Overview of Oceanic and Continental Remote Navigation Specifications

RNAV 10 (RNP 10) and RNP 4

Overview

- Learning Objectives: At the end of this presentation, you should:
  - Understand how RNP 10 and RNP 4 operations are incorporated into the PBN Manual
  - Be familiar with general issues associated with implementing RNP 10 and RNP 4
  - Understand the related communication and surveillance capabilities required for 50 NM and 30 NM lateral and longitudinal separation
- Summary

Application of Navigation Specification by Flight Phase

PBN Manual Vol II, Part A

NAVIGATION SPECIFICATION	FLIGHT PHASE							
				APPROACH				
	En Route Oceanic / Remote	En Route Continental	ARR	Initial	Intermed	Final	Missed	DEP
RNAV 10 (RNP 10)	10							
RNAV 5		5	5					
RNAV 2		2	2					2
RNAV 1		1	1	1	1		1	1
RNP 4	4							
Basic-RNP 1			1	1	1		1	1
RNP APCH				1	1	0.3	1	
RNP AR APCH				1 - 0.1	1 - 0.1	0.3 - 0.1	1 - 0.1	

Prior Guidance Material

- ICAO guidance material on RNP 10 was published in ICAO Doc 9613 Appendix E (1999)
- ICAO Guidance Material on RNP 4 was published in State Letter AN 13/33.7 04/86 (September 2004)
- This material has been updated and included in Vol II of the PBN Manual
  - Updates should not affect aircraft or operator compliance

RNAV 10 and RNP 10: Naming Convention Exception (1)

- RNP requires aircraft on-board performance monitoring and alerting
  - RNAV does not require such monitoring
- RNP 10 is addressed in RNAV section of PBN Manual because operation does not require on-board performance monitoring and alerting
- The designation “RNP 10” has been retained for operational and airworthiness approvals, charting, etc
  - Stakeholder feedback on costs of changing Airplane Flight Manuals, existing approval documentation, charting, automation

RNAV 10 and RNP 10: Naming Convention Exception (2)

CHAPTER 1

IMPLEMENTING RNAV 10
(DESIGNATED AND AUTHORISED AS RNP 10)

1.1. INTRODUCTION

1.1.1. Background

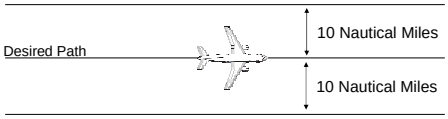
This chapter addresses the implementation of RNP 10 to support 50 NM lateral and the 50 NM longitudinal distance-based separation minima in oceanic or remote area airspace. This guidance has been titled RNAV 10 for consistency with the PBN Manual. This designation and version of the material do not change any requirements, and do not affect operators who obtained an RNP 10 authorization from their relevant State regulatory authority. Recognizing the extent of existing airspace designations and operational approvals using the designation RNP 10, it is anticipated that any new airspace designations or aircraft approvals will continue to use the designation RNP 10. RNAV 10 does not require on-board performance monitoring and alerting. However, the designation of the airworthiness and operational approval as well as airspace/route designation remains “RNP 10” in order to grandfather the present publications and extensive approvals. Recognizing the extent of existing airspace designations and operational approvals under RNP 10 designation, it is anticipated that any new airspace designations and aircraft approvals will continue to use the “RNP 10” term while the required PBN application will be now known as “RNAV 10.”

RNP 10 is a recognized inconsistency in RNAV and RNP naming

RNP 4 Naming Convention

- RNP requires aircraft on-board performance monitoring and alerting
  - RNAV does not require such monitoring
- RNP 4 guidance did not require on-board performance monitoring and alerting
  - Classify as RNAV 4?
- Technical evaluation of means of compliance concluded all aircraft qualifying under AN 13/33.7 had on-board performance monitoring and alerting capability
  - Adding a requirement for monitoring and alerting resolves naming inconsistency
  - **New requirement does not affect qualified aircraft or qualifying methods**
- Decision: Retain designation of RNP 4

RNP 10



RNP 10 Applications

- Pacific Ocean Flight Information Regions (FIRs) including
  - North Pacific and Central East Pacific Route Systems and Pacific Organized Track System
- European – South America (EUR-SAM) routes
- Peru – Chile routes
- Routes connecting Australia, Asia, Mid-East and Europe
- Africa – overland routes

