Required Navigation Performance (RNP)

ISAE - SUPAERO
Control & Guidance 1MAE702

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(presented by Marine GLIMOIS)
Airbus – Navigation Systems Engineering
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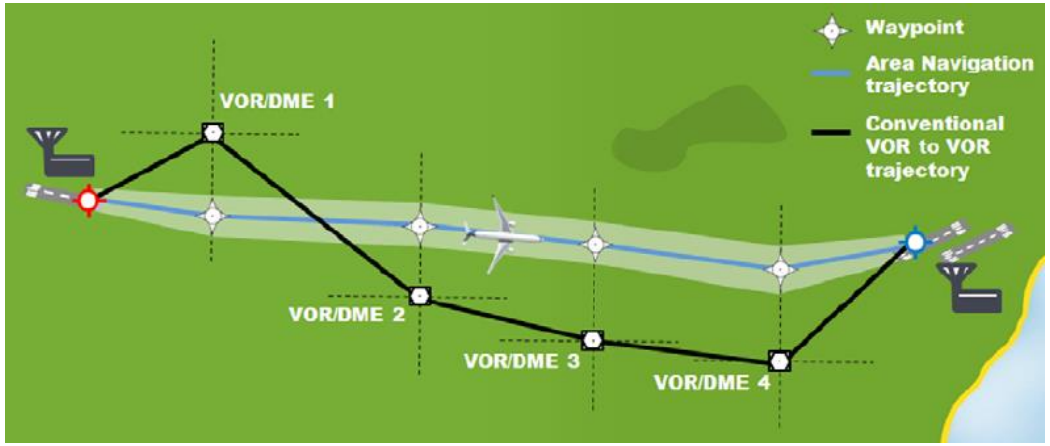
Introduction

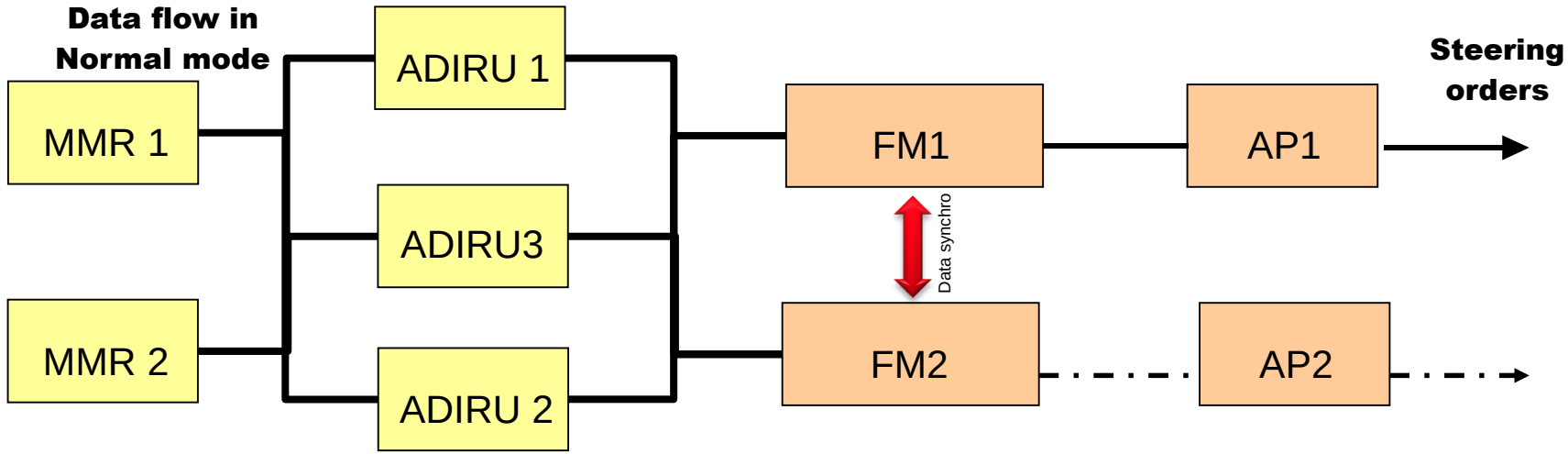
By means of its Navigation systems (FMS, GPS, Nav Radios, Inertial units,…) the aircraft can accurately:

- Define its position in space
- Steer along a pre-defined flight path



Navigation Sensors redundancies

Autopilot single chain : AP1 engaged



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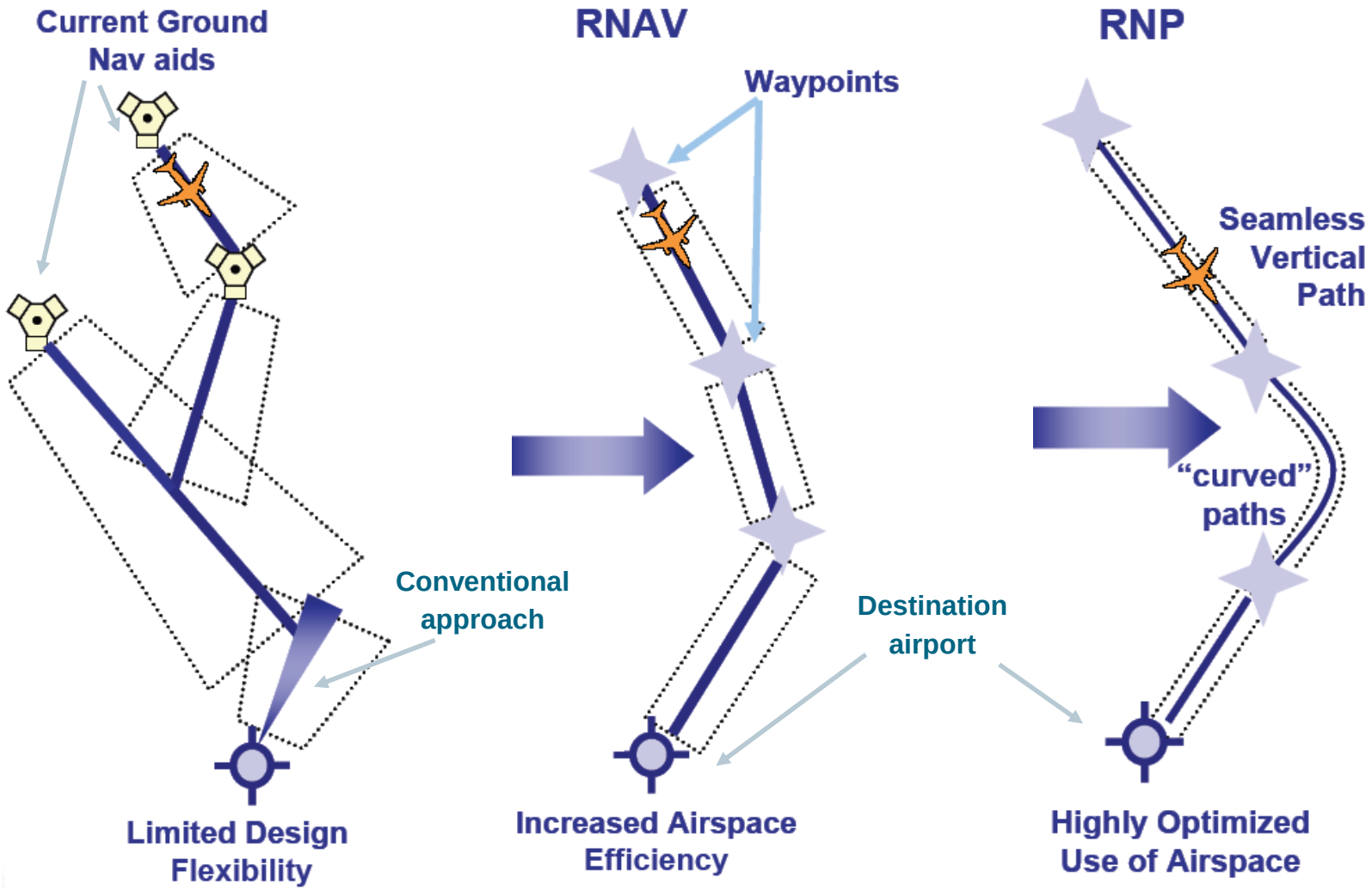
Introduction



