



Airbus

Julien Bernage

PBN flight operations specialist

Advantages of PBN

- to increase access to remote airports
- to reduce congestion in terminal airspace

#1

Aircraft Navigation From Conventional to PBN



1920
1930

1970's

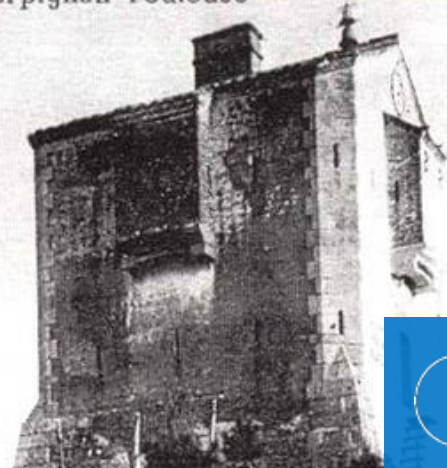
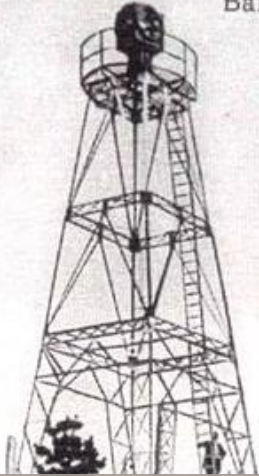
1980's

1990's

2000's

1920- First Step toward Instrumental flight

LE PERTHUS (Pyr. Or) — Phare de la ligne aérienne
Barcelone-Perpignan-Toulouse



**First NAVAID
at night!**

1923
Aeronautical
lighthouse

1920 - 1930 The pioneers of instrumental flight



1929 First
instrumental
flight

- + **1929**
First Instrumental flight by Jimmy Doolittle
- + **1930's**
ILS, gonio, NDB, VOR...
- + **1938**
First ILS approach



First ILS

#1

Aircraft Navigation From Conventional to PBN



1920
1930

1970's

1980's

1990's

2000's

Up to 1970's- ILS and NAVAIDs era



DME installation



Based on ground facilities

VOR installation

Up to 1970's- ILS and NAVAIDs era

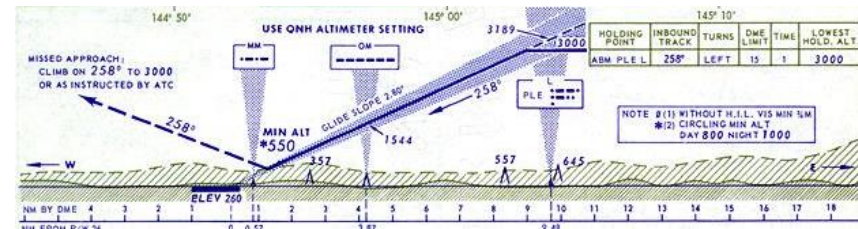


No complex system
onboard



Based on ground facilities

- + **Precision Approach**
ILS with vertical guidance
- + **Non Precision Approach**
Nav aids (VOR DME)



#1

Aircraft Navigation From Coventional to PBN



1920
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1970's

1980's

1990's

2000's

1980's - The Flight Management System and Inertial Reference System



FMS+IRS: revolution in the cockpit

- + **AC position and Navigation Display**
Map with Flight Plan and A/C symbol
- + **Distance to threshold**
Altitude distance checks
- + **RNAV concept**
Waypoints in coordinate

RNAV: aRea NAVigation

1980's - The Flight Management System and Inertial Reference System



FMS+IRS: revolution in the cockpit



1980's - The Flight Management System and Inertial Reference System



FMS+IRS: revolution in the cockpit

- + **A/C position and Navigation Display**
Map with Flight Plan and A/C symbol
- + **Distance to threshold**
Altitude distance checks
- + **RNAV concept**
Waypoints in coordinate
- + **Lateral guidance on FPLN**
Approach coded in Nav DataBase, selection
- + **Vertical Guidance** in Barometric

RNAV: aRea NAVigation

1980's - The Flight Management System and Inertial Reference System



Onboard Landing System

FMS propose **vertical profile** and **guidance**

#1

Aircraft Navigation From Coventional to PBN



1920
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2000's

1990's - The GNSS – Global Navigation Satellite System



Bring accuracy and integrity on position

+ **PBN concept**
the Navigation Performance

PBN Concept: Positioning



Total System Error

~~Path Definition Error~~

~~NDE~~

+

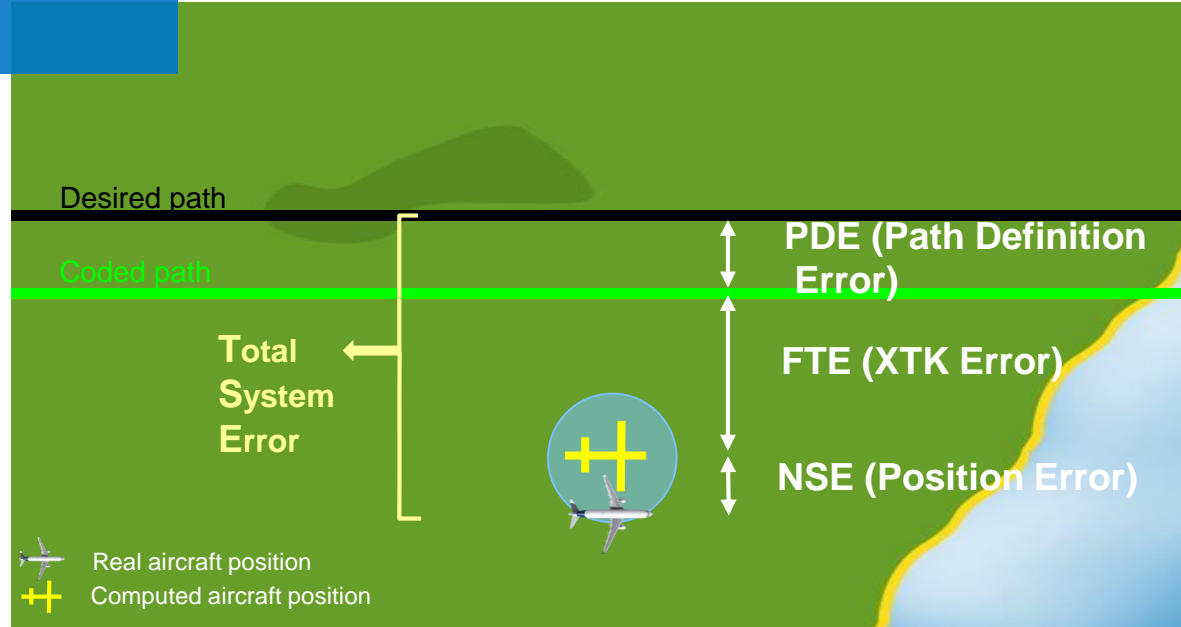
Guidance Error (FTE)

XTK

+

Position Error (NSE)

