PANS-OPS Flight Procedure Design Training for CAAs

23 August – 03 September 2021

14 – PBN departures

(Doc. 8168, Vol. 2, Part I, Section 3, Part III, Sections 1 & 3)

Outlines

1. General
2. Straight departure
3. Turning departures
4. Design methodology
5. Protection

General

- General criteria apply as amplified or modified here;
- What is remaining?
  - DER;
  - Area1;
  - 15° max change of track for straight departure;
  - Bank angle : 15°;
  - Bank angle delay (if needed) : 3s;
  - Pilot reaction : 3s;
  - Climb gradien;
  - MOC;
  - Average flight path for nominal trajectory;
  - Turn at an altitude;

General

- What is new (specific to PBN departure)?
  - Minimum distances;
  - Turn at FB WP;
  - Turn at FO WP;
  - Use of wind spiral for all turn protections;
  - Max turn angle :120° (except for DF);
  - No bank angle delay for a fly-by WP;
  - Protection deals with max TAS and low TAS.
  - PBN applications:
    - RNP 1, RNAV 1, RNAV 2;
    - Amended RF turn protection
    - Minimum turn angle: 5° (except where free turn back to waypoint (DF leg used)

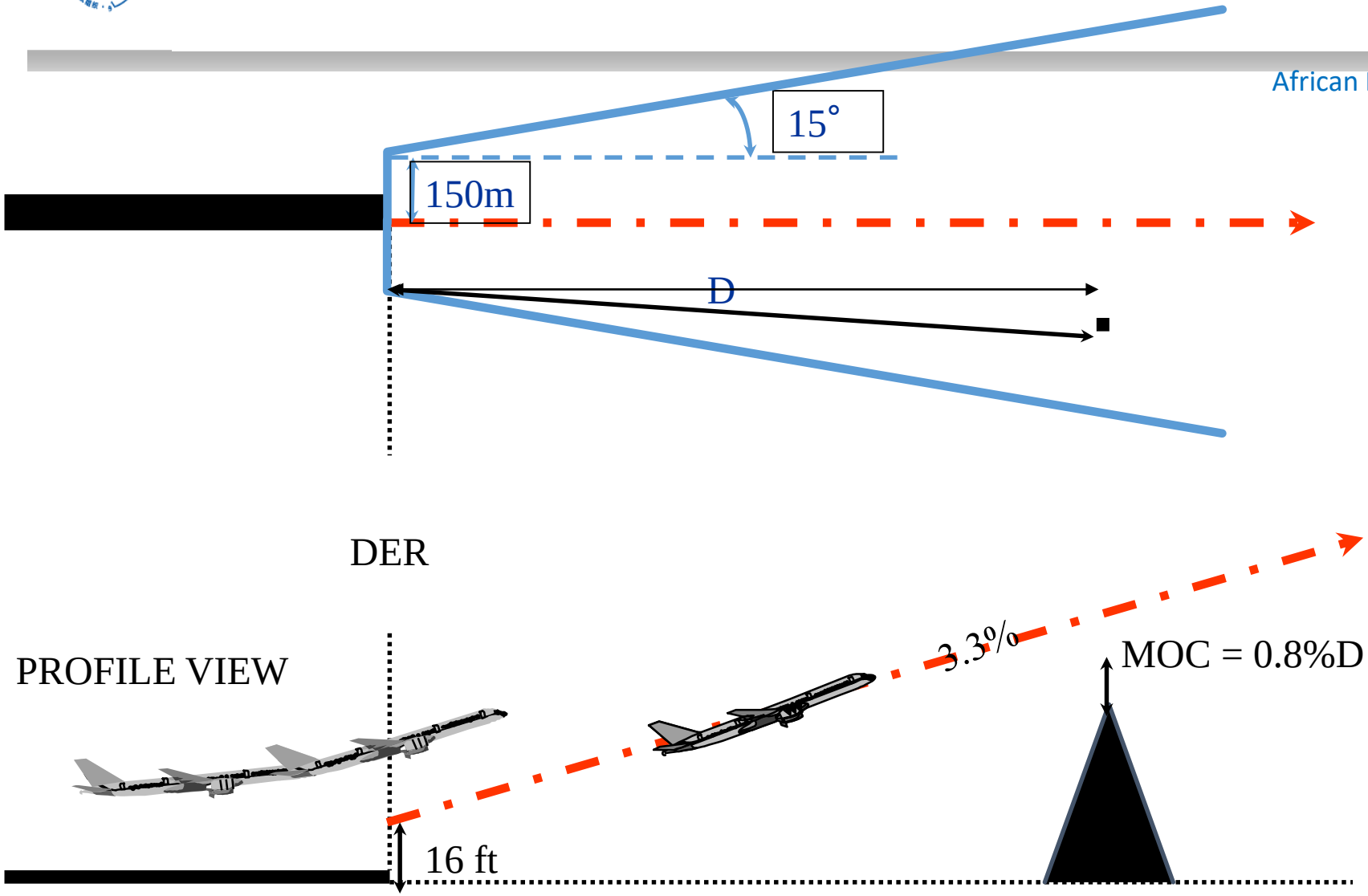
General

- Criteria for initial departure:
  - < 15 NM ARP.
- Criteria for terminal departure:
  - Within less than 30 NM around ARP;
  - WHICHEVER the sensor.
- Criteria for SID :
  - For part of the track outside 30 NM from ARP;
  - Whichever the sensor.
- Merging Areas.