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Introduction

- RNP: **R**equired **N**avigation (& Guidance) **P**erformance

  ⇨ RNAV based concept

- What's RNAV ?
  - a**R**ea **NAV**igation : navigation along desired flight path from waypoint to waypoint instead of navaid to navaid navigation
  - No longer restricted to fly over the location of ground-based NAVAIDS
  - **Safety** of operations relying on a combined use of A/C **navigation accuracy**, route separation and Air Traffic Control interventions

- RNP is RNAV with on-board performance monitoring and alerting
  - RNP refer to a **level of performance** required for a specific procedure or a specific block of airspace
  - RNAV with an **Integrity** and **Continuity containment**
  - Aircraft navigation system **monitors its performance** and provides crew to monitor the achieved Navigation Performance
  - Enhancement of pilot's situation **awareness**
  - Reduce **obstacle clearance** or closer **route spacing** without ATC intervention

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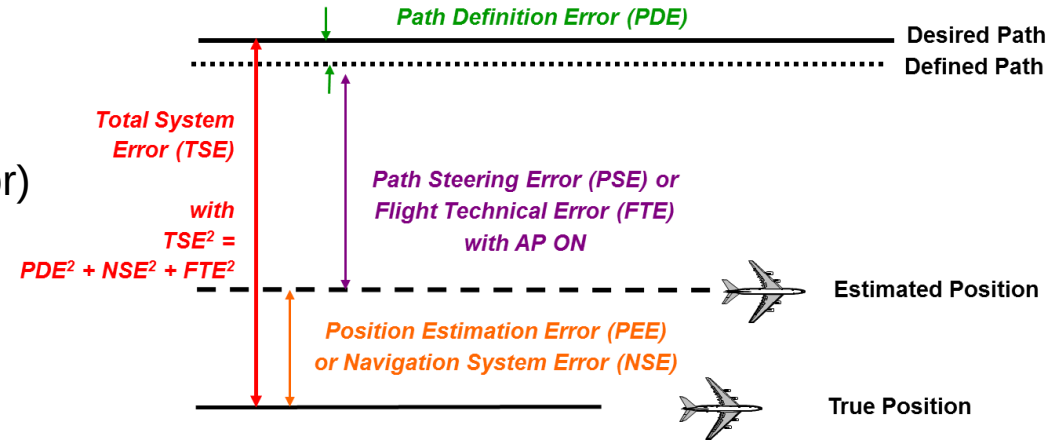
Required Navigation Performance

Airworthiness criteria for **Navigation performances** are defined by the **MASPS DO 236** (Minimum Aviation System Performance Standard)

Contributors to RNP performance

- PDE (Path Definition Error)
- NSE/PEE (Navigation System Error/Position Estimation Error)
- FTE/PSE (Flight Technical Error/Path Steering Error)



Accuracy

- Track-keeping **± 1xRNP 95 % of the flight time**

Lateral containment

- <u>Integrity:</u> The probability that the TSE (Total System Error) of each aircraft operating in RNP airspace exceeds the specified cross track containment limit (2xRNP) without annunciation shall be less than $1x10^{-5}$ per flight hour
- <u>Continuity:</u> The probability of annunciated loss of RNP capability shall be less than $1x10^{-4}$ per flight hour

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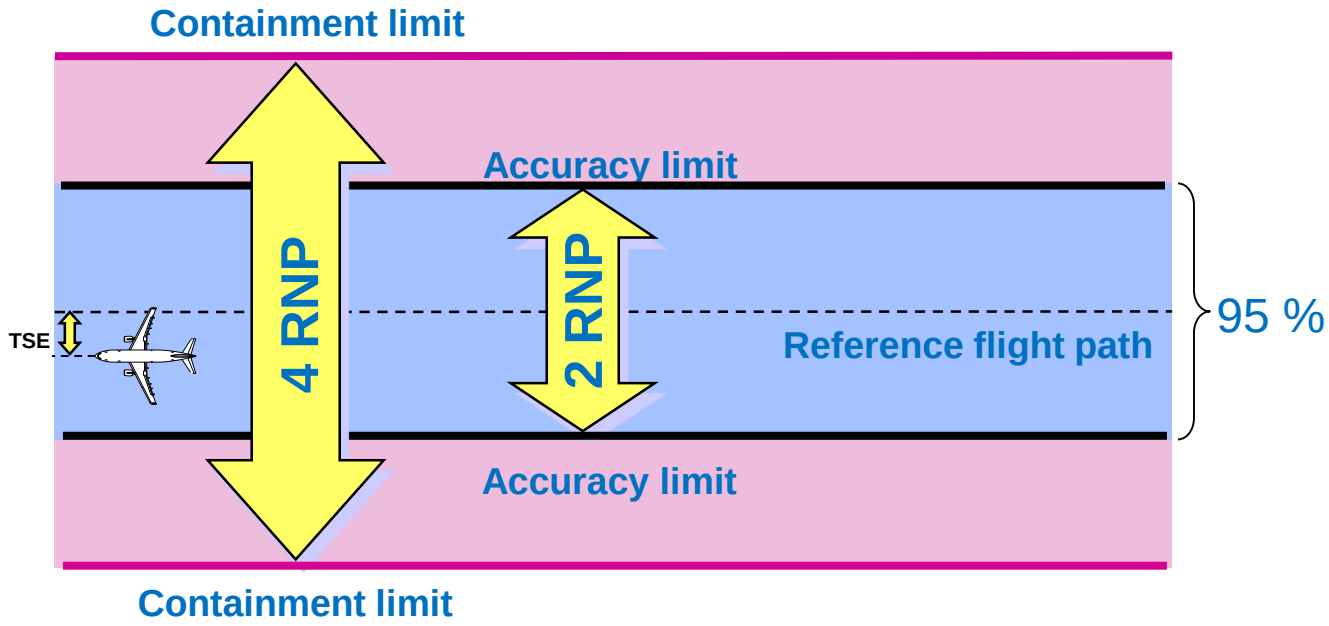
Required Navigation Performance

