RNAV 1 & RNP1

ICAO PBN Workshop
Tanzania
Overview

• RNAV 1 introduction
• Existing guidance material
• Aircraft Requirements
• RNAV 1 Operational approval process
• RNP 1
• Difference between RNP 1 and RNAV 1
RNAV 1 introduction

It addresses Terminal Area

• Departure (SID) and Arrival (STAR)
• Initial Approach Phase
RNAV 1 introduction - SID: AIP information

RNAV SID chart

Required sensors: GNSS and DME/DME/INS

RNAV SID name ≠ conv. SID

Identification of critical DME

update of the IRS if inertial system maybe required

<table>
<thead>
<tr>
<th>SID</th>
<th>ITINERARIES / Routes</th>
<th>CLR initale / initial clearance</th>
<th>RMK</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIP 5A</td>
<td>A droite RM 139⁰, de NÉZ rejoindre MN054 direction 08⁰, Ensuite jusqu’à USANEO et BASIP</td>
<td>FL 160 (R) FL 070 (H)</td>
<td></td>
</tr>
<tr>
<td>DME critique, critical DME : NÉZ</td>
<td>A 400 AAL to the right MAG 139⁰, After NÉZ proceed to MN054 on course 08⁰, Then to USANEO and BASIP</td>
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</tbody>
</table>
RNAV 1 introduction - STAR : AIP information

RNAV STAR chart

RNAV STAR name ≠ conv. STAR
RNAV 1 introduction - INA RNAV

INA RNAV – NETRO RWY 32L

INA RNAV – ODRAN 1A RWY 06
RNAV1 - regulation guidance materials
RNAV 1 existing Guidance material

- ICAO Doc 9613 PBN Manuel VOL II Part B Chapter 3: RNAV 1 nav spec

- AC 90-96A: For a US operator to get a P-RNAV approval

- AC 90-100A: Provides operational and airworthiness guidance for operation on U.S. Area Navigation (RNAV) routes, Instrument Departure Procedures (DPs), and Standard Terminal Arrivals (STARs).

- JAA TGL10: Airworthiness and operational approval for Precision RNAV operations in designated European airspace.

- P-RNAV is the application of RNAV 1 in Europe
The TGL 10 contains

- Airworthiness certification means
  - Accuracy
  - Integrity
  - Continuity of function

- Functional requirements

- Acceptable means of Airworthiness compliance

- Operational Criteria (Chapter 10)

Aircraft requirements For certification by EASA

For OPS approval by National Authority
Aircraft Requirements for RNAV 1
# RNAV 1 & 2 ICAO PBN Manual Summary

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<tr>
<th>PBN APPLICATION</th>
<th>RNAV2</th>
<th>RNAV1</th>
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<td>Navaid infrastructure</td>
<td>DME GNSS INS</td>
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</tr>
<tr>
<td>Nav Spec</td>
<td>On board</td>
<td>GNSS DMEDME DMEDME/IRU</td>
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<td></td>
<td>TSE</td>
<td>&lt;2 NM</td>
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<td>Leg type</td>
<td>IF CF TF DF VA VM VI CA FA FM</td>
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<td>Function</td>
<td>Data base ( LOA) FB turn</td>
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<td>Radar</td>
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<td>voice</td>
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<tr>
<td>ATM</td>
<td>Separation minima</td>
<td>Radar separation</td>
</tr>
<tr>
<td></td>
<td>Publication</td>
<td>RNAV 2 Critical DME if any</td>
</tr>
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</table>
Lateral navigation

- The Flight plan is generated from the arrival or the departure procedure extracted from the navigation database.
- RNAV system performance must be based on GNSS, DME/DME, or DME/DME/IRU. Possible positioning sensors DME/DME, GNSS and INS with automatic radio updating.
- The RNAV system outputs necessary navigation parameters and desired path to displays and autopilots.

