ICAO AFI/MID ASBU
Implementation Workshop
23-26 Nov 2015 , Cairo

PBN Implementation from Industry perspective

RNAV, RNP & RNP AR

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Airbus ProSky

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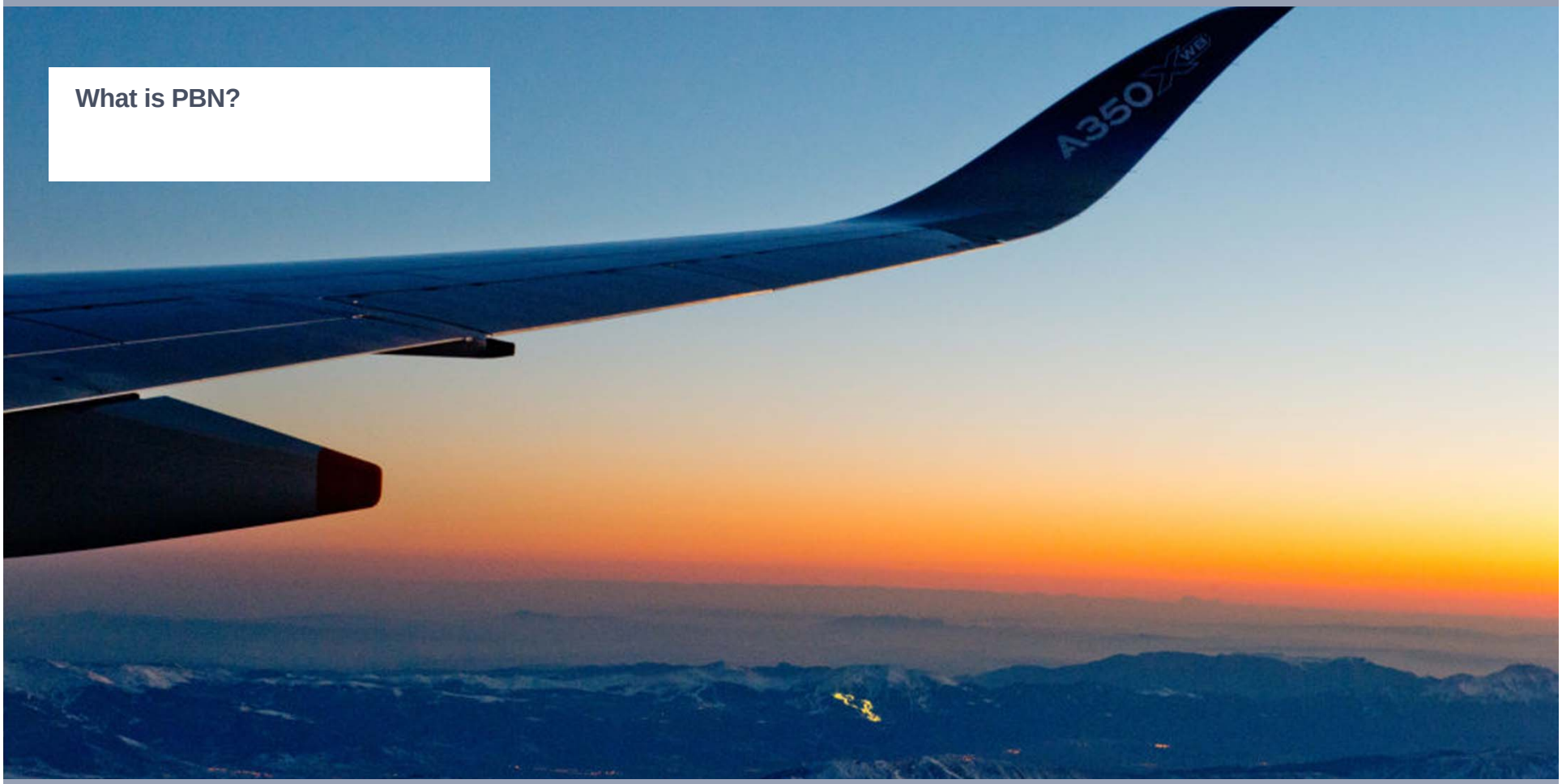
Objectives

- What is PBN? What's the difference between RNAV, RNP and RNP AR?
- Why customers(airlines/ANSPs) need it?
- Why they need support for the deployment of PBN?

What is PBN?



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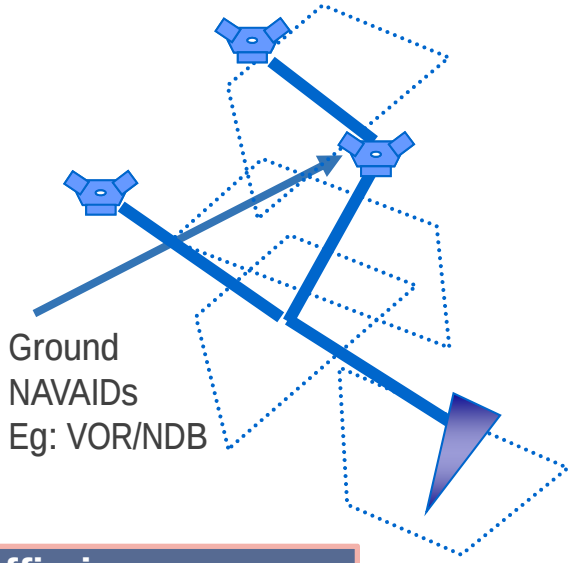
Conventional Navigation Means

- Visual flight
- Position computation based on Ground Navigation Aids
  - NDB
  - VOR
  - DME
  - ILS
- Radar Guidance

Conventional Routes

- Defined based on old aircraft capabilities and use of conventional navigation means
  - Large protection areas and separation criteria to cope with limited accuracy of position estimation
- Based on Ground Navigation Aids
  - Overfly
  - Relative position
- Limited design flexibility
  - Leading to traffic saturation



Widely used but no more suitable due to traffic increase and high fuel cost

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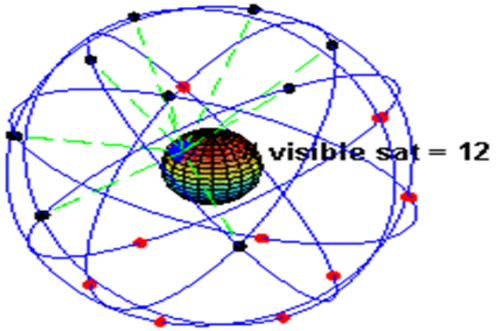
Global Navigation Satellite System



Providing highly accurate and reliable positioning

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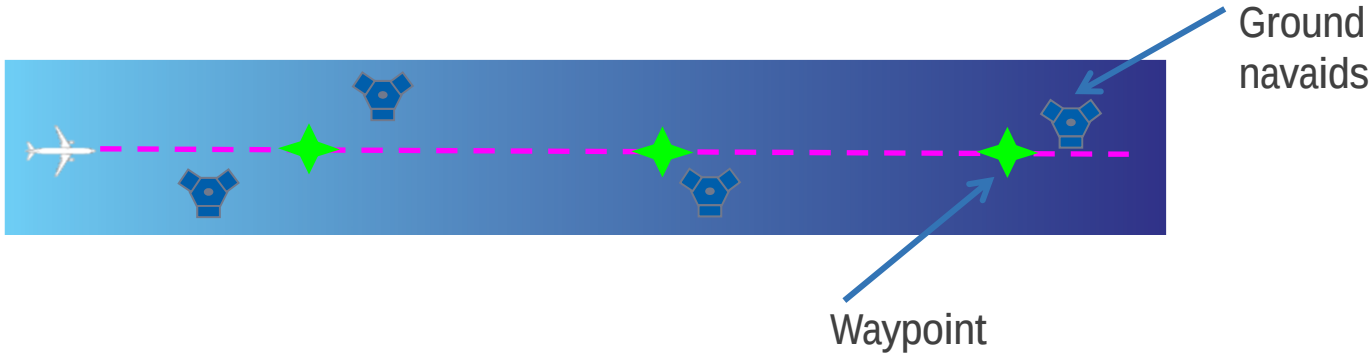
RNAV Definition