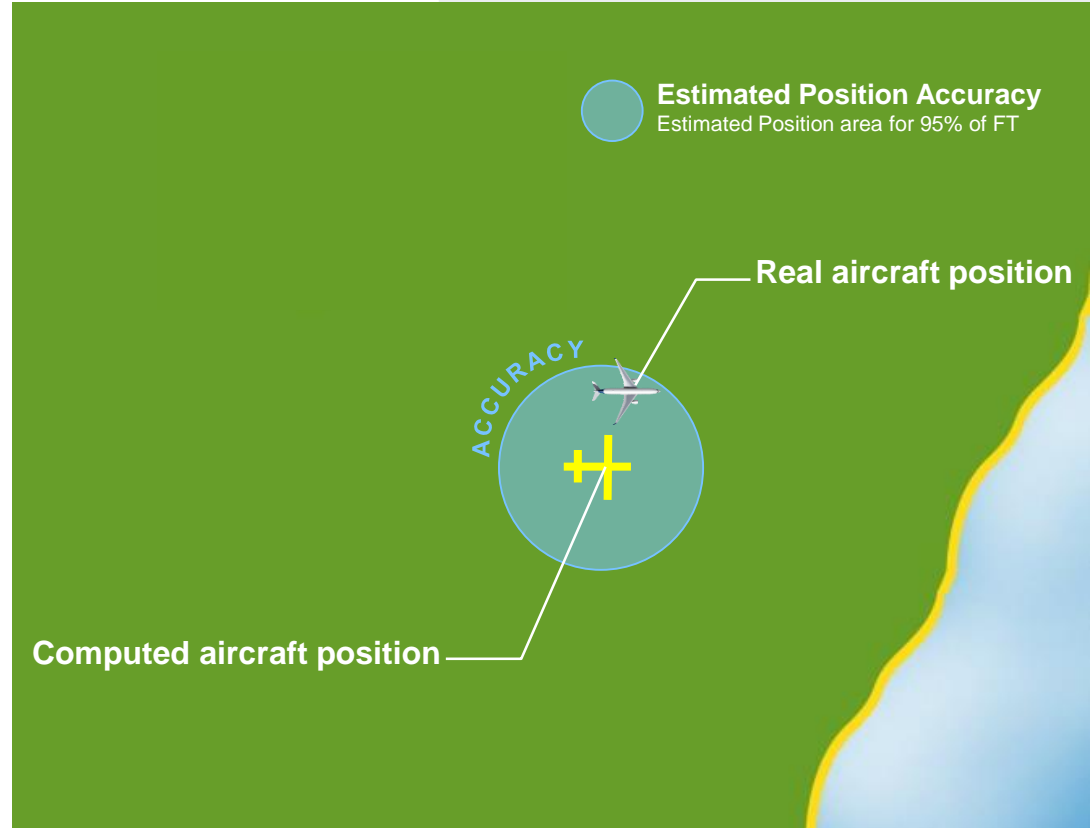
computation



PBN Concept: Design of a RNP or RNAV procedure

+ **On-board position error estimated**

Accuracy

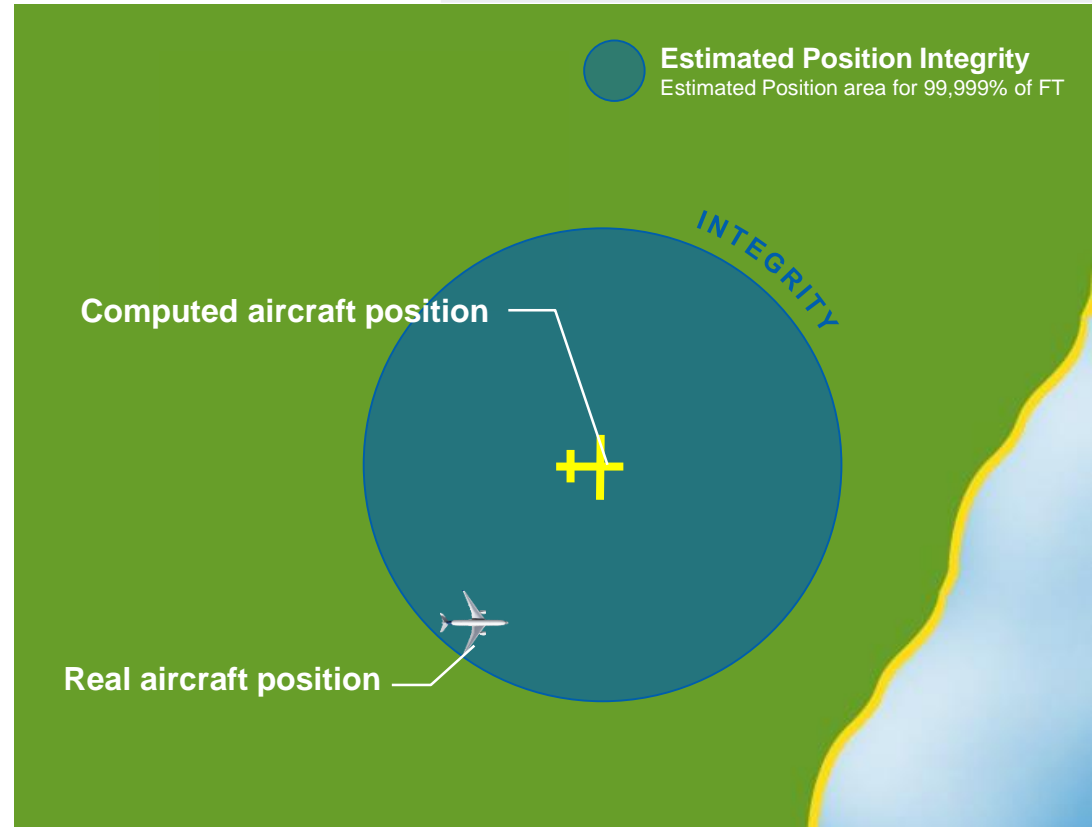


PBN Concept: Design of a RNP or RNAV procedure

+ **On-board position error estimated**

Accuracy

Integrity



PBN Concept

+ Accuracy criteria

TSE 95 % < 1 RNP

Under normal condition

A/C position inside 2 RNP corridor 95% of flight time

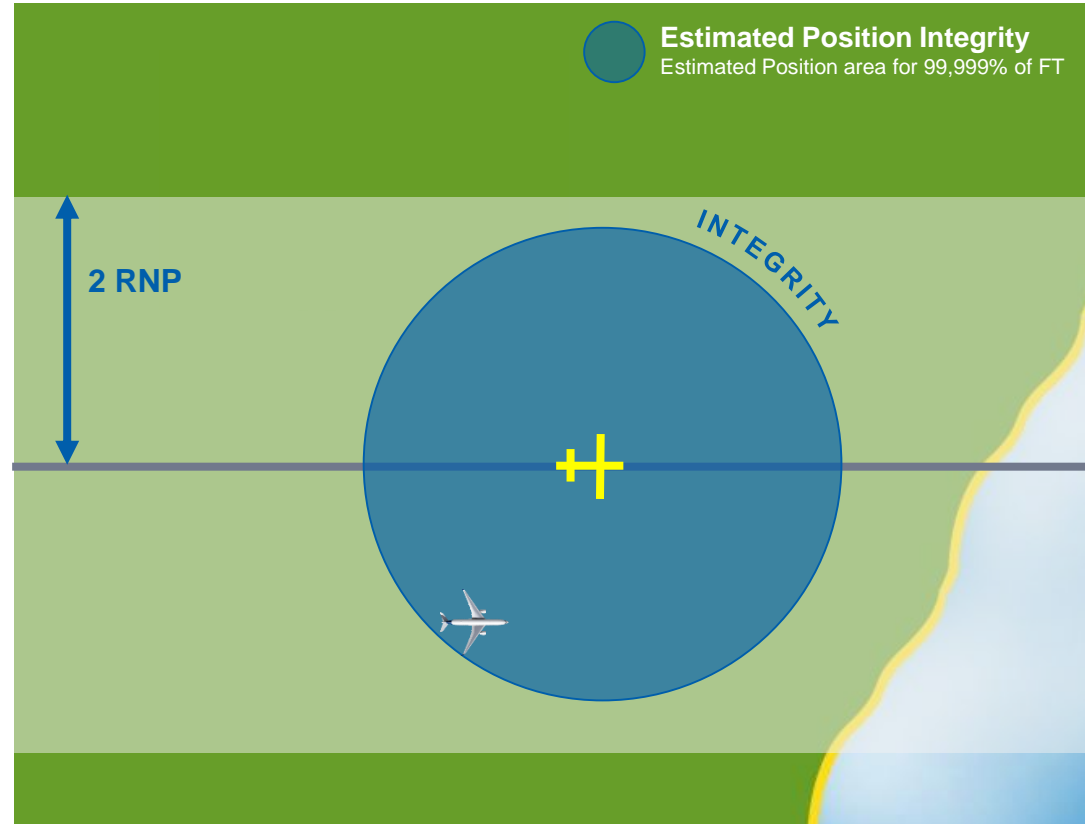


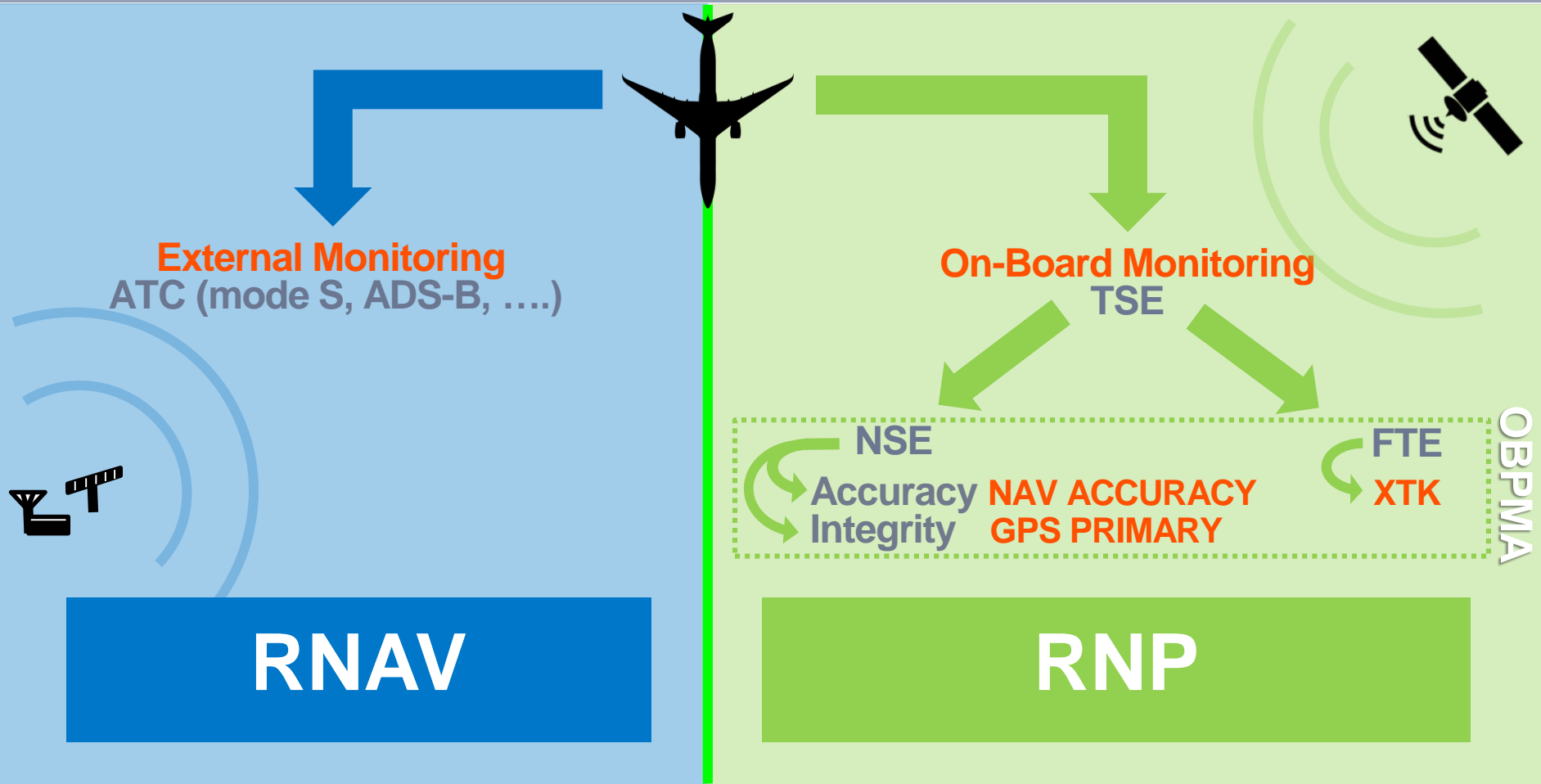
PBN Concept

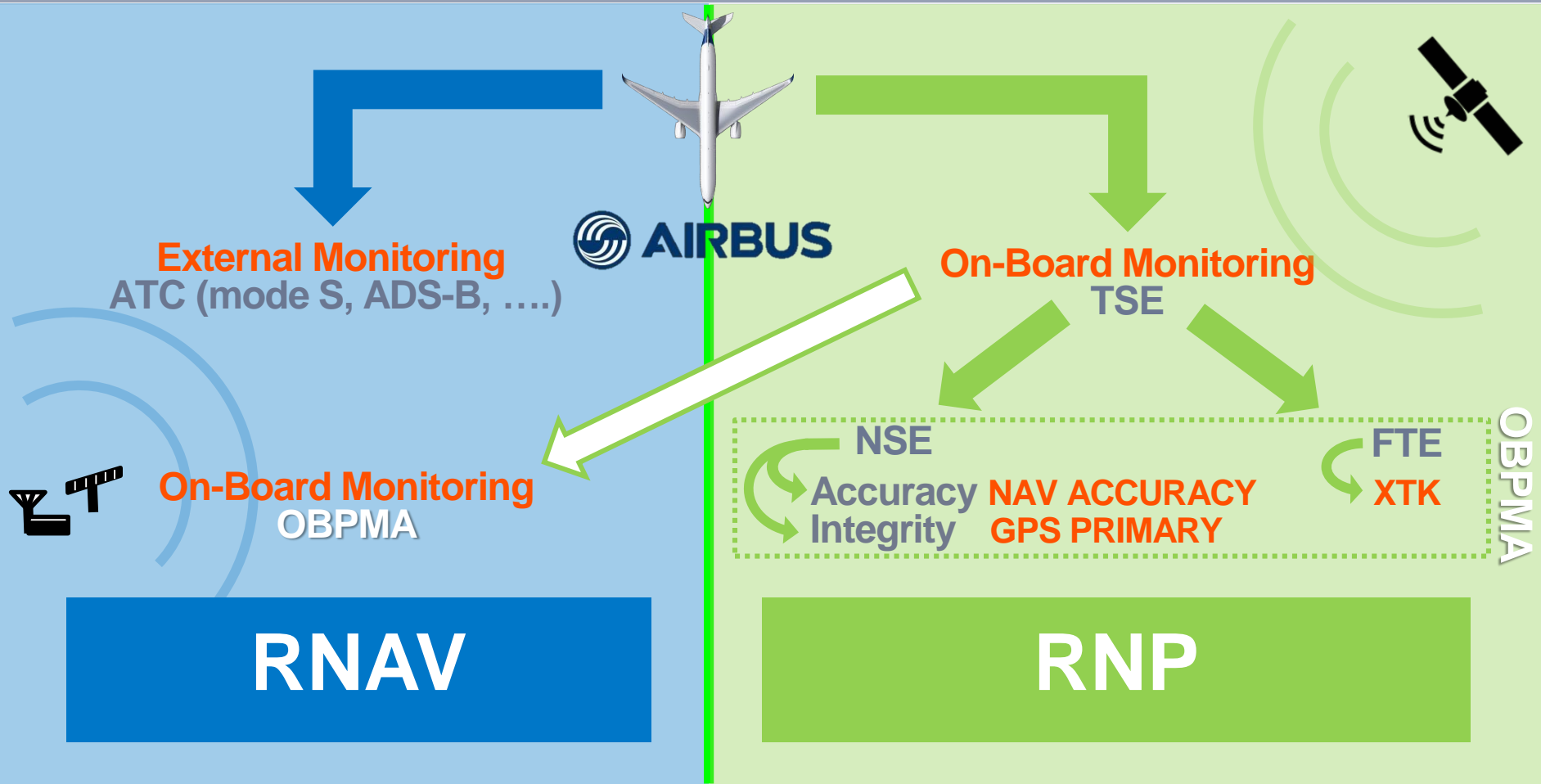
+ Integrity criteria

TSE 99.999% < 2 RNP

A/C position inside 4 RNP corridor
99.999% of flight time







#1

Aircraft Navigation From Coventional to PBN



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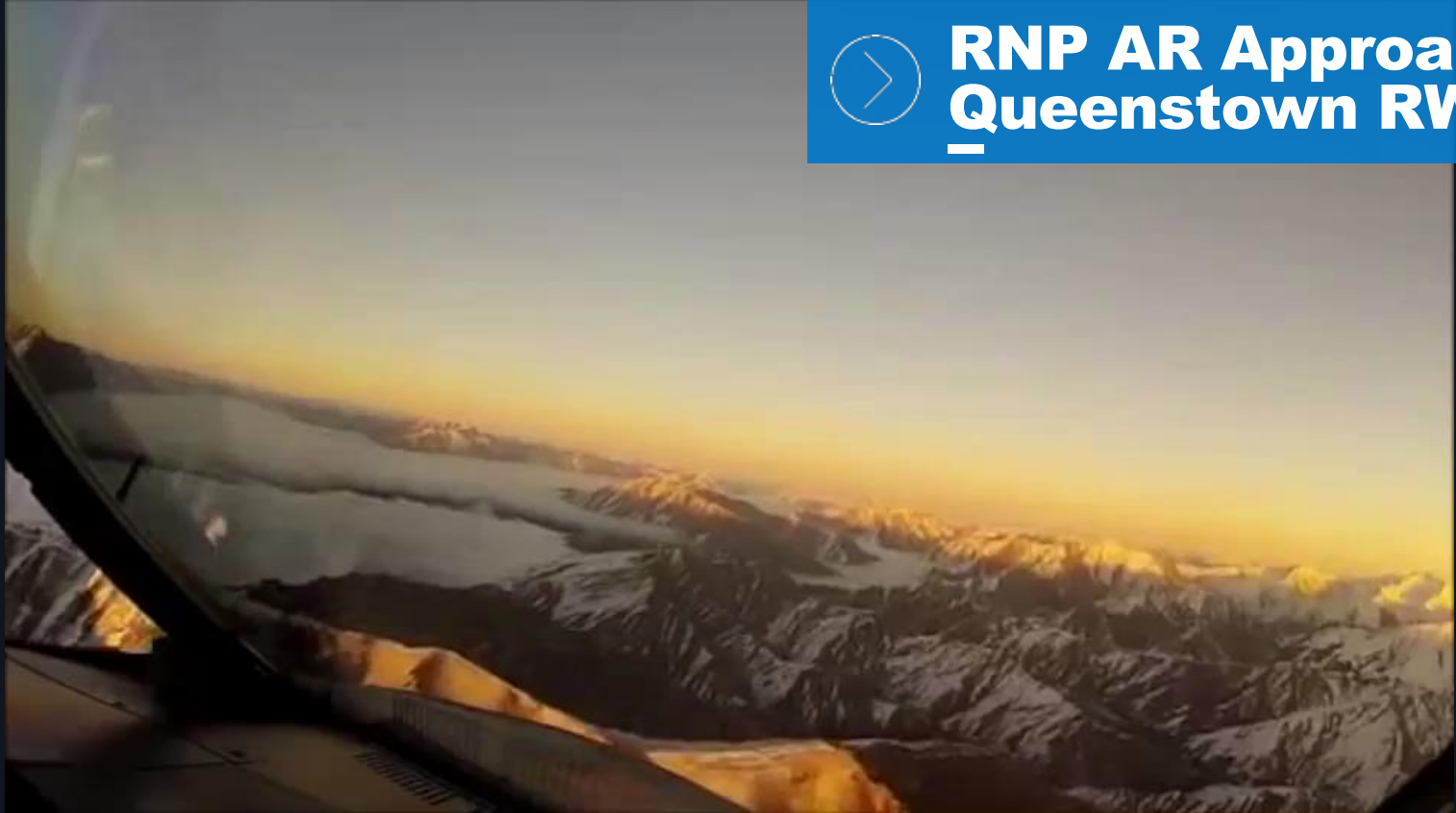
1990's

2000's

RNP objectives



RNP AR Approach Queenstown RWY 05



RNP objectives



➤ **Give access to remote areas**



PBN in terminal Area to face congested airspace

Manage High density Traffic



Advantages of PBN for ANSP

+ Independent routes

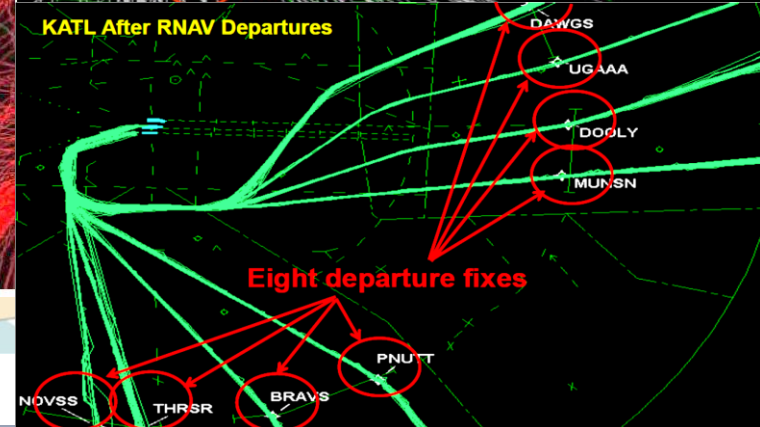
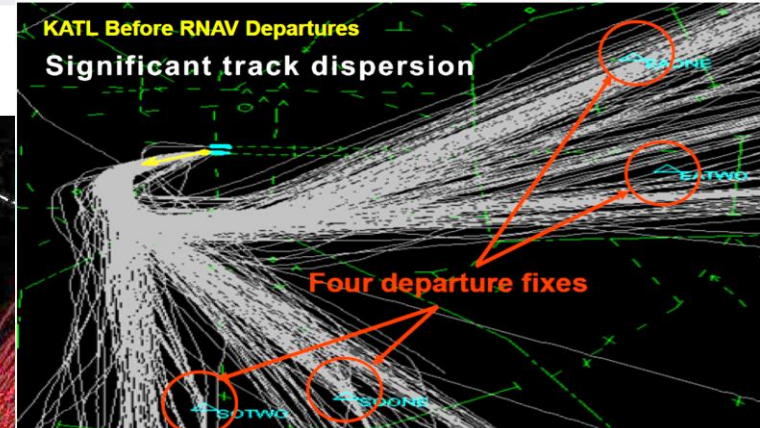
Not based from NAVAIDs location

