RNP APCH / RNP AR APCH:
different requirements

Case Study presented by:

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ENAC

La référence aéronautique

Outline

1. The RNP concept
2. ANSP and operators' considerations for RNP APCHs
3. Outcome and benefits
4. System Engineering implementation
5. Project Management
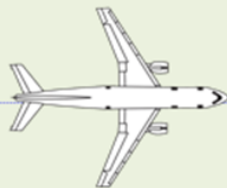
Outline

What is Required Navigation Performance?

➤A sub-concept of what is called now

Performance Based Navigation

➤Shift from navigation requirements based on sensor performance to:

➤Requirements based on **aircraft performance: PBN requirements**

navigation specification   (RNAV *X* or RNP *X*)
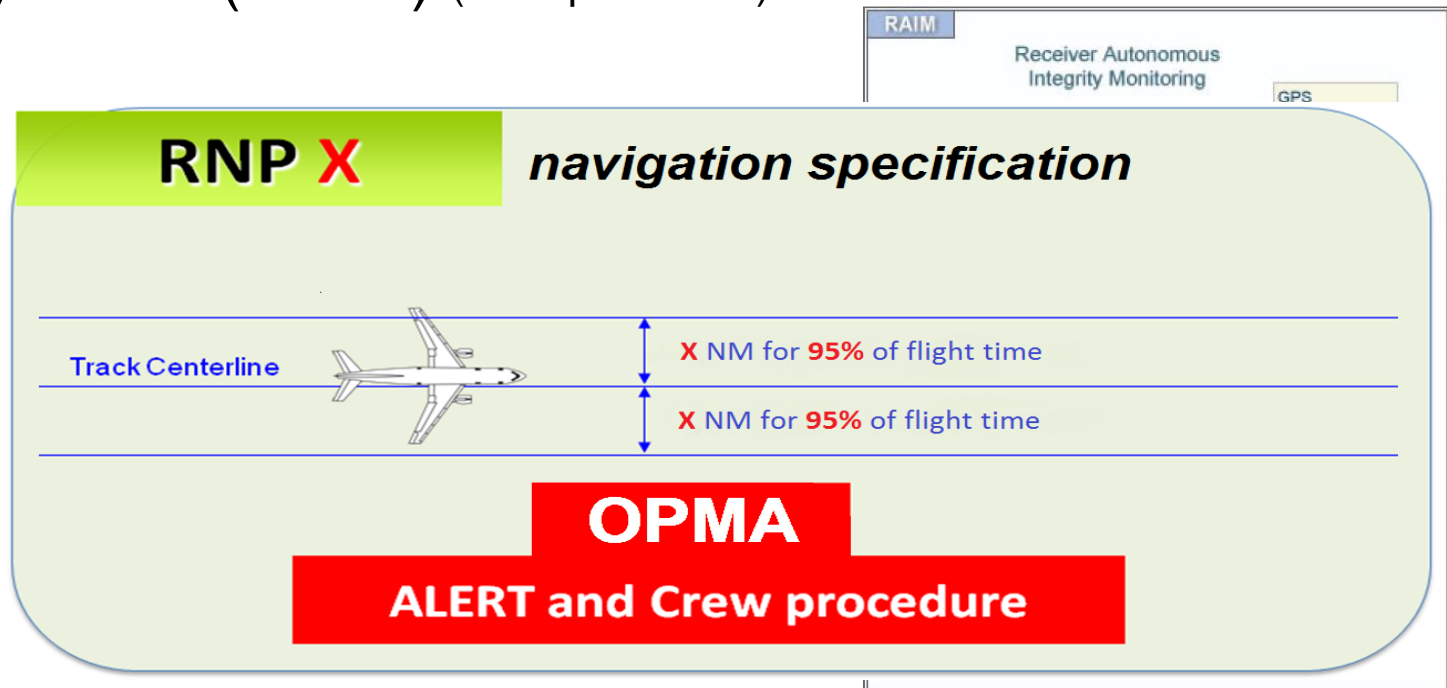
Track Centerline

X NM for **95%** of flight time

X NM for **95%** of flight time

The RNP concept

➢ The key element of *Required Navigation Performance*: **On-board Performance Monitoring & Alerting function**
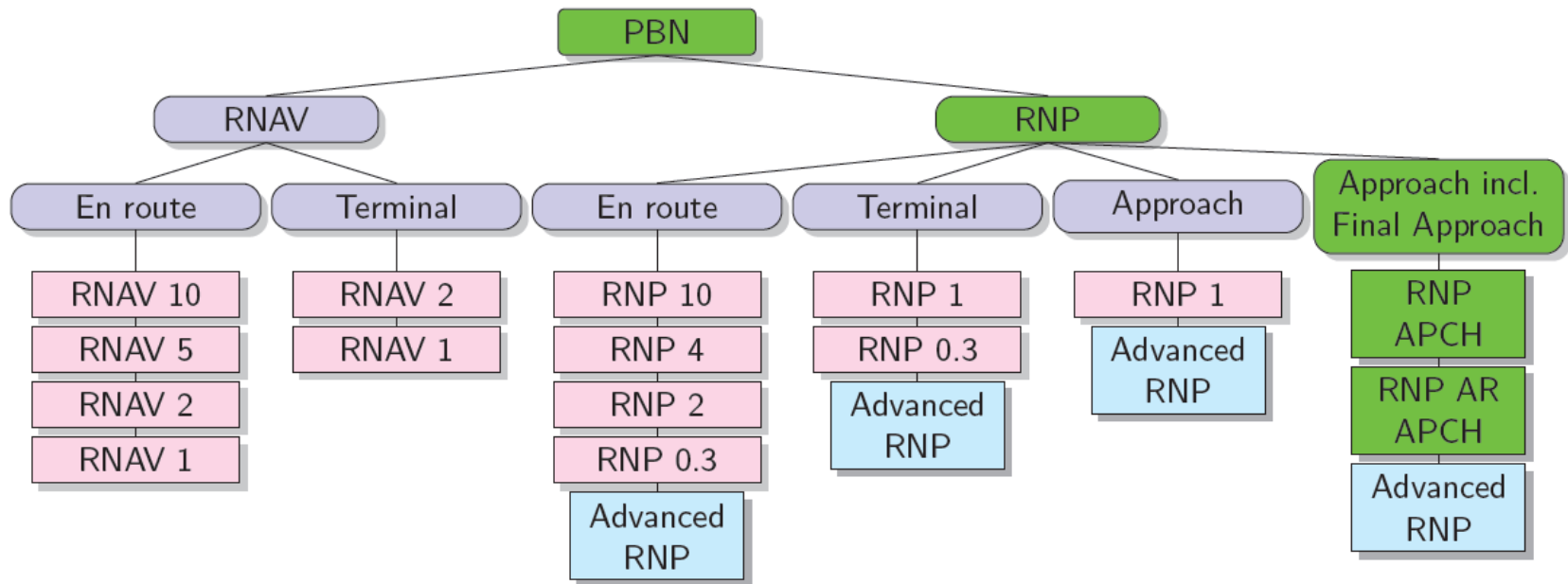
How?