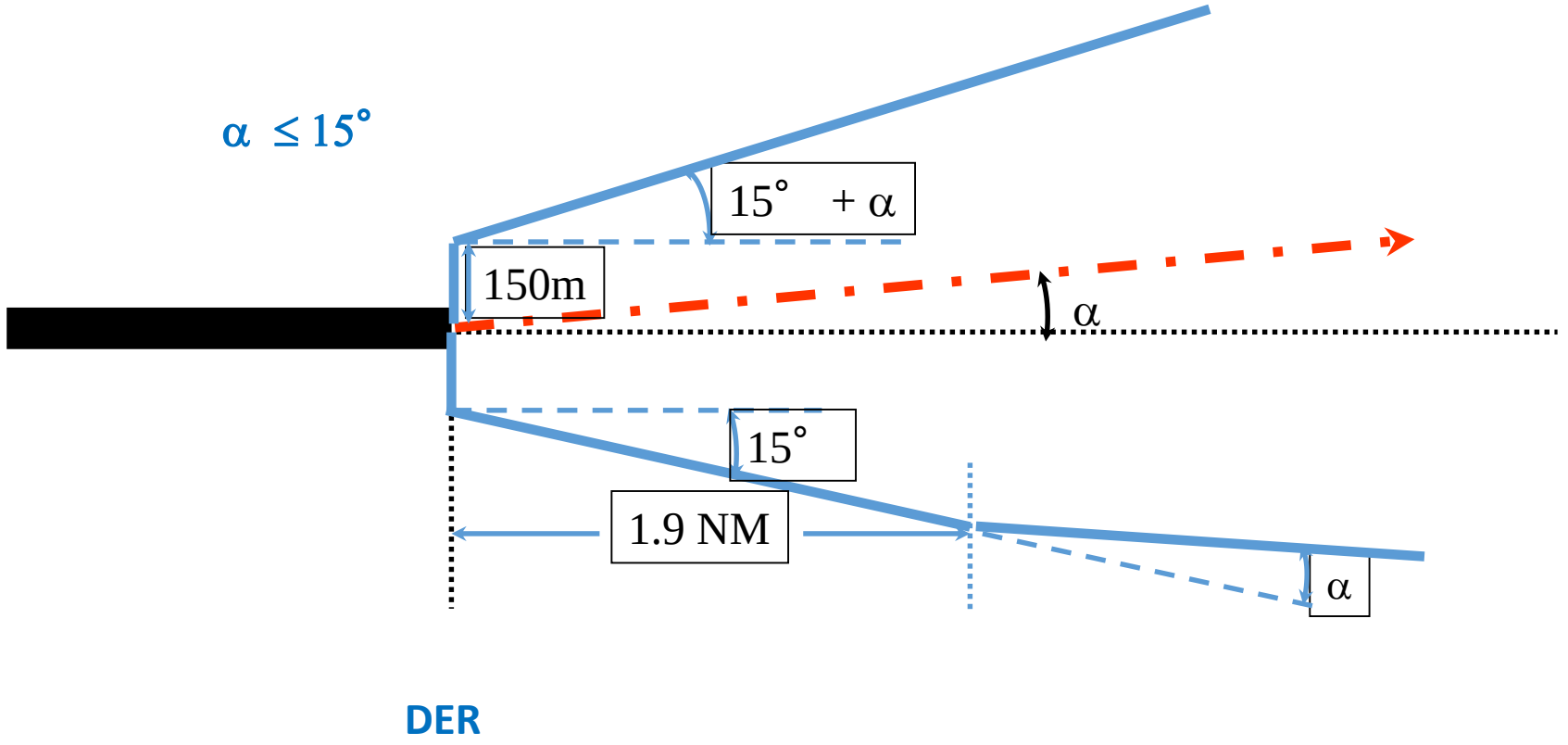
General

- Two types of departures:
  - Straight departure:
    - Initial track offset ≤ 15°.
  - Turning departure:
    - Turn at an altitude;
    - Turn at a TP.

