2.4.3 *Use of DME.* If available, DME can be used as a turning point fix. For DME accuracy values, see Part I, Section 2, Chapter 2, 2.4.4, "DME".

2.4.4 *Facility tolerances – To be developed*

3. SPLAY

3.1 *Primary area splay*

3.1.1 The primary area splays at an angle of:

a) 5.7° (10%) — VOR; and

b) 7.95° (14%) — NDB.

3.1.2 *Primary area splay calculations.* These values are calculated as the root sum square of the system use accuracies values as given in 2.2 and 2.3. This gives a 95 per cent probability of containment (2 SD) of ± 9.87 per cent (5.64°) in the case of VOR, and ± 13.96 per cent (7.95°) in the case of NDB. The value of the primary area limit is rounded up to ± 10 per cent (5.7°) in the case of VOR. The value of the primary area limit is rounded up to ± 14 per cent (8.0°) in the case of NDB.

3.2 *Buffer area/secondary area splay.* The buffer area/secondary area splays at an angle of:

a) 9.1° (15.86%) — VOR; and

b) 13.0° (23%) — NDB.

3.3 *VOR buffer area/secondary area splay calculations.* In the calculation of the 99.7 per cent probability of containment (3 SD), the value of ± 1.0° for the monitor tolerance is taken into account to replace 1.5 x 3.5° for the ground system tolerance by a maximum value of 3.5° + 1.0° = 4.5°. The combination on a root sum square basis gives a 3 SD limit of ± 14.08 per cent (8.01°). An additional value of ± 1.0° is added, resulting in a total area limit of ±15.86 per cent (9.01°). The splay of the total area is rounded up to ± 16 per cent (9.1°). (See Figure II-3-1-2 of Chapter 3.)

3.4 *NDB buffer area/secondary area splay calculations.* The calculation of the 99.7 per cent probability of containment (3 SD) and the addition of a ± 1.0° buffer results in a total area limit of ± 22.94 per cent (12.92°). The splay of the total area is rounded up to ± 23 per cent (13.0°).

Section 4

HOLDING CRITERIA

Chapter 1

HOLDING CRITERIA

Note 1.— Guidance on parameters relating to holding areas for supersonic transport (SST) aircraft is contained in the "Statement of Operational Requirements" in ICAO Circular 126.

Note 2.— The criteria contained in this part are related to right turns holding patterns. If no operational considerations prevail, right turns holding patterns should be established. For left turns holding patterns, the corresponding entry and holding procedures are symmetrical with respect to the inbound holding track.

1.1 SHAPE AND TERMINOLOGY ASSOCIATED WITH HOLDING PATTERN

The shape and terminology associated with the holding pattern are given in Figure II-4-1-1.

1.2 ENTRY AND HOLDING PROCEDURES

The construction of a holding pattern shall be based on the following entry and holding procedures.

1.2.1 Entry procedures

Note.— Variations of the basic procedure to meet local conditions may be authorized by States after appropriate consultation with operators concerned.

1.2.1.1 *Entry sectors*

1.2.1.1.1 The entry into the holding pattern shall be according to heading, as it relates to the three entry sectors shown in Figure II-4-1-2. There is a zone of flexibility of 5° on either side of the sector boundaries.

1.2.1.1.2 In the case of holding on VOR intersections or VOR/DME fixes, entries will be limited to the radials. The criteria also provide for the protection of entries along DME arcs, but these should only be designed if there is a specific operational difficulty which makes the use of other entry procedures impossible.

1.2.1.2 *Sector 1 procedure (parallel entry)*

a) Overhead the fix, the aircraft is turned onto an outbound heading (to a track parallel to the inbound track) for the appropriate period of time or distance; then

b) turned left onto the holding side to intercept the inbound track or to return to the fix.

1.2.1.3 *Sector 2 procedure (offset entry)*

a) Overhead the fix, the aircraft is turned onto a heading so that the track makes an angle of 30° from the reciprocal of the inbound track on the holding side; and

b) flown outbound:

   1) for the appropriate period of time, where timing is specified; or

   2) until the appropriate DME distance is attained, where distance is specified; or

   3) where a limiting radial is also specified, either:

      i) until the radial is encountered; or

      ii) until the appropriate DME distance is reached, whichever occurs first; and then

c) turned right to intercept the inbound track to the holding fix.

1.2.1.4 *Sector 3 procedure (direct entry)*

Overhead the fix, the aircraft is turned right and follows the holding pattern.

1.2.1.5 *Special VOR/DME holding entry procedure*

1.2.1.5.1 For entry into a VOR/DME holding pattern an entry radial to a secondary fix at the end of the outbound leg may be established (see Figure II-4-1-3 a) and b)). In this case Sector 1 and Sector 2 entries are not authorized.

1.2.1.5.2 The holding pattern will be entered directly along the entry radial or by the Sector 3 entry procedure. Having reached the secondary fix, the aircraft will turn right and follow the holding pattern. In this case the entry radial shall be published and clearly depicted.

1.2.2 Holding procedures

1.2.2.1 After completion of the sector entry, and overhead the fix for the second time (or on completion of a subsequent holding pattern) the aircraft is turned to fly an outbound track:

a) for the appropriate period of time, if timing is specified; or

b) until the appropriate DME distance is reached if distance is specified; and that

c) on completion of the outbound leg the aircraft will be positioned for the turn onto the inbound track, allowing for the effect of wind; and then

turned to intercept the inbound track to the holding fix.

1.2.2.2 See 1.3.2, "Timing and distance" for the application of timing and distance limitations.

1.3 CONSTRUCTION OF HOLDING AREAS

1.3.1 Method of construction

1.3.1.1 Holding areas shall be constructed by a method which uses the input parameters and conditions specified in this part. One practical method is to construct a holding template that accommodates all the factors which may cause the aircraft to deviate from the nominal holding pattern. The limits of the holding area are then defined by applying this template to the boundaries of the fix tolerance area.

1.3.1.2 Details of the construction and application of this holding template method are described in Part I, Section 4, Chapter 3, Appendix A and typical templates are contained in the *Template Manual for Holding, Reversal and Racetrack Procedures* (Doc 9371).

1.3.1.3 The calculations associated with the construction of basic holding areas and the respective omnidirectional entry areas require the use of the parameters given in 1.3.2 to 1.3.10.

1.3.1.4 *Aircraft holding at 520 km/h (280 kt)/0.8 Mach.* The possibility of aircraft having to hold at 520 km/h (280 kt)/0.8 Mach indicated airspeed in conditions of turbulence shall be taken into account. Whenever the holding area cannot accommodate aircraft required to hold at 520 km/h (280 kt)/0.8 Mach, suitable air traffic control (ATC) procedures should be established to handle aircraft requesting this speed.

Note.— Such ATC procedures might take the form of action to protect additional airspace or issue an alternative clearance, including holding outside the normal holding areas, or diversion.

1.3.2 Timing and distance

1.3.2.1 *Start of timing*

Outbound timing starts abeam the fix or on attaining the outbound heading, whichever comes later.

1.3.2.2 *Outbound timing*

1.3.2.2.1 *Aeroplane timing*. In constructing the outbound leg length based on time flown, the outbound timing should be:

a) one minute up to and including 4 250 m (14 000 ft); and

b) one and one-half minutes above 4 250 m (14 000 ft);

however, it may be increased provided the protected airspace is adjusted in accordance with the principles contained in this chapter.

1.3.2.2.2 *Helicopter timing*. The outbound timing should be:

a) one minute up to and including 1 830 m (6 000 ft); and

b) Category A fixed-wing aeroplane criteria above 1 830 m (6 000 ft).

1.3.2.3 *Outbound distance*

The specified DME outbound distance should be expressed in terms of distance equivalent to at least one minute of flight time at the selected true air speed (TAS). When this is done, make certain that:

a) at least 30 seconds will be available on the inbound track after completion of the inbound turn; and that

b) slant range is taken into account.

1.3.2.4 *Limiting radial*

In the case of holding away from the station, if the distance from the holding fix to the VOR/DME station is so short that there is no chance of even the most adverse outbound track or Sector 2 entry track intersecting the limiting DME distance, a limiting radial shall be specified. A limiting radial may also be specified where airspace conservation is essential.

Note.— The limiting radial shall be a radial from the VOR/DME on which the holding is based. (See 4.4.)

1.3.3 Indicated airspeed

1.3.3.1 *General*

1.3.3.1.1 Areas should be calculated and drawn to accommodate the fastest aircraft category. The indicated airspeeds shown in Table II-4-1-2 should be used in calculating holding areas.

1.3.3.1.2 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 constructed in this manner, the normal operational adjustments made by the pilots of such aircraft should keep the aircraft within the area.

1.3.3.1.3 For conversion from indicated airspeeds to true airspeeds, see temperature considerations in 1.3.7, “Temperature” and Appendix A to this chapter.

Note.— The speeds given in Table II-4-1-2 are converted and rounded to the nearest multiple of five for operational reasons and from the standpoint of operational safety are considered to be equivalent.

1.3.3.2 *Airspeeds*

The speeds upon which the holding area is based should be published.

1.3.3.3 *Entry speeds under limited position fixing capabilities*

Where position fixing capabilities preceding the holding fix are limited, the competent authority should consider planning holding areas to accommodate initial entry speeds greater than prescribed.

1.3.4 Angle of bank or rate of turn

The angle of bank to be taken into consideration should be 25°. The formula for deriving rate of turn from angle of bank is contained in Appendix A to this chapter. Graphs for deriving rate of turn from angle of bank appear at Appendix A to this chapter, Figures II-4-1-App A-1 and II-4-1-App A-2.

1.3.5 Navigation accuracy

Accuracy values for constructing holding areas are given in Part I, Section 2, Chapter 2, 2.3.3, "System use accuracy".

1.3.6 Wind velocity

3.6.1 Where statistical wind data are available, the maximum wind speed within 95 per cent probability should be used on an omnidirectional basis for calculations. However, component wind velocities derived from the 95 per cent statistical data may be used instead of omnidirectional winds.

3.6.2 Where statistical wind data are not available, omnidirectional winds calculated from either of the formulae contained in Appendix A to this chapter, 6.6, or read from the graph at Appendix A to this chapter (Figure II-4-1-App A-4) should be used.

Note.— Where two adjacent holding pattern areas overlap, it may be possible to designate these patterns as laterally separated. In such cases the State concerned establishes that winds from different directions would be required in order for conflict to occur. The basic holding area plus the entry area should be applied in determining lateral separation between each pattern and other adjacent areas of probability, e.g. air routes.

1.3.7 Temperature

Where climatological data are available the maximum temperature within the 95 per cent probability should be used for calculations. Where adequate climatological data are not available, the international standard atmosphere (ISA) plus 15° Celsius temperature gradient should be used. ISA + 15°C graph is in Appendix A to this chapter (Figure II-4-1-App A-5). Tables of conversion from indicated airspeeds to true airspeeds at ISA + 15°C are contained at Appendix A to this chapter (Tables II-4-1-App A-1 and II-4-1-App A-2).

1.3.8 Flight levels

Where a holding area is to be applied to a block of flight levels it should be applied *only* to the level for which plotted or *below.*

1.3.9 Flight technical tolerance

The tolerances in this section are applied as shown in Part I, Section 4, Chapter 3, Figure I-4-3-8.

1.3.9.1 *Fix tolerance.* On passage over the fix, an overall tolerance of 11 seconds shall be applied to the fix position tolerance area. This is comprised of:

a) 6 seconds tolerance for pilot reaction; and

b) 5 seconds for establishment of bank.

1.3.9.2 *Outbound leg tolerance.* On the outbound leg, an overall tolerance of + 15 seconds to – 5 seconds shall be applied. This is comprised of:

a) ± 10 seconds tolerance for timing; and

b) 5 seconds for establishment of bank.

1.3.9.3 *DME distance tolerance.* In cases where DME is utilized a tolerance of 11 seconds should be applied to the DME distance tolerance.

1.3.10 Heading tolerance

A tolerance of ± 5° in heading should be allowed for on the outbound leg of the pattern.

1.3.11 Effect of entry track on the dimension of the basic holding area

The area of holding patterns shall be adjusted for the various types of entries by applying the parameters in 3.2 through 3.10 to the entry procedures. This generally requires additional airspace to the basic area (see 1.3.12, "Obstacle clearance").

1.3.12 Obstacle clearance

1.3.12.1 *Holding area components.* The holding area includes the basic holding area, the entry area, and the buffer area.

a) The basic holding area at any particular level is the airspace required at that level for a standard holding pattern based on the allowances for aircraft speed, wind effect, timing errors, holding fix characteristics, etc.

b) The entry area includes the airspace required to accommodate the specified entry procedures.

c) The buffer area extends 9.3 km (5.0 NM) (Cat H, 3.7 km (2 NM) at or below 1 830 m (6 000 ft)) beyond the boundary of the holding area. In this buffer area the height and nature of obstacles shall be taken into consideration when determining the minimum usable holding level in the holding pattern.

1.3.12.2 *MOC*

1.3.12.2.1 The minimum permissible holding level shall provide a clearance of at least:

a) 300 m (984 ft) above obstacles in the holding area; and

b) the appropriate value from Table II-4-4-1 above obstacles in the buffer area. This value decreases stepwise outward.

1.3.12.2.2 *Obstacle clearance over high terrain.* Over high terrain or in mountainous areas, obstacle clearance up to a total of 600 m (1 969 ft) shall be provided to accommodate the possible effects of turbulence, down draughts and other meteorological phenomena on the performance of altimeters, as indicated in the guidance material in Part II, Section 4, Chapter 1, Appendix B. (See also Figure II-4-1-4. For Cat H, see Figure II-4-1-5.)

1.4 SPECIAL CONDITIONS FOR PLANNING VOR/DME HOLDING PROCEDURES AND CONSTRUCTION OF ASSOCIATED AREAS

1.4.1 General

The general provisions of sections 1.1, 1.2 and 1.3 of this chapter apply. Information contained in Part I, Section 4, Chapter 3, Appendix A should be used for calculating and constructing the holding area.

1.4.2 VOR/DME system requirements

The use of the VOR/DME system is limited by the following requirements:

a) the holding area must lie within the designated operational coverage of the VOR and DME;

b) the cone of ambiguity of the VOR:

   1) must not overlap the holding area for holding away from the station; and

   2) must not overlap the holding fix in the case of holding towards the station;

c) the minimum usable DME ground distance must overlap neither the holding fix nor the limiting distance of the outbound leg; and

d) the VOR and DME facilities must be collocated and the inbound track aligned on the specified VOR radial.

The minimum usable ground distance to a VOR/DME fix for holding is subject to the limitations given in Part I, Section 2, Chapter 2, 2.6.1, “Minimum usable ground distance to a VOR/DME fix”.

1.4.3 DME arc radius

1.4.3.1 If DME arc is used to provide track guidance for entry to the holding pattern, the arc radius shall not be less than 13 km (7 NM).

1.4.3.2 Variations, to meet local conditions, may be authorized after appropriate consultation with the operator concerned.

1.4.4 Operationally-preferred procedures

The following procedures should be used, if possible:

a) the inbound track should be towards the facility. However, if it is necessary to hold away from the station, the holding distance should be chosen so as to avoid the necessity for a limiting radial; and

b) the entry to the pattern should be along the inbound track to the holding fix.

Note 1.— The entry may be assisted by radar, by establishment of a navigation fix beyond the holding pattern on the extended inbound track, etc.

Note 2.— Entries on DME arcs should only be designed if there is a specific operational difficulty which makes the use of other entry procedures impossible.

Note 3.— Entry procedures from other navigation facilities may require additional protected airspace.

1.4.5

In calculations of the VOR cone effect area and DME slant range conversions, the height above the facility (hl) is to be used (see Appendix A to this Chapter, 6.4 and 6.5).

1.5 PROMULGATION

1.5.1 Special VOR/DME holding entry procedure

1.5.1.1 For entry into a VOR/DME holding pattern an entry radial to a secondary fix at the end of the outbound leg may be established (see Figure II-4-1-3 a) and b)). In this case Sector 1 and Sector 2 entries are not authorized.

1.5.1.2 The holding pattern will be entered directly along the entry radial or by the Sector 3 entry procedure. Having reached the secondary fix, the aircraft will turn right and follow the holding pattern. In this case the entry radial shall be published and clearly depicted.

1.5.2 Airspeeds

1.5.2.1 The speeds upon which the holding area is based should be published.

1.5.2.2 *Slant range distances for VOR/DME holding*

1.5.2.2.1 The distance of holding fix and the limiting outbound distance shall be expressed in whole kilometres (nautical miles) as the slant-range from the DME station.

1.5.2.2.2 Slant-range distances together with the limiting radial (where specified), shall be published on the appropriate aeronautical chart to be used by the pilot.

Table II-4-4-1. Minimum obstacle clearance in the buffer area over low flat terrain

Distance beyond the boundary of the holding area		*Minimum obstacle clearance over low flat terrain*	
Kilometres	*Nautical miles*	*Metres*	*Feet*
0 to 1.9	0 to 1.0	300	984
1.9 to 3.7	1.0 to 2.0	150	492
3.7 to 5.6	2.0 to 3.0	120	394
5.6 to 7.4	3.0 to 4.0	90	294
7.4 to 9.3	4.0 to 5.0	60	197
Category H			
0. to 3.7	0 to 2.0	linear	linear
		300 to 0	984 to 0

Table II-4-1-2. Airspeeds for holding area construction

Levels[1]	*Normal conditions*	*Turbulence conditions*
Helicopters up to 1 830 m (6 000 ft) inclusive	185 km/h (100 kt)	
up to 4 250 m (14 000 ft) inclusive	425 km/h (230 kt)[2] 315 km/h (170 kt)[4]	520 km/h (280 kt)[3] 315 km/h (170 kt)[4]
above 4 250 m (14 000 ft) to 6 100 m (20 000 ft) inclusive above 6 100 m (20 000 ft) to 10 350 m (34 000 ft) inclusive	445 km/h (240 kt)[5] 490 km/h (265 kt)[5]	520 km/h (280 kt) or 0.8 Mach, whichever is less[3]
above 10 350 m (34 000 ft)	0.83 Mach	0.83 Mach

1. The levels tabulated represent *altitudes* or corresponding *flight levels* depending upon the altimeter setting in use.
2. When the holding procedure is followed by the initial segment of an instrument approach procedure promulgated at a speed higher than 425 km/h (230 kt), the holding should also be promulgated at this higher speed wherever possible.
3. See 1.3.1.4, "Aircraft holding at 520 km/h (280 kt)/0.8 Mach".
4. For holdings limited to Cat A and B aircraft only and Cat H above 1 830 m (6 000 ft).
5. Wherever possible, 520 km/h (280 kt) should be used for holding procedures associated with airway route structures.

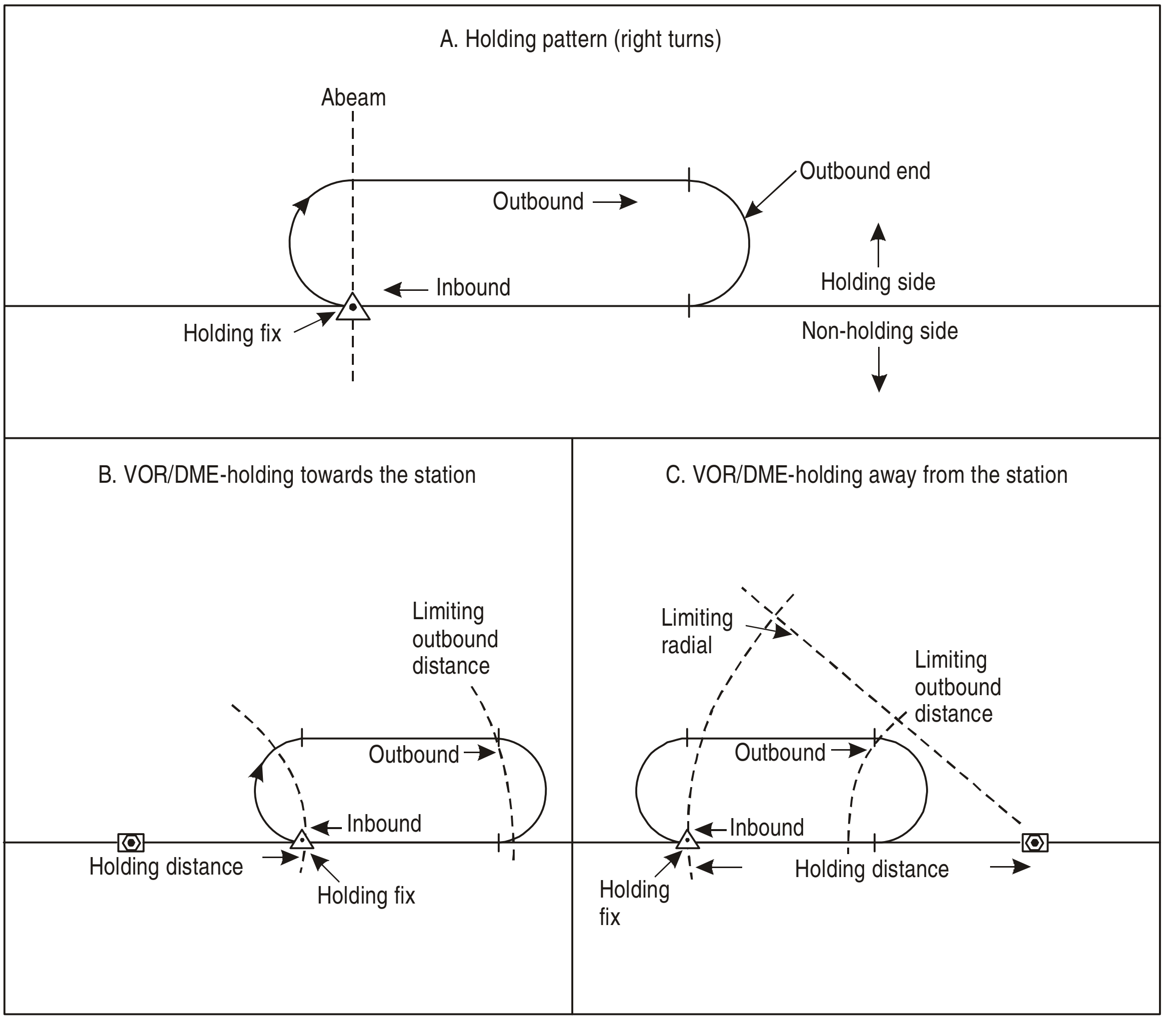


Figure II-4-1-1. Shape and terminology associated with right turns holding pattern

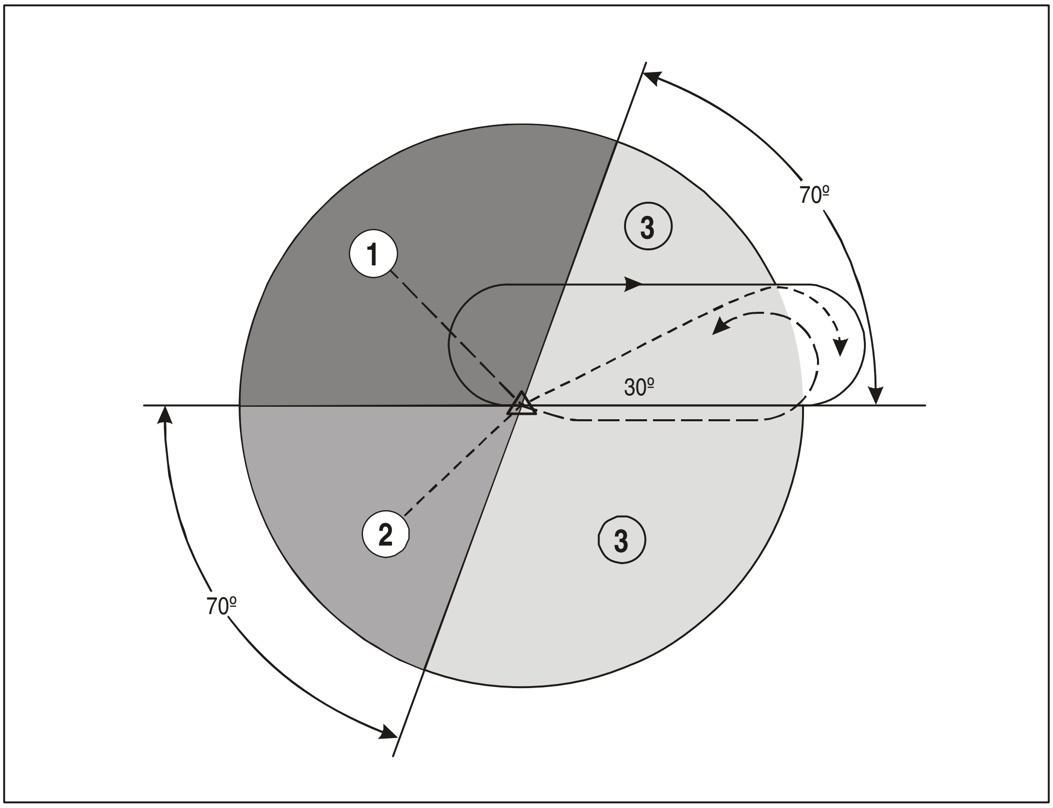


Figure II-4-1-2. Entry sectors

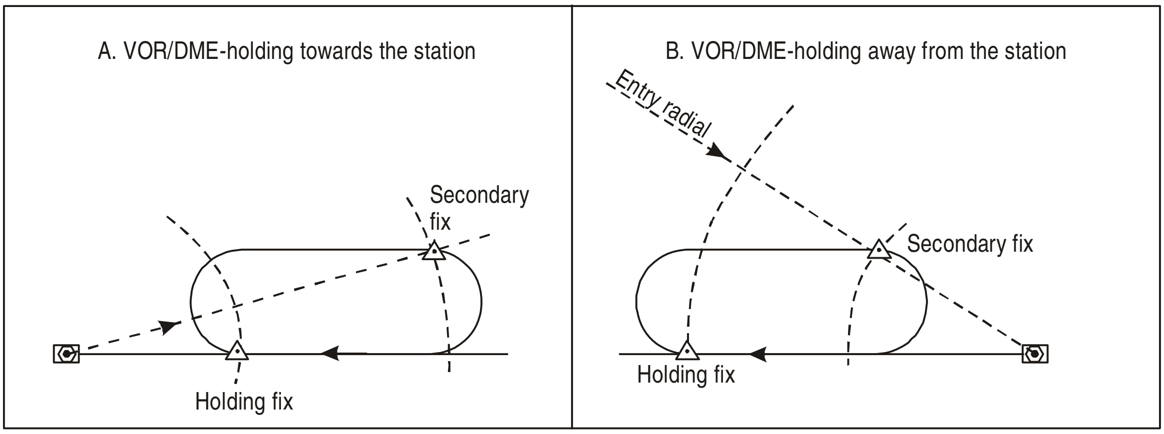


Figure II-4-1-3. Entry to a VOR/DME fix on the outbound leg

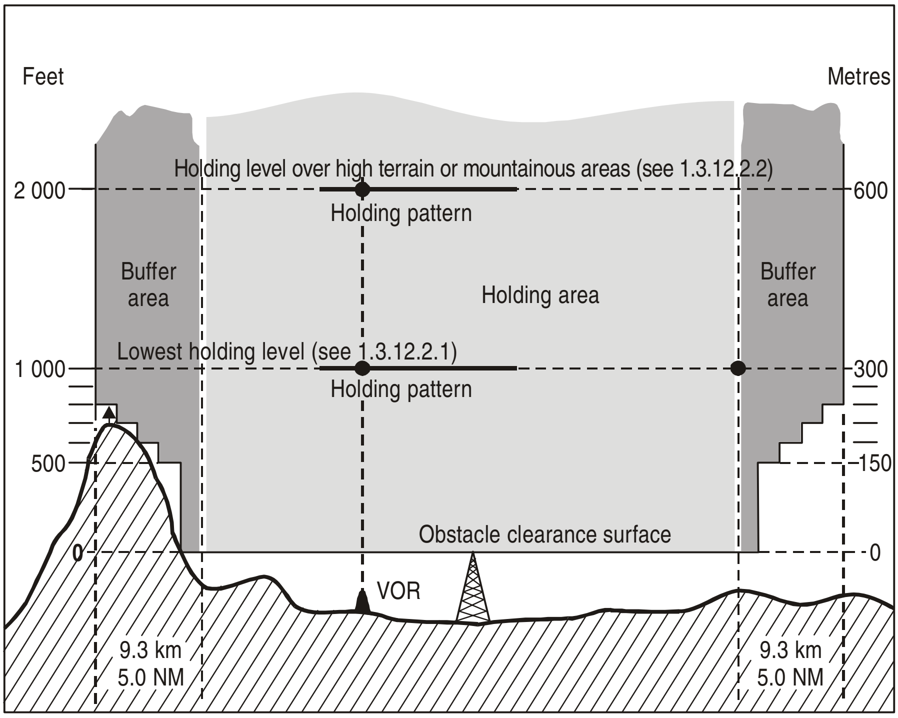


Figure II-4-1-4. Minimum holding level as determined by the obstacle clearance surface related to the holding area and the buffer area

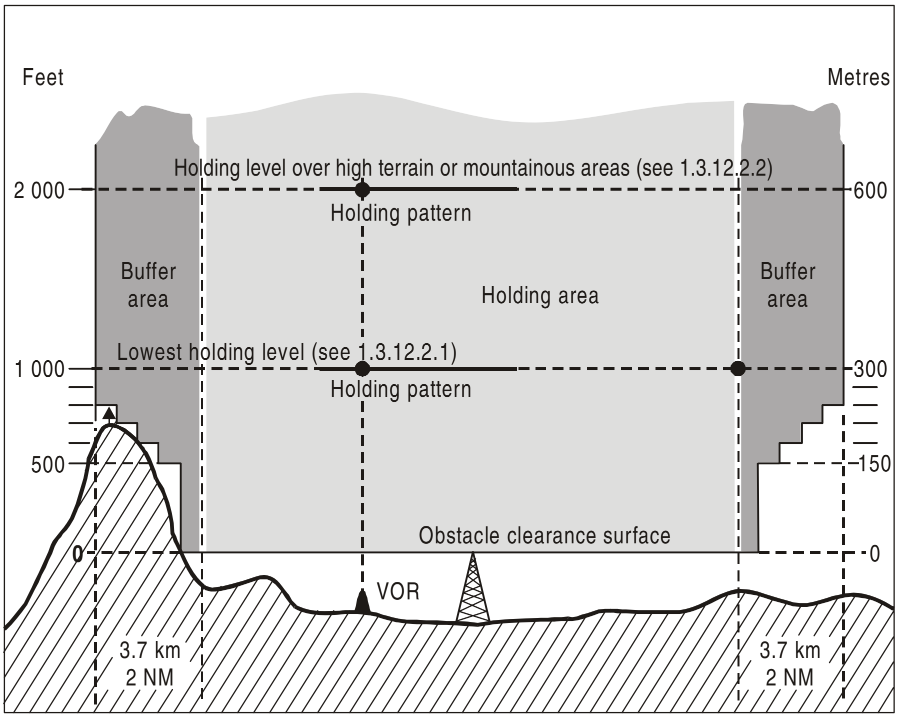


Figure II-4-1-5. Holding area up to 1 830 m (6 000 ft) for helicopters

Appendix A to Chapter 1

PARAMETERS FOR HOLDING AREA CONSTRUCTION

The material in this attachment provides general information on some of the parameters used for holding area construction. Parameters for which information is provided are as follows:

1. Turn parameters
2. Accountable wind vs. altitude
3. Temperature vs. altitude
4. DME slant range vs. ground distance
5. True airspeed (TAS) vs. indicated airspeed (IAS) and altitude
6. Formulae for basic holding area parameter calculations.

1. TURN PARAMETERS

(See also Part I, Section 2, Chapter 3)

Applicable turn parameters are given in Figures II-4-1-App A-1, II-4-1-App A-2 and II-4-1-App A-3.

2. ACCOUNTABLE WIND VS. ALTITUDE

The accountable omnidirectional wind speed given in Figure II-4-1-App A-4 for specified altitude is calculated according to the following formula:

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

or

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

3. TEMPERATURE VS. ALTITUDE

See Figure II-4-1-App A-5.

4. DME SLANT RANGE VS. GROUND DISTANCE

See Figures II-4-1-App A-6 and II-4-1-App A-7.

5. TRUE AIRSPEED (TAS) VS. INDICATED AIRSPEED (IAS) AND ALTITUDE

Table II-4-1-App A-1 gives the true airspeed in km/h and Table II-4-1-App A-2 gives the true airspeed in kt at temperature ISA + 15°C including correction for the compressibility effect. For calculation formula, see 6.1 of this attachment.

Note.— These tables are only to be used in the construction of holding areas.

