PBN procedure operational impact, training and operator OPS approval

Dakar, March 27, 2014

AIRBUS
PRO SKY

Presented by
Céline BAILLARD – Head of Safety Programs

Agenda

- PBN operational benefits
- Airbus Safety initiatives
- Application from pilot’s perspective
- PBN operational approval

Agenda

- PBN operational benefits
- Airbus Safety initiatives
- Application from pilot’s perspective
- PBN operational approval

Performance Based Navigation is a Safety Enabler

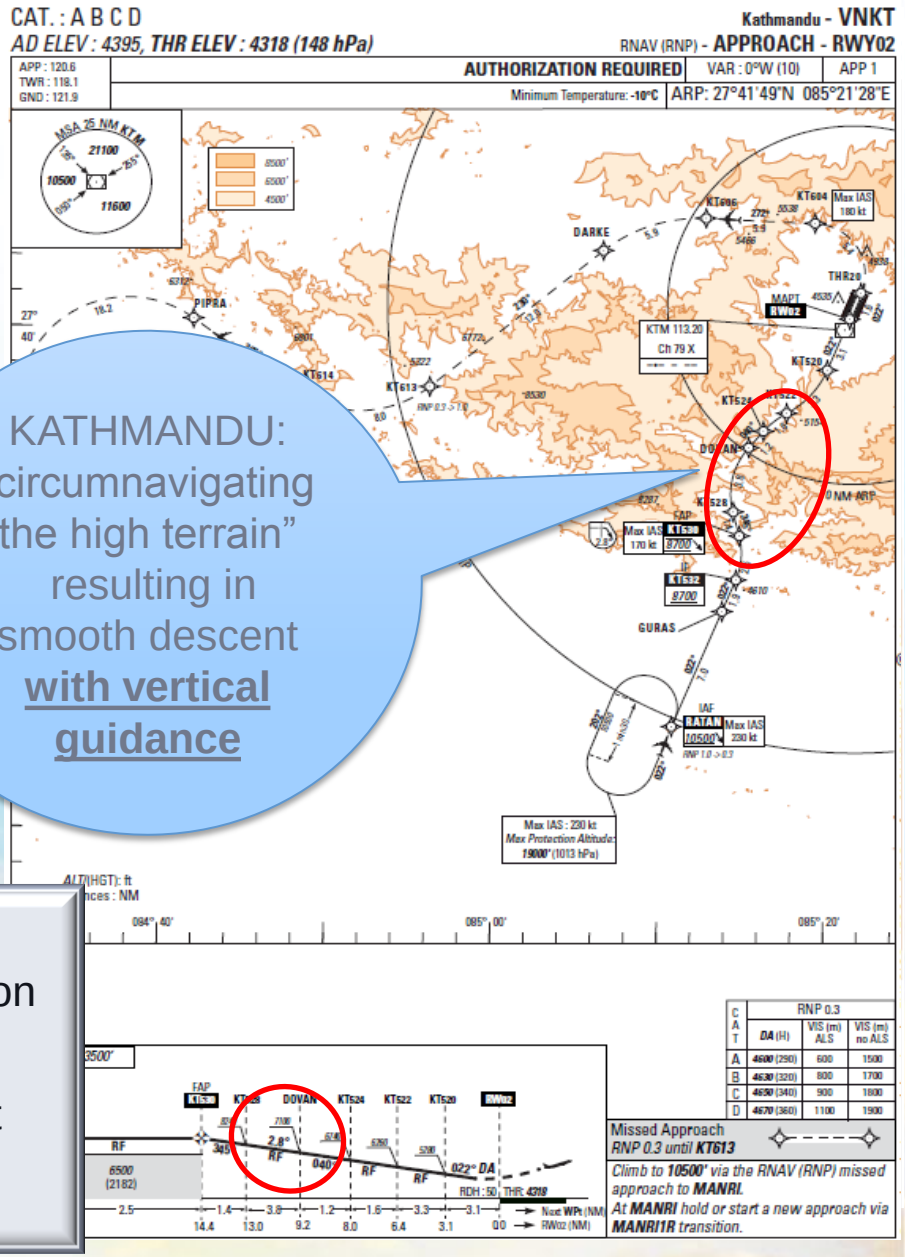
- ICAO Resolution A36-23, 36th Session, September 2007, urges States to implement :
  - Performance-Based Navigation (PBN)
  - Approaches with Vertical Guidance (APV)

"ICAO controlled flight into terrain (CFIT) studies have shown that runway-aligned approaches (LNAV only) are 25 times safer than circling approaches, and that once some form of vertical guidance is added to approaches the safety margin is increased again by a factor of 8" [1]

[1] Working Paper A37-WP/138, *Performance-based navigation – the implementation challenge*

PBN reduces the risk of unstabilized approaches and CFIT

KATHMANDU: "circumnavigating the high terrain" resulting in smooth descent **with vertical guidance**

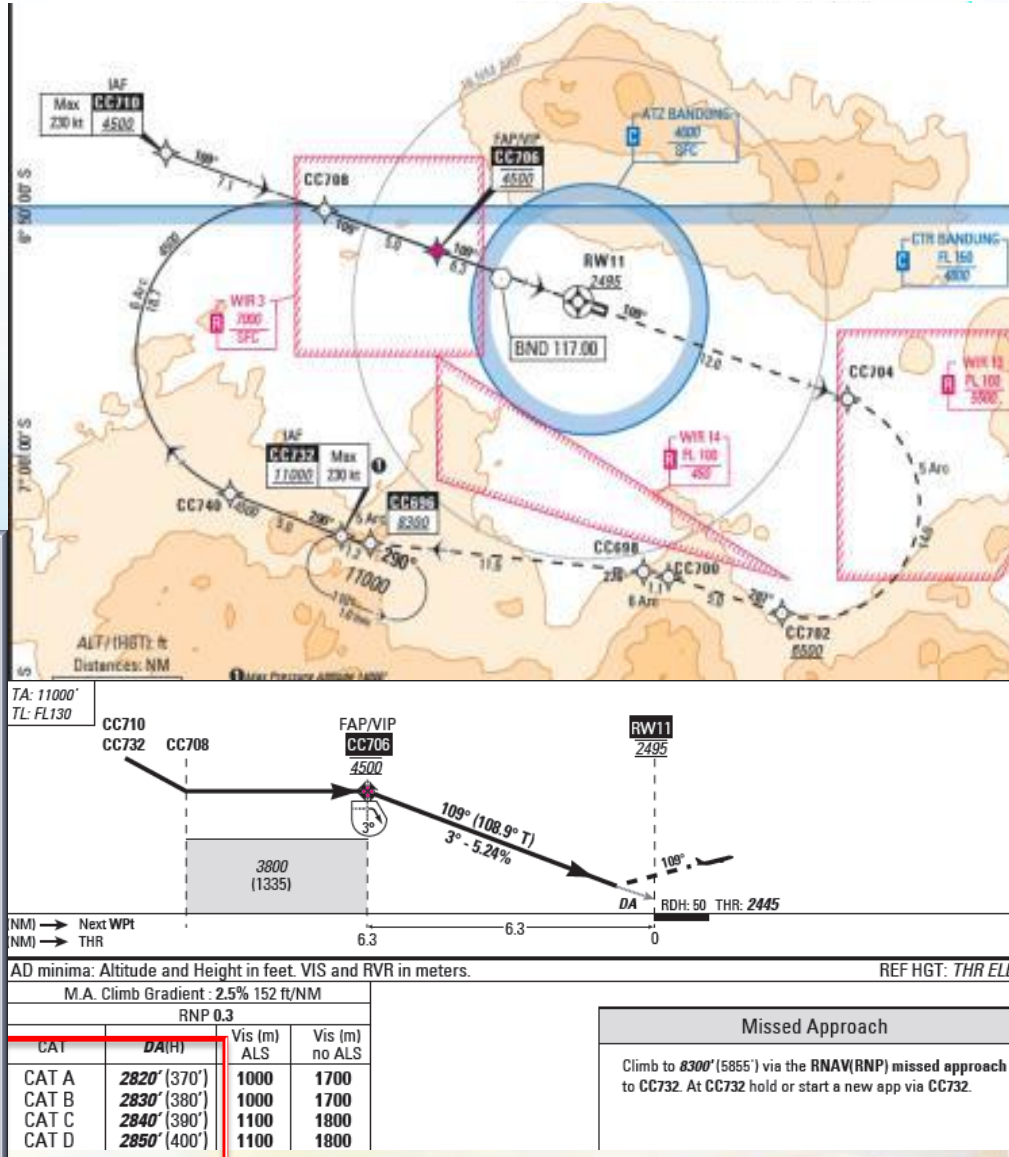


- Fully Managed Approach and Missed Approach
- Smooth and constant descent down to a Decision Altitude, for approaches with Vertical Guidance
- Lower minima : decision altitude as low as 250ft
- Less flight crew and ATC workload

