Doc 8168
OPS/611

Procedures for
Air Navigation Services

Aircraft Operations

Volume II
Construction of Visual and
Instrument Flight Procedures

This edition incorporates all amendments
approved by the Council prior to 3 October 2006
and supersedes, on 23 November 2006,
all previous editions of Doc 8168, Volume II.

Fifth edition – 2006

International Civil Aviation Organization

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AMENDMENTS

The issue of amendments is announced regularly in the *ICAO Journal* and in the supplements to the *Catalogue of ICAO Publications and Audio-visual Training Aids*, which holders of this publication should consult. The space below is provided to keep a record of such amendments.

RECORD OF AMENDMENTS AND CORRIGENDA

AMENDMENTS		
No.	Date	Entered by

CORRIGENDA		
No.	Date	Entered by

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FOREWORD

1. INTRODUCTION

1.1 The *Procedures for Air Navigation Services — Aircraft Operations* (PANS-OPS) consists of two volumes as follows:

Volume I — *Flight Procedures*
Volume II — *Construction of Visual and Instrument Flight Procedures*

The division of the PANS-OPS into the two volumes was accomplished in 1979 as a result of an extensive amendment to the obstacle clearance criteria and the construction of approach-to-land procedures (Amendments 13 and 14). Prior to 1979, all PANS-OPS material was contained in a single document. Table A shows the origin of amendments together with a list of the principal subjects involved and the dates on which the PANS-OPS and the amendments were approved by the Council and when they became applicable.

1.2 Volume I — *Flight Procedures* describes operational procedures recommended for the guidance of flight crew and flight operations personnel. It also outlines the various parameters on which the criteria in Volume II are based so as to illustrate the need to adhere strictly to the published procedures in order to achieve and maintain an acceptable level of safety in operations.

1.3 Volume II — *Construction of Visual and Instrument Flight Procedures* is intended for the guidance of procedures specialists and describes the essential areas and obstacle clearance requirements for the achievement of safe, regular instrument flight operations. It provides the basic guidelines to States, and those operators and organizations producing instrument flight charts that will result in uniform practices at all aerodromes where instrument flight procedures are carried out.

1.4 Both volumes present coverage of operational practices that are beyond the scope of Standards and Recommended Practices but with respect to which a measure of international uniformity is desirable.

1.5 The design of procedures in accordance with PANS-OPS criteria assumes normal operations. It is the responsibility of the operator to provide contingency procedures for abnormal and emergency operations.

2. COMMENTARY ON THE MATERIAL CONTAINED IN VOLUME II

2.1 Part I — General

2.1.1 This part contains the general criteria that apply to both conventional as well as RNAV and satellite-based procedures.

2.1.2 Section 1 describes the terminology to assist in the interpretation of terms which are used in the procedures and have a particular technical meaning. In some cases, the terms are defined in other ICAO documents. A list of abbreviations is also provided.

2.1.3 Section 2 provides the general criteria that apply to all phases of flight. In Amendment 12 to the 4th edition, criteria for the procedure identification were included.

2.1.4 Section 3 contains the departure procedures. The specifications concerning instrument departure procedures were first developed by the Obstacle Clearance Panel (OCP) in 1983. The material contained in Volume II was prepared for the use of the procedure design specialists and corresponding material for the use of flight operations personnel including flight crews is contained in Volume I.

2.1.5 In 1990 as a result of the work of an air navigation study group, new material was included concerning specifications, procedures and guidance material relating to the simultaneous operations on parallel or near-parallel runways, including the minimum distances between the runways.

2.1.6 Section 4 contains the general arrival and approach procedures. These procedures were first developed by the Operations Division in 1949 and issued in 1951 and have since been amended a number of times. In 1966, the Obstacle Clearance Panel (OCP) was created to update these procedures for application to all types of aeroplanes taking into account requirements for subsonic multi-jet aeroplanes and technical developments with respect to standard radio navigation aids. As a result of this work, instrument approach procedures criteria were completely revised. The new criteria were incorporated in 1979 in the First Edition of Volume II of PANS-OPS (Amendment 13).

2.2 Part II — Conventional procedures

2.2.1 This part decribes the procedures for conventional navigation that are specific to the sensor.

2.2.2 Section 1 contains the criteria for precision approaches**.** The (ILS) precision approaches are more precise than those formerly used for non-precision approach and are based on a scientifically validated method. This has been achieved by means of:

a) a collection of data on aircraft ILS precision approach performance measured during actual instrument meteorological conditions;

b) the development of a mathematical model reflecting the total ILS system performance and the matching of that model against the data collected under a) above;

c) the use of the model to extrapolate ILS precision approach performance in order to establish obstacle assessment surfaces;

d) the development of a model of the missed approach manoeuvre based on aircraft dynamics and matched against observed data, and the use of this model to extrapolate suitable margins for use in conjunction with the approach surfaces described in c); and

e) the combination of the ILS approach and the missed approach mathematical models into an integrated model covering the whole ILS procedure and able to provide an assessment of the risk of collision with obstacles in stated conditions.

2.2.3 A new concept of obstacle clearance for ILS has been incorporated in the new criteria in that the previously used obstacle clearance limit (OCL) concept has been replaced by the new obstacle clearance altitude/height (OCA/H) concept. Three methods of deriving OCA/H values are included which, in turn, involve progressive increases in the degree of sophistication in the treatment and accountability of obstacles. The first two methods employ the use of surfaces and the third uses a collision risk model (CRM) to derive OCA/H. The CRM is designed for use where an evaluation of the specific risk within the obstacle environment is needed to obtain the lowest obstacle clearance values compatible with the required level of safety. A computer programme has been developed for the CRM and is available for use through ICAO.

2.2.4 The precision approach criteria were expanded to MLS category I, II and III in 1994 and GBAS category I in 2004.

2.2.5 Section 2 contains the non-precision approach criteria. The obstacle clearance criteria for non-precision approaches, as amended by Amendment 13, have not been developed to the same degree of sophistication as the precision approach obstacle clearance criteria because the level of safety generally associated with the higher operating minima of non-precision approach procedures is already considered to be acceptable. The procedures, therefore, continue to be based upon available experience and the judgements of experts. They, however, were amended to provide a high degree of flexibility designed to assist the procedures specialist in obtaining the maximum operational advantage compatible with safety.

2.2.6 Based mainly on the experience gained by some States during trial application of the new criteria and as a result of the ICAO PANS-OPS workshop series held from 1980-1984, the criteria were amended twice (Amendments 1 and 4). The changes fall into three general categories as follows:

— editorial amendments to ease the understanding of the criteria

— simplification of calculations which have proved, in practice, to contain a high error potential

— removal of discrepancies which could have made the document difficult to apply and operationally penalizing.

Amendment 1 also aligned the presentation of units with Annex 5, Fourth Edition.

2.2.7 Section 3 contains the criteria for enroute operations for VOR and NDB. These criteria were added to the PANS-OPS in 1996. In 2004 simplified criteria were added to allow for less time consuming effort in large airspaces.

2.2.8 Section 4 contains the criteria for holding procedures. Holding procedures were first developed by the Operations Division in 1949 and issued in 1951. A major revision of these procedures was accomplished in 1965 as a result of the work of the Holding Procedures Panel (HOP). The material developed by the HOP was subsequently divided in 1979 and that part of the material concerning holding procedures was incorporated in PANS-OPS, Volume I and the material covering the construction of holding procedures incorporated in Volume II.

2.2.9 In 1982 as a result of the work of the Obstacle Clearance Panel (OCP) new material and changes to the old material were introduced concerning VOR/DME holding, use of holding procedures by helicopters, buffer areas and entry procedures. In 1986, changes were introduced concerning the VOR TO/FROM indication error zone, the minimum usable DME distance and holding speeds, particularly above 4 250 m (14 000 ft).

2.3 Part III — RNAV procedures and satellite based procedures

2.3.1 The first RNAV departure procedures were incorporated in PANS-OPS with the introduction of area navigation (RNAV) departure procedures based on VOR/DME in 1993 arising from the Ninth Meeting of the Obstacle Clearance Panel. Departure procedures for DME/DME, basic GNSS followed in 1998, Procedures for RNP and SBAS departure procedures were introduced in 2001 and 2004 respectively.

Arrival and approach procedures

2.3.2 Similar to the departure procedures, Area navigation (RNAV) criteria for instrument approach procedures were introduced for VOR/DME in 1993. Approach procedures for DME/DME, basic GNSS followed in 1998. Procedures for RNP 0.3 were introduced in 2001. As a result of a CFIT safety initiative, Baro-VNAV criteria based on DME/DME or Basic GNSS sensors were included in the document in 2001.

2.3.3 In 2004, GLS Cat I (ILS look alike) criteria based on GBAS receivers were introduced in PANS-OPS. GLS Cat II/III criteria can be expected after the Annex 10 SARPs have been finalized.

2.3.4 The T/Y bar concept was introduced for Basic GNSS in 1998 and made applicable for RNAV approach procedures in general in 2004. To facilitate pilots flying a T/Y bar approach, the Terminal Arrival Altitude (TAA) concept was also included.

Holding procedures

2.3.5 Area navigation (RNAV) criteria for holding procedures were included in 1993 arising from the ninth meeting of the Obstacle Clearance Panel. RNP holding procedures were added in 1998. In the 5th edition of PANS-OPS, as a result of the rewrite of PANS-OPS, the VOR/DME criteria were generalized to include DME/DME and basic GNSS as well.

2.4 PART IV — Helicopters

Part IV contains the criteria applicable for Helicopter Point-in-space procedures based on a Basic GNSS receiver which were introduced in 2004.

3. STATUS

Procedures for Air Navigation Services (PANS) do not have the same status as Standards and Recommended Practices. While the latter are *adopted* by Council in pursuance of Article 37 of the Convention and are subject to the full procedure of Article 90, PANS are *approved* by Council and are recommended to Contracting States for worldwide application.

4. IMPLEMENTATION

The implementation of procedures is the responsibility of Contracting States; they are applied in actual operations only after, and in so far as States have enforced them. However, with a view to facilitating their processing towards implementation by States, they have been prepared in a language which will permit direct use by operations personnel. While uniform application of the basic procedures in this document is very desirable, latitude is permitted for the development of detailed procedures which may be needed to satisfy local conditions.

5. PUBLICATION OF DIFFERENCES

5.1 The PANS do not carry the status afforded to Standards adopted by the Council as Annexes to the Convention and, therefore, do not come within the obligation imposed by Article 38 of the Convention to notify differences in the event of non-implementation.

5.2 However, attention of States is drawn to the provisions of Annex 15 related to the publication in their aeronautical information publications of lists of significant differences between their procedures and the related ICAO procedures.

6. PROMULGATION OF INFORMATION

The establishment and withdrawal of and changes to facilities, services and procedures affecting aircraft operations provided in accordance with the procedures specified in this document should be notified and take effect in accordance with the provisions of Annex 15.

7. UNITS OF MEASUREMENT

Units of measurement are given in accordance with the provisions contained in Annex 5. In those cases where the use of an alternative non-SI unit is permitted, the non-SI unit is shown in brackets immediately following the primary SI unit. In all cases the value of the non-SI unit is considered to be operationally equivalent to the primary SI unit in the context in which it is applied. Unless otherwise indicated, the allowable tolerance (accuracy) is indicated by the number of significant figures given and, in this regard, it is to be understood in this document that all zero digits, either to the right or left of the decimal marker, are significant figures.

Table A. Amendments to the PANS-OPS

Amendment	*Source(s)*	*Subject(s)*	*Approved* *Applicable*
(1st Edition)	Council Action	Previous operations procedures brought together into a single document.	26 June 1961 1 October 1961
1	Internal ICAO action to resolve inconsistencies	Alignment of the definition of "Final approach" and provisions relating to intermediate and final approach procedures.	27 June 1962 1 July 1962
2	AIS/MAP Divisional Meeting (1959)	Minimum sector altitudes.	14 December 1962 1 November 1963
3	Second Meeting of Holding Procedures Panel (1964)	Updating of holding procedures.	5 April 1965 5 May 1966
4	Meteorology and Operational Divisional Meeting (1964)	Addition of meteorological information for flight operations.	7 June 1965 (advisory material)
5 (2nd Edition)	Fourth Air Navigation Conference (1965) and Amendment 8 to Annex 2	ILS Category I procedures, radar approach procedures, introduction of ILS Category II procedures, altimeter setting procedures.	12 December 1966 24 August 1967
6	Fifth Air Navigation Conference (1967), First Meeting of Obstacle Clearance Panel (1968) and Air Navigation Commission	QNH altimeter setting procedures for take-off and landing, new advisory material relating to instrument approach procedures for offset facilities and editorial changes.	23 January 1969 18 September 1969
7	Sixth Air Navigation Conference (1969)	Operating procedures for the use of secondary surveillance radar (SSR) transponders.	15 May 1970 4 February 1971
8 (3rd Edition)	Second Meeting of the Obstacle Clearance Panel (1970)	New profile diagrams and editorial changes.	19 March 1971 6 January 1972
9	Third Meeting of the Obstacle Clearance Panel (1971)	Editorial changes relating to special procedures, areas and obstacle clearances — Precision Aids — ILS with glide path inoperative.	15 November 1972 16 August 1973
10	Council action in pursuance of Assembly Resolutions A17-10 and A18-10	Practices to be followed in the event of unlawful interference.	7 December 1973 23 May 1974
11	Air Navigation Commission study	Practice to be followed in the event of unlawful interference.	12 December 1973 12 August 1976
12	Ninth Air Navigation Conference (1976)	Definitions of flight level and transition altitude, operational use of transponders, advisory material on ground exchange of operational meteorological information.	9 December 1977 10 August 1978

Amendment	*Source(s)*	*Subject(s)*	*Approved Applicable*
13 (Volume II, 1st Edition)	Sixth Meeting of the Obstacle Clearance Panel (1978)	Complete revision of material related to procedure construction and obstacle clearance criteria for instrument approach procedures. Editorial rearrangement of the PANS-OPS into two volumes.	29 June 1979 25 November 1982
1 (Volume II, 2nd Edition)	Seventh Meeting of the Obstacle Clearance Panel (1981)	Modification and clarification of Part III and alignment of presentation of units with Annex 5, Fourth Edition.	8 February 1982 25 November 1982
2	Seventh Meeting of the Obstacle Clearance Panel (1981); Fourth Meeting of the Operations Panel (1981)	Changes to the holding criteria, e.g. introduction of VOR/DME holding criteria and a new holding area construction method in Part IV. Introduction of new Part V for helicopter procedures.	30 March 1983 24 November 1983
3	Seventh Meeting of the Obstacle Clearance Panel (1981)	Introduction of criteria for departure procedures	25 November 1983 22 November 1984
4 (Volume II, 3rd Edition)	Recommendations developed by the Obstacle Clearance Panel through correspondence and at its eighth meeting and by the Communications/ Operations Divisional Meeting (COM/OPS/1985)	Part III. — Introduction of a provision related to earliest location of MAPt; deletion of TP defined by a distance (timing); deletion of d_z min between SOC and TP in precision missed approach; amalgamation of provisions related to the protection of holding and racetrack procedures; refinement of ILS turning missed approach criteria; introduction of MLS interim criteria for ILS-type approaches; editorial amendments. Part IV. — VOR TO/FROM indication error zone; holding speeds; deletion of word "standard" in relation to holding; editorial amendments.	7 May 1986 20 November 1986
5	Obstacle Clearance Panel, Fourth Meeting of the Helicopter Operations (HELIOPS) Panel, Air Navigation Commission	Introduction of a new Chapter 5 related to simultaneous operations on parallel or near-parallel instrument runways; introduction in Part V of a new Chapter 2 — Procedures Specified for Use by Helicopters Only; editorial amendments.	23 March 1990 15 November 1990
6 (Volume II, 4th Edition)	Ninth Meeting of the Obstacle Clearance Panel (1990), Fifth Meeting of the Operations Panel (1989) and Amendment 69 to Annex 10.	Amendment of the definitions of minimum descent altitude/height (MDA/H), obstacle clearance altitude/ height (OCA/H) and minimum sector altitude and inclusion of the definitions of decision altitude/ height (DA/H), area navigation (RNAV) and waypoint. Introduction in Part II of a new Chapter 7 related to area navigation (RNAV) departure procedures based on VOR/DME. Amendment to Part II concerning departure criteria to include secondary areas; clarify the application of the gradient criteria; include the concept of close-in obstacles and deletion of the acceleration segment. Amendment to Part III, Chapter 5 to include a reference to the MLS in the text of the general criteria for the intermediate approach segment. Amendment to Part III, Chapter 7 related to missed approach segment. Amendment to Part III, Chapter 9 related to minimum sector altitudes. Amendment to Part III, Chapter 24 related to the procedures based on tactical vectoring. Introduction in Part III of a new Chapter 31 related to area navigation (RNAV) approach procedures based on VOR/DME. Amendment to Part III, Attachment C related to VOR/DME entry procedures. Amendment to Part III, Attachment K	3 March 1993 11 November 1993

Amendment	*Source(s)*	*Subject(s)*	*Approved* *Applicable*
		concerning the en-route approach interface to update its contents with the RNAV related material. Amendment to Part III, Attachment M related to MLS criteria for ILS-type approaches. Introduction in Part III of a new Attachment N related to visual manoeuvring using a prescribed track. Introduction in Part IV of a new Chapter 2 related to RNAV holding procedures based on VOR/DME. Amendment of the DME fix tolerances to reflect current DME/N accuracy characteristics.	
7	Air Navigation Commission	Simultaneous operations on parallel or near-parallel instrument runways	13 March 1995 9 November 1995
8	Tenth Meeting of the Obstacle Clearance Panel (1994)	Introduction of new definitions and abbreviations in Part I, Chapter 1. Modification of the provisions concerning departure procedures in Part II, Chapter 2, and departure procedures published information in Part II, Chapter 5. Modification of the area navigation (RNAV) departure provisions based on VOR/DME in Part II, Chapter 7. Modification of and new provisions concerning criteria for standard instrument arrivals in Part III, Chapter 3. Modification of the initial approach segments using reversal procedures in Part III, Chapter 4. Modification of the intermediate approach segment in Part III, Chapter 5. Modification of the missed approach segment in Part III, Chapter 7. Modification of the ILS criteria in Part III, Chapter 21. Modification of the localizer only procedure in Part III, Chapter 22. Revision of the radar procedure in Part III, Chapter 24. Modification of the VOR procedures with final approach fix in Part III, Chapter 26. Introduction of new chapters in Part III concerning MLS Categories I, II and III (Chapter 30), azimuth only or MLS with glide path inoperative (Chapter 30A) and MLS Category I with non-standard azimuth alignment (Chapter 30B). Revision of the area navigation approach procedures in Part III, Chapter 31. Modification of the holding procedures in Part IV, Chapter 1. Modification of the area navigation (RNAV) holding procedures based on VOR/DME in Part IV, Chapter 2. Introduction in Part VI of new obstacle clearance criteria for en-route. Revision of the background information on ILS in Attachment A to Part III. Revision of the examples of OAS calculations in Attachment B to Part III. Additions and editorial amendments to protection areas of RNAV holding procedures based on VOR/DME in Attachment C to Part III. Introduction of an example of alternative area navigation (RNAV) holding entries for reduced holding entry areas in Attachment C to Part IV.	4 March 1996 7 November 1996
9	Tenth Meeting of the Obstacle Clearance Panel (1994)	Amendment to Part II, paragraph 7.4 concerning RNAV departure turns based on fly-by waypoints.	12 March 1997 6 November 1997

Amendment	*Source(s)*	*Subject(s)*	*Approved* *Applicable*
10	Eleventh Meeting of the Obstacle Clearance Panel, Amendment 51 to Annex 4 and Amendment 38 to Annex 11	Introduction of new and amended definitions in Part I. Introduction of average flight path in Part II, Chapter 2. Modification of the turning departure parameters in Part II, Chapter 3. Introduction of a new Part II, Chapter 8 on area navigation (RNAV) departure procedures based on DME/DME. Introduction of new Attachment A to Part II on average flight path for departure procedures. Amendments to the standard instrument arrivals in Part III, Chapter 3. Modification of the final approach segment alignment and descent gradients in Part III and introduction of new criteria for steep angle approaches. Introduction of a new Part III, Chapter 32 on area navigation (RNAV) approach procedures based on DME/DME. Introduction of a new Part III, Chapter 33 on area navigation (RNAV) approach procedures for basic GNSS receivers. Inclusion of obstacle clearance area for RNP holdings in Attachment C to Part III. Introduction of RNAV material in Attachment K to Part III. Inclusion of new material related to the calculation of minimum length of segments limited by waypoints in Attachment M to Part III. Introduction of material related to approval of documentation for flight management systems in Attachment O to Part III. Introduction of formulas for the calculation of DME/DME fix tolerances and area widths in Attachment P to Part III. Introduction of material on basic GNSS receiver specifications in Attachment Q to Part III. Introduction of new material on steep angle approaches in Attachment R to Part III. Introduction of a new Part IV, Chapter 3 on RNP holding procedures. Introduction of a new Part VI, Chapter 2 on RNAV/RNP routes. Editorial amendments.	1 May 1998 5 November 1998
11	Amendment 52 to Annex 4, Eleventh Meeting of the Obstacle Clearance Panel, Twelfth Meeting of the Obstacle Clearance Panel	Introduction of new definitions and abbreviations in Part I. Introduction in Parts II and III of required navigation performance (RNP) procedures for departure, arrival and approach procedures, including criteria for fixed radius turns and basic GNSS departure and arrival procedures. Introduction in Part III of material with regard to the portrayal of terrain and minimum flight altitudes, a specification of maximum descent rate for the final approach segment for non-precision approach (NPA) procedures, barometric vertical navigation (baro-VNAV) criteria, and RNAV database path terminator concept. Amendment in Part III of basic GNSS approach procedures and DME/DME procedures to account for reversion. Deletion of Part V, Chapters 1 and 2. Integration of helicopter criteria throughout the document.	29 June 2001 November 2001

Amendment	*Source(s)*	*Subject(s)*	*Approved* *Applicable*
12	Thirteenth meeting of the Obstacle Clearance Panel (OCP/13)	Foreword — introduction of a phrase to amplify the notion that PANS-OPS applies to normal operations; Part I — introduction of new definitions and abbreviations; Part II — introduction of altitude depiction requirements, provisions to procedure identification on charts, improvements in the size of the area width of the obstacle protection area for distance measuring equipment DME/DME and required navigation performance (RNP) procedures, introduction of SBAS procedures; Part III — introduction of altitude depiction requirements, provisions to procedure identification on charts, amendment to the basis of categorization of aircraft, introduction of the procedure altitude concept to address CFIT, the T/Y bar approach layout for RNAV procedures, the TAA concept, amendment to the standard aircraft dimensions for determination of DA/H, improvements in the size of the area width of the obstacle protection area for distance measuring equipment DME/DME and required navigation performance (RNP) procedures, a complete revision of APV/Baro-VNAV criteria, introduction of GBAS Category I criteria, replacement of Attachment I with a PANS-OPS obstacle assessment surface (OAS0 CD-ROM; Part V — introduction of RNAV point-in-space (PinS) approach procedures for helicopters using basic GNSS receivers; Part VI — amendment to en-route criteria to include a simplified method.	27 April 2004 25 November 2004
13 (Volume II, 5th Edition)	Eleventh meeting of the Obstacle Clearance Panel (OCP/11)	Editorial amendment to provide a more logical layout and improve the consistency and clarity of the document in order to: a) facilitate correct implementation; and b) provide a better framework for future development.	2 October 2006 23 November 2006

Procedures for
Air Navigation Services

AIRCRAFT OPERATIONS

Part I

GENERAL

Section 1

DEFINITIONS, ABBREVIATIONS AND UNITS OF MEASUREMENT

Chapter 1

DEFINITIONS

When the following terms are used in this document, they have the following meanings:

Aerodrome elevation. The elevation of the highest point of the landing area.

Along-track tolerance (ATT). A fix tolerance along the nominal track resulting from the airborne and ground equipment tolerances.

Altitude. The vertical distance of a level, a point or an object considered as a point, measured from mean sea level (MSL).

Area minimum altitude (AMA). The lowest altitude to be used under instrument meteorological conditions (IMC) which will provide a minimum vertical clearance of 300 m (1 000 ft) or in designated mountainous terrain 600 m (2 000 ft) above all obstacles located in the area specified, rounded up to the nearest (next higher) 30 m (100 ft).

Note.— In the exact calculation 984 feet can be used as an equivalent to 300 metres.

Area navigation (RNAV). A method of navigation which permits aircraft operation on any desired flight path within the coverage of the station-referenced navigation aids or within the limits of the capability of self-contained aids, or a combination of these.

Base turn. A turn executed by the aircraft during the initial approach between the end of the outbound track and the beginning of the intermediate or final approach track. The tracks are not reciprocal.

Note.— Base turns may be designated as being made either in level flight or while descending, according to the circumstances of each individual procedure.

Change-over point. The point at which an aircraft navigating on an ATS route segment defined by reference to very high frequency omnidirectional radio ranges is expected to transfer its primary navigational reference from the facility behind the aircraft to the next facility ahead of the aircraft.

Note.— Change-over points are established to provide the optimum balance in respect of signal strength and quality between facilities at all levels to be used and to ensure a common source of azimuth guidance for all aircraft operating along the same portion of a route segment.

Circling approach. An extension of an instrument approach procedure which provides for visual circling of the aerodrome prior to landing.

Contour line. A line on a map or chart connecting points of equal elevation.

Cross-track tolerance (XTT). A fix tolerance measured perpendicularly to the nominal track resulting from the airborne and ground equipment tolerances and the flight technical tolerance (FTT).

Datum crossing point (DCP). The DCP is a point on the glide path directly above the LTP or FTP at a height specified by the RDH.

Dead reckoning (DR) navigation. The estimating or determining of position by advancing an earlier known position by the application of direction, time and speed data.

Decision altitude (DA) or decision height (DH). A specified altitude or height in the precision approach or approach with vertical guidance at which a missed approach must be initiated if the required visual reference to continue the approach has not been established.

Note 1.— Decision altitude (DA) is referenced to mean sea level and decision height (DH) is referenced to the threshold elevation.

Note 2.— The required visual reference means that section of the visual aids or of the approach area which should have been in view for sufficient time for the pilot to have made an assessment of the aircraft position and rate of change of position, in relation to the desired flight path. In Category III operations with a decision height the required visual reference is that specified for the particular procedure and operation.

Note 3.— For convenience where both expressions are used they may be written in the form "decision altitude/height" and abbreviated "DA/H".

Dependent parallel approaches. Simultaneous approaches to parallel or near-parallel instrument runways where radar separation minima between aircraft on adjacent extended runway centre lines are prescribed.

Descent fix. A fix established in a precision approach at the FAP to eliminate certain obstacles before the FAP, which would otherwise have to be considered for obstacle clearance purposes.

DME distance. The line of sight distance (slant range) from the source of a DME signal to the receiving antenna.

Elevation. The vertical distance of a point or a level, on or affixed to the surface of the earth, measured from mean sea level.

Fictitious threshold point (FTP). The FTP is a point over which the final approach segment path passes at a relative height specified by the reference datum height. It is defined by the WGS-84 latitude, longitude and ellipsoid height. The FTP replaces the LTP when the final approach course is not aligned with the runway extended centreline or when the threshold is displaced from the actual runway threshold. For non-aligned approaches the FTP lies on the intersection of the perpendicular from the FAS to the runway threshold. The FTP elevation is the same as the actual runway threshold elevation.

Final approach and take-off area (FATO). A defined area over which the final phase of the approach manoeuvre to hover or landing is completed and from which the take-off manoeuvre is commenced. Where the FATO is to be used by performance Class 1 helicopters, the defined area includes the rejected take-off area available.

Final approach segment. That segment of an instrument approach procedure in which alignment and descent for landing are accomplished.

Final approach track. The flight track in the final approach segment that is normally aligned with the runway centreline. For offset final approach segments, the final approach track is aligned with the orientation of the FTP and the FPAP.

Flight level (FL). A surface of constant atmospheric pressure which is related to a specific pressure datum, 1 013.2 hectopascals (hPa), and is separated from other such surfaces by specific pressure intervals.

Note 1.— A pressure type altimeter calibrated in accordance with the Standard Atmosphere:

a) when set to a QNH altimeter setting, will indicate altitude;

b) when set to a QFE altimeter setting, will indicate height above the QFE reference datum;

c) when set to a pressure of 1 013.2 hPa, may be used to indicate flight levels.

Note 2.— The terms "height" and "altitude", used in Note 1 above, indicate altimetric rather than geometric heights and altitudes.

Flight path alignment point (FPAP). The FPAP is a point in the same lateral plane as the LTP or FTP that is used to define the alignment of the final approach segment. For approaches aligned with the runway centreline, the FPAP is located at or beyond the opposite threshold of the runway. The delta length offset from the opposite threshold of the runway defines its location.

GBAS azimuth reference point (GARP). The GARP is defined to be beyond the FPAP along the procedure centreline by a fixed offset of 305 m (1 000 ft). It is used to establish the lateral deviation display limits.

Geoid. The equipotential surface in the gravity field of the Earth, which coincides with the undisturbed mean sea level (MSL) extended continuously through the continents.

Note.— The geoid is irregular in shape because of local gravitational disturbances (wind tides, salinity, current, etc.) and the direction of gravity is perpendicular to the geoid at every point.

Geoid undulation. The distance of the geoid above (positive) or below (negative) the mathematical reference ellipsoid.

Note.— In respect to the World Geodetic System — 1984 (WGS-84) defined ellipsoid, the difference between the WGS-84 ellipsoidal height and orthometric height represents WGS-84 geoid undulation.

Heading. The direction in which the longitudinal axis of an aircraft is pointed, usually expressed in degrees from North (true, magnetic, compass or grid).

Height. The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.

Holding procedure. A predetermined manoeuvre which keeps an aircraft within a specified airspace while awaiting further clearance.

Independent parallel approaches. Simultaneous approaches to parallel or near-parallel instrument runways where radar separation minima between aircraft on adjacent extended runway centre lines are not prescribed.

Independent parallel departures. Simultaneous departures from parallel or near-parallel instrument runways.

Initial approach fix (IAF). A fix that marks the beginning of the initial segment and the end of the arrival segment, if applicable.

Initial approach segment. That segment of an instrument approach procedure between the initial approach fix and the intermediate approach fix or, where applicable, the final approach fix or point.

Instrument approach procedure (IAP). A series of predetermined manoeuvres by reference to flight instruments with specified protection from obstacles from the initial approach fix, or where applicable, from the beginning of a defined arrival route to a point from which a landing can be completed and thereafter, if a landing is not completed, to a position at which holding or en-route obstacle clearance criteria apply. Instrument approach procedures are classified as follows:

Non-precision approach (NPA) procedure. An instrument approach procedure which utilizes lateral guidance but does not utilize vertical guidance.

Approach procedure with vertical guidance (APV). An instrument procedure which utilizes lateral and vertical guidance but does not meet the requirements established for precision approach and landing operations.

Precision approach (PA) procedure. An instrument approach procedure using precision lateral and vertical guidance with minima as determined by the category of operation.

Note.— Lateral and vertical guidance refers to the guidance provided either by:

a) a ground-based navigation aid; or

b) computer generated navigation data.

Intermediate approach segment. That segment of an instrument approach procedure between either the intermediate approach fix and the final approach fix or point, or between the end of a reversal, racetrack or dead reckoning track procedure and the final approach fix or point, as appropriate.

Intermediate fix (IF). A fix that marks the end of an initial segment and the beginning of the intermediate segment.

Landing threshold point (LTP). The LTP is a point over which the glide path passes at a relative height specified by the reference datum height. It is defined by the WGS-84 latitude, longitude and ellipsoid height. The LTP is normally located at the intersection of the runway centreline and threshold.

Level. A generic term relating to the vertical position of an aircraft in flight and meaning variously, height, altitude or flight level.

Minimum descent altitude (MDA) or minimum descent height (MDH). A specified altitude or height in a non-precision approach or circling approach below which descent must not be made without the required visual reference.

Note 1.— Minimum descent altitude (MDA) is referenced to mean sea level and minimum descent height (MDH) is referenced to the aerodrome elevation or to the threshold elevation if that is more than 2 m (7 ft) below the aerodrome elevation. A minimum descent height for a circling approach is referenced to the aerodrome elevation.

Note 2.— The required visual reference means that section of the visual aids or of the approach area which should have been in view for sufficient time for the pilot to have made an assessment of the aircraft position and rate of change of position, in relation to the desired flight path. In the case of a circling approach the required visual reference is the runway environment.

Note 3.— For convenience when both expressions are used they may be written in the form "minimum descent altitude/height" and abbreviated "MDA/H".

Minimum sector altitude (MSA). The lowest altitude which may be used which will provide a minimum clearance of 300 m (1 000 ft) above all objects located in an area contained within a sector of a circle of 46 km (25 NM) radius centred on a radio aid to navigation.

Minimum stabilization distance (MSD). The minimum distance to complete a turn manoeuvre and after which a new manoeuvre can be initiated. The minimum stabilization distance is used to compute the minimum distance between waypoints.

Missed approach holding fix (MAHF). A fix used in RNAV applications that marks the end of the missed approach segment and the centre point for the missed approach holding.

Missed approach point (MAPt). That point in an instrument approach procedure at or before which the prescribed missed approach procedure must be initiated in order to ensure that the minimum obstacle clearance is not infringed.

Missed approach procedure. The procedure to be followed if the approach cannot be continued.

Missed approach turning fix (MATF). A fix different from MAPt that marks a turn in the missed approach segment.

Mountainous area. An area of changing terrain profile where the changes of terrain elevation exceed 900 m (3 000 ft) within a distance of 18.5 km (10.0 NM).

Near-parallel runways. Non-intersecting runways whose extended centre lines have an angle of convergence/divergence of 15 degrees or less.

No transgression zone (NTZ). In the context of independent parallel approaches, a corridor of airspace of defined dimensions located centrally between the two extended runway centre lines, where a penetration by an aircraft requires a controller intervention to manoeuvre any threatened aircraft on the adjacent approach.

Obstacle assessment surface (OAS). A defined surface intended for the purpose of determining those obstacles to be considered in the calculation of obstacle clearance altitude/height for a specific ILS facility and procedure.