➢ Requirement for **Aircraft-Based Augmentation Systems** (ABAS) (example: RAIM)

PBN overview

➢ **Performance Based Navigation** is a term that came in as a result of collaboration between the ICAO, industry, regulators and ANSPs in order to **harmonize** definitions and specifications associated to both **RNAV** and **RNP**

RNP APCH vs. RNP AR APCH

➢**RNP APCH:** the use of RNP specifications in the approach phase

➢ **RNP Authorization Required (AR) APCH:** enhanced concept of RNP APCH, with smaller protection area and possible curved legs even after the FAF.

Our main objective:
Identify, list and demystify the differences between RNP APCH and RNP AR APCH in what concerns the ANSP and operators considerations

Comparison Table

		RNP APCH	RNP AR APCH
ANSP	**Navigation**		
	Publication, ATCO training		
Operator considerations	**Aircraft requirements**		
	Operating procedures		
	Training		
	Approval		

Outline

ANSP considerations

➢ **Communication and Surveillance:** no specific requirements (PANS-ATM (Doc 4444), ICAO RCP Manual (Doc 9869), ICAO Annex 10).

➢ **Navigation:** based mainly on the GNSS as the navigation aid to support operations down to LNAV or LNAV/VNAV minima.

➢ **Publication, ATCO training, Baro-VNAV support**

ANSP considerations

		RNP APCH	RNP AR APCH
ANSP	**Navigation**	*Missed approach segment may be based on conventional NAVAID*	*No exception, always GNSS*
	Publication, ATCO training	*Uniform accuracy for all procedures*	*Different accuracy for every distinct procedure*
Operator considerations	**Aircraft requirements**		
	Operating procedures		
	Training		
	Approval		

Operator Considerations

➢ Operator must be **approved** to perform either of the procedures, in terms of:

- aircraft requirements
- operational procedures
- knowledge and training
- navigation database validation
- safety assesment

Aircraft requirements

		RNP APCH	RNP AR APCH
ANSP	**Navigation**	*Missed approach segment may be based on conventional NAVAID*	*No exception, always GNSS*
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Operator considerations	**Aircraft requirements**	*"Standard" RNP Nav accuracy, RNP 1 and RNP 0.3 during final*	*Possibility to increase required accuracy: RNP 1-0.1 and RNP 0.3-0.1 during final*
	Operating procedures		
	Training		
	Approval		

Operating procedures

➢ **Pre-flight** and **in-flight** procedures concerning:

- Database validity
- Aircraft RNP capability
- GNSS availability
- AP/FD, Baro-VNAN when required
- NOTAMs, emergency procedures

Operating procedures

		RNP APCH	*RNP AR APCH*
ANSP	**Navigation**	*Missed approach segment may be based on conventional NAVAID*	*No exception, always GNSS*
	Publication, ATCO training	*Uniform accuracy for all procedures*	*Different accuracy for every distinct procedure*
Operator considerations	**Aircraft requirements**	*"Standard" RNP Nav accuracy, RNP 1 and RNP 0.3 during final*	*Posibility to increase required accuracy: RNP 1-0.1 and RNP 0.3-0.1 during final*
	Operating procedures	*Standard RNP protection area and NO curved legs after the FAF*	*Smaller protection area and curved legs after the FAF*
		AP/FD not mandatory	*AP/FD both mandatory in procedures with RF legs or accuracy less that 0.3nm.*
		Vertical navigation guidance NOT mandatory (Baro-VNAV)	*Vertical navigation guidance MANDATORY (Baro-VNAV)*
	Training		
	Approval		

Pilots/dispatch/operators knowledge and training

➢ A training program should be established for sufficient theoretical and practical training

If the procedure uses Baro-VNAV:

➢ Altimeter setting

➢ Cold temperature effect

should be taken into account
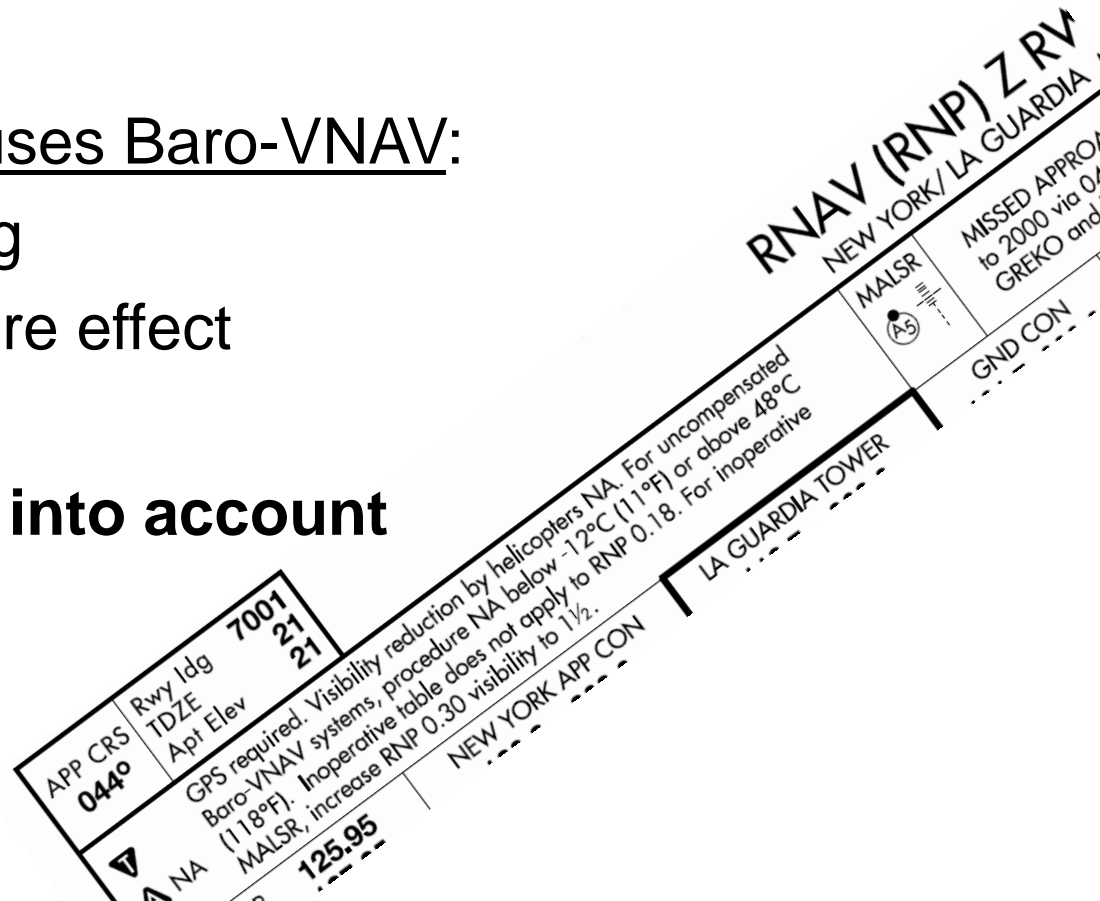
Knowledge and training

		RNP APCH	RNP AR APCH
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		Vertical navigation guidance NOT mandatory (Baro-VNAV)	*Vertical navigation guidance MANDATORY (Baro-VNAV)*
	Training	***Training only on GNSS is allowed (single pilot a/c)***	***Training for use of GNSS with FMS is mandatory***
	Approval		

