PANS-OPS Flight Procedure Design Training for CAAs

23 August – 03 September 2021

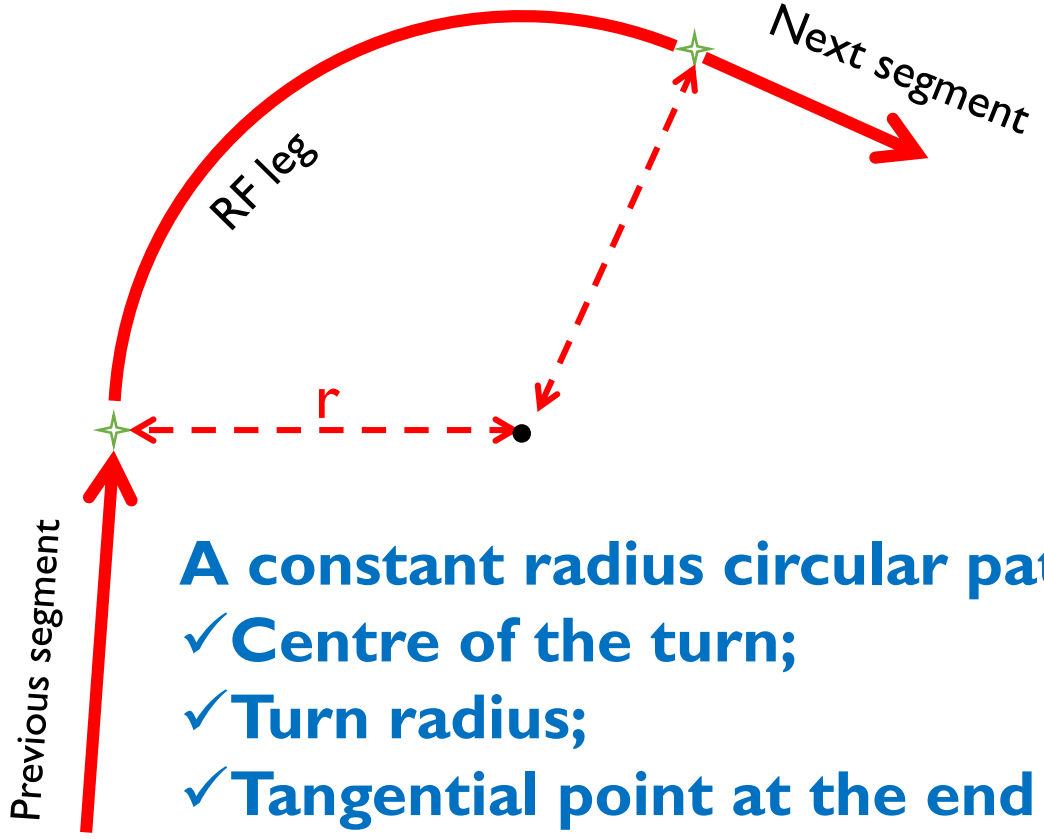
09 – RF turns

(Doc. 8168, Vol. 2, Part III, Sections 2 & 3)

Outlines

1. Overview
2. Nominal segment
3. Protection
4. Obstacles Assessment
5. Promulgation

What is an RF segment?



A constant radius circular path defined by a:

- ✓**Centre of the turn;**
- ✓**Turn radius;**
- ✓**Tangential point at the end of the turn.**

RF leg vs DME arc

- Flying a DME requests the pilot to fly zigzagging from left to right along the arc;
- To maintain the radius defined on RF leg the system will act on bank angle and TAS and may compensate the drift;
- The RF turn is the only turn method for which the track is unambiguously continuously defined during the turn. The PBN system can construct a defined path that exactly matches the procedure designer's intent:
  - ☞Obstacle rich environment;
  - ☞Environmental;
  - ☞More than120°.

Relevant PBN application

- Required only in Advanced RNP
- Can be used in RNP APCH and RNP1:
  - ☞"RF required" published on chart.
- May be used in:
  - ☞Departure procedure;
  - ☞Approach:
    - Initial
    - Intermediate
      - For RNAV+ILS=> NO RF for intermediate!
    - Missed approach.

RF leg requirements

- Use of a Flight Director (FD) or Auto-Pilot (AP) mandatory!
- The FMC, FD/AP must be capable of commanding a bank angle of up to 25 degrees above 400ft AGL:
  - ☞No turn below 400 ft;
  - ☞Max bank angle 25°.

- Flight guidance should remain in LNAV mode while on an RF leg when a procedure is abandoned or a go-around is initiated.

- To accommodate sudden jump due to gust, some provisions will be added in the protection area.