RNAV stands for Area Navigation

RNAV : Capability to fly any desired flight path, defined by waypoints such as geographic fixes (LAT/LONG) and not necessarily by ground navaids

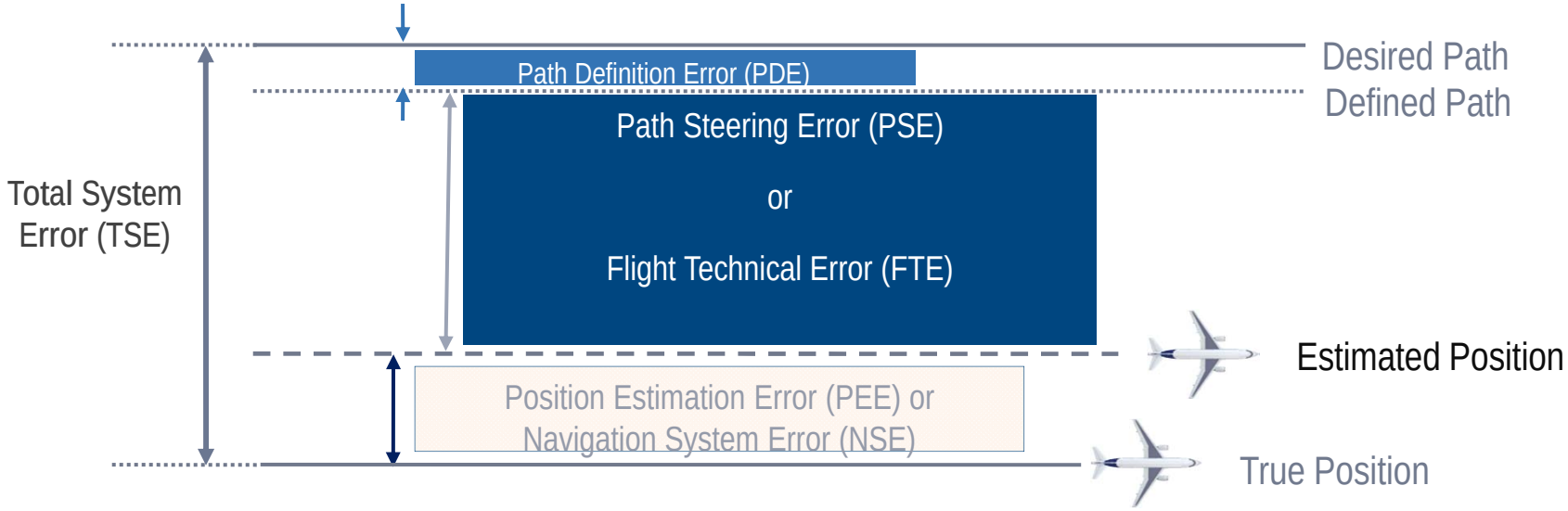


"RNAV X" capability represents the linear lateral Accuracy of the Navigation system expected to be achieved 95% of the flight time

"RNAV X" capability direcly affects the FMS navigation mode, thus the sensors required, without any Monitoring or Alerting function

RNP Concept

RNP Concept: Navigation Performance by reference to MASPS DO-236/ED-75



RNP Concept

DO-236 / ED-75 RNP requirements

> ACCURACY

- Aircraft must remain within accuracy limit 95% of flight time
  - The maximum TSE with 95% probability =< 1xRNP

> INTEGRITY

- Probability to transgress the containment limit set at 2 x RNP without alert must be <10-5/FH

> CONTINUITY

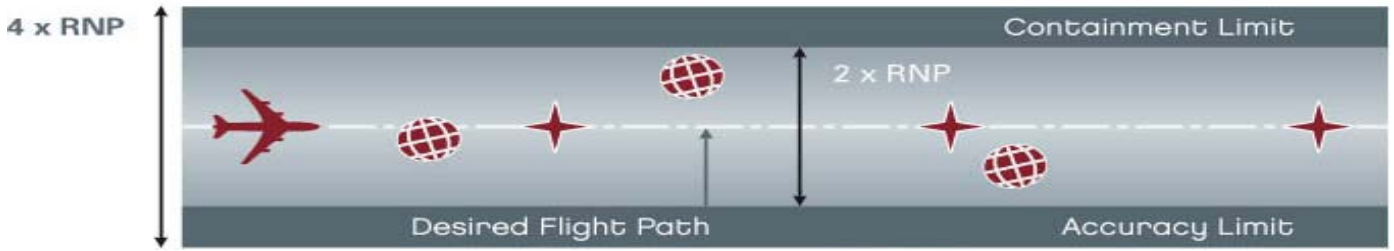
- Probability of RNP capability loss with alert must be <10-4/FH

RNP Concept

RNP =
- Navigation **accuracy**
- On board containment **integrity**
- **Continuity** of RNP capability

+

On Board Performance Monitoring and Alerting (OBPMA)



RNP X = +/- X NM corridor for the accuracy limit,
+/- 2*X NM corridor for the containment limit

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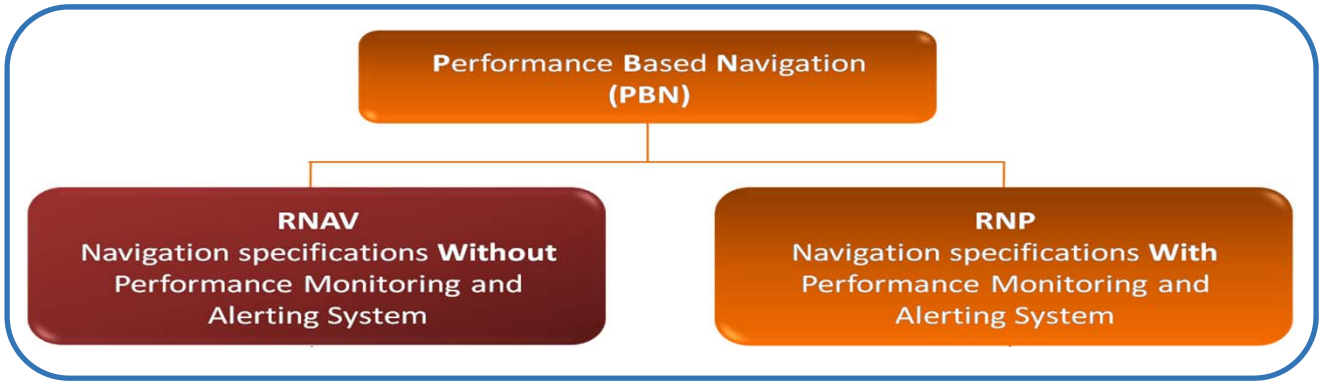
ICAO's PBN standardization



