ICAO APAC FPP
Flight Procedure Design Course
- Module 2
2D Approach NPA & RNP APCH

(09-20/May/2022)

Virtual Meeting Room

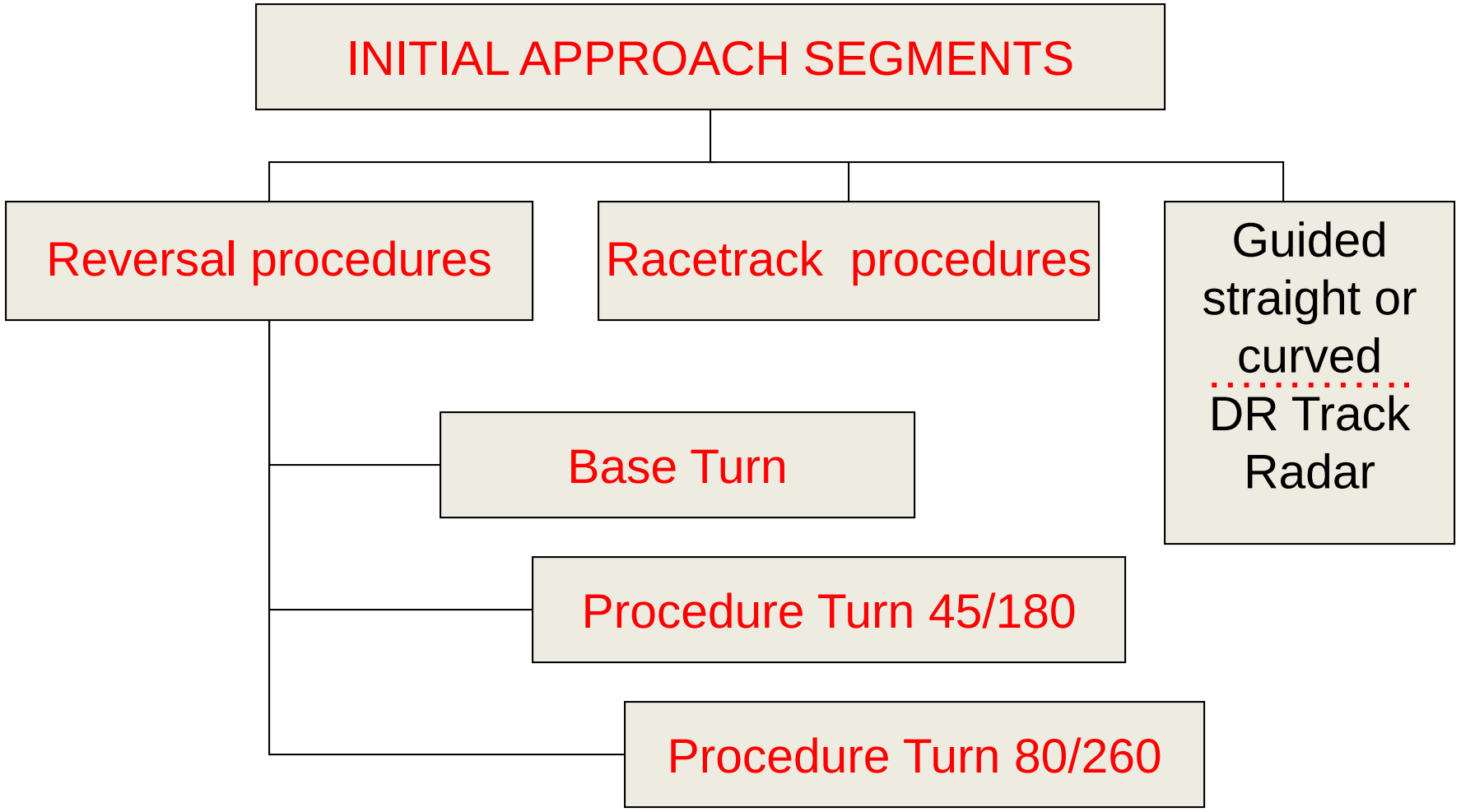
REVERSAL & RACETRACK PROCEDURES

DOC 8168 PART I SECTION 4 CHAPTER 3 & APPENDIX B/C

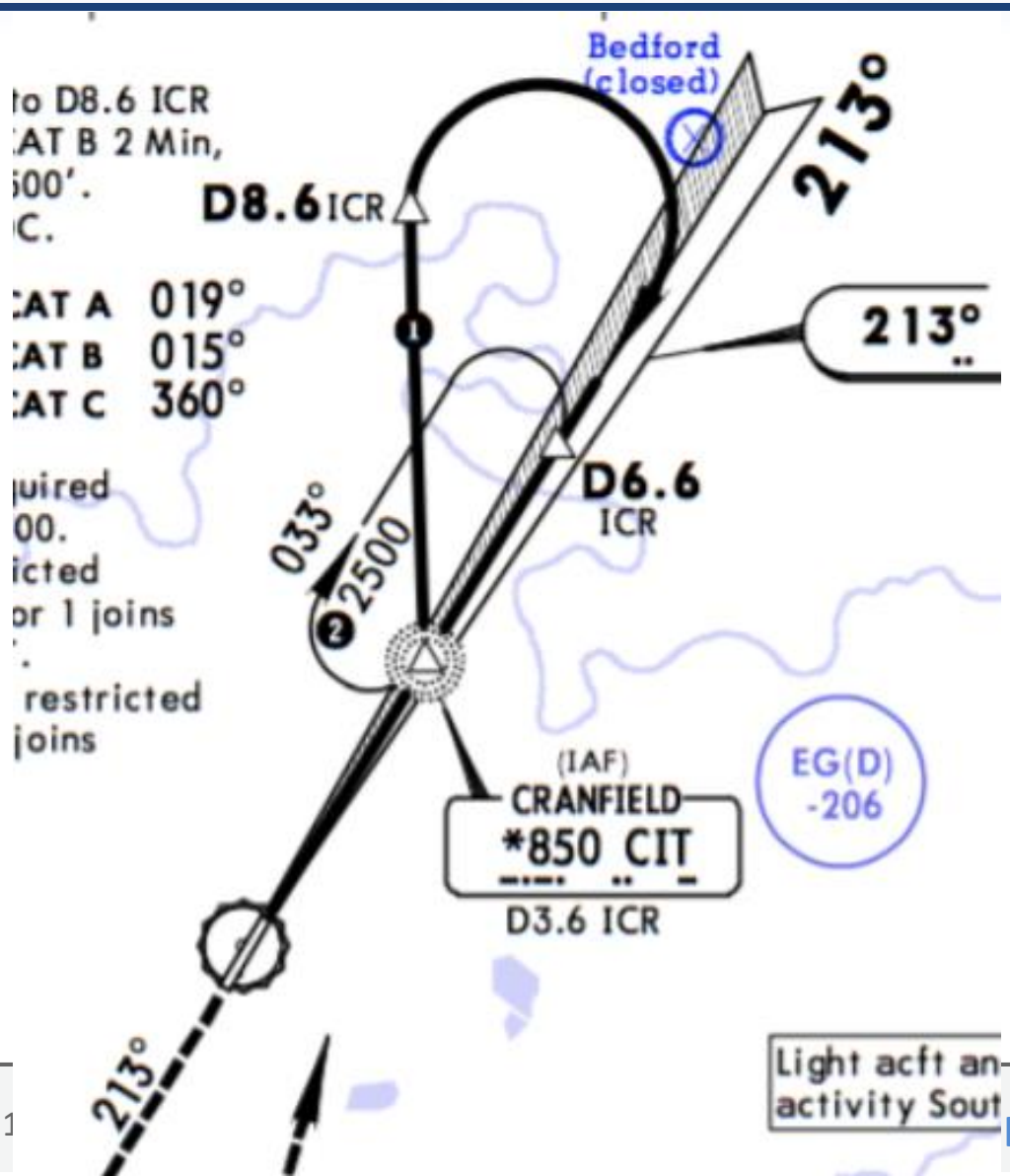
SESSION PLAN

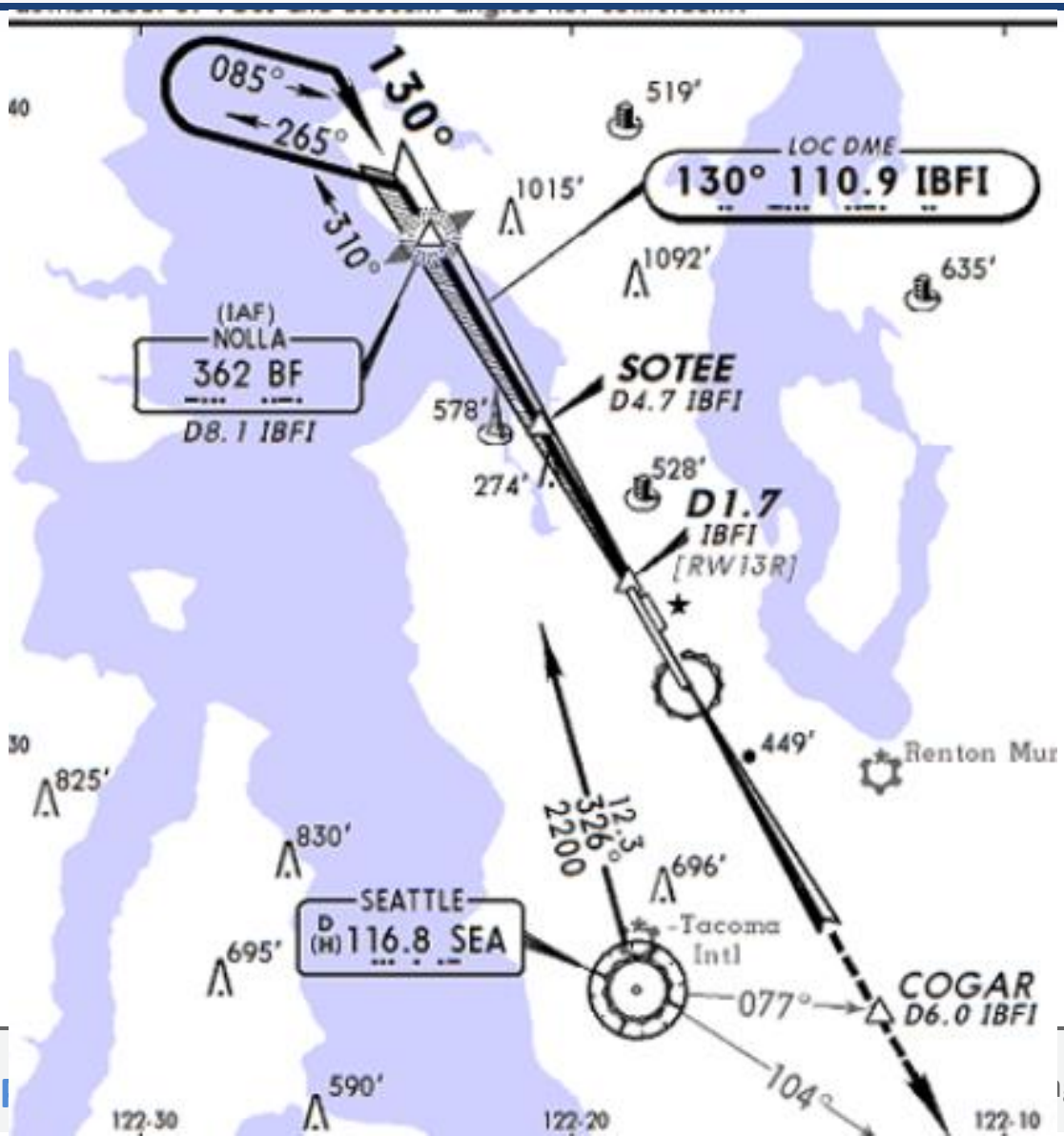
- Procedures
- Entry
- Protection Areas
- Interfaces

Procedures

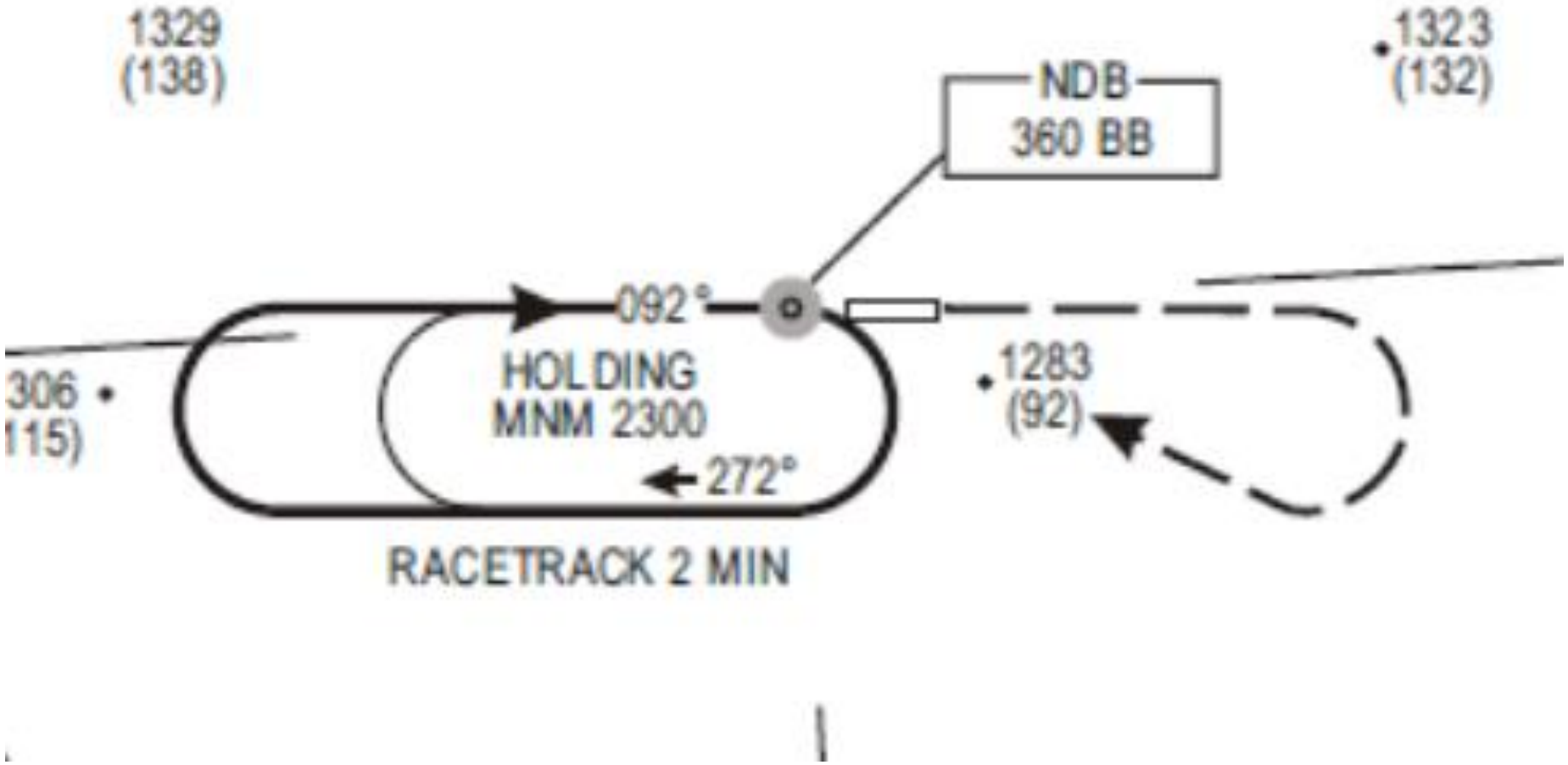

INITIAL APPROACH SEGMENTS
Reversal procedures
Racetrack procedures
Guided straight or curved
DR Track
Radar
Base Turn
Procedure Turn 45/180
Procedure Turn 80/260

Base Turn & Procedure Turn





Racetrack procedures



Turns

- No descent considered during turn
- Maximum height loss calculated along all NOMINAL tracks except turns
- Inbound track usually becomes intermediate or final approach track (especially for the case where no IF or no FAF)

Reversal procedures

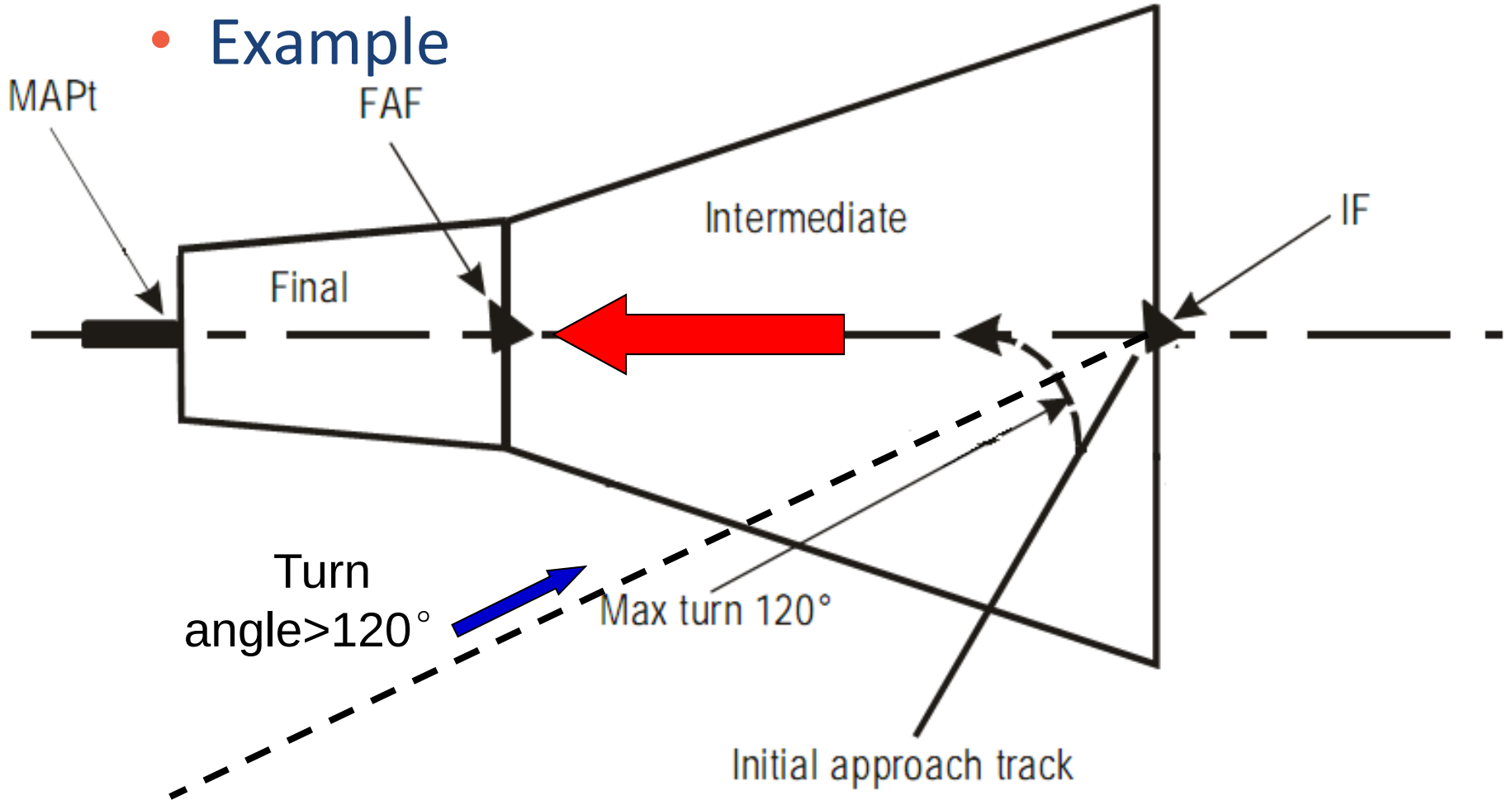
- Maximum angle between 2 segments : 120°
- Leading fix for turns more than 70°