- DO 236 airworthiness criteria sum-up:



RNP =

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

+

On Board **Performance Monitoring** and **Alerting**

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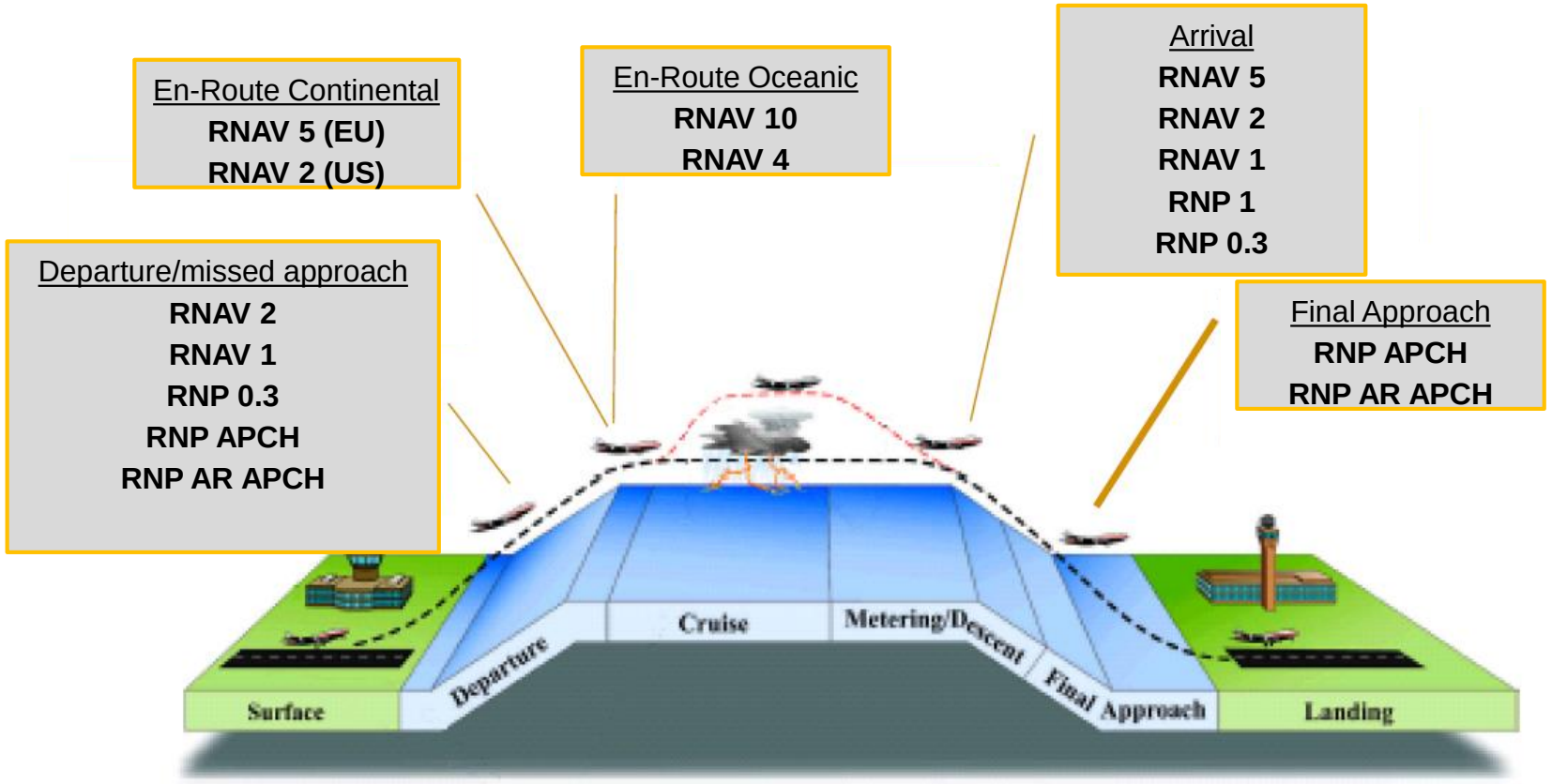
Navigation specifications

- Aircraft capacity to fly under specific performances (Performance-Based Navigation) are categorized in Navigation Specifications (Nav Specs)



Note: ICAO **Performance-Based Navigation** (PBN) specifies that aircraft RNP and RNAV systems performance requirements be defined in terms of accuracy, integrity, availability, continuity and functionality required for the proposed operations in the context of a particular airspace, when supported by the appropriate navigation infrastructure

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RNP Benefits

- Increased airport **ACCESS**
  - Lower minimum ⇨ airport access maintained in poor weather conditions, night operations, lower amount of Missed Approaches
  - New procedures made possible ⇨ opening the runway access
  - RNP procedures at alternate airport

- Increased **EFFICIENCY**
  - Optimum trajectory ⇨ Fuel economy, reduced flight time/distance
  - Increase Air Traffic Flow (smaller lateral separation)
  - Reduced sector complexity ⇨ Airspace/Traffic De-confliction
  - Environmental constraints ⇨ Noise abatement procedures

- Improved **PROCEDURE STANDARDIZATION – SAFETY**
  - Always the same path is flown
  - Good Navigation Accuracy Performance monitoring ⇨ containment provided throughout the operation
  - Simplified crew training: no more circling approaches

RNP AR (**A**uthorization **R**equired)

- Among the numerous types of RNP AR procedures, the one with the major benefits is RNP AR approach

- A procedure is RNP AR if one of the following characteristics applies
  - RNP levels **inferior to 0.3 NM** (down to 0.1 NM) in approach and inferior to 1 NM (down to 0.1 NM) in departure and missed approach
  - Protection areas laterally limited to **2xRNP** value, **without any additional buffer**
  - RNP AR allows the introduction of curved flight path – **RF legs** (Radius to Fix) legs in terminal area, including the **Final Approach Segment** (i.e. below the FAF)

