



# PBN – Performance Based Navigation AIR OPS (“EASA-OPS”)

AOC OPS Seminarium  
Solna 2016-11-14—15  
Jan Thell  
Sektionen för flygbolag

# PBN – Inledning

- Vad – Varför – *Performance Based Navigation* – PBN?
  - Från ”dåtid” till ”nutid”
  - Från ”Special OPS” till ”Normal OPS”
  - Från konventionella markbaserade radio NAV hjälpmedel (NDB/VOR) till *Performance-based Navigation* – områdesnavigering



# PBN – Inledning

Problem med många olika begrepp och termer

- PBN
- APV
- RNP
- RNAV
- RNP APCH
- RNP AR APCH
- LNAV
- LNAV/VNAV
- LPV
- ....etc.

➤ **Standardisering pågår!**

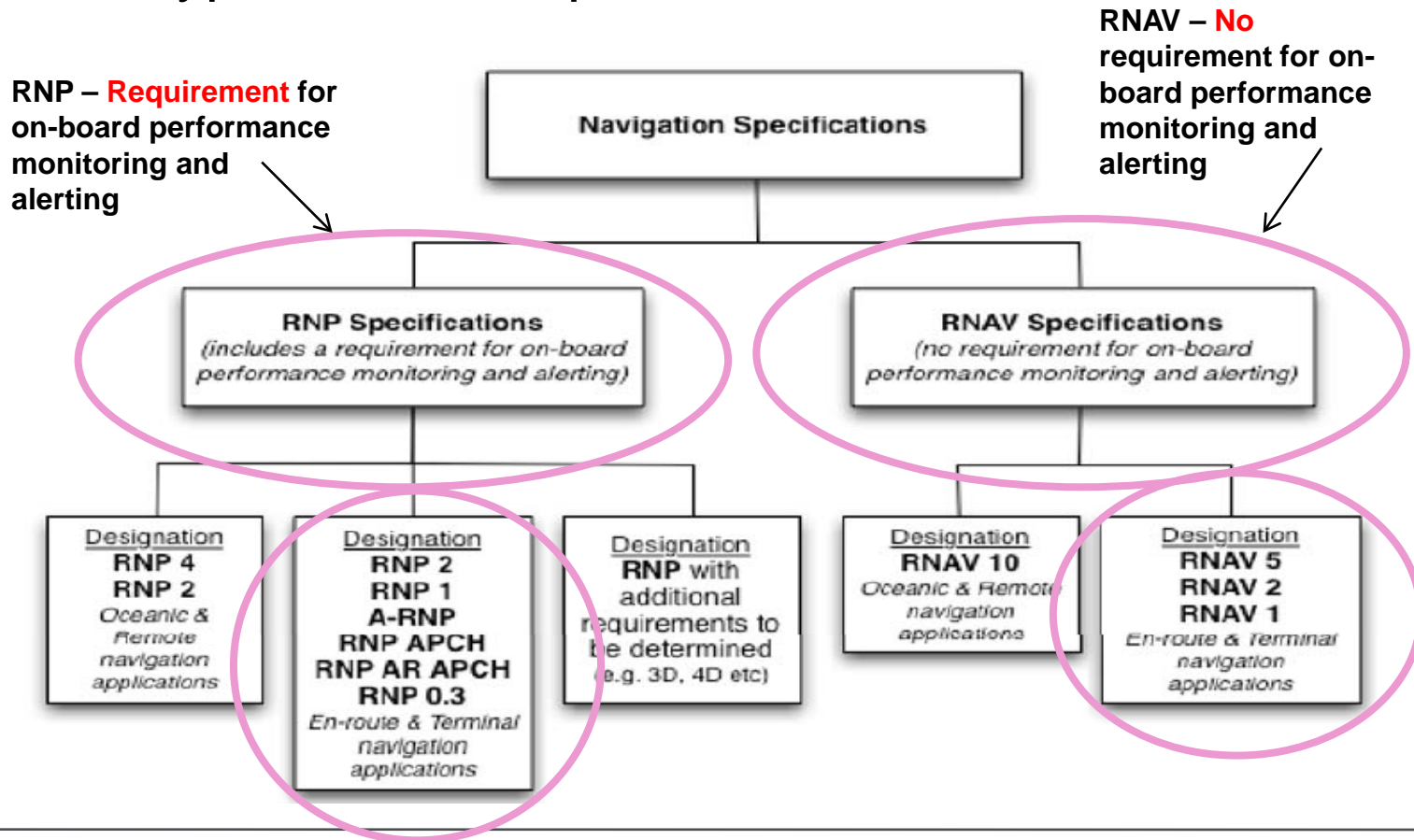


# PBN – ICAO

- ICAO regler – PBN – för global harmonisering
  - ICAO Annex 6 (Part I—III)
  - ICAO Doc 8168 (PANS-OPS)
  - **ICAO Doc 9613 PBN Manual**
    - Fourth Edition — 2013
  - **ICAO Doc 9997 PBN Ops Approval Manual**
    - Second Edition — 2015