+ Fully coded route

NDB

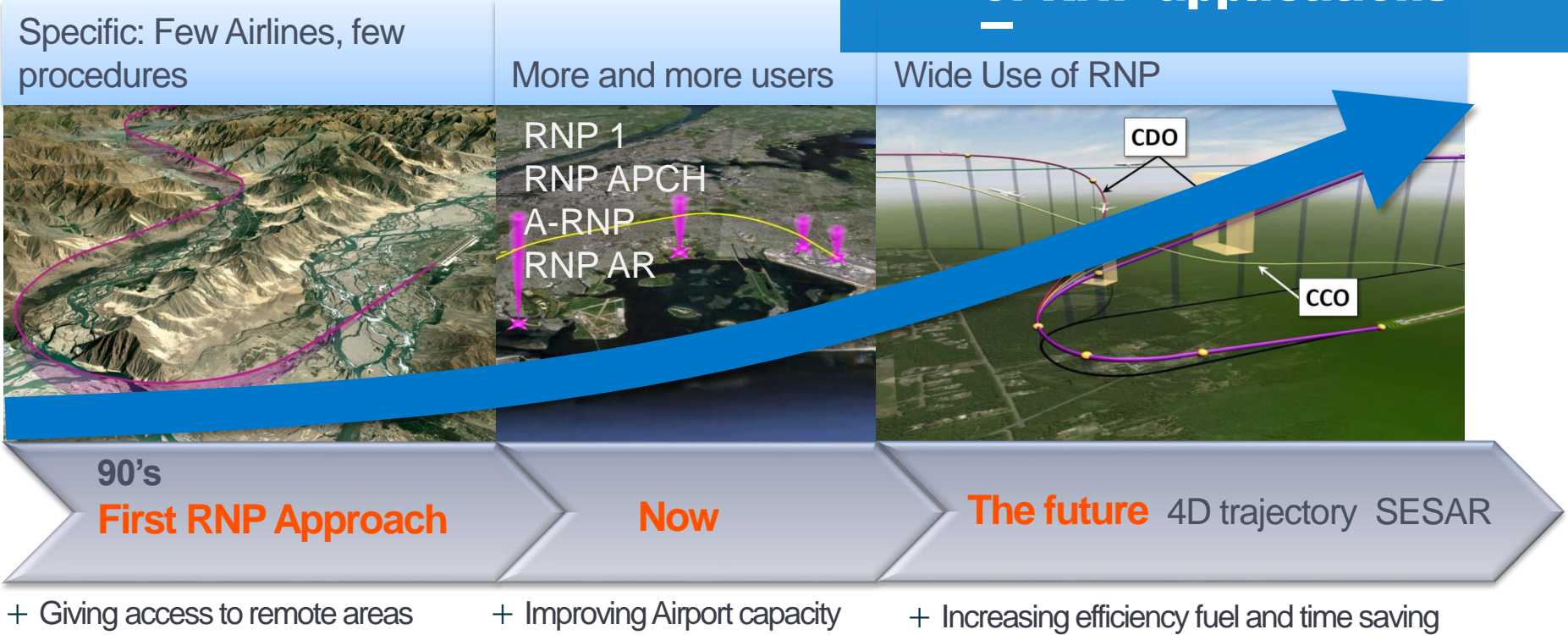
+ Lateral & Vertical containment

- Reduction of the separations
- Solution for traffic segregations between 2 airports
- Noise sensitive area avoidance



From a specific to a wide use of RNP

Increasing number of RNP applications

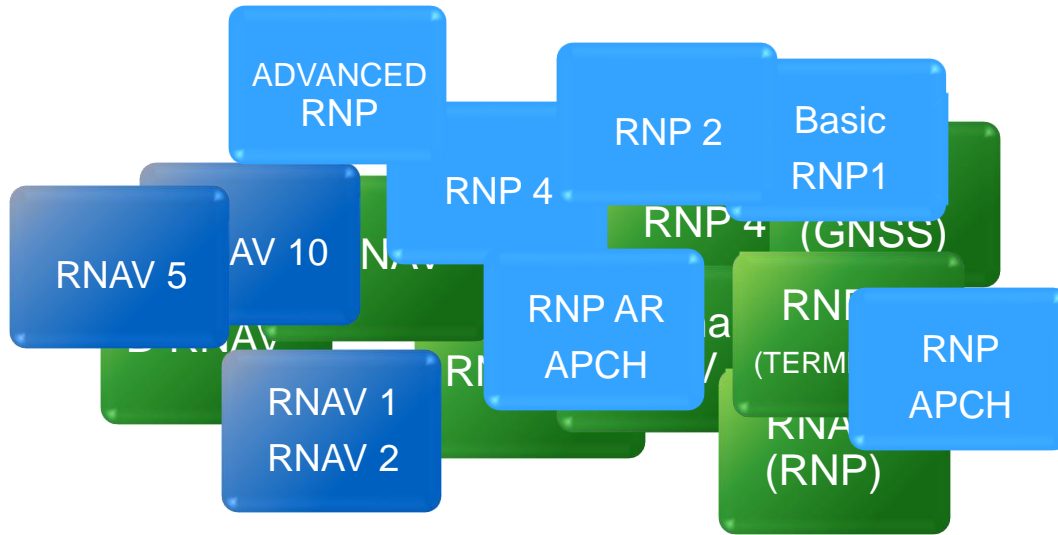


#2

PBN Operations Focus on Terminal Airspace



Lot of different operations and names



→ Difficult to find our way around

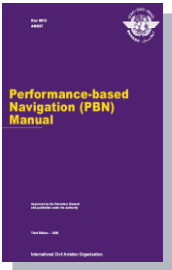
**ICAO
PBN MANUAL
(Doc 9613)
PANS-OPS
(Doc 8168)**

Navigation Specification	Navigation Accuracy (NM) per flight phase						
	En-route		Terminal	Approach			Departure
	Oceanic Remote	Continental		Initial Interm.	Final	Missed	
RNAV 10 (RNP 10)	10						
RNAV 5		5	5				
RNAV 2		2	2				2
RNAV 1		1	1	1		1	1
RNP 4	4						
RNP 2	2	2					
RNP 1			1	1		1	1
RNP APCH				1	0.3 or angular	1	
RNP AR APCH				1-0.1	0.3-0.1	1-0.1	



**PBN
Standard**

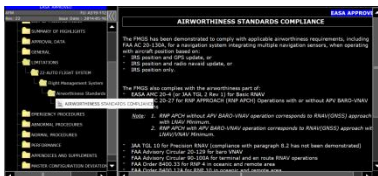
PBN Manual and Airbus documentation



**NOT a regulatory guidance
Standard and recommended practices**

A/C compliant to FAA or EASA regulations

**Operational documentation (AFM/FCOM)
Statement of compliance with EASA or FAA regulation**

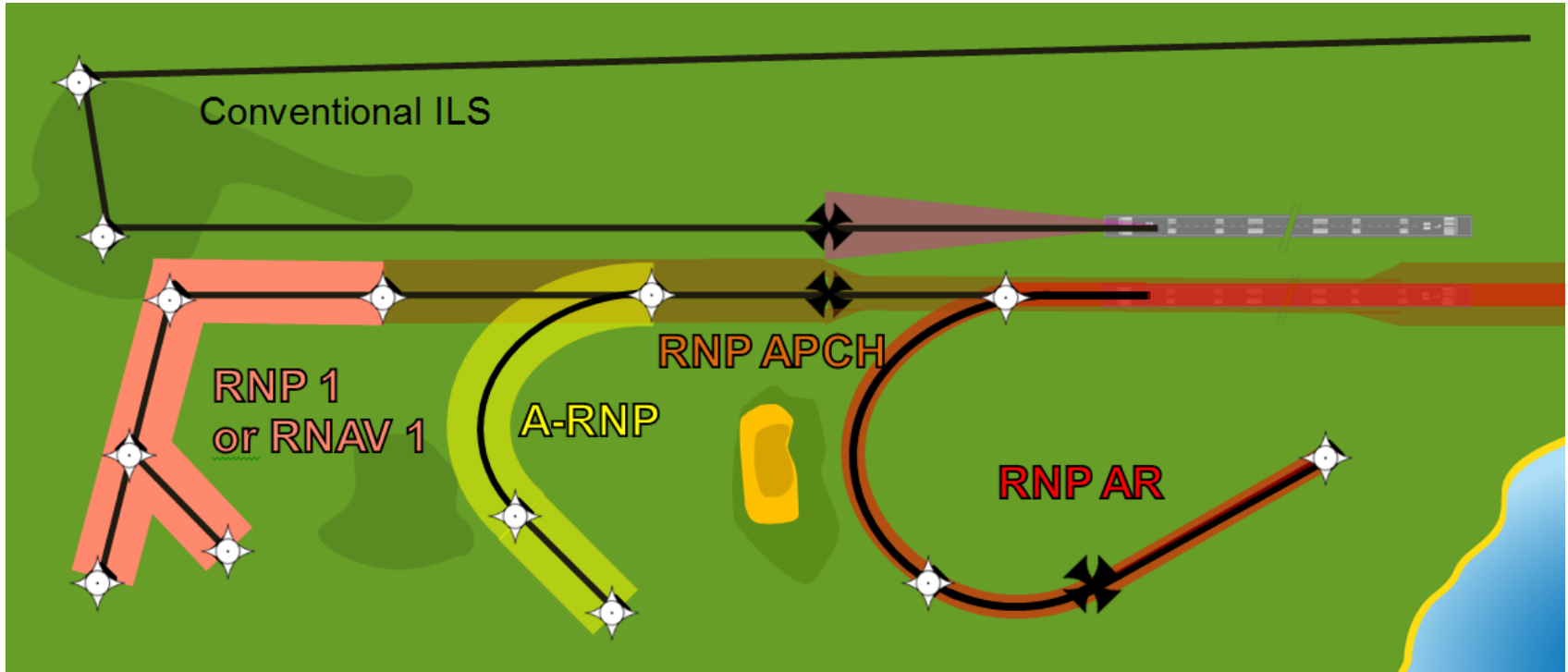


Airbus Flight Operations documentation

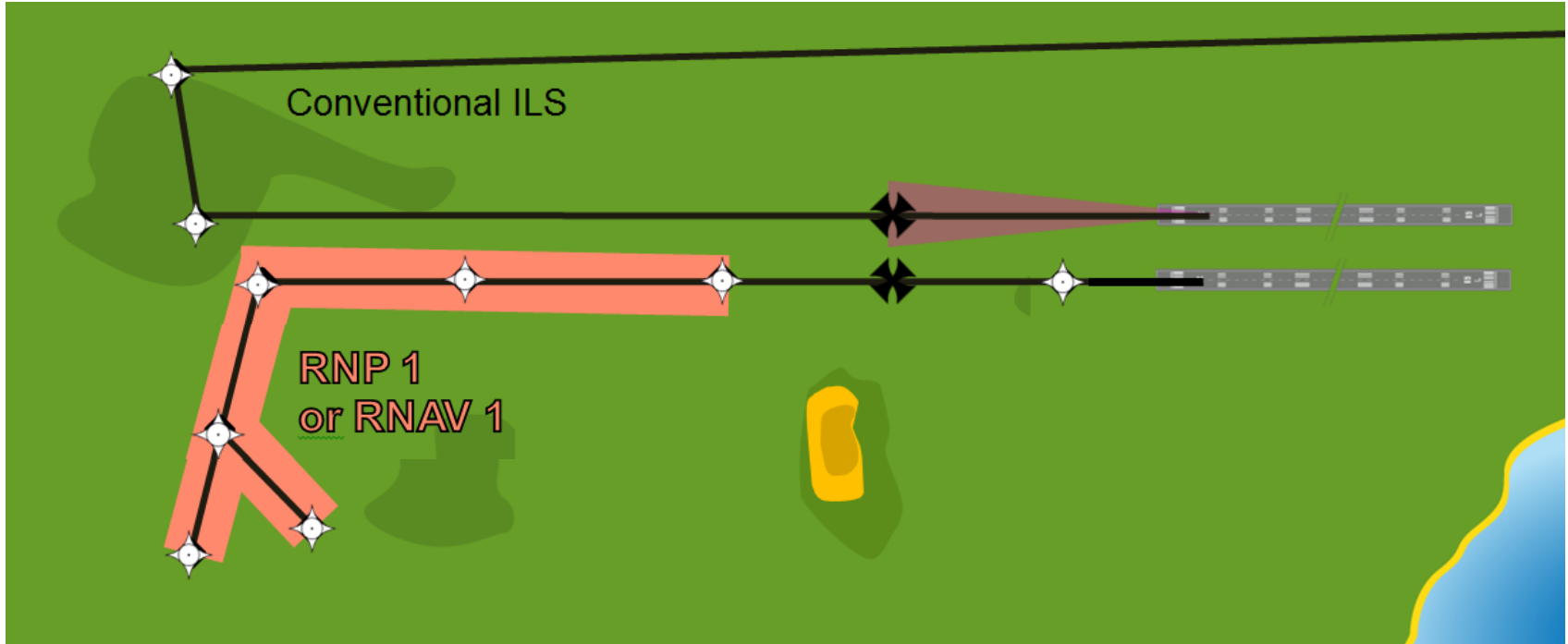
- + **PBN Capability** declared in **AFM (LIM / 22 AFS)**
- + **PBN procedures** detailed in **FCOM**
- + **Dispatch conditions for PBN** indicated in **MMEL**