Removal of visual and circle-to-land procedures

- **Drawbacks of Circling:**
  - Challenging flying procedure in marginal visual conditions
  - “Disliked” by most pilots
  - Identified as a major cause of several fatal accidents
  - Needs specific training

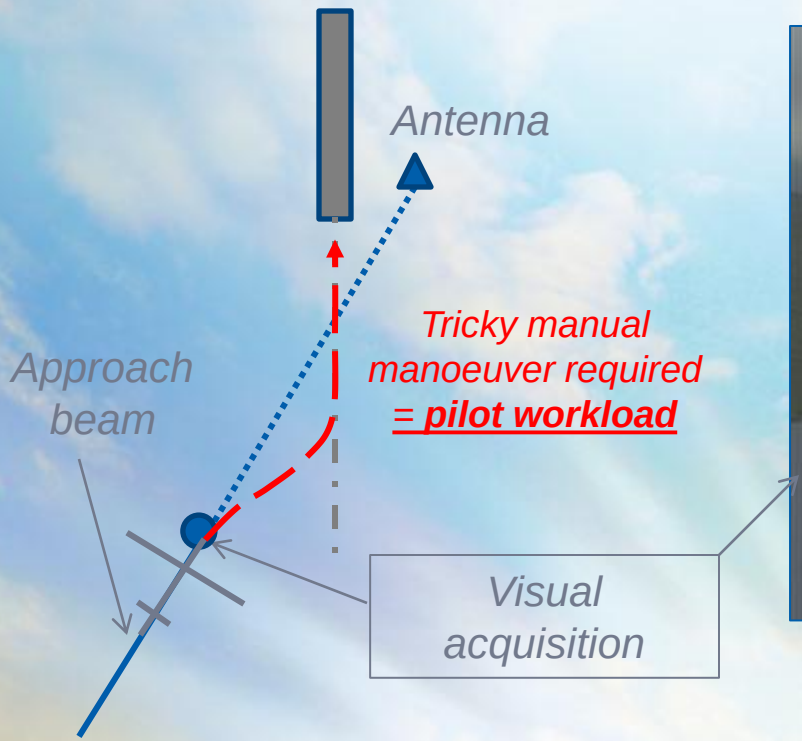
- Removal of circling and visual procedures **without need for additional ground infrastructure**
- Reduction of tailwind landings on short runways to avoid the circling
- Might require flexibility in terms of trajectories (curved path) depending on surrounding terrain



Replacement of offset procedures

Conventional LOC/DME approach: offset by over 12°

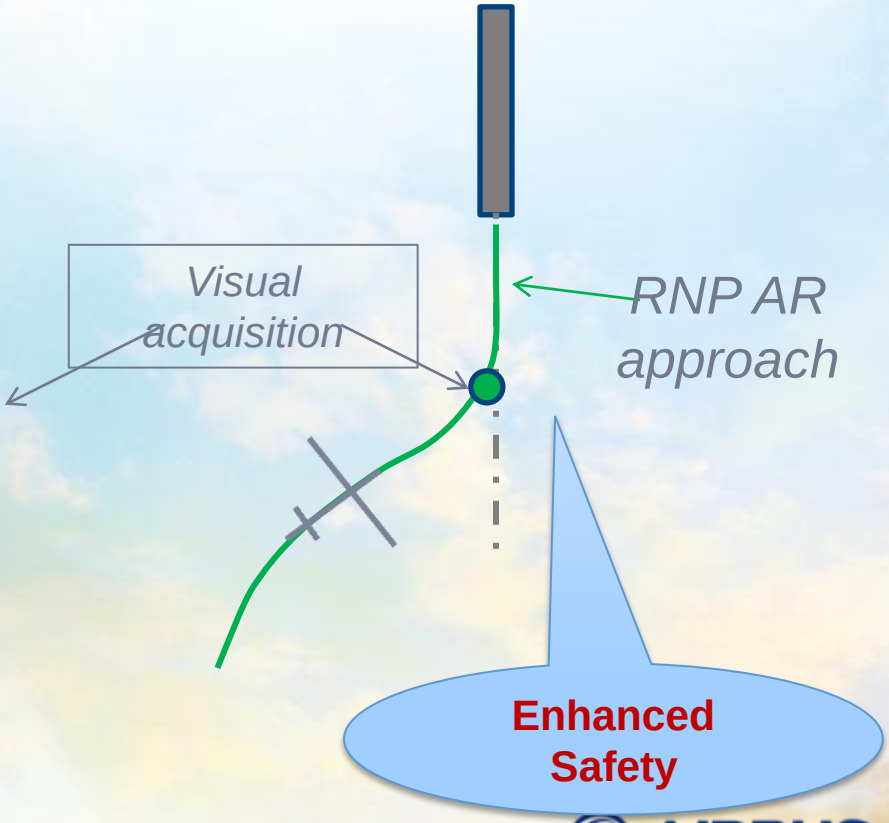
- Conventional approaches not aligned with runway center line
- Strong crosswinds conditions
- In poor weather conditions, runway reference visual acquisition difficult for pilots



Replacement of offset procedures

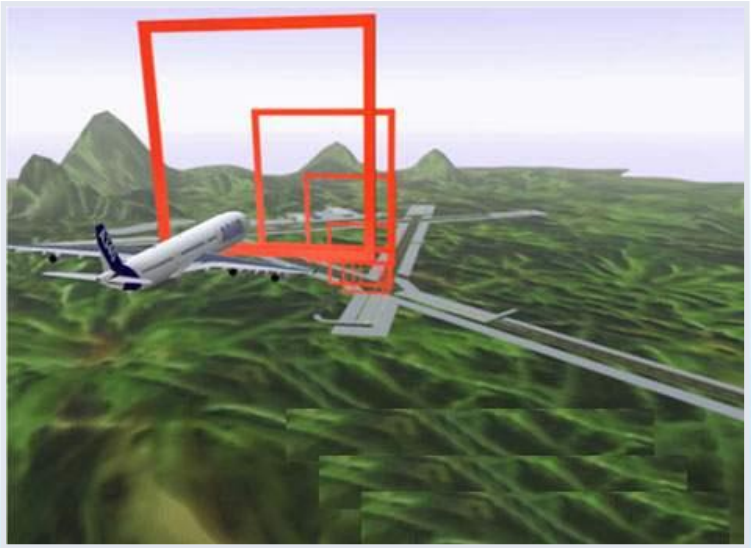
RNP AR curved paths : aircraft aligned with runway on short final

➢In poor weather conditions, runway reference visual acquisition easier for pilots



PBN Safety benefits

- Fully managed trajectories, laterally and vertically
- Stabilized approaches with smooth and constant descent slope
  - ✓ Unstabilized approaches are a major contributor in runway excursions (40%)
- Alignment with the runway axis
- Reduced crew and ATC workload
- Allowing replacement of existing circle to land and visual procedures



Agenda

- PBN operational benefits
- Airbus Safety initiatives
- Application from pilot’s perspective
- PBN operational approval