Communications and Surveillance Requirements Associated With RNP 10

- 50 NM Lateral Track Spacing (Annex 11, Attachment B)*
  - COMMUNICATIONS: Voice communications through third party
  - SURVEILLANCE: Procedural pilot position reports
- 50 NM Longitudinal Separation Using Automatic Dependent Surveillance (ADS) (Doc 4444, Ch 5)
  - COMMUNICATIONS: Direct controller-pilot communications (data link or voice)
  - SURVEILLANCE: Maximum ADS periodic report interval 27 minutes
- 50 NM Longitudinal Separation Not Using ADS: (Doc 4444, Ch 5)
  - COMMUNICATIONS: Direct controller-pilot communications (data link or voice)
  - SURVEILLANCE: Distance verification every 24 minutes

*** ICAO is moving Annex 11 Atch B material to separate publication**

Key Elements of Operational Approval: RNP 10

Route Design and Spacing Criteria: RNP 10

- ICAO Doc 8168, Vol II, *PANS OPS:*
  - Parts 1 and Part 3 General Criteria
  - Part 3, Section 1, Chapter 7
    - ➢Provisions for 10 NM
  - Part 3, Section 3, Chapter 8
- ICAO Annex 11 Attachment B, PANS ATM
  - Route spacing for RNP 10 is minimum of 50 NM lateral

Key Elements of Operational Approvals: RNP 10

Equipment/Systems: NAVAID Infrastructure

- RNP 10 is specifically prescribed for oceanic and continental remote applications
  - No ground NAVAID infrastructure is required
- Navigation is provided by inertial navigation or GNSS
- Status monitoring
  - Enroute NAVAID structure that supports aircraft position updating prior to entry into RNP 10 operations should be monitored
  - Notify users of outages (NOTAM)

System Performance (1)

- Accuracy
  - Lateral total system error: within ±10 NM for at least 95% of total flight time
  - Along-track error: within ±10 NM for at least 95% of total flight time
- Integrity
  - Malfunction of the aircraft navigation equipment classified as a Major Failure Condition under airworthiness regulations (i.e., 10^{-5} per hour)

System Performance (2)

- Continuity
  - Loss of function classified as a Major Failure Condition
  - Continuity requirement is satisfied by the carriage of dual independent LRNSs (excluding signal in space)
- Signal-in-Space (if using GNSS)
  - Aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 20 NM exceeds 10^{-7} per hour (ICAO Annex 10, Table 3.7.2.4-1)

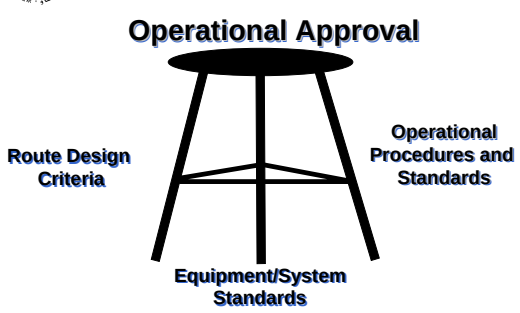
Compliant Systems: Aircraft Requirements

- Aircraft must be equipped with at least two (2) independent and serviceable Long-Range Navigation Systems (LRNSs) comprised of some combination of
  - Inertial navigation system (INS)
  - Inertial Referencing System (IRS)/Flight Management System (FMS)
  - Global Navigation Satellite System (GNSS)
    - Integrity and reliability through Fault Detection and Exclusion (FDE)

Criteria for Navigation Services RNP 10

	RNP 10
Dual GNSS	Meets RNP 10 requirements without time limitations. GNSS constellation must support operation.
Dual INS or IRU (Standard Time Limit)	Meets RNP 10 requirements for up to 6.2 hours if approved under 14 CFR Part 121, Appendix G or for NAT MNPS or RNAV operations in Australia
Dual INS or IRU (Extended Time Limit)	Additional certification action is required to extend time limit beyond standard
Single INS/IRU and Single GNSS	Meets RNP 10 requirements without time limitations

Key Elements of Operational Approvals: RNP 10

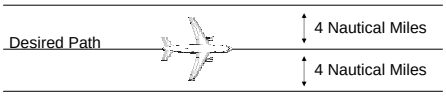


Operational Procedures: Example Dispatch Requirements

- IRU aircraft: Operator must establish that aircraft will comply with the time limit on the planned route
  - Route Start and Stop Point calculations
  - Availability of NAVAIDs to support radio updating prior to entering RNP 10 airspace
  - Head wind component data from acceptable sources
    - "One time" calculation
    - "Flight plan" winds aloft
  - Automatic or Manual Radio Position Updating
- GNSS aircraft: operators should ensure adequate en route coverage and FDE availability