  Solution: Reversal procedures

- The facility is located on or near the aerodrome

Reversal procedures

- Example



Reversal procedures

- Reversal procedures are used to establish the aircraft inbound on an intermediate or final approach track at the desired altitude.
- Base turn
- Procedure turn
  - 45° /180°
  - 80° /260°

Base Turn

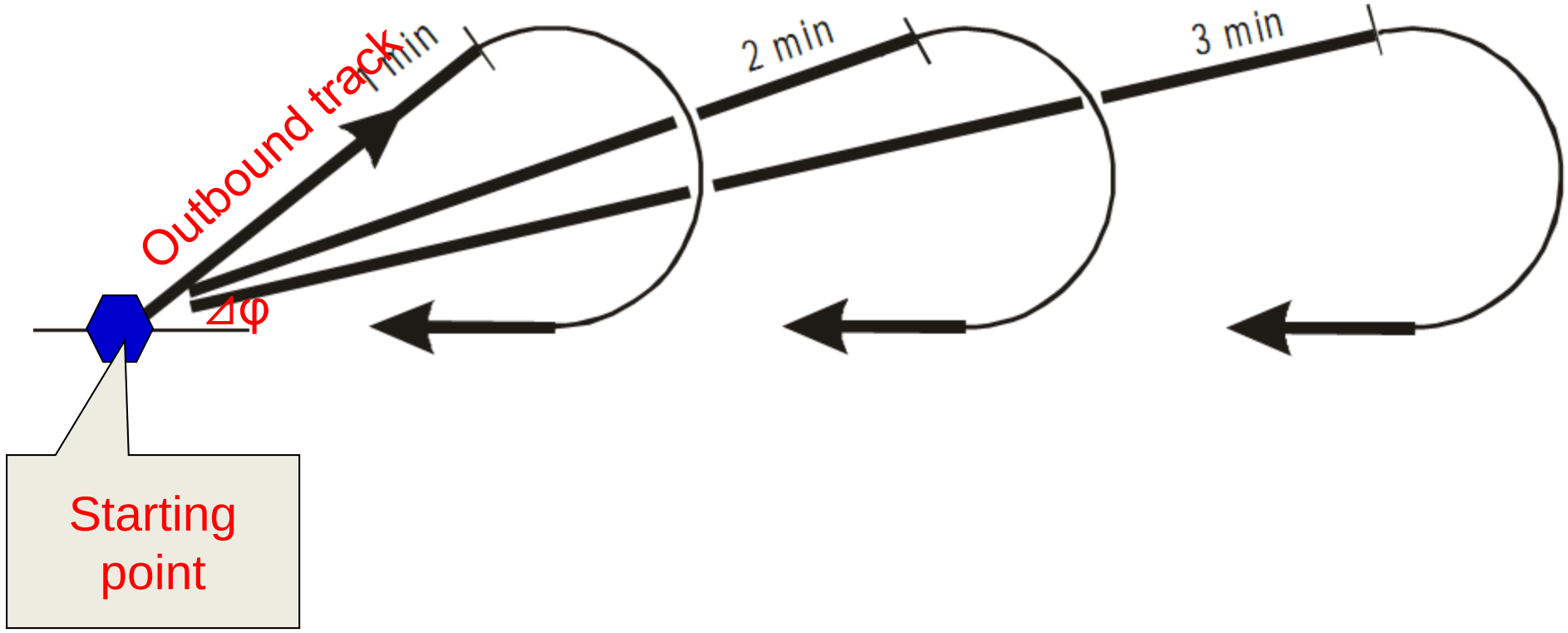

restricted
joins
033°
2500
213°
Bedford
(closed)
D6.6
ICR
213°
213°
(IAF)
CRANFIELD
*850 CIT
D3.6 ICR

Base turn

- Starting point: a facility
- Outbound track: may be timed or may be limited by a radial or DME distance
  - Outbound time:1 to 3 minutes using 1/2 minute increments
  - Different times may be published

Base turn

may be limited by a radial or DME distance



Base turn

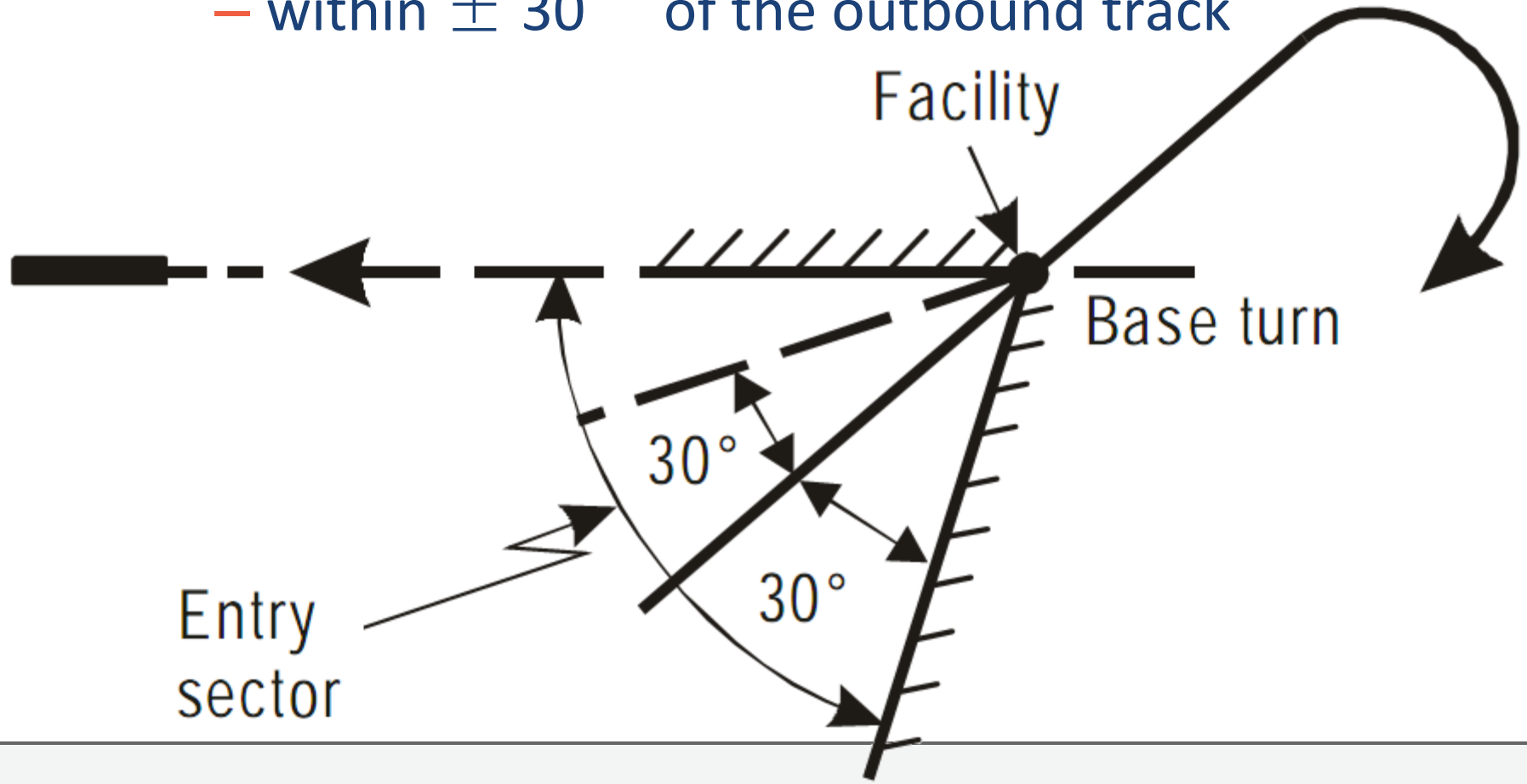
- $\Delta\phi$:
  - for true airspeed (TAS) less than or equal to 315 km/h (170 kt): = 36/t; and
  - for TAS exceeding 315 km/h (170 kt):
    - = (0.116 * TAS)/t where TAS is in km/h
    - = (0.215 * TAS)/t where TAS is in kt

Entry of Reversal procedures

- From a track within ± 30° of the outbound track
- A manoeuvre onto the outbound track, with a suitably located holding pattern, the holding must be shown on the approach chart.

Base turn

- Entry:
  - within ± 30° of the outbound track



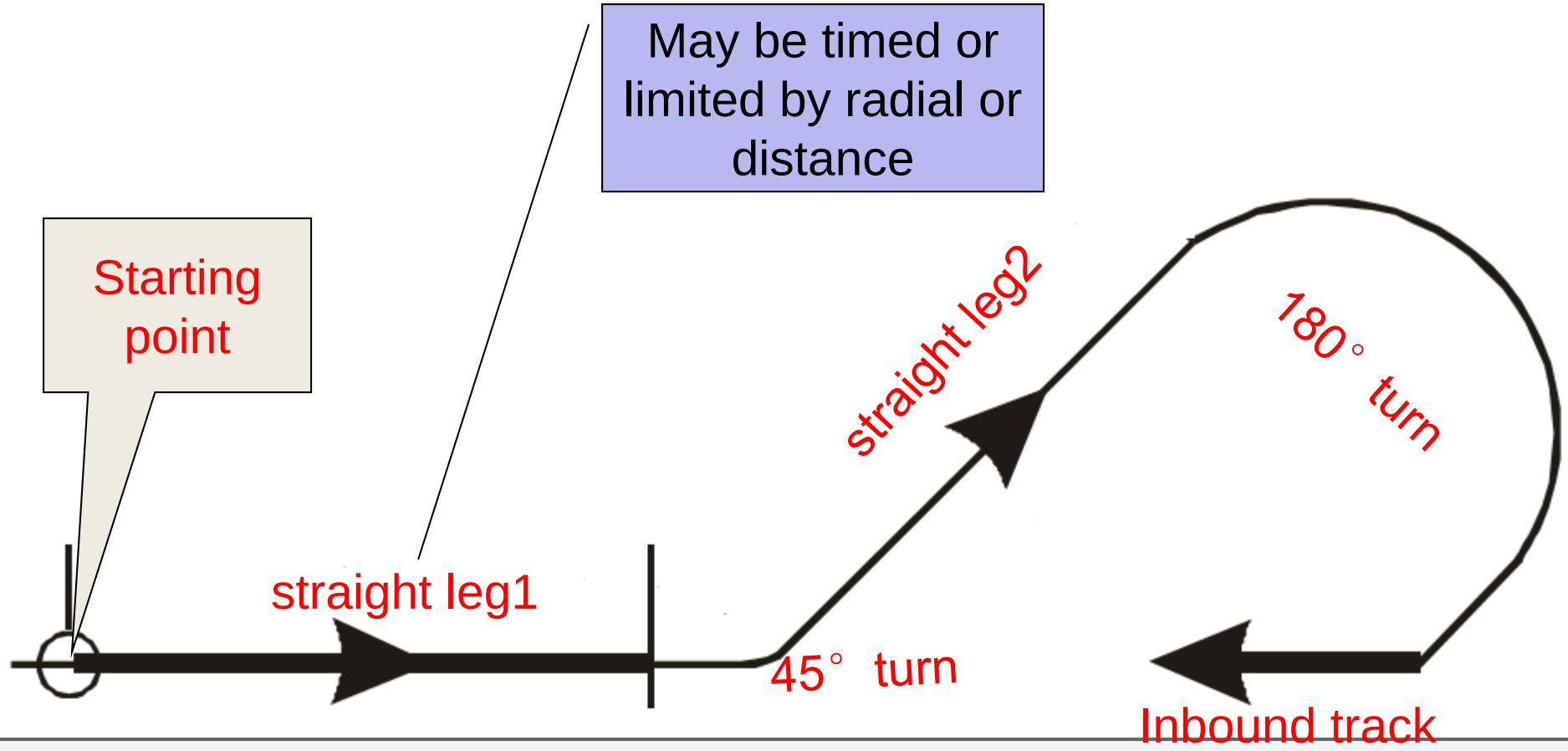
Procedure Turn

Procedure turn 45°/180°

- Starting point: a facility or fix
- straight leg1: timed; limited by a radial or DME distance
  - Time: between 1 and 3 minutes using 1/2 minute increments
  - Different times may be published
- straight leg2: timed
  - CAT A,B:1min
  - CAT C,D and E: 1min and 15 sec

Procedure turn

- 45° /180°

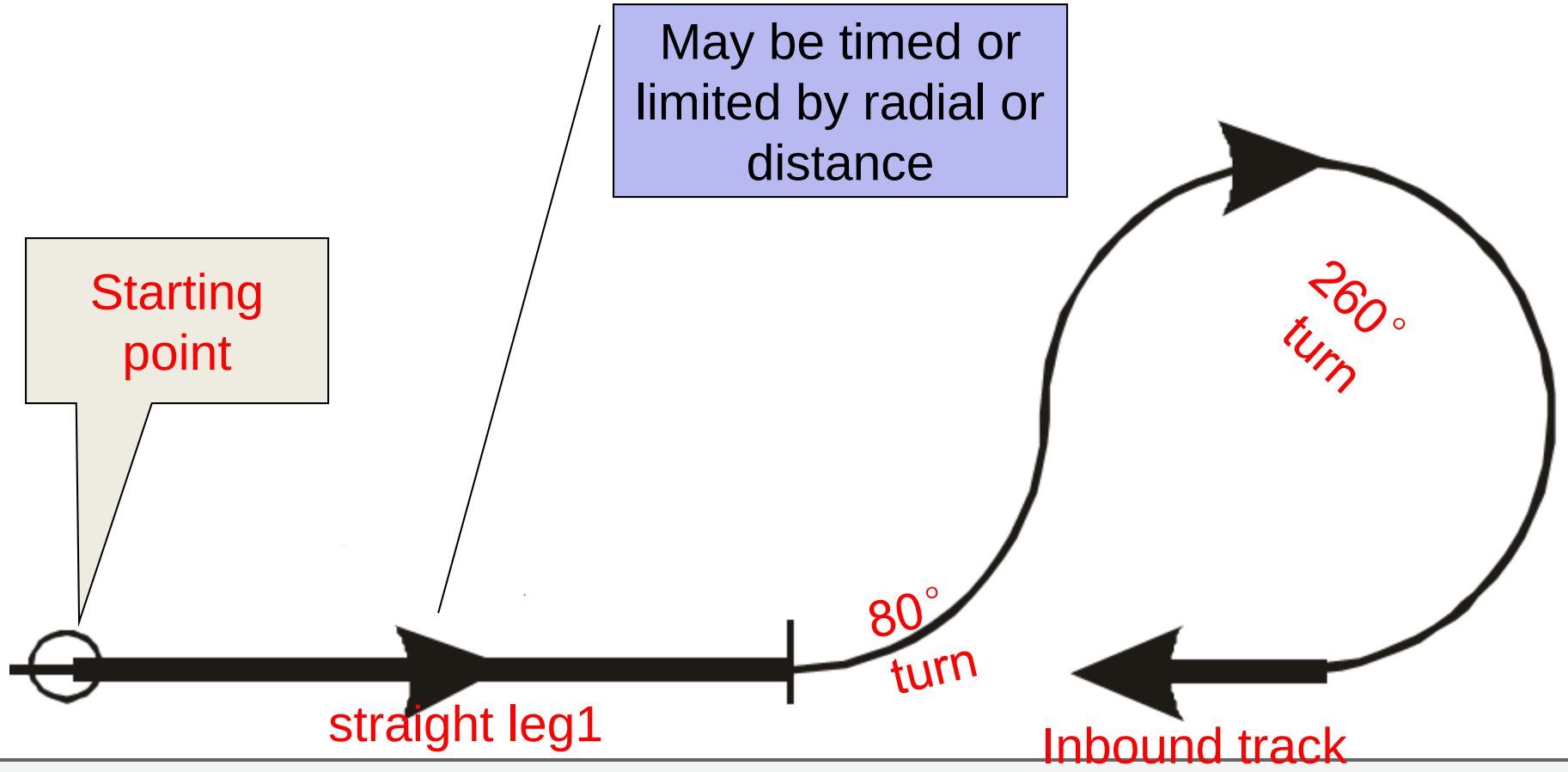


Procedure turn 80°/260°

- Starting point: a facility or fix
- straight leg1: timed; limited by a radial or DME distance
  - Time: between 1 and 3 minutes using 1/2 minute increments
  - Different times may be published