Turn radius calculation

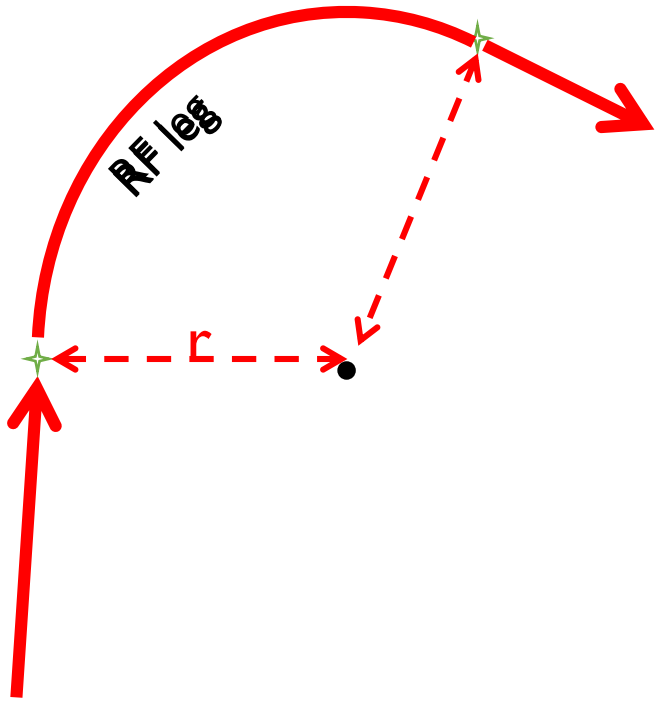
- New!!!
  - Radius computed adding a wind component
  - Bank angle can vary up to 25° (not segment dependant);
  - Minimum radius to consider:
    - **r ≥ 2*RNP**
    - **r ≥ ½AW of inbound and outbound segment**
- TAS computation parameters:
  - Arc length computed on the nominal path;
  - Maximum altitude during the turn;
  - Slope: 10% for SIDs/Missed approach.

Turn radius calculation

- New!!!
  - ☞Wind velocity:
    - Maximum wind speed at the highest point in the turn;
    - For SID and Missed approach :
      - 10 kt for height (h) ≤ 500 ft;
      - 20 kt for 500 ft < h ≤ 1 000 ft;
      - 30 kt for 1 000 ft < h ≤ 2 000 ft;
      - 40 kt for 2000 ft < h ≤ 3 000 ft;
      - ICAO wind above 3 000 ft.

Nominal segment

Turn radius calculation



$$r = \frac{(TAS+Vw)^2}{68\,626*\tan(\theta)}$$ with r in NM TAS and Vw in kt

$$r = \frac{(TAS+Vw)^2}{127\,094*\tan(\theta)}$$ with r in km TAS and Vw in km/h

$$r = \frac{(TAS+Vw)^2}{g*\tan(\theta)}$$ with r in m TAS and Vw in m/s

- Where:
  - θ : Bank angle in degrees;
  - TAS : True airspeed;
  - Vw : Wind velocity.

Length in intermediate segment

- Min Length : 2 NM including curved and straight legs;
- Max Track change : 45°;
- Min radius : 2.55 NM.

Nominal segment

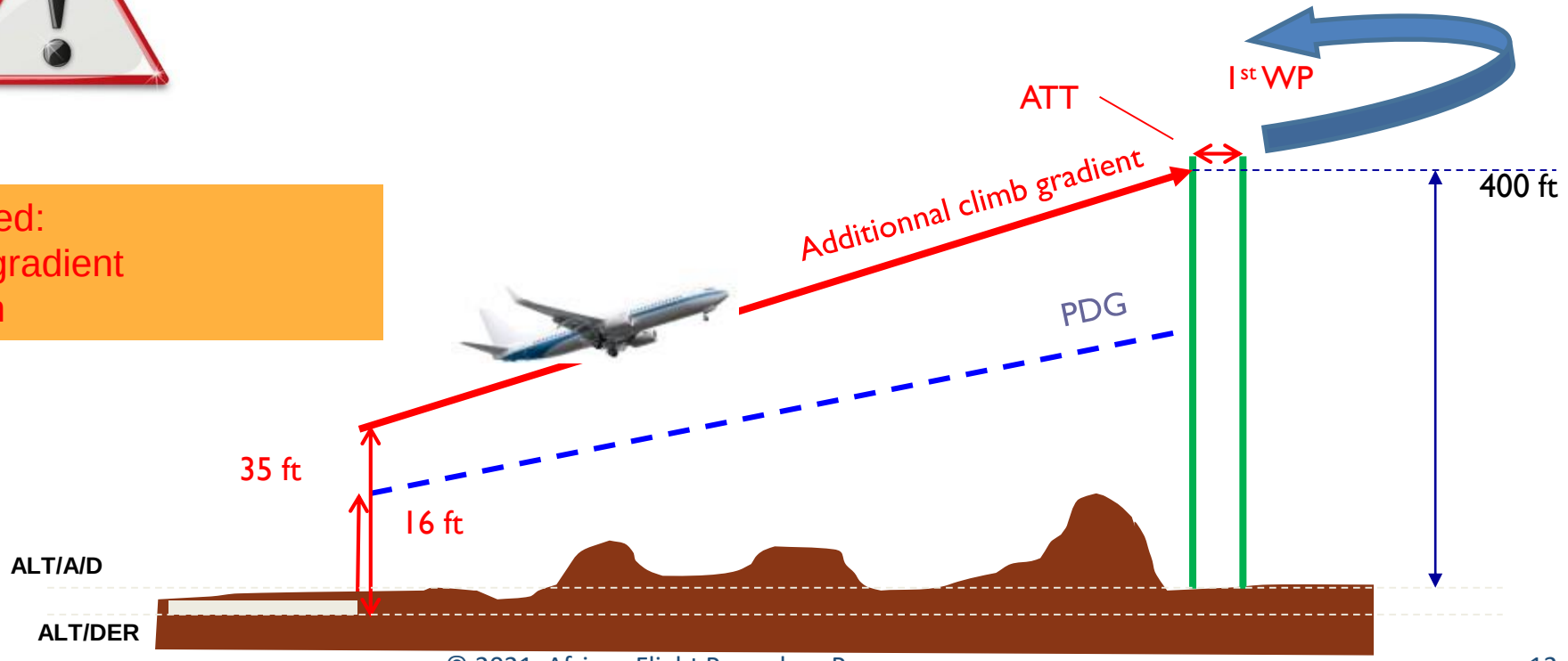
Minimum height in the initial departure segment