MANUALS	NAVIGATION SPECIFICATION	Navigation Accuracy (NM) per flight phase						
		En-Route			Approach			
		Oceanic Remote	Continental	Terminal	Initial Interm	Final	Missed	Departure
ICAO PBN MANUAL (Doc 9613)	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					
PANS-OPS (Doc 8168)	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	

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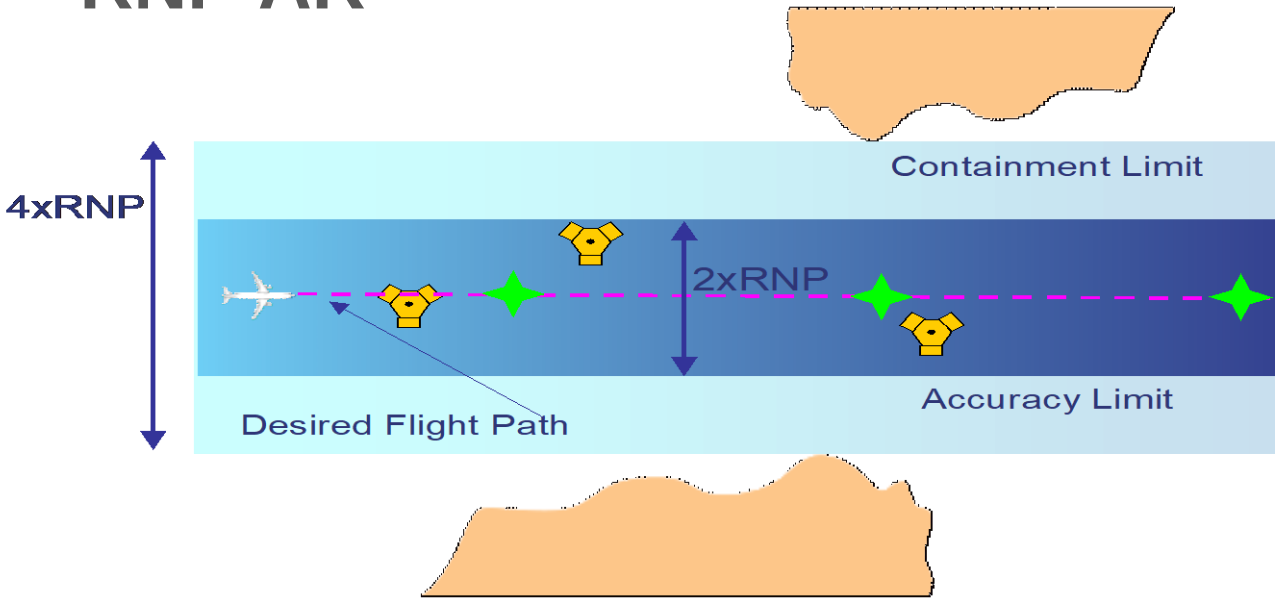
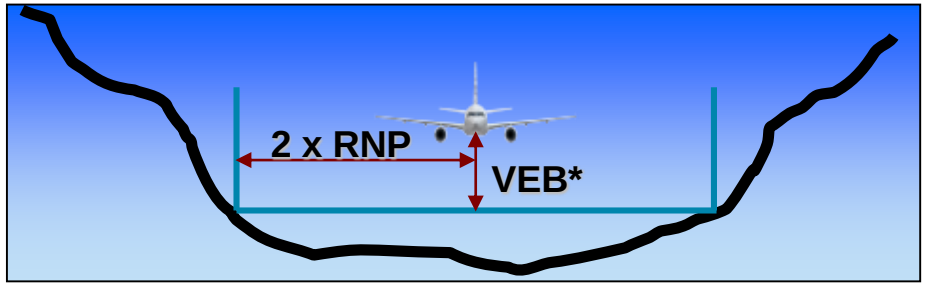
RNP AR



Lateral



Vertical

* Vertical Error Budget

RNP AR =

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

\+ On Board **Performance Monitoring** and **Alerting** \+ Authority operational Approval

RNP AR procedures require the authorization for the specific airline, aircraft and crew of the local authority

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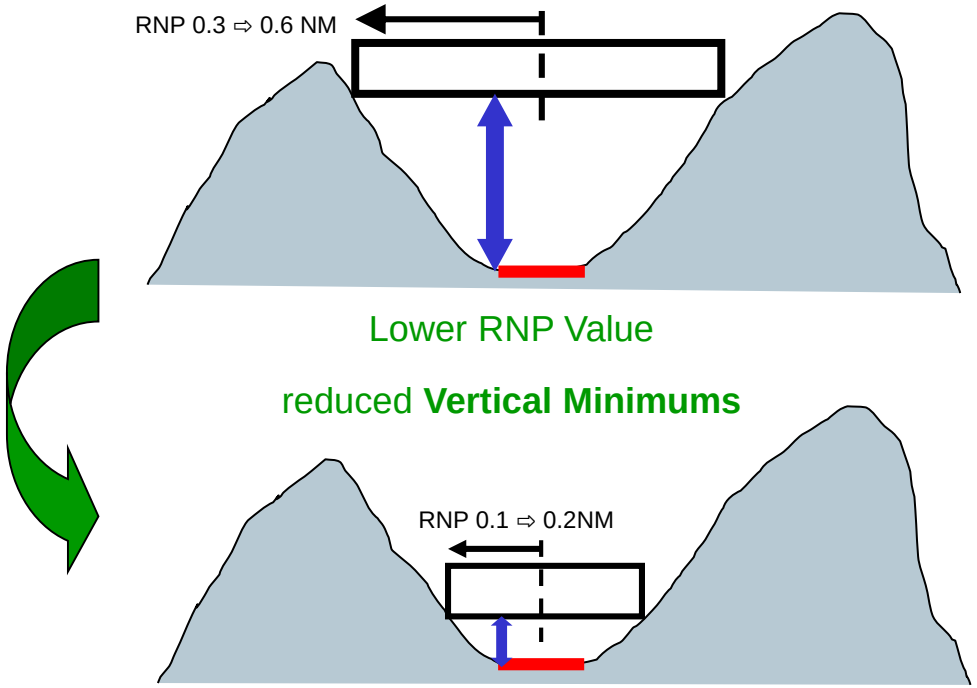
RNP AR

- Lower operational minimums
  - As low as **250ft** (APV Baro VNAV minimum): close to ILS CAT I (200ft) with the advantage of flexible path and no need of ground based equipment
  - Reduced number of diversions and missed approaches