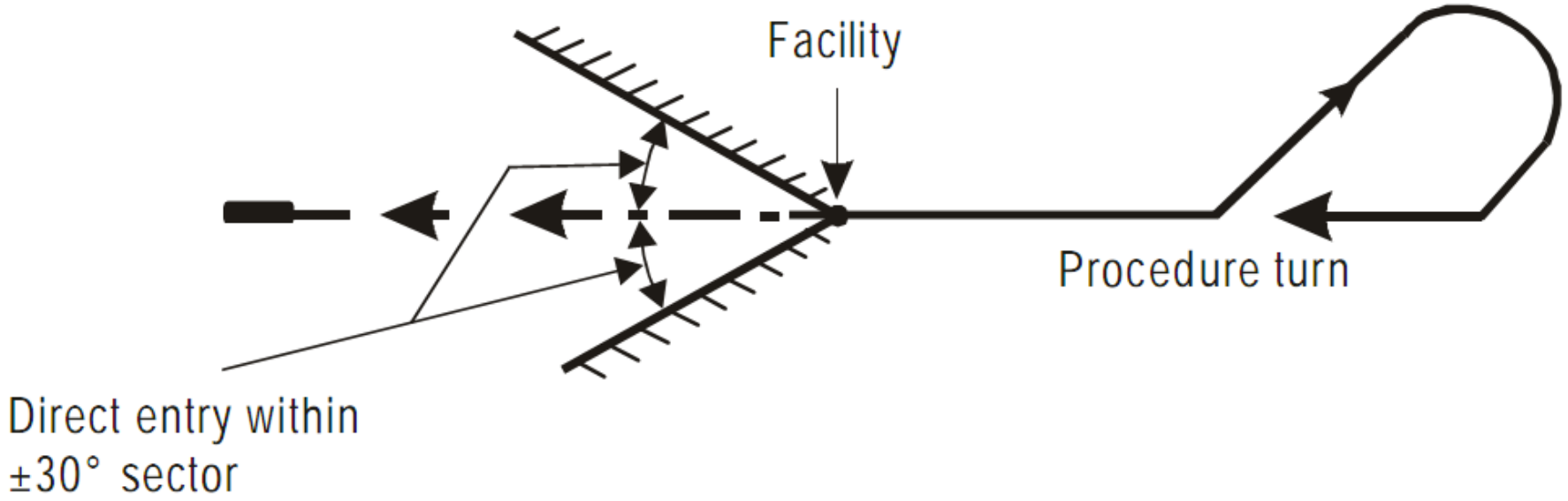
Procedure turn

- 80° /260°

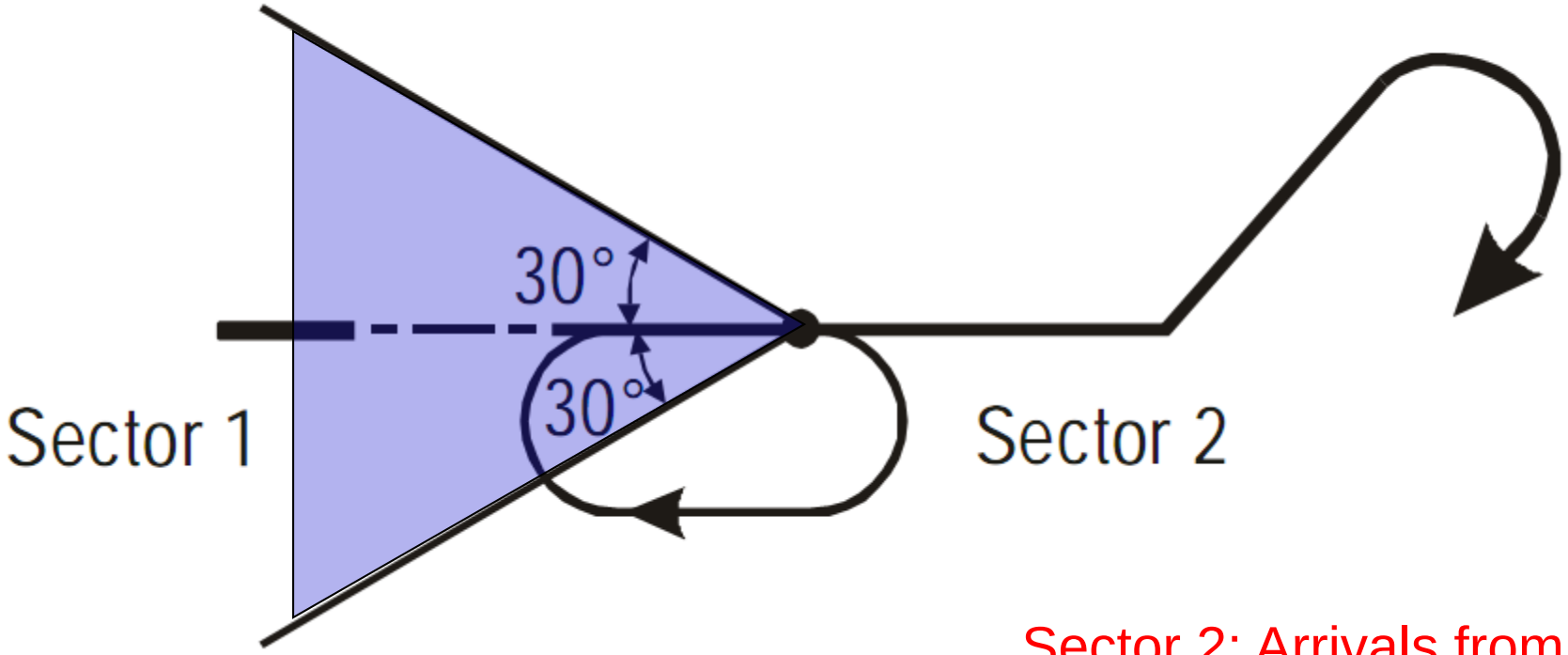


Procedure turn

- Entry:
  - within ± 30° of the outbound track



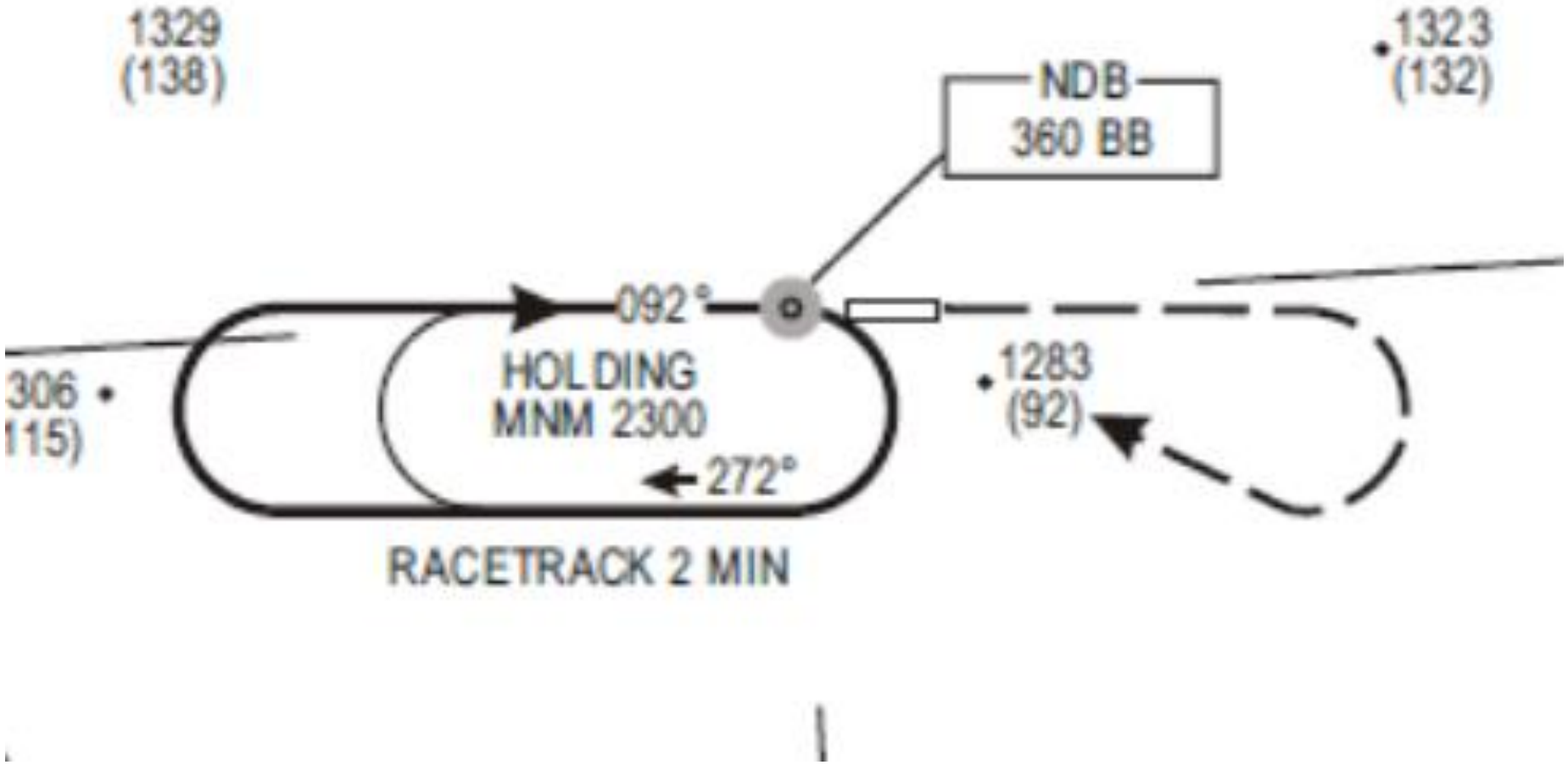
Entry with a holding



Sector 1: Arrivals from this sector may enter the reversal procedure directly

Sector 2: Arrivals from this sector must enter the holding prior to the reversal procedure

Racetrack procedures



Racetrack

- Maximum angle between 2 segments : 120° ;
- Leading fix for turns more than 70°
- entry into a reversal procedure is not practical

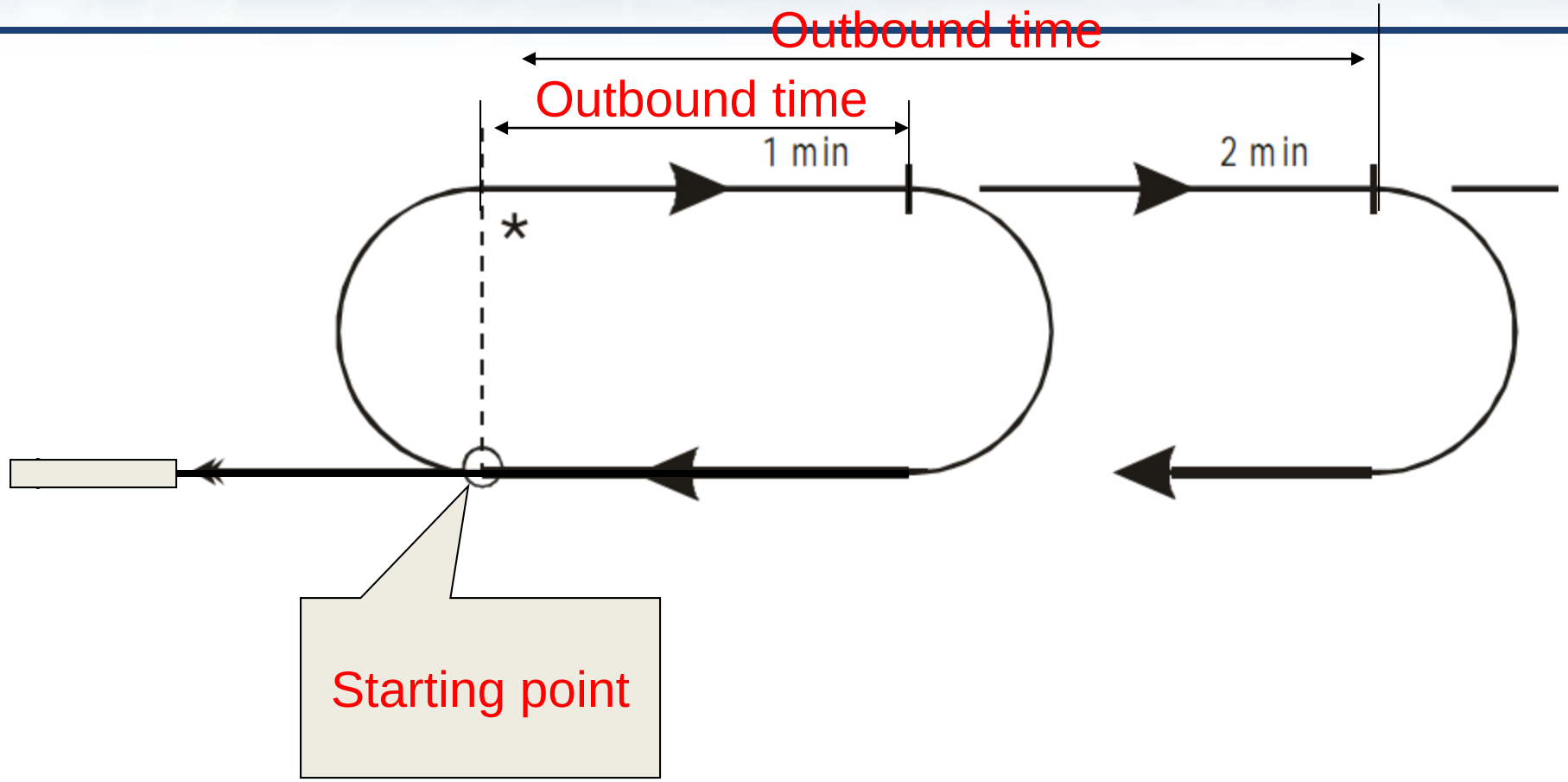
Solution: Racetrack procedures

- The facility is located on or near the aerodrome;

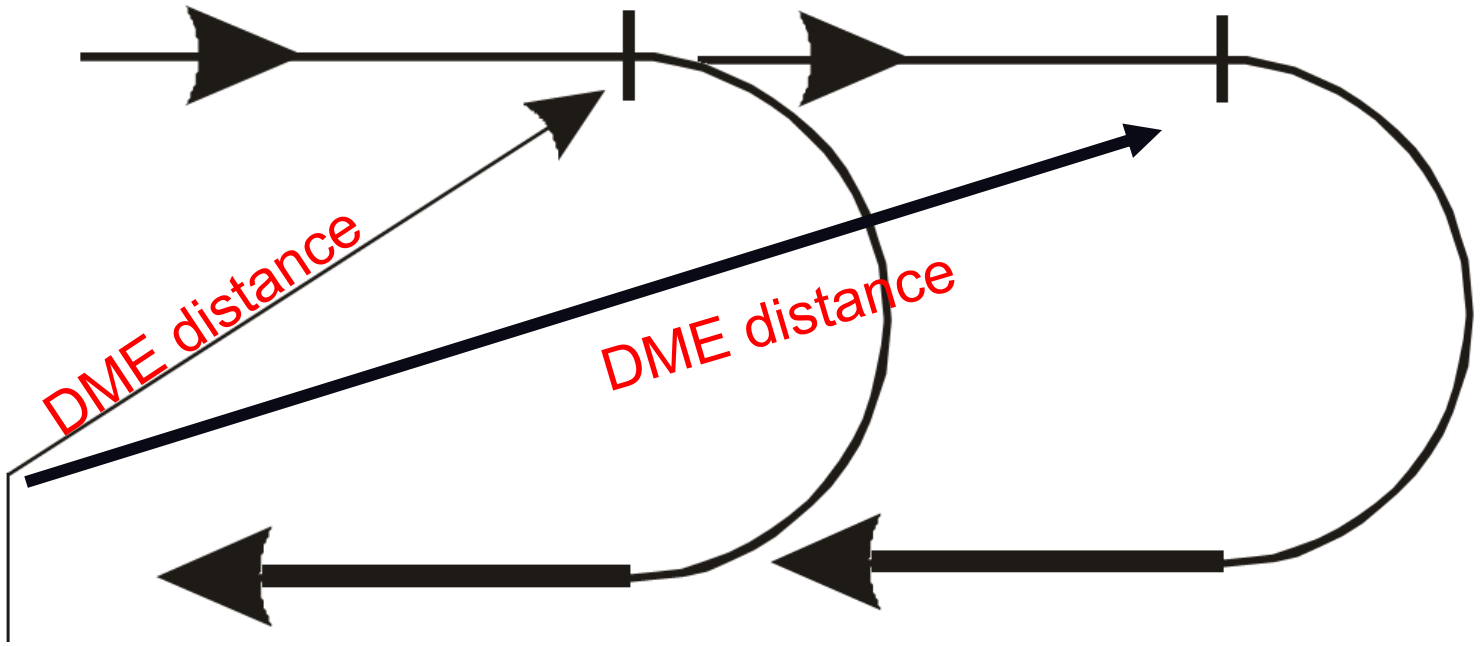
RACETRACK

- Starting point :facility or fix.
- Outbound time: 1 to 3 minutes
  - specified in 1/2 min increments
  - Different times may be published
- Limitation of outbound track:
  - by specifying a DME distance; or
  - a radial/bearing from a suitably located facility

RACETRACK



RACETRACK



Inbound leg

Outbound time

- May vary in accordance with aircraft categories
- Normally between 1-3 min, ½ minute interval
- Different times may be published
- Different protection areas designed to compute minimum altitude

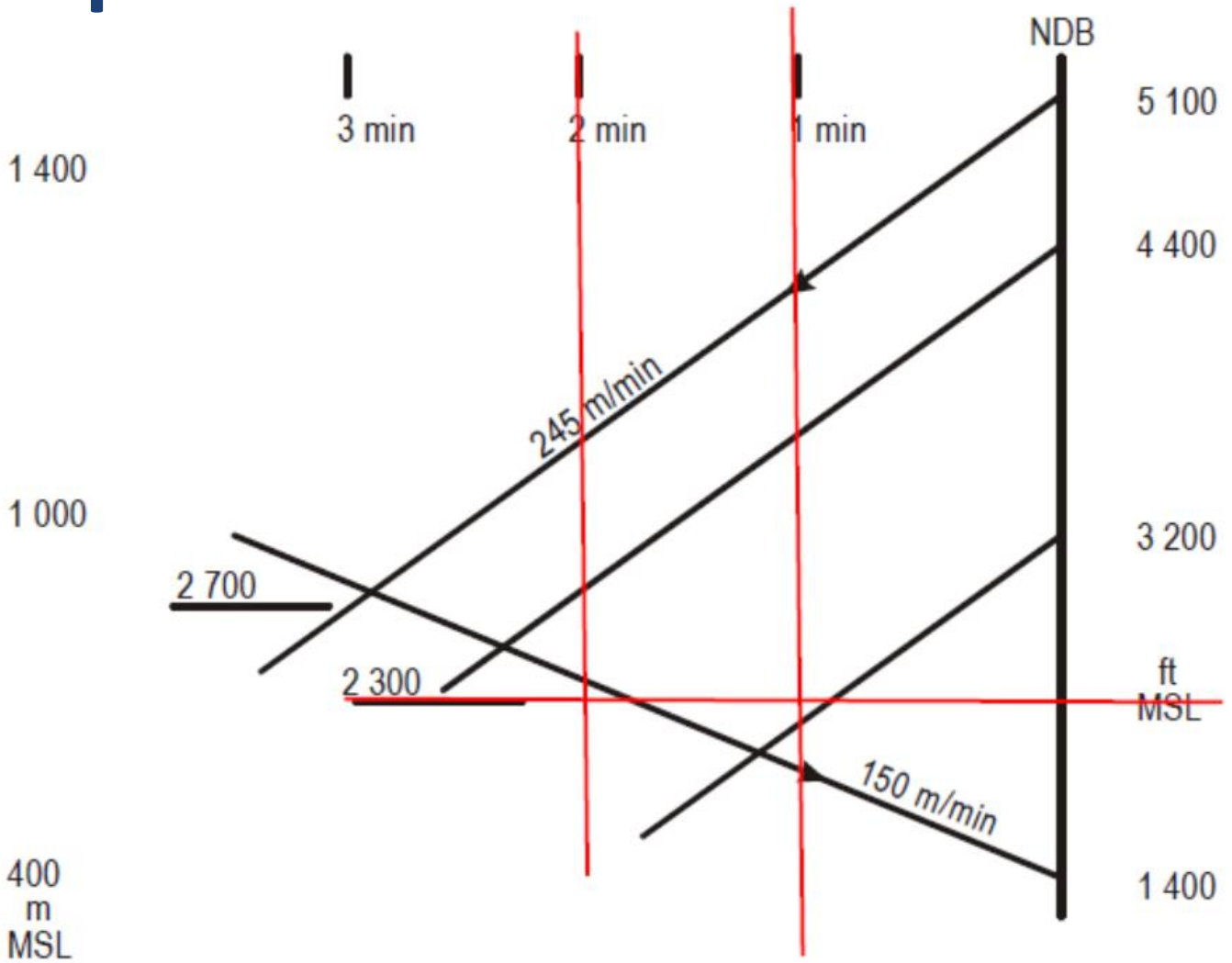
Only **ONE** minimum altitude for the initial segment (racetrack or reversal) if it is published on the same chart

Maximum/minimum descent to be specified on a reversal or racetrack procedure

		Maximum*	Minimum*
Outbound track	Cat A/B	245 m/min (804 ft/min)	N/A
	Cat C/D/E/H	365 m/min (1 197 ft/min)	N/A
Inbound track	Cat A/B	200 m/min (655 ft/min)	120 m/min (394 ft/min)
	Cat H	230 m/min (755 ft/min)	N/A
	Cat C/D/E	305 m/min (1 000 ft/min)	180 m/min (590 ft/min)

* Maximum/minimum descent for 1 minute nominal outbound time in m(ft). For maximum descent rates related to a final approach segment, see Chapter 5, 5.3.