6. FORMULAE FOR BASIC HOLDING AREA PARAMETER CALCULATIONS

6.1 True airspeed calculation formula *(including compressibility effect)*

$$V = 102.06\sqrt{T}\sqrt{\sqrt{1+0.00067515\,\frac{IAS^2}{P}\left(1+\frac{IAS^2}{6003025}\right)}-1}$$

where: T = temperature in K at ISA + 15;

P = pressure in hPa;

IAS = indicated airspeed in km/h; and

V = true airspeed in km/h

or

$$V = 55.1088\sqrt{T}\sqrt{\sqrt{1+0.0023157\,\frac{IAS^2}{P}\left(1+\frac{IAS^2}{1750200}\right)}-1}$$

where: T = temperature in K at ISA + 15;

P = pressure in hPa;

IAS = indicated airspeed in kt; and

V = true airspeed in kt.

For values of P and T, see the *Manual of ICAO Standard Atmosphere* (Doc 7488).

6.2 Rate of turn calculation formula

$$R = \frac{\tan\alpha}{0.055V}$$

where: α = angle of bank in degrees;

V = true airspeed in metres per second; and

R = rate of turn in degrees per second.

or

$$R = \frac{\tan \alpha}{0.055V}$$

where: α = angle of bank in degrees;

V = true airspeed in nautical miles per minute; and

R = rate of turn in degrees per second.

6.3 Radius of turn (r)

$$r = \frac{0.18V}{\pi R}$$

where: V = true airspeed in metres per second;

R = rate of turn; and

r = radius of turn in kilometres

or

$$r = \frac{3V}{\pi R}$$

where: V = true airspeed in nautical miles per minute;

R = rate of turn; and

r = radius of turn in nautical miles.

6.4 Cone effect area radius calculation formula

$$z = hl \tan \gamma l$$

where: hl = height above the facility in thousands of metres;

γl = 1/2 cone angle in degrees; and

z = radius of the cone effect area in kilometres

or

$$z = 0.164\ h1 \tan \gamma 1$$

where: h1 = height above facility in thousands of feet;

γl = 1/2 cone angle in degrees; and

z = radius of the cone effect area in nautical miles.

6.5 Minimum usable DME ground distance calculation formula

$$dm = hl \tan 55°$$

where: hl = height above the facility in thousands of metres; and

dm = minimum usable DME ground distance in kilometres

or

$$dm = 0.164\ hl \tan 55°$$

where: hl = height above the facility in thousands of feet; and

dm = minimum usable DME ground distance in nautical miles.

6.6 Wind velocity calculation formula

$$w = 12\ h + 87$$

where: h = altitude in thousands of metres;

w = wind speed in kilometres per hour (up to 220)

or

$$w = 2\ h + 47$$

where: w = wind speed in knots (up to 120); and

h = altitude in thousands of feet.

Table II-4-1-App A-1. True airspeed (TAS) vs. indicated airspeed (IAS) and altitude (SI units)

Altitude (metres)	*315 km/h*	*425 km/h*	*445 km/h*	*490 km/h*	*520 km/h*	*0.8 M*	*0.83 M*
300	327.6	442.10			540.72		
600	332.28	448.42			548.28		
900	337.32	454.86			556.2		
1 200	342.0	461.43			564.12		
1 500	347.4	468.13			571.68		
1 800	352.8	474.97			580.32		
2 100	357.48	481.95			588.6		
2 400	362.88	489.04			596.88		
2 700	369.0	496.33			605.88		
3 000	374.4	503.75			614.52		
3 300	380.52	511.31			623.52		
3 600	385.92	519.04	568.08		632.88		
3 900	391.68	526.92			641.88		
4 200	398.52	534.97			651.6		
4 500					661.68		
4 800			577.08		671.4		
5 100			585.72		681.48		
5 400			595.08		691.92		
5 700			604.08		702.72		
6 000			613.8		713.52		
6 300				684.15	724.32		
6 600				694.83	735.48		
6 900				705.74	747.0		
7 200				716.86	758.5		
7 500				728.21	770.4		
7 800				739.80	782.28		
8 100				751.62	794.8		
8 400				763.68	807.48		
8 700				775.99	820.08		
9 000				788.55	833.4		
9 300				801.37	846.2	863.90	888.48
9 600				814.45	860.4	860.14	
9 900				827.79			
10 200				841.41			
10 500							
10 800							884.55
11 100 and above							881.67

Table II-4-1-App A-2. True airspeed (TAS) vs. indicated airspeed (IAS) and altitude (non-SI units)

Altitude (feet)	*170 kt*	*230 kt*	*240 kt*	*265 kt*	*280 kt*	*0.8 M*	*0.83 M*
1 000	177.0	239.26			291.0		
2 000	179.4	242.68			295.2		
3 000	182.4	246.16			299.4		
4 000	184.8	249.72			304.2		
5 000	187.8	253.34			308.4		
6 000	190.8	257.04			312.6		
7 000	193.2	260.82			317.4		
8 000	196.2	264.67			322.2		
9 000	199.2	268.60			327.0		
10 000	202.8	272.61			331.8		
11 000	205.8	276.71			336.6		
12 000	208.8	280.88	307.8		342.0		
13 000	212.4	285.15			346.8		
14 000	215.4	289.50			352.2		
15 000					357.6		
16 000			312.6		363.0		
17 000			317.4		368.4		
18 000			322.2		374.4		
19 000			327.6		380.4		
20 000			333.0		386.4		
21 000				369.98	392.4		
22 000				375.76	398.4		
23 000				381.65	405.0		
24 000				387.67	411.0		
25 000				393.81	417.6		
26 000				400.07	424.2		
27 000				406.46	431.4		
28 000				412.98	438.0		
29 000				419.63	445.2		
30 000				426.42	452.4		
31 000				433.35	460.2	466.47	479.74
32 000				440.42	467.4	464.44	
33 000				447.64			
34 000				455.00			
35 000							
36 000							477.62
37 000 and above							476.06

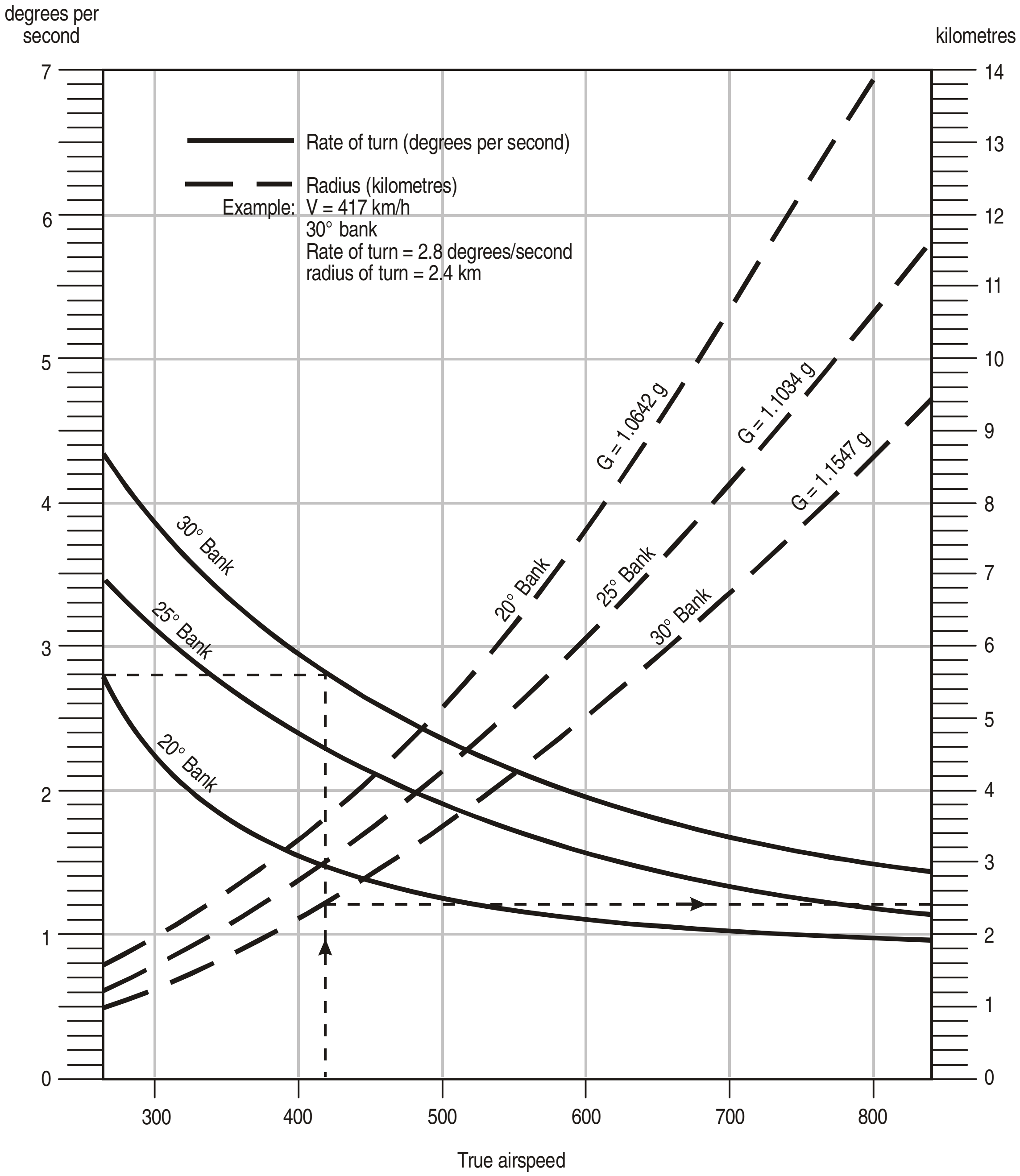


Figure II-4-1-App A-1. Angle of bank, rate of turn, radius of turn and g values at varying airspeeds (SI units)

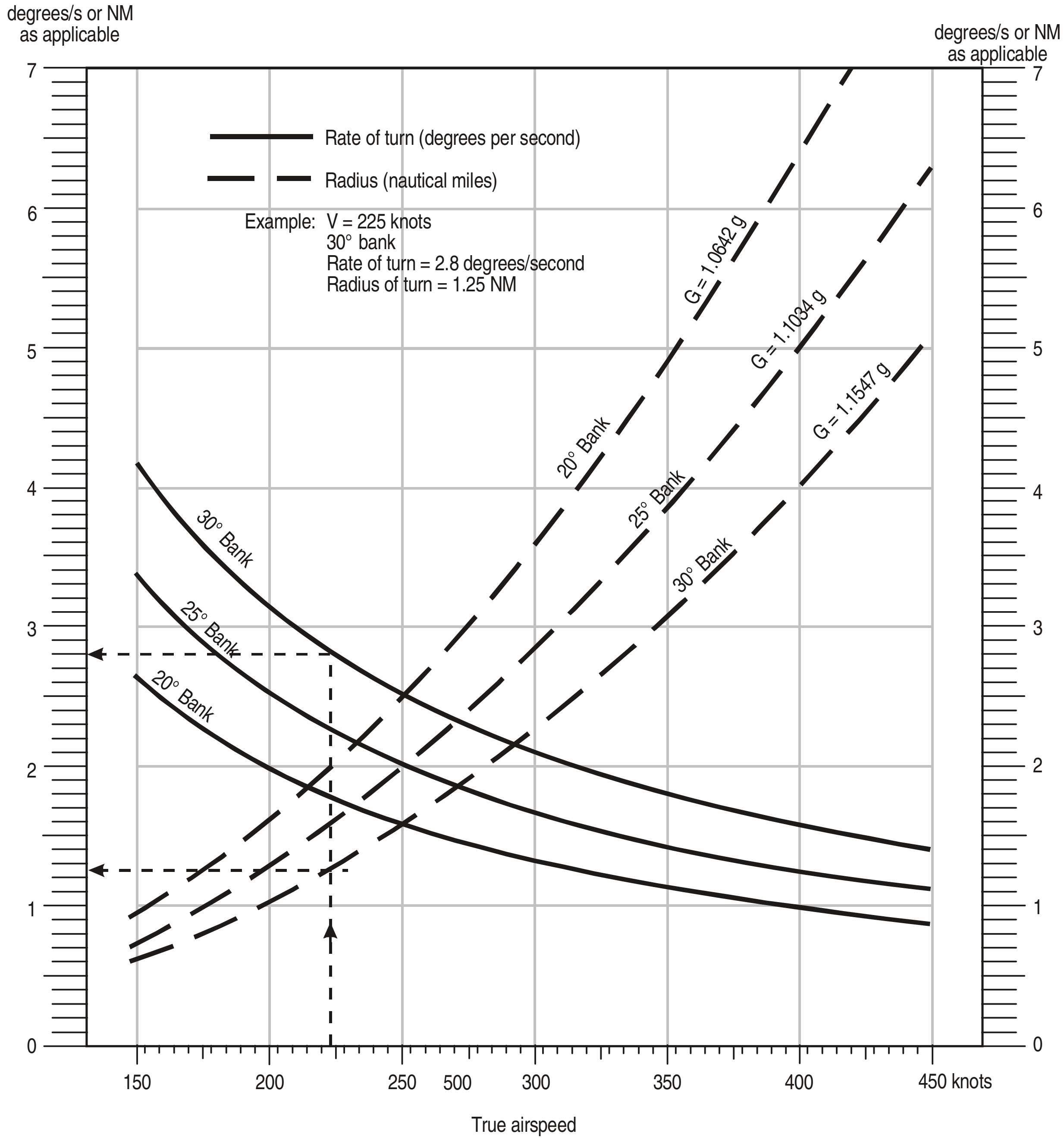


Figure II-4-1-App A-2. Angle of bank, rate of turn, radius of turn and g values at varying airspeeds (non-SI units)

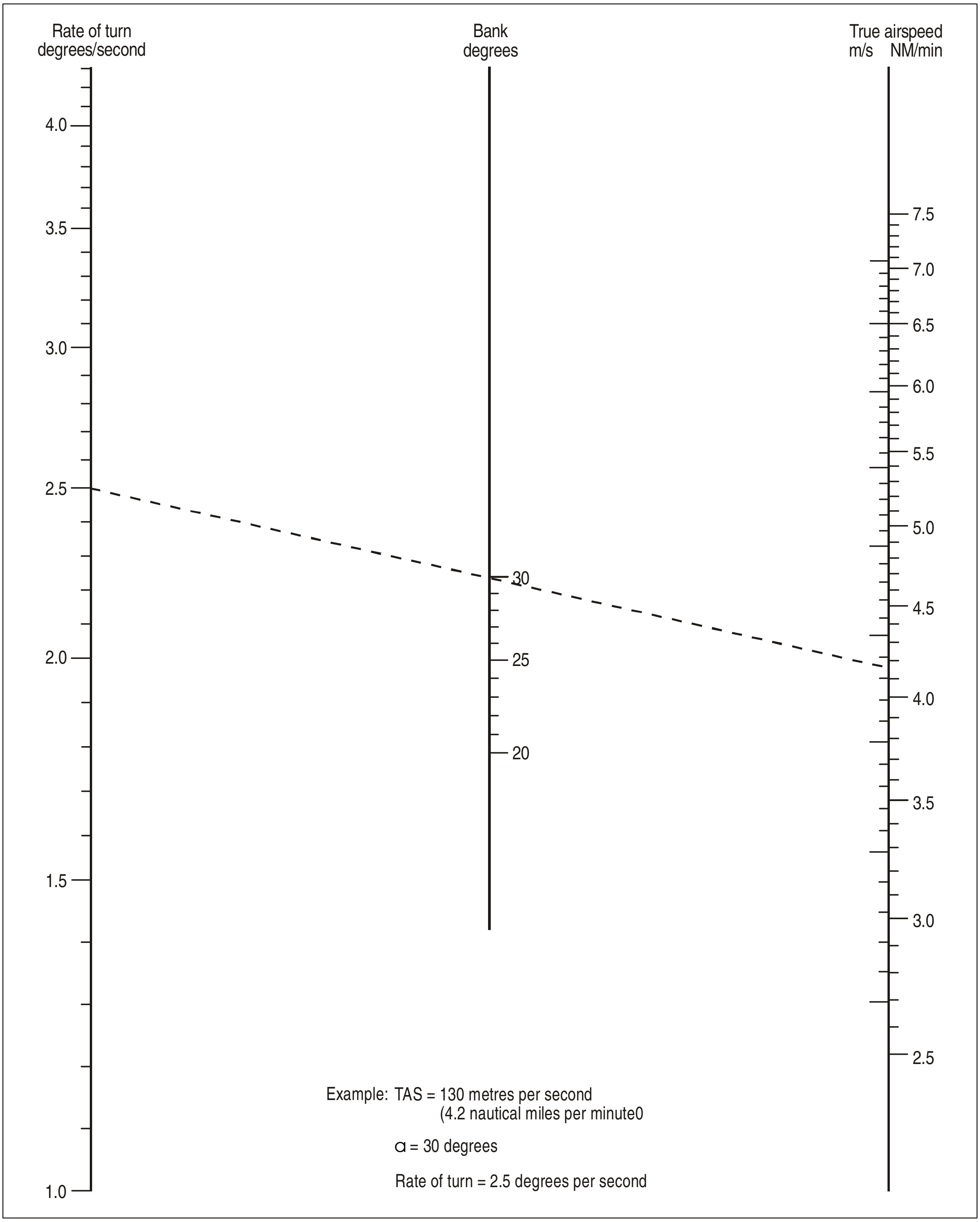
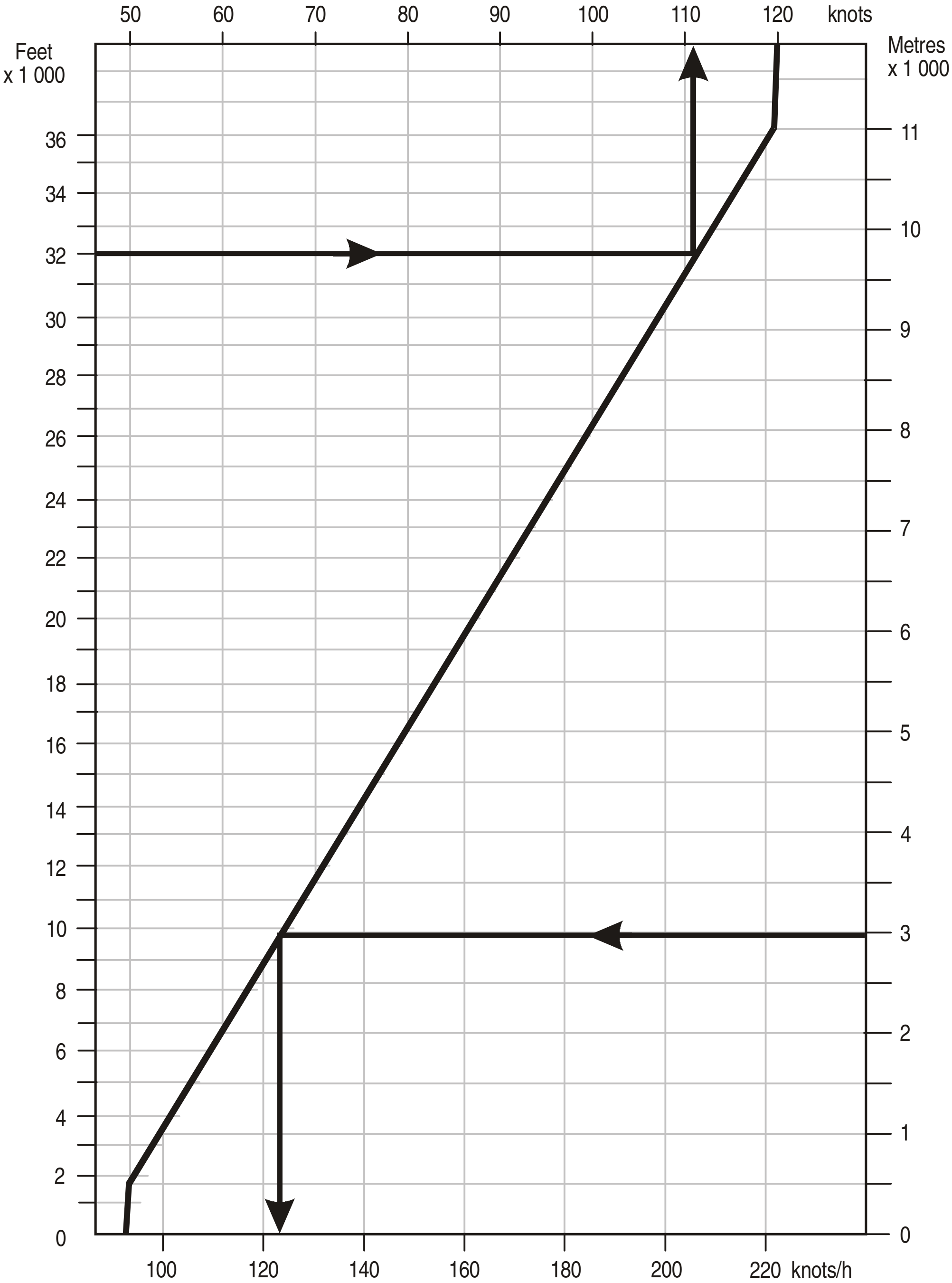


Figure II-4-1-App A-3. Rate of turn, in terms of bank and true airspeed



Example 1: 3 000 metres, 123 kilometres per hour
Example 2: 32 000 feet, 111 knots

Figure II-4-1-App A-4. Accountable wind vs. altitude

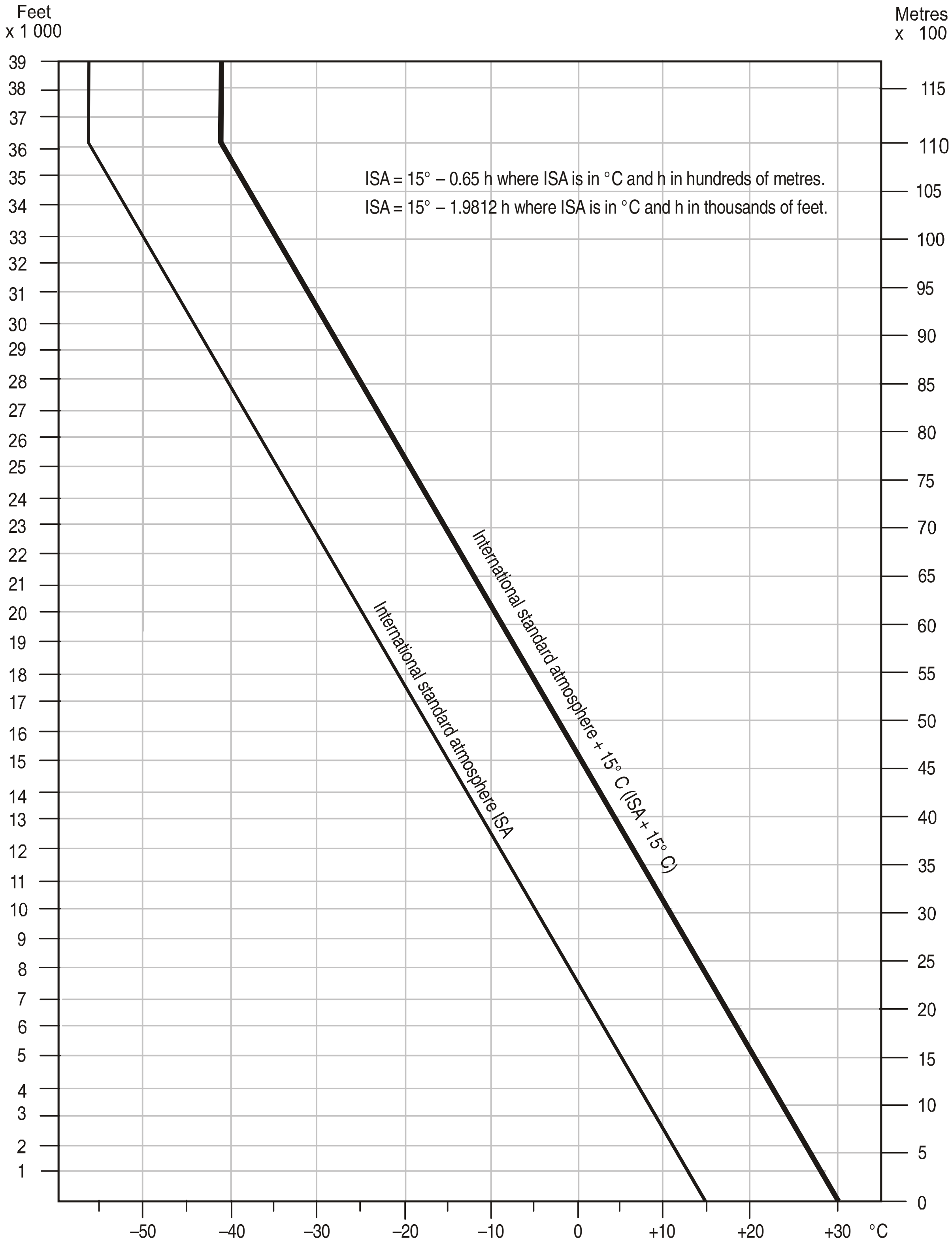
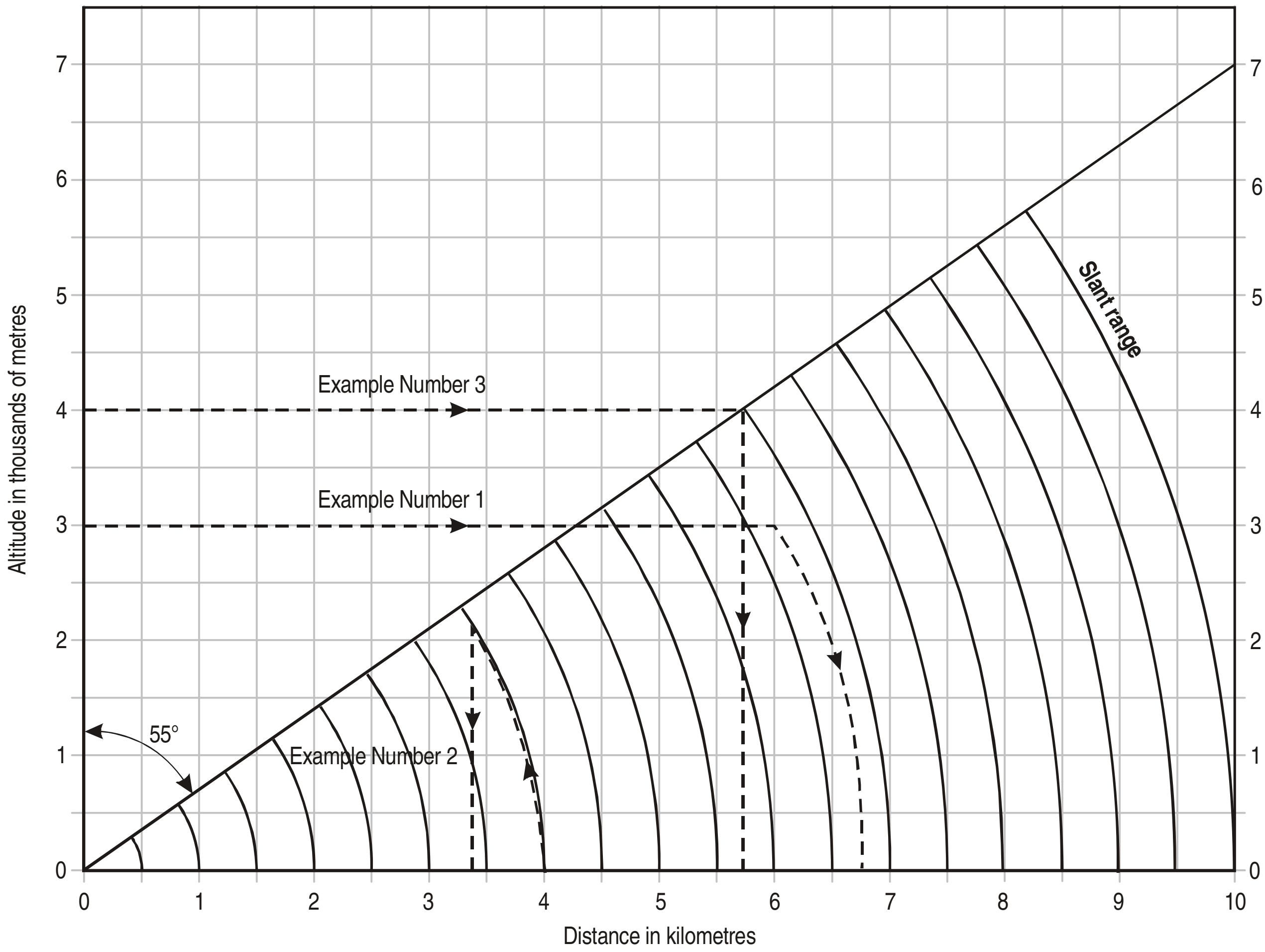


Figure II-4-1-App A-5. Temperature vs. altitude



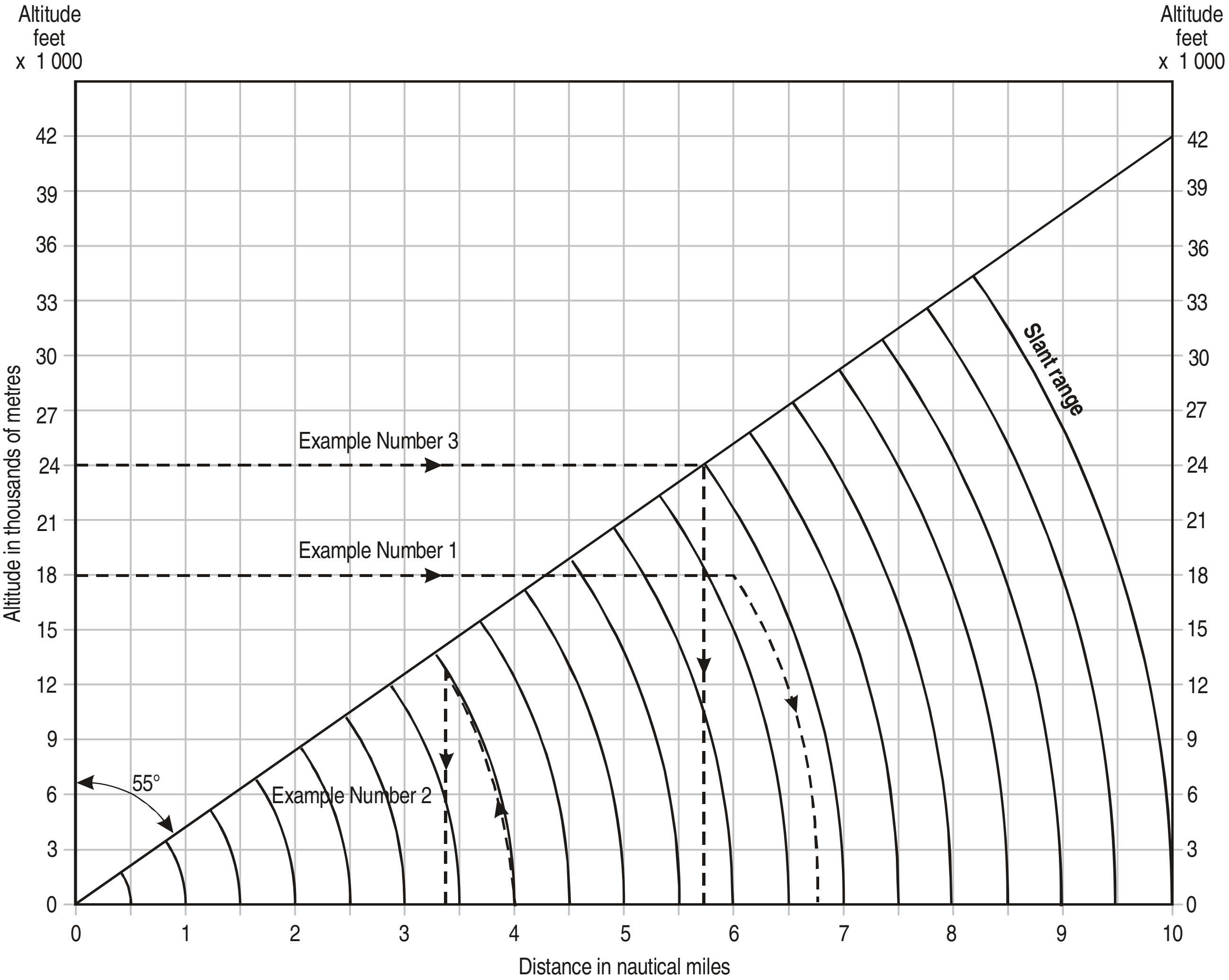
For distances over 10 km and/or altitudes in excess of 7 000 m, multiply chart values by 10 (e.g. read as 1.7 km at 1 200 m or as 17 km at 12 000 m).

To determine slant range, extend altitude line to a point vertically above ground distance. Follow arc down to base line and read slant range (Example No. 1).

To determine ground distance, read slant range arc upward to selected altitude line. Follow vertically down to ground distance line (Example No. 2).