Straight departure

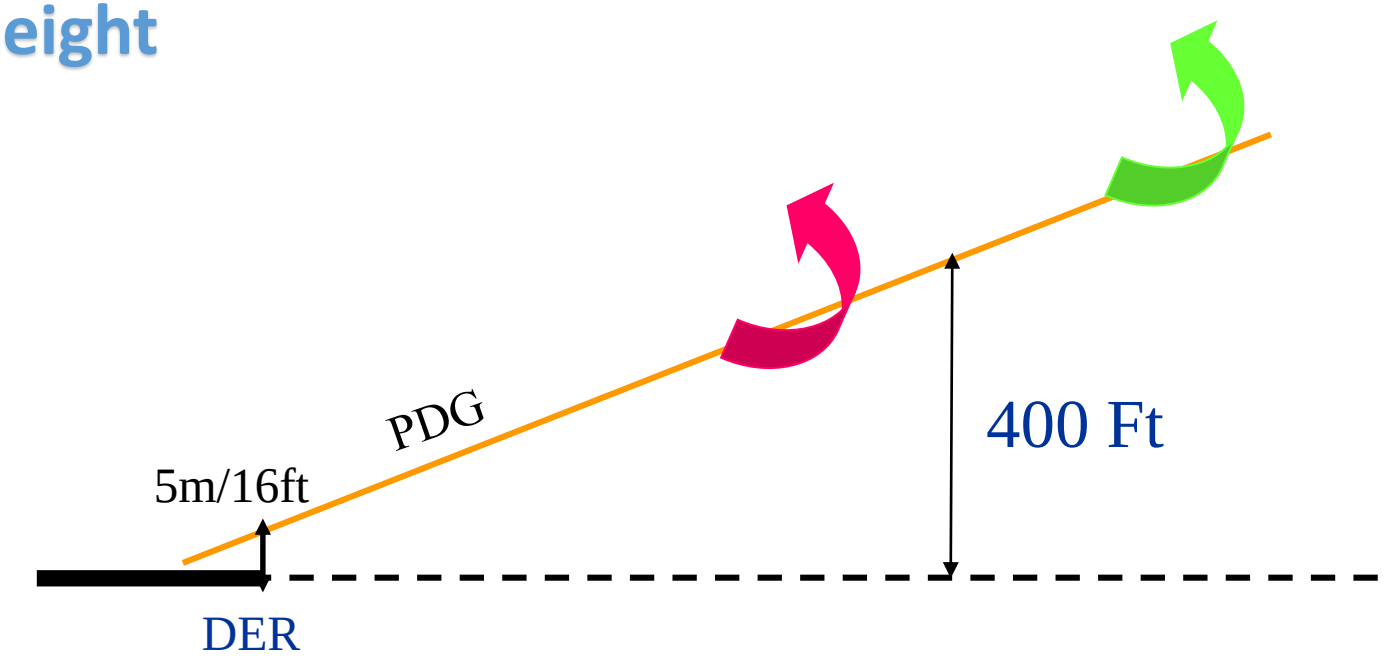


Straight departure



Turning departures

Lowest turning height

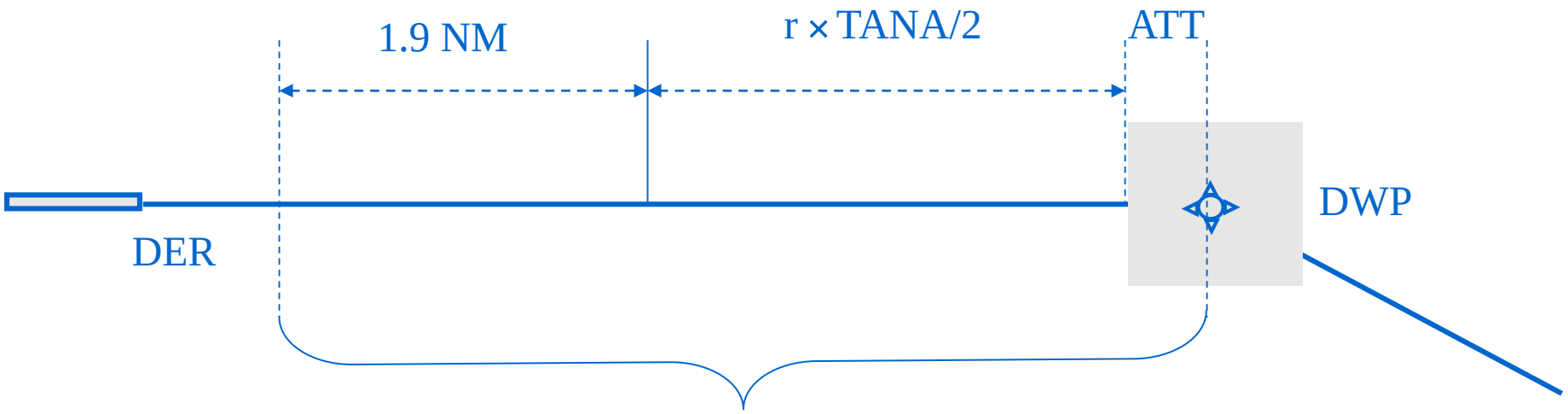


According to ICAO : NO TURN BELOW 400 FT / 120 m

Operationally: NO TURN BELOW 500 FT

Turning departures

Turn at TP: minimum length with a FB waypoint

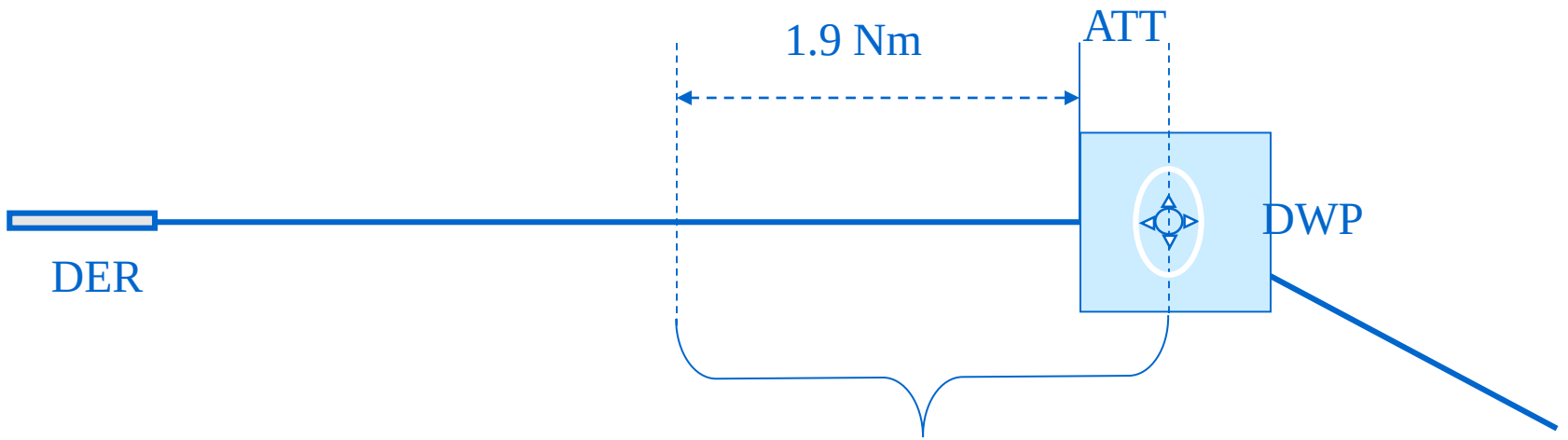


D min (Nm) = 1.9 + r × TANA/2 + ATT

Replace 1.9 NM by (120 m / PDG) / 1 852 if PDG ≠3.3 %

Turning departures

Turn at TP: minimum length with a FO waypoint



D min (Nm) = 1.9 + ATT

Replace 1.9NM by (120m / PDG) / 1852 if PDG ≠3.3 %

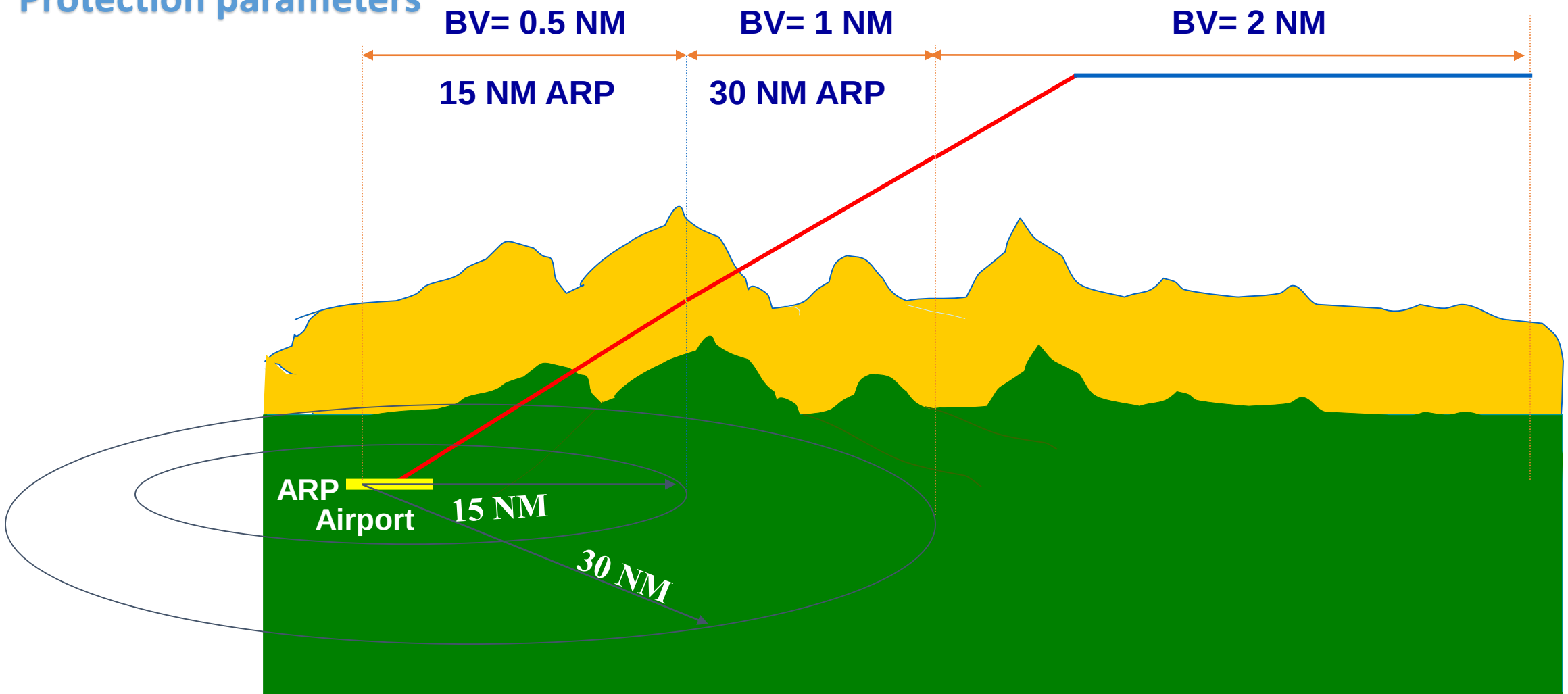
Design methodology

- According to airspace concept, select the appropriate navigation application (e.g. RNP1, RNAV1, RNAV 2);
- According to terrain constraint, noise abatement and operational issues, define the nominal path:
  - ☞For cat C and D aircraft use average flight path.
- Locate the first waypoint:
  - ☞Check minimum length of the first leg [DER- WP] according to the type of WP.
- Draw the straight departure protection area;
- Assess the obstacles (define OIS if needed) and deduce climb gradient.

Design methodology

- Assess close obstacles after turn (validate climb gradient and turn;
- Draw the straight protection area of the next leg:
  - ☞Check minimum length of the leg according to the type of WP.
- Draw the turn protection area according to the type of WP and connect to the straight area;
- Assess obstacles and validate climb gradient, altitude at WPs and connection to en-route structure.