Maximum/minimum descent to be specified on a reversal or racetrack procedure



RACETRACK ENTRY

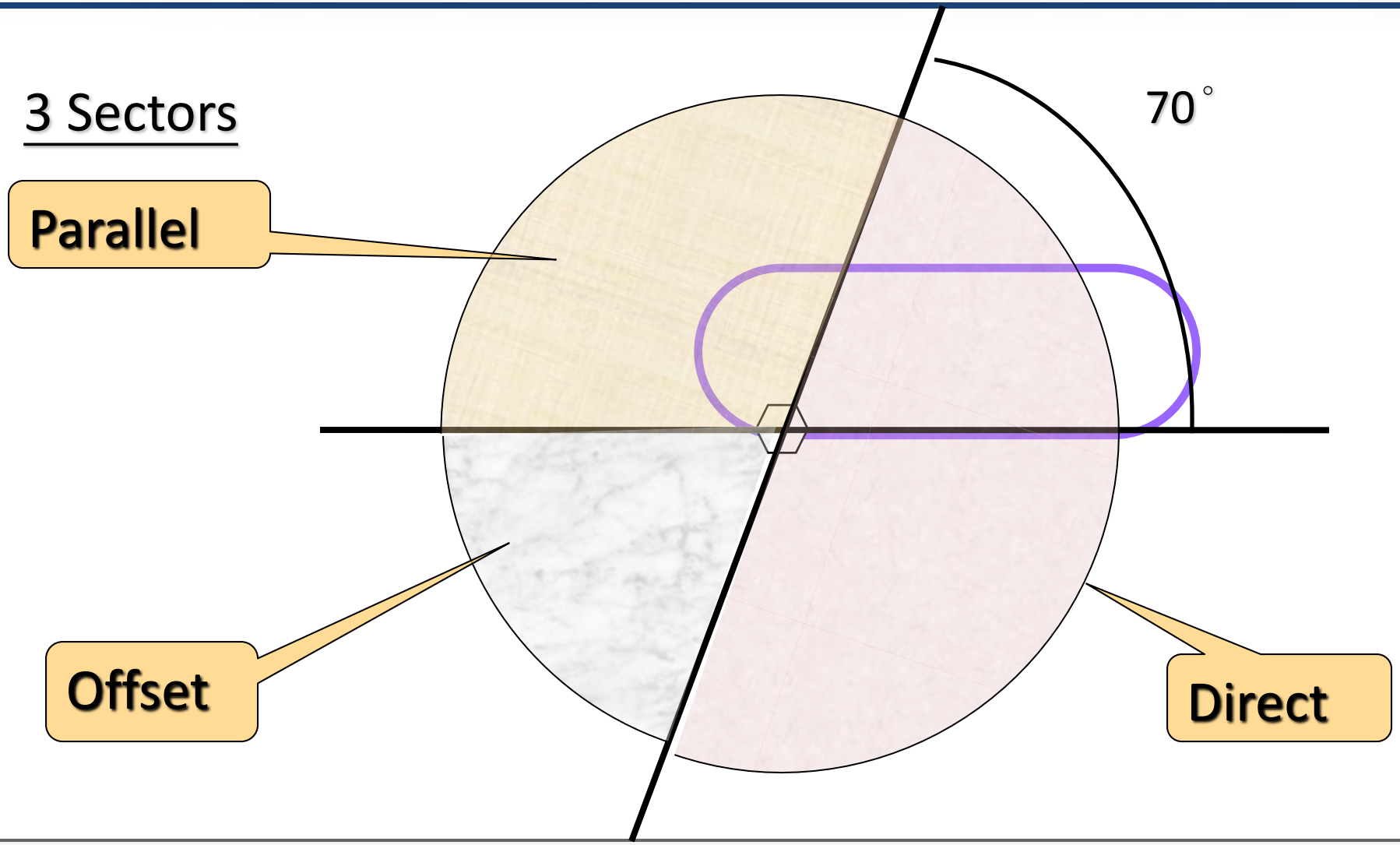
- Entry : similar to entry procedures for holding patterns additional considerations:

❖Offset entry time: 1 min 30 s.

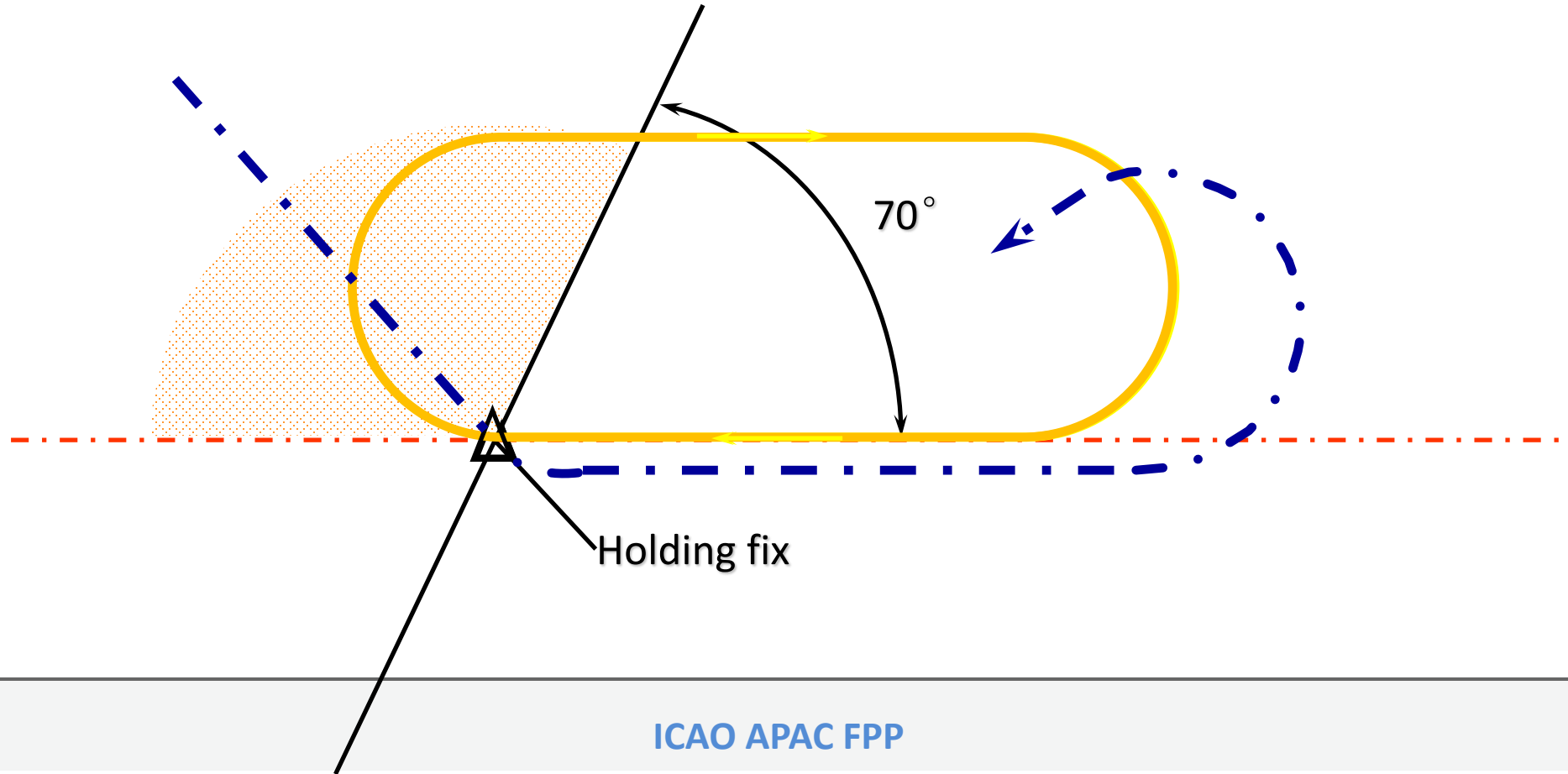
❖A heading parallel to the outbound track for the remainder .

❖Parallel entry shall not return directly to the facility without first intercepting the inbound track.

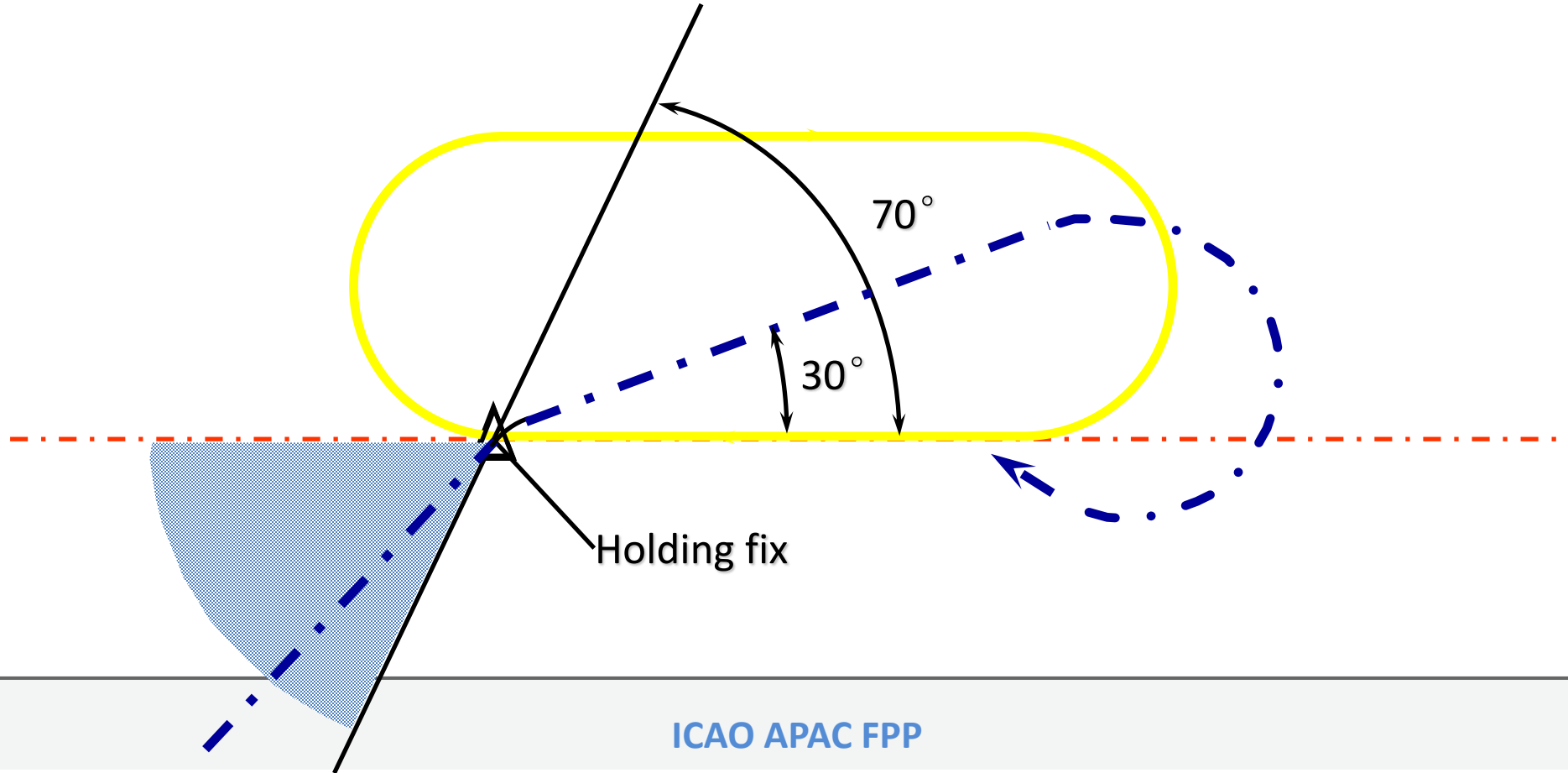
OMNIDIRECTIONAL ENTRIES



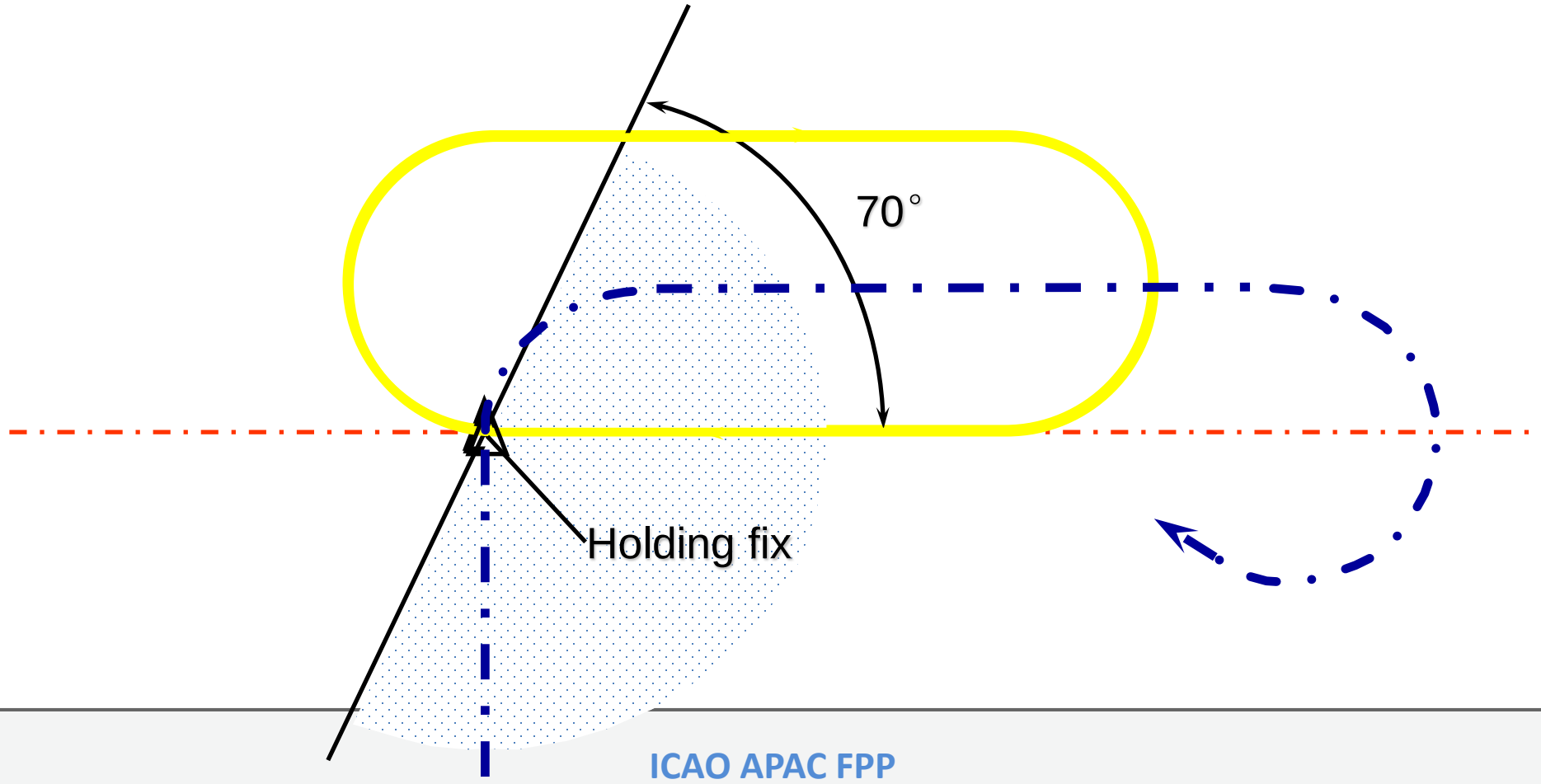
SECTOR 1 -PARALLEL ENTRY



SECTOR 2 - OFFSET ENTRY



SECTOR 3 - DIRECT ENTRY



Protection Areas

Appendix C to Chapter 3

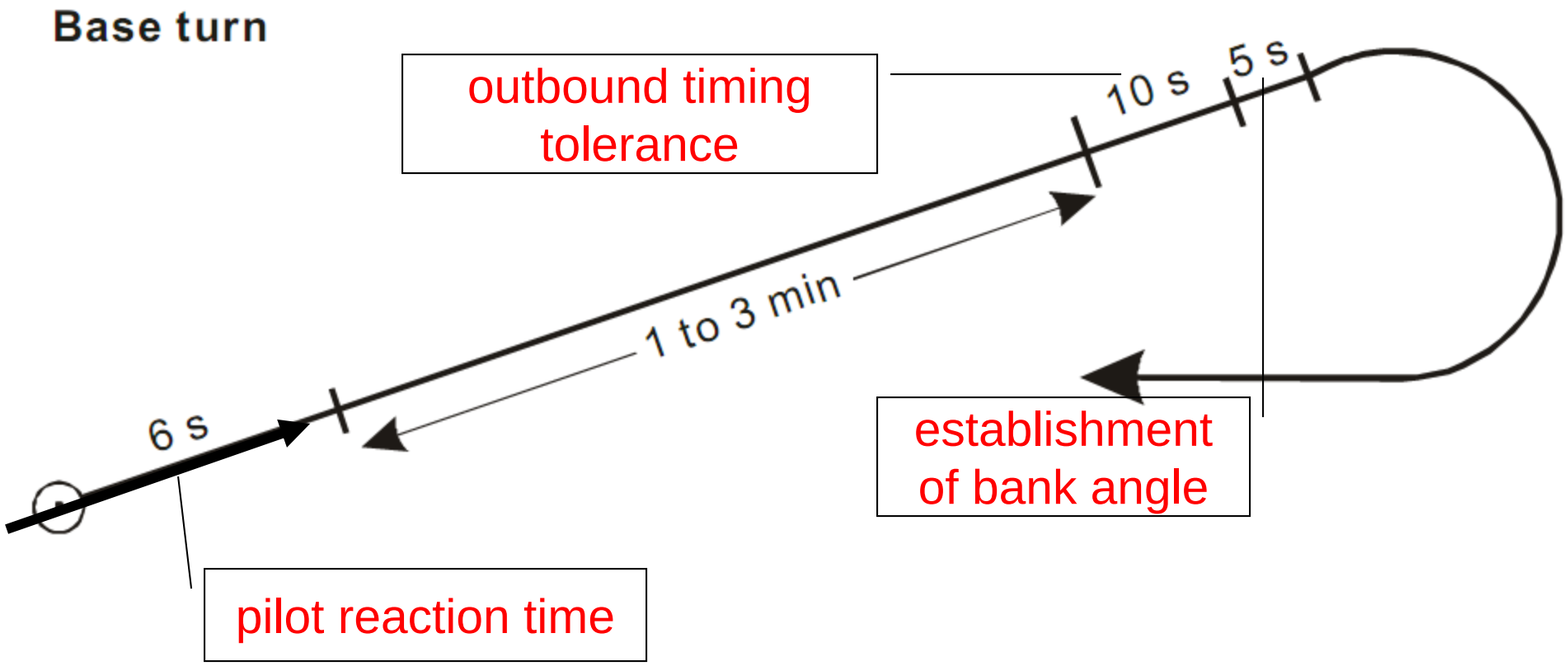
Parameters

- Altitude : the specified altitude
- temperature: ISA+ 15° C
- wind speed: ICAO 2h +47 or statistical data
- bank angle: 25° or the bank angle giving a turn rate of 3° per second

Parameters

- fix tolerance area
- flight technical tolerance
  - 1) outbound timing tolerance of ±10 s;
  - 2) pilot reaction time of 0 to + 6 s;
  - 3) establishment of bank angle, + 5 s;
  - 4) heading tolerance ± 5° .