- All PBN is based on area navigation (RNAV)
- To meet the required airspace operational requirements, PBN defines :
  - RNAV specifications
  - RNP specifications

RNP = RNAV + OBPMA

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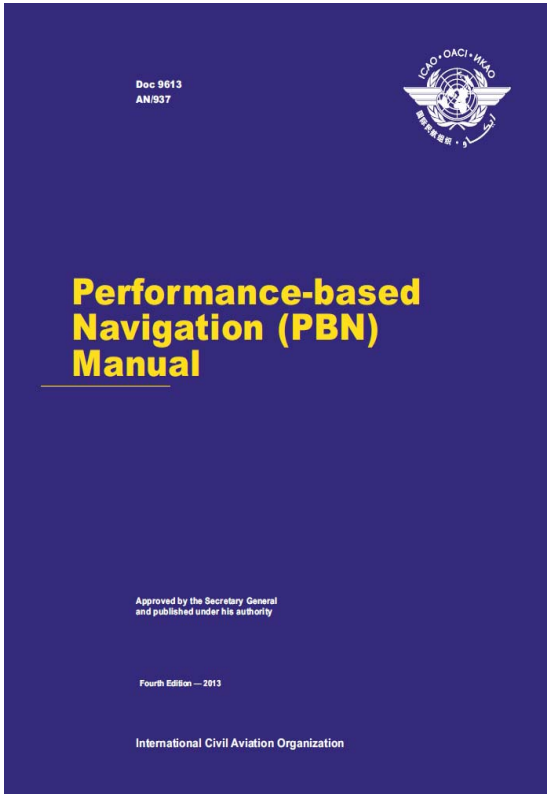
PBN Manual



VOLUME I

Concept

and

Implementation Guidance

VOLUME II

Implementing

RNAV and RNP

4th edition released in 2014: Introduction of new operations

PBN Manual: 4th edition

RNAV

On Board Perf. Monitoring and Alerting system not mandatory

- EN-ROUTE
  - RNAV 10
- TERMINAL
  - RNAV 5
  - RNAV 1
  - RNAV 2

RNP

On Board Perf. Monitoring and Alerting system mandatory

- EN-ROUTE
  - RNP 4
  - RNP 2
- TERMINAL
  - RNP1
- APPROACH
  - RNP APCH
  - RNP AR APCH

RNP 0.3
for helicopter

PBN Navigation Specifications

- A NAVIGATION SPECIFICATION defines :
  - What ***PERFORMANCE*** of RNAV system is required for aircraft operating on air traffic routes or instrument approach procedures, in a designated airspace
    - Defined in term of accuracy, integrity, continuity and availability
  - What ***FUNCTIONALITIES*** RNAV system must have to achieve performance
    - e.g. Display type, leg types….
  - What ***NAVIGATION SENSORS*** must be integrated in RNAV system to achieve performance
  - What ***REQUIREMENTS*** are placed on AIR CREW to achieve the required performance from the RNAV system

PBN Nav Spec: RNAV 1 & 2

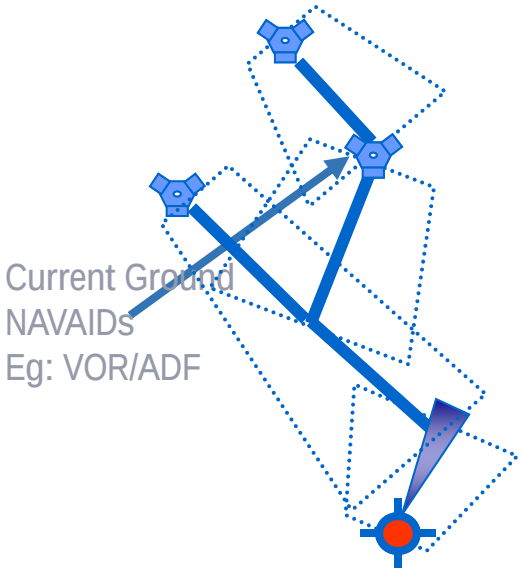
PBN APPLICATION		RNAV2	RNAV1
Navaid infrastructure		DME GNSS INS	DME GNSS INS
Nav Spec	On board	GNSS DMEDME DMEDME/IRU	GNSS DMEDME DMEDME/IRU
	TSE	<2 NM	<1 NM
	Leg type	IF CF TF DF VA VM VI CA FA FM	IF CF TF DF VA VM VI CA FA FM
	Function	Data base (LOA) FB turn	Data base (LOA) FB turn
Surveillance		Radar	Radar separation Specific Safety Assessment
Communication		voice	voice
ATM	Separation minima	Radar separation	Radar separation
	Publication	RNAV 2 Critical DME if any	RNAV1 Critical DME if any

PBN Nav Spec: RNP APCH & RNP AR

PBN APPLICATION		RNP APCH	RNP AR
Navaid infrastructure		GNSS	GNSS
Nav Spec	On board	OPMA	OPMA
	TSE	Final 0.3 NM	From 0.3 to 0.1
	Leg type	IF TF DF (VA CA FA)*	IF CF TF DF VA VM VI CA FA FM RF
	Function	Data base (LOA) FB turn	Data base (LOA) FB turn VNAV
Surveillance		ATS or procedural	ATS or procedural
Communication		voice	voice
ATM	Separation minima	Doc 4444	Doc 4444
	Publication	RNP APCH RNAV (GNSS)	RNP AR RNAV (RNP)

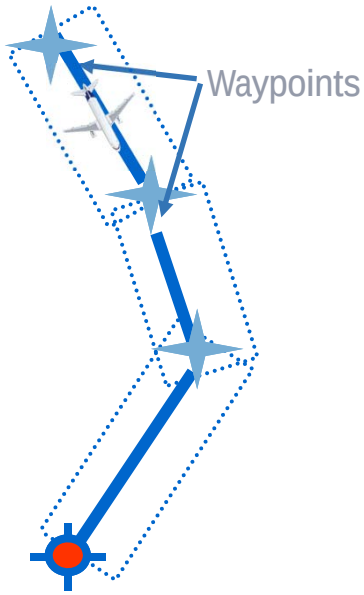
Conventional v.s. RNAV & RNP in procedure design

Conventional Navigation



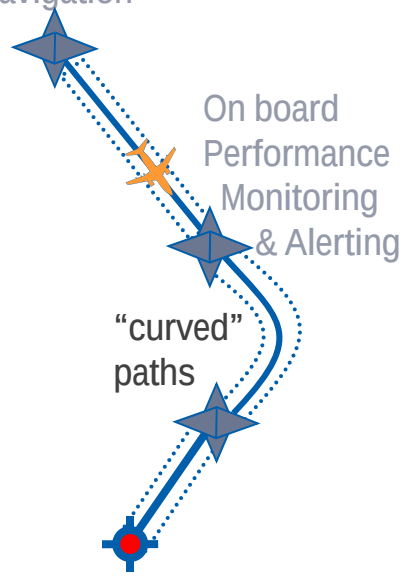
Limited use of airspace
due to Waypoints ground based navaids defined

