Introduction to Navigation Specifications
Learning Objectives

• Organisation of PBN Manual Vol II
• Vol II Part A, General
  – PBN concept review
  – Navigation performance
    ➢ System performance error components
    ➢ Role and application of on-board performance monitoring and alerting
• Use of navigation specifications
• Relationship with existing criteria
• Vol II Parts B and C
• Summary
Organisation of PBN Manual, Volume II

• Part A: General
• Part B: Implementing RNAV (*including RNAV Specifications*)
• Part C: Implementing RNP (*including RNP Specifications*)
• Attachment A: Barometric VNAV
PBN Concept Review

- NAVIGATION APPLICATION
- NAVAID INFRASTRUCTURE
- NAVIGATION SPECIFICATION
PBN Concept Review

- Requirements placed on the RNAV system
  - Performance required for accuracy, integrity, continuity and availability
  - Functions available to achieve required performance
  - Navigation sensors to achieve required performance
  - Flight crew procedures to achieve required performance

- RNP specifications require on-board performance monitoring and alerting…RNAV specifications do not
Navigation Performance

• **System performance error components**
  – Lateral navigation errors
  – Longitudinal navigation errors

• **On-board performance monitoring and alerting**
  – Role
  – Application
System Performance
Error Components (1)

- Lateral navigation errors (95%)
  - 3 main errors: PDE, NSE and FTE
System Performance Error Components (2)

- Longitudinal navigation errors (95%)
  - Along-track navigation errors (NSE)
  - No FTE in longitudinal dimension
  - No current navigation specifications require 4-D control
Role of On-board Performance Monitoring and Alerting

- The PBN concept uses “on-board performance monitoring and alerting” instead of “containment”
- The associated ICAO terms were previously containment area, contained airspace, containment value, containment distance, obstacle clearance containment
- Replaced by the navigation accuracy of TSE
Role of On-board Performance Monitoring and Alerting (2)

• On-board performance monitoring and alerting:
  – Allows the flight crew to determine whether the RNP system satisfies the navigation performance required in the navigation specification
    ➢ Dependent on system architecture
  – Relates to both lateral and longitudinal navigation performance
• “On-board” means the performance monitoring and alerting is on-board the aircraft

• “Monitoring” relates to NSE and FTE
  – PDE is constrained through database integrity and functional requirements on the defined path
  – “Monitoring” refers to the monitoring of the aircraft’s performance; ability to determine positioning error and/or to follow the desired path

• “Alerting” is related to monitoring
  – Flight crew alerted if navigation system not performing to requirement
Application of On-board Performance Monitoring and Alerting (1)

• **Performance monitoring**
  – Aircraft (or aircraft and pilot in combination)
  – Required to monitor TSE
  – Provides an alert if accuracy requirement is not met, or if probability that TSE exceeds 2x accuracy value is larger than $10^{-5}$

• **Net effect of RNP navigation specifications is to bound TSE distribution**
  – PDE negligible; FTE known; NSE varies
Application of On-board Performance Monitoring and Alerting (2)

- RNP navigation specifications provide assurance that TSE is suitable for the operation
- Aircraft
  - TSE remains $\leq$ required accuracy for 95% of flight time; and
  - Probability TSE for each aircraft exceeds specified TSE ($2\times$RNP) without annunciation is $< 10^{-5}$
- Performance monitoring is not error monitoring
Application of On-board Performance Monitoring and Alerting (3)

• **Safety assessment**
  – Performance monitoring and alerting for RNP 4, Basic-RNP 1 and RNP APCH does not obviate need for safety assessments
  – Cannot assume appropriate route spacing is 4xRNP
  – Navigation database errors not covered by nav specs

• **RNP AR APCH**
  – Additional requirements to more tightly control each error source
Use of Navigation Specifications

- Use and scope of navigation specifications by flight phase
- Relationship with existing criteria
- Vol II, Parts B and C organisation
  - Navigation specification template
Use and Scope of Navigation Specification by Flight Phase

PBN Manual includes airworthiness, operational and training guidance

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Use and Scope of Navigation Specifications

- ICAO navigation specifications do not address all airspace requirements (e.g., comm, surv) necessary for operation in a particular airspace, route or area
  - These will be listed in the AIP and ICAO Regional Supplementary Procedures
  - Incumbent upon States to undertake a safety assessment in accordance with provisions outlined in Annex 11 and PANS-ATM, Chapter 2

- ICAO PBN Manual provides a standardized set of criteria, but is not a stand-alone certification document
  - Examples: RNP 4, RNAV 1, RNP AR APCH
Navigation Specifications and the Approval Process

- Navigation specifications are used by States as *basis* for aircraft certification and operational approval.
- A navigation specification does not in itself constitute regulatory guidance material:
  - Aircraft approved by State of manufacture
  - Operators approved in accordance with their National Operating Rules
- Compliance with one navigation specification does not guarantee compliance with another.
Relationship with Existing Criteria

- Not re-inventing the wheel
- Taking existing criteria e.g., Orders, ACs, AMC, and TGL etc.
- A more logical structure
- Common format and content
- More complete to enable uniform implementation
Common Organisation of Volume II, Parts B and C

Where “X” represents the chapter number:

- X.1 Introduction
- X.2 ANSP Considerations
- X.3 Navigation Specification
- X.4 References
Air Navigation Service Provider Considerations

- **Navigation infrastructure**
  - Sufficient for proposed operation, including reversionary modes

- **Communication and ATS surveillance**
  - Determine reliance on radar

- **Obstacle clearance and route spacing**
  - References PANS-OPS

- **Publication**
  - Incorporation into AIP, and reference to ICAO Annex 15
Air Navigation Service Provider Considerations

- **Controller**
  - Core training and training specific to the Nav Spec

- **Status monitoring**
  - Navaid infrastructure monitoring

- **ATS System monitoring**
## Overview of Specific Navigation Services

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Navigation Specification

- Background
- Approval process
- Aircraft requirements
- Operating procedures
- Pilot knowledge and training
- Navigation database
- Oversight of operators
Approval Process

- **Aircraft Eligibility**
  - Can be based on Aircraft Flight Manual or supplemental information

- **Operational Approval**
  - Operating procedures
  - Flight crew training
  - Control of navigation database process, where required

- **Approval obtained in accordance with State operating rules**
Aircraft Requirements

- **Performance Requirements**
  - Accuracy, Integrity, Continuity, GNSS signal-in-space
  - Performance monitoring and alerting
    - Only applicable for RNP systems
- **Criteria for Specific Navigation Services**
  - Defines allowable systems and required performance
- **Functional requirements**
  - Just as important as performance
- **Navigation database requirements**
Operating Procedures

- Pre-flight planning
- General operating procedures
- Performance expectations (deviation from path)
  - Pilot has critical role in performance monitoring
- Contingency procedures
Pilot Knowledge and Training

• Lists training tasks considered important, which may already be part of operator’s training program

• System-specific information on how navigation system functions is vital to success
Summary

• PBN Concept = navigation specification + navaid infrastructure + navigation application

• Navigation performance
  – System performance error components
  – On board performance monitoring and alerting

• Use of navigation specifications
  – Navigation Specification provides implementation guidance for PBN operations -- not a stand-alone certification document

• Relationship with existing criteria

• Common organisation of Vol II Parts B and C
  – ANSP considerations, navigation specification
Feedback and Questions