

AMENDMENT No. 14

TO THE

**PROCEDURES
FOR
AIR NAVIGATION SERVICES**

AIRCRAFT OPERATIONS

(Doc 8168)

**VOLUME I
FLIGHT PROCEDURES**

FIFTH EDITION

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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

<i>Amendment</i>	<i>Source(s)</i>	<i>Subject(s)</i>	<i>Approved Applicable</i>
(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

<i>Amendment</i>	<i>Source(s)</i>	<i>Subject(s)</i>	<i>Approved Applicable</i>
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

<i>Amendment</i>	<i>Source(s)</i>	<i>Subject(s)</i>	<i>Approved Applicable</i>
	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

<i>Amendment</i>	<i>Source(s)</i>	<i>Subject(s)</i>	<i>Approved Applicable</i>
		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

<i>Amendment</i>	<i>Source(s)</i>	<i>Subject(s)</i>	<i>Approved Applicable</i>
		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.	
(Volume I, 5th Edition)			

**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

ADVANCE COPY

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.

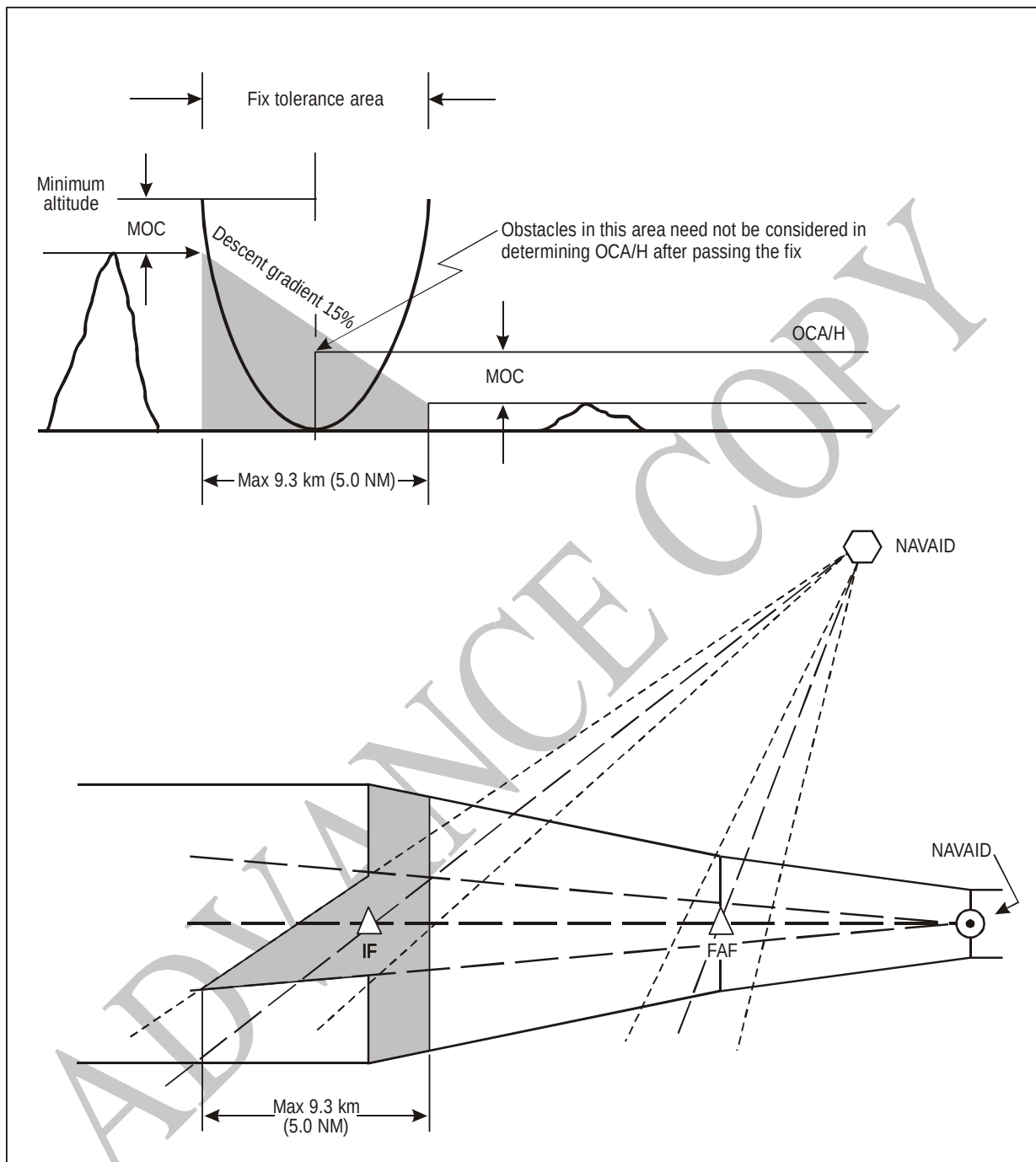


Figure I-2-1-1. Area where obstacles need not be considered

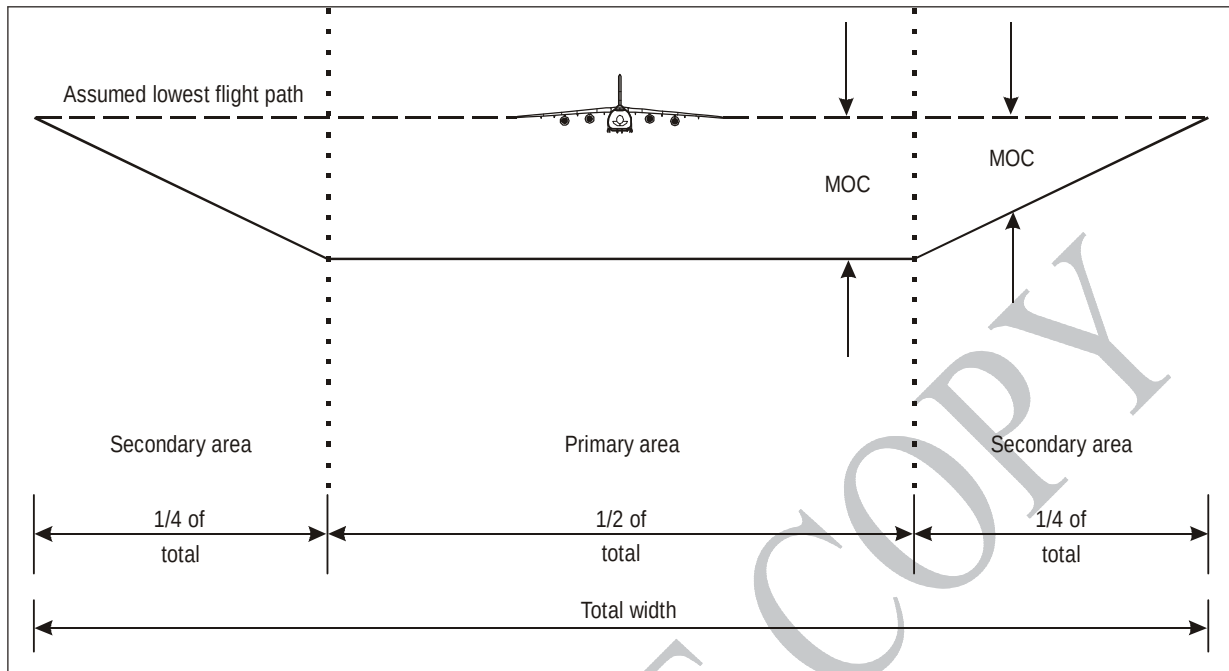