Focus on RNP in terminal area



RNAV 1 or RNP 1



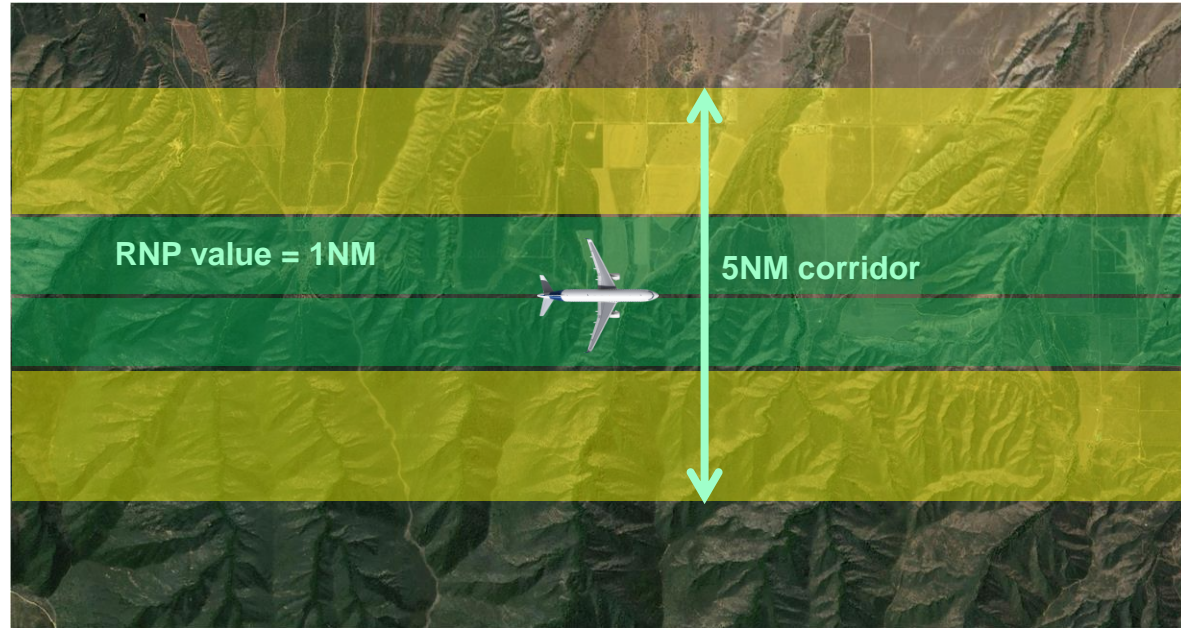
RNAV 1 and RNP 1 procedure design

+ Same **corridor definition but**

+ Same corridor definition

+ **1 NM RNP value**

+ **Terminal Airspace, for SID and STARS**



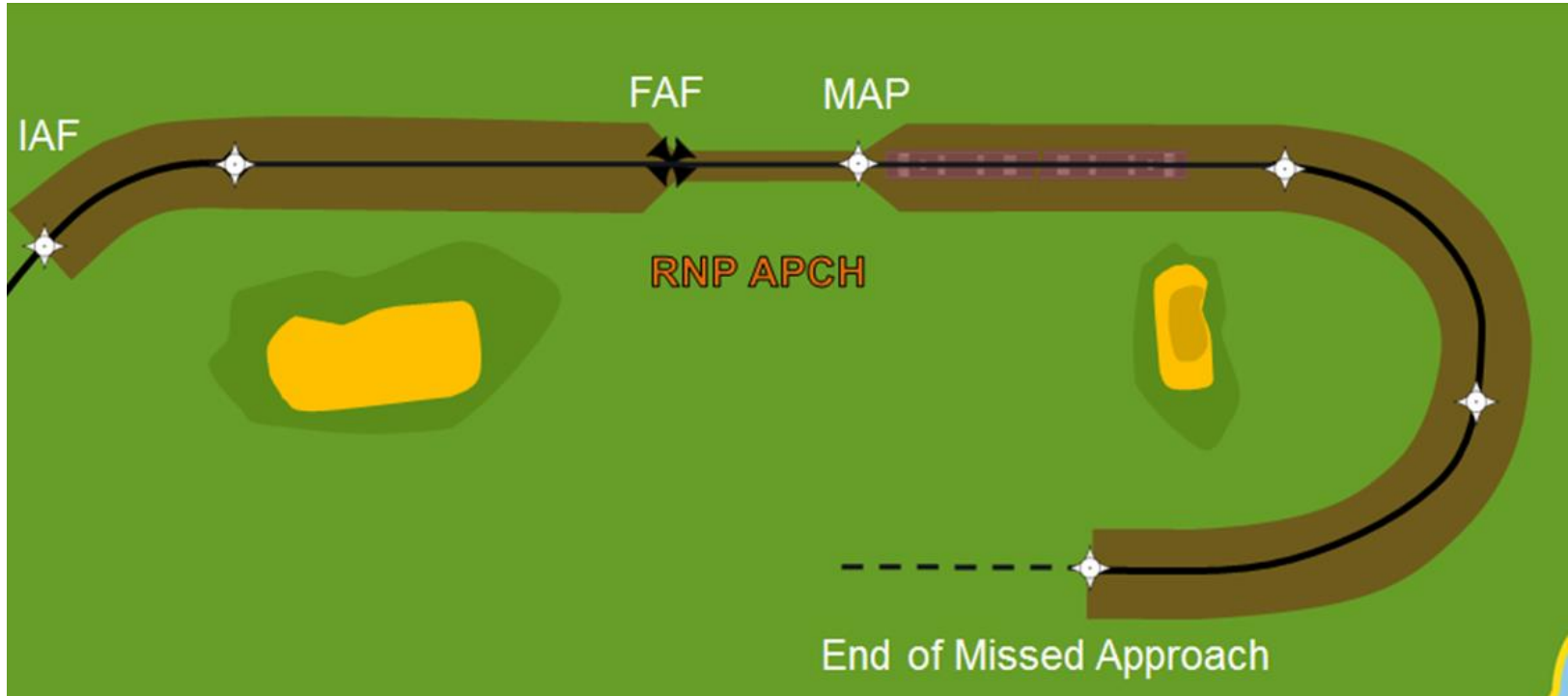
RNAV 1 vs RNP 1

+ Same **corridor definition BUT**

	RNAV 1	RNP 1
On Board Performance Monitoring and Alerting System need	OBPMA not mandatory → ATC controller needed	OBPMA mandatory: A/C autonomous
GPS	Optional (possibility to use IRS/NAVAIDS)	GPS Mandatory
Regulation	EASA TGL 10 FAA AC 90-100A	No EASA regulation FAA AC 90-105 (A)
Airbus A/C compliance	All Airbus	With GPS

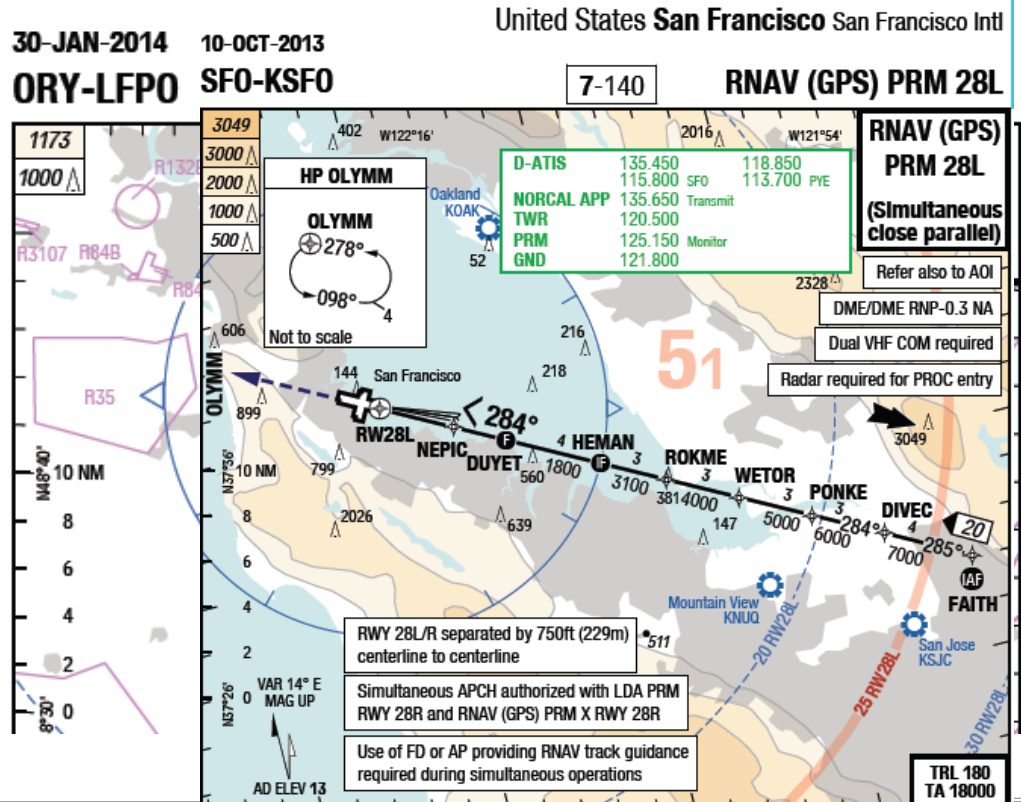


RNP APCH



RNP APCH concept

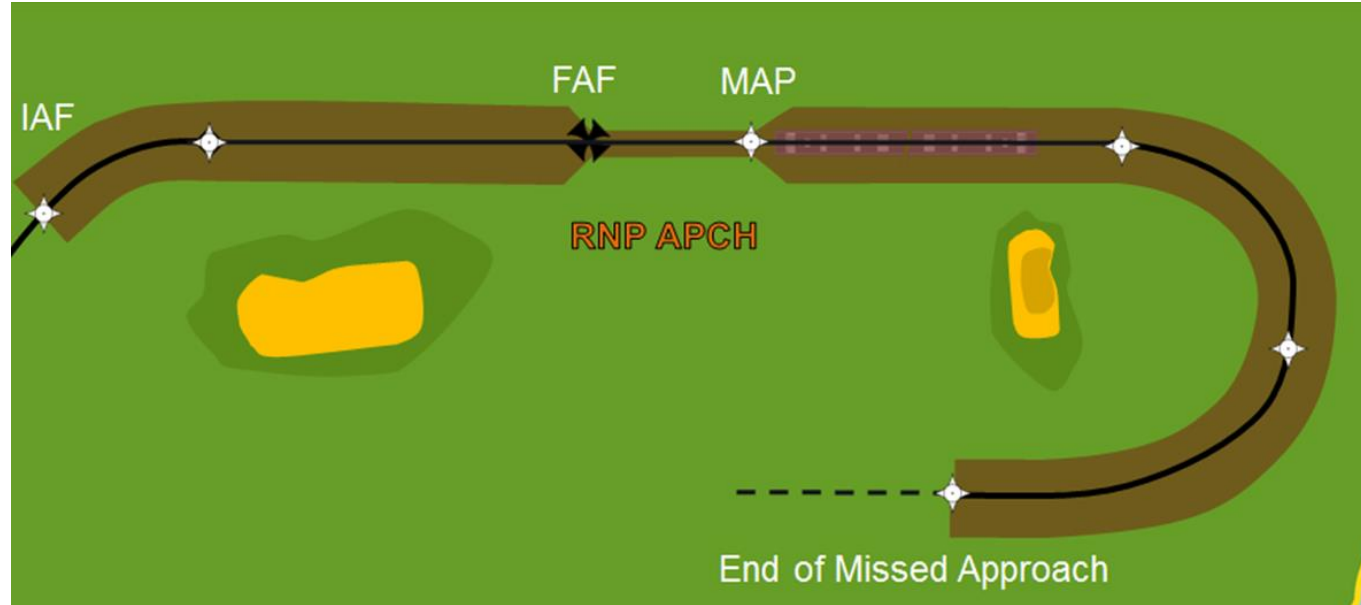
- + **Overlay of existing procedure**
- + **RNP value 0.3NM in final separation**
obstacle avoidance
lower minima
- + **Decongestion of Terminal Airspace**



RNP APCH

Concept:

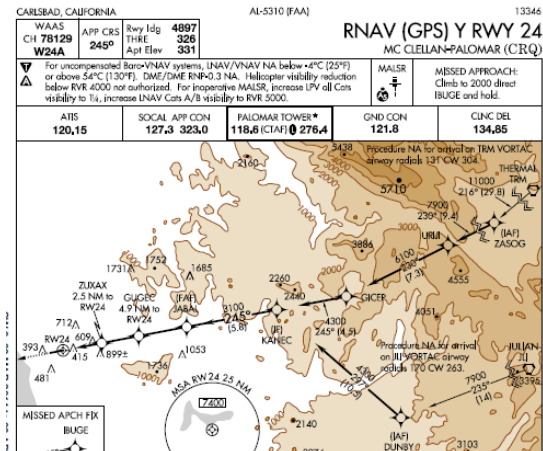
- + **Straight approach after FAF**
- + **RNP 0.3 NM in Final Leg**
- + **RNP 1 NM in Initial, Intermediate and Missed Approach**



RNP APCH concept

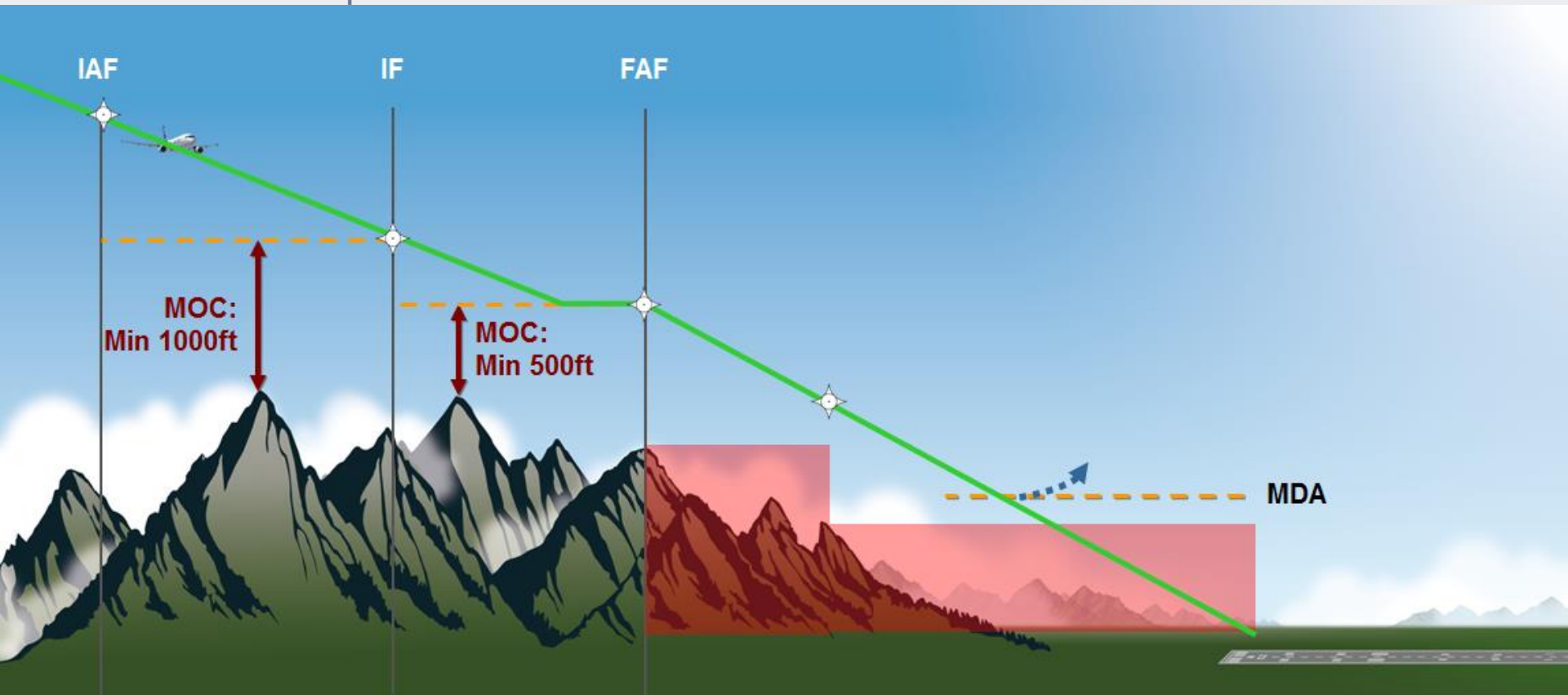
Concept:

- + **Straight approach after FAF**
- + **RNP 0.3 NM in Final Leg**
- + **RNP 1 NM in Initial, Intermediate and Missed Approach**
- + **Several minima**