Obstacle clearance altitude (OCA) or obstacle clearance height (OCH). The lowest altitude or the lowest height above the elevation of the relevant runway threshold or the aerodrome elevation as applicable, used in establishing compliance with appropriate obstacle clearance criteria.

Note 1.— Obstacle clearance altitude is referenced to mean sea level and obstacle clearance height is referenced to the threshold elevation or in the case of non-precision approaches to the aerodrome elevation or the threshold elevation if that is more than 2 m (7 ft) below the aerodrome elevation. An obstacle clearance height for a circling approach is referenced to the aerodrome elevation.

Note 2.— For convenience when both expressions are used they may be written in the form "obstacle clearance altitude/height" and abbreviated "OCA/H".

Note 3.— See Part I, Section 4, Chapter 5, 5.4 for specific applications of this definition.

Note 4.— See Part IV, Chapter 1 for Area navigation (RNAV) point-in-space (PinS) approach procedures for helicopters using basic GNSS receivers, Part IV, Chapter 1. The general criteria for OCA/H apply (Part I, Section 4, Chapter 5, 5.4) with the addition that the OCH is above the highest terrain/surface within 1.6 km (0.86 NM) of the MAPt.

Obstacle free zone (OFZ). The airspace above the inner approach surface, inner transitional surfaces, and balked landing surface and that portion of the strip bounded by these surfaces, which is not penetrated by any fixed obstacle other than a low-mass and frangibly mounted one required for air navigation purposes.

Point-in-space approach (PinS). The point-in-space approach is based on a basic GNSS non-precision approach procedure designed for helicopters only. It is aligned with a reference point located to permit subsequent flight manoeuvring or approach and landing using visual manoeuvring in adequate visual conditions to see and avoid obstacles.

Point-in-space reference point (PRP). Reference point for the point-in-space approach as identified by the latitude and longitude of the MAPt.

Precision approach procedure. An instrument approach procedure utilizing azimuth and glide path information provided by ILS or PAR.

Primary area. A defined area symmetrically disposed about the nominal flight track in which full obstacle clearance is provided. (See also *Secondary area.*)

Procedure altitude/height. A specified altitude/height flown operationally at or above the minimum altitude/height and established to accommodate a stabilized descent at a prescribed descent gradient/angle in the intermediate/final approach segment.

Procedure turn. A manoeuvre in which a turn is made away from a designated track followed by a turn in the opposite direction to permit the aircraft to intercept and proceed along the reciprocal of the designated track.

Note 1.— Procedure turns are designated "left" or "right" according to the direction of the initial turn.

Note 2.— Procedure turns may be designated as being made either in level flight or while descending, according to the circumstances of each individual procedure.

Racetrack procedure. A procedure designed to enable the aircraft to reduce altitude during the initial approach segment and/or establish the aircraft inbound when the entry into a reversal procedure is not practical.

Reference datum height (RDH). The height of the extended glide path or a nominal vertical path at the runway threshold.

Required navigation performance (RNP). A statement of the navigation performance necessary for operation within a defined airspace.

Note.— Navigation performance and requirements are defined for a particular RNP type and/or application.

Reversal procedure. A procedure designed to enable aircraft to reverse direction during the initial approach segment of an instrument approach procedure. The sequence may include procedure turns or base turns.

Secondary area. A defined area on each side of the primary area located along the nominal flight track in which decreasing obstacle clearance is provided. (See also *Primary area.*)

Segregated parallel operations. Simultaneous operations on parallel or near-parallel instrument runways in which one runway is used exclusively for approaches and the other runway is used exclusively for departures.

Significant obstacle. Any natural terrain feature or man-made fixed object, permanent or temporary, which has vertical significance in relation to adjacent and surrounding features and which is considered a potential hazard to the safe passage of aircraft in the type of operation for which the individual procedure is designed.

Note.— The term "significant obstacle" is used in this document solely for the purpose of specifying the objects considered in calculations of relevant elements of the procedure and intended to be presented on an appropriate chart series.

Standard instrument arrival (STAR). A designated instrument flight rule (IFR) arrival route linking a significant point, normally on an ATS route, with a point from which a published instrument approach procedure can be commenced.

Standard instrument departure (SID). A designated instrument flight rule (IFR) departure route linking the aerodrome or a specified runway of the aerodrome with a specified significant point, normally on a designated ATS route, at which the en-route phase of a flight commences.

Station declination. The angle between the 360°R of the VOR and true north.

Terminal arrival altitude (TAA). The lowest altitude that will provide a minimum clearance of 300 m (1 000 ft) above all objects located in an arc of a circle defined by a 46 km (25 NM) radius centred on the initial approach fix (IAF), or where there is no IAF on the intermediate approach fix (IF), delimited by straight lines joining the extremity of the arc to the IF. The combined TAAs associated with an approach procedure shall account for an area of 360 degrees around the IF.

Threshold (THR). The beginning of that portion of the runway usable for landing.

Track. The projection on the earth's surface of the path of an aircraft, the direction of which path at any point is usually expressed in degrees from North (true, magnetic or grid).

Vertical path angle (VPA). Angle of the published final approach descent in Baro-VNAV procedures.

Visual manoeuvring (circling) area. The area in which obstacle clearance should be taken into consideration for aircraft carrying out a circling approach.

Waypoint. A specified geographical location used to define an area navigation route or the flight path of an aircraft employing area navigation. Waypoints are identified as either:

Fly-by waypoint. A waypoint which requires turn anticipation to allow tangential interception of the next segment of a route or procedure, or

Flyover waypoint. A waypoint at which a turn is initiated in order to join the next segment of a route or procedure.

Chapter 2

ABBREVIATIONS

(used in this document)

AMA	Area minimum altitude
ANP	Actual navigation performance
AOB	Angle of bank
ARP	Aerodrome reference point
APV	Approach procedures with vertical guidance
ATC	Air traffic control
ATS	Air traffic services
ATT	Along-track tolerance
AZM	Azimuth
CAT	Category
C/L	Centre line
CDI	Course deviation indicator
COP	Change-over point
CRM	Collision risk model
DA/H	Decision altitude/height
DCP	Datum crossing point
DER	Departure end of the runway
DF	Direction finding
DME	Distance measuring equipment
DR	Dead reckoning
EDA	Elevation differential area
EUROCAE	European Organization for Civil Aviation Equipment
FAF	Final approach fix
FAP	Final approach point
FATO	Final approach and take-off area
FMC	Flight management computer
FMS	Flight management system
FPAP	Flight path alignment point
FTP	Fictitious threshold point
FTT	Flight technical tolerance
FL	Flight level
GARP	GBAS azimuth reference point
GBAS	Ground-based augmentation system
GP	Glide path
GNSS	Global navigation satellite system
GPWS	Ground proximity warning system
HL	Height loss
IAC	Instrument Approach Chart
IAF	Initial approach fix
IAP	Instrument approach procedure
IAS	Indicated airspeed

IF	Intermediate approach fix
IFR	Instrument flight rules
ILS	Instrument landing system
IMAL	Integrity monitor alarm
IMC	Instrument meteorological conditions
ISA	International standard atmosphere
KIAS	Knots indicated airspeed
LDAH	Landing distance available — helicopters
LLZ	Localizer
LORAN	Long range air navigation system
LTP	Landing threshold point
MAHF	Missed approach holding fix
MAPt	Missed approach point
MATF	Missed approach turning fix
MDA/H	Minimum descent altitude/height
MLS	Microwave landing system
MM	Middle marker
MOC	Minimum obstacle clearance
MSA	Minimum sector altitude
MSD	Minimum stabilization distance
MSL	Mean sea level
NDB	Non-directional beacon
NTZ	No transgression zone
OAS	Obstacle assessment surface
OCA/H	Obstacle clearance altitude/height
OCA/H_{fm}	OCA/H for the final approach and straight missed approach
OCA/H_{ps}	OCA/H for the precision segment
OCS	Obstacle clearance surface
OFZ	Obstacle free zone
OIS	Obstacle identification surface
OM	Outer marker
PA	Precision approach
PAPI	Precision approach path indicator
PAR	Precision approach radar
PDG	Procedure design gradient
PinS	Point-in-space approach
PRP	Point-in-space reference point
R	Rate of turn
RAIM	Receiver autonomous integrity monitoring
RASS	Remote altimeter setting source
RDH	Reference datum height (for APV and PA)
RNAV	Area navigation
RNP	Required navigation performance
RSR	En-route surveillance radar
RSS	Root sum square
SBAS	Satellite-based augmentation system
SD	Standard deviation
SI	International system of units
SID	Standard instrument departure
SOC	Start of climb
SST	Supersonic transport
ST	System computation tolerance
STAR	Standard instrument arrival

TAA	Terminal arrival altitude
TNA/H	Turn altitude/height
TAR	Terminal area surveillance radar
TAS	True airspeed
THR	Threshold
TMA	Terminal control area
TP	Turning point
TTT	Template tracing technique
VASIS	Visual approach slope indicator system
VDF	Very high frequency direction-finding station
VHF	Very high frequency
VOR	Very high frequency omnidirectional radio range
VPA	Vertical path angle
WGS	World geodetic system
XTT	Cross-track tolerance

Chapter 3

UNITS OF MEASUREMENT

3.1 Units of measurement are expressed to conform with Annex 5. The conversion of the non-SI value to the SI value has been accomplished by the use of the appropriate conversion factor listed in Annex 5 and by rounding normally to the nearest integer in SI-units.

3.2 Where a critical parameter is involved, rounding is done to obtain an accuracy of the same order. Where a parameter directly affects the flight crew in its control of the aircraft, rounding is normally to the nearest multiple of five. In addition, slope gradients are expressed in percentages. For slope gradients in other units, see *Instrument Flight Procedures Construction Manual* (Doc 9368).

3.3 The units of measurement for precision approach are stated in metres only. If these basic dimensions are converted to feet and rounded according to the normal ICAO practice before they are scaled to obtain OAS boundaries and heights, then significant anomalies will arise.

3.4 To prevent such anomalies, there are two alternatives. Either the boundaries and heights must be calculated in metres, converted to feet (× 3.2808) and then rounded up/down as necessary, or all tabulated dimensions must be multiplied by 3.2808, after which all subsequent calculations are in feet.

3.5 Calculations of area dimensions not related to ILS or MLS should be rounded up to 0.01 km (0.01 NM). Dimensions of areas related to ILS or MLS should be calculated and then rounded up to 1.0 m (1.0 ft).

Section 2

GENERAL PRINCIPLES

Chapter 1

GENERAL

1.1 INTRODUCTION

1.1.1 The specifications in this part have been formulated with a view to achieving a reasonable degree of standardization although the improbability of being able to achieve worldwide uniformity of procedure, areas and obstacle clearance for any single type of facility is fully recognized. It is intended therefore that States should take into account their local conditions, in relation to these criteria, when establishing procedures, areas and obstacle clearances.

1.1.2 Only one procedure should be specified for each type of radio aid in relation to a particular runway. Exceptions to this should be permitted only after joint consideration by the State authorities and the operators concerned. The attention of States is particularly drawn, therefore, to the general and basic criteria on which the specifications have been based and the manner in which these criteria should be applied.

1.1.3 Obstacle clearance is the primary safety consideration in developing instrument approach procedures, and because of variable factors such as terrain, aircraft characteristics and pilot ability, the detailed procedures set out in this part are based on present standard equipment and practices. However, the obstacle clearance included in the specifications are considered to be the minimum: they have been evolved taking into consideration the COM and AGA specifications and it is considered that they cannot be reduced with safety.

1.1.4 In the interest of efficiency, regularity and economy, every effort should be made to ensure that equipment is sited and procedures are evolved so as to keep to the minimum consistent with safety, both the time taken in executing an instrument approach and the airspace necessary for the associated manoeuvres.

1.2 AREAS

1.2.1 Each segment has an associated area. Normally the area is symmetrical on both sides of the intended track. In principle, this area is subdivided into primary and secondary areas. However, in some cases, only primary areas are permitted. When secondary areas are permitted, the outer half of each side of the area (normally 25 per cent of the total width) is designated as secondary area. See Figure I-2-1-1.

1.2.2 *Calculating secondary area width at a given point.* The width of the secondary areas at any point (p) between two fixes may be obtained by linear interpolation from the widths at these fixes according to the equation below (see Figure I-2-1-2):

$$W_{sp} = W_{s1} + D_p/L\ (W_{s2} - W_{s1})$$

where: W_{s1} = width of secondary area at first fix

W_{s2} = width of secondary area at second fix

W_{sp} = width of secondary area at point p

D_p = distance of point p from first fix, measured along the nominal track

L = distance between the two fixes, measured along the nominal track

1.3 OBSTACLE CLEARANCE

Full obstacle clearance is provided throughout the entire area unless secondary areas are identified. In this case full obstacle clearance is provided in the primary area and in the secondary area the obstacle clearance is reduced linearly from the full clearance at the inner edge to zero at the outer edge. See Figure I-2-1-1.

The MOC in the secondary areas may be obtained by a linear interpolation from the full MOC at the outer edge of the primary area to zero, according to the equation below (see Figure I-2-1-3):

$$MOC_{sy} = MOC_p*(1 - Y/W_s)$$

where: MOC_p = MOC in primary area

MOC_{sy} = MOC in secondary area for obstacle at distance Y from outer edge of primary area

W_s = Width of secondary area

Y = Distance of obstacle from the edge of the primary area, measured perpendicularly to the nominal track

1.4 EXAMPLE CALCULATIONS

All example calculations in this document are based on an altitude of 600 m (2 000 ft) above mean sea level (MSL) and a temperature of ISA + 15°C unless otherwise stated. For speed conversion the factors in the Appendix to Chapter 1 are used.

1.5 BEARINGS, TRACKS AND RADIALS

In planning procedures, degrees true shall be used. However, all published procedures shall be in degrees magnetic in accordance with Annex 4. Radials shall also be expressed in degrees magnetic, and shall further be identified as radials by prefixing the letter "R" to the magnetic bearing from the facility, for example, R-027 or R-310. The published radial shall be that radial which defines the desired flight track. In areas of magnetic unreliability (i.e. in the vicinity of the earth's magnetic poles) procedures may be established in degrees true.

1.6 NAVIGATION SYSTEM USE ACCURACY

1.6.1 The system accuracies used in the development of obstacle clearance criteria are based on minimum system performance factors. Where it can be shown that one or more of the parameters affecting these values are confidently maintained better than the minimum, smaller accuracy values may be used. The accuracy values result from the root sum square (RSS) of the system tolerances.

1.6.2 When a navigation aid is used to provide track guidance, the tolerance of the intersection fix is based on 2 sigma confidence limits (95 per cent) while the splay of the instrument approach/missed approach procedure areas is based on 3 sigma confidence limits (99.7 per cent). For VOR/NDB tolerances, see Chapter 2, Table I-2-2-1 and Figures I-2-2-9 and I-2-2-11.

1.7 INCREASED ALTITUDES/HEIGHTS FOR MOUNTAINOUS AREAS

1.7.1 When procedures are designed for use in mountainous areas, consideration must be given to induced altimeter error and pilot control problems which result when winds of 37 km/h (20 kt) or more move over such areas. Where these conditions are known to exist, MOC should be increased by as much as 100 per cent.

1.7.2 Procedures specialists and approving authorities should be aware of the hazards involved and make proper addition, based on their experience and judgement, to limit the time in which an aircraft is exposed to lee-side turbulence and other weather phenomena associated with mountainous areas. This may be done by increasing the minimum altitude/height over the intermediate and final approach fixes so as to preclude prolonged flight at a low height above the ground. The operator's comments should also be solicited to obtain the best local information. Such increases should be included in the State's Aeronautical Information Publication (AIP), Section GEN 3.3.5, "Minimum flight altitude". See Annex 15, Appendix 1 (Contents of Aeronautical Information Publication).

1.8 CHARTING ACCURACY

1.8.1 Charting tolerance should be added to the height and location of the controlling terrain feature or obstacle when instrument approach procedures are developed. Vertical tolerance is added to the depicted height or elevation of the object. Horizontal tolerance is added to the perimeter of the controlling terrain feature or obstacle.

1.8.2 When the application of these tolerances creates an unacceptable operational penalty, additional survey information should be used to refine the obstacle location and height data.

1.9 PRESENTATION OF SIGNIFICANT OBSTACLES AND SPOT ELEVATIONS ON CHARTS

To avoid the overloading of charts with information that may potentially obscure important navigation information, careful consideration must be given by the procedures specialists when providing the following information to the cartographers:

a) significant obstacles considered in the calculations of the relevant segments of the procedure; and

b) appropriate spot elevations required to improve the situational awareness of the underlying terrain.

Note.— Specifications for portraying relief and significant obstacles on the Instrument Approach Chart — ICAO *are set forth in Annex 4, Chapter 11.*

1.10 PROMULGATION

1.10.1 In planning procedures, degrees true shall be used. However, all published procedures shall be in degrees magnetic in accordance with Annex 4. Radials shall also be expressed in degrees magnetic, and shall further be identified as radials by prefixing the letter "R" to the magnetic bearing from the facility, for example, R-027 or R-310. The published radial shall be that radial which defines the desired flight track. In areas of magnetic unreliability (i.e. in the vicinity of the earth's magnetic poles) procedures may be established in degrees true.

1.10.2 Category H procedures shall not be promulgated on the same instrument approach chart (IAC) as joint helicopter/aeroplane procedures.

1.10.3 Where different values are used they should be promulgated. However, for DME the values in Chapter 2, 2.4.4, "DME" should always be used.

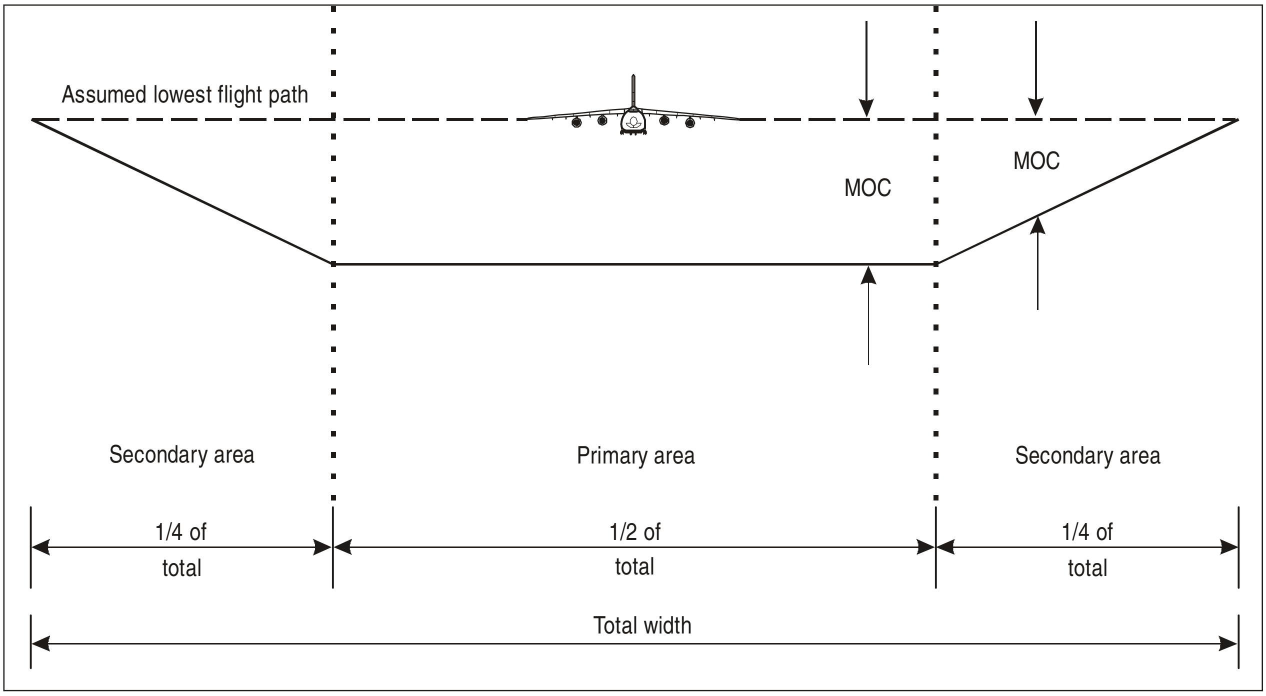

Figure I-2-1-1. Cross-section of straight segment area showing primary and secondary areas

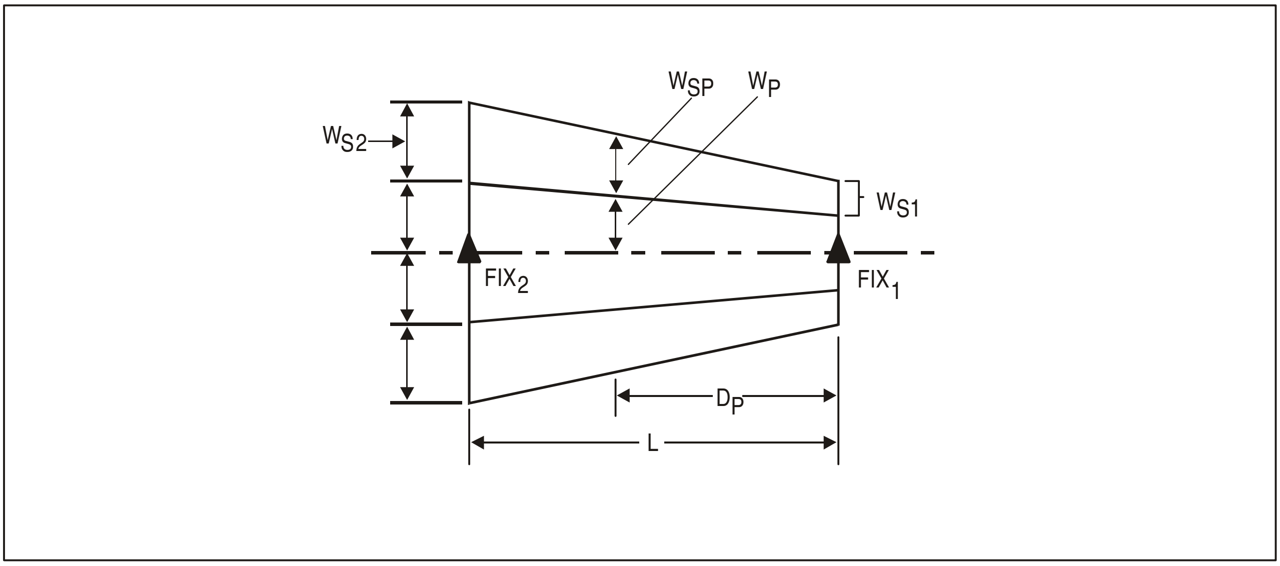

Figure I-2-1-2. Width of secondary area

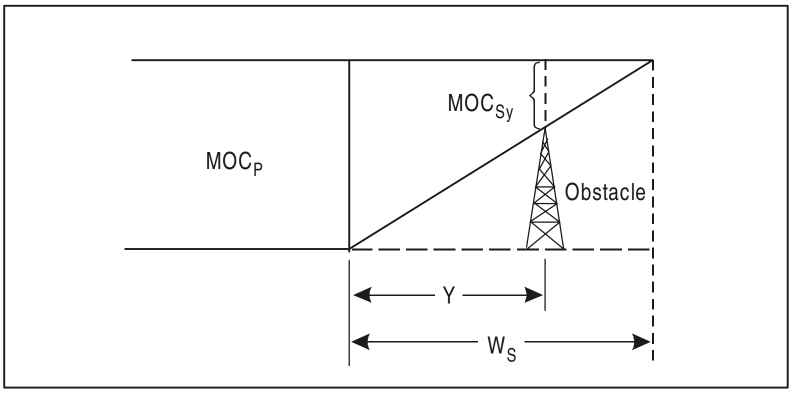

Figure I-2-1-3. Obstacle clearance in secondary areas

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Appendix to Chapter 1

CONVERSION TABLE FOR IAS TO TAS CALCULATIONS

1. This appendix provides conversion factors for the conversion of indicated airspeed to true airspeed for altitudes from 0 to 7 500 m (0 to 24 000 ft) and at temperatures from ISA – 30°C to ISA + 30°C.

2. To find true airspeed, simply multiply the indicated airspeed by the conversion factor at the given altitude and temperature. For example:

a) assume an altitude of 4 500 m, an indicated airspeed of 400 km/h and a temperature of ISA + 20°C. Then

TAS = 400 × 1.3034 = 521 km/h.

b) assume an altitude of 10 000 ft, an indicated airspeed of 220 kt and a temperature of ISA + 10°C. Then

TAS = 220 × 1.1852 = 261 kt.

3. For altitudes and temperatures not listed in Tables I-2-1-App-1 and Tables I-2-1-App-2, the formula presented beneath each table can be used to determine true airspeed.

4. Because compressibility was not considered in these tables, the speeds to which the conversion factors may be applied should be limited to those listed in Tables I-4-1-1 and I-4-1-2.

Table I-2-1-App-1

Altitude (metres)	*Conversion factor*							
	ISA30	*ISA20*	*ISA10*	*ISA*	*ISA+10*	*ISA+15*	*ISA+20*	*ISA+30*
0	0.9465	0.9647	0.9825	1.0000	1.0172	1.0257	1.0341	1.0508
500.0	0.9690	0.9878	1.0063	1.0244	1.0423	1.0511	1.0598	1.0770
1 000.0	0.9922	1.0118	1.0309	1.0497	1.0682	1.0774	1.0864	1.1043
1 500.0	1.0163	1.0366	1.0565	1.0760	1.0952	1.1046	1.1140	1.1325
2 000.0	1.0413	1.0623	1.0830	1.1032	1.1231	1.1329	1.1426	1.1618
2 500.0	1.0672	1.0890	1.1105	1.1315	1.1521	1.1623	1.1724	1.1923
3 000.0	1.0940	1.1167	1.1390	1.1608	1.1822	1.1928	1.2032	1.2239
3 500.0	1.1219	1.1455	1.1686	1.1912	1.2135	1.2245	1.2353	1.2568
4 000.0	1.1507	1.1753	1.1993	1.2229	1.2460	1.2574	1.2687	1.2910
4 500.0	1.1807	1.2063	1.2313	1.2558	1.2798	1.2917	1.3034	1.3266
5 000.0	1.2119	1.2385	1.2645	1.2900	1.3150	1.3273	1.3395	1.3636
5 500.0	1.2443	1.2720	1.2991	1.3256	1.3516	1.3644	1.3771	1.4022
6 000.0	1.2779	1.3068	1.3350	1.3627	1.3897	1.4031	1.4163	1.4424
6 500.0	1.3130	1.3430	1.3725	1.4013	1.4295	1.4434	1.4572	1.4843
7 000.0	1.3494	1.3808	1.4115	1.4415	1.4709	1.4854	1.4998	1.5281
7 500.0	1.3873	1.4201	1.4521	1.4835	1.5141	1.5292	1.5442	1.5737

The following formula is used for values not listed in the table:
$TAS = IAS \times 171233\,[(288 \pm VAR) - 0.006496H]^{0.5} \div (288 - 0.006496H)^{2.628}$
where: VAR = Temperature variation about ISA in °C, H = Altitude in metres.

Table I-2-1-App-2

Altitude (feet)	*Conversion factor*							
	ISA30	*ISA20*	*ISA10*	*ISA*	*ISA+10*	*ISA+15*	*ISA+20*	*ISA+30*
0	0.9465	0.9647	0.9825	1.0000	1.0172	1.0257	1.0341	1.0508
1 000.0	0.9601	0.9787	0.9969	1.0148	1.0324	1.0411	1.0497	1.0667
2 000.0	0.9740	0.9930	1.0116	1.0299	1.0479	1.0567	1.0655	1.0829
3 000.0	0.9882	1.0076	1.0266	1.0453	1.0637	1.0728	1.0818	1.0995
4 000.0	1.0027	1.0225	1.0420	1.0611	1.0799	1.0892	1.0984	1.1165
5 000.0	1.0175	1.0378	1.0577	1.0773	1.0965	1.1059	1.1153	1.1339
6 000.0	1.0327	1.0534	1.0738	1.0938	1.1134	1.1231	1.1327	1.1517
7 000.0	1.0481	1.0694	1.0902	1.1107	1.1307	1.1406	1.1505	1.1699
8 000.0	1.0639	1.0857	1.1070	1.1279	1.1485	1.1586	1.1686	1.1885
9 000.0	1.0801	1.1024	1.1242	1.1456	1.1666	1.1770	1.1872	1.2075
10 000.0	1.0967	1.1194	1.1418	1.1637	1.1852	1.1958	1.2063	1.2270
11 000.0	1.1136	1.1369	1.1597	1.1822	1.2042	1.2150	1.2258	1.2470
12 000.0	1.1309	1.1547	1.1781	1.2011	1.2236	1.2347	1.2457	1.2674
13 000.0	1.1485	1.1730	1.1970	1.2205	1.2435	1.2549	1.2661	1.2884
14 000.0	1.1666	1.1917	1.2162	1.2403	1.2639	1.2755	1.2871	1.3098
15 000.0	1.1852	1.2108	1.2360	1.2606	1.2848	1.2967	1.3085	1.3318
16 000.0	1.2041	1.2304	1.2562	1.2814	1.3062	1.3184	1.3305	1.3544
17 000.0	1.2235	1.2505	1.2769	1.3028	1.3281	1.3406	1.3530	1.3775
18 000.0	1.2434	1.2710	1.2981	1.3246	1.3506	1.3634	1.3761	1.4011
19 000.0	1.2637	1.2921	1.3198	1.3470	1.3736	1.3868	1.3998	1.4254
20 000.0	1.2846	1.3136	1.3421	1.3700	1.3973	1.4107	1.4240	1.4503
21 000.0	1.3059	1.3357	1.3649	1.3935	1.4215	1.4353	1.4489	1.4759
22 000.0	1.3278	1.3584	1.3883	1.4176	1.4463	1.4605	1.4745	1.5021
23 000.0	1.3502	1.3816	1.4123	1.4424	1.4718	1.4863	1.5007	1.5290
24 000.0	1.3731	1.4054	1.4369	1.4677	1.4980	1.5128	1.5276	1.5566

The following formula is used for values not listed in the table:
$TAS = IAS \times 171233\ [(288 \pm VAR) - 0.00198H]^{0.5} \div (288 - 0.00198H)^{2.628}$
where: VAR = Temperature variation about ISA in °C, H = Altitude in feet.

Chapter 2

TERMINAL AREA FIXES

2.1 GENERAL

2.1.1 Because all navigation facilities and waypoints have accuracy limitations, the geographic point which is identified is not precise, but may be anywhere within an area which surrounds the nominal point. The nominal point can be defined by:

a) an intersection (see 2.3, "Fix tolerance and fix tolerance area for intersecting fixes");

b) overheading a facility (see 2.5, "Fix tolerance overheading a VOR or NDB");

c) an RNAV waypoint; and

d) other kinds of navigation aids (see 2.4, "Fix tolerance for other types of navigation instruments").

2.1.2 As an example, Figure I-2-2-1 illustrates the intersection of an arc and a radial from the same VOR/DME facility, as well as the intersection of two radials or bearings from different navigation facilities. The area of intersection formed in this way is referred to in this document as the "fix tolerance area".

2.2 TERMINAL AREA FIXES

2.2.1 Terminal area fixes include, but are not limited to:

a) the initial approach fix (IAF);

b) the intermediate approach fix (IF);

c) the final approach fix (FAF); and

d) the holding fix,

and when necessary, a fix to mark the missed approach point (MAPt), or the turning point (TP).

2.2.2 Terminal area fixes should be based on similar navigation systems. The use of mixed type (as VHF/LF) fixes should be limited to those intersections where no satisfactory alternative exists.

2.3 FIX TOLERANCE AND FIX TOLERANCE AREA FOR INTERSECTING FIXES

The fix tolerance and fix tolerance area are obtained by using navigation information from either collocated or non-collocated facilities as shown in Figure I-2-2-1.

2.3.1 Fix tolerance areas

The fix tolerance areas are formed by the boundaries obtained from system use accuracies of the homing and intersecting radials (or arcs as appropriate) with respect to the nominal fix position. As the system use accuracy is expressed in angles, the size of the fix tolerance area is dependent on the distance of the fix to navigation aids.

2.3.2 Fix tolerance

The fix tolerance determines the operational acceptability of a fix. Fix tolerance is a distance measured along the nominal track and relative to the nominal fix position. It is defined by the intersections of the nominal track with the earliest and latest limits of the fix tolerance area, measured along the nominal track. The tolerance is expressed as a plus or minus value around the nominal fix. See Figures I-2-2-5 and I-2-2-6. Fix tolerance and system use accuracies are based on a 95 per cent probability of containment (2 SD).

2.3.3 System use accuracy for VOR, NDB and LLZ

System use accuracy is based on a root sum square calculation using the following tolerances:

a) ground system tolerance;

b) airborne receiving system tolerance; and

c) flight technical tolerance.

Difference between the overall system use accuracy of the intersecting facility and the along track facility is accounted for by the fact that flight technical tolerance is not applied to the former. See Table I-2-2-1 for system use accuracies and Table I-2-2-2 for the tolerances on which these values are based.

2.4 FIX TOLERANCE FOR OTHER TYPES OF NAVIGATION INSTRUMENTS

2.4.1 Terminal area radar

Radar fix accuracies need to consider:

a) mapping accuracies (normally 150 m (492 ft) or 3 per cent of the distance to the antenna);

b) azimuth resolutions of the radar (reduced to some extent to account for the controller interpretation of target centre);

c) flight technical tolerance (which recognizes communication lag as well as speed of the aircraft); and

d) controller technical tolerance (which recognizes sweep speed of the antenna and the speed of the aircraft).

The total fix tolerance is the result of a combination, on a root sum square (RSS) basis, as in Table I-2-2-3.

2.4.2 Radar fixes

Radar should not normally be the primary method of fix identification. However, where air traffic control (ATC) can provide the service, terminal area radar (TAR) within the limitations specified in 2.4.1, "Terminal area radar" may be used to identify any terminal area fix. En-route surveillance radar (RSR) may be used for initial approach and intermediate approach fixes.