Figure I-2-1-2. Relationship of minimum obstacle clearances in primary and secondary areas in cross-section

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.

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

	<i>VOR</i> ¹	<i>ILS</i>	<i>NDB</i>
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.

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:

- Terminal area surveillance radar (TAR) within 37 km (20 NM): fix tolerance is ±1.5 km (0.8 NM); and
- En-route surveillance radar (RSR) within 74 km (40 NM): fix tolerance is ±3.1 km (1.7 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:

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

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

For a cone angle of 50° , the accuracy of entry is $\pm 5^\circ$. Tracking through the cone is assumed to be within an accuracy of $\pm 5^\circ$. 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 $\pm 15^\circ$ from the prescribed track. Tracking through the cone is assumed to be within an accuracy of $\pm 5^\circ$. 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:

- 3.7 km (2.0 NM) for VOR; and
- 4.6 km (2.5 NM) for NDB.

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

- 7.8° for VOR; and
- 10.3° for NDB.

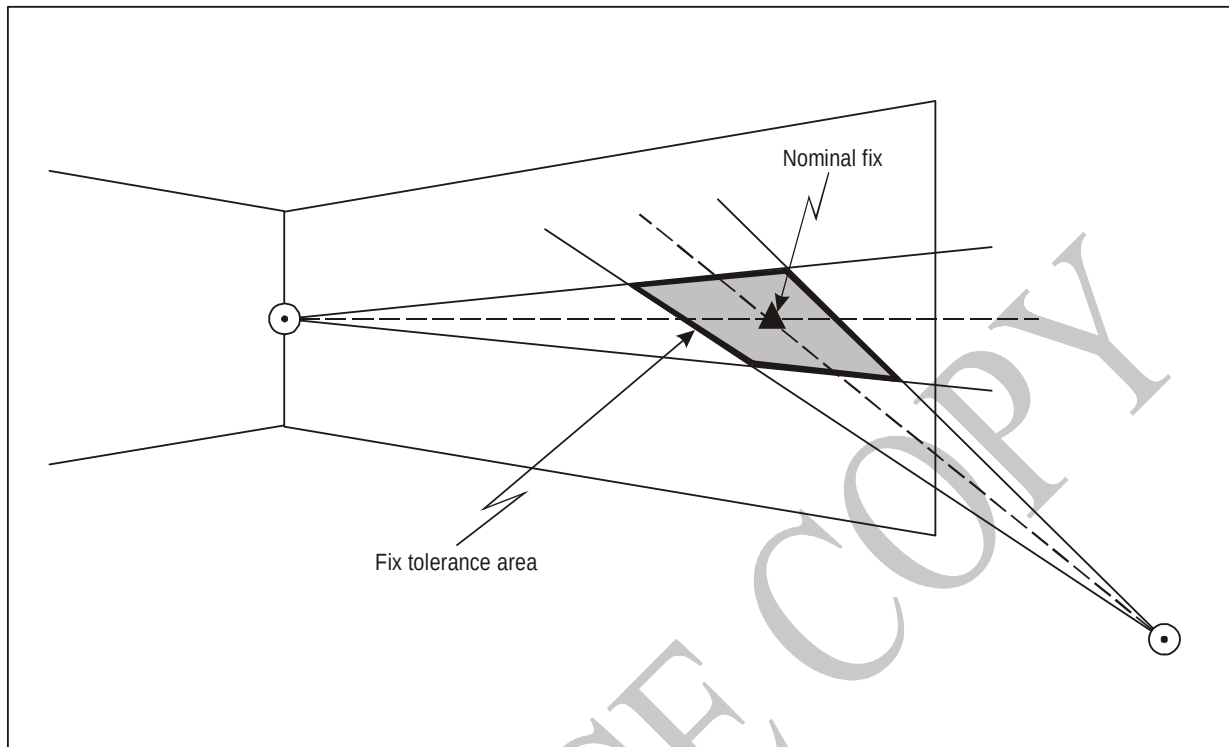
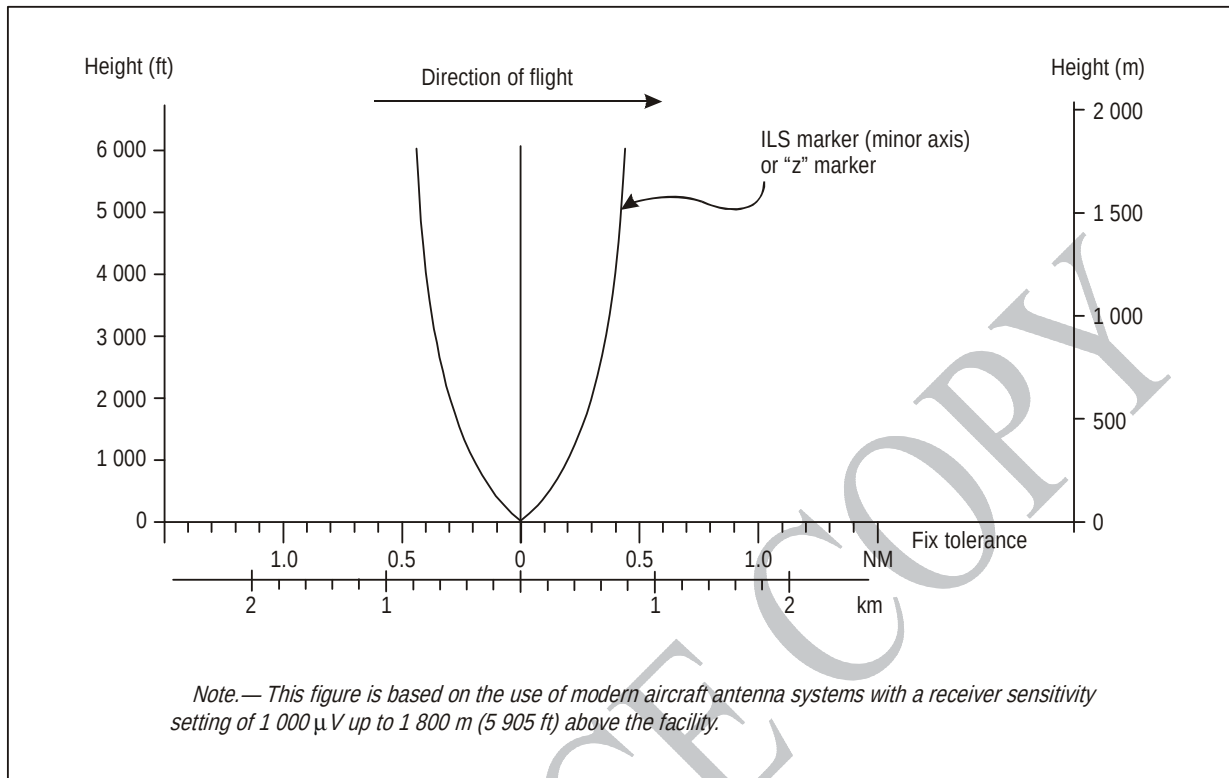