# PBN – RNAV – RNP

## ➤ Två typer av NAV Specifications



# PBN – Applications

➤ PBN NAV specifications published to date:

| Navigation specification  | Flight Phase             |                      |                |          |              |                  |                                    |                |
|---------------------------|--------------------------|----------------------|----------------|----------|--------------|------------------|------------------------------------|----------------|
|                           | En-route oceanic/ remote | En-route continental | Arrival        | Approach |              |                  |                                    | Departure      |
|                           |                          |                      |                | Initial  | Intermediate | Final            | Missed                             |                |
| RNAV 10                   | 10                       |                      |                |          |              |                  |                                    |                |
| RNAV 5 <sup>a</sup>       |                          | 5                    | 5              |          |              |                  |                                    |                |
| RNAV 2 <sup>b</sup>       |                          | 2                    | 2              |          |              |                  |                                    | 2              |
| RNAV 1 <sup>b</sup>       |                          | 1                    | 1              | 1        | 1            |                  | 1 <sup>c</sup>                     | 1              |
| RNP 4                     | 4                        |                      |                |          |              |                  |                                    |                |
| RNP 2                     | 2                        | 2                    |                |          |              |                  |                                    |                |
| Advanced RNP <sup>d</sup> | 2 <sup>e</sup>           | 2 or 1               | 1              | 1        | 1            | 0.3              | 1 <sup>c</sup>                     | 1              |
| RNP 1                     |                          |                      | 1 <sup>f</sup> | 1        | 1            |                  | 1 <sup>c</sup>                     | 1 <sup>e</sup> |
| RNP 0.3 <sup>g</sup>      |                          | 0.3                  | 0.3            | 0.3      | 0.3          | —                | 0.3                                | 0.3            |
| RNP APCH                  |                          |                      |                | 1        | 1            | 0.3 <sup>h</sup> | 1 <sup>c</sup> or 0.3 <sup>i</sup> |                |
| RNP AR APCH               |                          |                      |                | 1-0.1    | 1-0.1        | 0.3-0.1          | 1-0.1 <sup>j</sup>                 |                |

# PBN – Applications

- PBN Applications to support a particular airspace concept

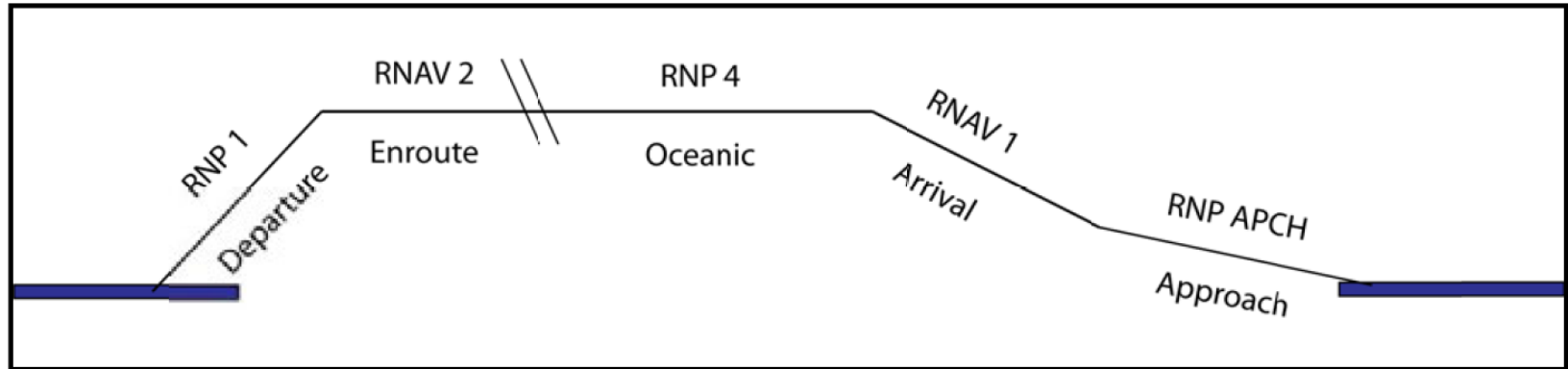


Figure 1-1. Navigation specifications to support a particular airspace concept

# PBN – Applications – EUR

- Aktuelle PBN spesifikasjoner i EUR
  - ENR
    - RNAV 5 (B-RNAV)
  - SID/STAR
    - RNAV 1 (P-RNAV) / RNP 1
  - APCH (APV)
    - RNP APCH (RNP 0,3 NM in final approach)
    - RNP AR APCH (RNP less than or equal to 0.3 NM or fixed radius turns (RF))



## ➤ Approach with Vertical Guidance (APV)

- ICAO har beslutat att påskynda införandet av inflygningsprocedurer där man som pilot har ett glidbanestöd (*Approach with Vertical Guidance – APV*) även vid NPA.