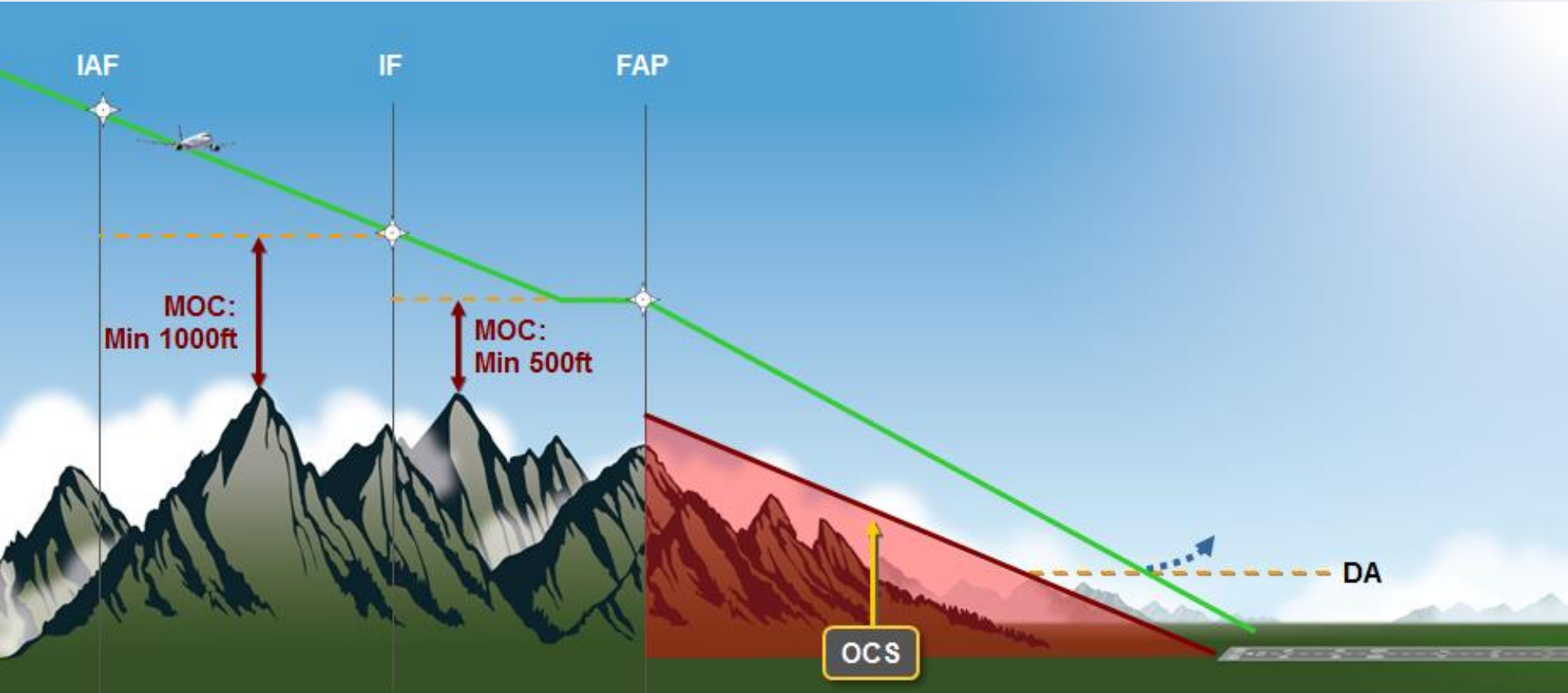


CATEGORY	A	B	C	D
LPV DA	737/45 411 (500-7/8)			NA
LNAV/VNAV DA	927-1½ 601 (600-1½)			NA
LNAV MDA	1000/40	674 (700-¾)	1000-1½ 674 (700-1½)	NA
CIRCLING	1000-1	669 (700-1)	1080-2¼ 749 (800-2¼)	NA

RNP APCH concept

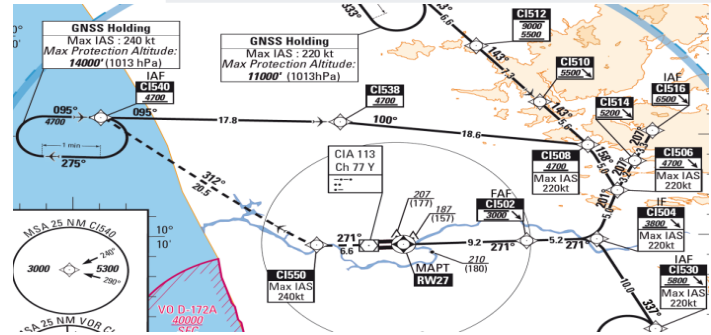


RNP APCH concept



RNP APCH

+ Operation charted RNAV(GNSS) or RNAV(GPS)

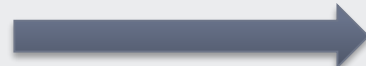


Regulation

Aircraft compliance



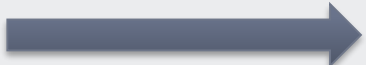
AC 90-105
AC 90-105A app A and B



LNAV/VNAV: FMS2+GPS



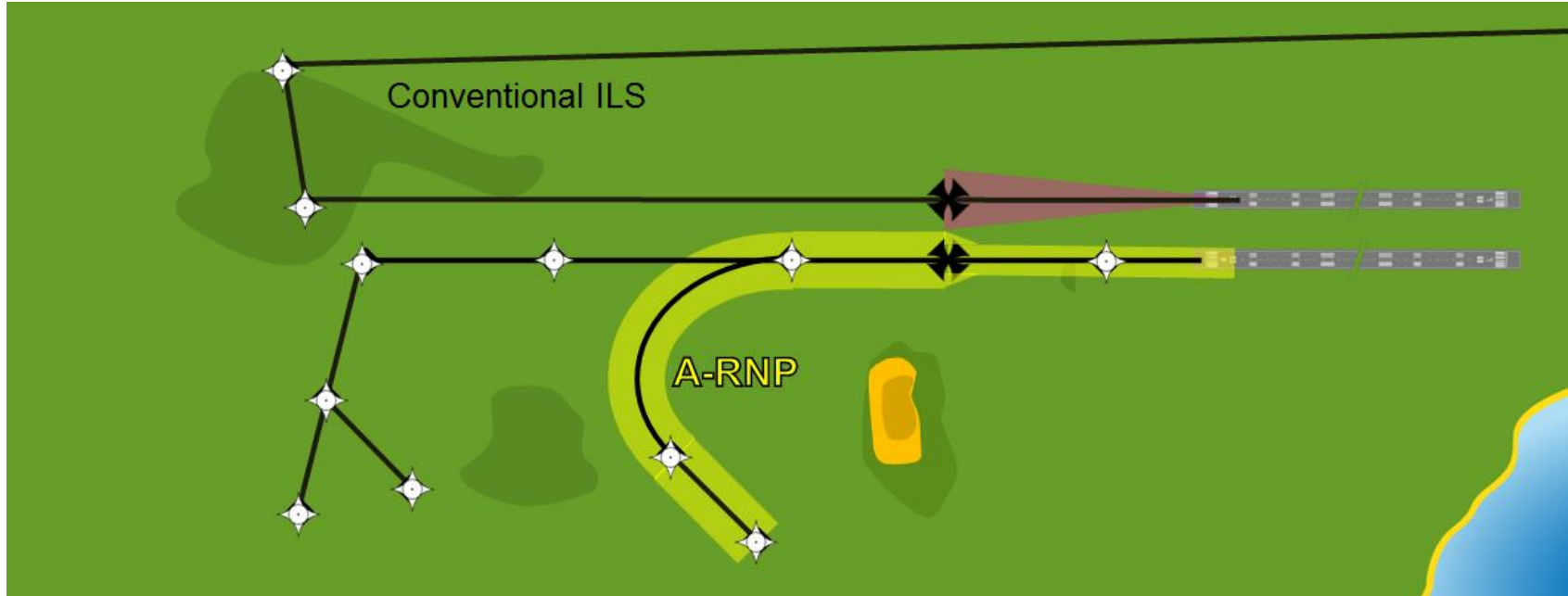
AMC 20-27



LNAV/VNAV: All A/C with GPS (except A300)



Advanced RNP and RF leg



Advanced RNP according to ICAO PBN Manual

New operation

+ Concern operation

RNAV 5, 2, 1
RNP 2, 1, APCH

+ Functional requirement

- **RF legs** **required**
- Fixed Radius Transition optional
- RNP scalability optional
- Higher continuity optional
- Baro VNAV optional
- Time Of Arrival Control optional (not yet defined)

In case of degraded or non B-RNP 1 approved, ACFT shall use PECAN/ATENA RNAV SIDs.

ACFT that do not have RF capability shall use PECAN/ATENA RNAV SIDs.

MSA valid within Hong Kong FIR only

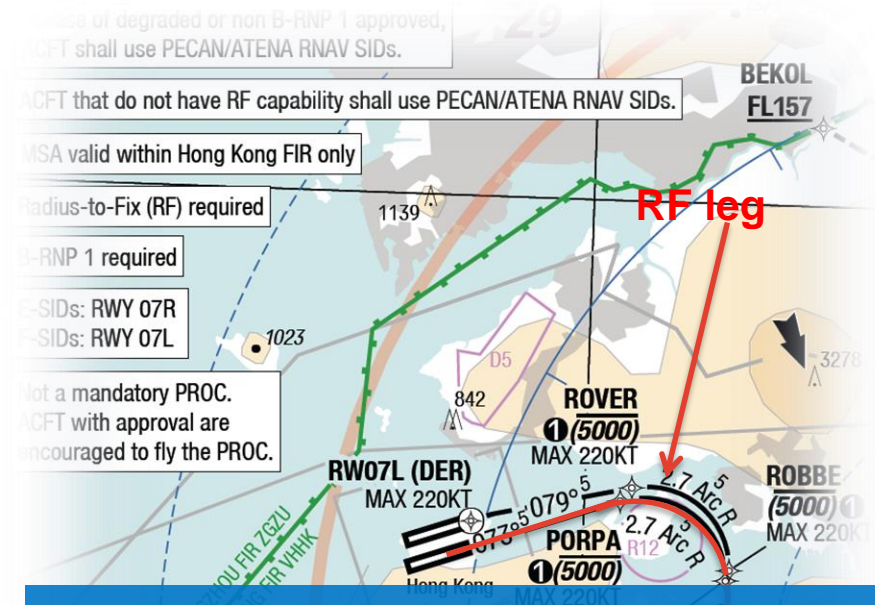
Radius-to-Fix (RF) required

B-RNP 1 required

E-SIDs: RWY 07R

F-SIDs: RWY 07L

Not a mandatory PROC.
ACFT with approval are encouraged to fly the PROC.

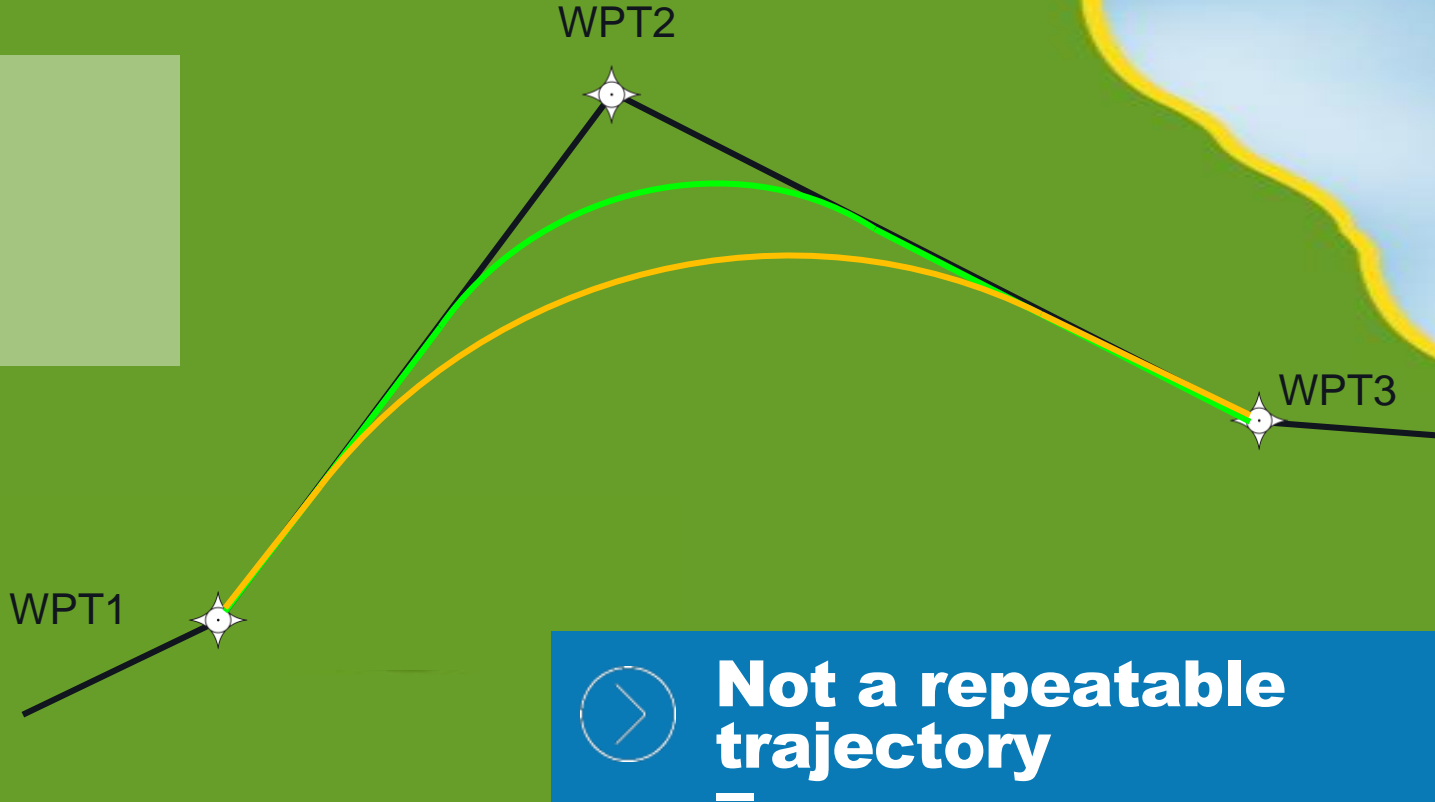


Focus on RF legs

RF legs

Without RF legs

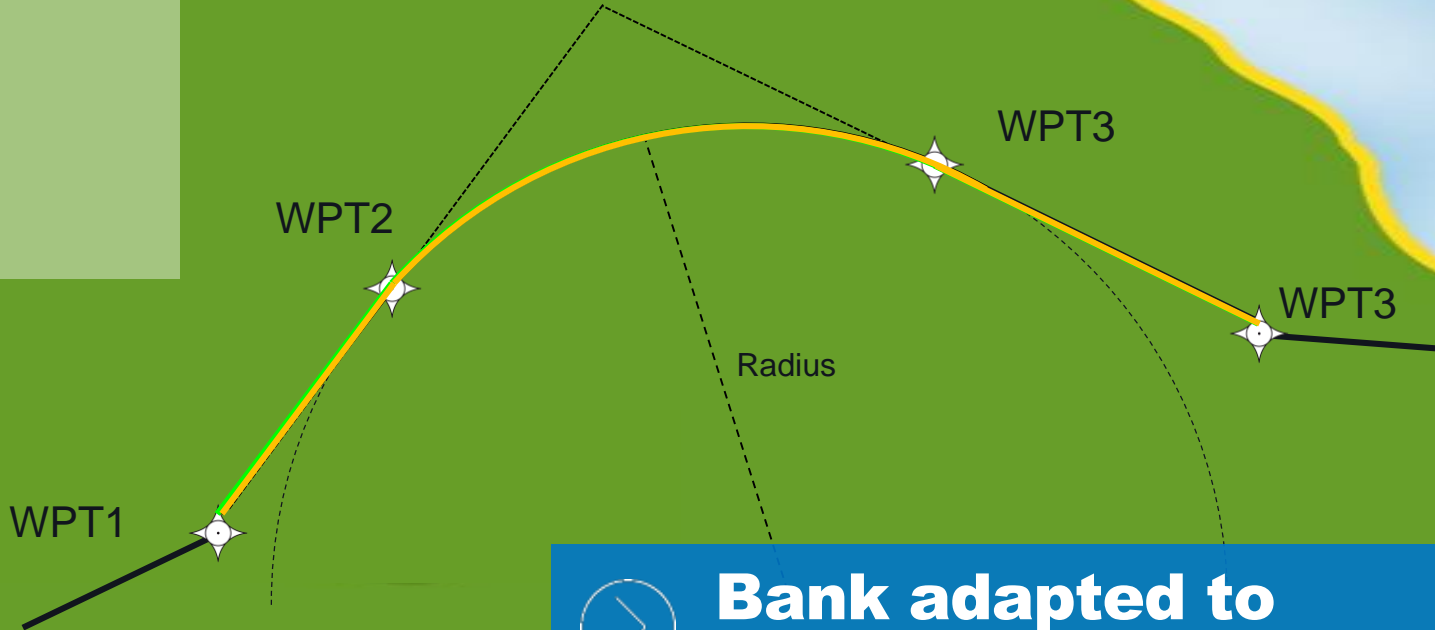
Fixed bank flight –by



ADVANCED RNP: RF legs

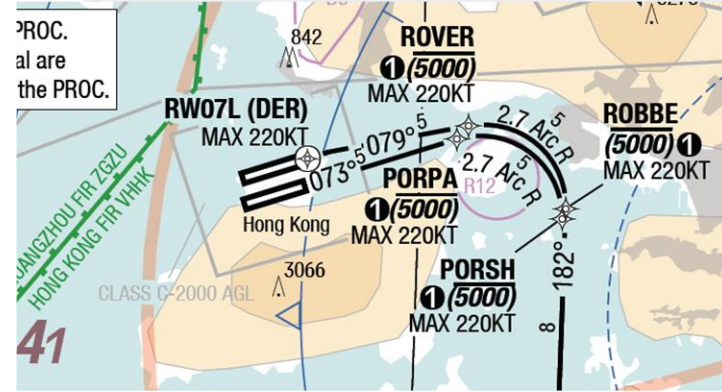
With RF legs

Fixed trajectory



RF leg capability

- + **Decongestion of Terminal Airspace**
- + **Use of RF legs on**
 - + **RNP 1**
 - + **RNP APCH outside Straight Final Approach**