Vertical navigation

- No requirement (optional function)
RNAV 1 – Aircraft requirements

The lateral TSE must be within ±1 NM (95%)

The TSE is the Root Sum Square (RSS) of

- Navigation system error (NSE)
- Path definition error (PDE)
- Flight technical error (FTE)
RNAV 1 – Aircraft requirements

Integrity and continuity requirements

- Probability of displaying Hazardously Misleading navigational or positional information simultaneously to both pilot shall be improbable (occurrence should be less than 10\(^{-5}\) per flight hour)
- Probability of loss of all navigation information should be improbable (occurrence should be less than 10\(^{-5}\) per flight hour).
RNAV 1 – Aircraft requirements

Required functions

- Display indicator with course selector automatically slaved to the RNAV computed path
- Navigation data base (should include the complete RNAV procedure)
- Display of the active navigation sensor type, the active (TO) waypoint, the distance and bearing to the active (TO) waypoint and the ground speed or time to the active (TO) waypoint
- Automatic tuning of DME navigation aids with capability to inhibit individual nav aids (When RNAV system is based on radio sensor).
- Capability for the « Direct To » function
RNAV 1 – Aircraft requirements

- Capability to execute transition database procedures (Fly-over and Fly-by turns)
- Capability to automatically execute leg transitions and maintain tracks consistent with the following path terminators:
  - Initial Fix (IF)
  - Track between two Fixes (TF)
  - Course to a Fix (CF)
  - Direct to a Fix (DF)
Capability to automatically execute leg transitions, or provide adequate means to manually follow, and maintain tracks consistent with the following path terminators:

- Course to an Altitude (CA)
- Fix to a Manual Termination (FM)
- Heading to an Altitude (VA)
- Heading to an Intercept (VI)
- Heading to a Manual Termination (VM)
Recommended functions (for TGL 10)

- Capability to fly parallel route (Offset function)
- Coupling to Flight director and/or automatic pilot
- Capability for vertical navigation based upon barometric inputs
- Means for automatic runway position update at the start of the take-off for non-GPS installation (To prevent the « map shift » at Take-Off)
- Capability to execute following leg transitions:
  - Holding pattern (Hx including HM, HA et HF)
Display system: course selector automatically slaved to the RNAV computed path.

Remote annunciator and selection.

Standalone RNAV system TSO C129.
RNAV 1 operational approval process
General aviation

• Aircraft has to be certified in accordance with TGL 10
• Operators have to modify their ops manual, check-list and QRH, an MEL (or equivalent documentation)
• No specific approval granted

Commercial Air Transport

• They have to be approved by their supervision authority to fly RNAV 1 procedures
PBN ops approval process– General Method

Impact of PBN in the OPS manual

Documents provided by the operator to approve the PBN approval request

1. Type, and registration number of the applicable aircraft => B1.
2. List of the navigation systems (name, version or part number, installed number) => B12
3. Aircraft Flight Manual (AFM) Pages giving the RNAV1 capability.
4. Description of the navigation system => part B12
5. Limitations of the system => B1/B12
6. Normal / abnormal / contingency operations (included in the operations manual)
7. MEL => B9
8. Crew training => part D
9. Navigation database policy
10. Aerodromes information => part C depending on the PBN nav spec approval request
11. Specific maintenance task if applicable
RNAV 1 - Aircraft eligibility

AFM

• In most of the cases P-RNAV certification or RNAV 1 certification should be mentioned with the reference to the standard in AFM.

• Check: Reference to TGL-10 and/or AC 90-100A

• Check on which sensors the certification has been done. (DME/DME, GNSS,..)
OPM manual part A
Pre-flight Planning

- Check that the procedures are based upon WGS 84.
- Procedures not based on WGS-84 should not be accessible by database, or should be forbidden by an airline NOTAM.
- Check the availability of the navigation infrastructure required for the intended operation,
- Required navigation aids critical for the operation has to be available
- Check the adequacy of the published RNAV1 procedure and the A/C capability
- Availability of the onboard navigation equipment necessary for the route to be flown must be confirmed.
RNAV 1 – A/C adequacy

Check A/C capability is adequate (RNAV 1 with GNSS)
RNAV 1 – Flight preparation

- If a stand-alone GPS is to be used for P-RNAV, the availability of RAIM must be confirmed during the time the procedure will be used (15mn before the procedure, until 15mn after the procedure use).

- Check NOTAM to take into account the latest information of eventual satellite non-availability => This information has to be used in the RAIM prediction.