RNAV Navigation



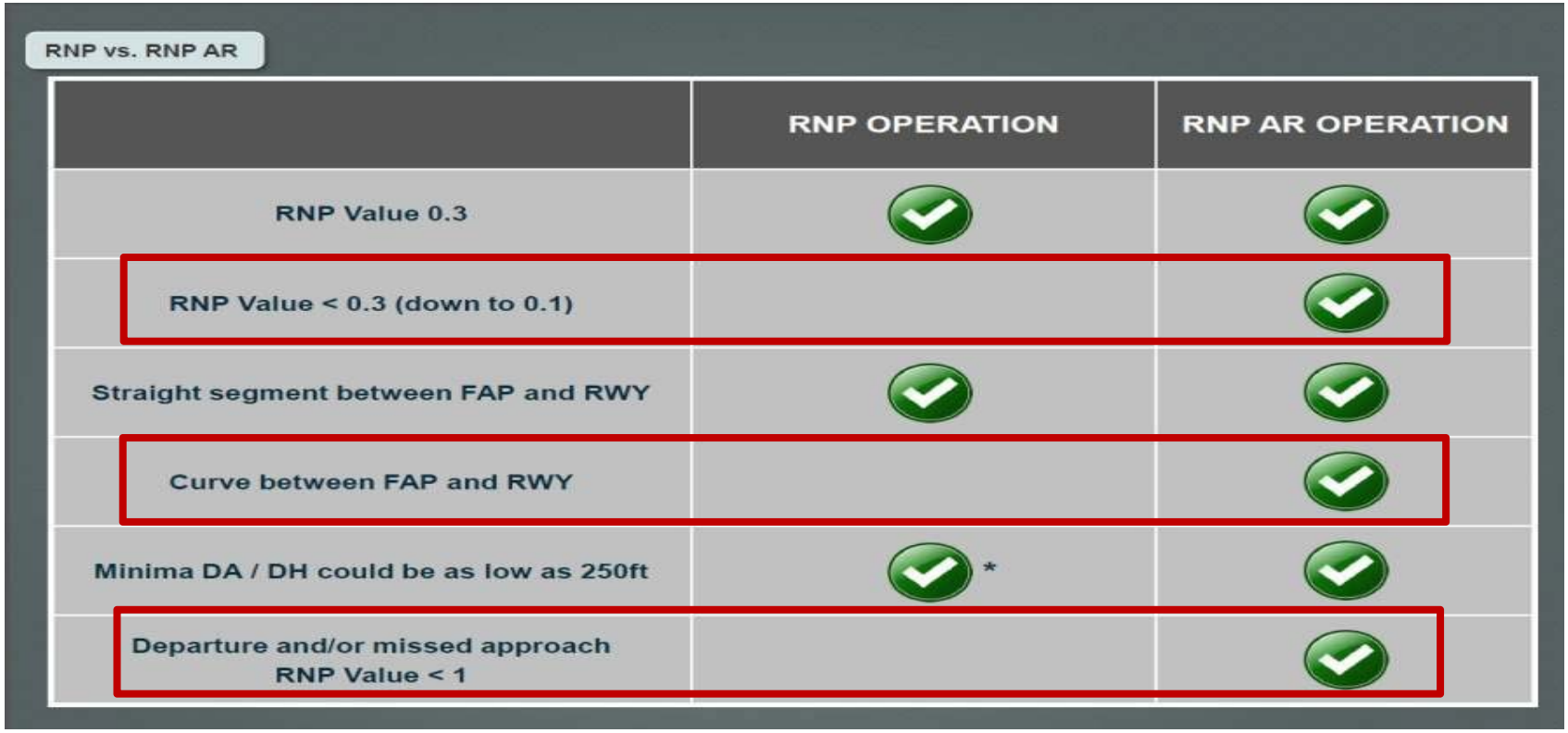
Improved use of airspace
due to Waypoints geographically defined

RNP Navigation



Optimum use of airspace
due to navigation system capability to contain aircraft position within a “tunnel”

RNP APCH v.s. RNP AR APCH



A word on A-RNP

New operations

RNAV

On Board Perf. Monitoring and Alerting system not mandatory

RNP

On Board Perf. Monitoring and Alerting system mandatory

EN-ROUTE

TERMINAL

EN-ROUTE

TERMINAL

APPROACH

RNAV 10

RNAV 5

RNAV 1
RNAV 2

RNP 4

RNP 2

RNP1

RNP
APCH

RNP AR
APCH

ADVANCED RNP (Advanced features: RF, FRT, …)

RNP 0.3
for helicopter

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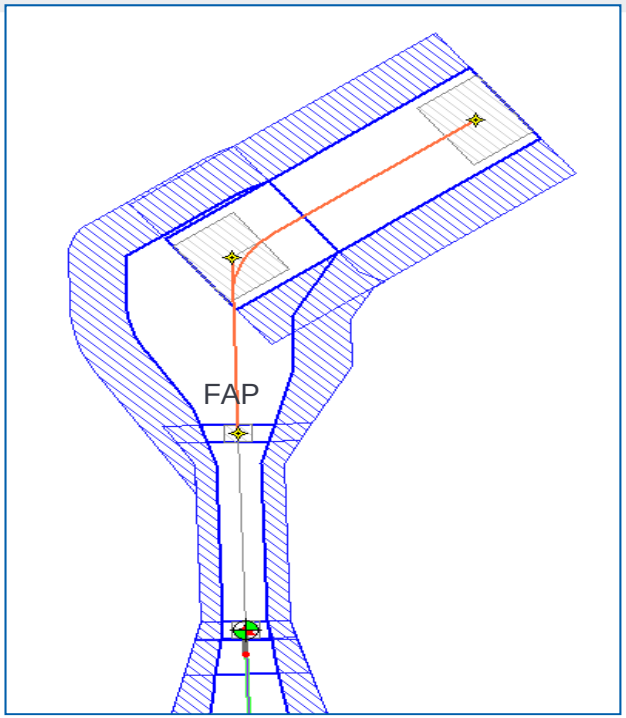
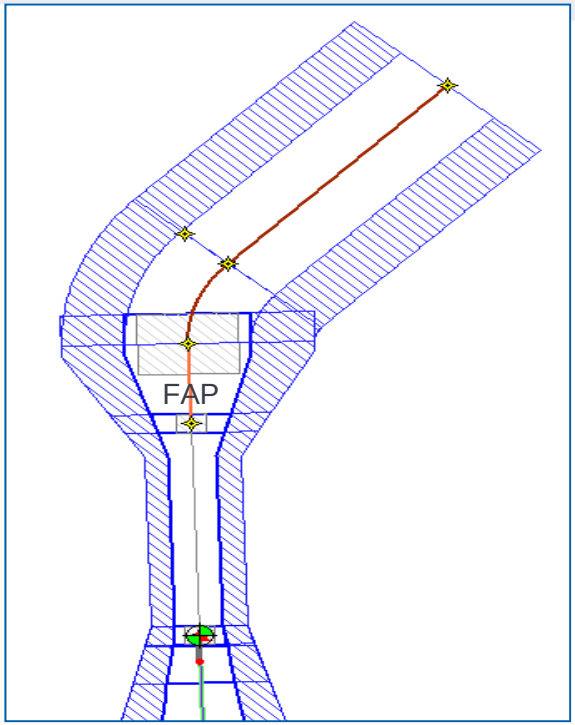
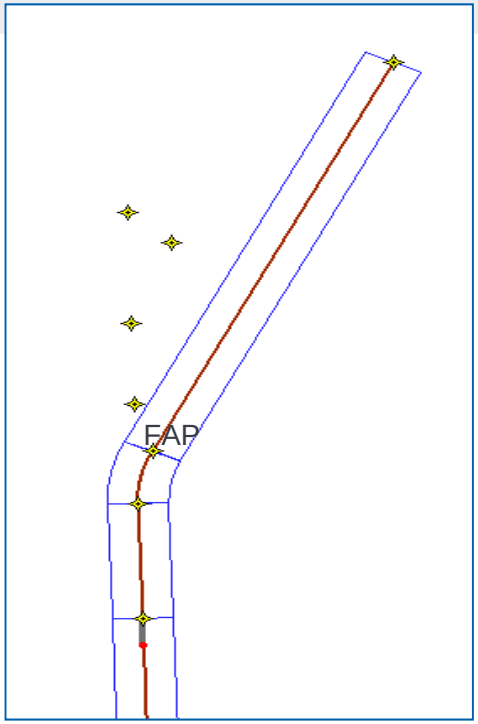
A word on A-RNP