Regulation

Aircraft Compliance



AC 90-105 app5 RF capability
AC 90-105A app I



with FMS2 + GPS



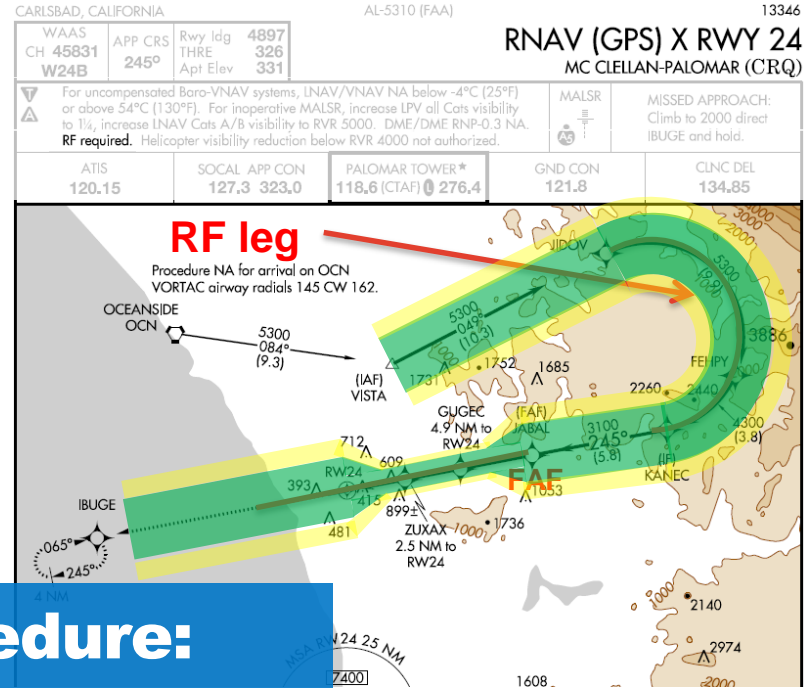
in future regulation CS-ACNS

RF leg with RNP 1 or RNP APCH

+ RF legs in Initial segment

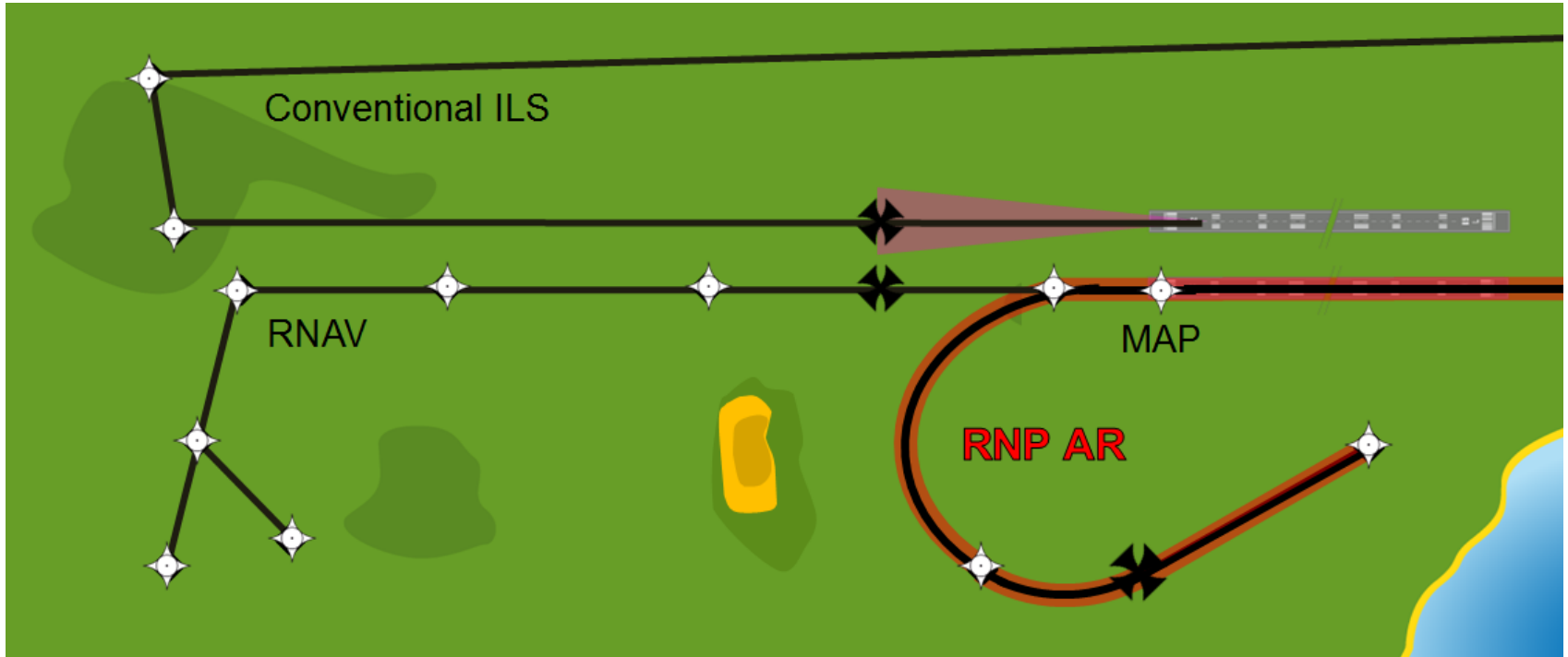
+ But still the same procedure design

- RNP=0.3 straight final approach (without RF)
- RNP=1 outside final approach segment
- Buffers



**For more complex procedure:
RNP AR is needed**

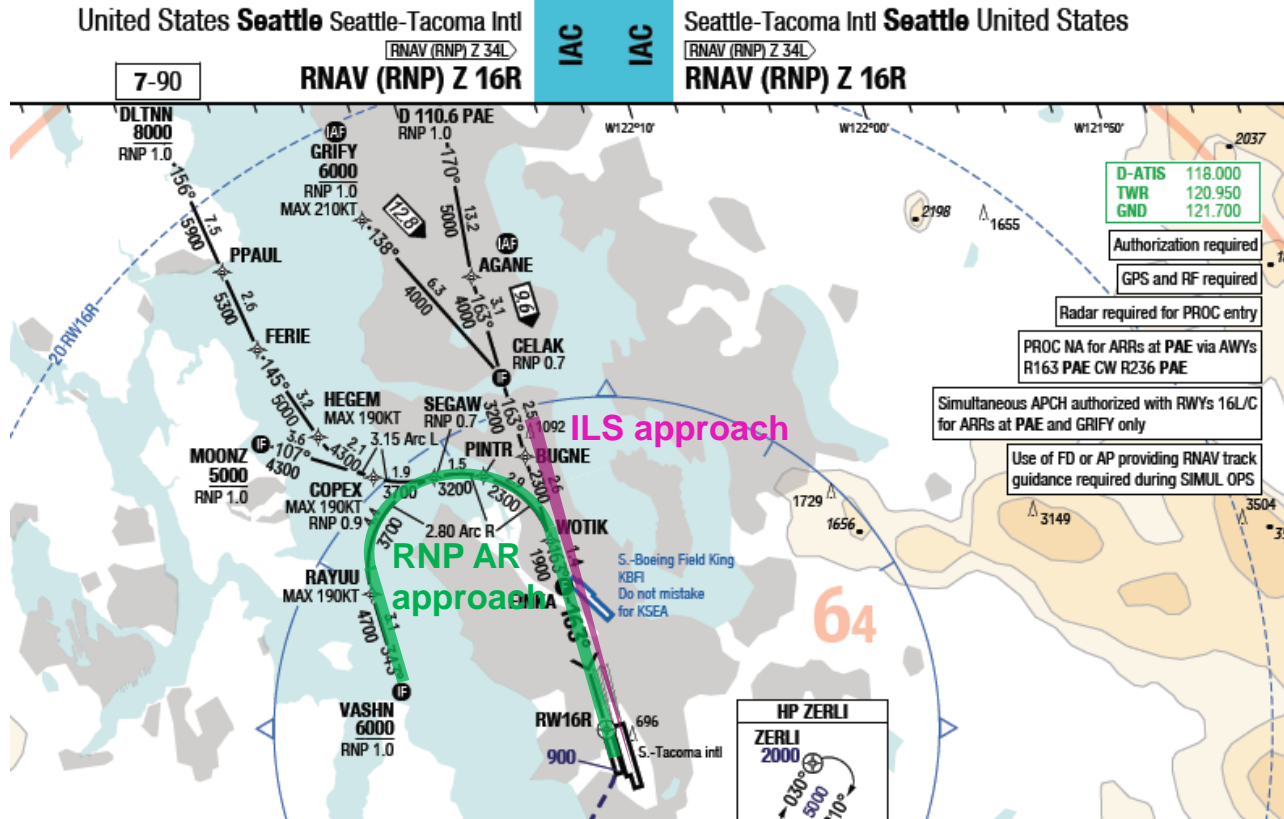
RNP AR: Authorisation Required



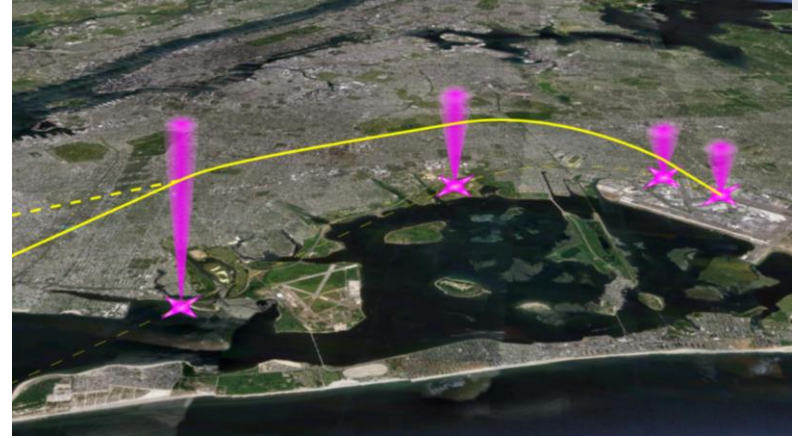
RNP AR in traffic-challenging environment

+ Late turn

+ Closely Space Parallel Operation



RNP AR: Authorisation Required



Regulation

Aircraft compliance



AC 90-101A



AMC 20-26



Specific aircraft modification

Specific equipment (minimum configuration)

A320 and A330 family

+ **Implies a Minimum configuration**
→ **2 MODs**

+ **RNP AR limited to 0.3NM**

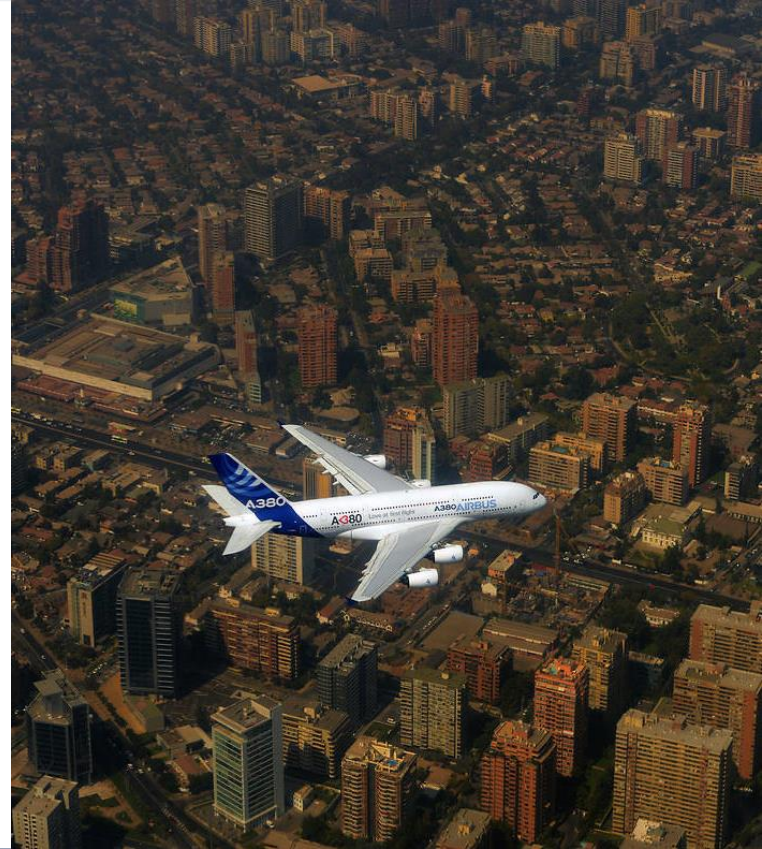
+ **RNP AR below 0.3NM**

- Airworthiness RNP value:
 - EASA → 0.3NM
 - FAA → 0.1NM
- RNP value down to 0.1NM depending of operation targeted,
 - maximum reachable RNP value must be assess during the **FOSA**