Navigation database

➢ Database updates are critical for the integrity of an RNP procedure

Safety assessment

➢ Ensure that failure conditions are assessed and mitigation means are applied to meet safety criteria

Approval process

| Pre-application | → | Formal application | → | Analysis of the documentation | → | Inspection and demonstration | → | Approval |
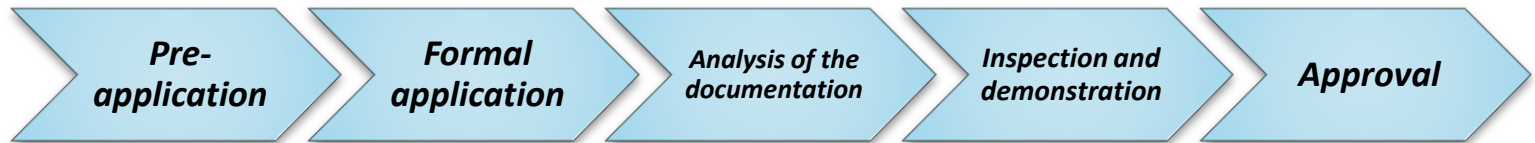
➤ A standard process is used to determine whether or not the applicant is capable of conducting the proposed operation in a safe and efficient manner.

Approval process

		RNP APCH	RNP AR APCH
ANSP	**Navigation**	*Missed approach segment may be based on conventional NAVAID*	*No exception, always GNSS*
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	Training	*Training only on GNSS is allowed (single pilot a/c)*	*Training for use of GNSS with FMS is mandatory*
	Approval	**Unique a/c approval for ALL procedures**	**Specific a/c approval for each procedure**
		Unique pilot approval for ALL procedures	**Approval to pilot to fly specific procedure**

Outline

1. The RNP concept
2. ANSP and operators' considerations for RNP APCHs
3. **Outcome and benefits**
4. System Engineering implementation
5. Project Management

Main results (1/2)

Both approaches need:

✓ State approval

✓ Airborne Based Augmentation System (ABAS)

✓ Ground based NAVAIDS not necessarily needed down to minima

✓ LNAV Minima <u>designed to be</u> achievable with Baro-VNAV

✓ ATCO/Crew training

Main results (2/2)

		RNP APCH	RNP AR APCH
ANSP	**Navigation**	*Missed approach segment may be based on conventional NAVAID*	*No exception, always GNSS*
	Publication, ATCO training	*Uniform accuracy for all procedures*	*Different accuracy for every distinct procedure*
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		Unique pilot approval for ALL procedures	*Approval to pilot to fly specific procedure*

Outcome

RNP APCH and RNP AR APCH:

- ➢ are based on the **same concept**,

- ➢ have **significant differences** in design and operations specifications,

- ➢ but are **non-conflicting** procedures and

- ➢ implement in **different areas**

Benefits (1/2)

➢ **Safety**: low track dispersion, track accuracy
➢ **Airfield accessibility**: in mountains and non equipped or congested airfields
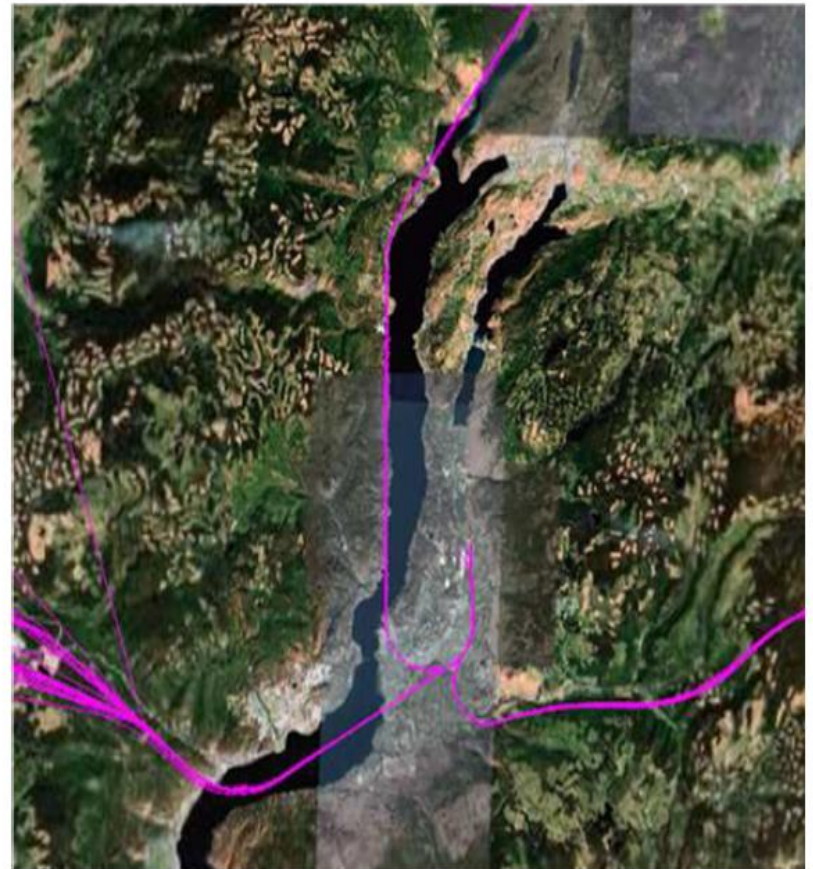
Benefits (2/2)