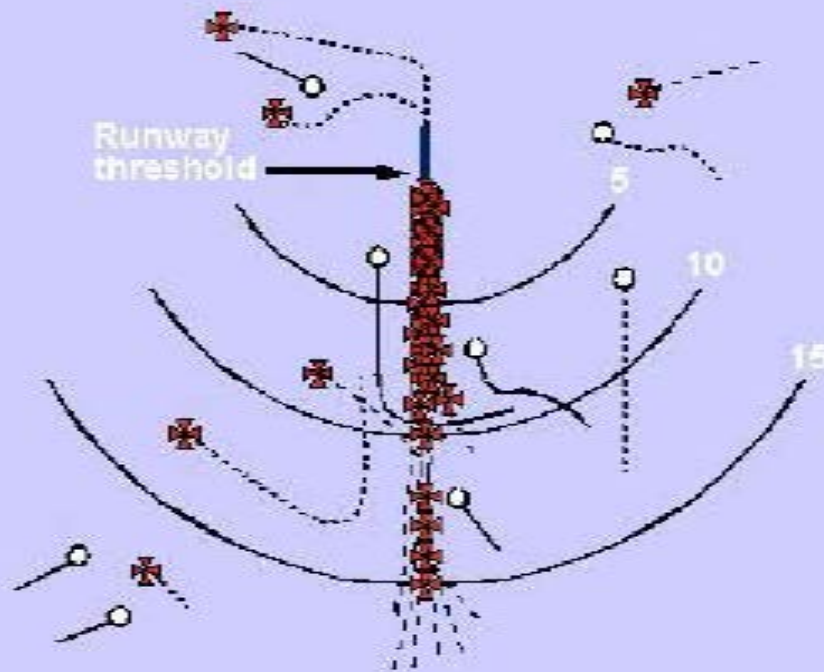
## ➤ Varför APV?...

- Brist på "*vertical situation awareness*" under slutlig inflygning skapar olyckor (Controlled Flight Into Terrain - CFIT)
- APV procedurer (vertikalt glidbanestöd) hjälper till att förhindra dessa olyckor!
- **I avvaktan på implementeringen av APV procedurer är det enligt CAT.OP.MPA.115 obligatoriskt att alla icke-precisionsinflygningar ska flygas med CDFA teknik**

# RNP APCH – APV

## Map location of CFIT accidents/incidents

From runway threshold, 40 accidents/incidents

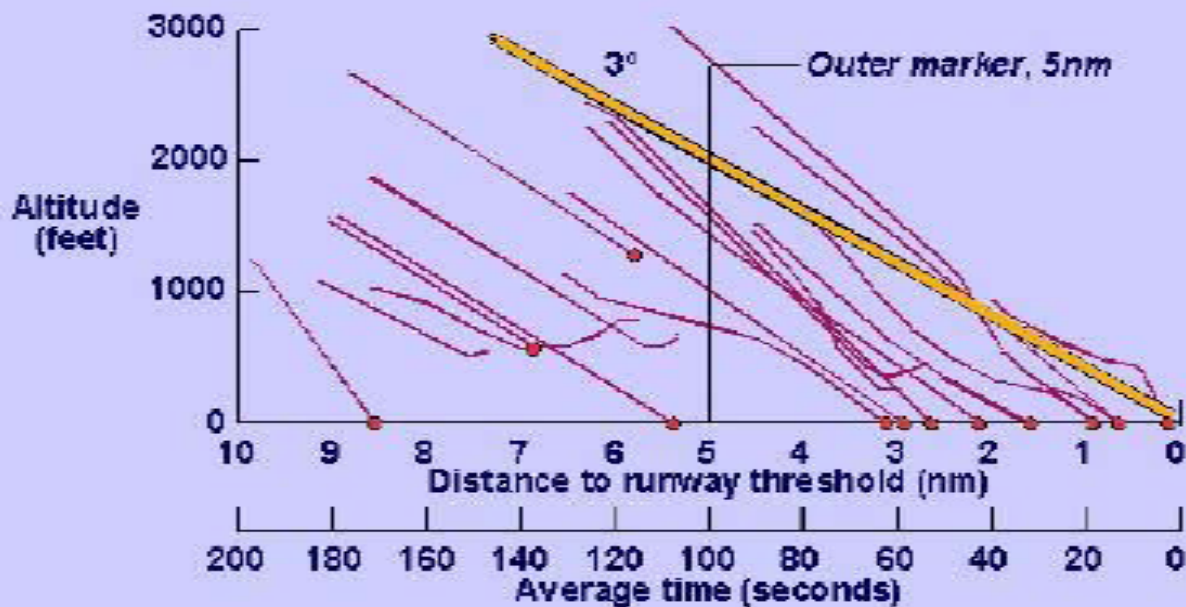


In most of the CFIT accidents, the airplane was lined up with the runway.