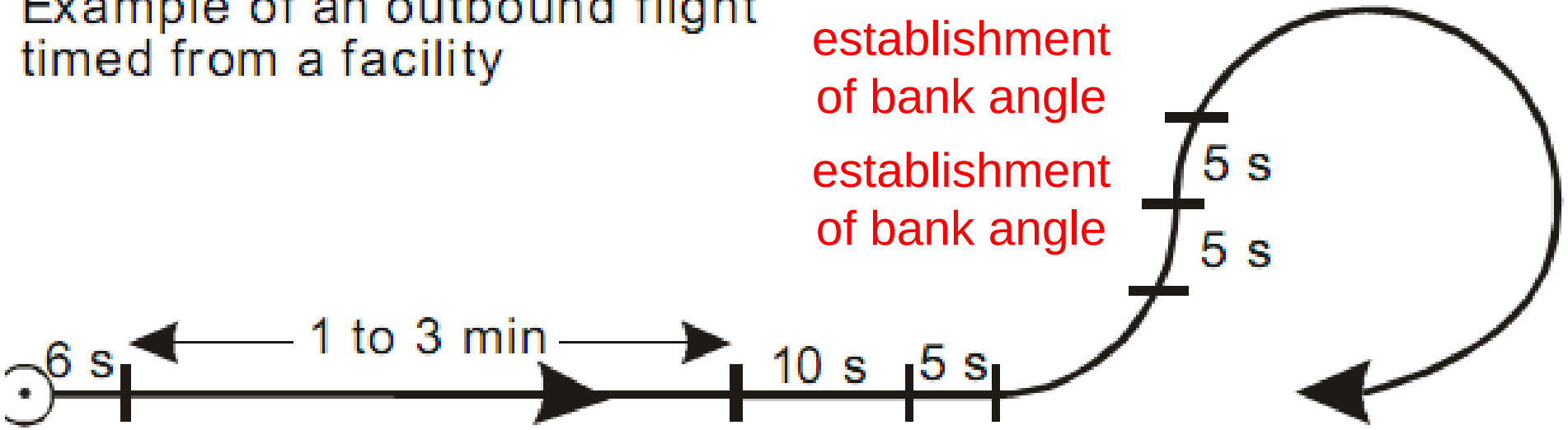
flight technical tolerance



tolerance

80°/260° procedure turn

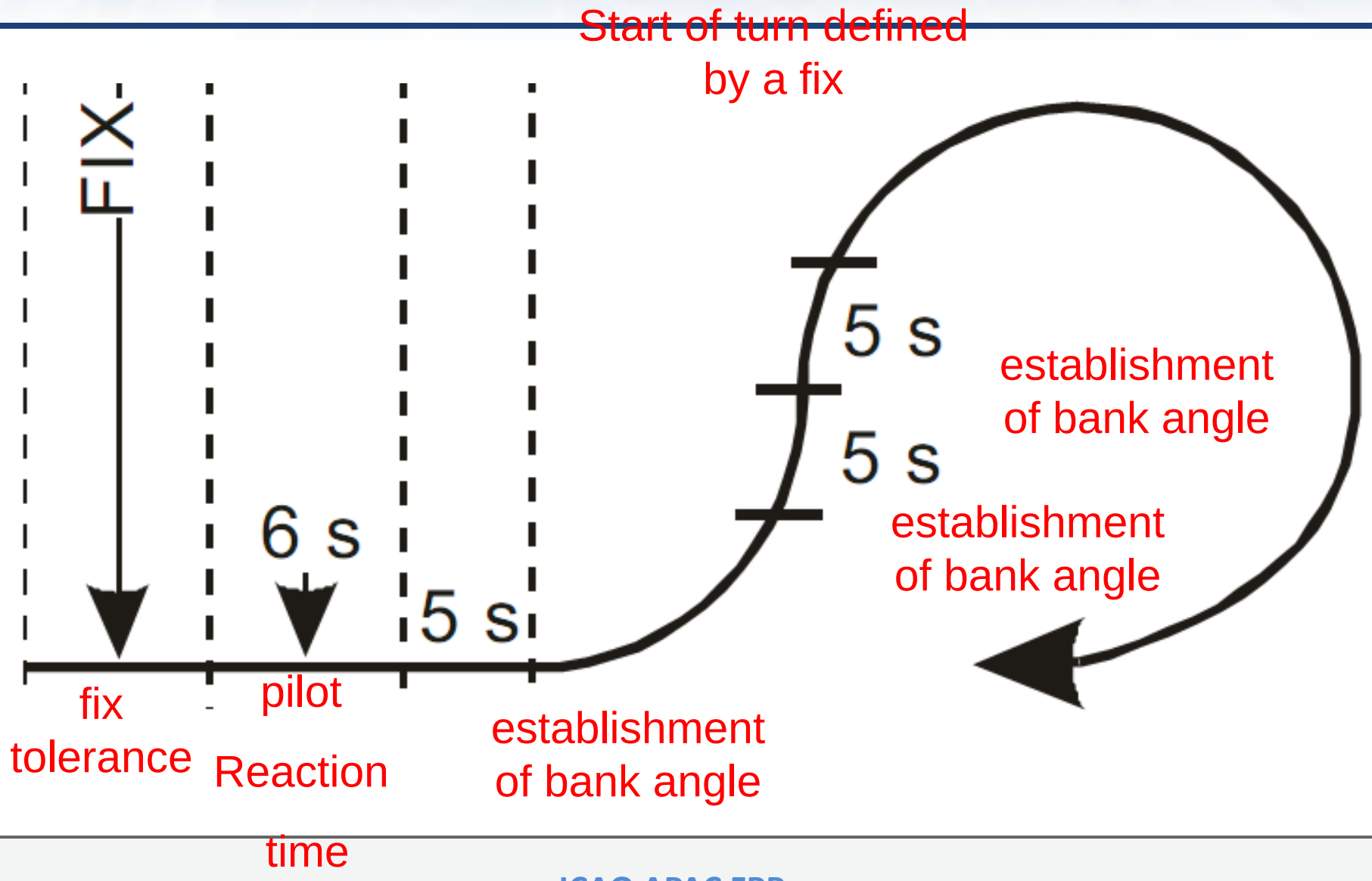
Example of an outbound flight timed from a facility



pilot Reaction time

outbound timing tolerance

tolerance

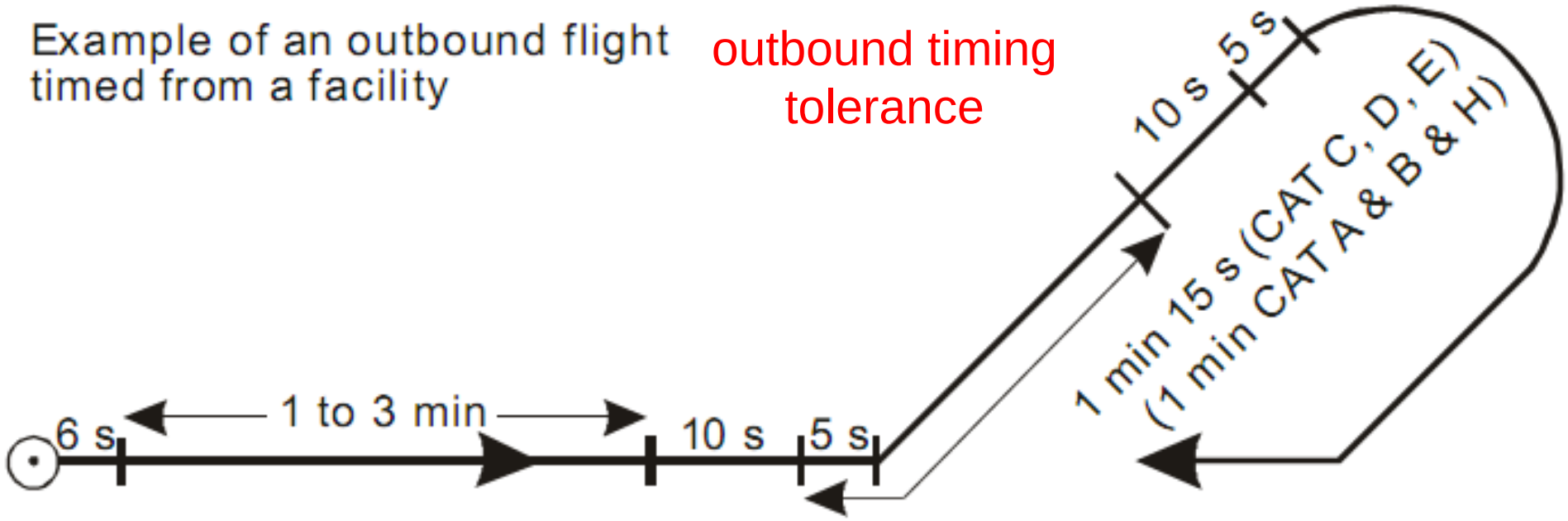

Start of turn defined by a fix
FIX
6 s
5 s
5 s
5 s
establishment of bank angle
establishment of bank angle
fix tolerance
pilot Reaction time
establishment of bank angle

tolerance

45°/180° procedure turn

Example of an outbound flight timed from a facility

outbound timing tolerance



outbound timing tolerance

WIND EFFECTS

- RACETRACK: The area based on the slow speed aircraft in strong winds may be larger than the area so constructed, it is considered that the normal operational adjustments made by pilots of such aircraft are such that the aircraft will be contained within the area;

- REVERSAL: Use of highest IAS and lowest IAS
  - Two different protection areas
  - Blended into one protection area

OPERATIONAL ASSUMPTIONS

- Start of outbound timing (racetrack):
  - using a facility - abeam the facility or on attaining the heading, whichever comes later; and
  - using a fix - from attaining the outbound heading;

- Outbound track adjustment (racetrack): adjusted to avoid crossing the nominal inbound track before the final turn;

Protection areas

- Basic area
  - maximum IAS
  - maximum altitude
  - outbound leg
- Entries
- Secondary area
  - 2.5 NM width all around
  - 1 NM using Appendix B application

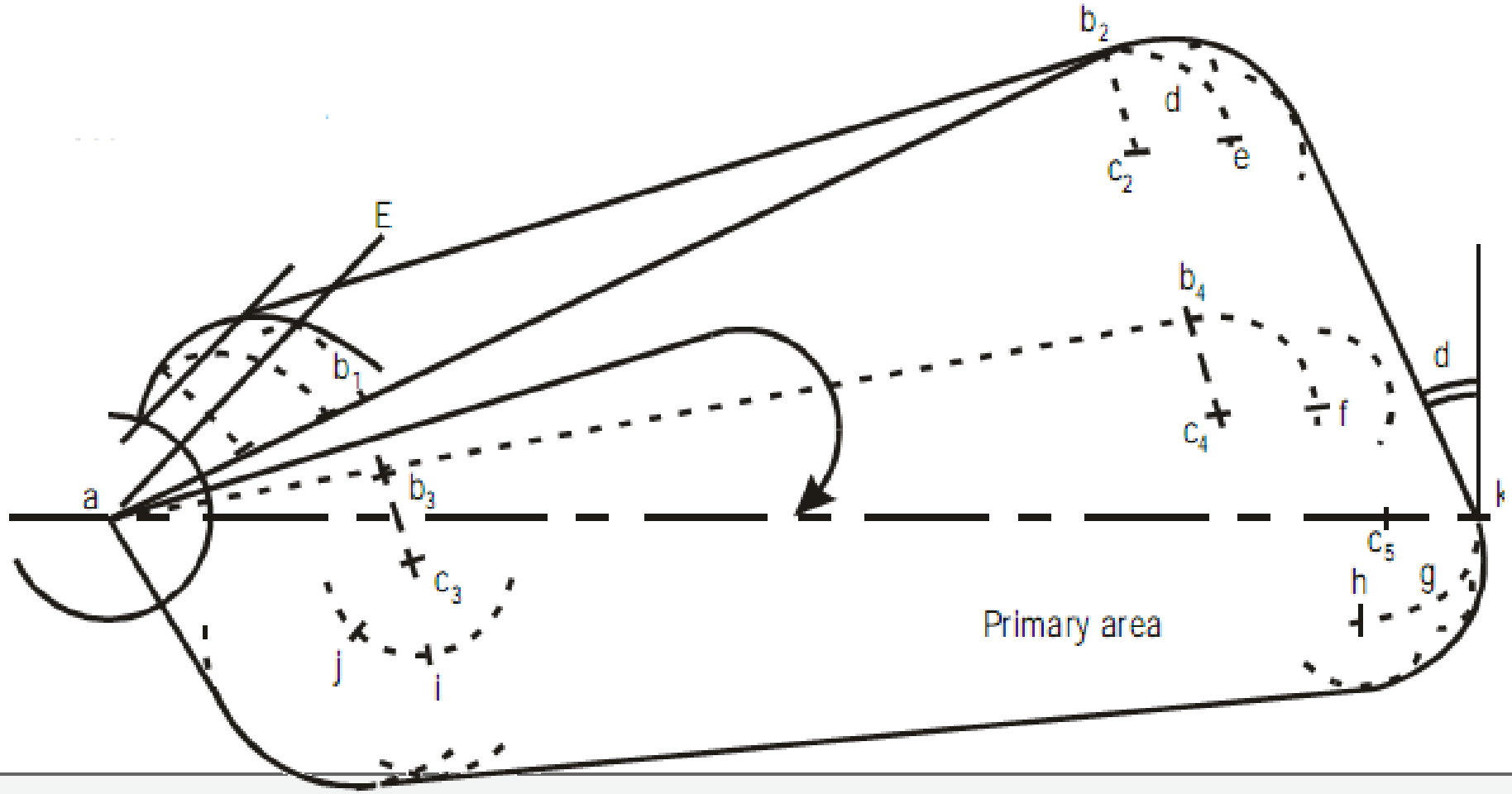
Use of Template

Template Manual for Holding, Reversal and Racetrack Procedures, DOC 9371-AN/912/2

Additive Tolerance Method

Base turn

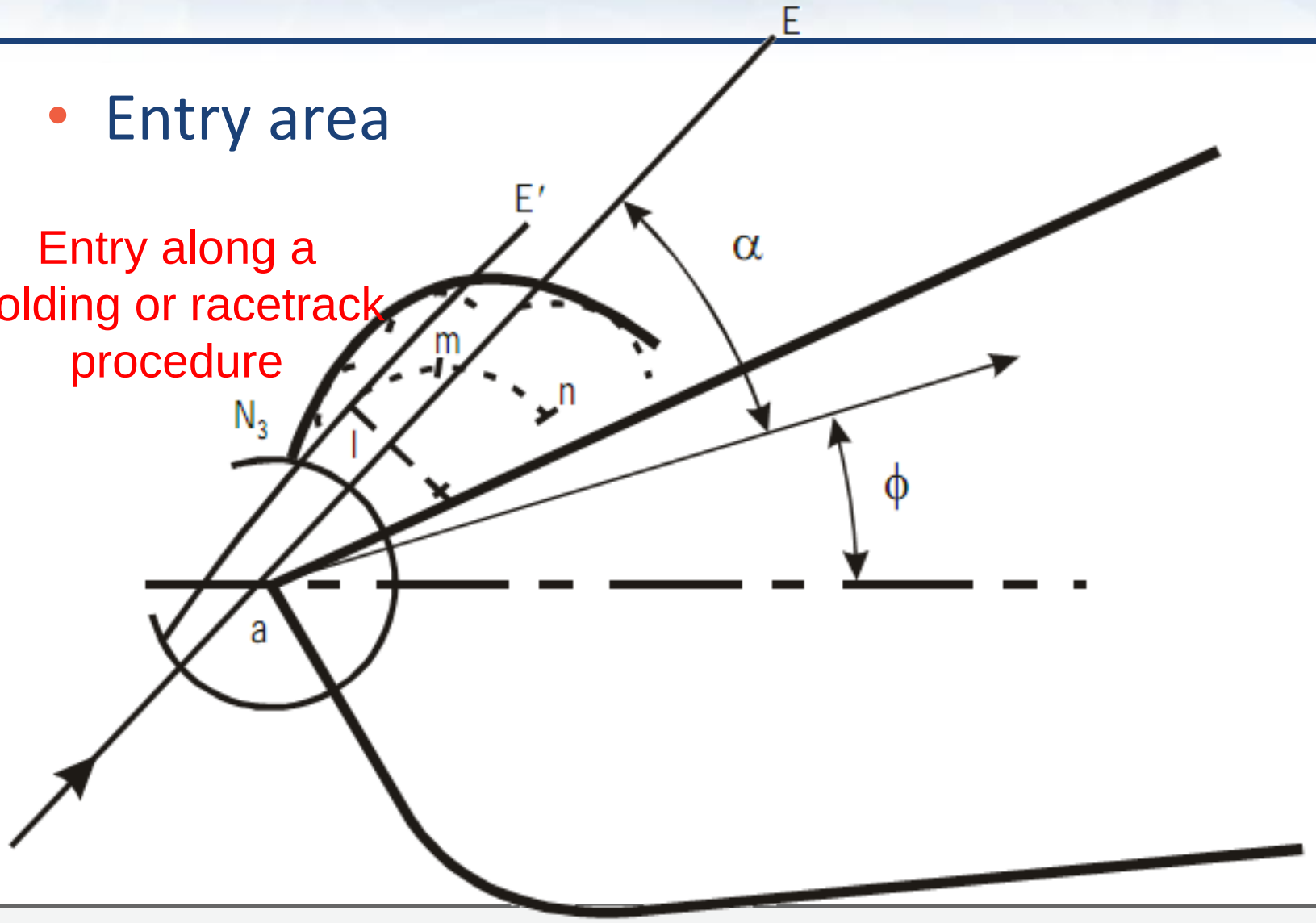
- Basic area



Base turn

- Entry area

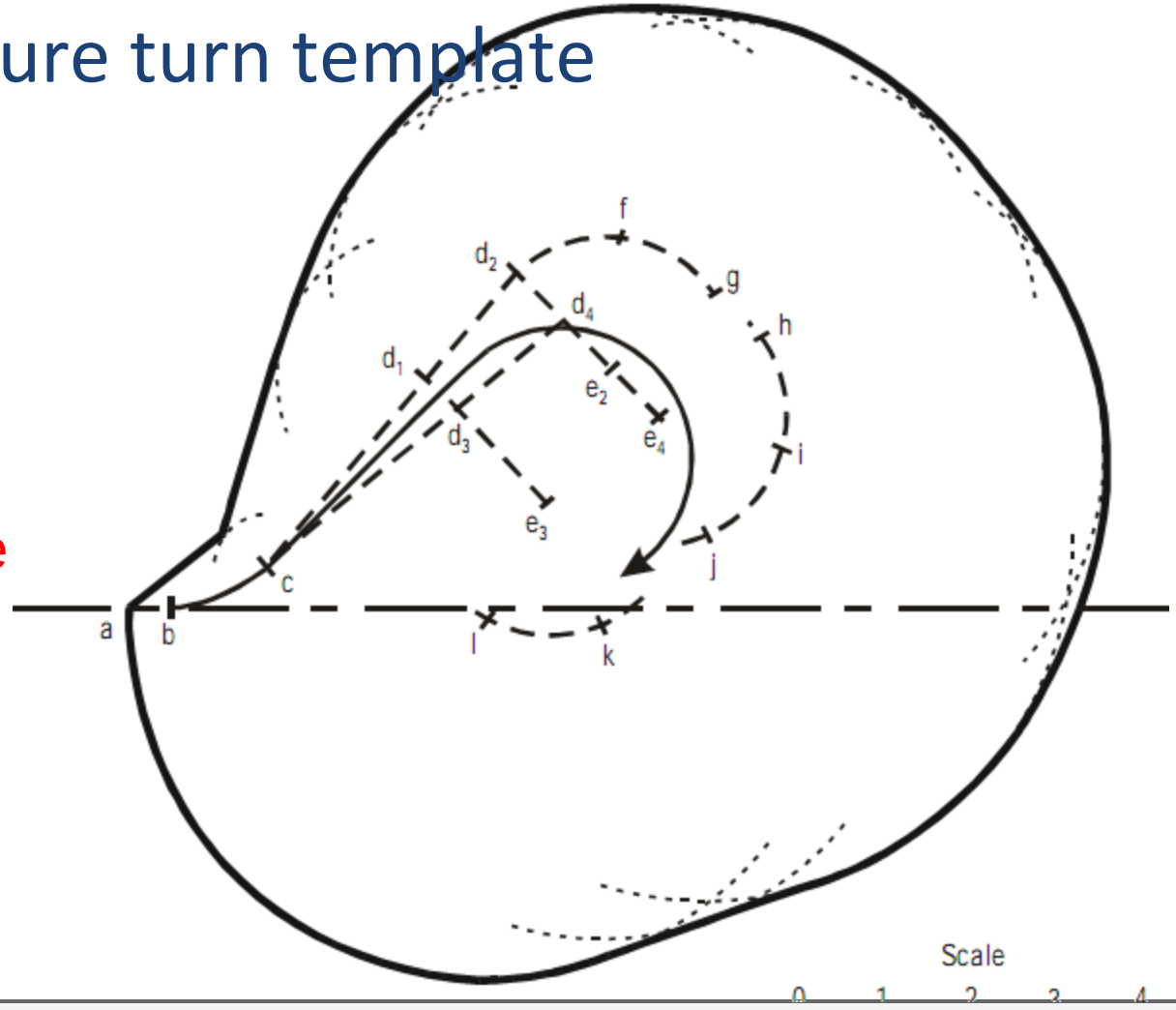
Entry along a holding or racetrack procedure



