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Procedures for
Air Navigation Services

Aircraft Operations

Volume I
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 I.

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. 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 operations personnel and flight crew. 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 (SARPs) 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 I

2.1 Part I — Flight Procedures — General

2.1.1 *Section 1 — Definitions, abbreviations and acronyms*

This section contains a description of 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 and acronyms is also provided.

2.1.2 *Section 2 — General principles*

Section 2 provides general principles to flight procedures such as accuracy to fixes and turn area construction.

2.1.3 *Section 3 — Departure procedures*

2.1.3.1 The specifications concerning instrument departure procedures were developed by the Obstacle Clearance Panel (OCP) in 1983. The material contained in Volume I was developed from criteria contained in Volume II and prepared for the use of flight operations personnel and flight crew.

2.1.3.2 The procedures include areas and obstacle clearance criteria for the instrument departure phase of flight covering the airborne portion of the take-off and climb to a point where obstacle clearance criteria associated with the next phase of flight are applicable. Minimum flight altitudes for each ATS route are determined and promulgated by each Contracting State in accordance with Annex 11, Chapter 2, 2.21.

2.1.3.3 Contingency procedures are required to provide for any situation in which the aeroplane is unable to utilize these instrument departure procedures. It is the responsibility of the operator to ensure that the performance requirements of Annex 6 are met by the provision of contingency procedures.

2.1.4 *Section 4 — Arrival and approach procedures*

These procedures were first developed by the Operations Division in 1949 and were approved by the Council for inclusion in the PANS-OPS 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 were completely revised. The new procedures were incorporated in 1980 in the First Edition of Volume I of PANS-OPS (Amendment 14).

2.1.5 *Section 5 — En-route criteria*

En-route obstacle clearance criteria were added to the document on 7 November 1996 as a result of the tenth meeting of the Obstacle Clearance Panel. The criteria were amended in 2004 to include simplified en-route criteria.

2.1.6 *Section 6 — Holding procedures*

The specifications concerning holding procedures were first developed by the Operations Division in 1949 and were approved by the Council for inclusion in the PANS-OPS in 1951. A major revision of this matter 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 flight operations was incorporated in PANS-OPS, Volume I, and the material covering the construction of holding procedures incorporated in Volume II. In 1982, as a result of the work of the Obstacle Clearance Panel, 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, and holding speeds, particularly above 4 250 m (14 000 ft).

2.1.7 *Section 7 — Noise abatement procedures*

2.1.7.1 Noise abatement procedures were developed by the Operations Panel (OPSP) and approved by the Council for inclusion in the PANS-OPS in 1983. These procedures were amended in 2001 by the Committee of Aviation Environmental Protection (CAEP).

2.1.7.2 For related provisions, see Annex 16, Volume I, and Annex 6, Part I.

2.1.8 *Section 8 — Procedures for use by helicopters*

Conditions under which the criteria in Part I may be applied to helicopters are specified in this section, which was revised at the third meeting of the HELIOPS Panel to include provisions on operational constraints on helicopter descent gradient and minimum final approach airspeeds. As a result of the fourth meeting of the HELIOPS Panel, specifications concerning flight procedures and the obstacle clearance criteria for use by helicopters only are included in this section.

2.1.9 *Section 9 — Procedures for the establishment of aerodrome operating minima*

Note.— This material is under development and no text is presently available. For related material, see Annex 6.

2.2 Part II — Flight Procedures — RNAV and Satellite-based

2.2.1 *Section 1— General*

This section contains general information on area navigation (RNAV) and satellite-based flight procedures. Material on TAA, SBAS and GBAS were added as a result of the thirteenth meeting of the Obstacle Clearance Panel (Amendment 13).

2.2.2 *Section 2 — Departure procedures*

Area navigation (RNAV) departure material regarding VOR/DME and DME/DME was included in 1995 (Amendment 9). Material on basic GNSS and RNP was added in 2001 (Amendment 11), and SBAS and GBAS in 2004 (Amendment 12).

2.2.3 *Section 3 — Arrival and non-precision approach procedures*

Area navigation (RNAV) approach material regarding VOR/DME and DME material was included in 1993 (Amendment 7). Material on basic GNSS and RNP was added in 2001 (Amendment 11), and GBAS in 2004 (Amendment 13).

2.2.4 *Section 4 — Approach procedures with vertical guidance*

Material on barometric vertical navigation (baro-VNAV) was added in 2001 (Amendment 11).

2.2.5 *Section 5 — Precision approach procedures*

Material on GBAS Category I was added in 2004 (Amendment 13).

2.2.6 *Section 6 — RNAV holding*

Area navigation (RNAV) holding procedures based on VOR/DME were included as a result of the ninth meeting of the Obstacle Clearance Panel, to become applicable in 1993 (Amendment 7).

2.2.7 *Section 7 — En route*

Material on RNAV and RNP routes was added in 1998 (Amendment 11).

2.3 Part III — Aircraft Operating Procedures

2.3.1 *Section 1 — Altimeter setting procedures*

The altimeter setting procedures were developed from the basic principles established by the third session of the Operations Division in 1949 and are the result of evolution through the recommendations of a number of Regional Air Navigation Meetings. They formerly appeared as Part 1 of the *Regional Supplementary Procedures* (Doc 7030) and had previously been approved by the Council for use in the majority of ICAO regions as supplementary procedures. Part 1 of Doc 7030 now contains only regional procedures which are supplementary to the procedures contained in this document. The incorporation of these procedures in the PANS-OPS was approved by the Council in 1961 on the understanding that this action was not to be construed as a decision of principle on the question of flight levels or on the relative merits of metres or feet for altimetry purposes. Subsequently the Council approved the definitions of flight level and transition altitude. To comply with Amendment 13 to Annex 5, the primary unit of atmospheric pressure was changed to hectopascal (hPa) in 1979.

2.3.2 *Section 2 — Simultaneous operations on parallel or near-parallel instrument runways*

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 simultaneous operations on parallel or near-parallel instrument runways, including the minimum distances between runways.

2.3.3 *Section 3 — Secondary surveillance radar (SSR) transponder operating procedures*

These procedures were originally developed at the Sixth Air Navigation Conference in 1969. The operating procedures are intended to provide international standardization for the safe and efficient use of SSR and to minimize the workload and voice procedures for pilots and controllers.

2.3.4 *Section 4 — Operational flight information*

Material related to Operational Flight Information was added to the PANS-OPS as a result of conclusion 9/30 of ASIA/PAC Air Navigation Planning and Implementation Regional Group.

2.3.5 *Section 5 — Standard operating procedures (SOPs) and checklists*

Material related to standard operating procedures was added to the PANS-OPS as result of conclusion 9/30 of ASIA/PAC Air Navigation Planning and Implementation Regional Group.

2.3.6 *Section 6 — Voice communication procedures and controller-pilot data link communications procedures*

Note.— This material is under development and while no text is presently available in this document, provisions and procedures relevant to aircraft operations have been combined with those concerning the provision of air traffic services in Annex 10, Volume II, and the Procedures for Air Navigation Services — Air Traffic Management *(PANS-ATM) (Doc 4444).*

3. STATUS

Procedures for Air Navigation Services (PANS) do not have the same status as SARPs. While the latter are *adopted* by the Council in pursuance of Article 37 of the Convention and are subject to the full procedure of Article 90, PANS are *approved* by the 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 provision 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, Fourth Edition. 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 tolerances (accuracy) are 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 Operations 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	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

Amendment	*Source(s)*	*Subject(s)*	*Approved* *Applicable*
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	Practices 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 operational meteorological information.	9 December 1977 10 August 1978
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. First part of editorial rearrangement of the PANS-OPS into two volumes.	29 June 1979 25 November 1982
14 (Volume I, 1st Edition)	Sixth Meeting of the Obstacle Clearance Panel (1978)	Second and final part of editorial rearrangement of the PANS-OPS into two volumes.	17 March 1980 25 November 1982
1 (Volume I, 2nd Edition)	Seventh Meeting of the Obstacle Clearance Panel (1981)	Consequential changes to Part III resulting from Amendment No. 1 to the PANS-OPS, Volume II, 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), Third and Fourth Meetings of the Operations Panel (1980 and 1981)	Changes to the holding criteria, e.g. introduction of VOR/DME holding criteria. Introduction of new Part V— Noise Abatement Procedures. Introduction of new Part X for helicopter-only procedures.	30 March 1983 24 November 1983
3	Seventh Meeting of the Obstacle Clearance Panel (1981)	Introduction of departure procedures and editorial amendments.	25 November 1983 22 November 1984
4	Council, Air Navigation Commission	Secondary surveillance radar (SSR) transponder operating procedures.	14 March 1986 20 November 1986
5 (Volume I, 3rd Edition)	Eighth Meeting of the Obstacle Clearance Panel (1984)	Deletion, in the missed approach segment, of the turn point defined by a distance (timing); change in VOR TO/FROM indication error zone; new holding speeds; editorial amendments.	7 May 1986 20 November 1986
6	Obstacle Clearance Panel, Third and Fourth Meetings of the HELIOPS Panel, Council, Air Navigation Commission	Introduction of new Part VII — Simultaneous operations on parallel or near-parallel instrument runways. Introduction in Part X (now renumbered as Part XI) of new and revised provisions related to procedures specified for use by helicopters only, and joint helicopter/aeroplane procedures. Editorial amendments.	23 March 1990 15 November 1990
7 (Volume I, 4th Edition)	Ninth Meeting of the Obstacle Clearance Panel (1990), Fifth	Amendment of the definitions of decision altitude/height (DA/H), minimum descent altitude/height (MDA/H), obstacle clearance	3 March 1993 11 November 1993

Amendment	*Source(s)*	*Subject(s)*	*Approved Applicable*
	Meeting of the Operations Panel (1989), Fourth Meeting of the Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel (1989) and Amendment 69 to Annex 10	altitude/height (OCA/H) and minimum sector altitude and inclusion of the definitions of area navigation (RNAV), waypoint and airborne collision avoidance system (ACAS). Amendment of Part II related to departure procedures 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 of Part III, Chapter 4, to include criteria on visual manoeuvring using a prescribed track. Introduction of Part III, Chapter 5, related to RNAV approach procedures based on VOR/DME. Deletion of Attachment A to Part III. Introduction in Part IV, Chapter 1, of RNAV holding procedures based on VOR/DME. Amendment of Part IV, Chapter 1, related to VOR/DME entry procedures. Amendment of Part V, Chapter 1, related to noise abatement procedures. Introduction of a new Part VIII, Chapter 3, concerning operation of ACAS equipment. Amendment of the DME fix tolerances to reflect current DME/N accuracy characteristics.	
8	Air Navigation Commission	Simultaneous operations on parallel or near-parallel instrument runways.	13 March 1995 9 November 1995
9	Tenth Meeting of the Obstacle Clearance Panel (1994), Fourth and Fifth Meetings of the Secondary Surveillance Radar Improvements and Collision Avoidance Systems Panel (1989 and 1993 respectively)	Introduction of new definitions and abbreviations in Part I, Chapter 1. Modification of the provisions concerning departure procedures in Part II, Chapter 2. Revision of the departure procedures published information in Part II, Chapter 4. Inclusion of a new Part II, Chapter 5, on area navigation (RNAV) departures based on VOR/DME. Inclusion of a new Part II, Chapter 6, on the use of FMS/RNAV equipment to follow conventional departure procedures. Modification of existing provisions and introduction of new provisions in Part III, Chapter 3, concerning criteria for arrival and reversal procedures. Modification of the RNAV approach procedures based on VOR/DME in Part III, Chapter 5. Inclusion of a new Part III, Chapter 6, on the use of FMS/RNAV equipment to follow conventional non-precision approach procedures. Modification of the holding procedures in Part IV. Amendment to Part VIII, Chapter 1, to reflect current technology in the area of secondary surveillance radar transponders, taking into account the use of MODE S transponders in addition to MODE A/C transponders and introduction of transponder failure procedures when the carriage of a functioning transponder is mandatory. Introduction of new requirements in Part VIII, Chapter 3, for the operation of ACAS equipment. Introduction of a new Part XII concerning en-route obstacle clearance criteria.	4 March 1996 7 November 1996
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. Modification of the turning departures in Part II, Chapter 2. Amendment of the factors affecting operational minima in Part III, Chapter 1. Modification of the final approach alignment and descent gradients in Part III, Chapter 2. Introduction of new material related	1 May 1998 5 November 1998

Amendment	*Source(s)*	*Subject(s)*	*Approved* *Applicable*
		to steep angle approaches in Part III, Chapter 3. Modification of the area navigation (RNAV) approach procedures based on VOR/DME in Part III, Chapter 5. Introduction of a new Part III, Chapter 7, on RNAV approach procedures for basic GNSS receivers. Introduction of a new Chapter 8 on RNAV approach procedures based on DME/DME. Updating of RNAV holding procedures in Part IV, Chapter 1. Introduction of material related to RNAV/RNP routes in Part XII, Chapter 1. Editorial amendments.	
11	Eleventh Meeting of the Obstacle Clearance Panel, Twelfth Meeting of the Obstacle Clearance Panel, Fifth Meeting of the Automatic Dependent Surveillance Panel, Conclusion 9/30 of ASIA/PAC Air Navigation Planning and Implementation Regional Group, Air Navigation Commission studies, Fifth Meeting of the Committee on Aviation Environmental Protection	Amendment of the Foreword to notify operational requirements and procedures for air traffic service (ATS) data link applications in Part XIV. Introduction of new definitions 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 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 of Part III regarding basic GNSS approach procedures and DME/DME procedures to account for reversion. Introduction of new Part VI, Chapter 3, regarding altimeter corrections. Deletion of material with regard to the global exchange of operational meteorological (OPMET) information in Part IX. Addition of Human Factors-related provisions in Parts IX and XIII. Integration of helicopter criteria throughout the document. Introduction of new noise abatement procedures.	29 June 2001 1 November 2001
12	Air Navigation Commission study concerning the operation of airborne collision avoidance system (ACAS) equipment, review by the Surveillance and Conflict Resolution Systems Panel (SCRSP) of ACAS II training guidelines for pilots	Revised provisions in Part VIII, Chapter 3, to improve the clarity of the text and to strengthen the provisions to prevent a manoeuvre in the opposite sense to a resolution advisory. Introduction of a new Attachment A to Part VIII — ACAS II Training Guidelines for Pilots.	30 June 2003 27 November 2003
13	Thirteenth Meeting of the Obstacle Clearance Panel (2003)	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 — amendment to GNSS area navigation (RNAV) departure procedures to account for multi-sensor RNAV systems, introduction of altitude depiction requirements, SBAS and GBAS departure procedures; Part III — amendment to the basis of categorization of aircraft, introduction of helicopter	27 April 2004 25 November 2004

Amendment	*Source(s)*	*Subject(s)*	*Approved Applicable*
		point-in-space procedures, introduction of the procedure altitude concept to address CFIT, introduction of altitude depiction requirements, amendment to GNSS RNAV approach procedures to account for multi-sensor RNAV systems, amendment to the standard aircraft dimensions for determination of DA/H, introduction of procedures for SBAS and GBAS, introduction of the TAA concept; Part XI — amendment to procedures specified for use by helicopters; Part XII — amendment to en-route criteria to include a simplified method; Part XIII — amendment to parameters for stabilized approach to include cold temperature correction.	
14 (Volume I, 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

FLIGHT PROCEDURES — GENERAL

Section 1

DEFINITIONS, ABBREVIATIONS AND ACRONYMS

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.

Airborne collision avoidance system (ACAS). An aircraft system based on secondary surveillance radar (SSR) transponder signals which operates independently of ground-based equipment to provide advice to the pilot on potential conflicting aircraft that are equipped with SSR transponders.

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

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.

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

Controlled airspace. An airspace of defined dimensions within which air traffic control service is provided in accordance with the airspace classification.

Note.— Controlled airspace is a generic term which covers ATS airspace Classes A, B, C, D and E as described in Annex 11, 2.6.

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.

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

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; and

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.

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. In RNAV applications this fix is normally defined by a fly-by waypoint.

Initial approach segment. That segment of an instrument approach procedure between the initial approach fix and the intermediate 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 approach 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 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. In RNAV applications this fix is normally defined by a fly-by waypoint.

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. 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.

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.

Normal operating zone (NOZ). Airspace of defined dimensions extending to either side of an ILS localizer course and/or MLS final approach track. Only the inner half of the normal operating zone is taken into account in independent parallel approaches.

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 Section 4, Chapter 1, 1.5, for specific application of this definition.

Note 4.— See PANS-OPS, Volume II, Part IV, Chapter 1, for area navigation (RNAV) point-in-space (PinS) approach procedures for helicopters using basic GNSS receivers.

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.

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.

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.

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 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).

Transition altitude. The altitude at or below which the vertical position of an aircraft is controlled by reference to altitudes.

Transition layer. The airspace between the transition altitude and the transition level.

Transition level. The lowest flight level available for use above the transition altitude.

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 AND ACRONYMS

(used in this document)

AAIM	Aircraft autonomous integrity monitoring
AC	Advisory Circular
ACAS	Airborne collision avoidance system
AGL	Above ground level
AHRS	Attitude and heading reference system
AIP	Aeronautical Information Publication
AIRAC	Aeronautical information regulation and control
APV	Approach procedure with vertical guidance
ATC	Air traffic control
ATIS	Automatic terminal information service
ATS	Air traffic services
ATTCS	Automatic take-off thrust control systems
baro-VNAV	Barometric vertical navigation
CAT	Category
CBT	Computer-based training
CDI	Course deviation indicator
C/L	Centre line
CPA	Closest point of approach
CRM	Crew resource management
DA/H	Decision altitude/height
DER	Departure end of the runway
DME	Distance measuring equipment
DR	Dead reckoning
EFIS	Electronic flight instrument system
EGPWS	Enhanced ground proximity warning system
ESDU	Engineering Sciences Data Unit
EUROCAE	European Organization for Civil Aviation Equipment
FAA	Federal Aviation Administration
FAF	Final approach fix
FAP	Final approach point
FAS	Final approach segment
FATO	Final approach and take-off area
FL	Flight level
FMC	Flight management computer
FMS	Flight management system
FSD	Full-scale deflection
ft	Foot (feet)
FTE	Flight technical error
FTT	Flight technical tolerance
GBAS	Ground-based augmentation system
GNSS	Global navigation satellite system

GP	Glide path
GPWS	Ground proximity warning system
hPa	Hectopascal(s)
HSI	Horizontal situation indicator
IAC	Instrument approach chart
IAF	Initial approach fix
IAP	Instrument approach procedure
IAS	Indicated airspeed
IF	Intermediate fix
IFR	Instrument flight rules
ILS	Instrument landing system
IMC	Instrument meteorological conditions
INS	Inertial navigation system
IRS	Inertial reference system
ISA	International standard atmosphere
JAA	Joint Aviation Authorities
KIAS	Knots indicated airspeed
kt	Knot(s)
km	Kilometre(s)
LNAV	Lateral navigation
LORAN	Long range air navigation system
m	Metre(s)
MAHF	Missed approach holding fix
MAPt	Missed approach point
MDA/H	Minimum descent altitude/height
MLS	Microwave landing system
MOC	Minimum obstacle clearance
MSA	Minimum sector altitude
MSD	Minimum stabilization distance
MSL	Mean sea level
NADP	Noise abatement departure procedure
NDB	Non-directional beacon
NM	Nautical mile(s)
NOTAM	Notice to airmen
NOZ	Normal operating zone
NPA	Non-precision approach
NTZ	No transgression zone
OCA/H	Obstacle clearance altitude/height
OFZ	Obstacle free zone
OIS	Obstacle identification surface
OM	Outer marker
PA	Precision approach
PAOAS	Parallel approach obstacle assessment surface
PAPI	Precision approach path indicator
PAR	Precision approach radar
PDG	Procedure design gradient
PinS	Point-in-space
PRP	Point-in-space reference point
PVT	Position, velocity and time
QFE	Atmospheric pressure at aerodrome elevation (or at runway threshold)
QNH	Altimeter sub-scale setting to obtain elevation when on the ground
RA	Resolution advisory
RAIM	Receiver autonomous integrity monitoring

RDH	Reference datum height
RNAV	Area navigation
RNP	Required navigation performance
RSR	En-route surveillance radar
RSS	Root sum square
RVR	Runway visual range
SBAS	Satellite-based augmentation system
SD	Standard deviation
SI	International system of units
SID	Standard instrument departure
SOC	Start of climb
SOPs	Standard Operating Procedures
SPI	Special position indicator
SSR	Secondary surveillance radar
SST	Supersonic transport
STAR	Standard instrument arrival
TA	Traffic advisory
TAA	Terminal arrival altitude
TAR	Terminal area surveillance radar
TAS	True airspeed
THR	Threshold
TMA	Terminal control area
TP	Turning point
TSO	Technical Standard Order
VASIS	Visual approach slope indicator system
VNAV	Vertical navigation
VOR	Very high frequency omnidirectional radio range
VPA	Vertical path angle
WGS	World geodetic system

Section 2

GENERAL PRINCIPLES

Chapter 1

GENERAL INFORMATION

1.1 GENERAL

1.1.1 Obstacle clearance is a primary safety consideration in the development of instrument flight procedures. The criteria used and the detailed method of calculation are covered in PANS-OPS, Volume II.

1.1.2 Procedures contained in PANS-OPS assume that all engines are operating.

Note.— Development of contingency procedures is the responsibility of the operator.

1.1.3 All procedures depict tracks. Pilots should attempt to maintain the track by applying corrections to heading for known wind.

1.1.4 All examples of calculations in this document are based on an altitude of 600 m (2 000 ft) above mean sea level (MSL) and a temperature of international standard atmosphere (ISA) +15°C unless otherwise stated.

1.1.5 For helicopters operated as Category A aeroplanes, failure to maintain the minimum speed could lead to an excursion of the protected airspace provided because of high drift angles or errors in turning point determinations. Similarly, high vertical speeds could hazard the helicopter when over a stepdown fix (see Figure I-2-1-1), or could result in the helicopter on departure initiating a turn at a height of 120 m (394 ft), but prior to reaching the departure area.

1.1.6 The minimum final approach speed considered for a Category A aeroplane is 130 km/h (70 kt). This is only critical when the missed approach point (MAPt) is specified by a distance from the final approach fix (FAF) (e.g. an "off aerodrome" NDB or VOR procedure). In these cases (if the FAF to MAPt distance exceeds certain values dependent on aerodrome elevation), a slower speed when combined with a tailwind may cause the helicopter to reach start of climb (SOC) after the point calculated for Category A aeroplanes. This will reduce the obstacle clearance in the missed approach phase.

1.1.7 Conversely, a slower speed combined with a headwind could cause the helicopter to reach the MAPt (and any subsequent turn altitude) before the point calculated for Category A aeroplanes, and hence depart outside the protected area.

1.1.8 Therefore, for helicopters, speed should be reduced below 130 km/h (70 kt) only after the visual references necessary for landing have been acquired and the decision has been made that an instrument missed approach procedure will not be performed.

1.2 OBSTACLE CLEARANCE

1.2.1 Obstacle clearance is a primary safety consideration in the development of instrument flight procedures. The criteria used and the detailed method of calculation are covered in PANS-OPS, Volume II. However, from the operational point of view it is stressed that the obstacle clearance applied in the development of each instrument procedure is considered to be the minimum required for an acceptable level of safety in operations.

1.2.2 The protected areas and obstacle clearance applicable to individual types of procedures are specified in Parts I and II.

1.3 AREAS

1.3.1 Where track guidance is provided in the design of a procedure, each segment comprises a specified volume of airspace, the vertical cross-section of which is an area located symmetrically about the centre line of each segment. The vertical cross-section of each segment is divided into primary and secondary areas. Full obstacle clearances are applied over the primary areas reducing to zero at the outer edges of the secondary areas (see Figure I-2-1-2).

1.3.2 On straight segments, the width of the primary area at any given point is equal to one-half of the total width. The width of each secondary area is equal to one-quarter of the total width.

1.3.3 Where no track guidance is provided during a turn specified by the procedure, the total width of the area is considered primary area.

1.3.4 The minimum obstacle clearance (MOC) is provided for the whole width of the primary area. In the secondary area, MOC is provided at the inner edges reducing to zero at the outer edges (see Figure I-2-1-2).

1.4 USE OF FLIGHT MANAGEMENT SYSTEM (FMS)/ AREA NAVIGATION (RNAV) EQUIPMENT

1.4.1 Where FMS/RNAV equipment is available, it may be used to fly conventional procedures provided:

a) the procedure is monitored using the basic display normally associated with that procedure; and

b) the tolerances for flight using raw data on the basic display are complied with.

1.4.2 Lead radials

Lead radials are for use by non-RNAV-equipped aircraft and are not intended to restrict the use of turn anticipation by the FMS.