➢ **Cost reduction** and **environmental** protection
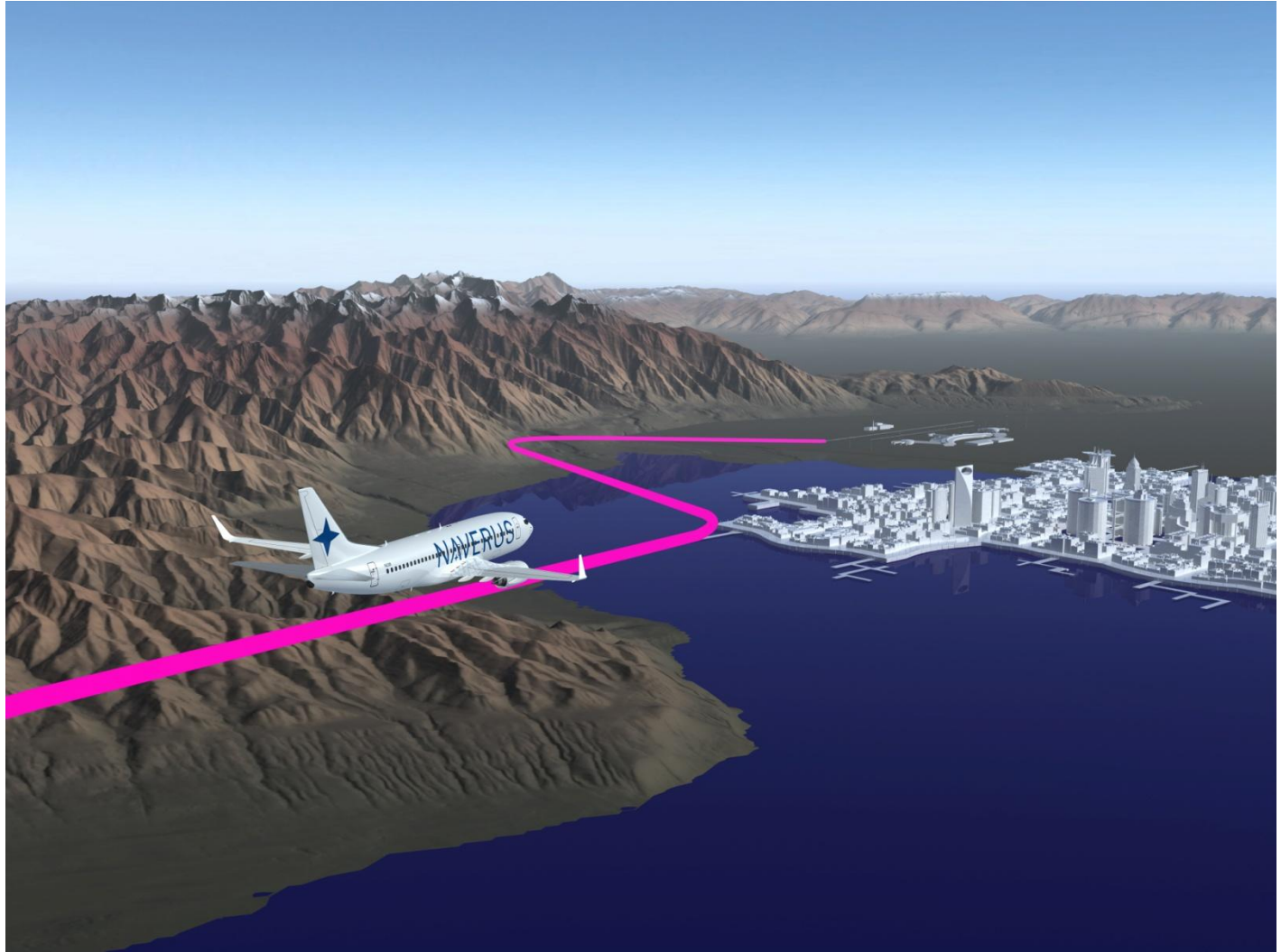
New concept: Advanced RNP

➤An **all-encompassing** navigation specification **for all phases of fight,** including final and missed approach
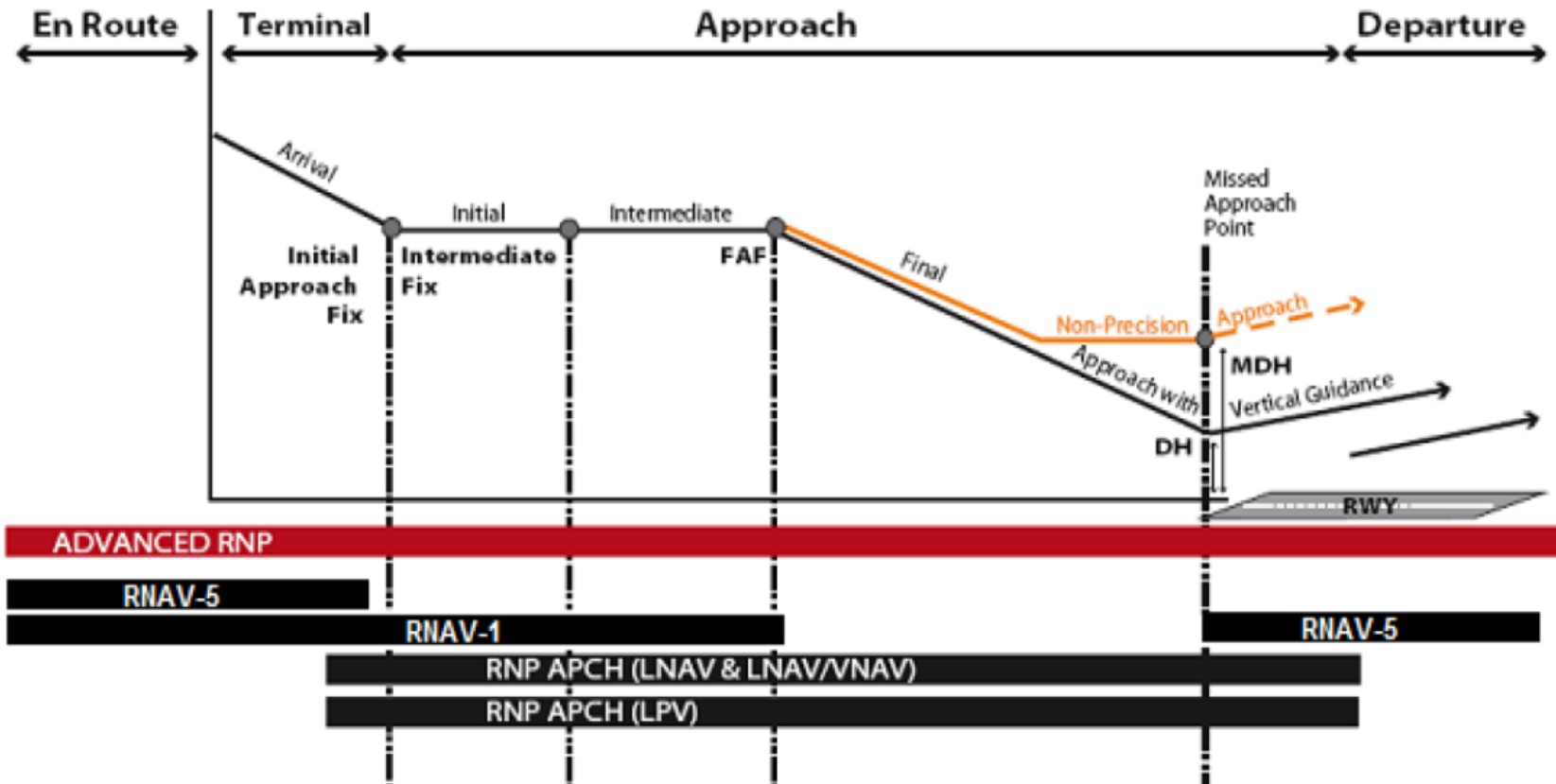
➤Unique set of operational requirements
➤New approval procedures

Outline

The System

> RNP approach procedure

> ICAO documentation (or implemented CAA documentation) concerning:

- ANSP considerations

- Operators consideration

- **Purpose:** allow a/c to land safely, with less cost, at particular airports.

- **Mission:** provide accurate approach path (down to specified minima) to approved a/c.