A380

+ **RNP AR MOD limited to 0.3 NM** only



A350 XWB

+ RNP AR 0.1NM basic

- AMC 20-26 down to 0.1NM

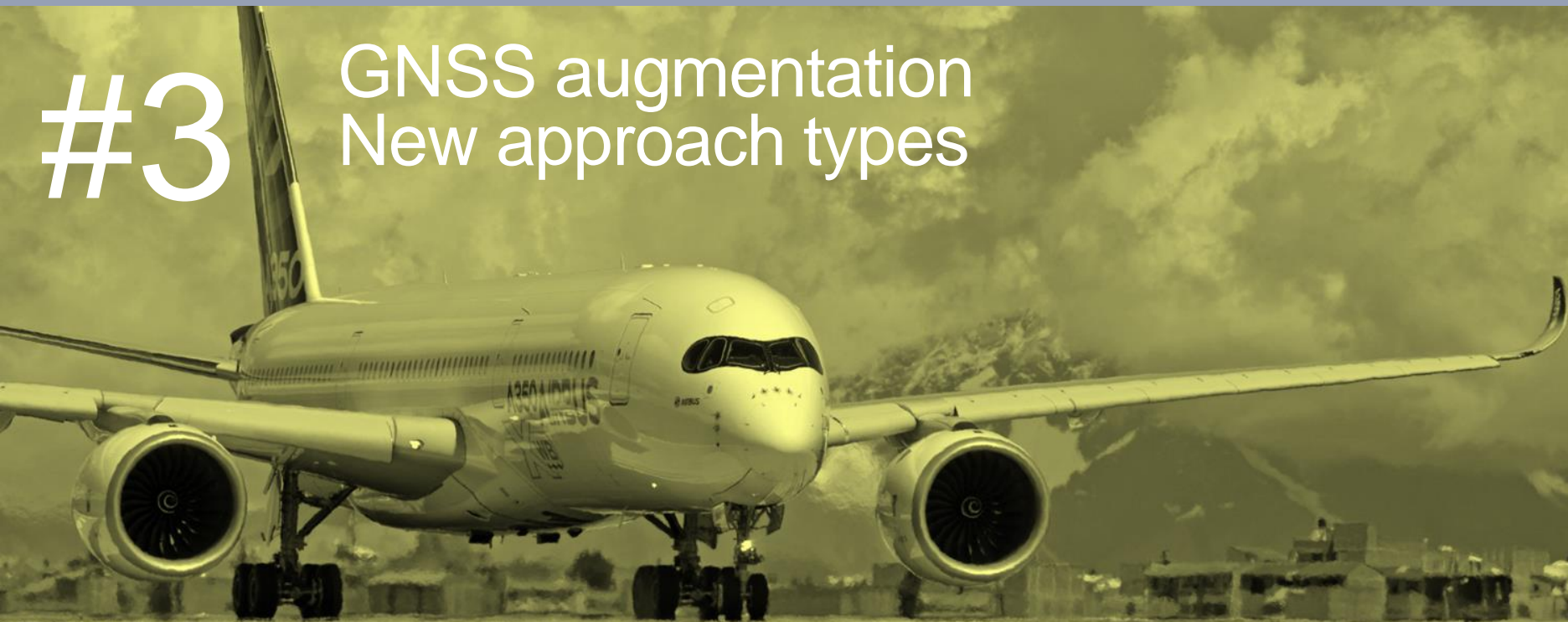
➔ Specific RNP AR Architecture & HMI design

- Triplex architecture
- RNP AR monitoring
- Back up functions
- Excessive deviation flashing



#3

GNSS augmentation New approach types



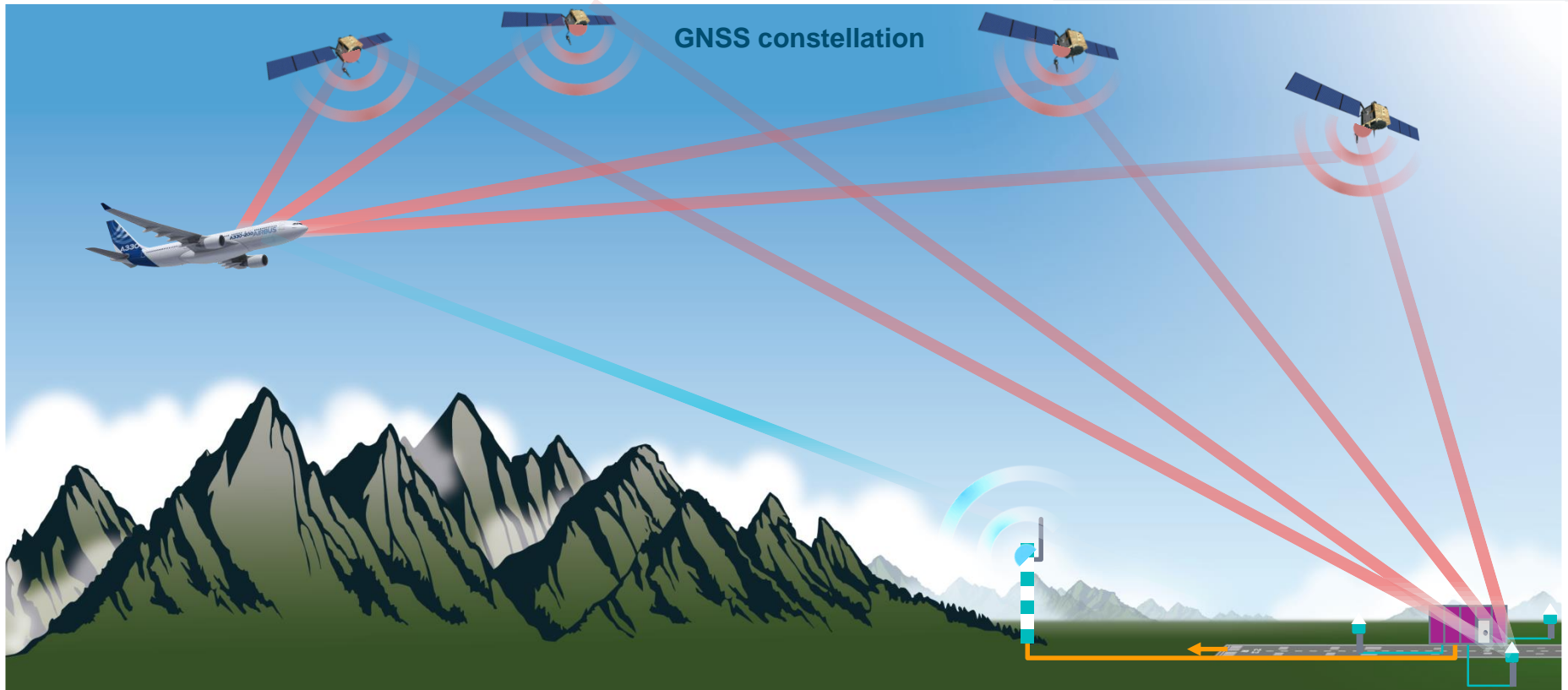
Differential GPS concept – New concept



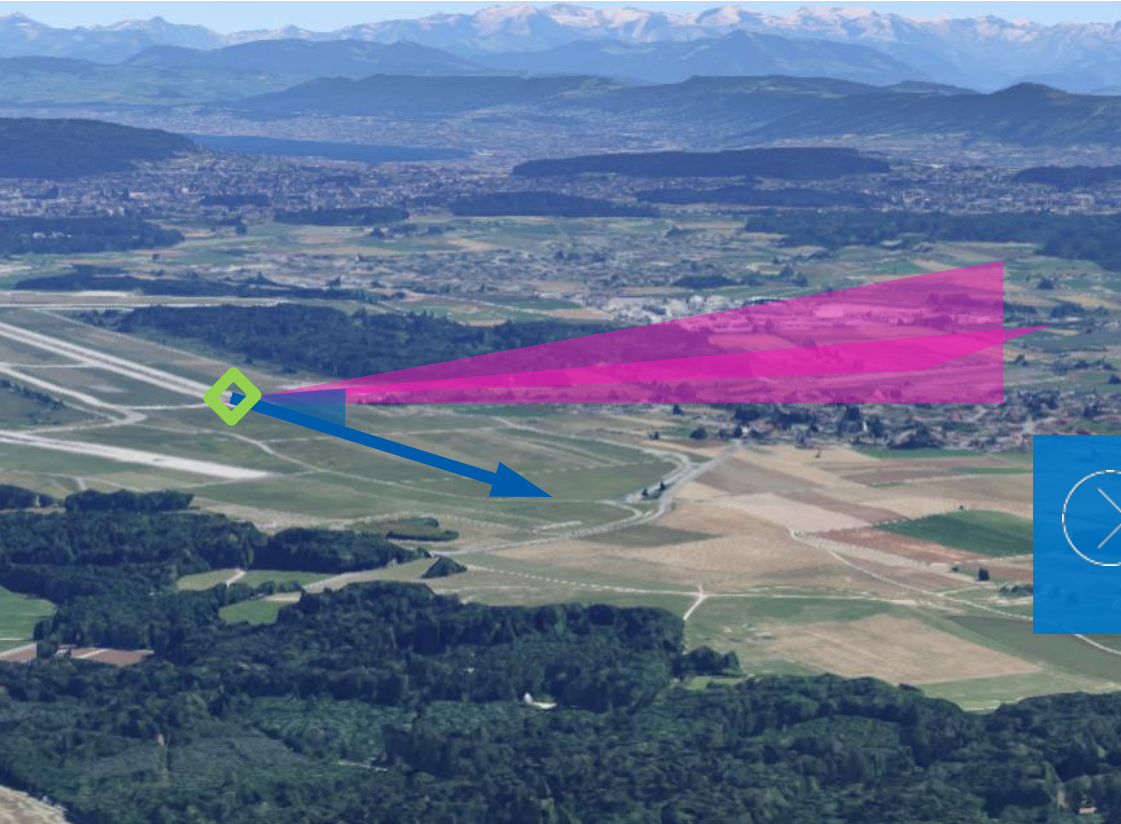
Augmentation of the accuracy and integrity

- + **GPS augmented position**
thanks to reference stations
- + **Vertical geometrical**
Not barometric sensitive
- + **2 solutions:**
GBAS (not part of PBN ops)
SBAS

GBAS Landing System: GLS



GLS: Data transmitted to the A/C



- + **GPS augmented position** by VHF
- + **Final Approach Segment data** by VHF

Anchor point coordinate
Course
Slope



MMR computes a virtual beam

- + **Flown in G/S | LOC**

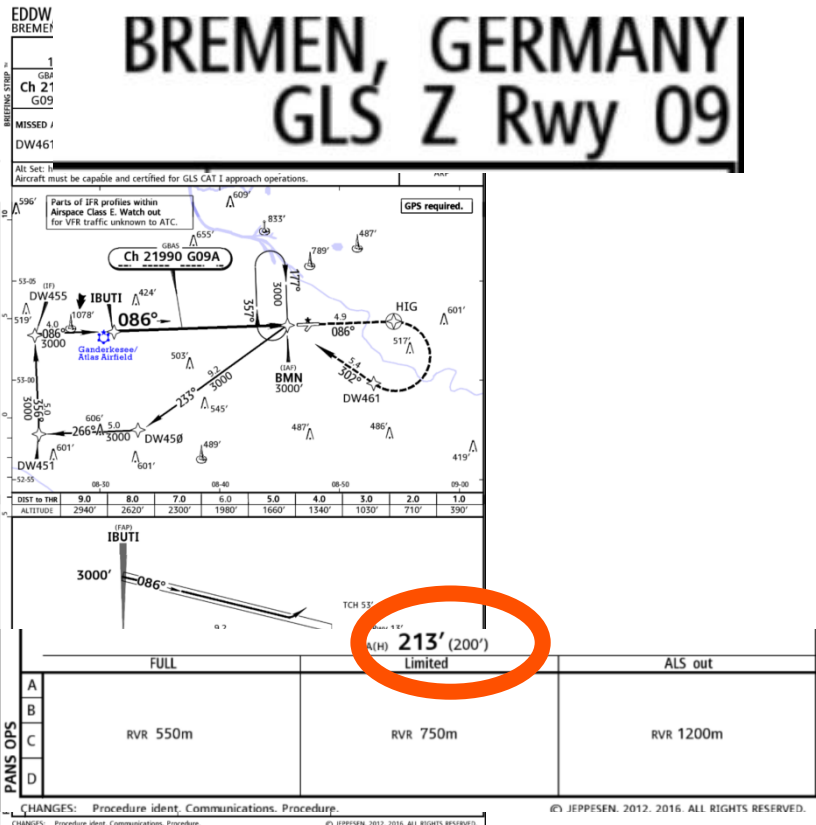
xLS concept: GLS



**Same guidance
mode as ILS**

- + **Geometric**
- + **Common FCOM/SOP for all straight in approaches**

GBAS on charts: GLS approach



+ Charted as GLS

- Angular protection **same as ILS**
- **Geometric** vertical guidance
- Minima down to **200 ft (CAT1)**

GLS approaches



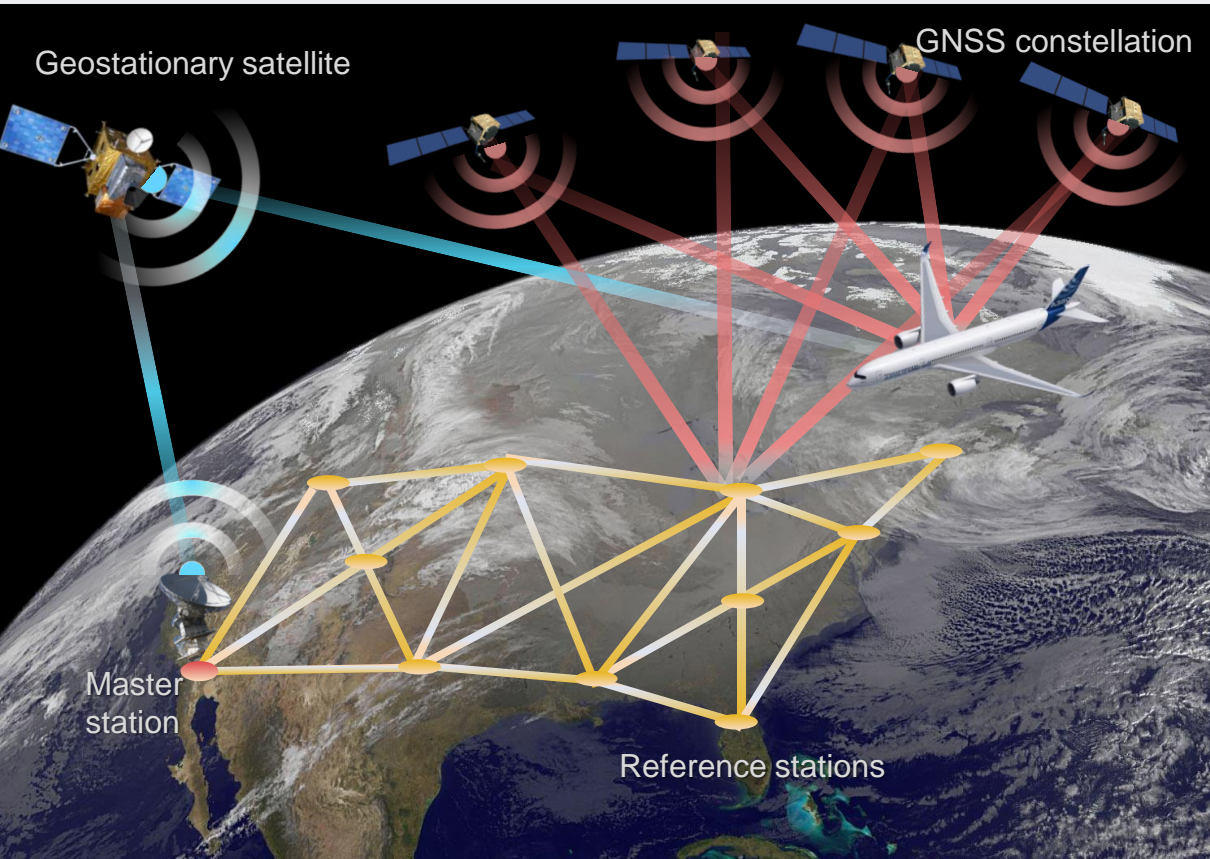
- + **One station for all runways** with different channel
- + **Customisation**
 - Displaced Threshold
 - Various slope
- + **CAT I autoland capability** available on A380, 350, 330 and 320
- + **CAT III autoland** Under study