(continued)

# RNP APCH – APV

## Vertical profile of some recent CFIT accidents/incidents



There was a lack of vertical situation awareness.

# RNP APCH – APV

- APV procedurer skall enligt ICAO vara publicerade senast 2016
- TS har sedan 2010 föreskrifter som kräver publicering av APV procedurer vid flygplats med instrumentbana (*Transportstyrelsens föreskrifter och allmänna råd om användning och utformning av luftrum och flygprocedurer*)
  - En instrumentflygplats ska ha en APV procedur till varje banriktning med instrumentinflygning senast 2016....
- Publicering pågår – viss fördröjning förutses...
  - [Införande av APV i Sverige 2016-10-18.pdf](#)
- En utfasning av NDB/VOR som endast betjänar inflygningsprocedurer kan påbörjas efter 2016?!

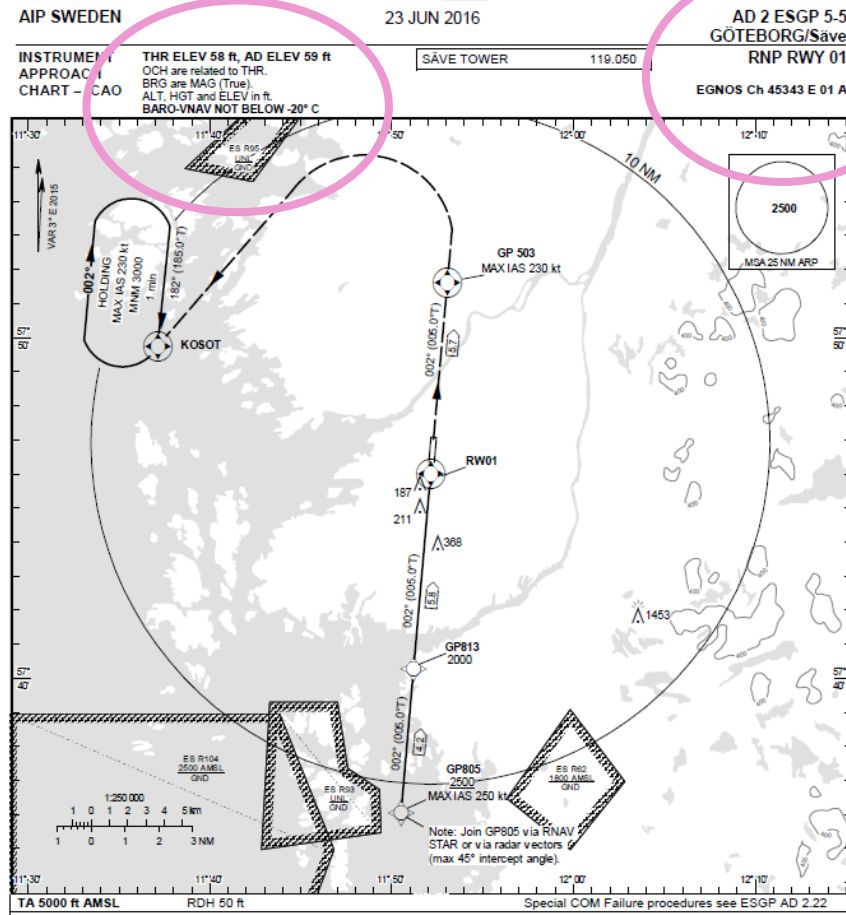
# RNP APCH – APV

## ➤ Namngivning av procedurer

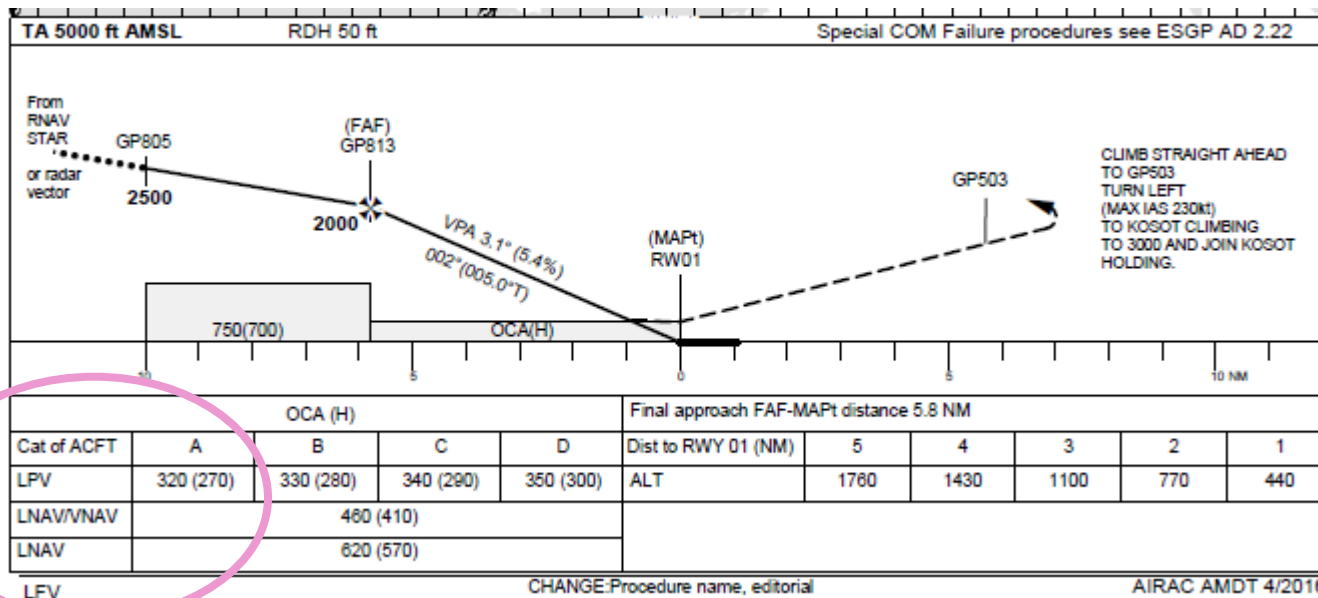
### ➤ Ref AIC A 3/2015

| Current naming     | New naming      |
|--------------------|-----------------|
| RNAV (GNSS) RWY 23 | RNP RWY 23      |
| RNAV (RNP) RWY 23  | RNP RWY 23 (AR) |

# RNP APCH – APV – ESGP



# RNP APCH – APV – ESGP



# PBN – R965 (R1199)

- **Från specialtillämpningar till standardtillämpningar**
  - Ändrade OPS och FCL regler
    - Avsikten med de förändrade reglerna är att **minska den administrativa bördan för operatörer och myndigheter – med bibehållen säkerhetsnivå**
