



ICAO | UNITING AVIATION

CELEBRATING 70 YEARS OF
THE CHICAGO CONVENTION



Workshop on PBN airspace Design

31 May - 04 June 2021





ICAO | UNITING AVIATION

CELEBRATING 70 YEARS OF
THE CHICAGO CONVENTION



Approach Navigation Specifications

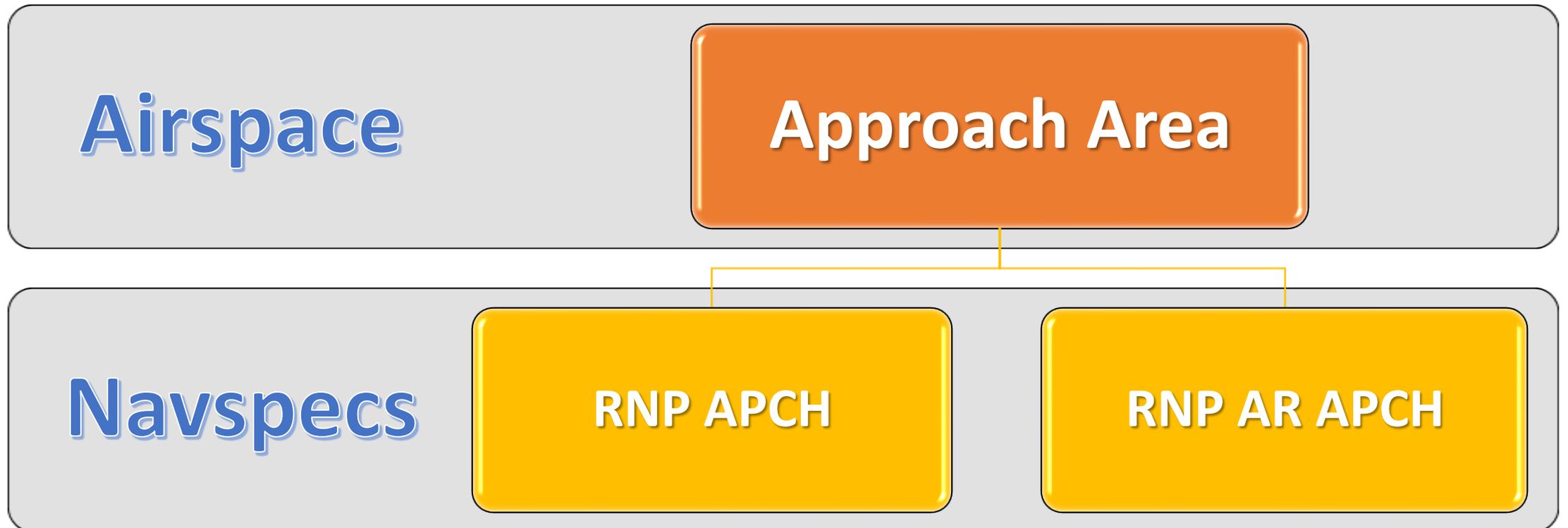




- General on approaches
- Facts about RNP approach
- Approach charts
- PBN approach equipment requirements
- RNP AR APCH



Approach navspecs





General on approaches

African Flight Procedure Programme (AFPP)

Instrument Approach Procedures

☐ Instrument approach procedures are classified as:

- ☞ **Non-precision approach (NPA):** An instrument approach procedure designed for 2D (LNAV) instrument approach operations Type A.
- ☞ **Approach procedure with vertical guidance (APV):** A PBN instrument approach procedure designed for 3D (LNAV/VNAV) instrument approach operations Type A.
- ☞ **Precision approach procedure (PA):** An instrument approach based on navigation systems (ILS, MLS, GLS) instrument approach operations Type A or Type B.



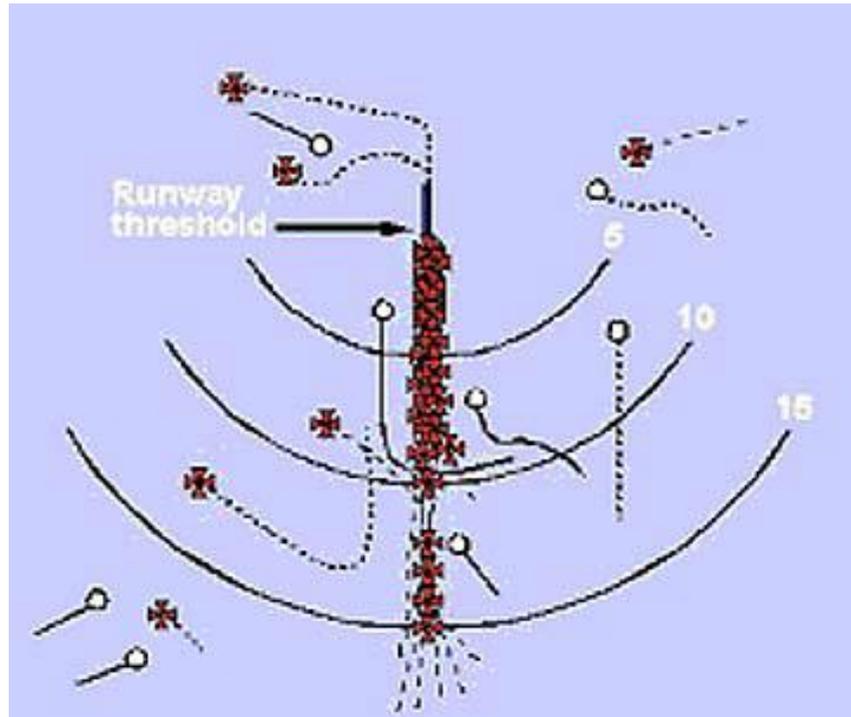
General on approaches

African Flight Procedure Programme (AFPP)

Why APV?

- ❑ ICAO General Assembly 36/23 resolution:
 - ☞ ICAO requires the implementation of **APV approaches** (APV Baro-VNAV and/or APV-SBAS [LPV]) to all instrument runway ends by 2016.
- ❑ There are three reasons for promoting APVs:
 1. To reduce controlled flights into terrain (CFIT) accidents by providing vertical guidance on most approaches;
 2. To provide the pilot with a glide slope; and
 3. To provide the lowest possible DA/H on each approach, thus improving airport accessibility.

The need for APV...