Airbus Safety Initiative for PBN implementation

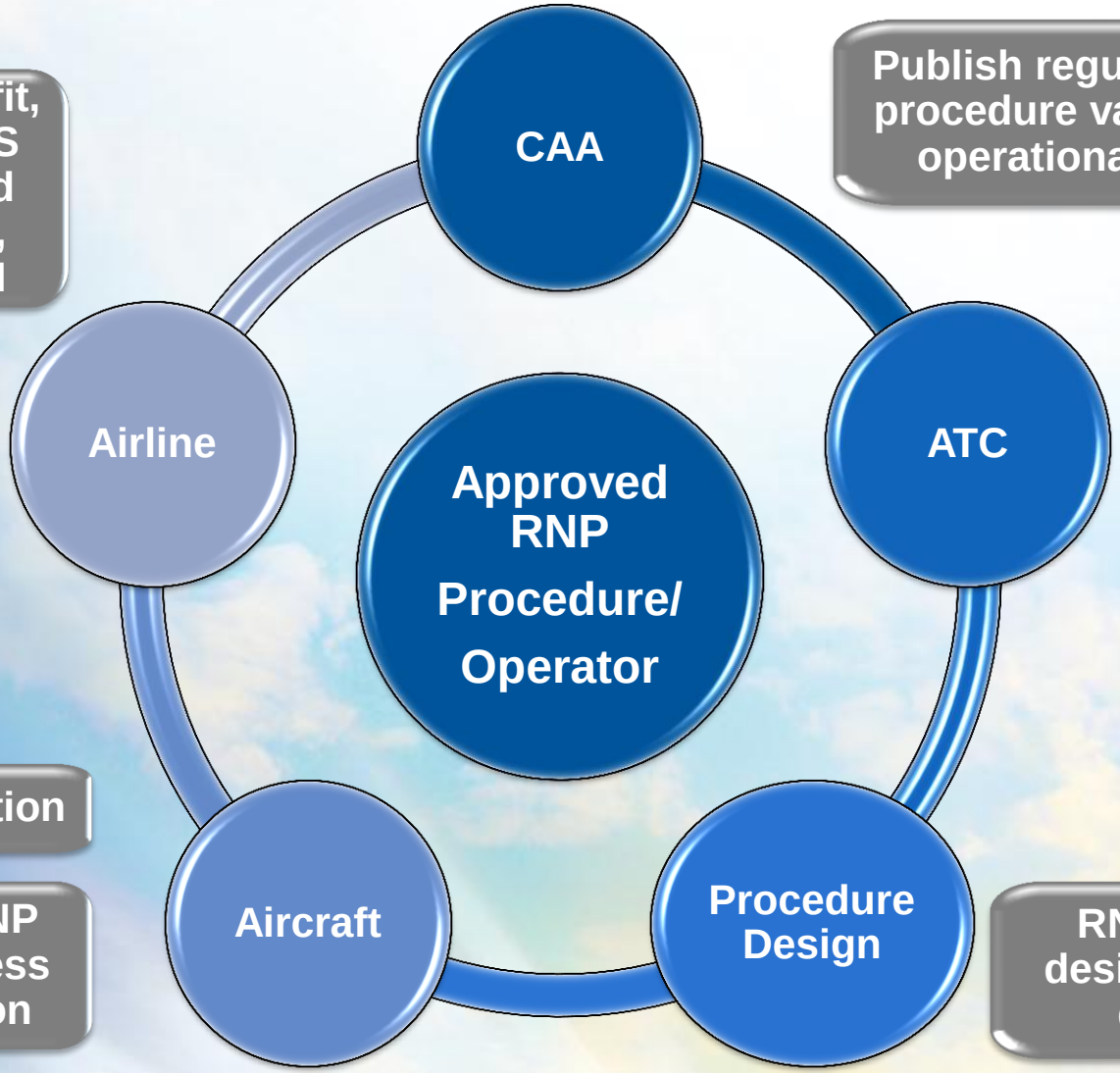
- Airbus promotes and actively supports the implementation of safe and efficient PBN operations worldwide
- Airbus safety initiative launched for the replacement of circle-to-land procedures by fully managed PBN procedures

PBN Approaches Deployment

In Aug. 2011, Airbus launched a worldwide program to support PBN implementation with a focus on **« RNP to replace Circle-to-Land »** Program

Airbus' intend is to have both a **"Train the Trainer" and regional approach** and to cooperate with local Authorities and airlines in order to facilitate the PBN deployment

Our approach : « Train the trainer »
Sharing “know-how” capabilities and best practices



Publish regulations, RNP procedure validation and operational approval

Airspace planning, air traffic control

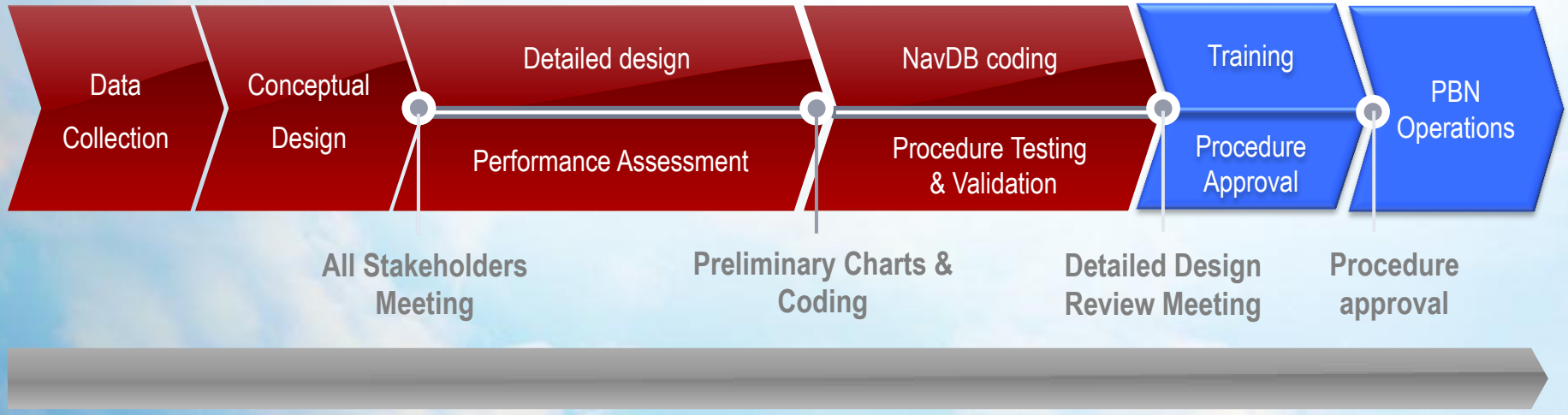
RNP procedure design and related documents

