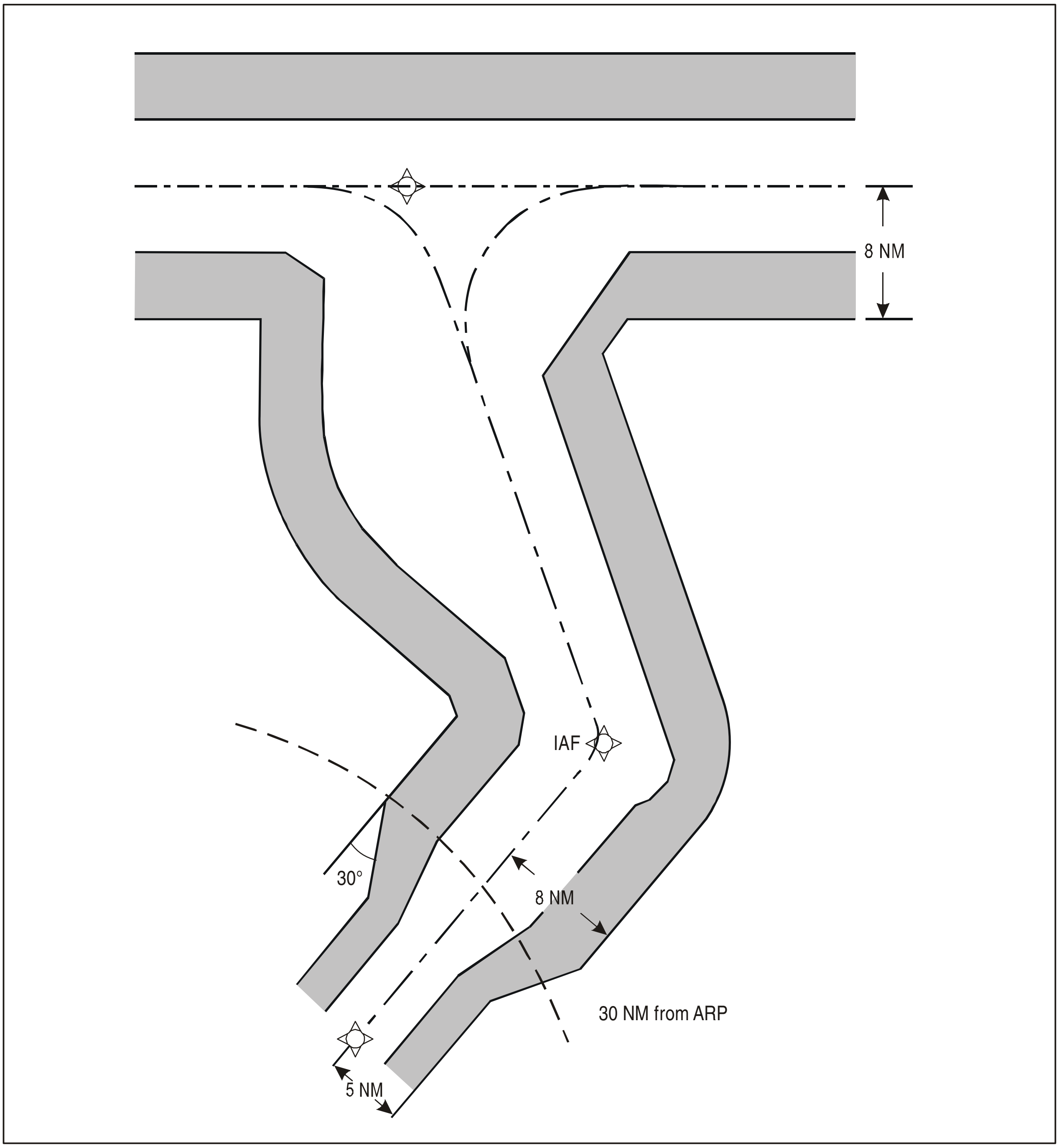


**Figure I-4-2-5. GNSS arrival criteria, IAF beyond 30 NM ARP: 8 NM ½ AW prior to 30 NM from ARP then 5 NM ½ AW**

*Note.— This example is based on 5 seconds roll anticipation 16 000 ft, 300 kt, 15° AOB, ISA + 10°C at en-route waypoint 6 000 ft, 250 kt, 25° AOB, ISA + 10°C at IAF.*

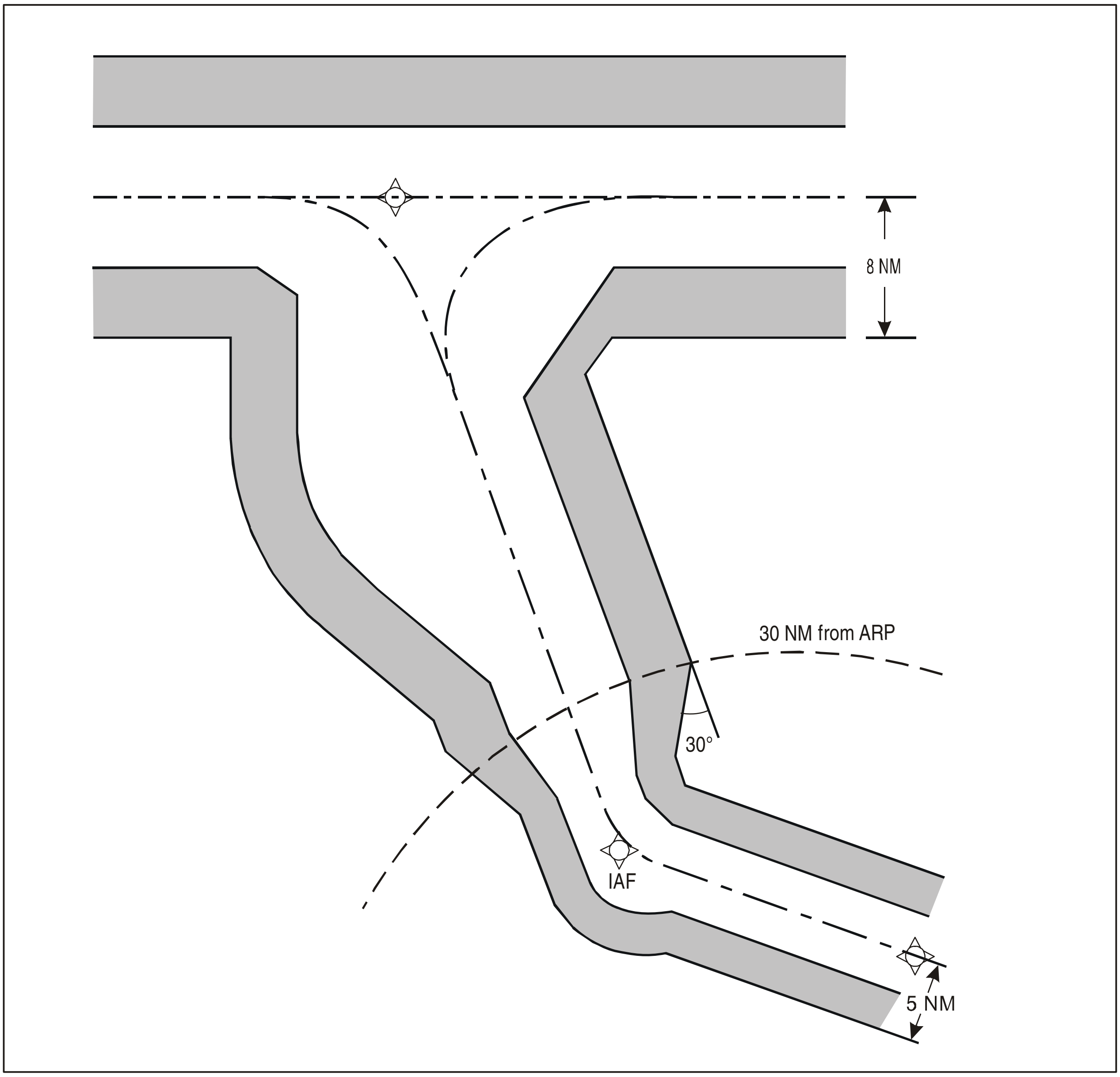


**Figure I-4-2-6. GNSS arrival criteria, IAF within 30 NM ARP: 8 NM ½ AW prior to 30 NM (46 km) from ARP then 5 NM ½ AW**

*Note.— This example is based on 5 seconds roll anticipation 16 000 ft, 300 kt, 15° AOB, ISA + 10°C at en-route waypoint 15 000 ft, 250 kt, 25° AOB, ISA + 10°C at IAF.*

# Chapter 3

# INITIAL APPROACH SEGMENT

## 3.1 GENERAL

3.1.1 The initial approach segment starts at the initial approach fix (IAF). In the initial approach the aircraft is manoeuvring to enter the intermediate segment. When the intermediate fix (IF) is part of the en-route structure, it may not be necessary to designate an initial approach segment. In this case the instrument approach procedure begins at the intermediate fix and intermediate segment criteria apply. An initial approach may be made along a VOR radial, NDB bearing, specified radar vector or a combination thereof. Where none of these is possible, a DME arc or a specified heading may be used.

3.1.2 Reversal and racetrack procedures as well as holding pattern descents are considered initial segments until the aircraft is established on the intermediate approach track. Where holding is required prior to entering the initial approach segment, the holding fix and initial approach fix should coincide. When this is not possible, the initial approach fix shall be located within the holding pattern on the inbound holding track.

3.1.3 Normally track guidance is required except that dead reckoning tracks may be used for distances not exceeding 19 km (10 NM). Although more than one initial approach may be established for a procedure, the number should be limited to that which is justified by traffic flow or other operational requirements.

## 3.2 ALTITUDE SELECTION

### 3.2.1 Minimum altitudes

Minimum altitudes in the initial approach segment shall be established in 100-ft or 50-m increments as appropriate. The altitude selected shall not be below the reversal or racetrack procedure altitude where such a procedure is required. In addition, altitudes specified in the initial approach segment must not be lower than any altitude specified for any portion of the intermediate or final approach segments.

### 3.2.2 Minimum altitudes for different aircraft categories

When different minimum altitudes are specified for different categories of aircraft, separate procedures shall be published.

### 3.2.3 Procedure altitude/height

All initial approach segments shall have procedure altitudes/heights established and published. Procedure altitudes/heights shall not be less than the OCA/H and shall be developed in coordination with air traffic control requirements. The initial segment procedure altitude/height should be established to allow the aircraft to intercept the final approach segment descent gradient/angle from within the intermediate segment.

## 3.3 INITIAL APPROACH SEGMENTS (OTHER THAN RADAR VECTORS) UTILIZING STRAIGHT TRACKS AND DME ARCS

### 3.3.1 Tracks

The angle of intersection between the initial approach track and the intermediate track should not exceed 120°. When the angle exceeds 70°, a radial, bearing, radar vector or DME information providing at least 4 km (2 NM) of lead (Cat H, 1.9 km (1 NM)) shall be identified to assist in leading the turn onto the intermediate track (see Figure I-4-3-1). When the angle exceeds 120°, the use of a racetrack or reversal procedure or dead reckoning (DR) track should be considered. Criteria for such procedures are in 3.4, "Initial approach segment using a racetrack procedure", 3.5, "Initial approach segment using a reversal procedure" and 3.3.3.3, "Area associated with dead reckoning (DR) track procedures".

### 3.3.2 DME arcs

An arc may provide track guidance for all or for a portion of an initial approach. The minimum arc radius shall be 13 km (7 NM) (Cat H, 9.3 km (5 NM)). An arc may join a track at or before the intermediate fix. When joining a track, the angle of intersection of the arc and the track should not exceed 120°. When the angle exceeds 70°, a radial which provides at least 4 km (2 NM) (Cat H, 1.9 km (1 NM)) of lead shall be identified to assist in leading the turn onto the intermediate track.

### 3.3.3 Area

3.3.3.1 The initial approach segment has no standard length. The length shall be sufficient to permit the altitude change required by the procedure. The width is divided into:

a) a primary area which extends laterally 4.6 km (2.5 NM) on each side of the track; and

b) a secondary area which adds an additional 4.6 km (2.5 NM) on each side of the primary area.
(See Figure I-4-3-2.)

3.3.3.2 *Area splay*

Where, because of an operational requirement, any portion of the initial approach is more than 69 km (37 NM) from the VOR or 52 km (28 NM) from the NDB providing track guidance, the area will start splaying at these distances at an angle of 7.8° for VOR or 10.3° for NDB. Within this splayed area, the width of the primary area shall remain one half of the total width of the area. (See Figure I-4-3-3.) For calculating secondary area width at a given point, see Section 2, Chapter 1, 1.2.1, "Calculating secondary area width at a given point".

*Note.— See also Appendix B, "Reduction of the width of a straight initial approach area after the IAF and interface between straight initial approach area and reversal procedure areas" for possible reduction of the width of straight initial approach area.*

3.3.3.3 *Area associated with dead reckoning (DR) track procedures*

Where DR track procedures are utilized, the area allocated for the turning portions of the dead reckoning segment shall be calculated to accommodate omnidirectional wind speed (w) derived by the following equation:

w = (12h + 87) km/h, where h is altitude in thousands of metres; or

w = (2h + 47) kt, where h is altitude in thousands of feet.

The area associated with the straight portion shall be expanded to account for the maximum drift from an unrecognized beam wind component of ± 56 km/h (± 30 kt) in addition to ± 5° heading tolerance, since the pilot is expected to have appraised the wind speed within ± 30 kt (56 km/h) on the previous segments. The minimum length of the intermediate track being intercepted shall provide sufficient additional distance to accommodate these tolerances and the associated fix tolerances. See Appendix A, "Initial approach using dead reckoning (DR)".

#### 3.3.4 Obstacle clearance

The obstacle clearance in the initial approach primary area shall be a minimum of 300 m (984 ft). In the secondary area, 300 m (984 ft) of obstacle clearance shall be provided at the inner edge, reducing linearly to zero at the outer edge. See Figure I-2-1-1 in Chapter 1. For calculating obstacle clearance at a given point, see Chapter 1, 1.6, "Obstacle clearance".

#### 3.3.5 Descent gradient

The optimum descent gradient in the initial approach is 4.0 per cent (Cat H, 6.5 per cent). Where a higher descent gradient is necessary to avoid obstacles, the maximum permissible is 8.0 per cent (Cat H, 10 per cent).

### 3.4 INITIAL APPROACH SEGMENT USING A RACETRACK PROCEDURE

#### 3.4.1 General

Racetrack procedures are used where sufficient distance is not available in a straight segment to accommodate the required loss of altitude and when entry into a reversal procedure is not practical. Racetrack procedures may also be specified as an alternative to reversal procedures to increase operational flexibility.

#### 3.4.2 Shape of a racetrack procedure

The racetrack procedure has the same shape as a holding pattern but with different operating speeds and outbound timing. The inbound track normally becomes the intermediate or final segment of the approach procedure.

#### 3.4.3 Starting point

The racetrack procedure starts at a designated facility or fix.

#### 3.4.4 Entry

3.4.4.1 Entry into a racetrack procedure shall be similar to entry procedures for holding patterns as specified in Part II, Section 4, Chapter 1, 2.1, with the following additional considerations:

a) offset entry from Sector 2 shall limit the time on the 30° offset track to 1 min 30 s. After this time the pilot should turn to a heading parallel to the outbound track for the remainder of the outbound time. If the outbound time is only 1 min, the time on the 30° offset track shall be 1 min also; and

b) parallel entry shall *not* return directly to the facility without first intercepting the inbound track (when proceeding onto the final approach segment).

3.4.4.2 *Restricted entry*

Where necessary to conserve airspace (or for other reasons), entry may be restricted to specific routes. When so restricted, the entry route(s) shall be specified in the procedure. Examples of restricted entries are shown in Appendix C.

### 3.4.5 Outbound time

3.4.5.1 The duration of the outbound flight of a racetrack procedure may be 1 to 3 minutes (specified in 1/2 min increments) to allow increased descent. This time may vary according to aircraft categories (see Tables I-4-1-1 and I-4-1-2 of Section 4, Chapter 1 in order to reduce the overall length of the protected area in cases where airspace is critical (see 3.4.5.2, "Timings for different categories of aircraft"). If airspace is critical and extension beyond 1 minute is not possible, the descent may involve more than one orbit in the racetrack according to descent/time relationship specified in 3.7 (Table I-4-3-1).

3.4.5.2 *Timings for different categories of aircraft*

Where different timings are specified for different categories of aircraft, separate procedures shall be published.

### 3.4.6 Limitation of length of outbound track

The length of the outbound track of a racetrack procedure may be limited by specifying a DME distance or a radial/bearing from a suitably located facility (see 3.6.6, "Use of DME or intersecting radial/bearing").

## 3.5 INITIAL APPROACH SEGMENT USING A REVERSAL PROCEDURE

### 3.5.1 General

Reversal procedures are used to establish the aircraft inbound on an intermediate or final approach track at the desired altitude. There are two types of reversal procedure: procedure turns and base turns. Both of these consist of an outbound track followed by a turning manoeuvre which reverses direction onto the inbound track. Reversal procedures are used when:

a) the initial approach is initiated from a facility (or fix in the case of a procedure turn) that is located on or near the aerodrome; or

b) a turn of more than 70° would be required at the IF, and a radial, bearing, radar vector, DR track, or DME information is not available to assist in leading the turn on to the intermediate track; or

c) a turn of more than 120° (90° for ILS, see Part II, Section 1, Chapter 1, 1.2.2, "Initial approach segment alignment" would be required at the IF.

Specifics of each reversal procedure are described below.

### 3.5.2 Starting point

The starting point for a base turn shall be a facility. The starting point for a procedure turn shall be a facility or a fix. The reversal procedure may be preceded by manoeuvring in a suitably located holding pattern.

### 3.5.3 Entry

Entry into a reversal procedure should be from a track within ± 30° of the outbound track (see Figures I-4-3-4 and I-4-3-5). Where entry is desired from tracks outside these limits, suitably protected airspace must be provided to allow the pilot to manoeuvre onto the outbound track. This manoeuvring will be in accordance with the entry procedures associated with a suitably located holding pattern, which must be shown on the approach chart (see Figure I-4-3-6).

### 3.5.4 Types of reversal procedures

The types of procedures permitted are illustrated in Figure I-4-3-7 and are described as follows.

3.5.4.1 *45°/180° procedure turns* start at a facility or fix and consist of:

a) a straight leg with track guidance; this straight leg may be timed or may be limited by a radial or DME distance (see 3.5.5, "Outbound time" and 3.5.6, "Limitation of length of outbound tracks");

b) a 45° turn;

c) a straight leg without track guidance. This straight leg is timed; it shall be:

   1) 1 minute from the start of the turn for Categories A, B and H aircraft; and

   2) 1 minute and 15 seconds from the start of the turn for Categories C, D and E aircraft; and

d) a 180° turn in the opposite direction to intercept the inbound track.

3.5.4.2 *80°/260° procedure turns* start at a facility or fix and consist of:

a) a straight leg with track guidance; this straight leg may be timed or may be limited by a radial or DME distance (see 3.5.5, "Outbound time" and 3.5.6, "Limitation of length of outbound tracks");

b) an 80° turn; and

c) a 260° turn in the opposite direction to intercept the inbound track.

CAUTION: The 45°/180° and the 80°/260° procedure turns are alternatives to each other and the protection area should be constructed to accommodate both procedures unless one is specifically excluded (see 3.6.4).

3.5.4.3 *Base turns* consist of a specified outbound track which may be timed or may be limited by a radial or DME distance (see 3.5.5, “Outbound time” and 3.5.6, “Limitation of length of outbound tracks”) , followed by a turn to intercept the inbound track. The divergence between the outbound and inbound track (φ) shall be calculated as follows:

a) for true airspeed (TAS) less than or equal to 315 km/h (170 kt): $\varphi = 36/t$; and

b) for TAS exceeding 315 km/h (170 kt):

   $\varphi = (0.116 \times TAS)/t$ where TAS is in km/h

   $\varphi = (0.215 \times TAS)/t$ where TAS is in kt

where t is the time in minutes specified for the outbound leg, and TAS corresponds to the maximum indicated airspeed (IAS) specified for the procedure.

3.5.4.4 *Outbound tracks or timing for different aircraft categories*. Where different outbound tracks or timing are specified for different categories of aircraft, separate procedures shall be published.

### 3.5.5 Outbound time

Where appropriate, outbound time of reversal procedures shall be specified. Normally it should be specified as a time between 1 and 3 minutes using 1/2 minute increments. It may be varied in accordance with aircraft categories (see Tables I-4-1-1 and I-4-1-2 of Section 4, Chapter 1) in order to reduce the overall length of the protected area in cases where airspace is critical. Extension of the outbound timing beyond 3 minutes must only be considered in exceptional circumstances.

### 3.5.6 Limitation of length of outbound tracks

The length of the outbound track of a reversal procedure may be limited by specifying a DME distance or a radial/bearing from a suitably located facility (see 3.6.6, “Use of DME or intersecting radial/bearing”).

## 3.6 RACETRACK AND REVERSAL PROCEDURE AREAS

### 3.6.1 General

The areas required to accommodate both the racetrack and reversal procedures described in 3.4 and 3.5 shall be based on the application of the area parameters specified in 3.6.2 below. These may be applied either on an additive tolerance basis or using statistical methods.

### 3.6.2 Area parameters

The parameters on which both racetrack and reversal procedures are based are:

a) *altitude (h):* the specified altitude for which the area is designed;

b) *temperature:* International standard atmosphere (ISA) for the specified altitude plus 15°C;

c) *indicated airspeed (IAS):* the highest procedural speed category for which the area is designed (see Tables I-4-1-1 and I-4-1-2 of Section 4, Chapter 1);

d) *true airspeed (TAS):* the IAS in c) above adjusted for altitude a) and temperature b);

e) *wind speed (w):* omnidirectional for the specified altitude h;

w = (12 h + 87) km/h where h is in thousands of metres

w = (2 h + 47) kt where h is in thousands of feet *or*

provided adequate statistical data are available, the maximum 95 per cent probability omnidirectional wind may be used (see Part II, Section 4, Chapter 1, 1.3.6, "Wind velocity");

f) *average achieved bank angle:* 25° or the bank angle giving a turn rate of 3° per second, whichever is the lesser;

*Note.— If the TAS is greater than 315 km/h (170 kt), the bank angle will always be 25°.*

g) *fix tolerance area:* as appropriate to the type of facility or fix and type of entry; and

h) *flight technical tolerance* which is comprised of the following variables (see Figure I-4-3-8):

1) outbound timing tolerance of ±10 s;

2) pilot reaction time of 0 to + 6 s;

3) establishment of bank angle, + 5 s; and

4) heading tolerance ± 5°.

### 3.6.3 Operational assumptions

The operational assumptions associated with procedure design criteria for racetrack and reversal procedures are:

a) *start of outbound timing — racetrack procedures:*

1) for racetrack procedures using a facility — outbound timing starts from abeam the facility or on attaining the appropriate outbound heading, whichever comes later; and

2) for racetrack procedures using a fix — appropriate outbound timing starts from obtaining the outbound heading;

b) *outbound track adjustment — racetrack procedures.* The outbound track for racetrack procedures will always be adjusted to avoid crossing the nominal inbound track before the final turn; and

c) *pilot correction for wind effects:*

1) for racetrack procedures, the area should be calculated and drawn for the fastest aircraft category to be accommodated. Although the area based on the slow speed (i.e. 165 km/h (90 kt)) aircraft in strong winds may in some places 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; and

2) for base and procedure turns, however, the area for 165 km/h (90 kt) should be checked. An additional template for these procedures is incorporated in the *Template Manual for Holding, Reversal and Racetrack Procedures* (Doc 9371).

### 3.6.4 Area construction

3.6.4.1 *Statistical area construction*

If statistical methods are used to combine the variables and then to extrapolate distributions to develop areas, the probability level associated with that extrapolation should meet an acceptable level of safety.

3.6.4.2 *Additive tolerance area construction*

A variety of methods may be used to construct areas. Whichever method is selected, the procedure design criteria specified in 3.5, "Initial approach segment using a reversal procedure", and the area parameters specified in 3.6.2, "Area parameters", apply. One additive tolerance method, the template tracing technique (TTT), is described in Appendix C.

*Note.— For applications where airspace is not critical, a method of constructing a simplified rectangular area (based on the TTT areas) is also contained in Appendix C.*

### 3.6.5 Area reduction

The area may be reduced under special circumstances. Methods of reduction include:

a) reduction of the maximum speed(s) specified for the procedure. Speeds below the minimum value for initial approach in a given aircraft category shall not be specified (see Tables I-4-1-1 and I-4-1-2 of Section 4, Chapter 1). If procedures are developed which exclude specific aircraft categories due to speed, this must be stated explicitly;

b) restricting use of the procedure to specified categories of aircraft;

c) restricting procedure entry to specific track(s); and

d) use of DME or radial/bearing to limit outbound track (see 3.6.6, "Use of DME or intersecting radial/bearing").

### 3.6.6 Use of DME or intersecting radial/bearing

If a DME distance or an intersecting radial or bearing is used to limit the outbound leg, the area may be reduced by applying the appropriate adjustments described in Appendix C, in this case the limiting distance or radial/bearing shall allow adequate time for the descent specified. The distance on the outbound track is thereby limited by the timing or by reaching the limiting DME distance or radial/bearing, whichever occurs first.

### 3.6.7 Secondary areas

Secondary areas shall be added to the outer boundary of all areas calculated using the criteria in 3.6.4, "Area construction". The width of the secondary area is 4.6 km (2.5 NM).

*Note.— See Appendix B, "Reduction of the width of a straight initial approach area after the IAF and interface between straight initial approach area and reversal procedure areas" for possible reduction of secondary area width.*

## 3.7 MAXIMUM DESCENT/NOMINAL OUTBOUND TIMING RELATIONSHIP FOR A REVERSAL OR RACETRACK PROCEDURE

### 3.7.1 General

Because the actual length of the track will vary, it is not possible to specify a descent gradient for the racetrack or reversal procedures. Instead, the maximum descents which can be specified on the outbound and inbound tracks of the procedure are listed in Table I-4-3-1 as a function of nominal outbound time.

*Note.— Where a 45° procedure turn is specified, an additional 1 minute may be added to the nominal outbound time in calculating the maximum descent outbound.*

Example: Reversal procedure with 2.5 minutes outbound track (Category A and B aircraft):

a) maximum descent to be specified on outbound track = 612 m (2 010 ft); and

b) maximum descent to be specified on inbound track = 500 m (1 638 ft).

### 3.7.2 Turns

In calculating maximum descents, no descent shall be considered as having taken place during turns.

## 3.8 OBSTACLE CLEARANCE

The prescribed minimum altitudes for either the racetrack or the reversal procedure shall not be less than 300 m (984 ft) above all obstacles within the appropriate primary areas. In the secondary area the minimum obstacle clearance shall be 300 m (984 ft) at the inner edge, reducing linearly to zero at the outer edge. See Chapter 1, 1.6, "Obstacle clearance".

**Table I-4-3-1. 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.

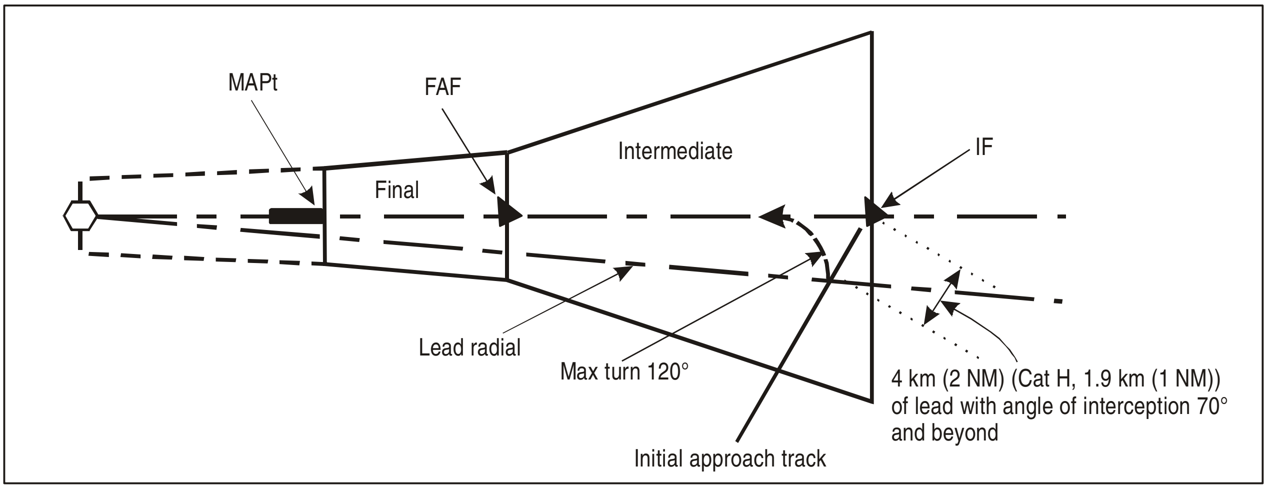


**Figure I-4-3-1. Lead radial for turns greater than 70°**

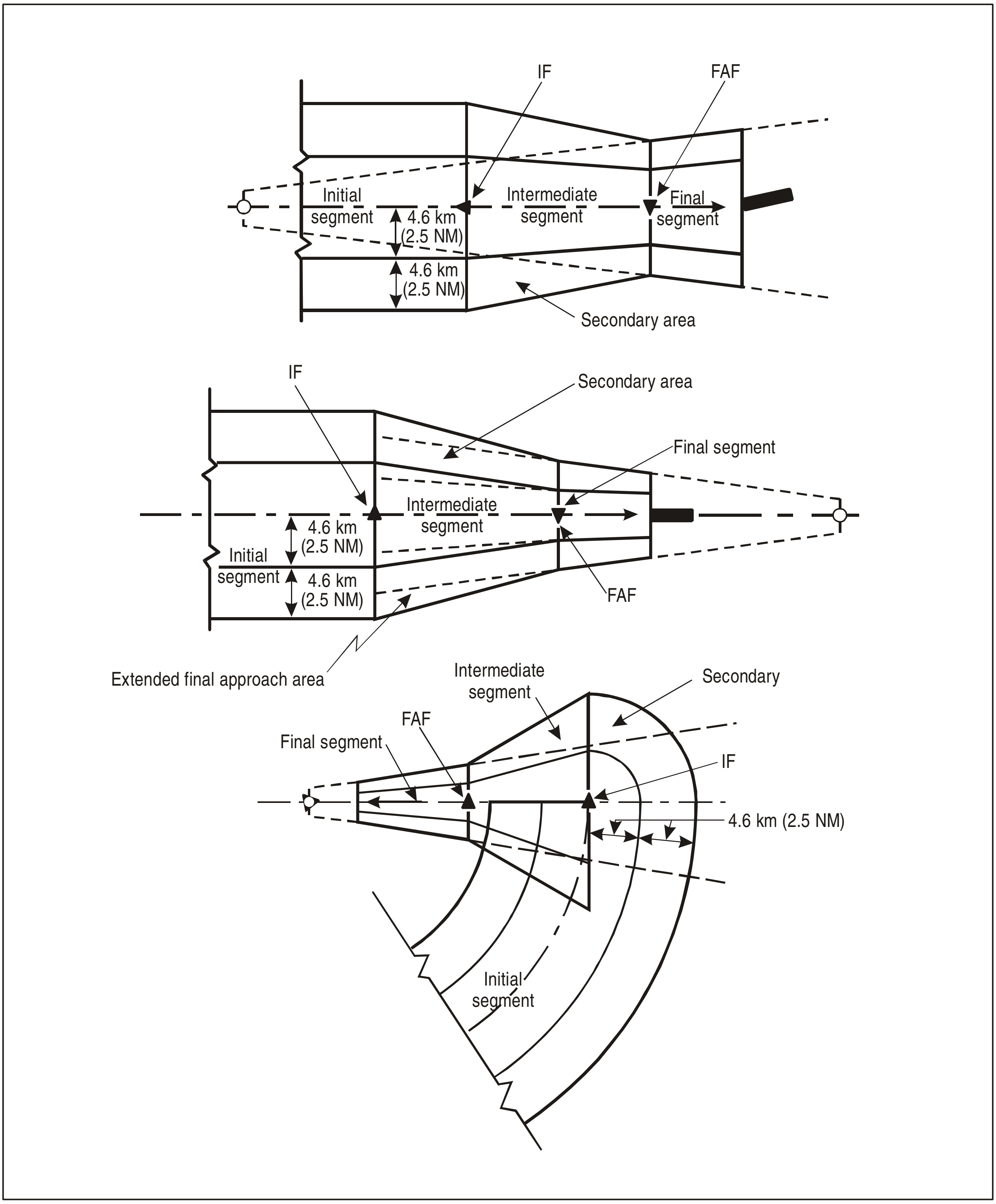


**Figure I-4-3-2. Typical segments (plan view)**

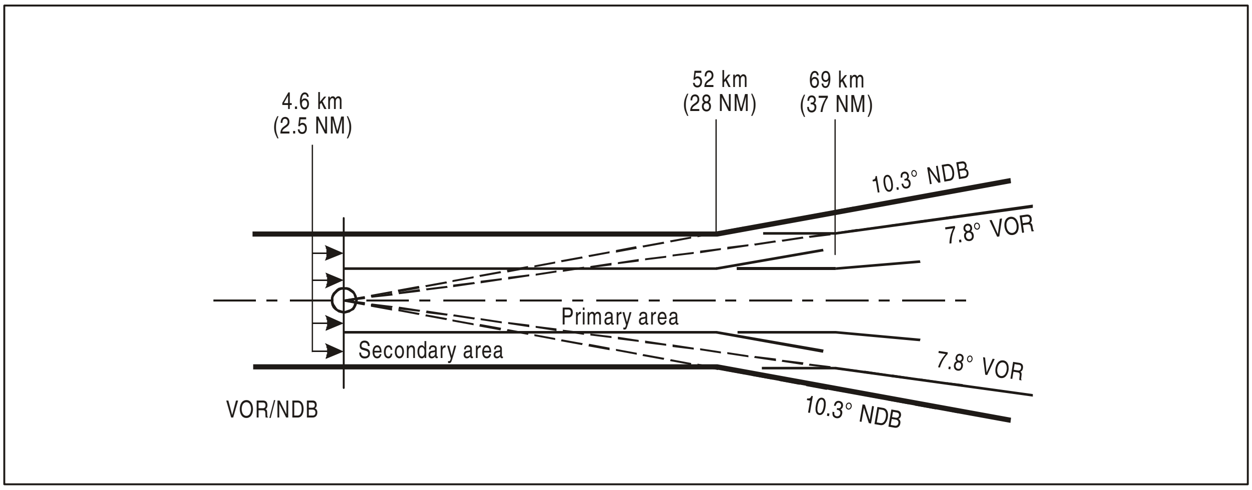


**Figure I-4-3-3. Initial approach area utilizing straight tracks**

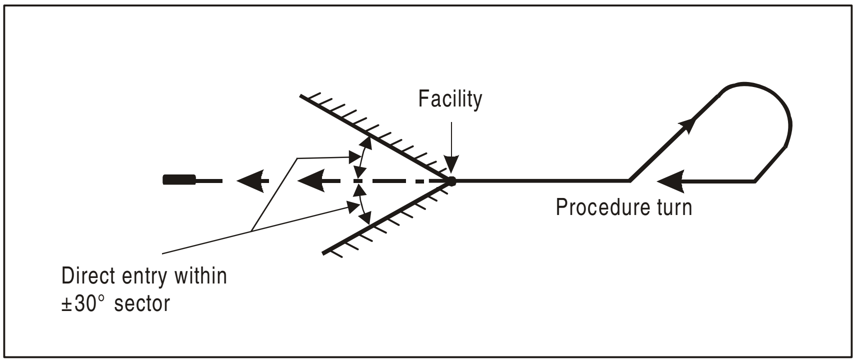


**Figure I-4-3-4. Entry to procedure turn**

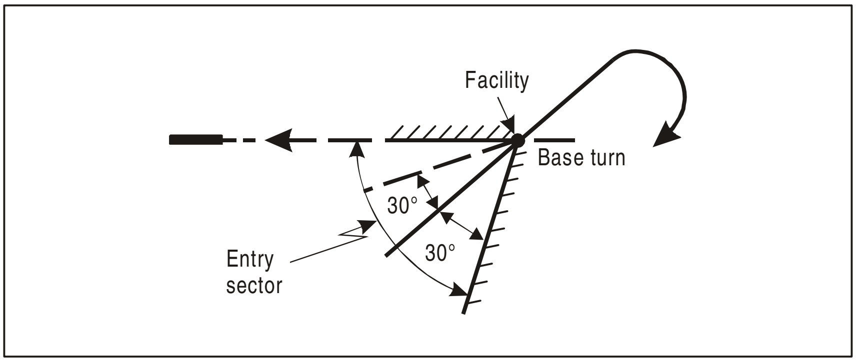


**Figure I-4-3-5. Entry to base turn**

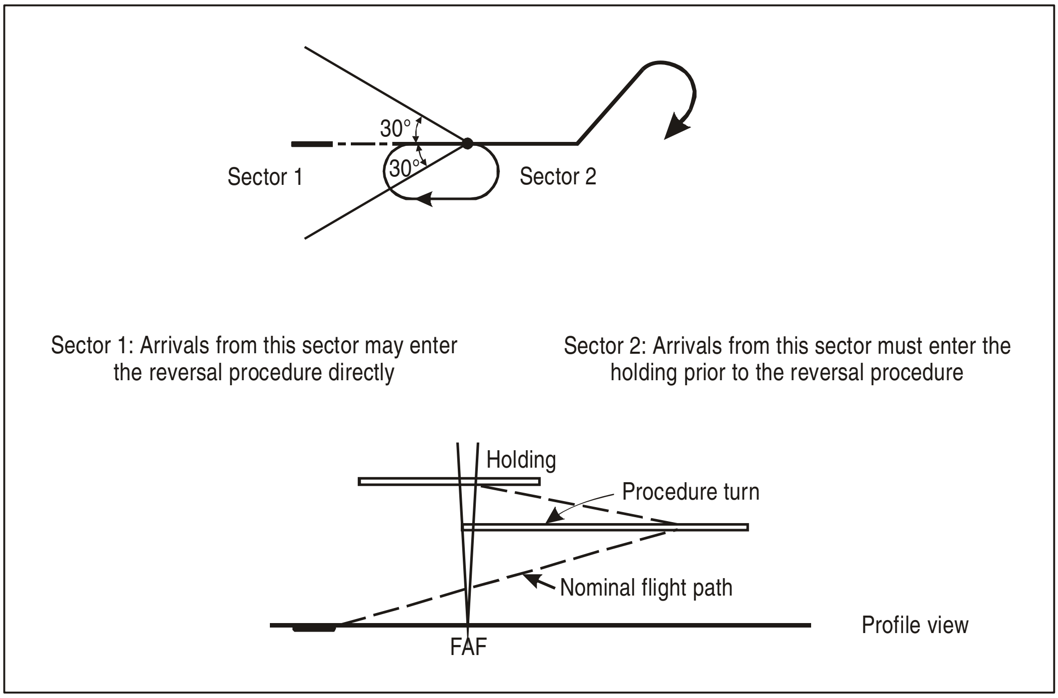


**Figure I-4-3-6. Example of omnidirectional arrival using a holding procedure in association with a reversal procedure**