System phases and modes

Creation	Operation	

Creation
- Procedure design
- Documentation elaboration

Operational
- All subsystems operational

Maintenance
- Parts or whole system for maintenance (procedures' review, navigation database update, etc.)
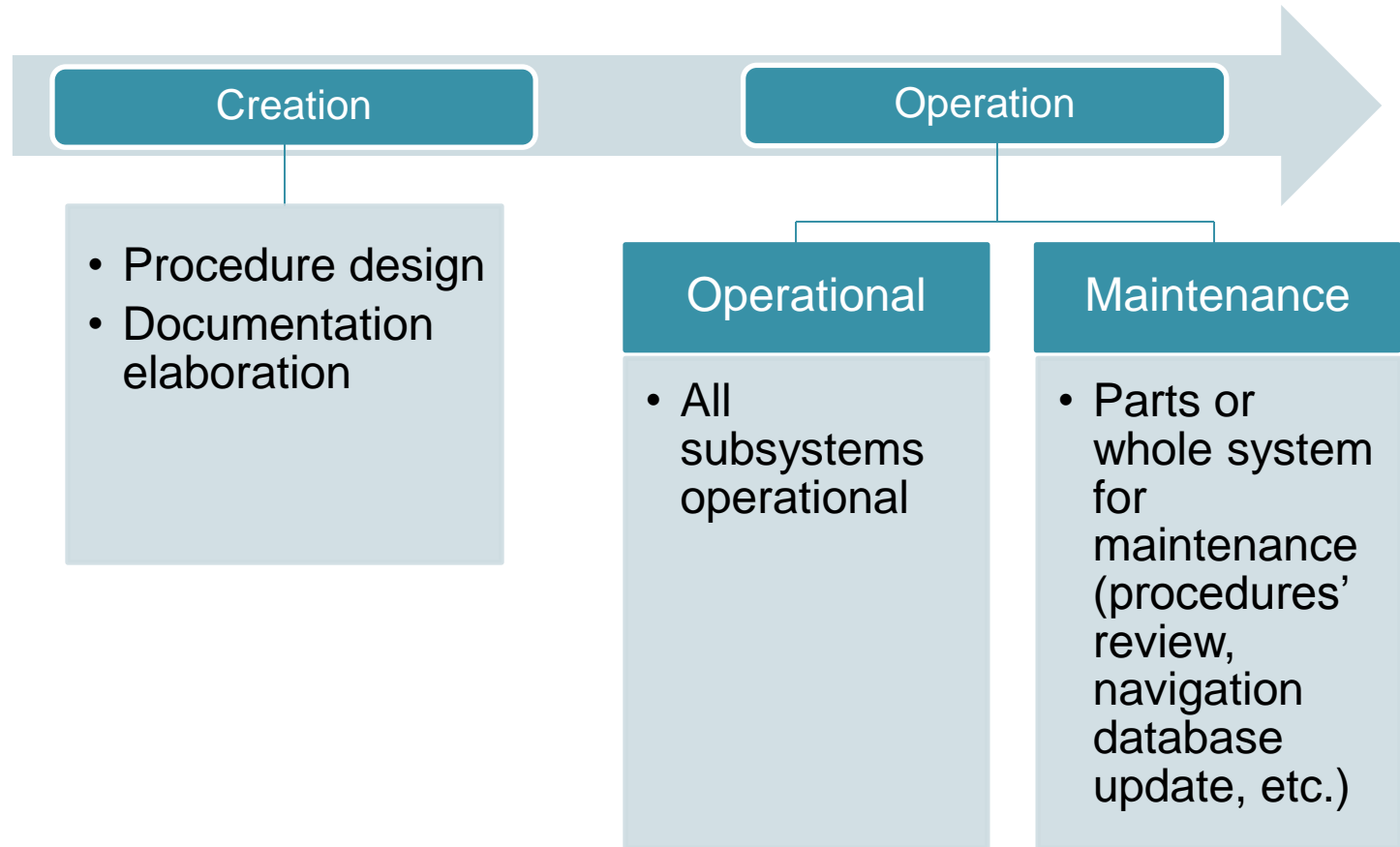
- Focus in operational phase

Actors & interfaces
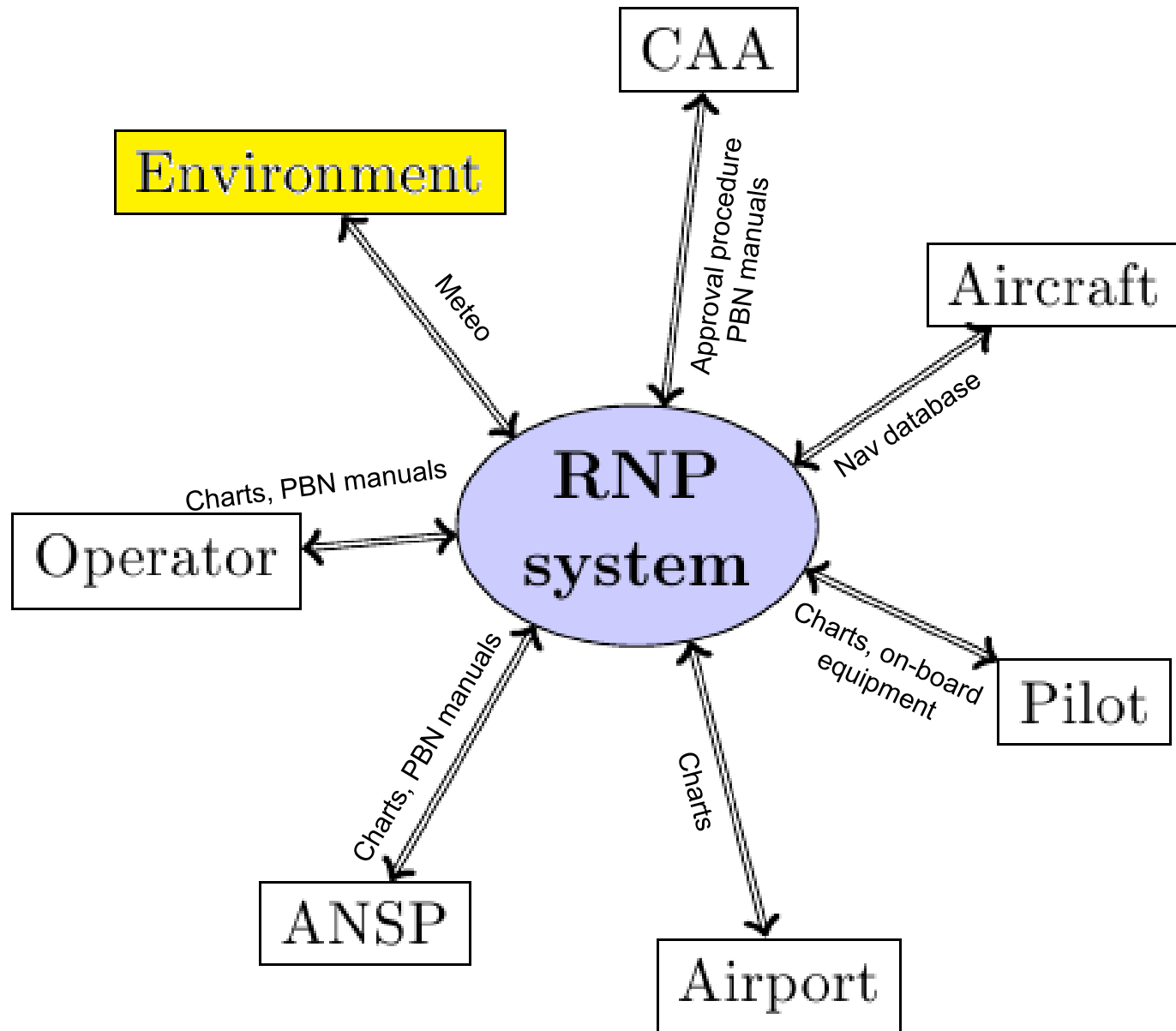
Service & constraint functions