Figure I-2-2-1. Fix tolerance area

**Figure I-2-2-2. ILS or "z" marker coverage**

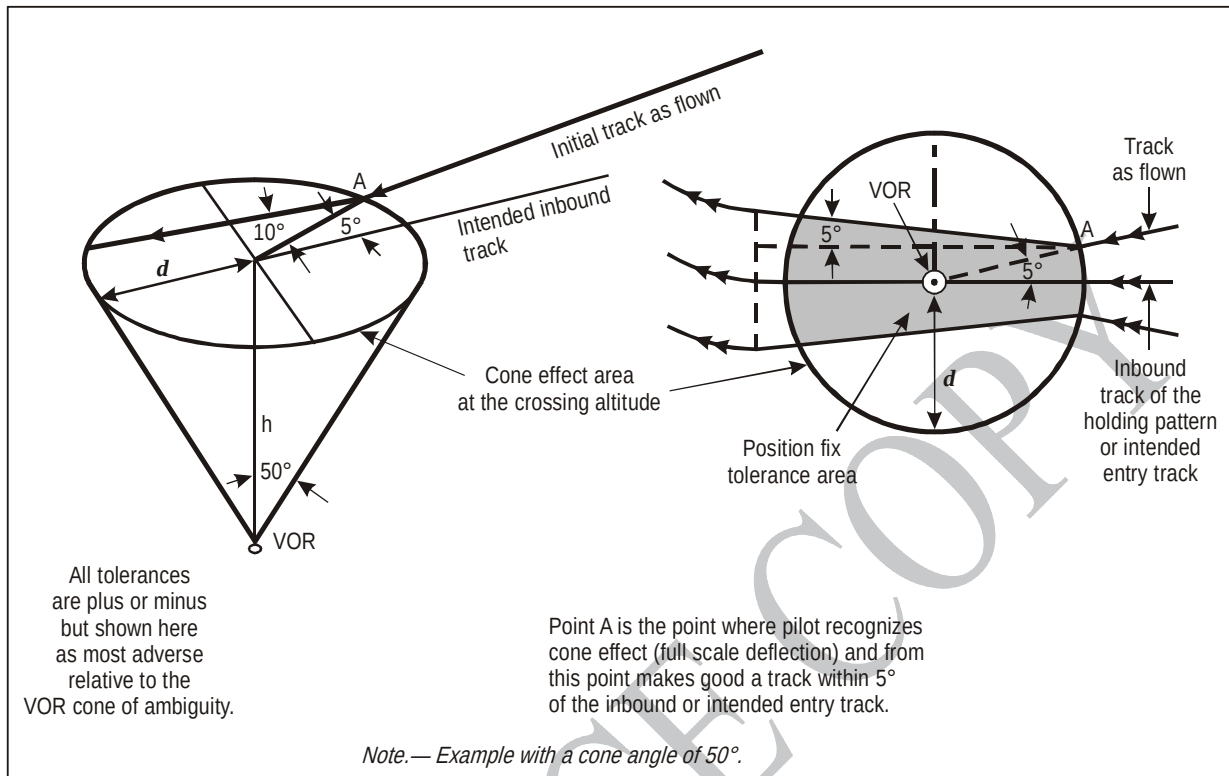


Figure I-2-2-3. Fix tolerance area overhead a VOR

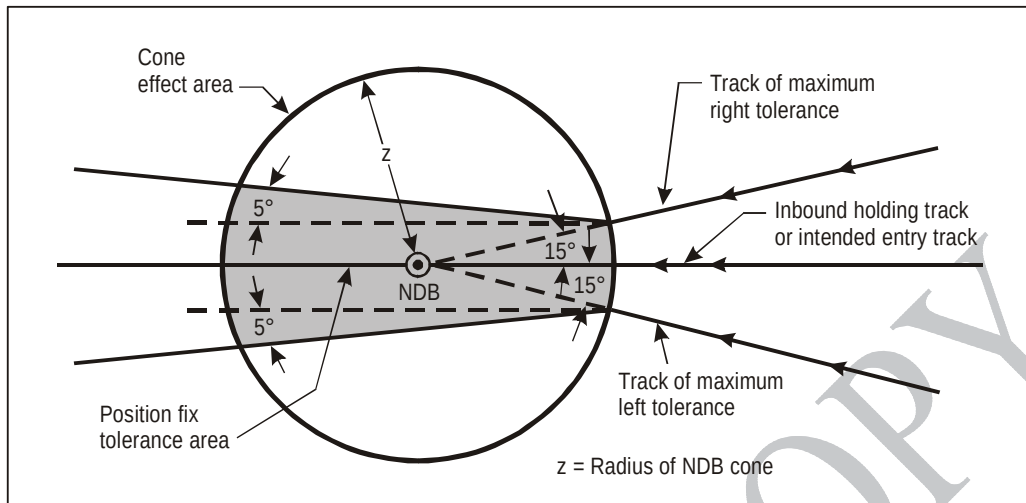


Figure I-2-2-4. Fix tolerance area overhead an NDB

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;
- 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