To determine minimum usable ground distance to VOR/DME fix, enter with the maximum altitude for the procedure. Ground distance is found vertically below intersection with diagonal (Example No. 3).

Figure II-4-1-App A-6. DME slant range vs. ground distance/ Minimum usable ground distance to a VOR/DME fix (SI units)



For distances over 10 miles and/or altitudes in excess of 35 000 ft, multiply chart values by 10 (e.g. read as 1 mile at 4 000 ft, or as 10 miles at 40 000 ft).

To determine slant range, extend altitude line to a point vertically above ground distance. Follow arc down to base line and read slant range (Example No. 1).

To determine ground distance, read slant range arc upward to selected altitude line. Follow vertically down to ground distance line (Example No. 2).

To determine minimum usable ground distance to VOR/DME fix, enter with the maximum altitude for the procedure. Ground distance is found vertically below intersection with diagonal (Example No. 3).

Figure II-4-1-App A-7. DME slant range vs. ground distance/ Minimum usable ground distance to a VOR/DME fix (non-SI units)

Appendix B to Chapter 1

DETERMINATION OF ADDITIONAL OBSTACLE CLEARANCE REQUIREMENTS FOR MINIMUM HOLDING LEVELS IN AREAS OF HIGH TERRAIN OR IN MOUNTAINOUS AREAS

1. When winds of 37 km/h (20 kt) or more move over precipitous terrain, lee or windward side turbulence can be created, varying in intensity. The degree of this turbulence is the result of many variables, such as wind speed, wind direction in relation to the terrain, atmospheric eddies, vortices, waves and other weather phenomena. One side effect of such turbulence is its associated effect on altimeter performance which can result in errors from a few to many feet depending upon the severity of the disturbance.

2. Criteria for establishing minimum holding altitudes in mountainous areas should take into consideration Bernoulli effect and precipitous terrain turbulence. A typical example which could produce Bernoulli effect, turbulence and associated altimeter error is shown in Figure II-4-1-App B-1.

3. Due to the many variables associated with such phenomena in mountainous areas it is impracticable to provide specific guidance that will cater to each situation. However, when establishing holding patterns in mountainous areas and when determining holding levels as a result of obstacle clearance considerations the following should be taken into account:

a) areas characterized by precipitous terrain;

b) weather phenomena peculiar to a particular area (including extreme down draughts); and

c) phenomena conducive to steep local pressure gradients.

4. In areas where it is believed that the conditions described above may exist, or in areas where high altitude holding is required because of high terrain, the minimum holding altitude should be at a level which minimizes the aircraft's exposure to obstacles due to the possible effect on altimeter performance of the meteorological phenomena mentioned. This level will vary from a minimum of 300 m (984 ft) above obstructions within the holding area to 600 m (1 969 ft) or more whenever experience indicates a history of turbulence or other associated phenomena in the area including the associated buffer area.

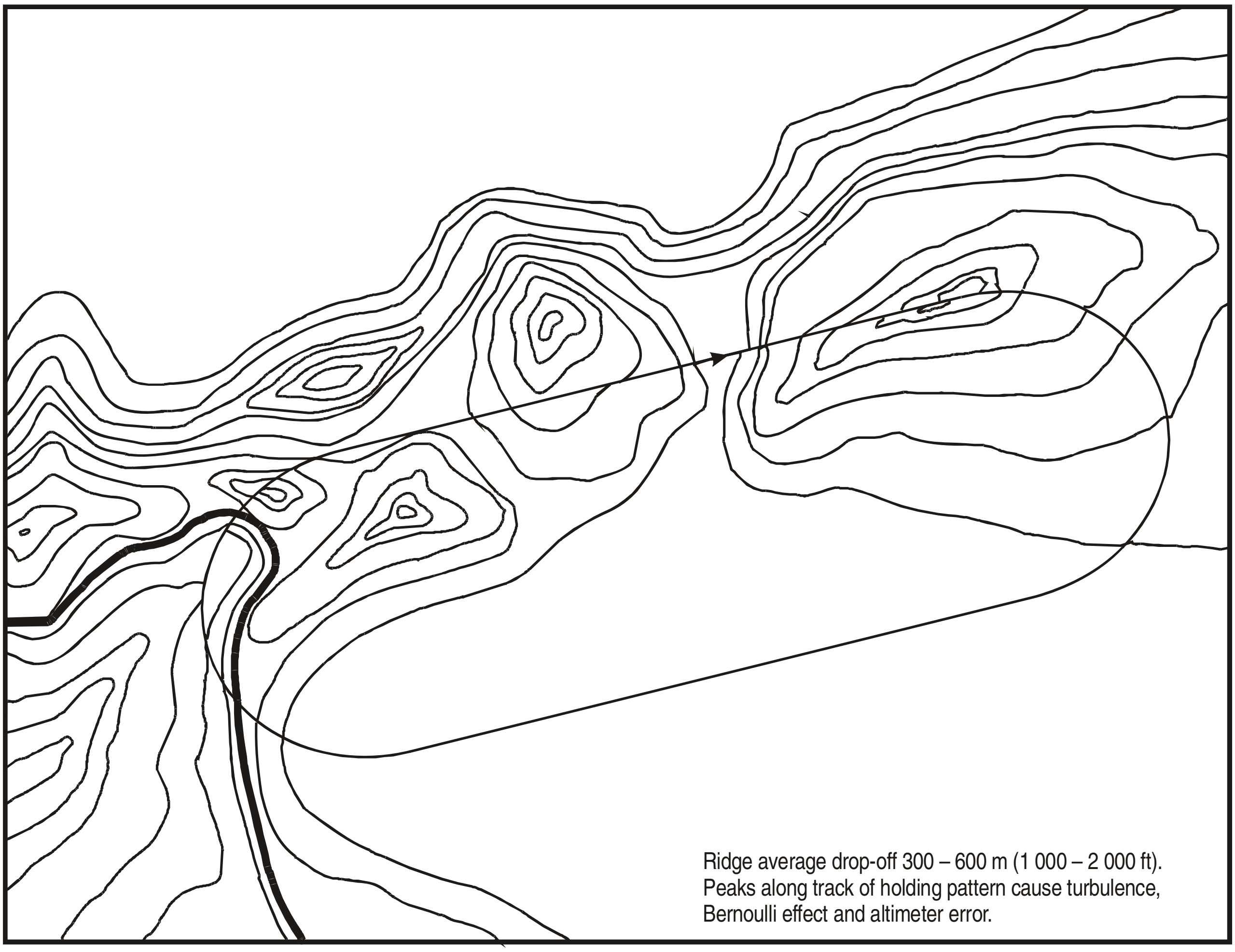


Figure II-4-1-App B-1

Attachment to Part II

ILS: BACKGROUND INFORMATION ON ILS OBSTACLE CLEARANCE AND ON AIRBORNE AND GROUND EQUIPMENT PERFORMANCE VALUES ASSOCIATED WITH CATEGORIES I AND II OBSTACLE ASSESSMENT SURFACES USED IN THE MATHEMATICAL MODEL

1. ILS OBSTACLE CLEARANCE

1.1 The ILS obstacle assessment surfaces differ in concept from the obstacle clearance surfaces defined for other instrument approach aids. In the calculation of minimum heights for other aids, the OCS are raised above the ground level until they are clear of obstacles, whereas the OAS remain fixed relative to the ground. The OAS remain fixed relative to threshold and are used to divide obstacles into two classes — accountable and non-accountable. Non-accountable obstacles are those which, although penetrating the basic Annex 14 surfaces, do not penetrate the OAS. No direct operating penalty is created by these obstacles provided their density is not considered excessive. In this respect the recommendations of Annex 14 (limiting penetrations of the defined surfaces) apply in the same way as with earlier ILS obstacle clearance surfaces. Recognizing that Annex 14 obstacle limitation surfaces are not always free of penetrations, a mathematical method (collision risk model) was developed to assess such obstacle penetrations in terms of risk. See OAS CD-ROM.

1.2 The collision risk model and the related obstacle assessment surfaces were designed to meet a level of operational safety of 1×10^{-7} per approach. This value was based loosely on the concept used by one State to determine mean time between failures for the ILS ground and airborne equipment. In that concept, the overall target level was set at one order better than the then current world accident rate (1×10^{-6}). This was arbitrarily divided between failures and performance, which should logically have resulted in a value of 5×10^{-8} for PANS-OPS. However, such precision was not matched by the accuracy of the data, and a 'round number' of 1×10^{-7} was considered more appropriate. It was also agreed that only items resulting in a change in probability exceeding one order should be treated as independent variables. The practical effect of a half-order change would have been a small increase in the dimensions of the iso-probability contours, plus an increase of about 2 m in the height loss element in both OAS and CRM. Further considerations included:

a) additional protection was already provided by the Annex 14 surfaces;

b) certification risk is measured against time and operations whereas the risk in approach is measured per sector, and must be factored by whether the flight involves an instrument approach and the percentage of occasions that the approach is in instrument conditions with weather conditions near minima; and

c) to apportion risk for pilot/system performance at the sub-order level was cosmetic rather than practical.

It thus appeared appropriate to accept a target level of safety of 10^{-7} for the performance related criteria in PANS-OPS.

1.3 The basic geometry of the OAS was defined by the approach surfaces. These were developed using a data-matched mathematical model. This model predicted aircraft position as a function of the main error-producing components of the total system and matched this against the results of a data collection programme. In the matching process equipment values appropriate to the sites in the collection programme were used in the model, and both equipment values and data were classed into Category I and Category II operations. Because the observed Category II autopilot performance was significantly better than that for Category II flight directors, the two were treated separately.

1.4 The data matched model produced lateral and vertical distributions at selected ranges in the final approach. These were combined to produce isoprobability contours at those ranges. Three factors defined the selection of an isoprobability contour for practical application. Firstly, the total risk summed over all ranges in the final approach was specified to lie within the overall safety target of 1×10^{-7}. Secondly, the isoprobability contours predicted the risk of being outside the contour at the range selected, whereas theoretical studies and data measurement suggested that the risk of being outside that contour at other ranges during the whole approach was about one order higher. Thirdly, it was recognized that the previous surfaces and any new surfaces should not be assumed to be solid walls. The existing provisions of Annex 14 were in no way reduced by the new criteria, and it was accepted that a probability of between 0.1 and 0.01 represented a realistic assessment of the risk of hitting an object between the Annex 14 surface and the OAS. These constraints led to the use of the isoprobability contour for 10^{-7} at the selected ranges as the basis for fitting practical surfaces. These surfaces, being planar, provided some additional safety.

1.5 The OAS were therefore constrained to contain the 10^{-7} isoprobability contours at all ranges. In addition, they were constrained to contain the minimum cross-selectional area; to protect aircraft within them climbing a 2.5 per cent gradient with a 20 per cent splay and to preclude those anomalies between categories of operation which would otherwise arise due to the use of simple planar surfaces.

1.6 An attempt was made to adjust the contours and surfaces to reflect the poorer performance theoretically possible according to one interpretation of Annex 10. The result was that the surfaces had to be expanded outside the previous PANS-OPS surfaces. The difference between the basic data-matched surfaces and those based on the poorer performance interpretation of Annex 10 was of the order of 10^{-2} in terms of probability. However, it was concluded that this increased risk was apparent rather than real and was due to the generous nature of both Annex 10 and the interpretation used. The practical surfaces were therefore based on the data-matched contours.

1.7 The Category I approach surfaces were extended to glide path intercept level, since the data showed a linear variation of approach performance with range. This was not the case with the Category II data, however. Because of this and because Category II operational performance constraints were often height related, the Category II surfaces were only extended up to 150 m (492 ft) above threshold.

1.8 The remaining surfaces were related to the previous PANS-OPS missed approach surface, there being little evidence upon which to base any change. However, to enable benefit to be obtained for aircraft having superior missed approach performance, provision was made for adjusting its gradient. To define the width of the missed approach surface, side planes were projected above and forward of the intersection of the approach surfaces and the plane of the glide path. These planes were adjusted to contain a 20 per cent splay combined with the gradient specified for the missed approach, and logically became the transitional surfaces linking approach and missed approach protection. They were not extended above 300 m (984 ft) for Cat I and 150 m (492 ft) for Cat II, the plan area covered at that level being considered adequate for even early missed approaches.

1.9 Having defined the accountable approach and missed approach obstacles, a suitable margin had to be added to ensure clearance of those obstacles. For approach obstacles, a simple model of the missed approach manoeuvre was developed. This related the height loss to vertical rate, the increment of normal acceleration applied by the pilot, and the inertia and aerodynamic characteristics of the aircraft. This model was incorporated into a computer programme which combined the relevant variables. By using input distributions obtained from flight tests and instrument tests, the model was used to predict the probability of height loss exceeding specified values. These probability distributions were matched against real flight missed approach data. This included that element of wind shear experienced in normal operations; other than this no specific allowance for wind shear was included. No allowance was included for ground effect. The results were scaled to relate to aircraft with other values of the speed at threshold, and the results were tabulated by aircraft category. An adjustment was found necessary for the radio altimeter case due to the higher than normal rates of descent resulting from steep glide path angles and high level airfields. Missed approach obstacles were defined as those located beyond 900 m after threshold. By that range all aircraft were considered to be climbing, and the margin above obstacles accounted for the fact that an increase in OCA/H also increased the distance available to climb prior to reaching a given obstacle.

1.10 The partitioning of approach/missed approach obstacles by range was the simplest method to produce the desired operational penalty differential and was safe in all cases. However, the resulting OCA/H could be such that the 'on glide path' OCA/H point was so far before the obstacle that it should be more correctly treated as a missed approach obstacle. Provision was therefore made for a more complex partitioning by defining approach/missed approach obstacles relative to a plane surface originating 900 m after threshold, and sloping upwards into the approach area parallel to the plane of the glide path.

1.11 The higher of the heights necessary for clearance of approach or missed approach obstacles was then taken as the obstacle clearance altitude/height to be applied in calculating operating minima as specified in Annex 6.

1.12 The use of obstacle assessment surfaces in calculating OCA/H involved applying the same margin above all obstacles without regard to the location of obstacles relative to the flight path. To account for this, and to provide a means of assessing obstacle density, a ''collision risk model'' was developed. This was a computer programme containing data describing the spread of aircraft about their intended path, both in the approach and instrument missed approach. The programme used these distributions to evaluate the risk or collision probability associated with individual obstacles. To allow for the fact that only a proportion of the approaches results in a missed approach, the computed risk of each obstacle in the missed approach region was factored by a missed approach rate. Taking account of the variability in missed approach rate experienced over different periods of time and at different locations, one per cent was deemed to be representative of the general order of missed approach rates likely to be experienced and was used in the CRM. Risks associated with individual obstacles were then accumulated to produce a total risk for the complete set of obstacles of interest. This final value, representing a probability of collision per approach, could then be compared with a predetermined target level of safety. In this way the effects of operational adjustments (i.e. reduction in obstacle density, increase in OCA/H, change of GP angle) could be assessed on an objective basis.

2. AIRBORNE AND GROUND EQUIPMENT PERFORMANCE VALUES ASSOCIATED WITH CATEGORIES I AND II OBSTACLE ASSESSMENT SURFACES USED IN THE MATHEMATICAL MODEL

2.1 Airborne and ground equipment values used in the mathematical model

Details of the equipment (ground and air) values associated with the Categories I and II obstacle assessment surfaces are contained in Tables II-Att-1 and II-Att-2. This is background information only and cannot be used directly as a means of assessing changes in equipment performance. It represents the actual performance of the systems observed. It is included as a permanent record of the values used to match the model with the observed aircraft positions and to provide a complete reference for any future revision. Guidance material relating to equipment performance characteristics is contained in Annex 10, Volume I, Part I, Attachment C.

2.2 Beam holding

The approach surfaces were based on observed displacement data rather than on indicated deviations. However, when the mathematical model was matched to predict the actual approach path envelopes it was found that a good fit could be obtained by assuming that pilots attempt to limit indicated deviations at 75 µA on both localizer and glide path. For the Cat I surfaces this was factored by the value 1.4.

2.3 Category II system failures

It has been assumed that failure of any part of the Category II system when the aircraft is below the relevant Category I missed approach level will be followed by the immediate initiation of a missed approach.

Table II-Att-1. Category I performance values used in the mathematical model
(See 2.1)

Item	*Distribution shape*	*Nominal value*	*Standard deviation*	*Truncation*	*Units*
Localizer					
Beam centring	normal	0	2.3	9.6	metres (m)
Beam sensitivity	normal	14.4×10^{-4}	6×10^{-5}	$\pm 2.448 \times 10^{-4}$	DDM/m
Receiver centring	double sided exponential	0	5	±7 SD	microamps (µA)
Receiver sensitivity	single exponential	968 (maximum)	32.3	484	µA/DDM
Beam bends	normal	0	3 at 1 200 m 8.5 at 7 800 m	±3.5 SD	µA
Beam holding	double sided exponential	0	from data matching	mean 105 SD 15	µA
Glide path					
Beam centring	normal	0	0.018	±0.075	Unit θ (GP angle)
Beam sensitivity	normal	0.625	0.039	±0.156	DDM/unitθ
Receiver centring	double sided exponential	0	5	±7 SD	µA
Receiver sensitivity	single exponential	859 (maximum)	28.6	430	µA/DDM
Beam bends	normal	0	10	±3 SD	µA
Beam holding	double sided exponential	0	from data matching	mean 105 SD 15	µA
This is background information only and cannot be used directly as a means of assessing changes in equipment performance.					

Table II-Att-2. Category II performance values used in the mathematical model
(See 2.1)

Item	*Distribution shape*	*Nominal value*	*Standard deviation*	*Truncation*	*Units*
Localizer					
Beam centring	normal	0	1.52	±7.62	metres (m)
Beam sensitivity	normal	14.4×10^{-4}	4.8×10^{-5}	$\pm 2.451 \times 10^{-4}$	DDM/m
Receiver centring	double sided exponential	0	3	±9 SD	microamps µA)
Receiver sensitivity	single exponential	968 (maximum)	32.3	484	µA/DDM
Beam bends	normal	0	2	±7	µA
Beam holding	double sided exponential	0	from data matching	mean 75 SD 15	µA
Glide path					
Beam centring	normal	0	0.015	±0.075	Unit θ (GP angle)
Beam sensitivity	normal	0.625	0.0344	±0.156	DDM/unit θ
Receiver centring	double sided exponential	0	5	±9 SD	µA
Receiver sensitivity	single exponential	859 (maximum)	28.6	430	µA/DDM
Beam bends	normal	0	8	±28	µA
Beam holding	double sided exponential	0	from data matching	mean 75 SD 15	µA
This is background information only and cannot be used directly as a means of assessing changes in equipment performance.					

Procedures for
Air Navigation Services

AIRCRAFT OPERATIONS

Part III

RNAV PROCEDURES AND SATELLITE-BASED PROCEDURES

Section 1

UNDERLYING PRINCIPLES

Chapter 1

FIXES

1.1 FIX IDENTIFICATION

The fixes used are those in the general criteria. Each fix shall be determined as a waypoint as specified in Annex 15.

1.2 SATISFACTORY FIXES

1.2.1 Initial and intermediate fixes

See Part I, Section 2, Chapter 2, 2.6.2, "Initial/intermediate approach fix".

1.2.2 Final, stepdown or missed approach fixes

To be satisfactory as a final approach fix, a stepdown fix, or a missed approach fix, the along-track tolerances of a fix shall be no greater than ± 3.7 km (2.0 NM). However, the along-track tolerance may be increased to not more than 25 per cent of the length of the final segment.

Note.— Contrary to the maximum tolerance of 1.9 km (1.0 NM) specified in Part I, Section 2, Chapter 2, 2.6.3, "Final approach fix for non-precision approaches", *RNAV fix tolerance may reach a maximum of 3.7 km (2.0 NM). In case of a conventional fix based on a crossing radial or DME, the maximum fix tolerance is based on the nominal flight track. The wider corners of the fix tolerance area are not taken into account. In case of an RNAV-designed procedure, the along-track tolerance is based on a more conservative calculation method based on the RSS of the along-track tolerance and the cross-track tolerance (see Part III, Section 1, Chapter 4). Based on this more conservative approach, the less demanding tolerance limitation of 3.7 km (2.0 NM) is considered adequate.*

1.2.3 Stepdown fixes

Criteria contained in Part I, Section 2, Chapter 2, 2.7.3, "Stepdown fix" and 2.7.4, "Obstacle close to a final approach fix or stepdown fix" relative to stepdown fixes apply.

Chapter 2

BASIC GNSS RNAV

2.1 GENERAL

Area navigation systems which use the procedure must be controlled through a navigation database.

2.2 EQUIPMENT FUNCTIONALITY FOR BASIC GNSS

2.2.1 General

2.2.1.1 The term "Basic GNSS receiver" designates the GNSS avionics that at least meet the requirements for a GPS receiver as outlined in Annex 10, Volume I and the specifications of RTCA/DO-208 or EUROCAE ED-72A, as amended by United States Federal Aviation Administration FAA TSO-C129A or European Aviation Safety Agency ETSO-C129A (or equivalent).

2.2.1.2 These documents specify the minimum performance standard that GNSS receivers must meet in order to comply with en-route, terminal area and non-precision approach procedures developed specifically for GNSS.

2.2.2 GNSS receiver capabilities

The main requirement of these standards is for the GNSS receiver to have the following capabilities incorporated:

a) integrity monitoring routines, for example RAIM — Receiver Autonomous Integrity Monitoring;

b) turn anticipation; and

c) capability for approach procedure retrieved from the read-only electronic navigation database.

2.2.3 Basic GNSS functionality

2.2.3.1 Basic GNSS has three modes: en-route, terminal and approach mode. Each mode has an associated RAIM alarm limit and CDI sensitivity. (See Table III-1-2-1.)

2.2.3.2 *Departure.* It is assumed that the terminal mode is selected (automatically or manually) before take-off or when the system is armed until the distance of 56 km (30 NM) from the reference point of the aerodrome (ARP) is reached. After 56 km (30 NM), it is assumed that the system is in the en-route mode.

2.2.3.3 *Arrival/Approach.* Up until 56 km (30 NM) from the ARP, it is assumed that the system is in the en-route mode. If properly armed, the system automatically changes to terminal mode sensitivity at 56 km (30 NM). On reaching a distance of 3.7 km (2.0 NM) from the FAF, the system switches to approach mode.

2.3 SYSTEM USE ACCURACY FOR BASIC GNSS RNAV PROCEDURES

2.3.1 General

2.3.1.1 Despite the inherent accuracy of the GNSS space segment position, the usability of a fix is also affected by the number of satellites available and their orientation with respect to the GNSS receiver. These factors vary from place to place and time to time. The ability of a receiver to detect and alert the pilot to these factors when they are unfavourable is a measure of the navigation system's operational capability.

2.3.1.2 To qualify for use as a non-precision approach navigation system, GNSS receivers must incorporate an integrity monitoring routine which alerts the pilot when the fixing information does not meet the required level of confidence. For integrity monitoring alarm limits see 2.3.3.2, "Integrity monitoring alarm limits".

2.3.2 Horizontal accuracy

The agreed level of horizontal accuracy of the GNSS space segment is assumed to be 100 m (328 ft) at the 95 per cent confidence level.

2.3.3 Navigation system accuracy/tolerances

2.3.3.1 The factors on which the navigation system accuracy of GNSS RNAV depends are:

a) inherent space segment accuracy;

b) airborne receiving system tolerance;

c) system computational tolerance; and

d) flight technical tolerance.

See Table III-1-2-2 for values.

2.3.3.2 *Integrity monitoring alarm limits.* The values of the space elements (including control element) and the airborne system tolerances (including system computation tolerance) are taken into account within the integrity monitoring alarm limits for basic GNSS systems. See Table III-1-2-2 for values.

2.4 FLIGHT TECHNICAL TOLERANCE (FTT)

FTT defines the total system cross-track tolerance (XTT). The FTT will vary with the type of position indicator used in the cockpit instrumentation. FTT contributions to cross-track tolerance are listed in Table III-1-2-2.

2.5 XTT, ATT AND AREA SEMI-WIDTH

The values specified in 2.3.3.1 and 2.4 define the total system ATT and XTT according to the following equations:

ATT = integrity monitor alarm limit (IMAL)
XTT = IMAL + FTT
area semi-width = 2XTT

Results of calculations for applicable fixes are listed in Table III-1-2-2.

Table III-1-2-1.

	RAIM alarm limit	*CDI sensitivity*
Enroute	3.7 km (2.0 NM)	9.3 km (5.0 NM)
Terminal	1.9 km (1.0 NM)	1.9 km (1.0 NM)
Approach	0.6 km (0.3 NM)	0.6 km (0.3 NM)

Table III-1-2-2. Total system tolerances and area semi-widths for basic GNSS receivers

	IAF/ MAHF (1) (km/NM)	*IAF/ MAHF (2) (km/NM)*	*Fix in initial segment (km/NM)*	*IF (km/NM)*	*FAF (km/NM)*	*MAPt (km/NM)*	*Fix in missed approach segment or departure procedure (km/NM) (2)*	*Fix in missed approach segment or departure procedure (km/NM) (1)*
Navigation System Accuracy (3)	0.23/0.12	0.23/0.12	0.23/0.12	0.23/0.12	0.23/0.12	0.23/0.12	0.23/0.12	0.23/0.12
Integrity Monitor alarm Limit (3)	3.70/2.00	1.85/1.00	1.85/1.00	1.85/1.00	0.56/0.30	0.56/0.30	1.85/1.00	3.70/2.00
Time to alarm	30 sec	10 sec	10 sec	10 sec	10 sec	10 sec	10 sec	30 sec
FTT	3.70/2.00	0.93/0.50	0.93/0.50	0.93/0.50	0.56/0.30	0.37/0.20	0.85/0.50	3.70/2.00
ATT	3.70/2.00	1.85/1.00	1.85/1.00	1.85/1.00	0.56/0.30	0.56/0.30	1.85/1.00	3.70/2.00
XTT	7.41/4.00	2.78/1.50	2.78/1.50	2.78/1.50	1.11/0.60	0.93/0.50	2.78/1.50	7.41/4.00
Area Semiwidth (6)	14.82/8.00	9.26/5.00 (4)	9.26/5.00 (4)	9.26/5.00 (4)	3.70/2.00 (5)	1.85/1.00	9.26/5.00 (4)	14.82/8.00

Notes.—

1. *IAF and missed approach segment or departure procedure fix positioned outside 56 km (30 NM) radial distance from the destination/departure airport ARP.*
2. *IAF and missed approach segment or departure procedure fix positioned within 56 km (30 NM) radial distance from the destination/departure airport ARP.*
3. *Includes all system computation tolerances.*
4. *Based on flight trials, which included turns onto the initial approach segment, the operational assessment leads to retain 9.26 km (5.00 NM) in place of 2 XTT when using basic GNSS receivers except when provisions of Part I, Section 4, Chapter 3, Appendix B are employed. Part I, Section 4, Chapter 3, Appendix B contains material for the possible reduction of the basic GNSS area width of the initial approach segment.*
5. *Based on flight trials.*
6. *Area semi-widths are determined according to the formulae defined in 2.5, "XTT, ATT and Area Semi-width".*

Chapter 3

DME/DME RNAV

3.1 GENERAL

3.1.1 Area navigation systems which use the procedure must be controlled through a navigation database.

3.1.2 Reference facilities

3.1.2.1 As it is not possible to know which DME facilities the airborne system will use for a position update, a check should be made to ensure the appropriate DME coverage is available throughout the proposed route, based upon at least two selected facilities (the coverage of DME stations is given in Figure III-1-3-1). This check should include:

a) the promulgated maximum range of the DME facility, taking the theoretical maximum radio horizon of the station into account (maximum 370 km/200 NM);

b) maximum and minimum intersection angle of the DME stations (between 30° and 150°); and

c) promulgated DME sectorization (if any).

3.1.2.2 Alternatively, the route may be assessed using a computer model that replicates the airborne system. The facilities selected should be published.

Note.— Airborne systems normally place all DME facilities within a maximum range (normally 370 km (200 NM)) in an update file. From that file systems use various algorithms to determine the most suitable facilities to use to determine the most probable position.

3.2 AIRBORNE AND GROUND EQUIPMENT REQUIREMENTS FOR DME/DME PROCEDURES

3.2.1 For procedures based on DME/DME, the calculation of cross-track tolerance (XTT), along-track tolerance (ATT) and area semi-widths are obtained from a conservative assumption that the chosen DME facility for position update may be located at a maximum reception range. To meet these criteria, the minimum equipment requirements must be satisfied, as listed below.

3.2.2 The standard assumptions for airborne and ground equipment on which DME/DME procedures are based are as follows.

a) For airborne equipment, either,

   1) at least a single FMC capable of DME/DME navigation and capable of automatic reversion to updated IRS navigation. This FMC shall be approved for operations within the TMA; or

2) at least a single FMC, capable of DME/DME navigation. This FMC shall be approved for operations within the TMA;

and, for both alternatives,

3) a navigation database with stored waypoints with coordinates based on WGS-84 (including speed and vertical constraints) containing the procedures to be flown that can automatically be loaded into the FMC flight plan.

Note 1.— Examples of requirements can be found in FAA AC25-15 and AC20-130 and in EUROCAE ED-76 and 77 and in ARINC 424.

Note 2.—The flight management system (FMS) is an integrated system consisting of airborne sensor, receiver and computer with both navigation and aircraft performance databases which provides optimum performance guidance to a display and automatic flight control system. The term is also used to describe any system which provides some kind of advisory or direct control capability for navigation, fuel management, route planning, etc. These systems are also described as performance management systems, flight management control systems and navigation management systems. The use of the term FMC in this chapter does not intend to cover anything other than the navigation part of the system.

b) For ground equipment, either,

1) two DME stations only. In this case, a larger protected airspace is used (aircraft without IRS navigation capability will not be able to fly these procedures); or

2) more than two DME stations. In this case, smaller protected airspace is used;

and, for both alternatives,

3) waypoints and DME station coordinates meeting the WGS-84 requirements.

3.3 DME/DME RNAV SYSTEM USE ACCURACY

3.3.1 The system use accuracy (DTT) of DME ground station and airborne receiving system for DME/DME RNAV procedures are ± (0.46 km (0.25 NM) + 1.25 per cent of the theoretical maximum radio horizon), based on the specified altitude/height at the waypoints. Use of the maximum error ensures that any DME facility within coverage can be safely used by aircraft flight management systems.

3.3.2 For procedures based on two DME stations only, the maximum DME system use accuracy is multiplied by 1.29 in order to take into account both the effects of track orientation relative to the DME facilities and the intersect angle between the two DME stations.

3.3.3 For procedures based on more than two DME stations, a 90° intersect angle is assumed and the maximum DME tolerance is not factored.

Note.— Theoretical maximum radio horizon in km is 4.11 $\sqrt{h}$, where h is in metres. Theoretical maximum radio horizon in NM is 1.23 $\sqrt{h}$, where h is in feet.

3.4 FLIGHT TECHNICAL TOLERANCE

The flight technical tolerance (FTT) will vary with the type of position indicator used in the cockpit instrumentation. For the arrival phase, the FTT also depends on the location of the IAF. It is assumed that the FTT has the following contributions to the cross-track tolerance:

a) departures:

1) ±0.19 km (±0.10 NM) at the DER; and

2) 0.93 km (0.50 NM) for all other fixes;

b) arrival:

1) FAF located more that 46 km (25 NM) from IAF: 3.70 km (2.00 NM); and

2) FAF located within 46 km (25 NM) of IAF: 1.85 km (1.00 NM);

c) initial and intermediate approach: ± 1.85 km (1.00 NM); and

d) final and missed approach: ± 0.93 km (0.50 NM).

3.5 SYSTEM COMPUTATIONAL TOLERANCE

The system computational tolerance (ST) is ±0.46 km (0.25 NM). This tolerance is based on the implementation of WGS-84.

3.6 XTT, ATT AND AREA SEMI-WIDTH

3.6.1 XTT and ATT

3.6.1.1 The combination of the tolerances specified in 3.3 to 3.5 on a root sum square basis gives the cross-track and along-track tolerance of any fix defined by waypoints as follows.

$$XTT = \pm (DTT^2 + FTT^2 + ST^2)^{1/2}$$
$$ATT = \pm (DTT^2 + ST^2)^{1/2}$$

where:

where:	DTT	=	DME system use accuracy
	ST	=	System computation tolerance
	FTT	=	Flight technical tolerance

3.6.1.2 Results of calculations of XTT, ATT for enroute, IAF, IF, FAF, MAPt, and TP are presented in Tables III-1-3-1, III-1-3-2, III-1-3-3 and III-1-3-4. For departures, the XTT and ATT can be derived from column FAF/MAPt/TP. A fix coincidental with the DER needs a special calculation taking into account an FTT of ±0.185 km (±0.1 NM) (see formulas in the Appendix).

3.6.1.3 In departures the area width at the first waypoint depends on the assumed height of the aircraft. A departure climb gradient of 3.3 per cent or equal to the procedure design gradient if greater than 3.3 per cent should be applied to obtain this height.