- Where PDG < computed co

400 Ft/DER at earliest tolerance of WP, an additional climb gradient is Ft height above DER to reach 400ft/ Alt A/D

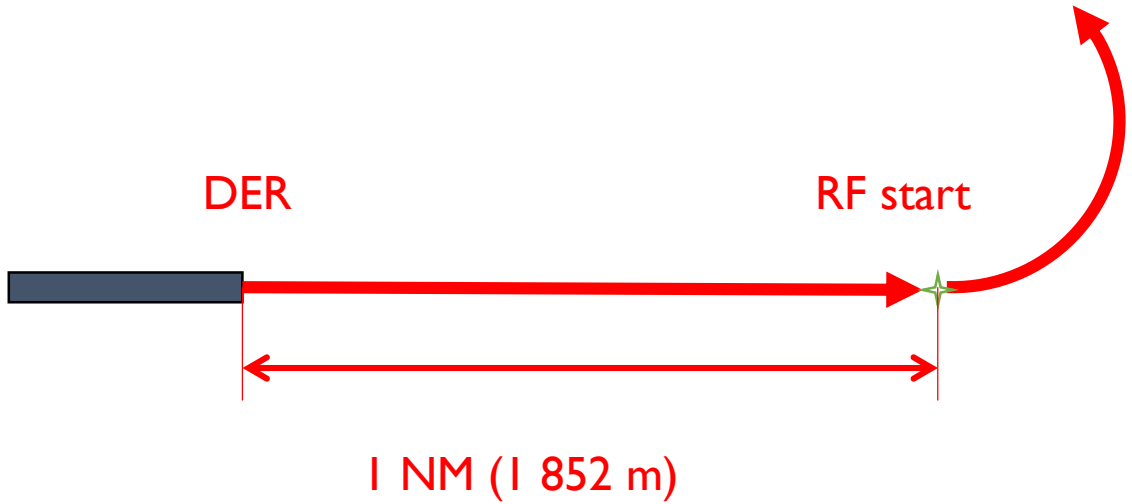
In this case it shall be published:

- An additionnal climb gradient
- WP altitude restriction



Minimum distance in departure segment

Minimum Distance DER- start of du RF



Protection of the departure segment

Protection parameters

Navigation specification		RNP	FTE	IMAL	ATT	XTT	BV	1/2AW
A-RNP	>30 NM ARP	1	0.5		0.8	1	2	3.5
	< 30 NM ARP	1	0.5		0.8	1	1	2.5
	SID<15 NM ARP	1	0.5		0.8	1	0.5	2
RNP 1	> 30 NM ARP		0.5	2	1.6	2	2	5
	< 30 NM ARP		0.5	1	0.8	1	1	2.5
	SID<15 NM		0.5	1	0.8	1	0.5	2
RNP APCH	< 30 NM ARP	1	0.5		0.8	1	1	2.5
	FAF	0.3	0.25		0.24	0.3	1	1.45
	MAPt	0.3	0.25		0.24	0.3	0.5	0.95
	MA <15 NM	1	0.5		0.8	1	0.5	2