CAA

Environment

SF$_5$: allow a/c to be approved by CAA

Aircraft

CF$_1$: Environmental conditions must allow System to be operational

SF$_3$: allow pilot to safely operate a/c

RNP system

Operator

Pilot

SF$_6$: allow pilots to be approved by CAA

SF$_2$: Allow the ANSP to ensure safe landing of aircraft

ANSP

SF$_1$: Allow the a/c to safely land/ perform missed approach at airport

Airport

SF$_4$: Allow operator to operate in airport

Function Breakdown and differentiation

		RNP APCH	RNP AR APCH	Associated Function
Established differences	*Navigation*	Missed approach segment may be based on conventional NAVAID	No exception, always GNSS	SF_2
	Publication, ATCO training	Uniform accuracy for all procedures	Different accuracy for every distinct procedure	
	Aircraft requirements	"Standard" RNP Nav accuracy, RNP 1 and RNP 0.3 during final	Possibility to increase required accuracy: RNP 1-0.1 and RNP 0.3-0.1 during final	SF_1
	Operating procedures	Standard RNP protection area and NO curved legs after the FAF	Smaller protection area and curved legs after the FAF	SF_3
		AP/FD not mandatory	AP/FD both mandatory in procedures with RF legs or accuracy less that 0.3nm.	
		Vertical navigation guidance NOT mandatory (Baro-VNAV)	Vertical navigation guidance MANDATORY (Baro-VNAV)	
	Training	FMS is not a mandate for single pilot a/c	Training for use of GNSS with FMS is mandatory	SF_6, CF_1
	Approval	Unique a/c approval for ALL procedures	Specific a/c approval for each procedure	SF_5, SF_6
		Unique pilot approval for ALL procedures	Approval to pilot to fly specific procedure	
Similarities	**Navigational database**	*Updates critical for integrity*		SF_4
	Safety assessment	*Ensure that failure conditions are assessed and mitigation means are applied to meet safety criteria*		

Outline

Objectives

➤ Present how the case study has been conducted and managed

Structure:

✓ Scope and deliverables,

✓ Stakeholders,

✓ Work Breakdown Structure (WBS) and schedule

✓ Cost management (only time & energy)

✓ Risk management,

✓ Resources management

✓ Communication management

The stakeholders

➤ The students
➤ The tutor Mr. Sebastien BARRAU
➤ The course director Mr. Fabrice FABRE

WBS / Scheduling

Task name	Dec. 2012			Jan. 2013					Feb. 2013			Mar. 2013		
	w50	w51	w52	w1	w2	w3	w4	w5	w6	w7	w8	w9	w10	w11
Discussion meeting with the tutor and document reception	12/12 12/12													
Documents' reading	13/12												12/3	
Elaboration of the work program and submission to tutor for observation					11/1	15/1								
Task sharing, report writing and cross-reading / weekly meeting with our tutor for observations on work-in-progress						15/1							12/3	
Part merging								3/2					12/3	
Presentation preparation													13/3	20/3
Presentation simulation														18/3 20/3
Presentation in front of the jury														21/3 21/3

Risk Management

- ✓ Time exceeder
- ✓ Content sufficiency
- ✓ Misunderstandings & incomprehension

Resource management

- ✓ Human resources and material resourses

Resources Task name	Students	Tutor	Course director
Discussion meeting with the tutor and document reception	✓	✓	
Documents' reading	✓		
Elaboration of the work program and submission to tutor for observation	✓	✓	
Task sharing, report writing and cross-reading / weekly meeting with our tutor for observations on work-in-progress	✓	✓	
Part merging	✓	✓	✓
Presentation preparation	✓	✓	
Presentation simulation	✓	✓	
Presentation in front of the jury	✓	✓	✓

Communication management

✓Meetings

✓Communication support (data and voice):

- • e-mails
- • telephone

Task name \ Resources	Students	Tutor	Course director
Number of meetings	13	7	1
Meeting place	Classrooms, study rooms	Tutor's office	Teacher's office

Main difficulties

➤ **Time constraints**: study, classes and weekly exams

➤ **Unexpected personal events**: personal timetable and unexpected events of each student and tutor

➤ **Human factors**: different age, different culture, different personal constraints and tempers, having to work together

"work within a team and as a team"

Thank you for your kind attention!