3.6.2 Area semi-width

3.6.2.1 Area semi-width *(*1/2 A/W) at a waypoint is determined by the following equation:

½A/W = XTT x 1.5 + BV

where: 1.5 XTT corresponds to 3 sigma

BV = Buffer value (for values see Table III-1-3-5)

3.6.2.2 Results of calculations of the semi-width are shown in Tables III-1-3-1, III-1-3-2, III-1-3-3 and III-1-3-4. For example calculations see the appendix to this chapter. For departures, the area semi-width can be derived from column FAF/MAPt/TP (see example calculations in the appendix to this chapter).

3.7 VIABILITY CHECK OF THE PROCEDURE

3.7.1 Viability check

A theoretical and operational viability check should be made of the route, including the effect of the waypoints' location and the (DME) environment on FMC performance.

3.7.2 Initial evaluation

An initial evaluation should be made using flight simulators and/or FMC simulation software tools to check the predicted flight path for continuity and repeatability of the route. Such evaluations should include the effect of minimum and maximum IAS, winds, and type of aircraft and FMC. The procedure should, where appropriate, be flown from different directions, since the facilities used for update depend on the direction of the flight.

3.7.3 Pre-promulgation flight check

The pre-promulgation flight check should include an analysis of the update history (use of DME stations for update). If the FMC uses DME stations outside their promulgated radio range, an additional check on the effect of the use of those stations should be made.

3.8 REVERSION MODE CHECKS

3.8.1 *VOR/DME.* The navigation computer mode may change from the DME/DME mode to the VOR/DME mode. It is assumed that the VOR/DME station closest to the route will be selected by the navigation computer for this purpose. Since the accuracy of that station may differ from the DME/DME accuracy, a check must be made of the effect of the navigation reversion mode. Therefore, for each segment along the route, the ½ AW must be determined based on tangent point distance (D1) and distance to tangent point (D2) from the VOR/DME station within range which is closest to the route. See Chapter 4, 4.5, "XTT, ATT and area semi-width".

3.8.2 *Basic GNSS.* Chapter 2, 2.5, "XTT, ATT and area semi-width" gives equivalent information for basic GNSS areas, which must also be checked if this is an option for the procedure.

3.8.3 If the resulting ½ AW is more than that resulting from the DME/DME or basic GNSS (if applicable) criteria, two options are available:

a) the identification must specify the sensor(s) allowed for the procedure. Pilots are expected to abandon the procedure in the event of a reversion to VOR/DME; or

b) the wider ½ AW is applied for that segment of the route where VOR/DME reversion may take place. In that case the identification of the route remains "RNAV", without a sensor suffix.

Table III-1-3-1. XTT, ATT, area semi-width for en-route phase of flight, IAF, IF, FAF, MAPt and TP fixes (km)
Table based on availability of two DME update stations (See *Note 2*)

Altitude (m) (Note 1)	*En-route*			*IAF/IF*			*FAF/MAPt/ TP*		
	XTT	*ATT*	*Semi-width*	*XTT*	*ATT*	*Semi-width*	*XTT*	*ATT*	*Semi-width*
4 500		For all altitudes		5.39	5.06	9.94			
4 200	7.56	6.59	15.04	5.25	4.91	9.73			
3 900				5.11	4.76	9.51			
3 600				4.96	4.60	9.29			
3 300				4.80	4.43	9.05			
3 000				4.64	4.25	8.81	4.35	4.25	7.45
2 700				4.47	4.07	8.56	4.17	4.07	7.18
2 400				4.29	3.87	8.29	3.98	3.87	6.90
2 100				4.11	3.66	8.01	3.78	3.66	6.59
1 800				3.91	3.44	7.71	3.56	3.44	6.27
1 500				3.70	3.20	7.39	3.33	3.20	5.92
1 200				3.47	2.93	7.05	3.07	2.93	5.54
900				3.21	2.63	6.67	2.79	2.63	5.10
600				2.93	2.27	6.24	2.45	2.27	4.60
300				2.59	1.81	5.73	2.03	1.81	3.97
150							1.75	1.48	3.55

Table III-1-3-2. XTT, ATT, area semi-width for en-route phase of flight, IAF, IF, FAF, MAPt and TP fixes (km)
Table based on availability of *more than two* DME update stations (See *Note 3*)

Altitude (m) (Note 1)	*En-route*			*IAF/IF*			*FAF/MAPt/ TP*		
	XTT	*ATT*	*Semi-width*	*XTT*	*ATT*	*Semi-width*	*XTT*	*ATT*	*Semi-width*
4 500	For all altitudes			4.35	3.94	8.38			
4 200	6.31	5.11	13.18	4.25	3.82	8.22			
3 900				4.14	3.70	8.06			
3 600				4.03	3.58	7.89			
3 300				3.91	3.45	7.72			
3 000				3.79	3.31	7.54	3.44	3.31	6.08
2 700				3.67	3.17	7.35	3.30	3.17	5.87
2 400				3.54	3.02	7.16	3.15	3.02	5.66
2 100				3.40	2.86	6.96	3.00	2.86	5.43
1 800				3.26	2.68	6.74	2.84	2.68	5.18
1 500				3.11	2.50	6.51	2.66	2.50	4.92
1 200				2.95	2.29	6.27	2.47	2.29	4.63
900				2.77	2.06	6.00	2.26	2.06	4.31
600				2.57	1.78	5.71	2.01	1.78	3.94
300				2.34	1.43	5.36	1.70	1.43	3.48
150							1.50	1.19	3.18

Table III-1-3-3. XTT, ATT, area semi-width for en-route phase of flight, IAF, IF FAF, MAPt AND TP fixes (NM)
Table based on availability of two DME update stations *(*See *Note 2)*

Altitude (ft) (Note 1)	*En-route*			*IAF/IF*			*FAF/MAPt/ TP*		
	XTT	*ATT*	*Semi-width*	*XTT*	*ATT*	*Semi-width*	*XTT*	*ATT*	*Semi-width*
15 000	For all altitudes			2.94	2.76	5.41			
14 000	4.08	3.56	8.10	2.86	2.68	5.29			
13 000				2.78	2.60	5.17			
12 000				2.70	2.51	5.05			
11 000				2.61	2.42	4.92			
10 000				2.53	2.32	4.79	2.37	2.32	4.06
9 000				2.43	2.22	4.65	2.27	2.22	3.91
8 000				2.34	2.11	4.50	2.17	2.11	3.75
7 000				2.23	2.00	4.35	2.06	2.00	3.59
6 000				2.13	1.88	4.19	1.94	1.88	3.41
5 000				2.01	1.74	4.01	1.81	1.74	3.22
4 000				1.88	1.60	3.83	1.67	1.60	3.01
3 000				1.75	1.43	3.62	1.52	1.43	2.77
2 000				1.59	1.24	3.38	1.33	1.24	2.50
1 000				1.40	0.98	3.10	1.10	0.98	2.15
500							0.95	0.81	1.92

Table III-1-3-4. XTT, ATT, area semi-width for en-route phase of flight, IAF, IF, FAF, MAPt and TP fixes (NM)
Table based on availability of *more than two* DME update stations (See *Note 3*)

Altitude (ft) (Note 1)	*En-route*			*IAF/IF*			*FAF/MAPt/ TP*		
	XTT	*ATT*	*Semi-width*	*XTT*	*ATT*	*Semi-width*	*XTT*	*ATT*	*Semi-width*
15 000	For all altitudes			2.37	2.15	4.55			
14 000	3.40	2.67	7.10	2.31	2.08	4.47			
13 000				2.25	2.02	4.38			
12 000				2.19	1.95	4.29			
11 000				2.13	1.88	4.19			
10 000				2.06	1.80	4.10	1.87	1.80	3.31
9 000				2.00	1.72	3.99	1.80	1.73	3.20
8 000				1.92	1.64	3.89	1.72	1.64	3.08
7 000				1.85	1.56	3.78	1.63	1.56	2.95
6 000				1.77	1.46	3.66	1.55	1.46	2.82
5 000				1.69	1.36	3.53	1.45	1.36	2.67
4 000				1.60	1.25	3.40	1.34	1.25	2.52
3 000				1.50	1.12	3.25	1.23	1.12	2.34
2 000				1.39	0.97	3.09	1.09	0.97	2.14
1 000				1.27	0.78	2.90	0.92	0.78	1.89
500							0.82	0.64	1.72

Notes referring to the tables above.—

1. The altitude applied for the calculation is assumed to be the minimum altitude (rounded up to the next higher value) of the previous segment of the procedure in case of an arrival/approach phase of flight. In case of a turn altitude for departure/missed approach procedure, a climb gradient of 3.3 per cent or equal to the lowest specified climb gradient if greater than 3.3 per cent is assumed. For specific cases, e.g. high altitude airports, the assumed height of the aircraft is applied, instead of the altitude. In that case, the height must be related to the lowest DME station located within the maximum range of DME reception.

2. A minimum altitude/minimum climb gradient is assumed because at such altitude, the system must be able to use at least two DME stations. The tolerances (XTT, ATT) and the semi-width can be calculated at this altitude. When the aircraft is at a higher altitude, the system can receive some other DME stations but there is no reason for the system to choose a less accurate navigation solution. The calculation done at the minimum altitude remains valid.

3. Tables to be used only for aircraft meeting navigation requirements as indicated in 3.2.2 a)1).

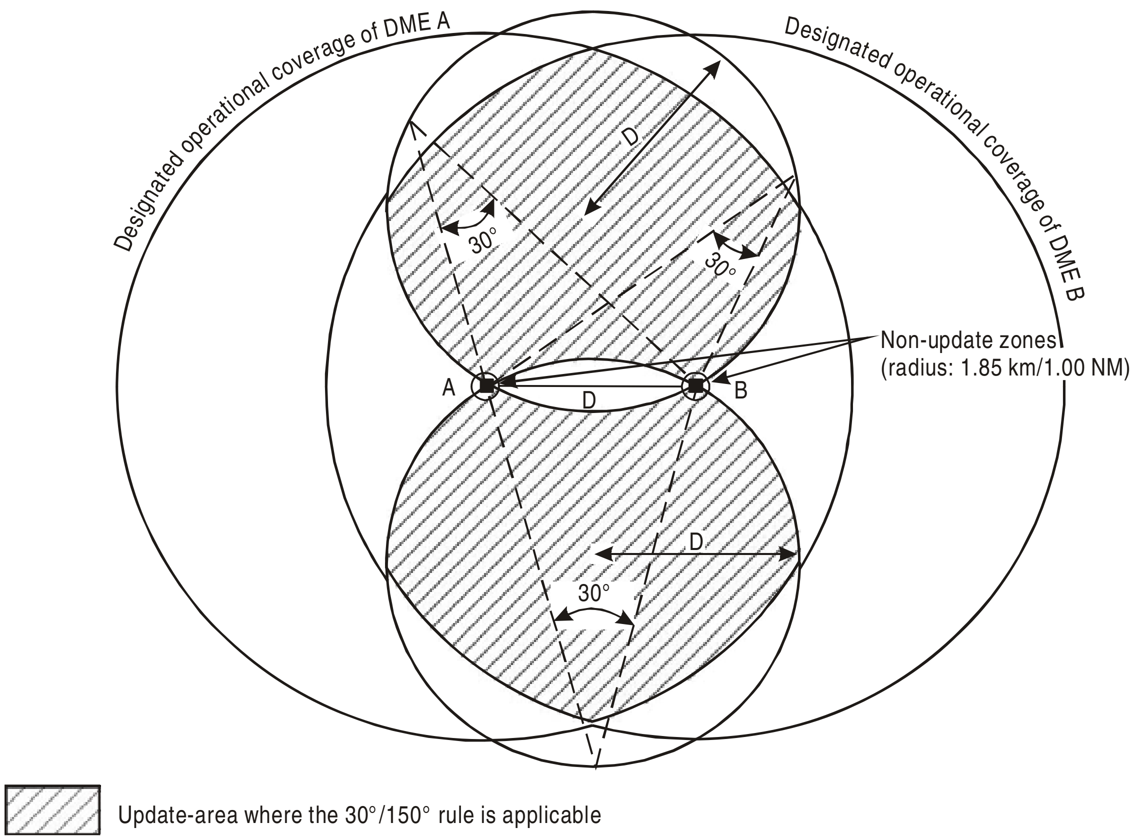
4. Tables to be used for aircraft meeting navigation requirements as indicated in 3.2.2 a)2).

5. For derivation of the values refer to 3.6, "XTT, ATT and area semi-width". For calculation examples see the Appendix.

Table III-1-3-5. DME/DME area semi-width

	Area semi-width
Departure	1.5XTT + 0.93 km (0.50 NM)
En-route and arrival segment [1]	1.5XTT + 3.70 km (2.00 NM)
Arrival segment [2]	1.5XTT + 1.85 km (1.00 NM)
IAF and IF	1.5XTT + 1.85 km (1.00 NM)
FAF, MAPt and TP	1.5XTT + 0.93 km (0.50 NM)
Holding[3]	

1. Routes which start more than 46 km (25 NM) from the IAF (XTT is determined with BV = 3.70 km (2.00 NM)).
2. Routes which start 46 km (25 NM) or less from the IAF (XTT is determined with BV = 1.85 km (1.00 NM)).
3. Holding areas use different principles (see Section 3, Chapter 7).



DME/DME UPDATE AREA FOR 2 DME STATIONS LOCATED AT A DISTANCE 'D' APART

Step 1 — A circle centred on each station with a radius equal to the Designated Operational Coverage (DOC) with a maximum of 370.4 km (200.0 NM) must be drawn.

Step 2 — The 30 - 150° DME intercept circles with a radius equal to the distance 'D' on either side of both DME stations must be drawn.

Step 3 — Then the no-update zone circles of 1.9 km (1.0 NM) centred on both DME stations are drawn.

The area with dual DME update is comprised within an area where both the following conditions exist:

1. the area within the DOC/370.4 km (200.0 NM) and
2. the area of the 30/150 degrees intersect angle.

Excluded from DME/DME coverage is the area comprised within:

1. the no update zone circles and
2. the area between the two DME stations.

Figure III-1-3-1. Maximum update area of two DME stations A and B

Appendix to Chapter 3

DERIVATION AND CALCULATION OF ATT, XTT AND AREA SEMI-WIDTH

1. CALCULATION EXAMPLES FOR DME/DME XTT AND ATT AND THE AREA SEMI-WIDTH WHEN DME STATIONS COMMISSIONED PRIOR TO 1 JANUARY 1989 ARE USED

1.1 Calculation examples in case of two DME stations available

Area semi-width en-route:
(Maximum DME distance of 370.4 km (200 NM) is applicable)

SI units	*Non-SI units*
DTT = (0.0125 x 370.4) + 0.463 = 5.09 km	DTT = (0.0125 x 200.0) + 0.250 = 2.75 NM
ST = 0.46 km	ST = 0.25 NM
FTT = 3.70 km	FTT = 2.00 NM
BV = 3.70 km	BV = 2.00 NM
ATT = $[(1.29d)^2 + 0.46^2]$½ = 6.58 km	ATT = [(1.29d)2 + 0.252]½ = 3.56 NM
XTT = $[(1.29d)^2 + 3.72 + 0.46^2]$½ = 7.55 km	XTT = [(1.29d)2 + 2.02 + 0.252]½ = 4.08 NM
½A/W = 1.5 x XTT + BV = 15.03 km	½A/W = 1.5 x XTT + BV = 8.12 NM

Area semi-width at initial approach 1 500 m (5 000 ft):

SI units	*Non-SI units*
DTT = 0.0125 x 4.11 (1 500)½ + 0.463 = 2.45 km	DTT = 0.0125 x 1.23 (5 000)½ + 0.25 = 1.34 NM
ST = 0.46 km	ST = 0.25 NM
FTT = 1.90 km	FTT = 1.00 NM
BV = 1.90 km	BV = 1.00 NM
ATT = 3.19 km	ATT = 1.75 NM
XTT = 3.69 km	XTT = 2.01 NM
½A/W = 7.39 km	½A/W = 4.02 NM

Area semi-width at the MAPt, 150 m (500 ft):

SI units	*Non-SI units*
DTT = 0.0125 x 4.11 (150)½ + 0.463 = 1.09 km	DTT = 0.0125 x 1.23 (500)½ + 0.25 = 0.59 NM
ST = 0.46 km	ST = 0.25 NM
FTT = 0.93 km	FTT = 0.05 NM
BV = 0.93 km	BV = 0.05 NM
ATT = 1.48 km	ATT = 0.81 NM
XTT = 1.75 km	XTT = 0.94 NM
½A/W = 3.55 km	½A/W = 1.91 NM

1.2 Calculation examples in case of more than two DME stations available

Area semi-width en-route:
(Maximum DME distance of 370.4 km (200.0 NM) is applicable)

SI units	*Non-SI units*
DTT = (0.0125 + 370.4) + 0.463 = 5.09 km	DTT = (0.0125 + 200) + 0.25 = 2.75 NM
ST = 0.46 km	ST = 0.25 NM
FTT = 3.70 km	FTT = 2.0 NM
BV = 3.70 km	BV = 2.0 NM
ATT = $[(d)^2 + 0.46^2]$½ = 5.11 km	ATT = $[(d)^2 + 0.25^2]$½ = 2.76 NM
XTT = $[(d)^2 + 3.72 + 0.46^2]$½ = 6.31 km	XTT = $[(d)^2 + 2.02 + 0.25^2]$½ = 3.41 NM
½A/W = 1.5 x XTT + BV = 13.17 km	½A/W = 1.5 x XTT + BV = 7.12 NM

Area semi-width at initial approach 1 500 m (5 000 ft):

SI units	*Non-SI units*
DTT = 0.0125 x 4.11 (1 500)½ + 0.463 = 2.45 km	DTT = 0.0125 x 1.23 (5 000)½ + 0.25 = 1.34 NM
ST = 0.46 km	ST = 0.25 NM
FTT = 1.90 km	FTT = 1.00 NM
BV = 1.90 km	BV = 1.00 NM
ATT = 2.49 km	ATT = 1.36 NM
XTT = 3.11 km	XTT = 1.69 NM
½A/W = 6.52 km	½A/W = 3.54 NM

Area semi-width at the MAPt, 150 m (500 ft):

SI units	*Non-SI units*
DTT = 0.0125 x 4.11 (1 500)½ + 0.463 = 1.09 km	DTT = 0.0125 x 1.23 (500)½ + 0.25 = 0.59 NM
ST = 0.46 km	ST = 0.25 NM
FTT = 0.93 km	FTT = 0.50 NM
BV = 0.93 km	BV = 0.50 NM
ATT = 1.18 km	ATT = 0.64 NM
XTT = 1.50 km	XTT = 0.81 NM
½A/W = 3.18 km	½A/W = 1.72 NM

2. FORMULAS AND EXAMPLES FOR THE CALCULATION OF THE DME/DME ATT, XTT AND THE AREA SEMI-WIDTH WHEN DME STATIONS COMMISSIONED AFTER 1 JANUARY 1989 ARE USED

2.1 Formulas

2.1.1 DME stations commissioned after 1 January 1989 must adhere to more stringent requirements compared to DME stations installed prior to 1 January 1989. Annex 10, Volume I, 3.5.3.1.3.3 specifies the total system error to be 0.2 NM, (RSS 0.1 NM of the ground station and 0.17 NM of the airborne interrogator) without a distance-related component.

2.1.2 When a route is supported by DME stations commissioned after 1 January 1989 and operational benefits could be obtained, the following values can be applied for XTT, ATT and the area semi-width.

2.1.3 If the coverage of the DME stations is based on 2 stations, the DME tolerance value as part of the calculation, has been factored by 1.29 to cover the less than optimum 90-degree intersect angle, as calculated above.

Formulas:

$XTT = \pm (TSE^2 + FTT^2 + ST^2)^{½}$
$ATT = \pm (TSE^2 + ST^2)^{½}$
½A/W = XTT x 1.5 + BV

ATT, XTT and ½A/W:

En route phase of flight:

ATT = 0.32 NM (0.56 km) (0.36 NM (0.67 km) in case of 2 DME stations only)
XTT = 2.03 NM (3.76 km)
Area semi-width = 5.05 NM (9.35 km)

Arrival, initial and intermediate approach:

ATT = 0.32 NM (0.74 km) (0.36 NM (0.67 km) in case of 2 DME stations only)

XTT = 1.05 NM (1.94 km)
Area semi-width = 2.58 NM (4.77 km) (2.6 NM (4.8 km) in case of 2 DME stations only)

Final approach, missed approach and departure:

ATT = 0.32 NM (0.59 km) (0.36 NM (0.67 km) in case of 2 DME stations only)
XTT = 0.59 NM (1.09 km)
Area semi-width = 1.39 NM (2.57 km).

Note.— A check must be made using the line of sight formula as given in the note to Chapter 3, 3.3 to verify that no DME or TACAN stations may be used for update that does not comply with the mentioned Annex 10 requirements. If such a station is found within the update range, the values of the Tables III-1-3-1 through III-1-3-4 must be applied until a point on the route where it is likely that station is not used for update. If a TACAN not meeting the Annex 10 criteria falls within the possible update range, action must be taken to delete this station from the civil AIP. This prevents storage of this station in a navigation database used for position update.

2.2 DERIVATION OF ATT, XTT AND ½A/W, WHEN DME STATIONS COMMISSIONED ON OR AFTER 1 JANUARY 1989 ARE USED

(Only two DME stations available)

(To be developed)

2.3 DERIVATION OF ATT, XTT AND ½A/W, WHEN DME STATIONS COMMISSIONED AFTER 1 JANUARY 1989 ARE USED (More than 2 DME stations available)

En-route phase of flight:

SI unit			*Non SI units*		
TSE	=	0.37 km	TSE	=	0.2 NM
ST	=	0.46 km	ST	=	0.25 NM
FTT	=	3.70 km	FTT	=	2.0 NM
BV	=	3.70 km	BV	=	2.0 NM
ATT	=	$(0.370^2 + 0.463^2)^{½} = 0.57$ km	ATT	=	$(0.2^2 + 0.25^2)^{½} = 0.32$ NM
XTT	=	$(0.370^2 + 0.463^2 + 3.704^2)^{½} = 3.8$ km	XTT	=	$(0.2^2 + 0.25^2 + 2^2)^{½} = 2.0$ NM
½A/W	=	1.5 x XTT + BV = 9.3 km	½A/W	=	1.5 x XTT + BV = 5.0 NM

Arrival route, initial and intermediate approach:

SI unit	*Non SI units*
TSE = 0.37 km	TSE = 0.2 NM
ST = 0.46 km	ST = 0.25 NM
FTT = 1.85 km	FTT = 1.0 NM
BV = 1.85 km	BV = 1.0 NM
ATT = $(0.370^2 + 0.463^2)^{½}$ = 0.59 km	ATT = $(0.2^2 + 0.25^2)^{½}$ = 0.32 NM
XTT = $(0.370^2 + 0.463^2 + 1.852^2)^{½}$ = 1.94 km	XTT = $(0.2^2 + 0.25^2 + 1.0^2)^{½}$ = 1.1 NM
½A/W = 1.5 x XTT + BV = 4.77 km	½A/W = 1.5 x XTT + BV = 2.6 NM

Final, missed approach and departure:

SI unit	*Non SI units*
TSE = 0.37 km	TSE = 0.2 NM
ST = 0.46 km	ST = 0.25 NM
FTT = 0.93 km	FTT = 0.5 NM
BV = 0.93 km	BV = 0.5 NM
ATT = $(0.370^2 + 0.463^2)^{½}$ = 0.59 km	ATT = $(0.2^2 + 0.25^2)^{½}$ = 0.32 NM
XTT = $(0.370^2 + 0.463^2 + 0.9326^2)^{½}$ = 1.1 km	XTT = $(0.2^2 + 0.25^2 + 0.5^2)^{½}$ = 0.59 NM
½A/W = 1.5 x XTT + BV = 2.58 km	½A/W = 1.5 x XTT + BV = 1.39 NM

Chapter 4

VOR/DME RNAV

4.1 GENERAL

4.1.1 Area navigation systems which use the procedure must be controlled through a navigation database.

4.1.2 *Reference facility*. Criteria in this chapter apply to procedures based on one reference facility composed of a VOR and collocated DME equipment. This facility shall be published.

4.2 VOR/DME RNAV SYSTEM USE ACCURACY

4.2.1 Accuracy

The operational performances of the area navigation equipment shall be such that the tolerances which determine the system use accuracy remain within the values specified in 4.2.2 through 4.3 below. These values are based on 2 sigma (95 per cent) confidence limits.

4.2.2 Navigation accuracy factors

The factors on which the navigation accuracy of VOR/DME RNAV depends are:

a) ground station tolerance;

b) airborne receiving system tolerance;

c) flight technical tolerance;

d) system computation tolerance; and

e) distance from the reference facility.

4.2.3 System use accuracies

4.2.3.1 The system use accuracy of the VOR is equal to the VOR system use accuracy of the facility not providing track, which is equal to ± 4.5 degrees (see Part I, Section 2, Chapter 2).

4.2.3.2 The system use accuracy of the DME is equal to the DME system use accuracy (DTT) of the facility not providing track, which is equal to ± (0.46 km (0.25 NM) + 1.25 per cent of the distance to the antenna). (See Annex 10, Volume I, 3.5.3.1.3.2.)

4.2.3.3 For further information see Part I, Section I, Chapter 2, “Terminal area fixes”.

4.3 FLIGHT TECHNICAL TOLERANCE

The flight technical tolerance (FTT) will vary with the type of position indicator used in the cockpit instrumentation. For the arrival phase, the FTT also depends on the location of the IAF. It is assumed that the FTT has the following contributions to the cross-track tolerance:

a) departures:

1) ±0.19 km (±0.10 NM) at the DER; and

2) 0.93 km (0.50 NM) for all other fixes;

b) arrival:

1) FAF located more than 46 km (25 NM) from IAF: 3.70 km (2.00 NM); and

2) FAF located within 46 km (25 NM) of IAF: 1.85 km (1.00 NM);

c) initial and intermediate approach: ± 1.85 km (1.00 NM); and

d) final and missed approach: ± 0.93 km (0.50 NM).

4.4 SYSTEM COMPUTATION TOLERANCE

The system computation tolerance (ST) is assumed to be 0.93 km (0.50 NM).

4.5 XTT, ATT AND AREA SEMI-WIDTH

4.5.1 XTT and ATT

4.5.1.1 The combination of the tolerances specified in 4.2.2 to 4.4 on a root sum square basis gives the cross-track tolerance (XTT) and the along-track tolerance (ATT) of any fix as follows:

$$XTT = \pm [VT^2 + DT^2 + FTT^2 + ST^2]^{1/2}$$
$$ATT = \pm [AVT^2 + ADT^2 + ST^2]^{1/2}$$

(see Figures III-1-4-1 and III-1-4-2)

where:

D is the distance from the reference facility to the waypoint; $D = [D1^2 + D2^2]^{1/2}$

D1 is the tangent point distance. The tangent point is the perpendicular projection of the reference facility onto the nominal track. The tangent point distance (D1) is the distance from the reference facility to the tangent point.

D2 is the distance to the tangent point. This is the distance from the waypoint to the tangent point (see Figure III-1-4-1).

α	=	VOR system use accuracy (degrees)
DTT	=	DME system use accuracy
θ	=	arctan (D2/D1) (degrees) (if D1 = 0, $\theta = 90°$)
VT	=	D1 – D cos ($\theta + \alpha$)
DT	=	DTT cos θ
AVT	=	D2 – D sin ($\theta - \alpha$)
ADT	=	DTT sin θ

Note.— ATT does not contain an FTT component.

4.5.1.2 Results of calculations of XTT and ATT for FAF, SDF, TP, IF and IAF are presented in Tables III-1-4-1, and III-1-4-2. Where ground facility performance is demonstrated to be consistently better than in 4.2.3, "System use accuracies" the total system tolerance may be reduced by using the formulae.

4.5.2 Area semi-width

Area semi-width (1/2 A/W) at a waypoint is the greater of the following:

(1.5 × XTT + BV) or the appropriate fixed value as shown in Table III-1-4-5

where: 1.5 XTT corresponds to 3 sigma

BV is the buffer value.

Table III-1-4-5 shows the criteria for determining area semi-width at the various fixes and at the beginning of each segment. See also Tables III-1-4-3, and III-1-4-4 as well as 4.5.1, "XTT and ATT"

4.5.3 ATT and XTT track dependency

ATT and XTT are track dependent. Thus when a turn is specified at a fix, the ATT and XTT are different before and after the turn due to the individual fix geometry.

Table III-1-4-1. VOR/DME area navigation tolerances for IAF and IF (FTT = 1.9 km (1.0 NM))

Note.— Figures which do not comply with satisfactory fixes (see Chapter 1, 1.2.1 and 1.2.2) are shaded.

Kilometres (km)												
D1 (km)	*D2 (km)*	*0.0*	*10.0*	*20.0*	*30.0*	*40.0*	*50.0*	*60.0*	*70.0*	*80.0*	*90.0*	*100.0*
0.0	XTT ATT	2.1 1.0	2.2 1.1	2.6 1.2	3.1 1.3	3.8 1.3	4.4 1.4	5.1 1.5	5.9 1.6	6.6 1.7	7.4 1.9	8.1 2.0
10.0	XTT ATT	2.2 1.2	2.3 1.3	2.6 1.4	3.2 1.5	3.8 1.6	4.5 1.7	5.2 1.8	5.9 1.9	6.6 2.0	7.4 2.1	8.1 2.2
20.0	XTT ATT	2.2 1.8	2.3 1.9	2.7 2.0	3.2 2.0	3.8 2.1	4.5 2.2	5.2 2.3	5.9 2.4	6.7 2.5	7.4 2.6	8.2 2.7
30.0	XTT ATT	2.2 2.5	2.4 2.6	2.8 2.6	3.3 2.7	3.9 2.8	4.6 2.9	5.3 2.9	6.0 3.0	6.7 3.1	7.5 3.2	8.2 3.3
40.0	XTT ATT	2.3 3.3	2.5 3.3	2.8 3.4	3.3 3.4	4.0 3.5	4.6 3.6	5.3 3.6	6.0 3.7	6.8 3.8	7.5 3.9	8.3 3.9
50.0	XTT ATT	2.3 4.0	2.5 4.1	2.9 4.1	3.4 4.2	4.0 4.2	4.7 4.3	5.4 4.4	6.1 4.4	6.8 4.5	7.6 4.6	8.3 4.6
60.0	XTT ATT	2.4 4.8	2.6 4.8	3.0 4.9	3.5 4.9	4.1 5.0	4.7 5.0	5.4 5.1	6.1 5.2	6.9 5.2	7.6 5.3	8.4 5.4
70.0	XTT ATT	2.5 5.6	2.7 5.6	3.0 5.6	3.5 5.7	4.1 5.7	4.8 5.8	5.5 5.8	6.2 5.9	6.9 6.0	7.7 6.0	8.4 6.1
80.0	XTT ATT	2.5 6.3	2.7 6.4	3.1 6.4	3.6 6.5	4.2 6.5	4.9 6.6	5.5 6.6	6.2 6.7	7.0 6.7	7.7 6.8	8.5 6.9
90.0	XTT ATT	2.6 7.1	2.8 7.2	3.2 7.2	3.7 7.2	4.3 7.3	4.9 7.3	5.6 7.4	6.3 7.4	7.0 7.5	7.8 7.5	8.5 7.6
100.0	XTT ATT	2.7 7.9	2.9 7.9	3.3 8.0	3.8 8.0	4.4 8.1	5.0 8.1	5.7 8.1	6.4 8.2	7.1 8.2	7.8 8.3	8.6 8.4

Nautical miles (NM)												
D1 (NM)	*D2 (NM)*	*0.0*	*5.0*	*10.0*	*15.0*	*20.0*	*25.0*	*30.0*	*35.0*	*40.0*	*45.0*	*50.0*
0.0	XTT ATT	1.1 0.6	1.2 0.6	1.4 0.6	1.6 0.7	1.9 0.7	2.3 0.8	2.6 0.8	3.0 0.9	3.3 0.9	3.7 1.0	4.1 1.0
5.0	XTT ATT	1.2 0.6	1.2 0.7	1.4 0.7	1.6 0.8	1.9 0.8	2.3 0.9	2.6 0.9	3.0 1.0	3.3 1.0	3.7 1.1	4.1 1.1
10.0	XTT ATT	1.2 0.9	1.2 1.0	1.4 1.0	1.7 1.0	2.0 1.1	2.3 1.1	2.6 1.2	3.0 1.2	3.4 1.3	3.7 1.3	4.1 1.4
15.0	XTT ATT	1.2 1.3	1.3 1.3	1.4 1.3	1.7 1.4	2.0 1.4	2.3 1.4	2.7 1.5	3.0 1.5	3.4 1.6	3.8 1.6	4.1 1.7
20.0	XTT ATT	1.2 1.6	1.3 1.7	1.5 1.7	1.7 1.7	2.0 1.8	2.3 1.8	2.7 1.8	3.0 1.9	3.4 1.9	3.8 1.9	4.2 2.0
25.0	XTT ATT	1.3 2.0	1.3 2.0	1.5 2.1	1.8 2.1	2.1 2.1	2.4 2.2	2.7 2.2	3.1 2.2	3.4 2.3	3.8 2.3	4.2 2.3
30.0	XTT ATT	1.3 2.4	1.4 2.4	1.5 2.4	1.8 2.5	2.1 2.5	2.4 2.5	2.7 2.6	3.1 2.6	3.5 2.6	3.8 2.7	4.2 2.7
35.0	XTT ATT	1.3 2.8	1.4 2.8	1.6 2.8	1.8 2.9	2.1 2.9	2.4 2.9	2.8 2.9	3.1 3.0	3.5 3.0	3.9 3.0	4.2 3.1

Nautical miles (NM)												
D1 (NM)	*D2 (NM)*	*0.0*	*5.0*	*10.0*	*15.0*	*20.0*	*25.0*	*30.0*	*35.0*	*40.0*	*45.0*	*50.0*
40.0	XTT ATT	1.4 3.2	1.4 3.2	1.6 3.2	1.9 3.2	2.2 3.3	2.5 3.3	2.8 3.3	3.2 3.3	3.5 3.4	3.9 3.4	4.2 3.4
45.0	XTT ATT	1.4 3.6	1.5 3.6	1.7 3.6	1.9 3.6	2.2 3.6	2.5 3.7	2.8 3.7	3.2 3.7	3.5 3.7	3.9 3.8	4.3 3.8
50.0	XTT ATT	1.4 4.0	1.5 4.0	1.7 4.0	1.9 4.0	2.2 4.0	2.5 4.1	2.9 4.1	3.2 4.1	3.6 4.1	3.9 4.2	4.3 4.2

Table III-1-4-2. VOR/DME area navigation tolerances for FAF, SDF and TP (FTT = 0.93 km (0.5 NM))

Note.— Figures which do not comply with satisfactory fixes (see Chapter 1, 1.2.1 and 1.2.2) are shaded.

