ICAO PBN Workshop
Tanzania

RNP4
RNP 4 - Overview

• Introduction
• Aircraft requirements
• Operational Approval
• Ground based navigation aids do not exist except possibly at isolated locations
• Oceanic and remote regions of the world are restructured to provide capacity and operating benefits.
• Reduced route spacing:
• RNP 4, originally developed to support 30 NM lateral and the 30 NM longitudinal distance-based separation minima in oceanic or remote area airspace.
Surveillance and Communication performances consideration

Additional communication and surveillance equipage may be required to satisfy ATM operational performance. (doc 4444, ICAO annex 11, regional supplementary procedures 7030/4)

• In non radar environment to get credit of 30 NM lateral and the 30 NM longitudinal distance-based separation minima:
  • communication capability of Direct Controller-Pilot voice Communications or Controller-Pilot data link communication (CPDLC) and Automatic dependant surveillance (ADS-C) are required.
  • e.g. Tasman Sea, Pacific - Communication mean: Direct Voice CPC required or CPDLC ATS - Surveillance mean: ADS-C with a reporting rate of 14 minutes
• When there is a request to get RNP4 approval, inform the operator of those additional requirements. A CPDLC and ADSC-C (also known as FANS) approval could be useful.
### Extrait chap PANS-ATM 5.4.2.6

<table>
<thead>
<tr>
<th>separation Minima</th>
<th>Type de RNP</th>
<th>Maximum ADS-C periodic reporting interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>93 km (50 NM)</td>
<td>10</td>
<td>27 minutes</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>32 minutes</td>
</tr>
<tr>
<td>55,5 km (30 NM)</td>
<td>4</td>
<td><strong>14 minutes</strong></td>
</tr>
</tbody>
</table>
Airborne RNAV system performance

Lateral navigation

- Navigation equipment: 2 fully serviceable independent LRNS including each a GNSS sensor (stand alone or sensor to a multi-sensors system)
- The RNAV system outputs necessary navigation parameters and desired path to displays and autopilots

Vertical navigation

- No requirement
Airborne RNAV system performance

The lateral TSE must be within ±4 NM (95% of total flight time).

The TSE is the Root Sum Square (RSS) of:

- Navigation system error (NSE)
- Path definition error (PDE)
- Flight technical error (FTE)
airborne RNAV system performance

On-board performance monitoring and alerting function

alert if

- the probability that the lateral \textbf{TSE} exceeds 8 NM is greater than 10−5 / hour
- The accuracy requirement is not met
- the probability of \textbf{signal-in-space errors} causing a lateral position error greater than 4 NM exceeds 10−7 per hour \(\Rightarrow\) \(\text{HAL = 4NM}\)
airborne RNAV system performance

Required function

The display of navigation data must use either

- a lateral deviation display or
- a navigation map display
airborne RNAV system performance

Lateral deviation display

- Non numeric lateral deviation display: CDI or (E)HIS.
- TO/FROM indication
- Located in the primary field of view
- Suitable lateral deviation indicator scaling (Full scale of 4Nm)
- Display scaling may be set automatically in accordance with the navigation database
- The course selector of the lateral deviation display should be automatically slewed to the RNAV computed path,
Navigation map display

- readily visible to the pilot, with appropriate map scales (scaling may be set manually by the pilot), and giving equivalent functionality to a lateral deviation display.
Alerting requirements

- The system must provide an annunciation if the manually entered navigation accuracy is larger than the navigation accuracy associated with the current airspace as defined in the navigation database.

- When approaching RNP airspace from non-RNP airspace, alerting must be enabled when the cross-track to the desired path is equal to or less than one-half the navigation accuracy and the aircraft has passed the first fix in the RNP airspace.

- Alert if the navigation accuracy is not met or if the integrity cannot be guarantee (RAIM alert)
Airborne RNAV system performance

- parallel offset;
  - The system must have the capability to fly parallel tracks at a selected offset distance (up to 20 NM, in increment of 1NM).
- flight planning path selection;
- flight planning fix sequencing;
- navigation database access;
- WGS-84 geodetic reference system;
Airborne RNAV system performance

- Capability to execute transition database procedures (Fly-by transition criteria)
- Capability to automatically execute leg transitions and maintain tracks consistent with the following path terminators:
  - Track between two Fixes (T.F)
  - Course to a Fix (C.F)
  - Direct to a Fix (D.F)
RNP4 – operational approval

- Evidence of aircraft eligibility
- Operating procedures for the navigation system
- Control of those procedures (Ops manual)
- Navigation Database process
- MEL
- Flight Crew training requirements
RNP 4 - Operational requirements

- Annex 6
- ICAO Supplementary Regional Procedures doc 7030 Mid/Asia/Rac-10
- IR OPS SPA.PBN.100
- FAA order 8400.33 dated 9/15/05
RNP 4 - Aircraft eligibility

3 Aircraft eligibility groups (airworthiness)

• **Group 1: RNP certification**
  Aircraft with formal certification and approval of RNP integration in the aircraft. RNP compliance is documented in the aircraft’s flight manual.