Protection parameters



Protection parameters

Phase of Flight	BV (NM) for CAT A-E	BV (NM) for CAT H
En-route : greater than 30 NM from departure ARP	2	1
Terminal within 30 NM of the ARP but more than 15 NM from ARP	1	0.7
SIDs within 15 NM of the ARP	0.5	0.35

Protection parameters

Phase of Flight	FTE (95%) Specific to required navigation specification
En-route (GREATER THAN 56 km (30 NM) from ARP	RNAV 2 – 1.9 km (1 NM) RNAV 1 – 926 m (0.5 NM) RNP 2 – 1.9 km (1 NM) RNP 1 – 926 m (0.5 NM)
Terminal WITHIN 56 km (30 NM) of the ARP	RNAV 2 – 1.9 km (1 NM) RNAV 1 – 926 m (0.5 NM) RNP 1 – 926 m (0.5 NM)

Protection

XTT value

(according to navigation specification)

Identify distance to ARP for Buffer Value (BV)

Semi-Area Width calculation

1/2 A/W = 1.5 XTT + BV

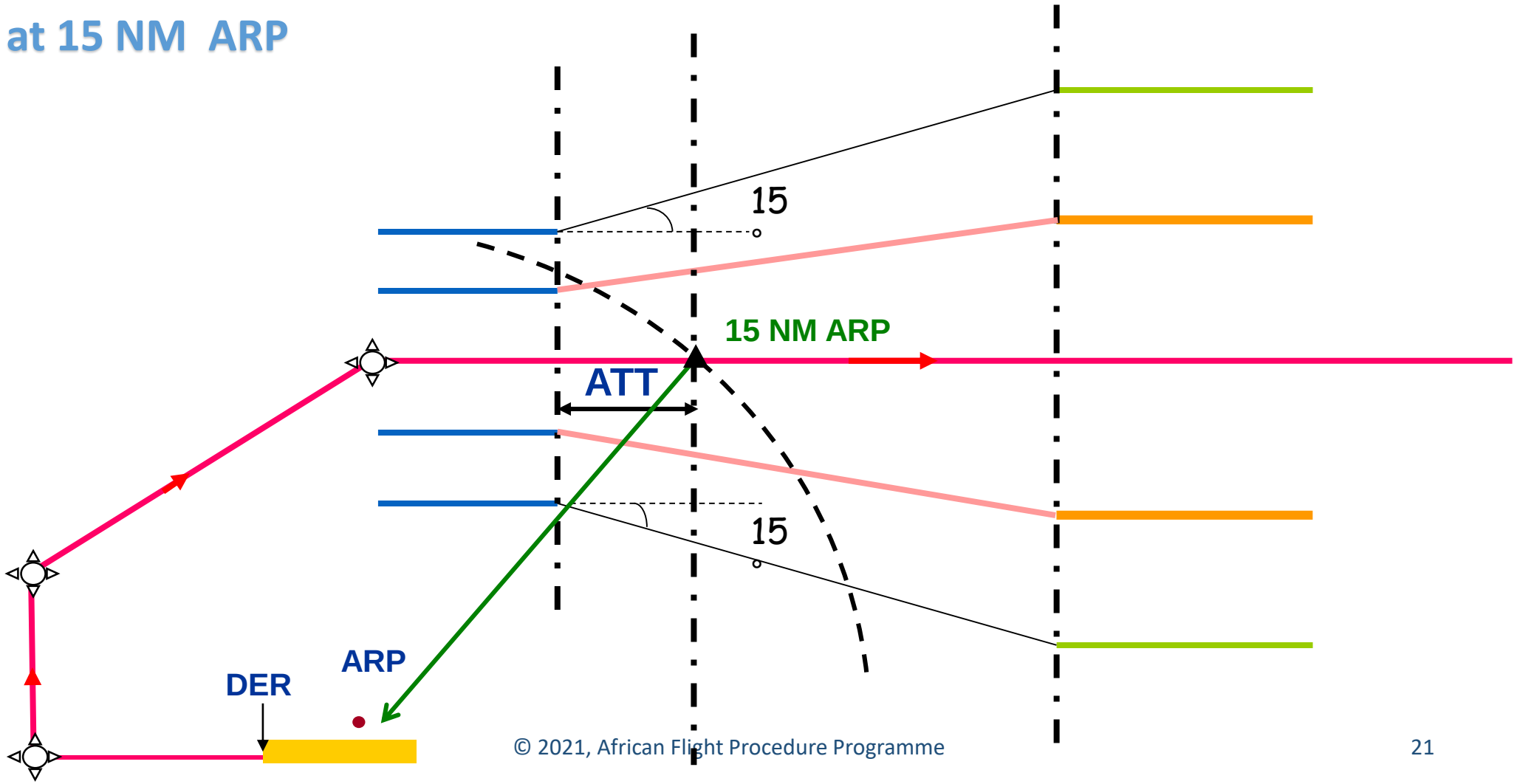
Protection parameters (NM)

Navigation specification		RNP	FTE	IMAL	ATT	XTT	BV	1/2AW
RNP 1	> 30 NM ARP	1	0.5		0.8	1	2	3.5
	Terminal	1	0.5		0.8	1	1	2.5
	SID <15 NM ARP	1	0.5		0.8	1	0.5	2
RNAV 2	> 30 NM ARP		1	2	1.6	2	2	5
	Terminal		1	1	0.8	1	1	2.5
	SID <15 NM ARP		1	1	0.8	1	0.5	2
RNAV 1	> 30 Nm ARP		0.5	2	1.6	2	2	5
	Terminal		0.5	1	0.8	1	1	2.5
	SID <15 NM ARP		0.5	1	0.8	1	0.5	2