2.4.3 Fixes for VOR or NDB with DME

2.4.3.1 VOR/DME fixes use radial and distance information derived normally from facilities with collocated azimuth and DME antennas. However, where it is necessary to consider a VOR/DME fix derived from separate facilities, the fix is only considered satisfactory where the angles subtended by the facilities at the fix results in an acceptable fix tolerance area. See Figure I-2-2-1.

2.4.3.2 Where the DME antenna is not collocated with the VOR and NDB providing track guidance, the maximum divergence between the fix, the tracking facility and the DME shall not be more than 23 degrees.

2.4.3.3 For the use of DME with ILS, see Part II, Section 1, Chapter 1, 1.4.4, "Glide path verification check".

2.4.4 DME

The accuracy is ± (0.46 km (0.25 NM) + 1.25 per cent of the distance to the antenna). This value is the RSS total of minimum accuracy, monitor tolerance and flight technical tolerance, the latter two being so small as to be completely dominated by the larger airborne value.

Note 1.— No reduction can be justified based on flight test information.

Note 2.— Tolerance values assume that published procedures will take into account slant range distance.

2.4.5 75 MHz marker beacon

Use Figure I-2-2-2 to determine the fix tolerance for ILS and "Z" markers during approach procedures.

If the facility defines the MAPt, the fixed value of zero is used (see Section 4, Chapter 6, 6.1.6.2.1, "MAPt tolerance when MAPt is defined by a navigation facility or fix").

2.5 FIX TOLERANCE OVERHEADING A STATION

2.5.1 VOR

Fix tolerance areas should be determined using a cone effect area based on a circular cone of ambiguity, generated by a straight line passing through the facility and making an angle of 50 degrees from the vertical. However, where a State has determined that a lesser angle is appropriate, fix tolerance areas may be adjusted using either of the formulae contained in 6.4 of Part II, Section 4, Chapter 1, Appendix A. Entry into the cone is assumed to be achieved within such an accuracy from the prescribed track as to keep the lateral deviation abeam the VOR:

$$d = 0.2\ h \text{ (d and h in km)}$$

or $d = 0.033\ h$ (d in NM, h in thousands of feet).

For a cone angle of 50 degrees, the accuracy of entry is ± 5°. From the points of entry, tracking through the cone is assumed to be achieved within an accuracy of ± 5°. Passage over the VOR is assumed to be indicated within the limits of the cone of ambiguity. See Figure I-2-2-3. If the facility defines the MAPt or the turning point in the missed approach, fixed values are used (see Section 4, Chapter 6, 6.1.6.1.2 and 6.4.6.2).

2.5.2 NDB

A cone effect area based upon an inverted cone of ambiguity extending at an angle of 40 degrees either side of the facility should be used in calculating the areas. Entry into the cone is assumed to be achieved within an accuracy of ± 15° from the prescribed inbound track. From the points of entry, tracking through the cone is assumed to be achieved within an accuracy of ± 5°. See Figure I-2-2-4. If the facility defines the MAPt or the turning point in the missed approach, fixed values are used (see Section 4, Chapter 6, 6.1.6.2.1 and 6.4.6.2).

2.6 OPERATIONAL APPLICATION OF FIXES FOR FLIGHT PROCEDURE PLANNING

2.6.1 Minimum usable ground distance to a VOR/DME fix

The minimum usable ground distance to a VOR/DME fix can be determined from the following equations.

$$d_m = h_l \tan 55°$$

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

d_m = minimum usable DME ground distance in kilometers

or

$$d_m = 0.164\ h_l \tan 55°$$

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

d_m = minimum usable DME ground distance in nautical miles.

2.6.2 Initial/Intermediate approach fix

To be satisfactory as an intermediate or initial approach fix, the fix tolerance (along track tolerance (ATT) for RNAV) must not be larger than ± 3.7 km (± 2.0 NM) with the following exception. When the FAF is a VOR, NDB or VOR/DME fix, the fix tolerance may be increased to not greater than ± 25 per cent of the corresponding segment's length (intermediate or initial, as appropriate).

Example: If the intermediate or initial segment is 10 NM in length, then the fix tolerance may be 2.5 NM.

Measurements are made from the nominal fix positions along the nominal flight track. See Figure I-2-2-5.

2.6.3 Final approach fix for non-precision approaches

For use as a FAF, the fix shall be located not farther than 19 km (10 NM) from the landing surface. The fix tolerance at the FAF crossing level should not exceed ± 1.9 km (1.0 NM). See Figure I-2-2-6.

2.6.4 Missed approach fixes

2.6.4.1 *General*

A missed approach fix may be used in non-precision approaches. The fix tolerance shall not exceed the longitudinal tolerance of the MAPt calculated assuming that the MAPt is defined by a distance from the FAF. See Section 4, Chapter 6.

2.6.4.2 *Use of 75 MHz marker beacon*

The use of an ILS 75 MHz marker as an MAPt is limited to the case of ILS approach with glide path unserviceable. See Part II, Section 2, Chapter 1, "Localizer only".

2.6.5 Limiting radials/DME distances

Where no missed approach track guidance is available a turn point can be defined by the intersection of the nominal track with a limiting VOR radial, NDB bearing or DME distance. Although this is not a fix, the missed approach calculations are made by assuming a fix tolerance area drawn as shown on Figure I-2-2-7 (see Section 4, Chapter 6, 6.4.6 and Part II, Section 1, Chapter 1, 1.5.3.3 for turn area).

2.7 USE OF FIXES FOR DESCENT AND RELATED OBSTACLE CLEARANCE

2.7.1 Distance available for descent

When applying descent gradient criteria to an approach segment (initial, intermediate or final approach areas), the gradient is calculated between the nominal positions of the related fixes. See Figure I-2-2-8.

2.7.2 Obstacle clearance after passing a fix

It is assumed that descent will begin at the earliest point within the fix tolerance area of the first fix and will end at the nominal position of the second fix. Obstacle clearance appropriate to the segment being entered shall be provided:

a) within the fix tolerance area of the first fix; and

b) between the nominal positions of the two fixes.

See Figure I-2-2-9 for an example of an intermediate approach segment.

2.7.3 Stepdown fix

2.7.3.1 A stepdown fix permits additional descent within a segment by identifying a point at which a controlling obstacle has been safely overflown. Preferably, only one stepdown fix should be established in the final approach segment, except in the case where the fix can be provided by radar or DME. In this case no more than two stepdown fixes should be specified. See Figure I-2-2-10.

2.7.3.2 The use of the stepdown fix in the final approach segment shall be limited to aircraft capable of simultaneous reception of the flight track and a crossing indication unless otherwise specified. Where a stepdown fix is used in the final approach segment, an OCA/H shall be specified both with and without the stepdown fix.

2.7.3.3 A stepdown fix should meet the criteria which apply to the fix associated with that segment. That is:

a) the criteria for the IAF and the IF in the initial and intermediate approach segments respectively; and

b) the criteria for the FAF in the final approach segment.

The criteria for the IAF and the IF are shown in 2.6.2 above. The criteria for the FAF are shown in 2.6.3.

2.7.3.4 Where fixes can be provided by a suitably located DME, a series of descending steps on a specified track or within a specified sector converging to the aerodrome of landing may be constructed. This procedure shall be designed to provide obstacle clearance appropriate to the segment in which the fix is located, from the en-route phase of flight through the final approach segment.

2.7.4 Obstacle close to a final approach fix or stepdown fix

Obstacles which are within the fix tolerance area and are no more than 9.3 km (5.0 NM) past the earliest point of the fix tolerance area need not be considered in establishing the OCA/H or the minimum altitude/height of the following segment provided that these obstacles are found under a plane:

a) perpendicular to the vertical plane containing the nominal final approach flight path and on a 15 per cent horizontal gradient (Cat H, 15 per cent or descent gradient of the nominal track multiplied by 2.5, whichever is greater); and

b) passing through the earliest point of the fix tolerance area at an altitude/height equal to the minimum altitude/height required at the fix, minus the obstacle clearance required for the segment preceding the fix. (See Figure I-2-2-11.)

2.8 PROTECTION AREA FOR VOR AND NDB

The values for protection areas are based on the system use accuracies (2 SD) shown in Table I-2-2-1 and are extrapolated to a 3 SD value (99.7 per cent probability of containment).

VOR splay:
Terminal = 7.8°
NDB splay:
Terminal = 10.3°

Table I-2-2-1. System use accuracy (2SD) of facility providing track guidance and facility not providing track guidance

	VOR[1]	ILS	NDB
System use accuracy of facility NOT providing track	+/– 4.5°	+/– 1.4°	+/– 6.2°
System use accuracy of facility providing track	+/– 5.2°	+/– 2.4°	+/– 6.9°

1. The VOR values of +/– 5.2° and +/– 4.5° may be modified according to the value of a) in Table I-2-2-2, resulting from flight tests.

Table I-2-2-2. Tolerances on which system use accuracies are based

The values in Table I-2-2-1 are the result of a combination, on a root sum square basis, of the following tolerances	VOR	ILS	NDB
a) ground system tolerance	+/– 3. 6°	+/– 1°[1]	+/– 3°
b) airborne receiving tolerance	+/– 2.7°	+/– 1°	+/– 5.4°
c) light technical tolerance[2]	+/– 2.5°	+/– 2°	+/– 3°

1. Includes beam bends.

2. Flight technical tolerance is only applied to navigation aids providing track. It is not applied to fix intersecting navigation aids.

Table I-2-2-3.

Parameter	*TAR* within 37 km (20 NM)		*RSR* within 74 km (40 NM)	
Video map accuracy	1.1 km	0.6 NM	2.2 km	1.2 NM
Azimuth accuracy	0.7 km	0.4 NM	1.5 km	0.8 NM
Flight technical tolerance	0.7 km (5 s at 500 km/h)	0.3 NM (5 s at 250 kt)	1.4 km (10 s at 500 km/h)	0.7 NM (10 s at 250 kt)
Controller technical tolerance	0.6 km	0.3 NM	1.1 km	0.6 NM
Total fix tolerance (RSS'd)	± 1.6 km	± 0.8 NM	± 3.2 km	± 1.7 NM

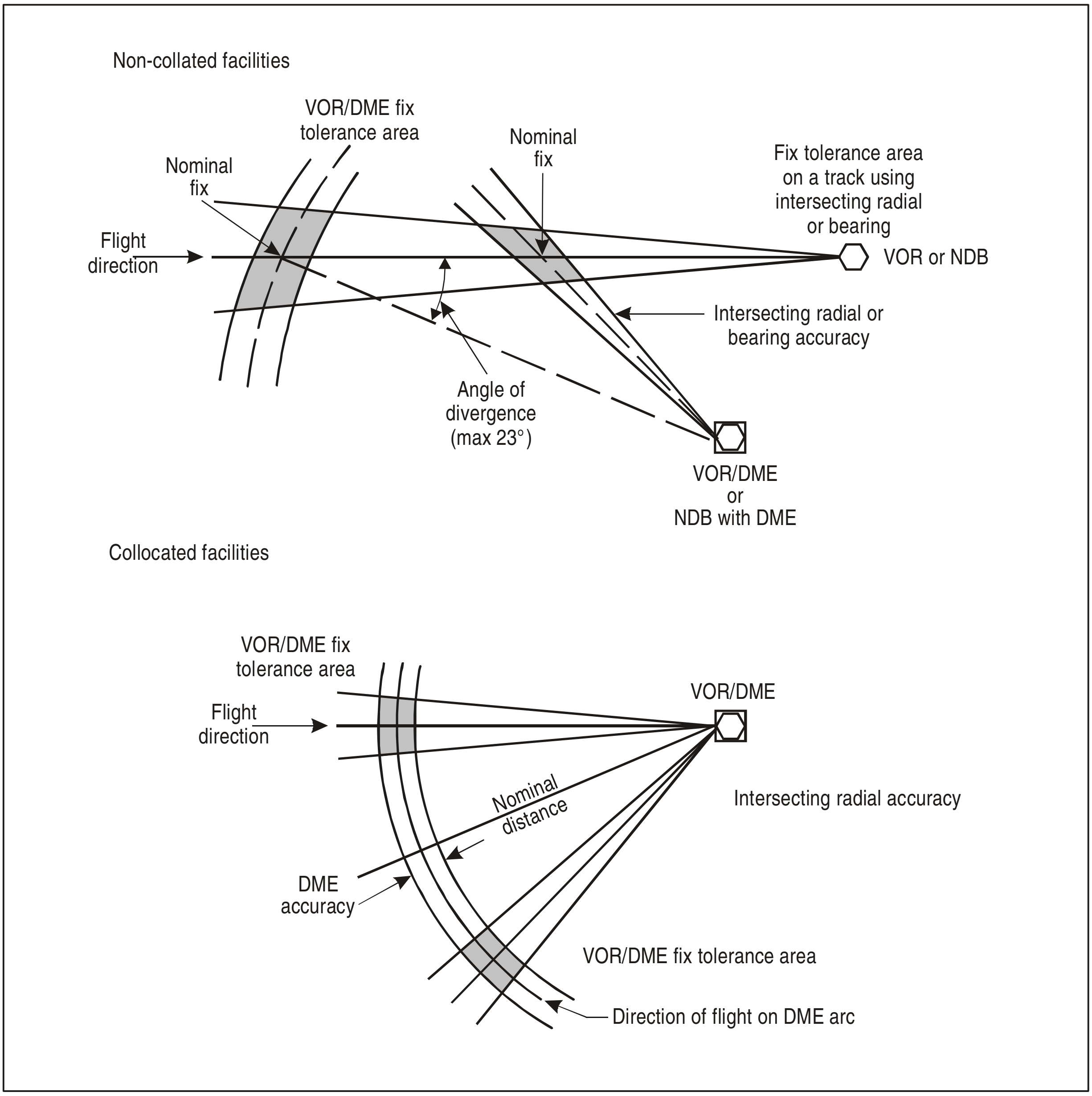
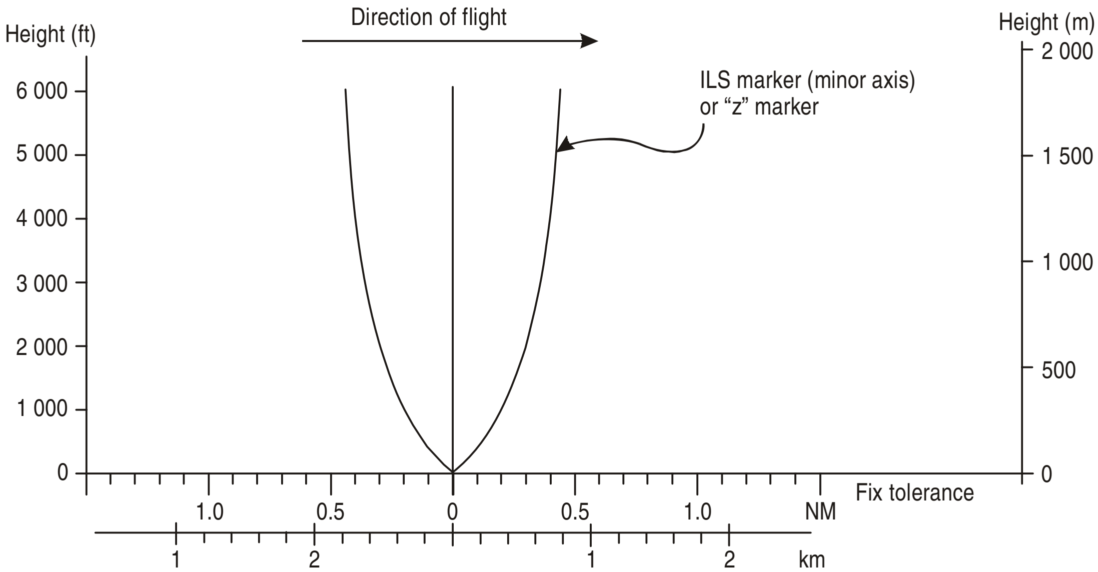
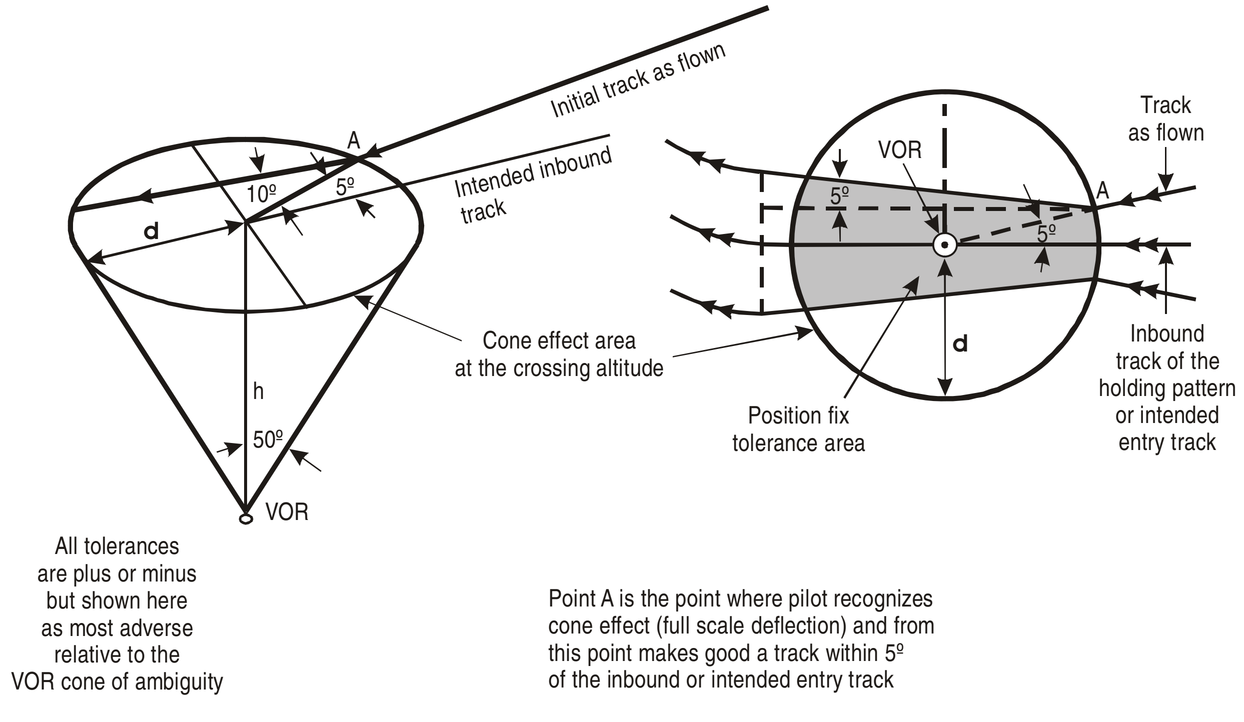


Figure I-2-2-1. Intersection fix tolerance areas



Note.— This figure is based on the use of modern aircraft antenna systems with a receiver sensitivity setting of 1 000 µV up to 1 800 m (5 905 ft) above the facility.

Figure I-2-2-2. ILS or "Z" marker coverage



Note.— Example with a cone angle of 50°.

Figure I-2-2-3. Fix tolerance area overhead a VOR

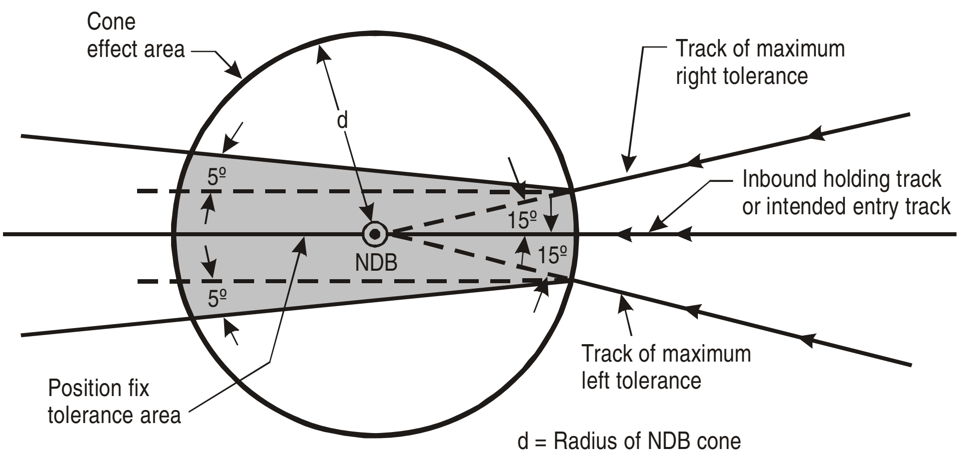


Figure I-2-2-4. Fix tolerance area overhead an NDB

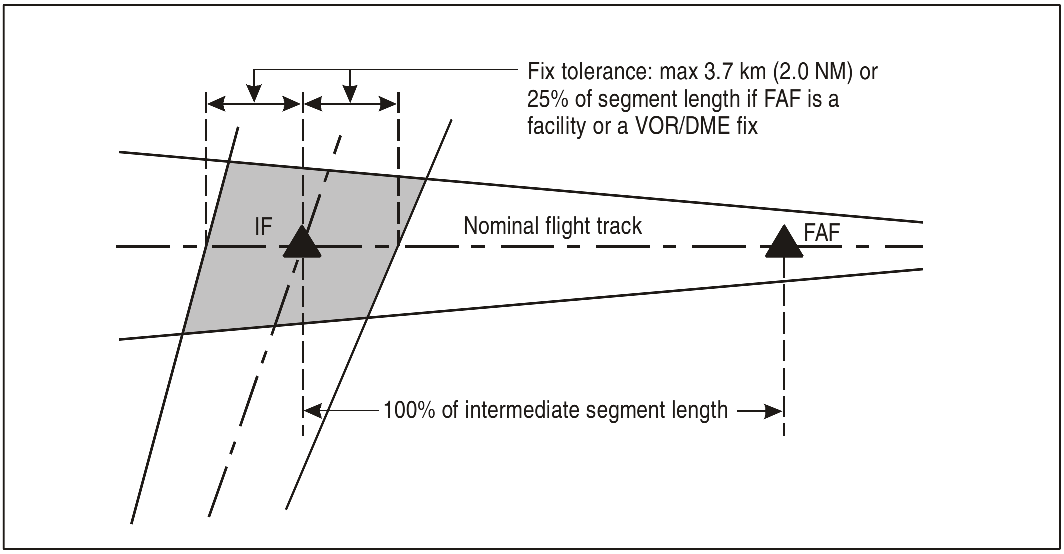


Figure I-2-2-5. Fix tolerance in the immediate approach segment

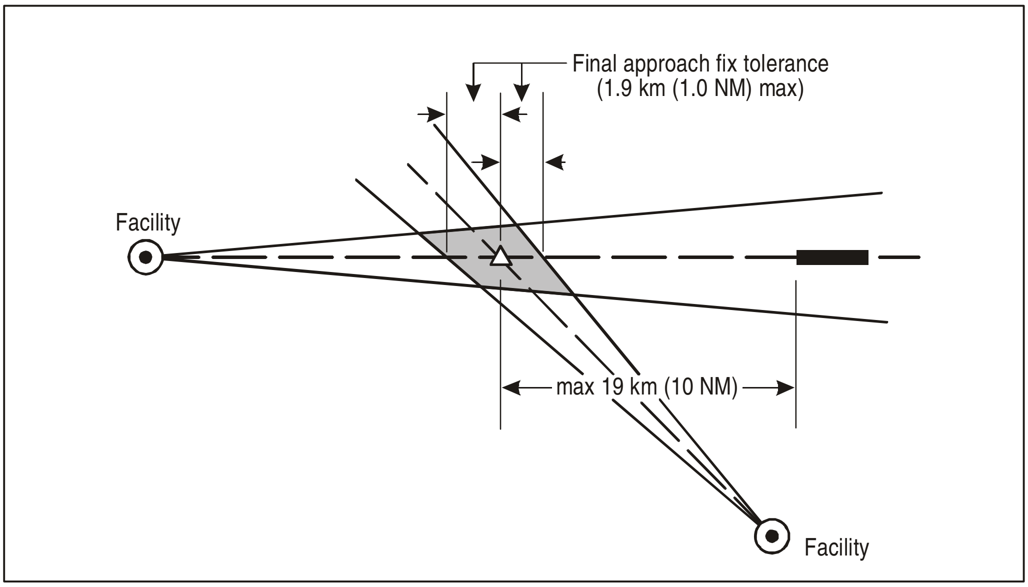


Figure I-2-2-6. Final approach fix (FAF) tolerance

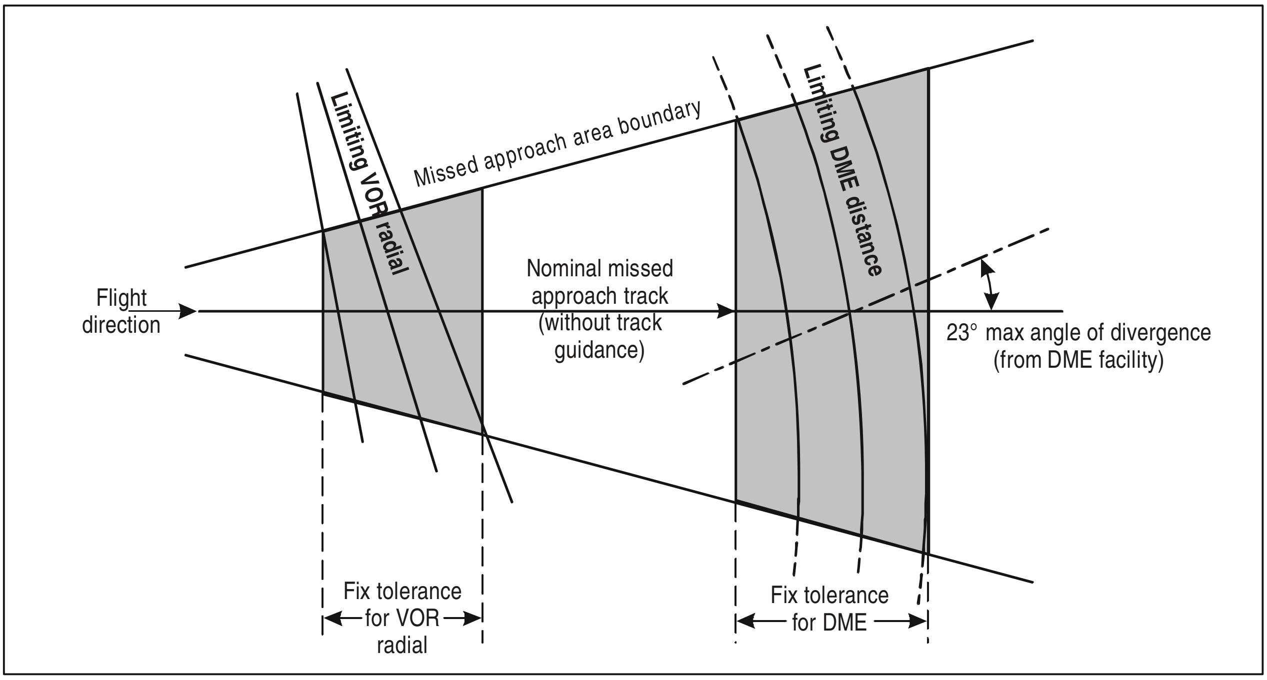


Figure I-2-2-7. Assumed fix tolerance areas for limiting radial/bearing or DME distance

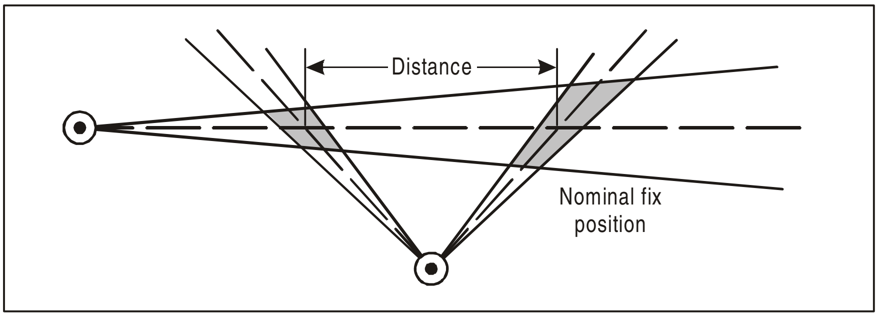


Figure I-2-2-8. Distance between fixes

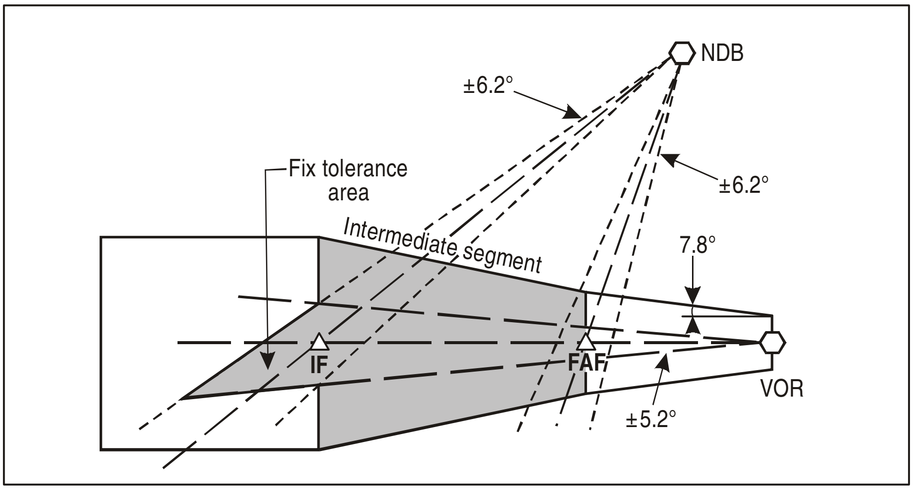


Figure I-2-2-9. Area requiring obstacle clearance

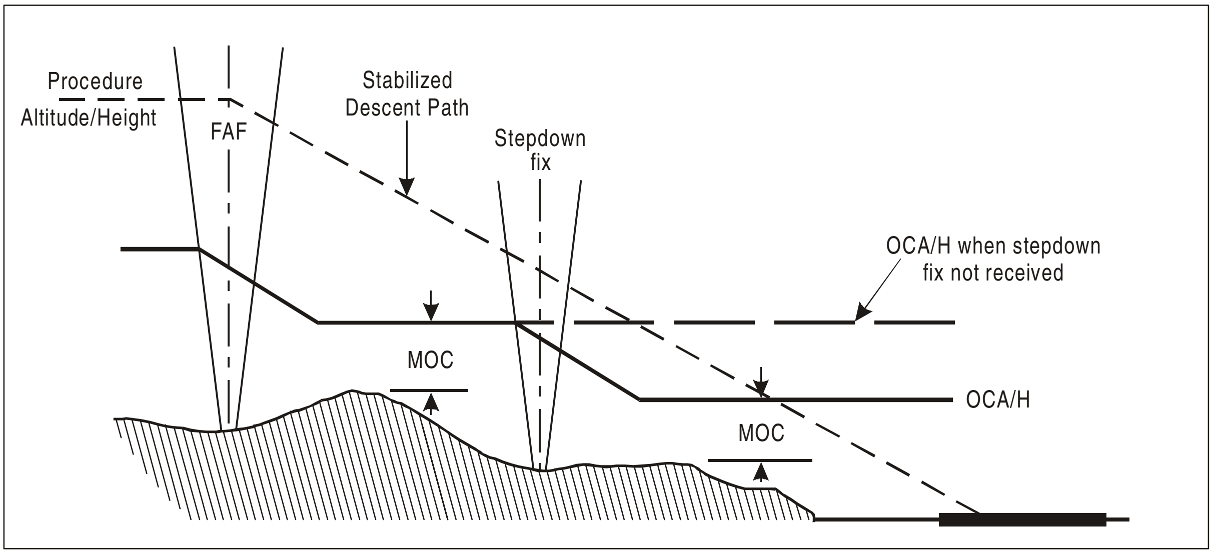


Figure I-2-2-10. Stepdown fix with dual OCA/H

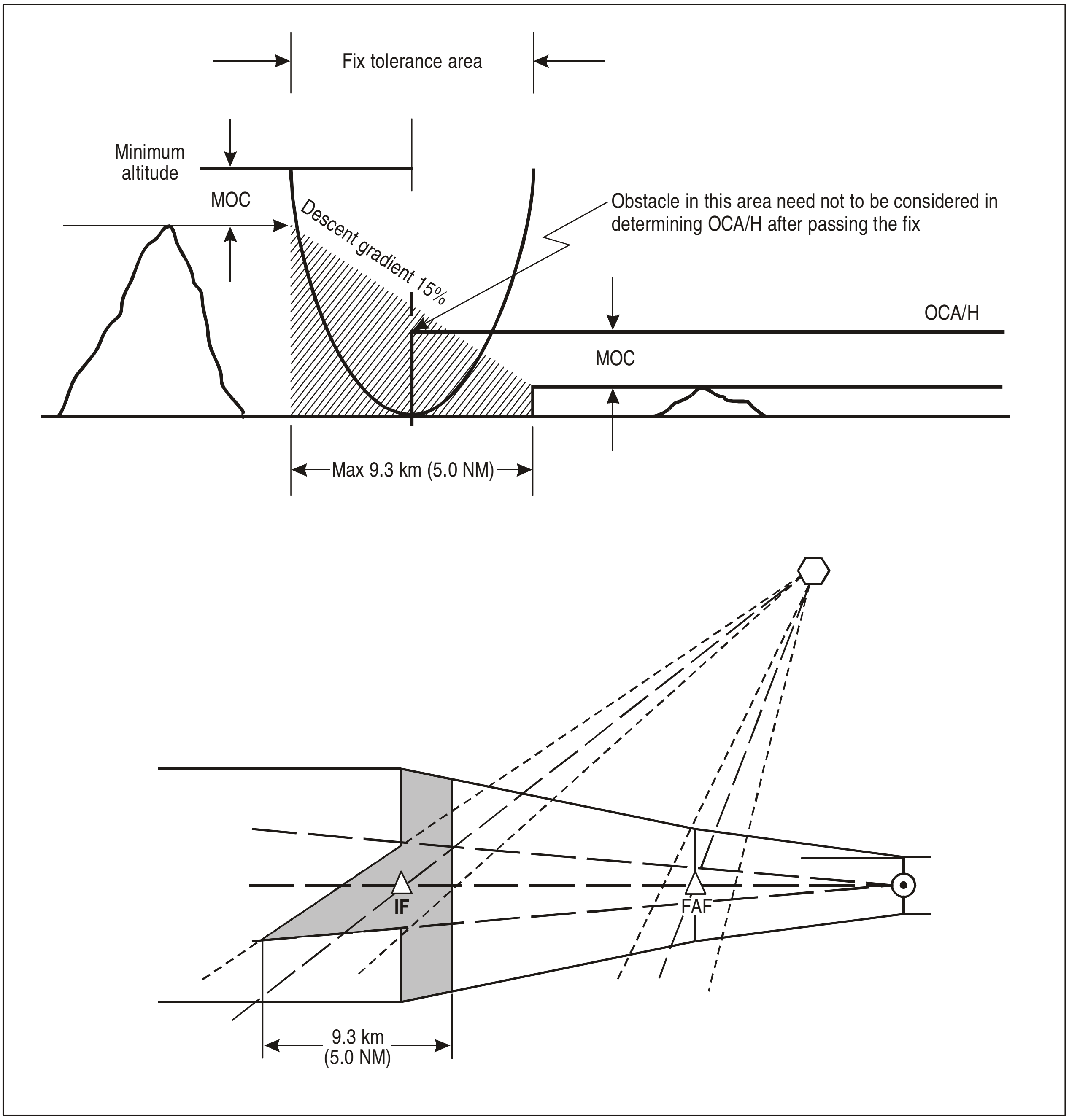


Figure I-2-2-11. Area where obstacles need not be considered

Chapter 3

TURN AREA CONSTRUCTION

3.1 GENERAL

3.1.1 This chapter describes the general criteria for the construction of turn areas for use in the different segments of instrument flight procedures. The methodologies presented — wind spiral and bounding circle — apply to the phases of flight shown below. All other turns are constructed by means of arcs (see the appropriate chapters).

a) Departure.

b) Missed approach.

c) Final approach fix (turns > 10 degrees).

d) RNAV turns at the IAF and IF (turns > 30 degrees).