RNP APCH



A-RNP



RNP AR

NOTE:
RF are optional for RNP APCH
RF are required for A-RNP and RNP AR (RF in Final segment only possible for RNP AR)

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Regulation requirements for on-board equipment

	FAA regulations	EASA regulations	Airbus A/C compliance
RNP 1	AC90-105	No regulation	With GPS
RNP APCH	AC90-105 AC90-107 (not yet released)	AMC20-27 AMC20-28	**LNAV**: with GPS **LNAV/VNAV**: with FMS2+GPS **LPV:** A350
Advanced RNP	AC90-105	No regulation	With FMS2+GPS
RNP AR	AC90-101A	AMC20-26	With specific MOD

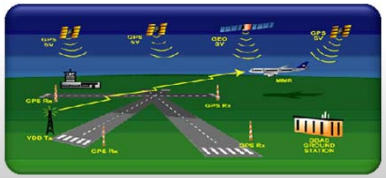
Each application has its strengths and weaknesses

TMA Application	A/c equipage requirements & training	Flexibility of trajectories	Minima	Ops approval
RNP AR	High (a/c upgrade required, crews to be trained)	High(use of RF legs)	Medium	Heavy
Advanced RNP(RNP APCH with RF legs)	Low	Medium(use of RF legs)	Medium	Medium
RNP APCH	Low	Low	Medium/High	Light*

The selection of Nav Spec is always a compromise between the benefits expected, cost of operation(a/c upgrade, ops approval, crew training), ATM infrastructure readiness

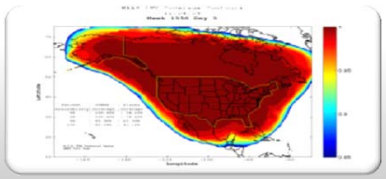
* Europe is planning to remove requirements for ops approval for RNP APCH

Approaches: different augmentations



GLS (GBAS)

- Precision Approach
- Lateral and vertical guidance
- Decision Altitude vs. MDA
- CAT I only (for now)



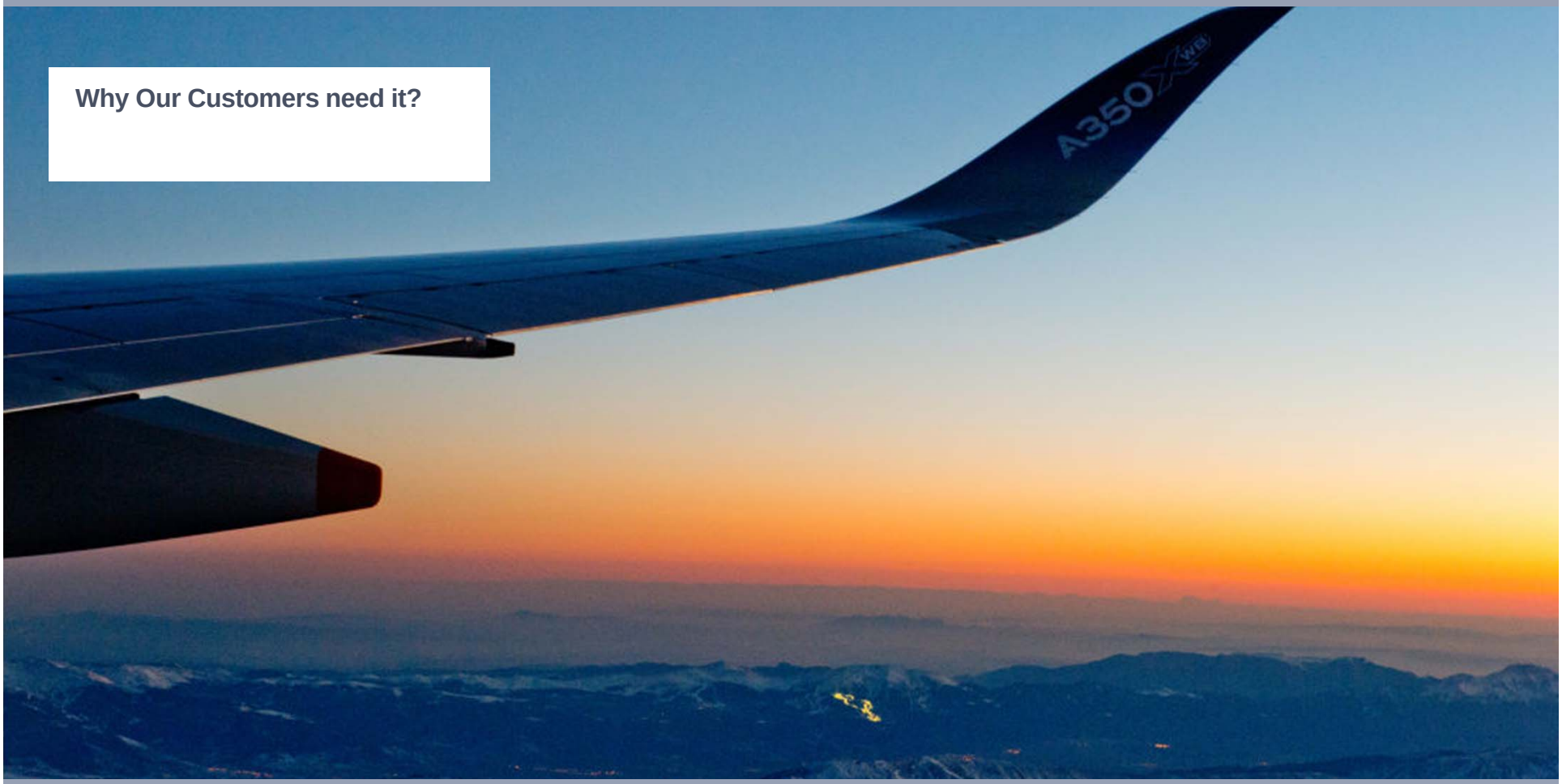
LPV (SBAS)

- Localizer Performance with Vertical Guidance
- Only available in the U.S. and in Europe
- Charted as RNAV (GNSS)
- Not supported by Boeing and Airbus today except on A350

RNP (ABAS)

- Non Precision Approach with lateral guidance
- Based on GNSS (lateral) & Baro VNAV (Vertical Guidance)
- RNP APCH & RNP AR
- Charted as RNAV (GNSS) or RNAV (RNP)

Why Our Customers need it?