  - För att möjliggöra förändringen genomförs ändringar i flera olika EU/EASA regler
    - Certifikatregler (FCL) R1178 – krav på teoretisk och praktisk kunskap om PBN för alla med en instrumentbehörighet (IR)
      - Ändringsförordning **R2016/539** till **R1178/2011**
      - Baserat på NPA 2013-25
    - Flygdrift (OPS) – kraven på specialtillstånd (SPA) slopas för merparten av de PBN specifikationer som finns tillgängliga i dag
      - Ändringsförordning **R2016/1199** till **R965/2012**
      - Baserat NPA 2013-25



# PBN – R965 (R1199)

- Ändringsförfordning R1199 till R965
  - Gällande från den **25 augusti 2016**
  - **Nya/ändrade IR till Part DEF, ARO, CAT, SPA, NCC, NCO och SPO**
- EASA har publicerat AMC/GM till R1199
  - ED Decision 2016/014/R—2016/021/R
  - **Nya/ändrade AMC/GM till Part DEF, ARO, ORO, CAT, SPA, NCC, NCO och SPO**
- Motsvarande förändringar i ICAO Annex 6, Part I
  - Gällande från den **10 november 2016**

# PBN – R965 (R1199)

- Endast krav på tillstånd (Part SPA) för *Complex navigation specifications PBN operations*
- *Complex navigation specifications PBN operations*
  - SPA.PBN.100 PBN operations
  - (a) An approval is required for each of the following PBN specifications:
    - (1) RNP **AR** APCH; and
    - (2) RNP 0.3 for helicopter operation

# PBN – R965 (R1199)

- Tillstånd till *Complex navigation specifications PBN operations* ska framgå av Ops. Spec.