Aircraft RNP airworthiness certification

Documentation

Aircraft retrofit, training, OPS manuals and procedures, update FDM

Methodology is key



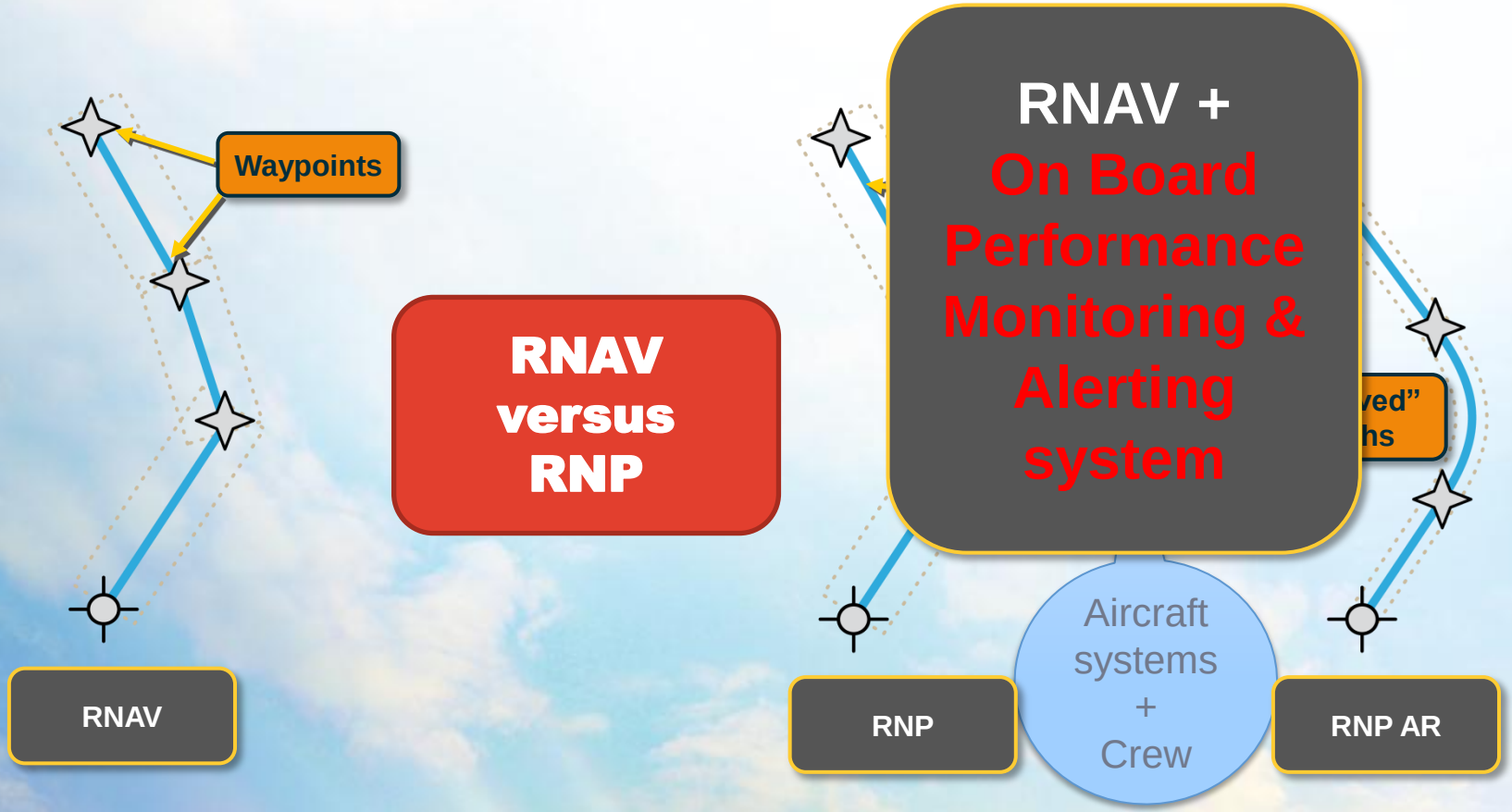
Including training for :

- Data surveyors and procedure designers
- Flight inspectors
- Air Traffic Controllers
- Dispatchers and flight crews

Agenda

- PBN operational benefits
- Airbus Safety initiatives
- Application from pilot’s perspective
- PBN operational approval

From RNAV to RNP



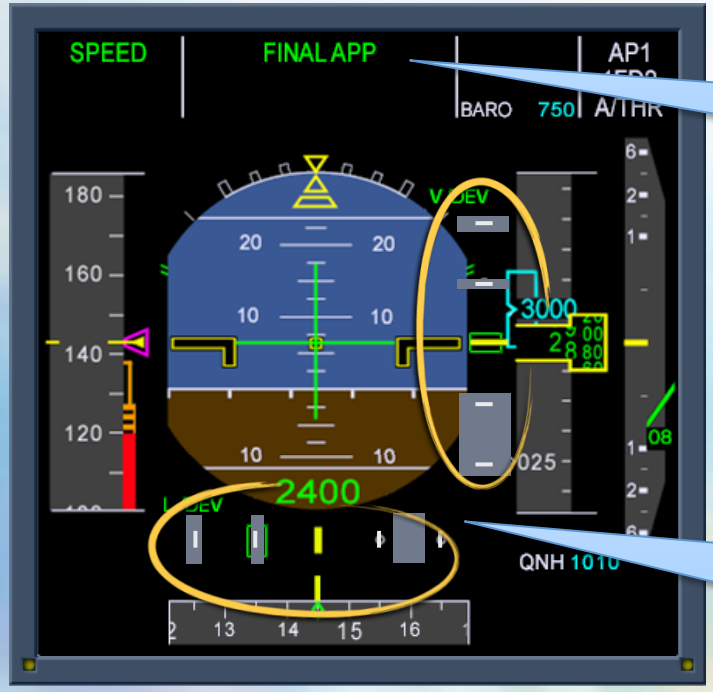
- **ON BOARD MONITORING AND ALERTING (OBPMA)**
  - **Monitoring**: aircraft system ability to determine and display to the flight crew the positioning error and deviation from the desired path
  - **Alerting**: capability of the aircraft systems to alert the crew in case of RNP capability loss

PBN – Crew involvement

PBN - Parameters to be monitored

PBN – Trajectory Control

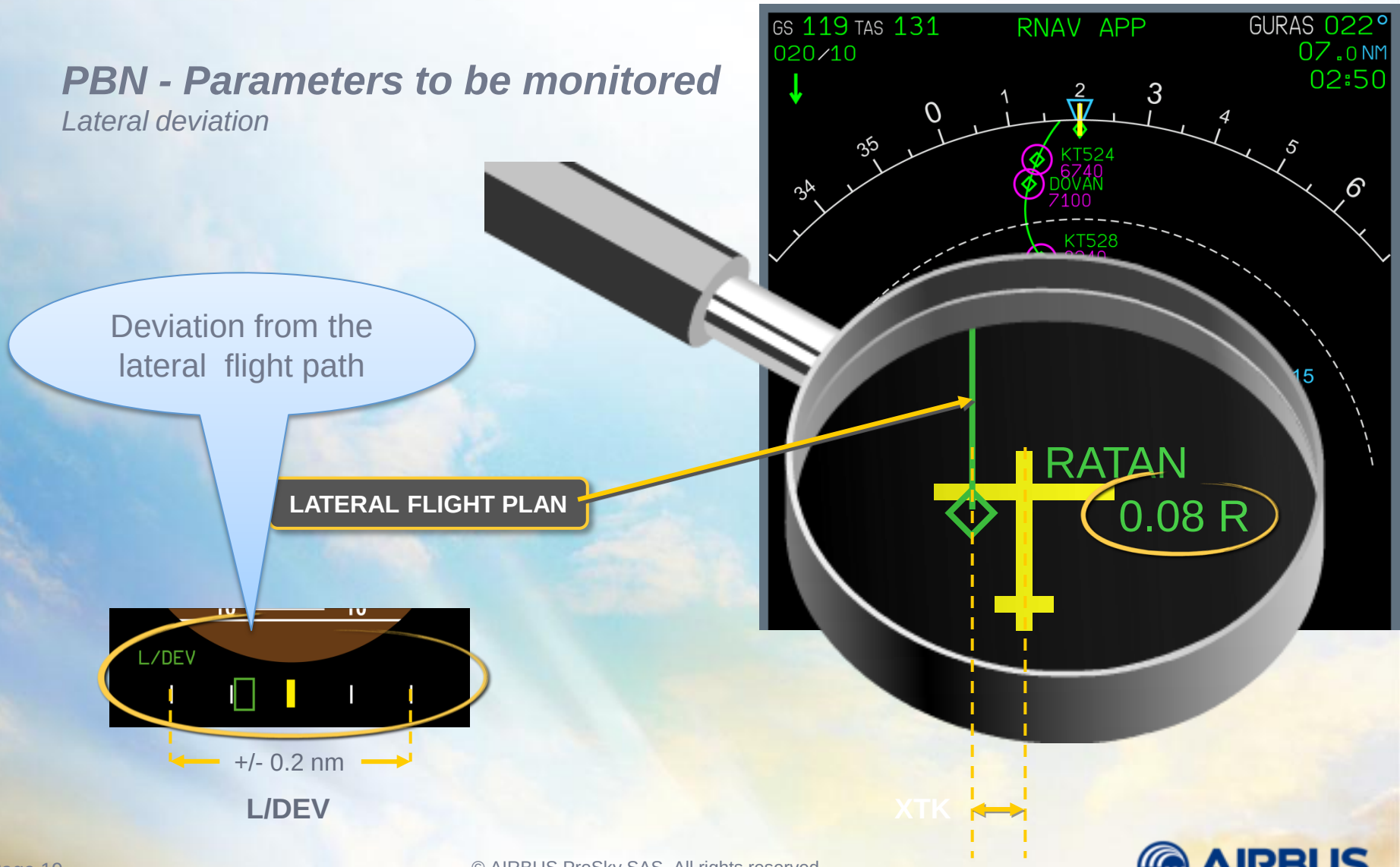
Main parameters controlled and monitored by the Flight Crew



Auto pilot mode for NPA lateral and vertical guidance.

