

• ICAO PBN Workshop  
Tanzania

RNP4



# RNP 4 - Overview

- Introduction
- Aircraft requirements
- Operational Approval

# Oceanic and remote regions

- 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.

# RNP 4 + CPDLC + ADS-C

## Extrait chap PANS-ATM 5.4.2.6

separation Minima	Type de RNP	Maximum ADS-C periodic reporting interval
93 km (50 NM)	10	27 minutes
	4	32 minutes
<b>55,5 km (30 NM)</b>	<b>4</b>	<b>14 minutes</b>

# 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

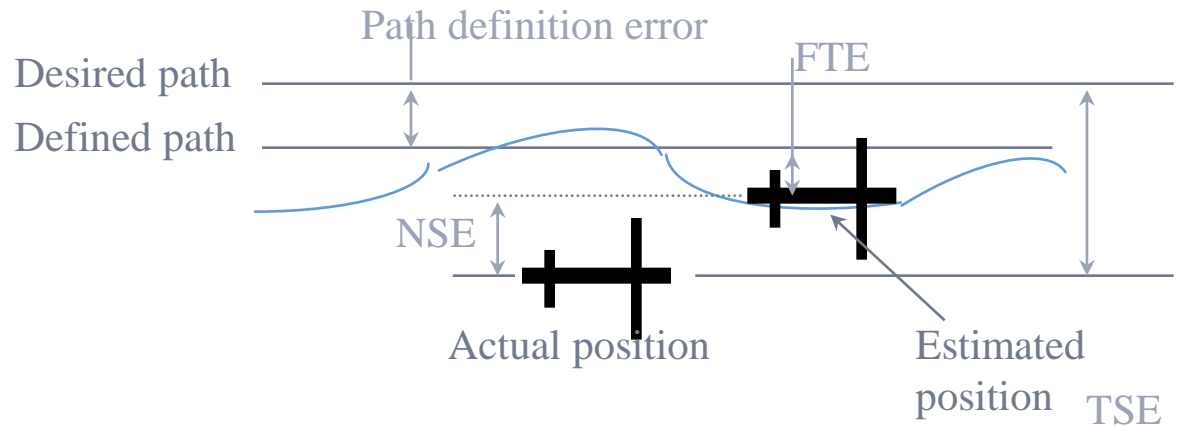
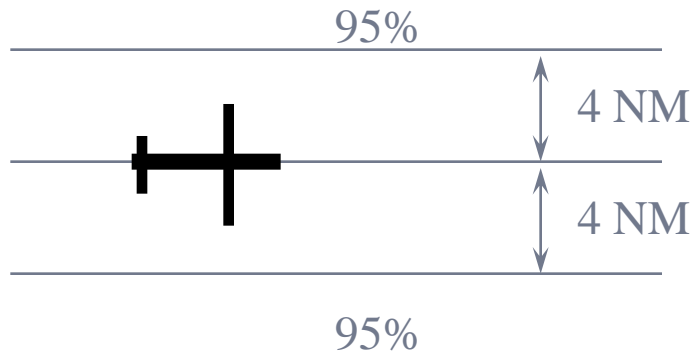
- No requirement

# Airborne RNAV system performance

The lateral TSE must be within  $\pm 4$  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)

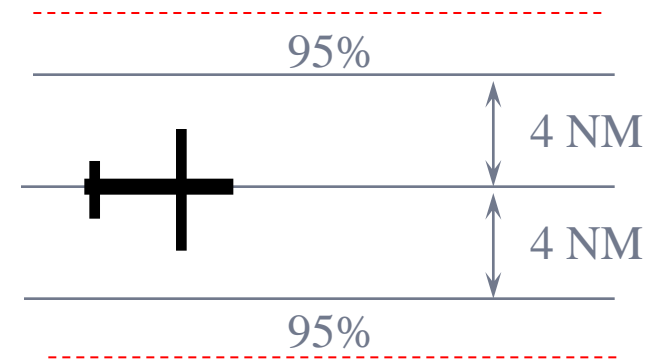


# airborne RNAV system performance

## On-board performance monitoring and alerting function

### alert if

- the probability that the lateral **TSE** exceeds 8 NM is greater than  $10^{-5}$  / hour
- The accuracy requirement is not met
- the probability of **signal-in-space errors** causing a lateral position error greater than 4 NM exceeds  $10^{-7}$  per hour => (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,