Back-up slides

Area Navigation
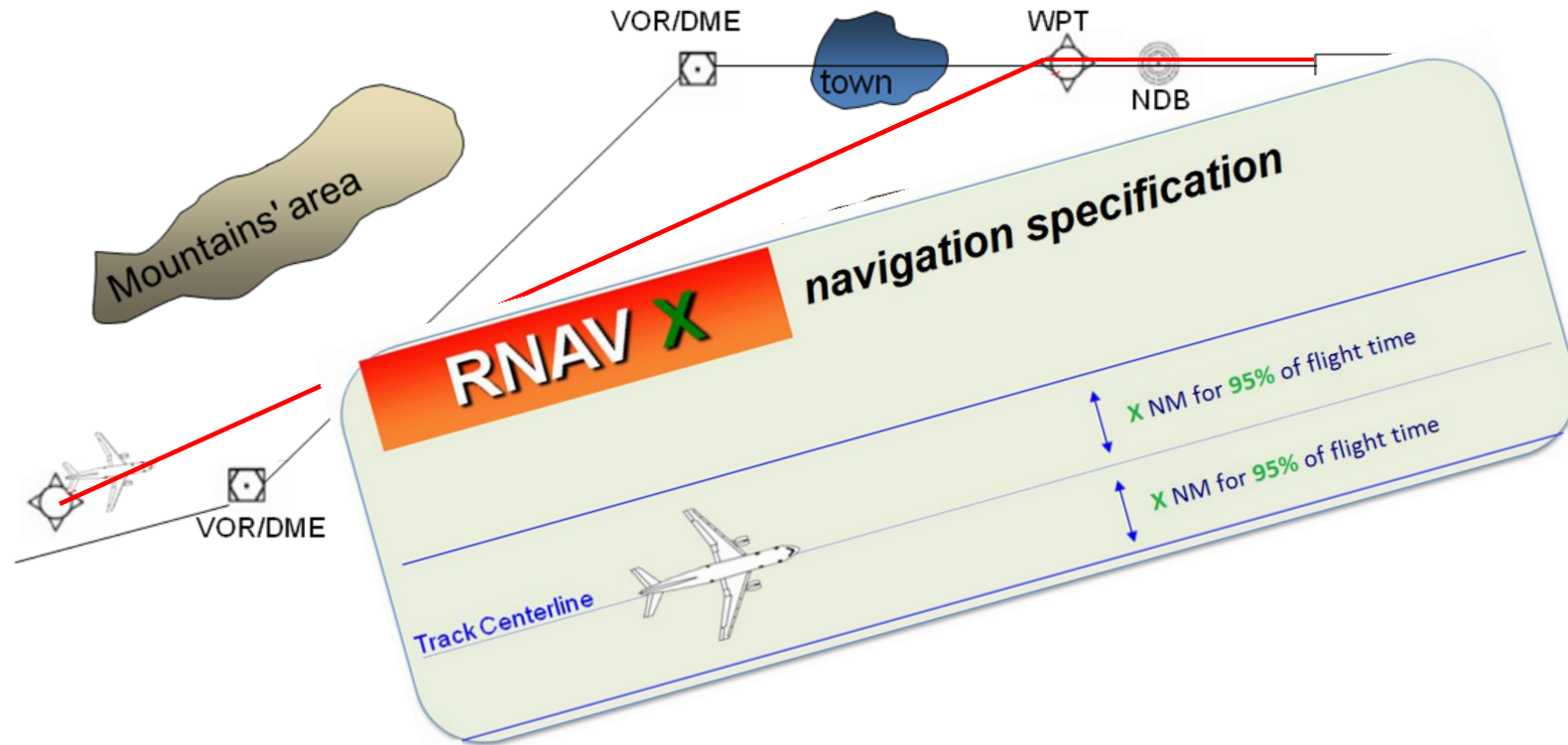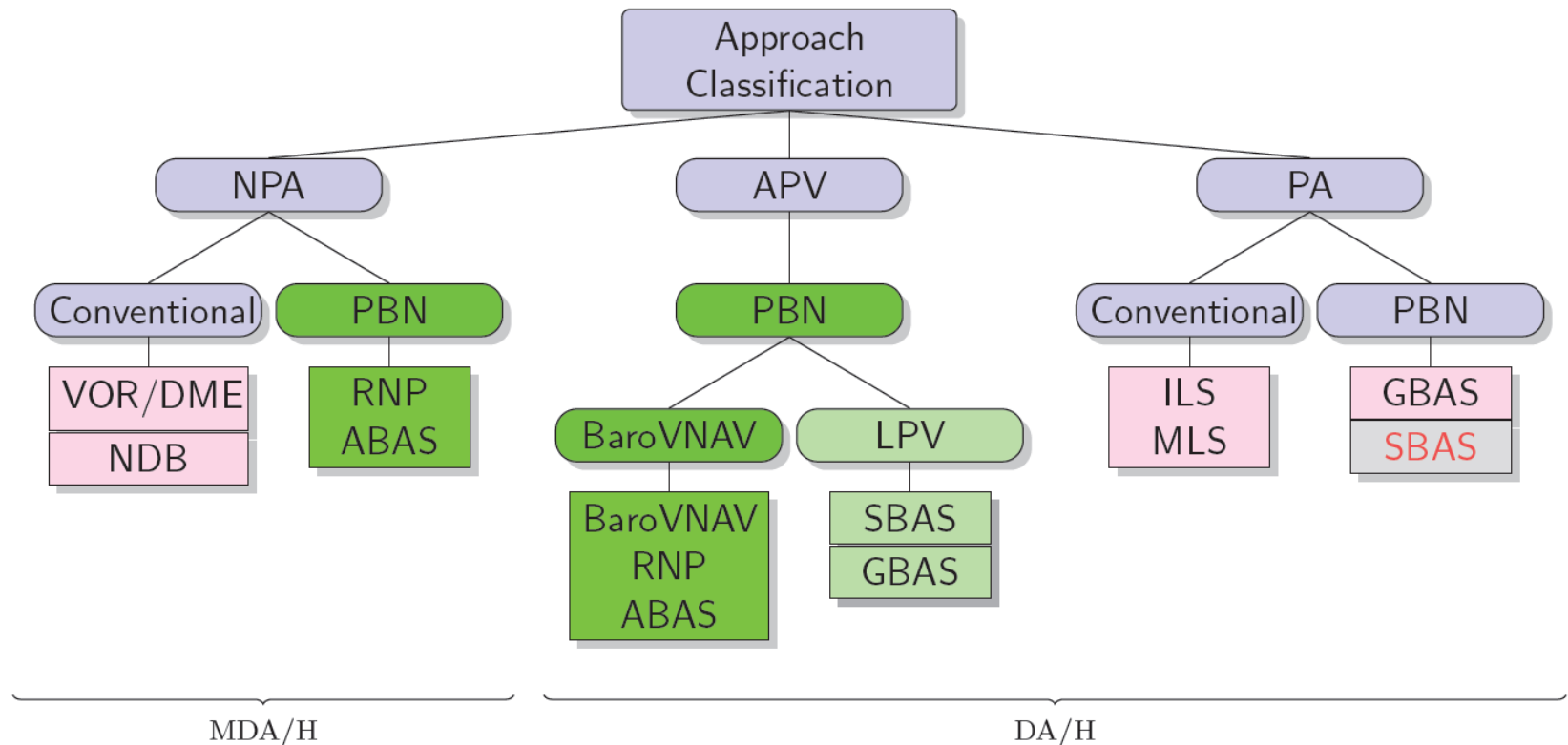

➢**Area Navigation (RNAV)**: introduction of waypoints
➢Route and airspace optimization, efficiency
➢**How:** Applicable at first in NAVaid-covered areas (DME/DME, VOR/DME), extended to oceanic (INS), and reached remote areas due to the **GNSS**

RNP approaches classification

> **NPA:** non-precision approach
> **APV:** approach with vertical guidance
> **PA:** precision approach

Left Chart (Durban)

INSTRUMENT APPROACH CHART

AERODROME ELEV 304'
HEIGHTS RELATED TO
THR RWY 06 - ELEV 287'

RADAR APP	125.75
TWR	118.45
GND	121.65
ATIS	127.00

DURBAN
(KING SHAKA INTERNATIONAL)
RNAV (GNSS) RWY 06
CAT A - D

RNP APCH

ELEV, ALT & HGT IN FEET
DIST IN NM
BRG ARE MAG
VAR 24°W (2009)

KING SHAKA
FALE ARP
29°36'42.38"S
031°07'09.53"E
304

LE1M1 (MATF)
LE1M2 (MATF)

LE1MP (MAPT)
690
TGV 115.6

2.3 NM
1060

LE1N1 (IAF)
5000
MAX 250KT IAS

LE1F1 (FAF)
3000

LE1T1 (IF)
4000
MAX 250KT IAS

LE1N2 (IAF)
5000
MAX 250KT IAS

LE1N3 (IAF)
5000
MAX 250KT IAS

TAA 5000'

062°
151° 3000
252° 3000
332°
152°

WARNING
ONLY SPECIFICALLY AUTHORISED AND
CERTIFIED PILOTS AND AIRCRAFT
ARE ALLOWED TO FLY THIS APPROACH.

DIST (NM) to LE1MP	7	6	5	4	3	2	
ADVISORY ALT (HGT)	2680 (2393)	2350 (2063)	2020 (1733)	1680 (1393)	1350 (1063)	1010 (723)	

TRANSITION ALT 5500
TRANSITION LEVEL ATC

MISSED APPROACH:
Climb straight ahead to 3000 ALT
to LE1M1 and LE1M2. At LE1M2
turn right to LE1N3 for
radar vectors.