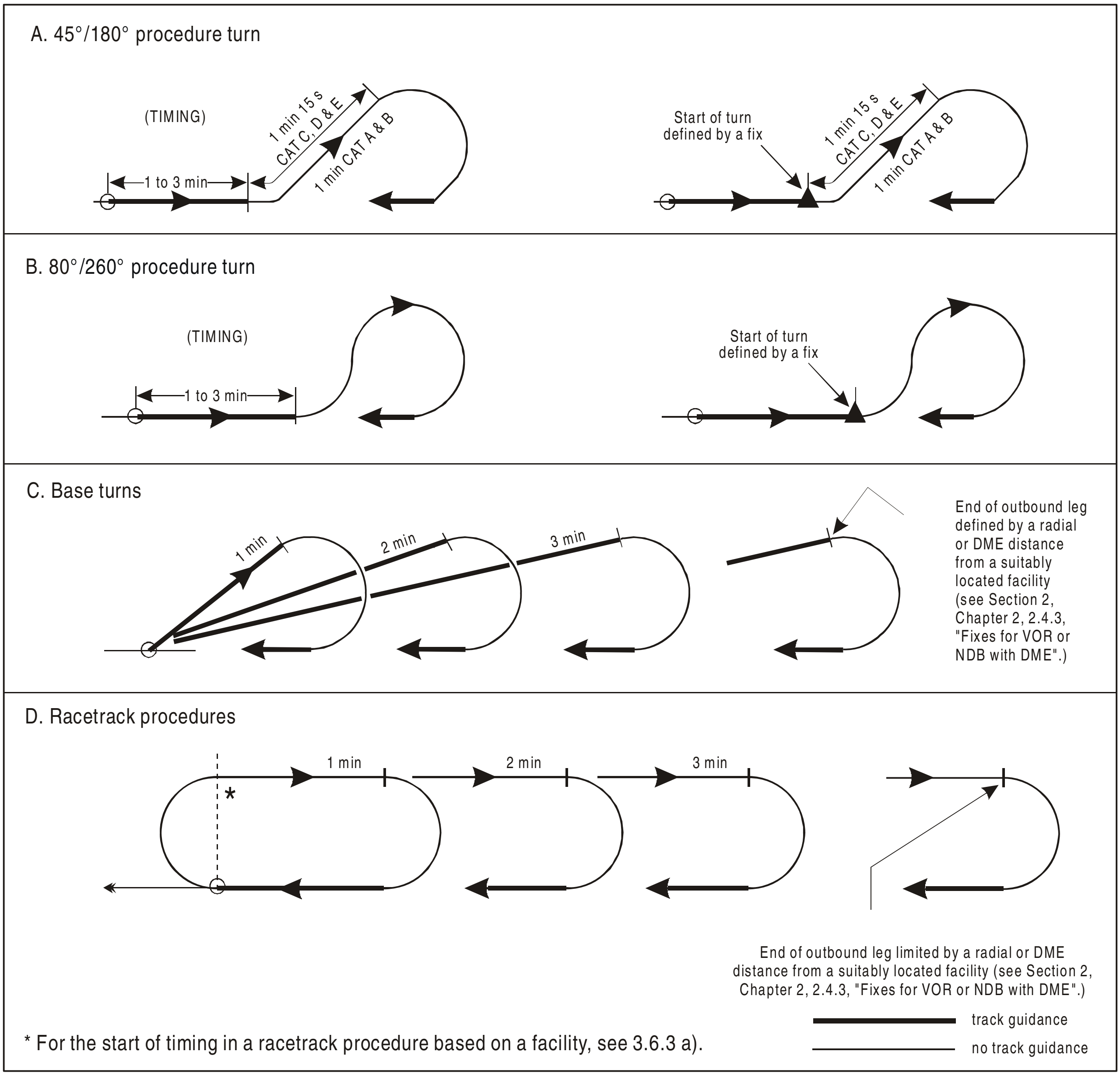


**Figure I-4-3-7. Types of reversal and racetrack procedures**

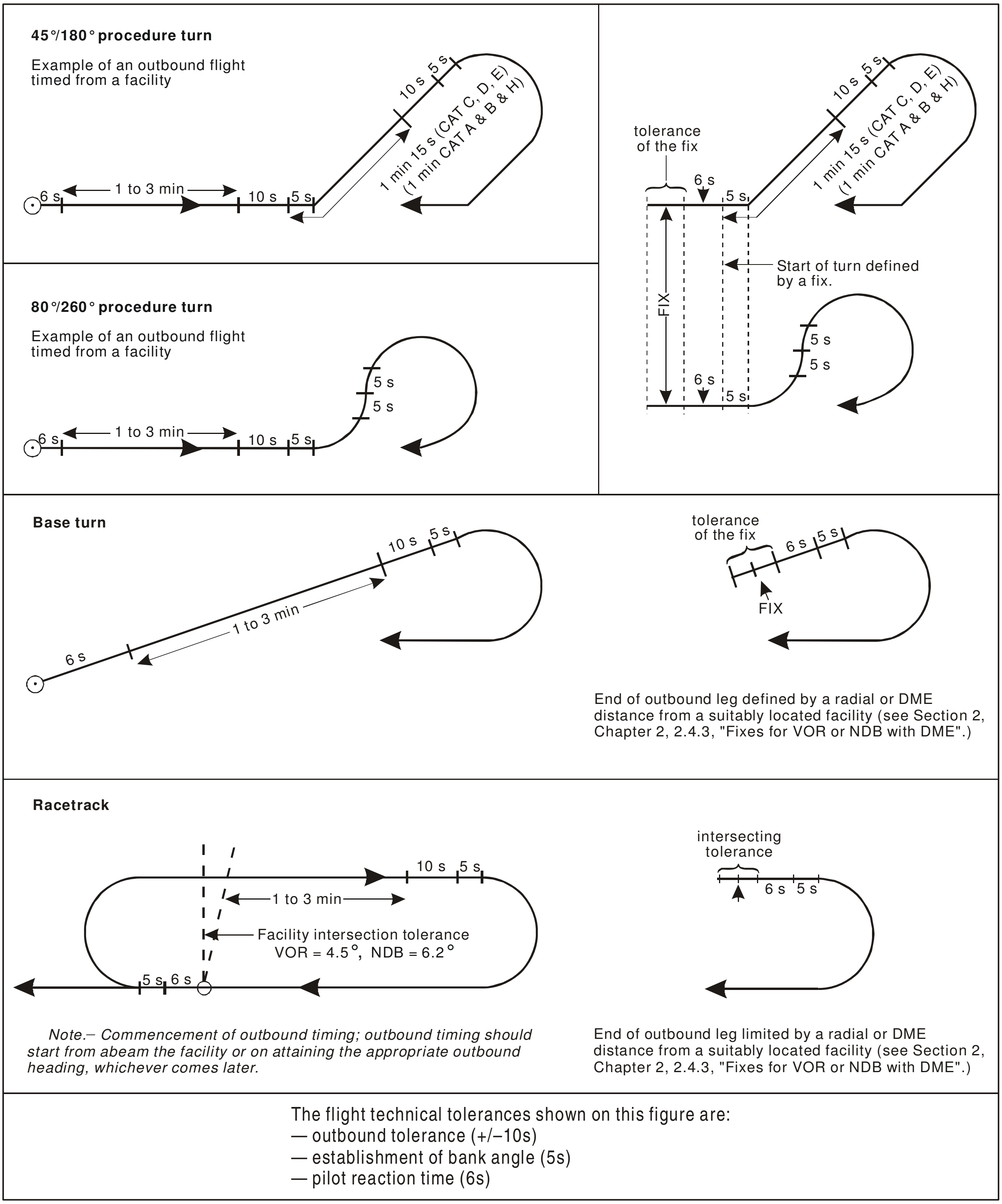


**Figure I-4-3-8. Application of flight technical tolerance**

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# Appendix A to Chapter 3

# INITIAL APPROACH USING DEAD RECKONING (DR)

## 1. GENERAL

### 1.1 Purpose

1.1.1 A dead reckoning (DR) track procedure may be used to reduce the angle of turn onto the final approach track where such a turn would otherwise exceed the limits specified in Part II, Section 1, Chapter 1, “Initial approach segment alignment”. Its main purposes are:

a) to save time and airspace by avoiding a reversal manoeuvre;

b) to provide pilots with a comfortable flight pattern. The chances of overshooting the final approach track in case of a suitably designed intercepting DR track are less than in the case of a large turn initiated by a lead radial; and

c) to provide air traffic control (ATC) with flexibility by designing DR track segments of different length to accommodate two ranges of speeds. This will allow a slower aircraft followed by a faster one to be assigned to a shorter track to the advantage of both aircraft.

1.1.2 Several DR tracks may be designed using the criteria in this attachment. This allows ATC to vary the initial track of the aircraft under radar surveillance by assigning a track number to the aircraft. And if radar vectoring is required, this track will provide the ATC with a reference (on the radar scope) which shows the most appropriate way to proceed from the initial approach fix (IAF) to the final approach point (FAP).

### 1.2 Required navigation facilities

This type of procedure requires either two VORs or a VOR/DME to define the fix from which the DR track begins. Track guidance on final and intermediate approach may be provided either by VOR, NDB or localizer (LLZ). Because this procedure is intended for use at major airports, it has been illustrated for the instrument landing system (ILS) case. When any portion of DR segment between the nominal position of start point and the localizer course lies outside of the service volume of the localizer, a homing facility close to the final approach track (for example at the airport) is required.

*Note.— In case of non-precision approach, the areas shall be adapted to the type of facility providing guidance on final approach.*

## 2. PARAMETERS

### 2.1 Aircraft speed

— *Aircraft Categories A and B*: Indicated airspeed (IAS) from 165 to 335 km/h (90 to 180 kt); and

— *Aircraft Categories C, D and E:* IAS from 335 to 465 km/h (180 to 250 kt).

The corresponding true airspeeds (TAS) are calculated taking into account the following factors:

a) *temperature:* International standard atmosphere (ISA) + 15°C; and

b) *altitude:* 1 500 m (5 000 ft) and 3 000 m (10 000 ft).

### 2.2 Wind speed

An omnidirectional wind shall be used. The wind speed (w) in km/h (kt) is determined by the formula:

w = (12 h + 87) km/h where h is in thousands of metres

w = (2 h + 47) kt where h is in thousands of feet.

However, for the straight part of the dead reckoning segment an omnidirectional wind of 56 km/h (30 kt) shall be taken into account. This assumes that the pilot is given the wind speed at the aerodrome and has appraised the wind within 56 km/h (30 kt) on the previous leg, the length of which shall be specified on approach charts.

### 2.3 Flight technical tolerances

a) *Bank angle.* 25° or the angle corresponding to a rate of turn of 3° per second, whichever is the lesser.

b) *Tolerances:*

   1) pilot reaction time: 0 to + 6 s;

   2) bank establishment time: + 5 s; and

   3) heading tolerance: ±5°.

### 2.4 Fix tolerances

These are established taking into account the accuracy of the facility used:

a) VOR facility providing track guidance: ±5.2°;

b) VOR intersecting facility: ±4.5°; and

c) DME distance indications: 0.46 km (0.25 NM) + 1.25 per cent of the distance to the antenna.

### 2.5 Table of basic values

See Table I-4-3-App A-1.

## 3. TRACK CONSTRUCTION

### 3.1 General

3.1.1 *Types of procedures.* A distinction should be made between two types of procedures:

a) the U-type procedures (see Figure I-4-3-App A-1) in which the turn preceding the dead reckoning segment and the turn joining the final approach track are made in the same direction; and

b) the so-called S-type procedures (see Figure I-4-3-App A-2) in which these two turns are in opposite directions.

3.1.2 *Components of procedures.* These two procedures can be broken down as follows.

a) *First leg of the initial approach.* This track is defined by a VOR radial. In order to limit the tolerance area associated with the start point of the turn preceding the dead reckoning segment, the length of this track should not exceed 56 km (30 NM).

b) *Dead reckoning segment*

   1) *Orientation.* In all cases the angle between the dead reckoning track and the final approach path shall be 45°.

   2) *Length.* The maximum length is 19 km (10 NM). The minimum length is calculated so that an aircraft meeting the most adverse wind conditions is able to complete the turn preceding the dead reckoning segment before initiating the turn onto the final approach track. The minimum length depends on the type of procedure.

c) *Intermediate approach segment.* The intermediate approach segment begins where the DR track intercepts the intermediate approach track. An intermediate fix is required at this point. The minimum length of the intermediate approach segment depends upon speed and altitude (see Table I-4-3-App A-3). The minimum length of this segment is calculated to allow an aircraft arriving at an angle of 45° — without any indication of the start of the joining turn other than the ILS information — to join and stabilize on the intermediate approach track even in the most adverse conditions.

### 3.2 Characteristics of the S-type procedures

3.2.1 This type of procedure introduces fewer constraints than the preceding one (see Figure I-4-3-App A-2).

3.2.2 *Start point of the turn onto the DR track.* The start point shall be defined by a fix for which the tolerance shall not exceed ±3.7 km (±2.0 NM).

3.2.3 *Minimum length of the DR segment*. The minimum length of the dead reckoning segment to be adopted will be one of the two following values:

a) start point of the turn defined by VOR intersection: 9 km (5 NM); and

b) start point of the turn defined by VOR/DME indication: 7 km (4 NM).

These values are adequate provided that the length of the first leg does not exceed 19 km (10 NM); otherwise, they should be increased by 15 per cent of the distance in excess of 19 km (10 NM). **Example**: Start point of the turn defined by VOR intersection; for a 37 km (20 NM) first leg, the length of the DR segment shall not be less than 10.5 km or 6.5 NM.

### 3.3 Characteristics of the U-type procedures

3.3.1 *Position of the initial approach fix (IAF).* The IAF can be a facility (VOR or VOR/DME) or a fix from which track guidance is available. This fix or facility shall be located outside a sector contained between the final approach path and a straight line L (see Figure I-4-3-App A-1). Line L is determined as follows:

a) from the FAP draw line D at an angle Ψ to the final approach path.

   The length of D varies with the type of facility. Lengths for each type appear in Table I-4-3-App A-3; and

b) at the end point of line D, draw line L perpendicular to line D.

3.3.1.1 Values for Ψ were determined as follows:

a) take the angle (45°) between the dead reckoning segment and the ILS axis;

b) add the maximum angle between the first leg of the initial segment and the dead reckoning segment:

   1) 45° + 120° = 165° for VOR/DME; and

   2) 45° + 105° = 150° for VOR/VOR;

c) take the total from steps 1 and 2, and subtract this from 180. This gives the maximum angle between the first leg of the initial segment and the reverse of ILS axis:

   1) 180° – 165° = 15° for VOR/DME; and

   2) 180° – 150° = 30° for VOR/VOR;

d) subtract the value obtained in c) from 90° in order to have the direction of the perpendicular:

   1) 90° – 15° = 75° for VOR/DME; and

   2) 90° – 30° = 60° for VOR/VOR; and

e) subtract a buffer value of 5° for technical tolerance to give the following values:

   1) 70° for VOR/DME; and

   2) 55° for VOR/VOR.

3.3.2 *Limitation of the angle of turn preceding the dead reckoning segment*

a) *Start point of turn defined by an intersection of VOR radials.* The angle between the first leg of the initial approach and the dead reckoning segment should not exceed 105°. The angle of intersection of VOR radials should not be less than 45° (See Figure I-4-3-App A-1); and

b) *Start point of turn defined by a VOR/DME fix*. In this case the angle of turn should not exceed 120°.

*Note.— If a homing facility located on the final approach track in the vicinity of the FAP allows the pilot to control the development of the turn preceding the DR segment, the conditions specified in 3.3.1, "Position of the initial approach fix (IAF)" and 3.3.2, "Limitation of the angle of turn preceding the dead reckoning segment" may be relaxed.*

3.3.3 *Minimum length of the dead reckoning segment*

The minimum length of the dead reckoning segment depends on the following parameters:

a) the speed of the aircraft;

b) the angle of turn;

c) the definition of the point of start of turn;

d) the altitude; and

e) the length of the first leg of the initial approach.

Segment lengths appropriate for selected angles of turn are shown in Tables I-4-3-App A-4 through I-4-3-App A-7. Linear interpolation can be applied to determine intermediate values.

*Note.— All values shown in the tables are adequate provided the length of the first leg does not exceed 19 km (10 NM). Otherwise these values should be increased by 10 per cent of the distance in excess of 19 km (10 NM). Example: Table I-4-3-App A-7, angle of turn: <45°. If the first leg is 22 km (12 NM) long, the minimum lengths of the DR segment become 6.3 and 9.3 km or 3.7 and 5.2 NM.*

## 4. AREAS

### 4.1 Areas associated with the U-type procedures *(see Figures I-4-3-App A-3 and I-4-3-App A-4)*

4.1.1 *Initial approach area for the first leg.* This is established according to the criteria in Part III, Chapter 3, 3.3.3, "Area".

4.1.2 Area for the turn and for the dead reckoning segment.

a) *Inner edge, primary area.* Join point A to point B.

1) Point A is on the OAS "X" surface abeam the FAP, on the side of the DR segment.

2) Point B is located on the first leg of the initial approach at a distance D before the nominal start point of the turn where:

D = 4.6 km (2.5 NM) when it is defined by the intersection of VOR radials;

D = 1.9 km (1.0 NM) when it is defined by the VOR/DME indication.

b) *Inner edge, secondary area*. The secondary area associated with the first leg of the initial approach will end on the inside of the turn over this straight line.

c) *Outer edge, primary area.* This is defined by:

1) an arc of a circle centred on the start point of the turn whose radius R is a function of aircraft speed and altitude. Tables I-4-3-App A-8 and I-4-3-App A-9 give the values of the radius R;

2) a straight line which is tangent to the arc of circle and which splays outward at an angle θ to the dead reckoning track according to speed where:

θ = 22° for IAS 165/335 km/h (90/180 kt);

θ = 14° for IAS 335/465 km/h (180/250 kt);

3) a straight line from point A to point C, splayed at an angle of 15° from the intermediate approach track where:

Point A is on the OAS X surface abeam the final approach point (FAP); and

Point C is abeam the intermediate approach fix (IF); and

4) a straight line originating from point C parallel to the intermediate approach track.

d) *Outer edge, secondary area.* The secondary area is located outside of the turn preceding the dead reckoning segment. It is extended up to the outer limit of the protection area defined above.

### 4.2 Areas associated with the S-type procedures *(see Figures I-4-3-App A-5 and I-4-3-App A-6)*

a) *Area for the first leg of the initial approach.* See Part III, Chapter 4, 4.3.3, “Area”.

b) *Area for the turn and the dead reckoning segment.*

1) *Outer edge.* This is formed by a straight line joining point A to point S. Point A is located abeam the FAP on the OAS X surface; point S is located abeam the start point of turn on the outer edge of the initial approach area.

2) *Inner edge.*

i) First locate point B' on the first leg at a distance from the start point of the turn equal to:

1.9 km (1.0 NM) if the start point is defined by VOR/DME reference;

3.7 km (2.0 NM) if the start point is defined by VOR intersection.

ii) Identify point B abeam B' at a distance of 9.3 km (5.0 NM).

iii) From point B, draw a straight line splaying apart from the DR track at a 22° angle (heading tolerance plus maximum drift angle for the lowest speed category).

iv) Locate A' on the OAS X surface abeam the FAF.

v) From A' draw a straight line splaying at 15° from the intermediate approach track to a point C abeam the IF.

vi) From C draw a straight line parallel to the intermediate approach track.

**Table I-4-3-App A-1. Basic values**

| *IAS km/h (kt)* | *165 (90)* | *335 (180)* | | *465 (250)* | |
|---|---|---|---|---|---|
| TAS at 1 500 m km/h (5 000 ft) (kt) | 185 (100) | 370 (199) | | 510 (276) | |
| TAS at 3 000 m km/h (10 000 ft)(kt) | | | 400 (216) | | 555 (299) |
| Turn radius km (NM) | 1.05 (0.57) | 2.30 (1.24) | 2.70 (1.46) | 4.42 (2.39) | 5.18 (2.80) |
| Bank angle | 17° | 25° | 25° | 25° | 25° |
| Rate of turn (°/s) | 3 | 2.55 | 2.35 | 1.84 | 1.70 |
| Maximum drift for a wind of 56 km/h (30 kt) | 17° | 9° | 8° | 6° | 6° |
| Heading tolerance + max drift angle | 22° | 14° | 13° | 11° | 11° |
| 11 s of flight at km (TAS + W)(NM) | 0.89 (0.48) | 1.35 (0.78) | 1.61 (0.87) | 1.89 (1.02) | 2.07 (1.12) |

**Table I-4-3-App A-2. Length of the intermediate approach segment**

| | *IAS km/h (kt)* | |
|---|---|---|
| *Altitude* | *165/335 (90/180)* | *335/465 (180/250)* |
| 1 500 m (5 000 ft) | 11 km (6 NM) | 17 km (9 NM) |
| 3 000 m (10 000 ft) | 12 km (6.5 NM) | 20 km (11 NM) |

*Note.— For the intermediate attitudes, linear interpolation can be applied.*

**Table I-4-3-App A-3. Lengths of line D for types of facility and airspeed**

| Facility | Ψ | D for IAS < 335 km/h (180 kt) | D for IAS < 465 km/h (250 kt) |
|---|---|---|---|
| VOR/VOR | 55° | 16 km (8.5 NM) | 23 km (12.5 NM) |
| VOR/DME | 70° | 12 km (6.5 NM) | 18 km (9.5 NM) |

**Table I-4-3-App A-4. Minimum length of the DR segment**
**Start point defined by VOR intersection — Altitude: 1 500 m (5 000 ft)**

| | *Angle of turn* | | | |
|---|---|---|---|---|
| *IAS km/h (kt)* | *≤45°* | *60°* | *90°* | *105°* |
| 165/335 km/h (90/180 kt) | 10 km (5.5 NM) | 11 km (6 NM) | 12 km (6.5 NM) | 12 km (6.5 NM) |
| 335/465 km/h (180/250 kt) | 13 km (7 NM) | 14 km (7.5 NM) | 15 km (8 NM) | 16 km (8.5 NM) |

**Table I-4-3-App A-5. Minimum length of the DR segment**
**Start point defined by VOR intersection — Altitude: 3 000 m (10 000 ft)**

| | *Angle of turn* | | | |
|---|---|---|---|---|
| *IAS km/h (kt)* | *≤45°* | *60°* | *90°* | *105°* |
| 165/335 km/h (90/180 kt) | 11 km (6 NM) | 12 km (6.5 NM) | 13 km (7 NM) | 14 km (8.5 NM) |
| 335/465 km/h (180/250 kt) | 15 km (8 NM) | 16 km (8.5 NM) | 18 km (9.5 NM) | 19 km (10 NM) |

**Table I-4-3-App A-6. Minimum length of the DR segment**
**Start point defined by VOR/DME fix — Altitude: 1 500 m (5 000 ft)**

| | *Angle of turn* | | | |
|---|---|---|---|---|
| *IAS*<br>*km/h (kt)* | *≤45°* | *60°* | *90°* | *105°* |
| 165/335 km/h<br>(90/180 kt) | 6 km<br>(3.5 NM) | 8 km<br>(4.5 NM) | 9 km<br>(5 NM) | 10 km<br>(5.5 NM) |
| 335/465 km/h<br>(180/250 kt) | 9 km<br>(4.5 NM) | 11 km<br>(5.5 NM) | 13 km<br>(6.5 NM) | 15 km<br>(7.5 NM) |

**Table I-4-3-App A-7. Minimum length of the DR segment**
**Start point defined by VOR/DME fix — Altitude: 3 000 m (10 000 ft)**

| | *Angle of turn* | | | |
|---|---|---|---|---|
| *IAS*<br>*km/h (kt)* | *≤45°* | *60°* | *90°* | *105°* |
| 165/335 km/h<br>(90/180 kt) | 6 km<br>(3.5 NM) | 9 km<br>(5 NM) | 11 km<br>(6 NM) | 12 km<br>(6.5 NM) |
| 335/465 km/h<br>(180/250 kt) | 9 km<br>(5 NM) | 11 km<br>(6 NM) | 15 km<br>(8 NM) | 18 km<br>(9.5 NM) |

*Note.— All values shown in the tables are adequate provided the length of the first leg does not exceed 19 km (10 NM). Otherwise these values should be increased by 10 per cent of the distance in excess of 19 km (10 NM). Example: Table I-4-3-App A-7, angle of turn: ≤45°. If the first leg is 22 km (12 NM) long the minimum lengths of the DR segment become 6.3 and 9.3 km or 3.7 and 5.2 NM.*

**Table I-4-3-App A-8. R values for a start point of turn**
**defined by VOR intersection**

| | *Altitude* | |
|---|---|---|
| *IAS*<br>*km/h (kt)* | *1 500 m*<br>*(5 000 ft)* | *3 000 m*<br>*(10 000 ft)* |
| 165/335 km/h<br>(90/180 kt) | 10.2 km<br>(5.5 NM) | 11.1 km<br>(6 NM) |
| 335/465 km/h<br>(180/250 kt) | 12.0 km<br>(6.5 NM) | 13.9 km<br>(7.5 NM) |

**Table I-4-3-App A-9. R values for a start point of turn defined by VOR/DME**

| | *Altitude* | |
|---|---|---|
| *IAS km/h (kt)* | *1 500 m (5 000 ft)* | *3 000 m (10 000 ft)* |
| 165/335 km/h (90/180 kt) | 9.3 km (5.0 NM) | 9.3 km (5.0 NM) |
| 335/465 km/h (180/250 kt) | 10.2 km (5.5 NM) | 12.0 km (6.5 NM) |

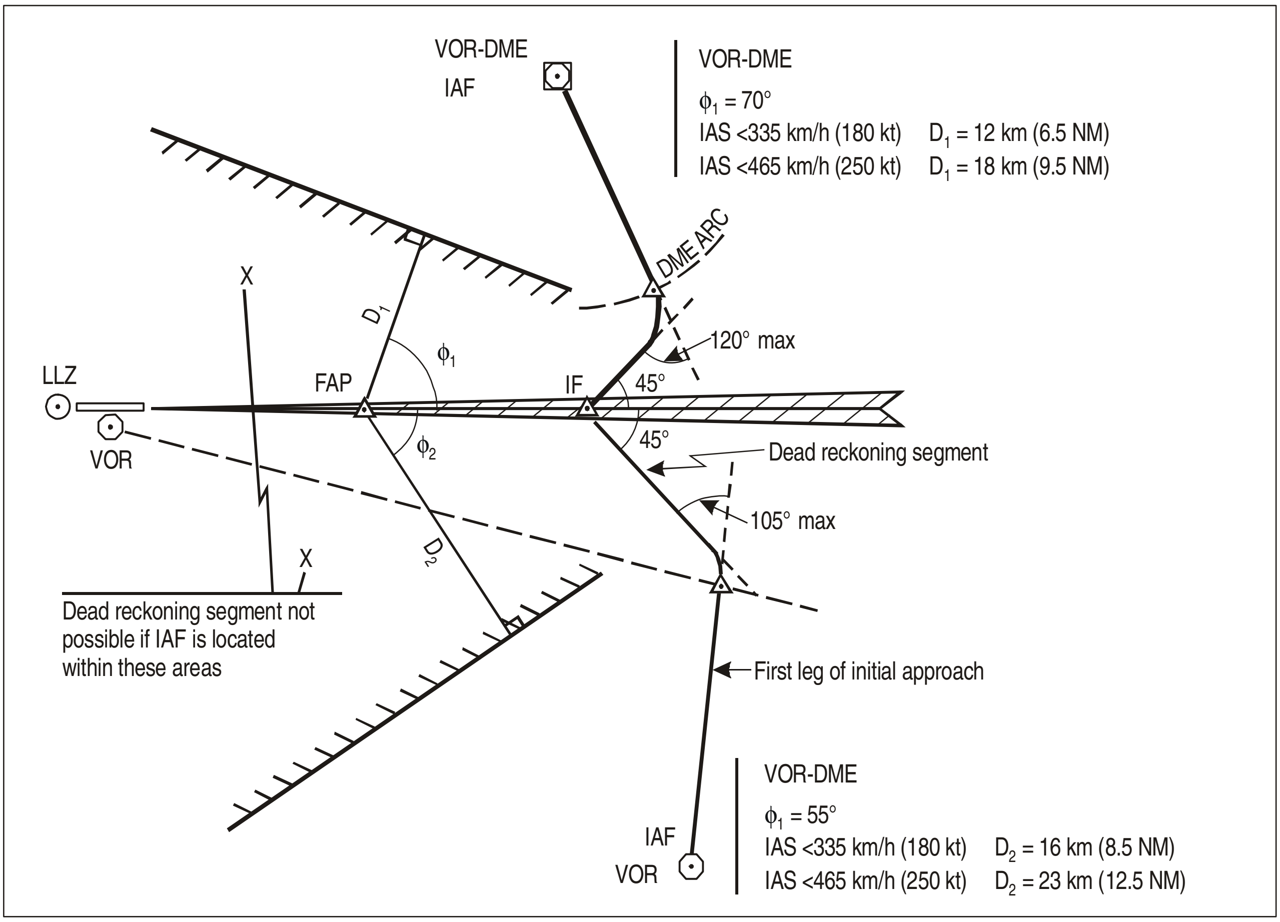



**Figure I-4-3-App A-1. U-type procedure conditions for locating the IAF**

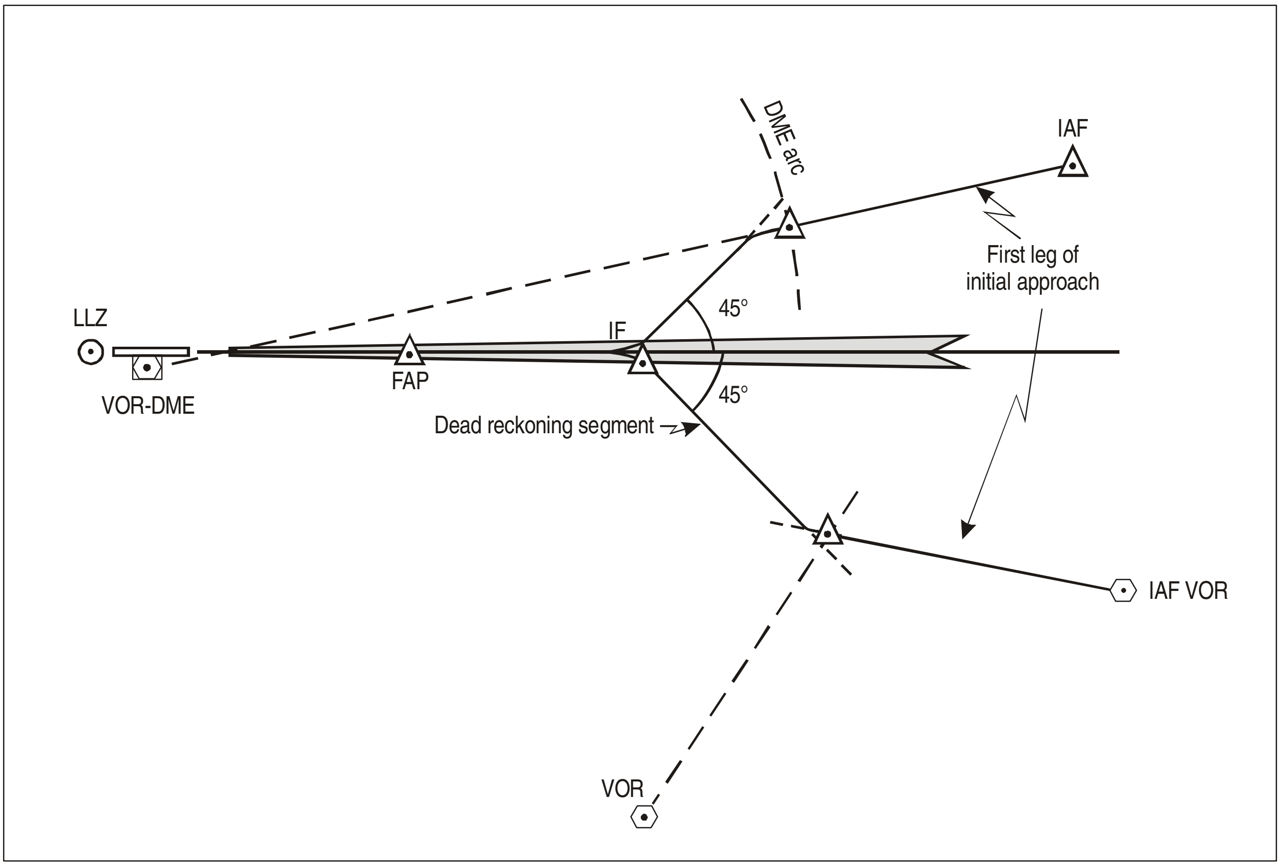
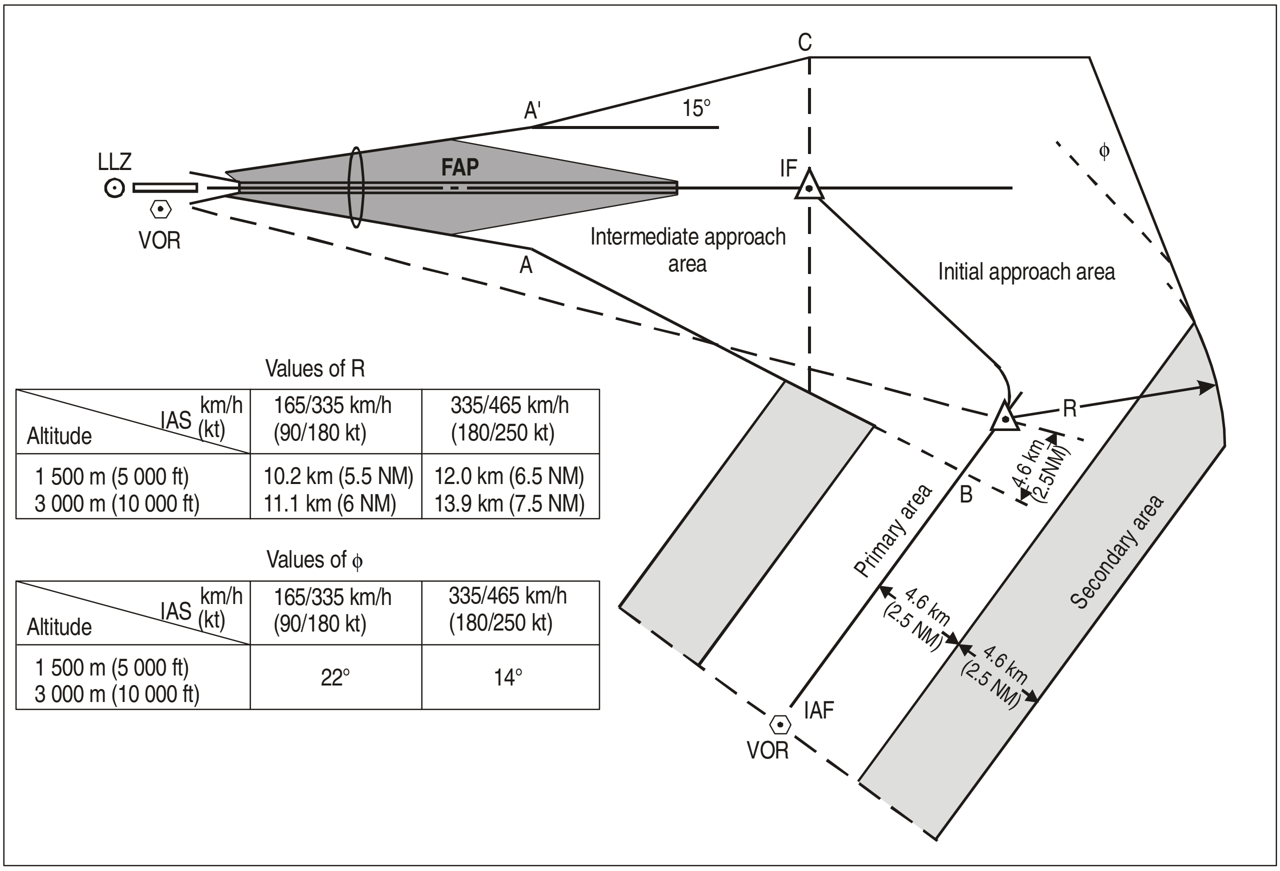