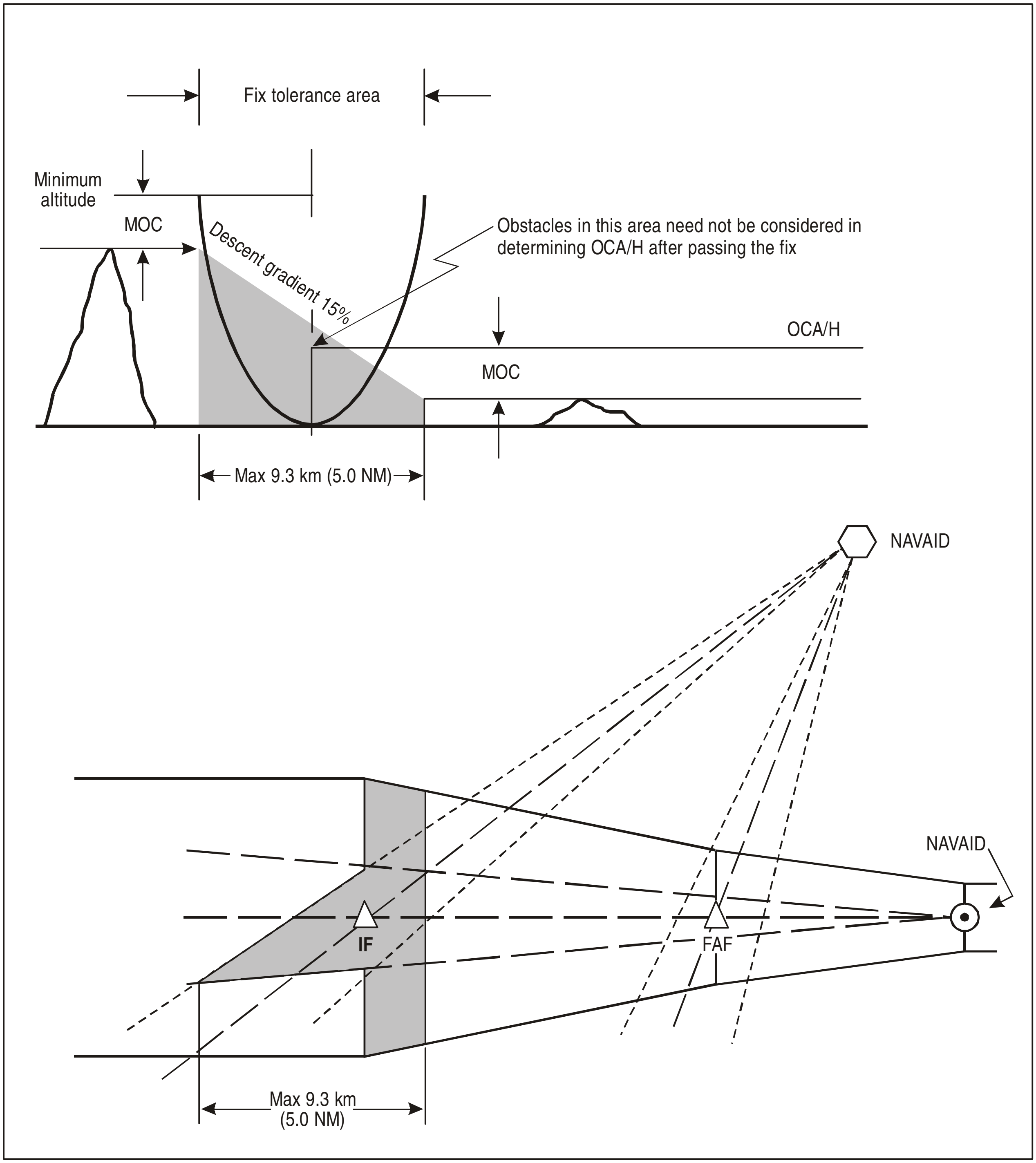


Figure I-2-1-1. Area where obstacles need not be considered

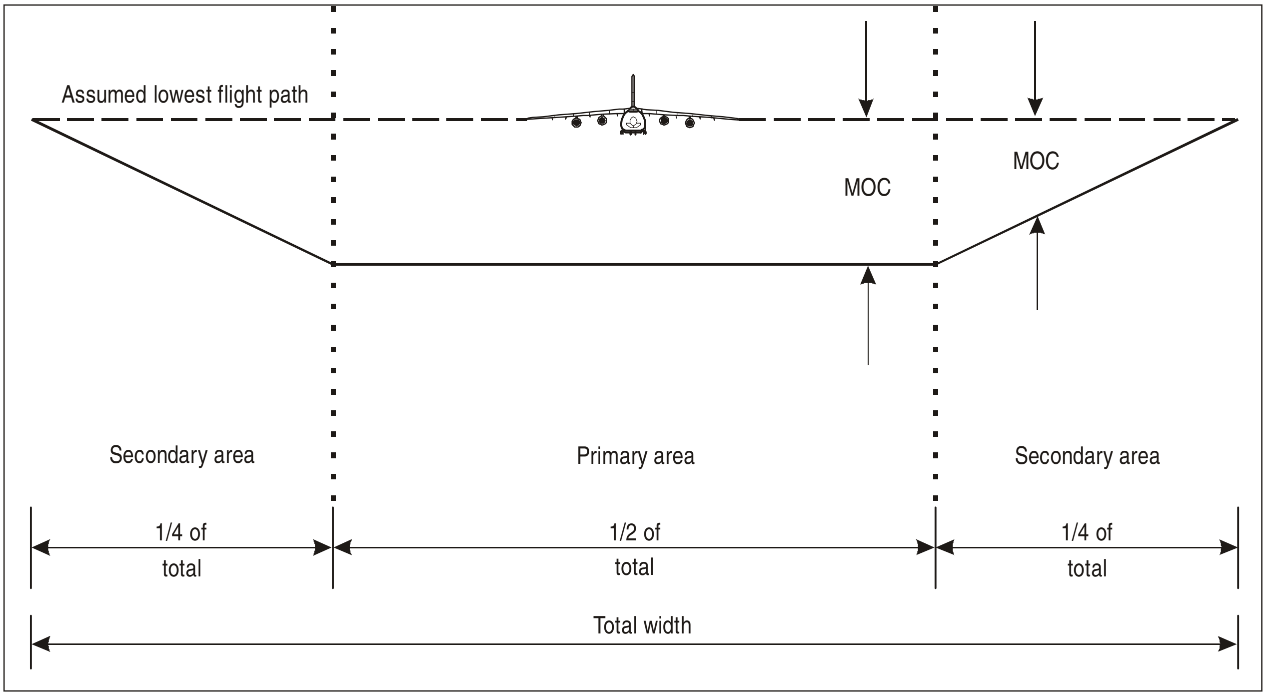


Figure I-2-1-2. Relationship of minimum obstacle clearances in primary and secondary areas in cross-section

Chapter 2

ACCURACY OF FIXES

2.1 GENERAL

Fixes and points used in designing flight procedures are normally based on standard navigation systems.

2.2 FIX FORMED BY INTERSECTION

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 called the fix tolerance area which surrounds its plotted point of intersection. Figure I-2-2-1 illustrates the intersection of two radials or tracks from different navigation facilities.

2.3 FIX TOLERANCE FACTORS

2.3.1 The dimensions of the fix tolerance area are determined by the system use accuracy of the navigation aid(s) on which the fix is based, and the distance from the facility.

2.3.2 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.

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 SYSTEMS

2.4.1 Surveillance radar

Radar fix tolerances are based on radar mapping accuracies, azimuth resolution, flight technical tolerance, controller technical tolerances, and the speed of aircraft in the terminal area. The fix tolerances are listed below:

a) terminal area surveillance radar (TAR) within 37 km (20 NM): fix tolerance is ±1.5 km (0.8 NM); and

b) en-route surveillance radar (RSR) within 74 km (40 NM): fix tolerance is ±3.1 km (l.7 NM).

2.4.2 Distance measuring equipment (DME)

Fix tolerance is ±0.46 km (0.25 NM) + 1.25 per cent of distance to the antenna.

2.4.3 75 MHz marker beacon

Use Figure I-2-2-2 to determine the fix tolerance for instrument landing system (ILS) and “z” markers for use with instrument approach procedures.

2.4.4 Fix tolerance overheading a station

2.4.4.1 *Very high frequency omnidirectional radio range (VOR)*

Fix tolerance overheading a VOR is based upon a circular cone of ambiguity generated by a straight line passing through the facility and making an angle of 50° from the vertical, or a lesser angle as determined by flight test. 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:

$d = 0.2\ h$ (d and h in km); or

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

For a cone angle of 50°, the accuracy of entry is ±5°. Tracking through the cone is assumed to be within an accuracy of ±5°. Station passage is assumed to be within the limits of the cone of ambiguity. See Figure I-2-2-3 for an illustration of fix tolerance area.

2.4.4.2 *Non-directional beacon (NDB)*

Fix tolerance overheading an NDB is based upon an inverted cone of ambiguity extending at an angle of 40° either side of the facility. Entry into the cone is assumed to be achieved within an accuracy of ±15° from the prescribed track. Tracking through the cone is assumed to be within an accuracy of ±5°. See Figure I-2-2-4 for an illustration of fix tolerance area.

2.5 AREA SPLAY

2.5.1 The construction of area outer boundaries is derived from the fix tolerance of the facility providing track. This value is multiplied by a factor of 1.5 to provide a 99.7 per cent probability of containment (3 SD).

2.5.2 The area width at a facility is:

a) 3.7 km (2.0 NM) for VOR; and

b) 4.6 km (2.5 NM) for NDB.

2.5.3 The area splays from the facility at the following angle:

a) 7.8° for VOR; and

b) 10.3° for NDB.

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

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

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 system tolerance	±2.7°	±1°	±5.4°
c) flight 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.

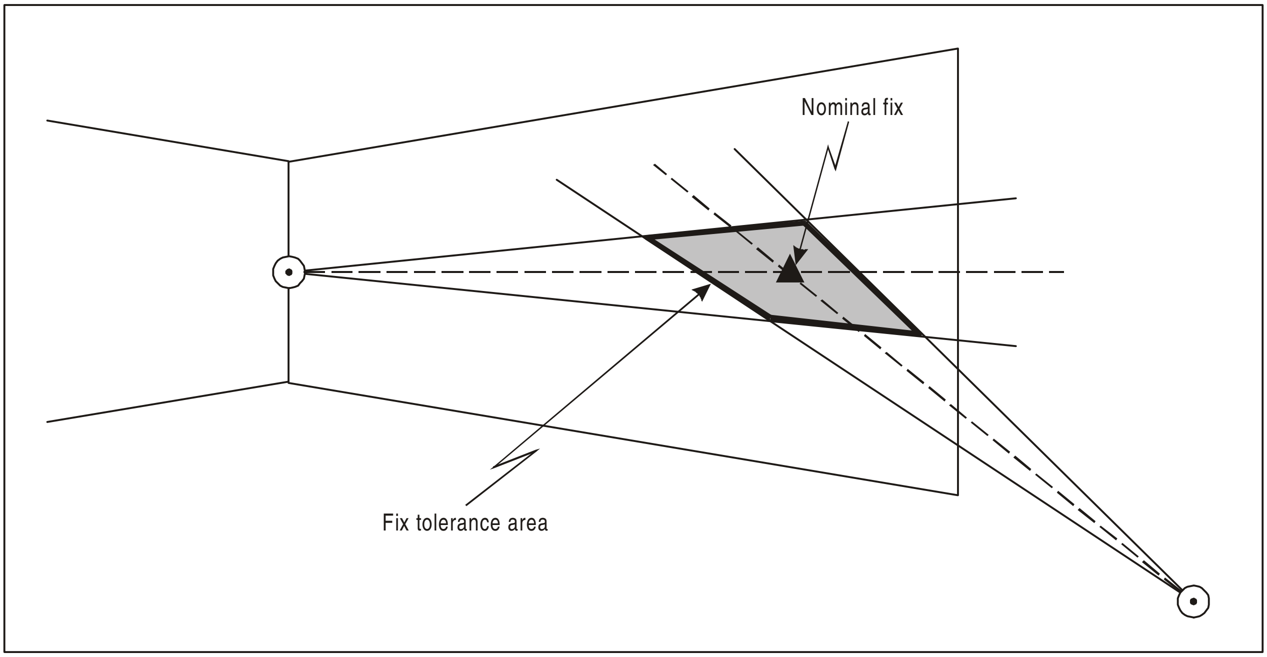
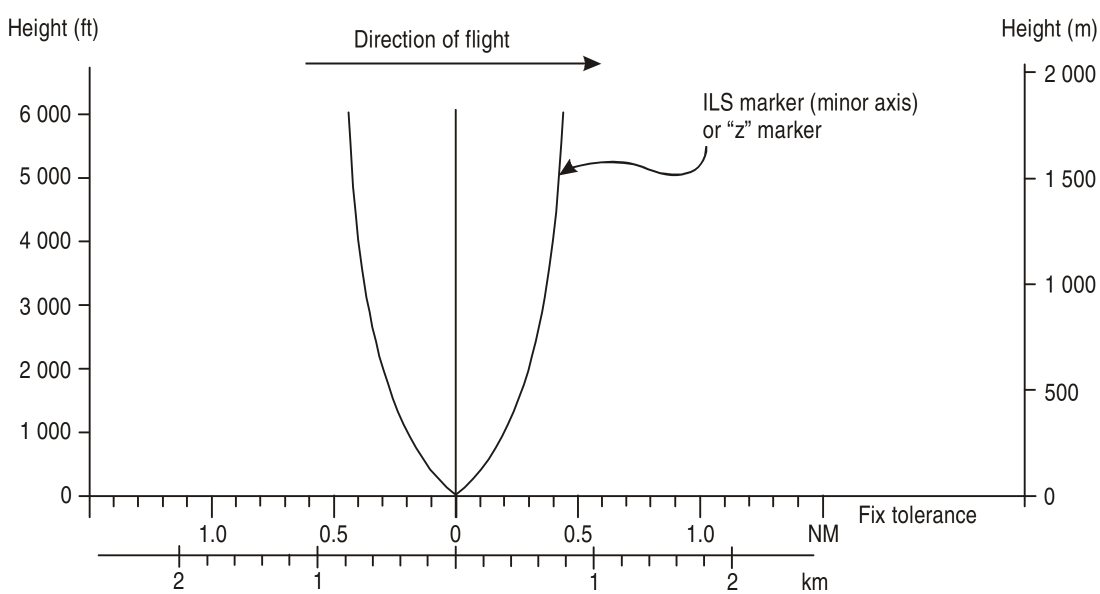


Figure I-2-2-1. Fix tolerance area



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

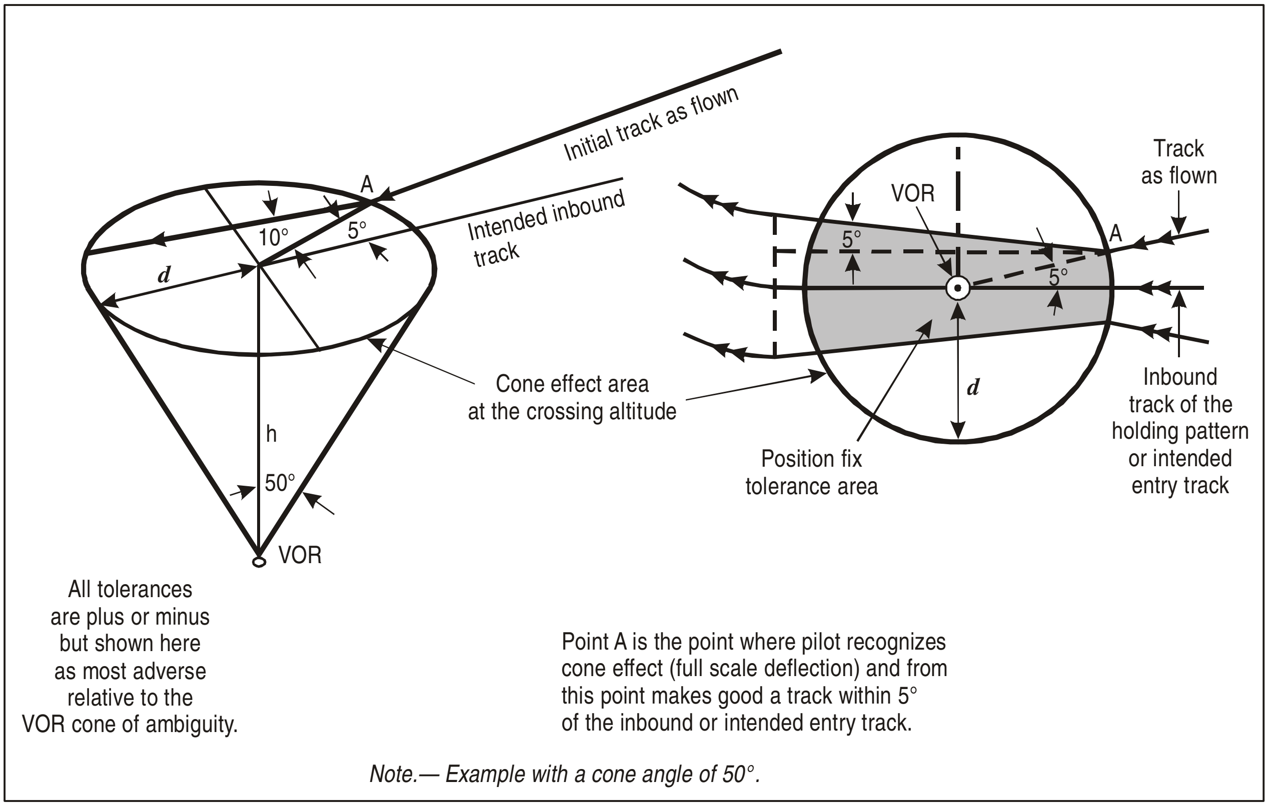


Figure I-2-2-3. Fix tolerance area overhead a VOR

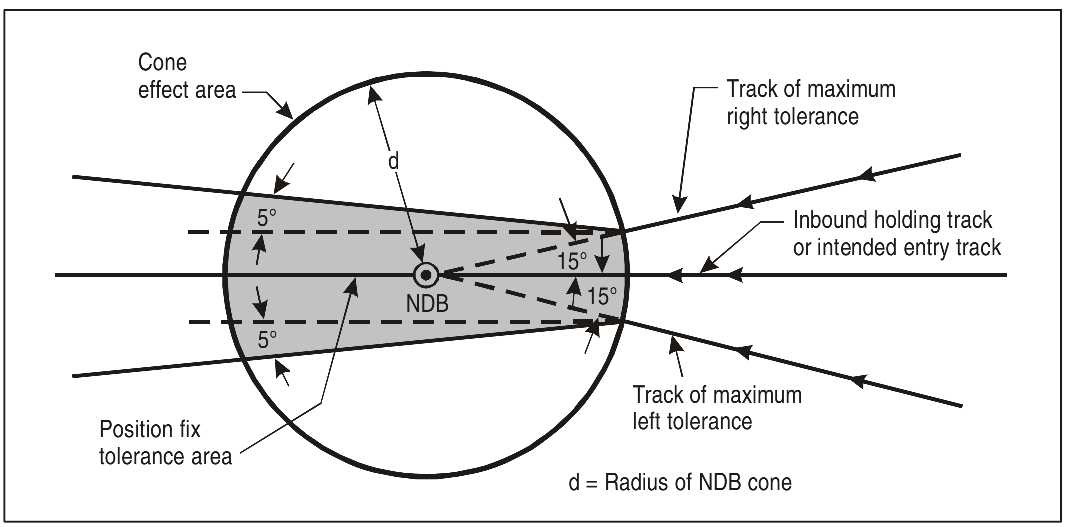


Figure I-2-2-4. Fix tolerance area overhead an NDB

Chapter 3

TURN AREA CONSTRUCTION

3.1 GENERAL

3.1.1 This chapter gives an overview of the methods used in turn construction and lists the parameters that are considered in the process.

3.1.2 The turning point (TP) is specified in one of two ways:

a) *at a designated facility or fix* — the turn is made upon arrival overhead a facility or fix; or

b) *at a designated altitude* — the turn is made upon reaching the designated altitude unless an additional fix or distance is specified to limit early turns (departures and missed approach only).

3.2 TURN PARAMETERS

The parameters on which the turn areas are based are shown in Table I-2-3-1. For the specific application of the parameters in the table, see the applicable chapters in this document.

3.3 PROTECTION AREA FOR TURNS

3.3.1 As with any turning manoeuvre, speed is a controlling factor in determining the aircraft track during the turn. The outer boundary of the turning area is based on the highest speed of the category for which the procedure is authorized. The inner boundary caters for the slowest aircraft. The construction of the inner and outer boundaries is described in more detail below:

Inner boundary — The inner boundary starts at the earliest TP. It splays outward at an angle of 15° relative to the nominal track.

Outer boundary — (See Figure I-2-3-1.) The outer boundary is constructed in the following sequence:

a) it starts at Point A. The parameters that determine Point A are:

   1) fix tolerance; and

   2) flight technical tolerance;

b) then from Point A, there are three methods for constructing the curving portion of the turn outer boundary:

   1) by calculating the wind spiral;

2) by drawing bounding circles; and

3) by drawing arcs; and

c) after the curved area is constructed, a straight section begins where the tangent of the area becomes parallel to the nominal track (Point P). At this point:

1) if there is no track guidance available, the outer boundary splays at 15°; or

2) if track guidance is available after the turn, the turning area may be reduced as shown in Figure I-2-3-2 B, C and D. The outer edges of the turning area end where they intersect the area splay of the navaid giving track.

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.

3.3.2.2 The outer boundary of the turn area is constructed using a spiral derived from the radius of turn. The spiral results from applying wind effect to the ideal flight path. See Figure I-2-3-3.

3.3.2.3 *Example of Wind Spiral Construction*

Figure I-2-3-4 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

3.3.3.1 As an alternative to the wind spiral, a simplified method can be used in which circles are drawn to bound the turning area. Figure I-2-3-5 shows how this is applied.

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

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

					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 Table 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% omnidirectional wind or 56 km/h (30 kt) for wind spirals	15º until 305 m (1º000 ft) 20º between 305 m (1 000 ft) and 915 m (3 000 ft) 25º above 915 m (3 000 ft)	3	3	N/A	N/A
En route	585 km/h (315 kt)	Specified altitude	95% probability wind or ICAO standard wind[4]	15º	5	10	N/A	N/A
Holding	Tables I-6-1-1 and I-6-1-2[1]	Specified altitude	ICAO standard wind [4]	23º	N/A	5	N/A	N/A
Initial approach – reversal and racetrack procedures	Table I-4-1-1 or Table I-4-1-2	Specified altitude	ICAO standard wind[4] or statistical wind	25º	5	0–6	10	5
Initial approach – DR track procedures	CAT A, B: 165 to 335 km/h (90 to 180 kt) CAT C, D, E: 335 to 465 km/h (180 to 250 kt)	CAT A, B: 1 500 m (5 000 ft) CAT C, D, E: 3 000 m (10 000 ft)	ICAO standard wind[4] DR leg: 56 km/h (30 kt)	25º	5	0–6	N/A	5
IAF, IF, FAF	See Tables 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% omnidirectional wind or 56 km/h (30 kt)	25º	3	3	N/A	N/A

					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
Missed approach	Table I-4-1-1 or Table 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 Tables 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 Tables 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 in this document.*
2. *The rate of turn associated with the stated bank angle values in this table shall not be greater than 3°/s.*

Note 1.— Where operationally required to avoid obstacles, reduced speeds as slow as the IAS for intermediate missed approach may be used. In this case, 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 15° C. Holding procedures are an exception; the calculation formula appears in PANS-OPS, Volume II, Part II, Section 4, Chapter 1, Appendix A, paragraph 6.

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. In this case, the procedure is annotated "Departure turn limited to __________ km/h (kt) IAS maximum".

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

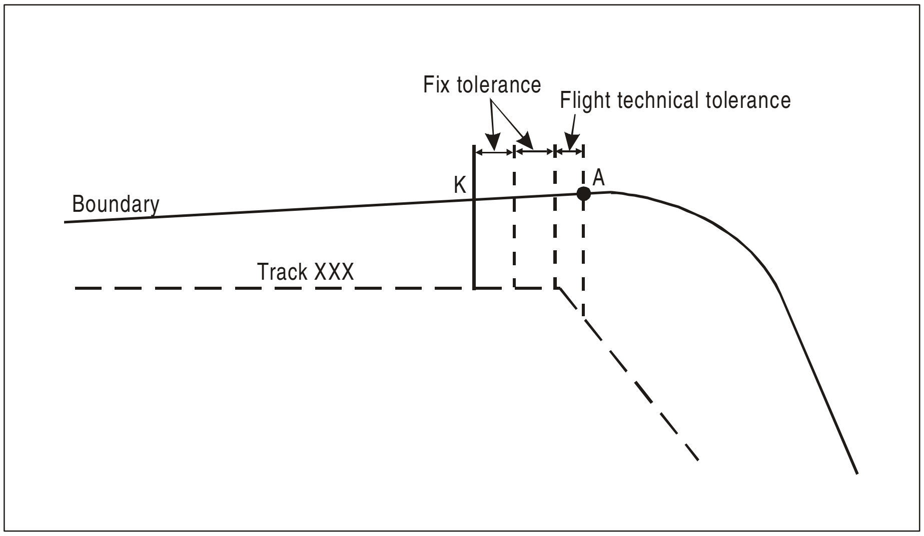


Figure I-2-3-1. Start of construction of outer boundary

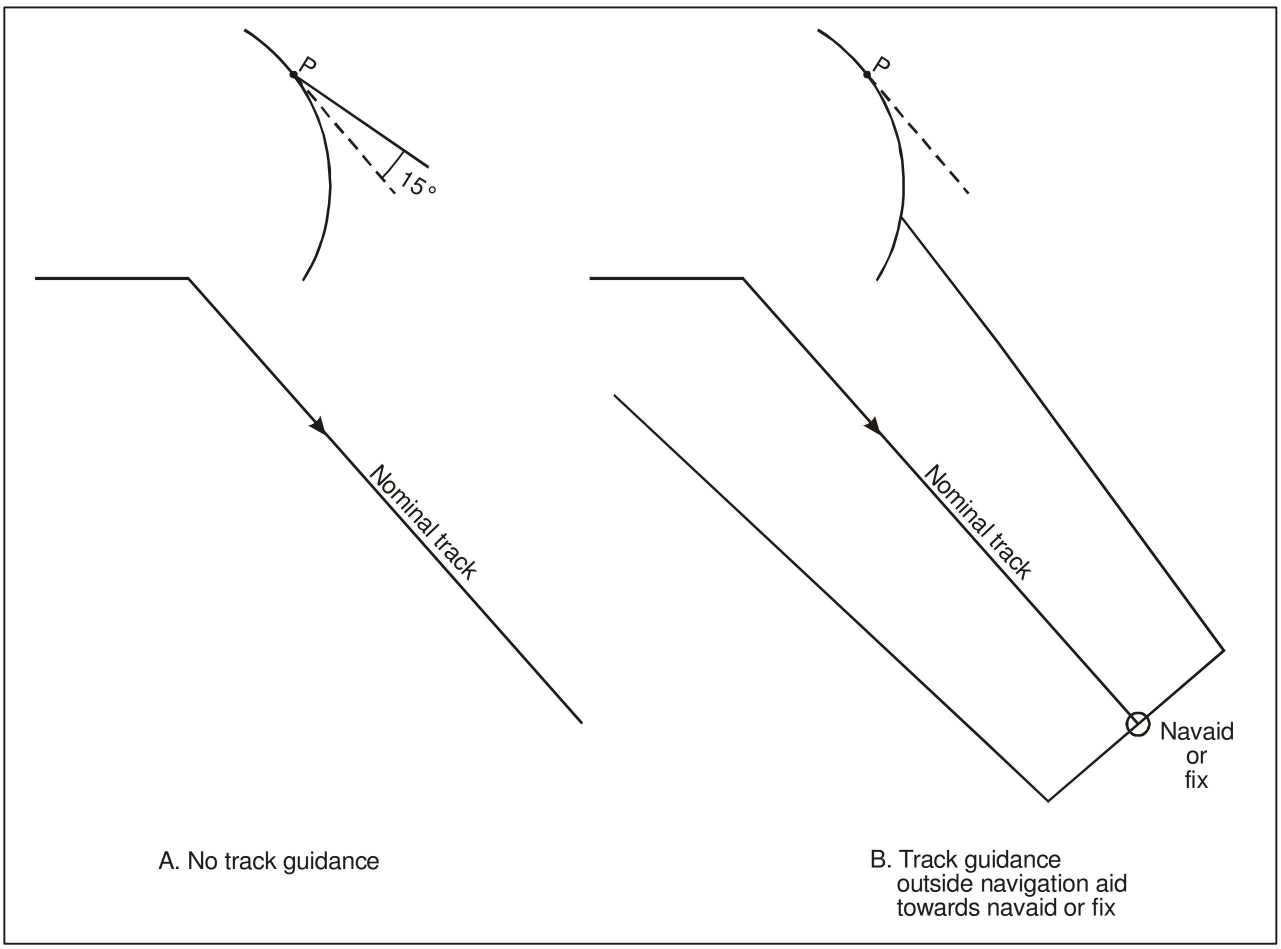


Figure I-2-3-2 A and B. Turn outer boundary construction after Point P

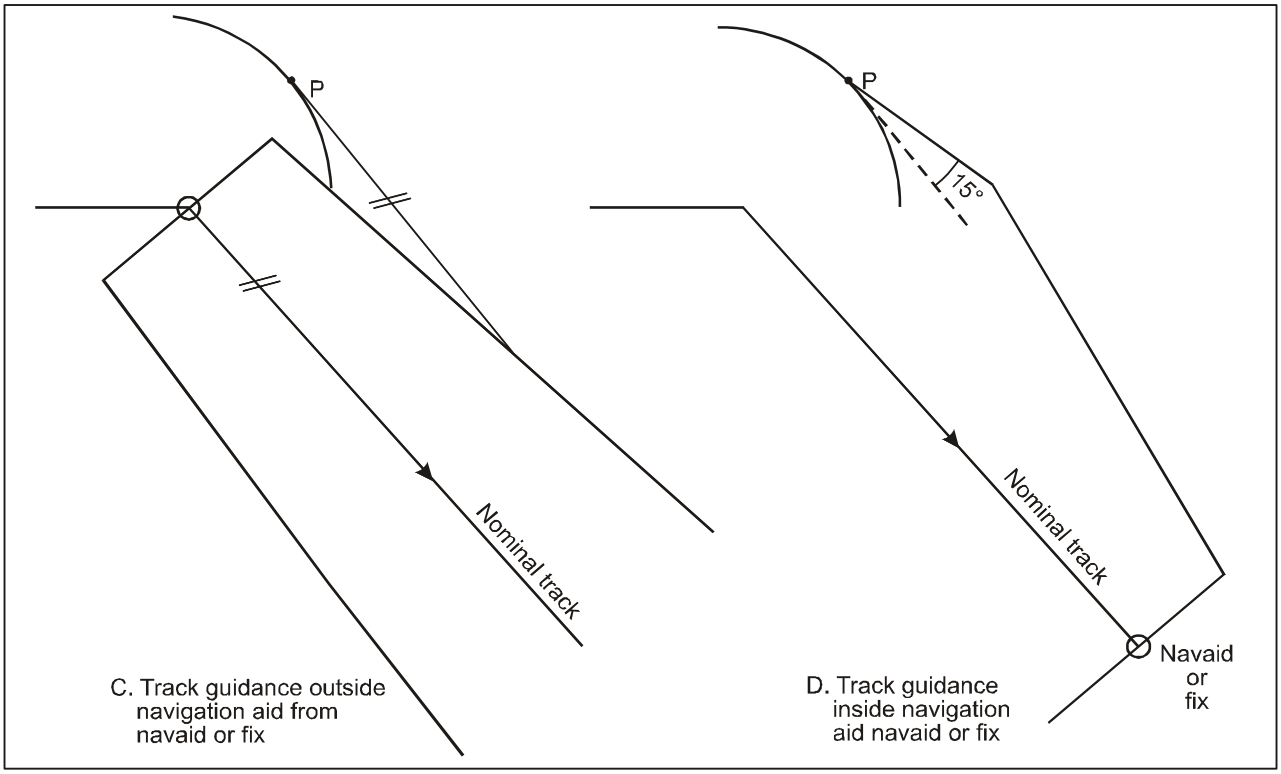


Figure I-2-3-2 C and D. Track guidance outside navigation aid from navaid or fix/ Track guidance inside navigation aid or fix