Procedure turn

- procedure turn template

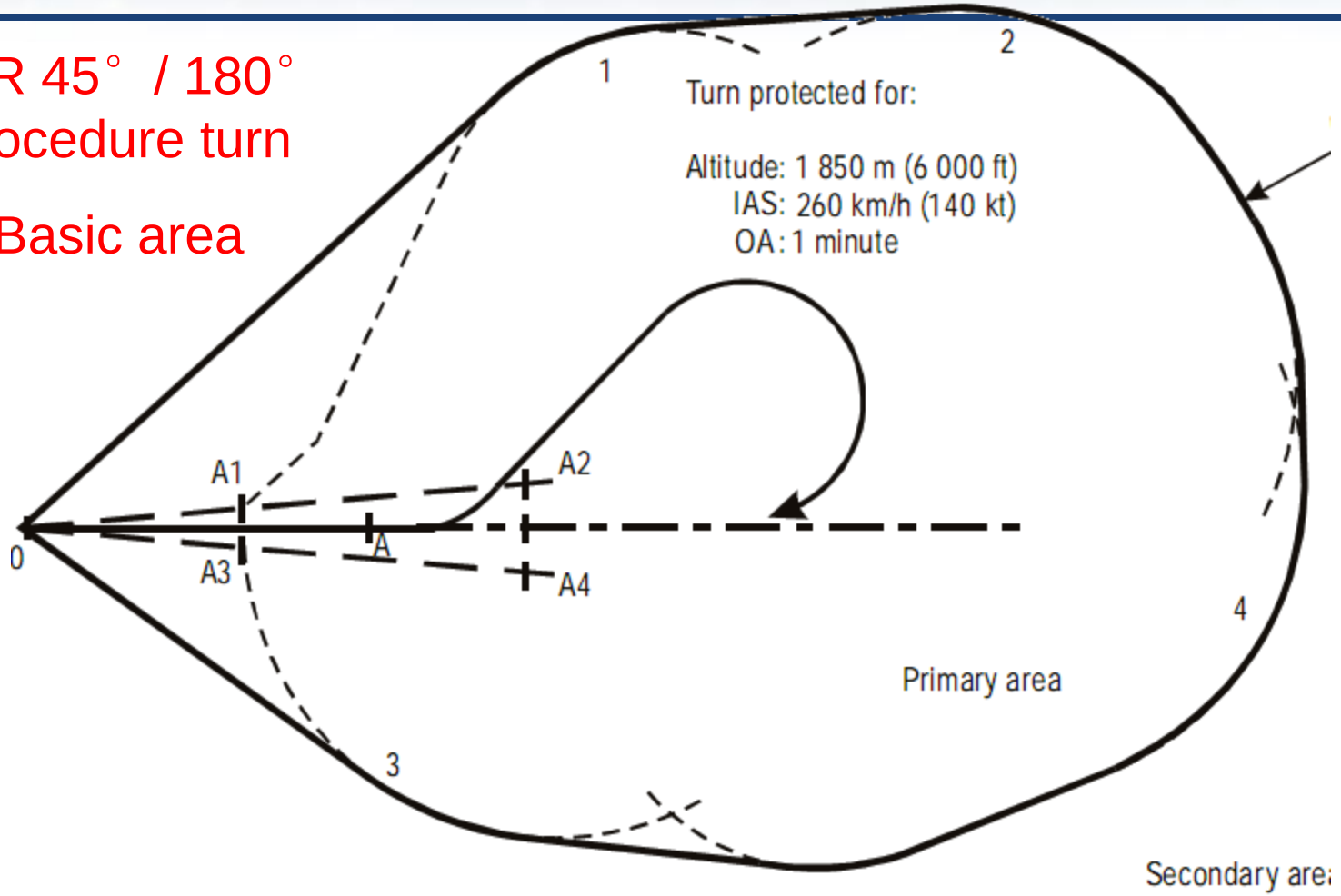
45° /180° procedure turn template



Procedure turn

VOR 45° / 180° procedure turn

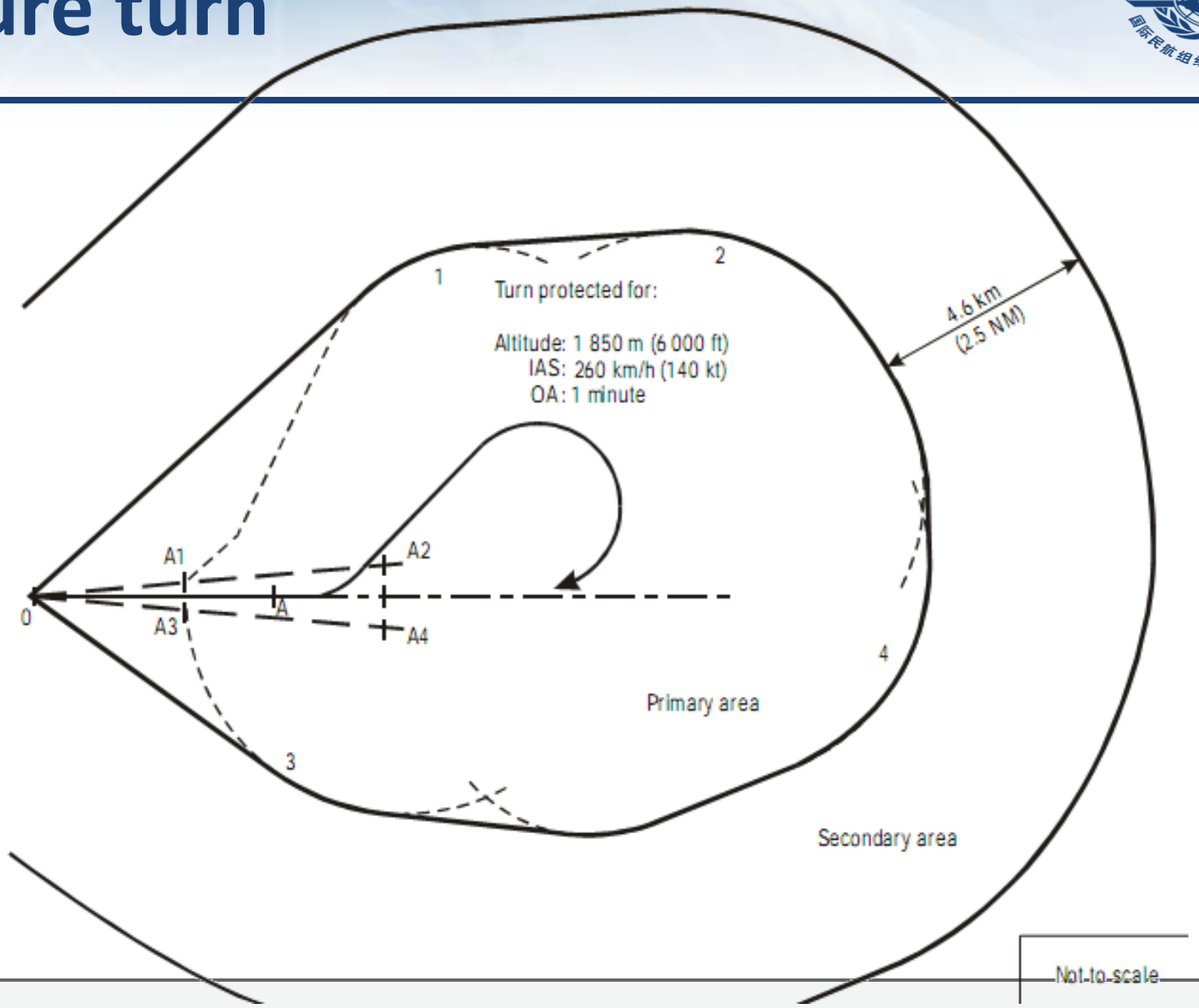
Basic area



Procedure turn

Basic Area &

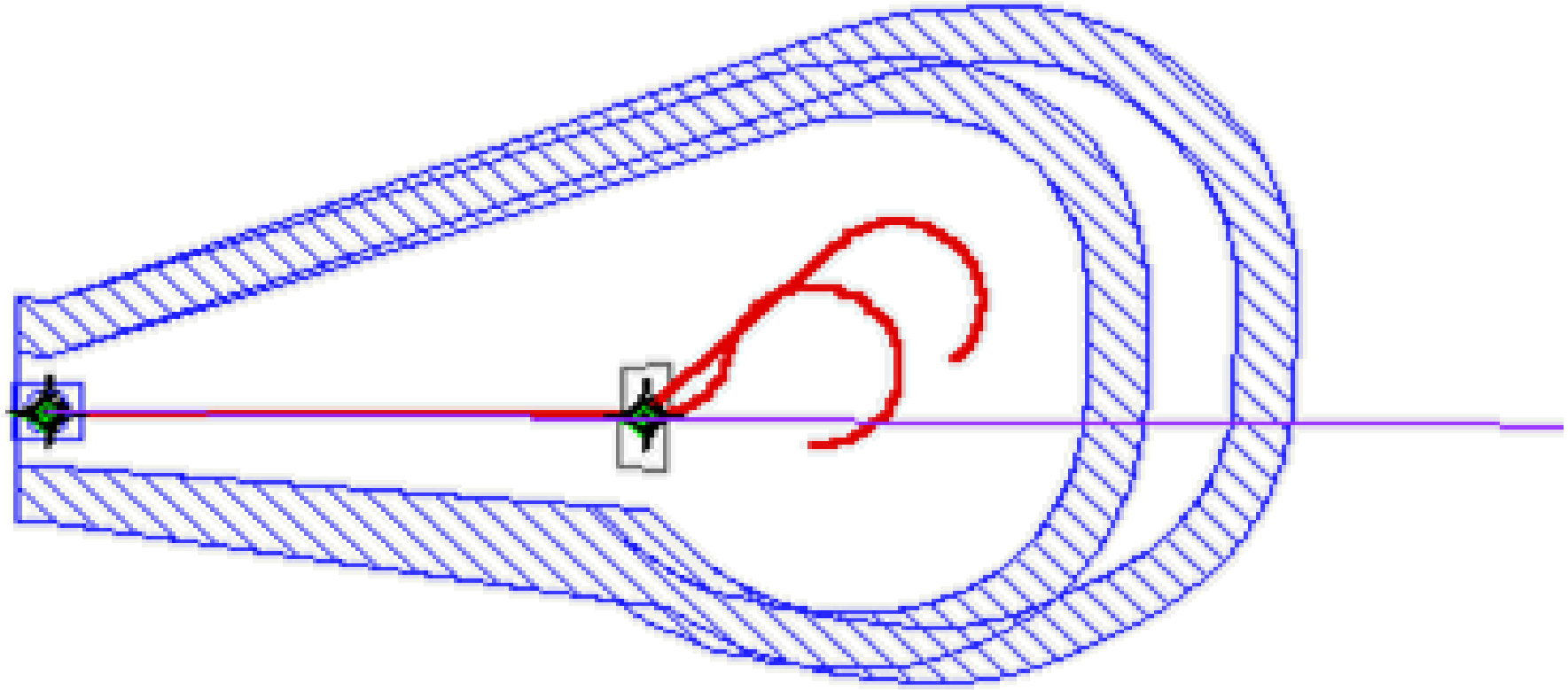
Secondary Area



Procedure turn

WARNING :

The protection area should take into account 80°/260° and 45°/180° (unless one is specifically excluded).



AREAS REDUCTION

- reduction of the maximum speed(s) specified for the procedure.
- restricting use of the procedure to specified categories of aircraft;
- restricting procedure entry to specific track(s); and
- use of DME or radial/bearing to limit outbound track

OBSTACLE CLEARANCE

- Primary area
  - 300 m (984 ft)
- Secondary area
  - 300 m (984 ft) at the inner edge, reducing linearly to zero at the outer edge.

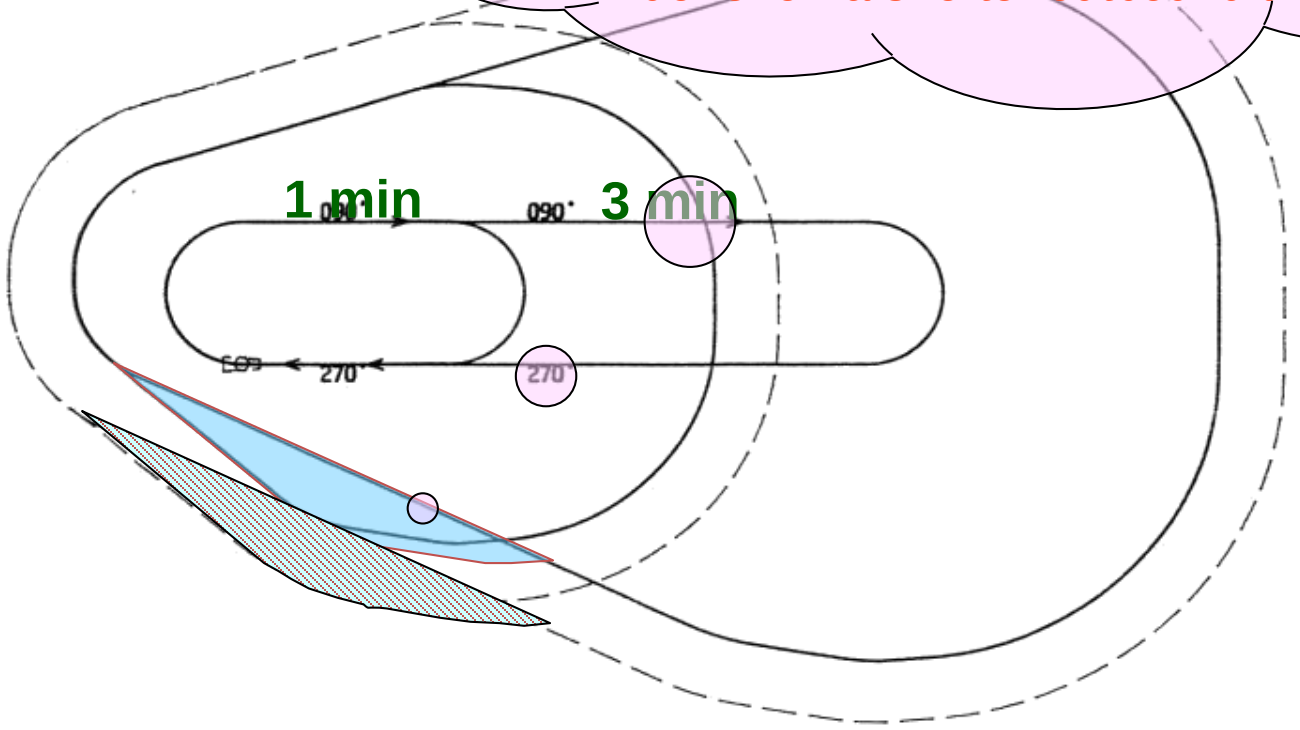
Criteria for mountainous areas ?

RACETRACK

T : 1 and 3 min

WARNING !

Protection area corresponding to
racetrack with the greatest outbound time
DOESN 'T always
include the protection area
done for a shorter outbound time



RNAV Holding

OBJECTIVES

- Identify difference between RNAV holding with holding functionality or without holding functionality and the impact on the protection area

- Identify the different ways to define the holding outbound and their impacts on the protection area

RNAV holding

- One holding waypoint
- RNAV system with holding functionality
  - RNAV application to be developed
- RNAV system without holding functionality
  - RNAV 1 and 2, RNP 1, RNP APCH, RNP AR APCH, A-RNP

Base point tolerance

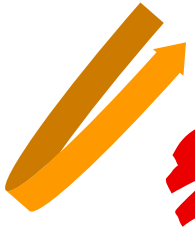
- Holding point is Flyover WP

- Tolerance of the waypoint according to
  - the RNAV navigation application
  - the sensor (s)
  - the distance to ARP

What is an RNAV holding procedure?

Flying holding procedure

Manually with WP



By the RNAV system

Flying HOLDING procedure

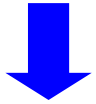
On a WP manually

Outbound timing

- Protection with
  - holding template as described in
    - Part 1 section 4 chapter 3 attachment C
  - using tolerance of holding WP according to sensor

Flying HOLDING procedure

On a WP manually



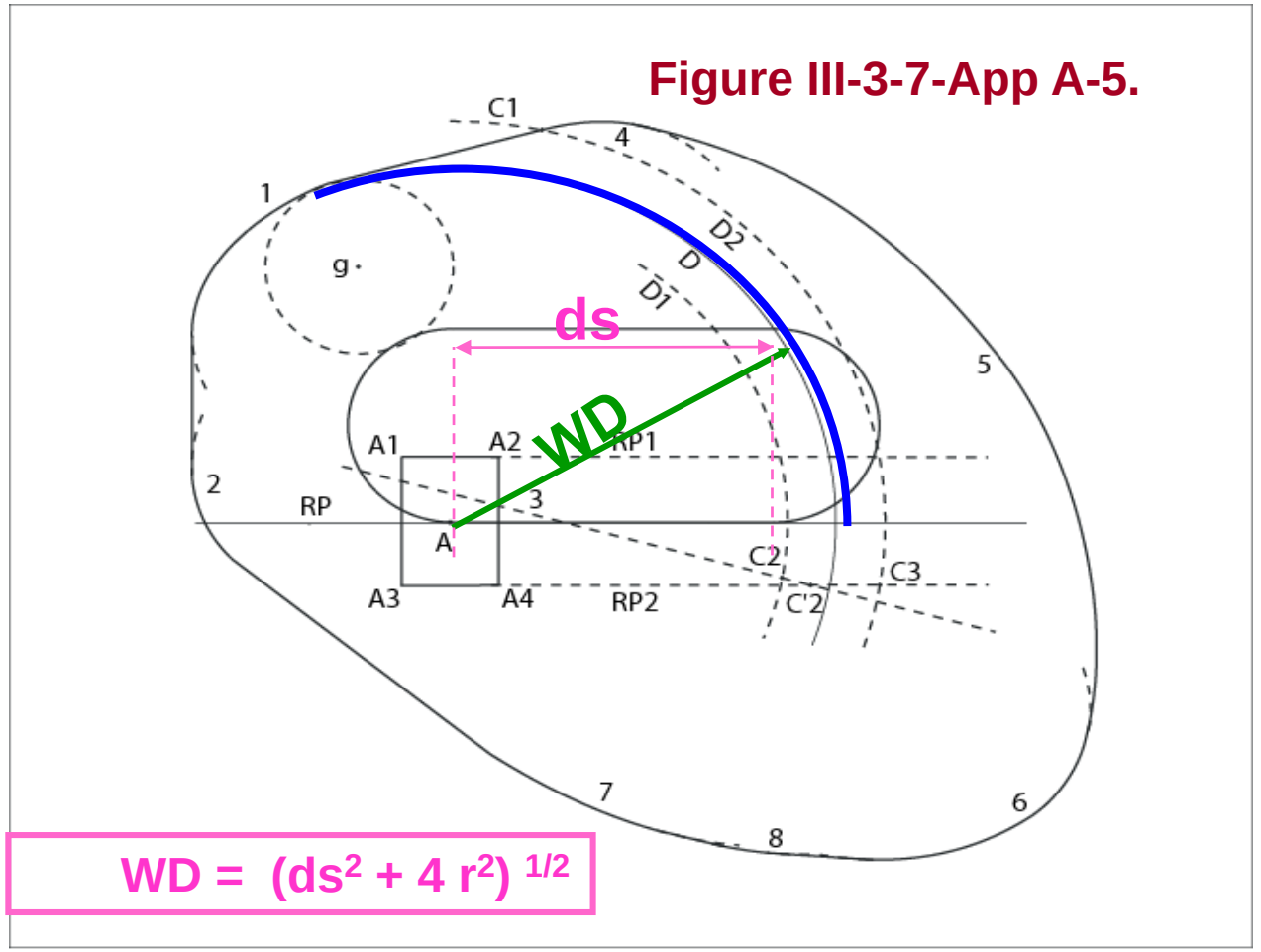
Outbound leg defined by a distance
from the holding waypoint : **WD**

- Protection with
  - holding template as described in
    - Part III, Section 3, Appendix A to Chapter 7 § 3.2.2.2

RNAV system without holding functionality
Outbound leg limited by distance from WP