- Exceptionally Where the responsible airspace authority has specified in the AIP that dual P-RNAV systems are required for specific terminal P-RNAV procedure, the availability of dual P-RNAV systems must be confirmed.

- The Navigation database has to be validated in accordance with the procedure chosen by the airline.

- The flight plan has to be filled in in accordance with the capability.

See PANS ATM doc 4444
PBN OPS approval process – Flight Plan

Item 10 = R and Item 18 = PBN / following letters in accordance with the following table

Note.- Operators of aircraft approved for P-RNAV relying solely on VOR/DME for the determination of position shall insert ‘Z’ in item 10 of the flight plan and the descriptor EURPRNAV in item 18 of the flight plan, following the NAV/ indicator.
RNAV1 - Normal procedures

The ops manual has to contain the following flight crew check and limitations:

- The Navigation Data Base has to be current.
- Check the active flight plan by comparing the charts with the MAP display and MCDU:
  - WPt sequence,
  - reasonableness of track angles, distances,
  - altitude and speed constraints if any,
  - fly-by and fly-over WPts.
- If the procedure requires it, check that updating will use the specific navaid.
- Creation of new WPt by manual entry is not permitted:
  - Modification of a published procedure is forbidden.
- Monitor the trajectory by cross checks with conventional navigation aids.
Phraseology has to comply with Doc 7030 and 4444

Example:
Abnormal situation because of a system failure the crew has to warn the ATC
« Unable RNAV »
Contingency procedures have to be developed to address
- Failure of the RNAV system
- Failure of the navigation sensors
- Coasting on inertial sensors beyond a specified time limit

The RNAV 1 capability loss has to be notified to ATC in order to decide the appropriate course of action

In case of RNAV 1 capability loss, the crew should invoke contingency procedures and navigate using alternative means of navigation.
RNAV 1 - Incident reporting

• Any significant incidents experienced during RNAV 1 procedures have to be reported
  • Navigation database errors
  • Unexpected deviations in lateral or vertical not caused by the pilot.
  • Misleading information without failure warning
  • Map shifts
  • Total loss of navigation equipment
  • Pb with ground navigational facilities
RNAV 1 - MEL

MEL

- The airline must develop a MEL taking into account its operational capability (in our case RNAV1).
- Loss of functions (systems)
- Database out of date (taken into account by TGL 26)
RNAV 1 Flight Crew training

• Pilots must be familiar with
  • the basic principles of RNAV,
  • limitations and functions of the RNAV system.
  • the operation and particularities of the RNAV equipment
• They should be aware of the operational procedures applicable
  • to pre-flight planning
  • performance of these procedures.
• The minimum training shall comprise a theoretical part and a practical part.
  • Use of the RNAV system
  • Training to cover the impact of the RNAV 1 capability loss
  • Ability to manage correctly « direct To » clearance, Radar « headings », insertion of Wpt from the database (user Wpt or Wpt entered manually are forbidden).
RNAV 1 navigation database

Navigation data base integrity

- Shall comply with ED 76/DO 200A methodology standard or an equivalent approved procedure.
  - A navigation data base supplier holding an FAA or EASA LOA (Letter Of Authorization)
Area of Operation: TERMINAL

RNP 1
**Area of Operation: TERMINAL**

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Main differences between RNP 1 and RNAV1?

• Performance differences:
  • RNP 1 is a RNP nav spec: Integrity has to be managed.
  • RNP 1 accommodates GNSS whereas RNAV 1 can accommodate GNSS, DME/DME and DME/DME/IRS

• Functional differences
  • RF leg is optional for RNP 1 whereas it is not considered in RNAV1

• What does it mean?
  • A state publishing a RNP 1 SID or STAR would protect the procedure with the exclusive use of GNSS and may decide to use a « RF leg » in the procedure. In that case RNP1 and « RF required » should be clearly required on the chart.
  • Some discussions at ICAO to open the RNP1 to DME/DME. The question therefore is how to handle integrity of the « DME/DME signal »?
    • It could be done with additional on board information (IRS for instance)
    • Taken into account that DME infrastructure is sufficient (RNAV1 DME infrastructure could be sufficient => clarification still needed)