| Specific Approvals:  | Yes                      | No                       | Specification <sup>(9)</sup>                  | Remarks         |
|--|--------------------------|--------------------------|---|-----------------|
| Dangerous Goods  | <input type="checkbox"/> | <input type="checkbox"/> |   |                 |
| Low Visibility Operations  |                          |                          | CAT <sup>(10)</sup> ....                      |                 |
| Take-off   |                          |                          | RVR <sup>(11)</sup> : m                       |                 |
| Approach and Landing   | <input type="checkbox"/> | <input type="checkbox"/> | DA/H: ft RVR: m                               |                 |
| RVSM <sup>(12)</sup> <input type="checkbox"/> N/A                    | <input type="checkbox"/> | <input type="checkbox"/> |   |                 |
| ETOPS <sup>(13)</sup> <input type="checkbox"/> N/A                   | <input type="checkbox"/> | <input type="checkbox"/> | Maximum Diversion Time <sup>(14)</sup> : min. |                 |
| Complex navigation specifications for PBN operations <sup>(15)</sup> | <input type="checkbox"/> | <input type="checkbox"/> |   | <sup>(15)</sup> |
| Minimum navigation performance specification                         | <input type="checkbox"/> | <input type="checkbox"/> |   |                 |

# PBN – ICAO Annex 6 – Part I

- Motsvarande krav i ICAO Annex 6 Part I –
  - AR NAV spec. for PBN OPS ska framgå av Ops. Spec.

| SPECIFIC APPROVAL                               | YES                      | NO                       | DESCRIPTION <sup>9</sup>   | REMARKS |
|---|--------------------------|--------------------------|--|---------|
| Dangerous goods                                 | <input type="checkbox"/> | <input type="checkbox"/> |  |         |
| Low visibility operations                       |                          |                          |  |         |
| Approach and landing                            | <input type="checkbox"/> | <input type="checkbox"/> | CAT <sup>10</sup> : ____ RVR: ____ m DH: ____ ft   |         |
| Take-off  | <input type="checkbox"/> | <input type="checkbox"/> | RVR <sup>11</sup> : ____ m   |         |
| Operational credit(s)                           | <input type="checkbox"/> | <input type="checkbox"/> | <sup>12</sup>  |         |
| RVSM <sup>13</sup> <input type="checkbox"/> N/A | <input type="checkbox"/> | <input type="checkbox"/> |  |         |
| EDTO <sup>14</sup> <input type="checkbox"/> N/A | <input type="checkbox"/> | <input type="checkbox"/> | Threshold time <sup>15</sup> : ____ minutes<br>Maximum diversion time <sup>15</sup> : ____ minutes |         |
| AR navigation specifications for PBN operations | <input type="checkbox"/> | <input type="checkbox"/> | <sup>16</sup>  |         |

# PBN – Attachment

## ➤ PBN kompetenser i Attachment

|  |                                     |                                     |              |  |
|--|-------------------------------------|-------------------------------------|--------------|--|
| <b>Flight Crew</b><br>ATQPs  | <input type="checkbox"/>            | <input checked="" type="checkbox"/> | ORO.FC.A.245 |  |
| <b>Flight Crew</b><br>Procedures for flight crew to operate on more than one type or variant.  | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | ORO.FC.140   |  |
| <b>Flight Crew</b><br>Training and checking programmes, general                                | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | ORO.FC.145   |  |
| <b>Flight Crew</b><br>Training and checking programmes/competences, PBN Type: RNAV 5: A/C type | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | ORO.FC.145   |  |
| <b>Flight Crew</b><br>Training and checking programmes/competences, PBN Type: RNAV 1: A/C type | <input checked="" type="checkbox"/> | <input type="checkbox"/>            | ORO.FC.145   |  |

# PBN – R965 (R1199) – DEF/ARO

## ➤ Part DEF

- PBN relaterade definitioner till
  - IR (Annexes II to VIII)
  - AMC/GM (Definitions for terms used in AMC and GM)
- Förklaringar till nya PBN relaterade förkortningar och akronymer (Abbreviations and acronyms)

## ➤ Part ARO

- **New IR - ARO.OPS.240 Specific approval of RNP AR APCH**
- (a) When compliance with the requirements in SPA.PBN.105 has been demonstrated by the applicant, the competent authority **shall grant a generic specific approval or a procedure-specific approval for RNP AR APCH.**

# PBN – R965 (R1199) – ORO

## ➤ Part ORO

### ➤ New AMC – AMC2 ORO.GEN.160 Occurrence reporting **REPORTABLE EVENTS OF PBN OPERATIONS**

- (a) A reportable event should be an event that adversely affects the safety of the operation.....
- (b) Technical defects and the exceedance of technical limitations.....
- (c) The operator should have in place a system for investigating a reportable event.....