3.1.2 Turn parameters

3.1.2.1 This section shows the parameters on which the turn areas are based, together with the variables which represent them in the drawings. The values for the following parameters vary according to the phase of flight. Their values are listed in Table I-2-3-1, "Turn construction parameter summary". For the specific application of the parameters in the table, see the applicable chapters. Tables I-2-3-2 and I-2-3-3 show example calculations of various turning parameters for a selection of IAS.

a) Altitude.

b) Indicated airspeed (IAS).

c) Wind.

d) Bank angle.

e) Flight technical tolerances.

3.1.2.2 *Other turn factors and calculations used in turn construction*

a) *Fix tolerance.* As appropriate for the type of fix. See Section 2, Chapter 2, "Terminal area fixes". See also Part II, Section 3, "En-route criteria".

b) *Rate of turn (R) in degrees/second.* This is calculated as follows:

1) $R = (6\ 355 \tan \alpha)/\pi V$, where V is the TAS in km/h; and

2) R = (3 431 tan α)/πV, where V is the TAS in kt;

up to a maximum value of 3 degrees/second.

c) *Radius of turn (r) at a designated angle of bank in still air, in km or NM as appropriate.* The turn radius for a given value of R is derived as follows:

r = V/(20 π R) where V is the TAS.

d) *Wind effect (E_θ) for the time taken to change heading θ degrees, in km or NM as appropriate.*

e) *Gravity.* The value used implicitly in the formulae is 9.80665 m/s^2 (68 625 NM/hour^2).

f) c = 6 seconds pilot reaction time.

3.2 TURN INNER BOUNDARY CONSTRUCTION

3.2.1 Turn at an altitude/height

The inner boundary normally originates at the beginning of the turn initiation area from whichever edge of the area provides the best lateral protection (inner edge if turn < 75°, outer edge if turn ≥ 75°). It then diverges outwards in the direction of the nominal track with a splay of 15 degrees (see Figures I-2-3-1 a) and b)).

3.2.2 Turns at a designated turning point

On the inner edge of the turn, the primary area boundary starts at the K-line. The edges of the primary and secondary areas are connected to their counterparts in the subsequent sections. For these connections, the following rules apply:

a) if the point to connect is outside the protection area associated with the subsequent section, then the boundary converges with the nominal track after the turn at an angle equal to half the angle of turn (A/2); and

b) if the point to connect is inside the protection area associated with the subsequent section, then the boundary diverges from the nominal track at an angle of 15 degrees.

3.3 TURN OUTER BOUNDARY CONSTRUCTION

3.3.1 Construction is as follows:

a) Point A (see Figure I-2-3-2) is where the curve begins. The parameters that determine its location are:

1) fix tolerance; and

2) flight technical tolerance;

b) from this point there are two methods for constructing the curving portion of the turn outer boundary:

1) by calculating the wind spiral. (See 3.3.2, “Turn area using wind spiral”); or

2) by drawing bounding circles (simplified method). See 3.3.3, “Turn area using bounding circles”; and

c) at point P where the tangent of the area becomes parallel to the nominal track after the turn the boundary is formed as follows:

1) if no track guidance is available, the outer boundary starts to splay at 15 degrees relative to the nominal track (see Figure I-2-3-3 a); and

2) if track guidance is available, see 3.3.4, “Additional track guidance”.

3.3.2 Turn area using wind spiral

3.3.2.1 In the wind spiral method, the area is based on a radius of turn calculated for a specific value of true airspeed (TAS) and bank angle. The outer boundary of the turn area is constructed using a spiral derived from the radius of turn (r). The spiral results from applying wind effect E_θ to the ideal flight path. See Figure I-2-3-4.

The wind effect is calculated using the formula shown below:

$$E_\theta = (\theta/R) * (w/3600) \text{ km (NM)}$$

where θ is the angle of turn.

Note.— An automated version of the wind effect calculation appears on the PANS-OPS Software CD ROM (CD-101) under the Tools menu.

3.3.2.2 *Example of wind spiral construction template*

Figure I-2-3-5 has been calculated assuming:

a) an omnidirectional wind of 56 km/h (30 kt);

b) an altitude of 600 m (1 970 ft) above mean sea level (MSL); and

c) a final missed approach speed of 490 km/h (265 kt).

3.3.3 Turn area using bounding circles

As an alternative to the wind spiral, a simplified method can be used in which circles are drawn to bound the turning area. See Figure I-2-3-6.

Unlike the wind spiral method, the wind effect (E) used here is always that of a course change of 90°.

The construction method is:

1. Start at point A on the outer edge of the area.

2. At a distance r from point A, abeam the nominal flight path, construct a circle having radius E.

3. From point X, draw an arc having the following radius:

$$\sqrt{r^2 + E^2}$$

This begins the boundary for turns between 0 and 90 degrees.

4. Start at point A' on the inner edge of the turn.

5. At a distance r from point A' , abeam the nominal flight path, construct a second circle having radius E.

6. From point X', draw an arc having the following radius:

$$\sqrt{r^2 + E^2}$$

This completes the boundary for turns between 0 and 90 degrees.

7. Connect the two arcs described in steps 3 and 6.

8. From point Y, draw an arc having the following radius:

$$r + E$$

This extends the boundary for turns between 90 and 180 degrees.

9. From point Z, draw an arc having the following radius:

$$r + 2E$$

This extends the boundary for turns between 180 and 270 degrees.

Note.— An automated version of the wind effect calculation appears on the PANS-OPS Software CD ROM (CD-101) under the tools menu.

3.3.4 Additional track guidance

3.3.4.1 After the turn an operational advantage may be obtained by using suitably located facilities to reduce the dimensions of the area. Examples of typical turning areas with additional track guidance are shown in Figure I-2-3-3 b) to d).

3.3.4.2 If the point (P) where the tangent of the wind spiral or bounding circle becomes parallel to the nominal track after the turn is:

a) outside the navigation aid tolerance:

   1) for flights towards the navigation aid: connect the outer boundary to the edge of the navigation aid tolerance at the navigation aid location. (See Figure I-2-3-3 b));

   2) for flights away from the navigation aid: connect the outer boundary to the edge of the navigation aid tolerance with a line parallel to the nominal track. (See Figure I-2-3-3 c)); and

b) inside the navigation aid tolerance: connect the outer boundary to the edge of the navigation aid tolerance with a line splayed from the nominal track at an angle of 15 degrees. (See Figure I-2-3-3 d).)

3.3.5 Secondary areas with additional track guidance

3.3.5.1 A secondary area can be created on the outer side of the turn as soon as the aircraft has track guidance. On the outer edge of the turn this area is based on a 30º line from the nominal track up to the point (P) where the tangent becomes parallel to the nominal track after the turn.

3.3.5.2 The same principle applies for the area on the inner side of the turn, except that the 30º line from the nominal track is up to the point from whichever edge of the area provides the best lateral protection. See Figure I-2-3-7.

Table I-2-3-1. Turn construction parameter

					FTT (seconds)			
					c (seconds)			
Segment or fix of turn location	*Speed (IAS)*[1]	*Altitude/height*	*Wind*	*Bank angle*[2]	*Bank establishment time*	*Pilot reaction time*	*Outbound timing tolerance*	*Heading tolerance*
Departure	Final missed approach IAS + 10%, see Table I-4-1-1 or I-4-1-2[3]	Turn at altitude/height: Specified altitude/height Turn at turn point: A/D elevation + height based on 10% climb from DER	95% omni-directional wind or 56 km/h (30 kt) for wind spirals	15° until 305 m (1 000 ft) 20° between 305 (1 000 ft) and 915 m (3 000 ft) 25° above 915m (3 000 ft)	3	3	N/A	N/A
En-route	585 km/h (315 kts)	Specified altitude	95% probability wind, or ICAO standard wind[4]	15°	5	10	N/A	N/A
Holding	Table II-4-1-1[1]	Specified altitude	ICAO standard wind[4]	23°	N/A	5	N/A	N/A
Initial approach – reversal and racetrack procedures	Table I-4-1-1 or I-4-1-2	Specified altitude	ICAO standard wind[4] or statistical wind	25°	5	0-6	10	5
Initial approach – DR track procedures	CAT A, B – 165 to 335 km/h (90 to 180 kts) CAT C, D, E – 335 to 465 km/h (180 to 250 kts)	CAT A, B 1500m (5 000 ft) CAT C, D, E - 3000 m (10 000 ft)	ICAO standard wind[4] DR leg; – 56 km/h (30 kts)	25°	5	0-6	N/A	5

Segment or fix of turn location	*Speed (IAS)*[1]	*Altitude/height*	*Wind*	*Bank angle*[2]	*FTT (seconds)*			
					c (seconds)			
					Bank establishment time	*Pilot reaction time*	*Outbound timing tolerance*	*Heading tolerance*
IAF, IF FAF	See Table I-4-1-1 and I-4-1-2 Use initial approach speed for turn at IAF or IF Use maximum final approach speed for turn at FAF.	Specified altitude	95% omni-directional wind or 56 km/h (30 kt)	25º	3	3	N/A	N/A
Missed approach	Table I-4-1-1 or I-4-1-2[3]	A/D elevation + 300 m (1 000 ft)	56 km/h (30 kt)	15º	3	3	N/A	N/A
Visual manoeuvring using prescribed track	See Table I-4-1-1 and I-4-1-2	A/D elevation + 300 m (1 000 ft)	46 km/h (25 kt)	25º	N/A	N/A	N/A	N/A
Circling	See Table I-4-1-1 and I-4-1-2	A/D elevation + 300 m (1 000 ft)	46 km/h (25 kt)	20º	N/A	N/A	N/A	N/A

GENERAL NOTES:
1. *For the specific application of the parameters in the table, see the applicable chapters.*
2. *The rate of turn associated with the stated bank angle values in this table shall not be greater than 3º /s.*

Note 1.— Where operationally required to avoid obstacles, reduced speeds as slow as the IAS for intermediate missed approach may be used, provided the procedure is annotated "Missed approach turn limited to _______ km/h (kt) IAS maximum."

Note 2.— The conversion from IAS to TAS is determined using a temperature equal to ISA at the corresponding altitude plus 15º C. Holding procedures are an exception; the calculation formula includes correction for compressibility and appears in Part II, Section 4, Appendix to Chapter 1.

Note 3.— Where operationally required to avoid obstacles, reduced speeds as slow as the IAS tabulated for "intermediate missed approach" in Tables I-4-1-1 and I-4-1-2 increased by 10 per cent may be used, provided the procedure is annotated "Departure turn limited to __________ km/h (kt) IAS maximum". In order to verify the operational effect of a desired speed limitation, the speed value should be compared with the statistical speed as published in Section 3, Appendix to Chapter 3.

Note 4.— ICAO standard wind = 12 h + 87 km/h (h in 1 000 m), 2 h + 47 kts (h in 1 000 ft)

Table I-2-3-2. Example of calculations of various turning parameters for a selection of IAS (calculated for 600 m MSL) (for abbreviations, see 3.1.2, "Turn parameters")

IAS *(km/h)*	*TAS* *(600 m, ISA + 15)* *IAS conversion* *factor** *(km/h)*	*c* *6 seconds* *(TAS + 56) 6* *3 600* *(km)*	*R* *542* *TAS* *(deg/s)*	*r* *TAS* *62.8R* *(km)*	*E* *1.4* *R* *(km)*
205	217	0.46	2.50	1.38	0.56
280	296	0.59	1.83	2.57	0.76
345	364	0.70	1.49	3.89	0.94
400	422	0.80	1.28	5.23	1.09
445	470	0.88	1.15	6.49	1.21
490	518	0.96	1.05	7.85	1.34
510	539	0.99	1.01	8.54	1.39

* For conversion from IAS to TAS, see the Appendix to Chapter 1.

Table I-2-3-3. Example of calculations of various turning parameters for a selection of IAS (calculated for 2 000 ft MSL) (for abbreviations, see 3.1.2, "Turn parameters")

IAS *(kt)*	*TAS* *(2 000 ft, ISA + 15)* *IAS conversion* *factor** *(kt)*	*c* *6 seconds* *(TAS + 30) 6* *3 600* *(NM)*	*R* *293* *TAS* *(deg/s)*	*r* *TAS* *62.8R* *(NM)*	*E* *0.75* *R* *(NM)*
110	116	0.24	2.53	0.73	0.30
150	159	0.32	1.84	1.37	0.41
185	195	0.38	1.50	2.07	0.50
200	211	0.40	1.39	2.42	0.54
240	254	0.47	1.15	3.51	0.65
265	280	0.52	1.05	4.25	0.72
275	291	0.54	1.01	4.60	0.74

* For conversion from IAS to TAS, see the Appendix to Chapter 1.

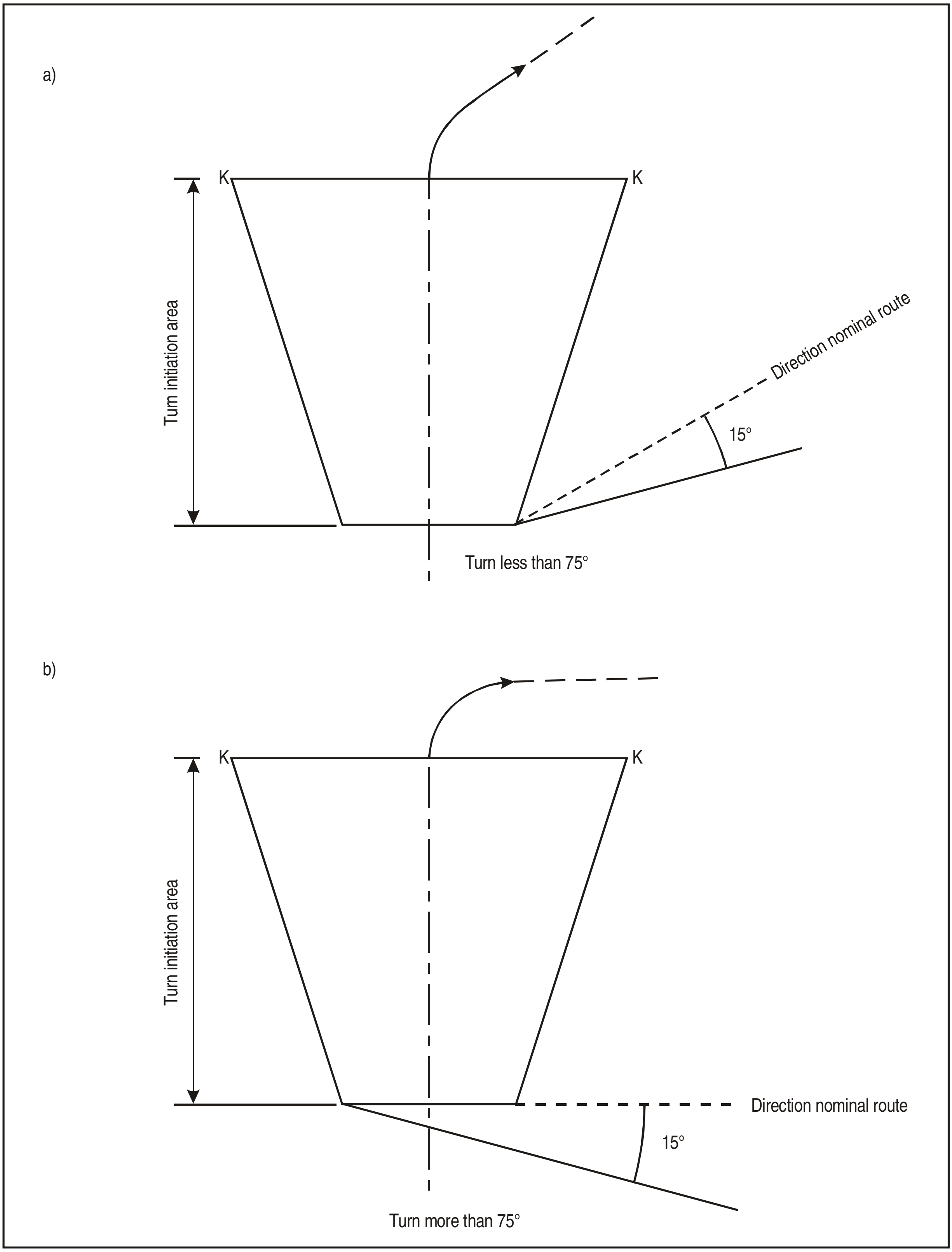


Figure I-2-3-1 Turn inner boundary protection

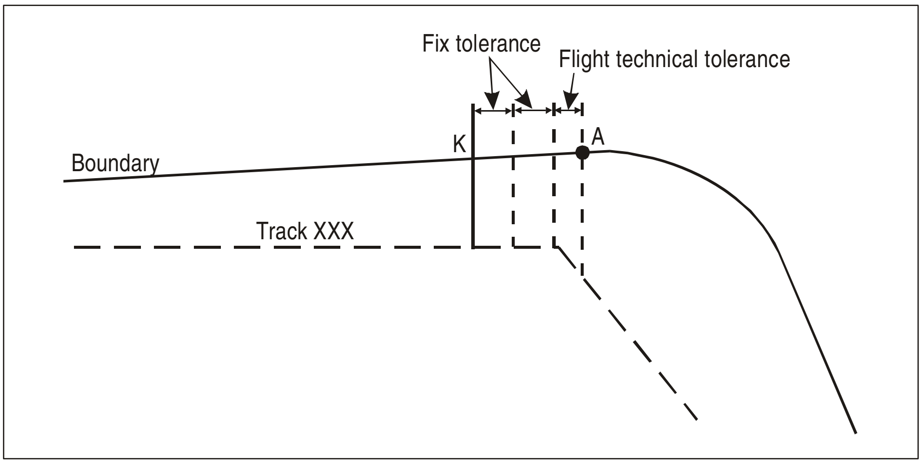


Figure I-2-3-2 Start of construction of outer boundary

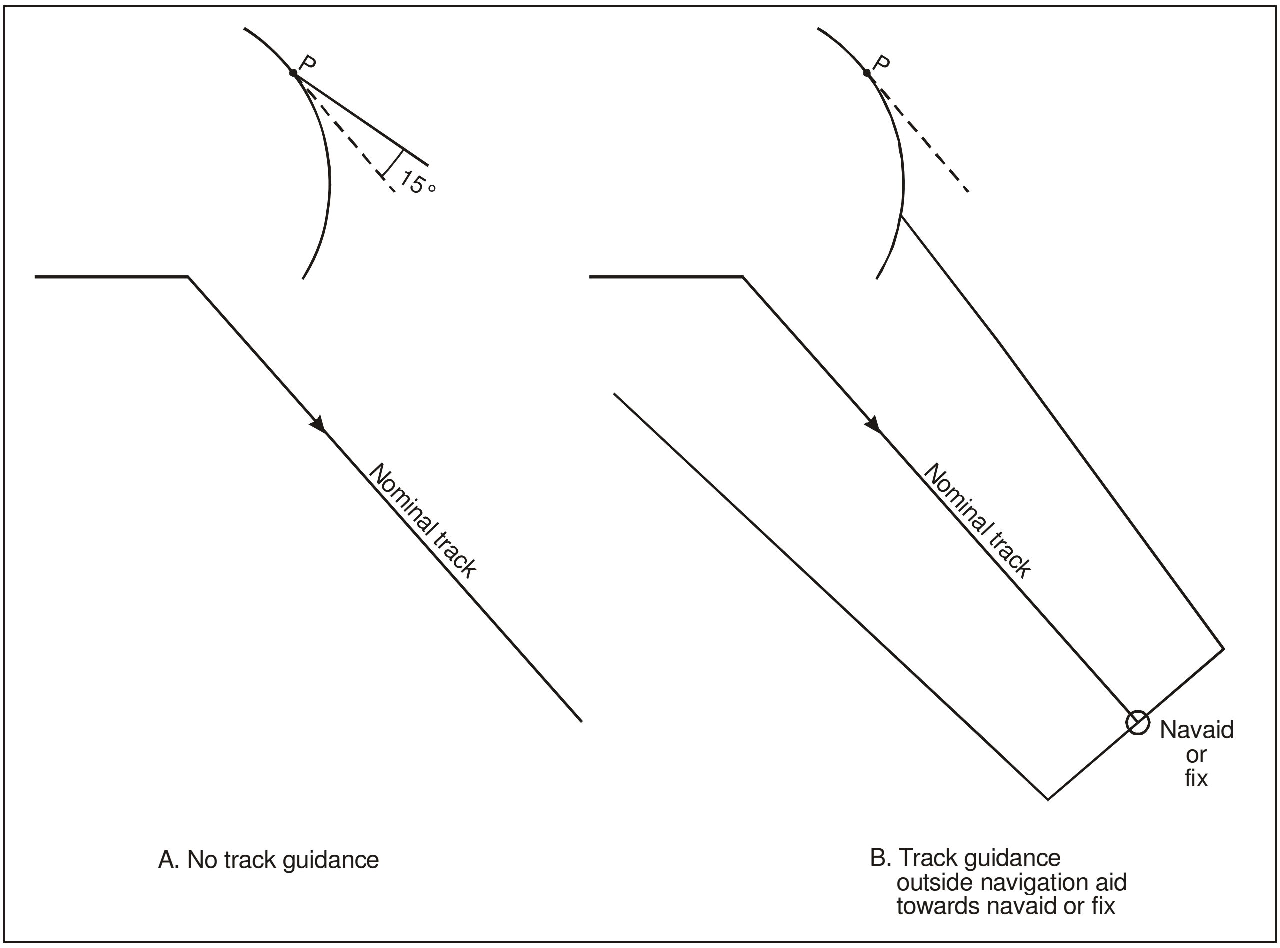


Figure I-2-3-3 a) and b) Turn outer boundary construction after Point P

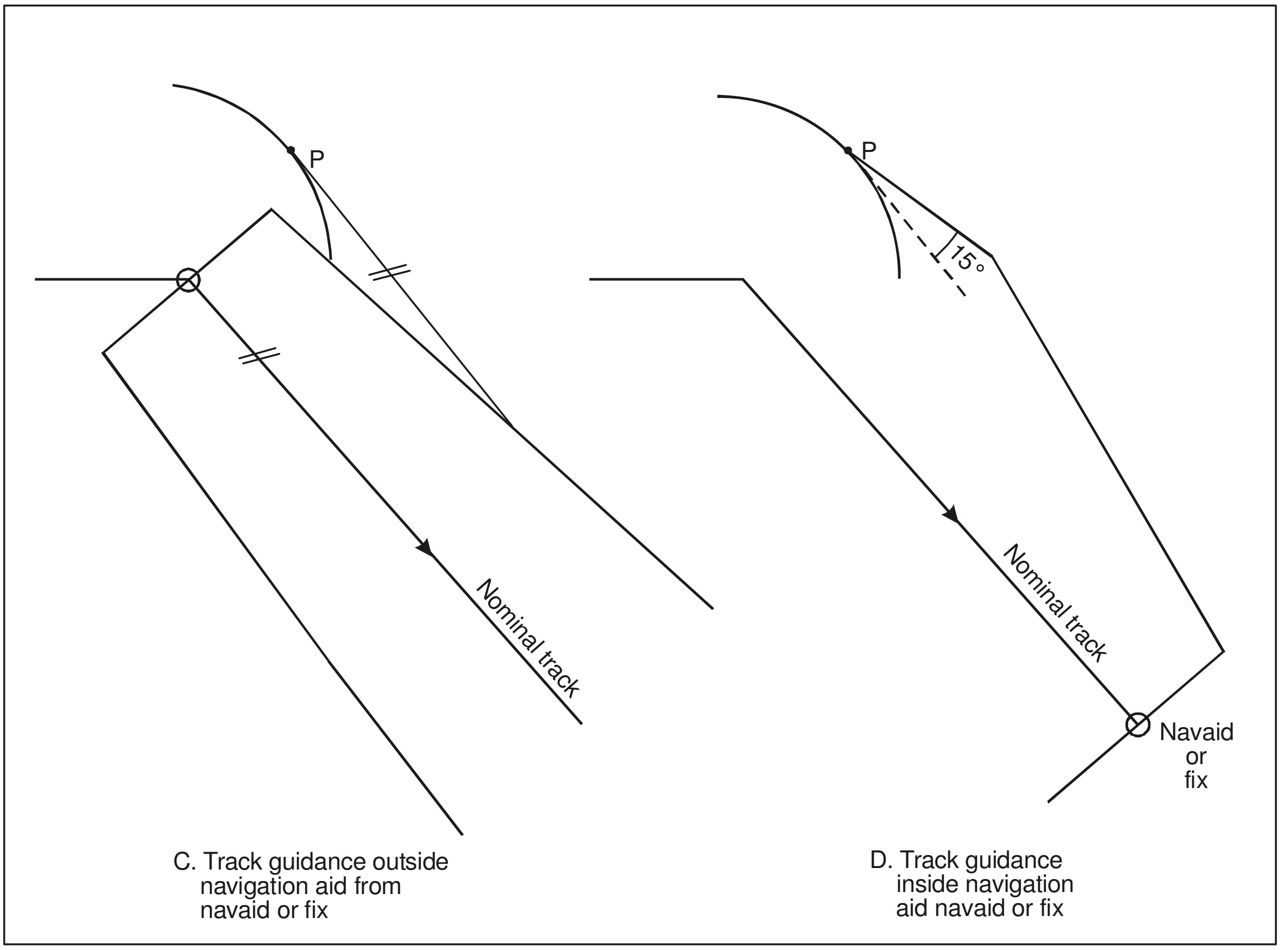
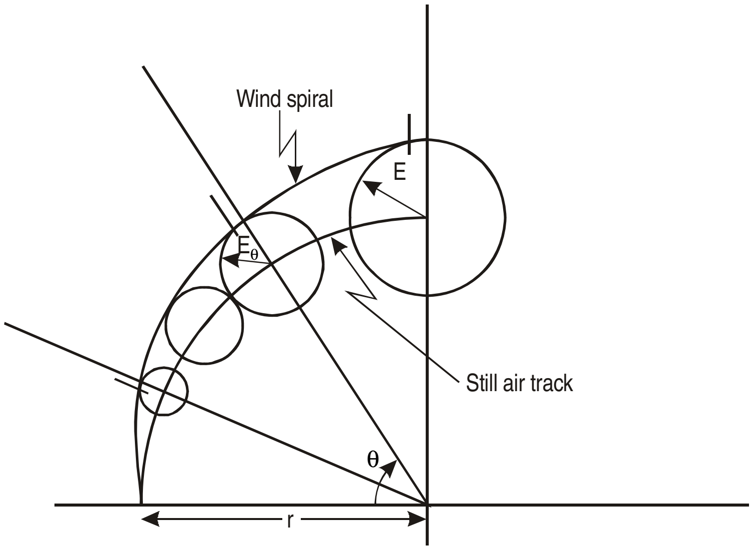


Figure I-2-3-3 c) and d) Track guidance outside navigation aid from navaid or fix/ Track guidance inside navigation aid or fix



r is the still air radius of turn in km (NM)
E_θ is the wind effect for the time taken to change heading by θ degrees

$E_\theta = \frac{\theta}{R} \times \frac{w}{3\,600}$ km (NM) where R is the rate of turn in °/s and w the wind speed in km/h (kt)

Figure I-2-3-4 Wind spiral

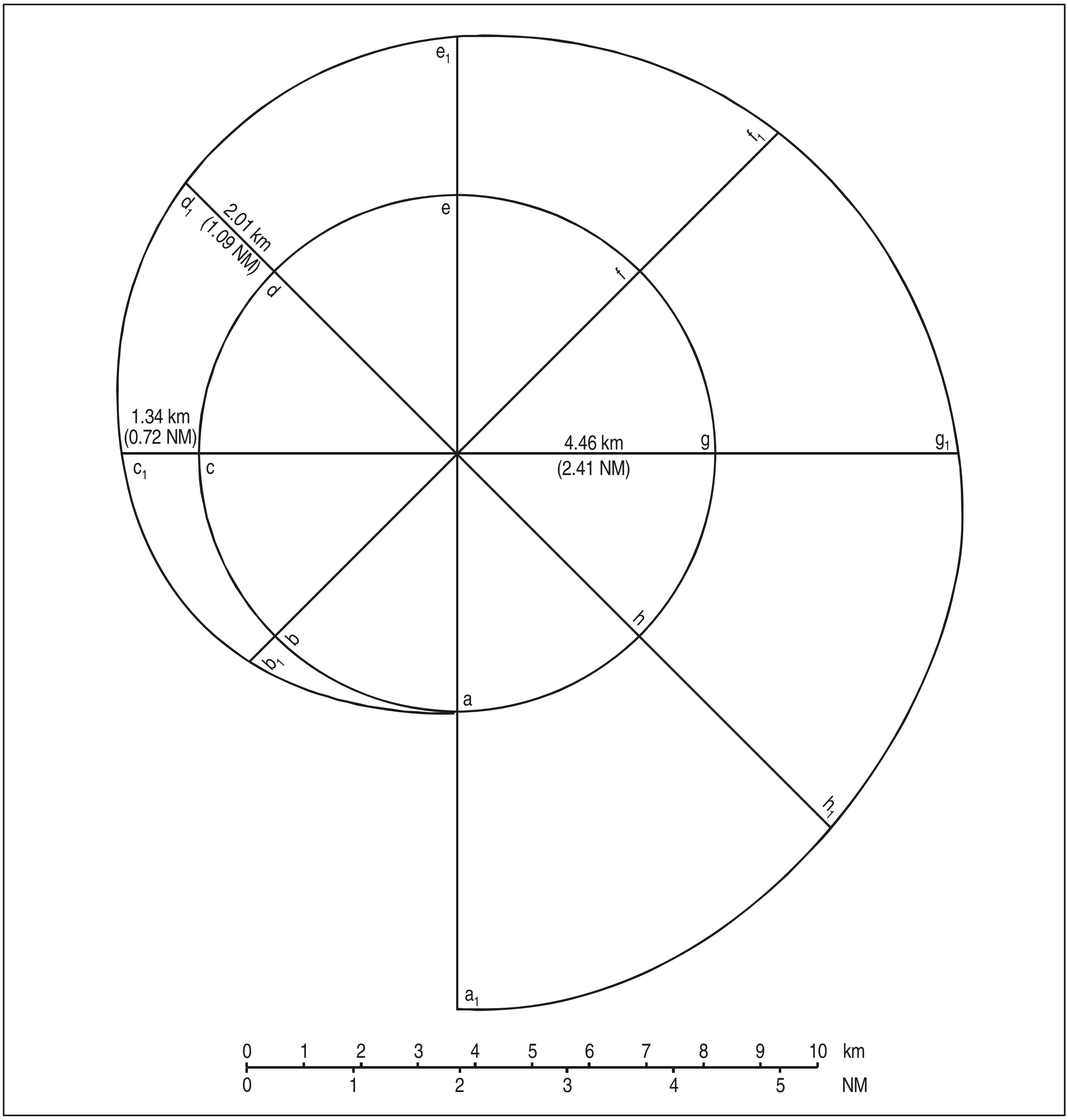


Figure I-2-3-5 Template for plotting omnidirectional wind (wind spiral)

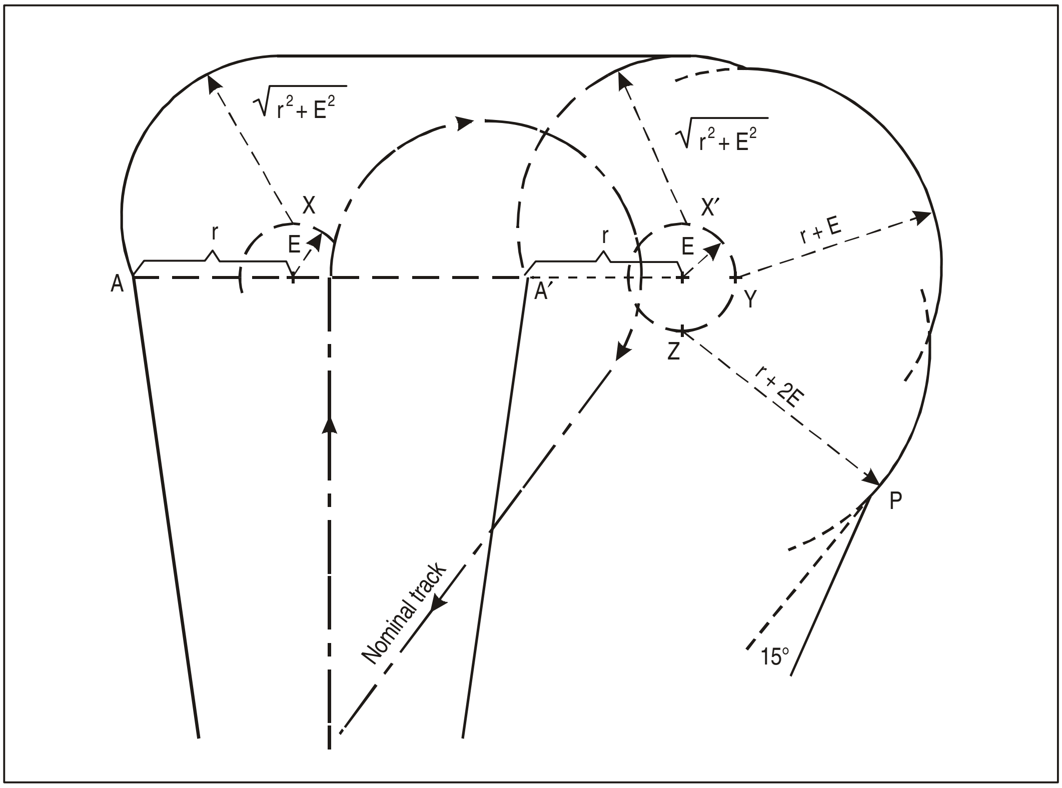


Figure I-2-3-6 Outer turn boundary construction

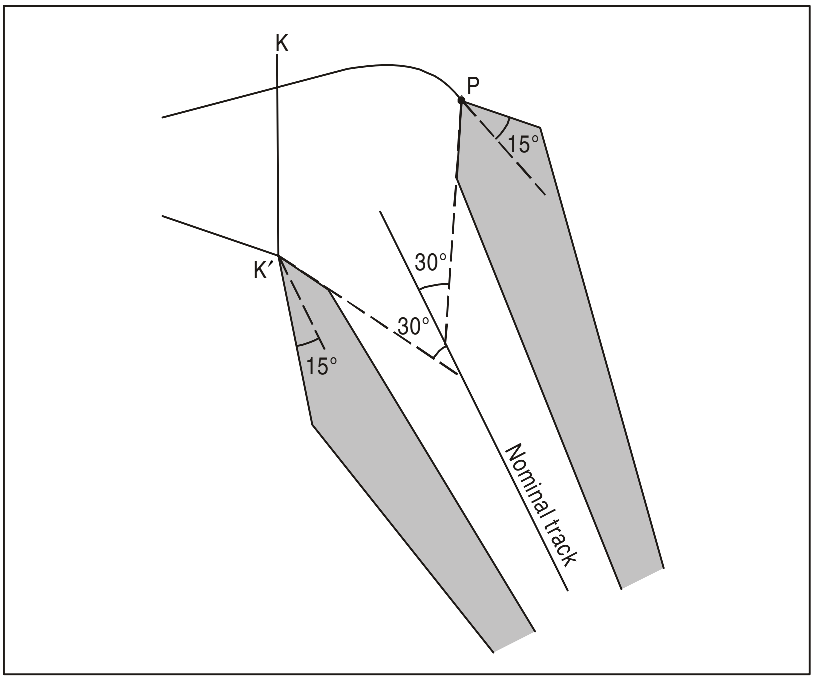


Figure I-2-3-7 Connection of secondary areas with additional track guidance

Section 3

DEPARTURE PROCEDURES

Chapter 1

INTRODUCTION TO DEPARTURE PROCEDURES

1.1 GENERAL

A departure procedure designed in accordance with this section provides obstacle clearance immediately after take-off until the aircraft intercepts an en-route segment. Departure procedures include, but are not limited to, standard departure routes and associated procedures (Annex 11, Appendix 3).