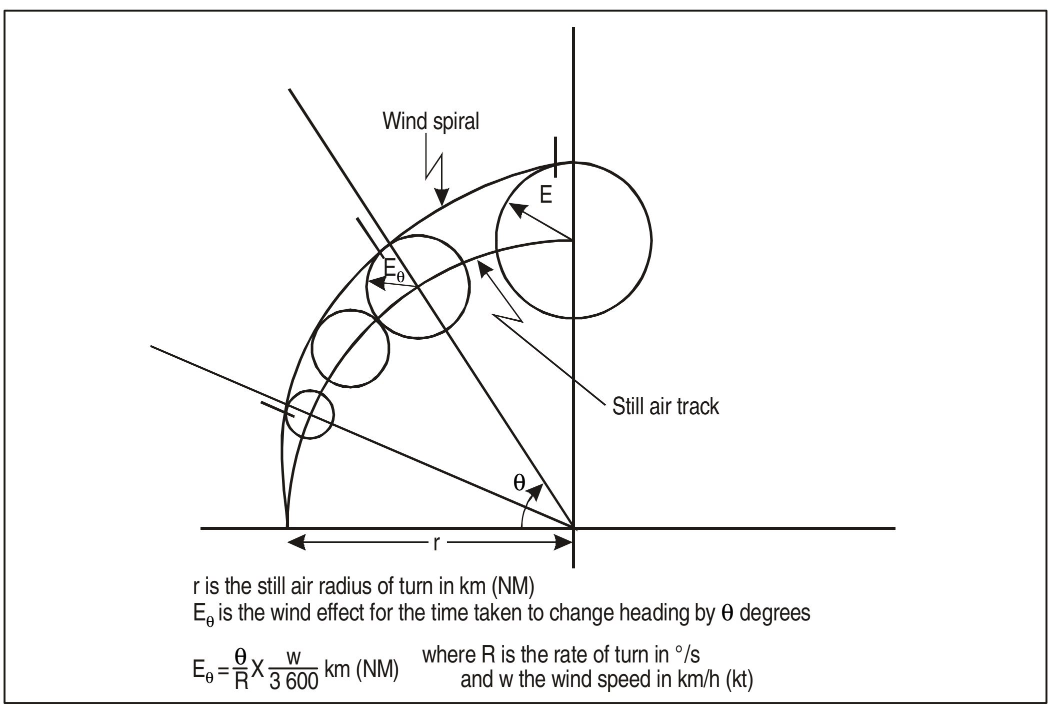


Figure I-2-3-3. Wind spiral

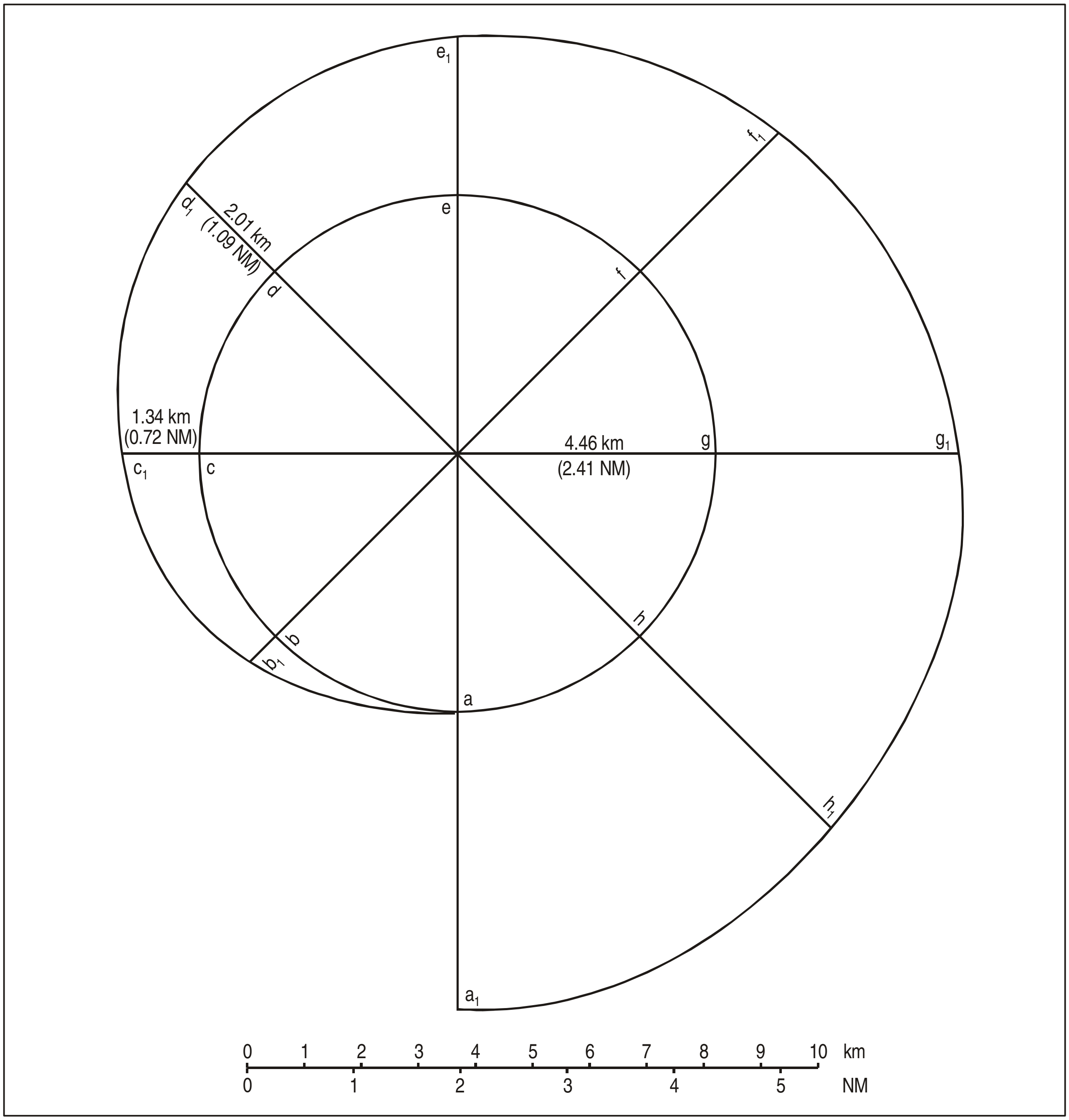


Figure I-2-3-4. Template for plotting omnidirectional wind (wind spiral)

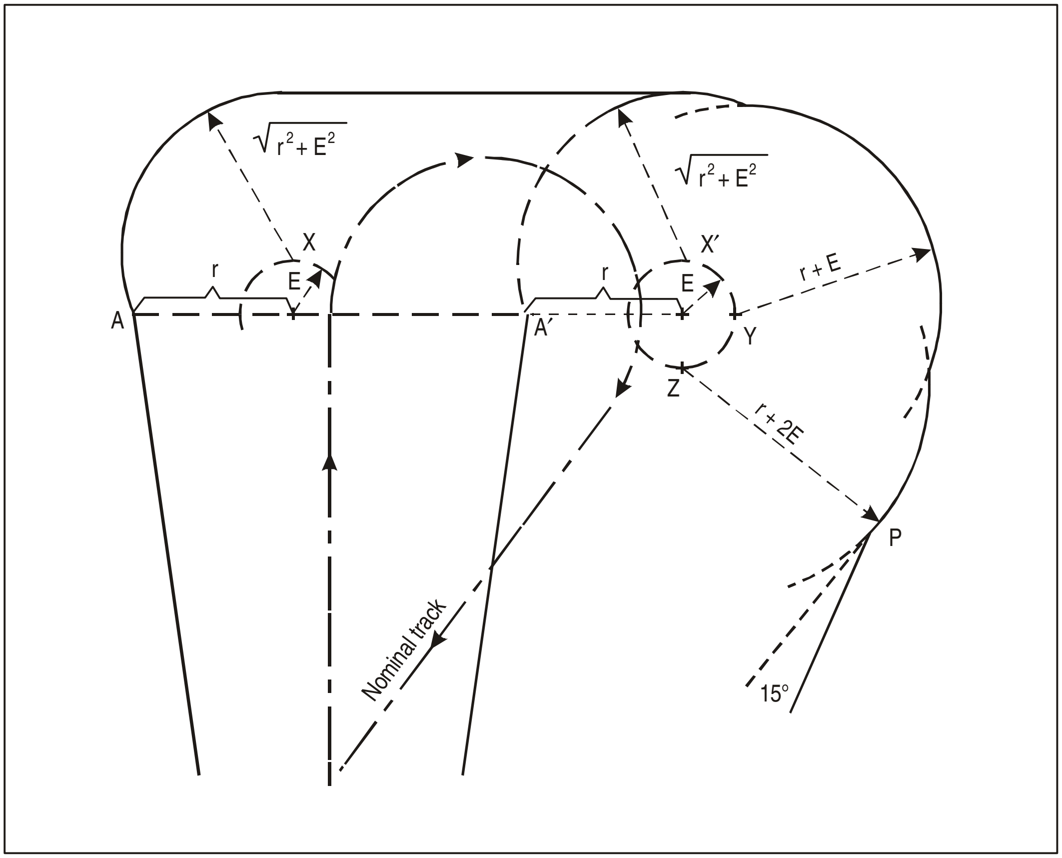


Figure I-2-3-5. Outer turn boundary construction

Section 3

DEPARTURE PROCEDURES

Chapter 1

GENERAL CRITERIA FOR DEPARTURE PROCEDURES

1.1 INTRODUCTION

1.1.1 Application

1.1.1.1 The criteria in this section are designed to provide flight crews and other flight operations personnel with an appreciation, from the operational point of view, of the parameters and criteria used in the design of instrument departure procedures. These include, but are not limited to, standard instrument departure (SID) routes and associated procedures (see Annex 11, Appendix 3).

Note.— Detailed specifications for instrument departure procedure construction, primarily for the use of procedures specialists, are contained in PANS-OPS, Volume II, Part I, Section 3.

1.1.1.2 These procedures assume that all engines are operating. In order to ensure acceptable clearance above obstacles during the departure phase, instrument departure procedures may be published as specific routes to be followed or as omnidirectional departures, together with procedure design gradients and details of significant obstacles.

1.2 OPERATOR'S RESPONSIBILITY

1.2.1 Contingency procedures

Development of contingency procedures, required to cover the case of engine failure or an emergency in flight which occurs after V_1, is the responsibility of the operator, in accordance with Annex 6. An example of such a procedure, developed by one operator for a particular runway and aircraft type(s), is shown in Figure I-3-1-1. Where terrain and obstacles permit, these procedures should follow the normal departure route.

1.2.2 Turning procedures

When it is necessary to develop a turning procedure to avoid an obstacle which would have become limiting, then the procedure should be described in detail in the appropriate operator's manual. The point for start of turn in this procedure must be readily identifiable by the pilot when flying under instrument conditions.

1.2.3 Automatic take-off thrust control systems (ATTCS) and noise abatement procedures

The use of automatic take-off thrust control systems (ATTCS) and noise abatement procedures needs to be taken into consideration by the pilot and the operator.

1.3 INSTRUMENT DEPARTURE PROCEDURE

1.3.1 Design considerations

The design of an instrument departure procedure is, in general, dictated by the terrain surrounding the aerodrome. It may also be required to provide for air traffic control (ATC) requirements in the case of SID routes. These factors in turn influence the type and siting of navigation aids in relation to the departure route. Airspace restrictions may also affect the routing and siting of navigation aids.

1.3.2 Non-prescribed departure routes

At many aerodromes, a prescribed departure route is not required for ATC purposes. Nevertheless, there may be obstacles in the vicinity of some aerodromes that have to be considered in determining whether restrictions to departures are to be prescribed. In such cases, departure procedures may be restricted to a given sector(s) or may be published with a procedure design gradient in the sector containing the obstacle. Departure restrictions are published as described in Chapter 4, "Published Information for Departures".

1.3.3 Omnidirectional departures

1.3.3.1 Where no suitable navigation aid is available, the criteria for omnidirectional departures are applied.

1.3.3.2 Omnidirectional departures may specify sectors to be avoided.

1.3.4 Aerodrome operating minima

1.3.4.1 Where obstacles cannot be cleared by the appropriate margin when the aeroplane is flown on instruments, aerodrome operating minima are established to permit visual flight clear of obstacles (see Part I, Section 8).

1.3.4.2 Wherever possible, a straight departure is specified which is aligned with the runway centre line.

1.3.4.3 When a departure route requires a turn of more than 15° to avoid an obstacle, a turning departure is constructed. Flight speeds for turning departure are specified in Table I-3-2-1 (see also Chapter 2, 2.3.6, "Turn speeds"). Wherever limiting speeds other than those specified in Table I-3-2-1 are promulgated, they must be complied with in order to remain within the appropriate areas. If an aeroplane operation requires a higher speed, then an alternative departure procedure must be requested.

1.3.5 Establishment of a departure procedure

A departure procedure is established for each runway where instrument departures are expected to be used. It will include procedures for the various categories of aircraft.

1.3.6 Wind effect

The procedures assume that pilots will not compensate for wind effects when being radar vectored. They also assume that pilots will compensate for known or estimated wind effects when flying departure routes which are expressed as tracks to be made good.

1.4 OBSTACLE CLEARANCE

1.4.1 The minimum obstacle clearance equals zero at the departure end of the runway (DER). From that point, it increases by 0.8 per cent of the horizontal distance in the direction of flight assuming a maximum turn of 15°.

1.4.2 In the turn initiation area and turn area, a minimum obstacle clearance of 90 m (295 ft) is provided.

1.4.3 Where precipitous and mountainous terrain exist, consideration is given by the procedures designer to increasing the minimum obstacle clearance (see also PANS-OPS, Volume II, Part I, Section 2, Chapter 1, 1.7).

1.5 PROCEDURE DESIGN GRADIENT (PDG)

1.5.1 The procedure design gradient (PDG) is intended as an aid to the procedures designer, who adjusts the route with the intention of minimizing the PDG consistent with other constraints.

1.5.2 Unless otherwise published, a PDG of 3.3 per cent is assumed.

1.5.3 The PDG is not intended as an operational limitation for those operators who assess departure obstacles in relation to aircraft performance, taking into account the availability of appropriate ground/airborne equipment.

1.5.4 Basis of the PDG

The PDG is based on:

a) an obstacle identification surface (OIS) having a 2.5 per cent gradient or a gradient determined by the most critical obstacle penetrating the surface, whichever is the higher (see Figure I-3-1-2); and

b) an additional margin of 0.8 per cent.

1.5.5 Gradient specification

1.5.5.1 Published gradients are specified to an altitude/height after which the minimum gradient of 3.3 per cent is considered to prevail (see the controlling obstacle in Figure I-3-1-2). For conversion of climb gradient for cockpit use, see Figure I-3-1-3.

1.5.5.2 The final PDG continues until obstacle clearance is ensured for the next phase of flight (i.e. en-route, holding or approach). At this point, the departure procedure ends and is marked by a significant point.

1.6 FIXES AS AN AID IN OBSTACLE AVOIDANCE

Whenever a suitably located DME exists, additional specific height/distance information intended for obstacle avoidance may be published. RNAV waypoint or other suitable fixes may be used to provide a means of monitoring climb performance.

1.7 RADAR VECTORS

Pilots should not accept radar vectors during departure unless:

a) they are above the minimum altitude(s)/height(s) required to maintain obstacle clearance in the event of engine failure. This relates to engine failure between V_1 and minimum sector altitude or the end of the contingency procedure as appropriate; or

b) the departure route is non-critical with respect to obstacle clearance.

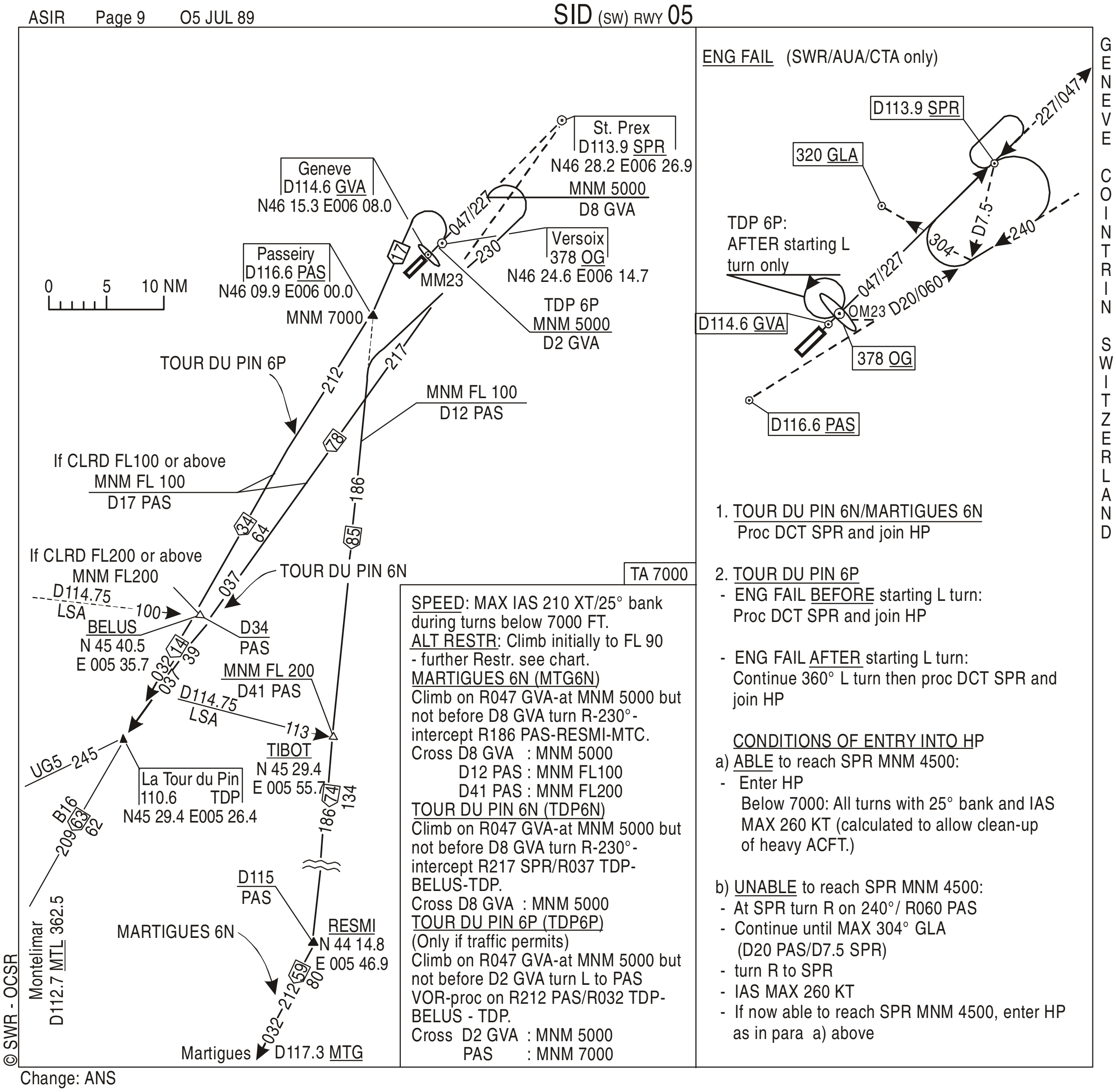


Figure I-3-1-1. Example of contingency routes in relation to departure routes

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

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

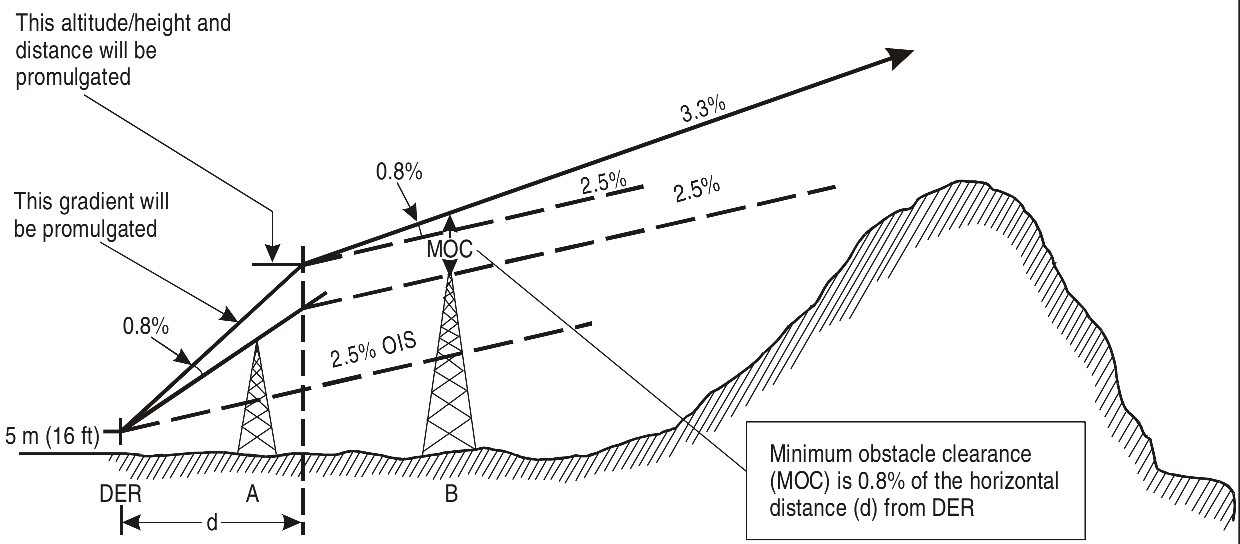


Figure I-3-1-2. Climb gradient reduction in departure

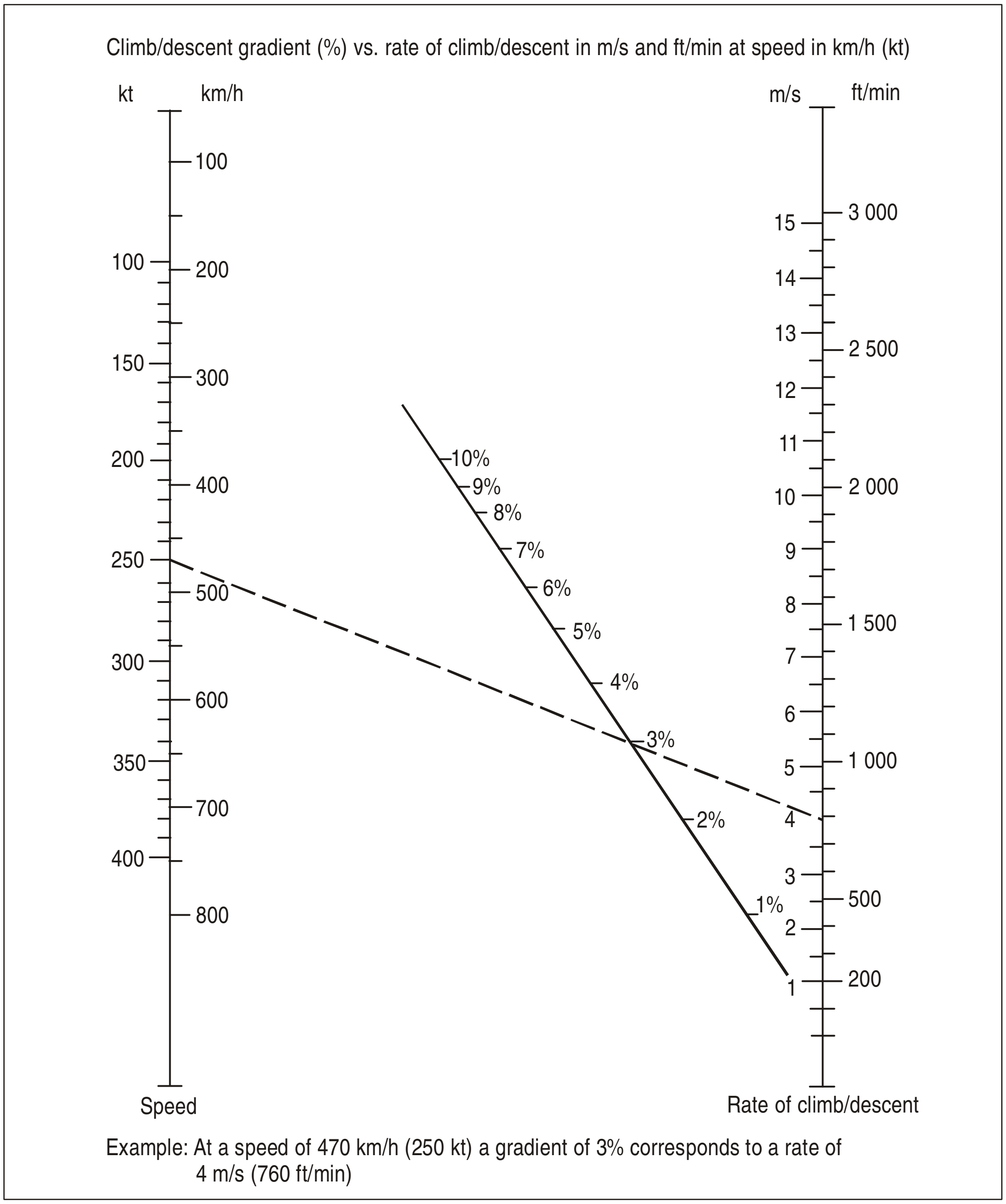


Figure I-3-1-3. Conversion nomogram

Chapter 2

STANDARD INSTRUMENT DEPARTURES

2.1 GENERAL

2.1.1 A standard instrument departure (SID) is a departure procedure that is normally developed to accommodate as many aircraft categories as possible. Departures that are limited to specific aircraft categories (see Section 4, Chapter 1, 1.3, "Categories of aircraft") are clearly annotated.