**Figure I-4-3-App A-2. S-type procedure**




Values of R

| Altitude \ IAS km/h (kt) | 165/335 km/h (90/180 kt) | 335/465 km/h (180/250 kt) |
|---|---|---|
| 1 500 m (5 000 ft)<br>3 000 m (10 000 ft) | 10.2 km (5.5 NM)<br>11.1 km (6 NM) | 12.0 km (6.5 NM)<br>13.9 km (7.5 NM) |

Values of ϕ

| Altitude \ IAS km/h (kt) | 165/335 km/h (90/180 kt) | 335/465 km/h (180/250 kt) |
|---|---|---|
| 1 500 m (5 000 ft)<br>3 000 m (10 000 ft) | 22° | 14° |

**Figure I-4-3-App A-3. U-type VOR/VOR procedure construction of protection areas**

Values of R

| Altitude \ IAS km/h (kt) | 165/335 km/h (90/180 kt) | 335/465 km/h (180/250 kt) |
|---|---|---|
| 1 500 m (5 000 ft) | 9.3 km (5.0 NM) | 10.2 km (5.5 NM) |
| 3 000 m (10 000 ft) | 9.3 km (5.0 NM) | 12.0 km (6.5 NM) |

Values of $\phi$

| Altitude \ IAS km/h (kt) | 165/335 km/h (90/180 kt) | 335/465 km/h (180/250 kt) |
|---|---|---|
| 1 500 m (5 000 ft)<br>3 000 m (10 000 ft) | 22° | 14° |

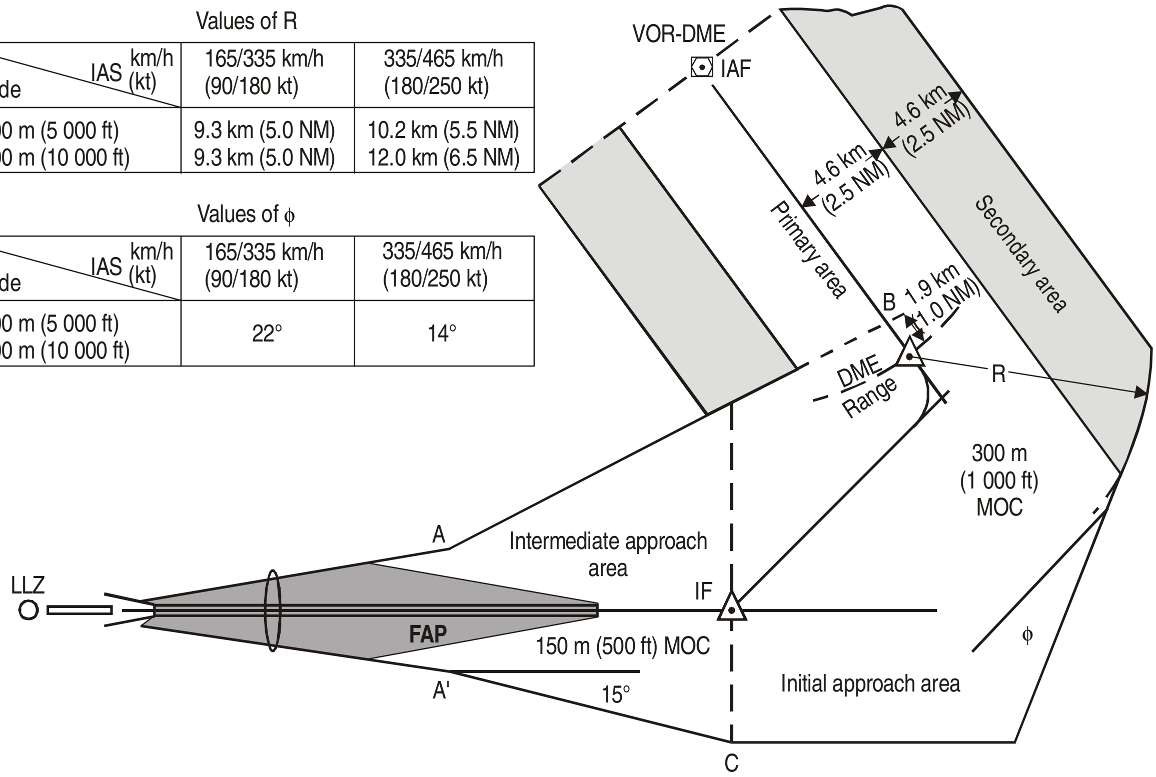



**Figure I-4-3-App A-4. U-type VOR/DME procedure construction of protection areas**

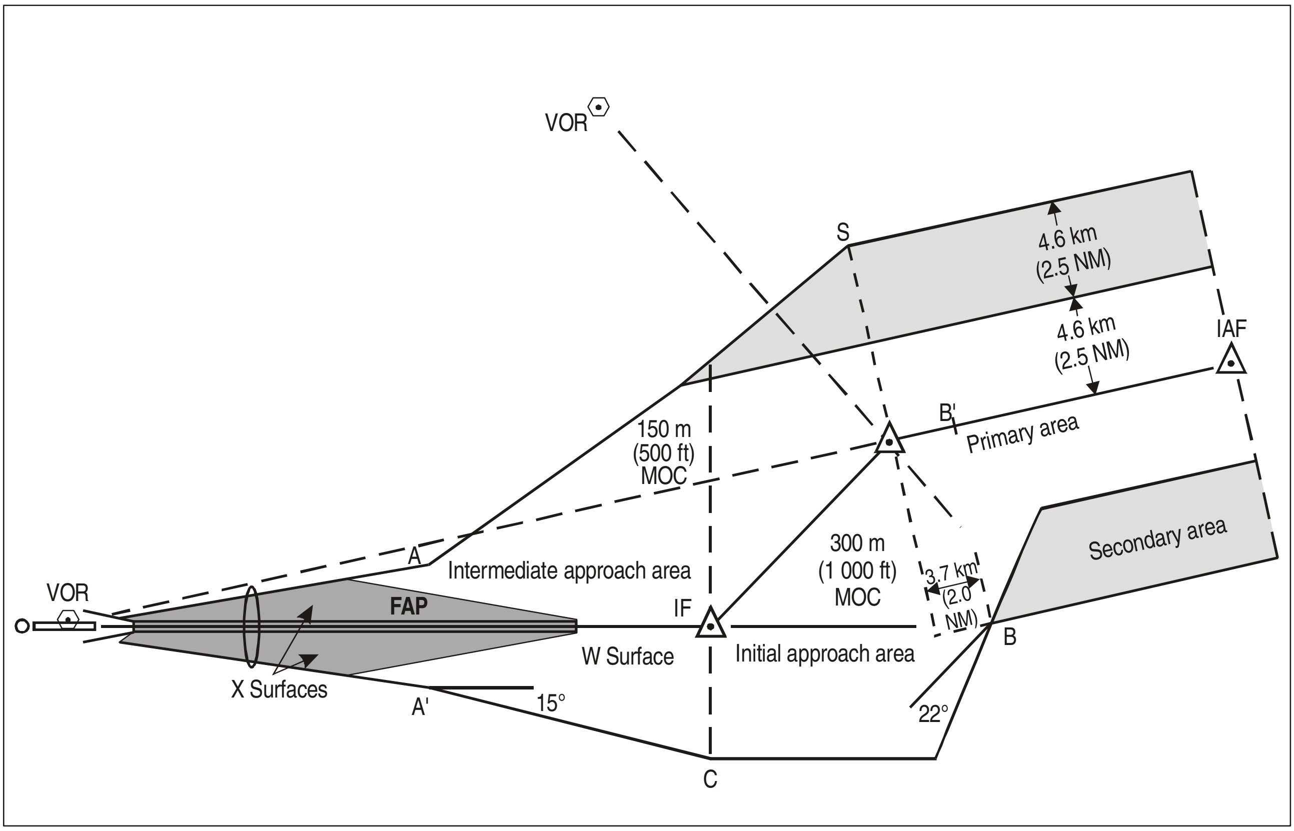



**Figure I-4-3-App A-5. S-type VOR/VOR procedure construction of protection areas**

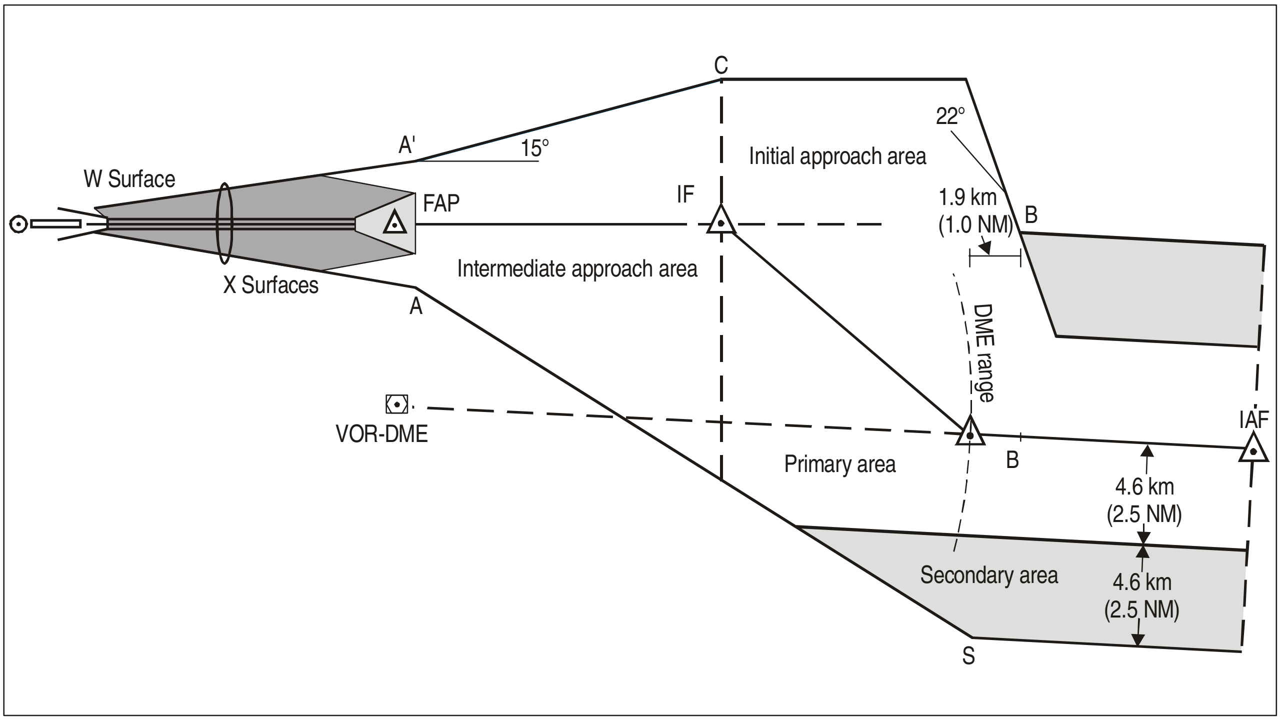



**Figure I-4-3-App A-6. S-type VOR/DME procedure construction of protection areas**

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# Appendix B to Chapter 3

# REDUCTION OF THE WIDTH OF A STRAIGHT INITIAL APPROACH AREA AFTER THE IAF AND INTERFACE BETWEEN STRAIGHT INITIAL APPROACH AREA AND REVERSAL PROCEDURE AREAS

*(see Chapter 3, 3.3.2)*

## 1. REDUCTION OF THE WIDTH OF A STRAIGHT INITIAL APPROACH AREA AFTER THE IAF

### 1.1 General

Where the initial approach includes a straight segment ending at an intermediate approach fix (IF) defined by a VOR, NDB or RNAV waypoint, its width at the IF is reduced from the appropriate en-route width to:

a) ± 3.7 km (2.0 NM) at a VOR;

b) ± 4.6 km (2.5 NM) at an NDB; or

c) the calculated area width for an RNAV waypoint.

### 1.2 Justification

The guidance provided is considered sufficient. The cone effect area radius is:

a) 3.7 km (2.0 NM) for a VOR at 3 000 m (10 000 ft); and

b) 4.6 km (2.5 NM) for an NDB at 5 500 m (18 000 ft).

The area width at the IF for the RNAV case can be calculated. It is assumed that the flight technical tolerance is diminishing after the aircraft has passed the initial approach fix (IAF).

### 1.3 VOR cases

1.3.1 *The IAF is at a distance of more than 40.5 km (21.9 NM) from the VOR.* From a distance of 40.5 km (21.9 NM) from the VOR and up to the VOR, the width of the area on each side of the nominal track is reduced linearly from 9.3 km (5.0 NM) to 3.7 km (2.0 NM), the outer boundary of the area converging at an angle of 7.8° with the nominal track (Figure I-4-3-App B-1).

1.3.2 *The IAF is at a distance of less than 40.5 km (21.9 NM) from the VOR.* The width of the area on each side of the nominal track is reduced linearly from 9.3 km (5.0 NM) at the IAF to 3.7 km (2.0 NM) at the VOR (Figure I-4-3-App B-2).

### 1.4 NDB cases

1.4.1 *The IAF is at a distance of more than 25.5 km (13.8 NM) from the NDB.* From a distance of 25.5 km (13.8 NM) from the NDB and up to the NDB the width of the area on each side of the nominal track is reduced linearly from 9.3 km (5.0 NM) to 4.6 km (2.5 NM), the outer boundary of the area converging at an angle of 10.3° with the nominal track (Figure I-4-3-App B-3).

1.4.2 *The IAF is at a distance of less than 25.5 km (13.8 NM) from the NDB.* The width of the area on each side of the nominal track is reduced linearly from 9.3 km (5.0 NM) at the IAF to 4.6 km (2.5 NM) at the NDB (Figure I-4-3-App B-4).

### 1.5 RNAV case

1.5.1 *Requirements.* The RNAV system shall meet the following requirements:

a) the accuracy (including position determination, RNAV computation and CDI centering) shall be better or equal to 0.4 km (0.2 NM) (2 sigma value);

b) the equipment shall include a system to provide integrity with a maximum alarm limit of 1.9 km (1.0 NM) and a maximum time to alarm of 10 seconds; and

c) the CDI sensitivity shall be better than or equal to 1.9 km (1.0 NM) (full-scale deflection).

1.5.2 *Area.* The width of the area on each side of the nominal track is reduced linearly from 9.3 km (5.0 NM) at the initial approach waypoint (IAF) to 5.6 km (3.0 NM) at the next waypoint (Figure I-4-3-App B-5). If the distance (d) between the IAF and the next waypoint is less than 6.5 km (3.5 NM), an area width of 5-0.577d shall be used in place of 5.6 km (3.0 NM) in order to limit the angle of convergence to 30° (Figure I-4-3-App B-6).

1.5.3 Figure I-4-3-App B-7 illustrates the combination of turn protection and area narrowing.

*Note.— Reduction of the initial approach segment width should only be considered for GNSS receivers which provide an input to an integrated navigation system, i.e. FMS/multi-sensor systems.*

## 2. PROTECTION OF A TURN AT THE IF

Where a turn at the IF greater than 10° is specified, the intermediate approach area should be widened on the outer side of the turn, using the method described in Chapter 6, 6.4.6.3.3 based on a bank angle of 25° (or on that angle giving a turn rate of 3°/s, whichever is the lesser) and on the maximum initial speed for the aircraft category. Figure I-4-3-App B-8 shows an example of this additional area to protect the turn.

## 3. INTERFACE BETWEEN STRAIGHT INITIAL APPROACH AREA AND REVERSAL PROCEDURE AREAS

The secondary area width of a reversal procedure is:

a) 1.9 km (1.0 NM) if it is based on a VOR; and

b) 2.3 km (1.25 NM) if it is based on an NDB.

The corresponding areas are related as shown in Figure I-4-3-App B-9.

*Note.— In Figure I-4-3-App B-9 the VOR facility marks the turning point in the initial approach segment. The intermediate approach segment starts only after completion of the reversal procedure turn.*

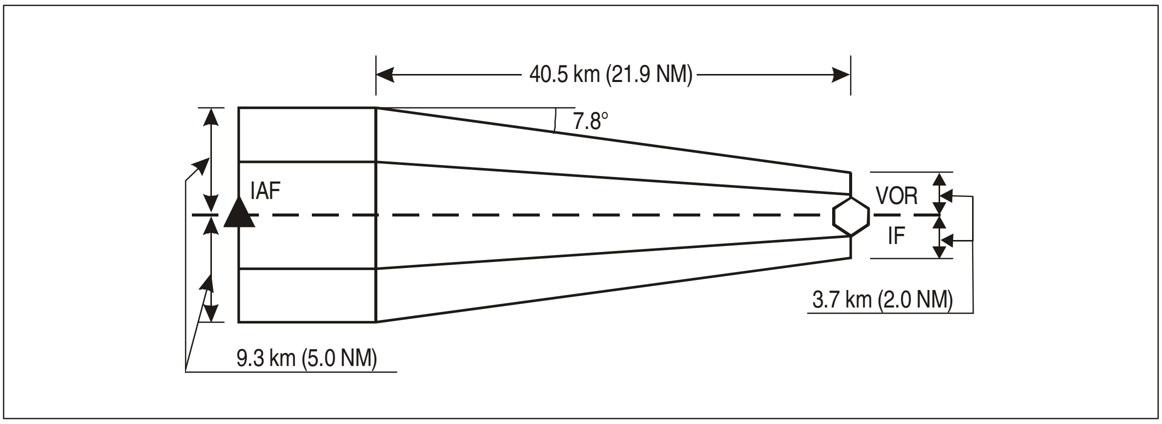


**Figure I-4-3-App B-1. Case where the IAF is more than 40.5 km (21.9 NM) from the VOR**

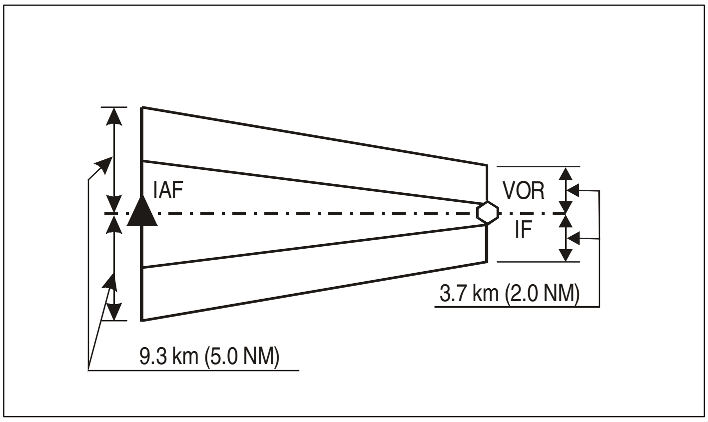


**Figure I-4-3-App B-2. Case where the IAF is less than 40.5 km (21.9 NM) from the VOR**

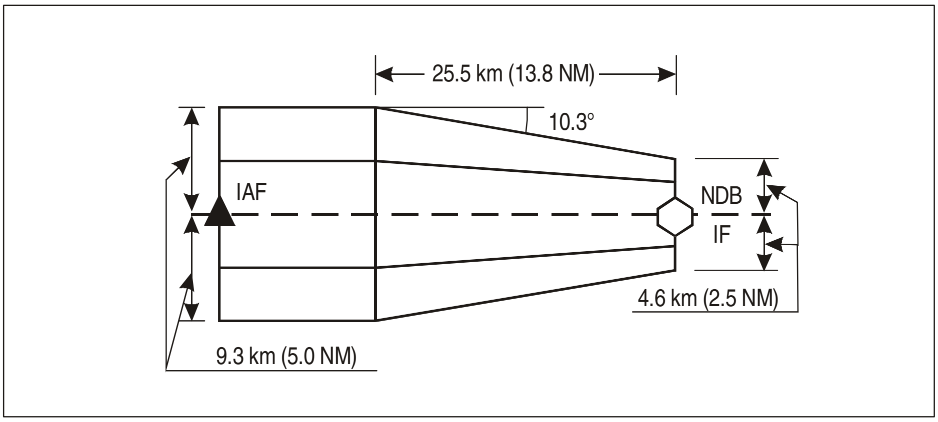


**Figure I-4-3-App B-3. Case where the IAF is more than 25.5 km (13.8 NM) from the NDB**

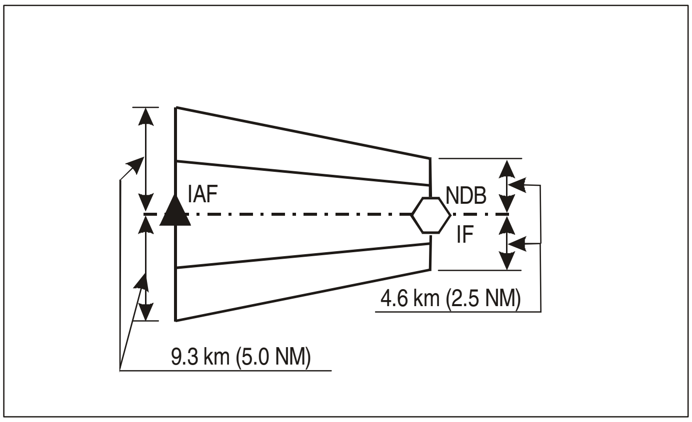


**Figure I-4-3-App B-4. Case where the IAF is less than 25.5 km (13.8 NM) from the NDB**

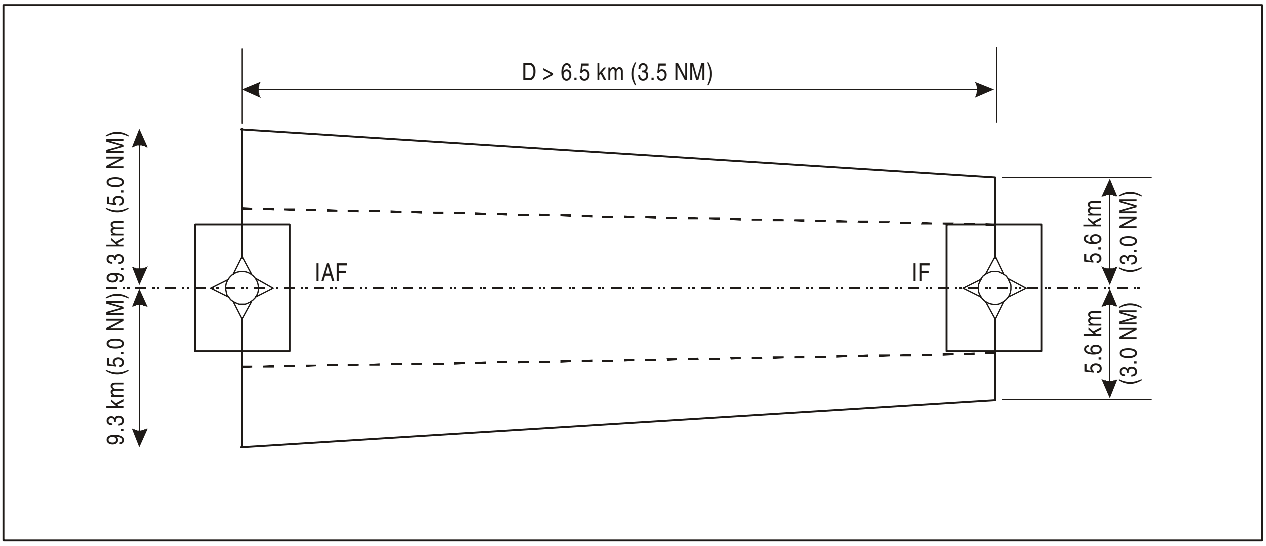


**Figure I-4-3-App B-5. RNAV area**

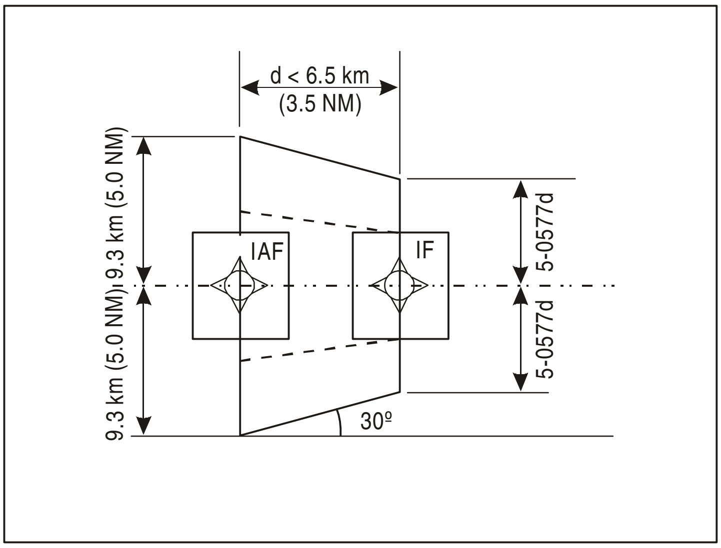


**Figure I-4-3-App B-6. RNAV area**

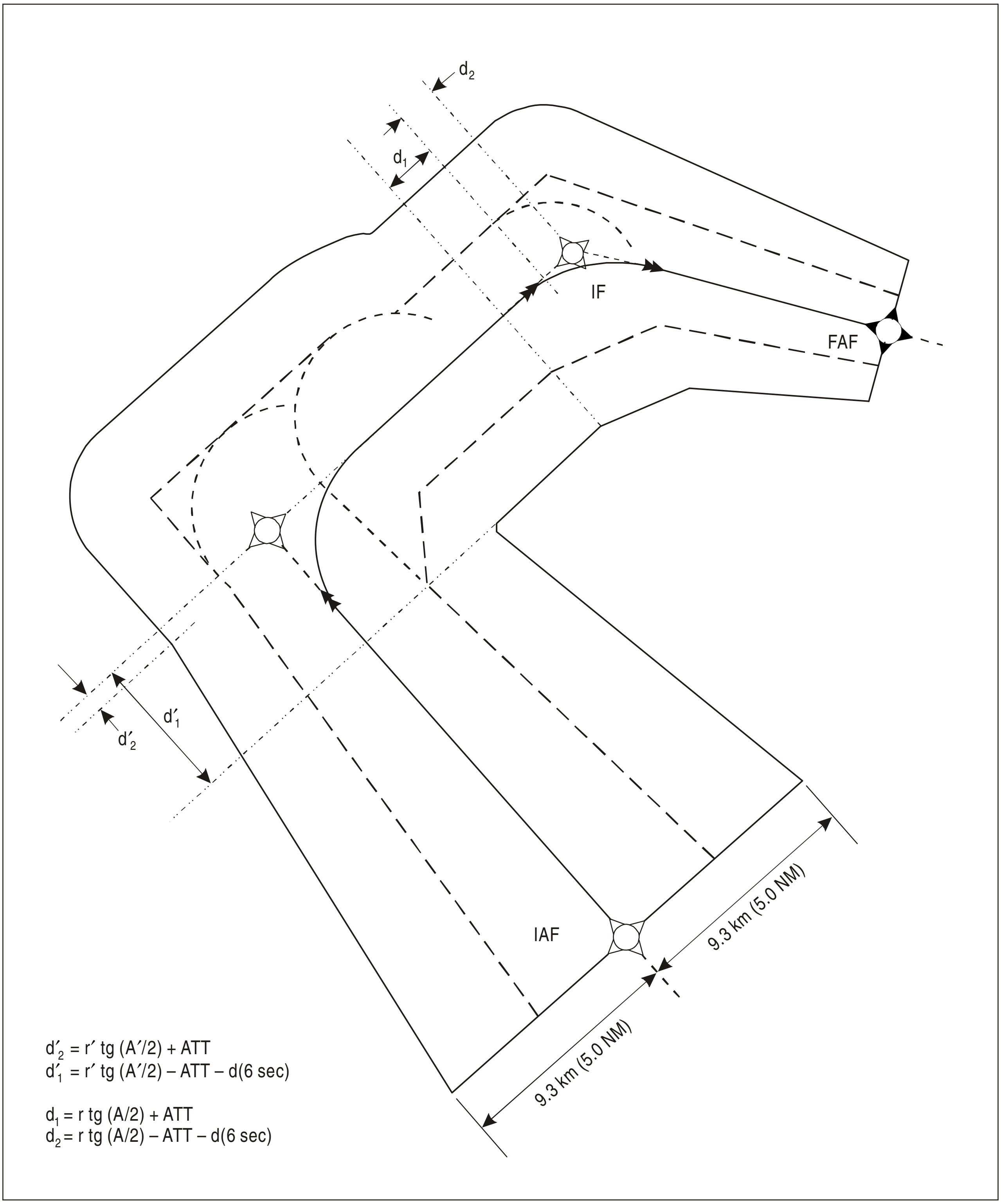


**Figure I-4-3-App B-7. RNAV turn protection**

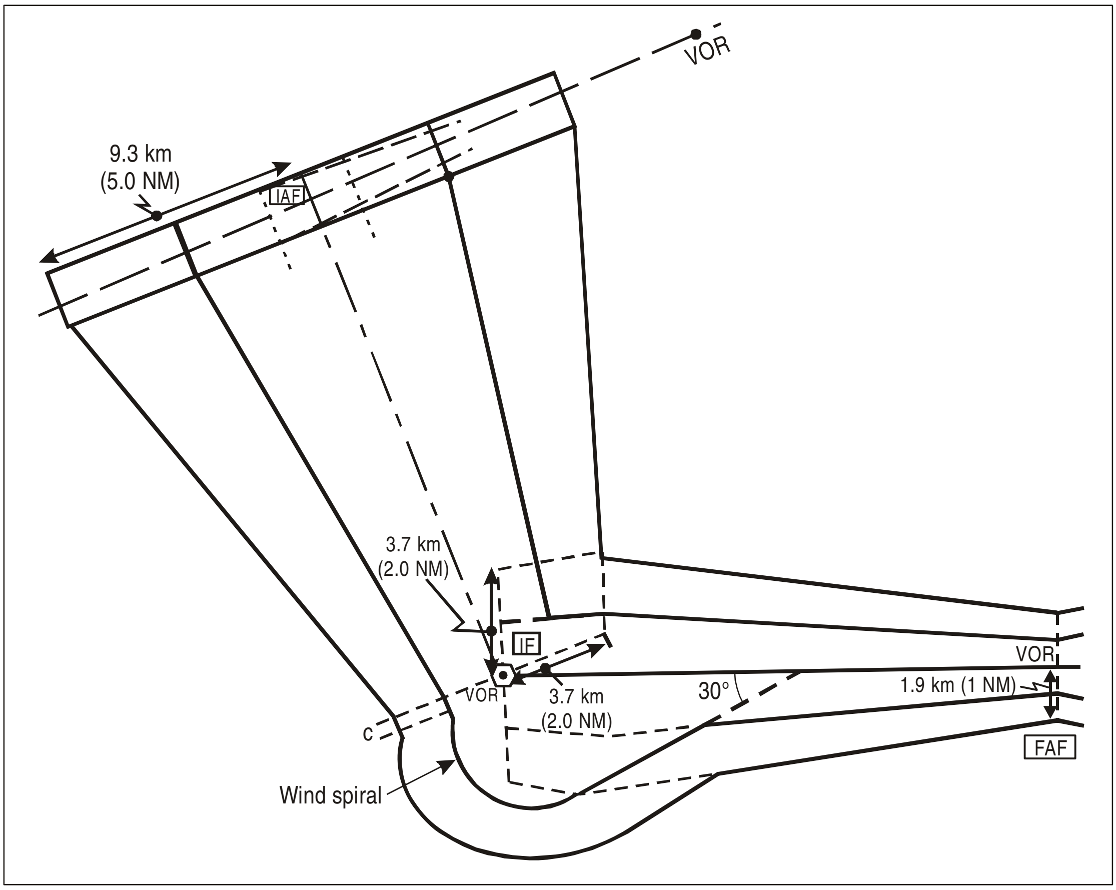


**Figure I-4-3-App B-8. Reduction in area widths — initial segment jointed to intermediate segment by a turn**

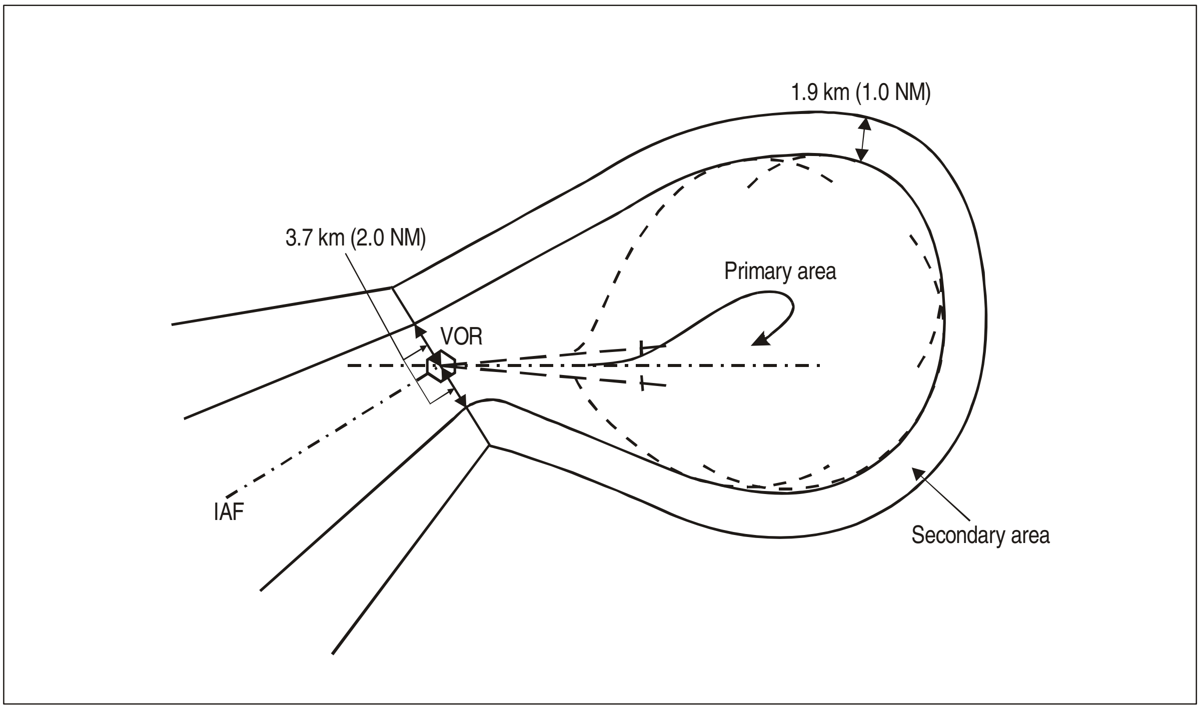


**Figure I-4-3-App B-9 Interface between primary and secondary areas of initial approach and reversal procedures (example with a VOR)**

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# Appendix C to Chapter 3

# CONSTRUCTION OF OBSTACLE CLEARANCE AREAS FOR REVERSAL AND HOLDING PROCEDURES

## 1. INTRODUCTION

The construction of obstacle clearance areas for reversal procedures (Part III, Section 3, Chapter 7) is based on the direct application of the tolerance criteria specified in Part I, Section 2, Chapter 2. These may be applied either on an additive tolerance basis, or using statistical methods.

## 2. STATISTICAL AREA CONSTRUCTION

If statistical methods are used to combine the variables and then to extrapolate distributions to develop areas, the probability level associated with that extrapolation should meet an acceptable level of safety.

## 3. ADDITIVE TOLERANCE AREA CONSTRUCTION

A variety of methods may be used; whichever method is used, the criteria and parameters given in 3.5 of Part III, Section 3, Chapter 7 apply. The method described in this attachment is the template tracing technique (TTT).

### 3.1 Protection area of a base turn

3.1.1 *General*

The primary area of a base turn can be drawn either by applying the construction method of the template specified in 3.1.2 of this attachment or by using one of the precalculated templates contained in the *Template Manual for Holding, Reversal and Racetrack Procedures* (Doc 9371) for the appropriate timing, speed and altitude. This template caters for all factors which can cause an aircraft to deviate from the nominal track, tolerances of the navigational facility, flight technical tolerances and wind effect, so that it represents the primary area of the base turn.

3.1.2 *Construction of the base turn template*
*(Reference Table I-4-3-App C-1 and*
*Diagram I-4-3-App C-1)*

3.1.2.1 Draw a line representing the axis of the procedure and locate point "a" on the fix — draw the nominal outbound leg and inbound turn:

— *angle between outbound leg and procedure axis:* θ (Table I-4-3-App C-l, line 10)

— *outbound leg length:* L (Table I-4-3-App C-l, line 13)

— *radius of turn:* r (Table I-4-3-App C-l, line 5).

3.1.2.2 *Protection of the outbound leg* From “a” draw two lines at an angle of 5.2° for a VOR and 6.9° for an NDB on each side of the nominal outbound leg. Locate points bl, b2, b3 and b4 on these lines (Table I-4-3-App C-l, lines 14 and 15). These points determine the area containing the beginning of the inbound turn.

3.1.2.3 *Protection of the inbound turn*

3.1.2.3.1 With a centre on c2 at a distance r from b2 on the perpendicular to the nominal outbound leg and a radius r, draw an arc beginning at b2. Locate points d and e after 50 and 100 degrees of turn after b2. Similarly, draw an arc beginning at b4 and locate point f after 100 degrees of turn after b4 and draw an arc beginning at b3 and locate points i and j after 190 and 235 degrees of turn after b3.