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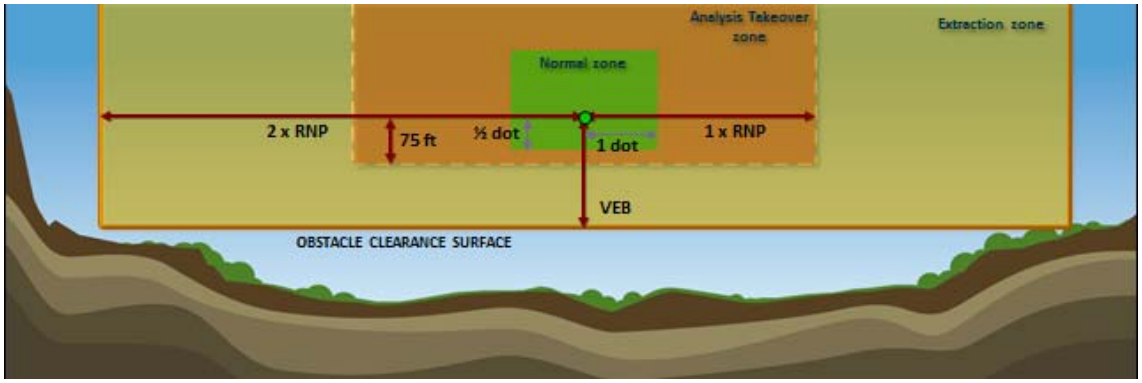
What PBN can bring to our customers?

3D trajectories

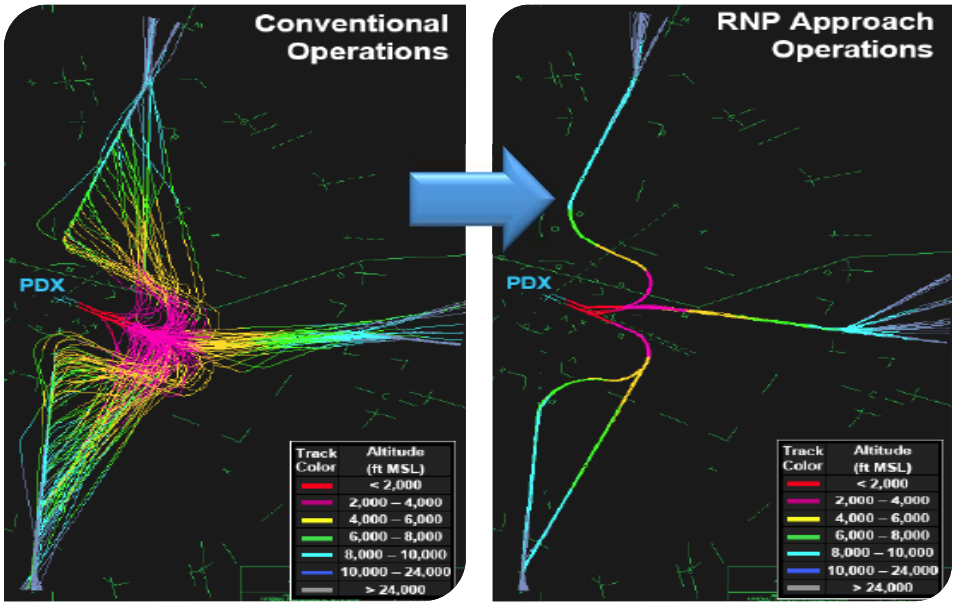
- Laterally, accurate and flexible trajectories
- Vertically, managed descent with CDO

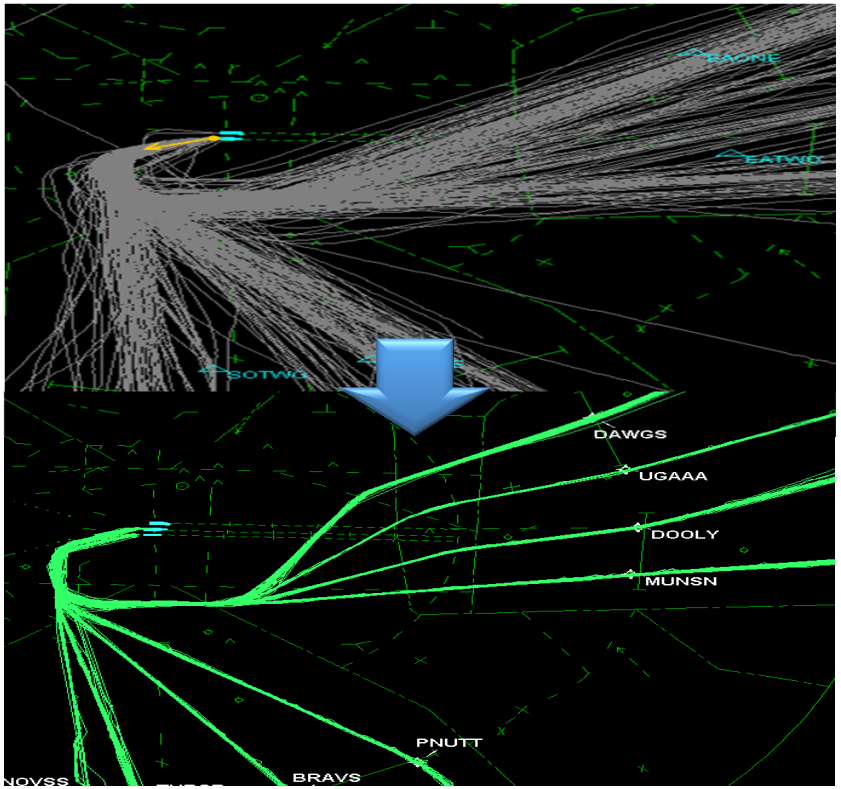
Benefits in

- Airspace Capacity
- Safety
- Airport Access
- Efficiency (Track miles savings)
- Environment(noise,CO2)



PBN Benefits for ATC





Higher Predictability

Trajectory and time: better sequencing

Less Dispersion of Traffic

Easier to manage crossing of SIDs and Stars

Less Communication

Allowing ATCos to concentrate on their Tasks

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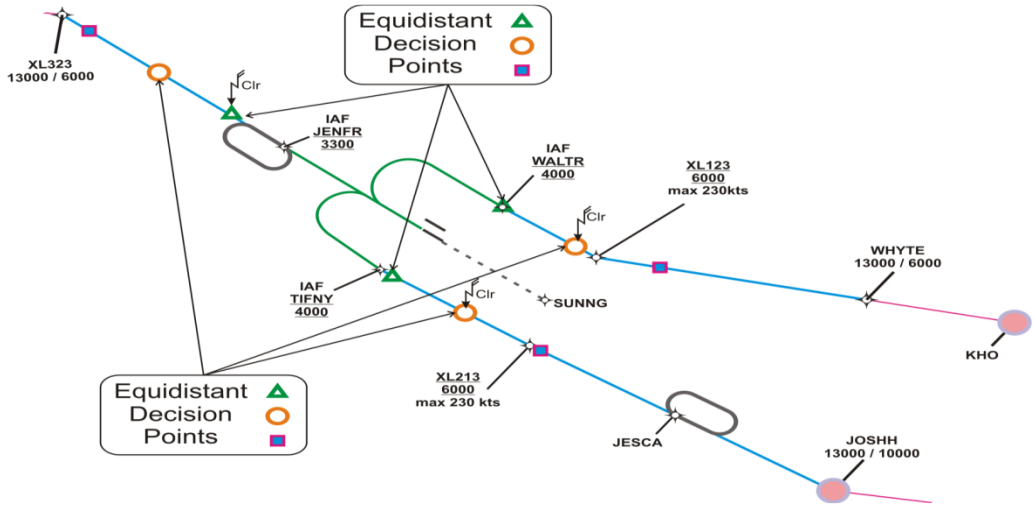
PBN Benefits for Airlines