1.2 CONSULTATION

A departure procedure may also be required for air traffic control, airspace management or other reasons (e.g. noise abatement) and the departure route or procedure may not be determined by obstacle clearance requirements alone. Departure procedures should be developed in consultation with the operators, ATC and other parties concerned. (See Volume I, Part I, Section 7 for noise abatement considerations.)

1.3 STANDARDIZATION

The specifications contained in this section are based on conventional navigation equipment and operating practices and have been formulated with a view to achieving a reasonable degree of standardization. Exceptions should be permitted only after joint consideration by the State authority and the operators concerned. For RNAV departures, refer also to the requirements in Part III.

1.4 ECONOMY

In the interest of efficiency and economy, every effort should be made to ensure that procedures are designed, consistent with safety, to minimize both the time taken in executing a departure and the airspace required.

1.5 ROUTES

Departure procedures may be published as specific routes (see Chapter 3) or as omnidirectional departures (see Chapter 4).

1.6 RELATED MATERIAL

For the construction of obstacle clearance areas associated with turns, reference should be made to the standard techniques contained in Section 2, Chapter 3, "Turn area construction". Navigation aid characteristics and fix tolerances are specified in Section 2, Chapter 2, "Terminal area fixes".

1.7 ABNORMAL AND EMERGENCY OPERATIONS

1.7.1 The design of procedures in accordance with this section assumes normal operations and that all engines are operating.

1.7.2 It is the responsibility of the operator to conduct an examination of all relevant obstacles and to ensure that the performance requirements of Annex 6 are met by the provision of contingency procedures for abnormal and emergency operations. Where terrain and/or obstacle considerations permit, the contingency procedure routing should follow that of the departure procedure.

1.7.3 It is the responsibility of the State to make available the obstacle information described in Annexes 4 and 6, and any additional information used in the design of departures in accordance with this Section.

Chapter 2

GENERAL CONCEPTS FOR DEPARTURE PROCEDURES

2.1 ESTABLISHMENT OF A DEPARTURE PROCEDURE

2.1.1 For each runway at aerodromes where instrument departures are expected to be used, a departure procedure shall be established and promulgated.

2.1.2 A departure procedure should be designed to accommodate all aircraft categories where possible. Where departures are limited to specific categories, the departure chart shall clearly identify the applicable categories. (See Section 4, Chapter 1, 1.8.7, "Restrictions on category and IAS").

2.2 DESIGN PRINCIPLES

2.2.1 Departures may be designed as straight departures or turning departures (see Chapter 3).

2.2.2 An omnidirectional departure procedure may be designed that permits a turn in any direction after reaching a specified altitude/height (see Chapter 4).

2.2.3 A straight departure may permit a turn of 15° or less.

2.2.4 An aircraft will maintain the runway direction until reaching a minimum height of 120 m (294 ft) (Cat H, 90 m (295 ft)) above the runway/FATO before commencing a turn.

2.2.5 A turning departure will specify a turn either at a turn point or an altitude/height.

2.2.6 The standard procedure design gradient (PDG) is 3.3 per cent (Cat H, 5.0 per cent). The PDG begins at a point 5 m (16 ft) above the departure end of the runway (DER).

2.2.7 The standard PDG provides an additional clearance of 0.8 per cent of the distance flown from the DER, above an obstacle identification surface (OIS). The OIS has a gradient of 2.5 per cent (Cat H, 4.2 per cent).

2.2.8 Where an obstacle penetrates the OIS, a steeper PDG may be promulgated to provide obstacle clearance of 0.8 per cent of the distance flown from the DER.

2.2.9 Before any turn greater than 15° may be executed, a minimum obstacle clearance of 90 m (295 ft) (Cat H, 80 m (265 ft)) must be reached. Alternatively, 0.8 per cent of the distance from the DER may be used, if this value is higher. This minimum obstacle clearance must be maintained during subsequent flight.

2.3 BEGINNING OF THE DEPARTURE PROCEDURE

2.3.1 Aeroplanes

2.3.1.1 For aeroplanes the departure procedure begins at the departure end of the runway (DER), which is the end of the area declared suitable for take-off (i.e. the end of the runway or clearway as appropriate.)

2.3.1.2 Since the point of lift-off will vary, and in order to protect for turns prior to the DER, the protected area begins at a point 600 m from the start of runway. This is based on the assumption that the minimum turn height of 120 m (394 ft) above the elevation of the DER could be reached 600 m from the start of runway.

Note.— The elevation of the DER is the elevation of the end of the runway or the elevation of the end of the clearway, whichever is higher.

2.3.2 Helicopters

2.3.2.1 For helicopters, the departure procedure begins at the departure end of the runway (DER). The DER is the end of the area declared suitable for take-off (i.e. end of the runway or clearway or the end of the final approach and take-off (FATO) area).

2.3.2.2 To account for the climb performance of helicopters, and to protect for early turns, the protected area commences at the beginning of the runway or area available for take-off based on the assumption that the minimum turn height of 90 m (295 ft) above the elevation of the DER could be reached overhead the start of takeoff (see Figure II-3-2-1).

Note.— The elevation of the DER is the higher of the elevations of the beginning and end of the runway/FATO.

2.4 END OF THE DEPARTURE PROCEDURE

The departure procedure ends at the point where the PDG reaches the minimum altitude/height authorized for the next phase of flight (i.e. en-route, holding or approach).

2.5 MINIMUM OBSTACLE CLEARANCE (MOC)

2.5.1 The minimum obstacle clearance (MOC) in the primary area is 0.8 per cent of the distance flown from the DER. The MOC is zero at the DER.

2.5.2 The MOC is provided above an obstacle identification surface or, where an obstacle penetrates the OIS, above the elevation of the obstacle.

2.5.3 In addition to the above prior to the commencement of a turn of more than 15 degrees, MOC of 90 m (295 ft) (Cat H, 80 m (265 ft)) is required.

2.5.4 Where mountainous terrain is a factor, consideration shall be given to increasing the minimum obstacle clearance (see Section 2, Chapter 1, 1.7, “Increased altitudes/heights for mountainous areas”).

2.6 OBSTACLE IDENTIFICATION SURFACE (OIS)

2.6.1 The obstacle identification surface (OIS) is a sloping surface used to identify obstacles in the departure area. For straight departures the origin of the OIS is 5 m (16 ft) above the DER. For omnidirectional departures several OIS are considered as described in Chapter 4, “Omnidirectional Departures.” The OIS gradient is 2.5 per cent (Cat H, 4.2 per cent).

2.6.2 Survey of OIS

2.6.2.1 The OIS should be surveyed at regular intervals to validate obstacle information so that the minimum obstacle clearance is assured and the integrity of departure procedures is safeguarded. The competent authority should be notified whenever an object is erected that penetrates the OIS.

Note.— Yearly checks are considered to meet the requirement for “regular intervals.”

2.6.2.2 Distances to obstacles should be referenced to the DER.

2.7 PROCEDURE DESIGN GRADIENT (PDG)

2.7.1 The procedure design gradient (PDG) is the published climb gradient measured from the origin of the OIS (5 m (16 ft) above DER). Provided no obstacles penetrate the OIS the procedure design gradient (PDG) is the OIS gradient plus 0.8 per cent. (3.3 per cent, Cat H 4.2 per cent).

2.7.2 Where the 2.5 per cent OIS is penetrated, the departure route should be adjusted to avoid the penetration. If this is not possible then the PDG may be increased to provide the minimum obstacle clearance above the penetration (0.8 per cent of the distance from the DER). (See Figure I-3-2-2.)

2.7.3 A PDG in excess of 3.3 per cent and the altitude to which the increased gradient extends shall be promulgated.

2.7.4 Where the PDG is increased to avoid a penetrating obstacle, the PDG shall be reduced to 3.3 per cent at the point past the critical obstacle where obstacle clearance of 0.8 per cent of the distance from the DER can be provided. (See Figure I-3-2-2.)

2.7.5 An increased gradient that is required to a height of 60 m (200 ft) or less, (normally due to low, close-in obstacles) shall not be promulgated (see Figure I-3-2-3). The position and elevation/height of close-in obstacles penetrating the OIS shall be promulgated (see Chapter 5, “Published information for departure procedures”).

2.8 AVERAGE FLIGHT PATH

2.8.1 When close conformance to the nominal track is important (for noise abatement/ATC constraints, etc.), actual flight track data may be used to determine the average flight path.

2.8.2 Guidance material (based on statistical data) on how to establish an average flight path is given in Chapter 3, Appendix. The aircraft performance used to determine the average flight path must not be used for obstacle clearance calculation purposes.

2.9 CHARTING ACCURACY

Charting accuracy must be taken into account by applying vertical and horizontal tolerances, as described in Section 2, Chapter 1, 1.8, "Charting accuracy". When the application of these tolerances creates an unacceptable operational penalty, additional survey information should be used to refine the obstacle location and height data.

2.10 ADDITIONAL SPECIFIC HEIGHT/DISTANCE INFORMATION

Whenever a suitably located DME exists, or when suitably located RNAV fixes can be established, additional specific height/distance information intended for obstacle avoidance should be published in order to provide a means of monitoring aircraft position relative to critical obstacles.

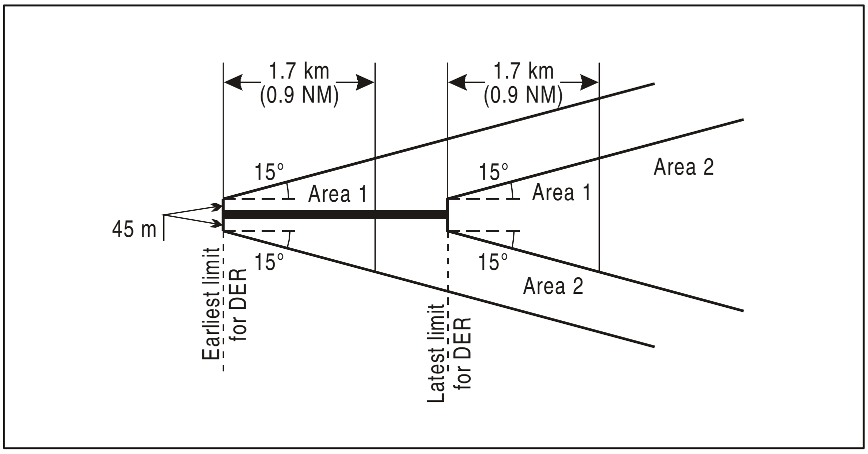


Figure I-3-2-1. Beginning of the departure procedure — helicopters

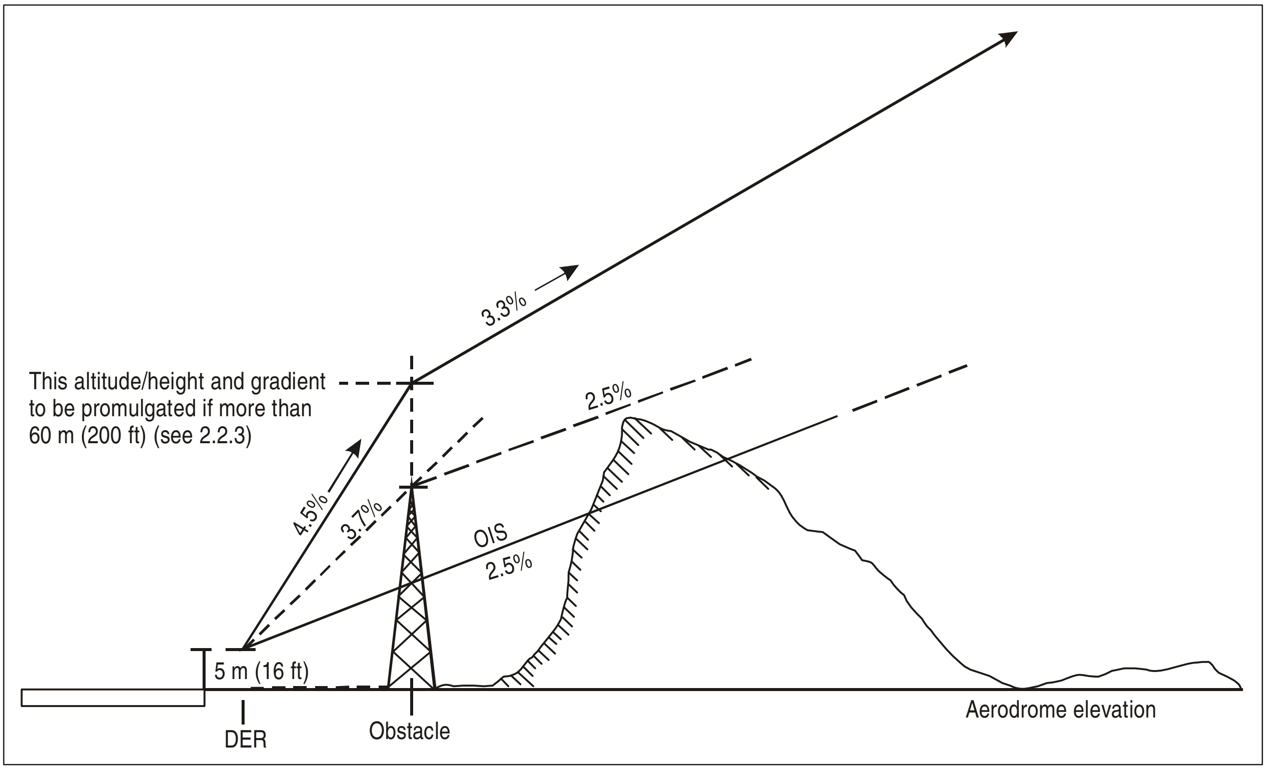


Figure I-3-2-2. Procedure design gradient

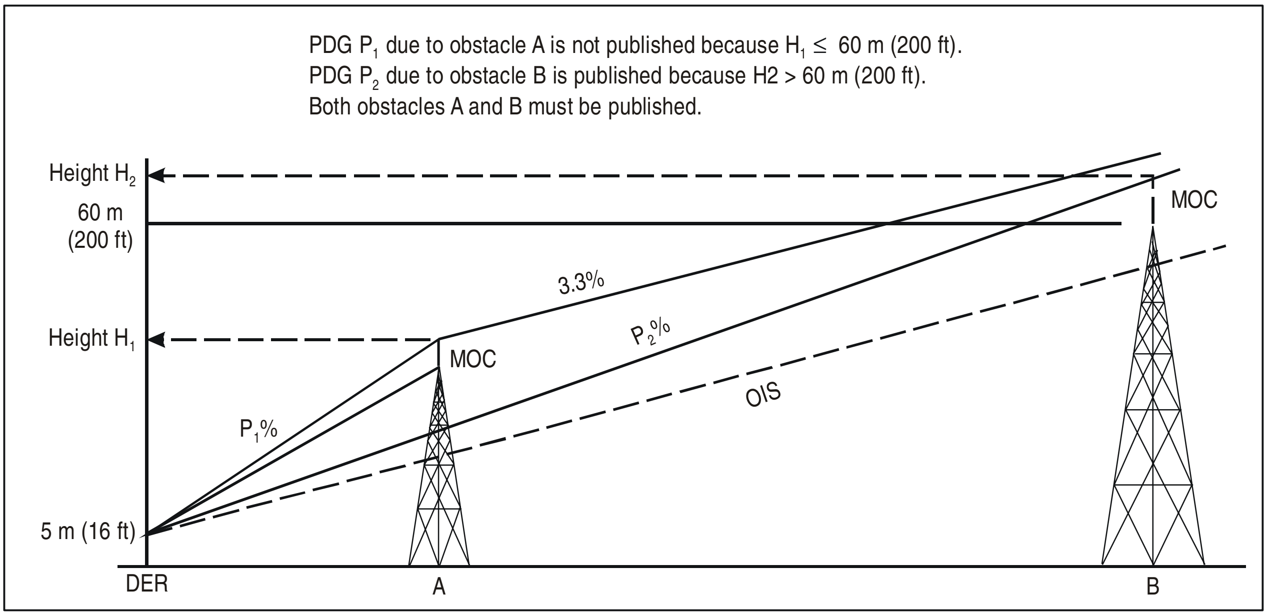


Figure I-3-2-3. Close-in obstacles

Chapter 3

DEPARTURE ROUTES

3.1 GENERAL

3.1.1 There are two basic types of departure route: straight and turning.

3.1.2 Track guidance shall be provided:

a) within 20.0 km (10.8 NM) from the departure end of the runway (DER) for straight departures; and

b) within 10.0 km (5.4 NM) after completion of turns for turning departures.

3.1.3 Surveillance radar may be used to provide track guidance.

3.2 STRAIGHT DEPARTURES

3.2.1 General

3.2.1.1 A departure in which the initial departure track is within 15° of the alignment of the runway centre line is a straight departure. Wherever practical, the departure track should be the extended runway centre line (see Figure I-3-3-1).

3.2.1.2 For helicopters, the departure track must intersect the runway centre line within 1.7 km (0.9 NM) from the DER, or the departure track must be within 90 m laterally from the runway centre line at the DER.

3.2.2 Types of straight departure

Straight departures are divided into two main categories, depending upon the availability of initial track guidance:

a) straight departure without track guidance:

   1) departure with no track adjustment;

   2) departure with track adjustment (track adjustment point not specified); and

   3) departure with track adjustment (track adjustment point specified); and

b) straight departure with track guidance:

   1) facility ahead or behind; and

   2) offset (track parallel/track offset/track crossing).

3.2.3 Track adjustment

In the construction of areas it is assumed that any track adjustments will take place no further along the track than a point at which the PDG reaches 120 m (394 ft) (Cat H, 90 m (295 ft)) above the elevation of the DER, or at a specified track adjustment point.

3.2.4 Straight departure without track guidance

3.2.4.1 *Departure with no track adjustment*

The area begins at the DER and has an initial width of 300 m (Cat H, 90 m). It is centred on the runway centre line and splays at an angle of 15° on each side of the extended runway center line (see Figure I-3-3-1). The area terminates at the end of the departure procedure as specified in Chapter 2, 2.4, "End of the departure procedure."

3.2.4.2 *Departure with track adjustment*

3.2.4.2.1 The initial departure track may be adjusted by 15° or less. When adjusted, the splay of the area boundary on the side of the track adjustment is increased by the track adjustment angle, starting at the DER.

3.2.4.2.2 On the side opposite the track adjustment, the boundary is adjusted by the same amount at a point where the PDG reaches 120 m (394 ft) (Cat H, 90 m (295 ft)). This distance is nominally 3.5 km/1.9 NM (Cat H, 1.7 km/0.9 NM) from the DER for a 3.3 per cent PDG (Cat H, 5.0 per cent) (see Figure I-3-3-2).

3.2.4.2.3 *Track adjustment point specified.* If a track adjustment point is specified (see Figure I-3-3-3):

a) the splay of the area boundary on the side of the track adjustment is increased by the track adjustment angle, from the earliest tolerance of the track adjustment point; and

b) the splay of the area boundary on the side opposite the track adjustment is reduced by the track adjustment angle from the latest tolerance of the track adjustment point.

3.2.5 Straight departure with track guidance

3.2.5.1 *General*

The area is constructed as described in 3.2.4, "Straight departure without track guidance" and extended to the point where the boundaries intercept the area associated with the navigation aid providing the track guidance (see Figures I-3-3-4 to I-3-3-8).

3.2.5.2 *Areas associated with a navigation aid*

The areas associated with a navigation aid other than a localizer consist of appropriate portions of the trapezoids specified in Part II, Section 2, Chapters 4 and 6. The general principle of secondary areas is applied.

3.3 TURNING DEPARTURES

3.3.1 General

3.3.1.1 A departure incorporating a turn of more than 15° is a turning departure. Turns may be specified at an altitude/height, or at a fix or at a facility.

3.3.1.2 Straight flight is assumed until reaching a height of at least 120 m (394 ft) (Cat H, 90 m (295 ft)) above the elevation of the DER. No provision is made for turning departures which require a turn below 120 m (394 ft) (Cat H, 90 m (295 ft)) above the elevation of the DER. Where the location and/or height of obstacles makes it impossible to construct turning departures which satisfy the minimum turn height criterion, departure procedures should be developed on a local basis in consultation with the operators concerned.

3.3.1.3 The areas considered in the design of turning departures are defined as:

a) the turn initiation area; and

b) the turn area.

The turn initiation area is an area within which the aircraft conducts a straight climb in order to reach the MOC required prior to the beginning of a turn (90 m (295 ft) (Cat H, 80 m (265 ft)). The turn area is the area in which the aircraft is considered to be turning.

3.3.2 Turn initiation area

3.3.2.1 For aeroplanes, the turn initiation area starts at a point 600 m from the start of runway. For helicopters the turn initiation area starts at the beginning of the area available for runway or the start of runway. From the start of the turn initiation area to the DER, the area is 300 m wide (Cat H, 90 m).

3.3.2.2 Where the departure chart prohibits turns prior to the DER the turn initiation area starts at the DER. For helicopters, an earliest limit for a turning departure may be located at an appropriate position along the runway/FATO.

3.3.2.3 The turn initiation area terminates at the TP. The TP may be defined by:

a) the earliest fix tolerance of the TP fix (turn at designated turn point); or

b) the position at which the PDG reaches the specified turn altitude/height.

3.3.2.4 The TP may be located no closer to the DER than the distance required at the PDG to reach the higher of 120 m (394 ft) (Cat H, 90 m (295 ft)) or the specified turn altitude/height. The turn initiation area is identical to the area associated with a straight departure with no track guidance as described in 3.2.4, "Straight departure without track guidance."

(See Figures I-3-3-9 and I-3-3-10.)

3.3.3 Turn area

The turn area is constructed in the same manner as the turning missed approach area (see Section 4, Chapter 6, 6.4, "Turning missed approach"). The inner and outer boundaries of the turn area are constructed as specified in 3.2, "Turn inner boundary construction" and 3.3, "Turn outer boundary construction" in Section 2, Chapter 3, "Turn area construction".

3.3.4 Turn parameters

The parameters on which turn areas are based are:

a) altitude:

   1) *turn designated at an altitude/height:* turn altitude/height;

   2) *turn at a designated turning point:* aerodrome elevation plus 10 per cent of the distance from the DER to the TP (i.e. allowing for a 10 per cent climb);

b) *temperature:* ISA + 15°C corresponding to a) above;

c) *indicated airspeed:* the speed tabulated for "final missed approach" in Section 4, Chapter 1, Tables I-4-1-1 and I-4-1-2 for the applicable aircraft category, increased by 10 per cent to account for increased aircraft mass at departure. However, where operationally required to avoid obstacles, reduced speeds not less than 1.1 times the IAS tabulated for "intermediate missed approach" in Section 4, Chapter 1, Tables I-4-1-1 and I-4-1-2 may be used, provided the procedure is annotated "Departure turn limited to __________ km/h (kt) IAS maximum". In order to verify the operational effect of a speed limitation, the speed should be compared with the statistical speed as published in the Appendix to Chapter 3.

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

e) *wind:* maximum 95 per cent probability wind on an omnidirectional basis, where statistical wind data are available. Where no wind data are available, an omnidirectional 56 km/h (30 kt) wind should be used;

f) *bank angle:* 15° average achieved;

g) *fix tolerance:* as appropriate for the type of fix;

h) *flight technical tolerances:* a distance equivalent to 6 seconds of flight (3 second pilot reaction and 3 second bank establishing time) at the specified speed. (See c) above. This value is represented by the letter c in this chapter); and

i) *secondary areas:* secondary areas are applied where track guidance is available.

3.3.5 Turn at a specified altitude/height

3.3.5.1 *General*

A turn may be prescribed upon reaching a specified altitude/height to accommodate the situation where there is:

a) an obstacle located in the direction of the straight departure that must be avoided; and/or

b) an obstacle located abeam the straight departure track that must be overflown after the turn.

3.3.5.2 *Turning altitude or height calculations*

A turn altitude/height is selected which results in a turning point that ensures that the aircraft avoids the straight ahead obstacle or overflies the abeam obstacle with the required MOC. Turn height (TNH) is computed by:

$$TNH = d_r PDG + 5\text{ m } (16\text{ ft})$$

where: d_r is the horizontal distance from DER to the TP; and

PDG is the procedure design gradient.

3.3.5.3 *Obstacle clearance calculation*

a) *Turn initiation area.* The minimum obstacle clearance in the turn initiation area is calculated using the horizontal distance from the DER measured along the nominal track, at the design PDG. (See Chapter 2, 2.5, "Minimum obstacle clearance".) Note that a turn may be commenced at the specified turn altitude, and that normal aircraft performance will often result in this altitude being reached before the end of the turn initiation area (TP). Therefore, the minimum obstacle clearance for turning must also be provided above all obstacles in the turn initiation area. This criterion will be met if the maximum obstacle elevation in the turn initiation area is:

   1) maximum obstacle elevation/height = TNA/H – 90 m (295 ft) for aeroplanes; and

   2) maximum obstacle elevation/height = TNA/H – 80 m (265 ft) for helicopters.

b) *Turn area.* The minimum obstacle clearance in the turn area is calculated as follows.

   1) *Obstacles located before the TP (K-line).* MOC is the greater of the minimum MOC for turning (90 m (295 ft) (Cat H, 80 m/265 ft)) and 0.008 (d_r* + d_o) where:

   d_r* is the distance measured along the departure track corresponding to the point on the turn initiation area boundary where the distance d_o is measured, and

   d_o is the shortest distance from the turn initiation area boundary to the obstacle.

   2) *Obstacles located after the TP (K-line).* MOC is the greater of the minimum MOC for turning (90 m (295 ft) (Cat H, 80 m/265 ft)), and 0.008 (d_r + d_o) where:

   d_r is the horizontal distance from DER to the K-line, and

   d_o is the shortest distance from the turn initiation area boundary to the obstacle.

   See Figures I-3-3-9 and I-3-3-10.

   The maximum permissible elevation/height of an obstacle in the turn area can be computed by:

   Maximum obstacle elevation/height = TNA/H + d_o PDG – MOC

3.3.6 Turn at a designated TP

3.3.6.1 *General*

A designated TP is selected to allow the aircraft to avoid an obstacle straight ahead. The straight departure criteria apply up to the earliest TP.

3.3.6.2 *Turn point tolerance*

3.3.6.2.1 The longitudinal limits of the TP tolerance are:

a) earliest limit, the end of the turn initiation area (K-line); and

b) latest limit, determined by:

   1) K-line plus;

   2) TP fix tolerance plus; and

   3) flight technical tolerance *c,* where c is calculated in accordance with 3.3.4 h).

3.3.6.2.2 Where the TP is defined by passage over a navigation aid, the fix tolerance is computed at the elevation of the DER plus 10 per cent of the distance from the DER to the TP (i.e. allowing for a 10 per cent climb gradient). Where the TP is defined by a DME distance, the maximum angle that a line joining the TP and the DME may make with the nominal departure track shall not be more than 23°. (See Section 2, Chapter 2, 2.4.2, "Fixes for VOR or NDB with DME" and Figure I-2-2-1.)

3.3.6.3 *Construction*

a) *Inner boundary.* The inner boundary of the turn area is constructed in accordance with Section 2, Chapter 3, "Turn area construction".

b) *Outer boundary*. The outer boundary of the turn area:

   1) begins at the latest TP tolerance (see also Figures I-3-3-11, a) b) c) and d)); and

   2) continues along the wind spiral or bounding circles constructed in accordance with Section 2, Chapter 3, "Turn area construction"; and up to the point (P) where the tangent becomes parallel to the nominal track after the turn. Examples of turns with track guidance after the turn, flying to or from a facility are provided in Figures I-3-3-11 c) and d) respectively.

c) *For turns more than 90°* the area after the turn is constructed as shown on Figure I-3-3-12.