Controlled Flight Into Terrain on approach is the greatest cause of fatal crashes.





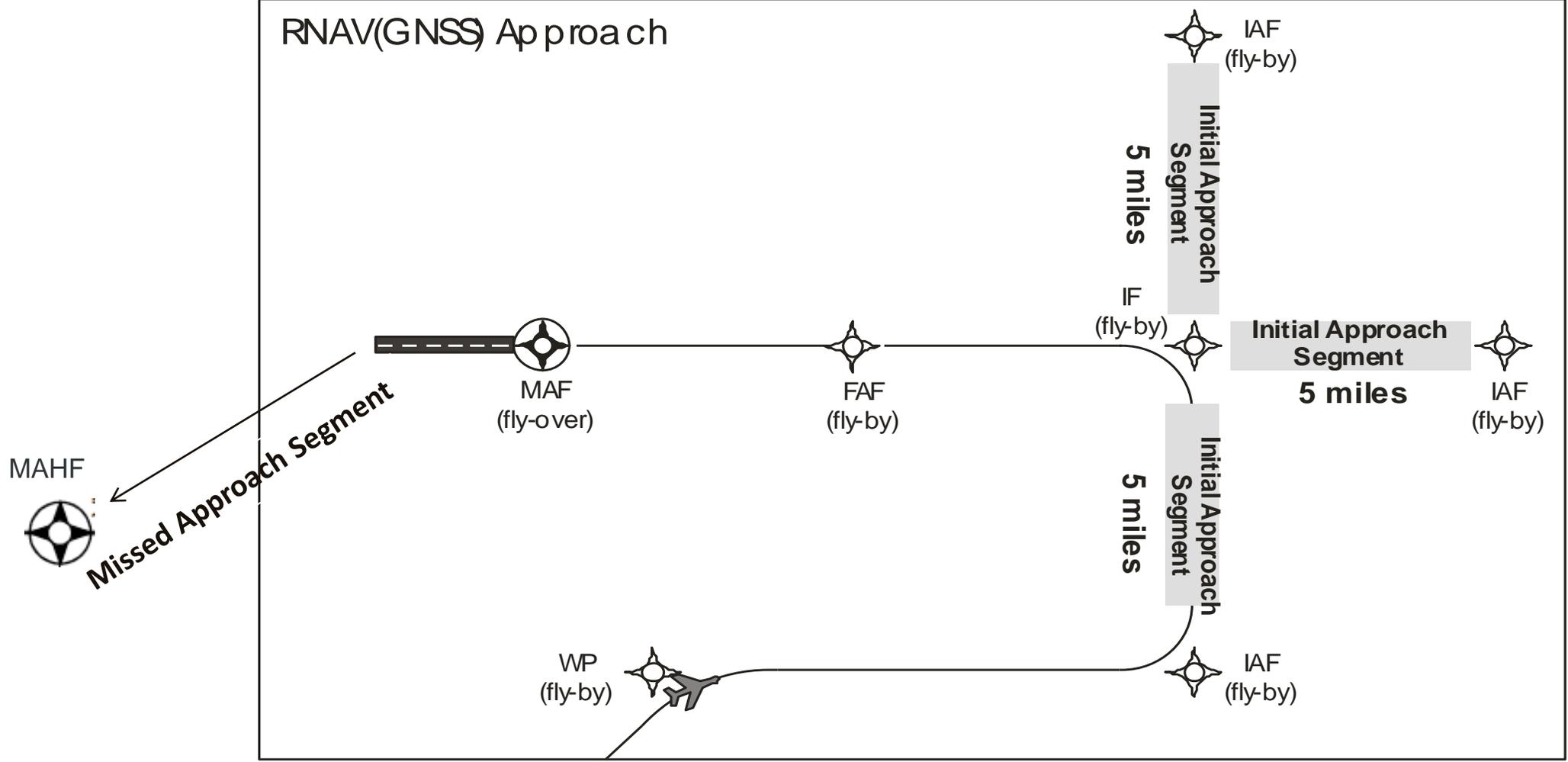
Facts about RNP approach

African Flight Procedure Programme (AFPP)

RNAV (GNSS) Approach

- ❑ RNP APCH is the name of the Nav Spec;
- ❑ RNAV (GNSS) RWY XX is used for charting;
- ❑ Common name – GNSS or GPS or RNAV approach
 - 👉 Or LNAV approach... more about this later
- ❑ Requires GNSS for on-board performance monitoring and alerting;
- ❑ 1.0 NM accuracy required on initial, intermediate and missed approach segment, 0.3 NM accuracy required on the final segment.
- ❑ 2D (LNAV) aircraft descends to an MDA (Minimum Descent Altitude);
- ❑ It is a non-precision approach (NPA).

RNAV(GNSS) Approach





PBN approaches

□ Up to three (3) types of minima can be listed on a RNAV (GNSS) chart, and Operators may be requesting any of, or all of the three approvals:

☞ **RNP APCH – LNAV:**

- Can be flown by stand-alone GNSS receivers or GNSS equipped FMS aircraft.

☞ **RNP APCH – LNAV/VNAV:**

- Satisfies minimum requirements for APV.
- Requires FMS integrating GNSS lateral navigation and Barometric VNAV; or SBAS receiver (TSO-C145/46) operating in SBAS service area.

☞ **RNP APCH – LPV or LP**



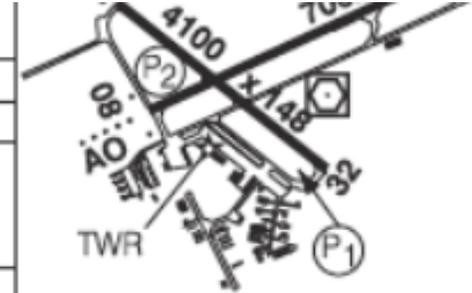
LNAV, LNAV/VNAV & LPV minima

African Flight Procedure Programme (AFPP)

OCA / H					Distance RR409-RW28 : 5 NM							
Cat of ACFT	A	B	C	D	Speed (knots)	110	120	130	140	150	170	180
LNAV	460 (449)				Time (min:sec)	2:44	2:30	2:19	2:09	2:00	1:46	1:40
Cat of ACFT	A	B	C	D	Speed (knots)	110	120	130	140	150	170	180