3.1.2.3.2 *Influence of the wind*

a) The wind effect is calculated for each point of the turn by multiplying E, the wind effect during one degree, by the number of degrees of turn;

b) draw arcs with centres d, e, f, i and j and radii $W_d$, $W_e$,$W_f$ , $W_i$ and $W_j$ (Table I-4-3-App C-1, lines 16 to 19). The arc centred on f is called arc f;

c) draw a line tangent to the arc centred on e (or f if more conservative) making an angle d (Table I-4-3-App C-1, line 20) with the perpendicular to the inbound track and locate point k at its intersection with the inbound track. With a centre on C5 at a distance r from k on the nominal inbound track, and a radius r, draw an arc beginning at k. Locate points g and h after 50 and 100 degrees of turn after k; and

d) draw arcs with centres g and h and radii $W_g$ and $W_h$ (Table I-4-3-App C-1, lines 16 and 17).

3.1.2.4 *Drawing of the protection area of the base turn.* The outline of the protection area is composed of:

a) the spiral envelope of the arcs centred on “d” and “e”;

b) the spiral envelope of the arcs centred on “g” and “h”;

c) the spiral envelope of the arcs centred on “i” and “j”;

d) the tangent to the spiral a) passing through “a”;

e) the tangent to the spirals a) and b) or the tangent to the spiral a) and arc f, a portion of arc f, and the tangent to arc f and b);

f) the tangent to the spirals b) and c); and

g) the tangent to the spiral c) passing through “a”.

*Note.— If point a lies within spiral c), the outbound time should be increased.*

3.1.2.5 *Protection of the entry*

3.1.2.5.1 *Entry along a straight segment (see 3.2.5)*

3.1.2.5.2 *Entry along a holding or racetrack procedure (see Diagram I-4-3-App C-2)*

3.1.2.5.2.1 Let ø be the angle between the inbound track of the holding or racetrack procedure and the outbound track of the base turn. From a, draw line E making an angle α from the nominal outbound track and draw the position fix tolerance area with reference to that line, as described in 3.3.2.2.4.4 for a VOR and 3.3.2.2.4.5 for an NDB.

3.1.2.5.2.2 Draw line E' parallel to E passing through $V_3$ (respectively $N_3$) and locate point *l* (Table I-4-3-App C-1, line 21). Draw an arc of 100° with a radius r tangent to line E' at *l* and locate points m and n after 50° and 100° of turn from *l*. Draw arcs with centres *l*, m and n and radii $W_l$, $W_m$ and $W_n$ (Table I-4-3-App C-1, lines 22, 23 and 24).

3.1.2.5.2.3 Draw the spiral envelope of the arcs centred on *l*, m and n and its tangent from $V_3$ (respectively $N_3$).

3.1.2.5.2.4 Draw the tangent between the entry spiral above and the protection area of the base turn.

3.1.3 *Secondary area*

Draw the secondary area limit at a distance of 4.6 km (2.5 NM) from the boundary of the primary area.

*Note.— See Appendix B to Chapter 3 for a possible reduction of the width of the secondary area.*

## 3.2 Protection area of a procedure turn

3.2.1 *General*

The construction of the protection area of a procedure turn is made in two steps.

a) The first is to construct a procedure turn template (see 3.2.2 or 3.2.3) or to use one of the precalculated templates contained in the *Template Manual for Holding, Reversal and Racetrack Procedures* (Doc 9371) for the appropriate speed and altitude. This template caters for all factors which can cause an aircraft to deviate from the nominal track, except those which define the tolerance area of the beginning of the outbound track.

b) The second step is to draw the protection area of the procedure turn by moving the template point "a" around the tolerance area of the beginning of the outbound turn as described in 3.2.4 of this attachment.

3.2.2 *Construction of the 45° — 180° procedure turn template*
*(Reference Table I-4-3-App C-2 and*
*Diagram I-4-3-App C-3)*

3.2.2.1 *Nominal track.* Draw a line representing the axis of the procedure and locate points "a" and "b" on it (Table I-4-3-App C-2, line 10). Beginning at "b" and ending at "c", draw the nominal outbound turn of 45°. Draw between "c" and "d" the nominal outbound leg and beginning at "d" the nominal inbound turn of 180°.

— *radius of the turns*: r (Table I-4-3 App C-2, line 5)

— *outbound leg length*: cd (Table I-4-3 App C-2, line 11).

3.2.2.2 *Influence of the flight technical tolerances*

a) From “c” draw two lines at 5 degrees on each side of the nominal outbound leg.

b) Locate points “d1”, “d2”, “d3” and “d4” on these lines (Table I-4-3 App C-2, lines 12 and 13).

c) With a centre on “e2” at a distance r from “d2” on the perpendicular line to the nominal outbound leg (line passing through d2 and d4), and a radius r, draw the inbound turn beginning at “d2”. Locate points “f” and “g” after 50 and 100 degrees of turn from “d2”. With centres on “e3” and “e4”, draw the corresponding arcs beginning at “d3” and “d4”. Locate points “h”, “i” and “j” after 100, 150 and 200 degrees from “d4” and points “k” and “l” after 200 and 250 degrees of turn from “d3”.

3.2.2.3 *Influence of the wind*

a) The wind effect is calculated for each point by multiplying the wind speed w by the flying time from point “a”.

b) Draw arcs with centres “c”, “d2”, “f”, “g”, “h”, “i”, “j”, “k” and “l” and radii $W_c$, $W_{d2}$, $W_f$, $W_g$, $W_h$, $W_i$, $W_j$, $W_k$ and $W_l$ (Table I-4-3 App C-2, lines 14 to 21).

3.2.2.4 *Drawing of the outline of the template.* The outline of the template is composed of:

a) the tangent passing through “a” to the arc centred on “c”;

b) the common tangent to the arcs centred on “c” and “d2”;

c) the spiral envelope of the arcs centred on “d2”, “f” and “g”;

d) the spiral envelope of the arcs centred on “h”, “i” and “j”;

e) the spiral envelope of the arcs centred on “k” and “l”;

f) the common tangent to the spirals c) and d);

g) the common tangent to the spirals d) and e); and

h) the tangent passing through “a” to the spiral e).

3.2.3 *Construction of the 80° — 260° procedure turn template*
(Reference Table I-4-3-App C-3 and
Diagram I-4-3-App C-4)

3.2.3.1 *Nominal track.* Draw a line representing the axis of the procedure and locate points “a” and “b” on it (Table I-4-3-App C-3, line 10). With a centre “c” at a distance r (Table I-4-3-App C-3, line 5) from “b” on the perpendicular line to the procedure axis passing through “b”, draw the nominal outbound turn of 80° and locate point “d” at the end of this turn. From “d” draw the tangent to the nominal outbound turn and locate point “e” on this tangent (Table I-4-3-App C-3, line 11). With a centre on “f” and a radius r, draw the nominal inbound turn of 260° beginning at “e”.

3.2.3.2 *Influence of the flight technical tolerances*

a) On the nominal outbound turn, locate points “dl” and “d2” after 75 and 85 degrees of turn from “b”.

b) From “dl” and “d2”, draw the tangents to the outbound turn and locate points “el” and “e2” on these tangents (Table III-C-3, line 11).

c) With a centre on “f2” at a distance r from “e2” on the perpendicular line to d2e2, draw the inbound turn at “e2”. Locate points “g”, “h”, “i” and “j” after 45, 90, 135 and 180 degrees of turn from “e2”.

d) With a centre on “fl”, draw the inbound turn beginning at “el” and locate points “k”, “l” and “m” after 180, 225 and 270 degrees of turn from “el”.

3.2.3.3 *Influence of the wind*

a) The wind effect is calculated for each point by multiplying the wind speed w by the flying time from the point “a”, beginning of the turn.

b) Draw arcs with centres “e2”, “g”, “h”, “i”, “j”, “k”, “l” and “m” and radii $W_{e2}$, $W_g$, $W_h$, $W_i$, $W_j$, $W_k$ and $W_l$ (Table I-4-3-App C-3, lines 12 to 19).

3.2.3.4 *Drawing of the outline of the template.* The outline of the template is composed of:

a) the spiral envelope of the arcs centred on “e2”, “g”, “h”, “i” and “j”;

b) the spiral envelope of the arcs centred on “k”, “l” and “m”;

c) the common tangent to the spirals a) and b);

d) the tangent passing through “a” to the spiral a); and

e) the tangent passing through “a” to the spiral b).

3.2.4 *Drawing of the protection area of the procedure turn*
(Reference Diagram I-4-3-App C-5)

3.2.4.1 *Tolerance area of the beginning of the outbound turn*

3.2.4.1.1 From the facility, point 0, draw the radial of the procedure and its two protection lines. These lines make an angle of 6.9° if the facility is NDB, 5.2° if the facility is a VOR, or 2.4° if the facility is a localizer, on each side of the radial.

3.2.4.1.2 Locate point A on the nominal beginning of the outbound turn.

3.2.4.1.3 According to the type of facility at 0 and eventually at A or 0, draw the tolerance area of point A Al A2 A3 A4 as described on the Figures I-4-3-App C-1 to I-4-3-App C-5.

*Note.— Units in following formulas:*

| | *SI units* | *Non-SI units* |
|---|---|---|
| *t* | *s* | *s* |
| *v and w'* | *km/s* | *NM/s* |
| *Distances* | *Km* | *NM* |

The values of v, w' and h are given by Table I-4-3-App C-1 (lines 3, 8 and 6 respectively). D is the specified DME distance expressed in km (NM) and d1 is the tolerance of this DME indication:

d1 = 0.46 km (0.25 NM) + 0.0125 D

3.2.4.2 *Primary area*

a) Place the template point "a" on "Al", with the template procedure axis parallel to the inbound track, and draw the curve "l" (part of the outline of the template).

b) In the same manner, place the template point "a" successively on "A2", "A3" and "A4" to draw curves "2", "3" and "4".

c) Draw the common tangents to curves "1" and "2", "2" and "4", "3" and "4" and the tangent from "0" to curve "l" and from "0" to curve "3".

3.2.4.3 *Secondary area.* Draw the secondary area limit at a distance of 4.6 km (2.5 NM) from the boundary of the primary area.

3.2.5 *Interface between initial segment area and base and procedure turn areas*

3.2.5.1 *General.* The primary area of the initial segment, the boundaries of which are 4.6 km (2.5 NM) apart from the nominal path, shall be blended with the primary area of the turn procedure, which is described above in 3.1.2 (base turn) and 3.2.4 (procedure turn). The secondary areas of the two phases of the procedure shall be blended so that a constant width of 4.6 km (2.5 NM) is respected.

3.2.5.2 *Construction of the secondary area outerboundary (see Figures I-4-3-App C-6 and I-4-3-App C-7).* On one side of the initial segment path the outer boundaries of the two secondary areas will intersect. On the other side of the initial segment path, the outer boundary of the secondary area consists of an arc of circle, 9.2 km (5 NM) from the facility, and the tangent to that circle and the outer boundary of the secondary area of the turn.

3.2.5.3 *Construction of the primary area boundary.* The boundary of the primary area is drawn in 4.6 km (2.5 NM) from the outer boundary of the secondary area.

### 3.3 Protection area of racetrack and holding procedures

3.3.1 *General*

*Note.— The methods described in this paragraph are related to right turn procedures. For left turn procedures, the corresponding areas are symmetrical with respect to the inbound track.*

3.3.1.1 The protection area of a racetrack procedure consists of a primary area and a secondary area; the protection area of a holding procedure consists of an area and a buffer area. Since the construction of the primary area of a racetrack and of the area of a holding is the same, they are referred to by the same term hereafter — *the basic area of the procedure.*

3.3.1.2 The construction of the basic area of the procedure is made in two steps.

3.3.1.2.1 The first step is to construct a template or to take a precalculated one from the *Template Manual for Holding, Reversal and Racetrack Procedures* (Doc 9371), for the appropriate time, speed and altitude. This template caters for all factors which can cause an aircraft to deviate from the nominal pattern except those related to the fix tolerance area. It is applicable to all types of procedures including VOR or NDB overhead, intersection of VOR radials, VOR/DME and their entries.

3.3.1.2.2 The second step is to draw the basic area of the procedure by moving the template-origin around the fix tolerance area for procedures overhead a facility or at the intersection of VOR radials, or by using it as described in 3.3.4 for VOR/DME procedures, and by adding areas to protect entries as required.

3.3.1.3 Finally, a secondary area of 4.6 km (2.5 NM) is added around the basic area for a racetrack, and a buffer area of 9.3 km (5.0 NM) is added around the basic area for a holding.

3.3.2 *First step: construction of the template*
*(Reference Table I-4-3-App C-4 and Diagram I-4-3-App C-6)*

3.3.2.1 The parameters used in the construction of the template are contained in Chapter 3, 3.6.2 for the racetrack and in Part II, Section 4, Chapter 1, 1.3, "Construction of holding areas", for the holding procedures.

3.3.2.2 After completion of the calculations indicated in Table I-4-3-App C-4, the template is constructed as follows.

3.3.2.2.1 Draw a line representing the axis of the procedure and the nominal pattern. Locate point "a" at the procedure fix. (The radius of turn r is given at line 5 and the outbound length L is given at line 11 of Table I-4-3-App C-4.)

3.3.2.2.2 *Influence of the navigation tolerances*

3.3.2.2.2.1 Locate points "b" and "c" on the procedure axis (Table I-4-3-App C-4, lines 12 and 13); "b" and "c" represent the earliest (5 s after "a") and the latest (11 s after "a") still air positions of the beginning of the outbound turn.

3.3.2.2.2.2 Draw an arc of 180° with a radius r tangent to the procedure axis at "c", which represents the latest still air outbound turn. Locate points "d", "e", "f" and "g" after 45, 90, 135 and 180° of turn from "c".

3.3.2.2.2.3 Draw an arc of 270° with a radius r tangent to the procedure axis at "b", which represents the earliest still air outbound turn. Locate points "h", "o" and "p" after 180, 225 and 270° of turn from "b".

3.3.2.2.2.4 From "g" draw two lines at 5° on each side of the nominal outbound leg. Locate points "il", "i2", "i3" and "i4'" on these lines (Table I-4-3-App C-4, lines 14 and 15). "i1" and "i3" are plotted (60T – 5) seconds after "g"; "i2" and "i4" should be (60T + 15) seconds after "h", but for the sake of simplification they are plotted (60T + 21) seconds after "g". il i2 i3 i4 determine the area containing the still air position of the beginning of the inbound turn.

3.3.2.2.2.5 With a centre at a distance r below “i2” on the perpendicular line to the nominal outbound leg, and a radius r draw an arc of 180° beginning at “i2” and ending at “n2”. Locate points “j” and “k” after 45 and 90° of turn from “i2”. Draw the corresponding arc beginning at “i4” and ending at “n4”. Locate points “1” and “m” after 90 and 135° of turn from “i4”.

3.3.2.2.2.6 The end of the inbound turn in still air conditions is contained in the area nl n2 n3 n4 reduced from il i2 i3 i4 by a translation of one diameter of nominal turn.

3.3.2.2.3 *Influence of the wind*

3.3.2.2.3.1 The wind effect is calculated for each point by multiplying the wind speed (Table I-4-3-App C-4, line 7) with the flying time from “a” to the point.

3.3.2.2.3.2 *Influence of the wind during the outbound turn:* Draw arcs with centres “b”, “c”, “d”, “e” and “f” and radii $W_b$, $W_c$, $W_d$, $W_e$ and $W_f$ (Table I-4-3-App C-4, lines 16 to 20).

3.3.2.2.3.3 The area containing the end of the outbound turn is determined by two arcs with centres ‘‘g’’ and ‘‘h’’ and radii $W_g$ and $W_h$ (Table I-4-3-App C-4, lines 21 and 22) and their common tangents.

3.3.2.2.3.4 The area containing the beginning of the inbound turn is determined by the four arcs with the centres ‘‘i1’’, ‘‘i2’’, ‘‘i3’’ and ‘‘i4’’ and radii $W_{i1}$, $W_{i2}$, $W_{i3}$ and $W_{i4}$ (Table I-4-3-App C-4, lines 25 and 26) and their four common tangents.

3.3.2.2.3.5 *Influence of the wind during the inbound turn:* Draw arcs with centres ‘‘j’’, ‘‘k’’, ‘‘l’’, ‘‘m’’, ‘‘n4’’ and ‘‘n3’’ and radii $W_j$, $W_k$, $W_l$, $W_m$, $W_{n4}$ and $W_{n3}$ (Table I-4-3-App C-4, lines 27 to 31).

3.3.2.2.3.6 Draw arcs with centres ‘‘o’’ and ‘‘p’’ and radii $W_o$ and $W_p$ (Table I-4-3-App C-4, lines 23 and 24).

3.3.2.2.4 *Drawing of the template*

3.3.2.2.4.1 The outline of the template is composed of:

a) the spiral envelope of the arcs centred on ‘‘c’’, ‘‘d’’, ‘‘e’’, ‘‘f’’ and ‘‘g’’;

b) the arc centred on ‘‘il’’ and the common tangent to this arc and the spiral a);

c) the common tangent to the arcs centred on ‘‘i1’’ and ‘‘i2’’;

d) the spiral envelope of the arcs centred on “i2”, “j” and “k”, the spiral envelope of the arc centred on “l”, “m” and “n4” and their common tangent;

e) the arcs centred on “n3” and “n4” and their common tangent; and

f) the tangent to the arc centred on “n3” and to the spiral a).

3.3.2.2.4.2 The protection of the outbound leg in the direction of the D axis is represented by the common tangents to the arcs centred on “g”, “i3” and “i4”, called line “3” (see Diagrams I-4-3-App C-6, I-4-3-App C-7 and I-4-3-App C-8).

3.3.2.2.4.3 The protection of a turn of more than 180° is represented by:

a) the spiral envelope of the arcs centred on "c", "d", "e", "f" and the tangent to this spiral passing through "a"; and

b) the spiral envelope of the arcs centred on "h", "o" and "p" and the tangent to this spiral and to the area drawn in 3.3.2.2.3.3.

3.3.2.2.4.4 *VOR position fix tolerance area*

a) *Manual construction.* The VOR position fix tolerance area Vl V2 V3 V4 is determined as follows (see Figure I-4-3-App C-8):

   1) draw a circle with centre on the VOR and a radius of zV:

      zV = h tan $\alpha$

      where $\alpha$ is 50° or a lesser value, as determined by the appropriate authority (see Part I, Section 2, Chapter 2, 2.5.1), corresponding to the cone effect;

   2) draw two lines 5° from the perpendicular to the inbound track;

   3) draw two lines perpendicular to lines 2) at a distance qV on each side of the inbound track:

      qV = 0.2 h (h in km and qV in km)
      qV = 0.033 h (h in thousands of feet and qV in NM);

   4) locate points Vl, V2, V3, V4 at the four intersections of lines 3) with the circle 1).

b) *Use of template.* See the *Template Manual for Holding, Reversal and Racetrack Procedures* (Doc 9371).

3.3.2.2.4.5 *NDB position fix tolerance area*

a) *Manual construction.* The NDB position fix tolerance area Nl N2 N3 N4 is determined as follows (see Figure I-4-3-App C-9):

   1) draw a circle with centre on the NDB (point "a") and a radius zN = h tan 40° to obtain the cone effect area;

   2) draw the parallel lines at a distance qN = zN sin 15° on each side of the inbound track;

   3) draw two lines making an angle of 5° with the precedents on the points "N2" and "N4"; and

   4) locate points "Nl" and "N3" at the intersections of the lines 3) and the circle 1).

b) *Use of template.* See the *Template Manual for Holding, Reversal and Racetrack Procedures* (Doc 9371).

3.3.2.2.4.6 *Point "R".* This point is used to determine the lowest position of the limiting radial, so that this radial does not cross the area containing the end of the outbound turn. It is located as follows:

a) draw the tangent to the area containing the end of the outbound turn passing through the intersection point of the outline of the template with the C axis; and

b) locate point "R" at the intersection of this tangent with the curve drawn in 3.3.2.2.4.3 b).

3.3.2.2.4.7 *Point "E".* This point is used to determine the omnidirectional entry area in the direction of the C and D axis. It is located by its coordinates XE and YE from the outline of the template:

a) draw a line perpendicular to the inbound track at a distance XE (Table I-4-3-App C-4, line 32) from the extreme position of the outline of the template in the direction of the C axis (common tangent to the circles centred on "k" and "l");

b) draw a line parallel to the inbound track at a distance YE (Table I-4-3-App C-4, line 33) from the extreme position of the outline of the template in the direction of the D axis (circle centred on "n4"); and

c) locate point "E" at the intersection of these two lines.

Explanation:

XE is the greatest displacement along the C axis of an aeroplane making an entry procedure. This occurs for a sector 3 entry at an angle of 90° with the procedure axis and a wind along the C axis (see Figure I-4-3-App C-10).

The maximum displacement along the C axis due to wind effect occurs at point $E_{max}$, after that portion of turn corresponding to the drift angle. For simplicity this angle has a value of 15° in the formula.

$$XE = 2r + (t + 15)v + (11 + 90/R + t + 15 + 105/R)w'$$

YE is the greatest displacement along the D axis of an aeroplane making an entry procedure. This occurs for a sector 1 entry at an angle of 70° with the procedure axis and a wind along the D axis (see Figure I-4-3-App C-11).

The maximum displacement along the D axis due to wind effect occurs at point $E_{max}$, after that portion of turn corresponding to the drift angle. For simplicity, this angle has a value of 15° in the formula.

$$YE = 11v \cos 20° + r \sin 20° + r + (t + 15)\, v \tan 5° + (11 + 20/R + 90/R + t + 15 + 15/R)w'$$

### 3.3.3 *Second step: construction of the basic area and the associated omnidirectional entry area overhead a VOR or NDB or at the intersection of VOR radials*

#### 3.3.3.1 *Construction of the basic area (Reference Diagram I-4-3-App C-9)*

##### 3.3.3.1.1 *Procedure fix tolerance area*

###### 3.3.3.1.1.1 *Procedure overhead a VOR*

a) Locate point "A" on the VOR; and

b) draw around "A" the position fix tolerance area of the VOR given by the template (area Vl V2 V3 V4) and locate points "Al", "A2", "A3" and "A4" on the four corners of this area.

3.3.3.1.1.2 *Procedure overhead an NDB*

a) Locate point “A” on the NDB; and

b) draw around “A” the position fix tolerance area of the NDB given by the template (area Nl N2 N3 N4) and locate points “Al”, “A2”, “A3” and “A4” on the four corners of this area.

3.3.3.1.1.3 *Procedure at the intersection of VOR radials*

a) Locate point “A” at the intersection of the homing and intersecting radials; and

b) draw around “A” the position fix tolerance area determined by the tolerances of the homing and intersecting radials Part I, Section 2, Chapter 2, 2.3.3, “System use accuracy” and locate points “Al”, “A2”, “A3” and “A4” on the four corners of this area.

3.3.3.1.2 *Construction of the procedure area*

3.3.3.1.2.1 Place the template point “a” on A3, with the template procedure axis parallel to the inbound track, and draw the curve “3” (part of the outline of the template) and the line “3” (protection of the outbound leg in the direction of the D axis).

3.3.3.1.2.2 Place the template point “a” successively on “Al”, “A2” and “A4” to draw curves “l”, “2” and “4”.

3.3.3.1.2.3 Draw the common tangents to curves “l” and “2”, “2” and “4”, “3” and “4”, “3” and “1”.

3.3.3.2 *Construction of the entry area*

3.3.3.2.1 *Construction of the entry area assuming omnidirectional entry overhead a VOR or an NDB (Reference Diagrams I-4-3-App C-10, I-4-3-App C-11 and I-4-3-App C-12)*

3.3.3.2.1.1 Draw the circle centred on “A” passing through “Al” and “A3”.

3.3.3.2.1.2 Locate point “E” on a series of points along this circle (with the template axis parallel to the inbound track) and for each point draw a curve at the outer limit of the template in the direction of the C and D axis; curve “5” is the envelope of these curves.

3.3.3.2.1.3 Draw the limit of the entry sectors 1 and 3 (line making an angle of 70° with the inbound track). With the template axis on this line, draw the entry fix tolerance area El E2 E3 E4 given by the template for the VOR or the NDB.

3.3.3.2.1.4 Place the template point “a” on El and E3 (with the template axis parallel to the separating line of the sectors 1 and 3) and draw curves “6” and “7” and their common tangent.

3.3.3.2.1.5 With a centre on “A”, draw the arc tangent to curve “6” until intersecting curve “1”.

3.3.3.2.1.6 Line 8 is the symmetric of lines 6 and 7 about the 70° dividing line. Draw common tangents to curves “5”, “6”, “7” and “8” as appropriate.

3.3.3.2.2 *Construction of the entry area assuming entries along the homing and intersecting radial in the case of a procedure based on the intersection of VOR radials (Reference Diagram I-4-3-App C-14*)

3.3.3.2.2.1 *Protection of the entry along the reciprocal of the inbound track*. Place the template point "E" on "A2" and "A4" (with the template axis parallel to the inbound track) and draw curves "5" and "6" (parts of the outline of the template) and their common tangent.

3.3.3.2.2.2 *Protection of the entries along the intersecting radial.* In addition to the area provided by the curves "5" and "6" above, if the intersecting VOR is located in sector 2 or in the part of sector 3 opposite to sector 2 the protection area is determined as follows.

3.3.3.2.2.2.1 Determine the entry fix tolerance area El E2 E3 E4 by applying the tolerance for a homing VOR (Part I, Section 2, Chapter 2, Table I-2-2-1) to the intersecting radial and the tolerance for an intersecting VOR (Part I, Section 2, Chapter 2, Table I-2-2-1) to the homing radial.

3.3.3.2.2.2.2 Place the template point "a" on E3 and E4 (with the template axis parallel to the intersecting radial) and draw curves "7" and "8" (protection of a turn of more than 180°: inner curve of the template) and their common tangent.

3.3.3.3 *Area reduction for a procedure overhead a facility when entries from Sector 1 are not permitted (Reference Diagram I-4-3-App C-13)*

3.3.3.3.1 If the aircraft intercepts the procedure radial before the end of the outbound leg, the pilot is assumed to follow the indications of this radial without drifting any further from the procedure axis.

3.3.3.3.2 If line 3 intersects the protection line of the procedure axis (VOR or NDB along track errors) the area may be reduced as shown on Diagram I-4-3-App C-13; rotate the template 180° and place point "a" on the protection line of the procedure axis, tangent to the area in the direction of the C axis; draw a parallel line to the protection line, tangent to the entry curve. The area under that parallel, in the direction of the D axis, may be eliminated.

3.3.3.3.3 This reduction is allowed only when entries from Sector 1 are not permitted.

3.3.4 *Construction of the basic area and the associated along-the-radial entry area for VOR/DME procedure*

3.3.4.1 *Procedure towards the station (Reference Diagram I-4-3-App C-15)*

3.3.4.1.1 *Construction of the basic area*

3.3.4.1.1.1 *Selection and calculation of the distance parameters (see Figure I-4-3-App C-12).* The distance parameters are chosen and calculated in the following sequence:

a) choice of the nominal distance: D

   D is the slant range between the VOR/DME facility and the procedure point at the specified altitude;

b) choice of the outbound distance: ds

   ds is the horizontal length of the outbound leg; ds should conform to the relationship ds > vt, where t is the outbound timing, as specified in Chapter 3, 3.5.5, "Outbound time" for racetrack procedures and in Part II, Section 4, Chapter 1, 1.3.2.2, "Outbound timing" for holding procedures;

c) calculation of the horizontal distance: Ds

Ds is the distance between the VOR/DME facility (S) and the projection of the procedure point on the horizontal plane passing through S (point A)

$$\text{Ds} = \sqrt{\text{D}^2 - \text{hl}^2}$$

(Ds, D and hl in km); or

$$\text{DS} = \sqrt{\text{D}^2 - 0.027\ \text{hl}^2}$$

(Ds and D in NM and hl in thousands of feet)

d) calculation of the limiting outbound distance: DL

DL is the slant range between the VOR/DME facility and the end of the outbound track at the specified altitude

$$\text{DL} = \sqrt{(\text{Ds} + \text{ds})^2 + 4\text{r}^2 + \text{hl}^2}$$

(DL, Ds, ds, r, hl in km); or

$$\text{DL} = \sqrt{(\text{Ds} + \text{ds})^2 + 4\text{r}^2 + 0.027\ \text{hl}^2}$$

(DL, Ds, ds, r in NM and hl in thousands of feet)

DL is then rounded to the next higher km (or NM), unless the decimal part is less than 0.25 km (or NM) in the case of a procedure at or below 4 250 m (or 14 000 ft) or 0.5 km (or NM) in the case of a procedure above 4 250 m (or 14 000 ft), in which case it is rounded to the next lower km (or NM);

e) calculation of the horizontal limiting outbound distance: DLs

DLs is the distance between the VOR/DME facility and the vertical projection of the end of the outbound track onto the horizontal plane passing through S

$$\text{DLs} = \sqrt{\text{DL}^2 - \text{hl}^2}$$

(DLs, DL, hl in km); or

$$\text{DLs} = \sqrt{\text{DL}^2 - 0.027\ \text{hl}^2}$$

(DLs, DL in NM and hl in thousands of feet)

3.3.4.1.1.2 *Fix tolerance area and limiting outbound distance*

a) Draw from S the procedure radial "RP" and two lines "RP1" and "RP2" making an angle $\alpha$ (tolerance for a homing VOR, Part I, Section 2, Chapter 2, Table I-2-2-1) with RP on each side of it;

b) with a centre on S, draw arcs “Ds” with a radius Ds, “Dl” with a radius Ds – dl, “D2” with a radius Ds + dl, “DLs”, “DL1” and “DL2” with radii DLs, DLs – d2 and DLs + d2

where dl and d2 are the DME tolerance associated with D and DL:
dl is 0.46 km (0.25 NM) + 0.0125 D;
d2 is 0.46 km (0.25NM) + 0.0125 DL

c) locate points “A” at the intersection of “RP” and “Ds”
“Al” and “A2” at the intersections of “RP1”
with “Dl” and “D2”
“A3” and “A4” at the intersections of “RP2”
with “D1” and “D2”.

3.3.4.1.1.3 *Protection of the outbound turn and outbound leg*

a) Place racetrack template point “a” on Al, with axis parallel to the inbound track, and draw curve “1” (part of the outline of the template);

b) place template point “a” on A3, with axis parallel to the inbound track, and draw curve “2” (part of the outline of the template) and line “3” (protection of the outbound leg on the non-manoeuvring side); and

c) draw the common tangent to curves “1” and “2” and extend the straight part of curve “1” and the line “3” in the direction of the outbound end.

3.3.4.1.1.4 *Area containing the end of the outbound leg*

a) Locate points Cl and C’3 at the intersection of the extension of curve “l” with the arcs DL1 and DL2;

b) locate point C2 between Cl and C’3 at a distance (dl + d2 – 1.8) km or (dl + d2 – 1) NM from C’3;

c) draw a parallel line to the inbound track through C2 and locate points C3 at the intersection of this line with arc DL2;

d) do the same thing as in a), b) and c) with the line “3” instead of curve “l” and points C4, C’6, C5 and C6 instead of Cl, C’3, C2 and C3 (see Figure I-4-3-App C-13 a)); and

e) if the aircraft intercepts the VOR radial before reaching the limiting outbound distance, the pilot is assumed to follow the indications of the VOR without drifting any further from the procedure axis, so:

where C5 and C6 are further from the procedure axis than RP2 (see Figure I-4-3-App C-13 b)), replace C5 and C6 by the intersections of RP2 with line “3” and DL2, and the end of the outbound leg is contained in the area Cl, C2, C3, C4, C5 and C6; and

where C4, C5 and C6 are further from the procedure axis than RP2 (see Figure I-4-3-App C-13 c)), replace C4 and C6 by the intersections of RP2 with DL1 and DL2, and the end of the outbound leg is contained in the area Cl, C2, C3, C4 and C6.

3.3.4.1.1.5 *Protection of the inbound turn.* Rotate the template 180°, then:

a) place template point “a” on C2 and C3, with axis parallel to the inbound track, and draw curves “4” and “5” (part of the protection line of a turn of more than 180°) and their common tangent;

b) move the template point "a" along arc DL2 from C3 to C6 (with axis parallel and opposite to the inbound track) and draw curve "6";

c) place template point "a" on C6, C4 and eventually on C5 and draw curves "7", "8" and eventually "9" and their common tangent; and

d) draw the tangent to curves "8" and "2".

3.3.4.1.2 *Construction of the entry areas*

3.3.4.1.2.1 *Arrival to a VOR/DME holding pattern may be:*

— along the axis of the inbound track;

— along a published track;

— by radar vectoring, when aircraft must be established on prescribed protected flight paths;

and the entry point may be either:

a) the holding fix; or

b) the fix at the end of the outbound leg.

*When the entry point is at the holding fix, two cases may be considered:*

*Case 1.1* — arrival via the VOR radial for the inbound leg;

*Case 1.2* — arrival via the DME arc defining the holding fix.

When the entry point is at the fix at the end of the outbound leg, the only case is arrival via the VOR radial passing through the fix at the end of the outbound leg.

3.3.4.1.2.2 It is also possible to make use of guidance from another radio facility (e.g. NDB); in that case, protection of the entry should be the subject of a special study based on general criteria.

3.3.4.1.2.3 The radius of a DME arc used as guidance for arrival at a VOR/DME holding should be not less than 18.5 km (10 NM).

3.3.4.1.2.4 The minimum length for the last segment of the arrival track terminating at the entry point is a function of the angle (θ) between the penultimate segment or radar path and the last segment. The values are shown in the following table:

| | θ | | | |
|---|---|---|---|---|
| | 0° – 70° | 71° – 90° | 91° – 105° | 106° – 120° |
| Minimum distance in km (NM) | 7.5 (4) | 9.5 (5) | 13 (7) | 16.5 (9) |

3.3.4.1.2.5 *Method of arrival at a VOR/DME holding and the corresponding entry procedures.* The methods are described in more detail as follows:

*Case 1* — entry at the holding fix;

*Case 1.1* — entry at the holding fix via a radial forming the fix:

a) *Arrival on the VOR radial for the inbound leg, on the same heading as the inbound track.* The arrival path (or last segment thereof) is aligned with the inbound track and follows the same heading. The entry consists of following the holding pattern (see Figure I-4-3-App C-14 a)).

   Protection of the entry: The entry is protected by the holding protection area.

b) *Arrival on the VOR radial for the inbound leg, on a heading reciprocal to the inbound track.* On arrival over the holding fix, the aircraft turns onto the holding side on a track making an angle of 30° with the reciprocal of the inbound track, until reaching the DME outbound limiting distance, at which point it turns to intercept the inbound track. In the case of a VOR/DME holding entry away from the facility with a limiting radial, if the aircraft encounters the radial ahead of the DME distance, it must turn and follow it until reaching the DME outbound limiting distance, at which point it turns to join the inbound track (see Figure I-4-3-App C-14 b)).

*Case 1.2* — entry at the holding fix via the DME arc forming the fix:

a) *Arrival on the DME arc defining the holding fix, from the holding side.* On arrival over the holding fix, the aircraft turns and follows a track parallel to and reciprocal to the inbound track, until reaching the DME limiting outbound distance, at which point it turns to intercept the inbound track (see Figure I-4-3-App C-14 c)).

b) *Arrival on the DME arc defining the holding fix, from the non-holding side.* On arrival over the holding fix, the aircraft turns and follows a track parallel to and on the same heading as the outbound track, until reaching the DME outbound limiting distance, at which point it turns to intercept the inbound track (see Figure I-4-3-App C-14 d)).

   An arrival track leading to a Case 1.2 a) entry should not be specified unless absolutely necessary, particularly in a VOR/DME holding procedure away from the facility. If an appropriate DME distance is chosen, this type of arrival can actually be replaced by one on a DME arc terminating in the extension of the inbound track (see Figures I-4-3-App C-14 e) and f)).

*Case 2* — entry at the fix at the end of the outbound leg via a radial forming the limiting fix:

a) outbound from the facility;

b) inbound from the facility.

On arrival over the fix at the end of the outbound leg, the aircraft turns and follows the holding pattern.

3.3.4.1.2.6 The sector 1 entry along the DME arc is protected as follows:

a) take a tracing of the template, turn it over and place point “a” on A3 with axis on the line Al, A3 to draw curve “13”;

b) draw the line “14” parallel to line “3” (used in the construction of the basic area) and tangent to curve “13”, and locate point C10 at the intersection of this line with arc DL2;

c) place point "a" of the tracing on C10, with axis parallel and opposite to the inbound track and move it along DL2 up to the intersection of DL2 and RP1 to draw curve "15".

3.3.4.1.2.7 *Protection of sector 2 entry procedure*

3.3.4.1.2.7.1 It is assumed that having passed the fix, the pilot makes good (±5° error) a track making an angle of 30° with the inbound track on the manoeuvring side and reaching the limiting outbound distance, turns inbound. In addition, the flying time on the 30° offset track is limited to 1 min 30 s after which the pilot is expected to turn to a heading parallel to the outbound track until reaching the limiting outbound distance, where the pilot turns inbound.

3.3.4.1.2.7.2 For a procedure with outbound of more than 1 min 30 s the protection of sector 2 entry procedure is assured by the basic area.