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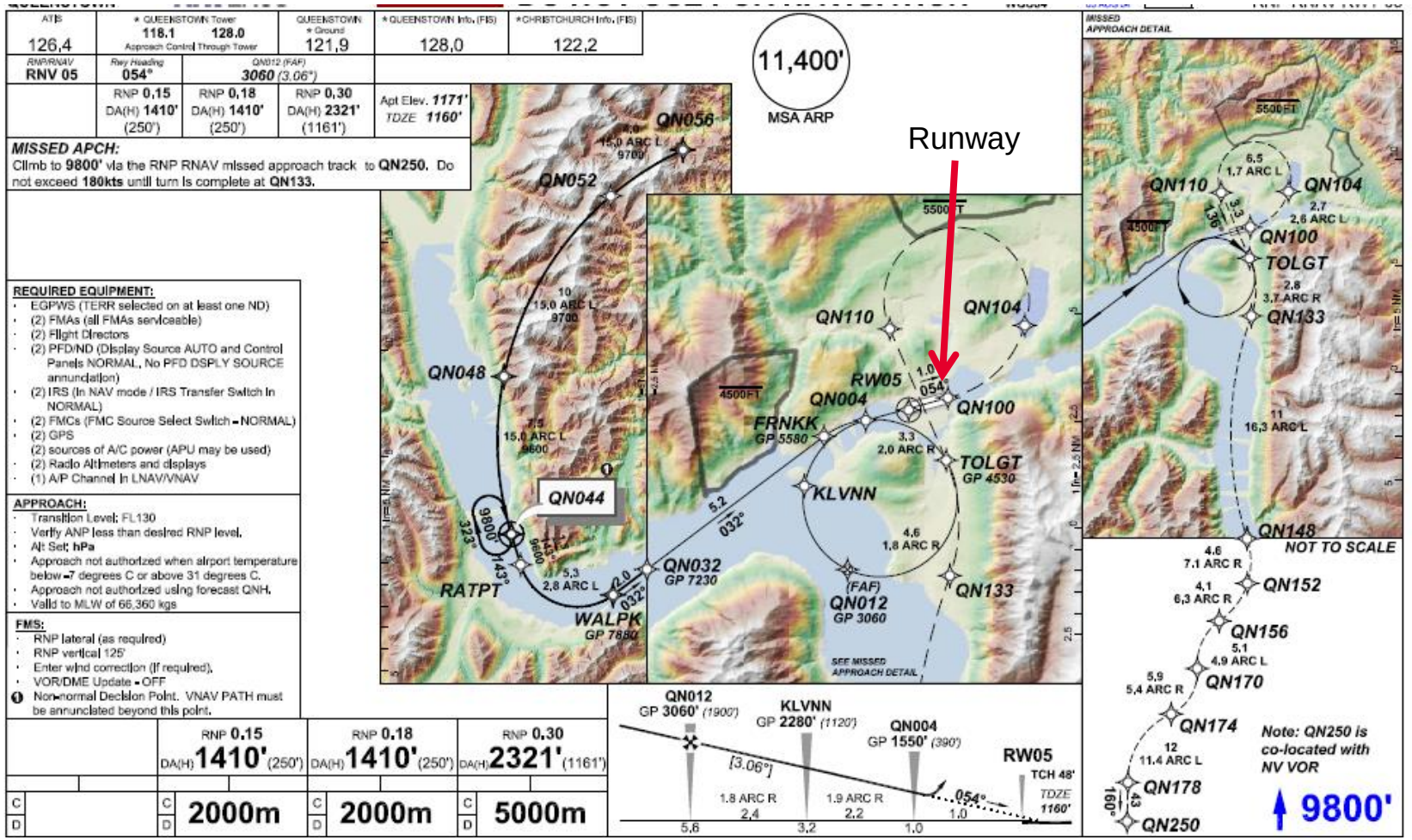
RNP AR – Application examples: Airport access (challenging terrain)

Operations at Queenstown:

- before RNP introduction:
  - ILS installation not possible due to terrain interference
  - NPA with basic VOR/DME
  - DH 3500 ft
- with RNP AR capability:
  - DH reduced to 270 ft
  - Agreement received in 2005 with RNP 0.15 capability



NPA: Non Precision Approach

DH: Decision Height

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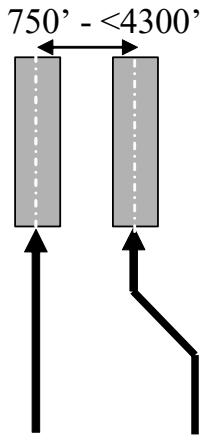
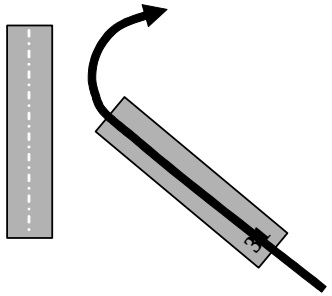
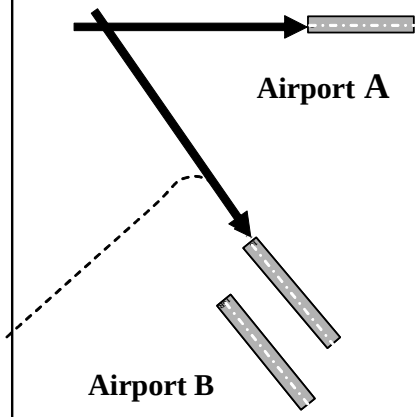
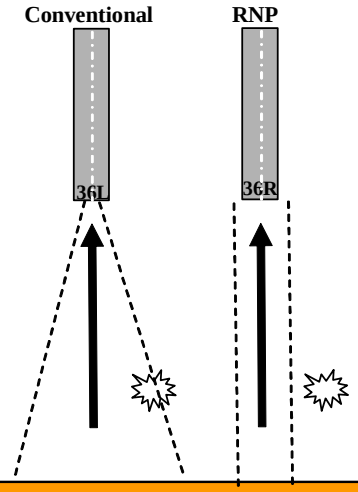
RNP AR – Application examples: Airport efficiency

Parallel Operations	Converging Operations	Adjacent Airport Operations	Single Runway Access and Safety
			
10 to 15 Top Airports	**15 to 20 Top Airports**	**10 to 15 Top Airports**	**Several hundred runway ends**
Arrival capacity gains up to 60% over single runway operations	**Arrival capacity gains up to 50% over single runway operations**	**Increased arrival and departure rates for adjacent airports involved**	**Guidance to the runway and approach minimums lower than existing minima**