It is the responsibility of the Crew to keep LDEV & VDEV inside the operational limits

PBN - Parameters to be monitored

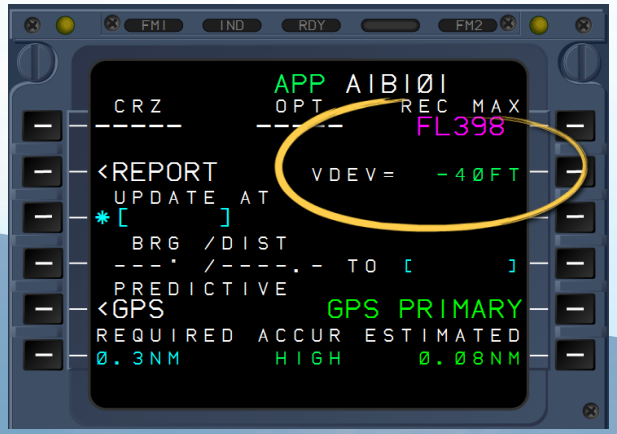


PBN - Parameters to be monitored

PBN - Parameters to be monitored

Vertical deviation

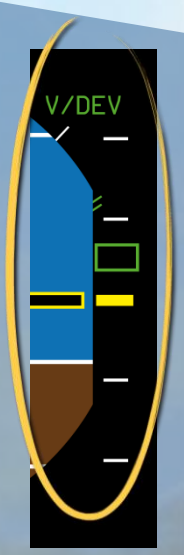
Deviation from the vertical flight path



VERTICAL FLIGHT PLAN

INDICATED VERTICAL DEVIATION

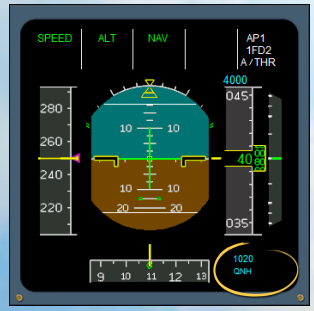
V/DEV



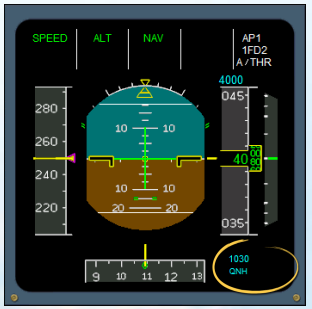
PBN - Parameters to be monitored

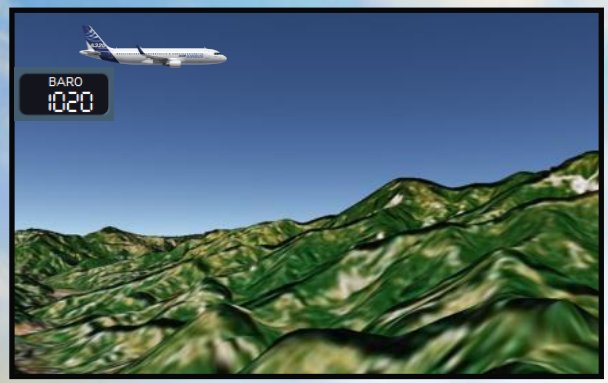
PBN - Parameters to be monitored

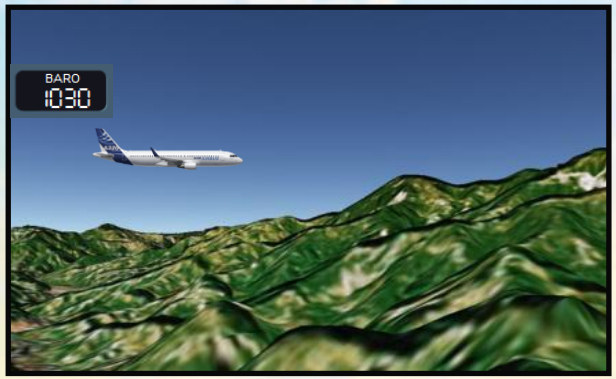
Altimeter setting



The correct Altimeter Setting is ONLY crew monitored





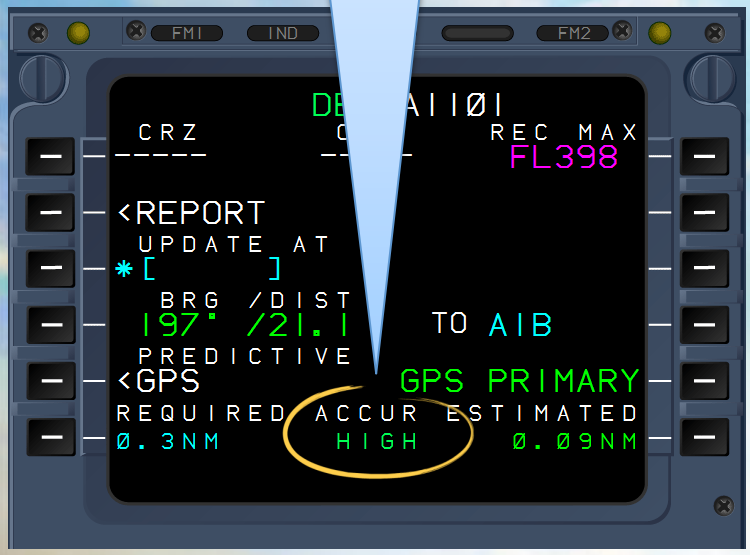


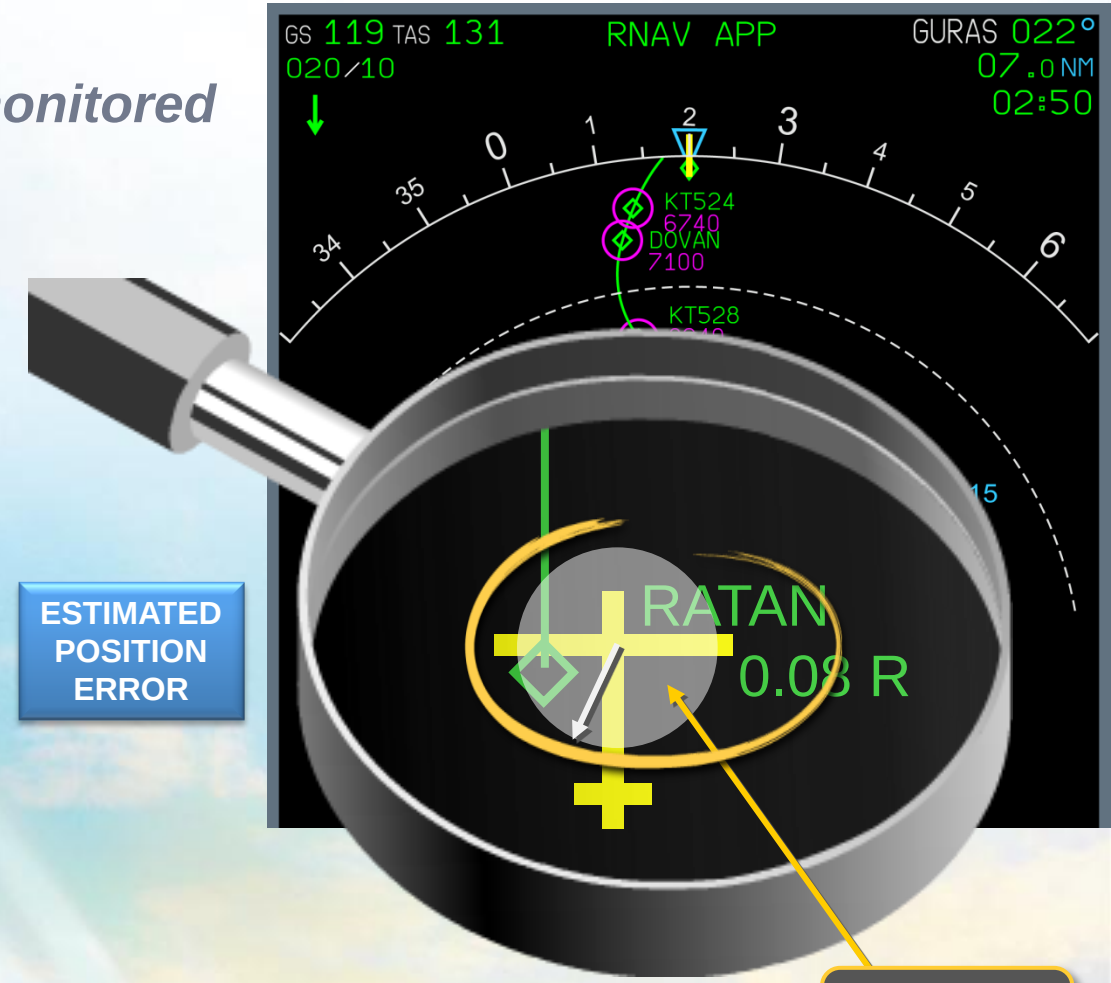
PBN - Parameters to be monitored

PBN - Parameters to be monitored

Navigation system

Accuracy level of the navigation system





ESTIMATED POSITION ERROR

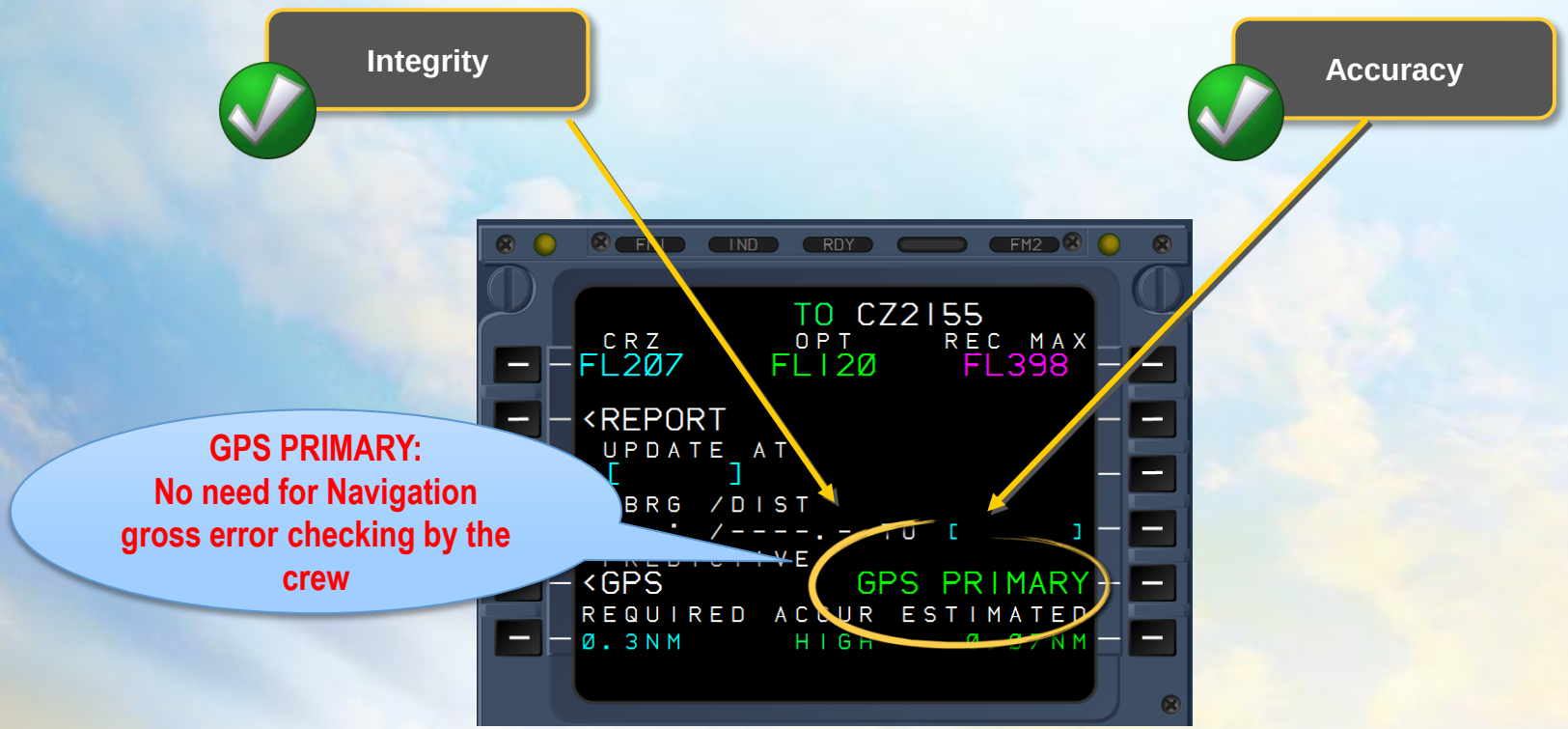
ESTIMATED POSITION

PBN – Indicating and Alerting

PBN – Indicating and Alerting

Indication of navigation system status in-flight

Combined checking of system accuracy and integrity results in message GPS PRIMARY



PBN – Indicating and Alerting

PBN – Indicating and Alerting

Alerts of the Navigation system

GPS PRIMARY LOST means “UNABLE RNP”

GPS PRIMARY LOST on ND (not clearable)

GPS PRIMARY LOST
message in MCDU scratchpad

Aural triple click during
a non-precision approach

Agenda

- PBN operational benefits
- Airbus Safety initiatives