LNAV	460 (449)	
Vis. Straight-in	1600 m	2000m
LNAV/VNAV	290 (282)	
Vis. Straight-in	1600 m	1600m
Circling	610(599)	800(780)
Vis. Circling	1600 m	3600m

CATEGORY	A		B		C		D	
	LPV	1280		(251)		1		
LNAV / VNAV	NOT AUTHORIZED							
LNAV	1500		(471)		1½			
CIRCLING	1560		(505)		1½		1560 (505) 2	
	1660		(605)		2		1660 (605) 2	





Approach charts

African Flight Procedure Programme (AFPP)

Naming convention

- ❑ The naming convention for approaches is changing:
 - ☞ “RNAV (GNSS) RWY 28” should become “RNP RWY 28” by 2022.
- ❑ Potential implementation issues identified:
 - ☞ Confusion with a mixture of procedures using old and new naming convention within a State’s airspace.
 - More confusing with RNP AR procedures also being used.
 - ☞ Alignment of chart name, FMS name and R/T phraseology.
- ❑ ICAO has issued Circular 353 Transition Planning for Change to Instrument Flight Procedure Approach Chart Identification from RNAV to RNP to define the process.
 - ☞ Circular 353 replaces Circular 336.



Approach charts

African Flight Procedure Programme (AFPP)

Naming convention

Navigation specification	Existing chart identification	New chart identification
RNP APCH	RNAV (GNSS) RWY 23	RNP RWY 23
RNP AR APCH	RNAV (RNP) RWY 23	RNP RWY 23 (AR)



Naming convention: Parenthetical suffices

Condition	Suffix	Example
Procedure has only a LPV line of minima	LPV only	RNP RWY 23 (LPV only)
Procedure has only a LNAV/VNAV line of minima	LNAV/VNAV only	RNP RWY 23 (LNAV/VNAV only)
Procedure has both LPV and LNAV/VNAV lines of minima but no LNAV line of minima	LPV, LNAV/VNAV only	RNP RWY 23 (LPV, LNAV/VNAV only)
Procedure has only a LP line of minima	LP only	RNP RWY 23 (LP only)



Examples of box requirements

Navigation specification	Examples of additional requirements in PBN requirements box
RNP APCH	RF required
RNP AR APCH	RNP <0.3 Missed Approach RNP <1
Advanced RNP	RNP <1 in initial and intermediate segment
RNP 0.3 (H)	RF required

**INSTRUMENT
APPROACH
CHART — ICAO**

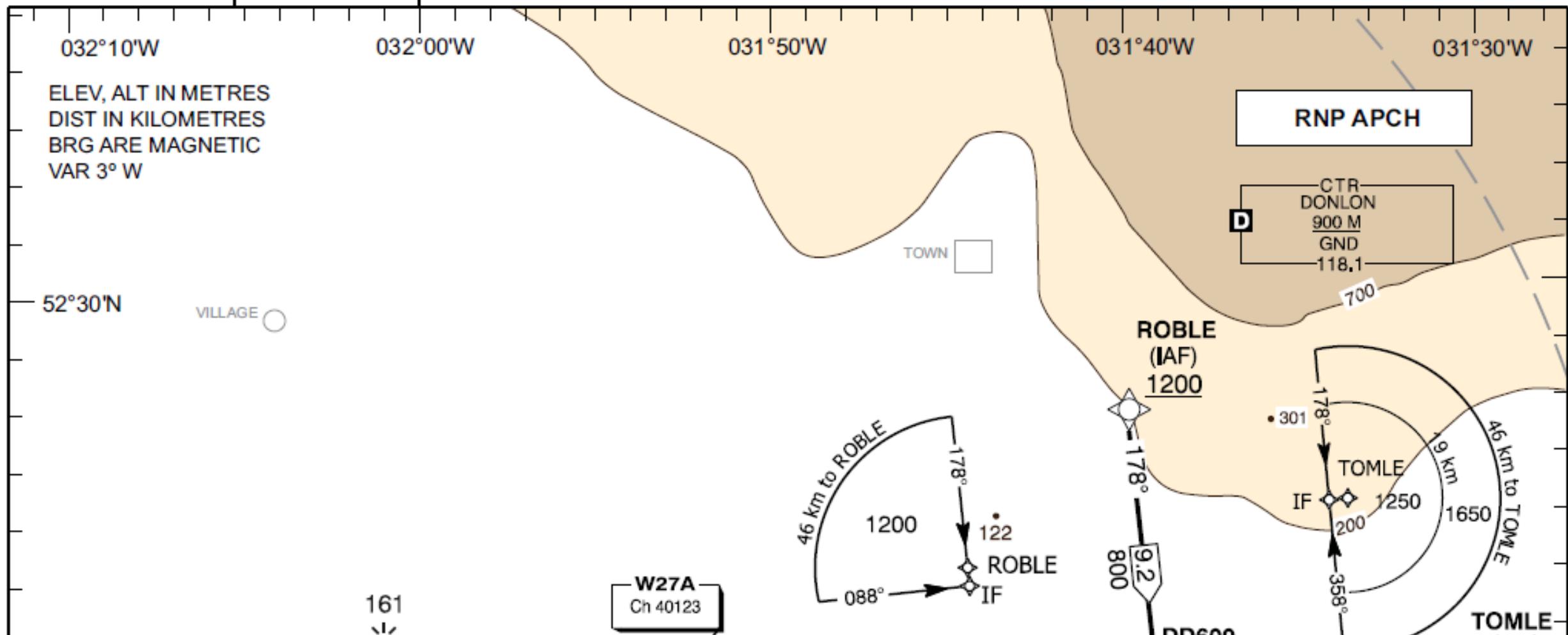
**SBAS
CH 40123
W27A**

AERODROME ELEV 30 m
HEIGHTS RELATED TO
THR RWY 27L — ELEV 20 m

APP	119.1
TWR	118.1

DONLON/Intl (EADD)

RNP Z RWY 27L



161
↙

W27A
Ch 40123

NEW DESIGNATION (with PBN requirements box)



INSTRUMENT APPROACH CHART – ICAO	SBAS Ch 40123 W27A	AERODROME ELEV 30 m HEIGHTS RELATED TO THR RWY 27L - ELEV 20 m	APP 119.1 TWR 118.1	DONLON/INTL (EADD) RNP RWY 27L
----------------------------------	--------------------	--	------------------------	-----------------------------------