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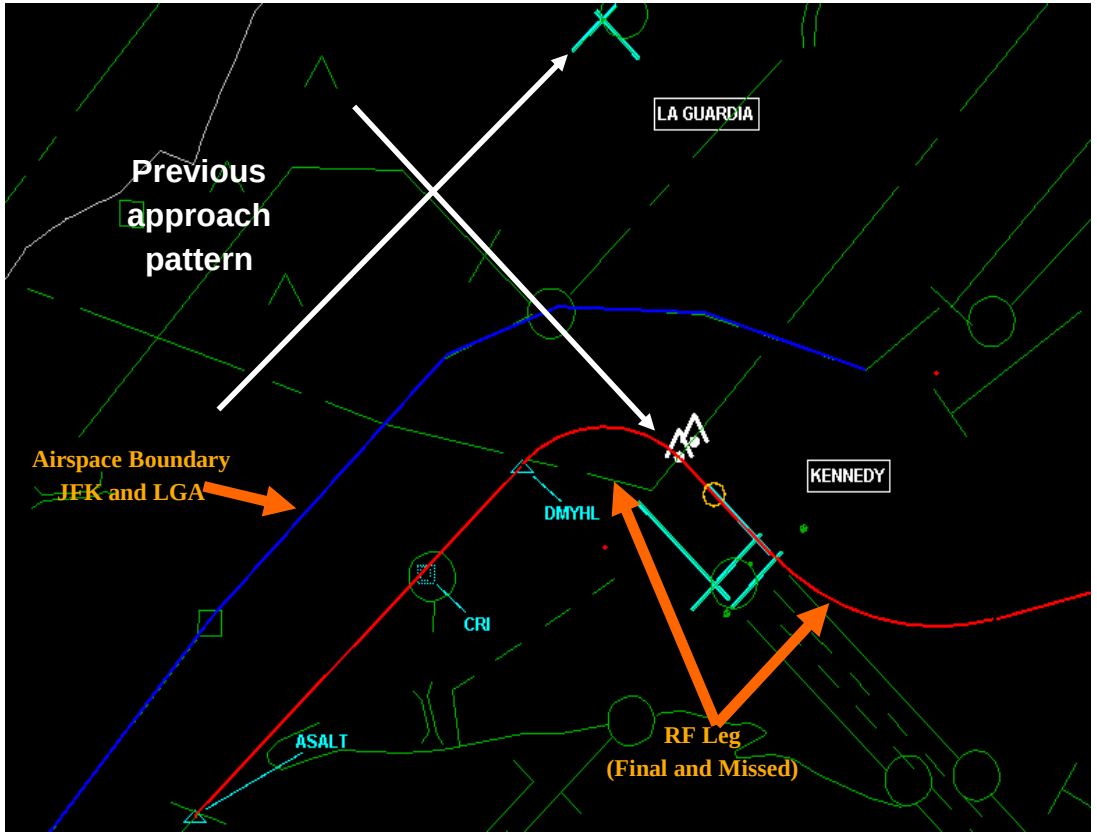
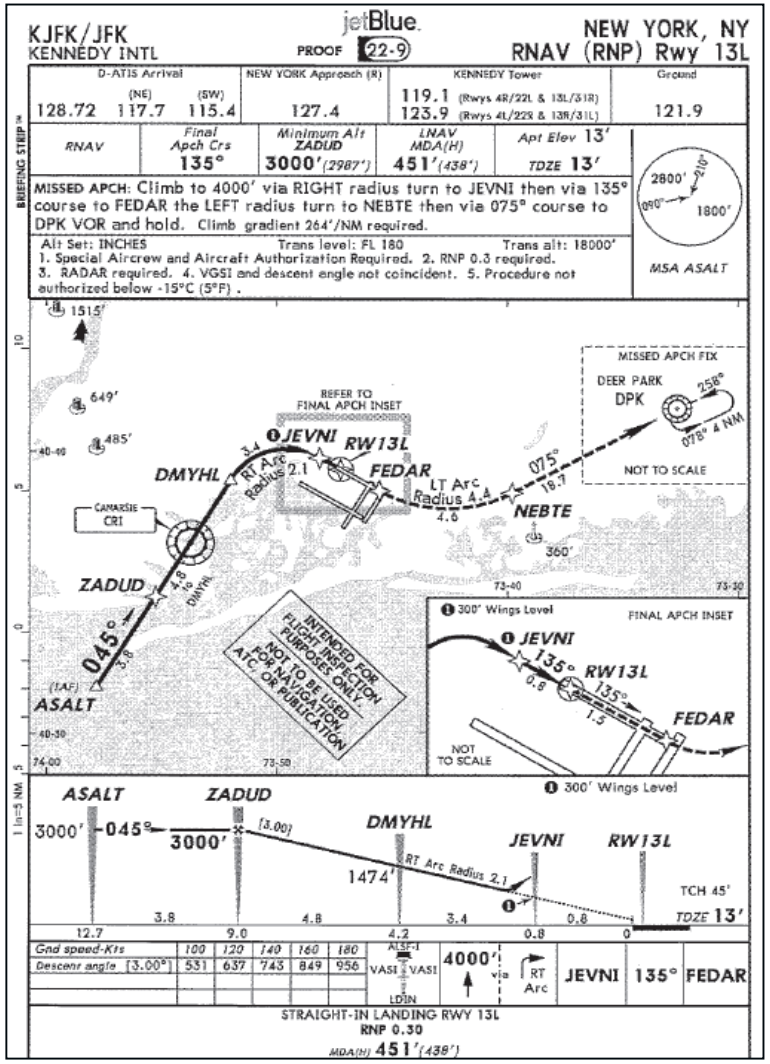
RNP AR – Application examples: Close airports

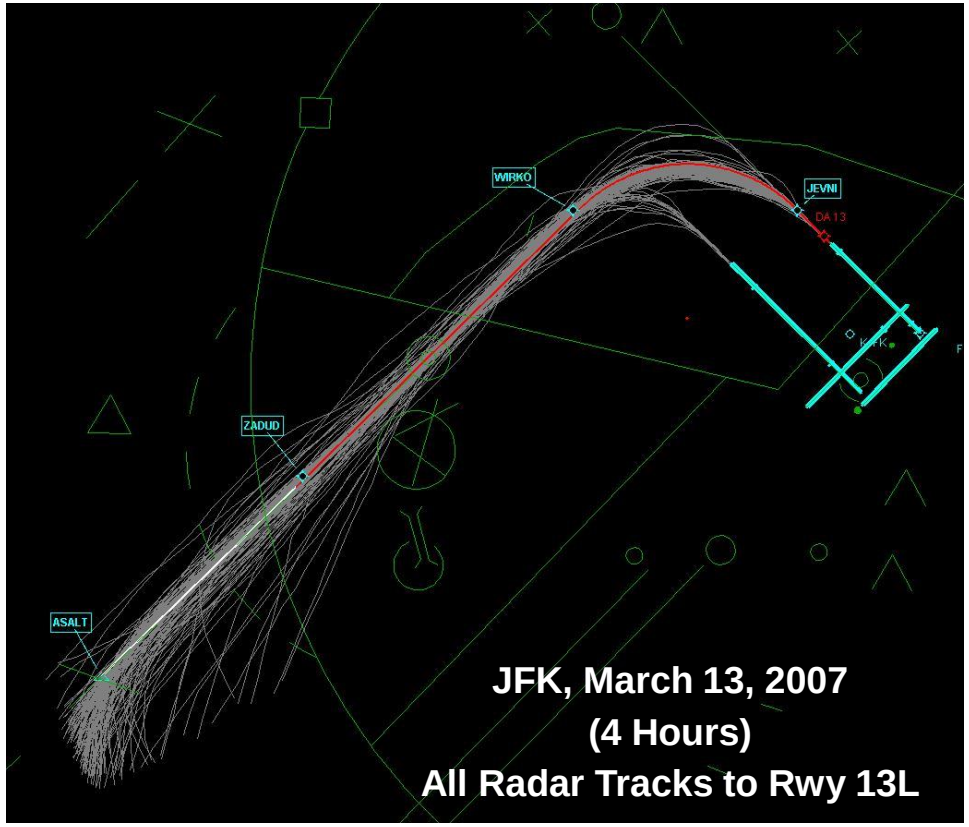
- Laguardia airport very close to Kennedy (JKFK)
- Approach perpendicular to KJFK runway and final turn to avoid Laguardia airspace