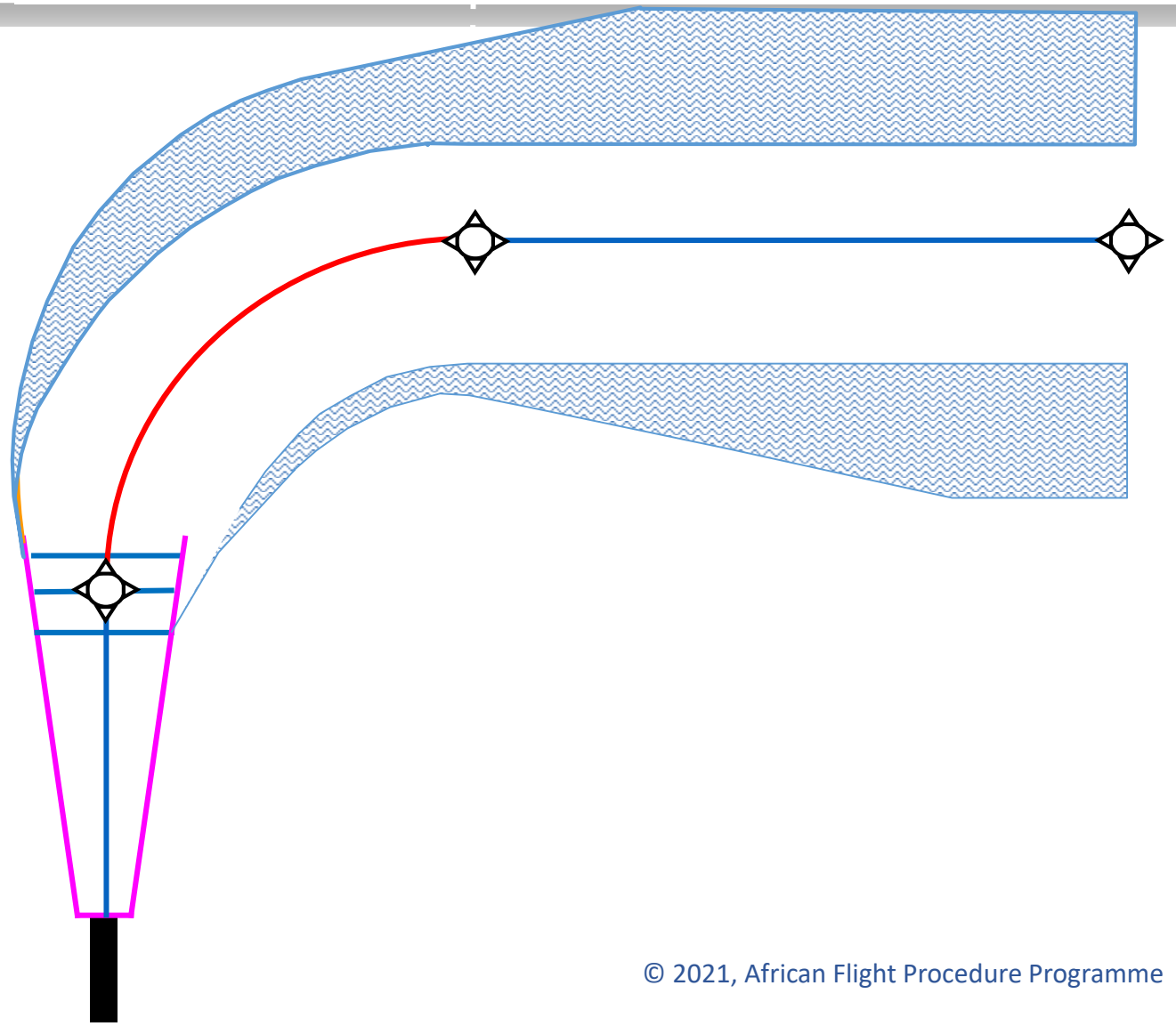
Reduced ATT computation for first WP

- ATT is proportionally to XTT:
  - At DER : ½AW = 150 m so ATT= 0.8 x 150 =120 m
  - ATT is 120 m for X =0
  - ATT is full value when 15° splay reaches 1/2AW so for x = [1/2AW-150]/tan15°
  - In between a reduced ATT can be computed as follow:

$$\text{Reduced ATT} = \frac{ATT - 120}{(1/2AW - 150)/\tan(\theta)} * X + 120$$

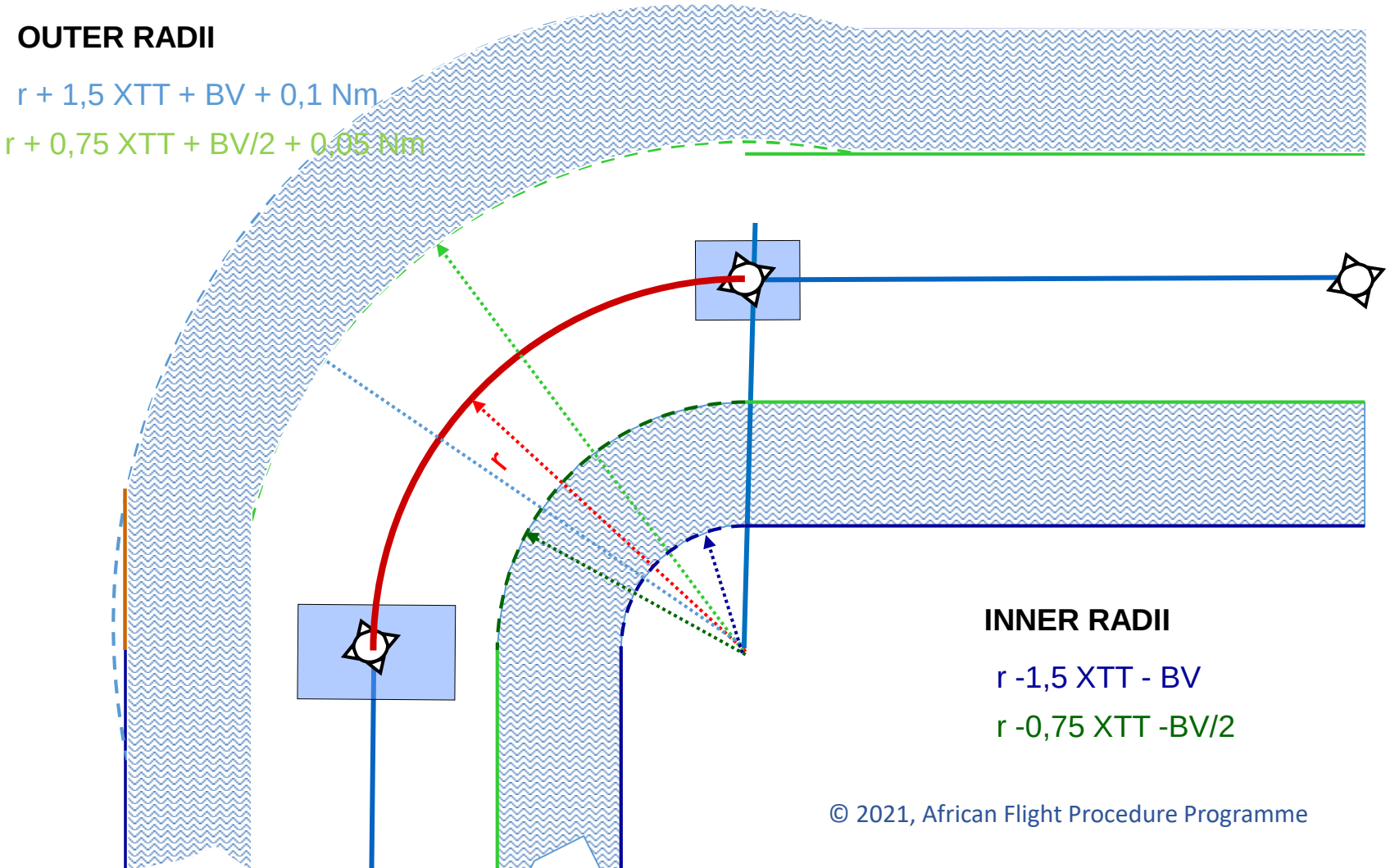
X : Distance, in meters, from the DER;
ATT : Full value appropriate to the RNP accuracy; and
120 m : Reduced ATT at the DER.