Kilometres (km)												
D1 (km)	*D2 (km)*	*0.0*	*5.0*	*10.0*	*15.0*	*20.0*	*25.0*	*30.0*	*35.0*	*40.0*	*45.0*	*50.0*
0.0	XTT ATT	1.3 1.0	1.4 1.1	1.5 1.1	1.8 1.1	2.0 1.2	2.4 1.2	2.7 1.3	3.0 1.3	3.4 1.3	3.8 1.4	4.1 1.4
5.0	XTT ATT	1.4 1.0	1.4 1.1	1.6 1.2	1.8 1.2	2.1 1.2	2.4 1.3	2.7 1.3	3.1 1.4	3.4 1.4	3.8 1.5	4.2 1.5
10.0	XTT ATT	1.4 1.2	1.5 1.3	1.6 1.3	1.8 1.4	2.1 1.4	2.4 1.5	2.7 1.5	3.1 1.6	3.4 1.6	3.8 1.7	4.2 1.7
15.0	XTT ATT	1.5 1.5	1.5 1.5	1.7 1.6	1.9 1.6	2.1 1.7	2.4 1.7	2.8 1.8	3.1 1.8	3.5 1.8	3.8 1.9	4.2 1.9
20.0	XTT ATT	1.5 1.8	1.6 1.8	1.7 1.9	1.9 1.9	2.2 2.0	2.5 2.0	2.8 2.0	3.1 2.1	3.5 2.1	3.8 2.2	4.2 2.2
25.0	XTT ATT	1.5 2.2	1.6 2.2	1.7 2.2	1.9 2.3	2.2 2.3	2.5 2.3	2.8 2.4	3.2 2.4	3.5 2.4	3.9 2.5	4.2 2.5
30.0	XTT ATT	1.6 2.5	1.6 2.5	1.8 2.6	2.0 2.6	2.2 2.6	2.5 2.7	2.9 2.7	3.2 2.7	3.5 2.8	3.9 2.8	4.3 2.9
35.0	XTT ATT	1.6 2.9	1.7 2.9	1.8 2.9	2.0 3.0	2.3 3.0	2.6 3.0	2.9 3.1	3.2 3.1	3.6 3.1	3.9 3.2	4.3 3.2
40.0	XTT ATT	1.6 3.3	1.7 3.3	1.9 3.3	2.1 3.3	2.3 3.4	2.6 3.4	2.9 3.4	3.3 3.5	3.6 3.5	4.0 3.5	4.3 3.6
45.0	XTT ATT	1.7 3.7	1.7 3.7	1.9 3.7	2.1 3.7	2.4 3.7	2.7 3.8	3.0 3.8	3.3 3.8	3.6 3.9	4.0 3.9	4.4 3.9
50.0	XTT ATT	1.7 4.0	1.8 4.0	1.9 4.1	2.2 4.1	2.4 4.1	2.7 4.1	3.0 4.2	3.3 4.2	3.7 4.2	4.0 4.3	4.4 4.3

Nautical miles (NM)												
D1 (NM)	*D2 (NM)*	*0.0*	*2.0*	*4.0*	*6.0*	*8.0*	*10.0*	*12.0*	*14.0*	*16.0*	*18.0*	*20.0*
0.0	XTT ATT	0.7 0.6	0.7 0.6	0.8 0.6	0.8 0.6	0.9 0.6	1.1 0.6	1.2 0.6	1.3 0.7	1.4 0.7	1.6 0.7	1.7 0.7
2.0	XTT ATT	0.8 0.5	0.8 0.6	0.8 0.6	0.9 0.6	1.0 0.6	1.1 0.6	1.2 0.7	1.3 0.7	1.4 0.7	1.6 0.7	1.7 0.7

Nautical miles (NM)												
D1 (NM)	*D2 (NM)*	*0.0*	*2.0*	*4.0*	*6.0*	*8.0*	*10.0*	*12.0*	*14.0*	*16.0*	*18.0*	*20.0*
4.0	XTT ATT	0.8 0.6	0.8 0.6	0.8 0.6	0.9 0.7	1.0 0.7	1.1 0.7	1.2 0.7	1.3 0.7	1.5 0.8	1.6 0.8	1.7 0.8
6.0	XTT ATT	0.8 0.7	0.8 0.7	0.8 0.7	0.9 0.7	1.0 0.8	1.1 0.8	1.2 0.8	1.3 0.8	1.5 0.8	1.6 0.9	1.7 0.9
8.0	XTT ATT	0.8 0.8	0.8 0.8	0.8 0.8	0.9 0.8	1.0 0.9	1.1 0.9	1.2 0.9	1.3 0.9	1.5 0.9	1.6 1.0	1.8 1.0
10.0	XTT ATT	0.8 0.9	0.8 0.9	0.9 1.0	0.9 1.0	1.0 1.0	1.1 1.0	1.2 1.0	1.4 1.0	1.5 1.1	1.6 1.1	1.8 1.1
12.0	XTT ATT	0.8 1.1	0.8 1.1	0.9 1.1	0.9 1.1	1.0 1.1	1.1 1.1	1.3 1.1	1.4 1.2	1.5 1.2	1.6 1.2	1.8 1.2
14.0	XTT ATT	0.8 1.2	0.8 1.2	0.9 1.2	1.0 1.2	1.1 1.2	1.2 1.3	1.3 1.3	1.4 1.3	1.5 1.3	1.7 1.3	1.8 1.3
16.0	XTT ATT	0.8 1.4	0.9 1.4	0.9 1.4	1.0 1.4	1.1 1.4	1.2 1.4	1.3 1.4	1.4 1.4	1.5 1.4	1.7 1.5	1.8 1.5
18.0	XTT ATT	0.9 1.5	0.9 1.5	0.9 1.5	1.0 1.5	1.1 1.5	1.2 1.5	1.3 1.6	1.4 1.6	1.5 1.6	1.7 1.6	1.8 1.6
20.0	XTT ATT	0.9 1.6	0.9 1.7	0.9 1.7	1.0 1.7	1.1 1.7	1.2 1.7	1.3 1.7	1.4 1.7	1.6 1.7	1.7 1.7	1.8 1.8

Table III-1-4-3. VOR/DME area navigation area semi-width and ATT for IAF and IF (FTT = 2 km (1 NM))

Note.— Figures which do not comply with satisfactory fixes (Chapter 1, 1.2.1 and 1.2.2) are shaded.

Kilometres (km)												
D1 (km)	*D2 (km)*	*0.0*	*10.0*	*20.0*	*30.0*	*40.0*	*50.0*	*60.0*	*70.0*	*80.0*	*90.0*	*100.0*
0.0	1/2 A/W ATT	5.0 1.0	5.2 1.1	5.7 1.2	6.6 1.3	7.5 1.3	8.5 1.4	9.6 1.5	10.7 1.6	11.8 1.7	12.9 1.9	14.0 2.0
10.0	1/2 A/W ATT	5.1 1.2	5.3 1.3	5.8 1.4	6.6 1.5	7.5 1.6	8.6 1.7	9.6 1.8	10.7 1.9	11.8 2.0	13.0 2.1	14.1 2.2
20.0	1/2 A/W ATT	5.1 1.8	5.4 1.9	5.9 2.0	6.7 2.0	7.6 2.1	8.6 2.2	9.7 2.3	10.8 2.4	11.9 2.5	13.0 2.6	14.1 2.7
30.0	1/2 A/W ATT	5.2 2.5	5.4 2.6	6.0 2.6	6.8 2.7	7.7 2.8	8.7 2.9	9.7 2.9	10.8 3.0	11.9 3.1	13.1 3.2	14.2 3.3
40.0	1/2 A/W ATT	5.3 3.3	5.5 3.3	6.1 3.4	6.9 3.4	7.8 3.5	8.8 3.6	9.8 3.6	10.9 3.7	12.0 3.8	13.1 3.9	14.2 3.9
50.0	1/2 A/W ATT	5.4 4.0	5.6 4.1	6.2 4.1	7.0 4.2	7.9 4.2	8.9 4.3	9.9 4.4	11.0 4.4	12.1 4.5	13.2 4.6	14.3 4.6
60.0	1/2 A/W ATT	5.5 4.8	5.7 4.8	6.3 4.9	7.1 4.9	8.0 5.0	8.9 5.0	10.0 5.1	11.1 5.2	12.1 5.2	13.3 5.3	14.4 5.4
70.0	1/2 A/W ATT	5.6 5.6	5.8 5.6	6.4 5.6	7.2 5.7	8.1 5.7	9.0 5.8	10.1 5.8	11.1 5.9	12.2 6.0	13.3 6.0	14.5 6.1
80.0	1/2 A/W ATT	5.7 6.3	6.0 6.4	6.5 6.4	7.3 6.5	8.2 6.5	9.1 6.6	10.2 6.6	11.2 6.7	12.3 6.7	13.4 6.8	14.5 6.9

Kilometres (km)												
D1 (km)	*D2 (km)*	*0.0*	*10.0*	*20.0*	*30.0*	*40.0*	*50.0*	*60.0*	*70.0*	*80.0*	*90.0*	*100.0*
90.0	1/2 A/W ATT	5.8 7.1	6.1 7.2	6.6 7.2	7.4 7.2	8.3 7.3	9.2 7.3	10.3 7.4	11.3 7.4	12.4 7.5	13.5 7.5	14.6 7.6
100.0	1/2 A/W ATT	5.9 7.9	6.2 7.9	6.8 8.0	7.5 8.0	8.4 8.1	9.3 8.1	10.4 8.1	11.4 8.2	12.5 8.2	13.6 8.3	14.7 8.4

Nautical miles (NM)												
D1 (NM)	*D2 (NM)*	*0.0*	*5.0*	*10.0*	*15.0*	*20.0*	*25.0*	*30.0*	*35.0*	*40.0*	*45.0*	*50.0*
0.0	1/2 A/W ATT	2.7 0.6	2.8 0.6	3.0 0.6	3.4 0.7	3.9 0.7	4.4 0.8	4.9 0.8	5.4 0.9	6.0 0.9	6.6 1.0	7.1 1.0
5.0	1/2 A/W ATT	2.7 0.6	2.8 0.7	3.1 0.7	3.5 0.8	3.9 0.8	4.4 0.9	4.9 0.9	5.5 1.0	6.0 1.0	6.6 1.1	7.1 1.1
10.0	1/2 A/W ATT	2.8 0.9	2.9 1.0	3.1 1.0	3.5 1.0	3.9 1.1	4.4 1.1	5.0 1.2	5.5 1.2	6.0 1.3	6.6 1.3	7.2 1.4
15.0	1/2 A/W ATT	2.8 1.3	2.9 1.3	3.2 1.3	3.5 1.4	4.0 1.4	4.5 1.4	5.0 1.5	5.5 1.5	6.1 1.6	6.6 1.6	7.2 1.7
20.0	1/2 A/W ATT	2.8 1.6	3.0 1.7	3.2 1.7	3.6 1.7	4.0 1.8	4.5 1.8	5.0 1.8	5.6 1.9	6.1 1.9	6.7 1.9	7.2 2.0
25.0	1/2 A/W ATT	2.9 2.0	3.0 2.0	3.3 2.1	3.6 2.1	4.1 2.1	4.6 2.2	5.1 2.2	5.6 2.2	6.1 2.3	6.7 2.3	7.3 2.3
30.0	1/2 A/W ATT	3.0 2.4	3.1 2.4	3.3 2.4	3.7 2.5	4.1 2.5	4.6 2.5	5.1 2.6	5.6 2.6	6.2 2.6	6.7 2.7	7.3 2.7
35.0	1/2 A/W ATT	3.0 2.8	3.1 2.8	3.4 2.8	3.7 2.9	4.2 2.9	4.7 2.9	5.2 2.9	5.7 3.0	6.2 3.0	6.8 3.0	7.3 3.1
40.0	1/2 A/W ATT	3.0 3.2	3.2 3.2	3.4 3.2	3.8 3.2	4.2 3.3	4.7 3.3	5.2 3.3	5.7 3.3	6.3 3.4	6.8 3.4	7.4 3.4
45.0	1/2 A/W ATT	3.1 3.6	3.2 3.6	3.5 3.6	3.9 3.6	4.3 3.6	4.8 3.7	5.3 3.7	5.8 3.7	6.3 3.7	6.9 3.8	7.4 3.8
50.0	1/2 A/W ATT	3.1 4.0	3.3 4.0	3.5 4.0	3.9 4.0	4.3 4.0	4.8 4.1	5.3 4.1	5.8 4.1	6.4 4.1	6.9 4.2	7.5 4.2

Table III-1-4-4. VOR/DME area navigation semi-width for FAF, SDF, MAPt and TP (FTT = 0.9 km (0.5 NM)

Note.— Figures which do not comply with satisfactory fixes (see Chapter 1, 1.2.1 and 1.2.2) are shaded.

Kilometres (km)												
D1 (km)	*D2 (km)*	*0.0*	*5.0*	*10.0*	*15.0*	*20.0*	*25.0*	*30.0*	*35.0*	*40.0*	*45.0*	*50.0*
0	½ A/W ATT	2.9 1.0	3.0 1.1	3.2 1.1	3.6 1.1	4.0 1.2	4.5 1.2	5.0 1.3	5.5 1.3	6.0 1.3	6.6 1.4	7.1 1.4
5	½ A/W ATT	3.0 1.0	3.1 1.1	3.3 1.2	3.6 1.2	4.0 1.2	4.5 1.3	5.0 1.3	5.5 1.4	6.1 1.4	6.6 1.5	7.2 1.5
10	½ A/W ATT	3.1 1.2	3.1 1.3	3.3 1.3	3.7 1.4	4.1 1.4	4.5 1.5	5.0 1.5	5.5 1.6	6.1 1.6	6.6 1.7	7.2 1.7

Kilometres (km)												
D1 (km)	*D2 (km)*	*0.0*	*5.0*	*10.0*	*15.0*	*20.0*	*25.0*	*30.0*	*35.0*	*40.0*	*45.0*	*50.0*
15	½ A/W	3.1	3.2	3.4	3.7	4.1	4.6	5.1	5.6	6.1	6.7	7.2
	ATT	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.9	1.9
20	½ A/W	3.2	3.3	3.5	3.8	4.2	4.6	5.1	5.6	6.2	6.7	7.2
	ATT	1.8	1.8	1.9	1.9	2.0	2.0	2.0	2.1	2.1	2.2	2.2
25	½ A/W	3.2	3.3	3.5	3.8	4.2	4.7	5.2	5.7	6.2	6.7	7.3
	ATT	2.2	2.2	2.2	2.3	2.3	2.3	2.4	2.4	2.4	2.5	2.5
30	½ A/W	3.3	3.4	3.6	3.9	4.3	4.7	5.2	5.7	6.2	6.8	7.3
	ATT	2.5	2.5	2.6	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.9
35	½ A/W	3.3	3.4	3.6	4.0	4.4	4.8	5.3	5.8	6.3	6.8	7.4
	ATT	2.9	2.9	2.9	3.0	3.0	3.0	3.1	3.1	3.1	3.2	3.2
40	½ A/W	3.4	3.5	3.7	4.0	4.4	4.9	5.3	5.8	6.3	6.9	7.4
	ATT	3.3	3.3	3.3	3.3	3.4	3.4	3.4	3.5	3.5	3.5	3.6
45	½ A/W	3.4	3.5	3.8	4.1	4.5	4.9	5.4	5.9	6.4	6.9	7.5
	ATT	3.7	3.7	3.7	3.7	3.7	3.8	3.8	3.8	3.9	3.9	3.9
50	½ A/W	3.5	3.6	3.8	4.2	4.5	5.0	5.4	5.9	6.4	7.0	7.5
	ATT	4.0	4.0	4.1	4.1	4.1	4.1	4.2	4.2	4.2	4.3	4.3

Nautical miles (NM)												
D1 (NM)	*D2 (NM)*	*0.0*	*2.0*	*4.0*	*6.0*	*8.0*	*10.0*	*12.0*	*14.0*	*16.0*	*18.0*	*20.0*
0.0	½ A/W	1.6	1.6	1.7	1.8	1.9	2.1	2.3	2.5	2.7	2.9	3.1
	ATT	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7
2.0	½ A/W	1.6	1.6	1.7	1.8	1.9	2.1	2.3	2.5	2.7	2.9	3.1
	ATT	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7
4.0	½ A/W	1.7	1.7	1.7	1.8	2.0	2.1	2.3	2.5	2.7	2.9	3.1
	ATT	0.6	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8
6.0	½ A/W	1.7	1.7	1.7	1.8	2.0	2.1	2.3	2.5	2.7	2.9	3.1
	ATT	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9
8.0	½ A/W	1.7	1.7	1.8	1.9	2.0	2.2	2.3	2.5	2.7	2.9	3.1
	ATT	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	1.0	1.0
10.0	½ A/W	1.7	1.7	1.8	1.9	2.0	2.2	2.4	2.5	2.7	3.0	3.1
	ATT	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1
12.0	½ A/W	1.7	1.8	1.8	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.2
	ATT	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.2	1.2	1.2	1.2
14.0	½ A/W	1.7	1.8	1.8	1.9	2.1	2.2	2.4	2.6	2.8	3.0	3.2
	ATT	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	1.3	1.3	1.3
16.0	½ A/W	1.8	1.8	1.9	2.0	2.1	2.3	2.4	2.6	2.8	3.0	3.2
	ATT	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.5	1.5
18.0	½ A/W	1.8	1.8	1.9	2.0	2.1	2.3	2.4	2.6	2.8	3.0	3.2
	ATT	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6
20.0	½ A/W	1.8	1.8	1.9	2.0	2.1	2.3	2.5	2.6	2.8	3.0	3.2
	ATT	1.6	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.8

Table III-1-4-5. VOR/DME area semi-width

	1/2A/W is the greater of these values	
Departure	1.85 km (1.00 NM)	1.5 XTT + 0.93 km (0.50 NM)
En-route and arrival segment [1]	9.26 km (5.00 NM)	1.5 XTT + 3.70 km (2.00 NM)
Arrival segment [2]	9.26 km (5.00 NM)	1.5 XTT + 1.85 km (1.00 NM)
IAF and IF	3.70 km (2.00 NM)	1.5 XTT + 1.85 km (1.00 NM)
FAF, MAPt and TP	1.85 km (1.00 NM)	1.5 XTT + 0.93 km (0.50 NM)
Holding[3]		

1. Routes which start more than 46 km (25 NM) from the IAF (XTT is determined with BV = 3.70 km (2.00 NM)).
2. Routes which start 46 km (25 NM) or less from the IAF (XTT is determined with BV = 1.85 km (1.00 NM)).
3. Holding areas use different principles (see Section 3, Chapter 7).

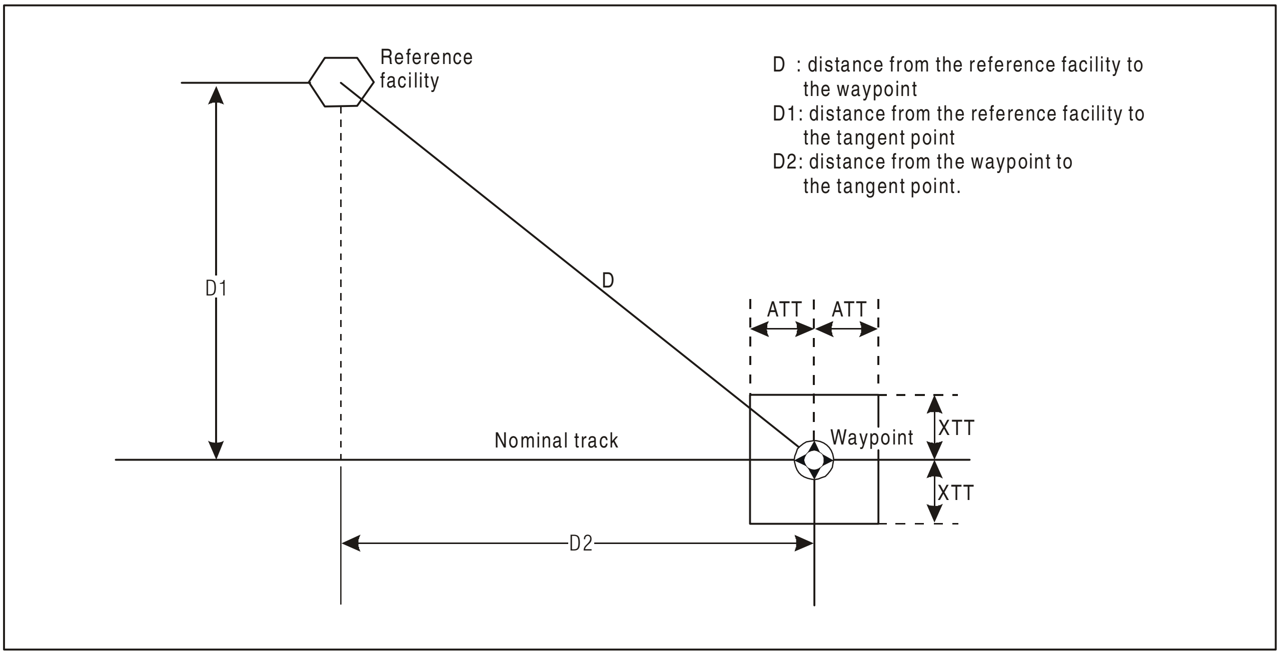


Figure III-1-4-1. Identification of waypoints

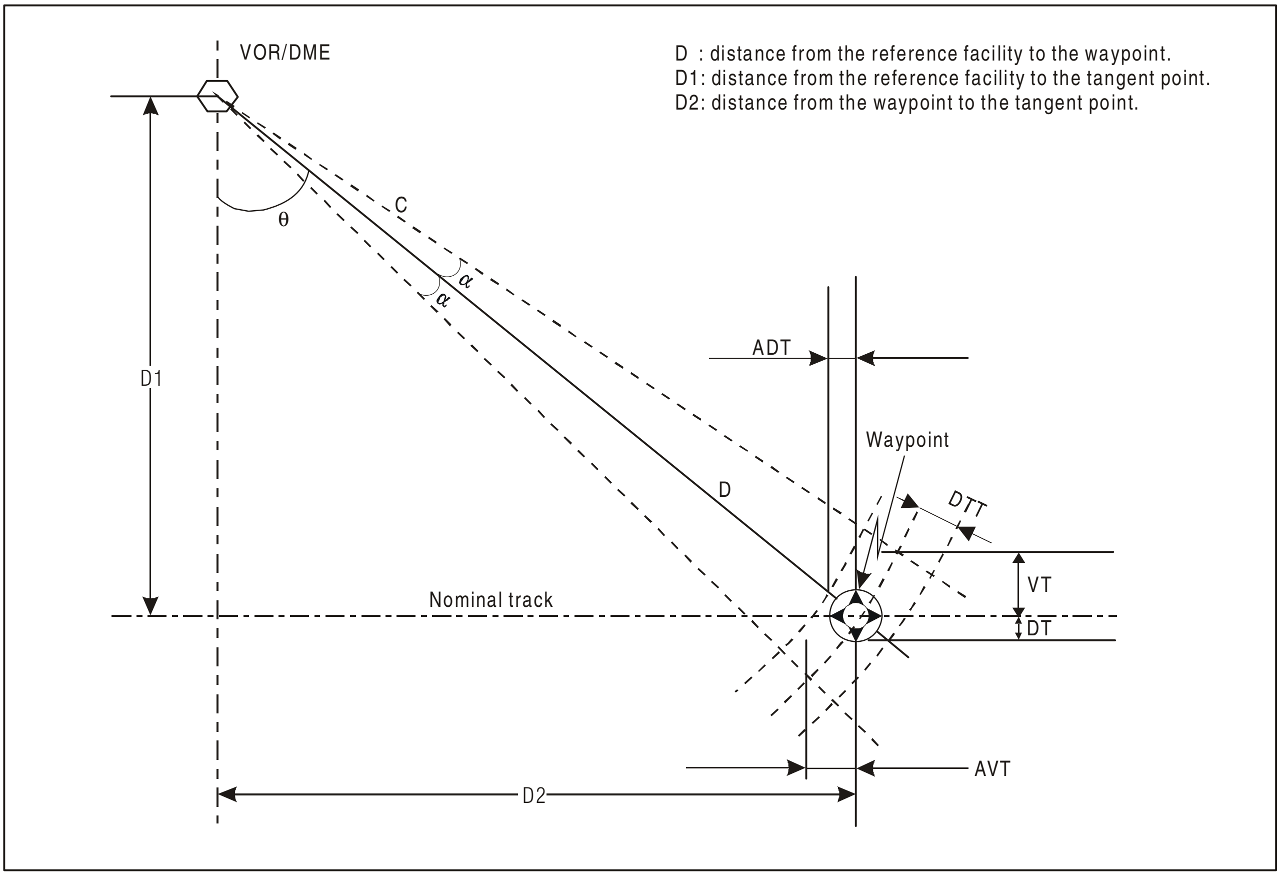


Figure III-1-4-2. Calculation of waypoint tolerances

Chapter 5

SBAS RNAV

5.1.1 SBAS departure criteria are based on the following procedures and equipment functionalities.

5.1.1.1 The departure guidance is selected before take-off. Once the departure procedure is activated, it is assumed that the equipment provide non-precision approach accuracy and integrity and that the display sensitivity is equal to 0.6 km (0.3 NM) until the turn initiation point of the first waypoint of the departure procedure.

5.1.1.2 Departure criteria assume SBAS GNSS receivers with departure function.

Note.— SBAS GNSS Receiver — GNSS avionics that at least meet requirements for an SBAS receiver in Annex 10, Volume I, and specifications of RTCA DO-229C, as amended by FAA TSO-C145A/146A (or equivalent).

5.1.1.3 After the turn initiation point of the first waypoint of the departure procedure it is assumed that the system is in terminal mode with a display sensitivity equal to 1.9 km (1.0 NM).

5.1.2 *XTT, ATT and area semi-width.* For departures ATT = 0.56 km (0.30 NM)

Chapter 6

GBAS RNAV

(To be developed)

Chapter 7

RNP

7.1 EQUIPMENT REQUIREMENTS

Area navigation systems which use the procedure must be controlled through a navigation database.

7.2 FIX TOLERANCE AREAS

It is assumed that the entire RNP 95 per cent error distribution is contained within a circle of radius equal to the RNP value. Fix tolerance areas are defined by circles with radius equal to the RNP value.

7.3 FLIGHT TECHNICAL TOLERANCE

It is assumed the system provides information which the pilot monitors and uses to intervene and thus limit excursions of the flight technical error (FTE) to values within those taken into account during the system certification process.

7.4 RNP VALUES

7.4.1 The four basic parameters used to define the total system performance requirements are accuracy, integrity, continuity and availability. However, the values included after the term RNP in this chapter provide only the accuracy parameter (expressed in nautical miles).

7.4.2 Departure procedures are normally based on RNP 1. Where necessary and appropriate, they may be based on RNP 0.5 or RNP 0.3. Departures are not associated with an RNP less than RNP 0.3.

7.4.3 Non-precision approach procedures are normally based on:

a) RNP 0.5 (initial approach only); or

b) RNP 0.3 (initial, intermediate, final approach).

Non-precision approach procedures are not associated with an RNP less than RNP 0.3.

7.4.4 En-route procedures are normally based on RNP 4 or higher. Where necessary and appropriate, they may be based on RNP 1.

7.5 XTT, ATT AND AREA SEMI-WIDTH

Cross-track and along-track tolerances (XTT and ATT) are equal to the RNP value.

RNP area semi-width is determined by the formula:

2 × XTT + BV

where:

BV = buffer value (see Table III-1-7-1)

Note — The buffer values are derived from an assessment of the worst case maximum excursion beyond the ANP alarm limits generated by the RNP system.

Example calculation

The calculation for RNP 1 departures is shown below.

XTT = 1.85 km (1.00 NM)

BV= 0.56 km (0.30 NM)

area semi-width =

2 × 1.85 + 0.56 = 4.26 km

2 × 1.00 +0.30 = 2.30 NM

Table III-1-7-1. RNP buffer values

Segment	*Buffer value (BV)*
Departure	0.93 km (0.50 NM)
En route[1] and arrival[2]	1.85 km (1.00 NM)
Arrival[3]/initial/intermediate approach	0.93 km (0.50 NM)
Final	0.37 km (0.20 NM)
Missed approach	0.56 km (0.30 NM)
Holding[4]	

1. For all RNP types equal to or exceeding RNP 1.
2. Arrival up to 46 km (25 NM) before the IAF.
3. Arrival closer than 46 km (25 NM) to the IAF.
4. Holding areas use different principles.

Note.— The buffer values in Table III-1-7-1 are derived from an assessment of the worst case maximum excursion beyond the ANP alarm limits generated by the RNP system.

Section 2

GENERAL CRITERIA

Chapter 1

MINIMUM LENGTH OF A SEGMENT LIMITED BY TWO TURNING WAYPOINTS

1.1 GENERAL

1.1.1 To prevent turning waypoints being placed so close that RNAV systems are forced to bypass them, a minimum distance between successive turning waypoints must be taken into account. Two types of waypoints are considered:

a) fly-by waypoint; and

b) flyover waypoint.

1.1.2 Four sequences are possible for a segment limited by two waypoints:

a) two fly-by waypoints;

b) fly-by waypoint, then flyover waypoint;

c) two flyover waypoints; and

d) flyover waypoint, then fly-by waypoint.

In addition, the particular case of the segment "DER — first waypoint" must also be considered.

1.1.3 The following method is based on theoretical studies combined with the results of simulations. Some differences may exist between RNAV systems; algorithms used by these systems are complex. For these reasons, simplifications were made when establishing theoretical formulae.

1.1.4 The aim of the method is not to determine a protection area, but to determine a minimum distance between two waypoints on a nominal trajectory. For this reason, wind effect and waypoint tolerances are not taken into account in the theoretical calculations. When it is necessary, greater values may be chosen.

1.2 DETERMINATION OF THE MINIMUM LENGTH OF THE RNAV SEGMENT

1.2.1 General

For each waypoint a minimum stabilization distance is determined. This is the distance between the waypoint and the point where the trajectory joins tangentially with the nominal track (Figure III-2-1-1). For successive waypoints, the minimum distance between them is the sum of both minimum stabilization distances. The tables in this chapter show minimum stabilization distances for various values of true airspeed and course change (at the waypoint).

1.2.2 Minimum stabilization distance tables

Tables III-2-1-1 through III-2-1-20 show minimum stabilization distance. These tables are organized according to the following three parameters:

a) units (SI or non-SI);

b) type of waypoint (fly-by or flyover); and

c) value of bank angle (15°, 20°, 25°).

Use the table below to locate the table which applies.