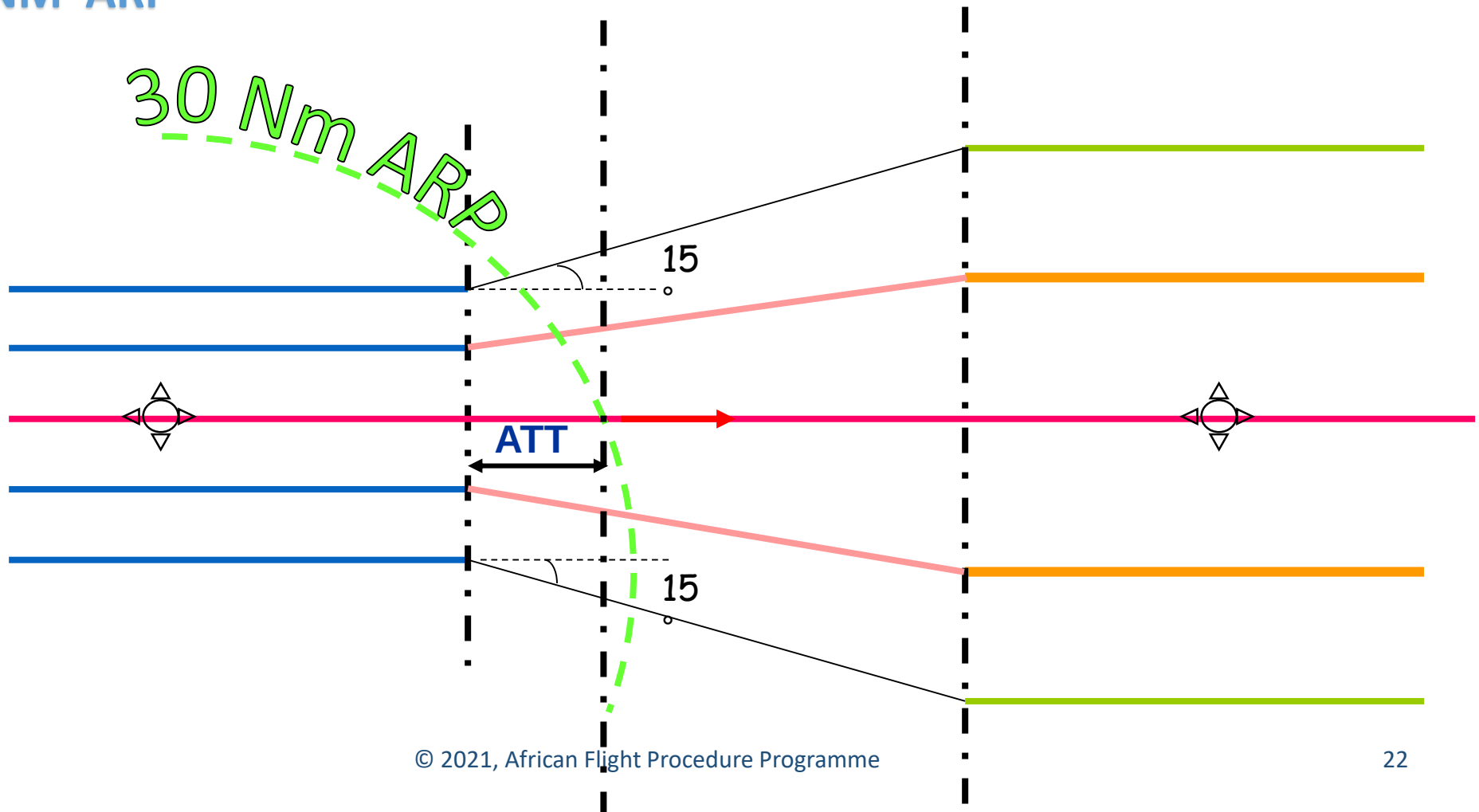
Merging methodology

- Area width of the subsequent segment is always equal or larger than the preceding one;
- When larger : **SPLAY with 15°** from the **EARLIEST ATT**;
- For RNP application and for RNAV application based on GNSS sensor, it occurs at **15 NM ARP** and **30 NM ARP**;
- Even if no waypoint is located at 15 NM DER, nor at 30 NM.

Merging at 15 NM ARP



Merging at 30 NM ARP



Merging at 15 & 30 NM ARP

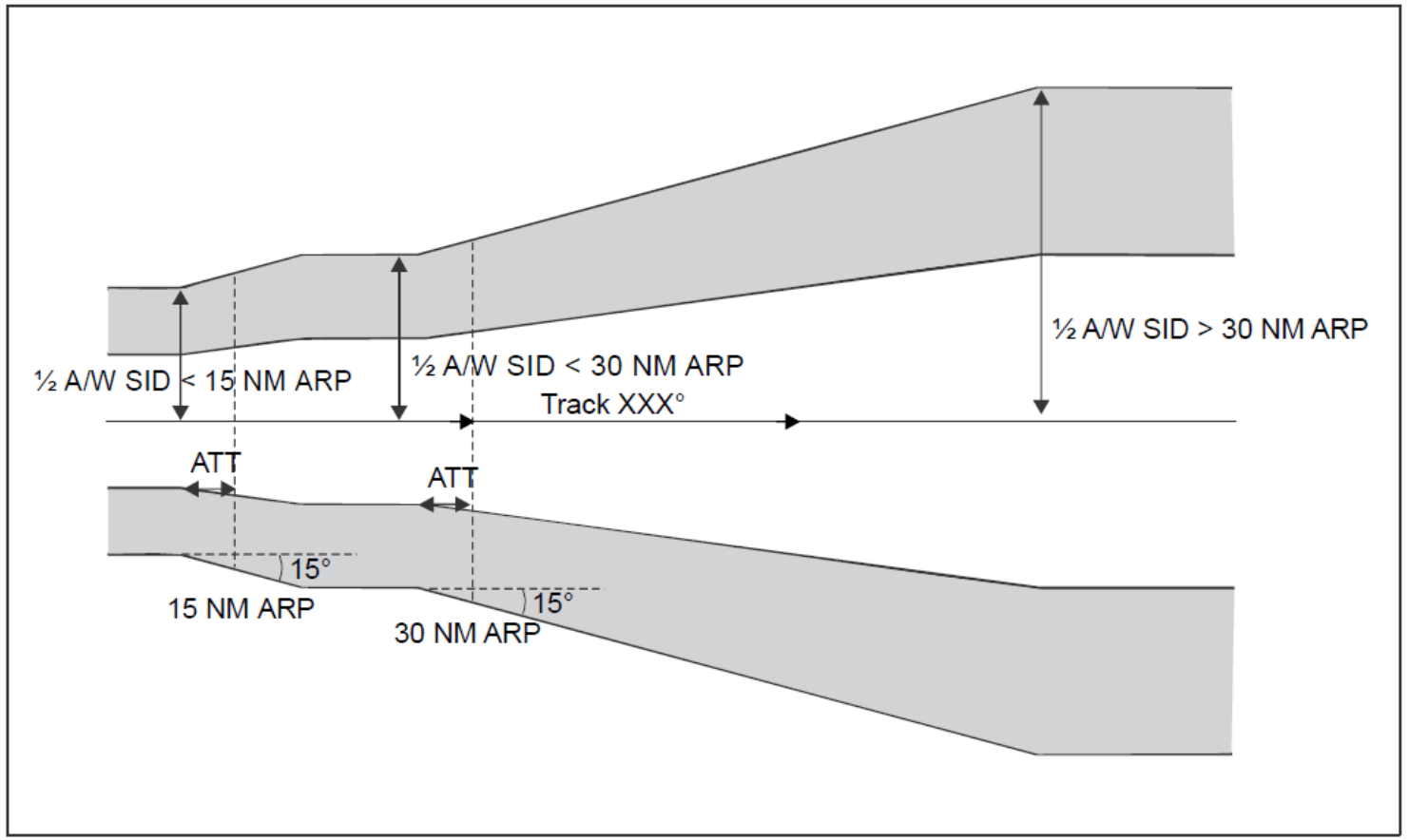


Figure III-1-1-3. Merging at phase-of-flight interfaces — departures

First straight segment

- Find the value of ½ area width for the fictitious WP in the table part III section3 chapter 1 table III-3-1-1:
  - ☞2 NM for RNP 1;
  - ☞2 NM for RNAV 1;
  - ☞……
- Calculate XTT and ½ AW for the first WP;
- Draw the straight segment area between the DER and the first WP.