# PBN – R965 (R1199) – ORO

## ➤ Part ORO forts.

### ➤ Subpart FC — Flight crew – SECTION II — ADDITIONAL REQUIREMENTS FOR **CAT** OPERATIONS

- Amended – AMC1 ORO.FC.230 Recurrent training and checking
- (1) **OPC** – (i) Aeroplanes – Where applicable, operator proficiency checks should include the following manoeuvres as pilot flying:
  - (A) rejected take-off....
  - (B) take-off with engine failure between V1 and V2....
  - (C) ~~precision-instrument~~ **3D approach operation to minima** with, in the case of multi-engine aeroplanes, one-engine-inoperative;
  - (D) ~~non-precision~~ **2D approach operation to minima**;
  - (E) at least one of the 3D or 2D approach operations should be an RNP APCH or RNP AR APCH operation;
  - (F) missed approach on instruments from minima with.....
  - (G) landing with one-engine-inoperative.....



# PBN – R965 (R1199) – CAT

## ➤ Part CAT (OP)

### ➤ New IR

### ➤ CAT.OP.MPA.126 Performance-based navigation

- The operator shall ensure that, when performance-based navigation (PBN) is required for the route or procedure to be flown:
  - (a) the relevant PBN navigation specification is stated in the **AFM** or other document that has been approved by the **certifying authority** as part of an airworthiness assessment or is based on such approval; and
  - (b) the aircraft is operated in conformance with the relevant navigation specification and limitations in the **AFM** or other document referred above.

# PBN – R965 (R1199) – CAT

## ➤ Part CAT (OP) forts.

### ➤ New AMC

### ➤ **AMC1—7 CAT.OP.MPA.126 Performance-based navigation**

- PBN OPERATIONS
- MONITORING AND VERIFICATION
- MANAGEMENT OF THE NAVIGATION DATABASE
- DISPLAYS AND AUTOMATION
- VECTORING AND POSITIONING
- ALERTING AND ABORT
- CONTINGENCY PROCEDURES

# PBN – R965 (R1199) – CAT

## ➤ Part CAT (OP) forts.

### ➤ Amended IR

- CAT.OP.MPA.135 Routes and areas of operation — general
- CAT.OP.MPA.175 Flight preparation

### ➤ New AMC

- AMC1 CAT.OP.MPA.135 Routes and areas of operation — general
  - RNAV 10
- AMC1–2 CAT.OP.MPA.175 Flight preparation
  - FLIGHT PREPARATION FOR PBN OPERATIONS
  - DATABASE SUITABILITY

# PBN – R965 (R1199) – CAT

## ➤ Part CAT (OP) forts.

- **New IR – CAT.OP.MPA.182 Destination aerodromes — instrument approach operations**

- The operator shall ensure that sufficient means are available to navigate and land at the destination aerodrome or at any destination alternate aerodrome in the case of loss of capability for the intended approach and landing operation.

- **New AMC – AMC1 CAT.OP.MPA.182 Destination aerodromes — instrument approach operations**

### PBN OPERATIONS

- The pilot-in-command should only select an aerodrome as a destination alternate aerodrome if an instrument approach procedure **that does not rely on GNSS is available** either at that aerodrome or at the destination aerodrome.

- **New GM – GM1 CAT.OP.MPA.182 Destination aerodromes — instrument approach operations**

### INTENT OF AMC1

# PBN – R965 (R1199) – CAT

## ➤ Part CAT (IDE)

### ➤ Amended IR

### ➤ CAT.IDE.A.345 Communication and navigation equipment for operations under IFR or under VFR over routes not navigated by reference to visual landmarks

#### ➤ CAT.IDE.A.345 – Point (f) is added:

- (f) For PBN operations the aircraft shall meet the airworthiness certification requirements for the appropriate navigation specification.

### ➤ New GM

### ➤ GM2—3 CAT.IDE.A.345

- AIRCRAFT ELIGIBILITY FOR PBN SPECIFICATION NOT REQUIRING SPECIFIC APPROVAL

### ➤ Det är här man finner vägledning om/hur NAV utrustningen uppfyller kraven för en viss PBN NAV Spec.

# PBN – R965 (R1199) – CAT

- **GM2 CAT.IDE.A.345**
- Ex. AIRCRAFT ELIGIBILITY FOR PBN SPECIFICATION NOT REQUIRING SPECIFIC APPROVAL:
  - **(j) RNP APCH — LNAV minima**
  - (1) If a statement of compliance with any of the following specifications or standards is found in the acceptable documentation as listed above, the aircraft is eligible for RNP APCH — LNAV operations.
    - (i) A-RNP;
    - (ii) AMC 20-27;
    - (iii) AMC 20-28;
    - (iv) FAA AC 20-138 for the appropriate navigation specification; and
    - (v) FAA AC 90-105 for the appropriate navigation specification.
    - (2) Alternatively, if .....