Protection of the departure segment



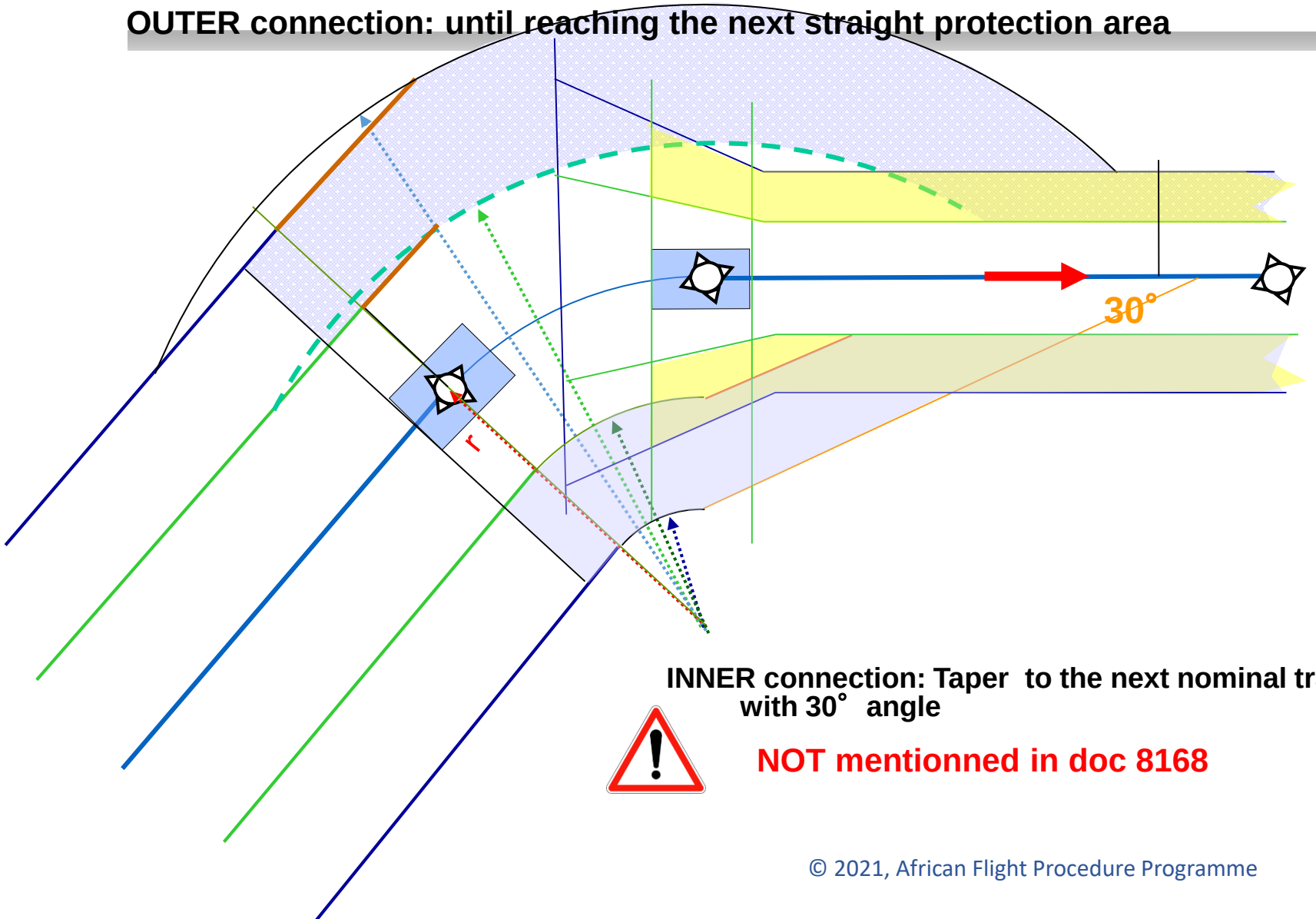
Protection for the RF leg

Figure III-2-2-13



Protection: 1/2AW Segment 1>1/2AW segment 2

OUTER connection: until reaching the next straight protection area



INNER connection: Taper to the next nominal track with 30° angle

NOT mentionned in doc 8168

Obstacles Assessment

❑ WHAT' S remaining?

- ☞MOC;
- ☞MOC in secondary area;
- ☞OIS for departure.

❑ What is new?

- ☞How to compute the required distance ?
  - For MOC in departure or gain in missed approach.

- ☞Body geometry of the A/C in departure.

Obstacles Assessment in climbing segment

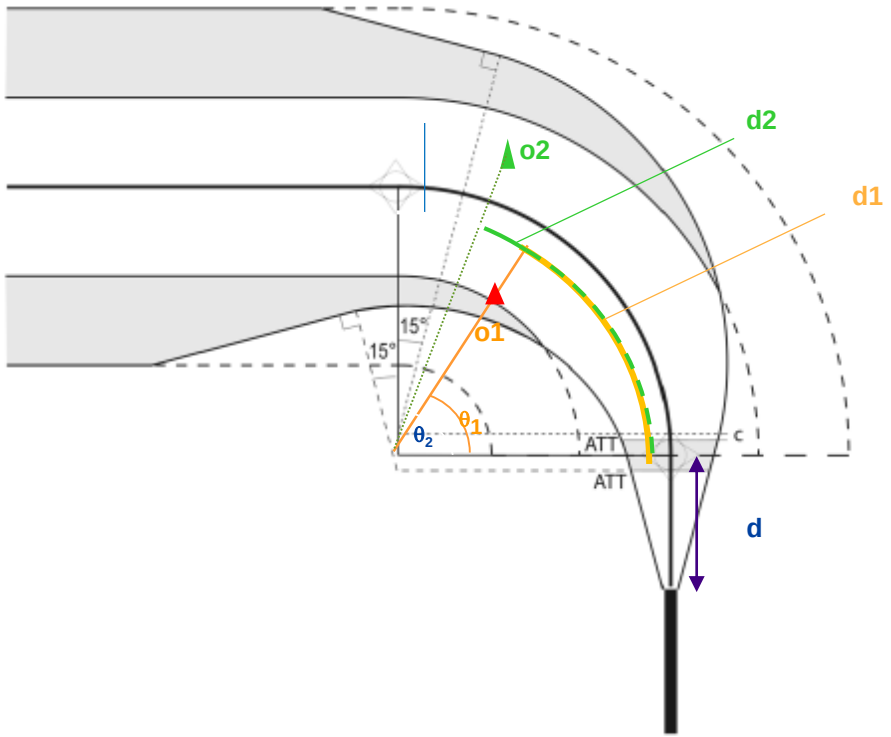


Figure III-2-2-14. Splay in RF turn

- Distance measured on r-0.1NM to compute:
  - OIS height in departure segment;
  - or height gain in missed approach.

Alto1 ≤ ((pdg-0.8%) (d+d1)) + 5 + Alt DER
With d1 = ((r - 0.1) $\pi\theta_1$)/180

Alt o2 ≤ ((pdg-0.8%)(d+d2)) + 5 + Alt DER
With d2 = ((r – 0.1)$\pi\theta_1$)/180

Obstacles Assessment in departure segment: body Geometry (BG)

- Within Straight leg and or RF leg:
  - Minimum MOC: 0.8% of distance from DER.
- Within RF leg:
  - As long as 75 m of MOC is not reached, Body Geometry of the A/C is taken into account.