2.1.2 SID termination

The SID terminates at the first fix/facility/waypoint of the en-route phase following the departure procedure.

2.1.3 Types of SID

There are two basic types of SID: straight departures and turning departures. SIDs are based on track guidance acquired:

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

b) within 10.0 km (5.4 NM) after completion of turns on departures requiring turns.

Track guidance may be provided by a suitably located facility (VOR or NDB) or by RNAV. See Figure I-3-2-1.

2.2 STRAIGHT DEPARTURES

2.2.1 Alignment

2.2.1.1 A straight departure is one in which the initial departure track is within 15° of the alignment of the runway centre line.

2.2.1.2 When obstacles exist which affect the departure route, procedure design gradients (PDGs) greater than 3.3 per cent may be specified. When such a gradient is specified, the altitude/height to which it extends shall be promulgated. After this point, the PDG of 3.3 per cent (Category H, 5.0 per cent) resumes.

2.2.1.3 Gradients to a height of 60 m (200 ft) or less, caused by close-in obstacles, are not specified. A note will be published stating that the close-in obstacles exist. See Figure I-3-2-2.

2.3 TURNING DEPARTURES

2.3.1 When a departure route requires a turn of more than 15°, it is called a turning departure. Straight flight is assumed until reaching an altitude/height of at least 120 m (394 ft), or 90 m (295 ft) for helicopters. Procedures normally cater for turns at a point 600 m from the beginning of the runway. However, in some cases turns may not be initiated before the DER (or a specified point), and this information will be noted on the departure chart.

2.3.2 For Category H procedures, procedure turns can be initiated 90 m (295 ft) above the elevation if the DER and the earliest initiation point are at the beginning of the runway/final approach and take-off area (FATO).

2.3.3 No provision is made in this document for turning departures requiring a turn below 120 m (394 ft) (90 m (295 ft) for helicopters) above the elevation of the DER.

2.3.4 Where the location and/or height of obstacles preclude(s) the construction of turning departures which satisfy the minimum turn height criterion, departure procedures should be developed by the competent authority in consultation with the operators concerned.

2.3.5 Types of turns

Turns may be defined as occurring at:

a) an altitude/height; and

b) a fix or facility.

2.3.6 Turn speeds

2.3.6.1 The speeds used are those of the final missed approach increased by 10 per cent to account for increased aeroplane mass in departure (see Table I-3-2-1).

2.3.6.2 In exceptional cases, where acceptable terrain clearances cannot otherwise be provided, turning departure routes are constructed with maximum speeds as low as the intermediate missed approach speed increased by 10 per cent (see Tables I-4-1-1 and I-4-1-2). In such cases, the procedure is annotated "Departure turn limited to __________ km/h (kt) IAS maximum".

2.3.7 Turn parameters

2.3.7.1 The parameters that are common to all turns appear in Table I-2-3-1 in Section 2, Chapter 3, "Turn Area Construction". The following parameters are specific to turning departures:

a) *altitude*:

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

   2) *turn at a designated turning point:* aerodrome elevation plus the height based on a 10 per cent climb from the DER to the turning point;

b) *airspeed:* See 2.3.6, "Turn speeds";

c) *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) is used; and

d) *flight technical tolerances:*

1) pilot reaction time 3 s; and

2) bank establishment time 3 s (total 6 s; see Figure I-3-2-3).

2.3.7.2 When obstacles exist prohibiting a turn before the DER or prior to reaching an altitude/height, an earliest turn point or a minimum turning altitude/height is specified.

Table I-3-2-1. Maximum speeds for turning departures

Aeroplane category	*Maximum speed km/h (kt)*
A	225 (120)
B	305 (165)
C	490 (265)
D	540 (290)
E	560 (300)
H	165 (90)

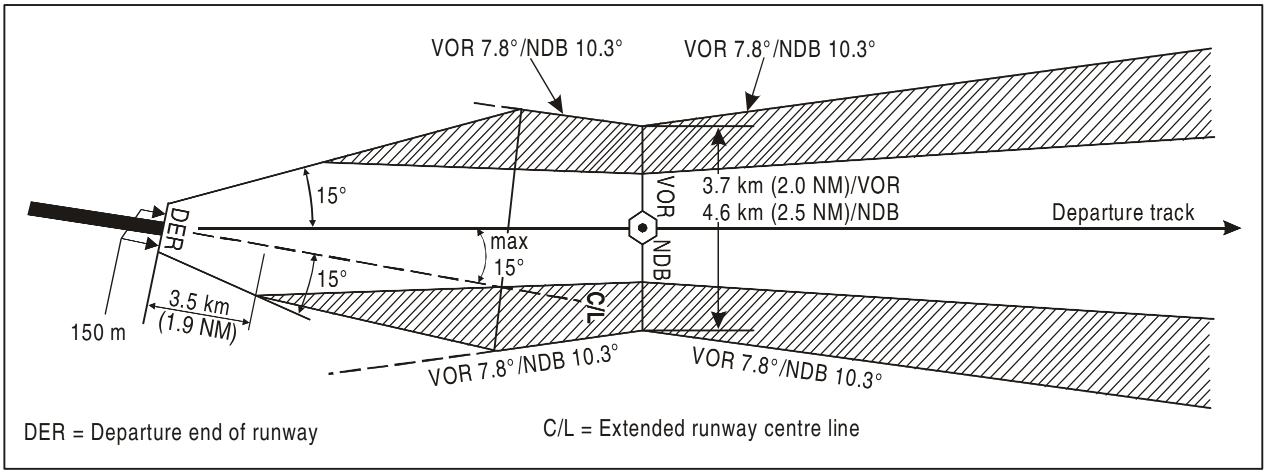


Figure I-3-2-1. Area for straight departure with track guidance

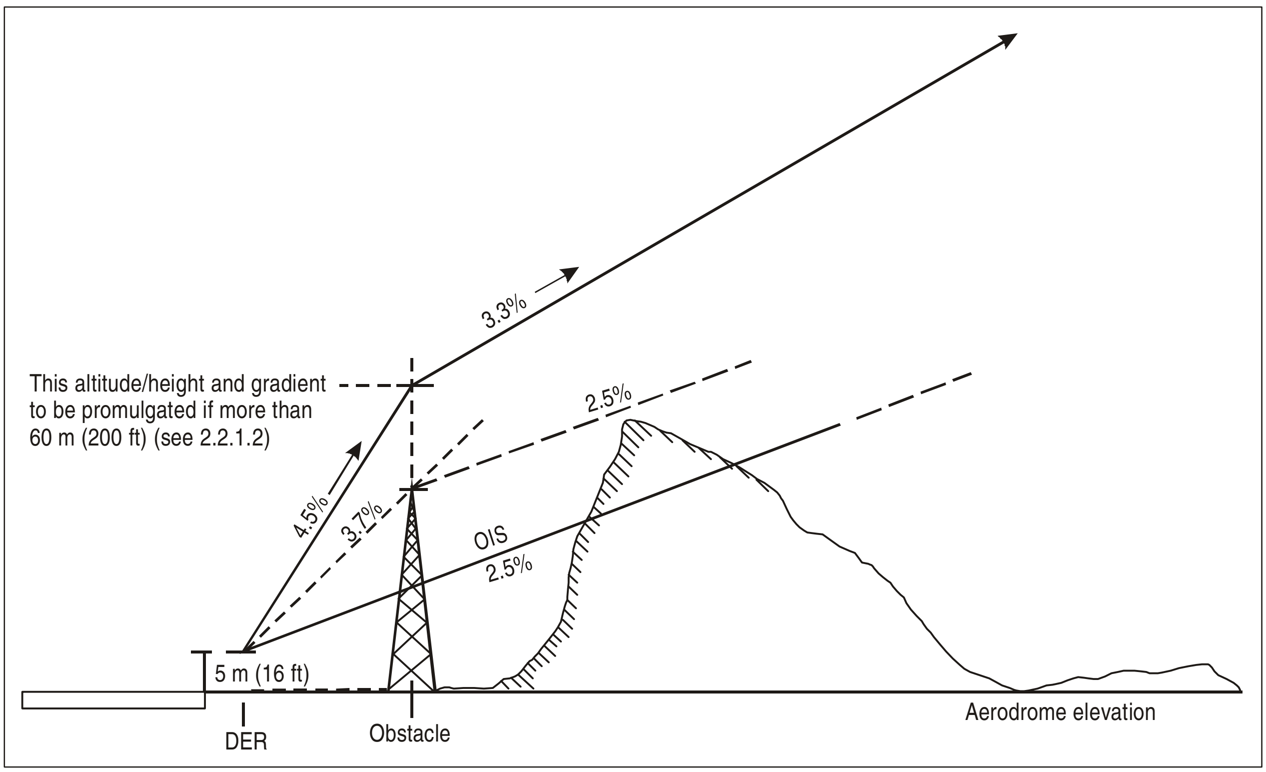


Figure I-3-2-2. Procedure design gradient

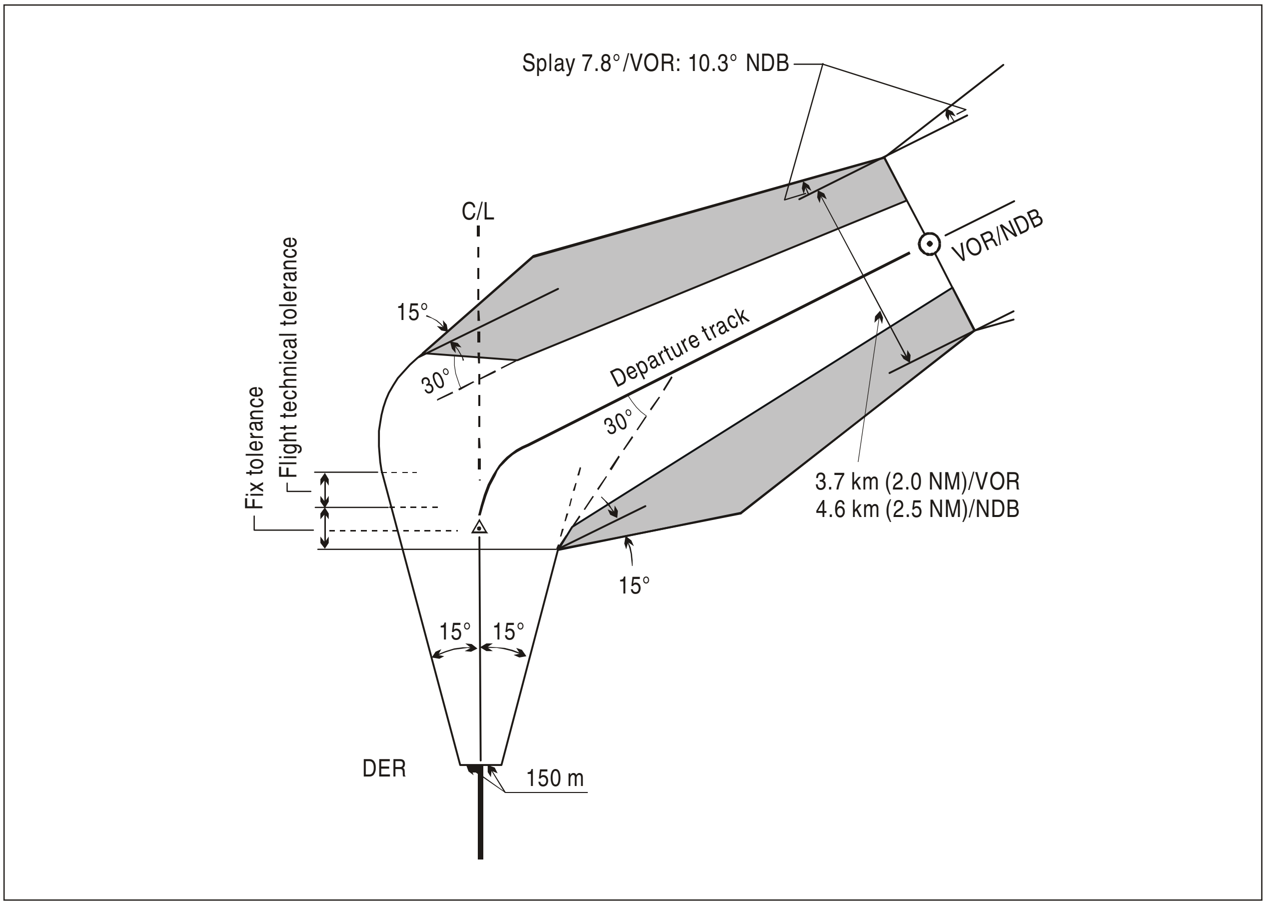


Figure I-3-2-3. Turning departure — turn at a fix

Chapter 3

OMNIDIRECTIONAL DEPARTURES

3.1 GENERAL

3.1.1 In cases where no track guidance is provided, departure procedures are designed using the omnidirectional method.

3.1.2 Where obstacles do not permit development of omnidirectional procedures, it is necessary to:

a) fly a standard instrument departure (SID) route; or

b) ensure that ceiling and visibility will permit obstacles to be avoided by visual means.

3.2 BEGINNING OF DEPARTURE

3.2.1 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).

3.2.2 Since the point of lift-off will vary, the departure procedure assumes that a turn at 120 m (394 ft) above the elevation of the aerodrome is not initiated sooner than 600 m from the beginning of the runway.

3.2.3 Procedures are normally designed/optimized for turns at a point 600 m from the beginning of the runway. However, in some cases turns may not be initiated before the DER (or a specified point), and this information will be noted on the departure chart.

3.2.4 For Category H procedures, procedure turns can be initiated 90 m (295 ft) above the elevation if the DER and the earliest initiation point are at the beginning of the runway/FATO.

3.3 PROCEDURE DESIGN GRADIENT (PDG)

3.3.1 Unless otherwise specified, departure procedures assume a 3.3 per cent (helicopters, 5 per cent) PDG and a straight climb on the extended runway centre line until reaching 120 m (394 ft) (helicopters, 90 m (295 ft)) above the aerodrome elevation.

3.3.2 The basic procedure ensures:

a) the aircraft climbs on the extended runway centre line to 120 m (394 ft) before turns can be specified; and

b) at least 90 m (295 ft) of obstacle clearance is provided before turns greater than 15° are specified.

3.3.3 The omnidirectional departure procedure is designed using any one of a combination of the following:

a) *Standard case:* Where no obstacles penetrate the 2.5 per cent obstacle identification surface (OIS), and 90 m (295 ft) of obstacle clearance prevails, a 3.3 per cent climb to 120 m (394 ft) will satisfy the obstacle clearance requirements for a turn in any direction (see Figure I-3-3-1 — Area 1).

b) *Specified turn altitude/height:* Where obstacle(s) preclude omnidirectional turns at 120 m (394 ft), the procedure will specify a 3.3 per cent climb to an altitude/height where omnidirectional turns can be made (see Figure I-3-3-1 — Area 2).

c) *Specified procedure design gradient:* Where obstacle(s) exist, the procedure may define a minimum gradient of more than 3.3 per cent to a specified altitude/height before turns are permitted (see Figure I-3-3-2 — Area 3).

d) *Sector departures:* Where obstacle(s) exist, the procedure may identify sector(s) for which either a minimum gradient or a minimum turn altitude/height is specified (e.g. "climb straight ahead to altitude/height ... before commencing a turn to the east/the sector 0°–180° and to altitude/height ... before commencing a turn to the west/the sector 180°–360°").

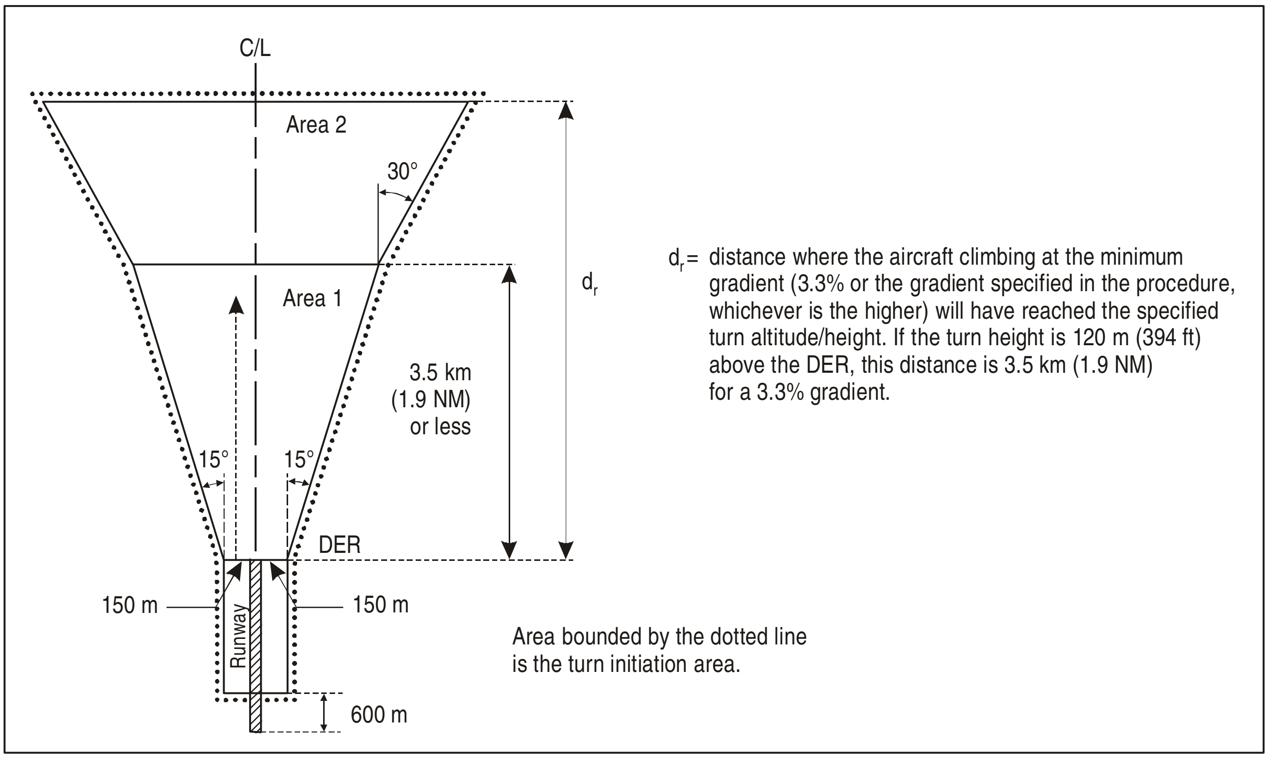


Figure I-3-3-1. Areas 1 and 2 and turn initiation area for omnidirectional departures

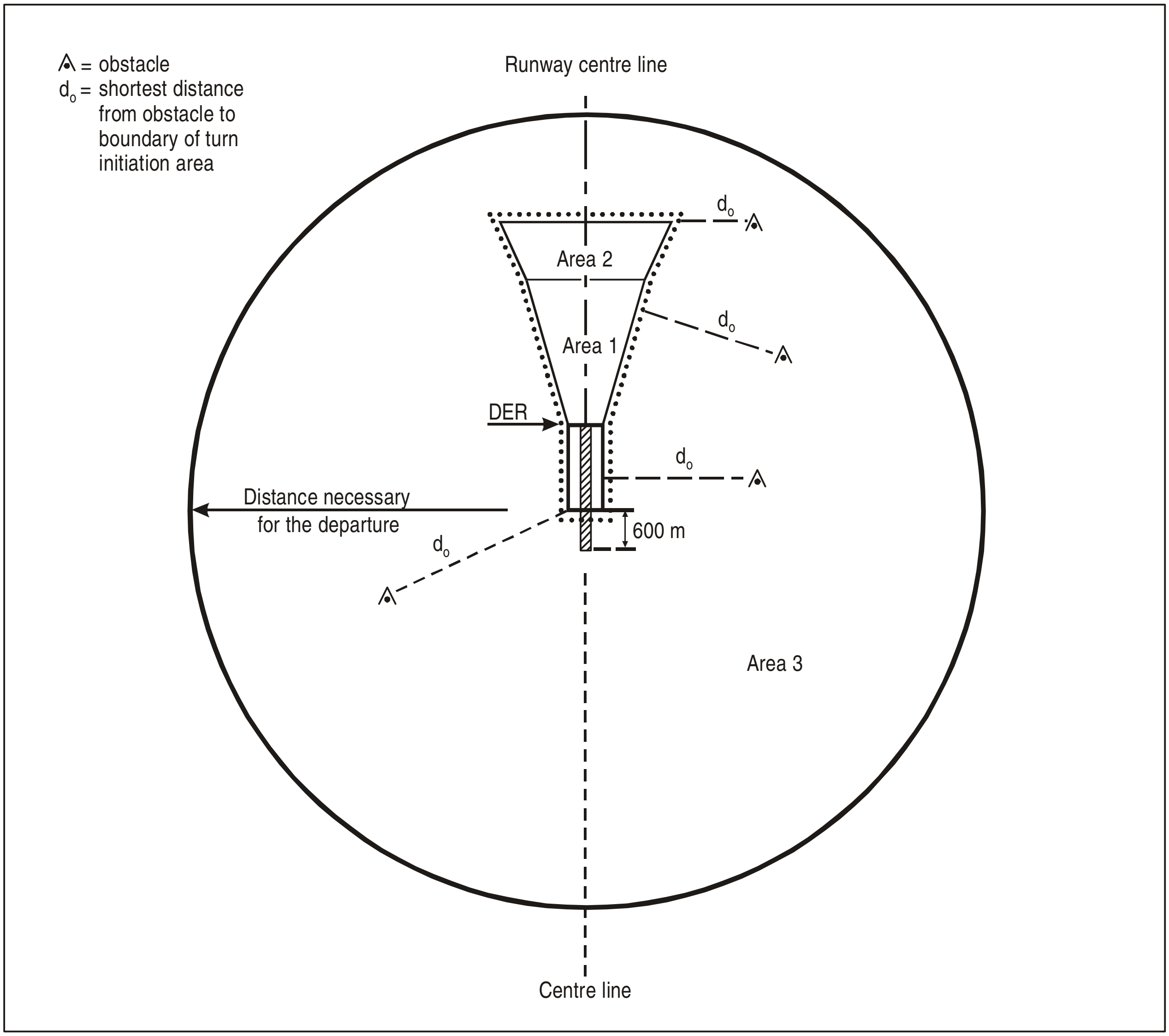


Figure I-3-3-2. Area 3 for omnidirectional departures

Chapter 4

PUBLISHED INFORMATION FOR DEPARTURES

4.1 GENERAL

4.1.1 The information listed in the following paragraphs will be published for operational personnel.

Note.— Standard departure routes are identified in accordance with Annex 11, Appendix 3. Instrument departure charts are published in accordance with Annex 4.

4.1.2 When it is necessary, after a turn, to fly a heading to intercept a specified radial/bearing, the procedure will specify:

a) the turning point;

b) the track to be made good; and

c) the radial/bearing to be intercepted.

Example: "at DME 4 km turn left to track 340° to intercept VOR R020"; or "at DME 2 turn left to track 340° to intercept VOR R020".

4.1.3 Departures that are limited to specific aircraft categories (see Section 4, Chapter 1, 1.3, "Categories of aircraft") will be clearly annotated.

4.1.4 When cloud base and visibility minima are limiting criteria, then this information will be published.

4.1.5 When a suitable fix is not available, procedure design gradients may be expressed in the following formats: "50 m/km (300 ft/NM)".

4.1.6 Where a suitable DME or fixes are available, the procedure design gradient is specified by a DME distance and associated altitude/height (e.g. "reach 1 000 m by DME 15 km" or "reach 3 500 ft by DME 8").

4.1.7 Turning points are identified by means of a fix or an altitude/height (e.g. "at DME 4 km" or "at 120 m" ("at DME 2" or "at 400 ft")).

4.1.8 When a gradient is promulgated to overfly obstacles in instrument meteorological conditions (IMC), *aerodrome operating minima* may be established for use as an alternative to the instrument procedure.

4.1.9 Additional specific height/distance information may be included in the chart in order to provide a means of monitoring aircraft position relative to critical obstacles.

4.1.10 When it is unnecessary to accommodate turns initiated as early as 600 m from the beginning of the runway, the turn initiation area starts at the DER. This information is noted on the departure chart.

4.1.11 Departure procedures may be developed to procedurally separate air traffic. In doing so, the procedure may be accompanied with 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-3-4-1. The method of charting altitudes/flight levels to correctly depict the designed procedure may differ between avionics manufacturers.