Segment or fix of turn location	Speed (IAS) ¹	Altitude/height	Wind	Bank angle ²	FTT (seconds)			
					c (seconds)		Outbound timing tolerance	Heading tolerance
					Bank establishment time	Pilot reaction time		
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	15° until 305 m (1 000 ft) 20° between 305 m (1 000 ft) and 915 m (3 000 ft) 25° 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	15°	5	10	N/A	N/A
Holding	Tables I-6-1-1 and I-6-1-2 ¹	Specified altitude	ICAO standard wind ⁴	23°	N/A	5	N/A	N/A
Initial approach – reversal and racetrack procedures	Table I-4-1-1 or Table I-4-1-2	Specified altitude	ICAO standard wind ⁴ or statistical wind	25°	5	0–6	10	5
Initial approach – DR track procedures	CAT A, B: 165 to 335 km/h (90 to 180 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)	25°	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)	25°	3	3	N/A	N/A

Segment or fix of turn location	Speed (IAS) ¹	Altitude/height	Wind	Bank angle ²	FTT (seconds)			
					c (seconds)			Heading tolerance
					Bank establishment time	Pilot reaction time	Outbound timing 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)	15°	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)	25°	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)	20°	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)

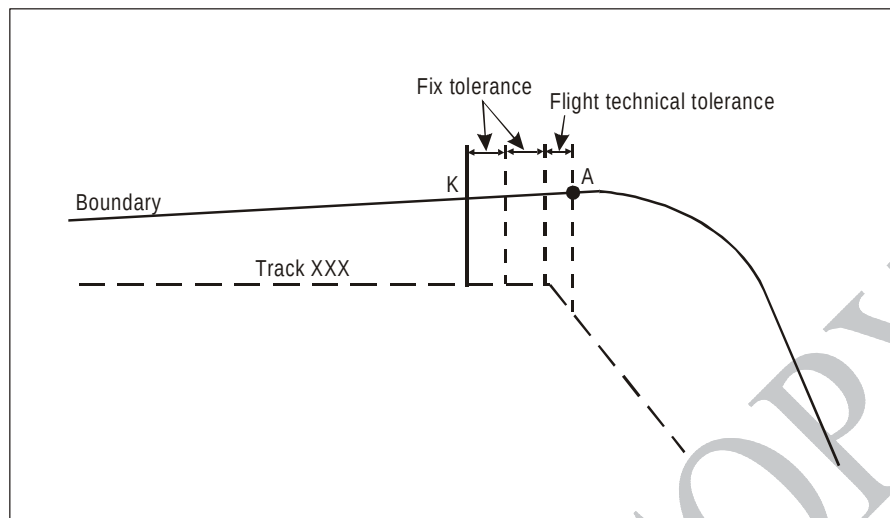


Figure I-2-3-1. Start of construction of outer boundary

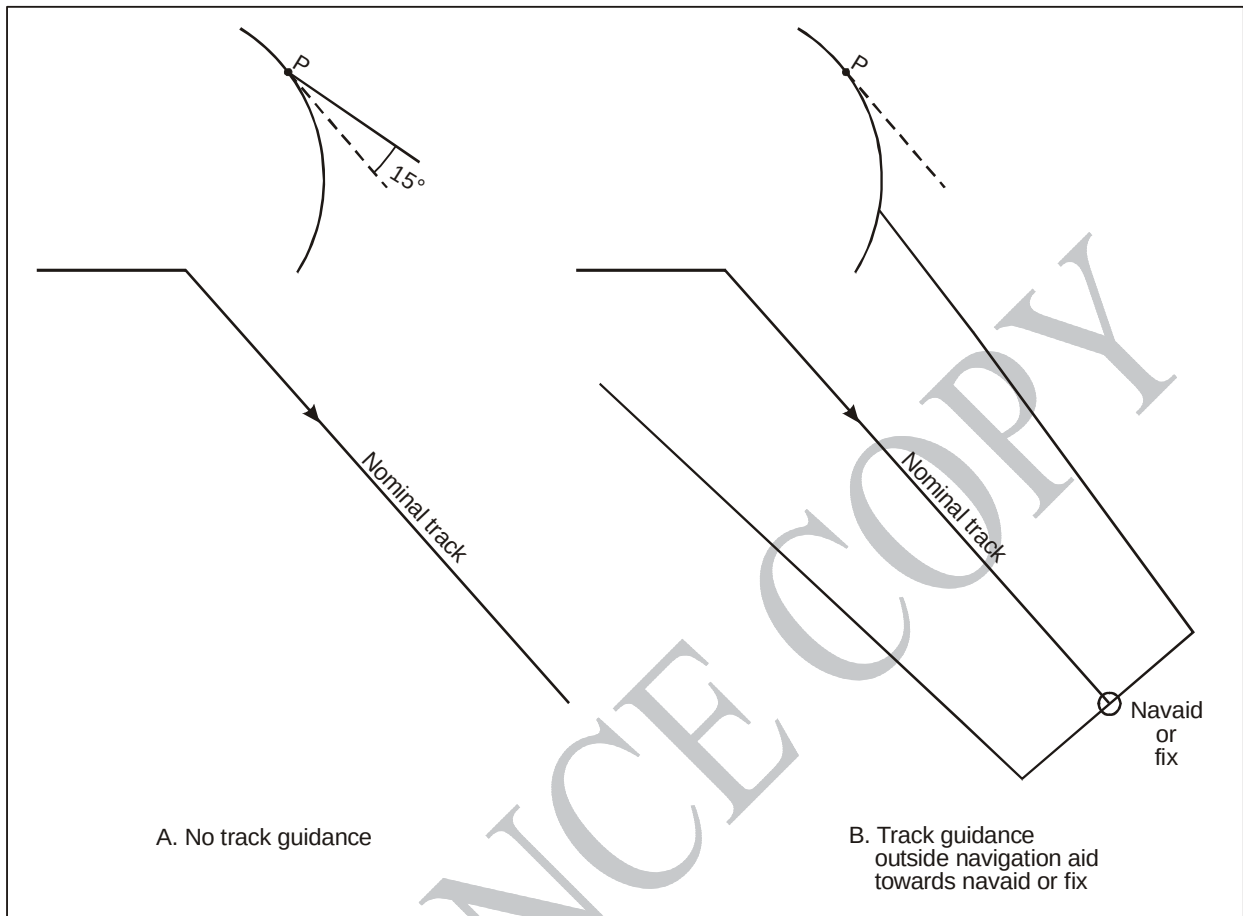
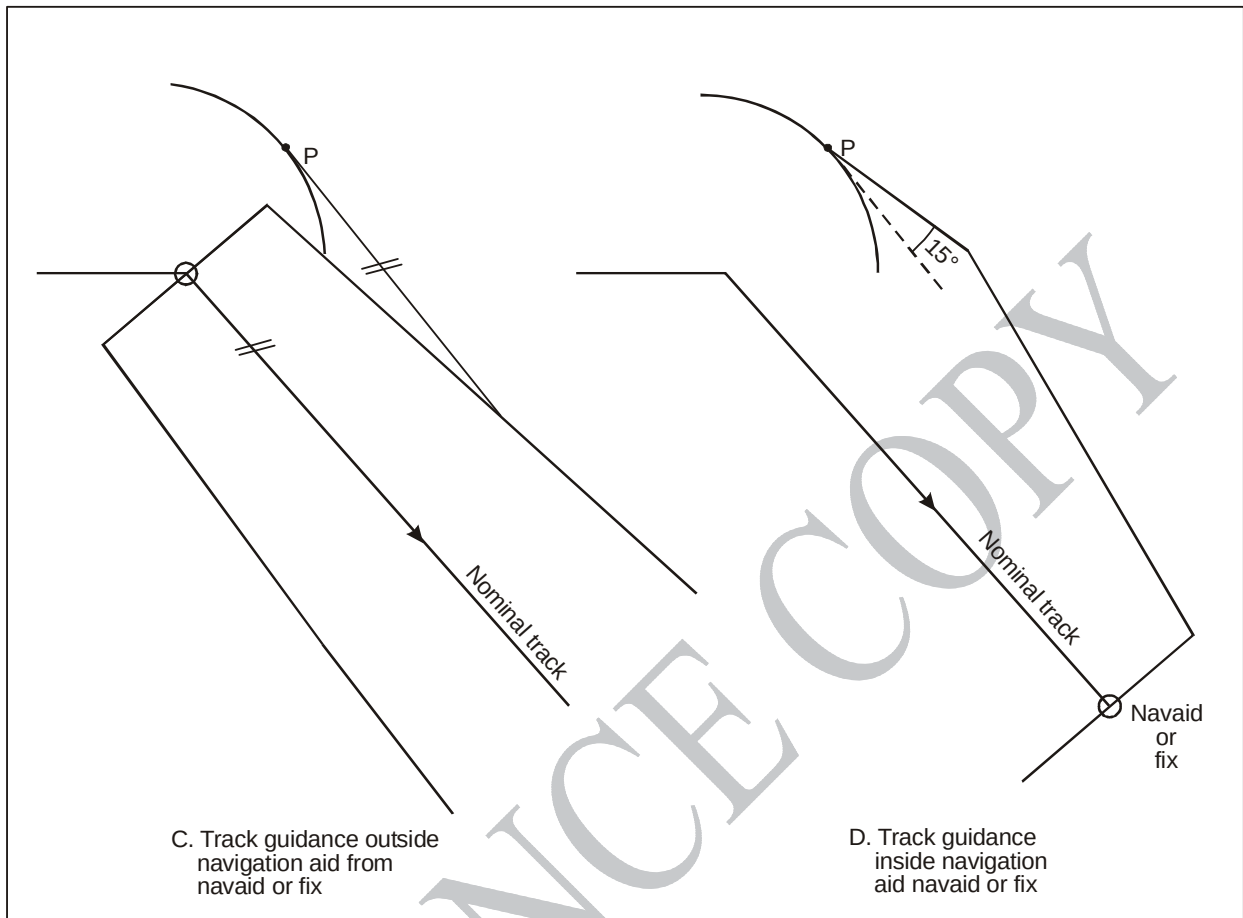