3.3.4.1.2.7.3 For a procedure with outbound of 1 min or 1 min 30 s, the protection area of sector 2 entry is drawn as follows:

a) from Al draw a line making an angle of 30° + 5° with RP and locate C7 at its intersection with DL2;

b) from A4 draw a line making an angle of 30° – 5° with RP and locate C8 at its intersection with DL2;

c) place template point "a" on C7 and move it along DL2 to C8, with axis making an angle of 30° with RP, to draw curve "11";

d) draw the common tangents to the curves "10" and "11" and to the basic area.

3.3.4.1.3 *Construction of the entry area for a reciprocal direct entry to a secondary point (Reference Diagram I-4-3-App C-16)*

3.3.4.1.3.1 It is assumed that reciprocal direct entries are made along the entry radial (RE) joining the VOR/DME station (S) to the secondary point (I) where the turn to inbound is initiated.

3.3.4.1.3.2 This direct entry area is drawn as follows:

a) measure the angle made by the procedure radial (RP) and the radial joining the VOR/DME station to the end of the nominal outbound leg (line SC) and round its value to the nearest entire degree to obtain the entry radial (RE) to be published;

b) locate point "I" at the intersection of RE and DLs;

c) from S draw the lines "RE1" and "RE2" making an angle $\alpha$ (tolerance for homing VOR; Part I, Section 2, Chapter 2, Table I-2-2-1) with RE on each side of it;

d) locate points "I1" and "I2" at the intersections of RE1 with DL1 and DL2 and points "I3" and "I4" at the intersections of RE2 with DL1 and DL2; and

e) place template point "a" on I2, with axis parallel to RE and move it along DL2 from I2 to I4 to draw curve "13".

3.3.4.2 *Procedure away from the station*
(Reference Diagram I-4-3-App C-17)

3.3.4.2.1 *Construction of the basic area*

3.3.4.2.1.1 *Selection and calculation of the distance parameters* (see Figure I-4-3-App C-15). The distance parameters are chosen and calculated in the following sequence:

a) choice of the nominal distance: D

D is the slant range between VOR/DME facility and the procedure point at the specified altitude;

b) choice of the outbound distance: ds

ds is the horizontal length of the outbound leg

ds should conform to the relationship ds ≥ vt, where t is the outbound timing, as specified in Chapter 3, 3.5.5, "Outbound time" for racetrack procedures and in Part II, Section 4, Chapter 1, 1.3.2.2, "Outbound timing", for holding procedures;

c) calculation of the horizontal distance: Ds

Ds is the distance between the VOR/DME facility (S) and the vertical projection of the procedure point on the horizontal plane through S

$$\mathrm{Ds} = \sqrt{\mathrm{D}^2 - \mathrm{hl}^2}$$

(Ds, D and hl in km); or

$$\mathrm{DS} = \sqrt{\mathrm{D}^2 - 0.027\ \mathrm{hl}^2}$$

(Ds and D in NM and hl in thousands of feet)

d) calculation of the limiting outbound distance: DL

DL is the slant range between the VOR/DME facility and the end of the outbound track at the specified altitude

$$\mathrm{DL} = \sqrt{(\mathrm{Ds} + \mathrm{ds})^2 + 4\mathrm{r}^2 + \mathrm{hl}^2}$$

(DL, Ds, ds, r, hl in km); or

$$\mathrm{DL} = \sqrt{(\mathrm{Ds} + \mathrm{ds})^2 + 4\mathrm{r}^2 + 0.027\ \mathrm{hl}^2}$$

(DL, Ds, ds, r in NM and hl in thousands of feet)

DL is then rounded to the next lower km or NM, unless the decimal part is greater than 0.75 km or NM in the case of a procedure at or below 4 250 m (or 14 000 ft) or 0.5 km or NM in the case of a procedure above 4 250 m (or 14 000 ft), in which case it is rounded to the next higher km or NM;

e) calculation of the horizontal limiting outbound distance: DLs

DLs is the distance between the VOR/DME facility and the vertical projection of the end of the outbound track onto the horizontal plane passing through S

$$DLs = \sqrt{DL^2 - hl^2}$$

(DL, hl in km); or

$$DLs = \sqrt{DL^2 - 0.027\ hl^2}$$

(DLs, DL in NM and hl in thousands of feet)

3.3.4.2.1.2 *Fix tolerance area and limiting outbound distance*

a) Draw from S the procedure radial “RP” and two lines, “RP1” and “RP2”, making an angle α (tolerance for a homing VOR, Part I, Section 2, Chapter 2, Table I-2-2-1) with RP on each side of it;

b) with a centre on S, draw arcs “Ds” with a radius Ds, “Dl” with a radius Ds + dl, “D2” with a radius Ds – dl, “DLs”, “DL1” and “DL2” with radii DLs, DLs + d2 and DLs – d2

where dl and d2 are the DME tolerances associated with D and DL:

d1 is 0.46 km (0.25 NM) + 0.125 D; and

d2 is 0.46 km (0.25 NM) + 0.0125 DL; and

c) locate points “A” at the intersection of RP and Ds:

“A1” and “A2” at the intersections of RP1 with D1 and D2; and

“A3” and “A4” at the intersections of RP2 with D1 and D2.

3.3.4.2.1.3 *Protection of the outbound turn and outbound leg*

a) Place template point “a” on Al, with axis parallel to the inbound track, and draw curve “l” (part of the outline of the template);

b) place template point “a” on A3, with axis parallel to the inbound track, and draw curve “2” (part of the outline of the template) and line “3” (protection of the outbound leg in the direction of the non-manoeuvring side); and

c) draw the common tangent to curves “l” and “2” and extend the straight part of curve “l” and the line “3” in the direction of the outbound end.

3.3.4.2.1.4 *Area containing the end of the outbound leg*

a) Locate points C1 and C’3 at the intersections of the extensions of curve “l” with the arcs DL1 and DL2. If no intersection occurs a limiting radial shall be specified (see 3.3.4.3 of this appendix);

b) locate point C2 between C1 and C’3 at a distance (dl + d2 – 1.8) km or (dl + d2 – 1) NM from C’3;

c) draw a parallel line to the inbound track through C2 and locate point C3 at the intersection of this line with arc DL2;

d) do the same thing as in a), b) and c) above, with the line "3" instead of curve "l" and points C4, C'6, C5 and C6 instead of C1, C'3, C2 and C3 (see Figure I-4-3-App C-16 a)); and

e) if the aeroplane intercepts the VOR radial before reaching the limiting outbound distance, the pilot is assumed to follow the indications of the VOR without drifting any further from the procedure axis, so:

where C5 and C6 are further from the procedure axis than RP2 (see Figure I-4-3-App C-16 b)), replace C5 and C6 by the intersections of RP2 with line "3" and DL2, and the end of the outbound leg is contained in the area C1, C2, C3, C4, C5, and C6;

where C4, C5 and C6 are further from the procedure axis than RP2 (see Figure I-4-3-App C-16 c)), replace C4 and C6 by the intersections of RP2 with DL1 and DL2, and the end of the outbound leg is contained in the area Cl, C2, C3, C4, and C6.

3.3.4.2.1.5 *Protection of the inbound turn.* Rotate the template 180°, then:

a) place template point "a" on C2 and C3, with axis parallel to the inbound track, and draw curves "4" and "5" (part of the protection line of a turn of more than 180°) and their common tangent;

b) move the template point "a" along arc DL2 from C3 to C6, with axis parallel to the inbound track, and draw curve "6";

c) place template point "a" on C6, C4 and eventually on C5 and draw curves "7", "8" and eventually "9" and their common tangents; and

d) draw the tangent to curves "8" and "2".

3.3.4.2.2 *Construction of the entry area.* It is assumed that all entries are executed along the VOR radial or the DME arc defining the fix. The entries made along the radial inbound to the fix or along the DME arc from the non-manoeuvring side are protected by the basic area. The protection of the entries made along the reciprocal to inbound or along the DME arc from the manoeuvring side needs, in addition to the basic area, the area constructed as follows. The entry along the DME arc from the manoeuvring side is a sector 1 entry procedure. As the reciprocal to the inbound track is the dividing line between entry sectors 1 and 2, it is assumed that both sector 1 and sector 2 entry procedures may be executed when entering along the reciprocal to inbound.

3.3.4.2.2.1 *Protection of sector 1 entry procedure*. When entering along the DME arc, it is assumed that having passed the fix the aircraft turns and follows a track parallel to the inbound track and on reaching the DME limiting outbound distance, turns inbound onto the manoeuvring side. For entries along the DME arc, the entry area is drawn as follows:

a) take a tracing of the template, turn it over and place point "a" on A3 with axis on the line Al A3 to draw curve "14";

b) draw the line "15" parallel to line "3" (used in the construction of the basic area) and tangent to curve "14", and locate point C10 at the intersection of this line with arc DL2; and

*Note.— If no intersection occurs, either the specified DME distances should be adjusted or the sector 1 entry along the DME arc shall not be allowed.*

c) place point “a” of the tracing on C10, with axis parallel and opposite to the inbound track, and move it along DL2 up to the intersection of DL2 and RP1 to draw curve “16”.

3.3.4.2.2.2 *Protection of sector 2 entry procedure.* It is assumed that having passed the fix, the pilot makes good (with ± 5° error) a track making an angle of 30° with the inbound track on the manoeuvring side and reaching the limiting outbound distance, turns inbound. In addition, the flying time on the 30° offset track is limited to 1 min 30 s after which the pilot is expected to turn to a heading parallel to the outbound track until reaching the limiting outbound distance, where the pilot turns inbound.

3.3.4.2.2.2.1 For a procedure with outbound of more than 1 min 30 s the protection of sector 2 entry procedure is assured by the basic area.

3.3.4.2.2.2.2 For a procedure with outbound of 1 min or 1 min 30 s, the protection area of sector 2 entry is drawn as follows:

a) from Al draw a line making an angle of 30° + 5° with RP and locate C7 at its intersection with DL2. If no intersection occurs, a limiting radial must be specified according to 3.3.4.3;

b) from A4 draw a line making an angle of 30° – 5° with RP and locate C8 at its intersection with DL2;

c) place template point “a” on C7 and move it along DL2 to C8, with axis making an angle of 30° with RP, to draw curve “10”; and

d) draw the common tangents to the curve “10” and to the basic area.

3.3.4.2.3 *Construction of the entry area for a reciprocal direct entry to a secondary point (Reference Diagram I-4-3-App C-18)*

3.3.4.2.3.1 The reciprocal direct entry is made along the entry radial (RE) joining the VOR/DME station (S) to the secondary point (I) where the turn to inbound is initiated.

3.3.4.2.3.2 The protection of this entry procedure is assured by the basic area.

3.3.4.2.3.3 The entry radial is determined as follows: Measure the angle made by the procedure radial (RP) and the radial joining the VOR/DME station to the end of the nominal outbound leg (line SC) and round its value to the nearest entire degree to obtain the entry radial (RE) to be published.

3.3.4.3 *Procedure away from the station with a limiting radial (Reference Diagram I-4-3-App C-19)*

3.3.4.3.1 *Construction of the basic area*

3.3.4.3.1.1 *Selection and calculation of the distance parameters (see Figure I-4-3-App C-15).* The distance parameters are chosen and calculated in the same manner as in 3.3.4.2.1.1 above.

3.3.4.3.1.2 *Fix tolerance area, limiting outbound distance and limiting radial.* The fix tolerance area and the limiting outbound distance are drawn in the same manner as in 3.3.4.2.1.2:

a) place template point “a” on A2 and locate the point “R” given by the template;

b) measure the angle between the line joining R and S and RP, add β (tolerance for an intersecting VOR, see Part I, Section 2, Chapter 2, Table I-2-2-1) and round the result to the next higher degree; and

c) from S draw line RL making an angle of the rounded value of c) with RP and line RL2 making the angle β with RL.

3.3.4.3.1.3 *Protection of the outbound turn and outbound leg*. Protection of the outbound turn and outbound leg is drawn in the same manner as in 3.3.4.2.1.3 above.

3.3.4.3.1.4 *Area containing the end of the outbound leg*

a) If the intersection of extension of curve 1 and RL2 is nearer to Al than the intersection of extension of curve 1 and DL1 (case of Diagram I-4-3-App C-19), locate point Cl at the intersection of extension of curve 1 with line RL2 and C2 and C3 at the intersections of RL2 with DL1 and DL2;

b) if the intersection of extension of curve 1 and RL2 is between the intersections of the same extension with DL1 and DL2, locate points Cl and C2 at the intersections of the extension of curve 1 with arc DL1 and line RL2 and point C3 at the intersection of RL2 with DL2;

c) if the intersection of extension of curve 1 and RL2 is further from Al than the intersection of the same extension with DL2, do the same as in 3.3.4.2.1.4 a), b) and c); and

d) locate points C4, C6 and eventually C5 in the same manner as explained in 3.3.4.2.1.4 d) and e).

3.3.4.3.1.5 *Protection of the inbound turn.* Rotate the template 180°, then:

a) place the template point “a” on Cl, C2 and C3, with axis parallel to the inbound track, and draw curves “4”, “5” and “6” (part of the protection line of a turn of more than 180°) and their common tangents;

b) move template point “a” along arc DL2 from C3 to C6, with axis parallel to the inbound track, and draw curve “7”;

c) place template point “a” on C6, C4 and eventually on C5, with axis parallel to the inbound track, and draw curves “8”, “9” and eventually “10” and their common tangents; and

d) draw the tangent to curves “9” and “2”.

3.3.4.3.2 *Construction of the entry area*

3.3.4.3.2.1 *Protection of sector 1 entry procedures.* For the protection of sector 1 entry procedure see 3.3.4.2.2.1 above.

3.3.4.3.2.2 *Protection of sector 2 entry procedures*. It is assumed that having passed the fix, the pilot makes good a track (with ±5° error) making an angle of 30° with the inbound track on the manoeuvring side and reaching the limiting outbound distance, turns inbound. In addition, the flying time on the 30° offset track is limited to 1 min 30 s after which the pilot is expected to turn a heading parallel to the inbound track until reaching the limiting outbound distance, where the pilot turns inbound.

3.3.4.3.2.2.1 For a procedure with outbound of more than 1 min 30 s the protection of sector 2 entry procedure is assured by the basic area.

3.3.4.3.2.2.2 For a procedure with outbound of 1 min or 1 min 30 s, the protection area of sector 2 entry is drawn as follows:

a) from Al draw a line making an angle of 30° + 5° with RP and locate C7 at its intersection with DL2 or RL2, whichever is the nearer to Al;

b) from A4 draw a line making an angle of 30° – 5° with RP and locate C8 at its intersection with DL2;

c) place template point "a" on C7, with axis making an angle of 30° with RP, and draw curve "11" (part of the protection line of a turn of more than 180°);

d) move template point "a" from C7 to C8 along arc DL2, or along line RL2 and then arc DL2 if C7 is on RL2, keeping the axis of the template making an angle of 30° with RP, to draw curve "12"; and

e) draw the common tangents to the curves "11" and "12" and to the basic area.

## 3.4 Area reduction for holding and racetrack procedures

3.4.1 *Area reduction by use of DME or limiting radial/bearing.* If a DME distance or an intersection of radial or bearing is used to limit the outbound leg of a procedure, the area may be reduced by applying the racetrack or holding template for the altitude in question in the following way:

a) construct the protection area in accordance with 3.3;

b) with the centre on S (= position of the DME station) draw arcs "DL" and "DL2" on the end of the outbound leg. The radius DL is the distance from S to the end of the nominal outbound legs. The radius DL2 is DL plus DME tolerance d2; d2 is 0.46 km (0.25 NM) + 0.0125 DL;

c) from S (= position of VOR or NDB) draw line "RL" through the end of the nominal outbound leg representing the intersecting radial or bearing. Draw line "RL2" by adding the respective tolerance of the intersecting facility (Part I, Section 2, Chapter 2, 2.3); and

d) place template point "a" on the intersection of "DL2" or "RL2" with the boundary of the protection area constructed in a).

The axis of the template has to be parallel to the nominal outbound track. Move template point "a" along "DL2" or "RL2" respectively drawing curve "R". The area between curve "R" and the outbound end of the area protected in accordance with a) can be deleted (see Figure I-4-3-App C-17).

3.4.2 *Area reduction for racetrack or holding procedures by limitation of entry routes.* If entry to a procedure is restricted to entry along the inbound radial, the basic area may be used without the additional areas required for omnidirectional entry (see examples in Figures I-4-3-App C-18 and I-4-3-App C-19).

## 3.5 Simplified area construction method for reversal and racetrack procedures

3.5.1 *General.* Reversal and racetrack procedure areas may be defined by simple rectangles. The dimensions of the rectangle for each type of procedure may easily be calculated from the equations given in this section. The rectangle will, in all cases, include or be slightly larger than the area constructed using the more detailed TTT method. The TTT method should be used to obtain maximum benefit wherever airspace is critical.

3.5.2 *Frame of reference.* The dimensions of the rectangles are related to a conventional x, y coordinate system, with its origin at the facility (see Figure I-4-3-App C-20). The x axis is parallel to the inbound track. Negative values of x are measured from the facility in the direction of the inbound track, positive values are measured from the facility against the direction of the inbound track. Positive values of y are measured on that side of the x axis containing the outbound track or manoeuvre of the reversal procedure/racetrack. The y axis is at right angles to the x axis.

3.5.3 *Area calculation.*

a) Decide the values of IAS and height for the reversal/racetrack procedure. Calculate the TAS at ISA + 15°C for the specified height (Attachment F). Calculate the wind speed (ICAO or statistical wind for the height specified).

b) Decide the type of procedure required:

Procedure turn (45/180) — Table I-4-3-App C-5 a)
Procedure turn (80/260) — Table I-4-3-App C-5 b)
Base turn — Table I-4-3-App C-5 c)
Racetrack — Table I-4-3-App C-5 d).

c) Note the equations from Table I-4-3-App C-5.

d) Substitute the values of TAS and wind speed calculated in a) above into the equations and calculate the required x and y values.

e) Adjust the values to account for fix tolerance.

f) Plot the area rectangle to the scale required.

g) Add the appropriate buffer area.

**Table I-4-3-App C-1. Calculations associated with the construction of the base turn template**

| DATA | | |
|---|---|---|
| | *SI UNITS* | *NON-SI UNITS* |
| IAS | 260 km/h | 140 kt |
| Altitude | 1 850 m | 6 000 ft |
| T | 2 min | 2 min |
| NDB | at 0 m | at 0 ft |
| Temperature | ISA + 15°C | ISA + 15°C |

| | | *CALCULATIONS USING SI UNITS* | | *CALCULATIONS USING NON-SI UNITS* | |
|---|---|---|---|---|---|
| *Line* | *Parameter* | *Formula* | *Value* | *Formula* | *Value* |
| 1 | K | Conversion factor for 1 850 m and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1244 | Conversion factor for 6 000 ft and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1231 |
| 2 | V | $V = K \times IAS$ | 292.34 km/h | $V = K \times IAS$ | 157.23 kt |
| 3 | v | $v = V \div 3\,600$ | 0.0812 km/s | $v = V \div 3\,600$ | 0.0437 NM/s |
| 4 | R | $R = 943.27 \div V$, or 3°/s, whichever is less | (3.23) 3°/s | $R = 509.26 \div V$, or 3°/s, whichever is less | (3.24) 3°/s |
| 5 | r | $r = V \div 62.83\,R$ | 1.55 km | $r = V \div 62.83\,R$ | 0.83 NM |
| 6 | h | in thousands of metres | 1.85 | in thousands of feet | 6 |
| 7 | w | $w' = 12h + 87$ | 109.2 km/h | $w' = 2h + 47$ | 59 kt |
| 8 | $w'$ | $w' = w \div 3\,600$ | 0.03 km/s | $w' = w \div 3\,600$ | 0.0164 NM/s |
| 9 | E | $E = w' \div R$ | 0.01 km/° | $E = w' \div R$ | 0.00546 NM/° |
| 10 | $\phi$ | for $V \leq 315$ km/h: $\phi = 36 \div T$ for $V > 315$ km/h: $\phi = 0.116\,V \div T$ | 18° | for $V \leq 170$ kt: $\phi = 36 \div T$ for $V > 170$ kt: $\phi = 0.215\,V \div T$ | 18° |
| 11 | zN | *$zN = h \tan 40°$ | 1.55 km | **$zN = 0.164\,h \tan 40°$ | 0.83 NM |
| 12 | t | $t = 60T$ | 120 s | $t = 60T$ | 120 s |
| 13 | L | $L = vt$ | 9.74 km | $L = vt$ | 5.24 NM |
| 14 | ab1 = ab3 | ***$ab1 = ab3 = (t - 5)(v - w') - zN$ | 4.34 km | ***$ab1 = ab3 = (t - 5)(v - w') - zN$ | 2.31 NM |
| 15 | ab2 = ab4 | ***$ab2 = ab4 = (t + 21)(v + w') + zN$ | 17.23 km | ***$ab2 = ab4 = (t + 21)(v + w') + zN$ | 9.30 NM |
| 16 | $W_d = W_g$ | $W_d = W_g = 50\,E$ | 0.5 km | $W_d = W_g = 50\,E$ | 0.27 NM |
| 17 | $W_e = W_f = W_h$ | $W_e = W_f = W_h = 100\,E$ | 1.0 km | $W_e = W_f = W_h = 100\,E$ | 0.55 NM |
| 18 | $W_i$ | $W_i = 190\,E$ | 1.9 km | $W_i = 190\,E$ | 1.04 NM |
| 19 | $W_j$ | $W_j = 235\,E$ | 2.35 km | $W_j = 235\,E$ | 1.28 NM |

| | | *CALCULATIONS USING SI UNITS* | | *CALCULATIONS USING NON-SI UNITS* | |
|---|---|---|---|---|---|
| *Line* | *Parameter* | *Formula* | *Value* | *Formula* | *Value* |
| 20 | drift angle d | d = arc sin (w ÷ V) | 23° | d = arc sin (w ÷ V) | 23° |
| 21 | $N_{3l}$ | $N_{3l}$ = 11 v | 0.9 km | $N_{3l}$ = 11 v | 0.48 NM |
| 22 | $W_l$ | $W_l$ = 11 w′ | 0.33 km | $W_l$ = 11 w′ | 0.18 NM |
| 23 | $W_m$ | $W_m = W_l$ + 50 E | 0.83 km | $W_m = W_l$ + 50 E | 0.45 NM |
| 24 | $W_n$ | $W_n = W_l$ + 100 E | 1.33 km | $W_n = W_l$ + 100 E | 0.73 NM |

* In case of a VOR base turn, line 11 reads zV = h tan 50°.

** In case of a VOR base turn, line 11 reads zV = 0.164 h tan 50°.

*** In case of VOR/DME base turn, where D is the specified DME distance limiting the outbound leg and d1 is the tolerance of the DME indication (d1 is 0.46 km (0.25 NM) + 0.0125 D), lines 14 and 15 read:
ab1 = ab3 = D – d1 + 5 (v – w′)
ab2 = ab4 = D + d1 + 11 (v + w′)

In case of a VOR base turn, lines 14 and 15 read:
ab1 = ab3 = (t – 5) (v – w) ′ – zV
ab2 = ab4 = (t + 21) (v + w′) + zV

**Table I-4-3-App C-2. Calculations associated with the construction of the 45°-180° procedure turn template**

| DATA | | |
|---|---|---|
| | *SI UNITS* | *NON-SI UNITS* |
| IAS | 260 km/h | 140 kt |
| Altitude | 1 850 m | 6 000 ft |
| T | 60 s (1 min for Cat A and B; 1.25 min for Cat C, D and E) | 60 s (1 min for Cat A and B; 1.25 min for Cat C, D and E) |
| Temperature | ISA + 15°C | ISA + 15°C |

| | | *CALCULATIONS USING SI UNITS* | | *CALCULATIONS USING NON-SI UNITS* | |
|---|---|---|---|---|---|
| *Line* | *Parameter* | *Formula* | *Value* | *Formula* | *Value* |
| 1 | K | Conversion factor for 1 850 m and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1244 | Conversion factor for 6 000 ft and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1231 |
| 2 | V | V = K IAS | 292.34 km/h | V = K IAS | 157.23 kt |
| 3 | v | v = V ÷ 3 600 | 0.0812 km/s | v = V ÷ 3 600 | 0.0437 NM/s |
| 4 | R | R = 943.27 ÷ V, or 3°/s, whichever is less | (3.23) 3°/s | R = 509.26 ÷ V, or 3°/s, whichever is less | (3.24) 3°/s |
| 5 | r | r = V ÷ 62.83 R | 1.55 km | r = V ÷ 62.83 R | 0.83 NM |
| 6 | h | in thousands of metres | 1.85 | in thousands of feet | 6 |
| 7 | w | w = 12h + 87 | 109.2 km/h | w = 2h + 47 | 59 kt |
| 8 | w′ | w′ = w ÷ 3 600 | 0.03 km/s | w′ = w ÷ 3 600 | 0.0164 NM/s |
| 9 | E | E = w′ ÷ R | 0.01 km/° | E = w′ ÷ R | 0.00546 NM/° |
| 10 | ab | ab = 5v | 0.41 km | ab = 5v | 0.22 NM |
| 11 | cd | cd = (t – 5 – 45 ÷ R) v | 3.25 km | cd = (t – 5 – 45 ÷ R) v | 1.75 NM |
| 12 | cd1, cd3 | cd1 = cd3 = cd – 5v | 2.84 km | cd1 = cd3 = cd – 5v | 1.53 NM |
| 13 | cd2, cd4 | cd2 = cd4 = cd + 15v | 4.47 km | cd2 = cd4 = cd + 15v | 2.41 NM |
| 14 | $W_c$ | $W_c = 5w' + 45 E$ | 0.60 km | $W_c = 5w' + 45 E$ | 0.33 NM |
| 15 | $W_{d2}$, $W_{d4}$ | $W_{d2} = W_{d4} = (t + 15) w'$ | 2.25 km | $W_{d2} = W_{d4} = (t + 15) w'$ | 1.23 NM |
| 16 | $W_f$ | $W_f = W_{d2} + 50 E$ | 2.75 km | $W_f = W_{d2} + 50 E$ | 1.50 NM |
| 17 | $W_g$, $W_h$ | $W_g = W_h = W_{d2} + 100 E$ | 3.25 km | $W_g = W_h = W_{d2} + 100 E$ | 1.78 NM |
| 18 | $W_i$ | $W_i = W_{d2} + 150 E$ | 3.75 km | $W_i = W_{d2} + 150 E$ | 2.05 NM |
| 19 | $W_j$ | $W_j = W_{d2} + 200 E$ | 4.25 km | $W_j = W_{d2} + 200 E$ | 2.32 NM |
| 20 | $W_k$ | $W_k = (t – 5)w' + 200 E$ | 3.65 km | $W_k = (t – 5)w' + 200 E$ | 1.99 NM |
| 21 | $W_l$ | $W_l = W_k + 50 E$ | 4.15 km | $W_l = W_k + 50 E$ | 2.27 NM |

**Table I-4-3-App C-3. Calculations associated with the construction of the 80°-260° procedure turn template**

| DATA | | |
|---|---|---|
| | *SI UNITS* | *NON-SI UNITS* |
| IAS | 405 km/h | 220 kt |
| Altitude | 1 850 m | 6 000 ft |
| Temperature | ISA + 15°C | ISA + 15°C |

| | | *CALCULATIONS USING SI UNITS* | | *CALCULATIONS USING NON-SI UNITS* | |
|---|---|---|---|---|---|
| *Line* | *Parameter* | *Formula* | *Value* | *Formula* | *Value* |
| 1 | K | Conversion factor for 1 850 m and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1244 | Conversion factor for 6 000 ft and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1231 |
| 2 | V | $V = K \times IAS$ | 455.38 km/h | $V = K \times IAS$ | 247.08 kt |
| 3 | v | $v = V \div 3\,600$ | 0.1265 km/s | $v = V \div 3\,600$ | 0.0686 NM/s |
| 4 | R | $R = 943.27 \div V$, or 3°/s, whichever is less | 2.07°/s | $R = 509.26 \div V$, or 3°/s, whichever is less | 2.06°/s |
| 5 | r | $r = V \div 62.83\ R$ | 3.5 km | $r = V \div 62.83\ R$ | 1.91 NM |
| 6 | h | in thousands of metres | 1.85 | in thousands of feet | 6 |
| 7 | w | $w = 12h + 87$ | 109.2 km/h | $w = 2h + 47$ | 59 kt |
| 8 | $w'$ | $w' = w \div 3\,600$ | 0.03 km/s | $w = w \div 3\,600$ | 0.0164 NM/s |
| 9 | E | $E = w' \div R$ | 0.0145 km/° | $E = w' \div R$ | 0.00796 NM/° |
| 10 | ab | $ab = 5v$ | 0.63 km | $ab = 5v$ | 0.34 NM |
| 11 | $d_e$, $d_{1e1}$, $d_{2e2}$ | $d_e = d_{1e1} = d_{2e2} = 10v$ | 1.27 km | $d_e = d_{1e1} = d_{2e2} = 10v$ | 0.69 NM |
| 12 | $W_{e2}$ | $W_{e2} = 15w' + 85\ E$ | 1.68 km | $W_{e2} = 15w' + 85\ E$ | 0.92 NM |
| 13 | $W_g$ | $W_g = 15w' + 130\ E$ | 2.34 km | $W_g = 15w' + 130\ E$ | 1.28 NM |
| 14 | $W_h$ | $W_h = 15w' + 175\ E$ | 2.99 km | $W_h = 15w' + 175\ E$ | 1.64 NM |
| 15 | $W_i$ | $W_i = 15w' + 220\ E$ | 3.64 km | $W_i = 15w' + 220\ E$ | 2.00 NM |
| 16 | $W_j$ | $W_j = 15w' + 265\ E$ | 4.29 km | $W_j = 15w' + 265\ E$ | 2.36 NM |
| 17 | $W_k$ | $W_k = 15w' + 255\ E$ | 4.15 km | $W_k = 15w' + 255\ E$ | 2.28 NM |
| 18 | $W_l$ | $W_l = 15w' + 300\ E$ | 4.80 km | $W_l = 15w' + 300\ E$ | 2.63 NM |
| 19 | $W_m$ | $W_m = 15w' + 345\ E$ | 5.45 km | $W_m = 15w' + 345\ E$ | 2.99 NM |

**Table I-4-3-App C-4. Calculations associated with the construction of the holding and racetrack template**

| DATA | | |
|---|---|---|
| | *SI UNITS* | *NON-SI UNITS* |
| IAS | 405 km/h | 220 kt |
| Altitude | 3 050 m | 10 000 ft |
| T | 1 min | 1 min |
| Temperature | ISA + 15°C | ISA + 15°C |

| | | *CALCULATIONS USING SI UNITS* | | *CALCULATIONS USING NON-SI UNITS* | |
|---|---|---|---|---|---|
| *Line* | *Parameter* | *Formula* | *Value* | *Formula* | *Value* |
| 1 | K | Conversion factor for 3 050 m and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1960 | Conversion factor for 10 000 ft and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1958 |
| 2 | V | V = K × IAS* | 484.38 km/h | V = K × IAS* | 263.08 kt |
| | | * The true airspeed may also be deduced from Part II, Section 1, Chapter 1, Appendix A. | | * The true airspeed may also be deduced from Part II, Section 1, Chapter 1, Appendix A. | |
| 3 | v | v = V ÷ 3 600 | 0.1346 km/s | v = V ÷ 3 600 | 0.07308 NM/s |
| 4 | R | R = 943.27 ÷ V, or 3°/s, whichever is less | 1.95°/s | R = 509.26 ÷ V, or 3°/s, whichever is less | 1.94°/s |
| 5 | r | r = V ÷ 62.83 R | 3.96 km | r = V ÷ 62.83 R | 2.16 NM |
| 6 | h | in thousands of metres | 3.05 | in thousands of feet | 10 |
| 7 | w | w = 12h + 87 | 123.6 km/h | w = 2h + 47 | 67 kt |
| 8 | w′ | w′ = w ÷ 3 600 | 0.03433 km/s | w′ = w ÷ 3 600 | 0.0186 NM/s |
| 9 | $E_{45}$ | $E_{45} = 45w' \div R$ | 0.792 km | $E_{45} = 45w' \div R$ | 0.431 NM |
| 10 | t | t = 60T | 60 s | t = 60T | 60 s |
| 11 | L | L = v t | 8.08 km | L = v t | 4.38 NM |
| 12 | ab | ab = 5v | 0.67 km | ab = 5v | 0.37 NM |
| 13 | ac | ac = 11v | 1.48 km | ac = 11v | 0.80 NM |
| 14 | $g_{i1} = g_{i3}$ | $g_{i1} = g_{i3} = (t - 5)v$ | 7.40 km | $g_{i1} = g_{i3} = (t - 5)v$ | 4.02 NM |
| 15 | $g_{i2} = g_{i4}$ | $g_{i2} = g_{i4} = (t + 21)v$ | 10.90 km | $g_{i2} = g_{i4} = (t + 21)v$ | 5.92 NM |
| 16 | $W_b$ | $W_b = 5w'$ | 0.17 km | $W_b = 5w'$ | 0.09 NM |
| 17 | $W_c$ | $W_c = 11w'$ | 0.38 km | $W_c = 11w'$ | 0.20 NM |
| 18 | $W_d$ | $W_d = W_c + E_{45}$ | 1.17 km | $W_d = W_c + E_{45}$ | 0.64 NM |
| 19 | $W_e$ | $W_e = W_c + 2E_{45}$ | 1.96 km | $W_e = W_c + 2E_{45}$ | 1.07 NM |
| 20 | $W_f$ | $W_f = W_c + 3E_{45}$ | 2.75 km | $W_f = W_c + 3E_{45}$ | 1.50 NM |
| 21 | $W_g$ | $W_g = W_c + 4E_{45}$ | 3.55 km | $W_g = W_c + 4E_{45}$ | 1.93 NM |

| | | CALCULATIONS USING SI UNITS | | CALCULATIONS USING NON-SI UNITS | |
|---|---|---|---|---|---|
| *Line* | *Parameter* | *Formula* | *Value* | *Formula* | *Value* |
| 1 | K | Conversion factor for 3 050 m and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1960 | Conversion factor for 10 000 ft and ISA + 15°C (see Part I, Section 2, Chapter 1, Appendix) | 1.1958 |
| 22 | $W_h$ | $W_h = W_b + 4E_{45}$ | 3.34 km | $W_h = W_b + 4E_{45}$ | 1.82 NM |
| 23 | $W_o$ | $W_o = W_b + 5E_{45}$ | 4.13 km | $W_o = W_b + 5E_{45}$ | 2.25 NM |
| 24 | $W_p$ | $W_p = W_b + 6E_{45}$ | 4.92 km | $W_p = W_b + 6E_{45}$ | 2.69 NM |
| 25 | $W_{i1} = W_{i3}$ | $W_{i1} = W_{i3} = (t + 6)w' + 4E_{45}$ | 5.43 km | $W_{i1} = W_{i3} = (t + 6)w' + 4E_{45}$ | 2.96 NM |
| 26 | $W_{i2} = W_{i4}$ | $W_{i2} = W_{i4} = W_{i1} + 14w'$ | 5.91 km | $W_{i2} = W_{i4} = W_{i1} + 14w'$ | 3.22 NM |
| 27 | $W_j$ | $W_j = W_{i2} + E_{45}$ | 6.71 km | $W_j = W_{i2} + E_{45}$ | 3.65 NM |
| 28 | $W_k = W_l$ | $W_k = W_l = W_{i2} + 2E_{45}$ | 7.50 km | $W_k = W_l = W_{i2} + 2E_{45}$ | 4.08 NM |
| 29 | $W_m$ | $W_m = W_{i2} + 3E_{45}$ | 8.29 km | $W_m = W_{i2} + 3E_{45}$ | 4.51 NM |
| 30 | $W_{n3}$ | $W_{n3} = W_{i1} + 4E_{45}$ | 8.60 km | $W_{n3} = W_{i1} + 4E_{45}$ | 4.68 NM |
| 31 | $W_{n4}$ | $W_{n4} = W_{i2} + 4E_{45}$ | 9.08 km | $W_{n4} = W_{i2} + 4E_{45}$ | 4.94 NM |
| 32 | XE | $XE = 2r + (t + 15)v + (t + 26 + 195 \div R)w'$ | 24.38 km | $XE = 2r + (t + 15)v + (t + 26 + 195 \div R)w'$ | 13.27 NM |
| 33 | YE | $YE = 11 v \cos 20° + r(1 + \sin 20°) + (t + 15)v \tan 5° + (t + 26 + 125 \div R)w'$ | 12.73 km | $YE = 11 v \cos 20° + r(1 + \sin 20°) + (t + 15)v \tan 5° + (t + 26 + 125 \div R)w'$ | 6.93 NM |

**Table I-4-3-App C-5. Rectangle equations**

***WARNING:*** *This table is based on a range of TAS values from 165 to 540 km/h (90 to 290 kt), wind speeds up to 120 km/h (65 kt), and for nominal outbound timing between 1 and 3 minutes. This table should not be used outside these ranges.*

| | *SI UNITS (distances in km; speeds in km/h; time in minutes)* | *NON-SI UNITS (distances in NM; speeds in kt; time in minutes)* |
|---|---|---|
| *a) equations for 45/180 procedure turn* | | |
| $x_{max}$ | TAS(0.0165t + 0.0431) + W(0.0165t + 0.0278) + 3.4 | TAS(0.0165t + 0.0431) + W(0.0165t + 0.0278) + 1.8 |
| $y_{max}$ | TAS(0.002t + 0.022) + W(0.002t + 0.0333) – 0.74 | TAS(0.002t + 0.022) + W(0.002t + 0.0333) – 0.4 |
| $y_{min}$ | TAS(–0.002t – 0.0137) + W(0.002t – 0.0594) + 1.67 | TAS(–0.002t – 0.0137) + W(–0.002t – 0.0594) + 0.9 |
| *b) equations for 80/260 procedure turn* | | |
| $x_{max}$ | TAS(0.0165t + 0.0421) + W(0.0165t + 0.0489) – 3.34 | TAS(0.0165t + 0.0421) + W(0.0165t + 0.0489) – 1.8 |
| $y_{max}$ | TAS(0.002t + 0.0263) + W(0.002t + 0.0322) – 1.85 | TAS(0.002t + 0.0263) + W(0.002t + 0.0322) – 1.0 |
| $y_{min}$ | TAS(–0.002t – 0.01) + W(0.002t – 0.0591) + 1.3 | TAS(–0.002t – 0.01) + W(–0.002t – 0.0591) + 0.7 |
| *c) equations for base turn* | | |
| $x_{max}$ | TAS(0.0173t + 0.0181) + W(0.0166t + 0.0209) – 0.93 | TAS(0.0173t + 0.0181) + W(0.0166t + 0.0209) – 0.5 |
| $y_{max}$ | TAS(–0.0004t + 0.0373) + W(–0.0072t + 0.0404) + 0.164t – 3.15 | TAS(–0.0004t + 0.0373) + W(–0.0072t + 0.0404) + 0.0887t – 1.7 |
| $y_{min}$ | TAS(–0.0122) + W(0.0151t – 0.0639) – 0.1845t + 1.48 | TAS(–0.0122) + W(0.0151t – 0.0639) – 0.0996t + 0.8 |
| *d) equations for racetrack* | | |
| $x_{max}$ | TAS(0.0167t + 0.0297) + W(0.0167t + 0.0381) – 1.67 | TAS(0.0167t + 0.0297) + W(0.0167t + 0.0381) – 0.9 |
| $x_{min}$ | TAS(–0.0241) + W(–0.037) + 2.04 | TAS(–0.0241) + W(–0.037) + 1.1 |
| $y_{max}$ | TAS(0.0012t + 0.0266) + W(0.0158t + 0.0368) + 0.843t – 5.37 | TAS(0.0012t + 0.0266) + W(0.0158t + 0.0368) + 0.455t – 2.9 |
| $y_{min}$ | TAS(–0.0015t – 0.0202) + W(–0.0167t – 0.027) + 1.3 | TAS(–0.0015t – 0.0202) + W(–0.0167t – 0.027) + 0.7 |

**EXAMPLE (SI UNITS)**

*Specification:* 2 min base turn for 260 km/h IAS, altitude 1 850 m, ICAO wind, VOR facility with a cone of ambiguity of 50°:

TAS = 260 × 1.1243 = 292 km/h
W = 12 × 1.85 + 87 = 109 km/h
Fix error = 1.85 × tan 50 = 2.20 km

*Calculation* (equations from c) above):

$x_{max}$ = 292(0.0173 × 2 + 0.0181) + 109(0.0166 × 2 + 0.0209) – 0.93 = 20.36 km/h
$y_{max}$ = 292(–0.0004 × 2 + 0.0373) + 109(–0.0072 × 2 + 0.0404) + 0.164 × 2 – 3.15 = 10.67 km/h
$y_{min}$ = 292(–0.0122) + 109(0.0151 × 2 – 0.0639) – 0.1845 × 2 + 1.48 = –6.12 km

*Template plotting values* (including addition for fix error of 2.20 km):

$x_{max}$ = 22.6 km
$y_{max}$ = 12.9 km
$y_{min}$ = –8.3 km

**EXAMPLE (NON-SI UNITS):**

*Specification:* 1 min 45/180 procedure turn for 140 kt IAS, altitude 6 000 ft, ICAO wind, NDB facility.