4.2 STANDARD INSTRUMENT DEPARTURES (SIDs)

4.2.1 For standard instrument departures (SIDs), all tracks, points, fixes and altitudes/heights (including turning altitudes/heights) required in the procedure are published.

4.2.2 The following information is also promulgated:

a) Significant obstacles which penetrate the OIS;

b) The position and height of close-in obstacles penetrating the OIS. A note is included on the SID chart whenever close-in obstacles exist which were not considered for the published PDG;

c) The highest obstacle in the departure area, and any significant obstacle outside the area which dictates the design of the procedure;

d) A PDG greater than 3.3 per cent. When such a gradient is specified, the altitude/height to which it extends shall be promulgated;

e) The altitude/height at which a gradient greater than 3.3 per cent stops. A note is included whenever the published procedure design gradient is based only on airspace restriction (i.e. PDG based only on airspace restriction);

f) Altitude/heights to be achieved during the departure when overheading significant points that can be identified by means of navigation facilities or fixes;

g) The fact that the average flight path has been designed by using statistical data on aircraft performance, when close conformance to an accurate desired track is important (for noise abatement/ATC constraints, etc.); and

h) All navigation facilities, fixes or waypoints, radials and DME distances which designate route segments. These are clearly indicated on the SID chart.

4.3 OMNIDIRECTIONAL DEPARTURES

4.3.1 Omnidirectional departures normally allow departures in any direction. Restrictions are expressed as:

a) sectors to be avoided; or

b) sectors having minimum gradients and/or minimum altitudes.

4.3.2 Sectors are described by bearings and distance from the centre of Area 3.

4.3.3 When more than one sector is involved, the published minimum gradient will be the highest of any sector that may be expected to be overflown.

4.3.4 The altitude to which the minimum gradient is specified will permit the aircraft to continue at the 3.3 per cent (helicopters, 5 per cent) minimum gradient through that sector, a succeeding sector, or to an altitude authorized for another phase of flight (i.e. en-route, holding or approach). See Figure I-3-1-2 in Chapter 1 of this section.

4.3.5 A fix may also be designated to mark the point at which a gradient in excess of 3.3 per cent (helicopters, 5 per cent) is no longer required.

Table I-3-4-1. Charted altitudes/flight levels

Altitude/Flight Level "Window"	17 000 10 000	FL220 10 000
"At or Above" Altitude/Flight Level	5 000	FL60
"At or Below" Altitude/Flight Level	5 000	FL210
"Mandatory" Altitude/Flight Level	3 000	FL50
"Recommended" Procedure Altitude/Flight Level	5 000	FL50
"Expected" Altitude/Flight Level	Expect 5 000	Expect FL50

Section 4

ARRIVAL AND APPROACH PROCEDURES

Chapter 1

GENERAL CRITERIA FOR
ARRIVAL AND APPROACH PROCEDURES

1.1 INTRODUCTION

This chapter explains:

a) the parameters and criteria used in the standardized development of instrument approach procedures; and

b) the procedures to be followed and the limitations to be observed in order to achieve an acceptable level of safety in the conduct of instrument approach procedures.

Note.— Detailed specifications for instrument approach procedure construction, primarily for the use of procedures specialists, are contained in PANS-OPS, Volume II, Part I, Section 4, for general criteria; Part II, Sections 1 and 2, for sensor-specific conventional criteria; and Part III for RNAV and RNP criteria.

1.2 INSTRUMENT APPROACH PROCEDURE

1.2.1 External factors influencing the approach procedure

The design of an instrument approach procedure is, in general, dictated by the terrain surrounding the aerodrome, the type of operations contemplated and the aircraft to be accommodated. These factors in turn influence the type and siting of navigation aids in relation to the runway or aerodrome. Airspace restrictions may also affect the siting of navigation aids.

1.2.2 Segments of the approach procedure

1.2.2.1 An instrument approach procedure may have five separate segments. They are the arrival, initial, intermediate, final and missed approach segments. See Figure I-4-1-1. In addition, an area for circling the aerodrome under visual conditions is also considered (see Chapter 7 of this section).

1.2.2.2 The approach segments begin and end at designated fixes. However, under some circumstances certain of the segments may begin at specified points where no fixes are available. For example, the final approach segment of a precision approach may start where the intermediate flight altitude intersects the nominal glide path (the final approach point).

Note.— See Chapters 2 to 6 of this section for detailed specifications on approach segments.

1.2.3 Types of approach

1.2.3.1 There are two types of approach: straight-in and circling.

1.2.3.2 *Straight-in approach*

Wherever possible, a straight-in approach will be specified which is aligned with the runway centre line. In the case of non-precision approaches, a straight-in approach is considered acceptable if the angle between the final approach track and the runway centre line is 30° or less.

1.2.3.3 *Circling approach*

A circling approach will be specified in those cases where terrain or other constraints cause the final approach track alignment or descent gradient to fall outside the criteria for a straight-in approach. The final approach track of a circling approach procedure is in most cases aligned to pass over some portion of the usable landing surface of the aerodrome.

1.3 CATEGORIES OF AIRCRAFT

1.3.1 Aircraft performance has a direct effect on the airspace and visibility required for the various manoeuvres associated with the conduct of instrument approach procedures. The most significant performance factor is aircraft speed.

1.3.2 Accordingly, categories of typical aircraft have been established. These categories provide a standardized basis for relating aircraft manoeuvrability to specific instrument approach procedures. For precision approach procedures, the dimensions of the aircraft are also a factor for the calculation of the obstacle clearance height (OCH). For Category D_L aircraft, an additional obstacle clearance altitude/height (OCA/H) is provided, when necessary, to take into account the specific dimensions of these aircraft (see Part II, Section 1, Chapter 1, 1.3).

1.3.3 The criterion 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 applied.

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

1.3.5 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 1.3.10, "Helicopters".

1.3.6 *Permanent change of category (maximum landing mass).* An operator may impose a permanent lower landing mass, and use of this mass for determining Vat 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.

1.3.7 As indicated in Tables I-4-1-1 and I-4-1-2, a specified range of handling speeds for each category of aircraft has been assumed for use in calculating airspace and obstacle clearance requirements for each procedure.

1.3.8 The instrument approach chart (IAC) will specify the individual categories of aircraft for which the procedure is approved. Normally, procedures will be designed to provide protected airspace and obstacle clearance for aircraft up to and including Category D. However, where airspace requirements are critical, procedures may be restricted to lower speed categories.

1.3.9 Alternatively, the procedure may specify a maximum IAS for a particular segment without reference to aircraft category. In any case, it is essential that pilots comply with the procedures and information depicted on instrument flight charts and the appropriate flight parameters shown in Tables I-4-1-1 and I-4-1-2 if the aircraft is to remain in the areas developed for obstacle clearance purposes.

1.3.10 Helicopters

1.3.10.1 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 IAC as joint helicopter/aeroplane procedures.

1.3.10.2 It is intended that 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.

1.3.10.3 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.

1.4 OBSTACLE CLEARANCE

Obstacle clearance is a primary safety consideration in the development of instrument approach procedures. The criteria used and the detailed method of calculation are covered in PANS-OPS, Volume II. However, from the operational point of view, it is stressed that the obstacle clearance applied in the development of each instrument approach procedure is considered to be the minimum required for an acceptable level of safety in operations. The protected areas and obstacle clearance applicable to individual types of approaches are specified in subsequent chapters of this section.

1.5 OBSTACLE CLEARANCE ALTITUDE/HEIGHT (OCA/H)

For each individual approach procedure an obstacle clearance altitude/height (OCA/H) is calculated in the development of the procedure and published on the instrument approach chart. In the case of precision approach and circling approach procedures, an OCA/H is specified for each category of aircraft listed in 1.3. Obstacle clearance altitude/height (OCA/H) is:

a) in a precision approach procedure, the lowest altitude (OCA) or alternatively the lowest height above the elevation of the relevant runway threshold (OCH), at which a missed approach must be initiated to ensure compliance with the appropriate obstacle clearance criteria; or

b) in a non-precision approach procedure, the lowest altitude (OCA) or alternatively the lowest height above aerodrome elevation or the elevation of the relevant runway threshold, if the threshold elevation is more than 2 m (7 ft) below the aerodrome elevation (OCH), below which an aircraft cannot descend without infringing the appropriate obstacle clearance criteria; or

c) in a visual (circling) procedure, the lowest altitude (OCA) or alternatively the lowest height above the aerodrome elevation (OCH) below which an aircraft cannot descend without infringing the appropriate obstacle clearance criteria.

1.6 FACTORS AFFECTING OPERATIONAL MINIMA

1.6.1 In general, minima are developed by adding the effect of a number of operational factors to OCA/H to produce, in the case of precision approaches, decision altitude (DA) or decision height (DH) and, in the case of non-precision approaches, minimum descent altitude (MDA) or minimum descent height (MDH). The general operational factors to be considered are specified in Annex 6. The detailed criteria and methods for determining operating minima are currently under development for this document. The relationship of OCA/H to operating minima (landing) is shown in Figures I-4-1-2, I-4-1-3 and I-4-1-4.

1.6.2 Operators may specify two types of approach procedures for non-precision approaches. The first is that described as: "descend immediately to not below the minimum stepdown fix altitude/height or MDA/H as appropriate". This method is acceptable as long as the achieved descent gradient remains below 15 per cent and the missed approach is initiated at or before the MAPt. Alternatively, operators are encouraged to use a stabilized approach technique for non-precision approaches. This technique requires a continuous descent with a rate of descent adjusted to achieve a constant descent gradient to a point 15 m (50 ft) above threshold, taking due regard of the minimum crossing altitudes/heights specified for the FAF and any prescribed stepdown fix. If the required visual reference approaching MDA/H is not achieved, or if the MAPt is reached before reaching the MDA/H, the missed approach must be initiated. In either case, aircraft are not permitted to go below the MDA/H at any time. The stabilized approach technique is also associated with operator-specified limits of speed, power, configuration and displacement at (a) specified height(s) designed to ensure the stability of the approach path and a requirement for an immediate go-around if these requirements are not met.

Note 1.— To achieve a constant descent gradient where stepdown fixes are specified, descent may be delayed until after passing the FAF, or the FAF crossed at an increased altitude/height (see Chapter 5, 5.2.5.5, "Stepdown fix with DME"). If a greater height is used, ATC clearance should be obtained to ensure separation.

Note 2.— When using the "stabilized approach" technique in a non-precision approach, the altitude/height at which the missed approach manoeuvre is initiated is a matter of pilot judgement based on the prevailing conditions and the overriding requirement to remain above the MDA/H. Where an operator specifies an advisory initiation altitude/height (above MDA/H) based on average conditions, the associated visibility requirements should be based on the MDA/H and not the advisory altitude/height.

Note 3.— In all cases, regardless of the flight technique used, cold temperature correction must be applied to all minimum altitudes (see Part III, Section 1, Chapter 4, 4.3, "Temperature correction").

1.7 DESCENT GRADIENT

1.7.1 In instrument approach procedure design, adequate space is allowed for descent from the facility crossing altitude/height to the runway threshold for straight-in approach or to OCA/H for circling approaches.

1.7.2 Adequate space for descent is provided by establishing a maximum allowable descent gradient for each segment of the procedure. The minimum/optimum descent gradient/angle in the final approach of a procedure with FAF is 5.2 per cent/3.0° (52 m/km (318 ft/NM)). Where a steeper descent gradient is necessary, the maximum permissible is 6.5 per cent/3.7° (65 m/km (395 ft/NM)) for Category A and B aircraft, 6.1 per cent/3.5° (61 m/km (370 ft/NM)) for Category C, D and E aircraft, and 10 per cent (5.7°) for Category H. For procedures with VOR or NDB on aerodrome and no FAF, rates of descent in the final approach phase are given in Table I-4-1-3. In the case of a precision approach, the operationally preferred glide path angle is 3.0° as specified in Annex 10, Volume I. An ILS glide path/MLS elevation angle in excess of 3.0° is used only where alternate means available to satisfy obstacle clearance requirements are impractical.

1.7.3 In certain cases, the maximum descent gradient of 6.5 per cent (65 m/km (395 ft/NM)) results in descent rates which exceed the recommended rates of descent for some aircraft. For example, at 280 km/h (150 kt), such a gradient results in a 5 m/s (1 000 ft/min) rate of descent.

1.7.4 Pilots should consider carefully the descent rate required for non-precision final approach segments before starting the approach.

1.7.5 Any constant descent angle shall clear all stepdown fix minimum crossing altitudes within any segment.

1.7.6 Procedure altitude/height

1.7.6.1 In addition to minimum IFR altitudes established for each segment of the procedure, procedure altitudes/heights will also be provided. Procedure altitudes/heights will, in all cases, be at or above any minimum crossing altitude associated with the segment. Procedure altitude/height will be established taking into account the air traffic control needs for that phase of flight.

1.7.6.2 Procedure altitudes/heights are developed to place the aircraft at altitudes/heights that would normally be flown to intercept and fly an optimum 5.2 per cent (3.0°) descent path angle in the final approach segment to a 15 m (50 ft) threshold crossing for non-precision approach procedures and procedures with vertical guidance. In no case will a procedure altitude/height be less than any OCA/H.

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

Aircraft category	V_{at}	*Range of speeds for initial approach*	*Range of final approach speeds*	*Maximum speeds for visual manoeuvring (circling)*	*Maximum 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_{s1g} 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 segments based on operational need. Refer to PANS-OPS, Volume II, Part IV, Chapter 1, "Area navigation (RNAV) point-in-space (PinS) approach procedures for helicopters using basic GNSS receivers".

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 for procedure calculations in knots (kt)

Aircraft category	V_{at}	*Range of speeds for initial approach*	*Range of final approach speeds*	*Maximum speeds for visual manoeuvring (circling)*	*Maximum 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	N/A	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_{s1g} 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 segments based on operational need. Refer to PANS-OPS, Volume II, Part IV, Chapter 1, “Area navigation (RNAV) point-in-space (PinS) approach procedures for helicopters using basic GNSS receivers”.

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.

Table I-4-1-3. Rate of descent in the final approach segment of a procedure with no FAF

Aircraft categories	*Rate of descent*	
	Minimum	*Maximum*
A, B	120 m/min (394 ft/min)	200 m/min (655 ft/min)
C, D, E	180 m/min (590 ft/min)	305 m/min (1 000 ft/min)

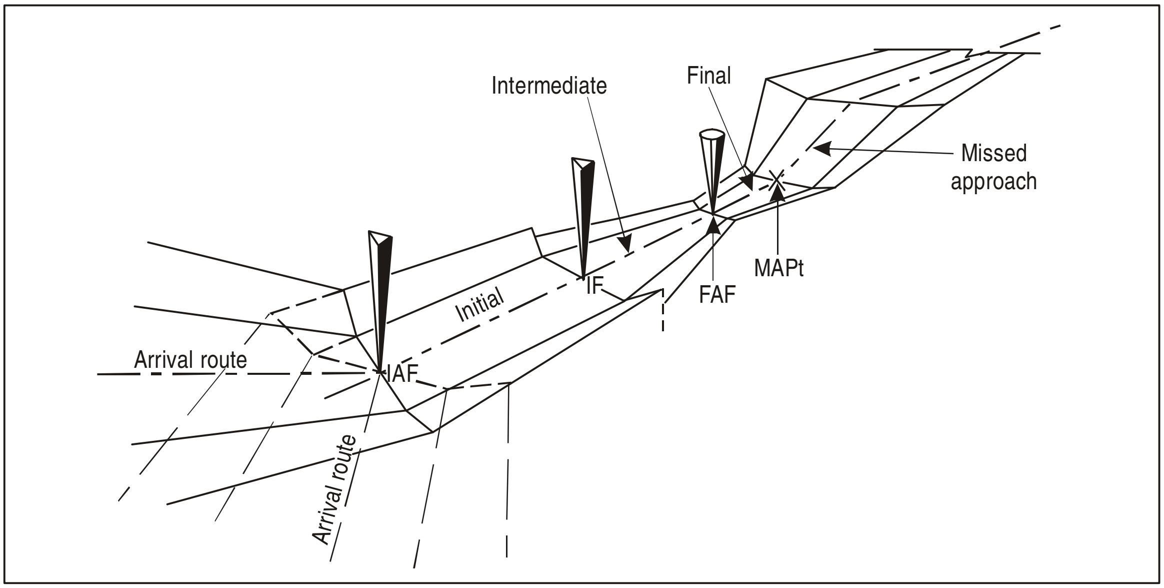


Figure I-4-1-1. Segments of instrument approach

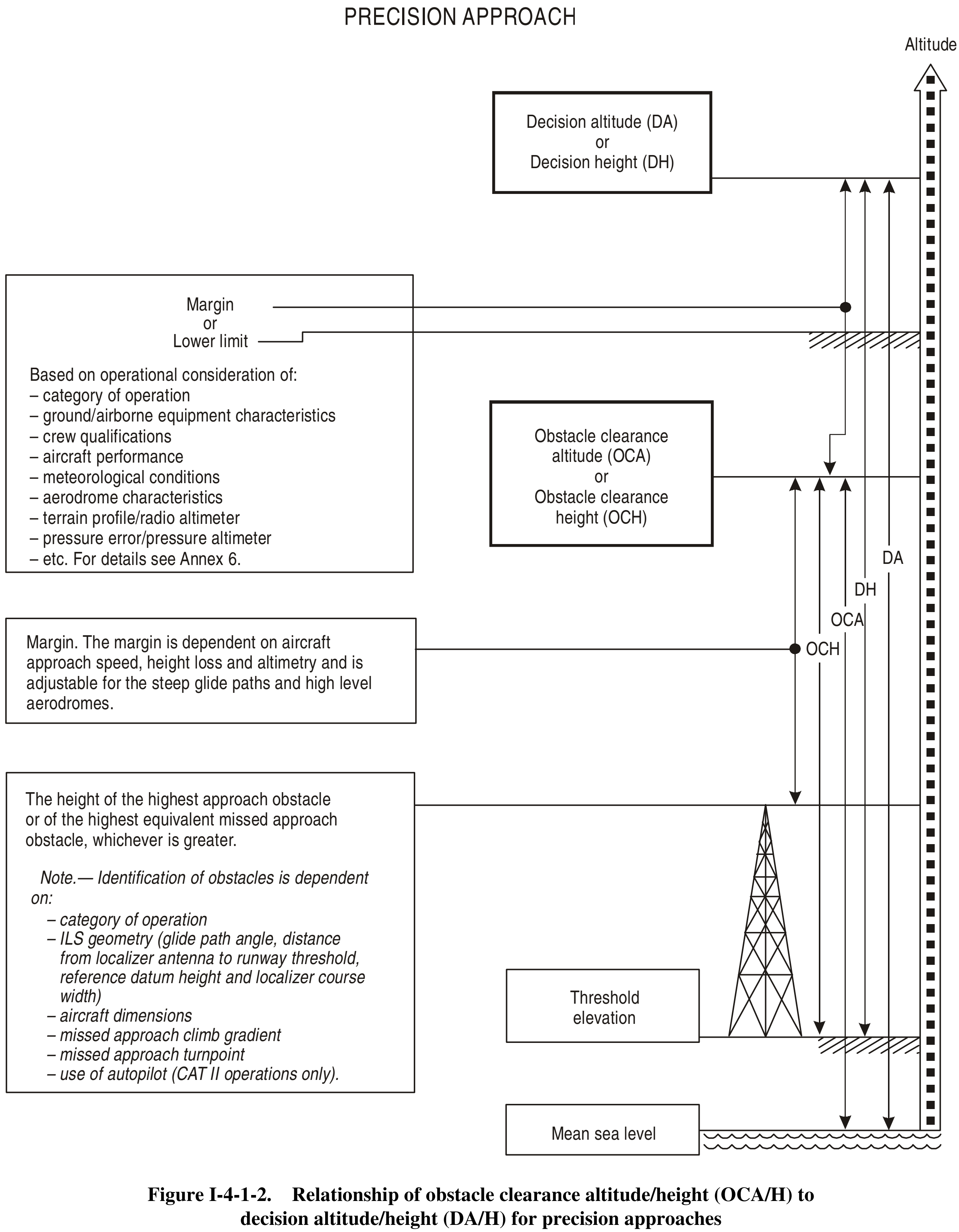


Figure I-4-1-2. Relationship of obstacle clearance altitude/height (OCA/H) to decision altitude/height (DA/H) for precision approaches

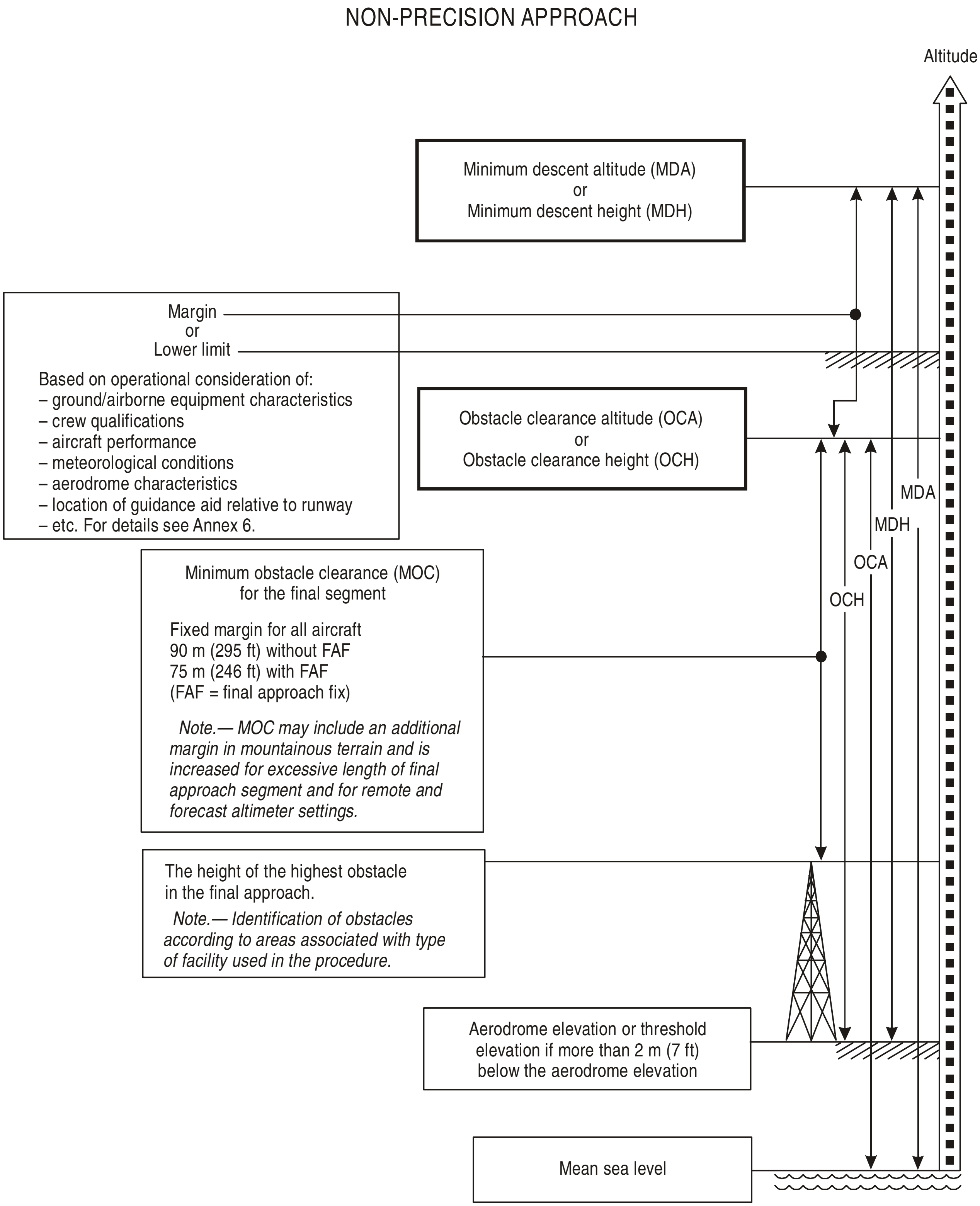


Figure I-4-1-3. Relationship of obstacle clearance altitude/height (OCA/H) to minimum descent altitude/height (MDA/H) for non-precision approaches (example with a controlling obstacle in the final approach)

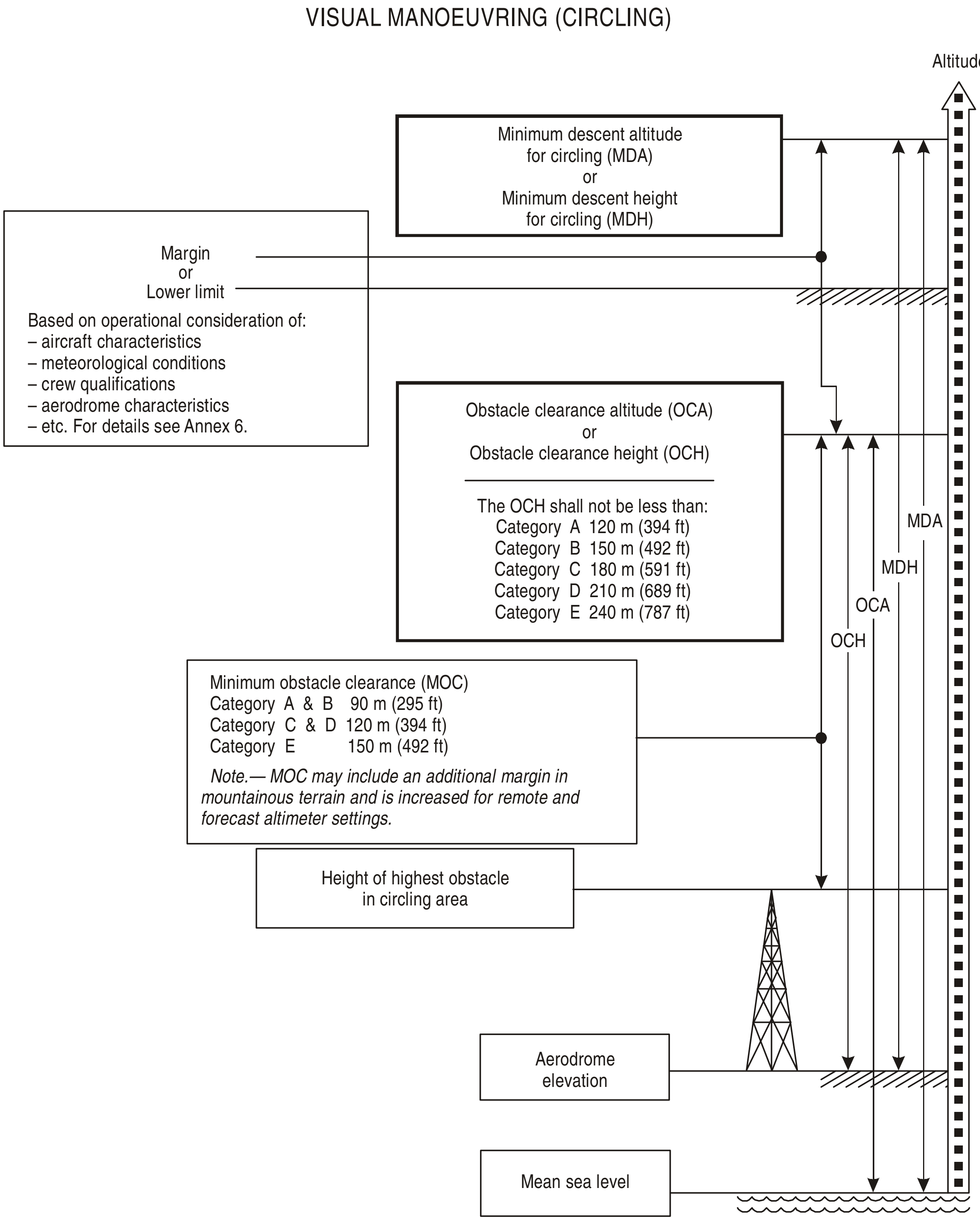


Figure I-4-1-4. Relationship of obstacle clearance altitude/height (OCA/H) to minimum descent altitude/height (MDA/H) for visual manoeuvring (circling)

Chapter 2

ARRIVAL SEGMENT

2.1 PURPOSE

2.1.1 A standard instrument arrival (STAR) route permits transition from the en-route phase to the approach phase.

2.1.2 When necessary or where an operational advantage is obtained, arrival routes from the en-route phase to a fix or facility used in the procedure are published.