Optimized use of airspace

Improved capacity
Traffic de-confliction
Improved predictability of arrival time



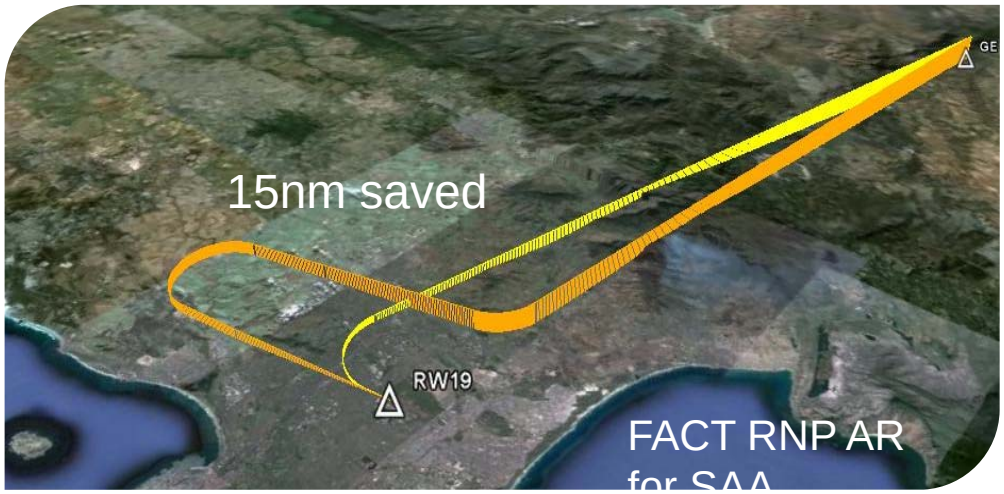
RNP AR at OMAA

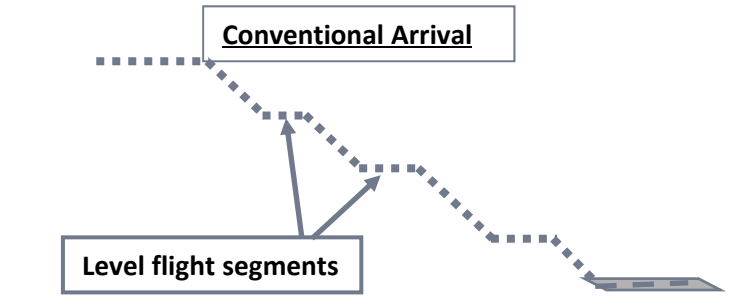
- De-confliction of OMAA arrivals and a corporate jet airport nearby
- Improved sequencing of traffic

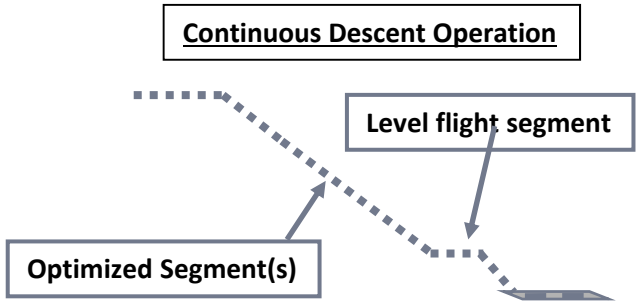
PBN Benefits for Airlines

Lower Fuel Burn

Less distance to Fly
Better Vertical Profile
Fully Managed Descent







About 200kg saved per CDO

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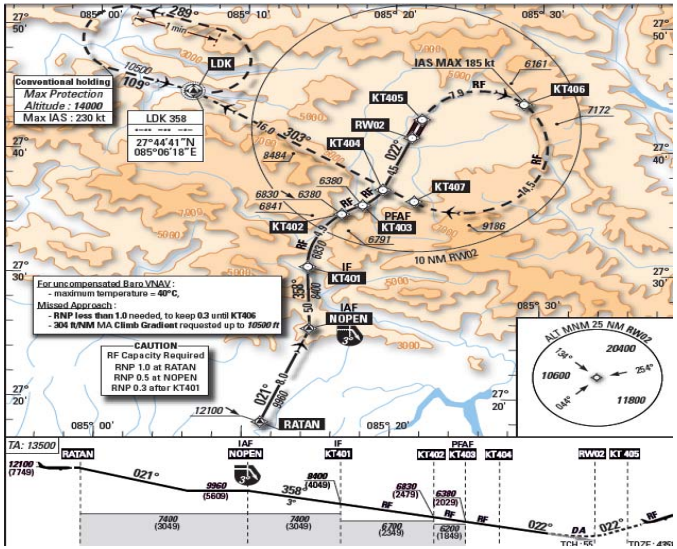
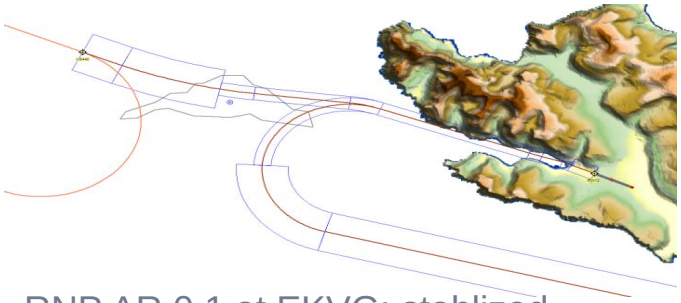
PBN Benefits for Airlines

Safety

Can potentially Remove Circle to Land
Better Energy Management
Fully Managed Approach