3.3.6.4 *Obstacle clearance in the turn area*

In order to ensure that the minimum obstacle clearance in the turn area has been provided, use the following equation to check the maximum height of an obstacle in the turn area above the elevation of the DER:

$$\text{Maximum height of obstacle} = PDG(d_r + d_o) + H - MOC$$

where: d_o = shortest distance from obstacle to line K-K (see Figure I-3-3-11 c)

d_r = horizontal distance from DER to line K-K (earliest TP)

PDG = promulgated procedure design gradient

H = OIS height at DER (5 m or 16 ft)

MOC = the greater of 0.008 ($d_r + d_o$) and 90 m (295 ft) (Cat H, 80 m (265 ft))

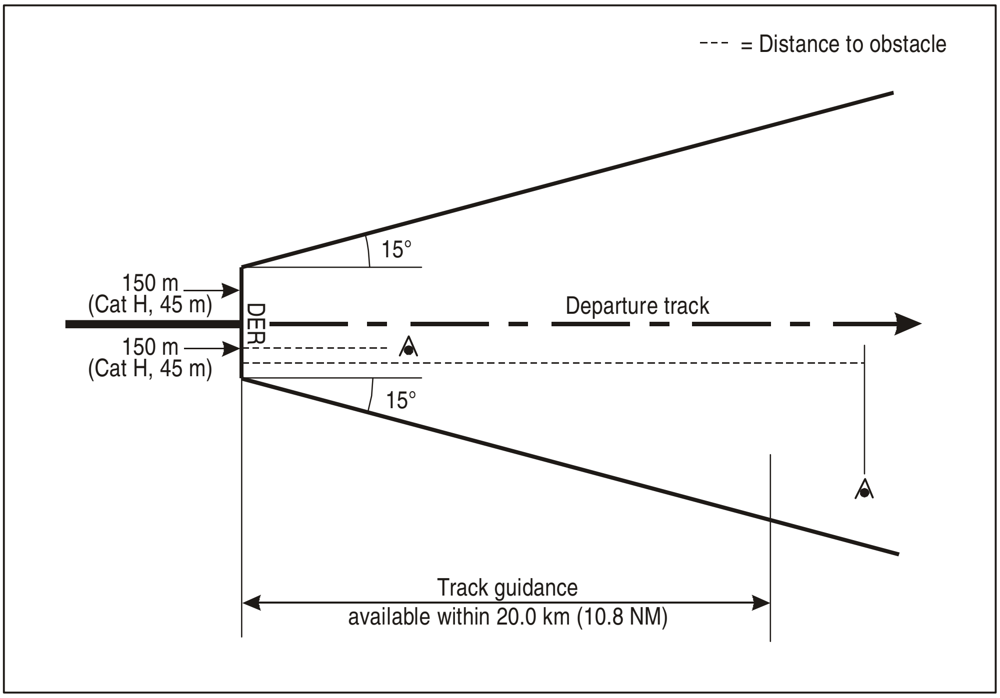


Figure I-3-3-1. Straight departure area without track guidance

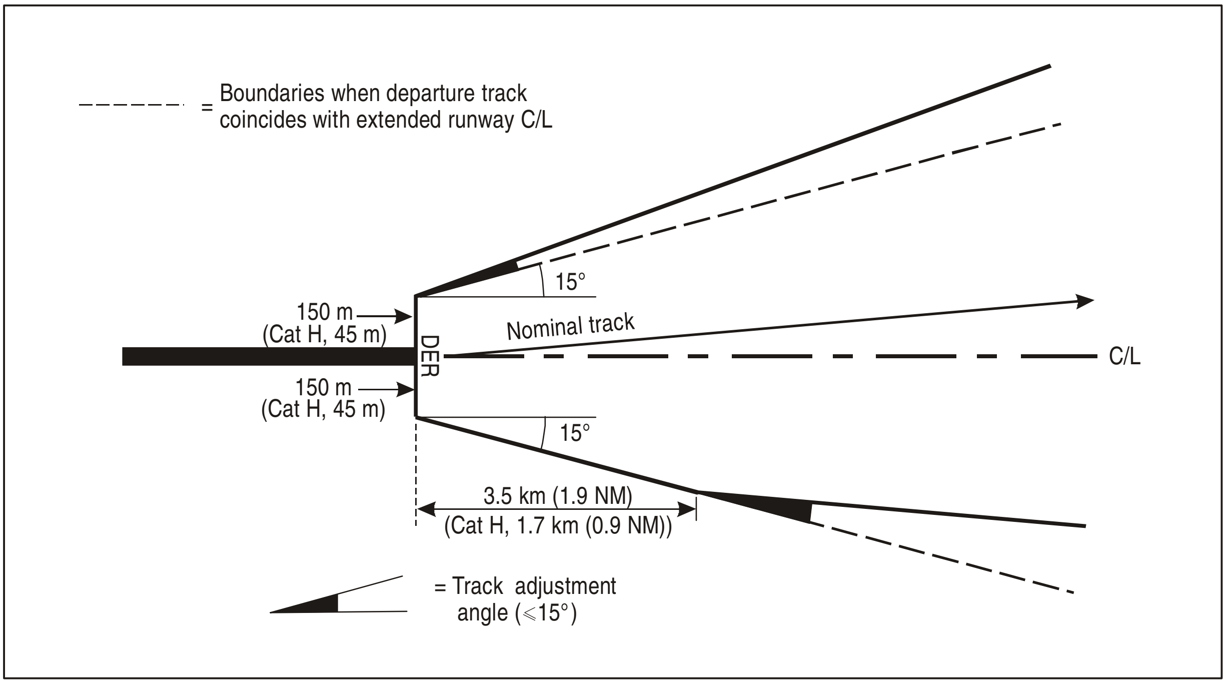


Figure I-3-3-2. Straight departure area with track adjustment (track adjustment point not specified)

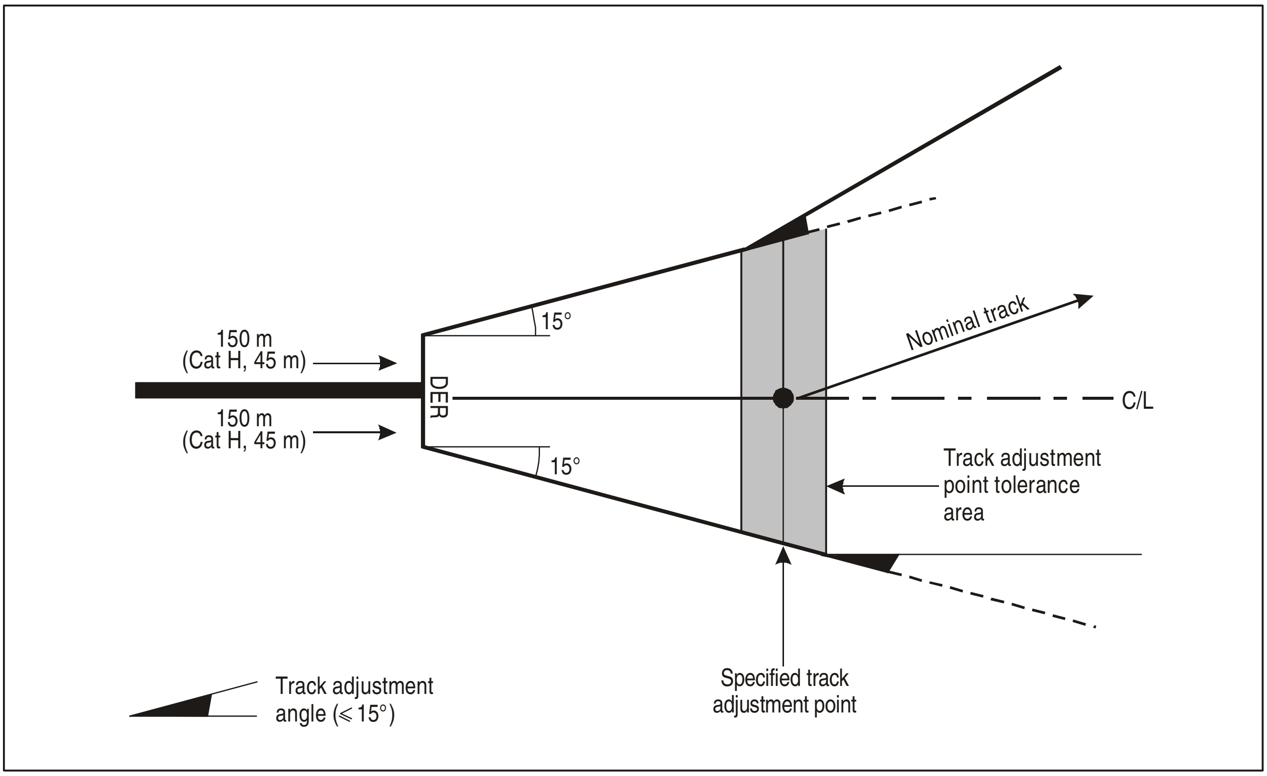


Figure I-3-3-3. Straight departure area with a specified track adjustment point

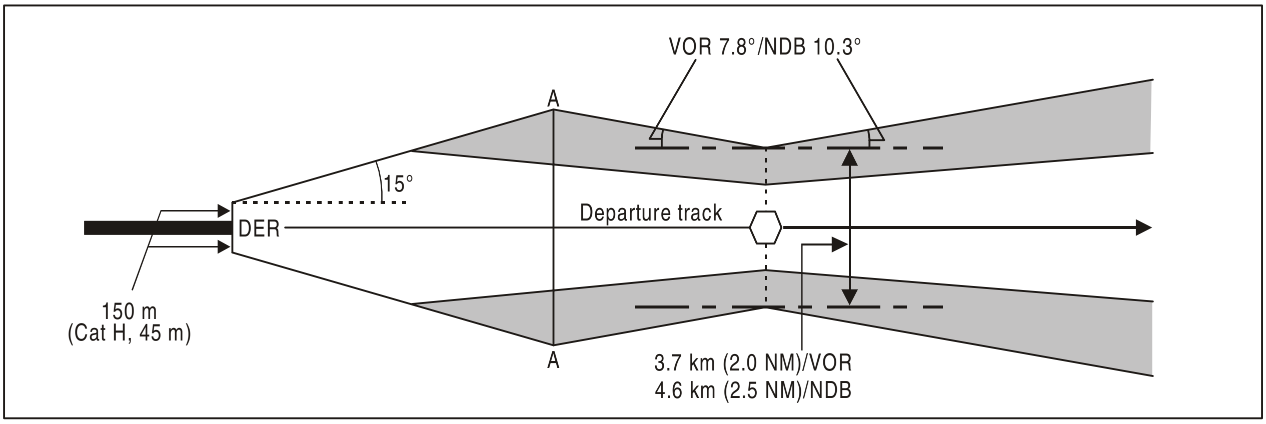


Figure I-3-3-4. Straight departure (facility ahead)

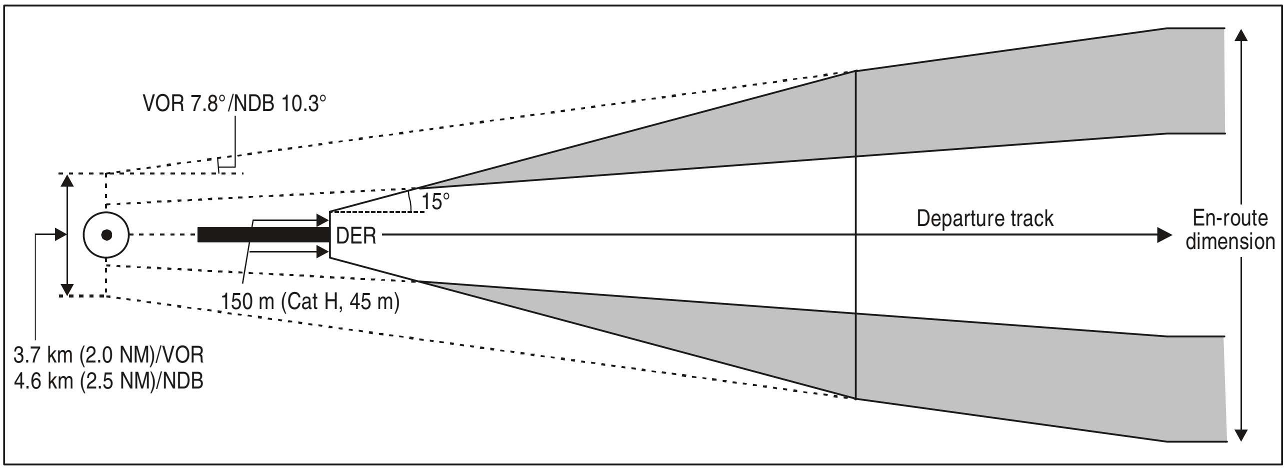


Figure I-3-3-5. Straight departure (facility behind)

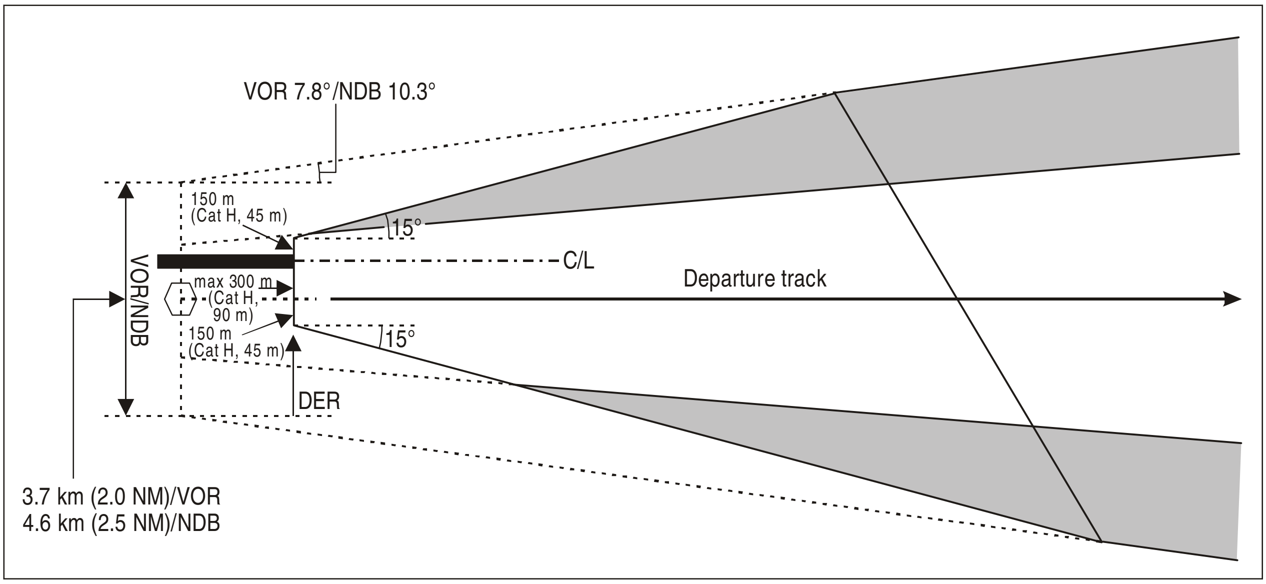


Figure I-3-3-6. Straight departure with offset departure track (track parallel to runway heading)

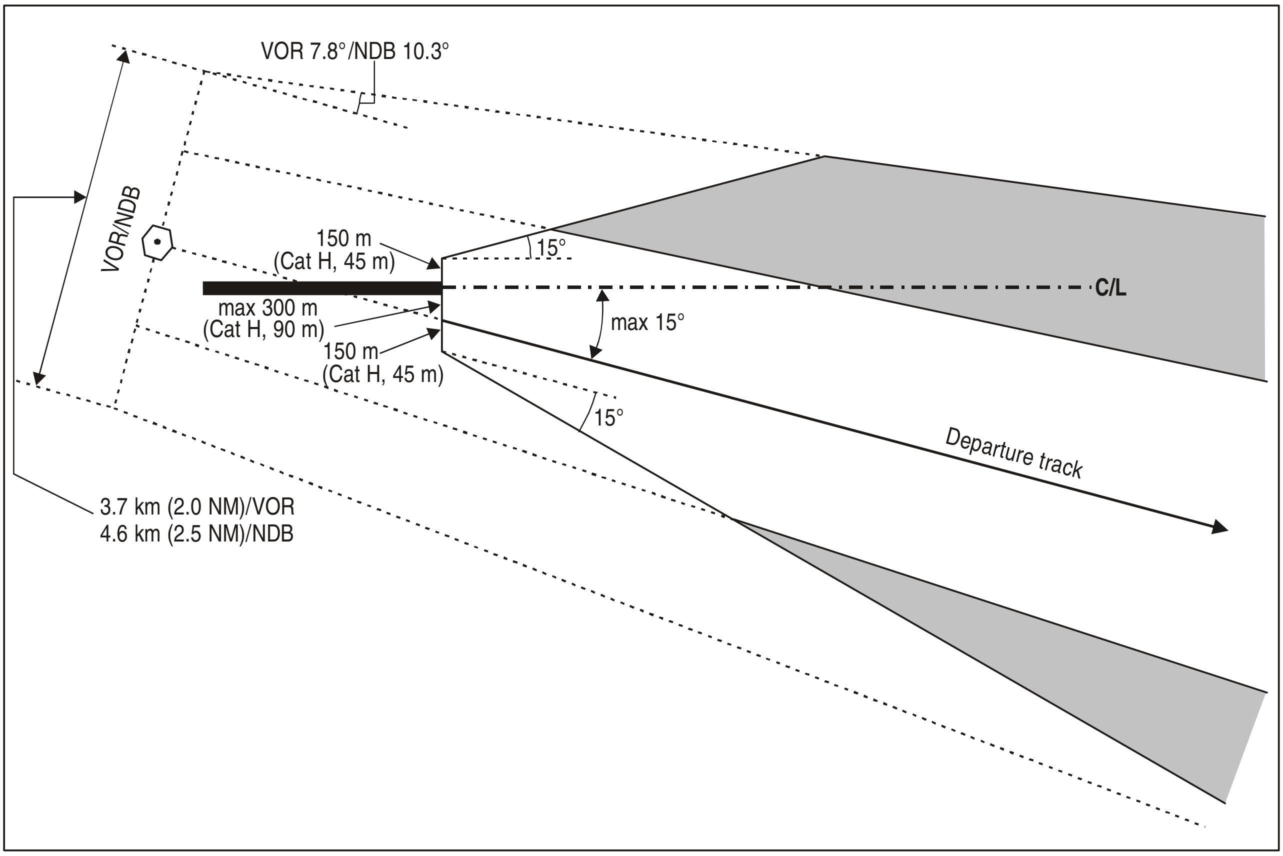


Figure I-3-3-7. Straight departure with offset departure track (track diverging from runway heading)

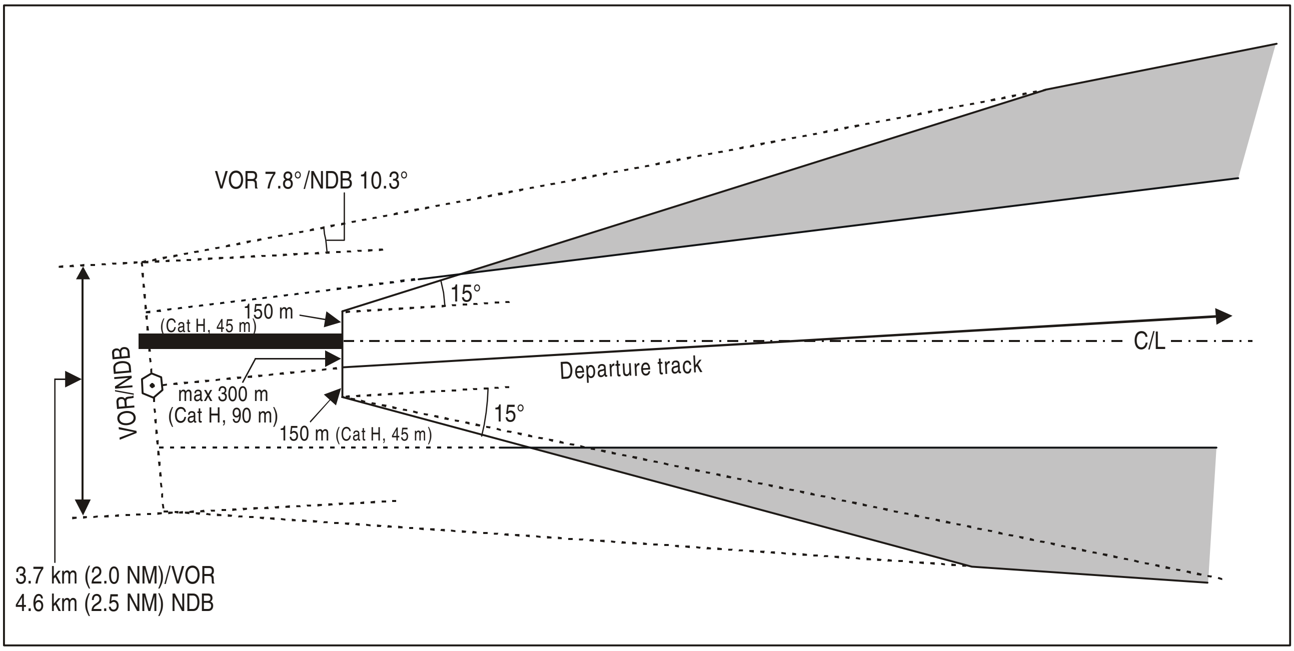


Figure I-3-3-8. Straight departure with offset departure track (track crossing runway heading)

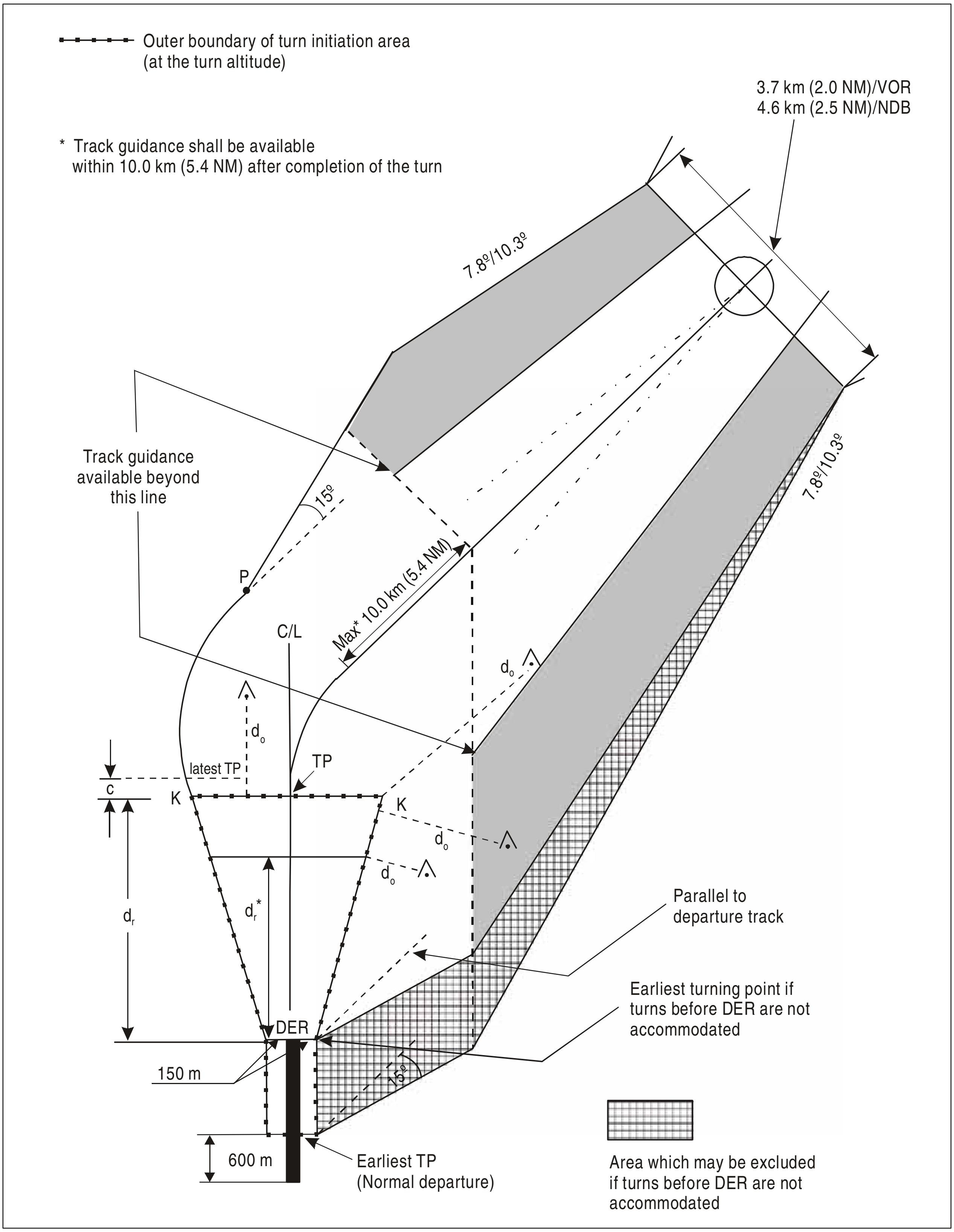


Figure I-3-3-9. Turning departure — turn at an altitude

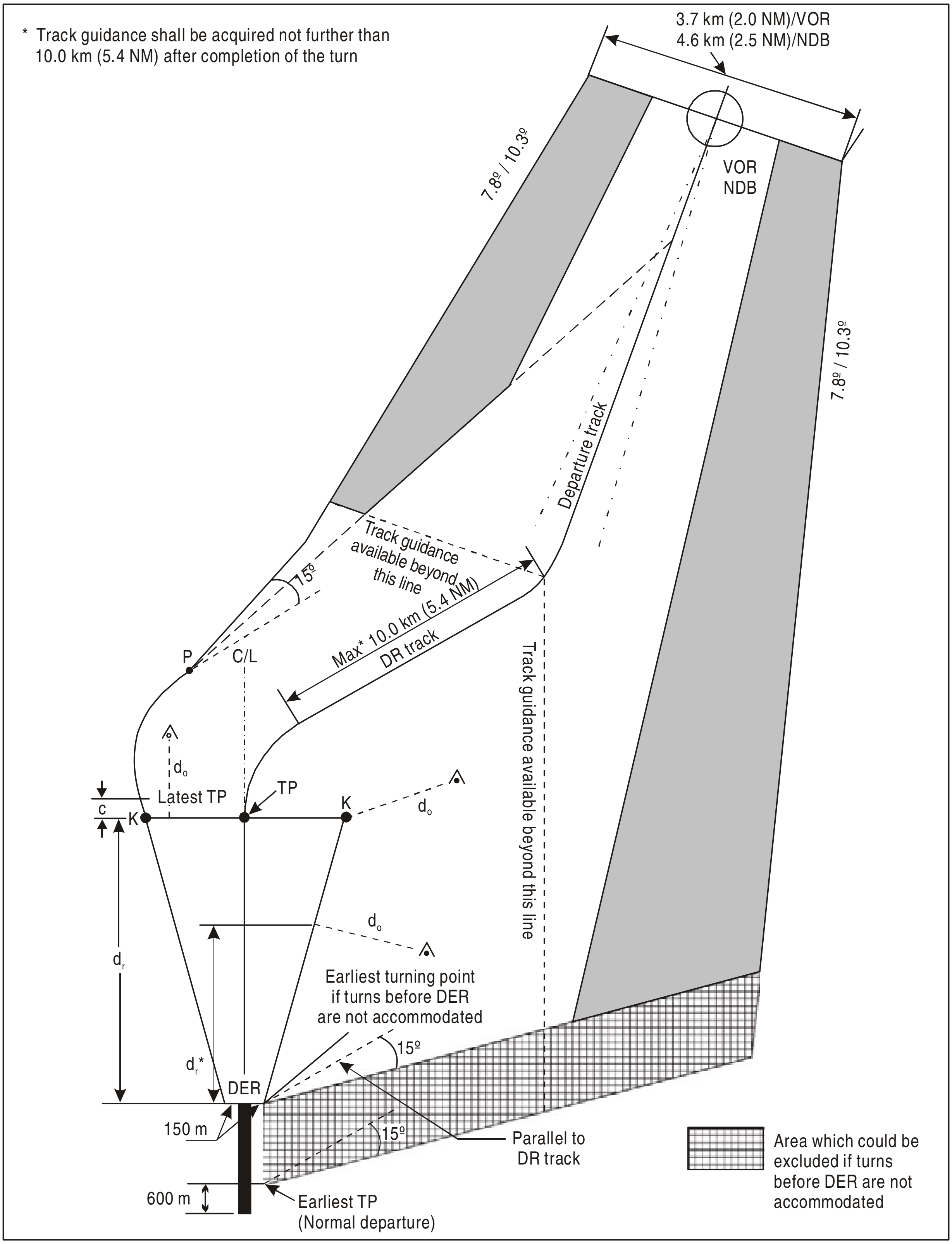


Figure I-3-3-10. Turning departure — turn at an altitude

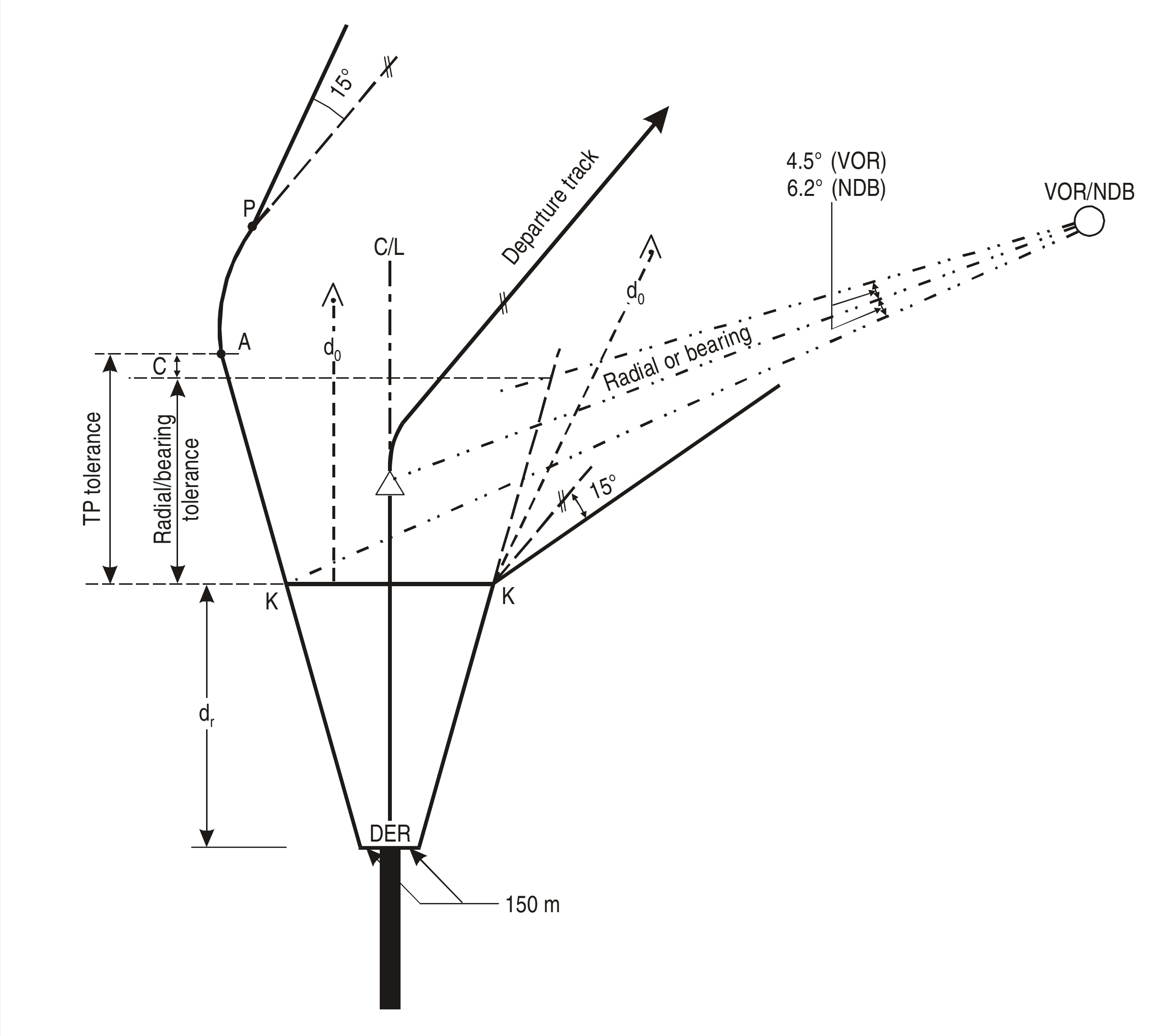


Figure I-3-3-11 a). Turning departure not overheading a facility — turning point tolerance area defined by intersecting radial

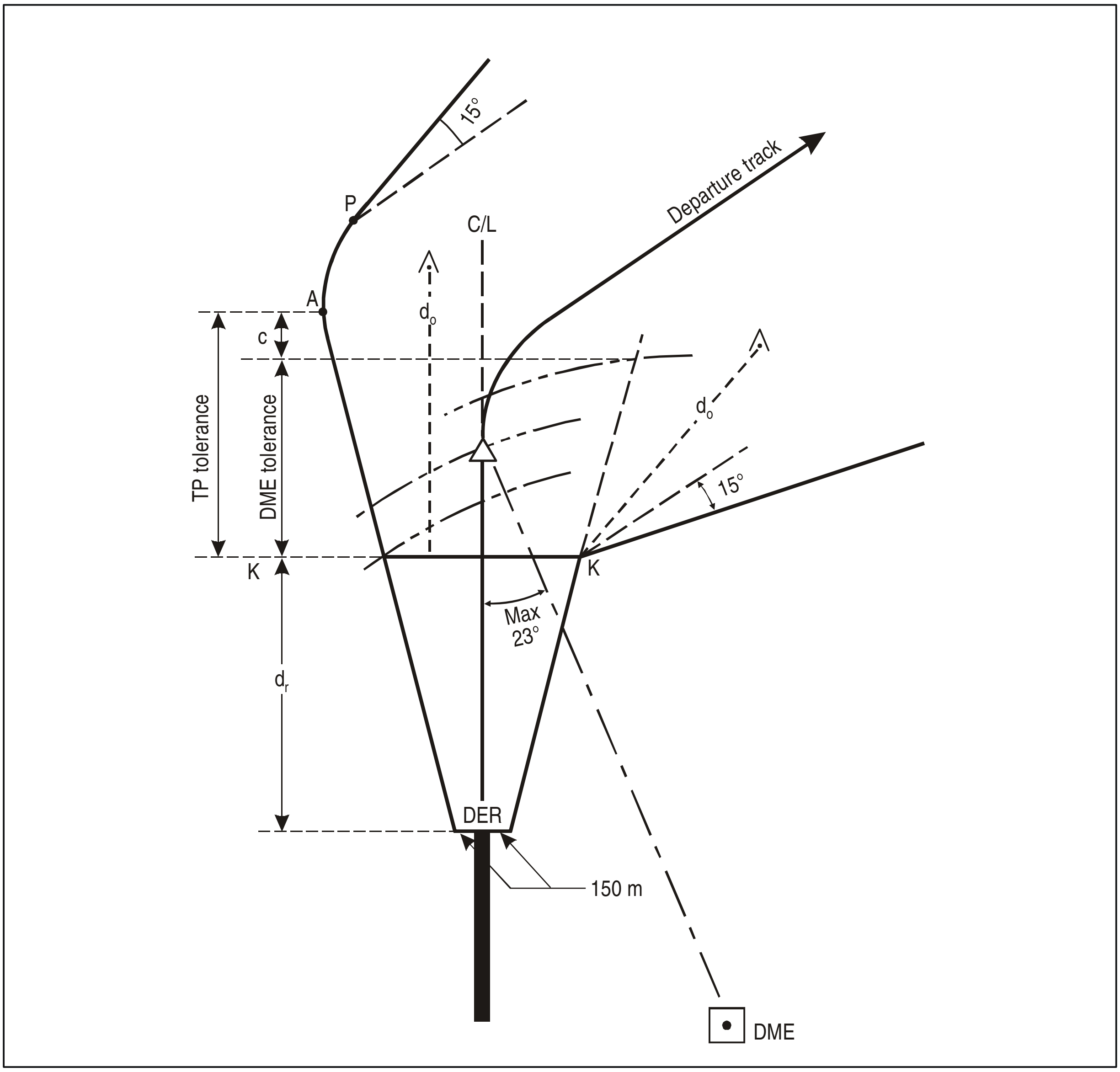


Figure I-3-3-11 b). Turning point not defined by overheading a facility (or RNAV fix)