2.2 PROTECTION OF THE ARRIVAL SEGMENT

2.2.1 The width of the protection area decreases from the “en-route” value until the “initial approach” value with a maximum convergence angle of 30° each side of the axis.

2.2.2 This convergence begins at 46 km (25 NM) before the initial approach fix (IAF) if the length of the arrival route is greater than or equal to 46 km (25 NM). It begins at the starting point of the arrival route if the length of the arrival route is less than 46 km (25 NM).

2.2.3 The arrival route normally ends at the IAF. Omnidirectional or sector arrivals can be provided taking into account minimum sector altitudes (MSA).

2.3 MINIMUM SECTOR ALTITUDES (MSA)/TERMINAL ARRIVAL ALTITUDES (TAA)

Minimum sector altitudes or terminal arrival altitudes are established for each aerodrome and provide at least 300 m (1 000 ft) obstacle clearance within 46 km (25 NM) of the navigation aid, initial approach fix or intermediate fix associated with the approach procedure for that aerodrome.

2.4 TERMINAL AREA RADAR (TAR)

When terminal area radar is employed, the aircraft is vectored to a fix, or onto the intermediate or final approach track, at a point where the approach may be continued by the pilot by referring to the instrument approach chart.

Chapter 3

INITIAL APPROACH SEGMENT

3.1 GENERAL

3.1.1 Purpose

3.1.1.1 The initial approach segment begins at the initial approach fix (IAF) and ends at the intermediate fix (IF). In the initial approach, the aircraft has left the en-route structure and is manoeuvring to enter the intermediate approach segment.

3.1.1.2 Aircraft speed and configuration will depend on the distance from the aerodrome, and the descent required.

3.1.2 Maximum angle of interception of initial approach segment

Normally track guidance is provided along the initial approach segment to the IF, with a maximum angle of interception of:

a) 90° for a precision approach; and

b) 120° for a non-precision approach.

See 3.3.9, "Dead reckoning (DR) segment", for an alternative where track guidance to the IF is not provided.

3.1.3 Minimum obstacle clearance

The initial approach segment provides at least 300 m (1 000 ft) of obstacle clearance in the primary area, reducing laterally to zero at the outer edge of the secondary area.

3.2 TYPES OF MANOEUVRES

3.2.1 Where no suitable IAF or IF is available to construct the instrument procedure in the form shown in Figure I-4-1-1, a reversal procedure, racetrack or holding pattern is required.

3.2.2 Reversal procedure

3.2.2.1 The reversal procedure may be in the form of a procedure or base turn. Entry is restricted to a specific direction or sector. In these cases, a specific pattern — normally a base turn or procedure turn — is prescribed.

3.2.2.2 The directions and timing specified should be strictly followed in order to remain within the airspace provided. It should be noted that the airspace provided for these procedures does not permit a racetrack or holding manoeuvre to be conducted unless so specified.

3.2.2.3 There are three generally recognized manoeuvres related to the reversal procedure, each with its own airspace characteristics:

a) *45°/180° procedure turn* (see Figure I-4-3-1 A), starts at a facility or fix and consists of:

   1) a straight leg with track guidance. This straight leg may be timed or may be limited by a radial or DME distance;

   2) a 45° turn;

   3) a straight leg without track guidance. This straight leg is timed. It is:

      i) 1 minute from the start of the turn for Category A and B aircraft; and

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

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

   The 45°/180° procedure turn is an alternative to the 80°/260° procedure turn [b) below] unless specifically excluded.

b) *80°/260° procedure turn* (see Figure I-4-3-1 B), starts at a facility or fix and consists of:

   1) a straight leg with track guidance. This straight leg may be timed or may be limited by a radial or DME distance;

   2) an 80° turn;

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

   The 80°/260° procedure turn is an alternative to the 45°/180° procedure turn [a) above] unless specifically excluded.

Note.— The duration of the initial outbound leg of a procedure may be varied in accordance with aircraft speed categories in order to reduce the overall length of the protected area. In this case, separate procedures are published.

c) *Base turn*, consisting of:

   1) a specified outbound track and timing or DME distance from a facility; followed by

   2) a turn to intercept the inbound track (see Figure I-4-3-1 C).

The outbound track and/or the timing may be different for the various categories of aircraft. Where this is done, separate procedures are published.

3.2.3 Racetrack procedure

3.2.3.1 A racetrack procedure consists of:

a) a turn from the inbound track through 180° from overhead the facility or fix on to the outbound track, for 1, 2 or 3 minutes; followed by

b) a 180° turn in the same direction to return to the inbound track (see Figure I-4-3-1 D).

As an alternative to timing, the outbound leg may be limited by a DME distance or intersecting radial/bearing.

3.2.3.2 *Entry into a racetrack procedure*

Normally a racetrack procedure is used when aircraft arrive overhead the fix from various directions. In these cases, aircraft are expected to enter the procedure in a manner similar to that prescribed for a holding procedure entry with the following considerations:

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

b) parallel entry shall not return directly to the facility without first intercepting the inbound track when proceeding to the final segment of the approach procedure; and

c) all manoeuvring shall be done in so far as possible on the manoeuvring side of the inbound track.

Note.— Racetrack procedures are used where sufficient distance is not available in a straight segment to accommodate the required loss of altitude and when entry into a reversal procedure is not practical. They may also be specified as alternatives to reversal procedures to increase operational flexibility (in this case, they are not necessarily published separately).

3.3 FLIGHT PROCEDURES FOR RACETRACK AND REVERSAL PROCEDURES

3.3.1 Entry

3.3.1.1 Unless the procedure specifies particular entry restrictions, reversal procedures shall be entered from a track within ±30° of the outbound track of the reversal procedure. However, for base turns, where the ±30° direct entry sector does not include the reciprocal of the inbound track, the entry sector is expanded to include it.

3.3.1.2 For racetrack procedures, entry shall be as specified in 3.2.3.2, “Entry into a racetrack procedure”, unless other restrictions are specified. See Figures I-4-3-2, I-4-3-3 and I-4-3-4.

3.3.2 Speed restrictions

These may be specified in addition to, or instead of, aircraft category restrictions. The speeds must not be exceeded to ensure that the aircraft remains within the limits of the protected areas.

3.3.3 Bank angle

Procedures are based on average achieved bank angle of 25°, or the bank angle giving a rate of turn of 3°/second, whichever is less.

3.3.4 Descent

The aircraft shall cross the fix or facility and fly outbound on the specified track, descending as necessary to the procedure altitude/height but no lower than the minimum crossing altitude/height associated with that segment. If a further descent is specified after the inbound turn, this descent shall not be started until the aircraft is established on the inbound track. An aircraft is considered established when it is:

a) within half full scale deflection for the ILS and VOR; or

b) within ±5° of the required bearing for the NDB.

3.3.5 Outbound timing racetrack procedure

3.3.5.1 When the procedure is based on a facility, the outbound timing starts:

a) from abeam the facility; or

b) on attaining the outbound heading,

whichever comes later.

3.3.5.2 When the procedure is based on a fix, the outbound timing starts from attaining the outbound heading.

3.3.5.3 The turn on to the inbound track should be started:

a) within the specified time (adjusted for wind); or

b) when encountering any DME distance; or

c) when the radial/bearing specifying a limiting distance has been reached,

whichever occurs first.

3.3.6 Wind effect

3.3.6.1 To achieve a stabilized approach, due allowance should be made in both heading and timing to compensate for the effects of wind so that the aircraft regains the inbound track as accurately and expeditiously as possible. In making these corrections, full use should be made of the indications available from the aid and from estimated or known winds.

3.3.6.2 When a DME distance or radial/bearing is specified, it shall not be exceeded when flying on the outbound track.

3.3.7 Descent rates

The specified timings and procedure altitudes are based on rates of descent that do not exceed the values shown in Table I-4-3-1.

3.3.8 Shuttle

A shuttle is normally prescribed where the descent required between the end of initial approach and the beginning of final approach exceeds the values shown in Table I-4-3-1.

Note.— A shuttle is descent or climb conducted in a holding pattern.

3.3.9 Dead reckoning (DR) segment

Where an operational advantage can be obtained, an ILS procedure may include a dead reckoning (DR) segment from a fix to the localizer (see Figure I-4-3-5). The DR track will intersect the localizer at 45° and will not be more than 19 km (10 NM) in length. The point of interception is the beginning of the intermediate segment and will allow for proper glide path interception.

Table I-4-3-1. Maximum/minimum descent rate to be specified on a reversal or racetrack procedure

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

* Maximum/minimum descent for 1 minute nominal outbound time in m (ft).

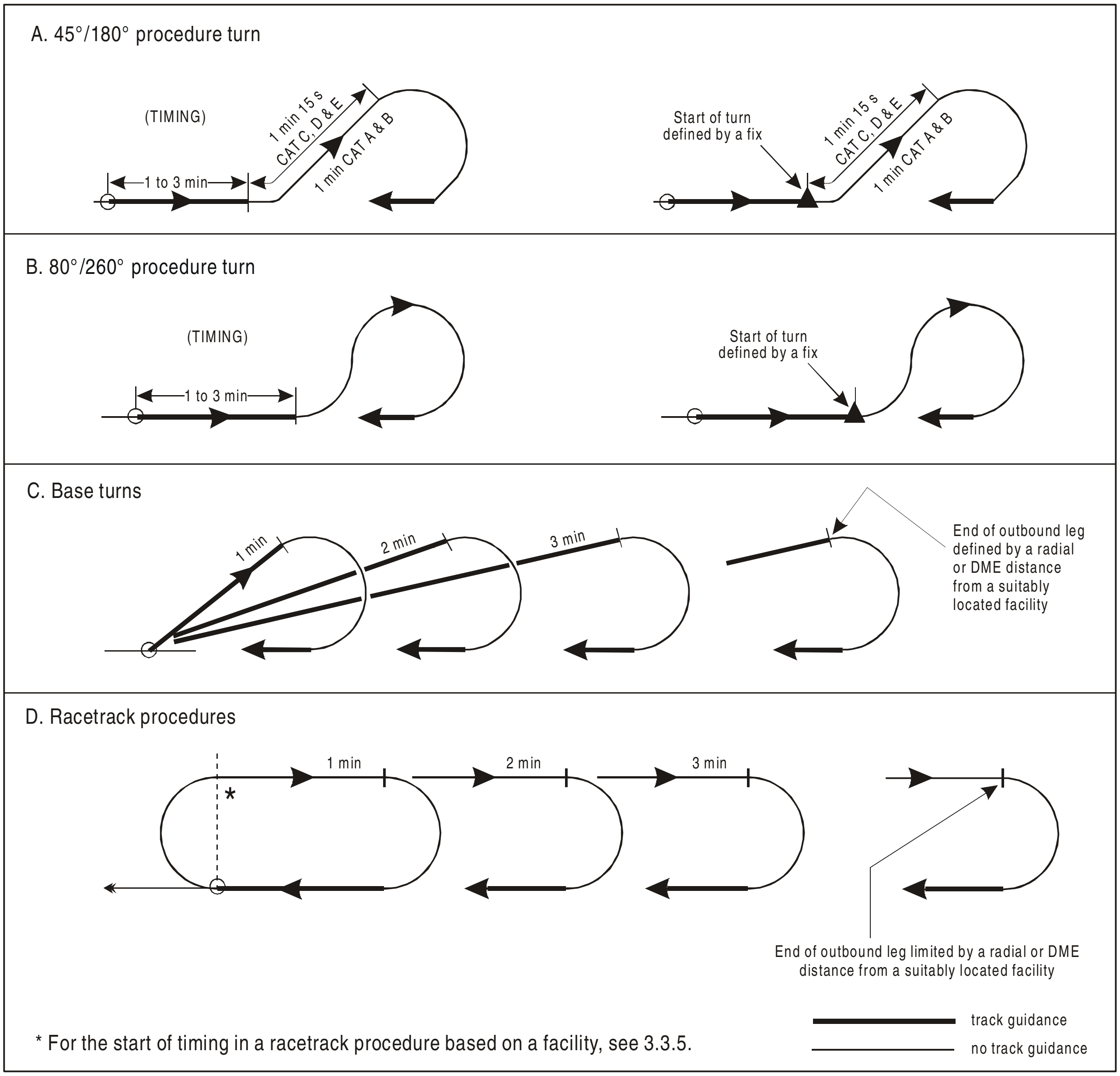


Figure I-4-3-1. Types of reversal and racetrack procedures

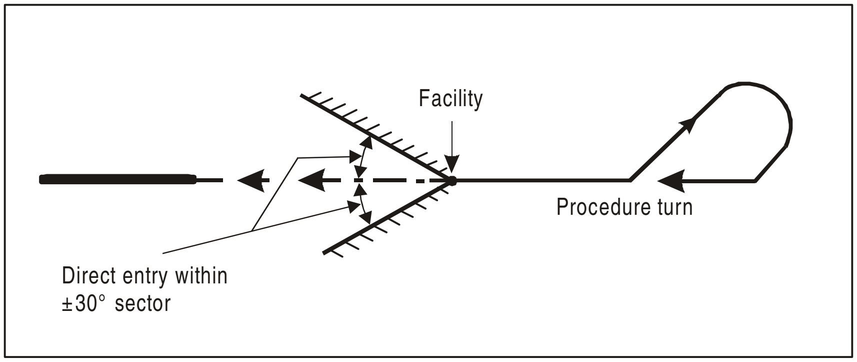


Figure I-4-3-2. Direct entry to procedure turn

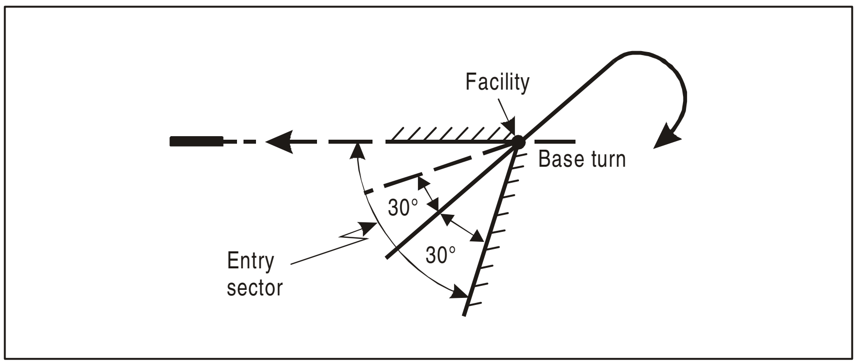


Figure I-4-3-3. Direct entry to base turn

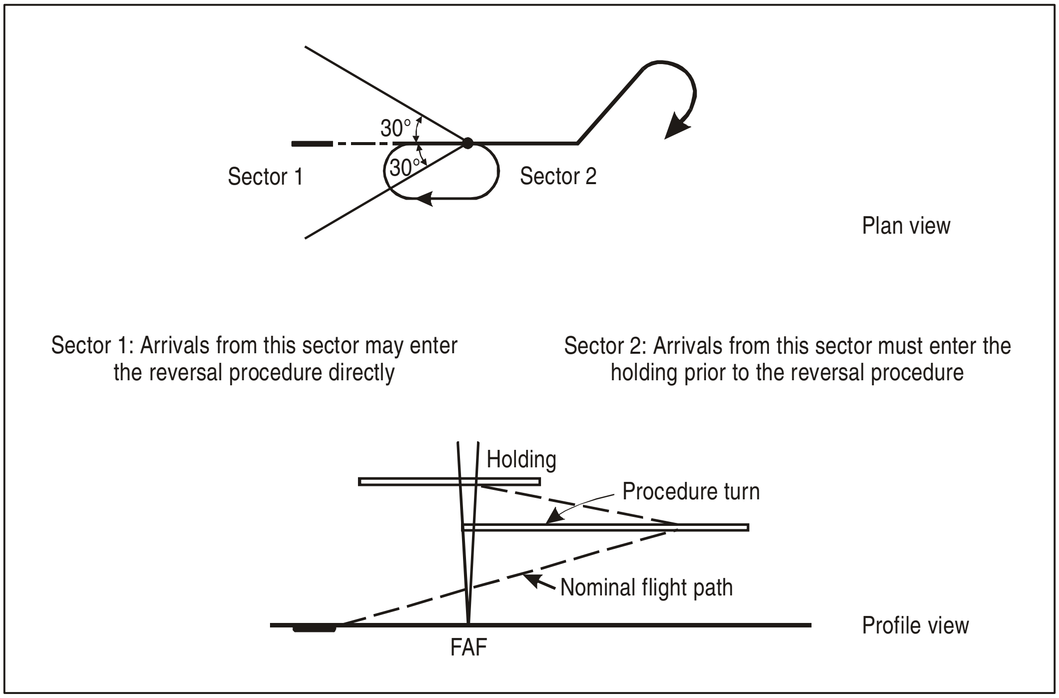


Figure I-4-3-4. Example of omnidirectional arrival using a holding procedure in association with a reversal procedure

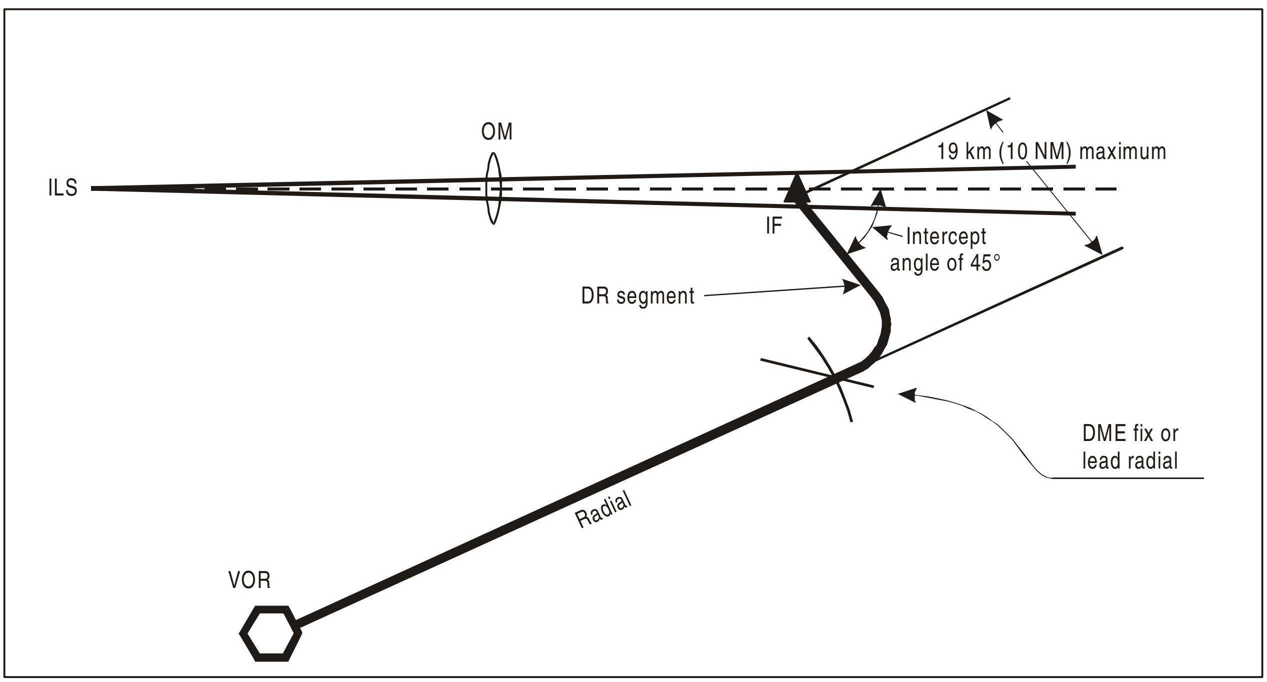


Figure I-4-3-5. Dead reckoning segment

Chapter 4

INTERMEDIATE APPROACH SEGMENT

4.1 GENERAL

4.1.1 Purpose

This is the segment during which the aircraft speed and configuration should be adjusted to prepare the aircraft for final approach. For this reason, the descent gradient is kept as shallow as possible.

4.1.2 Minimum obstacle clearance

During the intermediate approach, the obstacle clearance requirement reduces from 300 m (984 ft) to 150 m (492 ft) in the primary area, reducing laterally to zero at the outer edge of the secondary area.

4.1.3 Beginning and end of the segment

Where a final approach fix (FAF) is available, the intermediate approach segment begins when the aircraft is on the inbound track of the procedure turn, base turn or final inbound leg of the racetrack procedure. It ends at the FAF or final approach point (FAP), as applicable.

Note.— Where no FAF is specified, the inbound track is the final approach segment.

Chapter 5

FINAL APPROACH SEGMENT

5.1 GENERAL

5.1.1 Purpose

This is the segment in which alignment and descent for landing are made. Final approach may be made to a runway for a straight-in landing, or to an aerodrome for a visual manoeuvre.

5.1.2 Types of final approach

The criteria for final approach vary according to the type. These types are:

a) Non-precision approach (NPA) with final approach fix (FAF);

b) NPA without FAF;

c) Approach with vertical guidance (APV); and

d) Precision approach (PA).

5.2 NPA WITH FAF

5.2.1 FAF location

This segment begins at a facility or fix, called the final approach fix (FAF) and ends at the missed approach point (MAPt) (see Figure I-4-1-1). The FAF is sited on the final approach track at a distance that permits selection of final approach configuration, and descent from intermediate approach altitude/height to the appropriate MDA/H either for a straight-in approach or for a visual circling. The optimum distance for locating the FAF relative to the threshold is 9.3 km (5.0 NM). The maximum length should not normally be greater than 19 km (10 NM).

5.2.2 Optimum gradient

5.2.2.1 Compatible with the primary safety consideration of obstacle clearance (see Section 2, Chapter 1, 1.2, "Obstacle clearance"), a non-precision approach provides the optimum final approach descent gradient of 5.2 per cent, or 3°, providing a rate of descent of 52 m per km (318 ft per NM).

5.2.2.2 Consistent with 5.2.4, "FAF crossing", information provided in approach charts displays the optimum constant approach slope.

5.2.3 Standard operating procedures (SOPs)

Operators shall include in their SOPs (see Part III, Section 5, Chapter 1) specific guidance for using on-board technology with ground-based aids, such as distance measuring equipment (DME), in order to facilitate the execution of optimum constant approach slope descents during non-precision approaches.

5.2.4 FAF crossing

The FAF is crossed at the procedure altitude/height in descent but no lower than the minimum crossing altitude associated with FAF under international standard atmosphere (ISA) conditions. The descent is normally initiated prior to the FAF in order to achieve the prescribed descent gradient/angle. Delaying the descent until reaching the FAF at the procedure altitude/height will cause a descent gradient/angle to be greater than 3°. The descent gradient/angle is published to the nearest one-tenth of a degree for chart presentation and to the nearest one-hundredth of a degree for database coding purposes. Where range information is available, descent profile information is provided.

5.2.5 Stepdown fixes

5.2.5.1 A stepdown fix may be incorporated in some non-precision approach procedures. In this case, two OCA/H values are published:

a) a higher value applicable to the primary procedure; and

b) a lower value applicable only if the stepdown fix is positively identified during the approach (see Figure I-4-5-1).

5.2.5.2 Normally only one stepdown fix is specified. However, in the case of a VOR/DME procedure several DME fixes may be depicted, each with its associated minimum crossing altitude.

5.2.5.3 Procedure design caters to a maximum final approach flight descent path after the fix of 15 per cent (Category H, 15 per cent or descent gradient of the nominal track multiplied by 2.5, whichever is greater).

5.2.5.4 *Stepdown fixes with helicopters*

When obstacles are close to final approach or stepdown fixes, they are discounted for Category A aircraft if they lie below a 15 per cent plane relative to the earliest point defined by the fix tolerance area and MOC. Helicopters, on the other hand, are capable of nominal descent gradients which could penetrate this plane. Therefore, for helicopters, rates of descent after crossing the final approach fix and any stepdown fix should be limited accordingly.

5.2.5.5 *Stepdown fix with DME*

Where a stepdown procedure using a suitably located DME is published, the pilot shall not begin descent until established on the specified track. Once established on track, the pilot shall begin descent while maintaining the aeroplane at or above the published DME distance/height requirements.

Note.— The use of DME distance provides an additional check for en-route radar descent distances.

5.3 NPA WITHOUT FAF

5.3.1 Sometimes an aerodrome is served by a single facility located on or near the aerodrome, and no other facility is suitably situated to form a FAF. In this case, a procedure may be designed where the facility is both the IAF and the MAPt.

5.3.2 These procedures indicate:

a) a minimum altitude/height for a reversal procedure or racetrack; and

b) an OCA/H for final approach.

5.3.3 In the absence of a FAF, descent to MDA/H is made once the aircraft is established inbound on the final approach track. Procedure altitudes/heights will not be developed for non-precision approach procedures without a FAF.

5.3.4 In procedures of this type, the final approach track cannot normally be aligned on the runway centre line. Whether OCA/H for straight-in approach limits are published or not depends on the angular difference between the track and the runway and position of the track with respect to the runway threshold.

5.4 PRECISION APPROACH

5.4.1 Final approach point (FAP)

The final approach segment begins at the final approach point (FAP). This is a point in space on the final approach track where the intermediate approach altitude/height intercepts the nominal glide path/microwave landing system (MLS) elevation angle.