- Application from pilot’s perspective
- PBN operational approval

RNP APCH Regulation

- ICAO PBN manual doc 9613, 4th edition
  - Navigation specification RNP APCH, Chapter 5
- ICAO PBN Operational Approval manual doc 9997
  - RNP APCH §4.6
- USA, FAA AC 90-105
  - RNP approach or RNAV(GPS)
- Europe, EASA AMC 20-27
  - RNP APCH operations including APV BARO-VNAV

No need to update AMC 20-27 or AC 90-105 after the release of ICAO PBN Manual 4th edition

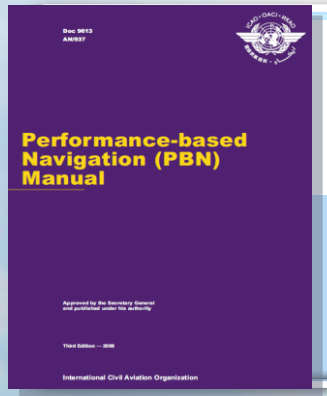
Operational Approval

RNP APCH
OPS Approval

- A/C qualification
- NDB validation
- RAIM predictions
- Operation manual, procedures and Checklist
- MEL
- Training program

RNP APCH
OPS Approval

- A/C qualification
- NDB validation
- RAIM predictions
- Operation manual, procedures and Checklist
- MEL
- Training program



Chapter 5

IMPLEMENTING RNP APCH

PBN

RNP APCH

Link with existing

RNAV (GNSS)

Related documents :

FAA AC90-105 and AC20-130A (for LNAV only)

EASA AMC 20-27

Airbus documentation : AFM

AIRBUS

A319
AIRPLANE FLIGHT MANUAL

LIMITATIONS

AUTO FLIGHT SYSTEM

FLIGHT MANAGEMENT SYSTEM

LIM-22-FMS

AIRWORTHINESS STANDARDS COMPLIANCE

1 Ident.: **TDU / LIM-22-FMS-00014048.0001001 / 14 DEC 12** **EASA APPROVED**
Criteria: (SA and (25205 or 26111 or 26485 or 26999 or 28382 or 30241 or 30631 or 30635))
Impacted DU: NONE
Impacted by TR165 Issue 1.0

The FMGS complies with the airworthiness part of the AMC 20-27 for RNP APPROACH (RNP APCH) Operations with or without APV BARO-VNAV Operations.