Protection

First straight segment

15 ° Splay from 150m / DER

COMPARE

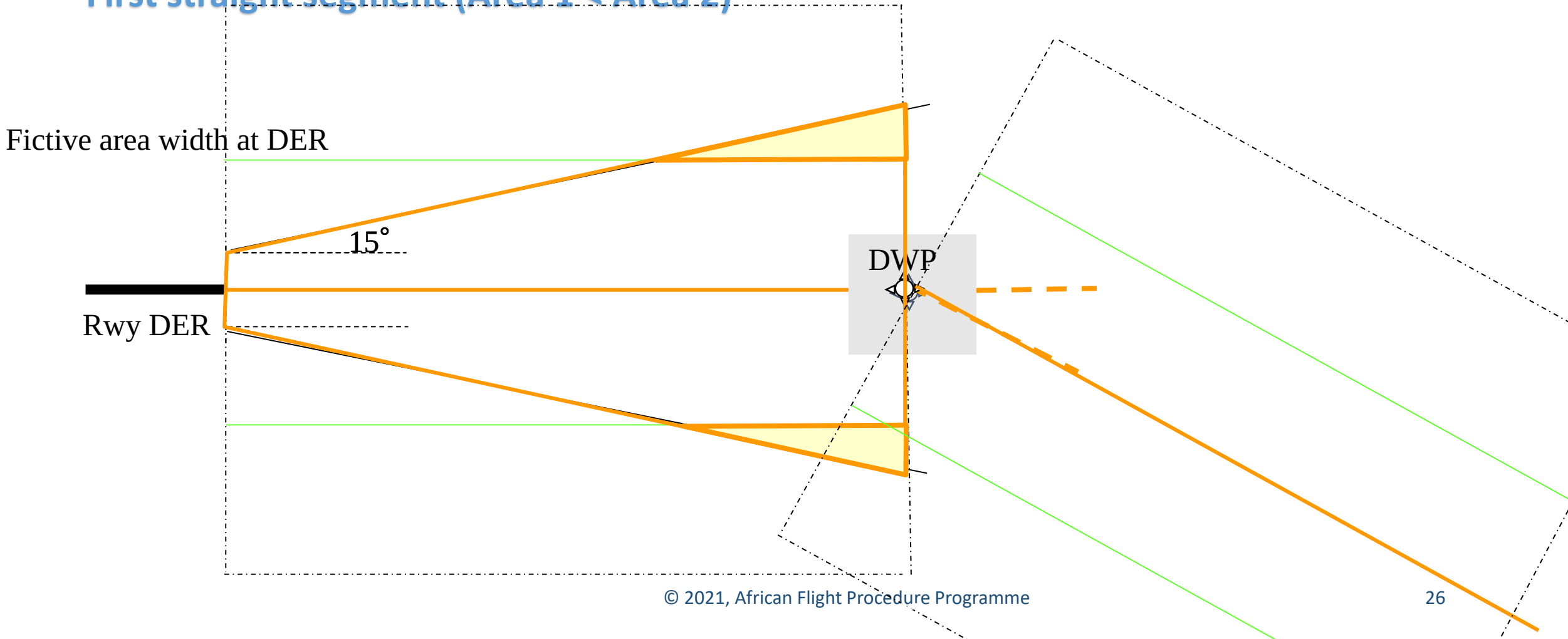
Area Width at Departure WP

> :Solution1

< :Solution2

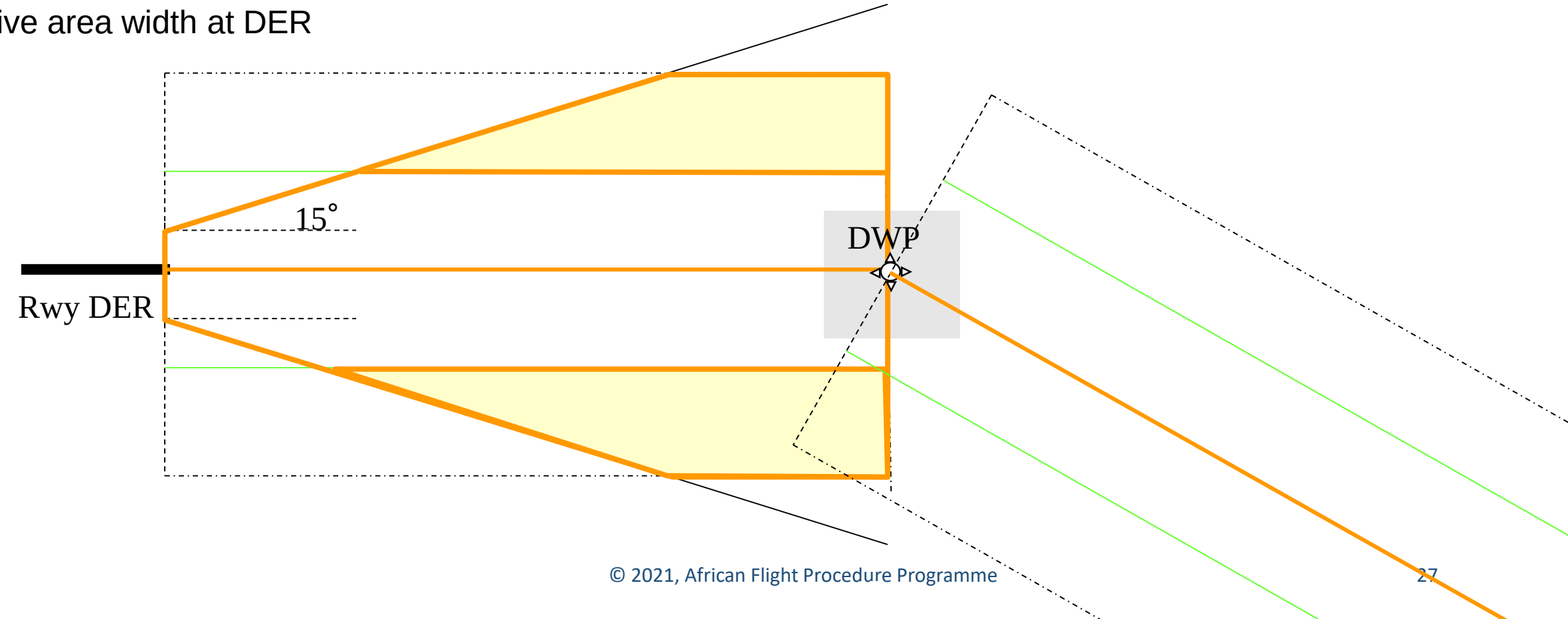
Protection

First straight segment (Area 1 < Area 2)



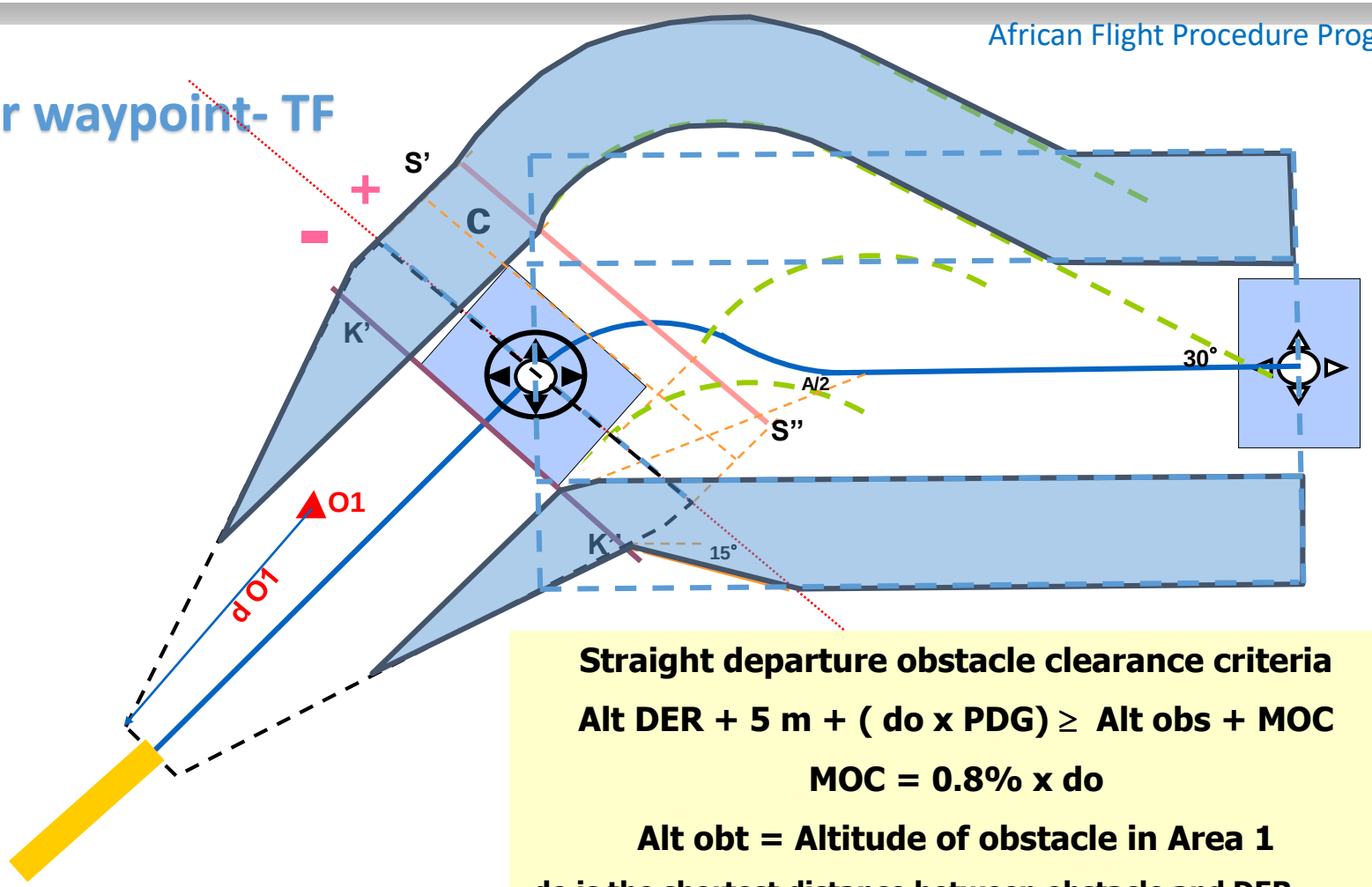
First straight segment (Area 1 > Area 2)