Figure I-2-3-2 A and B. Turn outer boundary construction after Point P



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

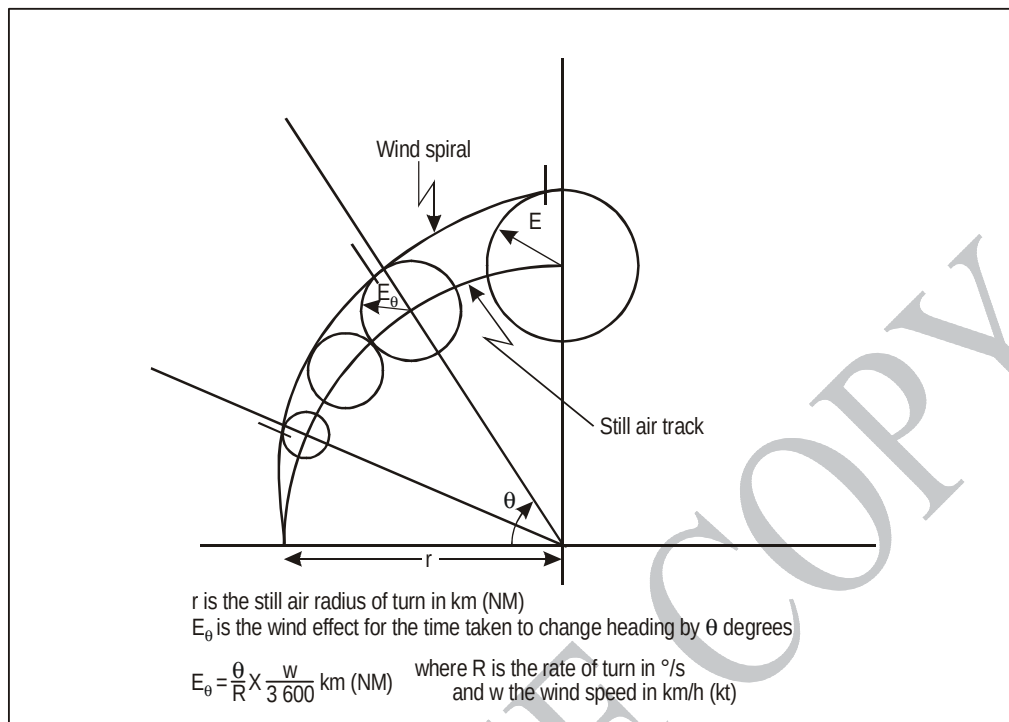


Figure I-2-3-3. Wind spiral

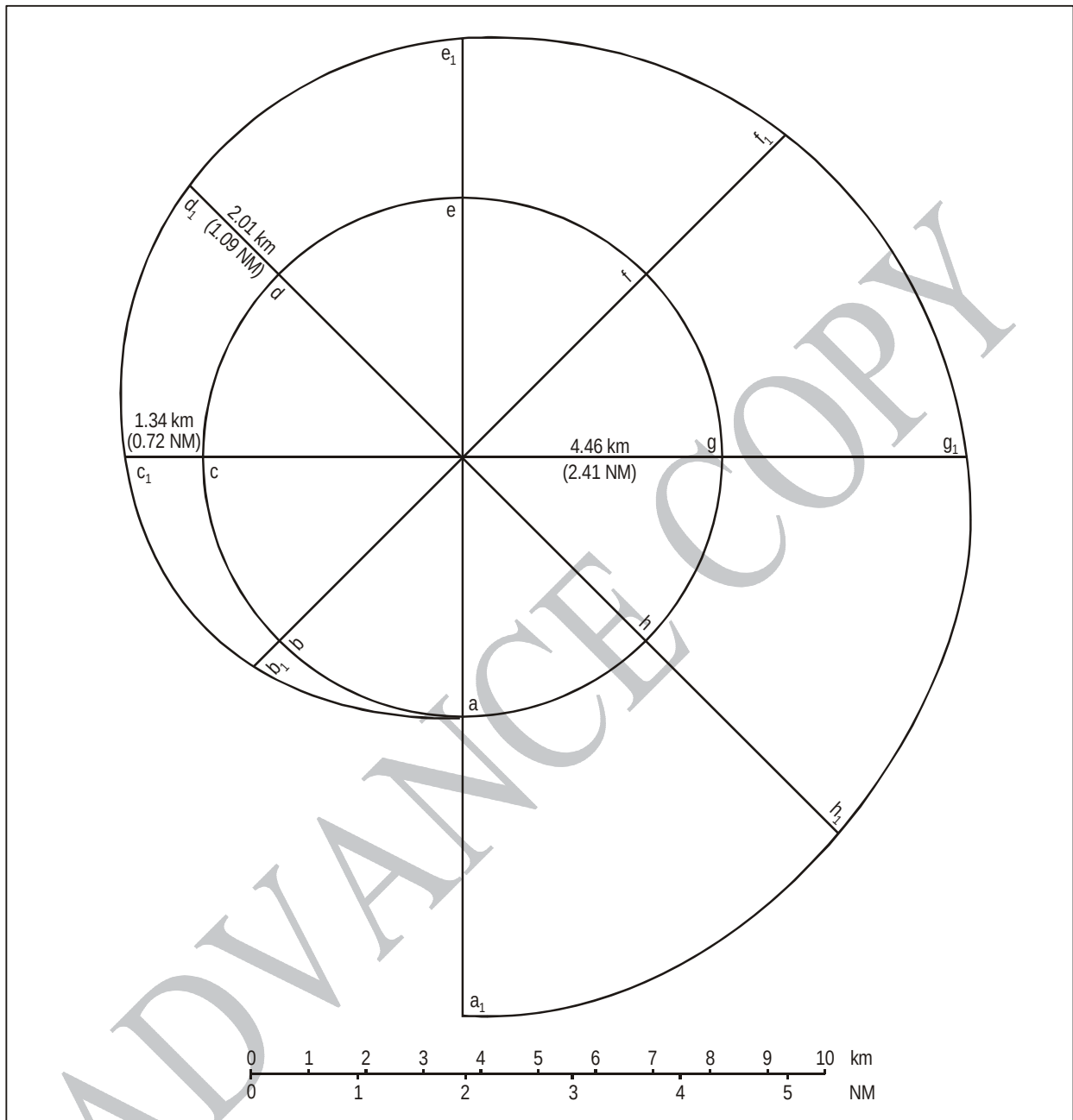


Figure I-2-3-4. Template for plotting omnidirectional wind (wind spiral)

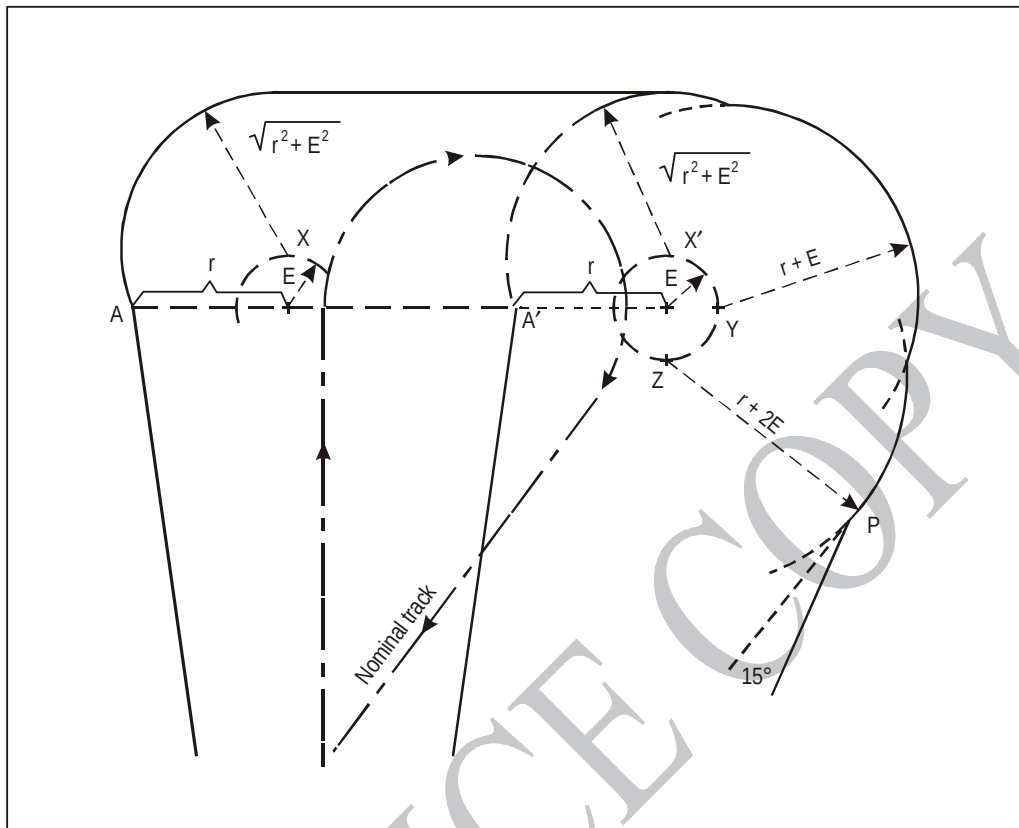


Figure I-2-3-5. Outer turn boundary construction

ADVANCE COPY

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.