RNP APCH

← Chart identification

← PBN requirements box

INSTRUMENT APPROACH CHART – ICAO	SBAS Ch 40123 W27A	AERODROME ELEV 30 m HEIGHTS RELATED TO THR RWY 27L - ELEV 20 m	APP 119.1 TWR 118.1	DONLON/INTL (EADD) RNP Z RWY 27L (LPV ONLY)
----------------------------------	--------------------	--	------------------------	--

RNP APCH

← (LPV only)

INSTRUMENT APPROACH CHART – ICAO	SBAS Ch 40123 W27A	AERODROME ELEV 30 m HEIGHTS RELATED TO THR RWY 27L - ELEV 20 m	APP 119.1 TWR 118.1	DONLON/INTL (EADD) RNP Y RWY 27L (LNAV/VNAV ONLY)
----------------------------------	--------------------	--	------------------------	--

RNP APCH

← (LNAV/VNAV only)

INSTRUMENT APPROACH CHART – ICAO	SBAS Ch 40123 W27A	AERODROME ELEV 30 m HEIGHTS RELATED TO THR RWY 27L - ELEV 20 m	APP 119.1 TWR 118.1	DONLON/INTL (EADD) RNP X RWY 27L (AR)
----------------------------------	--------------------	--	------------------------	--

RNP AR
RF required

← (AR)



PBN approach equipment requirements

African Flight Procedure Programme (AFPP)

RNP APCH – LNAV

❑ GNSS stand-alone systems:

☞ TSO-C129a / ETSO-C129a Class A1; or (E)TSO-C146() Class 1, 2 or 3.

☞ Stand-alone GNSS (TSO-C129) receivers **DO NOT** have approved vertical guidance/navigation capability and **cannot fly LNAV/VNAV approaches!!**

❑ GNSS sensors used in a multi-sensor system (FMS):

☞ TSO-C129()/(E)TSO 129() Class B1, C1, B3, C3 (FDE recommended); or

☞ (E)TSO-C145() Class 1, 2, or 3; or TSO-C196

❑ Look for compliance statement: **AC 20-130A** or **TSO-C115b** (RNP APCH capability must have been demonstrated).

Almost ALL TSO-C129a approved GNSS receivers either stand-alone or incorporated in an FMS are capable of RNP APCH – LNAV.



PBN approach equipment requirements

African Flight Procedure Programme (AFPP)

Applicable systems

- ❑ Stand-alone and multi-sensor FMS systems using GNSS, compliance with both:
 - ☞ **FAA AC 90-105 (RNP), EASA AMC 20-27 (LNAV, LNAV/VNAV),**
 - ☞ **AC 20-129 (LNAV/VNAV), AC 20-138A (GPS), AC 20-130A (FMS+GPS)**
 - TSO C115b published prior to TSO-C129a... should not be accepted for RNP APCH
- ❑ Assures automatic compliance with RNP APCH LNAV/VNAV.
- ❑ No need for further assessment or AFM documentation.
- ❑ Approval to this standard allows RNP APCH operations down to LNAV or LNAV/VNAV minima globally.



PBN approach equipment requirements

African Flight Procedure Programme (AFPP)

Functionalities

- Navigation database.
 - ☞ Load entire procedure (approach) from the database.
- Direct to function (DF)
- Automatic leg sequencing with fly-by or fly-over transitions.
- Track consistent with:
 - ☞ TF
 - ☞ DF (often used in missed approach)
 - ☞ RF (optional but not allowed in the Final Approach Segment)
- Indication of system failure, including sensor failure.
- Indicate when NSE alert limit is exceeded.



PBN approach equipment requirements

African Flight Procedure Programme (AFPP)

Functionalities (cont'd)

Flight Director and/or Autopilot:

☞ Not required for this type operation, however if lateral TSE cannot be demonstrated without these systems, it becomes mandatory.

Enhanced Navigation Display:

☞ Electronic map display could be made mandatory if PFD does not adequately display needed information.



PBN approach equipment requirements

African Flight Procedure Programme (AFPP)