• **Group 2: Prior Navigation certification**
  Stand alone GNSS:
  • 2 equipments
  • RAIM and FDE function

  Multisensors
  • 2 GNSS sensors
  • RAIM and FDE functions required except in case of Aircraft Autonomous Integrity Monitoring (AAIM) with the use of inertial navigation systems

• **Group 3: RNP 4 certification**
RNP 4 – Aircraft eligibility

Example of group 1

Example of group 3
RNP 4 – Flight preparation

Pre Flight Planning

• Check that the procedures are based upon WGS 84.
• Procedures not based on WGS-84 should not be accepted => analyze impact on PDE.
• Check eventual additional requirements (CPDLC and ADS-C)
• The flight plan has to be filled in in accordance with the RNAV and “FANS” capability (refer to PANS ATM doc 4444).
• Navigation Data Base is current (up to date with AIRAC cycle)
Availability of GNSS

- The operator must ensure that adequate navigation capability is available
- Check availability of FDE, if appropriate for the operation.
  - Maximum FDE outage time: 25 minutes - only applicable to stand alone GNSS and multi-sensor integrating GNSS w/o INS sensors inputs.
  - If predictions indicate that the maximum allowable FDE outage will be exceeded, the operation must be rescheduled to a time when FDE is available
RNP4 – Normal Procedures

En route

• At least two LRNSs, capable of navigating to RNP 4, and listed in the flight manual, must be operational at the entry point of the RNP airspace.

• A LRNS can be composed of
  • navigation sensor : GPS, IRS
  • A navigation computer : FMS
  • Control and display : (ex MCDU)
  • Navigation display : ND
NSE check

- In flight operating procedures must include mandatory cross-checking procedures to identify navigation errors in sufficient time to prevent inadvertent deviation from ATC-cleared routes.

FTE management

- All pilots are expected to maintain route centres lines, as depicted by on-board lateral deviation indicators and/or flight guidance during all RNP operations described in this manual unless authorized to deviate by ATC or under emergency conditions.

- For normal operations, cross-track error/deviation (the difference between the RNAV system computed path and the aircraft position relative to the path) should be limited to $\pm \frac{1}{2}$ the navigation accuracy associated with the route (i.e. 2 NM). Brief deviations from this standard (e.g. overshoots or undershoots) during and immediately after route turns, up to a maximum of one-times the navigation accuracy (i.e. 4 NM), are allowable.
RNP 4 – Contingency procedures

• If an item of equipment required for RNP 4 operations is unserviceable, then the pilot should consider an alternate route or diversion for repairs.

• Crews must advise ATC of any deterioration or failure of the navigation equipment that cause navigation performance to fall below the required level, and/or any deviations required for a contingency procedure.

• These are no different than normal oceanic contingency procedures with one exception: crews must be able to recognize, and ATC must be advised, when the aircraft is no longer able to navigate to its RNP 4 navigational capability.

• Ref to chapter 15.2 from ICAO PANS ATM 4444 SPECIAL PROCEDURES FOR IN-FLIGHT CONTINGENCIES IN OCEANIC AIRSPACE

• Procedures have to be defined in case of loss of RNP 4 capability
  • Before RNP 4 airspace entry
  • In RNP 4 airspace
PDE

Navigation data base integrity shall comply with ED 76/DO 200A methodology standard or an equivalent approved procedure.

=> LOA Type 1 and 2 guarantee compliance to this requirement.
MEL
The airline must develop a MEL taking into account its operational capability (in our case RNP 4)
Loss of functions (systems)
RNP 4 – Flight Crew training

• Operators/owners must ensure that flight crews are trained and have appropriate knowledge of the topics,
  • the limits of their RNP 4 navigation capabilities,
  • RNP 4 contingency procedures.
End of the presentation

Thank you for your attention – Any question?