Organization of minimum stabilization distance tables

Units	*Type of waypoint*	*Bank angle*	*Table number*
Aeroplane			
(SI)	Fly-by	15º	III-2-1-1
		20º	III-2-1-2
		25º	III-2-1-3
	Flyover	15º	III-2-1-4
		20º	III-2-1-5
		25º	III-2-1-6
(Non-SI)	Fly-by	15º	III-2-1-7
		20º	III-2-1-8
		25º	III-2-1-9
	Flyover	15º	III-2-1-10
		20º	III-2-1-11
		25º	III-2-1-12
Helicopter			
(SI)	Fly-by	15º	III-2-1-13
		20º	III-2-1-14
	Flyover	15º	III-2-1-15
		20º	III-2-1-16
(Non-SI)	Fly-by	15º	III-2-1-17
		20º	III-2-1-18
	Flyover	15º	III-2-1-19
		20º	III-2-1-20

1.2.3 Determination of indicated and true airspeeds

1.2.3.1 *Airspeeds for approach procedures.* Use speeds shown in Table I-4-1-1 or I-4-1-2 of Part I, Section 4, Chapter 1. If a speed limitation is needed, use the limited speed. Convert the indicated airspeed into true airspeed, taking into account the altitude for which the procedure is protected.

1.2.3.2 *Airspeeds for departure procedures.* Use speeds defined in Part I, Section 3, Chapter 3. If a speed limitation is needed, use Table I-3-3-App-1 in Part I, Section 3, Appendix to Chapter 3 to check if this speed limitation is not lower than operationally acceptable. Convert the indicated airspeed into true airspeed, taking into account an altitude resulting from a 7 per cent climb gradient originating from the DER.

1.2.4 Choice of bank angle

1.2.4.1 For approach phases, the bank angle is 25°/(or 3°/s), except in the missed approach phase where a 15° bank angle is assumed. See the criteria in Part I, Section 4.

1.2.4.2 For departure phases, according to the choice of criteria made in 2.3.2, "Airspeeds for departure procedures", the bank angle will be:

a) 15° if Part II, Section 3, Chapter 3 criteria are used; and

b) 15°, 20°, 25° according to the along track distance from the DER if the criteria in Part I, Section 3, Appendix to Chapter 3 are used.

1.2.5 Examples

1.2.5.1 *Two fly-by waypoints* (Figure III-2-1-2). For the first waypoint (WP1), find the minimum stabilization distance (A1), in the table, according to the bank angle and the true airspeed. For the second waypoint (WP2), find the minimum stabilization distance (A2) in the table, according to the bank angle and the true airspeed. The minimum distance between WP1 and WP2 = A1 + A2.

1.2.5.2 *Fly-by, then flyover waypoint* (Figure III-2-1-3). For the first waypoint (WP1), find the minimum stabilization distance (A1) according to the bank angle and the true airspeed. As the second waypoint (WP2) is a flyover way-point, the minimum distance between WP1 and WP2 is equal to A1 + 0 = A1.

1.2.5.3 *Two flyover waypoints* (Figure III-2-1-4). For the first waypoint (WP1), find the minimum stabilization distance (B1), according to the bank angle and the true airspeed. As the second waypoint is a flyover waypoint, the minimum distance between WP1 and WP2 is equal to B1 + 0 = B1.

1.2.5.4 *Flyover, then fly-by waypoint* (Figure III-2-1-5). For the first waypoint (WP1), find the minimum stabilization distance (B1), according to the bank angle and the true airspeed. For the second waypoint (WP2), find the minimum stabilization distance (A2), according to the bank angle and the true airspeed. The minimum distance between WP1 and WP2 is equal to B1 + A2.

1.3 PARTICULAR CASE OF THE SEGMENT: DER — FIRST WAYPOINT

The location of the first waypoint must provide a minimum distance of 3.5 km (1.9 NM) between the DER and the earliest turning point (K-line of Section 3, Chapter 1, Figure III-3-1-4). A shorter distance can be used when the PDG is higher than 3.3 per cent (see Part I, Section 3, Chapter 4, 4.1) (Figure III-2-1-6).

1.4 MINIMUM STABILIZATION DISTANCE
(Tables III-2-1-1 to III-2-1-20)

1.4.1 Flyover waypoint

1.4.1.1 *Components of the flyover turn.* A flyover turn is broken down into the following components for the purpose of calculating the minimum stabilization distance:

a) an initial roll-in at the flyover point; followed by

b) a straight 30° intercept course with the next leg;

c) a roll-out at the new course; and

d) a 10-second delay to account for bank establishing time.

1.4.1.2 *Model of the flyover turn.* In order to model the flyover turn procedure, its length is divided into five segments, L1 through L5 (see Figure III-2-1-7). The total length of the procedure is the sum of the five segments.

$$L1 = r1 \times \sin \theta$$
$$L2 = r1 \times \cos \theta \times \tan \alpha$$
$$L3 = r1\ (1/\sin \alpha - 2 \cos \theta / \sin (90° - \alpha))$$
$$L4 = r2 \tan (\alpha/2)$$
$$L5 = c \times V/3600$$
$$L5 = 5V/3600 \text{ (for Cat H)}$$

where: α = 30 degree intercept course with the next leg;
θ = turn angle;
c = 10 second bank establishment time;
r1 = roll-in radius; and
r2 = roll-out radius.

In the above equations,

if distances and turn radii are in NM, V is in kt;
if distances and turn radii are in km, V is in km/h.

1.4.1.3 *Bank angle of flyover turn.* For course changes equal to or less than 50°, the bank angle of both the roll-in and the roll-out are considered to be half of the course change. For course changes of more than 50°, the bank angle equals:

a) 15°, 20° or 25° according to the phases of flight for the roll-in (r1); and

b) 15° for the roll-out (r2).

For Category H aircraft, the minimum turn angle to be considered is 30º, the provision for course changes equal to or less than 50º does not apply.

1.4.2 Fly-by waypoint

1.4.2.1 *Model of the fly-by turn.* The model for calculating minimum stabilization distance for the fly-by waypoint is designed in a fashion similar to the flyover waypoint, as shown in Figure III-2-1-8. The model consists of a level turn with a constant radius r. The total length of the segment is the sum of L1 and L2, where:

L1 is the distance between the waypoint and the start of the turn.

L2 is a five-second delay to take into account the bank establishing time. The delay time is less than in the case of the flyover waypoint because the number of course changes is less.

L1 = r × tan (θ/2)
L2 = c × V/3600
L2 = 3V/3600 (for Cat H)

Where: c = 5 second bank establishment time;
r = turn radius; and
θ = turn angle.

In the above equations,

if distances and turn radii are in NM, V is in kt; or
if distances and turn radii are in km, V is in km/h.

1.4.2.2 *Bank angle of fly-by turn.* For course changes equal to or less than 50°, the bank angle of the roll is considered to be half of the established course change. For course changes of more than 50° the bank angle is equal to 15°, 20° or 25°, according to the phase of flight. For Category H aircraft, the minimum turn angle to be considered is 30º, the provision for course changes equal to or less than 50º does not apply.

Table III-2-1-1. Minimum stabilization distance between fly-by waypoints (SI units, 15° bank angle)

Course change (Degrees)*	*True airspeed (km/h)*														
	< or = 240	*260*	*280*	*300*	*320*	*340*	*360*	*380*	*400*	*440*	*480*	*520*	*560*	*600*	*640*
50	1.1	1.3	1.5	1.6	1.8	2.1	2.3	2.5	2.7	3.3	3.8	4.4	5.1	5.8	6.5
55	1.2	1.4	1.6	1.8	2.0	2.2	2.5	2.7	3.0	3.6	4.2	4.9	5.6	6.3	7.2
60	1.3	1.5	1.7	1.9	2.2	2.4	2.7	3.0	3.3	3.9	4.6	5.3	6.1	6.9	7.8
65	1.4	1.6	1.9	2.1	2.4	2.6	2.9	3.2	3.5	4.2	5.0	5.8	6.6	7.6	8.6
70	1.5	1.8	2.0	2.3	2.5	2.8	3.2	3.5	3.8	4.6	5.4	6.3	7.2	8.2	9.3
75	1.6	1.9	2.2	2.4	2.8	3.1	3.4	3.8	4.2	5.0	5.9	6.8	7.8	8.9	10.1
80	1.8	2.0	2.3	2.6	3.0	3.3	3.7	4.1	4.5	5.4	6.3	7.4	8.5	9.7	11.0
85	1.9	2.2	2.5	2.8	3.2	3.6	4.0	4.4	4.9	5.8	6.9	8.0	9.2	10.5	11.9
90	2.0	2.3	2.7	3.1	3.5	3.9	4.3	4.8	5.3	6.3	7.4	8.7	10.0	11.4	12.9
95	2.2	2.5	2.9	3.3	3.7	4.2	4.7	5.2	5.7	6.8	8.1	9.4	10.8	12.4	14.0
100	2.3	2.7	3.1	3.6	4.0	4.5	5.0	5.6	6.2	7.4	8.7	10.2	11.8	13.4	15.2
105	2.5	2.9	3.4	3.9	4.4	4.9	5.5	6.1	6.7	8.0	9.5	11.1	12.8	14.6	16.6
110	2.7	3.2	3.7	4.2	4.7	5.3	5.9	6.6	7.3	8.7	10.3	12.1	13.9	15.9	18.1
115	3.0	3.5	4.0	4.6	5.2	5.8	6.5	7.2	7.9	9.5	11.3	13.2	15.2	17.4	19.8
120	3.3	3.8	4.4	5.0	5.7	6.4	7.1	7.9	8.7	10.5	12.4	14.5	16.7	19.1	21.7

* Use the value of 50° for course changes lower than 50°.

Table III-2-1-2. Minimum stabilization distance between fly-by waypoints (SI units, 20° bank angle*)

*Course change** (Degrees)*	*True airspeed (km/h)* < or = 240	260	280	300	320	340	360	380	400	440	480	520	560	600	640
50	0.9	1.0	1.2	1.3	1.5	1.6	1.8	2.0	2.2	2.6	3.0	3.4	3.9	4.5	5.0
55	1.0	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.4	2.8	3.3	3.8	4.3	4.9	5.5
60	1.1	1.2	1.4	1.5	1.7	1.9	2.1	2.3	2.6	3.0	3.5	4.1	4.7	5.3	6.0
65	1.1	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.8	3.3	3.8	4.4	5.1	5.8	6.5
70	1.2	1.4	1.6	1.8	2.0	2.2	2.5	2.7	3.0	3.5	4.2	4.8	5.5	6.3	7.1
75	1.3	1.5	1.7	1.9	2.1	2.4	2.6	2.9	3.2	3.8	4.5	5.2	6.0	6.8	7.7
80	1.4	1.6	1.8	2.0	2.3	2.6	2.9	3.1	3.5	4.1	4.8	5.6	6.5	7.4	8.3
85	1.5	1.7	1.9	2.2	2.5	2.8	3.1	3.4	3.7	4.4	5.2	6.1	7.0	8.0	9.0
90	1.6	1.8	2.1	2.4	2.7	3.0	3.3	3.6	4.0	4.8	5.6	6.6	7.6	8.6	9.7
95	1.7	2.0	2.2	2.5	2.9	3.2	3.6	3.9	4.3	5.2	6.1	7.1	8.2	9.3	10.6
100	1.9	2.1	2.4	2.7	3.1	3.5	3.8	4.2	4.7	5.6	6.6	7.7	8.9	10.1	11.4
105	2.0	2.3	2.6	3.0	3.3	3.7	4.2	4.6	5.1	6.1	7.2	8.3	9.6	11.0	12.4
110	2.2	2.4	2.8	3.2	3.6	4.0	4.5	5.0	5.5	6.6	7.8	9.1	10.5	11.9	13.5
115	2.3	2.7	3.0	3.5	3.9	4.4	4.9	5.4	6.0	7.2	8.5	9.9	11.4	13.0	14.8
120	2.5	2.9	3.3	3.8	4.3	4.8	5.4	5.9	6.5	7.9	9.3	10.8	12.5	14.3	16.2

* 20° or 3°/s
** Use the value of 50° for course changes lower than 50°.

Table III-2-1-3 Minimum stabilization distance between fly-by waypoints (SI units, 25° bank angle*)

*Course change** (Degrees)*	*True airspeed (km/h)* < or = 240	260	280	300	320	340	360	380	400	440	480	520	560	600	640
50	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.7	1.8	2.1	2.5	2.8	3.2	3.7	4.1
55	1.0	1.1	1.2	1.2	1.3	1.5	1.6	1.8	2.0	2.3	2.7	3.1	3.5	4.0	4.5
60	1.1	1.2	1.2	1.3	1.4	1.6	1.8	1.9	2.1	2.5	2.9	3.4	3.8	4.3	4.9
65	1.1	1.2	1.3	1.4	1.5	1.7	1.9	2.1	2.3	2.7	3.1	3.6	4.1	4.7	5.3
70	1.2	1.3	1.4	1.5	1.7	1.8	2.0	2.2	2.4	2.9	3.4	3.9	4.5	5.1	5.7
75	1.3	1.4	1.5	1.6	1.8	2.0	2.2	2.4	2.6	3.1	3.6	4.2	4.8	5.5	6.2
80	1.4	1.5	1.6	1.8	1.9	2.1	2.3	2.6	2.8	3.4	3.9	4.6	5.2	5.9	6.7
85	1.5	1.6	1.8	1.9	2.0	2.3	2.5	2.8	3.0	3.6	4.2	4.9	5.6	6.4	7.2
90	1.6	1.7	1.9	2.0	2.2	2.4	2.7	3.0	3.3	3.9	4.6	5.3	6.1	6.9	7.8
95	1.7	1.9	2.0	2.2	2.3	2.6	2.9	3.2	3.5	4.2	4.9	5.7	6.6	7.5	8.4
100	1.9	2.0	2.2	2.3	2.5	2.8	3.1	3.4	3.8	4.5	5.3	6.2	7.1	8.1	9.1
105	2.0	2.2	2.3	2.5	2.7	3.0	3.3	3.7	4.1	4.9	5.7	6.7	7.7	8.7	9.9
110	2.2	2.3	2.5	2.7	2.9	3.3	3.6	4.0	4.4	5.3	6.2	7.2	8.3	9.5	10.8
115	2.3	2.5	2.7	2.9	3.2	3.5	3.9	4.4	4.8	5.7	6.8	7.9	9.1	10.4	11.7
120	2.5	2.7	3.0	3.2	3.4	3.9	4.3	4.7	5.2	6.3	7.4	8.6	9.9	11.4	12.9

* 25° or 3°/s
** Use the value of 50° for course changes lower than 50°.

Table III-2-1-4. Minimum stabilization distance between flyover waypoints (SI units, 15° bank angle)

Course change (Degrees)*	*True airspeed (km/h)* < or = 240	*260*	*280*	*300*	*320*	*340*	*360*	*380*	*400*	*440*	*480*	*520*	*560*	*600*	*640*
50	3.9	4.5	5.2	5.9	6.7	7.5	8.3	9.2	10.1	12.1	14.3	16.7	19.2	22.0	24.9
55	4.2	4.9	5.6	6.4	7.2	8.0	9.0	9.9	10.9	13.1	15.5	18.1	20.8	23.8	27.0
60	4.5	5.2	6.0	6.8	7.7	8.6	9.6	10.7	11.8	14.1	16.7	19.4	22.4	25.6	29.1
65	4.8	5.6	6.4	7.3	8.2	9.2	10.3	11.4	12.6	15.1	17.9	20.8	24.0	27.5	31.1
70	5.1	5.9	6.8	7.7	8.8	9.8	11.0	12.1	13.4	16.1	19.0	22.2	25.6	29.3	33.2
75	5.4	6.3	7.2	8.2	9.3	10.4	11.6	12.9	14.2	17.1	20.2	23.6	27.2	31.1	35.3
80	5.7	6.6	7.6	8.6	9.8	11.0	12.2	13.6	15.0	18.0	21.3	24.9	28.7	32.9	37.3
85	5.9	6.9	7.9	9.1	10.2	11.5	12.8	14.3	15.7	18.9	22.4	26.2	30.2	34.6	39.2
90	6.2	7.2	8.3	9.5	10.7	12.0	13.4	14.9	16.5	19.8	23.4	27.4	31.6	36.2	41.1
95	6.4	7.5	8.6	9.9	11.2	12.5	14.0	15.5	17.2	20.6	24.4	28.6	33.0	37.8	42.9
100	6.7	7.8	9.0	10.2	11.6	13.0	14.5	16.1	17.8	21.4	25.4	29.7	34.3	39.2	44.5
105	6.9	8.0	9.3	10.6	12.0	13.4	15.0	16.7	18.4	22.2	26.2	30.7	35.5	40.6	46.1
110	7.1	8.3	9.5	10.9	12.3	13.8	15.5	17.2	19.0	22.8	27.0	31.6	36.6	41.8	47.5
115	7.3	8.5	9.8	11.2	12.6	14.2	15.9	17.6	19.5	23.4	27.8	32.5	37.5	43.0	48.8
120	7.4	8.7	10.0	11.4	12.9	14.5	16.2	18.0	19.9	24.0	28.4	33.2	38.4	44.0	49.9

* Use the value of 50° for course changes lower than 50°.

Table III-2-1-5. Minimum stabilization distance between flyover waypoints (SI units, 20° bank angle*)

*Course change** (Degrees)*	*True airspeed (km/h)* < or = 240	*260*	*280*	*300*	*320*	*340*	*360*	*380*	*400*	*440*	*480*	*520*	*560*	*600*	*640*
50	3.2	3.7	4.2	4.8	5.4	6.0	6.6	7.3	8.1	9.7	11.4	13.2	15.2	17.4	19.6
55	3.4	3.9	4.5	5.1	5.7	6.4	7.1	7.9	8.7	10.4	12.2	14.2	16.4	18.7	21.2
60	3.7	4.2	4.8	5.4	6.1	6.9	7.6	8.4	9.3	11.1	13.1	15.3	17.6	20.1	22.7
65	3.9	4.4	5.1	5.8	6.5	7.3	8.1	9.0	9.9	11.8	14.0	16.3	18.8	21.4	24.2
70	4.1	4.7	5.4	6.1	6.9	7.7	8.6	9.5	10.5	12.6	14.8	17.3	19.9	22.8	25.8
75	4.3	4.9	5.7	6.4	7.3	8.1	9.1	10.0	11.1	13.3	15.7	18.3	21.1	24.1	27.3
80	4.5	5.2	5.9	6.8	7.6	8.6	9.5	10.6	11.7	14.0	16.5	19.3	22.2	25.4	28.8
85	4.7	5.4	6.2	7.1	8.0	9.0	10.0	11.1	12.2	14.7	17.3	20.2	23.3	26.6	30.2
90	4.9	5.6	6.5	7.4	8.3	9.4	10.4	11.6	12.7	15.3	18.1	21.1	24.4	27.8	31.6
95	5.1	5.9	6.7	7.7	8.7	9.7	10.8	12.0	13.3	15.9	18.8	22.0	25.4	29.0	32.9
100	5.3	6.1	7.0	7.9	9.0	10.1	11.2	12.4	13.7	16.5	19.5	22.8	26.3	30.1	34.1
105	5.5	6.2	7.2	8.2	9.3	10.4	11.6	12.9	14.2	17.0	20.2	23.5	27.2	31.1	35.2
110	5.6	6.4	7.4	8.4	9.5	10.7	11.9	13.2	14.6	17.5	20.7	24.2	28.0	32.0	36.3
115	5.8	6.6	7.6	8.6	9.7	10.9	12.2	13.6	15.0	18.0	21.3	24.8	28.7	32.8	37.2
120	5.9	6.7	7.7	8.8	10.0	11.2	12.5	13.8	15.3	18.4	21.7	25.4	29.3	33.5	38.1

* 20° or 3°/s
** Use the value of 50° for course changes lower than 50°.

Table III-2-1-6. Minimum stabilization distance between flyover waypoints (SI units, 25° bank angle*)

*Course change** (Degrees)*	*True airspeed (km/h)*														
	< or = 240	*260*	*280*	*300*	*320*	*340*	*360*	*380*	*400*	*440*	*480*	*520*	*560*	*600*	*640*
50	3.2	3.5	3.8	4.2	4.5	5.1	5.6	6.2	6.8	8.1	9.6	11.1	12.8	14.5	16.4
55	3.4	3.8	4.1	4.4	4.8	5.4	6.0	6.6	7.3	8.7	10.2	11.9	13.7	15.6	17.6
60	3.7	4.0	4.4	4.7	5.1	5.8	6.4	7.1	7.8	9.3	10.9	12.7	14.6	16.6	18.8
65	3.9	4.3	4.6	5.0	5.5	6.1	6.8	7.5	8.2	9.8	11.6	13.5	15.5	17.7	20.0
70	4.1	4.5	4.9	5.3	5.7	6.4	7.2	7.9	8.7	10.4	12.3	14.3	16.4	18.8	21.2
75	4.3	4.7	5.1	5.5	6.0	6.8	7.5	8.3	9.2	11.0	12.9	15.1	17.3	19.8	22.4
80	4.5	5.0	5.4	5.8	6.3	7.1	7.9	8.7	9.6	11.5	13.6	15.8	18.2	20.8	23.5
85	4.7	5.2	5.6	6.1	6.6	7.4	8.2	9.1	10.1	12.0	14.2	16.6	19.1	21.8	24.7
90	4.9	5.4	5.9	6.3	6.9	7.7	8.6	9.5	10.5	12.5	14.8	17.3	19.9	22.7	25.7
95	5.1	5.6	6.1	6.6	7.1	8.0	8.9	9.9	10.9	13.0	15.4	17.9	20.7	23.6	26.8
100	5.3	5.8	6.3	6.8	7.4	8.3	9.2	10.2	11.2	13.5	15.9	18.6	21.4	24.5	27.7
105	5.5	6.0	6.5	7.0	7.6	8.5	9.5	10.5	11.6	13.9	16.4	19.2	22.1	25.2	28.6
110	5.6	6.1	6.6	7.2	7.8	8.7	9.7	10.8	11.9	14.3	16.9	19.7	22.7	26.0	29.4
115	5.8	6.3	6.8	7.3	8.0	9.0	10.0	11.1	12.2	14.6	17.3	20.2	23.3	26.6	30.1
120	5.9	6.4	6.9	7.5	8.1	9.1	10.2	11.3	12.4	14.9	17.7	20.6	23.8	27.2	30.8

* 25° or 3°/s
** Use the value of 50° for course changes lower than 50°.

Table III-2-1-7. Minimum stabilization distance between fly-by waypoints (Non-SI units, 15° bank angle)

Course change (Degrees)*	*True airspeed (kt)*														
	< or = 130	*140*	*150*	*160*	*170*	*180*	*190*	*200*	*210*	*220*	*240*	*260*	*280*	*300*	*340*
50	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.8	2.1	2.4	2.7	3.4
55	0.7	0.7	0.8	0.9	1.1	1.2	1.3	1.4	1.5	1.7	2.0	2.3	2.6	3.0	3.7
60	0.7	0.8	0.9	1.0	1.1	1.3	1.4	1.5	1.7	1.8	2.1	2.5	2.9	3.2	4.1
65	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.8	2.0	2.3	2.7	3.1	3.5	4.5
70	0.8	0.9	1.1	1.2	1.3	1.5	1.6	1.8	2.0	2.1	2.5	2.9	3.4	3.8	4.9
75	0.9	1.0	1.1	1.3	1.4	1.6	1.8	1.9	2.1	2.3	2.7	3.2	3.7	4.2	5.3
80	1.0	1.1	1.2	1.4	1.6	1.7	1.9	2.1	2.3	2.5	3.0	3.4	4.0	4.5	5.7
85	1.0	1.2	1.3	1.5	1.7	1.9	2.1	2.3	2.5	2.7	3.2	3.7	4.3	4.9	6.2
90	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.5	2.7	2.9	3.5	4.0	4.7	5.3	6.8
95	1.2	1.4	1.5	1.7	2.0	2.2	2.4	2.7	2.9	3.2	3.8	4.4	5.0	5.8	7.3
100	1.3	1.5	1.7	1.9	2.1	2.3	2.6	2.9	3.1	3.4	4.1	4.7	5.5	6.2	8.0
105	1.4	1.6	1.8	2.0	2.3	2.5	2.8	3.1	3.4	3.7	4.4	5.2	5.9	6.8	8.7
110	1.5	1.7	2.0	2.2	2.5	2.8	3.1	3.4	3.7	4.1	4.8	5.6	6.5	7.4	9.5
115	1.6	1.9	2.1	2.4	2.7	3.0	3.3	3.7	4.1	4.4	5.3	6.1	7.1	8.1	10.3
120	1.8	2.0	2.3	2.6	3.0	3.3	3.7	4.0	4.4	4.9	5.8	6.7	7.8	8.9	11.4

* Use the value of 50° for course changes lower than 50°.

Table III-2-1-8. Minimum stabilization distance between fly-by waypoints (Non-SI units, 20° bank angle*)

*Course change** (Degrees)*	*True airspeed (kt)* < or = 130	*140*	*150*	*160*	*170*	*180*	*190*	*200*	*210*	*220*	*240*	*260*	*280*	*300*	*340*
50	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1.4	1.6	1.9	2.1	2.6
55	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.8	2.0	2.3	2.9
60	0.6	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.7	1.9	2.2	2.5	3.1
65	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.8	2.1	2.4	2.7	3.4
70	0.7	0.7	0.8	0.9	1.0	1.2	1.3	1.4	1.5	1.7	1.9	2.3	2.6	2.9	3.7
75	0.7	0.8	0.9	1.0	1.1	1.2	1.4	1.5	1.6	1.8	2.1	2.4	2.8	3.2	4.0
80	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.6	1.8	1.9	2.3	2.6	3.0	3.4	4.4
85	0.8	0.9	1.0	1.2	1.3	1.4	1.6	1.7	1.9	2.1	2.4	2.8	3.3	3.7	4.7
90	0.9	1.0	1.1	1.2	1.4	1.5	1.7	1.9	2.1	2.2	2.6	3.1	3.5	4.0	5.1
95	0.9	1.1	1.2	1.3	1.5	1.7	1.8	2.0	2.2	2.4	2.8	3.3	3.8	4.3	5.5
100	1.0	1.1	1.3	1.4	1.6	1.8	2.0	2.2	2.4	2.6	3.1	3.6	4.1	4.7	6.0
105	1.1	1.2	1.4	1.6	1.7	1.9	2.1	2.4	2.6	2.8	3.3	3.9	4.5	5.1	6.5
110	1.2	1.3	1.5	1.7	1.9	2.1	2.3	2.6	2.8	3.1	3.6	4.2	4.9	5.6	7.1
115	1.3	1.4	1.6	1.8	2.1	2.3	2.5	2.8	3.1	3.3	4.0	4.6	5.3	6.1	7.7
120	1.4	1.6	1.8	2.0	2.2	2.5	2.8	3.1	3.3	3.7	4.3	5.0	5.8	6.7	8.5

* 20° or 3°/s

** Use the value of 50° for course changes lower than 50°.

Table III-2-1-9. Minimum stabilization distance between fly-by waypoints (Non-SI units, 25° bank angle*)

*Course change** (Degrees)*	*True airspeed (kt)* < or = 130	*140*	*150*	*160*	*170*	*180*	*190*	*200*	*210*	*220*	*240*	*260*	*280*	*300*	*340*
50	0.5	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.2	1.3	1.5	1.7	2.2
55	0.5	0.6	0.6	0.7	0.7	0.8	0.9	0.9	1.0	1.1	1.3	1.5	1.7	1.9	2.4
60	0.5	0.6	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.4	1.6	1.8	2.0	2.6
65	0.5	0.7	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.5	1.7	1.9	2.2	2.8
70	0.6	0.7	0.8	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.8	2.1	2.4	3.0
75	0.6	0.8	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.5	1.7	2.0	2.3	2.6	3.2
80	0.7	0.8	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.8	2.1	2.4	2.8	3.5
85	0.7	0.9	0.9	1.0	1.1	1.2	1.3	1.4	1.6	1.7	2.0	2.3	2.6	3.0	3.8
90	0.7	0.9	1.0	1.1	1.1	1.3	1.4	1.5	1.7	1.8	2.1	2.5	2.8	3.2	4.1
95	0.8	1.0	1.1	1.1	1.2	1.4	1.5	1.6	1.8	2.0	2.3	2.7	3.1	3.5	4.4
100	0.8	1.1	1.2	1.2	1.3	1.5	1.6	1.8	1.9	2.1	2.5	2.9	3.3	3.8	4.8
105	0.9	1.2	1.2	1.3	1.4	1.6	1.7	1.9	2.1	2.3	2.7	3.1	3.6	4.1	5.2
110	1.0	1.3	1.3	1.4	1.5	1.7	1.9	2.1	2.3	2.5	2.9	3.4	3.9	4.4	5.6
115	1.1	1.4	1.5	1.6	1.7	1.8	2.0	2.2	2.5	2.7	3.2	3.7	4.2	4.8	6.1
120	1.2	1.5	1.6	1.7	1.8	2.0	2.2	2.4	2.7	2.9	3.5	4.0	4.6	5.3	6.7

* 25° or 3°/s

** Use the value of 50° for course changes lower than 50°.

Table III-2-1-10. Minimum stabilization distance between flyover waypoints (Non-SI units, 15° bank angle)

Course change* (Degrees)	True airspeed (kt) < or = 130	140	150	160	170	180	190	200	210	220	240	260	280	300	340
50	2.1	2.4	2.8	3.1	3.5	3.9	4.3	4.7	5.2	5.7	6.7	7.8	9.0	10.2	13.0
55	2.3	2.6	3.0	3.4	3.8	4.2	4.6	5.1	5.6	6.1	7.2	8.4	9.7	11.1	14.1
60	2.4	2.8	3.2	3.6	4.0	4.5	5.0	5.5	6.0	6.6	7.8	9.1	10.4	11.9	15.2
65	2.6	3.0	3.4	3.8	4.3	4.8	5.3	5.9	6.4	7.0	8.3	9.7	11.2	12.8	16.3
70	2.8	3.2	3.6	4.1	4.6	5.1	5.7	6.2	6.9	7.5	8.9	10.3	11.9	13.6	17.4
75	2.9	3.4	3.8	4.3	4.8	5.4	6.0	6.6	7.3	7.9	9.4	11.0	12.7	14.5	18.5
80	3.1	3.5	4.0	4.6	5.1	5.7	6.3	7.0	7.7	8.4	9.9	11.6	13.4	15.3	19.5
85	3.2	3.7	4.2	4.8	5.4	6.0	6.6	7.3	8.0	8.8	10.4	12.2	14.1	16.1	20.5
90	3.4	3.9	4.4	5.0	5.6	6.3	6.9	7.7	8.4	9.2	10.9	12.7	14.7	16.8	21.5
95	3.5	4.0	4.6	5.2	5.8	6.5	7.2	8.0	8.8	9.6	11.4	13.3	15.3	17.5	22.4
100	3.6	4.2	4.8	5.4	6.1	6.8	7.5	8.3	9.1	10.0	11.8	13.8	15.9	18.2	23.3
105	3.7	4.3	4.9	5.6	6.3	7.0	7.8	8.6	9.4	10.3	12.2	14.3	16.5	18.9	24.1
110	3.9	4.4	5.1	5.7	6.4	7.2	8.0	8.8	9.7	10.6	12.6	14.7	17.0	19.4	24.8
115	4.0	4.6	5.2	5.9	6.6	7.4	8.2	9.1	10.0	10.9	12.9	15.1	17.4	20.0	25.5
120	4.0	4.7	5.3	6.0	6.8	7.5	8.4	9.3	10.2	11.1	13.2	15.4	17.8	20.4	26.1

* Use the value of 50° for course changes lower than 50°.

Table III-2-1-11. Minimum stabilization distance between flyover waypoints (Non-SI units, 20° bank angle*)

Course change** (Degrees)	True airspeed (kt) < or = 130	140	150	160	170	180	190	200	210	220	240	260	280	300	340
50	1.7	2.0	2.2	2.5	2.8	3.1	3.4	3.8	4.1	4.5	5.3	6.2	7.1	8.1	10.3
55	1.9	2.1	2.4	2.7	3.0	3.3	3.7	4.1	4.4	4.9	5.7	6.6	7.6	8.7	11.1
60	2.0	2.2	2.5	2.9	3.2	3.6	3.9	4.3	4.8	5.2	6.1	7.1	8.2	9.3	11.9
65	2.1	2.4	2.7	3.0	3.4	3.8	4.2	4.6	5.1	5.5	6.5	7.6	8.7	10.0	12.7
70	2.2	2.5	2.9	3.2	3.6	4.0	4.4	4.9	5.4	5.9	6.9	8.1	9.3	10.6	13.5
75	2.3	2.6	3.0	3.4	3.8	4.2	4.7	5.2	5.7	6.2	7.3	8.5	9.8	11.2	14.3
80	2.5	2.8	3.2	3.6	4.0	4.5	4.9	5.4	6.0	6.5	7.7	9.0	10.3	11.8	15.1
85	2.6	2.9	3.3	3.7	4.2	4.7	5.2	5.7	6.2	6.8	8.1	9.4	10.9	12.4	15.8
90	2.7	3.0	3.4	3.9	4.4	4.9	5.4	5.9	6.5	7.1	8.4	9.8	11.3	13.0	16.5
95	2.8	3.1	3.6	4.0	4.5	5.1	5.6	6.2	6.8	7.4	8.8	10.2	11.8	13.5	17.2
100	2.9	3.3	3.7	4.2	4.7	5.2	5.8	6.4	7.0	7.7	9.1	10.6	12.2	14.0	17.8
105	3.0	3.4	3.8	4.3	4.8	5.4	6.0	6.6	7.3	7.9	9.4	10.9	12.6	14.4	18.4
110	3.0	3.4	3.9	4.4	5.0	5.6	6.2	6.8	7.5	8.2	9.7	11.3	13.0	14.9	19.0
115	3.1	3.5	4.0	4.5	5.1	5.7	6.3	7.0	7.7	8.4	9.9	11.6	13.3	15.3	19.5
120	3.2	3.6	4.1	4.6	5.2	5.8	6.4	7.1	7.8	8.5	10.1	11.8	13.6	15.6	19.9

* 20° or 3°/s
** Use the value of 50° for course changes lower than 50°.