RNP 4

BD2



RNP 4 Application

- 30 NM lateral and longitudinal separation is applied in Pacific oceanic FIRs between aircraft meeting prescribed CNS requirements
- RNP 4 is the prescribed navigation specification for 30/30 separation
- RNP 4 is not mandatory for Pacific oceanic operations; it is an operator option

Communications and Surveillance Requirements Associated With RNP 4

- 30 NM Lateral Track Spacing (Annex 11, Attachment B)*
  - COMMUNICATIONS: Direct Controller-Pilot Communications (Voice or controller-pilot data link)
  - SURVEILLANCE: ADS providing 5 NM lateral deviation alert
- 30 NM Longitudinal Separation Using ADS (Doc 4444, Ch 5)
  - COMMUNICATIONS: Direct controller-pilot communications (data link or voice)
  - SURVEILLANCE: Maximum ADS periodic report interval 14 minutes

* ICAO is moving Annex 11 Atch B material to separate publication

Key Elements of Operational Approval: RNP 4

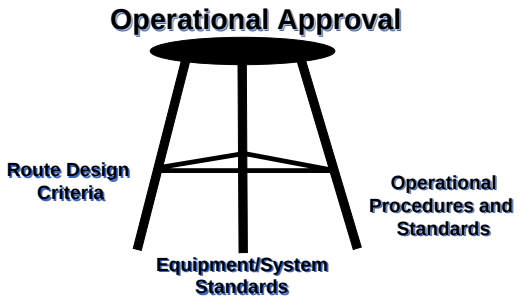
Slide 21

BD2 Need to update notes, says something is planned for April 07...
Bruce DeCleene, 5/30/2007

Route Design and Spacing Criteria: RNP 4

- ICAO Doc 8168, Vol II, *PANS OPS:*
  - Parts 1 and Part 3 General Criteria
  - Part 3, Section 1, Chapter 7
    - Provisions for 4 NM
  - Part 3, Section 3, Chapter 8
- ICAO Annex 11 Attachment B and PANS ATM
  - RNP 4 prescribed for 30 NM track or route spacing
  - May support application of separation standards/route spacing less than 30 NM in continental airspace provided a State has undertaken the necessary safety assessment

Key Elements of Operational Approvals: RNP 4



Equipment/Systems: NAVAID Infrastructure

- RNP 4 is prescribed for oceanic and continental remote airspace operations
  - No ground NAVAID infrastructure is required
- GNSS is the required sensor
- Air Traffic Service Provider must monitor status of GNSS
  - Issue timely warnings of outages

System Performance Monitoring and Alerting (1)

- Accuracy
  - Lateral total system error: within ± 4 NM for at least 95% of total flight time
  - Along-track error: within ± 4 NM for at least 95% of total flight time
- Integrity
  - Malfunction of the aircraft navigation equipment classified as a Major Failure Condition under airworthiness regulations (i.e., 10^{-5} per hour)

System Performance Monitoring and Alerting (2)

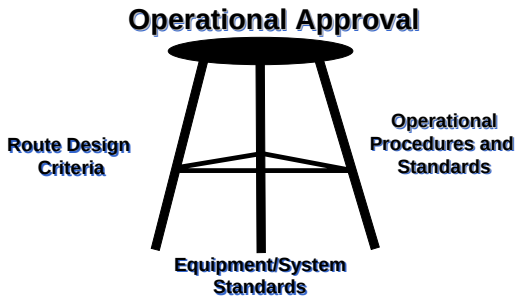
- Continuity
  - Loss of function classified as a Major Failure Condition
  - Continuity requirement is satisfied by the carriage of dual independent LRNSs (excluding signal in space)
- Performance Monitoring and Alerting
  - RNP system, or RNP System and pilot in combination, shall provide an alert if
    - The accuracy requirement is not met, or
    - The probability that lateral Total System Error exceeds 8 NM is greater than 10^{-5}
- Signal-in-Space
  - Aircraft navigation equipment shall provide an alert if the probability of signal-in-space errors causing a lateral position error greater than 8 NM exceeds 10^{-7} per hour (ICAO Annex 10, Table 3.7.2.4-1)