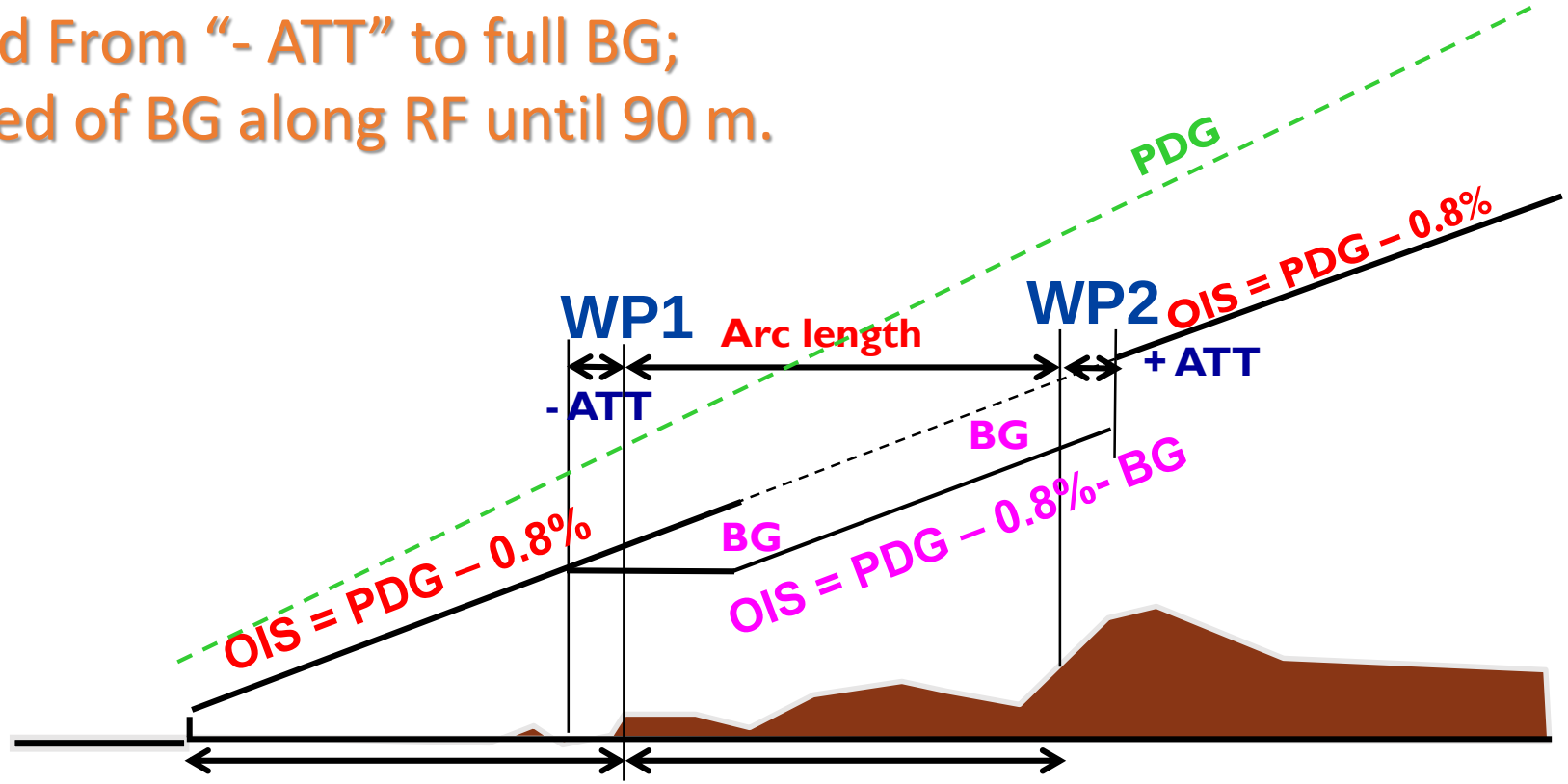
BG = wing semi-span*sin (α +5)

Where α=bank angle

For wing semi-span = 40 m (132ft) and bank 25 ° BG = 20 m

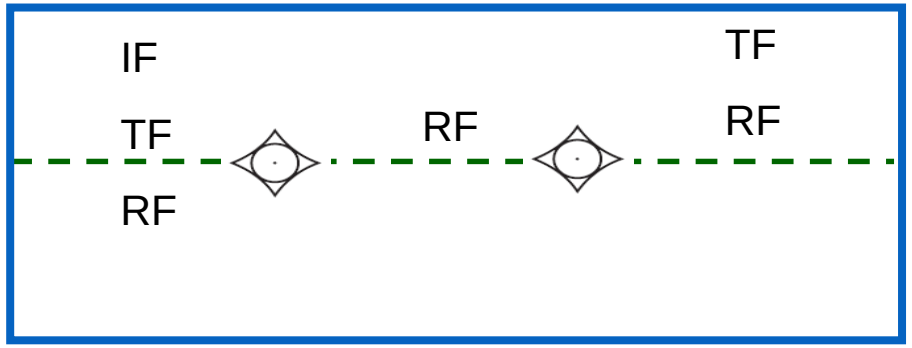
Obstacles Assessment in departure segment: body Geometry (BG)