TAS = 140 × 1.1231 = 157 kt

W = 2 × 6 + 47 = 59 kt

Fix error = 0.164 × 6 tan 40 = 0.83 NM

*Calculation* (equations from a) above):

$x_{max}$ = 157(0.0165 × 1 + 0.0431) + 59(0.0165 × 1 + 0.0278) + 1.8 = 13.77 NM

$y_{max}$ = 157(0.002 × 1 + 0.022) + 59(0.002 × 1 + 0.0333) – 0.4 = 5.45 NM

$y_{min}$ = 157(–0.002 × 1 – 0.0137) + 59(–0.002 × 1 – 0.0594) + 0.9 = –5.19 NM

*Template plotting values* (including addition of fix error of 0.83 NM):

$x_{max}$ = 14.6 NM

$y_{max}$ = 6.3 NM

$y_{min}$ = –6.0 NM

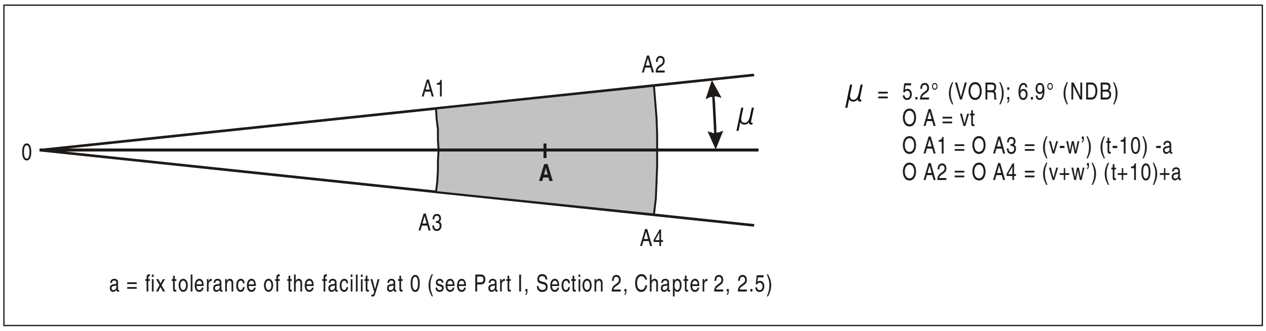


**Figure I-4-3-App C-1. VOR or NDB at 0 — time from 0 to A**

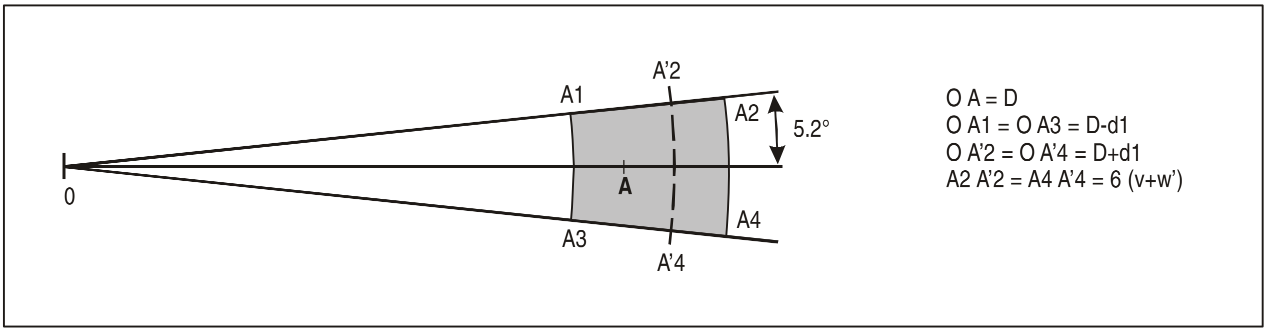


**Figure I-4-3-App C-2. VOR/DME at 0**

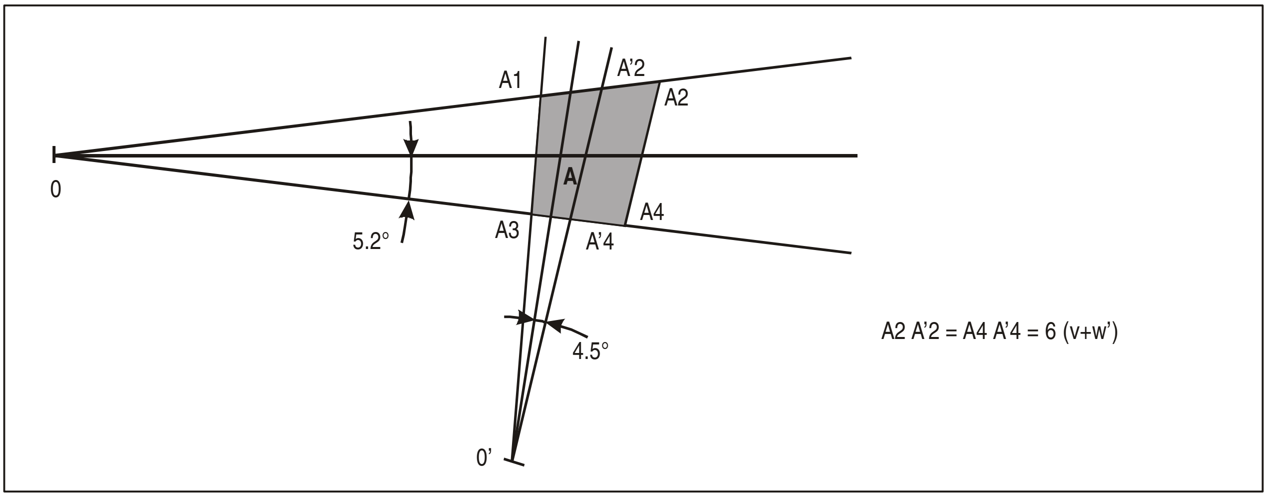


**Figure I-4-3-App C-3. VOR at 0 and VOR at 0'**

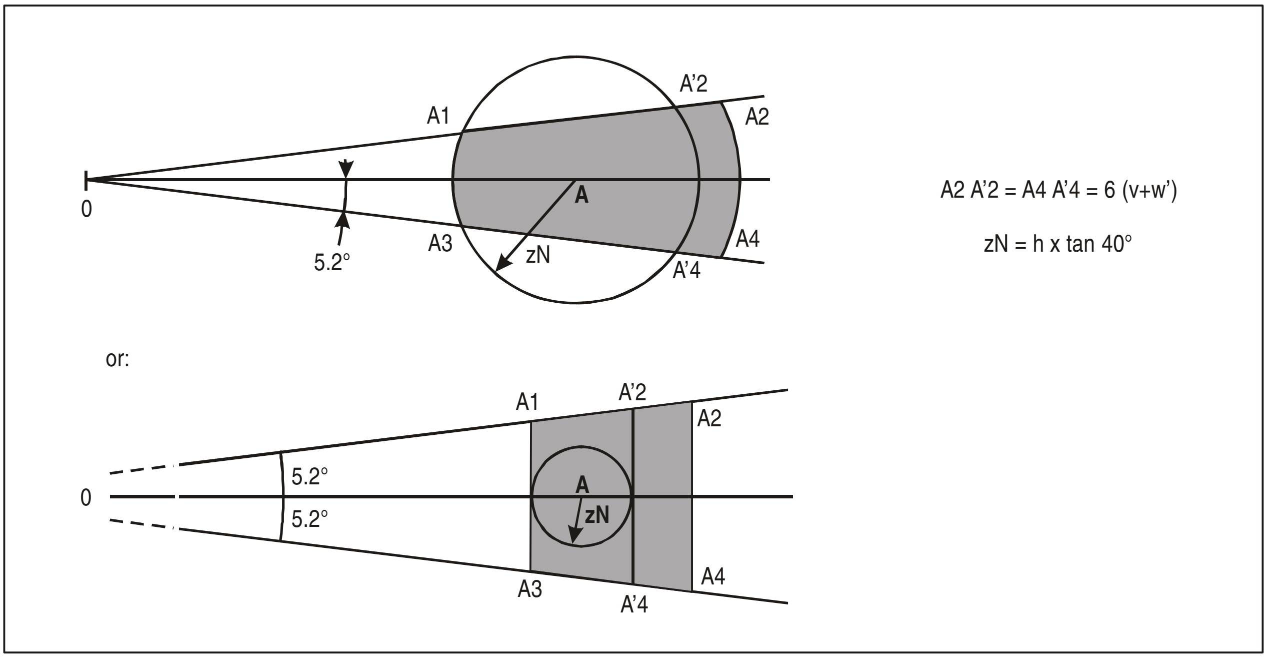


**Figure I-4-3-App C-4. VOR at 0 and NDB or locator at A**

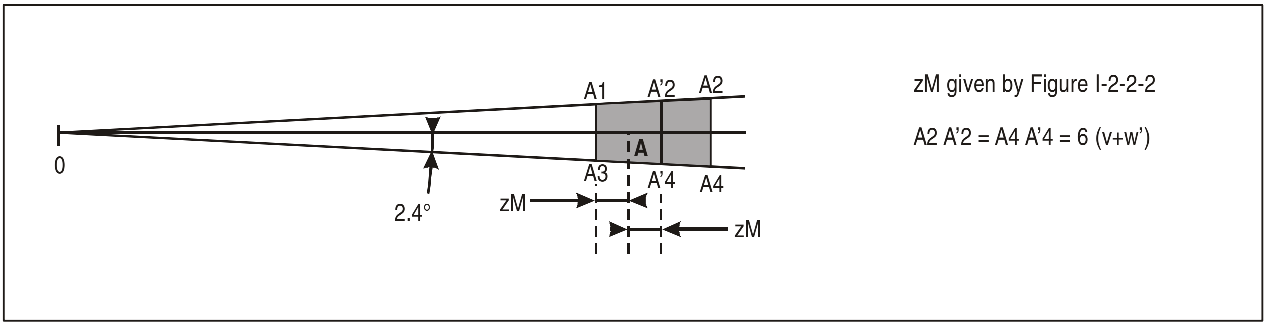


**Figure I-4-3-App C-5. Localizer at 0 and marker at A**

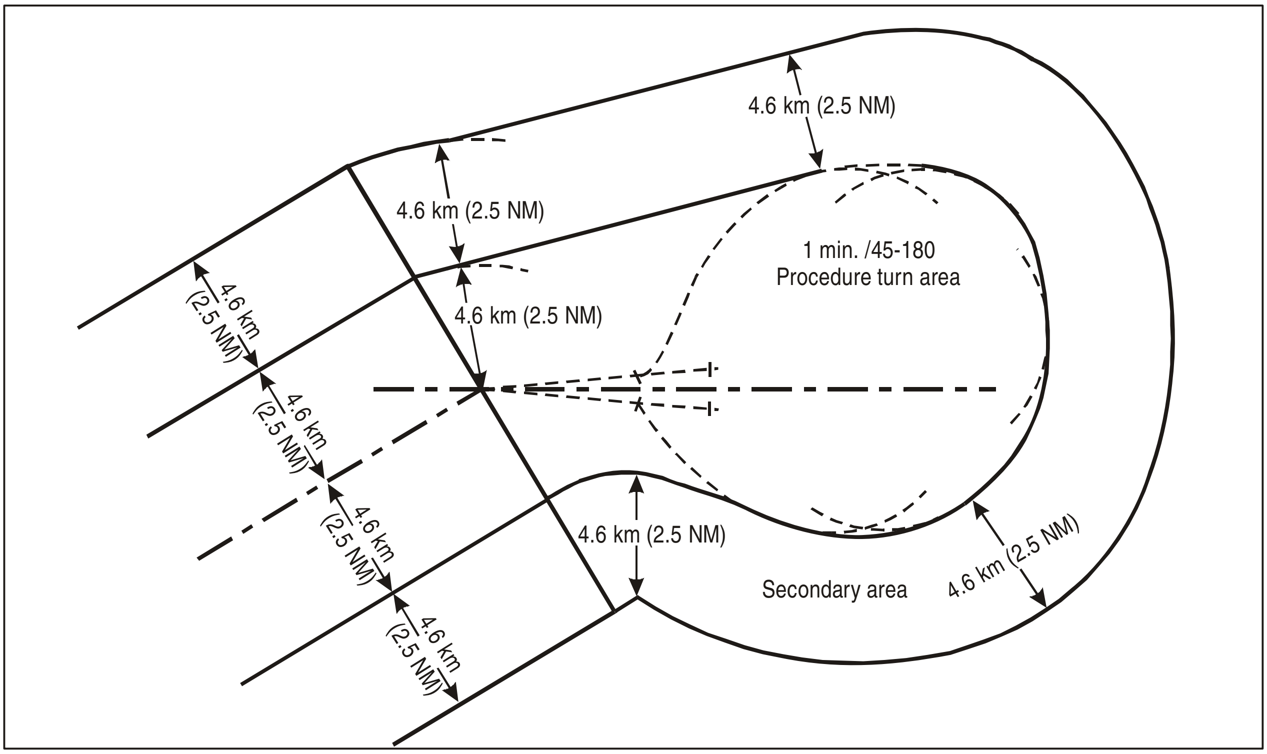


**Figure I-4-3-App C-6. Interface between initial segment areas and procedure turn areas**

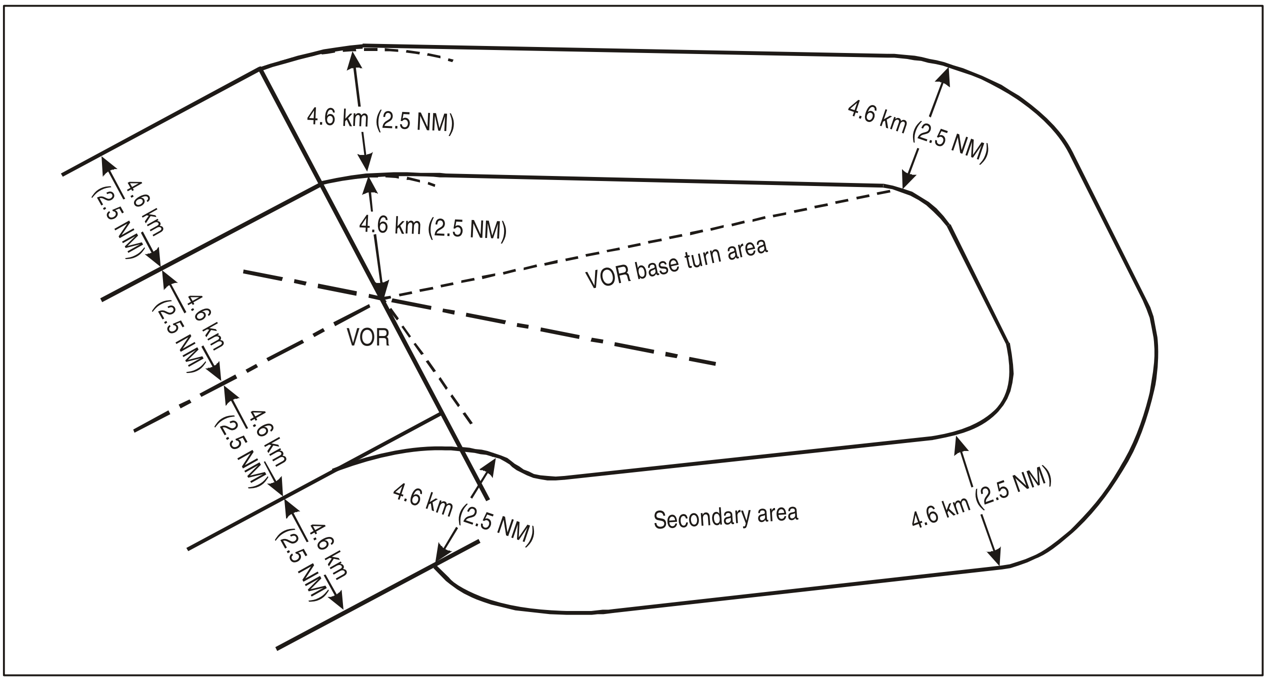


**Figure I-4-3-App C-7. Interface between initial segment areas and base turn areas**

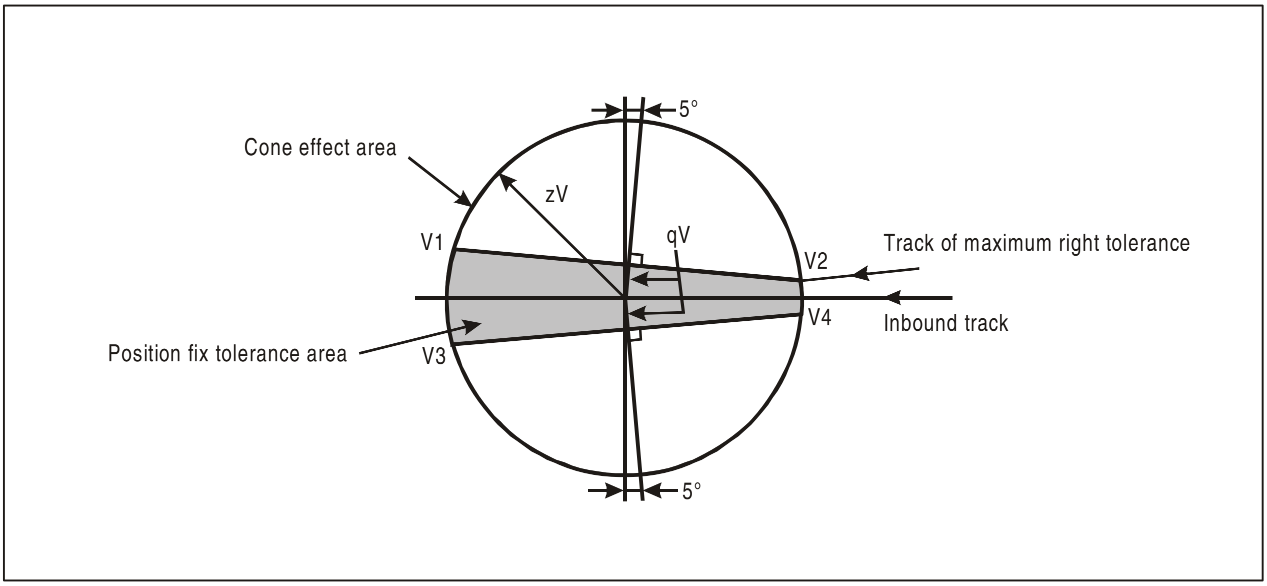


**Figure I-4-3-App C-8.**

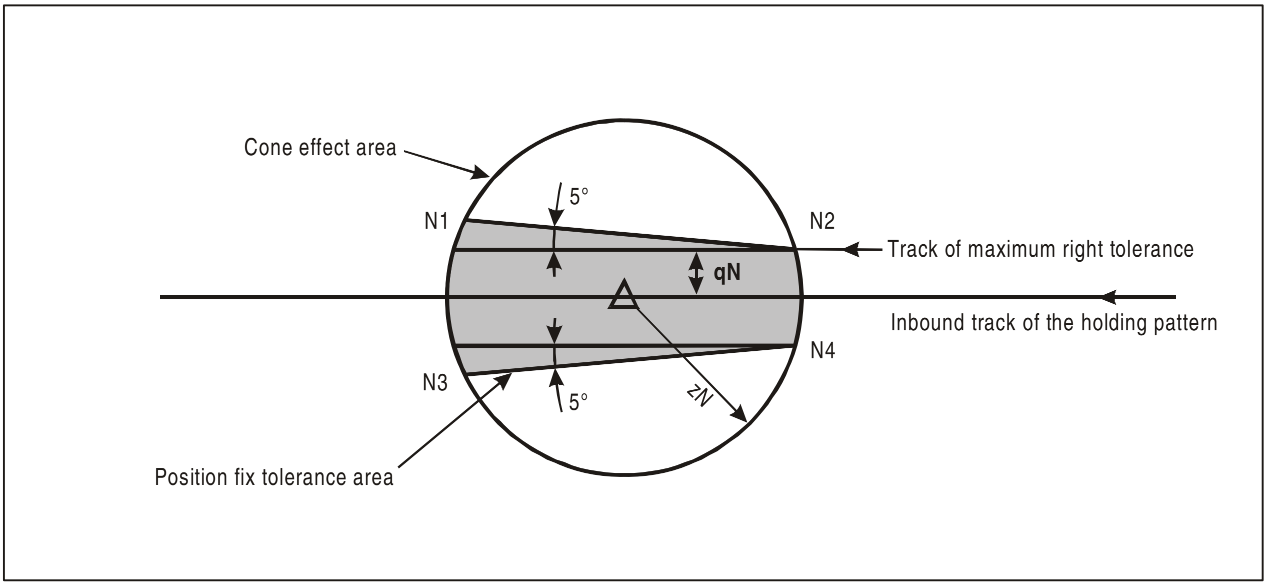


**Figure I-4-3-App C-9.**

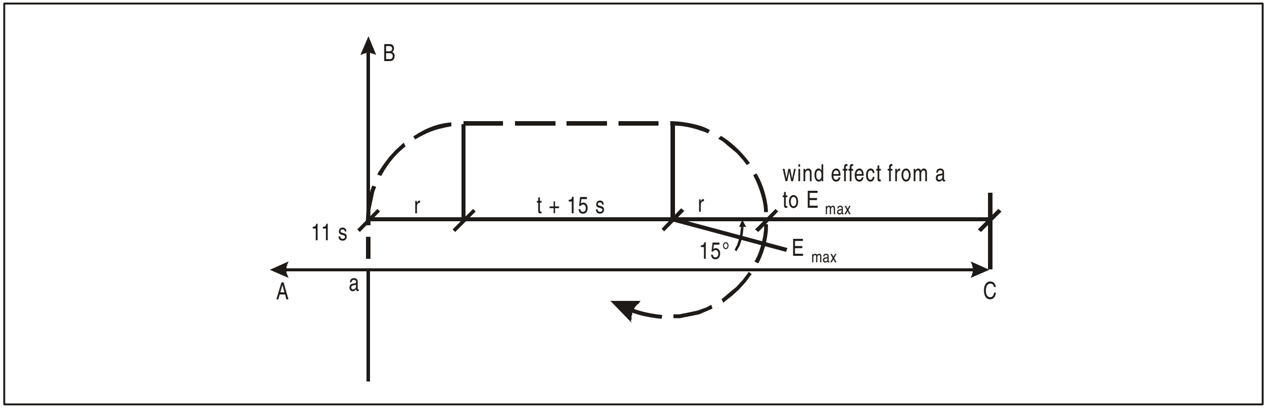


**Figure I-4-3-App C-10.**

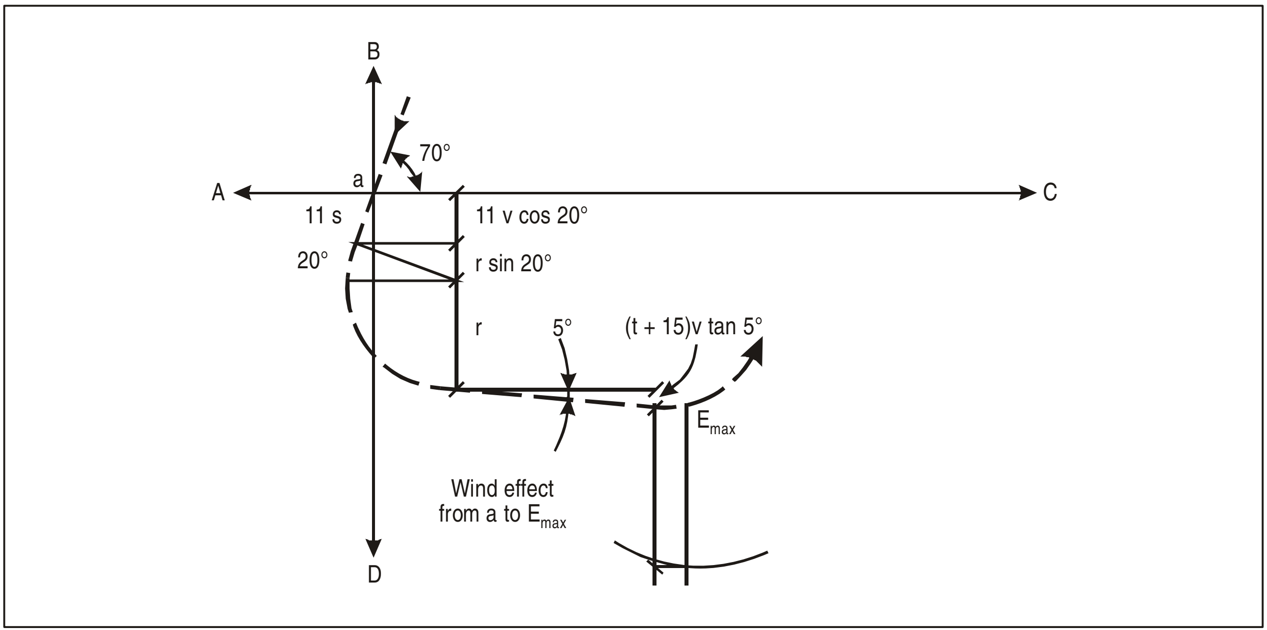


**Figure I-4-3-App C-11.**

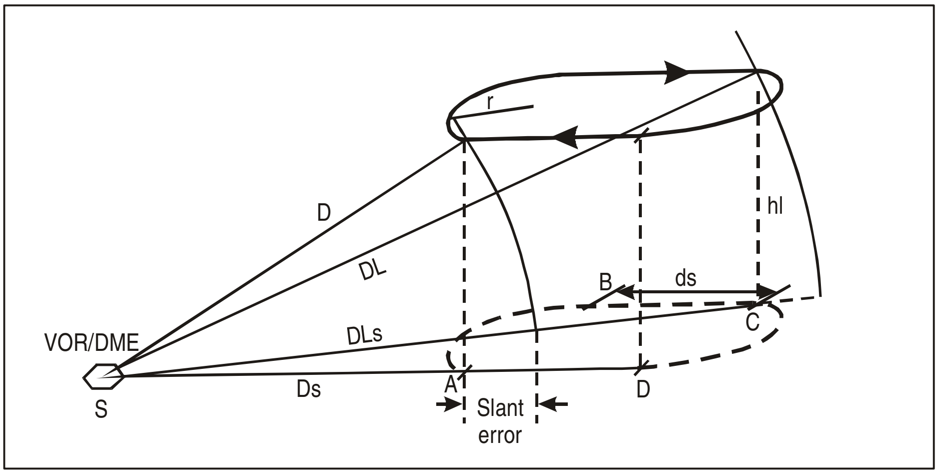


**Figure I-4-3-App C-12.**

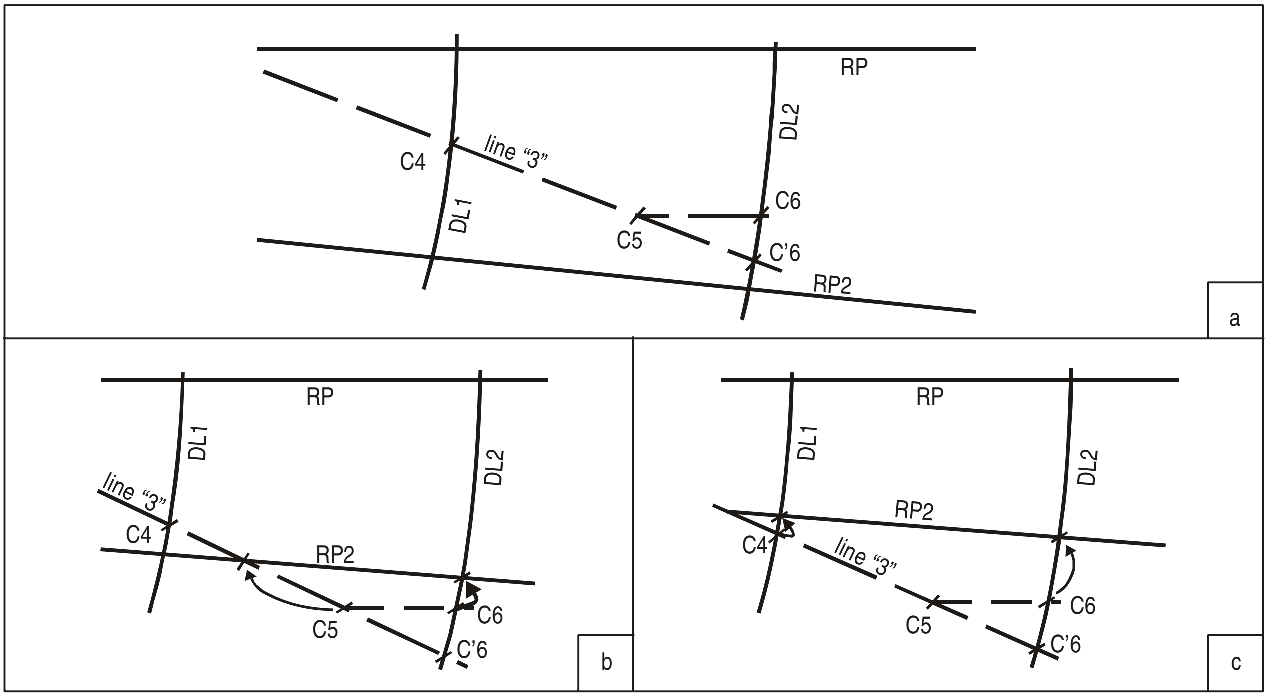


**Figure I-4-3-App C-13.**

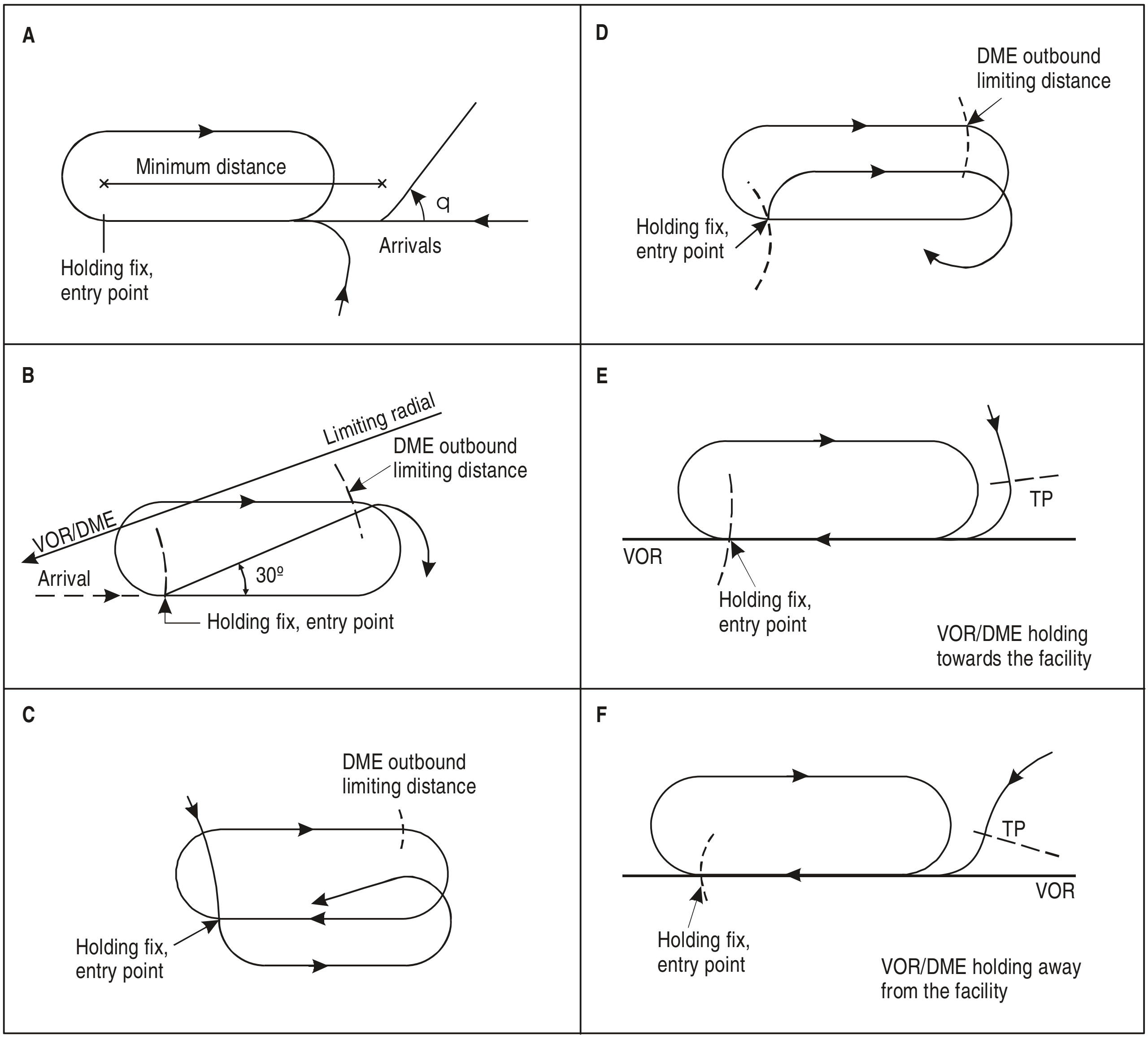