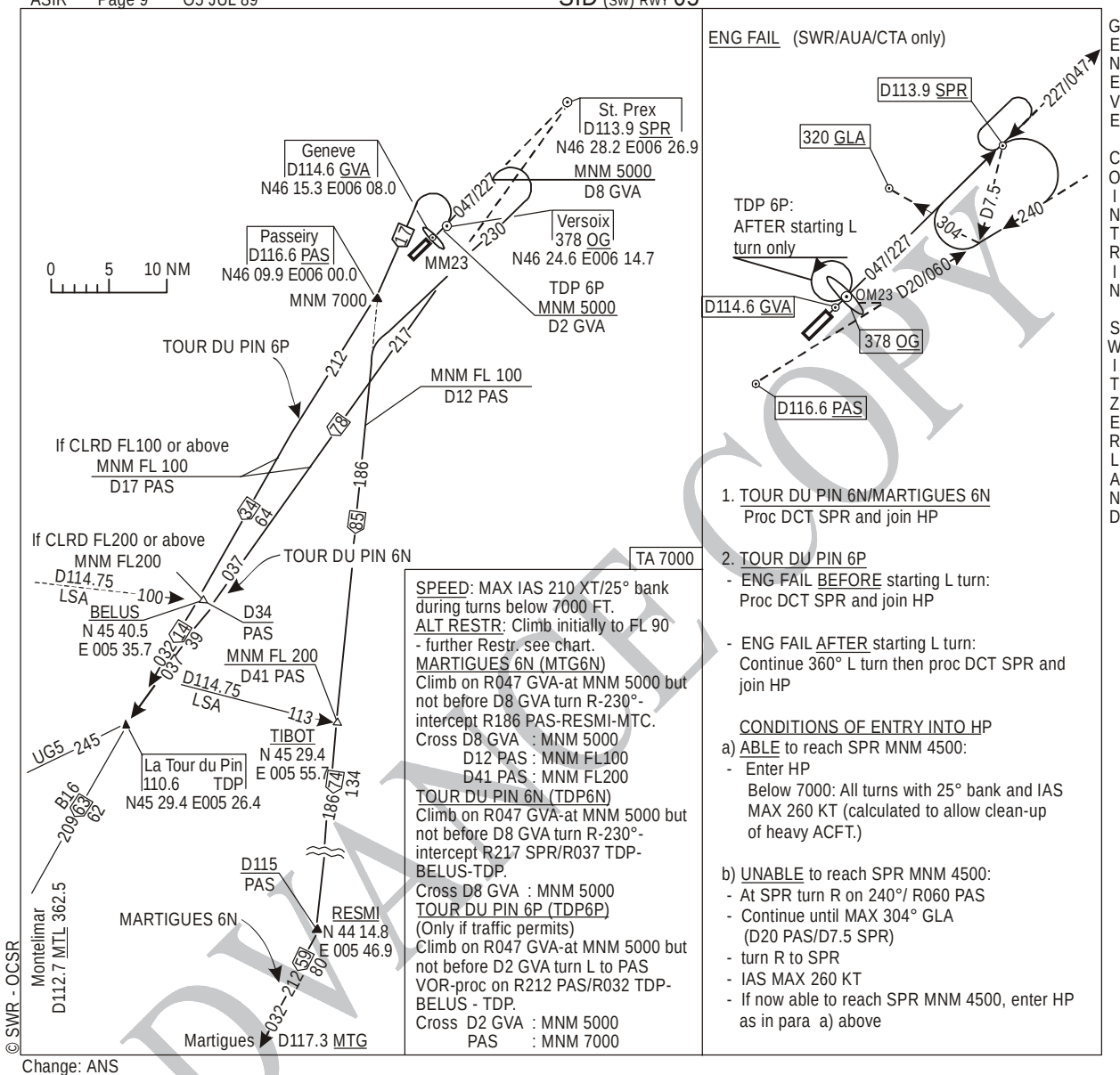


Figure I-3-1-1. Example of contingency routes in relation to departure routes

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.