- **Operational** (with dot: charts published)
- **Planned Installations**
- **Special Category, S-CAT I** (with dot: charts published)
- **Prototype/Research** (with dot: actively transmitting)



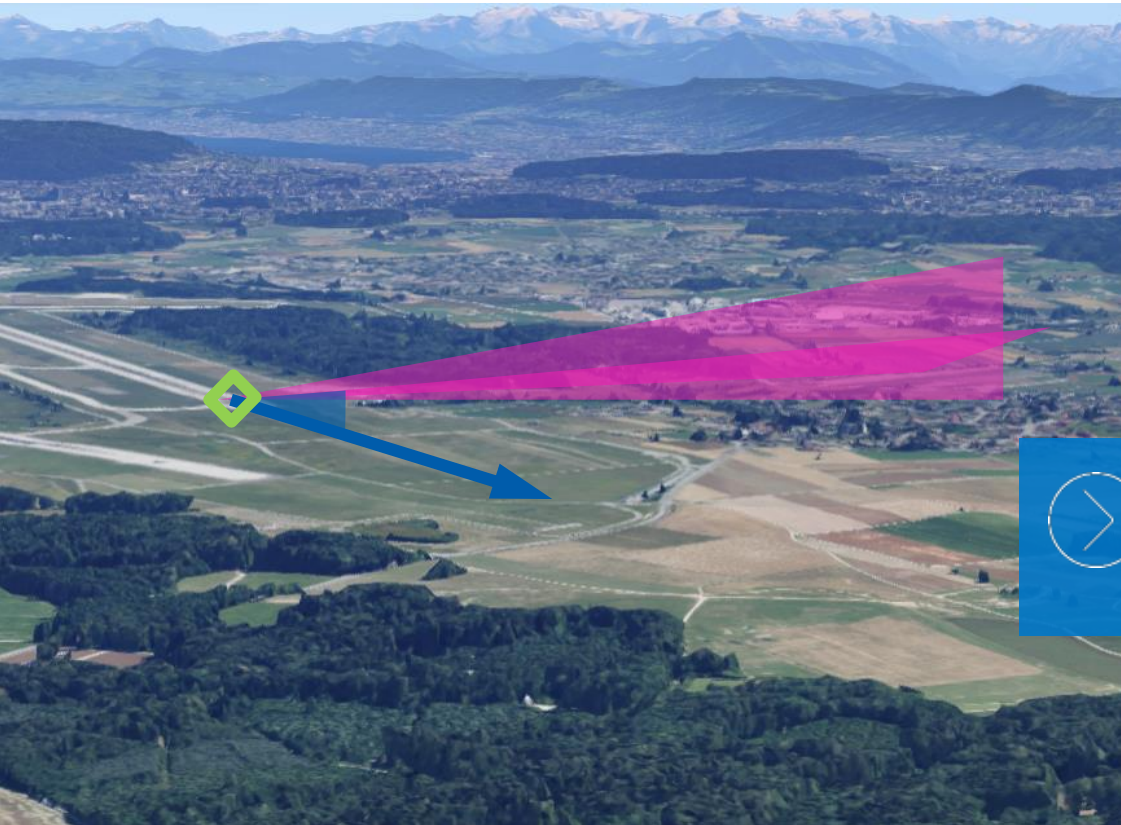
GLS
More and more deployed

Satellite Based Augmentation System



- + **Wide Area Network**
of reference stations
- + **Transmission of the data**
via geostationary satellite
- + **A/C system computes a virtual beam**
Angular geometric guidance

Data transmitted to the A/C



- + **GPS augmented position** by geostationary satellite
- + **Final Approach Segment data** in NDB
 - Anchor point coordinate
 - Course
 - Slope



MMR computes a virtual beam

- + **Flown in G/S | LOC**

xLS concept: SLS



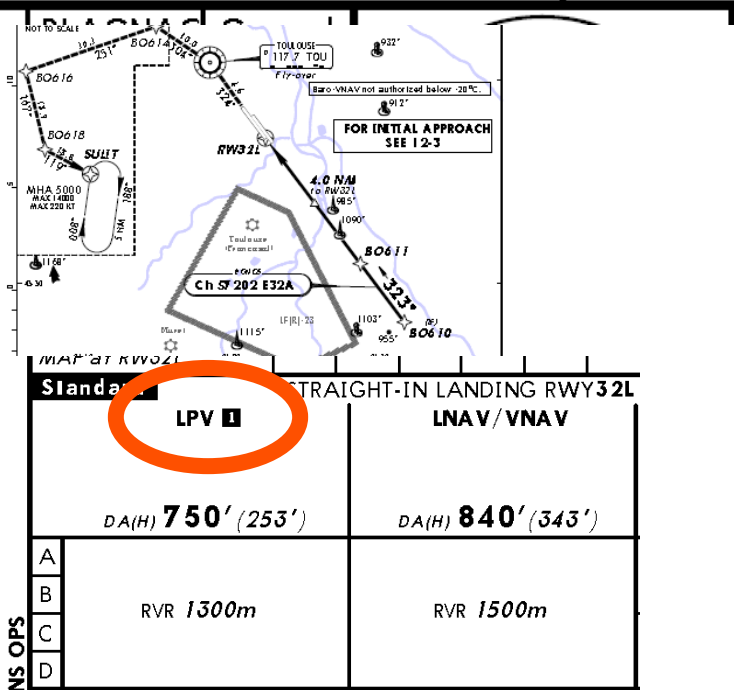
**Same guidance
mode as ILS**

- + **Geometric**
- + **Common FCOM/SOP for all
straight in approaches**

SBAS on charts: LPV minima

TOULOUSE, FRANCE

RNAV (GNSS) Rwy 32L



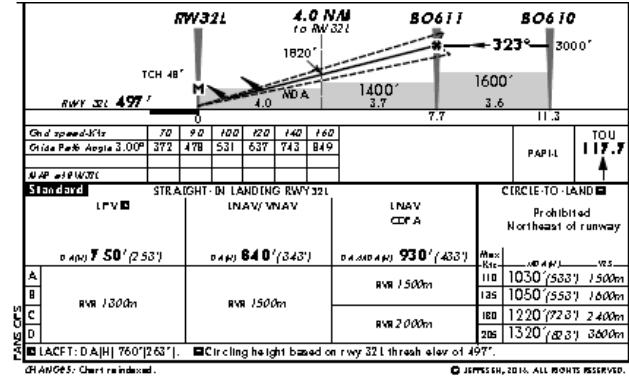
+ RNAV(GNSS) with LPV minima

+ RNAV(GNSS) Approach BUT

- Angular protection (in addition to linear) same as ILS
- Geometric vertical guidance
- Minima down to **200 ft** (CAT1)

RNP APCH with LPV minima

- + Equivalent to **CAT I**
- + **Customisation** (as GLS)
 - Displaced Threshold
 - Various slope
- + **No specific on-ground station** needed
- + Need to be **in an SBAS area** (in US with WAAS, in Europe with EGNOS)



Regulation

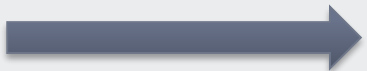
Aircraft compliance



AC 90-107



AMC 20 -28



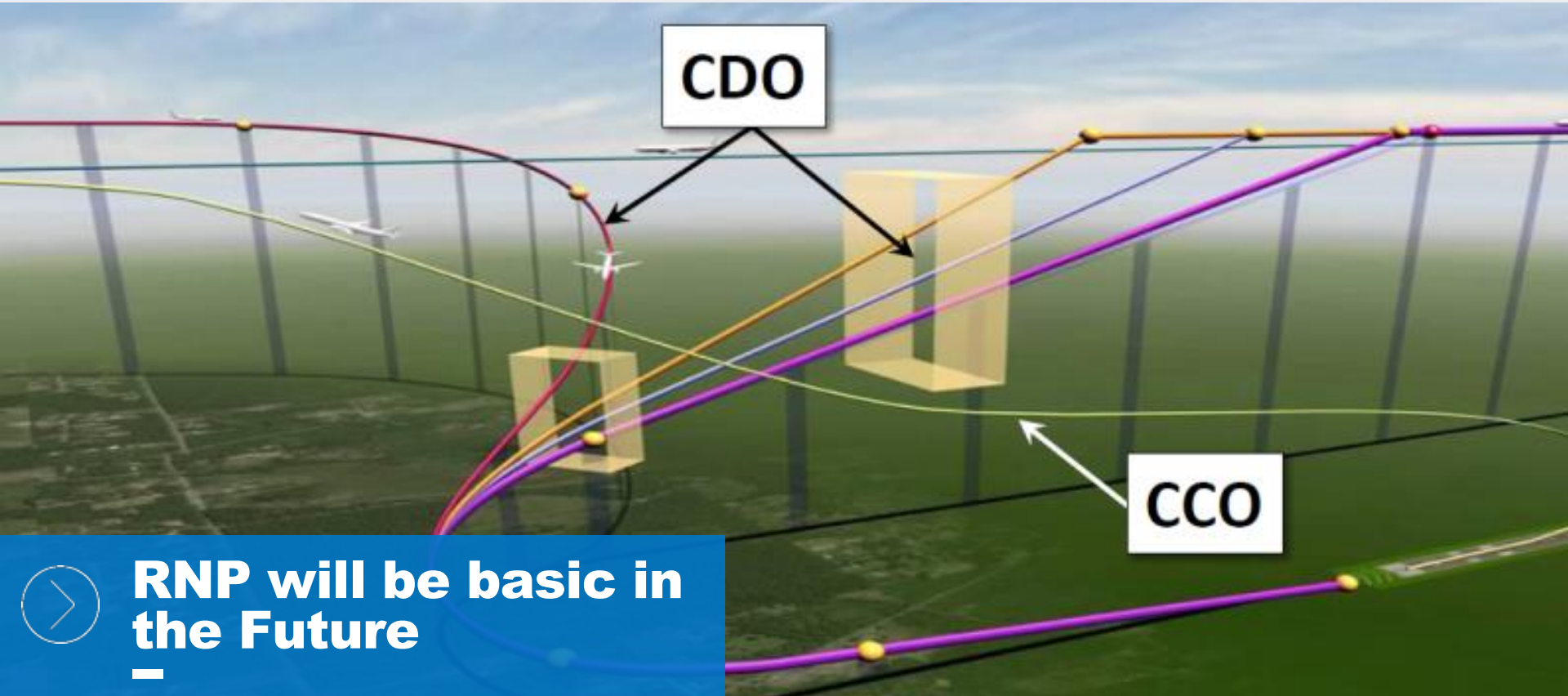
Optional on A350 (dedicated SB)
Feasibility study on other Airbus A/C

#4

Next Steps



Next Steps: Regulation changes on PBN



Next Steps: Regulation changes on PBN

- + **No more ops approval**, except for RNP AR (SPA.PBN.100)
- + **Generic ops approval** for non specific RNP AR (SPA.PBN.105)
- + RNP will be **part of ATPL and IR**
- + Generic RNP AR (Same rules for specific RNP AR (need of FOSA))



Target : 2018

European Aviation Safety Agency – Rulemaking Directorate
Notice of Proposed Amendment (NPA) 2013-25

Revision of operational approval criteria for performance-based navigation (PBN)
 RMT.0256 & RMT.0257 (MDM.062(A) & (B)) – 20.12.2013

Executive Summary

This NPA addresses an economic issue related to the administrative burden caused by specific approval (SPA) procedures for performance-based navigation (PBN), which, according to Commission Regulation (EU) No 965/2012, will be progressively applicable not only to commercial air transport (CAT) operators, but also to non-commercial operators of complex (NCC) or other than complex motor-powered (NCO) aircraft, as well as to aerial work operators (AWO).

Area Navigation (RNAV) was in fact developed in the 1960s in the USA to give aviators more flexibility in deciding their horizontal path (i.e. no longer obliged to overfly ground beacons). In time, new RNAV or Area Navigation (RNAV) was progressively introduced in Europe. The Agency is aware that requesting and obtaining a SPA for each PBN application constitutes an additional administrative task especially for non-commercial operators, but also for competent authorities.

This rulemaking task is hence necessary to review the obligation for SPA for all existing PBN applications and where appropriate, to amend the requirement. Pilot training for instrument rating (IR) needs to be revised in parallel, since the administrative simplification shall have no adverse effect on safety.

This NPA takes into account edition 4 (2013) of the ICAO Manual on performance-based navigation (Doc 9612) to pursue the following specific objectives:

- a) to develop rules on pilot training and checking requirements, which are an essential pre-requisite to the introduction of RNP 2, Advanced-RNP and RNP 0.3 in ICAO Doc 9612 and NCO operators; and
- b) to remove the requirement for SPA for some PBN operators;
- c) to reassess the need for a specific operational approval for each PBN operation for CAT, SPO, NCC, and NCO operators; and
- d) to take into account the introduction of RNP 2, Advanced-RNP and RNP 0.3 in ICAO Doc 9612 and the consequent possibility of 'bundling' approvals.

This NPA proposes amendments to Commission Regulations (EU) Nos 1178/2011 (Part FCL), 290/2012 (Part ARA and ORA) and 965/2012 (APF-OPS) and related AMC/OM, and amendments to CS-FSTD(A) and (H) and to a number of AMC 20-10 related to PBN. The proposed changes are expected to maintain safety while reducing the regulatory burden, also for oversight by competent authorities.

Applicability	Process map
Affected regulations and decisions: Commission Regulation (EU) No 1178/2011 (Part FCL) and Commission Regulation (EU) No 290/2012 (Part ARA and ORA) Commission Regulation (EU) No 965/2012 (Annex I - Definitions, Part MRO, CAT, SPA, SPO, Commission Regulation (EU) No 800/2013 (Annex VI Part NCC, Annex VII Part NCO)) Opinion No 02/2012 on Annex VIII Part SPO and related AMC/OM CS-FSTD(A) and (H) AMC 20-4, -5, -12, -16, -27 and -28	Concept Paper: No Terms of Reference: Issue 2 of 8 July 2013 Rulemaking group: Yes RIA type: Light Technical consultation during NPA drafting: No Duration of NPA consultation: 3 months Review group: Yes Focused consultation: Depending on the comments received on the NPA
Affected stakeholders: Commercial and non-commercial aircraft operators, pilots, ATO Original Equipment Manufacturers (OEM) and Flight Synthetic Training Devices (FSTD)	Publication date of the Opinion (simultaneously with CRD): 2015/Q1 Publication date of the Decision: 2016/Q1
Driver/origin: Level playing field	
Reference: Annex V (Part SPA) to Commission Regulation (EU) No 965/2012	

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RNP procedure are key factor for traffic congestion in terminal area



RNP capability basic for all A/C equipped with GPS



RNP AR need specific MOD and configuration



New approaches ILS like based on augmented GNSS positions



Getting to Grips

AIRBUS World

Context: [] Customization: [] Aircraft type: A300 | A300-600 | A3... Tail Number - PBN: [] ATA: 34

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