**Figure I-4-3-App C-14.**

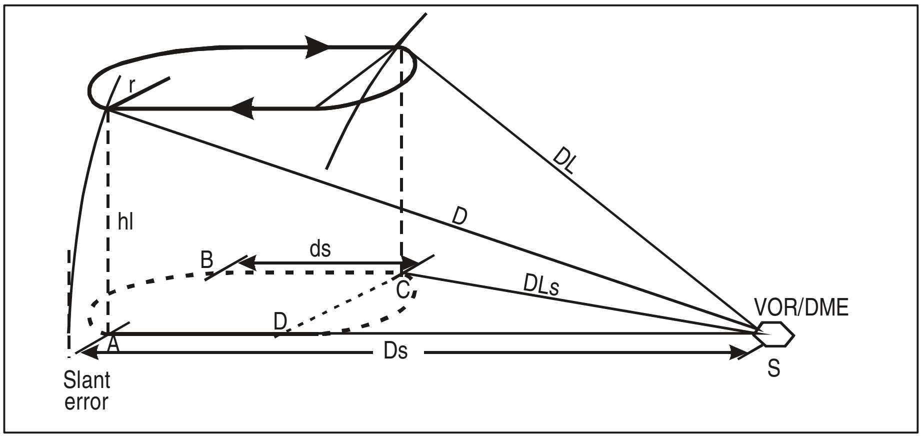


**Figure I-4-3-App C-15.**

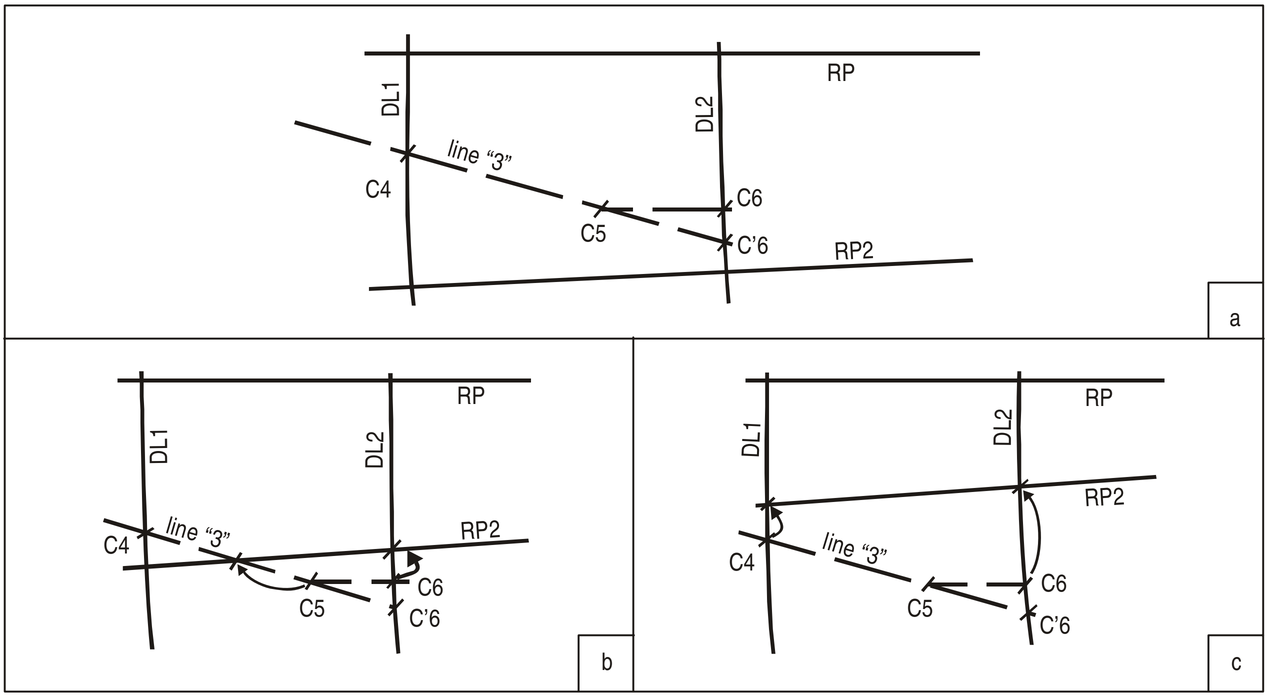


**Figure I-4-3-App C-16.**

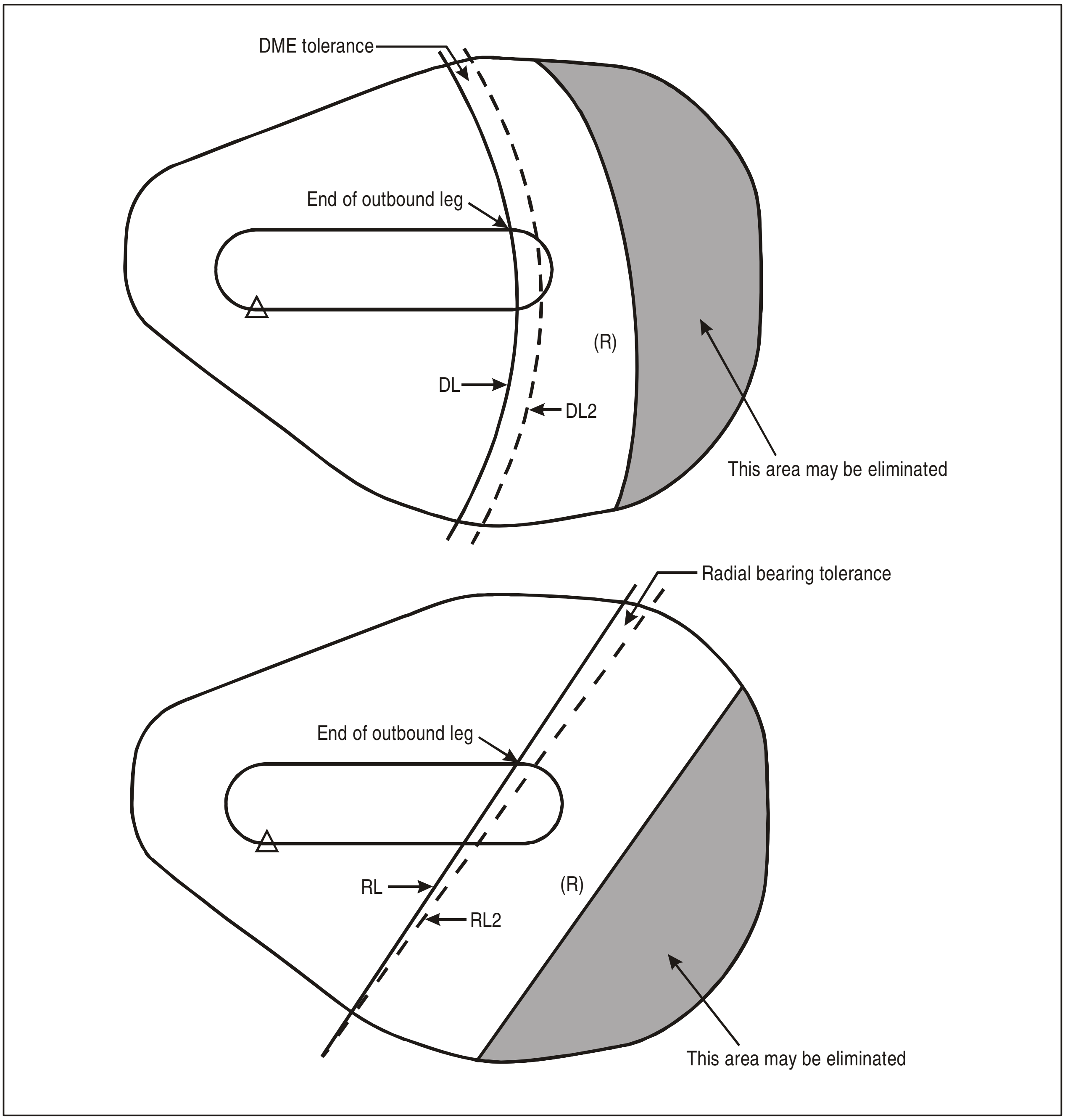


**Figure I-4-3-App C-17. Example for area reduction using DME or intersecting radial or bearing**

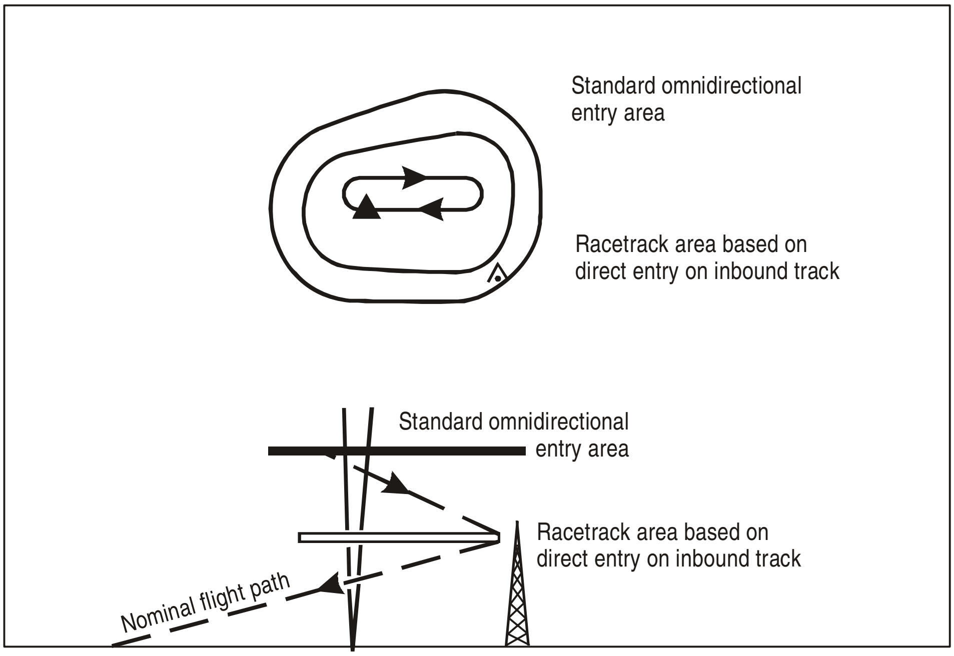


**Figure I-4-3-App C-18. Example of racetrack entry via standard/omnidirectional entry at higher altitude (racetrack area reduced for "on axis'' entry)**

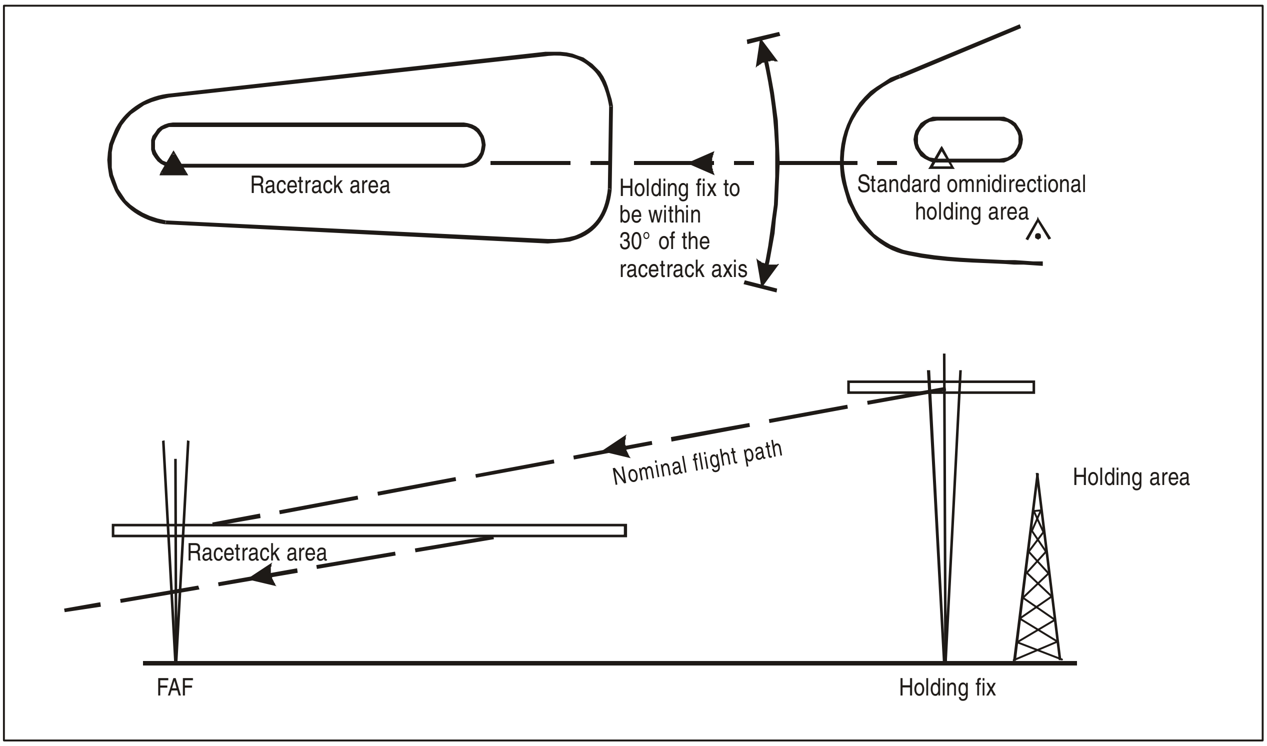


**Figure I-4-3-App C-19. Example of restricted racetrack entry via restricted or specified track(s) (racetrack area reduced for "on axis'' entry)**

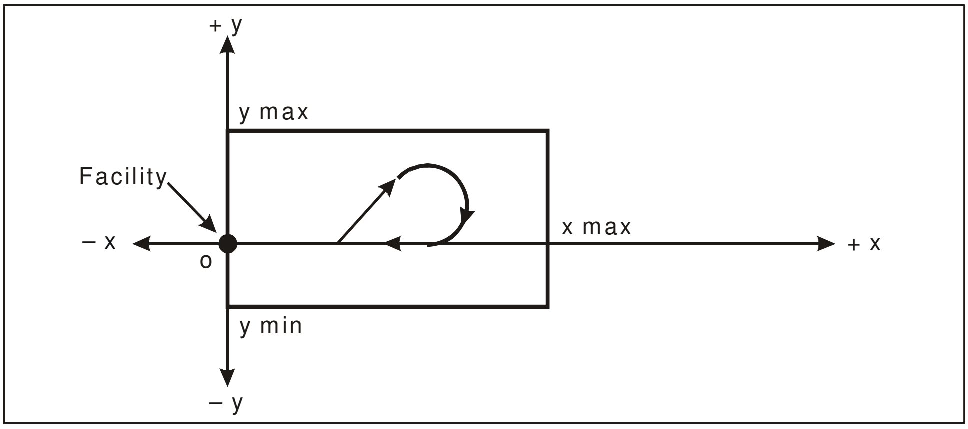


**Figure I-4-3-App C-20. Construction of simplified area — example showing rectangle for procedure turn**

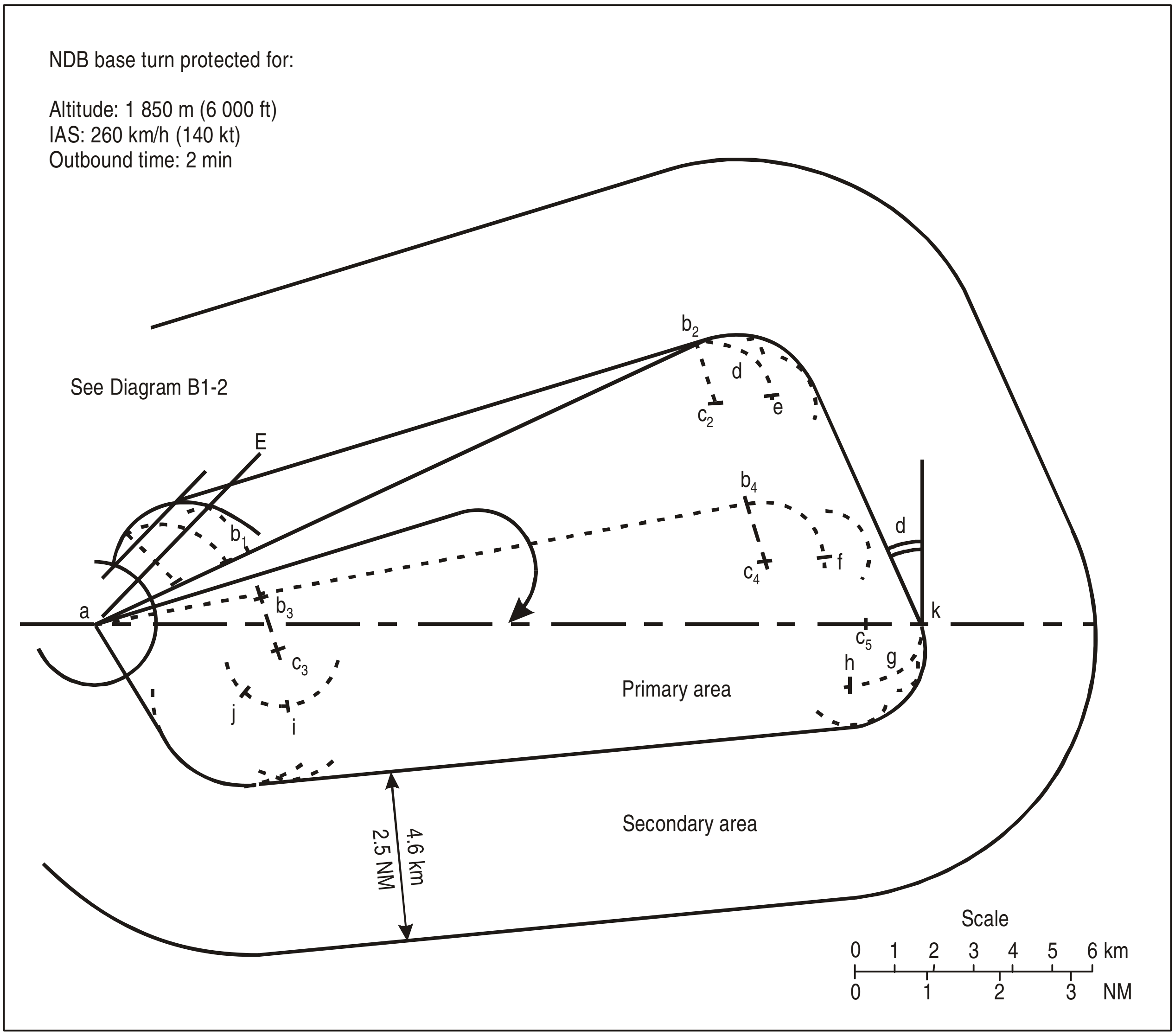


**Diagram I-4-3-App C-1. NDB base turn area**

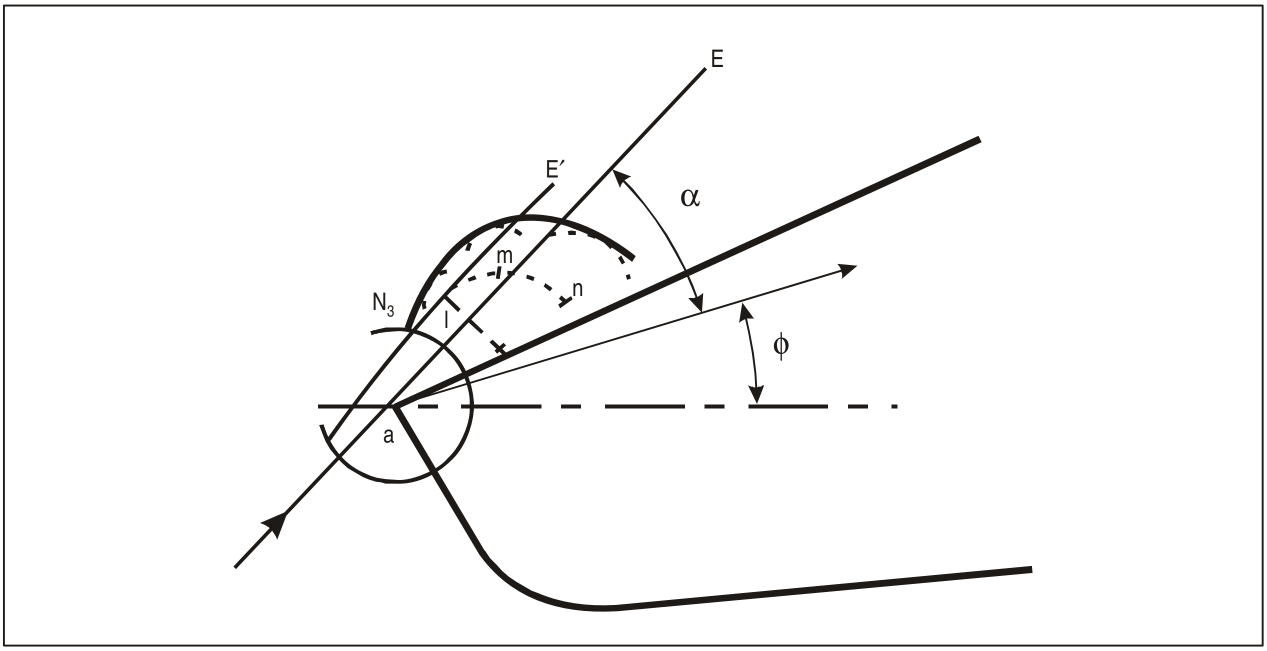


**Diagram I-4-3-App C-2. Protection of the entry to a base turn**

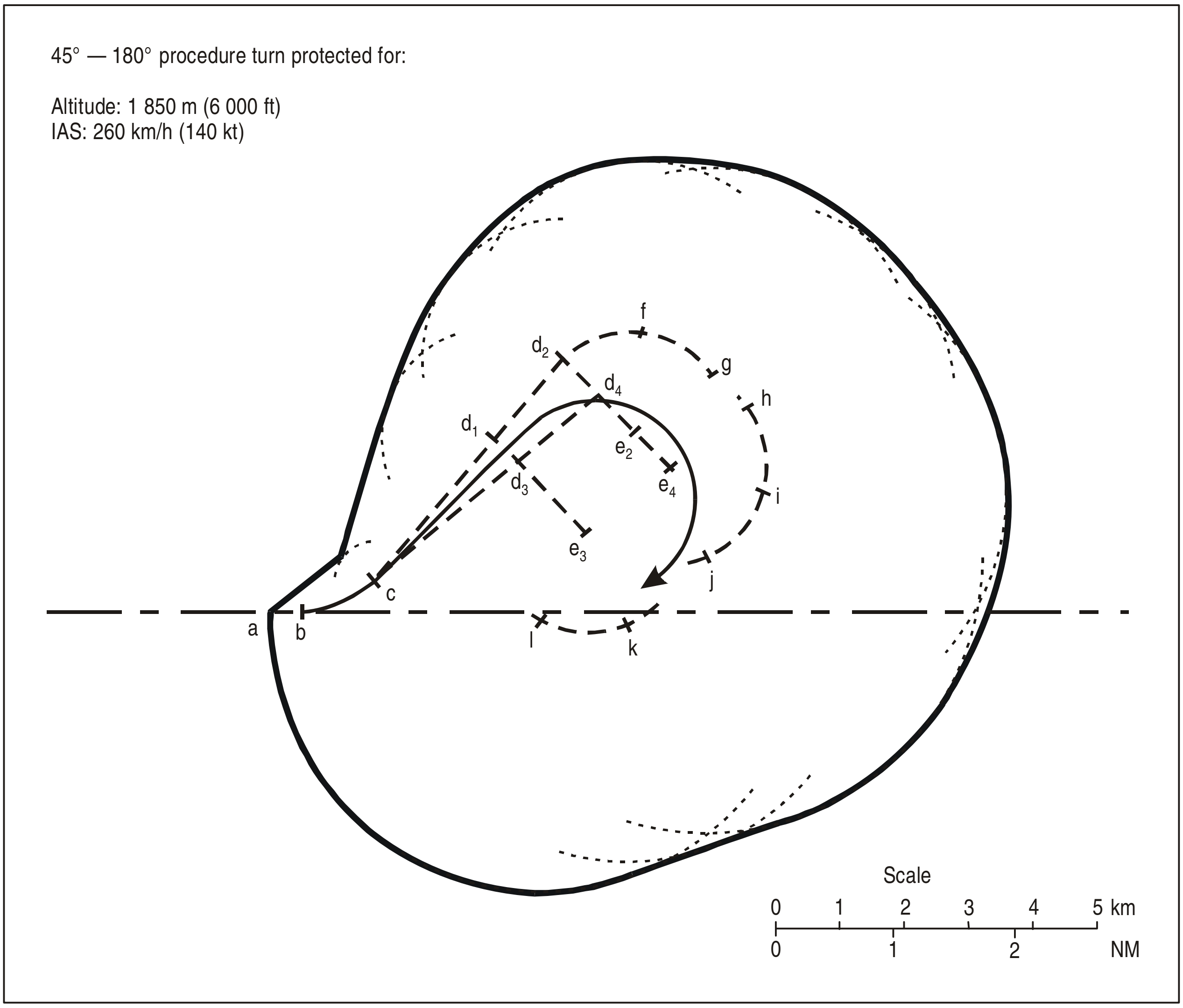


**Diagram I-4-3-App C-3. 45° — 180° procedure turn template**

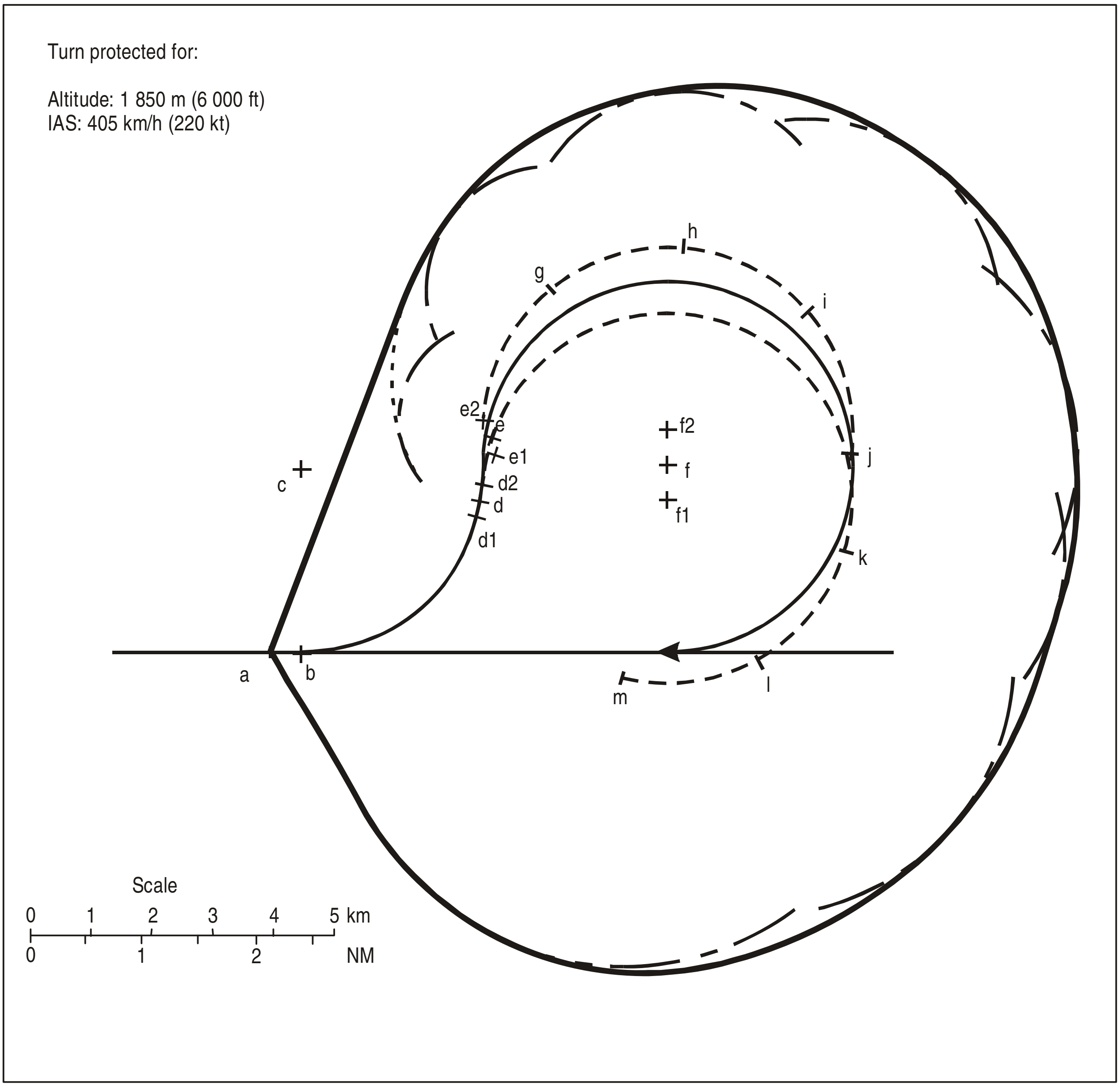


**Diagram I-4-3-App C-4. 80° — 260° procedure turn template**

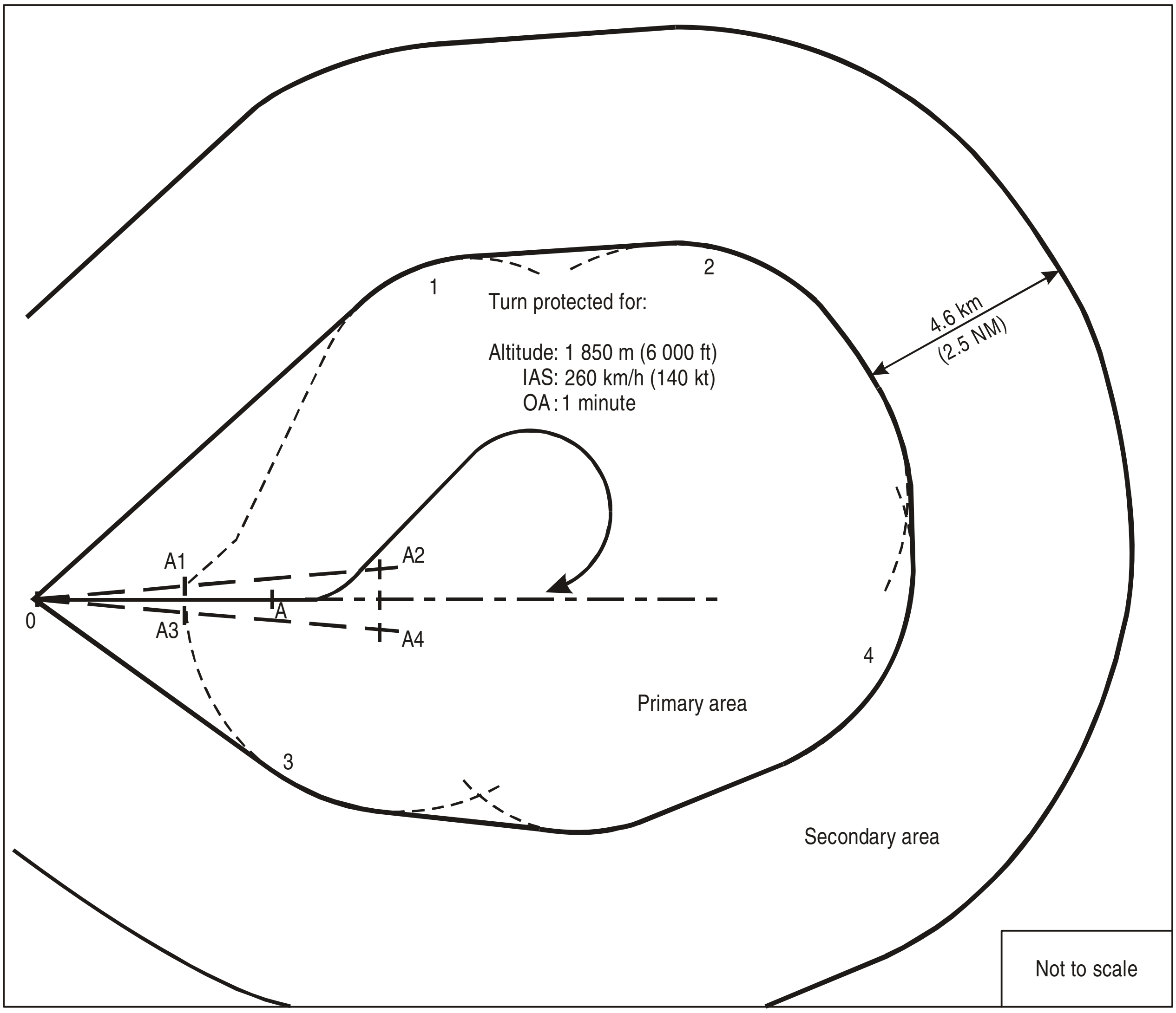


**Diagram I-4-3-App C-5. VOR 45° — 180° procedure turn**

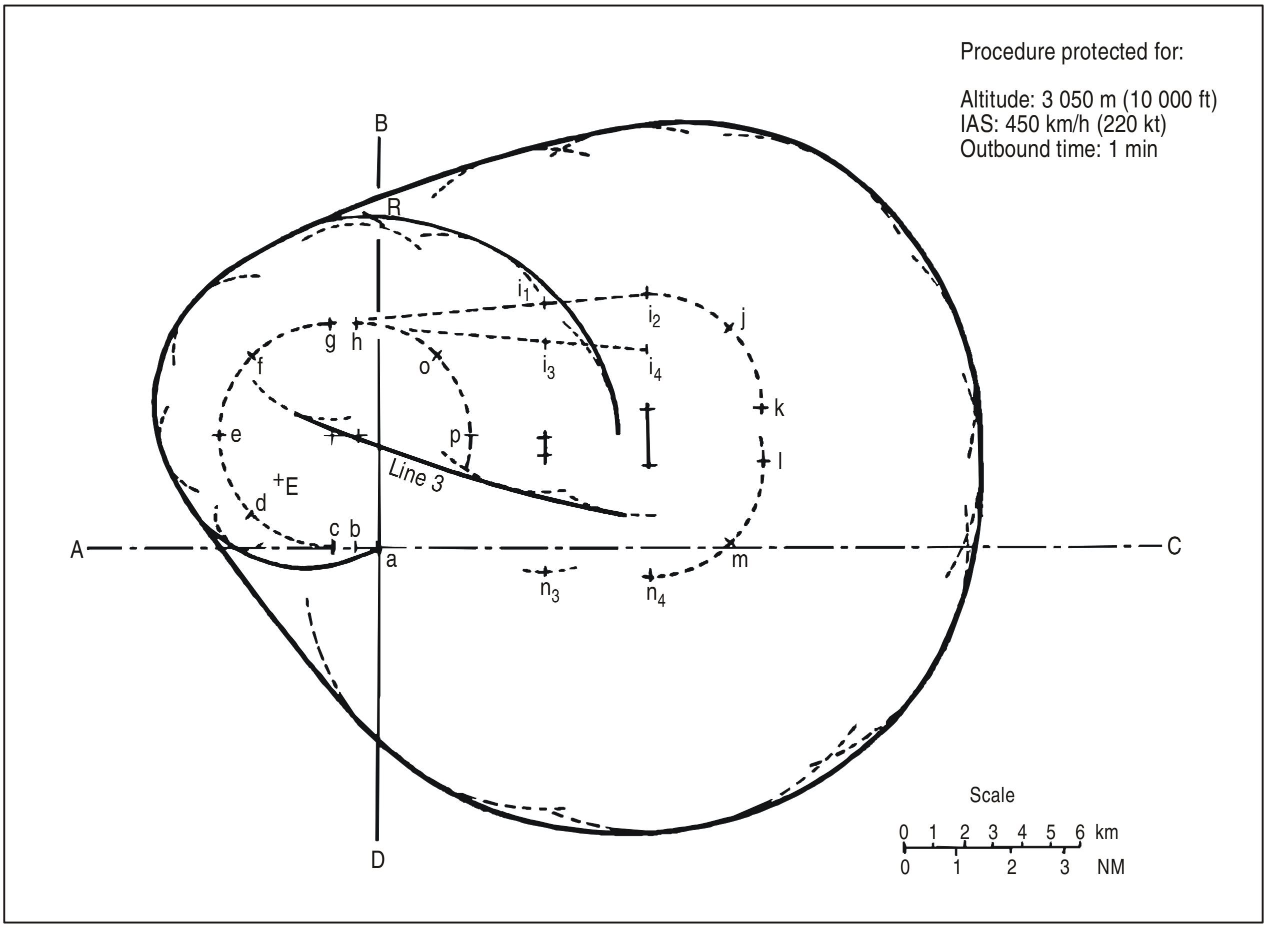


**Diagram I-4-3-App C-6. Holding/racetrack template with associated construction points**

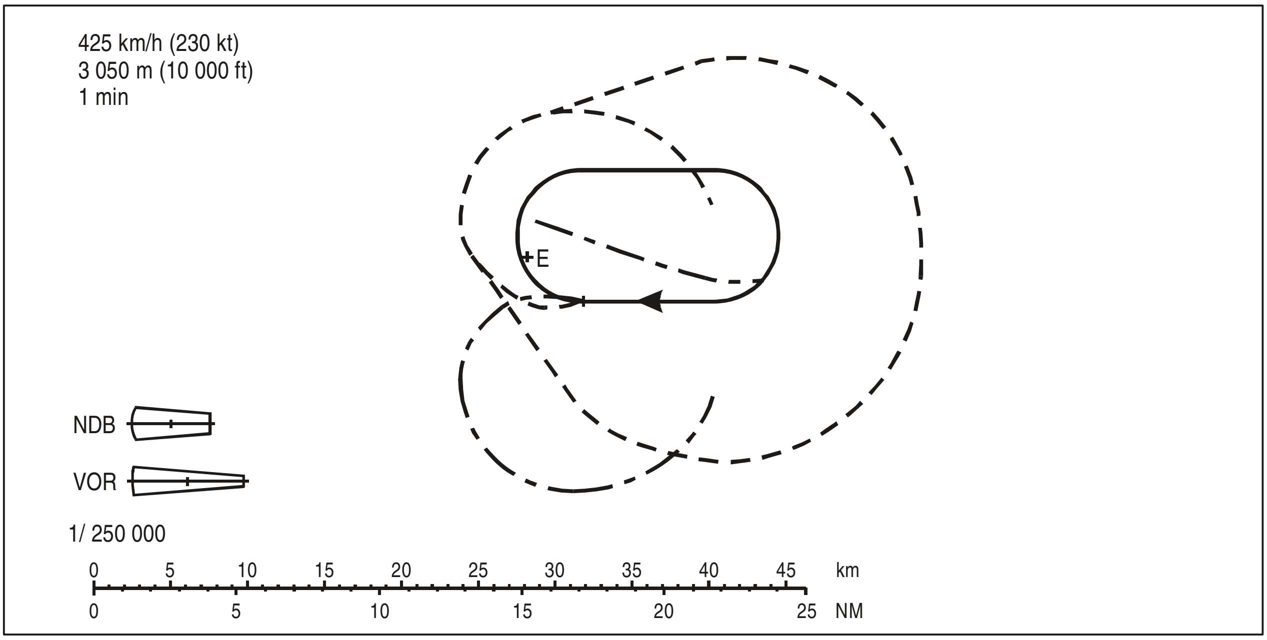


**Diagram I-4-3-App C-7. Holding template extracted from the** *Template Manual for Holding, Reversal and Racetrack Procedures* **(Doc 9371)**