Note:
1. *RNP APCH without APV BARO-VNAV operation corresponds to RNAV(GNSS) approach with LNAV Minimum.*
2. *RNP APCH with APV BARO-VNAV operation corresponds to RNAV(GNSS) approach with LNAV/VNAV Minimum.*

Compliance to AMC 20-27 for RNAV(GNSS) approaches with or without APV BARO-VNAV since January 2013

Airbus documentation : AFM

AIRBUS A319 AIRPLANE FLIGHT MANUAL	LIMITATIONS AUTO FLIGHT SYSTEM FLIGHT MANAGEMENT SYSTEM	LIM-22-FMS

AIRWORTHINESS STANDARDS COMPLIANCE

The FMGS 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 aircraft position based on:

- IRS position and radio navaid update, or
- IRS position only.

The FMGS 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 90-100A for terminal and en route RNAV operations
- FAA Order 8400.12A for RNP 10 in oceanic and remote area.
  RNP 10 oceanic/remote area operations are approved provided time limitations in IRS only navigation, acceptable to the operational authorities, are established.

Airbus documentation : AFM

AIRBUS

A319
AIRPLANE FLIGHT MANUAL

LIMITATIONS

AUTO FLIGHT SYSTEM

FLIGHT MANAGEMENT SYSTEM

LIM-22-FMS

NAVIGATION PERFORMANCE

- **With GPS PRIMARY:**
  The FMGS is certified in accordance with the performance requirements of MASPS ED-75/DO-236 for RNP RNAV operations.
  The RNP accuracy with GPS PRIMARY has been demonstrated to be :

	With AP ON in NAV	With AP OFF and FD ON in NAV	With AP OFF and FD OFF
En Route	1 nm	1 nm	1.1 nm
In Terminal Area	0.5 nm	0.51 nm	0.51 nm
In Approach	0.3 nm	0.3 nm	Not authorized

AFM statements for RNAV(GNSS) approaches to support RNP APCH

AIRBUS PROSKY

Aircraft equipment

	RNP APCH
Capability	GPSSU & MMR capable Dual FMS configuration FMS1 and FMS2 capable Only FMS2 capable of RF legs
Documentation AFM/FCOM	**For LNAV only :** All A/C compliant with AC20-130A **For APV BARO/VNAV** : All A/C equipped with FMS2 compliant to AMC20-27 stated in AFM

GPS roughly from MSN 1995 but as an option on A320 family at the beginning
On A300/A310 GPS MOD certified in 95, first retrofit in 96

FMS2 certified in 2003 on SA et LR
Last Legacy on A320 family : MSN2252 (delivered in 2004)
Last Legacy on A330/A340 aircraft : MSN554 (delivered in 2003)

RNP APCH OPS Approval

- A/C qualification
- NDB validation
- RAIM prediction
- Operation manual, procedures and Checklist
- MEL
- Training program

Requirements for RNP APCH operations

5.3.6 Navigation database

5.3.6.1 The navigation database should be obtained from a supplier that complies with RTCA DO 200A/EUROCAE document ED 76, Standards for Processing Aeronautical Data. An LOA issued by the appropriate regulatory authority demonstrates compliance with this requirement (e.g. FAA LOA issued in accordance with FAA AC 20-153 or EASA LOA issued in accordance with EASA Opinion Nr. 01/2005.

5.3.6.2 Discrepancies that invalidate a procedure must be reported to the navigation database supplier and affected procedures must be prohibited by an operator's notice to its pilots.

5.3.6.3 Aircraft operators should consider the need to conduct ongoing checks of the operational navigation databases in order to meet existing quality system requirements.

ICAO Doc 9613 extract – RNP APCH

4.6.9.1 RNP APCH operations are critically dependent on valid data
4.6.9.3 It should be noted that despite the requirement for the database supplier to comply with RTCA DO200A/EUROCAE ED 76, data errors will still occur

ICAO Doc 9997 Extract – RNP APCH

Navigation database validation

CGx AERO in SYS, all rights reserved

Generation date

Used template

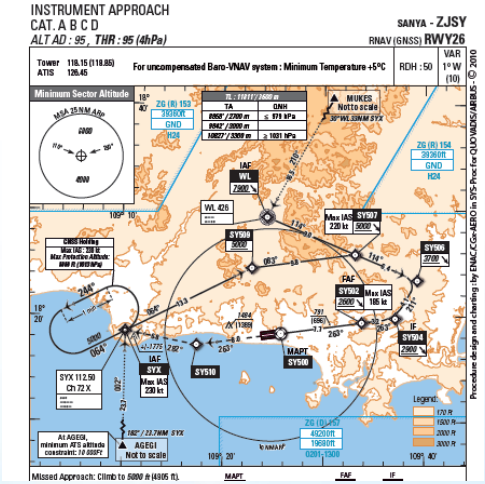
7.PROC_IAP_RNV09A

ADHP ICAO Code	ZU
ADHP ICAO Identifier	ZULS
Type	IAP
Nav. Type	R
Category	UKN
Designator	RNV09A

Seq N°	PT	W/P ID	OverFly	Fix role	TD	RMD VHF	THETA (°) magnetic	RHO Val	RHO uom	CRS Val (°)	CRS Type	TIME val	TIME uom	DIST val	DIST uom	ALT DESC	ALT
10	IF	LX900		IAF												+	21600.0
20	TF	LX440	N							275.006	TT			3.485	NM	+	16200.0
30	TF	LX424	N							274.789	TT			25.017	NM		
40	TF	LX422	N							274.651	TT			10.263	NM		
50	RF	LX418			R		275.839			290.642	TT			4.000	NM		
60	RF	LX414			R		291.642			308.755	TT			4.583	NM		
70	RF	LX811		IF	L		309.756			268.741	TT			1.606	NM	@	16200.0
80	RF	LX808			L		269.741			254.730	TT			3.668	NM	+	15110.0
90	RF	LX806			L		255.730			154.717	TT			3.675	NM	+	14020.0
10	IF	LX450		IAF												+	21600.0
20	TF	LX444	N							236.650	TT			17.500	NM	+	20000.0
30	RF	LX440			R		237.650			274.913	TT			6.678	NM	+	16200.0
40	TF	LX424	N							274.789	TT			25.017	NM		

1.Aerodromes | 2.Runways | 3.Runway Directions | 4.Navaids | 5.ILS | 6.Waypoints | 7.PROC_IAP_RNV27A

OR



Coding Table

AIP chart

to check with NDB Data

And

Navigation database validation

At each AIRAC cycle, comparison of the new cycle with the “Golden database “ and with the previous cycle

RNP APCH
OPS Approval

- Introduction + Ref Doc
- A/C qualification
- NDB validation
- RAIM prediction
- Operation manual, procedures and Checklist
- MEL
- Training program

Requirements for RNP APCH operations

EASA - AMC 20-27
Appendix 4

1.1 Preflight Planning.

f) For those GNSS systems relying on RAIM, its availability 15 min before Estimated Time of Arrival (ETA) until 15 min after ETA should be verified during the preflight planning. In the event of a predicted continuous loss of fault detection of more than five (5) minutes, the flight planning should be revised (e.g. delaying the departure or planning a different approach procedure).
Note 1: For certain systems, prediction is not systematic but is only required in specific cases and shall be detailed in the relevant section of the AFM
Note 2: RAIM availability prediction services may be provided to users by the air navigation service provider (ANSP), an avionics manufacturer or other entities.