5.4.2 Final approach length

5.4.2.1 The intermediate approach altitude/height generally intercepts the glide path/MLS elevation angle at heights from 300 m (1 000 ft) to 900 m (3 000 ft) above runway elevation. In this case, for a 3° glide path, interception occurs between 6 km (3 NM) and 19 km (10 NM) from the threshold.

5.4.2.2 The intermediate approach track or radar vector is designed to place the aircraft on the localizer or the MLS azimuth specified for the final approach track at an altitude/height that is below the nominal glide path/MLS elevation angle.

5.4.3 Outer marker/DME fix

5.4.3.1 The final approach area contains a fix or facility that permits verification of the glide path/MLS elevation angle/altimeter relationship. The outer marker or equivalent DME fix is normally used for this purpose. Prior to crossing the fix, descent may be made on the glide path/MLS elevation angle to the altitude/height of the published fix crossing.

5.4.3.2 Descent below the fix crossing altitude/height should not be made prior to crossing the fix.

5.4.3.3 It is assumed that the aircraft altimeter reading on crossing the fix is correlated with the published altitude, allowing for altitude error and altimeter tolerances. See Part III.

Note.— Pressure altimeters are calibrated to indicate true altitude under ISA conditions. Any deviation from ISA will therefore result in an erroneous reading on the altimeter. If the temperature is higher than ISA, then the true altitude will be higher than the figure indicated by the altimeter. Similarly, the true altitude will be lower when the temperature is lower than ISA. The altimeter error may be significant in extremely cold temperatures.

5.4.3.4 In the event of loss of glide path/MLS elevation angle guidance during the approach, the procedure becomes a non-precision approach. The OCA/H and associated procedure published for the glide path/MLS elevation angle inoperative case will then apply.

5.5 DETERMINATION OF DECISION ALTITUDE (DA) OR DECISION HEIGHT (DH)

5.5.1 In addition to the physical characteristics of the ILS/MLS/GBAS installation, the procedures specialist considers obstacles both in the approach and in the missed approach areas in the calculation of the OCA/H for a procedure. The calculated OCA/H is the height of the highest approach obstacle or equivalent missed approach obstacle, plus an aircraft category related allowance (see 5.5.8).

5.5.2 In assessing these obstacles, the operational variables of the aircraft category, approach coupling, category of operation and missed approach climb performance are considered. The OCA/H values, as appropriate, are promulgated on the instrument approach chart for those categories of aircraft for which the procedure is designed. OCA/H values are based on the standard conditions (among others) listed in the sub-paragraphs that follow.

5.5.2.1 *Aircraft dimensions:* See Table I-4-5-1.

5.5.2.2 *ILS:*

a) Category I flown with pressure altimeter;

b) Category II flown with radio altimeter and flight director;

c) missed approach climb gradient is 2.5 per cent; and

d) glide path angle:

— minimum: 2.5°

— optimum: 3.0°

— maximum: 3.5° (3° for Category II/III operations).

5.5.2.3 *MLS:*

a) Category I flown with pressure altimeter;

b) Category II flown autocoupled/flight director, with radio altimeter;

c) missed approach climb gradient is 2.5 per cent; and

d) elevation angle:

— minimum: 2.5°

— optimum: 3.0°

— maximum: 3.5° (3° for Category II/III operations).

5.5.2.4 Additional values of OCA/H may be promulgated to cater for specific aircraft dimensions, improved missed approach performance and use of autopilot in Category II approach when applicable.

5.5.3 Additional factors listed, including those in Annex 6, are considered by the operator and are applied to the OCA/H. This results in the DA/H value.

5.5.4 Non-standard procedures

5.5.4.1 Non-standard procedures are those involving glide paths greater than 3.5° or any angle when the nominal rate of descent exceeds 5 m/sec (1 000 ft/min). Procedure design takes into account:

a) increase of height loss margin (which may be aircraft-type specific);

b) adjustment of the protection surfaces;

c) re-survey of obstacles; and

d) the application of related operational constraints.

5.5.4.2 Non-standard procedures are normally restricted to specifically approved operators and aircraft, and are promulgated with appropriate aircraft and crew restrictions annotated on the approach chart. They are not to be used as a means to introduce noise abatement procedures.

5.5.4.3 The height loss/altimeter margin should be verified by certification or flight trials to cover the effects of minimum drag configuration, wind shear, control laws, handling characteristics, minimum power for anti-icing, GPWS modification, use of flight director/autopilot, engine spin-up time and V_{at} increase for handling considerations.

5.5.4.4 In addition, consideration should have been given to operational factors including configuration, engine-out operation, maximum tailwind/minimum headwind limits, weather minima, visual aids and crew qualifications, etc.

5.5.5 Protection of the precision segment

5.5.5.1 The width of the ILS/MLS/GBAS final approach protection area is much narrower than those of non-precision approaches. Descent on the glide path/MLS elevation angle must never be initiated until the aircraft is within the tracking tolerance of the localizer/azimuth.

5.5.5.2 The protection area assumes that the pilot does not normally deviate from the centre line more than half-scale deflection after being established on track. Thereafter the aircraft should adhere to the on-course, on-glide path/elevation angle position since a more than half course sector deflection or a more than half course fly-up deflection combined with other allowable system tolerances could place the aircraft in the vicinity of the edge or bottom of the protected airspace where loss of protection from obstacles can occur.

5.5.6 Operators must consider weight, altitude and temperature limitations and wind velocity when determining the DA/H for a missed approach, since the OCA/H might be based on an obstacle in the missed approach area and since advantage may be taken of variable missed approach climb performances.

5.5.7 Unless otherwise noted on the instrument approach chart, the nominal missed approach climb gradient is 2.5 per cent.

5.5.8 Table I-4-5-2 shows the allowance used by the procedures specialist for vertical displacement during initiation of a missed approach. It takes into account type of altimeter used and the height loss due to aircraft characteristics.

5.5.9 It should be recognized that no allowance has been included in the table for any abnormal meteorological conditions; for example, wind shear and turbulence.

Table I-4-5-1. Aircraft dimensions

Aircraft category	*Wing span (m)*	*Vertical distance between the flight paths of the wheels and the GP antenna (m)*
H	30	3
A, B	60	6
C, D	65	7
D_L	80	8

Note.— OCA/H for D_L aircraft is published when necessary.

Table I-4-5-2. Height loss/altimeter margin

Aircraft category (V_{at})	*Margin using radio altimeter*		*Margin using pressure altimeter*	
	Metres	*Feet*	*Metres*	*Feet*
A — 169 km/h (90 kt)	13	42	40	130
B — 223 km/h (120 kt)	18	59	43	142
C — 260 km/h (140 kt)	22	71	46	150
D — 306 km/h (165 kt)	26	85	49	161

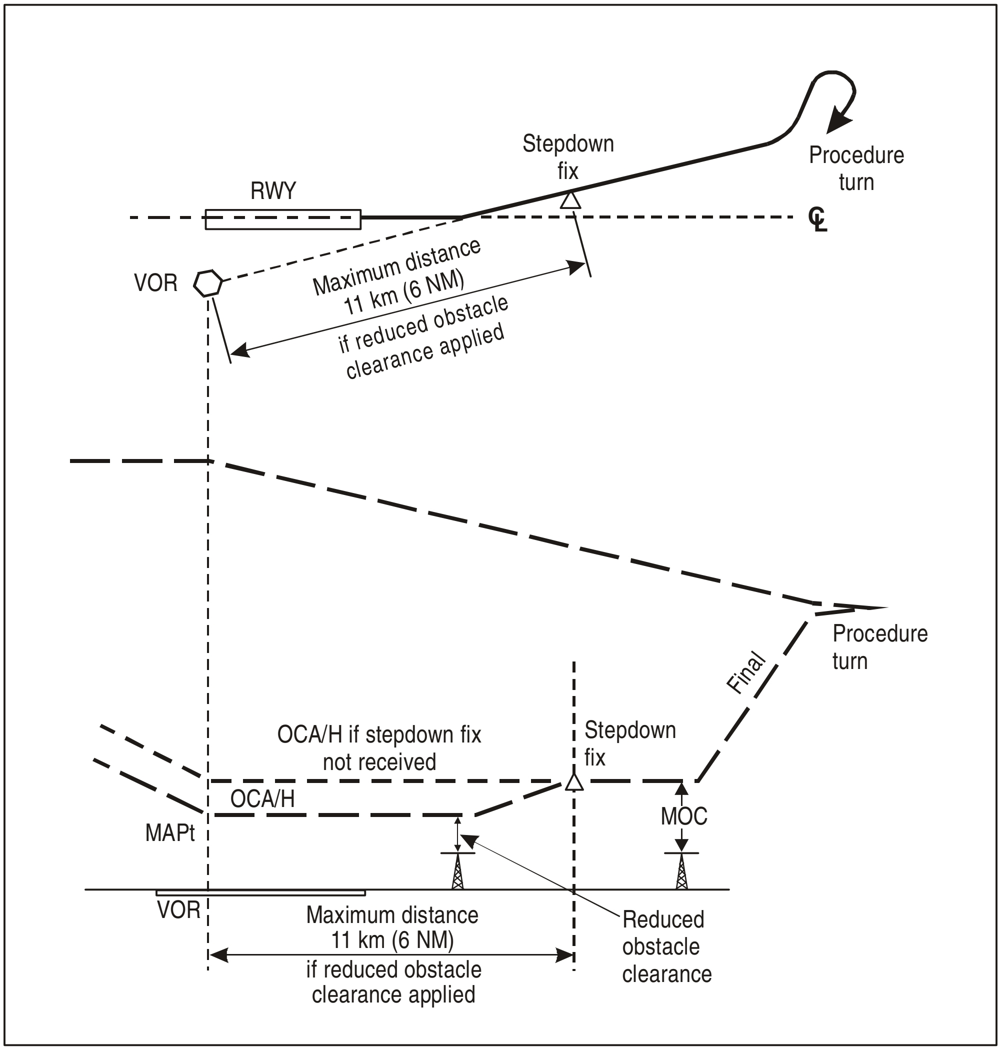


Figure I-4-5-1. Stepdown fix

Chapter 6

MISSED APPROACH SEGMENT

6.1 GENERAL

6.1.1 During the missed approach phase of the instrument approach procedure, the pilot is faced with the demanding task of changing the aircraft configuration, attitude and altitude. For this reason, the design of the missed approach has been kept as simple as possible and consists of three phases (initial, intermediate and final). See Figure I-4-6-1.

6.1.2 Purpose

Only one missed approach procedure is established for each instrument approach procedure. It is designed to provide protection from obstacles throughout the missed approach manoeuvre. It specifies a point where the missed approach begins, and a point or an altitude/height where it ends.

6.1.3 The missed approach should be initiated not lower than the decision altitude/height (DA/H) in precision approach procedures, or at a specified point in non-precision approach procedures not lower than the minimum descent altitude/height (MDA/H).

6.1.4 It is expected that the pilot will fly the missed approach procedure as published. If a missed approach is initiated before arriving at the missed approach point (MAPt), the pilot will normally proceed to the MAPt (or to the middle marker fix or specified DME distance for precision approach procedures) and then follow the missed approach procedure in order to remain within the protected airspace.

Note 1.— This does not preclude flying over the MAPt at an altitude/height greater than that required by the procedure.

Note 2.— In the case of a missed approach with a turn at an altitude/height, when an operational need exists, an additional protection is provided for the safeguarding of early turns. When it is not possible, a note is published on the profile view of the approach chart to specify that turns must not commence before the MAPt (or before an equivalent point in the case of a precision approach).

6.1.5 The MAPt in a procedure may be defined by:

a) the point of intersection of an electronic glide path with the applicable DA/H in APV or precision approaches; or

b) a navigation facility, a fix, or a specified distance from the final approach fix (FAF) in non-precision approaches.

When the MAPt is defined by a navigation facility or a fix, the distance from the FAF to the MAPt is normally published as well, and may be used for timing to the MAPt. In all cases where timing may not be used, the procedure is annotated “timing not authorized for defining the MAPt”.

Note.— Timing from the FAF based on ground speed may also be used to assist the planning of a stabilized approach. (See Chapter 3, 3.3.6.1)

6.1.6 If upon reaching the MAPt the required visual reference is not established, the procedure requires that a missed approach be initiated at once in order to maintain protection from obstacles.

6.1.7 Missed approach gradient

6.1.7.1 Normally procedures are based on a minimum missed approach climb gradient of 2.5 per cent. A gradient of 2 per cent may be used in the procedure construction if the necessary survey and safeguarding have been provided. With the approval of the appropriate authority, gradients of 3, 4 or 5 per cent may be used for aircraft whose climb performance permits an operational advantage to be thus obtained.

6.1.7.2 When a gradient other than 2.5 per cent is used, this is indicated on the instrument approach chart. In addition to the OCA/H for this gradient, the OCA/H applicable to the nominal gradient will also be shown.

6.1.7.3 *Special conditions.* It is emphasized that a missed approach procedure which is based on the nominal climb gradient of 2.5 per cent cannot be used by all aeroplanes when operating at or near maximum certificated gross mass and engine-out conditions. The operation of aeroplanes under these conditions needs special consideration at aerodromes which are critical due to obstacles on the missed approach area. This may result in a special procedure being established with a possible increase in the DA/H or MDA/H.

6.2 INITIAL PHASE

The initial phase begins at the MAPt and ends at the start of climb (SOC). This phase requires the concentrated attention of the pilot on establishing the climb and the changes in aeroplane configuration. It is assumed that guidance equipment is not extensively utilized during these manoeuvres, and for this reason, no turns are specified in this phase.

6.3 INTERMEDIATE PHASE

6.3.1 The intermediate phase begins at the SOC. The climb is continued, normally straight ahead. It extends to the first point where 50 m (164 ft) obstacle clearance is obtained and can be maintained.

6.3.2 The intermediate missed approach track may be changed by a maximum of 15° from that of the initial missed approach phase. During this phase, it is assumed that the aircraft begins track corrections.

6.4 FINAL PHASE

6.4.1 The final phase begins at the point where 50 m (164 ft) obstacle clearance is first obtained (for Category H procedures, 40 m (131 ft)) and can be maintained. It extends to the point where a new approach, holding or a return to en-route flight is initiated. Turns may be prescribed in this phase.

6.4.2 Turning missed approach

6.4.2.1 Turns in a missed approach procedure are only prescribed where terrain or other factors make a turn necessary.

6.4.2.2 If a turn from the final approach track is made, a specially constructed turning missed approach area is specified. See Section 2, Chapter 3, “Turn Area Construction”.

6.4.3 Airspeed

6.4.3.1 The protected airspace for turns is based on the speeds for *final missed approach (*see Tables I-4-1-1 and I-4-1-2).

6.4.3.2 However, where operationally required to avoid obstacles, the IAS as slow as for *intermediate missed approach* may be used. In this case, the instrument approach chart contains the following note: “Missed approach turn limited to ________ km/h (kt) IAS maximum”.

6.4.3.3 In addition, where an obstacle is located early in the missed approach procedure, the instrument approach chart is annotated “Missed approach turn as soon as operationally practicable to __________ heading”.

Note.— Flight personnel are expected to comply with such annotations on approach charts and to execute the appropriate manoeuvres without undue delay.

6.4.4 Turn parameters

The parameters which are common to all turns appear in Table I-2-3-1 in Section 2, Chapter 3, “Turn Area Construction”. The following parameters are specific to turning missed approaches:

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

b) *speed:* see 6.4.3, “Airspeed”;

c) *wind:* where statistical data are available, a maximum 95 per cent probability on an omnidirectional basis is used. Where no data are available, omnidirectional wind of 56 km/h (30 kt) is used; and

d) flight technical tolerances:

   1) *pilot reaction time:* 0 to +3 s; and

   2) *bank establishment time:* 0 to +3 s.

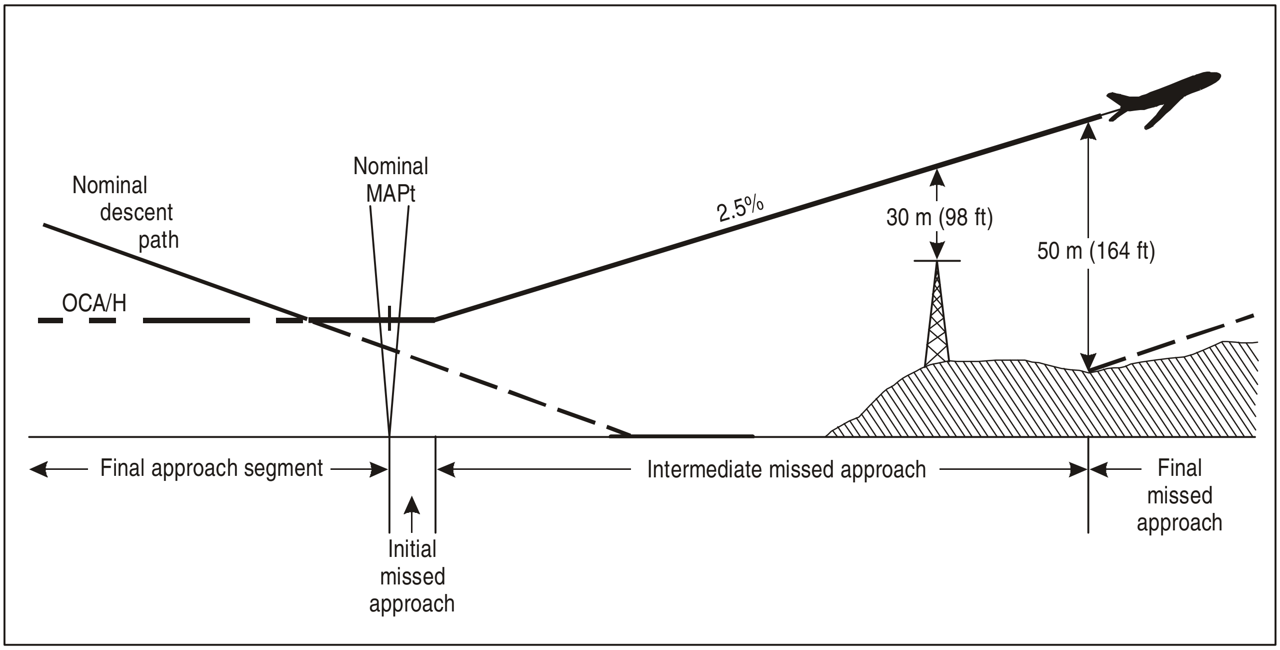


Figure I-4-6-1. Missed approach phases

Chapter 7

VISUAL MANOEUVRING (CIRCLING) AREA

7.1 PURPOSE

7.1.1 Visual manoeuvring (circling) is the term used to describe the phase of flight after an instrument approach has been completed. It brings the aircraft into position for landing on a runway which is not suitably located for straight-in approach, i.e. one where the criteria for alignment or descent gradient cannot be met.

7.1.2 Applicability to helicopters

Circling procedures are not applicable to helicopters. The helicopter pilot has to conduct a visual manoeuvre in adequate meteorological conditions to see and avoid obstacles in the vicinity of the final approach and take-off area (FATO) in the case of Category H procedures, or a suitable landing area in the case of Category A or point-in-space procedures. However, the pilot must be alert to any operational notes regarding ATS requirements while manoeuvring to land.

7.2 VISUAL FLIGHT MANOEUVRE

7.2.1 A circling approach is a visual flight manoeuvre. Each circling situation is different because of variables such as runway layout, final approach track, wind velocity and meteorological conditions. Therefore, there can be no single procedure designed that will cater for conducting a circling approach in every situation.

7.2.2 After initial visual contact, the basic assumption is that the runway environment should be kept in sight while at minimum descent altitude/height (MDA/H) for circling. The runway environment includes features such as the runway threshold or approach lighting aids or other markings identifiable with the runway.

7.3 PROTECTION

7.3.1 The visual manoeuvring (circling) area

The visual manoeuvring area for a circling approach is determined by drawing arcs centred on each runway threshold and joining those arcs with tangent lines (see Figure I-4-7-1). The radius of the arcs is related to:

a) *aircraft category*;

b) *speed:* speed for each category in Chapter 1, 1.3.5;

c) *wind speed:* 46 km/h (25 kt) throughout the turn; and

d) *bank angle:* 20° average or 3° per second, whichever requires less bank.

Note.— See Tables I-4-7-1 and I-4-7-2, and Figure I-4-7-1.

7.3.2 Obstacle clearance

When the visual manoeuvring (circling) area has been established, the obstacle clearance altitude/height (OCA/H) is determined for each category of aircraft (see Table I-4-7-3).

Note.— The information in Table I-4-7-3 should not be construed as operating minima.

7.3.3 Minimum descent altitude/height (MDA/H)

When the OCA/H is established, an MDA/H is also specified to allow for operational considerations. Descent below MDA/H should not be made until:

a) visual reference has been established and can be maintained;

b) the pilot has the landing threshold in sight; and

c) the required obstacle clearance can be maintained and the aircraft is in a position to carry out a landing.

7.3.4 Visual manoeuvring (circling) area exclusions

7.3.4.1 A sector in the circling area where a prominent obstacle exists may be ignored for OCA/H calculations if it is outside the final approach and missed approach areas. This sector is bounded by the dimensions of Annex 14, Volume I, instrument approach surfaces (see Figure I-4-7-1).

7.3.4.2 When this option is exercised, the published procedure prohibits circling within the entire sector in which the obstacle is located (see Figure I-4-7-2).

7.4 MISSED APPROACH PROCEDURE WHILE CIRCLING

7.4.1 If visual reference is lost while circling to land from an instrument approach, the missed approach specified for that particular procedure must be followed. The pilot will make an initial climbing turn toward the landing runway and overhead the aerodrome. At this point, the pilot will establish the aircraft climbing on the missed approach track.

7.4.2 The circling manoeuvre may be carried out in more than one direction. For this reason, different patterns are required to establish the aircraft on the prescribed missed approach course depending on its position at the time visual reference is lost.

7.5 VISUAL MANOEUVRING USING PRESCRIBED TRACK

7.5.1 General

7.5.1.1 In those locations where clearly defined visual features permit (and if it is operationally desirable), a State may prescribe a specific track for visual manoeuvring in addition to the circling area.

7.5.1.2 Since visual manoeuvring with a prescribed track is intended for use where specific terrain features warrant such a procedure, it is necessary for the flight crew to be familiar with the terrain and visual cues to be used in weather conditions above the aerodrome operating minima prescribed for this procedure.

7.5.1.3 This procedure is based on the aircraft speed category. It is published on a special chart on which the visual features used to define the track — or other characteristic features near the track — are shown.

7.5.1.4 Note that in this procedure:

a) navigation is primarily by visual reference and any radio navigation information presented is advisory only; and

b) the missed approach for the normal instrument procedure applies, but the prescribed tracks provide for manoeuvring to allow for a go-around and to achieve a safe altitude/height thereafter (joining the downwind leg of the prescribed track procedure or the instrument missed approach trajectory).

7.5.2 Standard track (general case)

7.5.2.1 Figure I-4-7-3 shows a standard track general case.

7.5.2.2 The direction and the length of each segment are defined. If a speed restriction is prescribed, it is published on the chart.

7.5.2.3 The length of the final segment is based on an allowance of 30 s of flight before the threshold (at IAS for final approach in Tables I-4-1-1 and I-4-1-2).

7.5.2.4 When a minimum altitude/height is specified at the beginning of the segment, the length of the final segment is adjusted, if necessary, taking into account the descent gradient/angle as specified in Chapter 1, 1.7.2. This descent gradient/angle is indicated on the chart.

7.5.3 Protection area associated with the prescribed track

The protection area is based on a corridor with a constant width, centred on the nominal track. The corridor starts at the "divergence" point and follows the track, including a go-around for a second visual manoeuvring with prescribed track (see Table I-4-7-4 and Figure I-4-7-4).

7.5.4 Minimum obstacle clearance (MOC) and OCA/H

The OCA/H for visual manoeuvring on prescribed tracks provides the minimum obstacle clearance (MOC) over the highest obstacle within the prescribed track area. It also conforms to the limits specified in Table I-4-7-3 and is not less than the OCA/H calculated for the instrument approach procedure which leads to the visual manoeuvre.

7.5.5 Visual aids

Visual aids associated with the runway used for the prescribed track (i.e. sequenced flashing lights, PAPI, VASIS, etc.) are shown on the chart with their main characteristics (i.e. slope of the PAPI or VASIS). Lighting on obstacles is specified on the chart.

Table I-4-7-1. Example of determining radii for visual manoeuvring (circling) area for aerodromes at 300 m MSL (SI units)

Category of aircraft/IAS (km/h)	*A/185*	*B/250*	*C/335*	*D/380*	*E/445*
TAS at 600 m MSL + 46 km/h wind factor (km/h)	241	310	404	448	516
Radius (r) of turn (km)	1.28	2.08	3.46	4.34	5.76
Straight segment (km)	0.56	0.74	0.93	1.11	1.30
Radius (R) from threshold (km)	3.12	4.90	7.85	9.79	12.82

Table I-4-7-2. Example of determining radii for visual manoeuvring (circling) area for aerodromes at 1 000 ft MSL (non-SI units)

Category of aircraft/IAS (kt)	*A/100*	*B/135*	*C/180*	*D/205*	*E/240*
TAS at 2 000 ft MSL + 25 kt wind factor (kt)	131	168	215	242	279
Radius (r) of turn (NM)	0.69	1.13	1.85	2.34	3.12
Straight segment (NM) (this is a constant value)	0.30	0.40	0.50	0.60	0.70
Radius (R) from threshold (NM)	1.68	2.66	4.20	5.28	6.94

Note.— Radius from threshold (R) = 2r + straight segment.