FTE



# airborne RNAV system performance

## 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.

  
**FTE**

# airborne RNAV system performance

## Alerting requirements

## NSE

- 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



### FLIGHT MANAGEMENT COMPUTER SYSTEM (FMCS) Software update U10 and later versions.

The Flight Management Computer System has been demonstrated to meet the requirements of Advisory Circular 20-130A for a multi-sensor area navigation system when operated with radio or Global Positioning System (GPS) updating. When operated in this configuration, the FMCS may be used for enroute and terminal area operations and instrument approach navigation (excluding ILS, LOC, LOC-BC, LDA, SDF, GLS, and MLS).

One FMCS, one CDU, one VOR, one IRU in NAV mode, and either one DME or GPS (if installed) operational at dispatch are required for RNAV operations (FAA AC20-130A, JAA AMJ 20X2), unless other appropriate procedures are used.

For configurations with a single FMCS installed, the single FMCS may be used as a supplement to other primary means navigation systems.

For configurations with two FMCS installed the following applies:

Two Inertial Reference Systems (IRS) in conjunction with two FMCS meet the requirements of Advisory Circular 25-15 for long range navigation.

Two FMCS, two CDUs, two sensors capable of meeting a selected RNP, and two IRUs in NAV mode operational at dispatch are required for primary means RNP navigation.

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Code 9000  
Section 3 Page 8



### NAVIGATION CAPABILITY OF THE FMCS

The navigation capability of the airplane is defined by the navigation signals available at the current airplane location and the operational sensor on the airplane. The following sections define the airplane's navigation capabilities in terms of GPS satellite signal available to fly a selected RNP and the range and/or typical values of RNP based on the position update mode.

#### 6.1 GPS/FMCS RNP AVAILABILITY

Figure 6.1-1 is a summary of FMCS/GPS/IRS RNP availability. The data is based on the following GPS receiver and satellite configuration assumptions, which apply to the FMCS system:

- 1) No Baro-Aiding (RAIM augmentation), no local area or wide area differential, or GIB (Global Integrity Broadcast) in the GPS receiver.
- 2) A 2.0 degree mask angle in the GPS receiver.
- 3) Dual FMCS, dual GPS receiver installation.

Number of Satellites in GPS Constellation	FMCS/GPS/IRS World-Wide Availability of Selected RNP					
	RNP 12.0	RNP 4.0	RNP 1.0	RNP 0.5	RNP 0.3	RNP 0.15
24 or more	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
23	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
22	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
21	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%

Note: RNP 4.0, 0.3, 0.15 require manual pilot selection.

Figure 6.1-1 FMCS/GPS/IRS World-Wide Availability of Selected RNP  
Based on the above results, the FMCS is capable of providing the levels of navigation with GPS as defined in Figure 6.1-2.

REV C

D6-30067-3

20

## Example of group 3

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D631A001  
APPLICABLE TO MSN 0055, 0043, 0045, 0049

### AIRWORTHINESS STANDARDS COMPLIANCE

The FMS has been demonstrated to comply with applicable airworthiness requirements, including FAA AC 20-130A, for a navigation system integrating multiple navigation sensors, when operating with IRS, updated by radio or GPS.

The FMS also complies with the airworthiness part of:

- EASA AMC 20-4 (or JAA TGL 2 REV 1) for Basic RNAV.
- JAA TGL 10 for Precision RNAV (compliance with paragraph 8.2 has not been demonstrated).
- FAA Advisory Circular 20-129 for baro VNAV.
- FAA Advisory Circular 80-100 for terminal and en route RNAV operations.
- FAA Order 8400.33 for RNP 4 in oceanic and remote area.
- FAA Order 8400.12A for RNP 10 in oceanic and remote area. RNP 10 oceanic/remote area operations are approved:
  - with GPS PRIMARY
  - without GPS PRIMARY (GPS deselected or inoperative), provided time limitations in IRS only navigation, acceptable to the operational authorities, are established.
- EUROCAE ED75A/DO236A, apart from vertical performance.