LE1T1 (IF)
062°

LE1F1 (FAF)
3000 (2713)

062°
5.24% (3.0°)

2.3
1060 (773)

LNAV ONLY

LE1MP (MAPT)

3000 (2713)
940 (653)
690 (403)
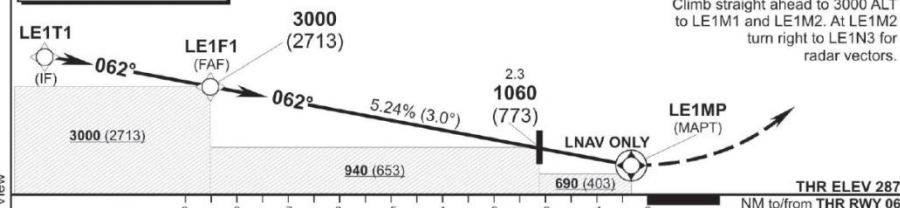
THR ELEV 287
NM to/from THR RWY 06

		A	B	C	D	GS	KT	80	100	120	140	160
Straight-in Approach	With 3.9% Missed APCH Gradient	690 (403)	690 (403)	690 (403)	690 (403)	LE1F1 to LE1MP	M:S	6:16	5:01	4:11	3:35	3:08
	With 2.5% Missed APCH Gradient	1220 (933)	1220 (933)	1220 (933)	1220 (933)	Rate of descent	FPM	425	531	637	743	849
	RVR	1200m	1400m	1400m	1800m	GS	KT	120	140	160	180	200
	ALS OUT	1500m	1500m	2000m	2000m	3.9% Missed APCH Climb Gradient	FPM	474	553	632	711	790
Circling		960(673)	990(703)	1170(883)	1440(1153)							

NOTE:
1. Minimum 3.9% Missed APCH Climb Gradient required to cross the
CTR BDRY at 3000 ALT or above.

CHANGE: SDF/Profile View

EFF: 18 NOV 10

SOUTH AFRICAN CIVIL AVIATION AUTHORITY

RNAV-01

Right Chart (Oulu, Finland)

INSTRUMENT
APPROACH CHART - ICAO

ELEV 47 FT
HEIGHTS RELATED TO
THR RWY 30 ELEV 33 FT

RNAV(GNSS) RWY 30
OULU AERODROME
OULU, FINLAND

NOTE
RNAV APPROACH
APPROVAL REQUIRED

RADIO DATA	
TWR / VDF	124.400
	119.700
APP / VDF	118.150
	119.700
ATIS (EN)	135.450
EMERG	121.500

Baro-VNAV
MIN T: -20°C

MAHE
MARUG
OUK
R-288.9 / 8.0

MAPt
RW30

IAF
ROGOT
2300
MAX IAS 240 KT

FAF
ARNON
1950

IAF / IF
KUMOK
2300

IAF
LUNOX
2300
MAX IAS 240 KT

MSA
2300
FM ARP
EFOU

25 NM

1 : 350 000

TA 5000

MISSED APPROACH
RNAV
RW30 – MARUG [A1700]

CONVENTIONAL
R-289 OUK to MARUG
climbing to 1700

MAPt
RW30

FAF
ARNON

From
KUMOK
2300

SDF LNAV
2.5 RW30

290°
8.1% (3.5°)

1950

1020

TCH 50 FT
5.0 NM

RWY 30 THR ELEV 33

OCA (H)	A	B	C	D
LNAV	400 (360)			
LNAV / VNAV	370 (330)			

DIST FM THR		1,0 NM	2,0 NM	3,0 NM	4,0 NM
Altitude (Height)		460 (430)	830 (800)	1200 (1170)	1570 (1540)
	kt	90	100	120	140	160
FAF - MAPt 5,0 NM	min:sec	3:20	3:00	2:30	2:09	1:52
Rate of descent	ft/min	560	620	740	870	990

Timing not authorized for defining the MAPt

05 MAY 2011

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EFOU AD 2.13 - 13

Left chart — Queenstown

NZQN AD 2 – 45.3

Changes from 15 NOV 12: G756.

AIP New Zealand

QUEENSTOWN
RNAV (RNP) Y RWY 05
UNATTENDED: 118.1

CAT C,D   ATIS: 126.4

ELEV 1171
RWY 05 THR ELEV 1160
TOWER: 118.1 128.9

Minimum Sector Altitude 25 NM ARP

HOLDING SUNGU

CAUTION
- Aerodrome surrounded by mountainous terrain
- Aerodrome surrounded by mountainous terrain
  - VFR ACFT may be OPR without reference to ATC in G756, G755 and G753

Contour interval 1000ft

NOTES:
- MNM altitude 9200ft
- MNM CTA containment altitude FL150
- MAX holding speed 240kt IAS
  If unable to reach 9200ft by SUNGU, climb to 9800ft via the RNAV (RNP) missed approach track to NV.

MISSED APCH: Climb to FL150 via the RNAV (RNP) missed approach track to NV, maintain 11,000ft or below until crossing QN882. Hold SUNGU FL150

Use Queenstown QNH only. See CAANZ RNP-AR operator approval for specific procedure minima.

Category	A	B	C	D
RNP 0.15		1438(278) −1300		
RNP 0.18		1625(465) −2300		
RNP 0.30		2229(1069) − 5.6		

OMUBO (FAF) 3100
IBABU (IAF)

OPERATOR SPEED RESTRICTIONS MAY APPLY
FOR OPERATORS WITH CAANZ APPROVAL ONLY

C NAVDG QNRNAVY05-8

Right chart — New York/La Guardia

APP CRS 044°	Rwy Idg 7001
	TDZE 21
	Apt Elev 21

▼ GPS required. Visibility reduction by helicopters NA. For uncompensated Baro-VNAV systems, procedure NA below -12°C (11°F) or above 48°C (118°F). Inoperative table does not apply to RNP 0.18. For inoperative MALSR, increase RNP 0.30 visibility to 1½.

⚠ NA

MALSR
MISSED APPROACH: Climb to 2000 via 044° track to GREKO and hold.

ATIS ARR	125.95	NEW YORK APP CON	LA GUARDIA TOWER	GND CON	CLNC DEL
ATIS DEP	127.05	120.8 263.0	118.7 263.0	121.7 263.0	135.2

RADAR REQUIRED

RNP AR APCH

GREKO   4 NM

MSA RW04 25 NM   2600

(IAF) GRITY   3000 085° (10.8)
(IF) TICKL   3000 045° (3.5)   RENUE
(IAF) MINKS   3000 056° (12)
(FAF) DNNIS   1700 045° (9.3)

VGSI and RNAV glidepath not coincident (VGSI Angle 3.00/TCH 74).

2000   GREKO   tr 044°

TICKL 3000
DNNIS 1700
045°   044°   RW04
GP 3.00° TCH 52
9.3 NM   5 NM

CATEGORY	A	B	C	D
RNP 0.18 DA		337/50 316 (400-1)		
RNP 0.30 DA		474/50 453 (500-1)		

AUTHORIZATION REQUIRED

ELEV 21	D	TDZE 21

044° to RW04

TDZ/CL Rwys 4, 13 and 22
HIRL Rwys 4-22 and 13-31
REIL Rwys 13, 22 and 31