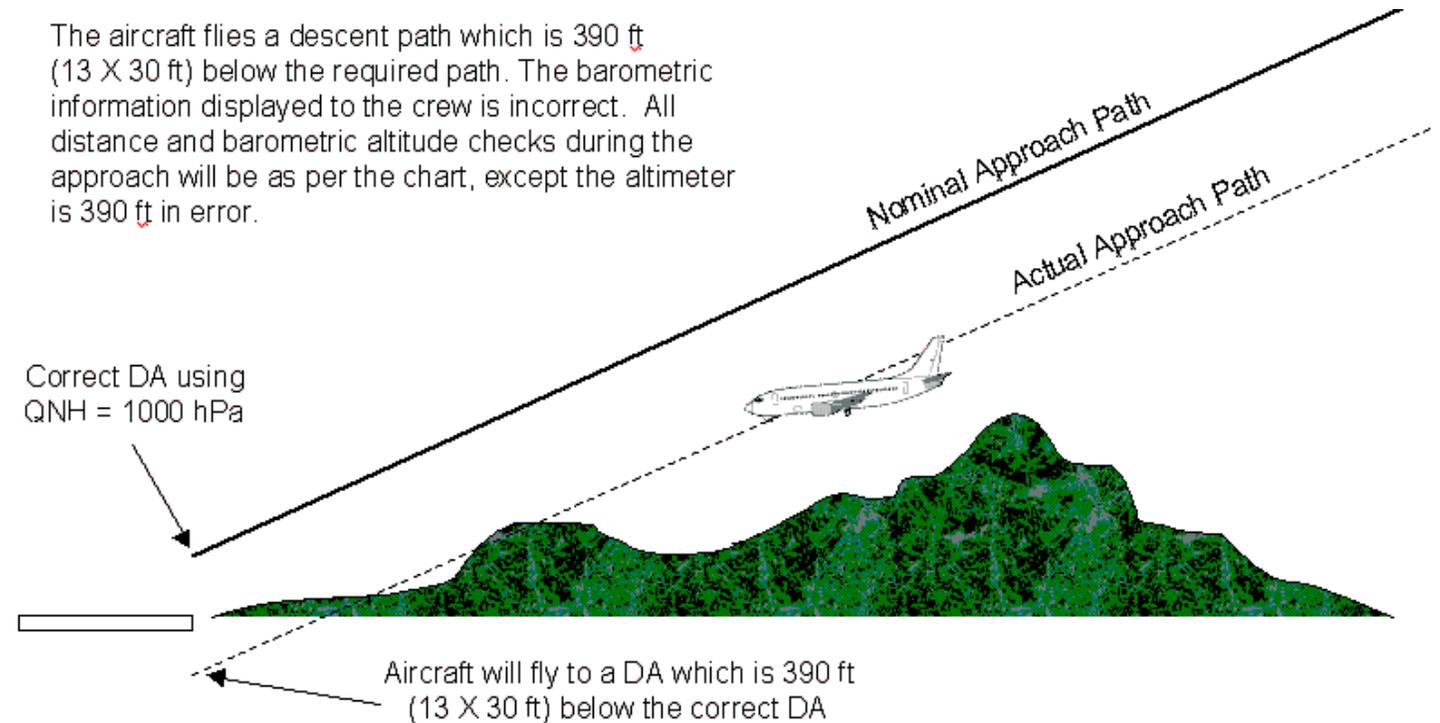
Temperature correction

- ❑ Cold temperatures reduces actual VNAV path angle.
- ❑ High temperatures increase actual VNAV path angle.
- ❑ Procedure design provides obstacle clearance:
 - 👉 **At the minimum operating temperature:**
 - Minimum operating temperature published on approach chart.
 - VNAV operations not permitted in lower temperatures.
 - LNAV operations may be flown.
- ❑ Aircraft equipped with automatic temperature compensation or using other VNAV systems (e.g. SBAS) may disregard temperature restrictions.

Altimeter Mis-set By 13 hPa

The aircraft flies a descent path which is 390 ft (13 X 30 ft) below the required path. The barometric information displayed to the crew is incorrect. All distance and barometric altitude checks during the approach will be as per the chart, except the altimeter is 390 ft in error.

- If altimeter subscale setting is in error, VNAV flight path error is 30 ft/hPa
- Significant safety risk
- Flight crew procedures and knowledge must be thorough





PBN approach equipment requirements

African Flight Procedure Programme (AFPP)

RNP APCH – LP/LPV

☐ GNSS stand-alone systems:

☞ (E)TSO-C146() SBAS receiver **Class Gamma 3**

☐ Integrated navigation system (FMS) incorporating an SBAS sensor:

☞ (E)TSO C145a **Class Beta 3.**

- Or (E)TSO-C146a or later, Class Gamma 3 or 4; or

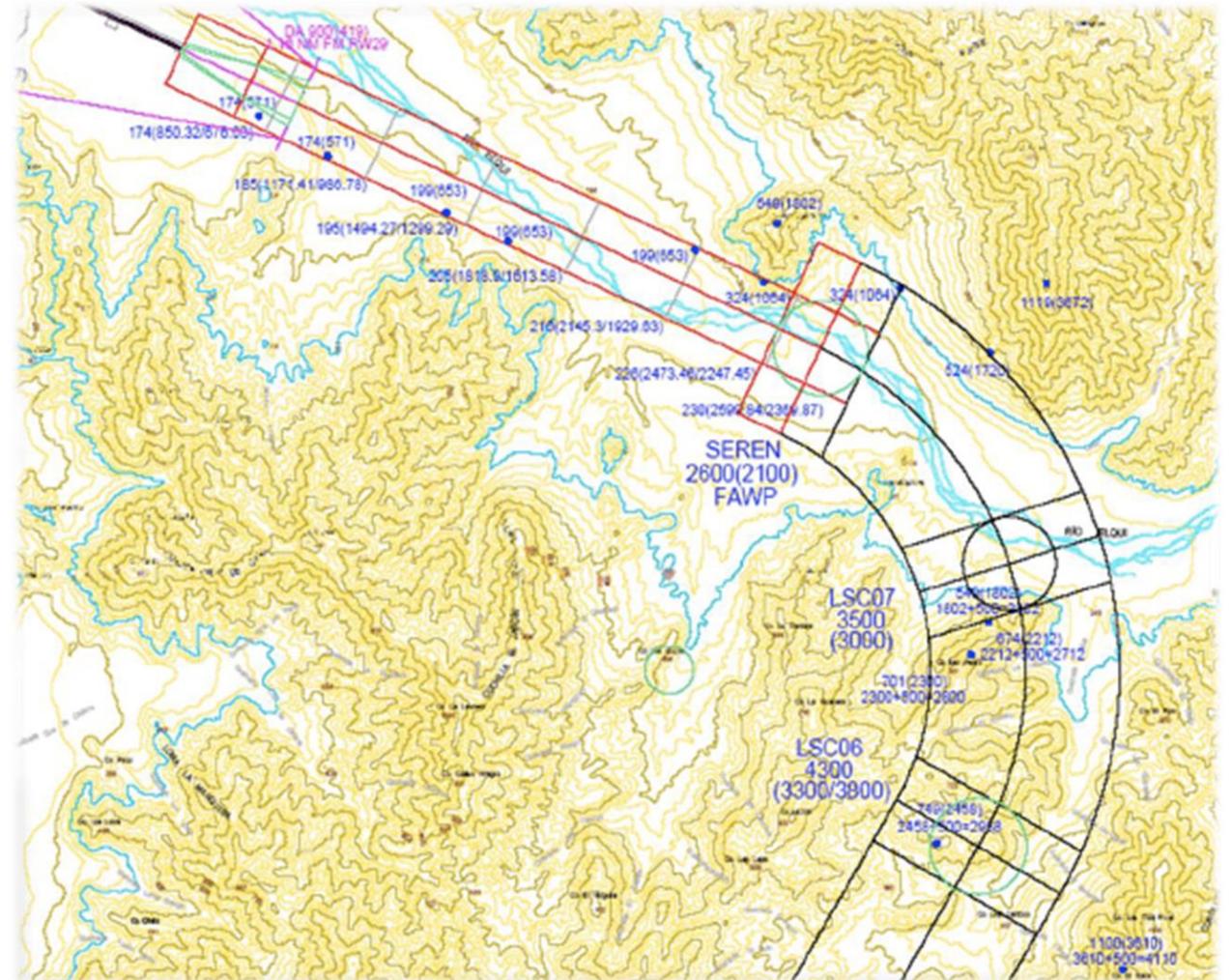
A LPV approach is 3-D approach operation flown to a DA
A LP approach is a 2-D approach operation flown to an MDA.