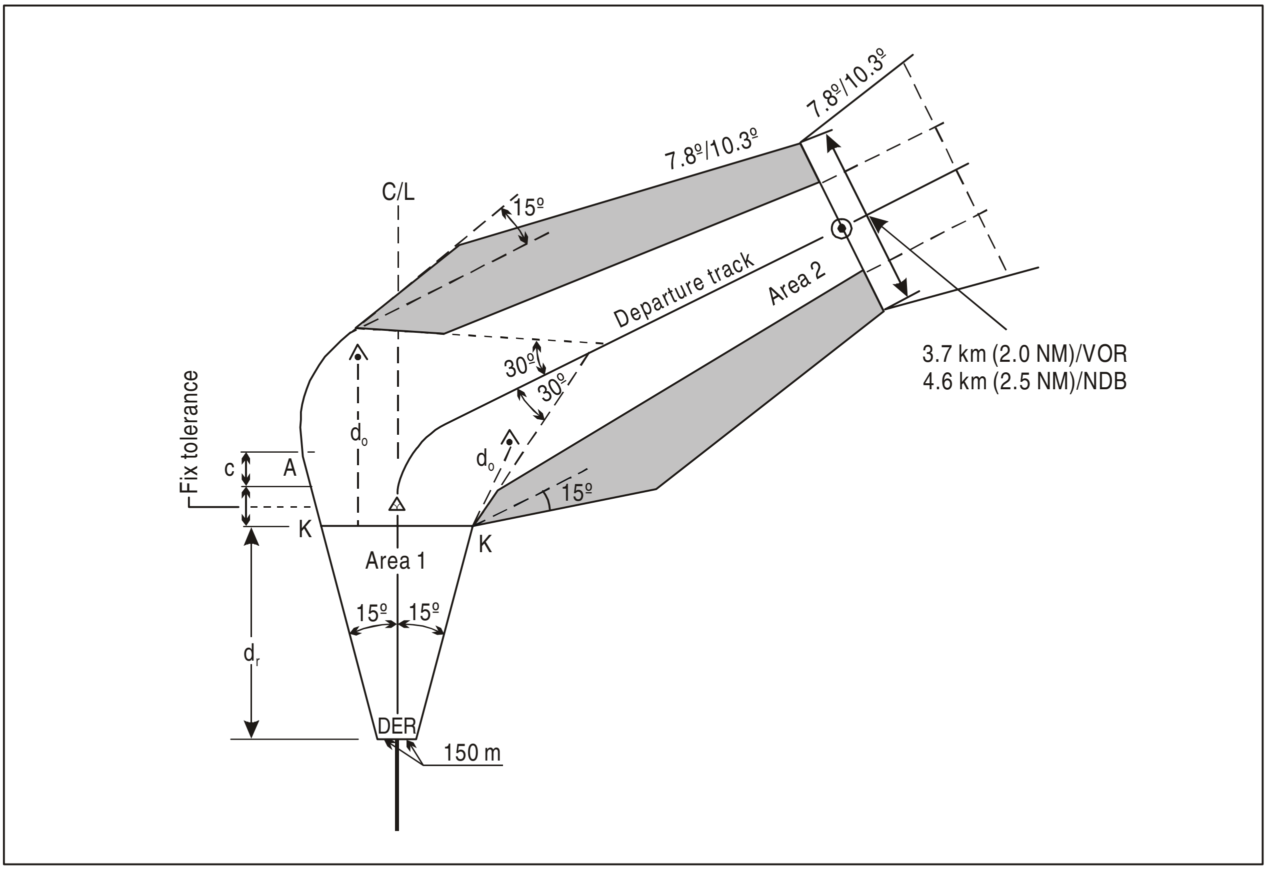


Figure I-3-3-11 c). Turning departure — turn at a fix

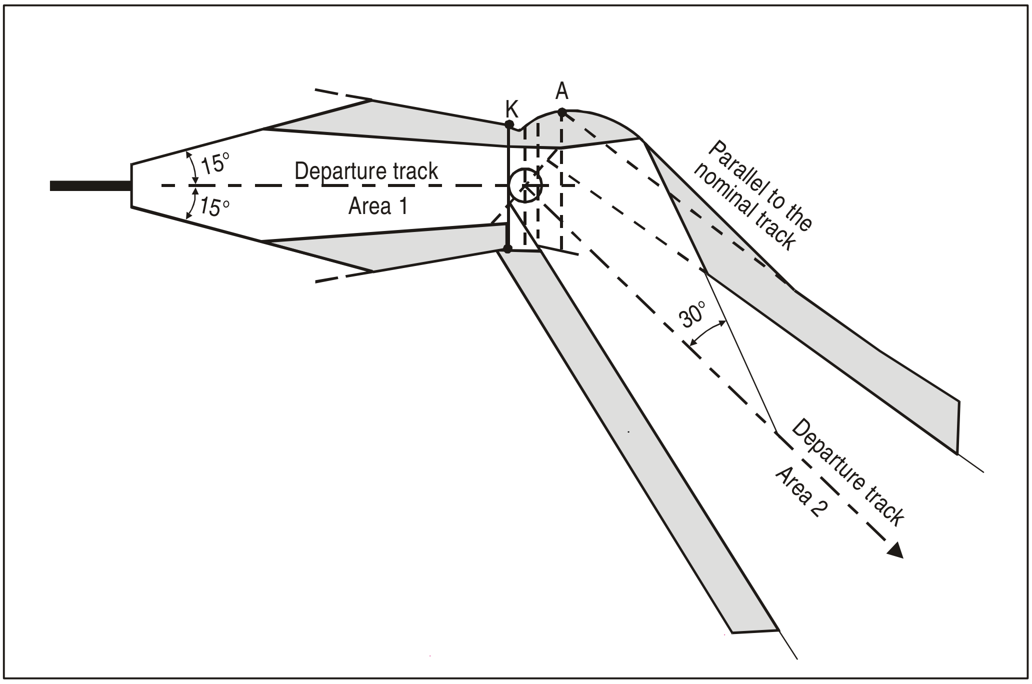


Figure I-3-3-11 d). Turning departure — turn over a facility

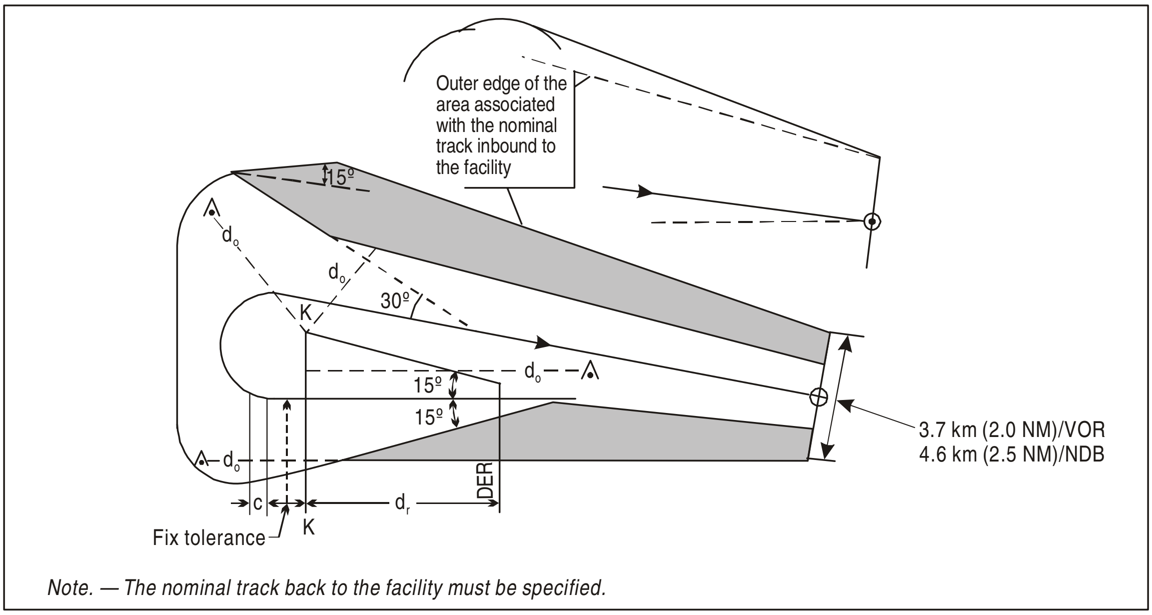


Figure I-3-3-12. Turning departure — turn at more than 90°

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Appendix to Chapter 3

GUIDANCE MATERIAL ON THE ESTABLISHMENT OF THE AVERAGE FLIGHT PATH OF A DEPARTURE PROCEDURE

1. INTRODUCTION

When close conformance to an accurate track, especially for turning departures, is important (for noise abatement/ATC constraints, etc.), statistical data on aircraft performance can be used to determine the procedure with the average flight path. The aircraft performances used to determine the average flight path must not be used for obstacle clearance calculation purposes. Although the data in Table I-3-3-App-1 is based on Cat D type of aircraft, it may also be applied to procedures for aircraft of lower category, causing an acceptable additional margin. In order to show the effect of this method, the average flight path is drawn on Figures I-3-3-App-1, I-3-3-App-2, I-3-3-App-3 and I-3-3-App-4.

2. CONSTRUCTION OF THE DESIRED AVERAGE FLIGHT PATH

2.1 Purpose

For the departure, the desired average flight path to deal with restrictions such as noise or ATC constraints can be drawn according to the speed/distance/bank angle in Table I-3-3-App-1. The purpose of the table is to give guidance for a realistic speed. For example it can be verified whether a proposed speed limitation would cause an operational problem. For RNAV procedure design, this table can be used as guidance for the minimum stabilization distance determination.

2.2 Table description

2.1.1 The indicated airspeed (IAS), bank angle and height above aerodrome can be found as a function of the distance from the DER. Apply the "along track" distance from the DER to the turning point/waypoint. When a speed restriction lower than the speed corresponding to a given distance in the speed table is required, this speed supersedes the value in the table.

2.2.2 For conversion from IAS to TAS (using Section 2, Appendix to Chapter 1), the climb of the aircraft must be taken into account. Use the altitude value from Table I-3-3-App-1 in the Appendix to Chapter 1 to convert IAS to TAS. A seven per cent climb gradient is applied originating from the DER. If a procedure design gradient higher than 7 per cent is used for obstacle clearance purposes or if a higher air traffic services (ATS) climb gradient is required, that climb gradient supersedes the assumed gradient in the table.

2.2.3 Due to probable limitation of bank angles as a function of altitude in the initial phase of the departure procedure:

a) a 15° bank angle is applied until 305 m (1 000 ft); and

b) a 25° bank angle from 915 m (3 000 ft) onwards.

As the resulting turn radii are influenced by a different bank angle, for a smooth transition a 20° bank angle is used between 305 m (1 000 ft) and 915 m (3 000 ft).

Table I-3-3-App-1. Average flight path determination
(Distance in km (NM), height in m (ft), bank angle in degrees, speed in km/h (kt) IAS)

Distance from DER	1.9 (1)	3.7 (2)	5.6 (3)	7.4 (4)	9.3 (5)	11.1 (6)	13 (7)	14.8 (8)	16.7 (9)	18.5 (10)	20.4 (11)	22.2 (12)	24.1 (13)	25.9 (14)	27.8 (15)	29.6 (16)	31.5 (17)	33.3 (18)	35.2 (19)	37 (20)	38.9 (21)	40.7 (22)	42.6 (23)	44.4 (24)	46.3 (25)
Height above rwy	130 (425)	259 (850)	389 (1 275)	518 (1 700)	648 (2 125)	777 (2 550)	907 (2 976)	1037 (3 401)	1167 (3 827)	1296 (4 252)	1476 (4 677)	1556 (5 103)	1685 (5 528)	1815 (5 953)	1945 (6 379)	2074 (6 804)	2204 (7 229)	2334 (7 655)	2463 (8 080)	2593 (8 505)	2723 (8 931)	2892 (9 356)	2982 (9 781)	3112 (10 207)	3241 (10 632)
Bank angle	15	15	20	20	20	20	20	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Speed	356 (192)	370 (200)	387 (209)	404 (218)	424 (229)	441 (238)	452 (244)	459 (248)	467 (252)	472 (255)	478 (258)	483 (261)	487 (263)	491 (265)	493 (266)	494 (267)	498 (269)	502 (271)	504 (272)	511 (276)	515 (278)	519 (280)	524 (283)	526 (284)	530 (286)

Note.— The speed shall not be higher than the maximum speed as indicated in Table I-4-1-1 and I-4-1-2.

Example:

Applicable data:
1 — Altitude aerodrome: 715 m (2 346 ft) MSL
2 — Required turn after 31.5 km (17 NM) track-miles flown

Find from the table:
1 — Assumed height aircraft: 2 204 m (7 229 ft) above field elevation
2 — Bank angle 25°
3 — Speed: 498 km/h (269 kt) IAS

Calculate turn radius:
1 — Altitude aircraft is 715 m (2 346 ft) (aerodrome elevation) + 2 204 m (7 229 ft) (height aircraft) = 2 919 m (9 575 ft) MSL
2 — TAS conversion factor (Section 2, Appendix to Chapter 1) rounded up to 10 000 ft: 1.1958
3 — TAS: 269 × 1.1958 = 596 km/h (322 kt)
4 — Turn radius average flight path 6.00 km (3.24 NM) (refer to Section 2, Chapter 3, paragraph 2, “radius of turn”).

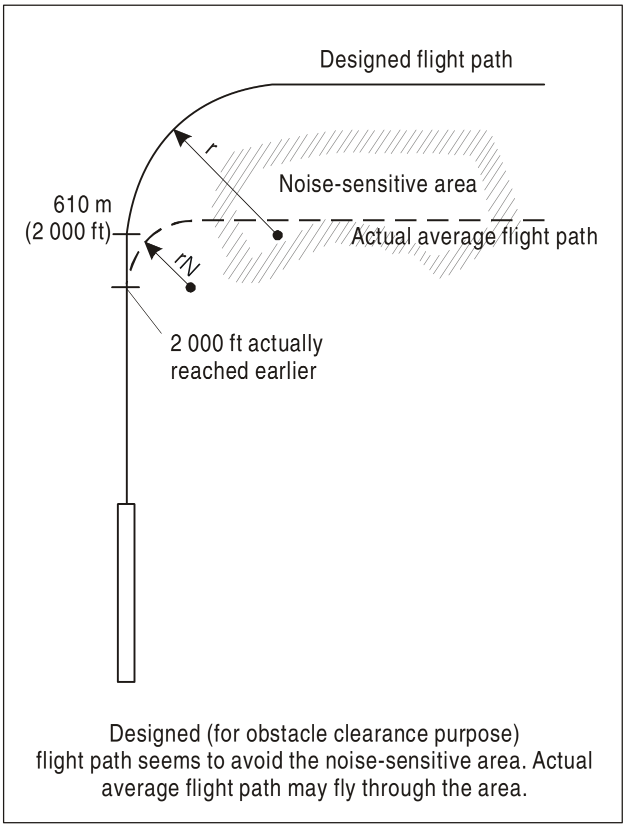

Figure I-3-3-App-1. Turn at a designated turning altitude — procedure without application of statistical data

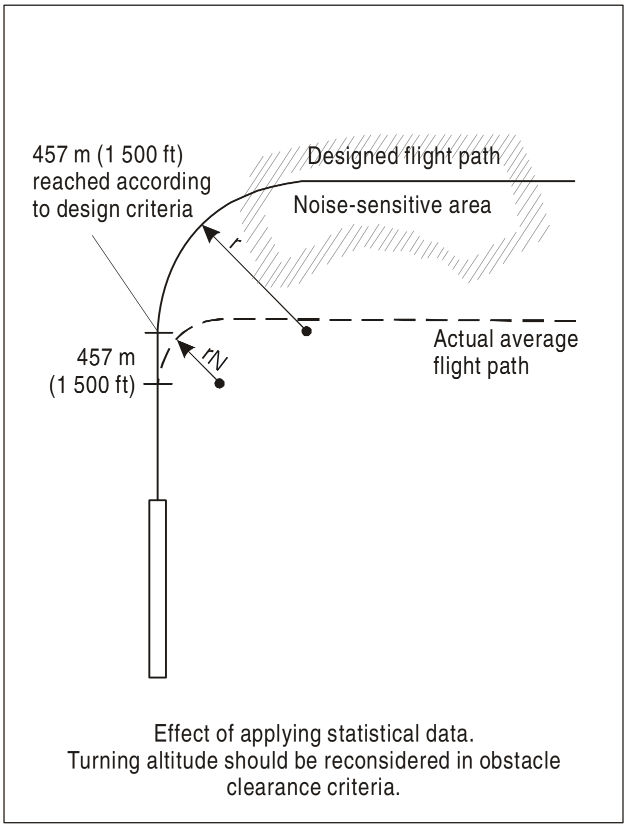

Figure I-3-3-App-2. Turn at a designated turning altitude — procedure with application of statistical data

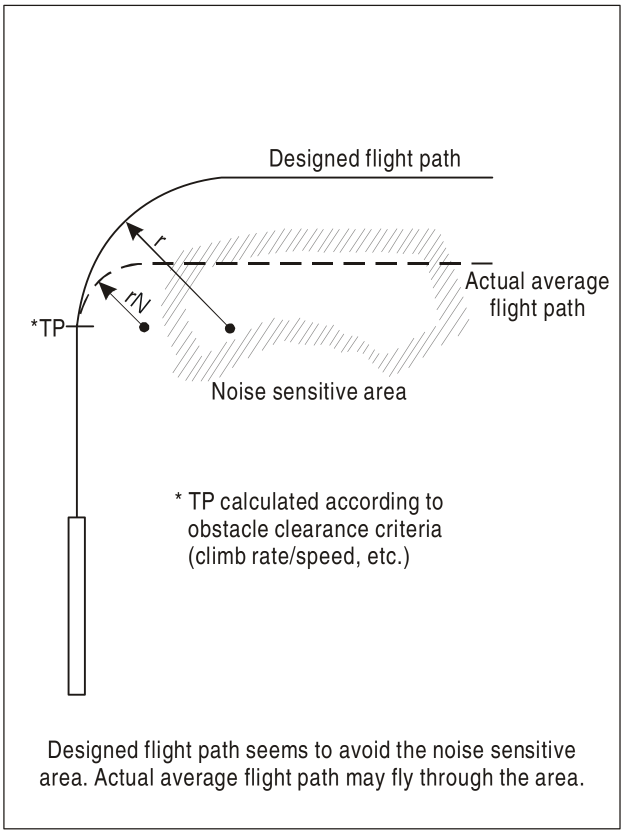

Figure I-3-3-App-3. Turn at a designated TP — procedure without application of statistical data

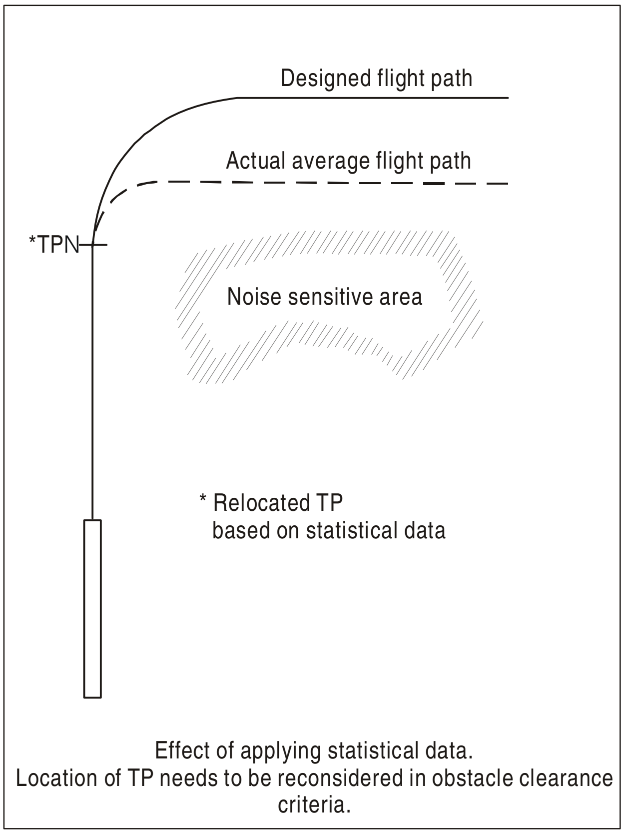

Figure I-3-3-App-4. Turn at a designated TP — procedure with application of statistical data

Chapter 4

OMNIDIRECTIONAL DEPARTURES

4.1 GENERAL

4.1.1 At many aerodromes, a departure route is not required for ATC purposes or to avoid particular obstacles. Nevertheless, there may be obstacles in the vicinity of the aerodrome which affect departures and an omnidirectional departure procedure is a convenient and flexible method of ensuring g obstacle clearance.

4.1.2 An omnidirectional departure procedure is designed on the basis that an aircraft maintains runway direction until a height of 120 m (394 ft) (Cat H, 90 m (295 ft) above the elevation of the DER before commencing a turn.

4.1.3 Where additional height is required for obstacle clearance the straight departure is continued until reaching the required turn altitude/height. A turn of no more than 15° is permitted during this extension of the straight departure. On reaching the specified turn altitude/height a turn in any direction may be made to join an en-route segment.

4.1.4 An omnidirectional departure may specify sectors with altitude or PDG limitations or may specify sectors to be avoided. Omnidirectional departures shall be published in accordance with Chapter 5.

4.2 AREAS

4.2.1 Turn initiation area

In omnidirectional turns, the turn initiation area is divided into two areas: Area 1 and Area 2.

4.2.1.1 *Area 1*

The turn initiation area is as described in Chapter 3 up to the point at which the PDG reaches the minimum turn height (120 m/394 ft, Cat H, 90 m/295 ft). This is Area 1. (See Figure I-3-4-1.)

4.2.1.2 *Area 2*

Past that point the turn initiation area splays at an angle of 30° to the departure track until the specified turn altitude/height is reached. This is Area 2 (see Figure I-3-4-1). Track adjustments of 15° or less may be made.

4.2.2 Turn area (Area 3)

4.2.2.1 The turn area (Area 3) provides for departures involving turns more than 15° (see Figure I-3-4-2). It covers the remaining portion of a circle centred on a point on the runway centre line 600 m from the start of takeoff (Cat H, the beginning of the runway or the FATO).

4.2.2.2 The radius of the circle is determined by the distance required at the PDG to reach the next en-route segment level or MSA.

4.3 OBSTACLE IDENTIFICATION

4.3.1 Turn initiation area OIS

A 2.5 per cent (Cat H, 4.2 per cent) OIS extends from 5 m (16 ft) above the elevation of the DER to the end of the turn initiation area.

4.3.2 Identification of obstacles in the turn area

4.3.2.1 An obstacle in the turn area shall be considered if it penetrates a 2.5 per cent gradient (Cat H, 4.2 per cent) which starts at the boundary of the turn initiation area at a height of 90 m/295 ft (Cat H, 80 m/265 ft) above the elevation of the DER. The gradient is computed using the shortest distance from the boundary of the turn initiation area to the obstacle.

4.3.2.2 Unless the procedure prohibits turns prior to the DER, an area beginning 600 m from the start of takeoff to the DER extending 150 m either side of the runway centerline shall be included in the turn initiation area for this purpose. (For helicopters this area commences at the start of the runway or the area available for takeoff and extends 45 m either side of the runway/FATO.) (See dotted boundary in Figure I-3-4-2.)

4.4 OBSTACLE CLEARANCE

4.4.1 Obstacle clearance in the turn initiation area

Obstacle clearance in the turn initiation area is as required in Chapter 3 for a turn at a specified altitude.

4.4.2 Obstacle clearance in the turn area

a) The minimum obstacle clearance in the turn area is the greater of:

   1) 90 m (295 ft) (Cat H, 80 m/265 ft); and

   2) $0.008\ (d_r{}^{*} + d_o)$, where:

      $d_r{}^{*}$ is the distance measured along the departure track corresponding to the point on the turn initiation area boundary where the distance d_o is measured; and

      d_o is the shortest distance from the turn initiation area boundary to the obstacle.

b) The maximum permissible elevation/height of an obstacle in the turn area can be computed by:

   Maximum obstacle elevation/height = TNA/H + d_o PDG – MOC

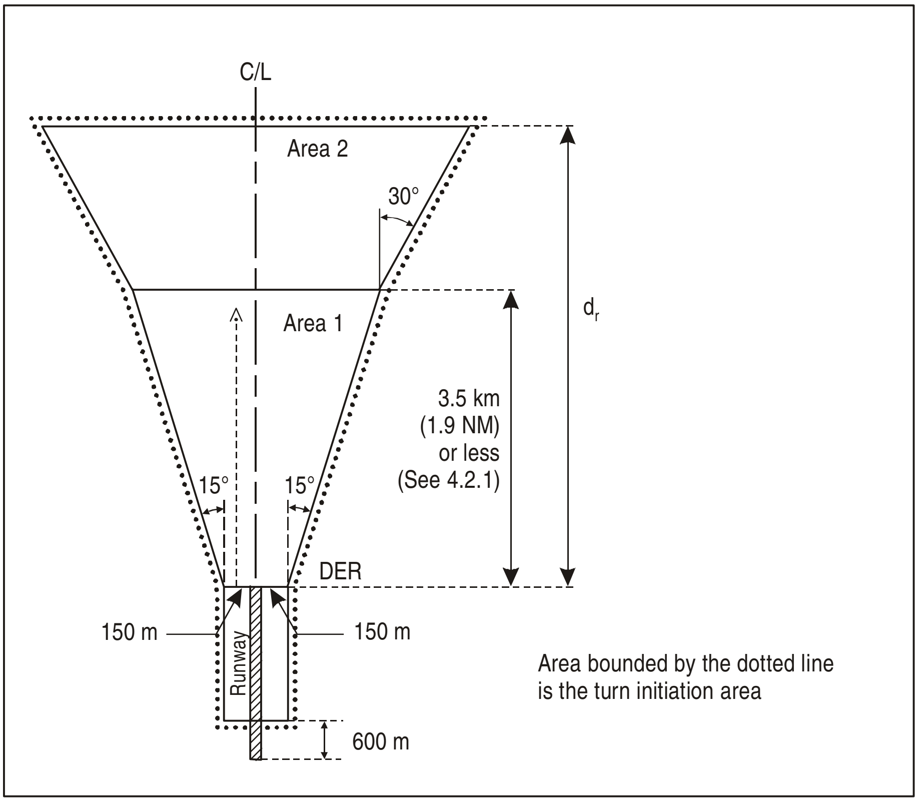

Figure I-3-4-1. Areas 1 and 2 and turn initiation area for omnidirectional departure

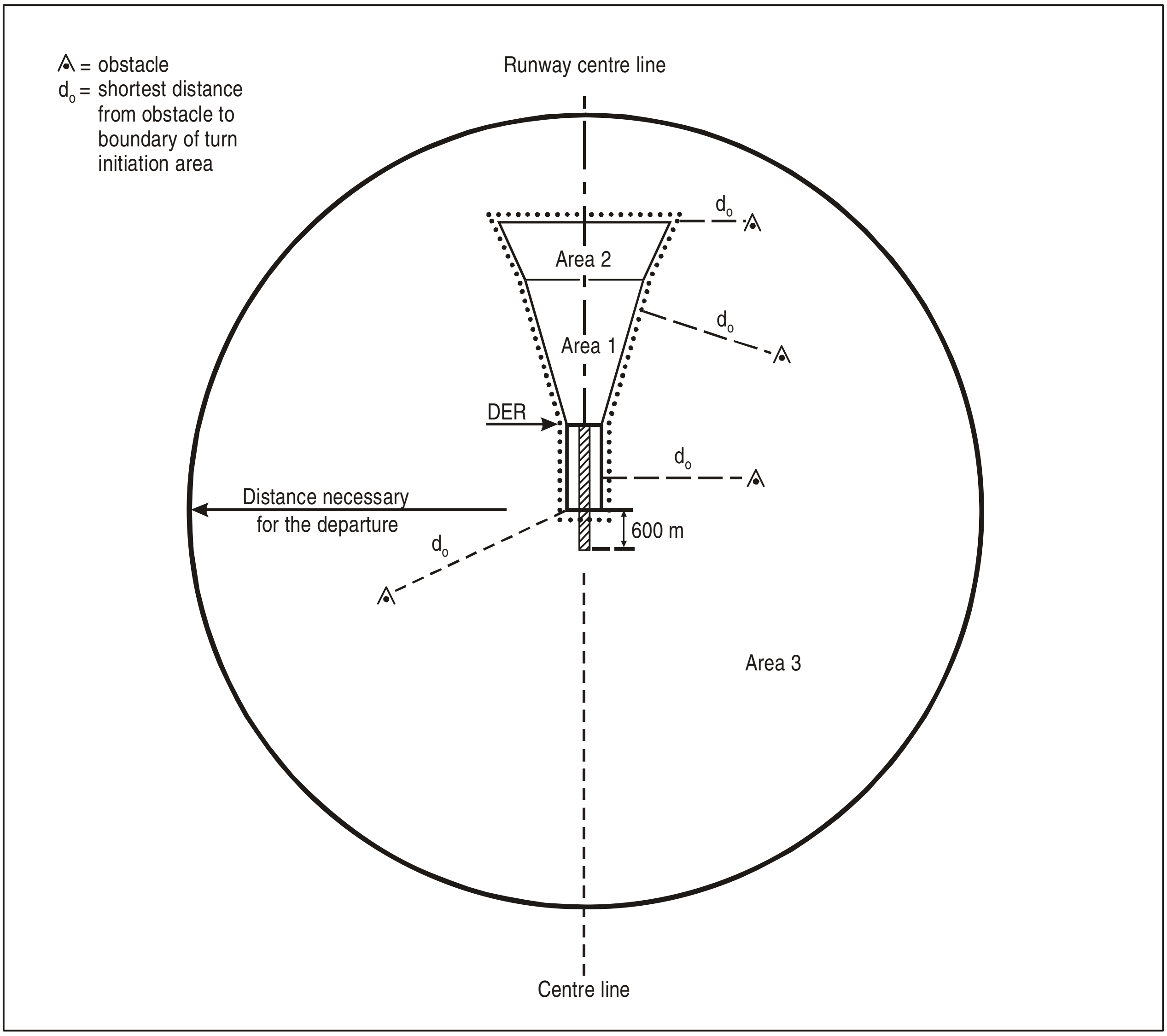

Figure I-3-4-2. Area 3 for omnidirectional departure

Chapter 5

PUBLISHED INFORMATION FOR DEPARTURE PROCEDURES

5.1 GENERAL

The minimum information to be published for a departure procedure is as follows:

a) all tracks, points, fixes and altitudes/heights (including turn altitudes/heights) required by the procedure;

b) all navigation facilities, fixes, waypoints, radials and DME distances used to define route segments;

c) significant obstacles which penetrate the obstacle identification surfaces (OIS);

d) the position and height of close-in obstacles penetrating the OIS. A note shall be included on the departure chart wherever close-in obstacles exist which were not considered in the determination of the published procedure design gradient (PDG) (see Figure II-3-2-3 in Chapter 2);

e) the highest obstacle in the departure area, and any significant obstacle outside that area controlling the design of the procedure;

f) a PDG greater than 3.3 per cent and the altitude/height to which it applies;

g) the altitude/height or fix at which a gradient in excess of 3.3 per cent (Cat H, 5.0 per cent) ceases to be required (see Figure I-3-5-1);

h) where an increased procedure design gradient is required by airspace restrictions only, a note stating that condition e.g. "4% climb gradient required due airspace restrictions only";

i) altitude/heights to be achieved at significant points in the departure, identified by navigation aids or fixes; and

j) when close conformance to a track is important (e.g. noise abatement/ATC constraints) a note stating that the average flight path is designed using statistical aircraft performance data (for construction of the average flight path, see the Appendix to Chapter 3).

Note.— Principles governing the identification of standard departure routes are contained in Annex 11, Appendix 3. Specifications for standard instrument departure charts are contained in Annex 4.

5.2 OMNIDIRECTIONAL DEPARTURES

An omnidirectional departure that restricts turn altitudes/heights and/or procedure design gradients to sectors shall be promulgated as follows:

a) restrictions shall be shown as sectors in which minimum altitudes and minimum turn altitudes/heights are specified, or in which stated procedure design gradients are required;

b) sectors may be defined in which flight is not permitted;

c) sectors shall be described by bearings and distance from the centre of the turn area;

d) sectors shall diverge at least 15° either side of the controlling obstacle; and

e) when more than one sector is published, the promulgated gradient shall be the highest PDG required in any sector that may be entered. The altitude/height to which the gradient applies must permit the subsequent use of a 3.3 per cent gradient (Cat H, 5.0 per cent) through that sector, a succeeding sector, or to an altitude/height authorized for another phase of flight (i.e. en-route holding or approach). A fix may also be designated to mark the point at which a gradient in excess of 3.3 per cent (Cat H, 5.0 per cent) ceases.

5.3 CHARTED ALTITUDES/FLIGHT LEVELS

Departure procedures may be developed to procedurally separate air traffic. In doing so, the procedure may be accompanied by altitudes/flight levels that are not associated with any obstacle clearance requirements, but are developed to separate arriving and departing air traffic procedurally. These altitudes/flight levels shall be charted as indicated in Table I-3-5-1. The method of charting of altitudes/flight levels to correctly depict the designed procedure may differ between avionics manufacturers.

5.4 OTHER REQUIREMENTS

a) When departures are limited to a particular category(ies) of aircraft, the procedure shall be clearly annotated.

b) Where a suitable fix is available, a procedure design gradient requirement may be promulgated by specifying a DME distance/altitude or position/altitude restriction (e.g. “reach 5000 ft by DME 15” or “reach 3500 ft by VWXYZ”).

c) A turn may be specified at a fix or an altitude/height, e.g. “at DME 4 turn right, track 170°” or “at 2 500 ft turn left track to VWXYZ”.

d) When it is necessary, after a turn, to track to intercept a specified radial/bearing, the procedure will specify:

   1) the turning point;

   2) the track to be made good; and

   3) the radial/bearing to be intercepted;

   (e.g. “at DME 4 turn left, track 340° to intercept BNE R020 (VOR)”; or “at DME 2 turn left, track 340° to intercept 010° track to STN (NDB)”).

e) Where a PDG in excess of the standard gradient is required to provide obstacle clearance, an alternative procedure using a lower PDG may be published for operations in VMC only.

f) Gradients to a height of 60 m (200 ft) or less due to close-in obstacles shall not be promulgated. A note shall be published stating that close-in obstacles exist.

g) Where a suitably located DME exists, or when suitably located RNAV fixes can be established, additional specific height/distance information intended for obstacle avoidance should be published in order to provide a means of monitoring aircraft position relative to critical obstacles.

h) Where turns prior to the DER are not accommodated, and the procedure design is based upon the turn initiation area commencing at the DER, the departure procedure shall include a note that turns are not permitted prior to the DER.