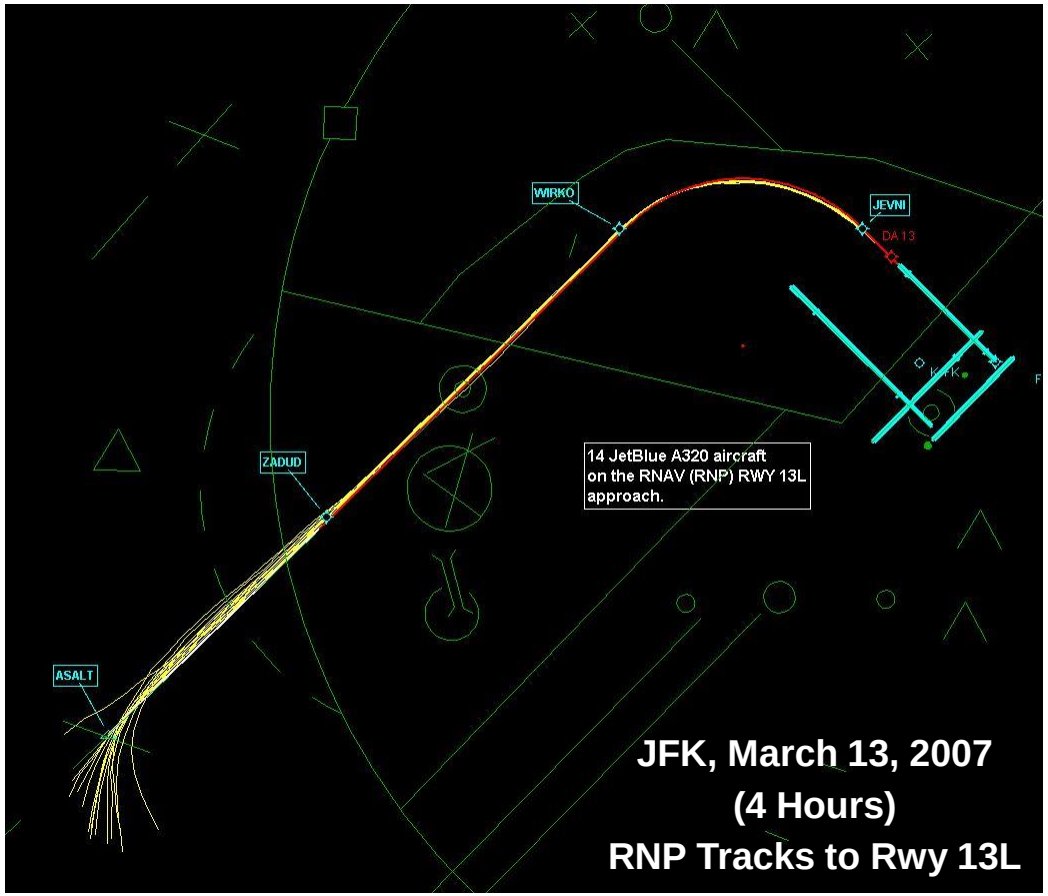




RNP AR – Application examples: Close airports

- New-York “Canarsie” Procedure (KJFK, USA)





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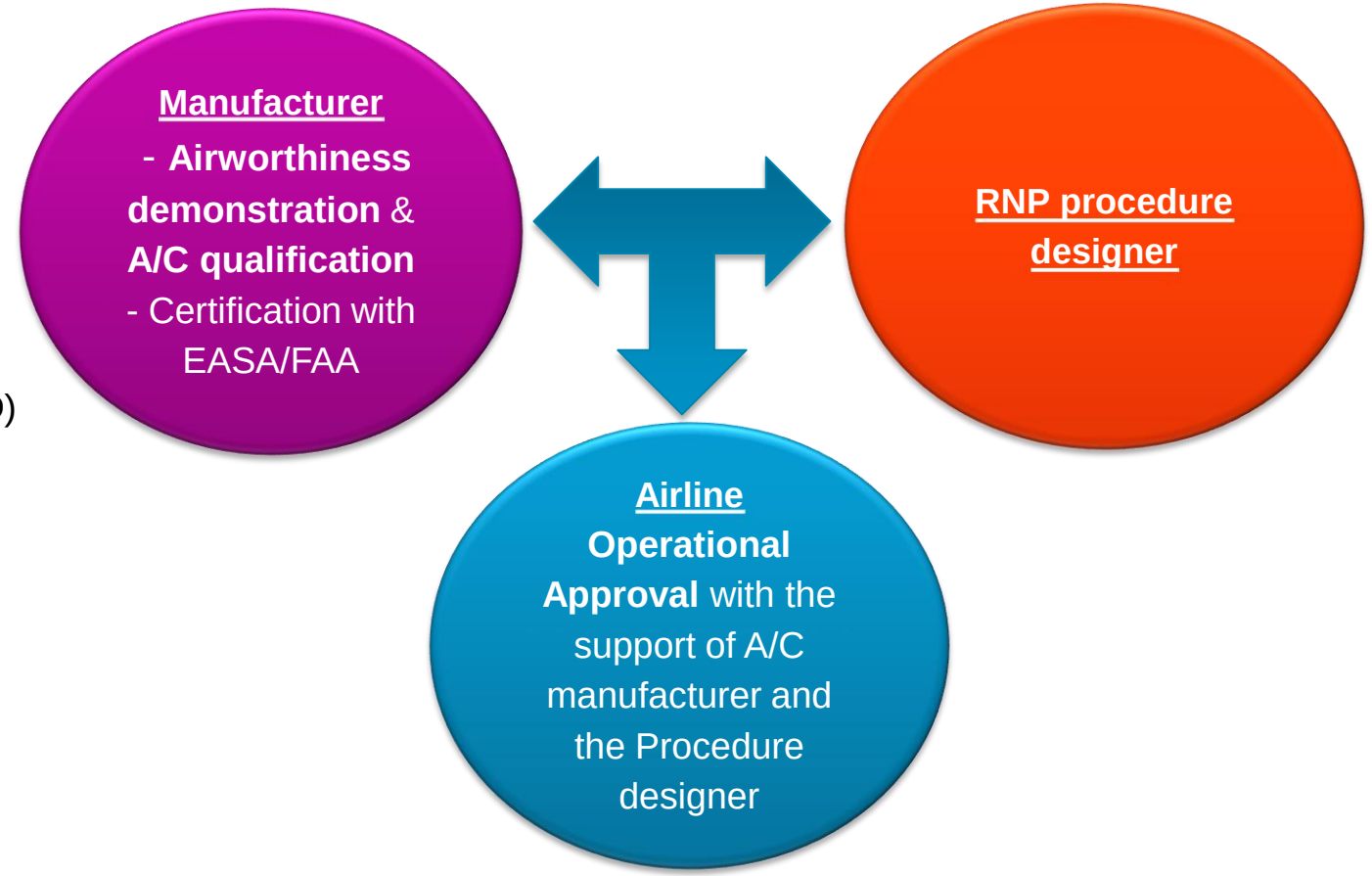
RNP AR –Obtaining the Authorization