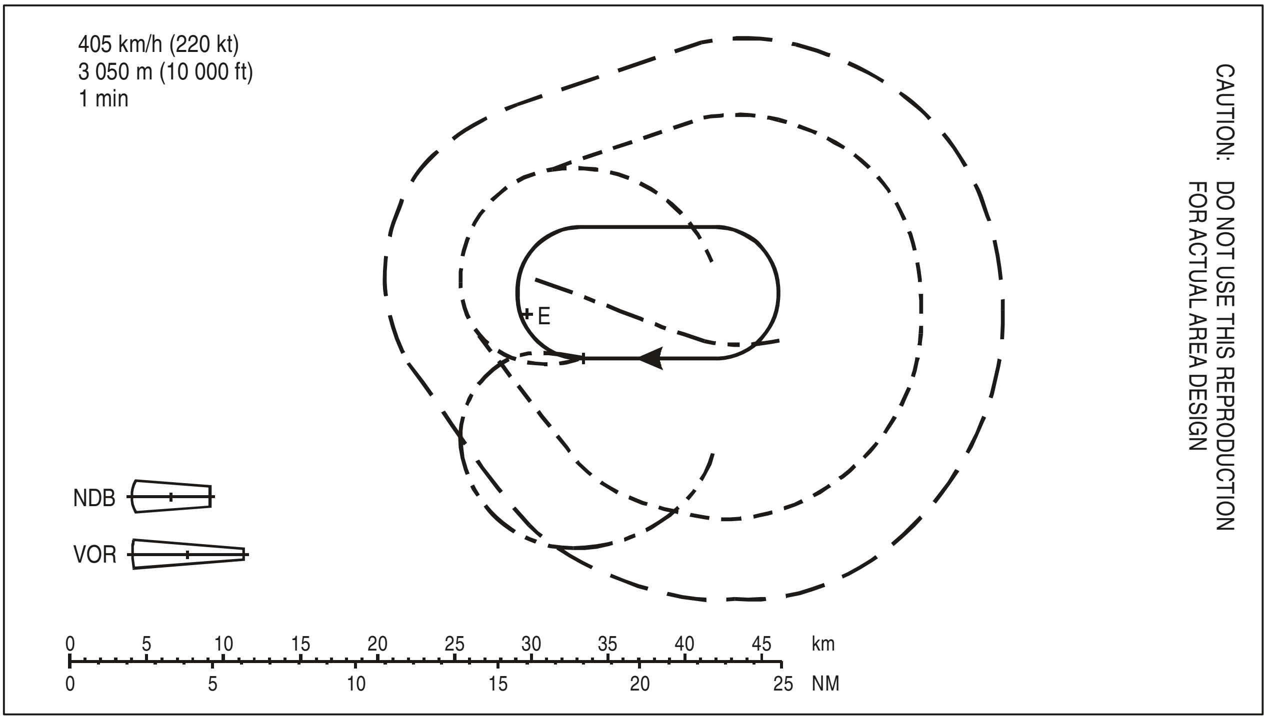


**Diagram I-4-3-App C-8. Racetrack template extracted from the** *Template Manual for Holding, Reversal and Racetrack Procedures* **(Doc 9371)**

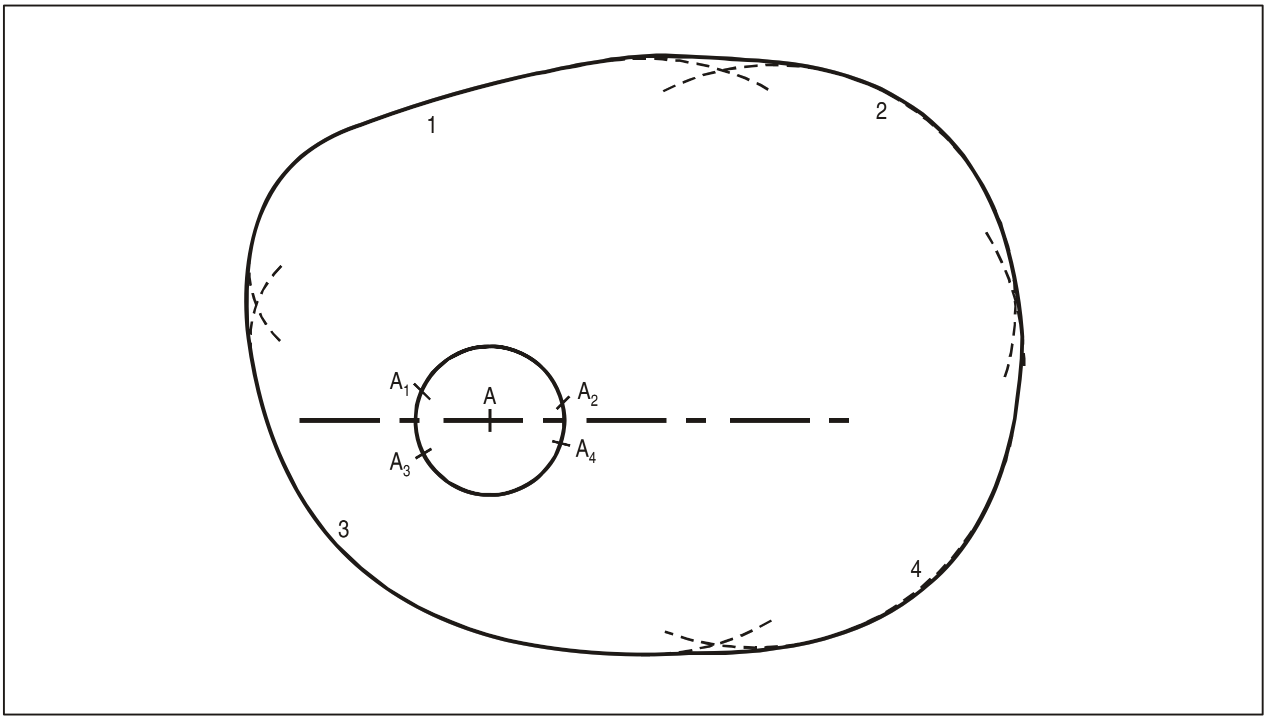


**Diagram I-4-3-App C-9. Construction of the basic area**

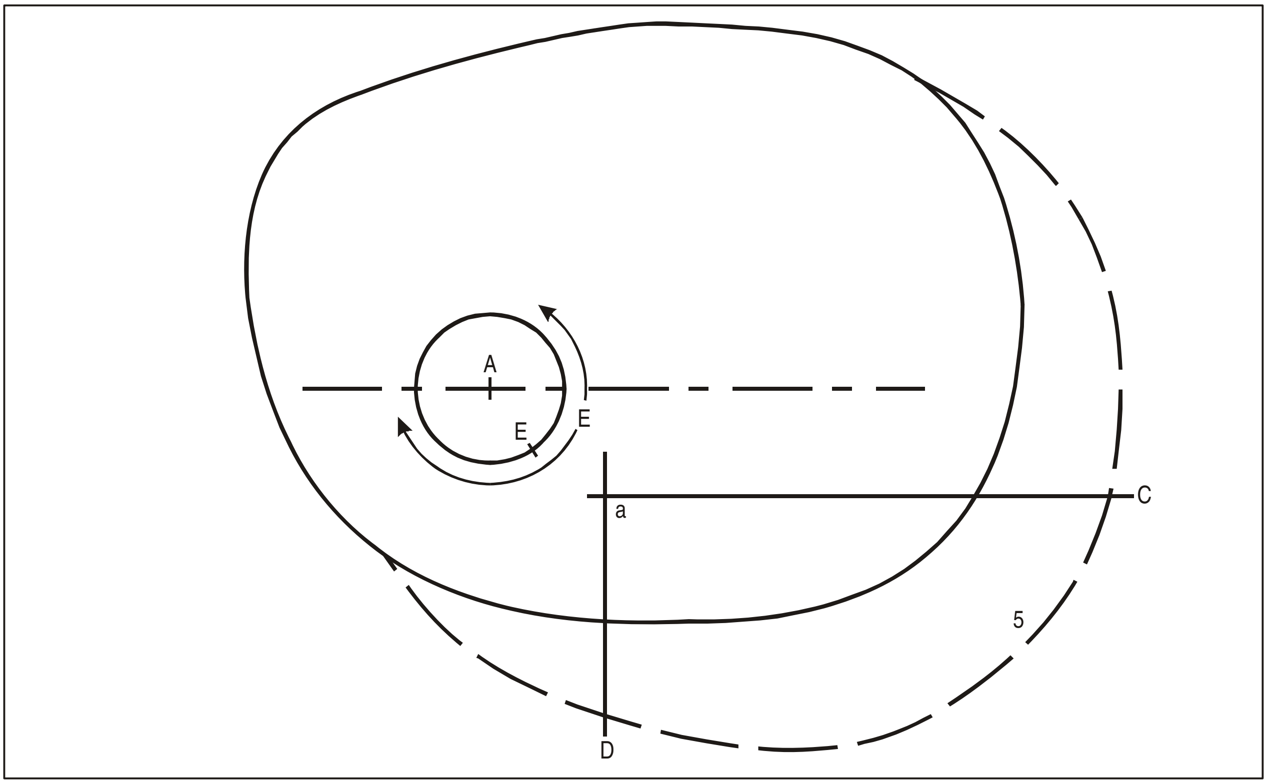


**Diagram I-4-3-App C-10. Construction of the entry area; use of point E, the axis of the template being parallel to the procedure axis**

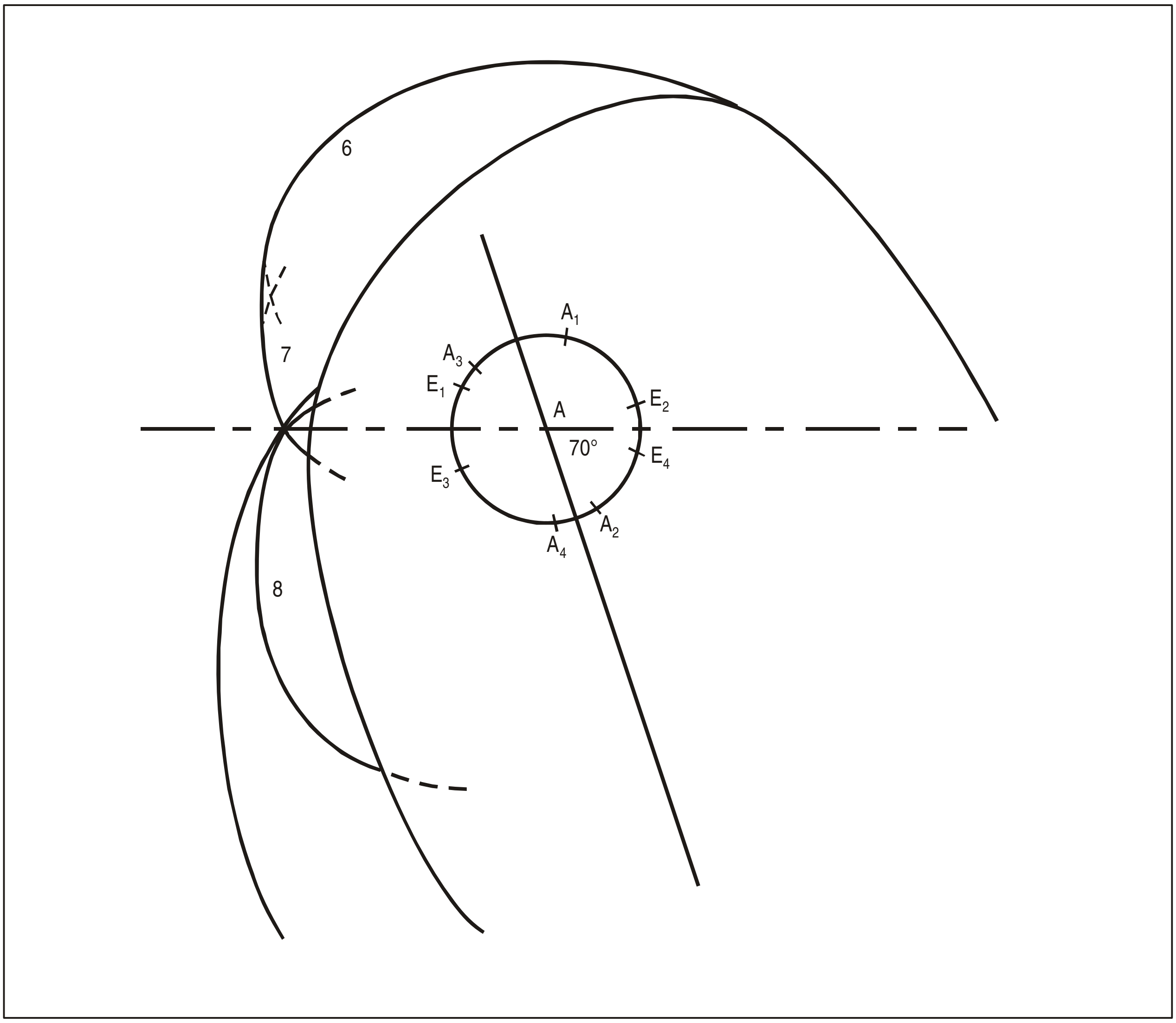


**Diagram I-4-3-App C-11. Construction of the entry area; the axis of the template making an angle of 70° with the procedure axis**

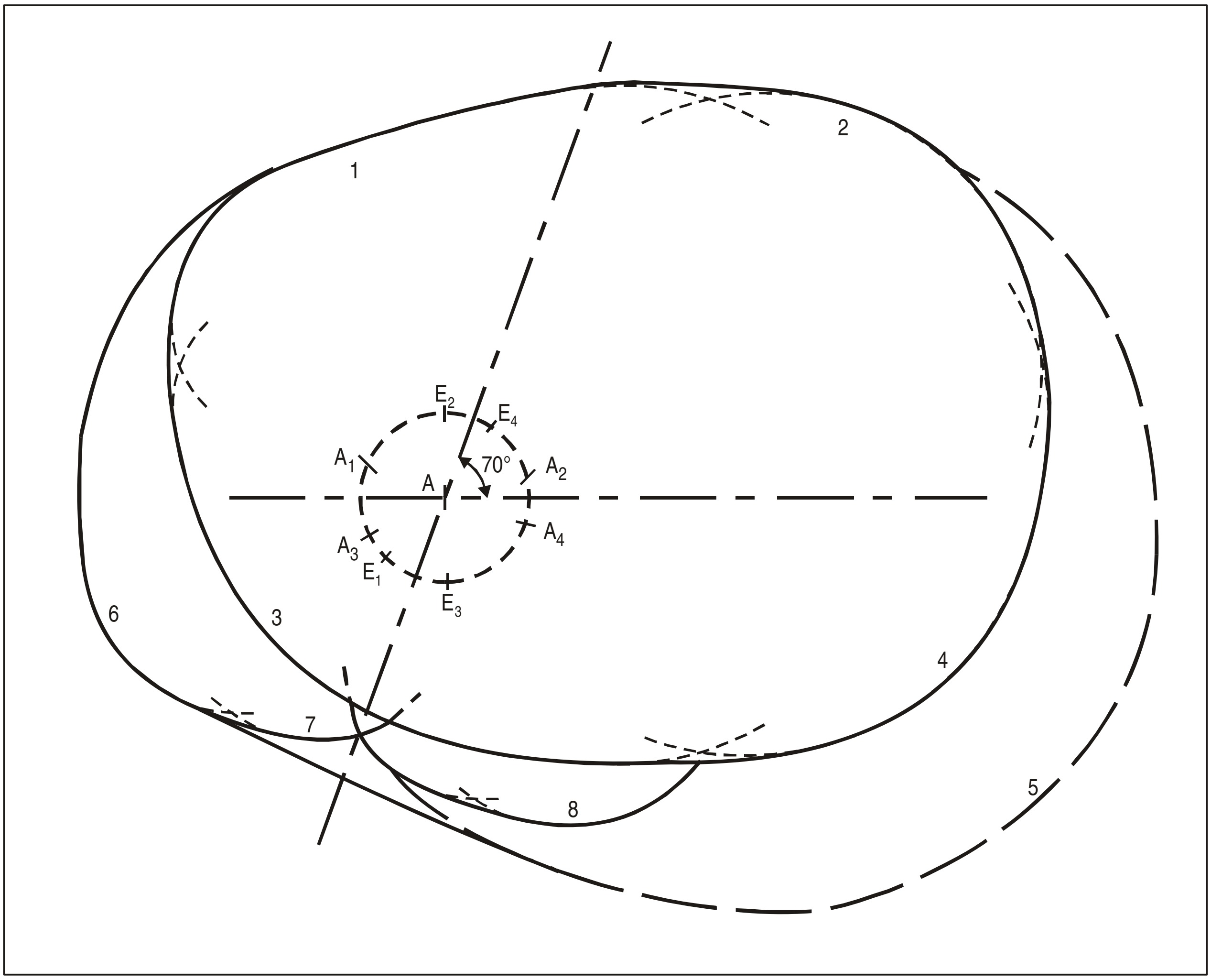


**Diagram I-4-3-App C-12. Basic area with omnidirectional entry areas; procedure overhead a facility**

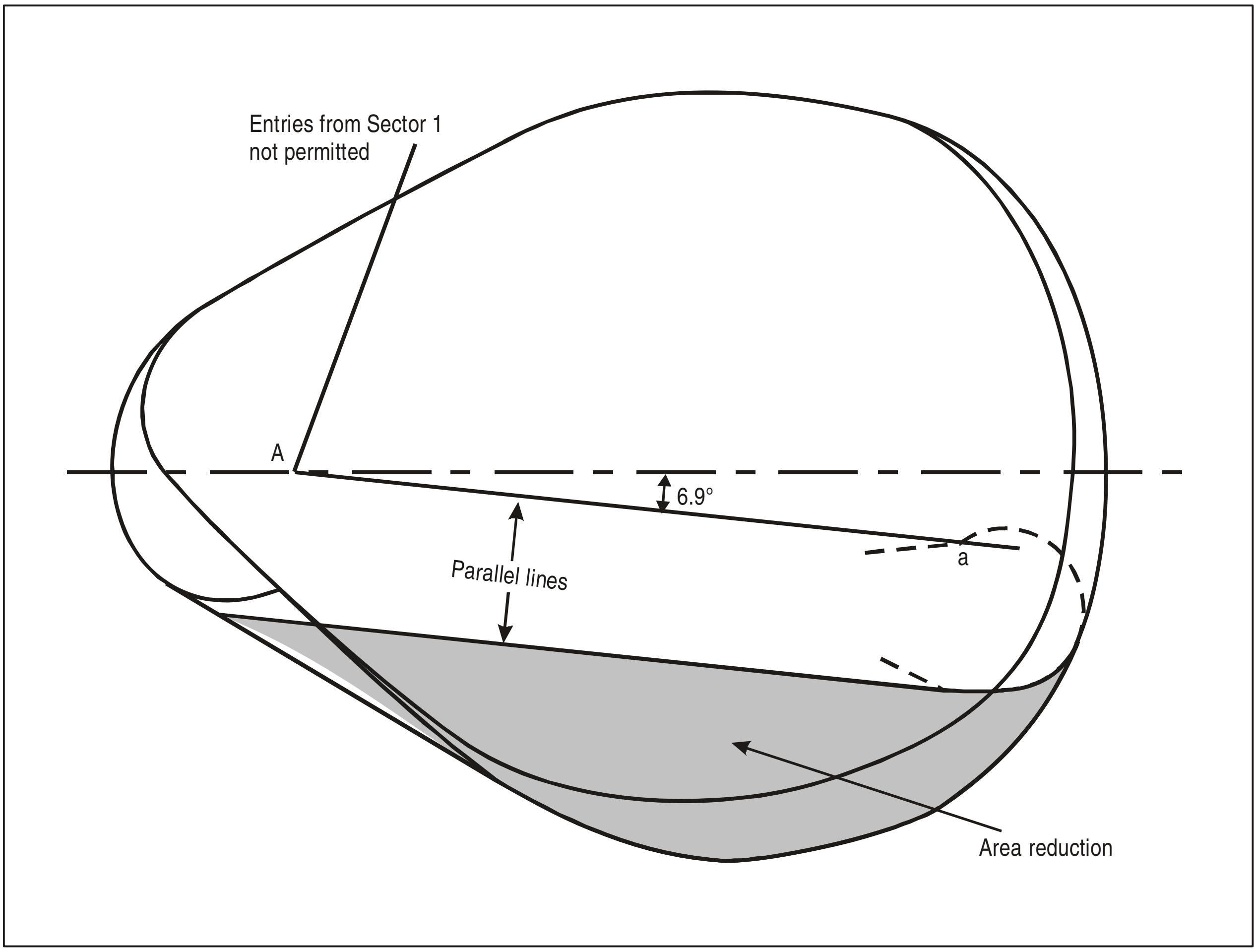


**Diagram I-4-3-App C-13. Area reduction for a procedure overhead an NDB when entries from Sector 1 are not permitted**

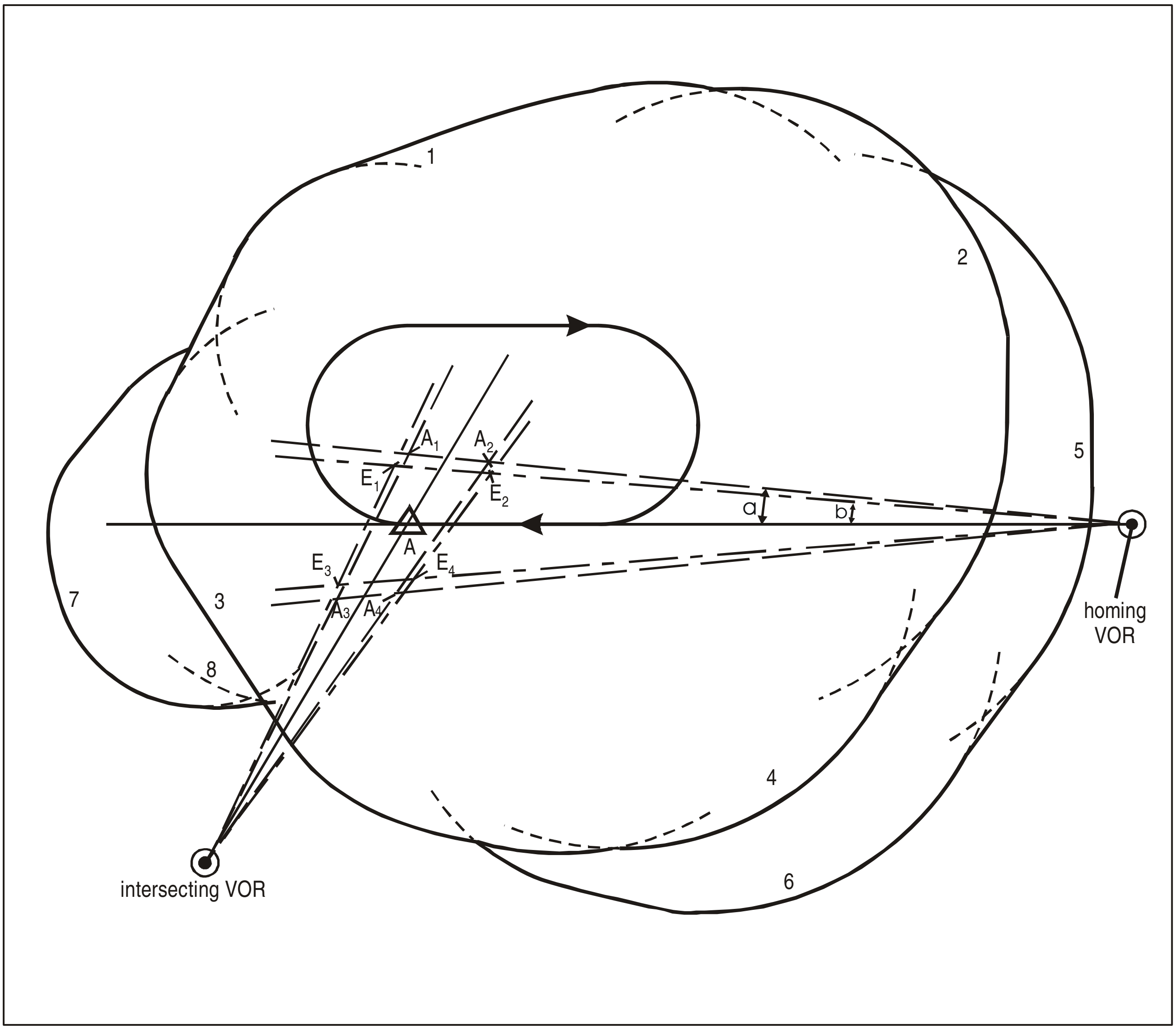


**Diagram I-4-3-App C-14. Procedure at the intersection of VOR radials — Basic area and the associated entry area assuming entries along the procedure track and intersecting radial**

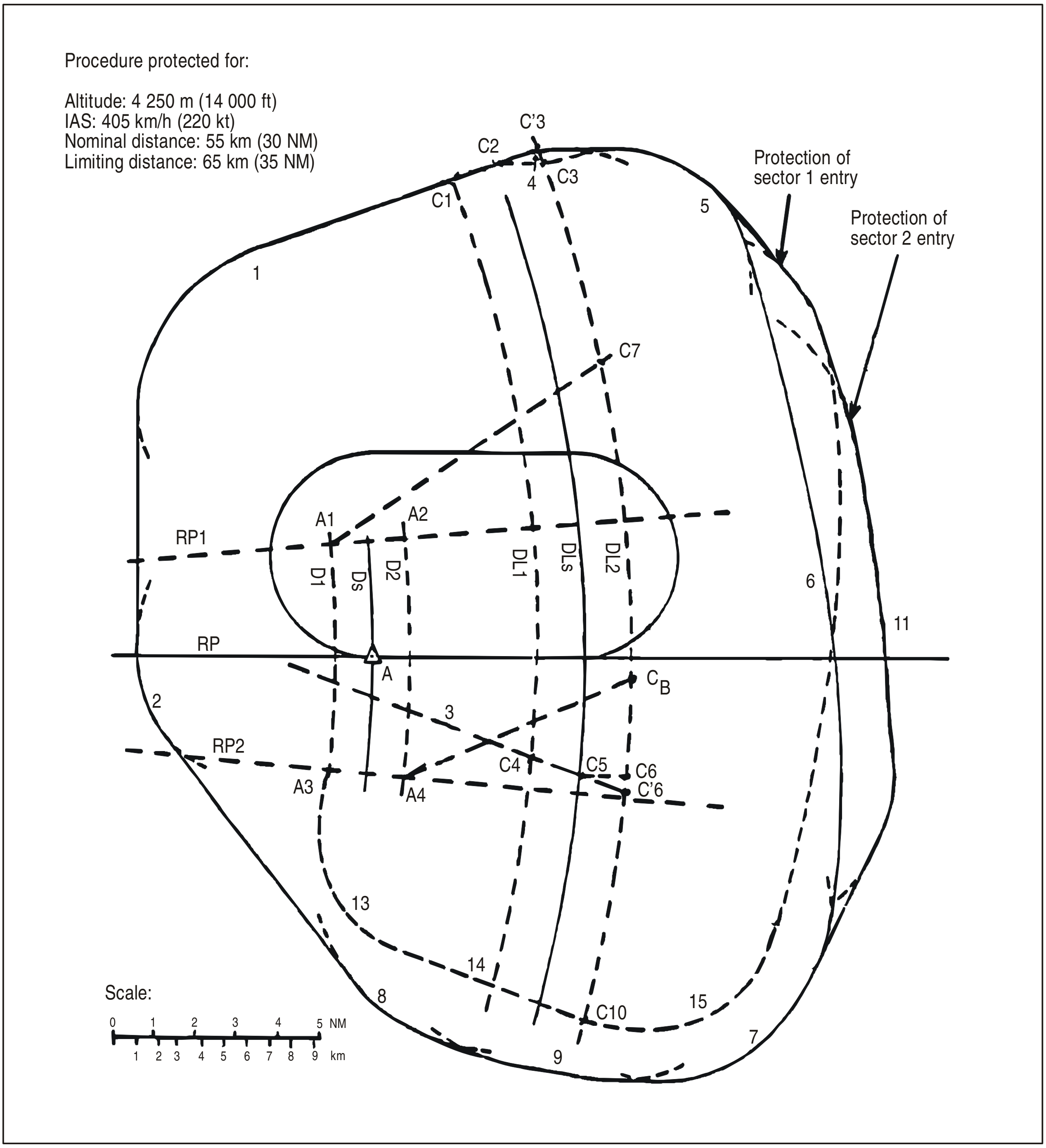


**Diagram I-4-3-App C-15. VOR/DME procedure towards the facility — basic area and associated area for entries**

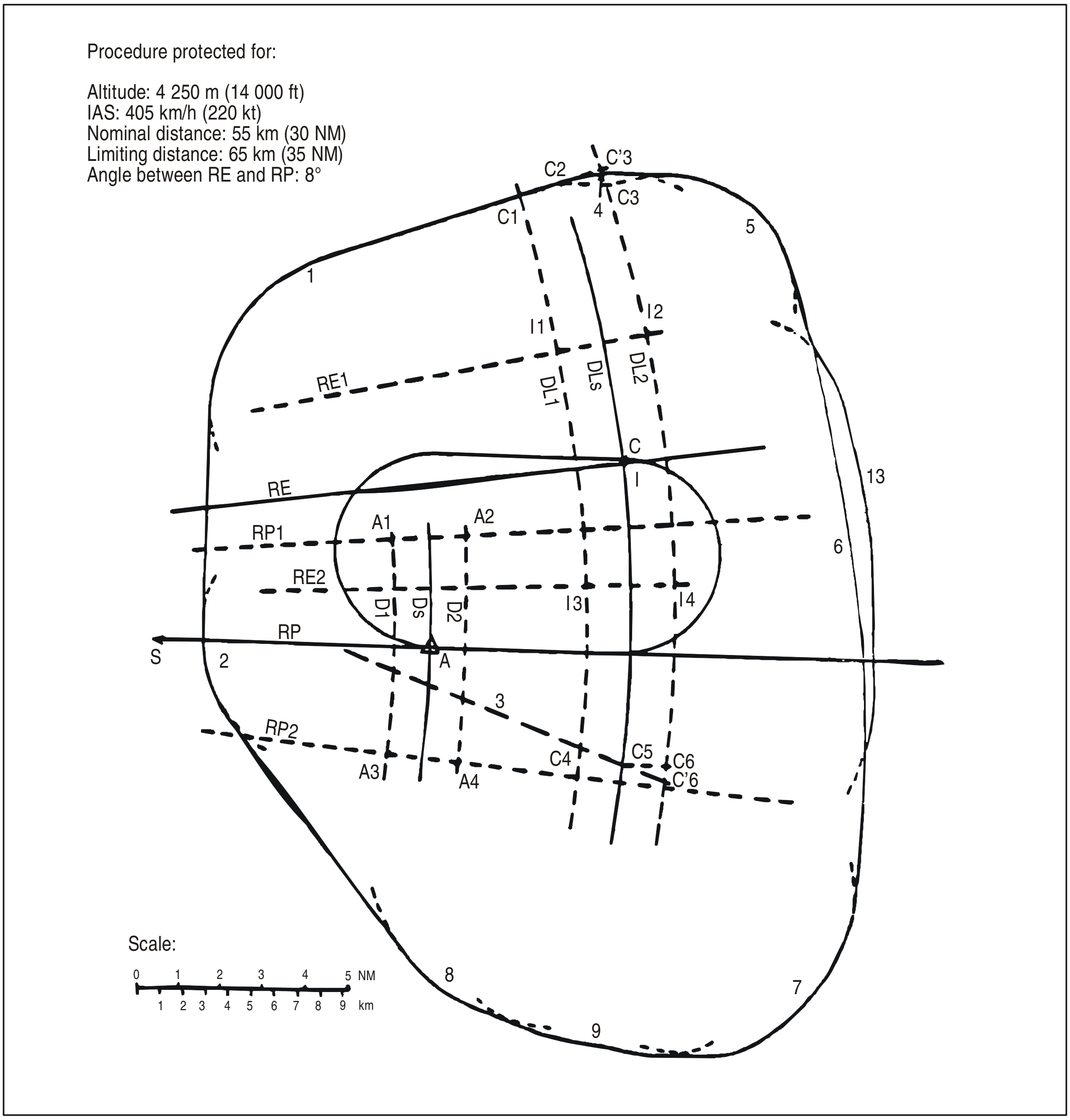


**Diagram I-4-3-App C-16. VOR/DME procedure towards the facility — basic area and associated area for reciprocal direct entry to the secondary point**

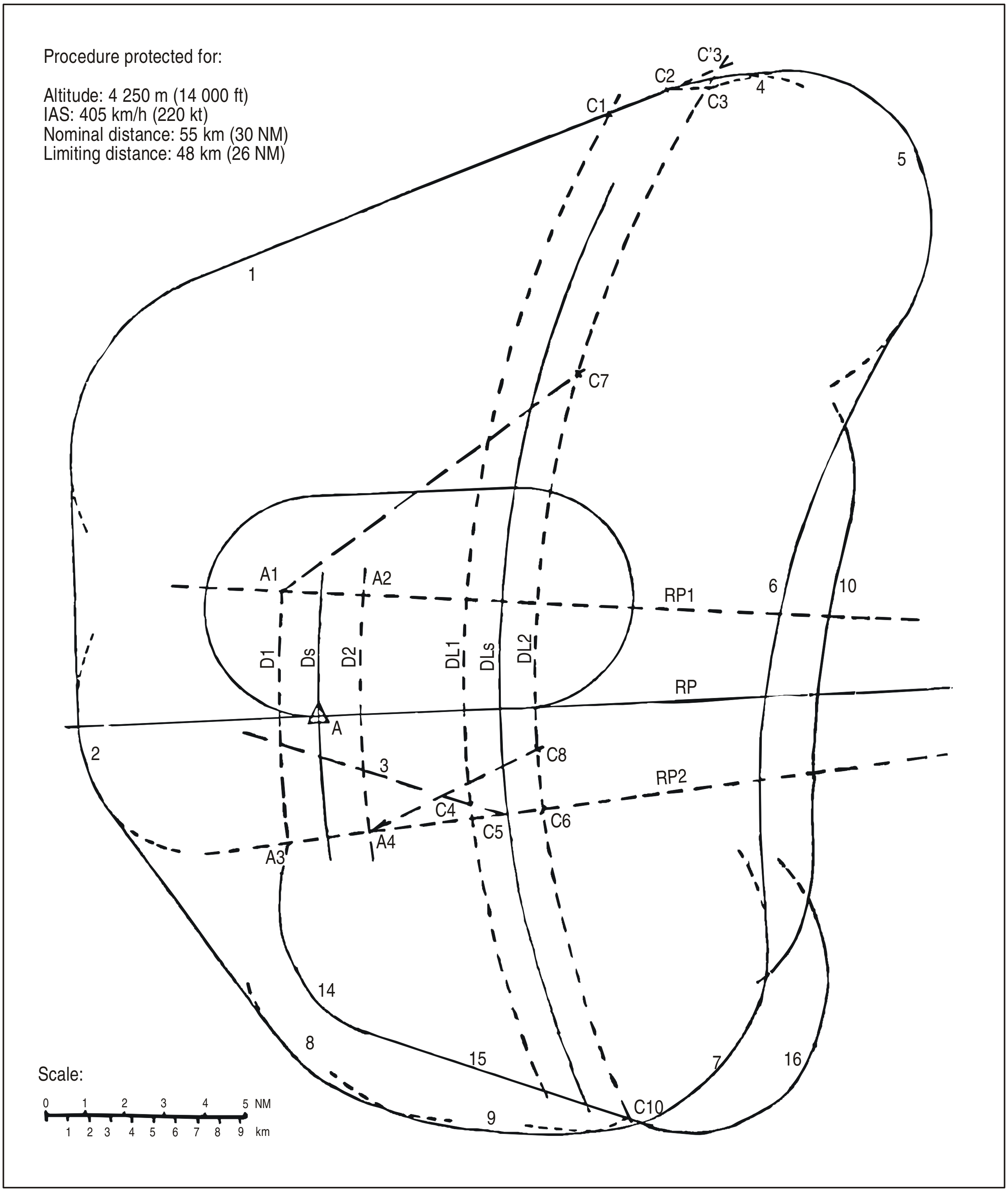


**Diagram I-4-3-App C-17. VOR/DME procedure away from the facility — basic area and associated area for entries**