Table I-3-5-1. Charted altitudes/flight levels

Altitude/Flight level “Window”	$\overline{\text{17 000}}$ $\underline{\text{10 000}}$	$\overline{\text{FL220}}$ $\underline{\text{10 000}}$
“At or above” altitude/flight level	$\underline{\text{7 000}}$	$\underline{\text{FL60}}$
“At or below” altitude/flight level	$\overline{\text{5 000}}$	$\overline{\text{FL50}}$
“Mandatory” altitude/flight level	$\underline{\overline{\text{3 000}}}$	$\underline{\overline{\text{FL30}}}$
“Recommended” procedure altitude/flight level	5 000	FL50
“Expected” altitude/flight level	Expect 5 000	Expect FL50

Because of obstacle B, the gradient cannot be reduced to 3.3% (2.5% + 0.8%) (Cat H, 5.0 per cent) just after passing obstacle A. The altitude/height or fix at which a gradient in excess of 3.3% (Cat H, 5.0 per cent) is no longer required is promulgated in the procedure.

Obstacles A and B will be promulgated. Mountain promulgated on Aerodrome Obstacle Chart Type C.

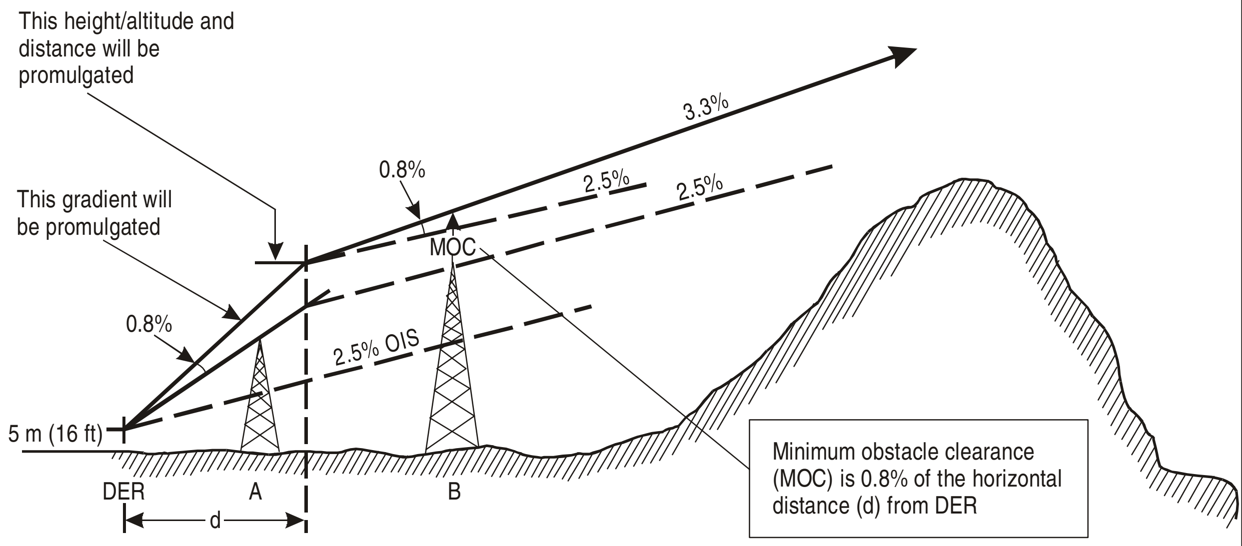

Figure I-3-5-1. Climb gradient reduction in departure

Chapter 6

SIMULTANEOUS OPERATIONS ON PARALLEL OR NEAR-PARALLEL INSTRUMENT RUNWAYS

Note.— Guidance material is contained in the Manual on Simultaneous Operations on Parallel or Near-Parallel Instrument Runways *(Doc 9643).*

6.1 INSTRUMENT DEPARTURES FROM PARALLEL RUNWAYS

When it is intended to use two instrument departure procedures from parallel runways simultaneously, the nominal departure tracks shall diverge by at least 15 degrees immediately after take-off (see Chapter 3, "Departure routes").

6.2 SEGREGATED OPERATIONS ON PARALLEL RUNWAYS

When it is intended to use an instrument departure procedure and an instrument approach procedure in the same direction on parallel runways simultaneously, the nominal tracks of the departure procedure and of the missed approach procedure shall diverge by at least 30 degrees as soon as practicable (see Part II, Section 1, Chapter 1, "ILS").

Section 4

ARRIVAL AND APPROACH PROCEDURES

Chapter 1

GENERAL CRITERIA FOR APPROACH/ARRIVAL PROCEDURES

1.1 SCOPE

Section 4 contains criteria common to all types of instrument arrival and approach procedures. Criteria which apply to specific types of facilities, such as ILS, are located in the chapters which deal with these kinds of guidance. Criteria which are specific to their implementation, as well as additions and exceptions to the general criteria, can be found in Part II, "Conventional procedures", and in Part III, "RNAV procedures and satellite-based procedures". Criteria for helicopters to runways are found in Parts I, II and III. Criteria for helicopters to heliports are found in Part IV.

Where characteristics of radio facilities are provided in this document, they are intended solely for the construction of procedures, and they do not replace or supplement corresponding material in Annex 10.

1.2 PROCEDURE CONSTRUCTION

An instrument approach procedure may have five separate segments. They are the arrival, initial, intermediate, final and missed approach segments. In addition, an area for circling the aerodrome under visual conditions should be considered. The approach segments begin and end at designated fixes. However, under some circumstances certain segments may begin at specified points where no fixes are available (or necessary). For example, the final approach segment of a precision approach may originate at the point of intersection of the designated intermediate flight altitude/height with the nominal glide path; the intermediate segment may begin at the end of the inbound turn.

1.3 FIX NAMES

The fixes are named according to the segment they precede. For example, the intermediate segment begins at the intermediate fix. Where no fix is available, as mentioned above in 1.2, "Procedure construction", the segments begin and end at specified points (e.g. the point where the glide path intersects the nominal intermediate altitude and the point where the glide path intersects the nominal DA/H). This document discusses the segments in the order in which the pilot would fly them in a complete procedure, that is from arrival through initial and intermediate to a final approach and, if necessary, the missed approach.

1.4 SEGMENT APPLICATION

Only those segments that are required by local conditions need be included in a procedure. In constructing the procedure, the final approach track should be identified first because it is the least flexible and most critical of all the segments. When the final approach has been determined, the other necessary segments should be blended with it to produce an orderly manoeuvring pattern which is responsive to the local traffic flow. See Figure I-4-1-1.

1.5 PROCEDURE ALTITUDE/HEIGHT

1.5.1 The aviation industry has identified that the majority of large aircraft accidents occur lined up with and within 19 km (10 NM) of the landing runway. To support the Controlled Flight Into Terrain (CFIT) prevention initiatives, instrument approach charts shall not only provide altitudes/heights to ensure appropriate obstacle clearance but also procedure altitudes/heights. Procedure altitudes/heights are intended to place the aircraft above any minimum altitude associated with obstacle clearance and to support a stabilized prescribed descent gradient/angle in the final segment.

1.5.2 All non-precision instrument approach procedures shall be developed to include not only the minimum altitudes/heights to ensure obstacle clearance, but also procedure altitudes/heights. Procedure altitudes/heights shall be developed to place the aircraft at altitudes/heights that would normally be flown to intercept and fly the prescribed descent gradient/angle in the final approach segment to a 15 m (50 ft) threshold crossing. In no case shall a procedure altitude/height be less than any OCA/H.

1.6 TRACK GUIDANCE

1.6.1 Track guidance should normally be provided for all phases of flight through the arrival, initial, intermediate, final and missed approach segments. When track guidance is provided, the appropriate segment shall lie within the established coverage of the navigation facility on which the track guidance is based.

1.6.2 When track guidance is not provided the obstacle clearance area shall be expanded as prescribed for dead reckoning (DR) segments in Chapter 3, "Initial approach segment" and in Appendix A to Chapter 3, "Initial approach using dead reckoning (DR)". Terminal area surveillance radar (TAR), when available, may be used to provide vectors to the final approach (see Part II, Section 2, Chapter 6, "SRE"). En-route surveillance radar (RSR) may be used to provide track guidance through initial approach segments up to and including the intermediate fix. Criteria for the construction of areas for missed approaches without track guidance are provided in Chapter 6, "Missed approach segment".

Note.— Detailed procedures regarding the use of primary radar in the approach control service are set forth in the PANS-ATM, Doc 4444, Procedures for Air Navigation Services — Air Traffic Management.

1.7 VERTICAL GUIDANCE

Optimum and maximum descent gradients are specified depending on the type of procedure and the segment of the approach. At least in the case of the final approach segment for non-precision approach procedures and, preferably, also for other approach segments where appropriate, the descent gradient(s) used in the construction of the procedure shall be published. Where distance information is available, descent profile advisory information for the final approach should be provided to assist the pilot to maintain the calculated descent gradient. This should be a table showing altitudes/heights through which the aircraft should be passing at each 2 km or 1 NM as appropriate.

1.8 CATEGORIES OF AIRCRAFT

1.8.1 Aircraft performance differences have a direct effect on the airspace and visibility required for manoeuvres such as circling approach, turning missed approach, final approach descent and manoeuvring to land (including base and procedure turns). The most significant factor in performance is speed. Accordingly, five categories of typical aircraft (see 1.8.4) have been established to provide a standardized basis for relating aircraft manoeuvrability to specific instrument approach procedures.

1.8.2 The criteria taken into consideration for the classification of aeroplanes by categories is the indicated airspeed at threshold (V_{at}) which is equal to the stall speed V_{so} multiplied by 1.3 or stall speed V_{s1g} multiplied by 1.23 in the landing configuration at the maximum certificated landing mass. If both V_{so} and V_{s1g} are available, the higher resulting V_{at} shall be used.

1.8.3 The landing configuration which is to be taken into consideration shall be defined by the operator or by the aeroplane manufacturer.

1.8.4 Aircraft categories will be referred to throughout this document by their letter designations as follows:

Category A — less than 169 km/h (91 kt) indicated airspeed (IAS)

Category B — 169 km/h (91 kt) or more but less than 224 km/h (121 kt) IAS

Category C — 224 km/h (121 kt) or more but less than 261 km/h (141 kt) IAS

Category D — 261 km/h (141 kt) or more but less than 307 km/h (166 kt) IAS

Category E — 307 km/h (166 kt) or more but less than 391 km/h (211 kt) IAS

Category H — see 1.8.8, "Helicopters".

1.8.5 The ranges of speeds (IAS) in Tables I-4-1-1 and I-4-1-2 are to be used in calculating procedures. For conversion of these speeds to TAS, see Part I, Section 1, Appendix to Chapter 1.

1.8.6 *Permanent change of category (maximum landing mass*). An operator may impose a permanent, lower, landing mass, and use of this mass for determining V_{at} if approved by the State of the Operator. The category defined for a given aeroplane shall be a permanent value and thus independent of changing day-to-day operations.

1.8.7 *Restrictions on category and IAS.* Where airspace requirements are critical for a specific category of aircraft, procedures may be based on lower speed category aircraft, provided use of the procedure is restricted to those categories. Alternatively the procedure may be designated as limited to a specific maximum IAS for a particular segment without reference to category.

1.8.8 *Helicopters*

a) The stall speed method of calculating aircraft category does not apply to helicopters. Where helicopters are operated as aeroplanes, the procedure may be classified as Category A. However, specific procedures may be developed for helicopters and these shall be clearly designated "H". Category H procedures shall not be promulgated on the same instrument approach chart (IAC) as joint helicopter/aeroplane procedures.

b) Helicopter-only procedures should be designed using the same conventional techniques and practices as those pertaining to Category A aeroplanes. Some criteria such as minimum airspeeds and descent gradients may be different, but the principles are the same.

c) The specifications for Category A aeroplane procedure design apply equally to helicopters, except as specifically modified herein. The criteria that are changed for helicopter-only procedures are appropriately indicated throughout the text.

1.8.9 For precision approach procedures, the dimensions of the aircraft are also a factor for the calculation of the OCH. For Category D_L aircraft, additional OCA/H is provided, when necessary, to take into account the specific dimensions of these aircraft (see Part II, Section 1, Chapters 1 and 3 and Part III, Section 3, Chapter 6 (GBAS Cat I)).

1.9 DESCENT GRADIENTS

Throughout the document, optimum and maximum descent gradients are specified. The optimum is the operationally preferred descent gradient. This should only be exceeded where alternative means of satisfying obstacle clearance requirements are impracticable. The maximum gradient shall not be exceeded. (See also Section 4, Chapter 9.)

Table I-4-1-1. Speeds (IAS) for procedure calculations in kilometres per hour (km/h)

Aircraft category	V_{at}	*Range of speeds for initial approach*	*Range of final approach speeds*	*Max speeds for visual manoeuvring (circling)*	*Max speeds for missed approach*	
					Intermediate	*Final*
A	<169	165/280(205*)	130/185	185	185	205
B	169/223	220/335(260*)	155/240	250	240	280
C	224/260	295/445	215/295	335	295	445
D	261/306	345/465	240/345	380	345	490
E	307/390	345/467	285/425	445	425	510
H	N/A	130/220**	110/165***	N/A	165	165
Cat H (PinS)***	N/A	130/220	110/165	N/A	130 or 165	130 or 165

V_{at} Speed at threshold based on 1.3 times stall speed V_{so} or 1.23 times stall speed V_{slg} in the landing configuration at maximum certificated landing mass. (Not applicable to helicopters.)

* Maximum speed for reversal and racetrack procedures.

** Maximum speed for reversal and racetrack procedures up to and including 6 000 ft is 185 km/h and maximum speed for reversal and racetrack procedures above 6 000 ft is 205 km/h.

*** Helicopter point-in-space procedures based on basic GNSS may be designed using maximum speeds of 220 km/h for initial and intermediate segments and 165 km/h on final and missed approach segments or 165 km/h for initial and intermediate segments and 130 km/h on final and missed approach based on operational need. Refer to Part IV, Chapter 1.

Note.— The V_{at} speeds given in Column 1 of this table are converted exactly from those in Table I-4-1-2, since they determine the category of aircraft. The speeds given in the remaining columns 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.

Table I-4-1-2. Speeds (IAS) for procedure calculations in knots (kt)

Aircraft category	V_{at}	*Range of speeds for initial approach*	*Range of final approach speeds*	*Max speeds for visual manoeuvring (circling)*	*Max speeds for missed approach*	
					Intermediate	*Final*
A	<91	90/150(110*)	70/100	100	100	110
B	91/120	120/180(140*)	85/130	135	130	150
C	121/140	160/240	115/160	180	160	240
D	141/165	185/250	130/185	205	185	265
E	166/210	185/250	155/230	240	230	275
H	N/A	70/120**	60/90***	N/A	90	90
Cat H (PinS)***	N/A	70/120	60/90	NA	70 or 90	70 or 90

V_{at} Speed at threshold based on 1.3 times stall speed V_{so} or 1.23 times stall speed V_{slg} in the landing configuration at maximum certificated landing mass. (Not applicable to helicopters.)

* Maximum speed for reversal and racetrack procedures.

** Maximum speed for reversal and racetrack procedures up to and including 6 000 ft is 100 kt and maximum speed for reversal and racetrack procedures above 6 000 ft is 110 kt.

*** Helicopter point-in-space procedures based on basic GNSS may be designed using maximum speeds of 120 KIAS for initial and intermediate segments and 90 KIAS on final and missed approach segments or 90 KIAS for initial and intermediate segments and 70 KIAS on final and missed approach based on operational need. Refer to Part IV, Chapter 1.

Note.— The V_{at} speeds given in Column 1 of Table I-4-1-1 are converted exactly from those in this table, since they determine the category of aircraft. The speeds given in the remaining columns 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.

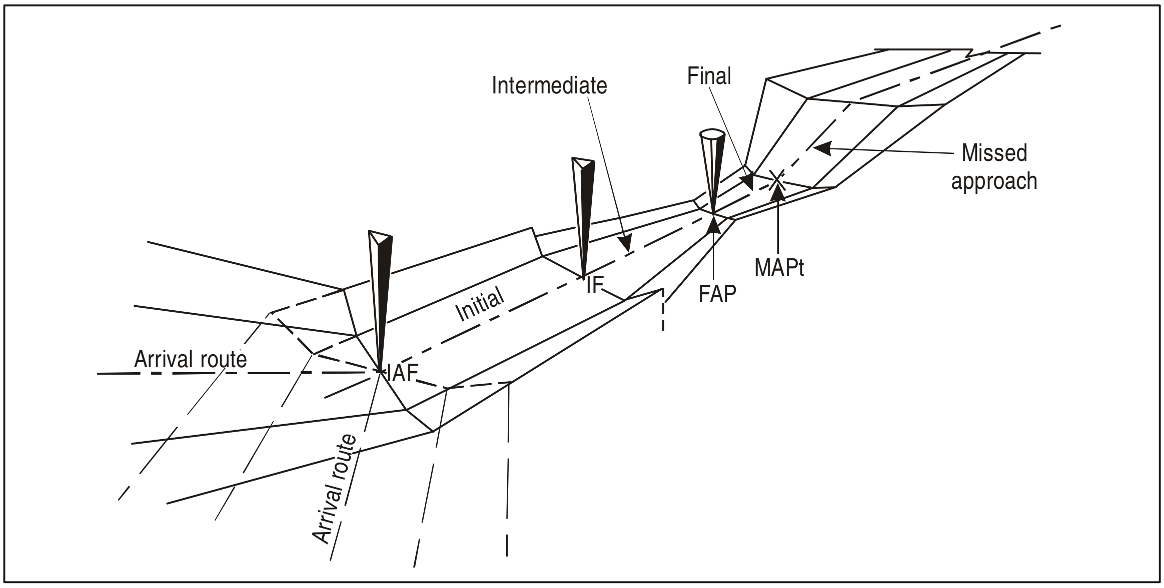

Figure I-4-1-1. Segment of instrument approach

Chapter 2

ARRIVAL SEGMENT

2.1 STANDARD INSTRUMENT ARRIVALS

2.1.1 General

This section contains criteria applicable to all standard instrument arrivals.

2.1.1.1 In some cases it is necessary to designate arrival routes from the en-route structure to the initial approach fix. Only those routes which provide an operational advantage shall be established and published. These should take local air traffic flow into consideration. The length of the arrival route shall not exceed the operational service range of the facilities which provide navigation guidance.

2.1.1.2 Standard instrument arrival routes (STARs) should be simple and easily understood and only those navigation facilities, fixes or waypoints essential to define the flight path of an aircraft and for Air Traffic Services (ATS) purposes will be included in the procedure.

2.1.1.3 A STAR should accommodate as many aircraft categories as possible.

2.1.1.4 A STAR should begin at a fix, e.g. radio navigation facility, intersection, distance measuring equipment (DME) fix or waypoint.

2.1.1.5 A STAR should permit transition from the en-route phase to the approach phase by linking a significant point normally on an ATS route with a point from which an instrument approach procedure is initiated.

2.1.1.6 A STAR should be designed to permit aircraft to navigate along the routes reducing the need for radar vectoring.

2.1.1.7 A STAR may serve one or more airports within a terminal area.

2.1.1.8 Airspeed and altitude/level restrictions, if any, should be included. These should take into account the operational capabilities of the aircraft category involved, in consultation with the operators.

2.1.1.9 Whenever possible, STARs should be designed with DME fixes or waypoints instead of intersections.

Note 1.— Material relating to the principles governing the identification of standard arrival routes and associated procedures are contained in Annex 11, Appendix 3.

Note 2.— Material relating to the publication of the Standard Arrival Chart — Instrument (STAR) — ICAO is contained in Annex 4, Chapter 10.

2.1.1.10 A DME arc may provide track guidance for all or a portion of an arrival route. The minimum arc radius shall be 18.5 km (10.0 NM).

An arc may join a straight track at or before the initial approach fix. In this case, the angle of intersection of the arc and the track should not exceed 120°.

When the angle exceeds 70°, a lead radial which provides at least a distance “d” of lead shall be identified to assist in leading the turn (d = r.tan $\frac{(\alpha)}{2}$; r = radius of turn; α = angle of turn).

2.1.2 Area construction

2.1.2.1 *Arrival routes 46 km or longer (25 NM)*

When the length of the arrival route is greater than or equal to 46 km (25 NM), en-route criteria apply to the 46 km (25 NM) prior to the initial approach fix (IAF). The area width decreases from 46 km (25 NM) with a convergence angle of 30° each side of the axis, until reaching the width determined by the initial approach criteria. See Figure I-4-2-1.

2.1.2.2 *Arrival routes less than 46 km (25 NM)*

When the length of the arrival route is less than 46 km (25 NM), the area width decreases from the beginning of the arrival route with a convergence angle of 30° each side of the axis, until reaching the width determined by the initial approach criteria. See Figure I-4-2-2.

2.1.2.3 *Turn protection*

Turns will be protected by using:

a) en-route criteria for distances greater than 46 km (25 NM) from the IAF; and

b) initial approach criteria for distances of 46 km (25 NM) or less from the IAF.

2.1.2.4 *Arrival based on a DME arc*

In case of an arrival based on a DME arc, 2.1.2.1 and 2.1.2.2 apply with the following exceptions:

a) the distance is measured along the DME arc; and

b) the tapering is over a distance of 9.6 km (5.2 NM), measured along the DME arc.

The construction method is as follows. From the centre of the DME arc (point O), draw lines OA and OB which intersect the limits at A1, A2, A3, A4 and B1, B2, B3, B4. Then, draw lines joining corresponding points A to B. See Figures I-4-2-3 and I-4-2-4.

2.1.2.5 *Basic GNSS receivers*

2.1.2.5.1 In addition to the general arrival criteria, the following criteria apply. Cross-track tolerance (XTT), along-track tolerance (ATT) and area semi-width for basic GNSS receivers are determined according to the formulae defined in Part III, Section 1, Chapter 2, 2.5, “XTT, ATT and area semi-width”.

2.1.2.5.2 The area width tapers at an angle of 30° each side of the axis, perpendicular to the point where the 30 NM (56 km) arc from the aerodrome reference point (ARP) intercepts the nominal track. Contrary to the general arrival criteria, the en-route width shall be used when more than 30 NM (56 km) from the ARP. See Figures I-4-2-5 and I-4-2-6.

2.1.3 Obstacle clearance

The obstacle clearance in the primary area shall be a minimum of 300 m (984 ft). In the secondary area 300 m (984 ft) of obstacle clearance shall be provided at the inner edge, reducing linearly to zero at the outer edge. See Figure I-4-1-2 in Chapter 1. For calculating obstacle clearance at a given point see Section 2, Chapter 1, 1.3, “Obstacle clearance”.

2.1.4 Procedure altitude/height

The procedure altitude/height shall not be less than the OCA/H and shall be developed in coordination with air traffic control requirements. The arrival segment procedure altitude/height may be established to allow the aircraft to intercept the prescribed final approach segment descent gradient/angle from within the intermediate segment.

2.2 OMNIDIRECTIONAL OR SECTOR ARRIVALS

Omnidirectional or sector arrivals can be provided taking into account the minimum sector altitudes (MSA) (see Chapter 9, “Minimum sector altitudes”), or terminal arrival altitudes (TAA) (see Part III, Section 2, Chapter 4, “Terminal arrival altitude (TAA)”).

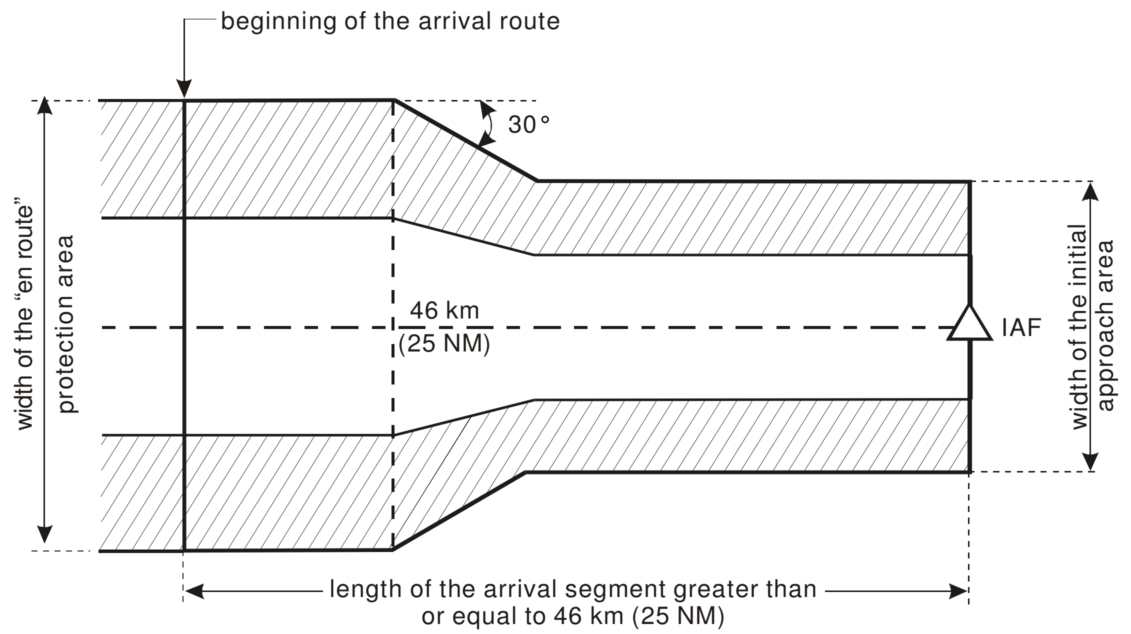

Figure I-4-2-1. Arrival segment — protection area (length of the arrival segment greater than or equal to 46 km (25 NM))

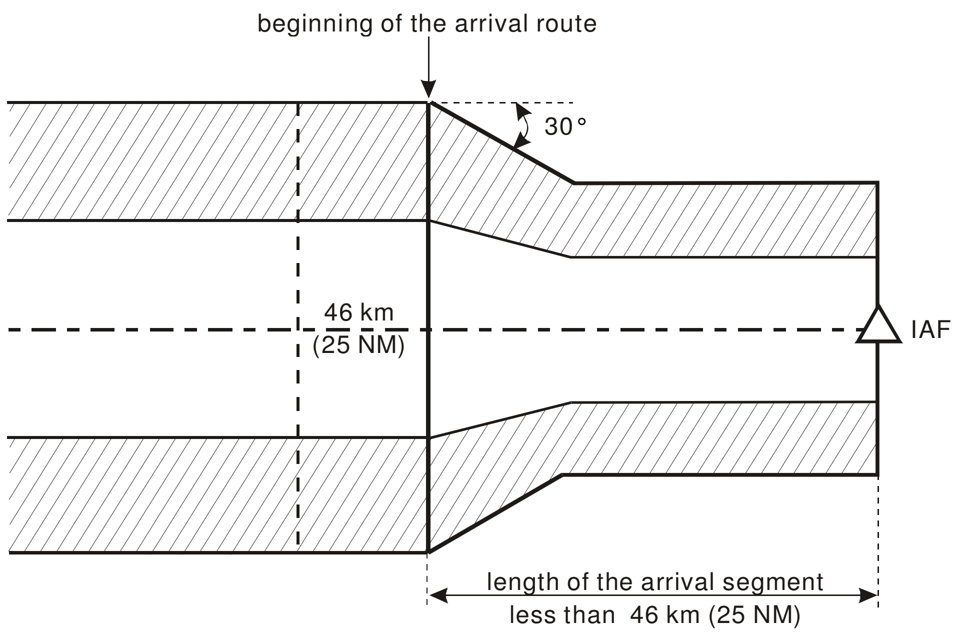

Figure I-4-2-2. Arrival segment — protection area (length of the arrival segment less than 46 km (25 NM))

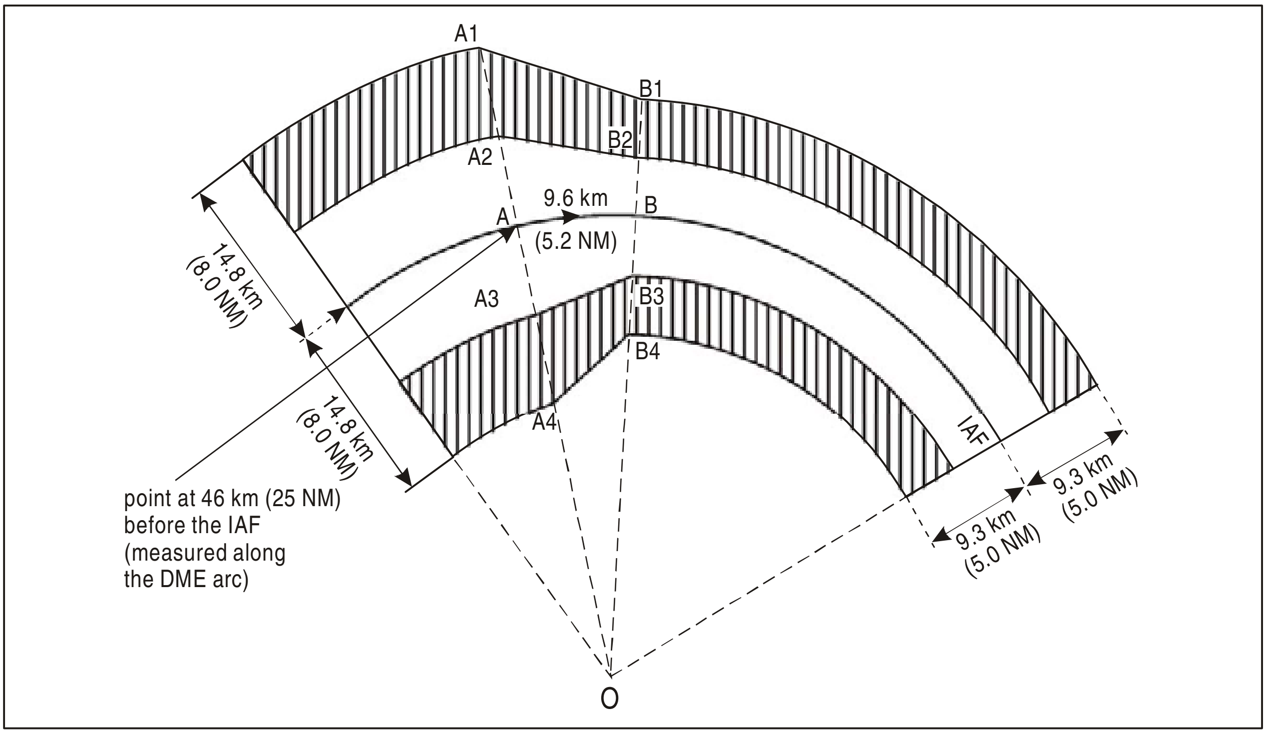

Figure I-4-2-3. DME arc — length of the arrival segment greater than or equal to 46 km (25 NM)

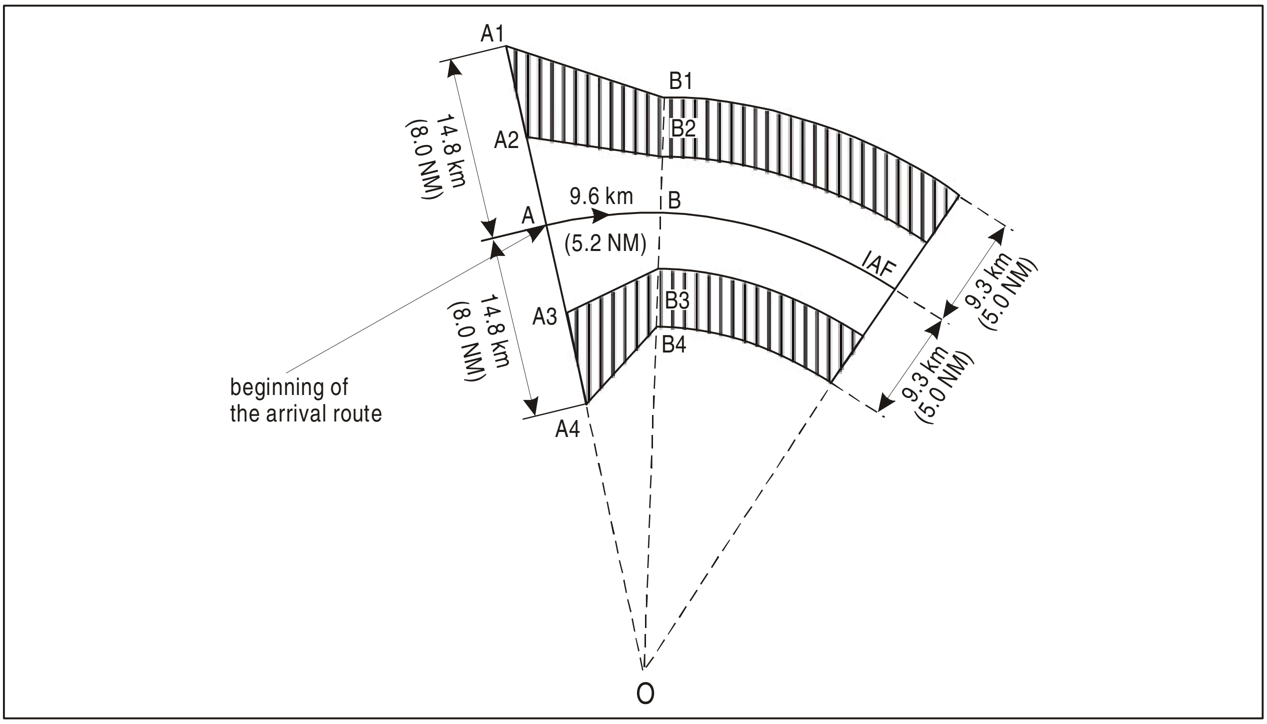

Figure I-4-2-4. DME arc — length of the arrival segment less than 46 km (25 NM)