- RNP AR approval process with existing regulations

EASA: AMC 20-26
FAA: AC 20-138C/AC 90-101A

- Aircraft performance
- Flyability checks
- Flight crew procedures
- Crew training
- Documentation (AFM, ACD)



ICAO: doc 9905 (proc. design manual)
FAA: order 8206.58

- Approach design
- Approach charts
- Nav. Database coding
- Nav. Database integrity
- Procedure maintenance

ICAO: AMC 20-26
FAA: AC 90-101A

FOSA
Flight Operation Safety Assessment

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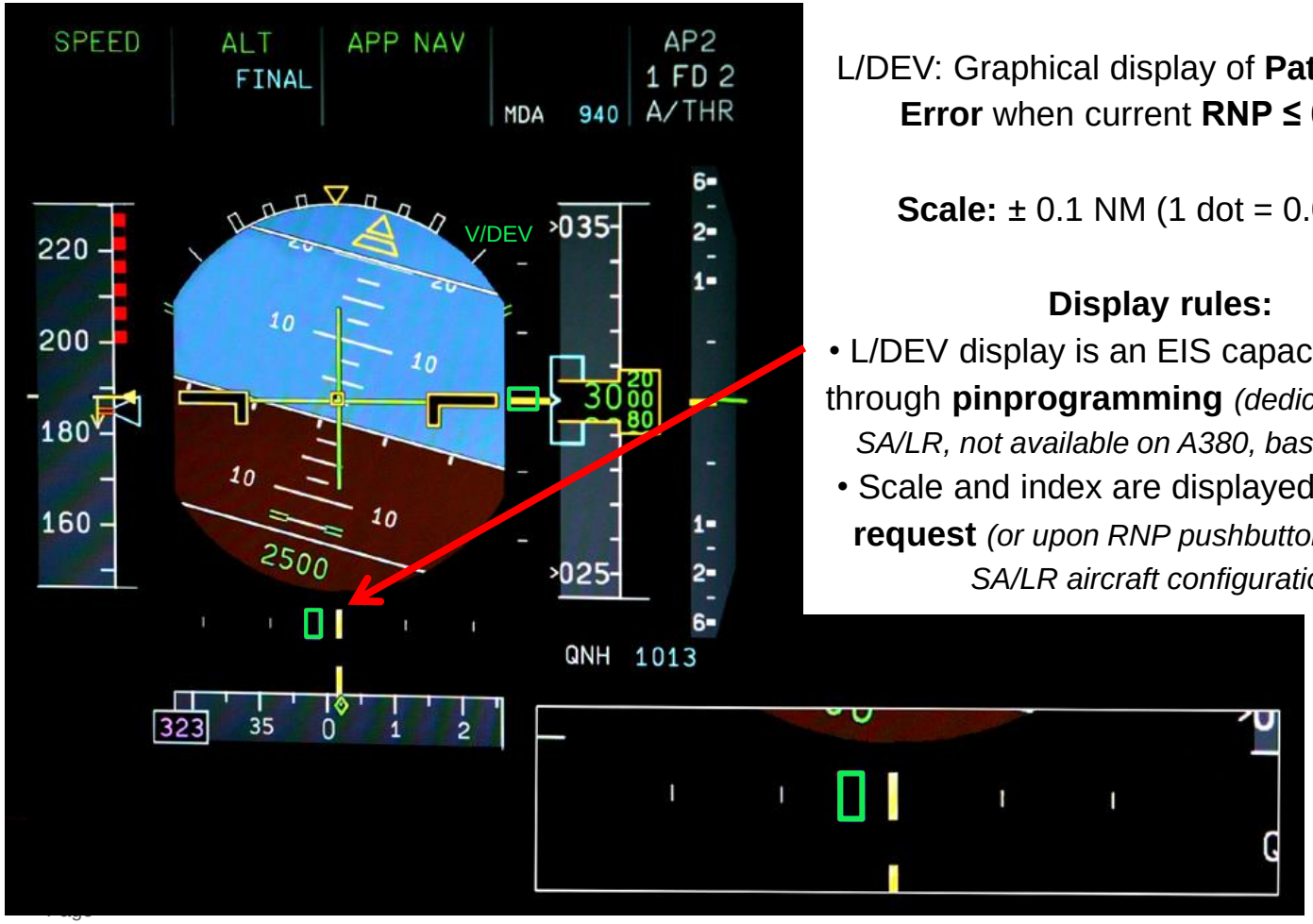
RNP AR –Cockpit implementation

- Path Steering error monitoring: dedicated crew indication
- L/DEV (Lateral Deviation) scale and index display on PFD



L/DEV: Graphical display of **Path Steering Error** when current **RNP ≤ 0.3 NM**

Scale: ± 0.1 NM (1 dot = 0.05 NM)

Display rules:

- L/DEV display is an EIS capacity activated through **pinprogramming** *(dedicated MOD on SA/LR, not available on A380, basic on A350)*
- Scale and index are displayed upon **FMS request** *(or upon RNP pushbutton on « old » SA/LR aircraft configuration)*

Cross Track Error

Thank you

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