Aircraft Functional Requirements RNP 4

On-board navigation system must have :

- Display of navigation data
- Path Terminator (ARINC 424)
  - Track to Fix (TF)
  - Direct to Fix (DF)
  - Direct-To function
  - Course to Fix (CF)
- Parallel offset
- Fly-by transition criteria
- User interface displays
- Flight planning path selection
- Flight planning fix sequencing
- User defined course to fix
- Path steering
- Alerting requirements
- WGS-84 reference system
- Automatic radio position updating

Key Elements of Operational Approvals: RNP 4



Operational Procedures: Example Dispatch Requirements

- Availability of GNSS
  - Operator must ensure adequate navigation capability is available enroute to enable the aircraft to navigate to RNP 4
  - Includes availability of Fault Detection and Exclusion
    - Receiver Autonomous Integrity Monitoring (RAIM) Prediction capability

Navigation Database

- Navigation database should be obtained from a supplier that complies with RTCA DO-200A/EUROCAE Doc ED 76, *Standards for Processing Aeronautical Data*
- Discrepancies that invalidate a route must be
  - Reported to the database provider and
  - Use prohibited by an operator's notice to flight crews
- Operators should consider the need to conduct periodic checks of their operational navigation databases

Summary

- RNP 10 and RNP 4 navigation specifications intended for Oceanic and Remote Continental Applications
  - RNP 10 remains a valid designation per the PBN Manual
- Requirements in new ICAO PBN Manual Vol II have not changed from earlier ICAO guidance
- Navigation Specifications are implemented along with Communications and Surveillance elements

Audience Response System Questions

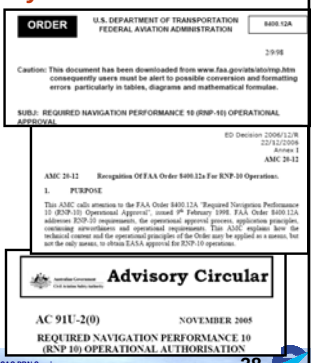
Backup Slides

ICAO PBN Guidance Material General Considerations

- Navigation Specifications provide technical and operational criteria
  - Does not imply a need for recertification of existing implementations
- A PBN Manual Vol II Navigation Specification does not <u>in itself</u> constitute regulatory guidance material
- States issue regulations applicable to operators/aircraft for which they are responsible

State Regulatory Guidance Material

- FAA Order 8400.12A
  REQUIRED NAVIGATION PERFORMANCE 10 (RNP-10) OPERATIONAL APPROVAL
- EASA AMC 20-12
  RECOGNITION OF FAA ORDER 8400.12A FOR RNP-10 OPERATIONS
- Civil Aviation Safety Authority of Australia (CASA) Advisory Circular (AC) 91U-2(0)
  REQUIRED NAVIGATION PERFORMANCE 10 (RNP 10) OPERATIONAL AUTHORISATION

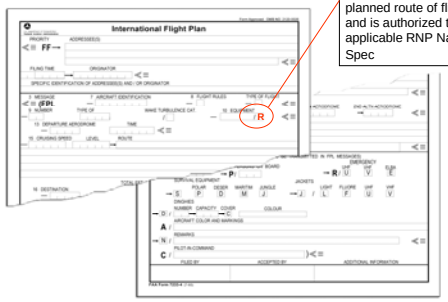

ORDER
U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
8400.12A
2/9/98
Caution: This document has been downloaded from www.faa.gov/ats/ato/rnp.htm consequently users must be alert to possible conversion and formatting errors particularly in tables, diagrams and mathematical formulae.
SUBJ: REQUIRED NAVIGATION PERFORMANCE 10 (RNP-10) OPERATIONAL APPROVAL
ED Decision 2006/12/R
22/12/2006
Annex 1
AMC 20-12
AMC 20-12 Recognition Of FAA Order 8400.12a For RNP-10 Operations.
1. PURPOSE
Advisory Circular
AC 91U-2(0)
NOVEMBER 2005
REQUIRED NAVIGATION PERFORMANCE 10 (RNP 10) OPERATIONAL AUTHORISATION

Operating Procedures (Pre-Flight)