Table III-2-1-12. Minimum stabilization distance between flyover waypoints (Non-SI units, 25° bank angle*)

*Course change** (Degrees)*	*True airspeed (kt)* < or = 130	*140*	*150*	*160*	*170*	*180*	*190*	*200*	*210*	*220*	*240*	*260*	*280*	*300*	*340*
50	1.7	1.9	2.1	2.2	2.4	2.6	2.9	3.2	3.5	3.8	4.5	5.2	6.0	6.8	8.6
55	1.9	2.0	2.2	2.4	2.5	2.8	3.1	3.4	3.7	4.1	4.8	5.6	6.4	7.3	9.2
60	2.0	2.2	2.3	2.5	2.7	3.0	3.3	3.6	4.0	4.3	5.1	5.9	6.8	7.8	9.9
65	2.1	2.3	2.5	2.7	2.9	3.2	3.5	3.9	4.2	4.6	5.4	6.3	7.2	8.3	10.5
70	2.2	2.4	2.6	2.8	3.0	3.3	3.7	4.1	4.5	4.9	5.7	6.7	7.7	8.7	11.1
75	2.3	2.5	2.7	3.0	3.2	3.5	3.9	4.3	4.7	5.1	6.0	7.0	8.1	9.2	11.7
80	2.5	2.7	2.9	3.1	3.3	3.7	4.1	4.5	4.9	5.4	6.3	7.4	8.5	9.7	12.3
85	2.6	2.8	3.0	3.2	3.5	3.9	4.3	4.7	5.1	5.6	6.6	7.7	8.9	10.1	12.9
90	2.7	2.9	3.1	3.4	3.6	4.0	4.4	4.9	5.4	5.9	6.9	8.0	9.3	10.6	13.5
95	2.8	3.0	3.2	3.5	3.7	4.2	4.6	5.1	5.6	6.1	7.2	8.4	9.6	11.0	14.0
100	2.9	3.1	3.4	3.6	3.9	4.3	4.8	5.2	5.8	6.3	7.4	8.6	10.0	11.4	14.5
105	3.0	3.2	3.5	3.7	4.0	4.4	4.9	5.4	5.9	6.5	7.7	8.9	10.3	11.7	15.0
110	3.0	3.3	3.6	3.8	4.1	4.5	5.0	5.6	6.1	6.7	7.9	9.2	10.6	12.1	15.4
115	3.1	3.4	3.6	3.9	4.2	4.7	5.2	5.7	6.2	6.8	8.1	9.4	10.8	12.4	15.8
120	3.2	3.4	3.7	4.0	4.3	4.8	5.3	5.8	6.4	7.0	8.2	9.6	11.1	12.6	16.1

* 25° or 3°/s
** Use the value of 50° for course changes lower than 50°.

Table III-2-1-13. Minimum stabilization distance between fly-by waypoints (SI units, 15º bank angle*)

*Course change** (degrees)*	*True airspeed (km/h)* ≤ 130	*150*	*170*	*190*	*210*	*230*	*240*
30	0.29	0.34	0.38	0.44	0.52	0.61	0.65
35	0.33	0.38	0.43	0.49	0.58	0.68	0.73
40	0.36	0.41	0.47	0.54	0.65	0.76	0.82
45	0.39	0.45	0.52	0.60	0.71	0.84	0.90
50	0.43	0.50	0.56	0.65	0.78	0.92	0.99
55	0.47	0.54	0.61	0.71	0.85	1.00	1.08
60	0.51	0.58	0.66	0.77	0.92	1.09	1.18
65	0.55	0.63	0.72	0.83	1.00	1.18	1.28
70	0.59	0.68	0.77	0.90	1.08	1.28	1.38
75	0.64	0.74	0.83	0.97	1.17	1.38	1.50
80	0.69	0.79	0.90	1.05	1.26	1.50	1.62
85	0.74	0.85	0.97	1.13	1.36	1.62	1.75
90	0.80	0.92	1.04	1.22	1.47	1.74	1.89
95	0.86	0.99	1.13	1.32	1.59	1.89	2.05
100	0.93	1.07	1.22	1.42	1.72	2.04	2.22
105	1.01	1.16	1.32	1.54	1.86	2.22	2.40
110	1.09	1.26	1.43	1.67	2.02	2.41	2.62
115	1.19	1.37	1.56	1.82	2.21	2.63	2.85

*Course change** (degrees)*	*True airspeed (km/h)*						
	≤ 130	*150*	*170*	*190*	*210*	*230*	*240*
120	1.30	1.50	1.70	1.99	2.42	2.88	3.13

* 15º or 3º/s
** Use the value 30º for course changes lower than 30º

Table III-2-1-14. Minimum stabilization distance between fly-by waypoints (SI units, 20º bank angle*)

*Course change** (degrees)*	*True airspeed (km/h)*						
	≤ 130	*150*	*170*	*190*	*210*	*230*	*240*
30	0.29	0.34	0.38	0.43	0.47	0.52	0.54
35	0.33	0.38	0.43	0.48	0.53	0.58	0.60
40	0.36	0.41	0.47	0.53	0.58	0.64	0.66
45	0.39	0.45	0.52	0.58	0.64	0.70	0.73
50	0.43	0.50	0.56	0.63	0.69	0.76	0.79
55	0.47	0.54	0.61	0.68	0.75	0.83	0.86
60	0.51	0.58	0.66	0.74	0.82	0.90	0.94
65	0.55	0.63	0.72	0.80	0.88	0.97	1.01
70	0.59	0.68	0.77	0.86	0.96	1.05	1.09
75	0.64	0.74	0.83	0.93	1.03	1.13	1.18
80	0.69	0.79	0.90	1.00	1.11	1.22	1.27
85	0.74	0.85	0.97	1.08	1.20	1.31	1.37
90	0.80	0.92	1.04	1.17	1.29	1.41	1.47
95	0.86	0.99	1.13	1.26	1.39	1.52	1.59
100	0.93	1.07	1.22	1.36	1.50	1.65	1.72
105	1.01	1.16	1.32	1.47	1.63	1.78	1.86
110	1.09	1.26	1.43	1.60	1.77	1.93	2.02
115	1.19	1.37	1.56	1.74	1.92	2.11	2.20
120	1.30	1.50	1.70	1.90	2.10	2.31	2.41

* 20º or 3º/s
** Use the value 30º for course changes lower than 30º

Table III-2-1-15. Minimum stabilization distance between flyover waypoints (SI units, 15º bank angle*)

*Course change*** *(degrees)*	*True airspeed (km/h)*						
	≤ 130	*150*	*170*	*190*	*210*	*230*	*240*
30	1.06	1.22	1.38	1.61	1.93	2.29	2.48
35	1.16	1.34	1.52	1.77	2.13	2.53	2.74
40	1.27	1.47	1.66	1.94	2.34	2.78	3.01
45	1.39	1.60	1.81	2.12	2.56	3.04	3.29
50	1.51	1.74	1.97	2.30	2.78	3.30	3.58
55	1.62	1.87	2.12	2.48	3.00	3.57	3.87
60	1.74	2.01	2.28	2.67	3.23	3.84	4.17
65	1.86	2.15	2.44	2.85	3.45	4.11	4.46
70	1.98	2.29	2.59	3.04	3.68	4.38	4.76
75	2.10	2.43	2.75	3.22	3.90	4.65	5.04
80	2.22	2.56	2.90	3.39	4.11	4.90	5.33
85	2.33	2.69	3.04	3.56	4.32	5.16	5.60
90	2.43	2.81	3.18	3.73	4.52	5.40	5.86
95	2.54	2.93	3.32	3.88	4.71	5.62	6.11
100	2.63	3.04	3.44	4.03	4.89	5.84	6.34
105	2.72	3.14	3.56	4.17	5.06	6.04	6.56
110	2.80	3.23	3.66	4.29	5.21	6.22	6.76
115	2.87	3.32	3.76	4.40	5.35	6.39	6.94
120	2.94	3.39	3.84	4.50	5.47	6.53	7.10

* 15º or 3º/s
** Use the value 30º for course changes lower than 30º

Table III-2-1-16. Minimum stabilization distance between flyover waypoints (SI units, 20º bank angle*)

*Course change** (degrees)*	*True airspeed (km/h)*						
	≤ 130	*150*	*170*	*190*	*210*	*230*	*240*
30	1.06	1.22	1.38	1.56	1.75	1.96	2.06
35	1.16	1.34	1.52	1.71	1.93	2.14	2.26
40	1.27	1.47	1.66	1.87	2.10	2.34	2.46
45	1.39	1.60	1.81	2.04	2.29	2.54	2.67
50	1.51	1.74	1.97	2.21	2.48	2.75	2.89
55	1.62	1.87	2.12	2.39	2.67	2.96	3.11
60	1.74	2.01	2.28	2.56	2.87	3.18	3.33
65	1.86	2.15	2.44	2.74	3.06	3.39	3.55
70	1.98	2.29	2.59	2.91	3.25	3.60	3.78
75	2.10	2.43	2.75	3.09	3.44	3.81	3.99
80	2.22	2.56	2.90	3.25	3.63	4.01	4.20
85	2.33	2.69	3.04	3.42	3.81	4.21	4.41
90	2.43	2.81	3.18	3.57	3.98	4.40	4.61
95	2.54	2.93	3.32	3.72	4.14	4.58	4.79
100	2.63	3.04	3.44	3.86	4.30	4.74	4.97
105	2.72	3.14	3.56	3.99	4.44	4.90	5.13
110	2.80	3.23	3.66	4.11	4.57	5.05	5.28
115	2.87	3.32	3.76	4.22	4.69	5.18	5.42
120	2.94	3.39	3.84	4.31	4.80	5.29	5.54

* 20º or 3º/s
** Use the value 30º for course changes lower than 30º

Table III-2-1-17. Minimum stabilization distance between fly-by waypoints (Non-SI units, 15º bank angle*)

*Course change** (degrees)*	*True airspeed (km/h)*						
	≤ 70	*80*	*90*	*100*	*110*	*120*	*130*
30	0.16	0.18	0.20	0.23	0.27	0.31	0.35
35	0.18	0.20	0.23	0.25	0.30	0.35	0.40
40	0.19	0.22	0.25	0.28	0.33	0.39	0.44
45	0.21	0.24	0.27	0.31	0.36	0.42	0.49
50	0.23	0.26	0.30	0.34	0.40	0.47	0.54
55	0.25	0.29	0.32	0.37	0.43	0.51	0.59
60	0.27	0.31	0.35	0.40	0.47	0.55	0.64
65	0.29	0.34	0.38	0.43	0.51	0.60	0.69
70	0.32	0.36	0.41	0.46	0.55	0.65	0.75
75	0.34	0.39	0.44	0.50	0.60	0.70	0.81

*Course change*** *(degrees)*	*True airspeed (km/h)*						
	≤ 70	*80*	*90*	*100*	*110*	*120*	*130*
80	0.37	0.42	0.48	0.54	0.64	0.76	0.88
85	0.40	0.46	0.51	0.58	0.69	0.82	0.95
90	0.43	0.49	0.55	0.63	0.75	0.88	1.03
95	0.46	0.53	0.60	0.68	0.81	0.95	1.11
100	0.50	0.57	0.64	0.73	0.88	1.03	1.20
105	0.54	0.62	0.70	0.79	0.95	1.12	1.31
110	0.59	0.67	0.76	0.86	1.03	1.22	1.42
115	0.64	0.73	0.82	0.94	1.12	1.33	1.55
120	0.70	0.80	0.90	1.03	1.23	1.46	1.70

* 15º or 3º/s
** Use the value 30º for course changes lower than 30º

Table III-2-1-18. Minimum stabilization distance between fly-by waypoints (Non-SI units, 20º bank angle*)

*Course change*** *(degrees)*	*True airspeed (km/h)*						
	≤ 70	*80*	*90*	*100*	*110*	*120*	*130*
30	0.16	0.18	0.20	0.23	0.25	0.27	0.29
35	0.18	0.20	0.23	0.25	0.28	0.30	0.33
40	0.19	0.22	0.25	0.28	0.30	0.33	0.36
45	0.21	0.24	0.27	0.30	0.33	0.36	0.39
50	0.23	0.26	0.30	0.33	0.36	0.40	0.43
55	0.25	0.29	0.32	0.36	0.40	0.43	0.47
60	0.27	0.31	0.35	0.39	0.43	0.47	0.51
65	0.29	0.34	0.38	0.42	0.46	0.51	0.55
70	0.32	0.36	0.41	0.45	0.50	0.55	0.59
75	0.34	0.39	0.44	0.49	0.54	0.59	0.64
80	0.37	0.42	0.48	0.53	0.58	0.63	0.69
85	0.40	0.46	0.51	0.57	0.63	0.68	0.74
90	0.43	0.49	0.55	0.61	0.68	0.74	0.80
95	0.46	0.53	0.60	0.66	0.73	0.79	0.86
100	0.50	0.57	0.64	0.72	0.79	0.86	0.93
105	0.54	0.62	0.70	0.77	0.85	0.93	1.01
110	0.59	0.67	0.76	0.84	0.93	1.01	1.09
115	0.64	0.73	0.82	0.92	1.01	1.10	1.19
120	0.70	0.80	0.90	1.00	1.10	1.20	1.30

* 20º or 3º/s
** Use the value 30º for course changes lower than 30º

Table III-2-1-19. Minimum stabilization distance between flyover waypoints (Non-SI units, 15º bank angle*)

*Course change** (degrees)*	*True airspeed (km/h)*						
	≤ 70	*80*	*90*	*100*	*110*	*120*	*130*
30	0.57	0.65	0.73	0.83	0.99	1.16	1.35
35	0.63	0.71	0.80	0.91	1.09	1.28	1.49
40	0.69	0.78	0.88	1.00	1.20	1.41	1.64
45	0.75	0.85	0.96	1.09	1.30	1.54	1.79
50	0.81	0.93	1.04	1.18	1.42	1.67	1.95
55	0.87	1.00	1.12	1.28	1.53	1.81	2.10
60	0.94	1.07	1.21	1.37	1.65	1.94	2.27
65	1.00	1.15	1.29	1.47	1.76	2.08	2.43
70	1.07	1.22	1.37	1.56	1.87	2.21	2.58
75	1.13	1.29	1.46	1.65	1.99	2.35	2.74
80	1.19	1.36	1.53	1.74	2.10	2.48	2.89
85	1.25	1.43	1.61	1.83	2.20	2.60	3.04
90	1.31	1.50	1.69	1.92	2.30	2.73	3.18
95	1.37	1.56	1.76	2.00	2.40	2.84	3.32
100	1.42	1.62	1.82	2.07	2.49	2.95	3.45
105	1.46	1.67	1.88	2.14	2.58	3.05	3.56
110	1.51	1.72	1.94	2.21	2.65	3.14	3.67
115	1.55	1.77	1.99	2.26	2.72	3.23	3.77
120	1.58	1.81	2.03	2.31	2.79	3.30	3.86

* 15º or 3º/s
** Use the value 30º for course changes lower than 30º

Table III-2-1-20. Minimum stabilization distance between flyover waypoints (Non-SI units, 20º bank angle*)

*Course change** (degrees)*	*True airspeed (km/h)*						
	≤ 70	*80*	*90*	*100*	*110*	*120*	*130*
30	0.57	0.65	0.73	0.82	0.91	1.01	1.12
35	0.63	0.71	0.80	0.90	1.00	1.11	1.22
40	0.69	0.78	0.88	0.98	1.10	1.21	1.33
45	0.75	0.85	0.96	1.07	1.19	1.32	1.45
50	0.81	0.93	1.04	1.16	1.29	1.43	1.57
55	0.87	1.00	1.12	1.25	1.39	1.54	1.69
60	0.94	1.07	1.21	1.35	1.50	1.65	1.81
65	1.00	1.15	1.29	1.44	1.60	1.76	1.93
70	1.07	1.22	1.37	1.53	1.70	1.87	2.05
75	1.13	1.29	1.46	1.62	1.80	1.98	2.16

*Course change*** *(degrees)*	*True airspeed (km/h)*						
	≤ 70	*80*	*90*	*100*	*110*	*120*	*130*
80	1.19	1.36	1.53	1.71	1.90	2.09	2.28
85	1.25	1.43	1.61	1.79	1.99	2.19	2.39
90	1.31	1.50	1.69	1.88	2.08	2.29	2.50
95	1.37	1.56	1.76	1.95	2.17	2.38	2.60
100	1.42	1.62	1.82	2.03	2.25	2.47	2.69
105	1.46	1.67	1.88	2.10	2.32	2.55	2.78
110	1.51	1.72	1.94	2.16	2.39	2.63	2.86
115	1.55	1.77	1.99	2.21	2.45	2.69	2.94
120	1.58	1.81	2.03	2.26	2.51	2.75	3.00