- Calculation of WD limiting outbound distance :
  - WD = $(ds^2 + 4\ r^2)^{1/2}$
- Protection with
  - holding template as described in
    - Part III, Section 3, Appendix A to Chapter 7 § 3.2.2.2
  - choice of the outbound length: ds
  - ds ≥ vt where t is the outbound timing, v is max TAS
  - r radius of turn

RNAV system without holding functionality
Outbound leg limited by distance from WP



RNAV system without holding functionality
Outbound leg limited by distance from WP

- Minimum value for WD
  - avoid that the WD distance crosses the area containing the end of the outbound turn

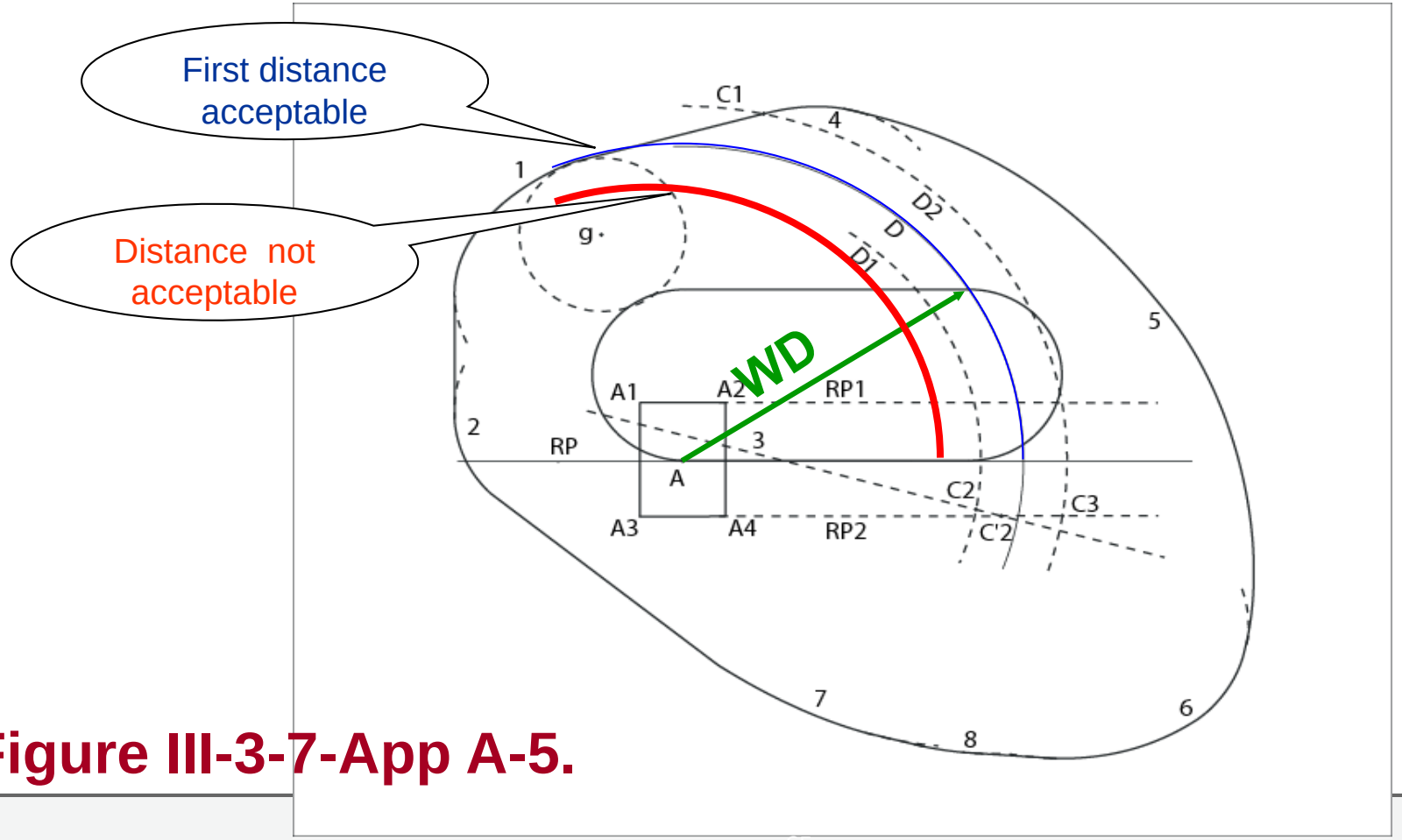


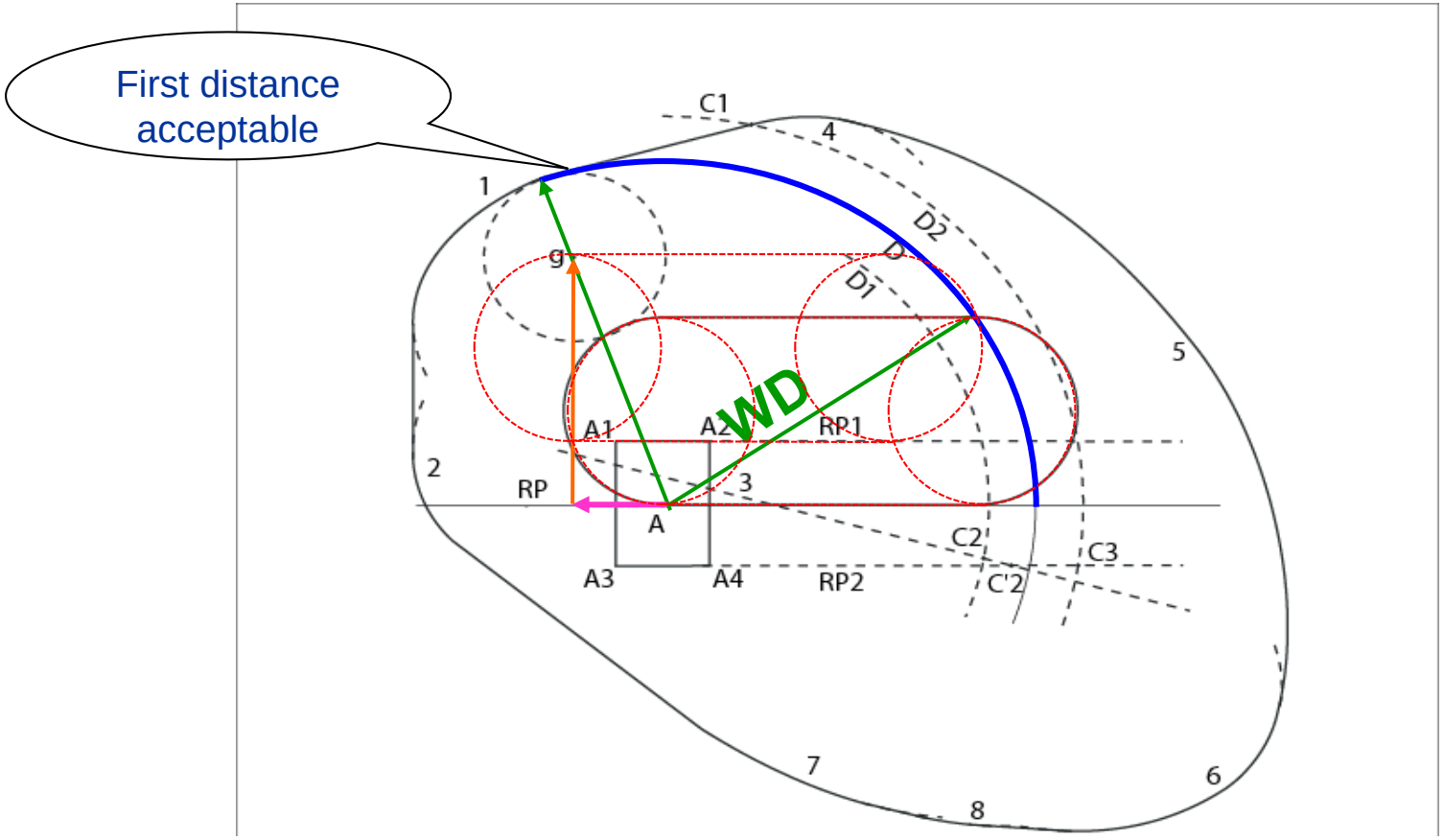
Figure III-3-7-App A-5.

RNAV system **without** holding functionality
Outbound leg limited by **distance from WP**

- Min WD = $[(ATT+11v)^2 +(2r+XTT)^2]^{1/2}$ + Wg
  - Wg is wind effect after 180° of outbound turn
  - r is radius of turn in still air at max TAS

- WD rounded up to the next tenth of km (or NM).

RNAV system without holding functionality
Outbound leg limited by distance from WP



$(MinWD - Wg)^2 = (XTT + 2r)^2 + (ATT + 11 \text{ sec of flight})^2$

$$\text{Min WD} = ((XTT+2r)^2 + (ATT + 11 \text{ sec of flight})^2)^{\frac{1}{2}} + Wg$$

Maneuvers for holding

CODING : Hx

Regulatory reference :

part III section 3 Chapter 7

ASSUMPTIONS

HOLDING FOR SYSTEM WITH HOLDING FUNCTIONALITY

- Compensate for wind effect
- Outbound leg = 2R
- Drift correction
- No heading tolerance

Holding template

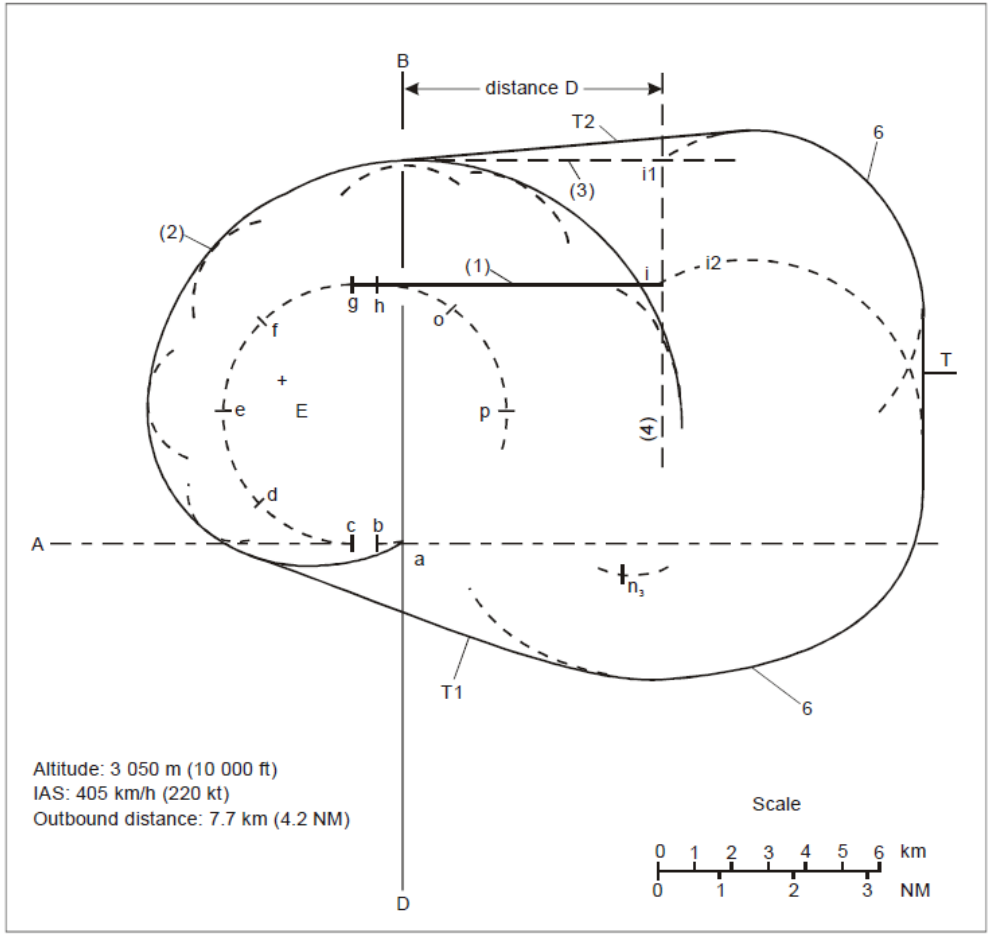


Figure III-3-7-App A-1. RNAV template for RNAV system with holding functionality

Holding area

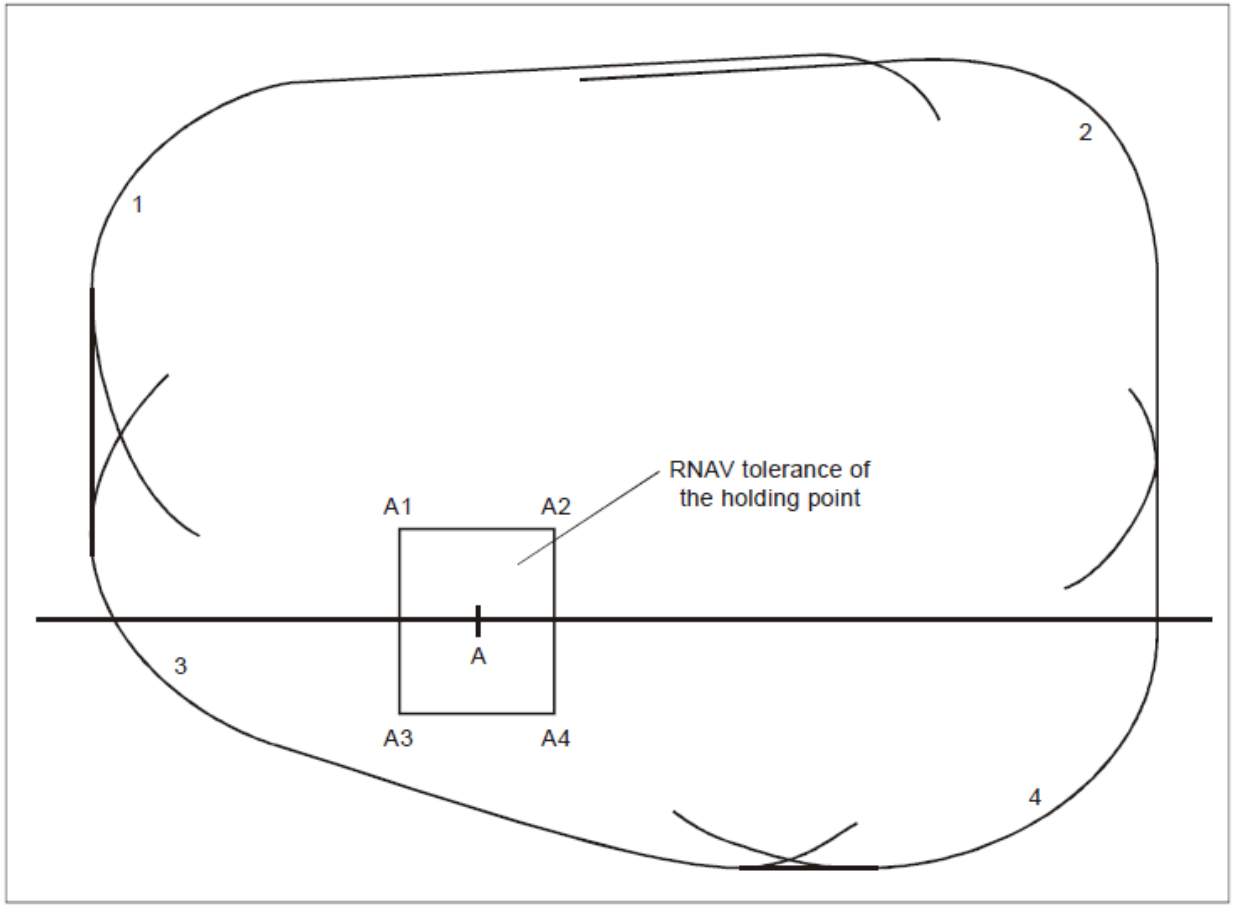


Figure III-3-7-App A-3. RNAV basic area for RNAV system with holding functionality

Sum up

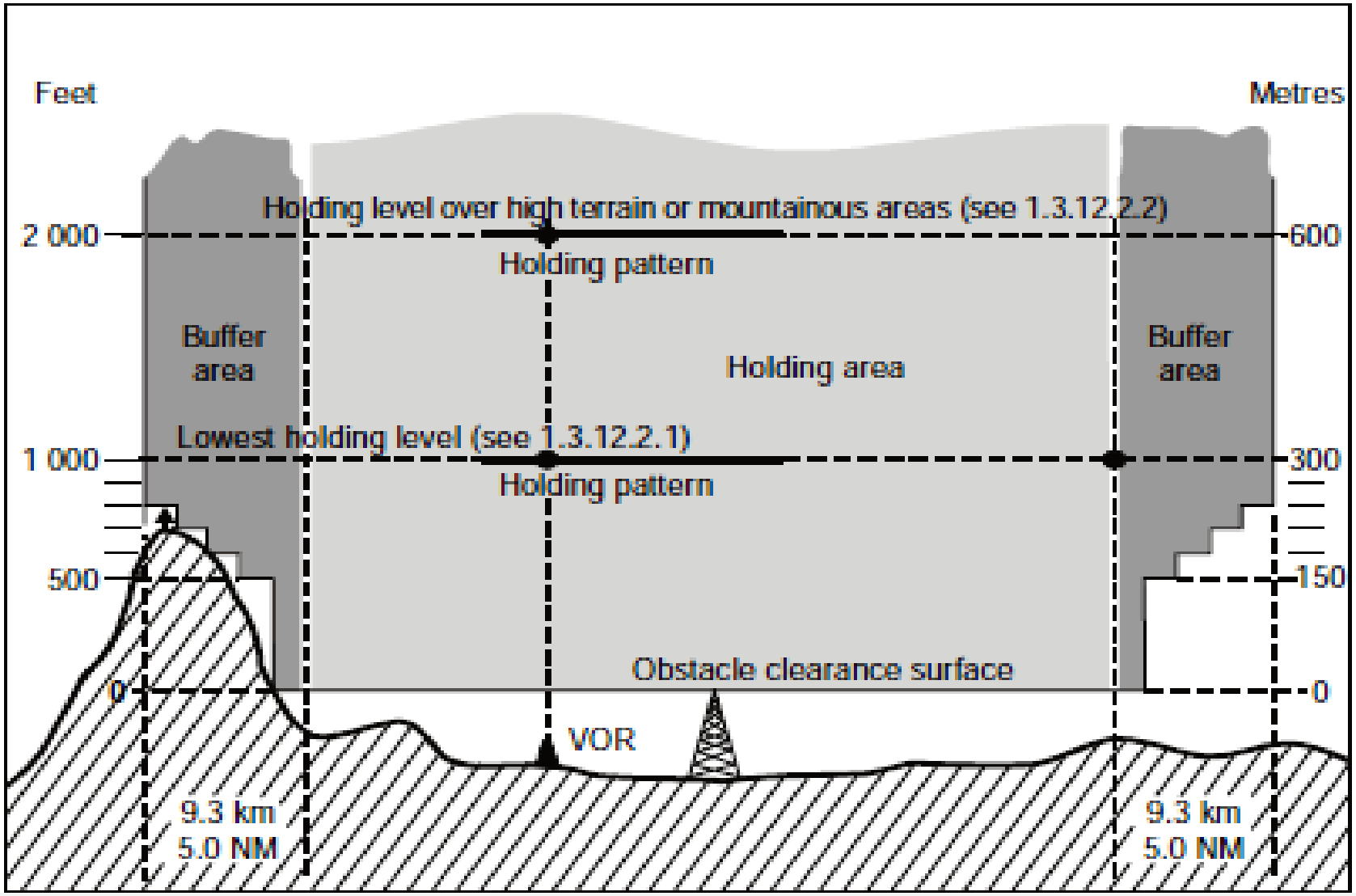
	VOR	RNAV holding without holding functionality	RNAV holding with holding functionality
Fix tolerance	OVER Head	WP tolerance	WP tolerance
HOLDING TEMPLATE	Template(C)	Template(C)	Template (RNAV)
Outbound leg	Time/DME arc	Time/ Outbound leg	Outbound leg