- ❑ RNP APCH segments
- ❑ Performance requirements
- ❑ Approach Procedure with Vertical Guidance
- ❑ Baro-VNAV (LNAV/VNAV) and temperature effects
- ❑ Existing charting vs. Circular 353 charting convention
 - 👉 RNAV (RNP) RWY 23 = RNP RWY 23



RNP AR APCH
**GENERAL
INFORMATION**





RNP AR APCH vs. RNP APCH

- ❑ RNP AR APCH is the PBN Nav Spec name;
- ❑ Charting designation is **RNAV (RNP) RWY 25**;
- ❑ Common name is ‘RNP’ approach or ‘AR’ approach (*Authorization Required*):
 - ☞ Requires GNSS for on-board performance monitoring and alerting;
 - ☞ Aircraft descends to a **DA** (Decision Altitude).
- ❑ RNP AR APCH is also one type of APV;
- ❑ The “glide slope” is **temperature dependent!**
- ❑ Controllers still use the same phraseology:
 - ☞ **“CLEARED RNAV APPROACH RUNWAY...”**



RNP AR APCH vs. RNP APCH

□ RNP AR APCH is defined as an approach procedure that may require a lateral TSE as low as ± 0.1 NM on any segment of the approach procedure:

☞ Initial, intermediate and missed = $1.0 - 0.1$ NM;

☞ Final = $0.3 - 0.1$ NM.

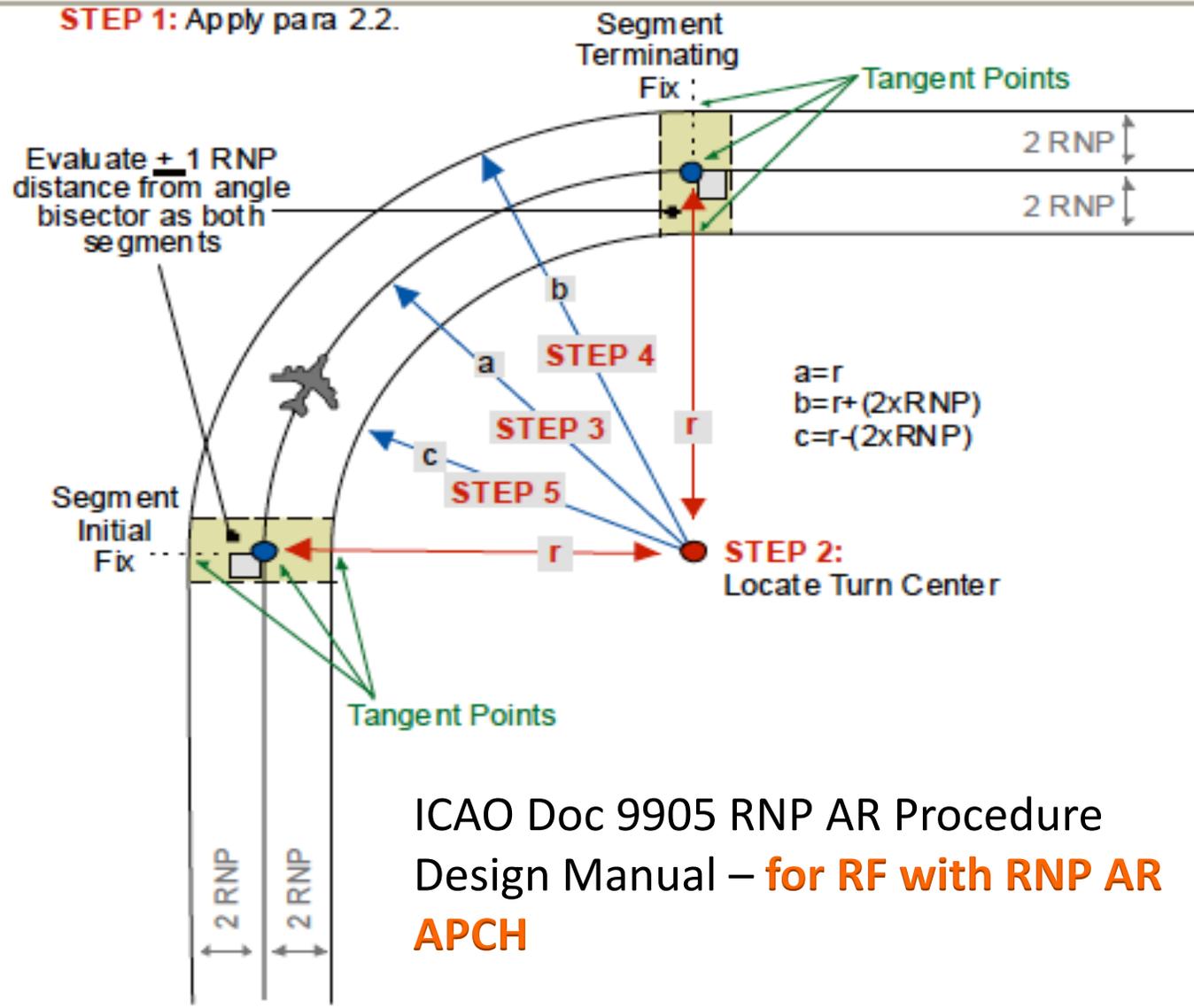
□ RNP APCH is an approach procedure that requires a lateral TSE of ± 1 NM in the:

☞ Initial, intermediate and missed approach segments.

□ and ± 0.3 NM in the:

☞ Final approach segment.