FAA - AC 90-105

Operational Considerations: Pre-Flight Planning

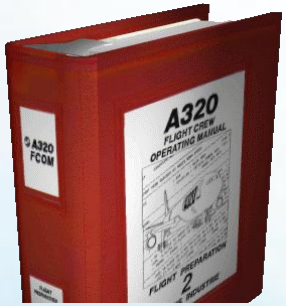
(1) For systems with RAIM-based integrity, RAIM prediction must be performed prior to departure. This capability can be a ground service and need not be resident in the aircraft's avionics equipment.

(2) Operators should be familiar with the prediction information available for the intended route. RAIM availability prediction should take into account the latest GPS constellation NOTAMs and avionics model (when available).

(4) In the event of a predicted, continuous loss of appropriate level of fault detection of more than 5 minutes, for any part of the RNP operation, the flight planning should be revised.

Prediction should be representative of aircraft systems and take into account:
- NANUs (GPS constellation NOTAMs)
- Representative terrain mask angle (minimum 5° mask angle)

RNP APCH
OPS Approval



- Introduction + Ref Doc
- A/C qualification
- NDB validation
- RAIM prediction
- Operation manual, procedures and Checklist
- MEL
- Training program

(OM, FCOM and checklists) will be updated to reflect RNP operations

Should cover normal and abnormal operations

Airbus documentation : FCOM

AIRBUS

A318/A319/A320/A321
FLIGHT CREW
OPERATING MANUAL

PROCEDURES

NORMAL PROCEDURES

STANDARD OPERATING PROCEDURES - APPROACH

RNAV (GNSS)

- **New layout** for Approaches in FCOM
- RNAV (GNSS) considered in new **Approach Guidance Management** chapter
- Depending of mode used for approach : FLS, FINAL APP, FPA

FCOM information for RNAV approaches to support RNP APCH

Equipment to start procedure

	RNP APCH
Required Equipment list to start a Procedure	1 RNAV system 1 FMS 1 MCDU 1 FD 1 PFD,1 ND on PF side both FCU channels 1 GPS (MMR)

RNP APCH
OPS Approval

- Introduction + Ref Doc
- A/C qualification
- NDB validation
- RAIM prediction
- Operation manual, procedures and Checklist
- MEL
- Training program

Equipment to start procedure

	RNP APCH
Aircraft equipment SA/LR	1 FMS + 1 GPS
MEL	*1 FM* *1 GPS*
AFM / FCOM	/

RNP APCH
OPS Approval

- Introduction + Ref Doc
- A/C qualification
- NDB validation
- RAIM prediction
- Operation manual, procedures and Checklist
- MEL
- Training program

-Flight crew training
-Dispatcher training
-Maintenance training

Training Requirements

	RNP APCH
Dispatcher Training	Approved generic training
Maintenance training	Approved generic training

- Only aircraft certified for the intended operation are allowed to fly the procedures
- The MEL must be applied
- The FMS navigation database must be up to date
- The PBN procedures must be available in the FMS database
- The PBN procedures have been checked in the NDB validation process
- Correct charts must be on board the aircraft
- RAIM Prediction must be checked
- ATC Flight Plan must be filled-in correctly
- Performance and Weather minima must be checked

Training Requirements

	RNP APCH
Crew Training	Approved generic training *(May be integrated in the current training program)*
Recurrent training *(crew)*	2 approaches as PF: LNAV and LNAV / VNAV *(May be integrated in existing recurrent training syllabus)*

RNP-APCH Crew Training Example

GROUND TRAINING:

- Charts presentation
- RNAV (GNSS) Procedure presentation
- CBT Final Approach (use of FINAL APP mode)
  - Including effect of temperature
- Refresher on Aircraft positioning and Baro VNAV can be performed as necessary
- ATC phraseology

RNP-APCH Crew Training Example

SIMULATOR TRAINING:

- FFS Syllabi *(2 Hours per crew)*

  3 approaches as PF:
  - LNAV only minima
  - LNAV / VNAV minima (use of FINAL APP)
  - Missed approach
  - Engine-out LNAV / VNAV minima (use of FINAL APP)

RNP-APCH training summary

- Flying an RNP APCH is same as flying a NPA in managed mode having the benefit of:
  - NDB validation process
  - Temperature limit indicated on chart

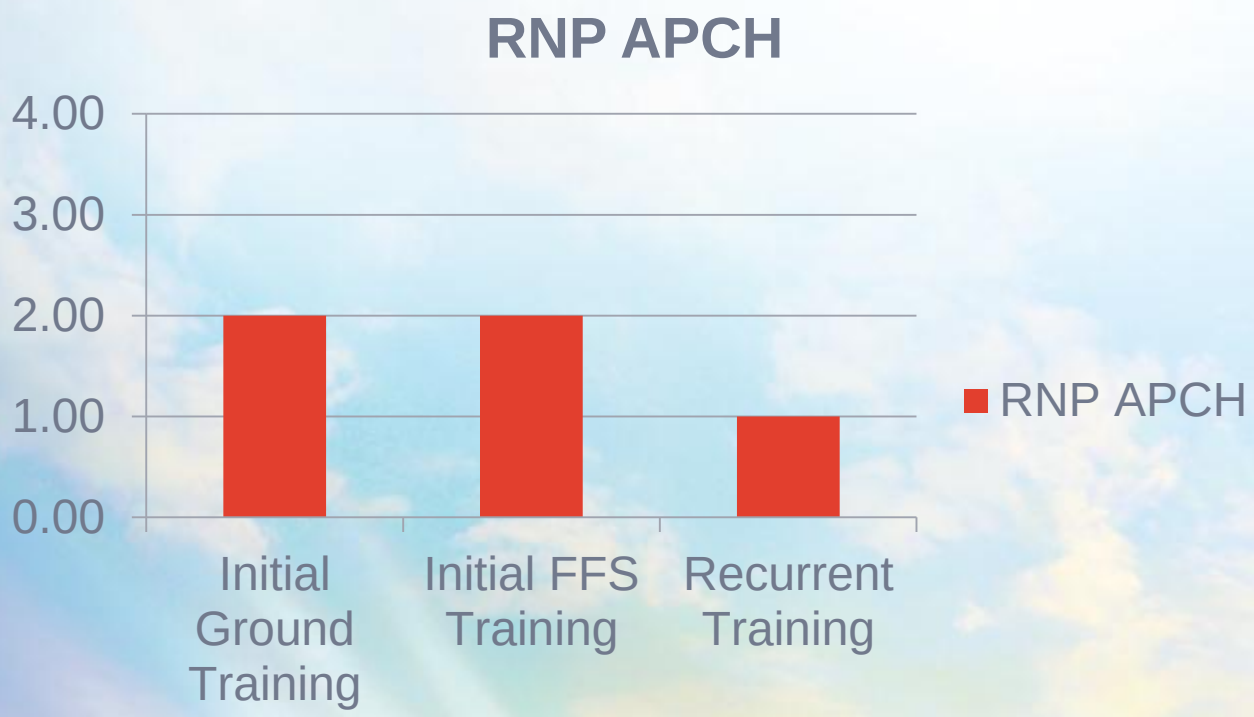
- Most of required training items are already in the existing Type Rating training program

- RNP-APCH recurrent training program may be integrated in current recurrent training

RNP-APCH training summary

Training Time per Crew (Hours)

(Training without airport specificities)



Conclusion

- PBN brings significant safety and operational benefits
- Airbus is committed to support PBN implementation using a Train the Trainer approach and sharing best practices
- Most of required training items are already embedded in the existing Type Rating training program, for operations down to RNP APCH specification
- Training is directed towards understanding of system's capability rather than developing a new approach technique
- Robust ground processes shall be implemented

Thank You