Fictive area width at DER



Protection

Turn at fly-Over waypoint- TF



Straight departure obstacle clearance criteria

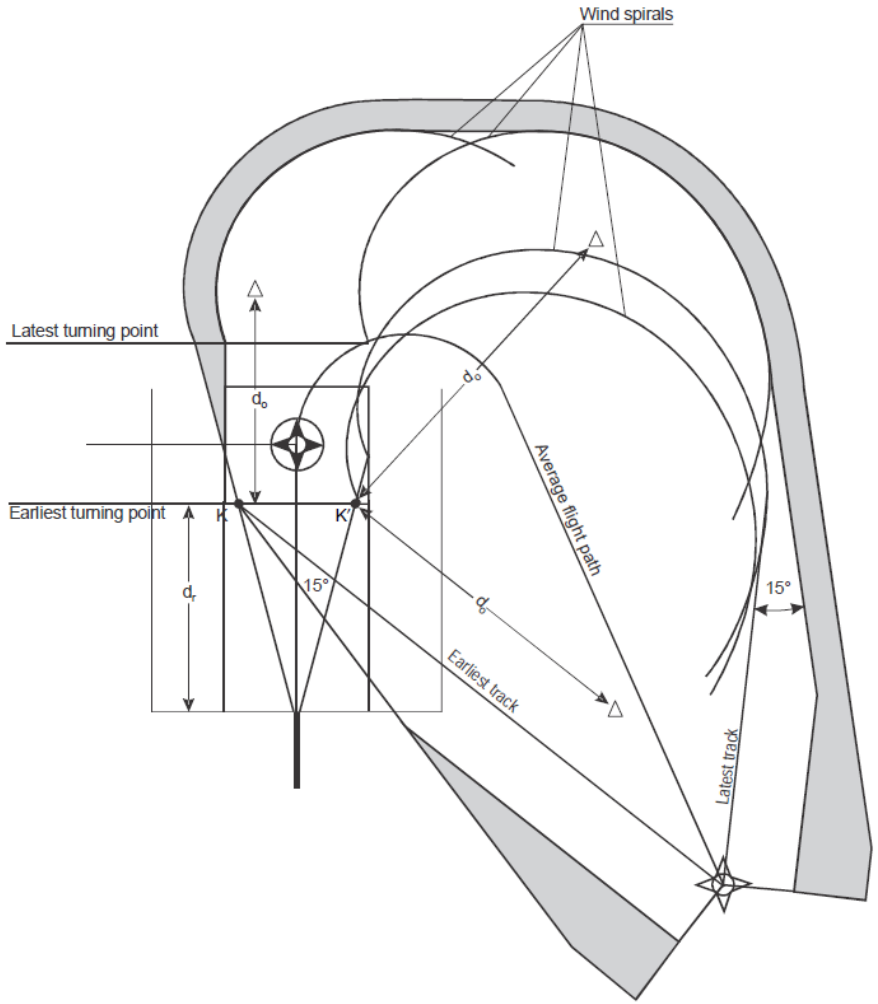
Alt DER + 5 m + (do x PDG) ≥ Alt obs + MOC

MOC = 0.8% x do

Alt obt = Altitude of obstacle in Area 1

do is the shortest distance between obstacle and DER

Turn at fly-Over waypoint- TF



TURN AT FLY-OVER FOLLOWED BY DF LEG

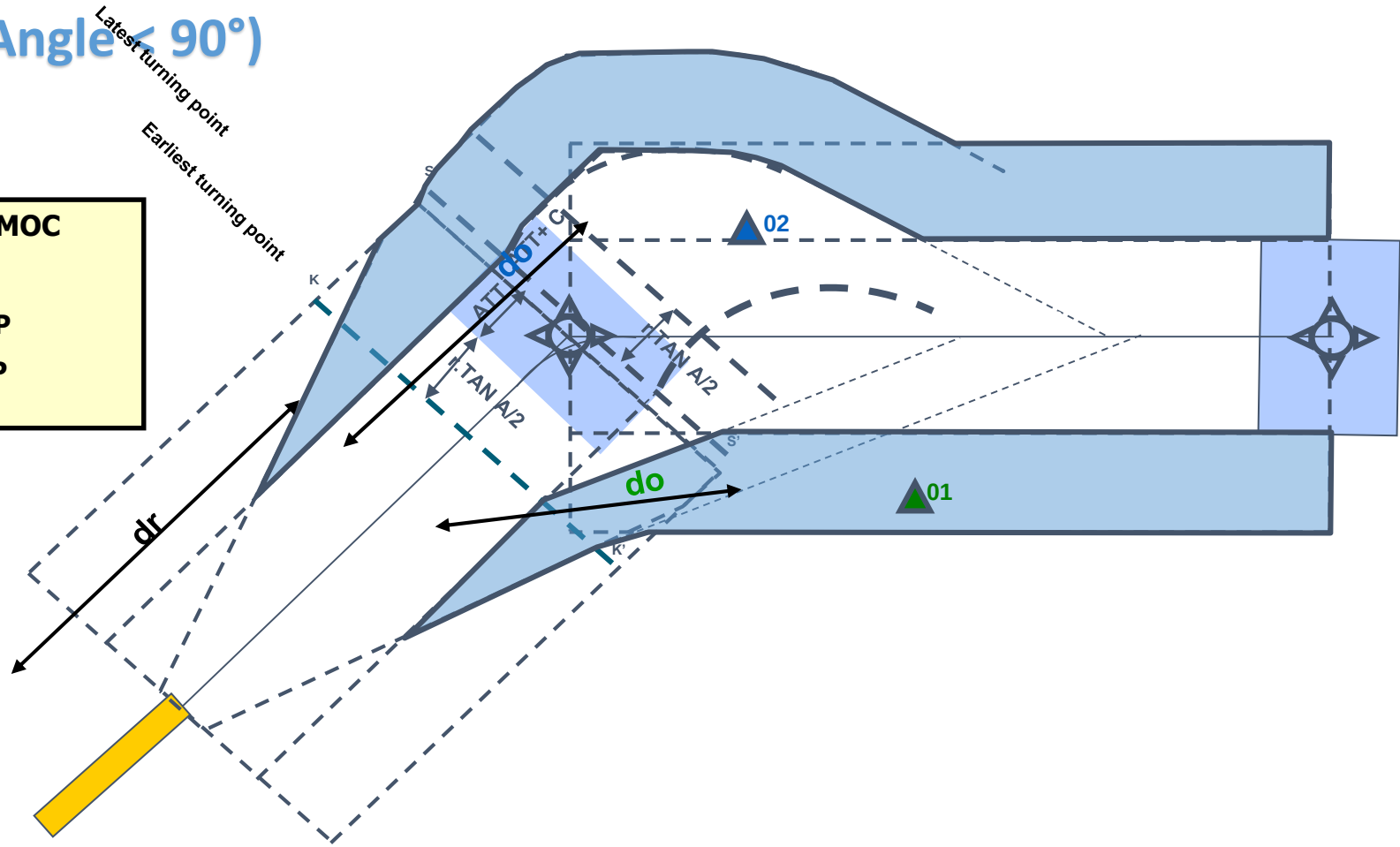
Turn at fly-By waypoint- TF (Angle < 90°)