Figure 4-8. RF turn construction



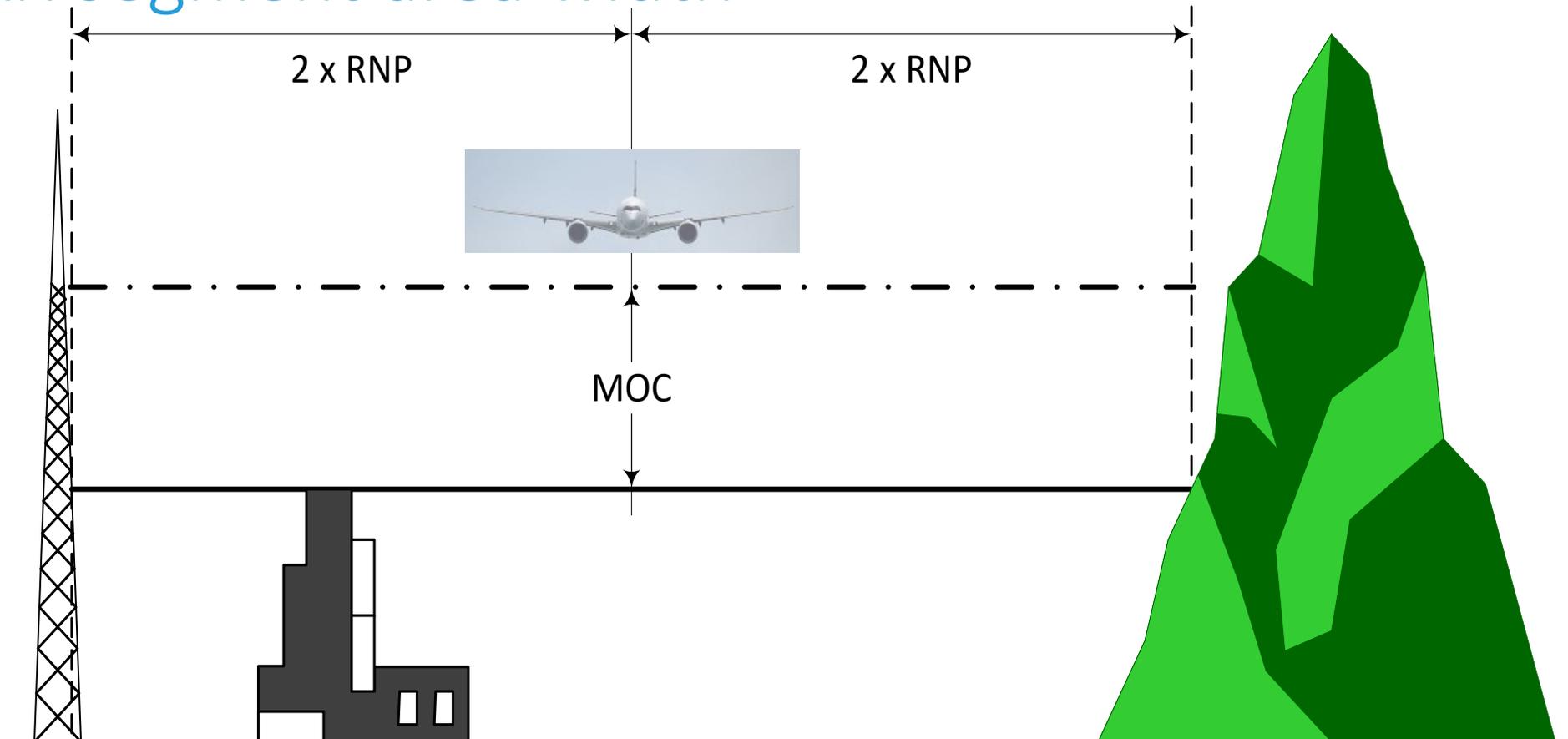
ICAO Doc 9905 RNP AR Procedure
Design Manual – **for RF with RNP AR
APCH**

The main advantage are the curved (RF) segments that require no more than 2 x RNP protection from terrain and man-made obstacles.

However, they are expensive to implement and Air Operators try to avoid the lengthy and costly Operational Approvals.

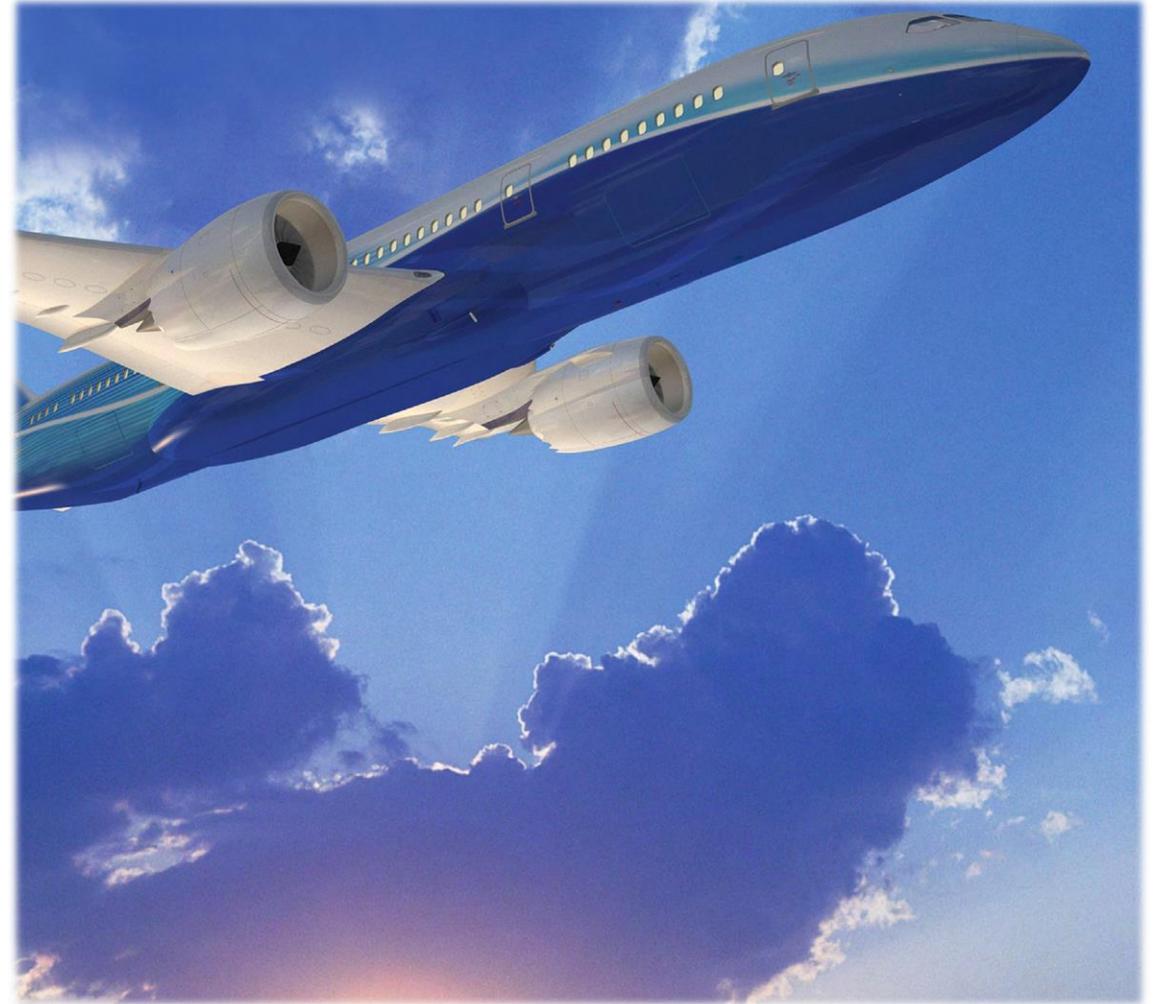
They should be implemented only at airports to address an operational requirement.