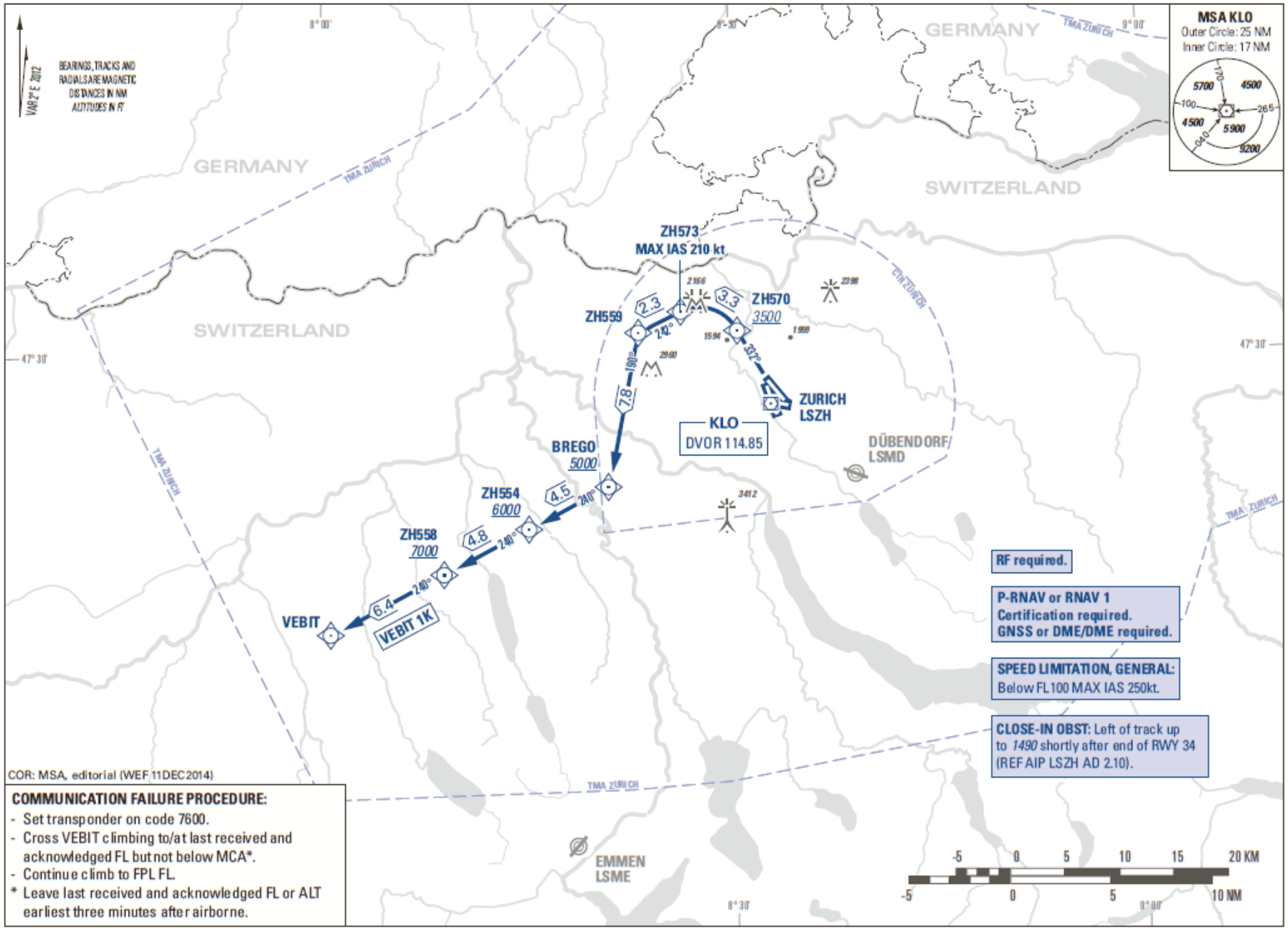
- If MOC < 75 m in RF : OIS takes BG:
  - Leveled From "- ATT" to full BG;
  - Lowered of BG along RF until 90 m.



Promulgation

- If the PDG doesn't reach 400 ft at the start of the RF turn, publish:
  - An additional gradient and;
  - An altitude restriction at the waypoint.
- RF is a required functionality for ARNP:
  - When using RF in any other application, on the chart is mentioned a note:
    - "RF required"!
- Path descriptors sequence for initial legs:





STANDARD INSTRUMENT DEPARTURE CHART (SID) - ICAO

TRANSITION LEVEL by ATC
TRANSITION ALTITUDE 7000

ZURICH LSZH
SID RWY 34 - RNAV 1

Questions:

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