Alt DER + 5 m + (dr x PDG) + (do x PDG) ≥ Alt obs + MOC

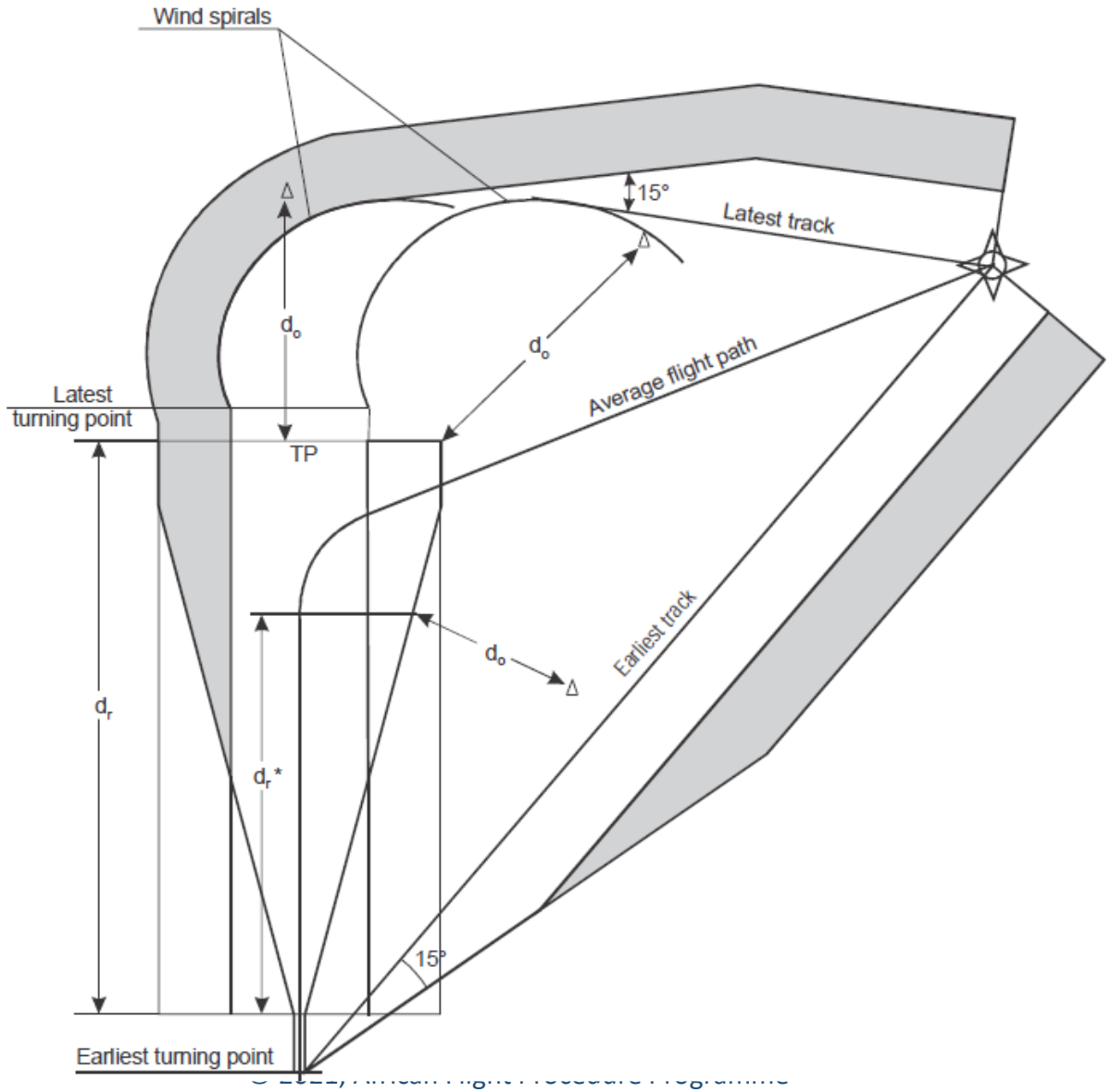
MOC = Max [0.8% (dr + do), 75 m]

dr is the shortest distance between DER and earliest TP

do is the shortest distance between obstacle and earliest TP

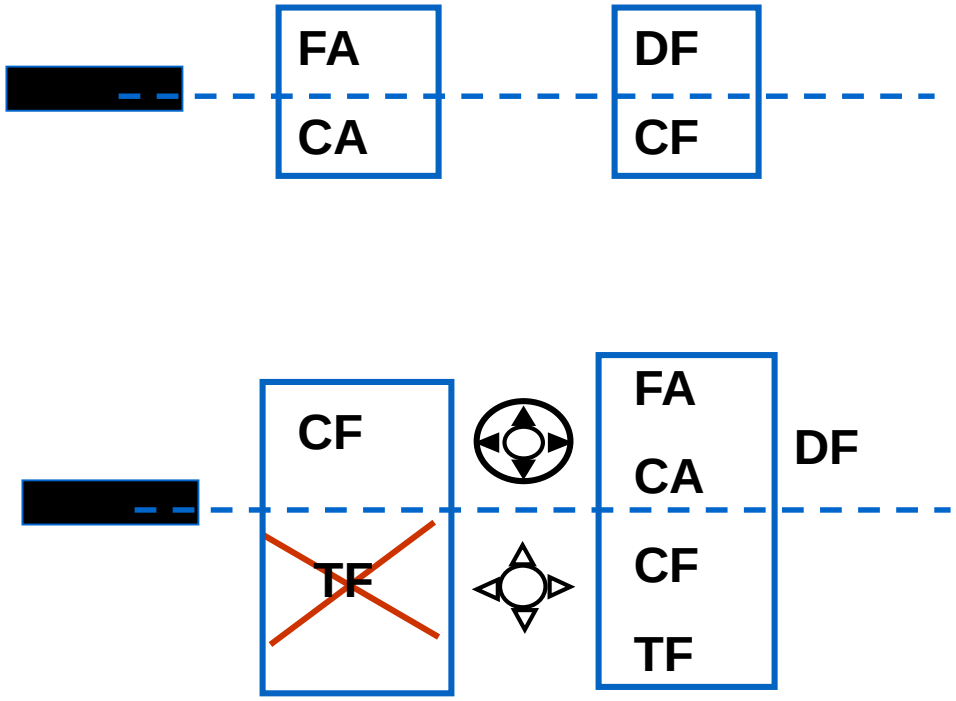


Turn at altitude with DF



Protection

Path terminator



TF : Track between Fixes

CF : Course to Fix

DF : Direct to Fix

FA : Fix to Altitude

CA: Course from fix to Altitude

After the first WP, the standard sequencing rule is applicable

Questions:

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