RNP AR segment area width





RNP AR APCH
**REVIEW OF
ALL PBN APPROACHES**



RNAV (GNSS) RWY 27:

- This is an ‘area navigation’ approach requiring as a minimum a “GNSS Stand-alone receiver”.

RNAV (RNP) RWY 09:

- This is an “area navigation” approach requiring an “RNP system”.
- FMS with RF and VNAV functionality, with ‘scalable’ performance selection 1.0 to 0.1 NM





Three (3) Types of APVs

❑ LNAV/VNAV (common name Baro-VNAV) can be flown with:

☞ FMS + VNAV;

☞ SBAS receiver but only in SBAS service!

❑ LPV (common name LPV):

☞ SBAS receiver also only in SBAS service, but this approach will not be published outside of SBAS service,

...and

❑ RNP AR APCH (common name RNP or AR approach) can be flown with...

☞ FMS + VNAV



RNP AR APCH
SUMMARY





Summary

- ❑ Characteristics of RNP AR APCH & General Information
- ❑ RNP AR APCH Current Naming Convention
- ❑ Intended use of RNP AR APCH
 - 👉 In mountainous terrain with bad weather
- ❑ Advantages/Benefits of RNP AR APCH
 - 👉 Curved Segments and 2 x RNP protection in the turns
- ❑ Difference between RNP AR APCH and RNP APCH



UNITING AVIATION

CELEBRATING 70 YEARS OF
THE CHICAGO CONVENTION



African Flight Procedure Programme (AFPP)

Questions?



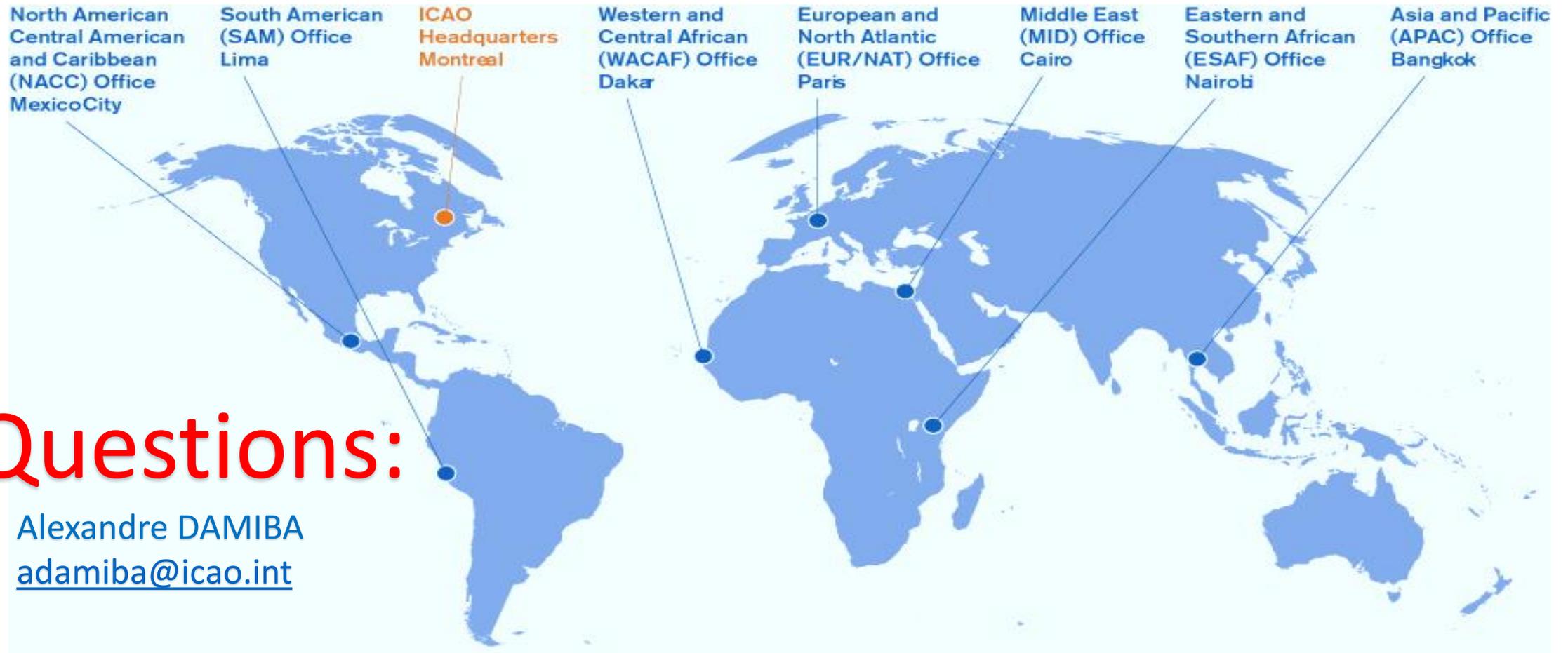
Comprehension Check

African Flight Procedure Programme (AFPP)

1. What is the PBN Nav Spec name of the commonly called “AR” approach?
2. What is the charting designation of a commonly called “RNP” approach?
3. What minima do aircraft descend to on an RNP AR APCH?
4. What is the lowest performance accuracy in NM on all segments?
5. Is RNP AR APCH also one type of APV?
6. What are the biggest benefits of RNP AR APCHs?
7. Where can these approaches be implemented and what are the general issues with implementation?
8. What is the phraseology for clearing an aircraft for an RNP AR APCH?



Questions?



Questions:

Alexandre DAMIBA
adamiba@icao.int