ENTRY AND MOC

- MOC as in conventional procedure
  - Base + entry : 300 m
  - Buffer 1 to 5 : 300 , 150 ,120, 90 , 60 (m)

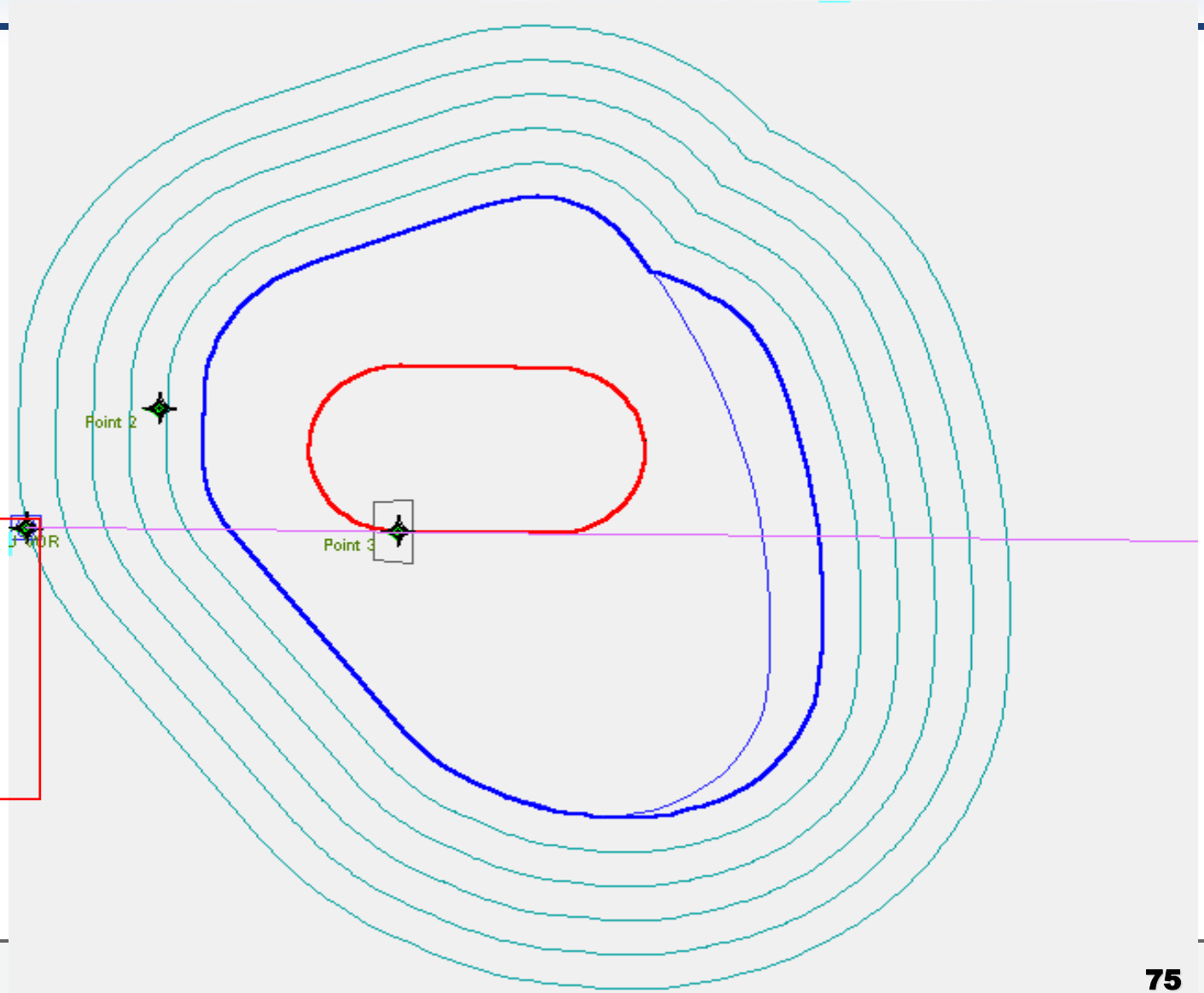
- Entry as in conventional procedure

MINIMUM HOLDING LEVEL

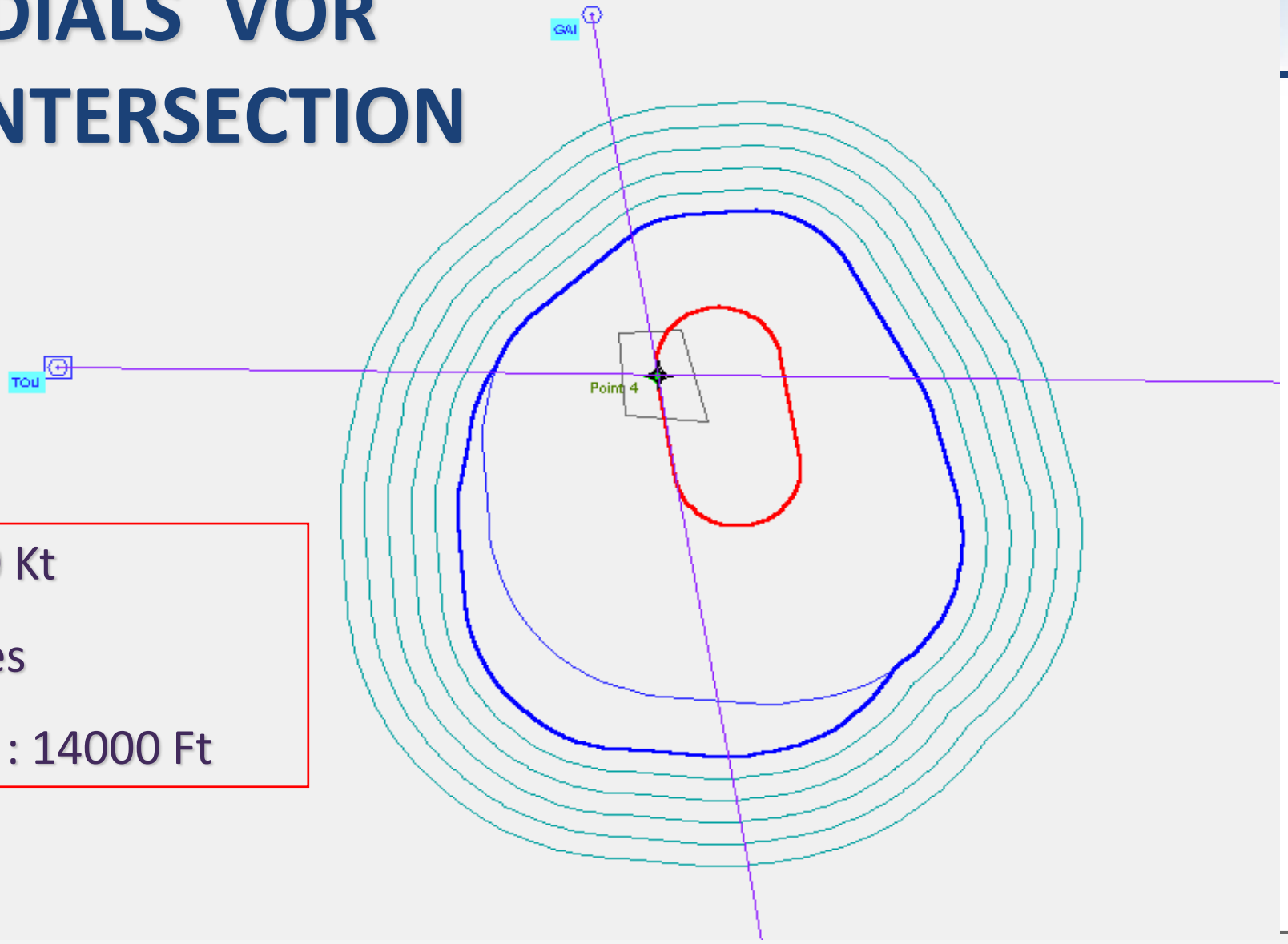


VORDME WITH 2 DISTANCES

- IAS : 220 Kt
- 5 entries
- Max Alt. : 14000 Ft



2 RADIALS VOR INTERSECTION



- IAS : 220 Kt
- 4 entries
- Max Alt. : 14000 Ft

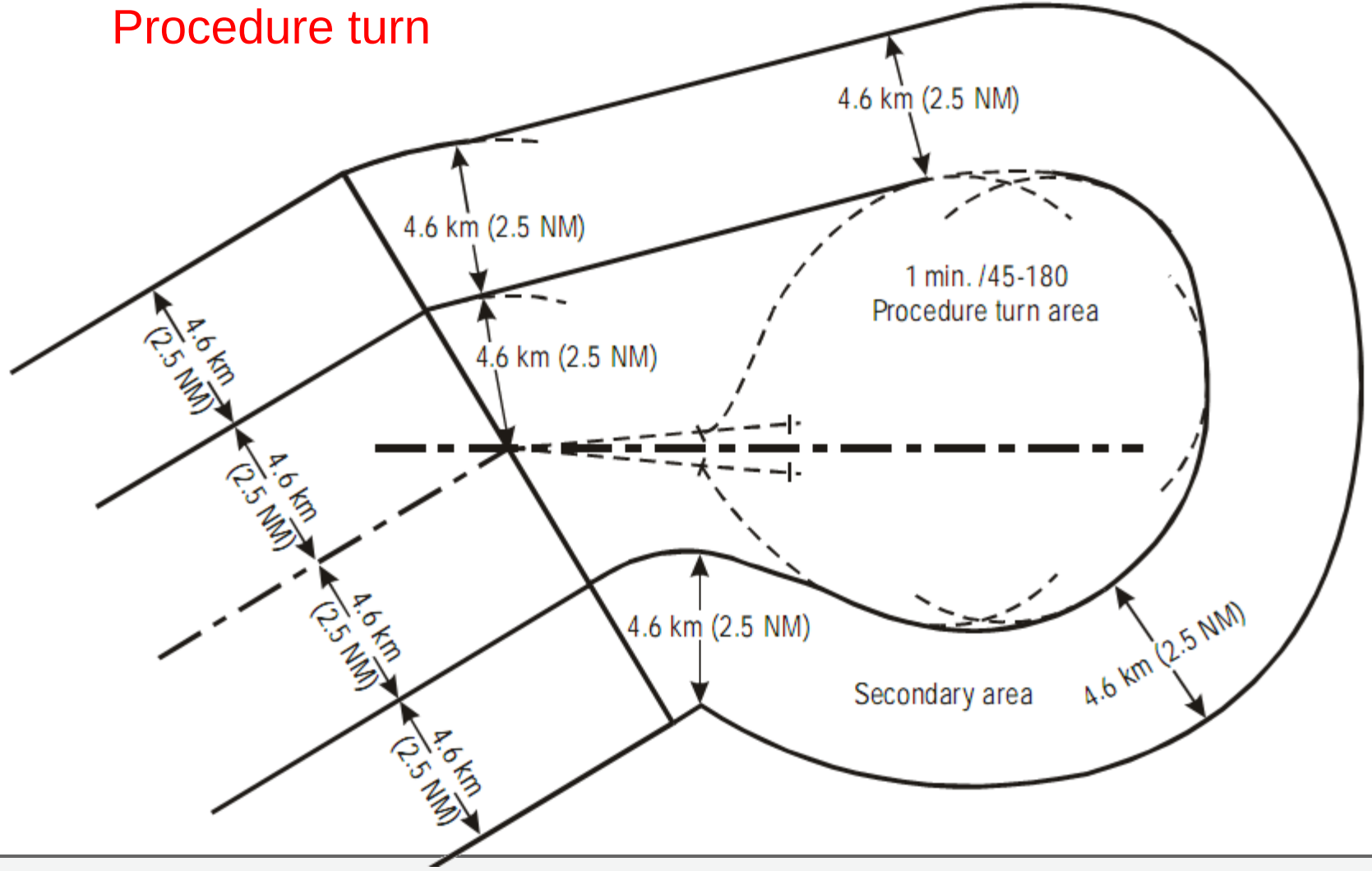
Interface

INTERFACE

- The primary area of the initial segment, the boundaries of which are 2.5 NM apart from the nominal path, shall be blended with the primary area of the turn procedure.

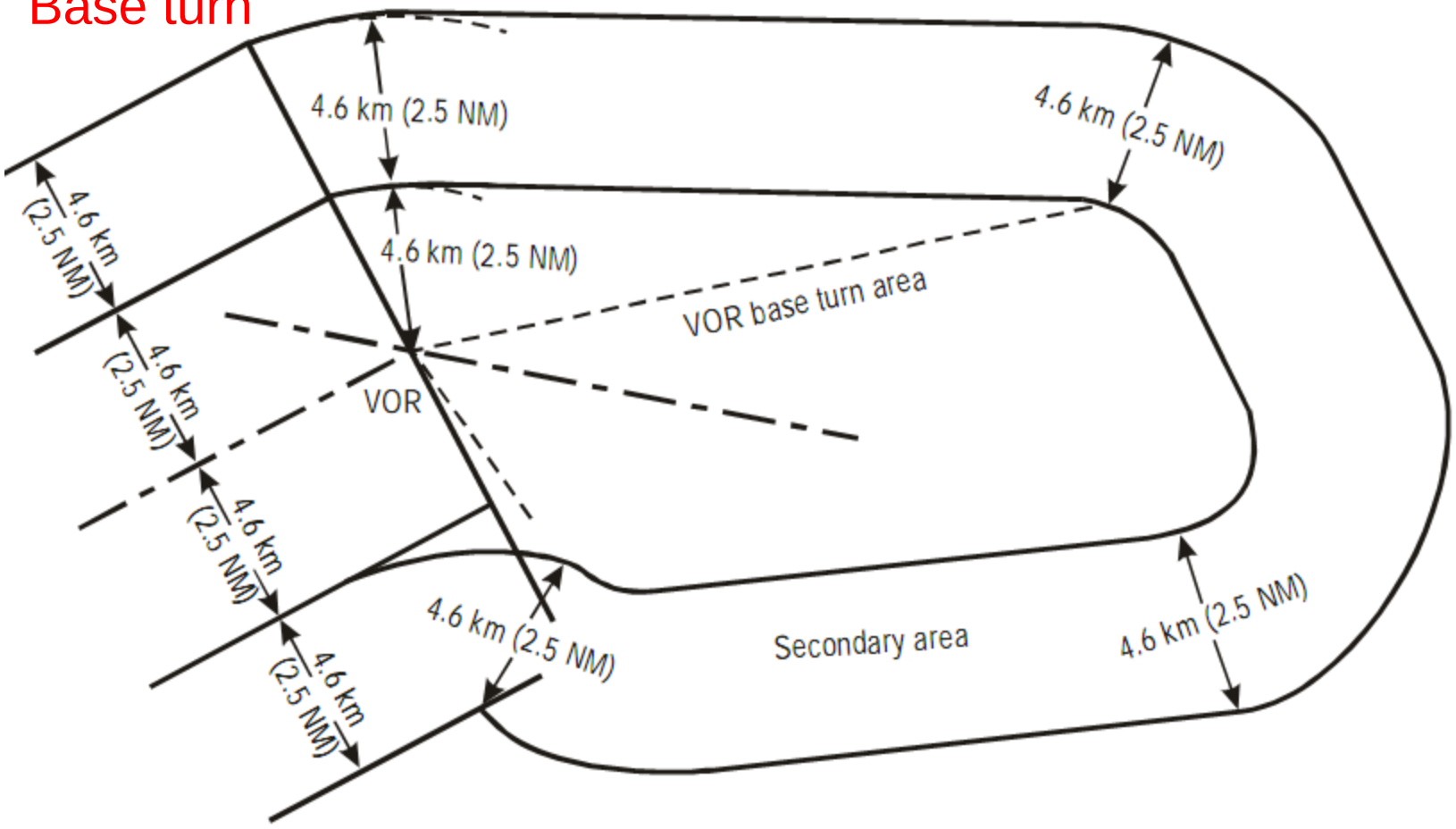
- The secondary areas of the two phases of the procedure shall be blended so that a constant width of 2.5 NM is respected.

Procedure turn



INTERFACE

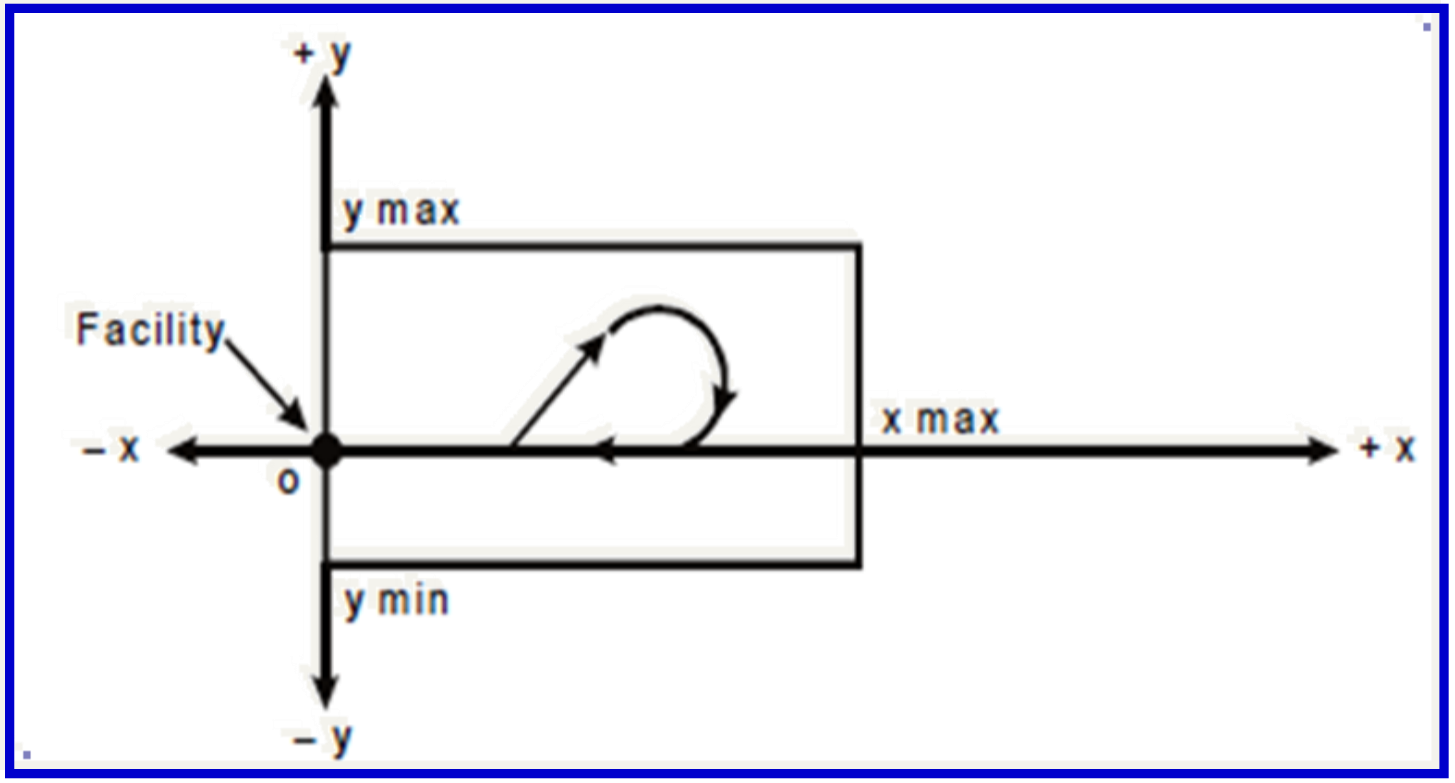
Base turn



SIMPLIFIED AREA BASICS

- Reversal and racetrack procedure areas may be defined by simple rectangles.
- The rectangle will, in all cases, include or be slightly larger than the area constructed using the more detailed TTT method.
- The dimensions of the rectangles are related to a conventional x, y coordinate system, with its origin at the facility.

SIMPLIFIED AREA BASICS



Let's Focus/Propose/Plan Together