Note: Compliance with the applicable airworthiness requirements does not constitute an operational approval.

# END

REVISIONS:  
1) Solution's actual efficiency changed; MSN 0043 0049 added.



# 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)

# RNP4 – Flight preparation

## 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

# RNP 4 – Normal Procedures

## 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 centrelines, 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

# RNP 4 – NAV Data Base

## 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.

The image shows a Letter of Acceptance Type 1 (LOA) issued by the European Aviation Safety Agency (EASA). The document is titled "LETTER OF ACCEPTANCE TYPE 1" and has a reference number of "EASA.LOA.0003". It is addressed to Lufthansa Systems FlightNav Inc., located at Stelzenstrasse 6-8, Air Center, 5th Floor, CH-8152 Glattpfurg, Switzerland. The LOA states that the Agency has investigated the company's procedures and found them to comply with the conditions for the issuance of Letters of Acceptance for navigation database suppliers. The document is published as an opinion of the EASA, dated 14 January 2005. It includes a table with the date of original issue (2 August 2005) and the date of issue (2 August 2005), signed by Dr. N. Loh for EASA. The document is titled "EASA LOA Nav. Database Suppliers – Sheet A".

European Aviation Safety Agency

**LETTER OF ACCEPTANCE TYPE 1**

REFERENCE: **EASA.LOA.0003**

The Agency has Investigated

**Lufthansa Systems FlightNav Inc**

Stelzenstrasse 6-8  
Air Center, 5<sup>th</sup> Floor  
CH-8152 Glattpfurg  
Switzerland

to the procedures defined in "Lufthansa Systems FlightNav Company Exposition",  
which have been found to comply with

"CONDITIONS FOR THE ISSUANCE OF LETTERS OF ACCEPTANCE FOR NAVIGATION  
DATABASE SUPPLIERS BY THE AGENCY".

Published as OPINION OF THE EUROPEAN AVIATION SAFETY AGENCY Nr. 01/2005  
dated 14 January 2005.

This Type 1 LOA does not authorise the supply of navigation databases directly to and  
users/operators.

CONDITIONS:

1. This acceptance requires compliance with the procedures specified in the LOA Exposition; and
2. This acceptance is valid whilst the accepted Navigational Database Provider remains in compliance with the Conditions for the issuance of Letters of Acceptance for navigation database Suppliers by the Agency" (Further in this LOA referred to as "Conditions") and the documented Data Quality Requirements.

Date of original issue:	Date of this issue:	Signed:
2 August 2005	2 August 2005	 For EASA - Dr. N. Loh

EASA LOA Nav. Database Suppliers – Sheet A



# RNP 4 – MEL example

## MEL

The airline must develop a MEL taking into account its operational capability (in our case RNP 4)  
Loss of functions (systems)

ITEM	3. NUMBER INSTALLED	4. NUMBER REQUIRED FOR DISPATCH	5. REMARKS OR EXCEPTIONS
55-02 Marker	C 1 0		May be inoperative provided no ILS procedure is planned. <i>Note:</i> Precision Approach affected. Refer to Part 5 09 07.00 page 9.
57-01 Radio Magnetic Information Switching and Indication A) DORMI	D 1 0		
58-01 Satellite Navigation A) Global Positioning System (GPS) (if installed)	D 2 1		a) For RNP-10 operations, one or more may be inoperative provided flight time without radio update is less than 3h42mn (or 4h30mn for flights within the Australian or the New Zealand airspace).
	C 2 0		b) For RNP-10 operations, one or more may be inoperative provided flight time without radio update is less than 3h42mn (or 4h30mn for flights within the Australian or the New Zealand airspace).
	- 2 2		a) For RNP-4 operations, both have to be operative.

# 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 ?