Table I-4-7-3. OCA/H for visual manoeuvring (circling) approach

Aircraft category	*Obstacle clearance m (ft)*	*Lowest OCH above aerodrome elevation m (ft)*	*Minimum visibility km (NM)*
A	90 (295)	120 (394)	1.9 (1.0)
B	90 (295)	150 (492)	2.8 (1.5)
C	120 (394)	180 (591)	3.7 (2.0)
D	120 (394)	210 (689)	4.6 (2.5)
E	150 (492)	240 (787)	6.5 (3.5)

Table I-4-7-4. Semi-width of the corridor

Aircraft category	A	B	C	D	E
Semi-width of the corridor (l)					
metres	1 400	1 500	1 800	2 100	2 600
feet	4 593	4 921	5 905	6 890	8 530

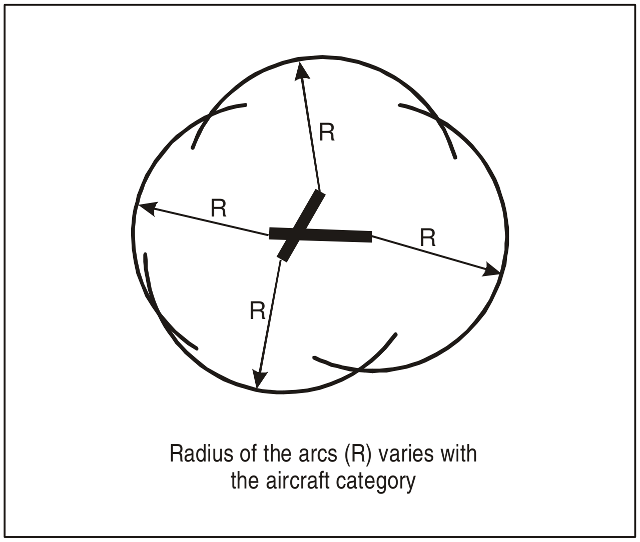


Figure I-4-7-1. Visual manoeuvring (circling approach) area

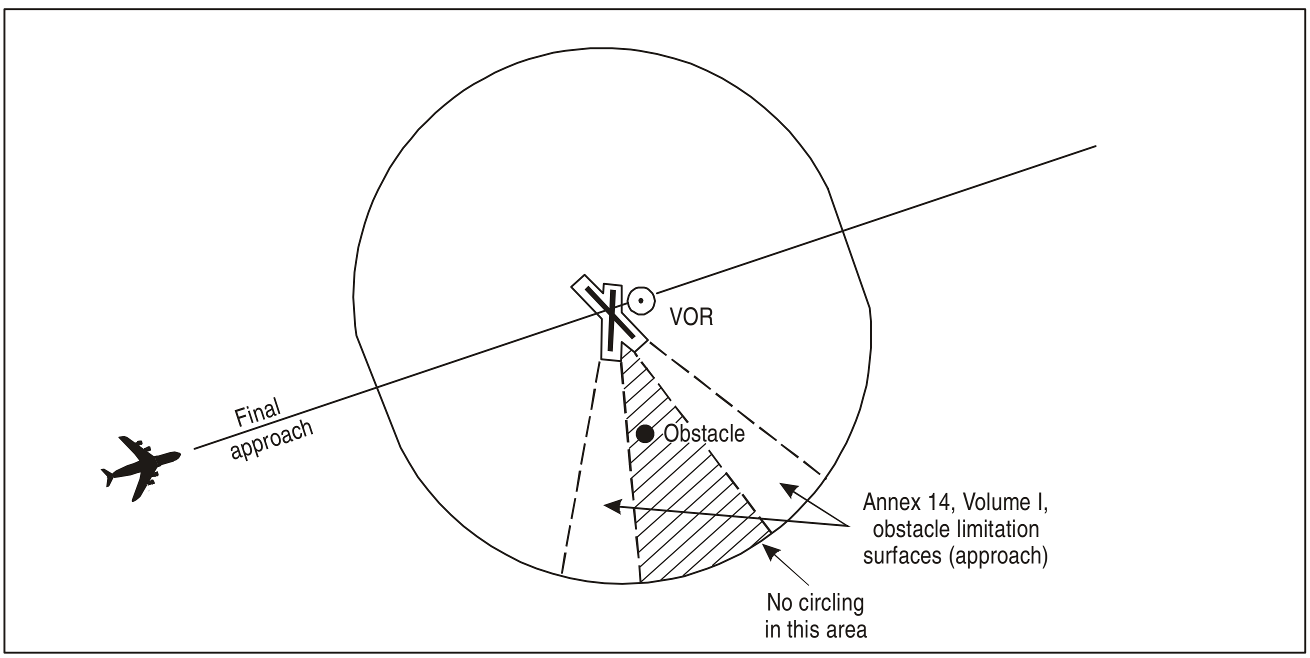


Figure I-4-7-2. Visual manoeuvring (circling) area — prohibition on circling

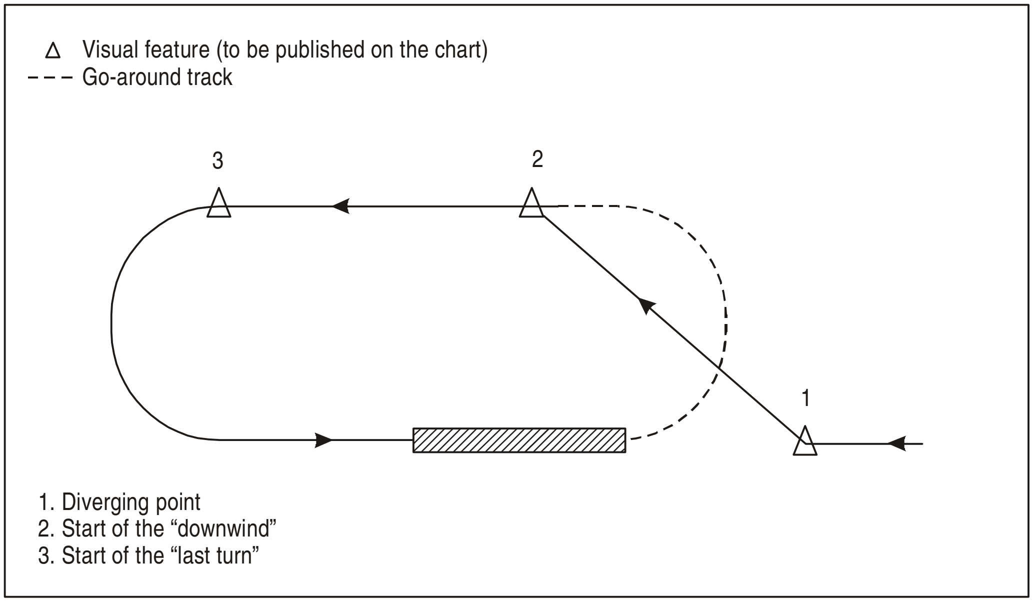


Figure I-4-7-3. Standard track general case

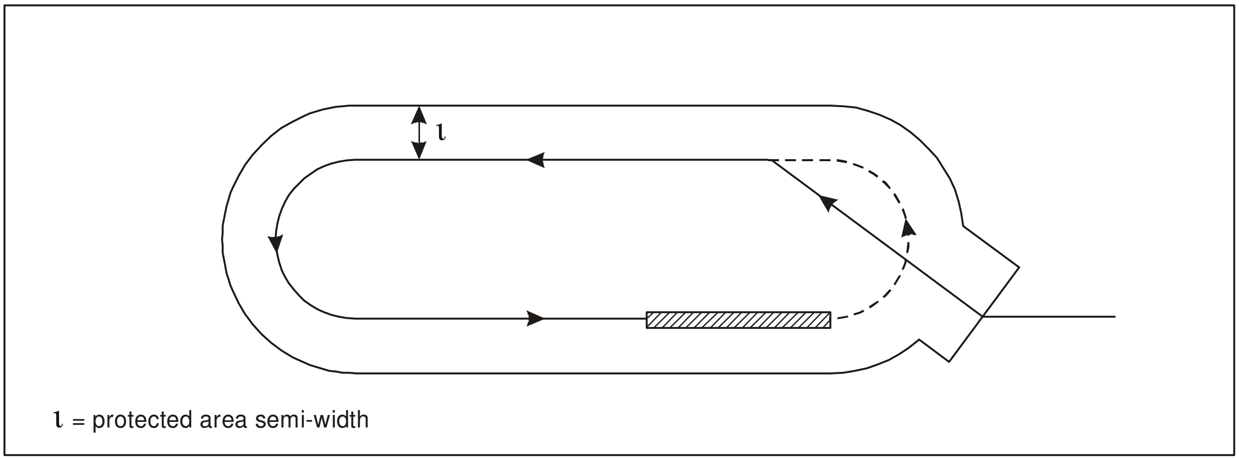


Figure I-4-7-4. Area

Chapter 8

CHARTING/AERONAUTICAL INFORMATION PUBLICATION (AIP)

8.1 GENERAL

Material relating to the publication of charts is contained in Annex 4 as follows:

a) Standard Arrival Chart — Instrument (STAR) — ICAO, in Annex 4, Chapter 10; and

b) Instrument Approach Chart — ICAO, in Annex 4, Chapter 11.

8.2 CHARTED ALTITUDES/FLIGHT LEVELS

In addition to minimum IFR altitudes established for each segment of the procedure, procedure altitudes/heights will also be provided. Procedure altitudes/heights will, in all cases, be at or above any minimum crossing altitude associated with the segment. Procedure altitude/height will be established taking into account the air traffic control needs for that phase of flight. (See Table I-4-8-1.)

8.3 ARRIVAL

In some cases it is necessary to designate arrival routes from the en-route structure to the initial approach fix. Only those routes that provide an operational advantage are established and published. These routes take local air traffic flow into consideration.

8.4 APPROACH

8.4.1 General

8.4.1.1 Optimum and maximum descent gradients and angles are specified depending on the type of procedure and the segment of the approach. The descent gradient(s)/angles used in the construction of the procedure are published for the final approach segment. It is preferable that they also be published for the other approach segments, where appropriate.

8.4.1.2 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.

8.4.2 Initial approach segment

8.4.2.1 Separate procedures are published when:

a) different minimum altitudes;

b) different timings; or

c) different outbound tracks

are specified for different categories of aircraft.

8.4.2.2 Speeds below the minimum value for initial approach in a given aircraft category are not specified (see Tables I-4-1-1 and I-4-1-2). If procedures are developed which exclude specific aircraft categories due to speed, this will be stated explicitly.

8.4.3 Final approach segment

8.4.3.1 An obstacle clearance altitude (OCA) and/or an obstacle clearance height (OCH) is published for each instrument approach and circling procedure. For non-precision approach procedures, values are expressed in 5 m or 10 ft increments by rounding up as appropriate.

8.4.3.2 A straight-in OCA/H is not published where final approach alignment or descent gradient criteria are not met. In this case, only circling OCA/H are published.

8.4.3.3 Procedures that require the use of forecast altimeter setting are so annotated on the approach charts.

8.4.4 Missed approach segment

8.4.4.1 Only one missed approach procedure is published for each approach procedure.

8.4.4.2 If the missed approach point (MAPt) is defined by a facility or fix at the MAPt, the procedure will be annotated "Timing not authorized for defining the MAPt".

8.4.4.3 If the MAPt is defined by a combination of timing over the distance from the nominal final approach fix (FAF) to the nominal MAPt, in addition to a facility or fix at the MAPt, the OCA/Hs for both timing and fix are published if an operational advantage can be obtained in this way. Alternatively, a single OCA/H is published (the higher of the two).

8.4.4.4 The OCA/H for the nominal 2.5 per cent is always published on the instrument approach chart (IAC). If additional gradients are specified in the construction of the missed approach procedure, they and their associated OCA/H values are published as alternative options.

8.4.4.5 The speeds for final missed approach are shown in Tables I-4-1-1 and I-4-1-2. However, where operationally required to avoid obstacles, reduced speeds as slow as the IAS for intermediate missed approach may be used. In such cases, the procedure is annotated "Missed approach turn limited to _______ km/h (kt) IAS maximum".

8.4.4.6 When a gradient other than the nominal gradient is used in the construction of the missed approach procedure, this is indicated in the IAC and, in addition to the OCA/H for the specific gradient, the OCA/H applicable to the nominal gradient is also shown.

8.4.5 Visual manoeuvring

8.4.5.1 A sector in the circling area where a prominent obstacle exists may be ignored for OCA/H calculations if it meets the criteria listed in PANS-OPS, Volume II, Part I, Section 4, Chapter 7, 7.4.1, "Area which can be ignored".

8.4.5.2 When this option is exercised, the published procedure will prohibit the pilot from circling within the total sector where the obstacle exists.

8.4.6 Visual manoeuvring with prescribed track

8.4.6.1 The length and magnetic orientation of the diverging segment will be published.

8.4.6.2 The length and magnetic orientation of the ''downwind'' leg will be published.

8.4.6.3 *Radius of turn.* If necessary (because constraining obstacles have to be avoided), the indicated airspeed may be reduced to not less than the maximum indicated airspeed for the final segment (see Tables I-4-1-1 and I-4-1-2) for the aircraft category. In such a case, the maximum indicated speed will be published on the chart.

8.4.6.4 Departure routes are labelled as RNAV only when that is the primary means of navigation utilized.

8.4.6.5 A text description is included, clearly stating the intent and requirements of the procedure design. This is to ensure that database coding will be executed correctly. For an example of textual description, see Figure I-4-8-1.

8.4.6.6 When procedures are identified as "RNAV", any of the following navigation sensors can be used: basic GNSS, DME/DME or VOR/DME. However, some procedures may identify specific sensor(s) that are required for the procedure, or separate procedures may be published, each identifying a permitted sensor.

Note.— Unless otherwise stated, all waypoints are fly-by waypoints.

8.4.7 Descent gradients/angles for charting

Descent gradients/angles for charting shall be promulgated to the nearest one-tenth of a per cent/degree. Descent gradients/angles shall originate at a point 15 m (50 ft) above the landing runway threshold. For precision approaches, different origination points may apply (see reference datum height (RDH) in specific chapters). Earth curvature is not considered in determining the descent gradient/angle.

8.4.8 Descent angles for database coding

Paragraph 8.4.7 applies, except only to descent angles and that the angles shall be published to the nearest one-hundredth of a degree.

8.4.9 FAF altitude and procedure altitude/height

8.4.9.1 The descent path reaches a certain altitude at the FAF. In order to avoid overshooting the descent path, the FAF published procedure altitude/height should be 15 m (50 ft) below this altitude. The procedure altitude/height shall not be less than the OCA/H of the segment preceding the final approach segment. See Figure I-4-8-2.

8.4.9.2 Both the procedure altitude/height and the minimum altitude for obstacle clearance shall be published. In no case will the procedure altitude/height be lower than any minimum altitude/height for obstacle clearance.

8.4.9.3 The designed stabilized descent path will clear the stepdown fix minimum obstacle clearance altitude. This is achieved by increasing the descent gradient/angle by:

a) increasing the procedure altitude/height at the FAF; or, if this is not possible,

b) moving the FAF toward the landing threshold.

8.5 PROCEDURE NAMING FOR ARRIVAL AND APPROACH CHARTS

8.5.1 Instrument flight procedure naming convention

8.5.1.1 This paragraph describes the general aspects of instrument procedure naming. Specific aspects are covered in the appropriate chapters. A standardized naming convention is required to avoid ambiguity between charts, electronic cockpit displays and ATC clearances. This convention affects the following charting aspects:

a) procedure identification;

b) additional equipment requirements; and

c) minimum boxes.

8.5.1.2 *Procedure identification*

8.5.1.2.1 *General.* The procedure identification shall only contain the name describing the type of radio navigation aid providing the final approach lateral guidance. Precision approach systems such as ILS or MLS shall be identified by the system name (ILS, MLS, etc). If two radio navigation aids are used for final approach lateral guidance, the title shall only include the last radio navigation aid used. For example:

> If an NDB is used as the FAF, and a VOR is used as the last navaid on the final approach to runway 06, the procedure shall be identified as VOR Rwy 06. If a VOR is used for the initial approach followed by a final approach to Rwy 24 using an NDB, the procedure shall be identified as NDB Rwy 24.

8.5.1.2.2 *Additional navaids*. If additional navigation aids are required (such as fix formations or transition routes) for the approach procedure, they shall be specified on the plan view of the chart, but not in the title.

8.5.1.2.3 *Multiple procedures.* A single approach chart may portray more than one approach procedure when the procedures for the intermediate approach, final approach and missed approach segments are identical. If more than one approach procedure is depicted on the same chart, the title shall contain the names of all the types of navigation aids used for final approach lateral guidance, separated by the word “or”. There shall be no more than three types of approach procedure on one chart. For example:

ILS or NDB Rwy 35L

8.5.1.2.4 *Helicopter approach*. Helicopter approaches to a runway shall be identified in the same way as fixed wing approaches, with the Category H included in the minimum box. A helicopter approach to a point in space or a helipad shall be identified by the navigation aid type used for final approach guidance, followed by the final approach track. For example:

VOR 235

8.5.1.2.5 *Circling approach.* When only circling minima are provided on a chart, the approach procedure shall be identified by the last navaid providing final approach guidance followed by a single letter, starting with the letter A. When there are two or more approaches at an airport (or a nearby airport), a different letter shall be used. If the IFR portion of the procedure is the same but there are different circling tracks for the same procedure, only one procedure with one title should be promulgated and the different circling procedures indicated in the procedure. The suffix letter shall not be used again for any procedures at that airport, at any other airport serving the same city, or at any other airport in the same State, serving a city with the same name. For example:

VOR-A

VOR-B

NDB-C

8.5.1.3 *Duplicate procedure identification*

8.5.1.3.1 A single letter suffix, starting with the letter Z, following the radio navigation aid type shall be used if two or more procedures to the same runway cannot be distinguished by the radio navigation aid type only. For example:

VOR Z Rwy 20
VOR Y Rwy 20

8.5.1.3.2 The single letter suffix shall be used as follows:

a) when two or more navigation aids of the same type are used to support different approaches to the same runway;

b) when two or more missed approaches are associated with a common approach, each approach shall be identified by a single letter suffix;

c) if different approach procedures using the same radio navigation type are provided for different aircraft categories; and

d) if two or more arrivals are used to a common approach and are published on different charts, each approach shall be identified by a single letter suffix. If additional radio navigation aids are required for the arrival, they shall be specified on the chart's plan view. For example:

ILS Z RWY 20 ("DNA VOR Arrival" shown in the plan view)
ILS Y RWY 20 ("CAB VOR Arrival" shown in the plan view)

8.5.1.4 *Additional equipment requirements*

8.5.1.4.1 All navigation equipment that is required for the execution of the approach procedure and not mentioned in the procedure identification shall be identified in notes on the chart. For example:

"VOR required" on an NDB approach.

"Dual ADF required" when required on an NDB approach where two ADFs are required.

"When inbound from XXX NDB, change over to YYY NDB at midpoint."

"DME required" on a VOR/DME arc approach.

8.5.1.4.2 Optional carriage of equipment that may support lower minima shall be evident from the minimum box. In such a case, it is not necessary to provide a note on the chart. See 8.5.1.5, "Minimum boxes".

8.5.1.5 *Minimum boxes*

The OCA/H for each aircraft category shall be published in the minimum box on the chart. Where an OCA/H is predicated on a specific navigation aid (e.g. stepdown fixes), or a specific RNAV functionality (e.g. LNAV/VNAV), or an RNP value, this shall be clearly identified. For example:

OCA/(OCH)	CAT A	CAT B	CAT C	CAT D	CAT H
LNAV/VNAV	560 (250)	560 (250)	630 (320)	630 (320)	560 (250)
LNAV	710 (400)	710 (400)	810 (500)	810 (500)	710 (400)

Or

OCA/(OCH)	CAT A	CAT B	CAT C	CAT D	CAT H
VOR/DME	610 (300)	610 (300)	610 (300)	610 (300)	610 (300)
VOR	660 (350)	660 (350)	660 (350)	660 (350)	660 (350)

Or

OCA/(OCH)	CAT A	CAT B	CAT C	CAT D	CAT H
CAT I	210 (170)	210 (170)	220 (180)	230 (190)	210 (170)
RNP 0.3	290 (250)	290 (250)	290 (250)	290 (250)	290 (250)

Table I-4-8-1. Charted altitudes/flight levels

Altitude/Flight Level "Window"	$\overline{\textit{17 000}}$ $\underline{\textit{10 000}}$	$\overline{\textit{FL220}}$ $\underline{\textit{10 000}}$
"At or Above" Altitude/Flight Level	$\underline{\textit{7 000}}$	$\underline{\textit{FL60}}$
"At or Below" Altitude/Flight Level	$\overline{\textit{5 000}}$	$\overline{\textit{FL50}}$
"Mandatory" Altitude/Flight Level	$\overline{\underline{\textit{3 000}}}$	$\overline{\underline{\textit{FL30}}}$
"Recommended" Procedure Altitude/Flight Level	*5 000*	*FL50*
"Expected" Altitude/Flight Level	*Expect 5 000*	*Expect FL50*

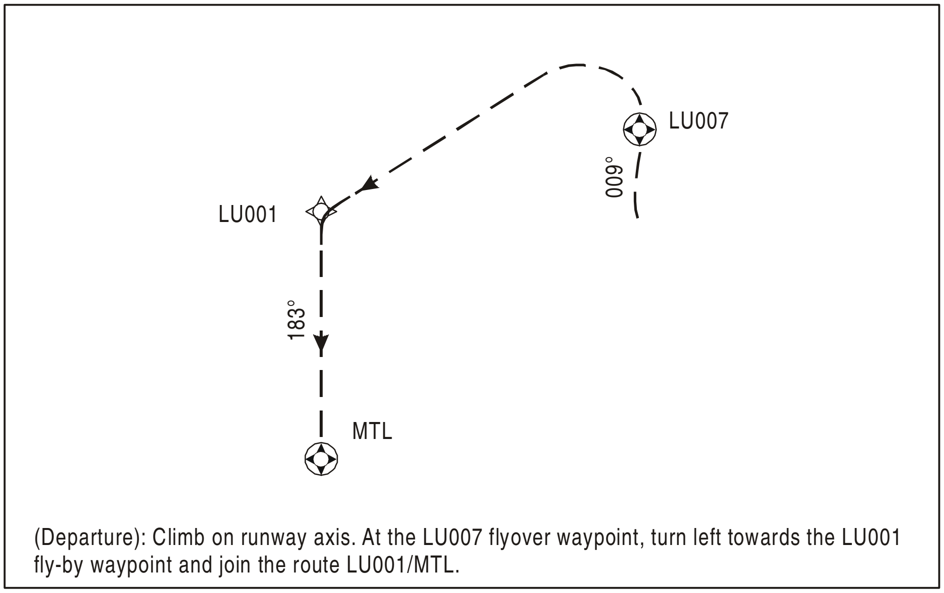
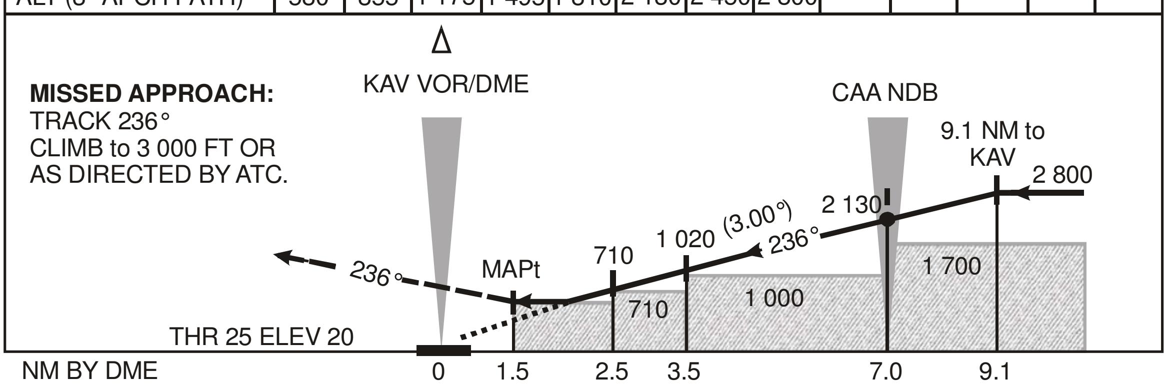


Figure I-4-8-1. Text description

DIST BY DME	2.1	3	4	5	6	7	8	9.1					
ALT (3° APCH PATH)	580	855	1 175	1 495	1 810	2 130	2 450	2 800					



OCA/H		A	B	C	D
Straight-in Approach	VOR/DME	580 (559)			
	VOR	1 000 (979)			
Circling		1 000 (979)		1 100 (1 079)	

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Figure I-4-8-2. Procedure altitude/height vs. minimum altitudes with stepdown fix

Section 5

EN-ROUTE CRITERIA

Chapter 1

EN-ROUTE CRITERIA

1.1 GENERAL

1.1.1 Procedures developed utilizing en-route criteria assume normal aircraft operations. Any requirements to satisfy Annex 6 aeroplane performance operating limitations must be considered separately by the operator.

1.1.2 Two methods can be used to determine en-route obstacle clearance areas:

a) a simplified method, which is the standard method; and

b) a refined method, which can be used when the simplified method is too constraining.

1.2 OBSTACLE CLEARANCE AREAS

1.2.1 In the simplified method, the obstacle clearance area is divided into a central primary area and two lateral buffer areas. In the refined method, the obstacle clearance area is divided into a central primary area and two lateral secondary areas. The width of the primary area corresponds to 95 per cent probability of containment (2 SD). The total width of the area corresponds to 99.7 per cent probability of containment (3 SD).

1.2.2 Reductions to secondary area widths

Secondary areas for en-route operations may be reduced when justified by factors such as:

a) relevant information on flight operational experience;

b) regular flight inspection of facilities to ensure better than standard signals; and/or

c) radar surveillance.

1.2.3 Area without track guidance

When track guidance is not provided, for example, outside the coverage of navigation facilities along the route, the primary area splays at an angle of 15° from its width at the last point where track guidance was available. The width of the buffer area (simplified method) or the secondary area (refined method) is progressively reduced to zero, ending in an area without track guidance where the full minimum obstacle clearance (MOC) is applied.

1.2.4 Maximum area width

There is no maximum area width for routes within the coverage of the facilities defining the route. Outside the coverage of the facilities defining the route, the area splays at 15°, as specified in 1.2.3, "Area without track guidance".

1.3 CHARTING ACCURACIES

Charting accuracies are taken into account when establishing minimum en-route altitudes by adding both a vertical and a horizontal tolerance to the depicted objects on the chart, as specified in PANS-OPS, Volume II, Part 1, Section 2, Chapter 1, 1.8.

1.4 OBSTACLE CLEARANCE

1.4.1 The MOC value to be applied in the primary area for the en-route phase of an IFR flight is 300 m (1 000 ft). In mountainous areas, this shall be increased depending on:

Variation in terrain elevation	*MOC*
Between 900 m (3 000 ft) and 1 500 m (5 000 ft)	450 m (1 476 ft)
Greater than 1 500 m (5 000 ft)	600 m (1 969 ft)

1.4.2 The MOC to be applied outside the primary area is as follows:

a) simplified method: in the buffer area, the MOC is equal to half the value of the primary area MOC; and

b) refined method: in the secondary area, the obstacle clearance is reduced linearly from the full clearance at the inner edge to zero at the outer edge.

1.4.3 A minimum altitude is determined and published for each segment of the route.

1.5 TURNS

1.5.1 Protection areas associated with turns

Turns can be executed overhead a facility or at a fix.

1.5.2 Turn parameters

The parameters which are common to all turns appear in Table I-2-3-1 in Section 2, Chapter 3, "Turn Area Construction". The following parameters are specific to en-route turns:

a) *altitude:* an altitude at or above which the area is designed;

b) *indicated airspeed:* 585 km/h (315 kt);

c) *wind:* omnidirectional for the altitude h

w = (12 h + 87) km/h, where h is in kilometres,

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

or provided adequate statistical data are available, the maximum 95 per cent probability omnidirectional wind; and

d) flight technical tolerances:

1) *maximum pilot reaction time:* 10 s; and

2) *bank establishment time:* 5 s.