability
  - Desired performance must be available at the destination
  - The flight crew must apply prediction during preflight
  - Prediction must account for known outages in navigation services
  - Prediction software must use same algorithms the aircraft uses

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**General Operating Procedures**

- Follow the procedures and limitations of the Aircraft Flight Manual (AFM)
  - Manufacturer documentation of RNP AR APCH capability may act as a supplement to the AFM
- Verify the flight plan loaded in the aircraft
- Load the entire RNP AR APCH procedure by name
- Ensure correct accuracy value is loaded in flight management system


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## General Operating Procedures (continued)

- Only fly procedures for which you are authorized
  - Appropriate accuracy value, use of RF legs, missed approach with accuracy value less than 1.0 NM
- Required equipment must be available and operational prior to beginning the approach
  - Like RNP APCH, failure of any required equipment prior to the approach should result in coordinating an alternate ATC clearance
- Verify GNSS updating of the RNP system prior to beginning an RNP AR APCH
  - Manufacturer documentation of aircraft performance and function may eliminate the need for this flight crew check
- Ensure a current, local altimeter setting is set prior to commencing the final approach segment




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## General Operating Procedures (continued)

- The flight crew may need to disable radio updating
  - Depends on aircraft qualification and procedure
- Expected pilot performance will keep cross-track deviation limited to:
  - ½ times the required navigation accuracy on straight segments
  - 1 times the navigation accuracy (1.0 nm) during and after turns
- Initiate a go-around if maximum deviation occurs:
  - 1 x RNP laterally
  - 75 feet vertically
  - May require new crew procedures and training, particularly for aircraft without suitably scaled non-numeric deviation displays




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## General Operating Procedures (continued)

- The flight must abandon an RNP AR APCH if a loss of GNSS occurs or a loss of required performance occurs
  - Aircraft alerting may help meet this requirement (e.g., 'UNABLE RNP')
- Manage track compliance during go-around
  - Particularly during early go-around on procedure with RF legs, maintain appropriate track and re-engage LNAV
- Adhere to airspeed limits published on a procedure
- Apply the temperature limits published on a procedure
  - Can be waived for aircraft with temperature compensation




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## RNP AR APCH Training

- RNAV training and experience → may provide a solid foundation for RNP approach operations
  - Unique attributes of RNP approach operations require training
- Understand operations procedures and best practices
  - Critical to safe operations during RNP AR APCH
- Individuals must complete appropriate ground &/or flight training before engaging in RNP approach operations
  - May require expanded aircraft systems training
  - Operators may address topics separately, or
  - Integrate RNP approach training with other training curriculum




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## RNP AR APCH Navigation Database

- The operator must validate the delivered aircraft navigation database against the published procedure
  - Must ensure the flight path is same as the published procedure
  - Must ensure the flight path is compatible with aircraft avionics
  - Database provider may or may not offer validation services
- The validation process must include ability to detect unintended changes in navigation database
- Avionics upgrades and software updates may require re-evaluation if they affect the path or performance




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## ANSP Considerations

- RNP AR APCH procedures are based on GNSS
  - Ensure no local interference
- Ensure procedure design is in accordance with criteria
  - Any characteristics outside scope of the procedure design criteria can have significant impact on the aircraft qualification and operational procedures



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## Summary

- RNP AR APCH operations based on diverse experience with modern aircraft
- Typical applications include airports in mountainous area or with airspace constraints
- Varying accuracy value, curved paths and RNP AR missed approach capabilities
  - More flexible than RNP APCH, fewer capable aircraft depending on RNP AR characteristics used on the procedure
- Important to coordinate among operator, ANSP, regulator and aircraft manufacturer when implementing
  - Initial approvals can be complex, take advantage of previous approvals in same aircraft



## Audience Response System Questions