* 20º or 3º/s
** Use the value 30º for course changes lower than 30º

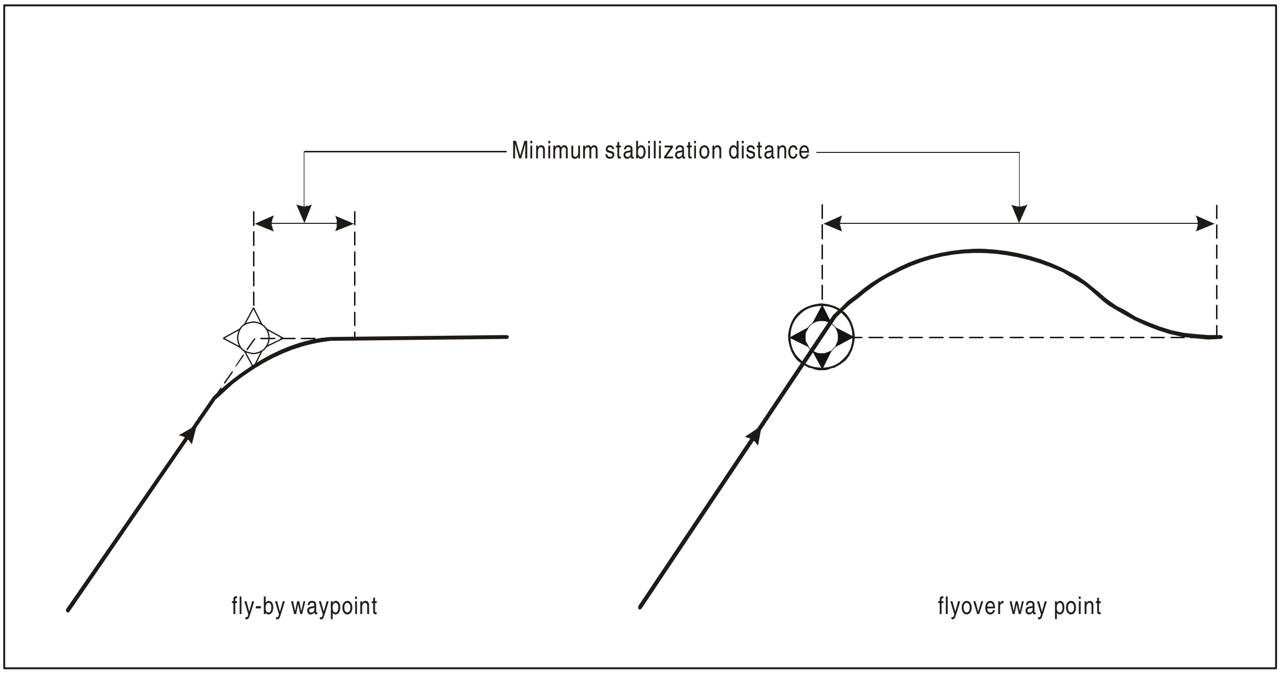


Figure III-2-1-1. Determining the minimum stabilization distance

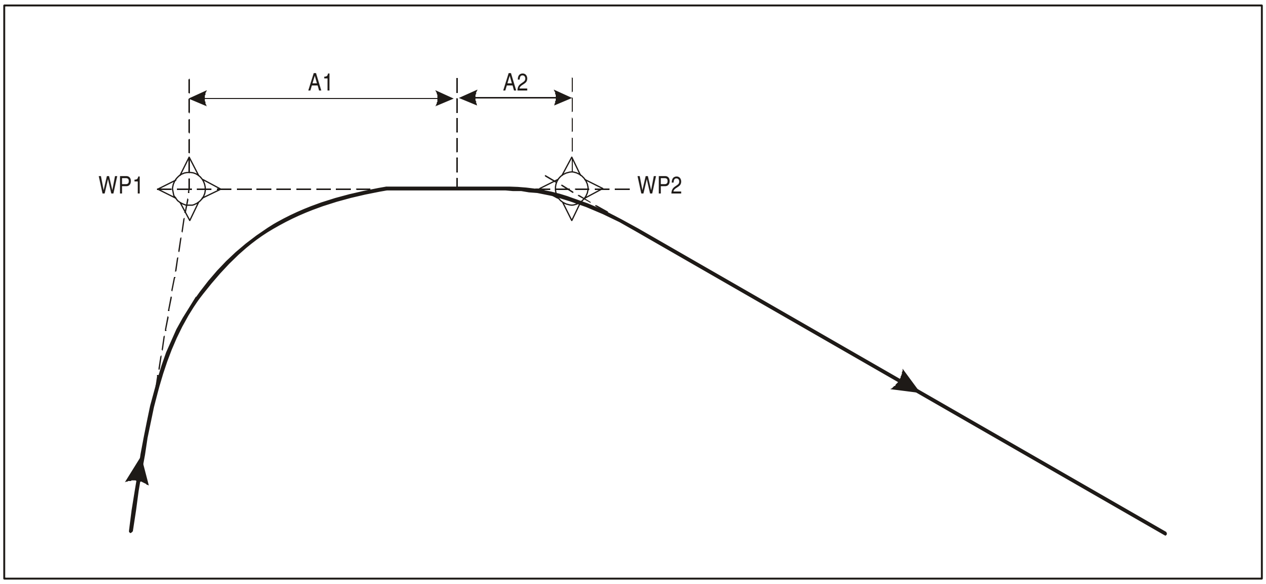


Figure III-2-1-2. Two fly-by waypoints

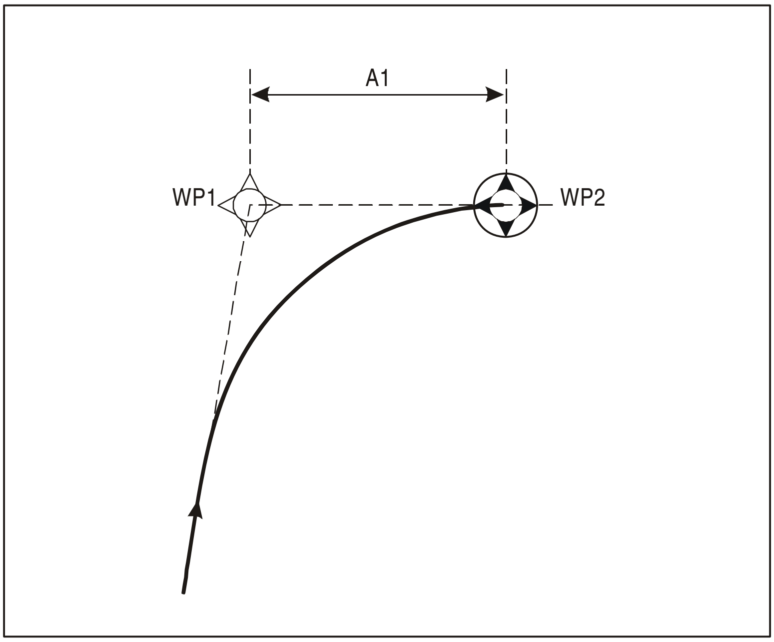


Figure III-2-1-3. Fly-by, then flyover waypoint

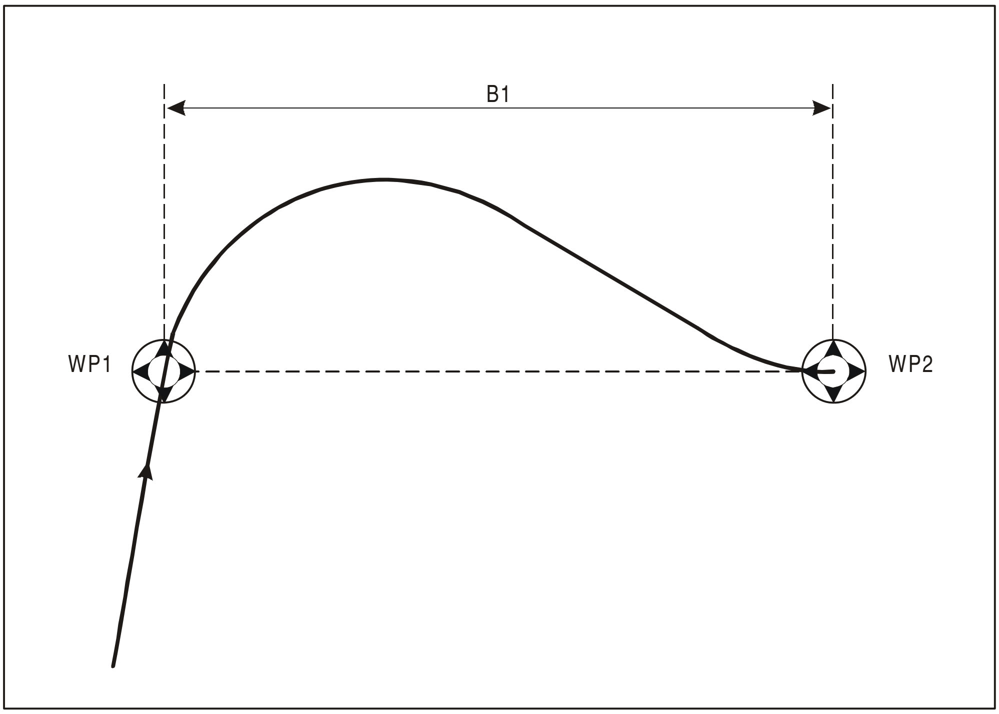


Figure III-2-1-4. Two flyover waypoints

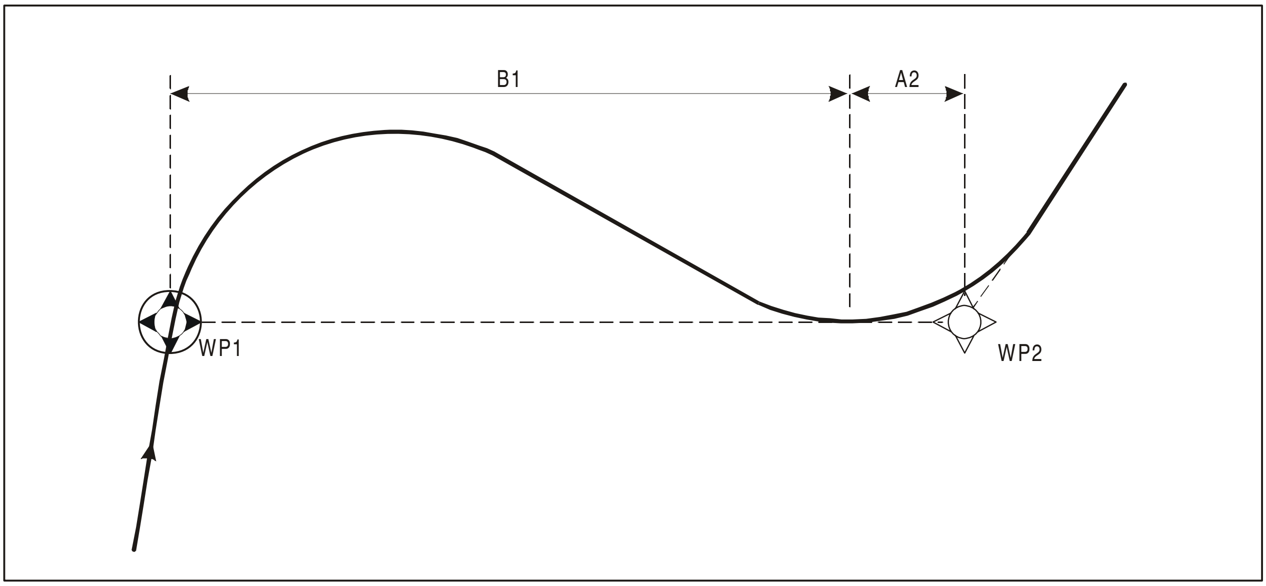


Figure III-2-1-5. Flyover, then fly-by waypoint

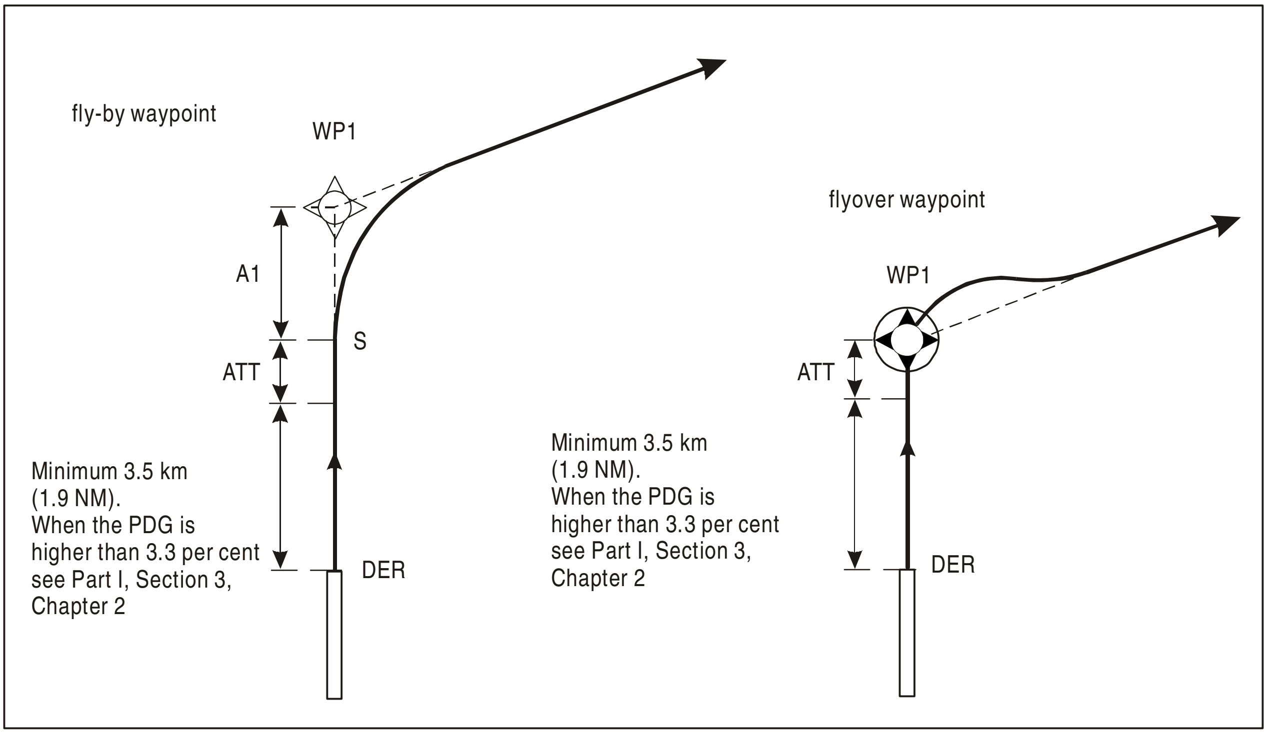


Figure III-2-1-6. Minimum stabilization distance, DER — first waypoint

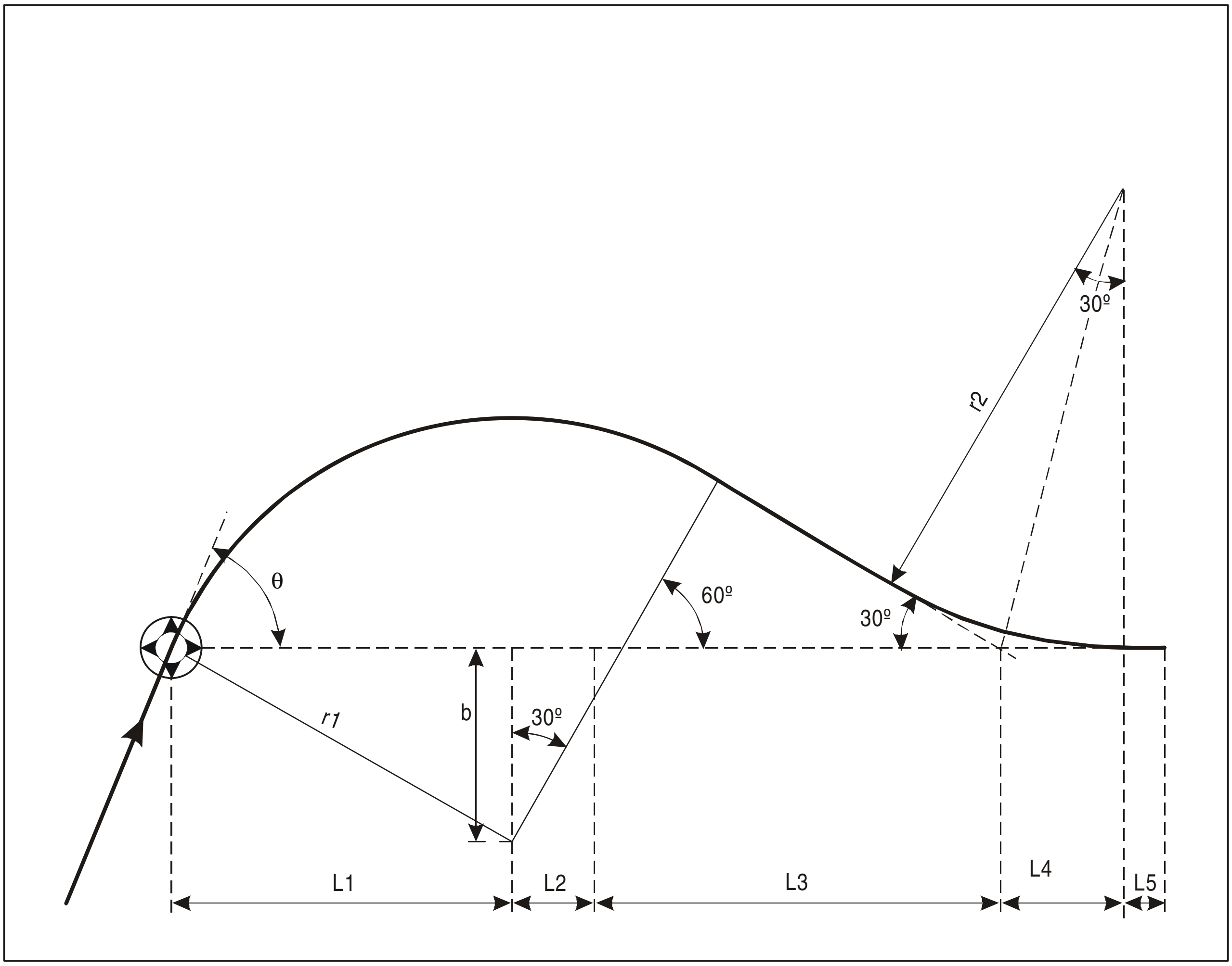


Figure III-2-1-7. Minimum stabilization distance — flyover waypoint

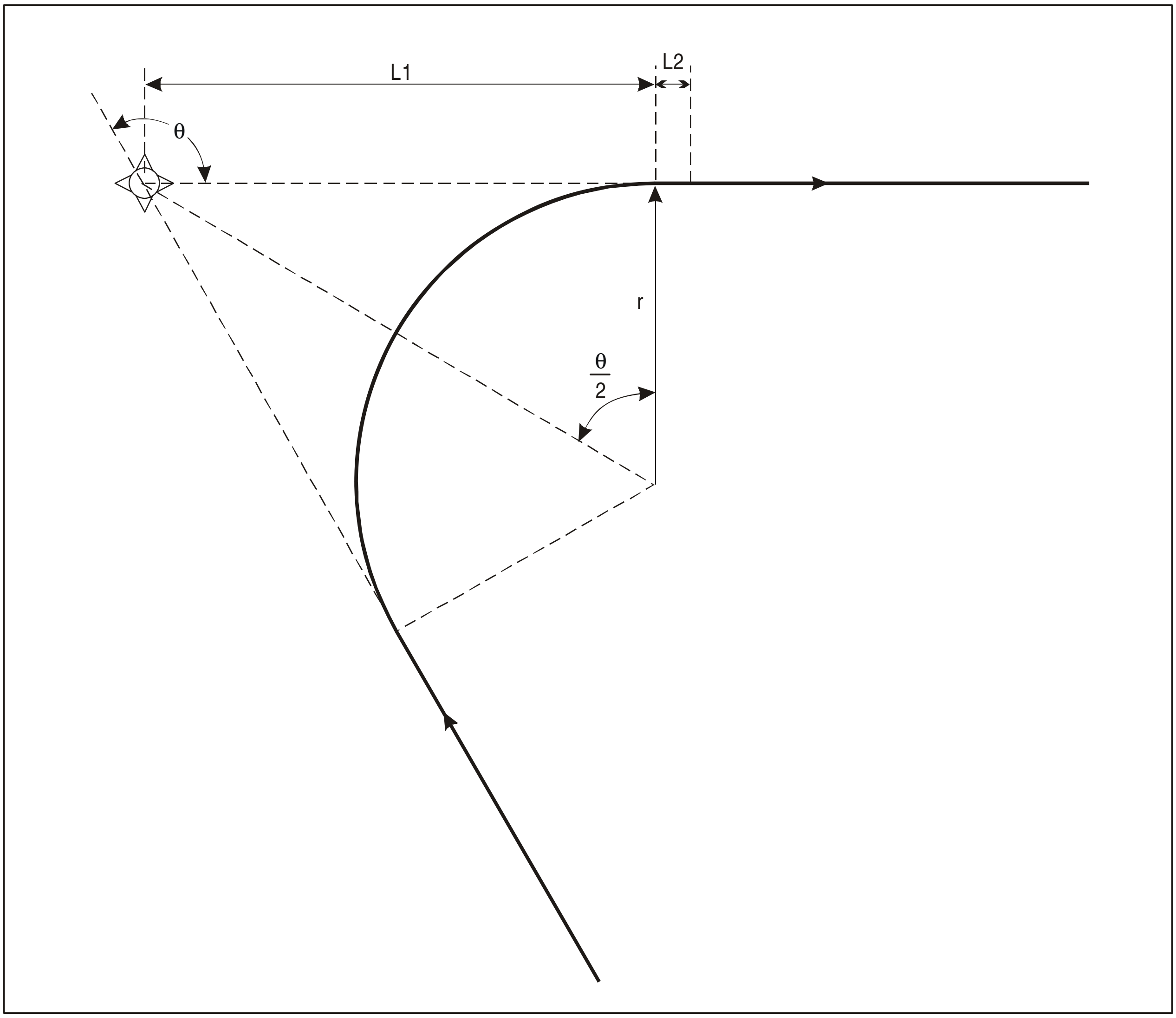


Figure III-2-1-8. Minimum stabilization distance — fly-by waypoint

Chapter 2

TURN PROTECTION AND OBSTACLE ASSESSMENT

(To be developed)

Chapter 3

RNAV T- or Y-BAR PROCEDURE CONSTRUCTION

3.1 GENERAL CONCEPT

3.1.1 *Introduction.* An RNAV non-precision approach procedure or APV incorporating a T- or Y-bar arrangement is based on a runway aligned final segment preceded by an intermediate segment and up to three initial segments arranged either side of and along the final approach track to form a T or a Y (see Figure III-2-3-1 and Figure III-2-3-2).

3.1.2 *Capture region.* A T- or Y-bar arrangement permits direct entry to the procedure from any direction, provided entry is made from within the capture region associated with an IAF. A capture region is defined in terms of an included angle at the IAF (see Figure III-2-3-1 and Figure III-2-3-2).

3.1.3 The lateral initial segments are based on course differences of 70° to 90° from the intermediate segment track. This arrangement ensures that entry from within a capture region requires a change of course at the IAF not greater than 110°.

3.1.4 The central initial segment may commence at the IF.

3.1.5 Where one or both offset IAFs are not provided, a direct entry will not be available from all directions. In such cases a holding pattern may be provided at the IAF to enable entry to the procedure via a procedure turn.

3.1.6 Terminal Arrival Altitudes (TAAs) may be provided to facilitate descent and entry to the procedure. (See Chapter 4.)

3.1.7 The IAF, IF and FAF are defined by fly-by waypoints. The missed approach segment starts with a flyover waypoint (MAPt) and ends at a missed approach holding fix (MAHF). For turning missed approaches a missed approach turning fix (MATF) may also be established to define the turn point.

3.1.8 Area widths are determined in accordance with the tolerances applicable to the navigation system associated with the procedure.

3.2 INITIAL APPROACH SEGMENT

3.2.1 *Alignment.* Offset IAFs are located such that a course change of 70° to 90° is required at the IF. The capture region for tracks inbound to the offset IAF extends 180° about the IAFs, providing a direct entry when the course change at the IF is 70° or more. The central IAF is normally aligned with the intermediate segment. Its capture region is 70° to 90° either side of the initial segment track, the angle being identical to the course change at the IF for the corresponding offset IAF. (See Figure III-2-3-1 and Figure III-2-3-2). For turns greater than 110° at the IAFs, Sector 1 or 2 entries should be used (see Figure III-2-3-3).

3.2.2 *Length.* The initial approach segments have no maximum length. The optimum length is 9.3 km (5.0 NM) (Cat H, 5.5 km (3.0 NM)). The minimum segment length shall be not less than the distance required by the highest initial approach speed (see Tables III-2-3-1 and III-2-3-2) for the fastest category of aircraft for which the approach is designed. This distance is the sum of the minimum stabilization distances required at the IAF and IF and can be derived from Table III-2-1-3 or Table III-2-1-9.

Note.— The optimum length of 9.3 km (5.0 NM) ensures that the minimum segment length for aircraft IAS up to 390° km/h (210 kt) below 3 050 m (10 000 ft) will be accommodated.

3.2.3 *Descent gradient.* The optimum descent gradient is 4% (Cat H, 6.5%). Where a higher gradient is necessary to avoid obstacles, the maximum permissible is 8% (Cat H, 10%). Descent gradient is based on the shortest possible track distance (TRD) for the fastest category of aircraft, and not the segment length.

3.2.4 *Calculation of track distance (TRD).* The TRD between two fly-by waypoints is defined as the segment length reduced by the stabilization distance at both turns (r tan $\theta/2$) and increased by the distance flown in the turn from abeam the waypoint to the tangent point ($2\pi r \times 0.5\theta/360$).

TRD = segment length – $r(\tan \theta_1/2 + \tan \theta_2/2) + \theta\ r\ (\theta_1 + \theta_2)/360$

where:

θ_1 = turn angle (degrees) at the beginning of the segment
θ_2 = turn angle (degrees) at the end of the segment
r = turn radius at 25° bank angle

Example for a first 110° turn and a second 70° turn:

TRD = segment length – 0.56r

3.2.5 *Shortest initial approach segments.* For the offset initial approach segments, the shortest possible track distance will occur when a 110° turn is made at the IAF and a 70° turn is made at the IF for a Y-bar procedure and when a 90° turn is made at either the IAF or the IF for a T-bar procedure. For the central initial approach segment, the shortest possible track distance will occur when a 90° turn is made at the IAF.

3.2.6 *Procedure entry altitude.* The procedure is entered at the 46 km (25 NM) minimum sector altitude or terminal arrival altitude. Where the initial approach waypoint forms part of an air route, the procedure should be entered at the minimum en-route altitude applicable to the route segment.

3.2.7 *Reversal procedures.* When all three initial segment legs are implemented there is no need for reversal procedures. Should one of the legs not be implemented, a racetrack pattern may be established at either or both of the other IAFs. In the event that the central IAF leg is one of the remaining legs, its capture region is adjusted to accommodate normal sector entries into a reversal procedure (see Figure III-2-3-3).

3.2.8 *Holding.* A holding pattern may be provided at any IAF and should be aligned with the initial segment track.

3.3 INTERMEDIATE APPROACH SEGMENT

3.3.1 *Alignment.* The intermediate approach segment should be aligned with the final approach segment whenever possible. If a turn at the FAF is necessary it shall not exceed 30°.

3.3.2 *Length.* The intermediate segment consists of two components — a turning component abeam the IF followed by a straight component immediately before the FAF. The length of the turning component is the minimum stabilization distance for the turn angle at the IF and can be determined from the tables in Chapter 1. The length of the straight component is variable but shall not be less than 3.7 km (2.0 NM) allowing the aircraft to be stabilized prior to the FAF.

3.3.3 *Descent gradient.* The general criteria at Part I, Section 4, Chapter 4, 4.3.3, "Procedure altitude/height and descent gradient" apply. Where a descent is required, the descent gradient shall be calculated for the shortest possible track distance for the fastest category of aircraft, and not the segment length. (For calculation of TRD see 3.2.4).

3.3.4 Where a track change occurs at the FAF, the reduction in track distance may be ignored as the difference is negligible. (Maximum angle of turn is 30°.)

3.4 FINAL APPROACH SEGMENT

3.4.1 *Alignment.* The optimum alignment of the final approach segment is the runway centre line. If this is not possible, the general criteria apply.

3.4.2 *Length.* The optimum length of the final approach segment is 9.3 km (5.0 NM) (Cat H, 3.7 km (2.0 NM)).

3.4.3 *Descent gradient.* The general criteria in Part I, Section 4, Chapter 5, 5.3, "Descent gradient" apply.

3.5 MISSED APPROACH SEGMENT

3.5.1 *Missed approach point.* The missed approach point shall be defined by a fly-over waypoint.

3.5.2 *Location of MAPt.* For a runway-aligned approach, the missed approach point shall be located at or before the threshold. Where the final segment is not aligned with the runway centreline, the optimum location is the intersection of the final approach track and the extended runway centreline. (See Figure III-3-3-1.) In order to provide obstacle clearance in the missed approach area the MAPt may be positioned closer to the FAF but no further than necessary and not beyond the point where the OCH intersects the path of a nominal 5.2 per cent/3° descent gradient to the runway.

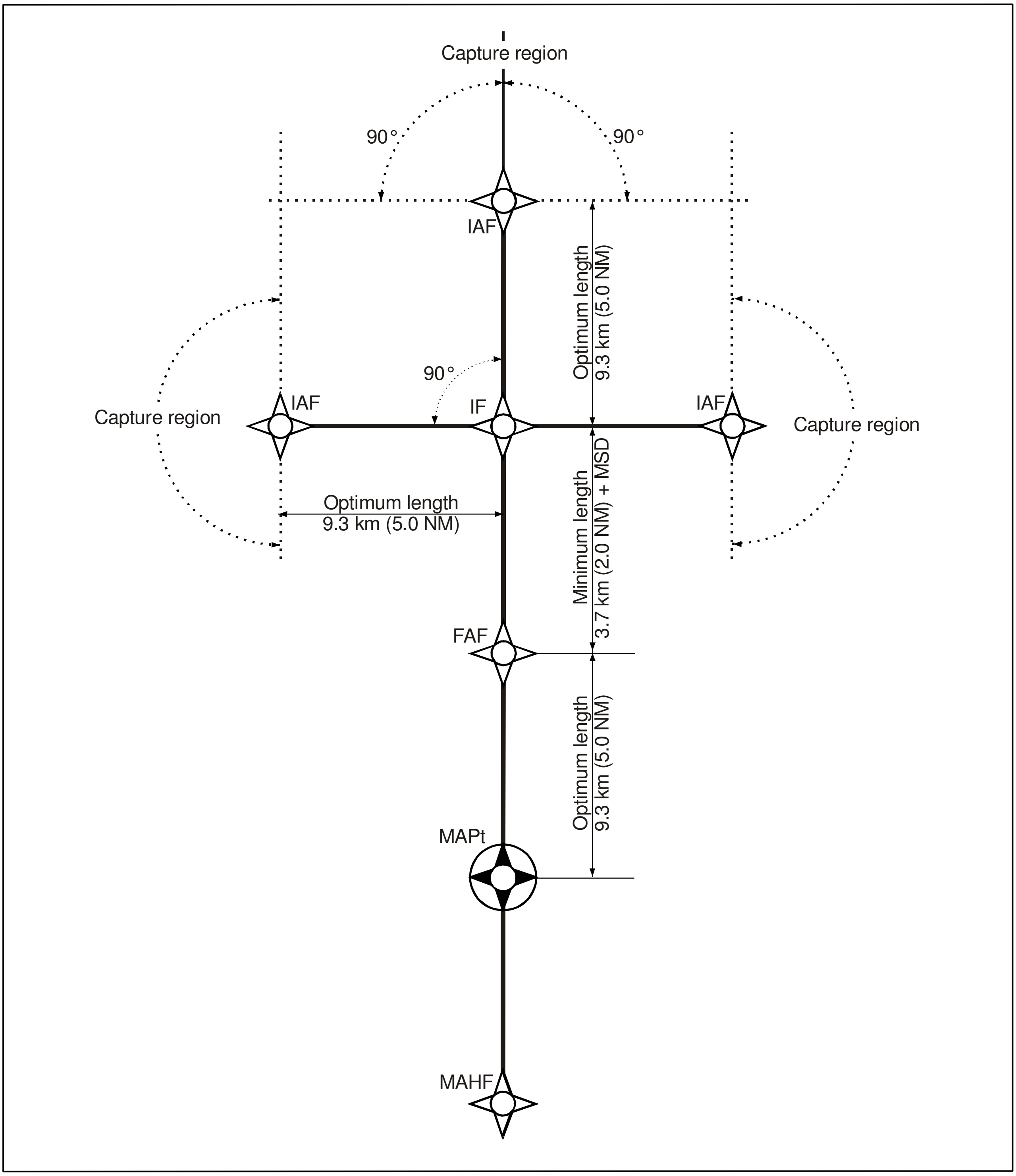


Figure III-2-3-1. T-bar general arrangement

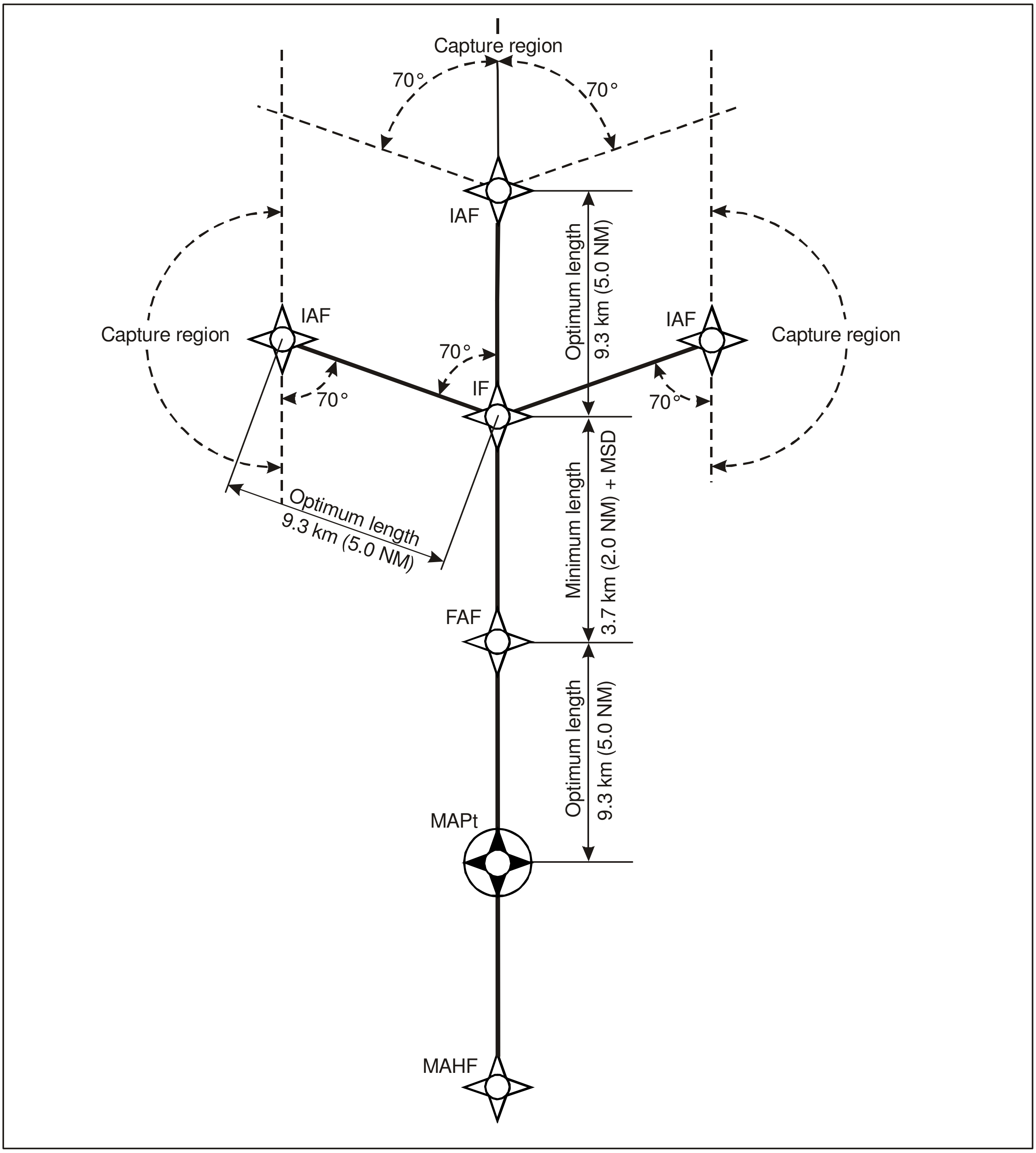


Figure III-2-3-2. Y-bar general arrangement

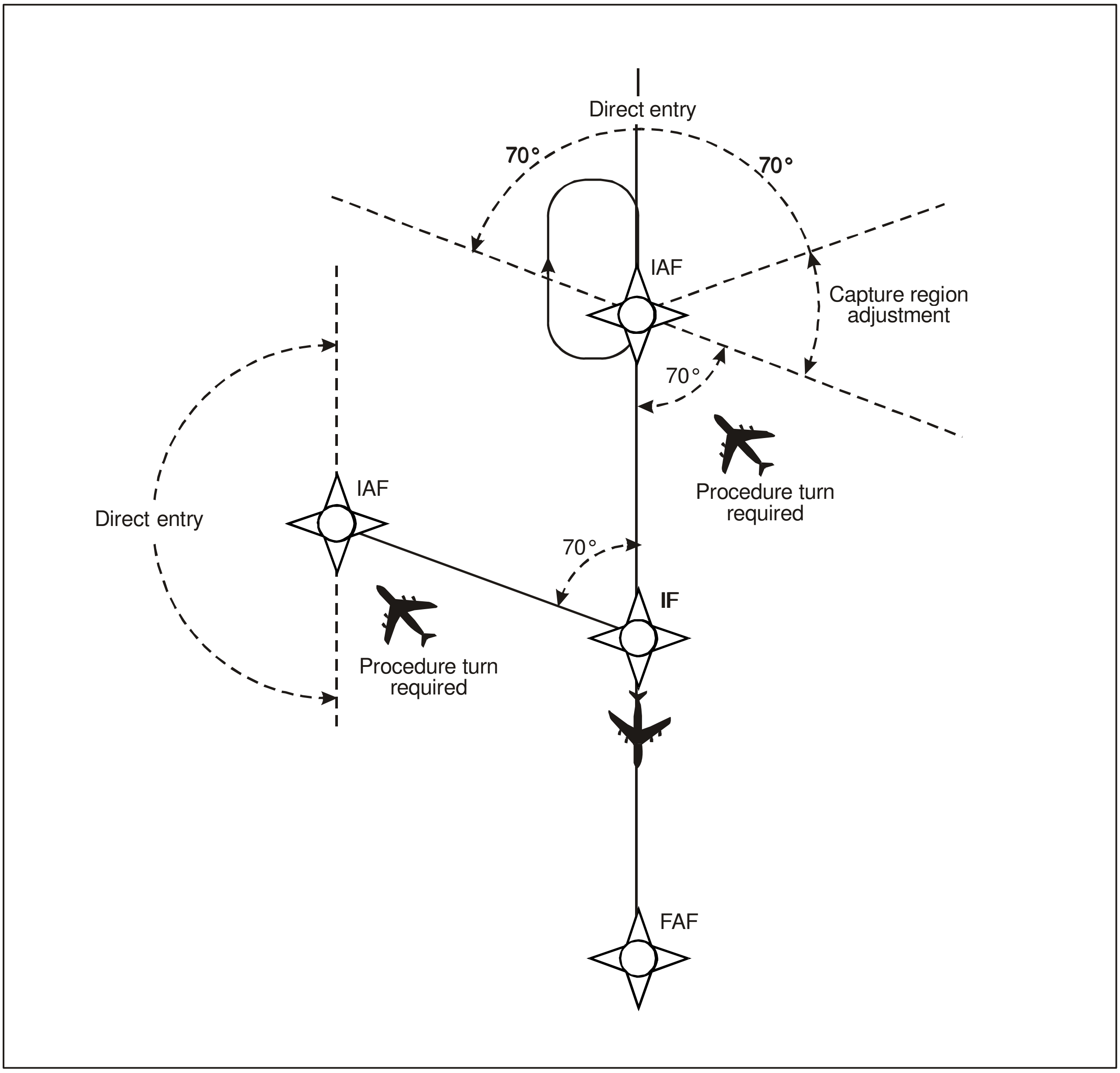


Figure III-2-3-3. Reversal procedures where offset initial not provided

Chapter 4

TERMINAL ARRIVAL ALTITUDE (TAA)

4.1 GENERAL

4.1.1 Terminal Arrival Altitudes (TAAs) are associated with an RNAV procedure based upon the T or Y arrangement described in Chapter 3.

4.1.2 TAAs shall be established for each aerodrome where RNAV instrument approach procedures have been established.

4.1.3 The TAA reference points are the initial approach and/or intermediate fixes.

4.1.4 Each TAA shall be calculated by taking the highest elevation in the area concerned, adding a clearance of at least 300 m (1 000 ft) and rounding the resulting value up to the next higher 50-m or 100-ft increment, as appropriate. If the difference between adjacent TAAs is insignificant (i.e. in the order of 100 m or 300 ft as appropriate) a minimum altitude applicable to all TAAs may be established.

4.1.5 A minimum altitude shall apply within a radius of 46 km (25 NM) of the RNAV waypoints on which the instrument approach is based. The minimum obstacle clearance when flying over mountainous areas should be increased by as much as 300 m (1 000 ft).

4.2 CONSTRUCTION

4.2.1 The standard arrangement consists of three TAAs: straight-in, right and left base.

4.2.2 TAA lateral boundaries are defined by the extension of the left and right base initial segments. The outer area boundaries are determined by arcs of 46 km (25 NM) radius centered on each of the three IAFs or on the two base area IAFs and the IF where the central initial segment is not provided. (See Figure III-2-4-1 and Figure III-2-4-2).

4.3 BUFFER AREA

Each TAA is surrounded by a buffer area of 9 km (5 NM). If obstacles within the buffer area are higher than the highest obstacle within the TAA area, then the minimum altitude shall be calculated by taking the highest elevation in the buffer area, adding a clearance of at least 300 m (1 000 ft) and rounding the resulting value to the nearest 50 m or 100 ft.

4.4 TAA STEP-DOWN ARCS AND SUBSECTORS

4.4.1 To accommodate terrain diversity, operational constraints or excessive descent gradients, an additional circular boundary or "step-down arc" may be defined dividing a terminal arrival altitude (TAA) into two areas with the lower altitude in the inner area. Additionally, the straight-in TAA may be divided into radial subsectors (see Figures III-2-4-3 to III-2-4-5).

4.4.2 Step-down arcs are limited to one per TAA. A step-down arc should be no closer than 19 km (10 NM) from the fix upon which the arc is centred and a minimum of 19 km (10 NM) from the 25 NM TAA boundary, in order to avoid too small a subsector.

4.4.3 The straight-in TAA area may also be divided radially into subsectors. The minimum size of any straight-in TAA subsector that also contains a step-down arc shall be no less than 45 arc degrees. The minimum size of any straight-in TAA subsector that does not contain a step-down arc shall not be less than 30 arc degrees.

4.4.4 Left and right TAA base areas may only have step-down arcs, and shall not be further divided into radial subsectors.

4.4.5 The width of the buffer area between adjacent step-down arcs and adjacent subsectors is 9 km (5 NM).

4.5 PROMULGATION

4.5.1 TAAs shall be depicted on the plan view of approach charts by the use of "icons" which identify the TAA reference point (IAF or IF), the radius from the reference point, and the bearings of the TAA boundaries. The icon for each TAA area will be located and oriented on the plan view with respect to the direction of arrival to the approach procedure, and will show all TAA minimum altitudes and step-downs arcs for that area.

4.5.2 The IAF for each TAA is identified by the waypoint name to help the pilot orient the icon to the approach procedure. The IAF name and the distance of the TAA area boundary from the IAF are included on the outside arc of the TAA area icon. TAA icons also identify where necessary the location of the intermediate fix by the letters "IF" and not the IF waypoint identifier to avoid misidentification of the TAA reference point and to assist in situational awareness. (See Figures III-2-4-3, III-2-4-4, III-2-4-5.)

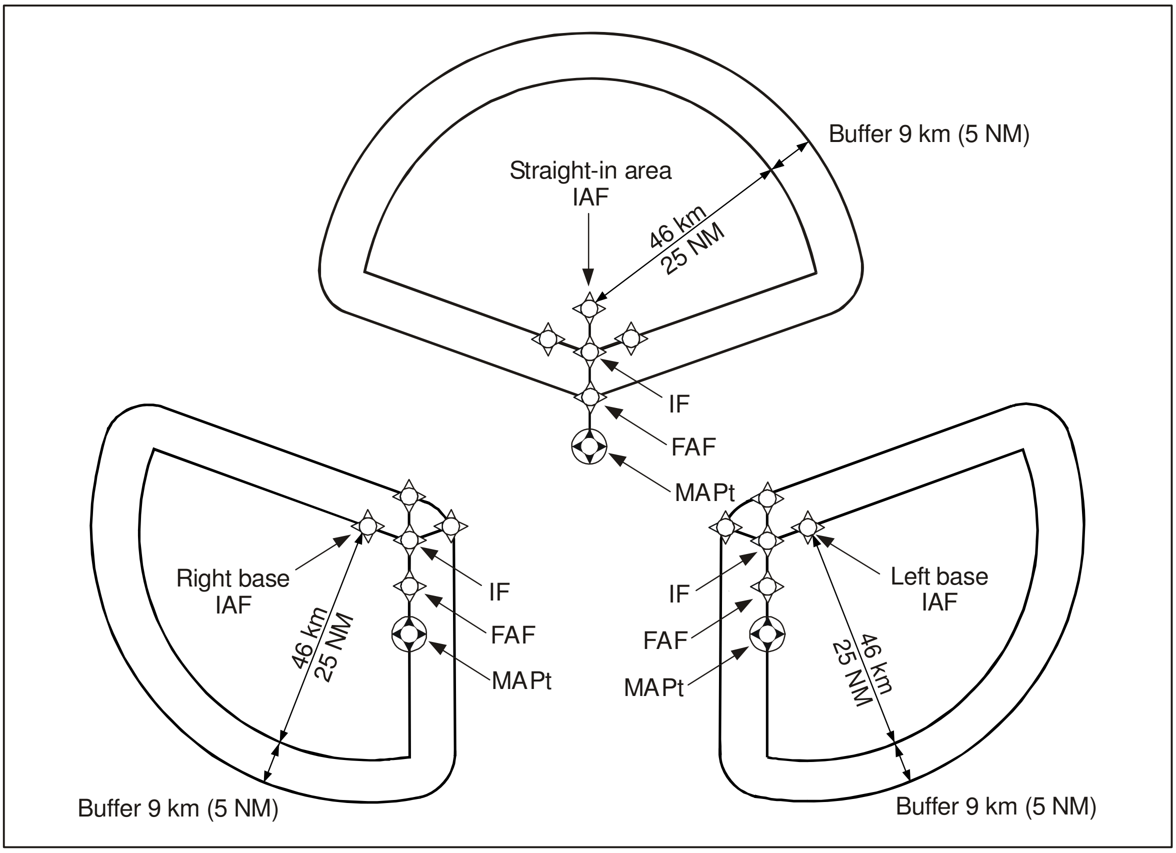


Figure III-2-4-1. TAA Y-bar arrangement