# PBN – R965 (R1199) – SPA

## ➤ Part SPA

- Replacement of IR – SPA.PBN.100 PBN is replaced by the following:
  - (a) An approval is required for each of the following PBN specifications:
    - **(1) RNP AR APCH; and**
    - **(2) RNP 0.3 for helicopter operation.**
  - (b).....

# PBN – R965 (R1199) – SPA

## ➤ New GM – GM1 SPA.PBN.100 PBN operations

| Navigation specification | FLIGHT PHASE |             |         |          |              |         |        |           |
|--------------------------|--------------|-------------|---------|----------|--------------|---------|--------|-----------|
|                          | En route     |             | Arrival | Approach |              |         |        | Departure |
|                          | Oceanic      | Continental |         | Initial  | Intermediate | Final   | Missed |           |
| RNAV 10                  | 10           |             |         |          |              |         |        |           |
| RNAV 5                   |              | 5           | 5       |          |              |         |        |           |
| RNAV 2                   |              | 2           | 2       |          |              |         |        | 2         |
| RNAV 1                   |              | 1           | 1       | 1        | 1            |         | 1      | 1         |
| RNP 4                    | 4            |             |         |          |              |         |        |           |
| RNP 2                    | 2            | 2           |         |          |              |         |        |           |
| RNP 1                    |              |             | 1       | 1        | 1            |         | 1      | 1         |
| A-RNP                    | 2            | 2 or 1      | 1-0.3   | 1-0.3    | 1-0.3        | 0.3     | 1-0.3  | 1-0.3     |
| RNP APCH (LNAV)          |              |             |         | 1        | 1            | 0.3     | 1      |           |
| RNP APCH (LNAV/VNAV)     |              |             |         | 1        | 1            | 0.3     | 1      |           |
| RNP APCH (LP)            |              |             |         | 1        | 1            |         | 1      |           |
| RNP APCH (LPV)           |              |             |         | 1        | 1            |         | 1      |           |
| RNP AR APCH              |              |             |         | 1-0.1    | 1-0.1        | 0.3-0.1 | 1-0.1  |           |
| RNP 0.3 (H)              |              | 0.3         | 0.3     | 0.3      | 0.3          |         | 0.3    | 0.3       |

Numbers specify the accuracy level



no specific approval required



specific approval required



# PBN – R965 (R1199) – SPA

## ➤ Part SPA forts.

### ➤ Replacement of IR

### ➤ SPA.PBN.105 PBN is replaced by the following:

- To obtain a PBN specific approval from the competent authority, the operator shall provide evidence that:
  - (a) the relevant airworthiness approval.....
  - (b) a training programme.....
  - (c) a safety assessment.....
  - (d) operating procedures have been established .....
  - (e) a list of reportable events has been specified.....
  - (f) a management RNP monitoring programme has been established .....

# PBN – R965 (R1199) – SPA

- **Part SPA forts.**
- **New AMC – SPA.PBN.105**
  - FLIGHT CREW TRAINING AND QUALIFICATIONS — GENERAL PROVISIONS
  - FLIGHT OPERATIONAL SAFETY ASSESSMENT (FOSA)
  - OPERATIONAL CONSIDERATIONS FOR RNP AR APCH
  - FLIGHT CONSIDERATIONS
  - NAVIGATION DATABASE MANAGEMENT
  - REPORTABLE EVENTS
  - RNP MONITORING PROGRAMME

# PBN – R965 (R1199) – Sammanfattning

- **Sammanfattning – PBN regler**
  - **CAT OP – IR/AMC/GM**
    - CAT.OP.MPA.126 Performance-based navigation
    - CAT.OP.MPA.135 Routes and areas of operation — general
    - CAT.OP.MPA.175 Flight preparation
    - CAT.OP.MPA.182 Destination aerodromes — instrument approach operations
  - **CAT IDE – IR/AMC/GM**
    - CAT.IDE.A.345 Communication and navigation equipment for operations under IFR or under VFR over routes not navigated by reference to visual landmarks
  - **SPA PBN – IR/AMC/GM**
    - RNP AR APCH

# PBN – R965 (R1199) – Sammanfattning

- **Urusta flygplanen med något av systemen för RNP APCH!**
  - GNSS + Baro-VNAV (LNAV/VNAV minima)
  - GNSS + SBAS (LPV minima)
  - GNSS (LNAV minima)
- **Beskriv förutsättningarna för aktuella PBN kompetenser i handbokssystemet (OM)**
  - Allmänna förutsättningar OM-A (kapitel 8)
  - Typspecifika förutsättningar OM-B
  - Navigering och procedurer OM-C
  - Utbildning/träning OM-D

- SLUT -

**Frågor ?**

Jan Thell

jan.thell@transportstyrelsen.se

+46 767 21 11 44