- Review maintenance logs and forms to determine the status of equipment required for RNP 10 operations
- Check the condition of the navigation antennas and surrounding aircraft skin
- Review applicable contingency procedures
  - Doc 4444 oceanic contingency procedures
  - Any additional Regional contingency procedures
  - Added: crews must be able to recognize, and advise ATC, when the aircraft is no longer able to navigate to its RNP 10 approval capability

Flight Plan Example

"R" placed in block 10 of the ICAO Flight Plan indicates that the pilot has reviewed the planned route of flight and is authorized the applicable RNP Nav Spec



Pilot Knowledge and Training

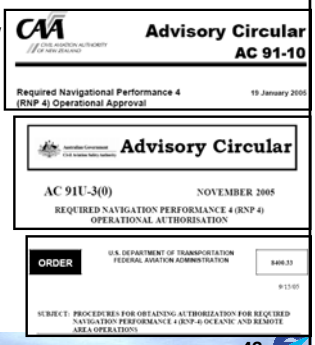
- Operators must ensure flight crews know:
  - Guidance material
  - Limits of navigation system capabilities
  - Effects of updating
  - Applicable contingency procedures

Additional Considerations

- State AIP should clearly indicate RNP 10 application
- All routes based on WGS-84 coordinates
- Recommended Controller Training
  - Core Training (RNAV System basic information)
  - Flight Plan requirements
  - ATC Procedures including
    - Separation
    - Contingencies
    - Transition between Oceanic/Remote and En Route
- Reporting of Gross Navigational Errors

State Regulatory Guidance Material

- Civil Aviation Safety Authority of New Zealand Advisory Circular 91-10
  REQUIRED NAVIGATION PERFORMANCE 4 (RNP 4) OPERATIONAL APPROVAL
- Civil Aviation Safety Authority of Australia Advisory Circular 91U-3(0)
  REQUIRED NAVIGATION PERFORMANCE 4 (RNP 4) OPERATIONAL AUTHORISATION
- FAA Order 8400.33
  PROCEDURES FOR OBTAINING AUTHORIZATION FOR REQUIRED NAVIGATION PERFORMANCE 4 (RNP 4) OCEANIC AND REMOTE AREA OPRERATIONS



Compliant Aircraft

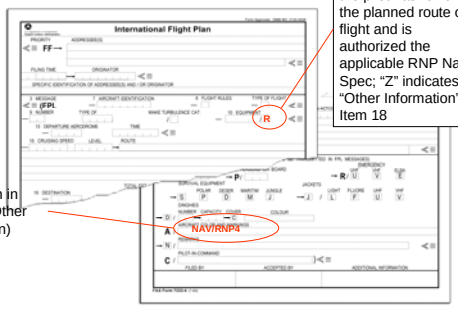
- Two (2) Long Range Navigation Systems (LRNS)
  - GNSS is a required sensor
    - Stand-alone navigation system or
    - Part of a multi-sensor system
    - Integrity and reliability through Fault Detection and Exclusion (FDE)
  - Design meets aircraft standards and is reflected in AFM

Operating Procedures (Pre-Flight)

- Review the maintenance logs and forms to ascertain the status of equipment required for flight in RNP 4 airspace or on routes requiring RNP 4 navigation capability
- Ensure maintenance action has been taken to correct defects in the required equipment
- Review contingency procedures for operations in RNP 4 airspace or on routes requiring RNP 4 capability
  - Generally same as normal oceanic contingency procedures
  - Added: Crews must be able to recognize, and inform ATC when aircraft can no longer navigate to RNP 4 capability

Flight Plan Example

"R" placed in block 10 of the ICAO Flight Plan indicates that the pilot has reviewed the planned route of flight and is authorized the applicable RNP Nav Spec; "Z" indicates "Other Information" in Item 18



Annotation in Item 18 (Other Information)

Pilot Knowledge and Training

- Operators must ensure flight crews know:
  - Guidance material
  - Limits of their RNP 4 navigation capabilities
  - Applicable contingency procedures

Additional Considerations

- State AIP should clearly indicate RNP 4 application
- All routes based on WGS-84 coordinates
- Recommended Controller Training
  - Core Training (RNAV System basic information)
  - Flight Plan requirements
  - ATC Procedures including
    - Separation
    - Contingencies
    - Transition between Oceanic/Remote and En Route
    - Phraseology
  - CPDLC communication
  - ADS-C system and simulation training
  - Effects of periodic reporting delay/failure on longitudinal separation