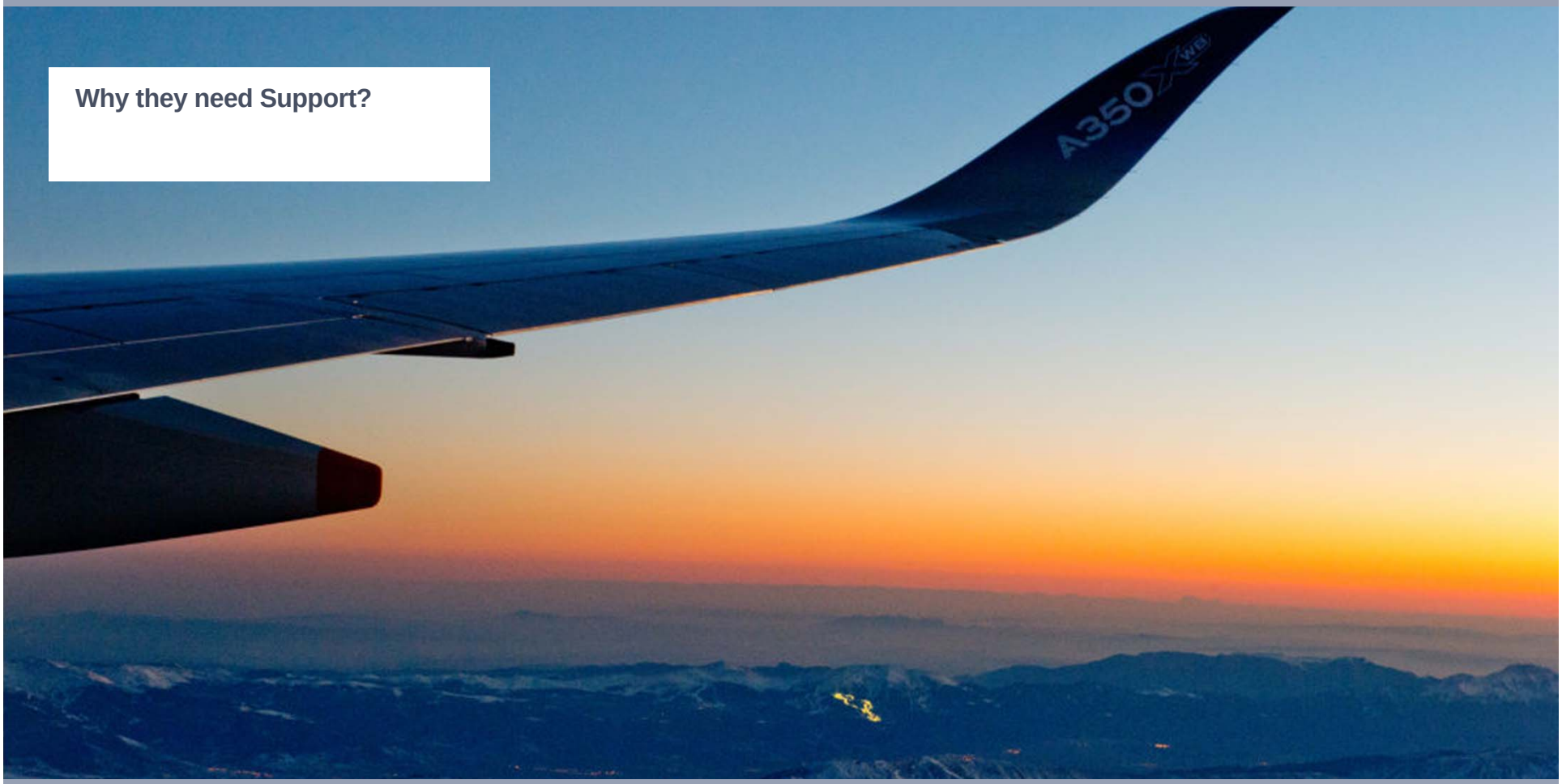


Conventional approach: 5.5° then changed to 3°
3nm to THR
RNP AR 0.3 at VNKT: 2.8° CDO



RNP AR 0.1 at EKVG: stablized approach avoiding terrain and turbulance area
RNP AR 0.1 to ILS: lower minima

Why they need Support?



What it takes to implement PBN?

In high density airspace or terrain challenging environment, the deployment of PBN requires knowledge in

- procedure design
- air traffic management
- a/c performance and systems
- a/c operation services

Difficult for ANSP or airlines to do it alone given the wide range of expertise required, esp. when it comes to deployment in complex environment(high density airspace or challenging terrain)

And there come the regulations

	Airworthiness	OPS	Procedure
Legacy RNP	DO 236	JAR OPS AC 120.29A	PANS OPS TERPS
FAA **RNP AR**** Formerly **SAAAR***	AC 90.101A AC 120.29A		Order 8260.52
FAA **RNP APCH** LNAV and LNAV/VNAV	AC 90.105		Order 8260.54A
ICAO **Basic** RNP	ICAO PBN Manual Doc 9613 PBN Operational Approval Manual Doc 9997		Doc 8168 Vol-II And Doc 9905 (RNP AR)
ICAO RNP **(AR)****			
EASA **RNP APCH** LNAV and LNAV/VNAV	AMC 20-27		
EASA **RNP AR**	AMC 20-26		

* Special Aircraft and Aircrew Authorization Required

** Authorization Required

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What it takes to implement PBN

There's A LOT to do to materialize the operational benefits and be compliant with all applicable regulations.

- Airspace & procedure design
- Ops approval package
- FOSA
- Flight crew and ATC controller training
- Operational services

Need of a project and collaboration management

A full range of PBN services by Airbus ProSky

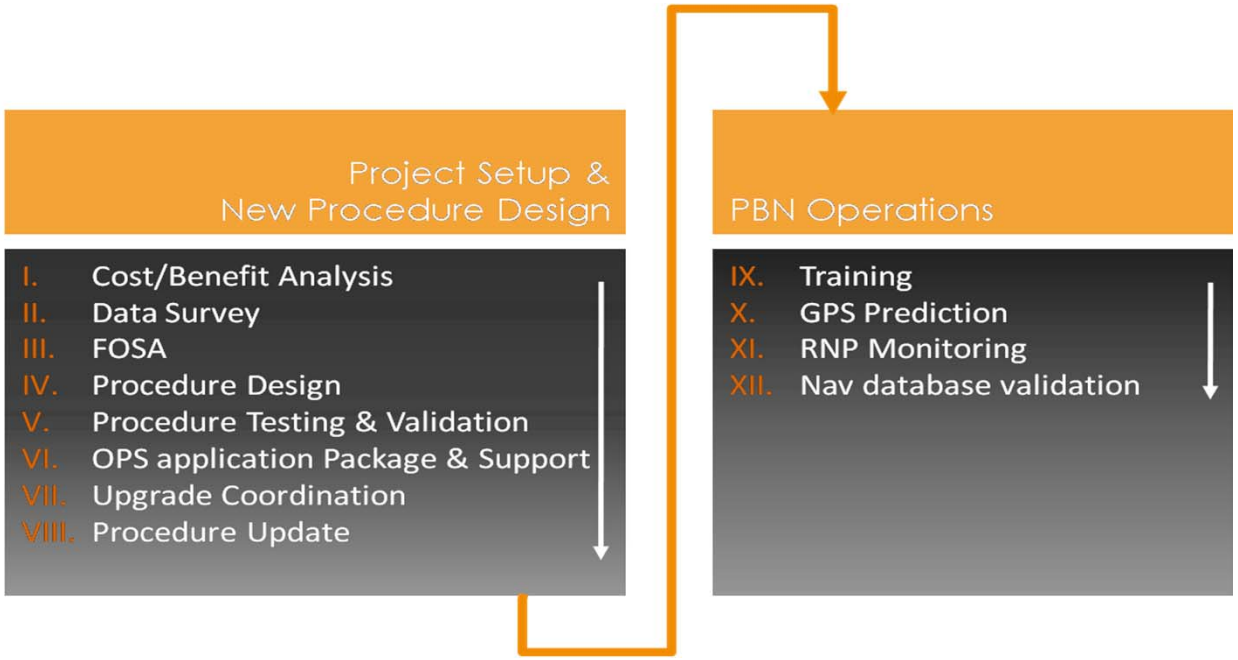
Airbus ProSky Services Offering

Project Setup & New Procedure Design

- **Cost/Benefit Analysis**
- **Data Survey**
- **FOSA**
- **Procedure Design**
- **Procedure Test & Validation**
- **OPS Application Package**

PBN Operations

- **Training**
- **GPS Prediction**
- **RNP Monitoring**
- **NDB Services**



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Airbus ProSky
An ATM Service Company by Airbus

We are a link of the ATM collaboration chain

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