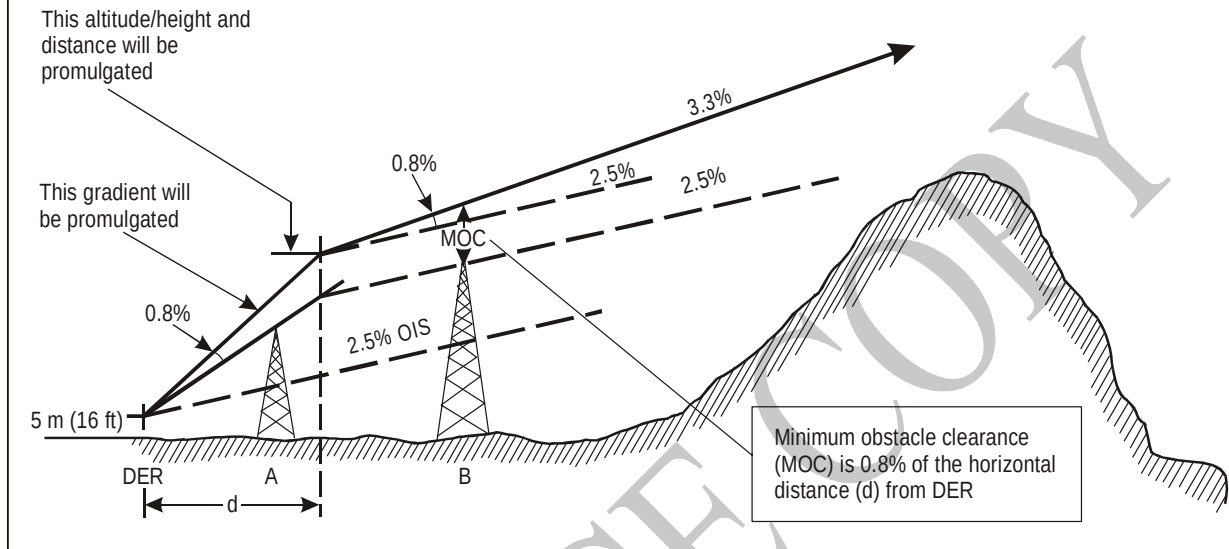


Figure I-3-1-2. Climb gradient reduction in departure

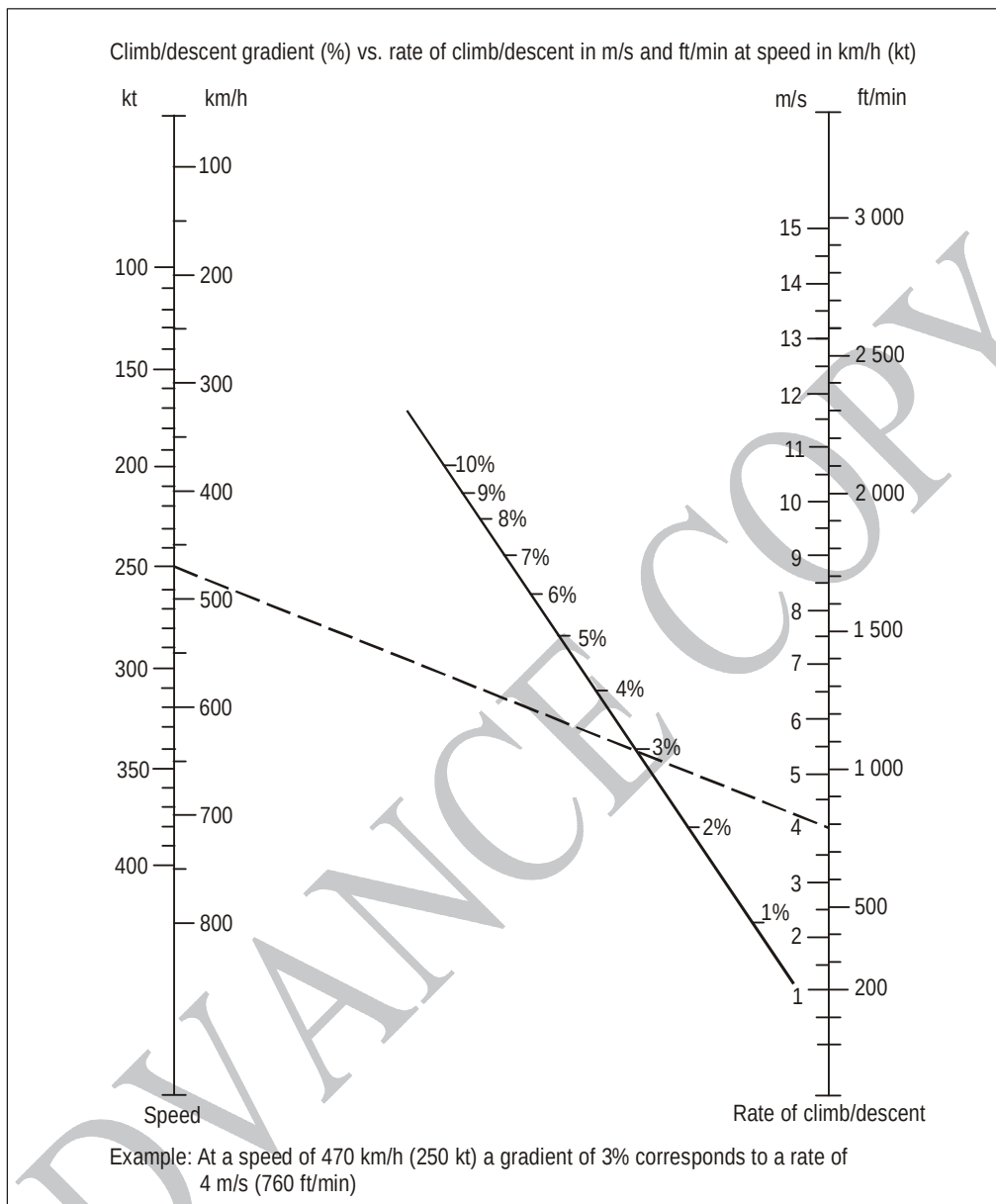


Figure I-3-1-3. Conversion nomogram

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).

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

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

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.

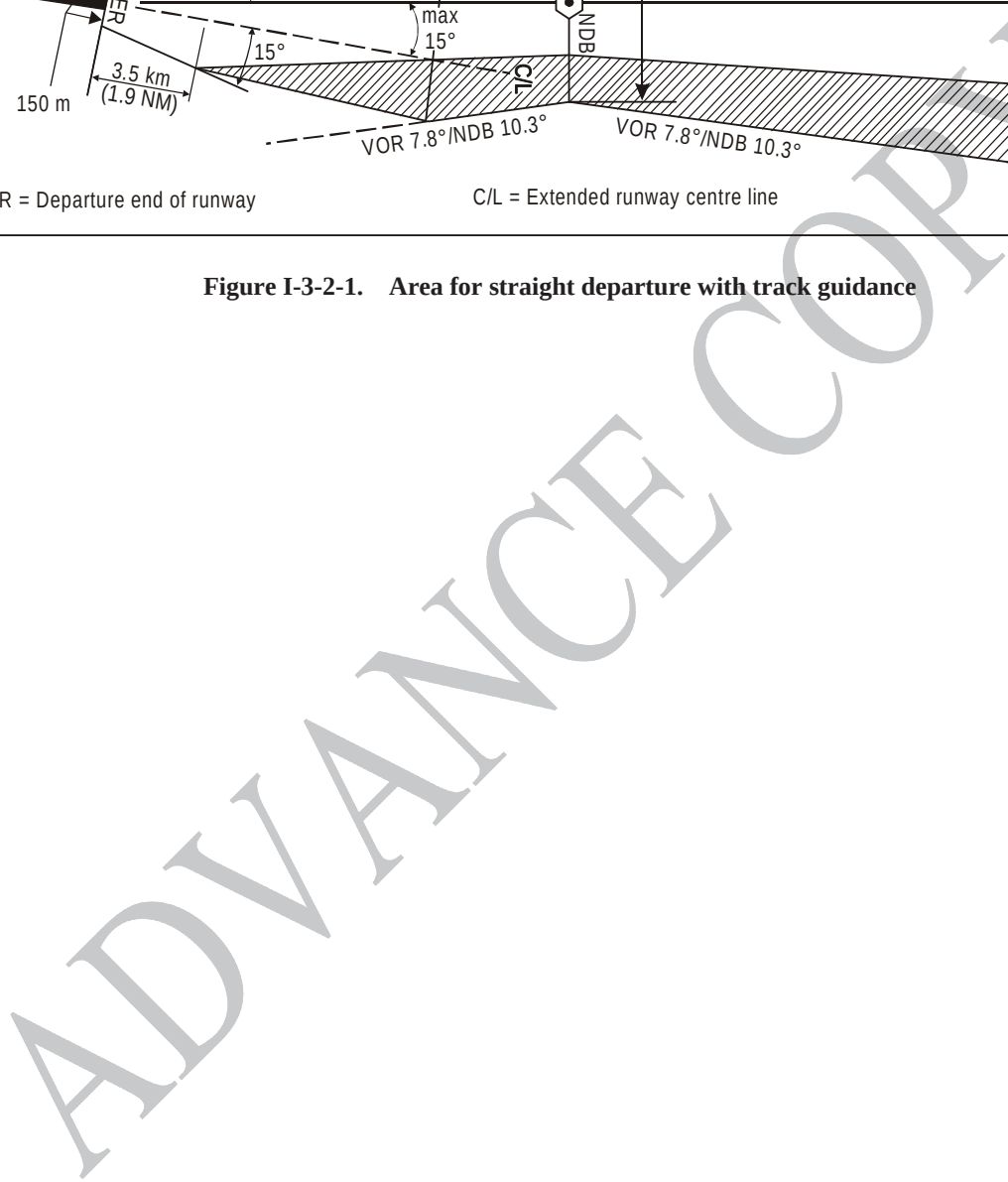


Figure I-3-2-1. Area for straight departure with track guidance

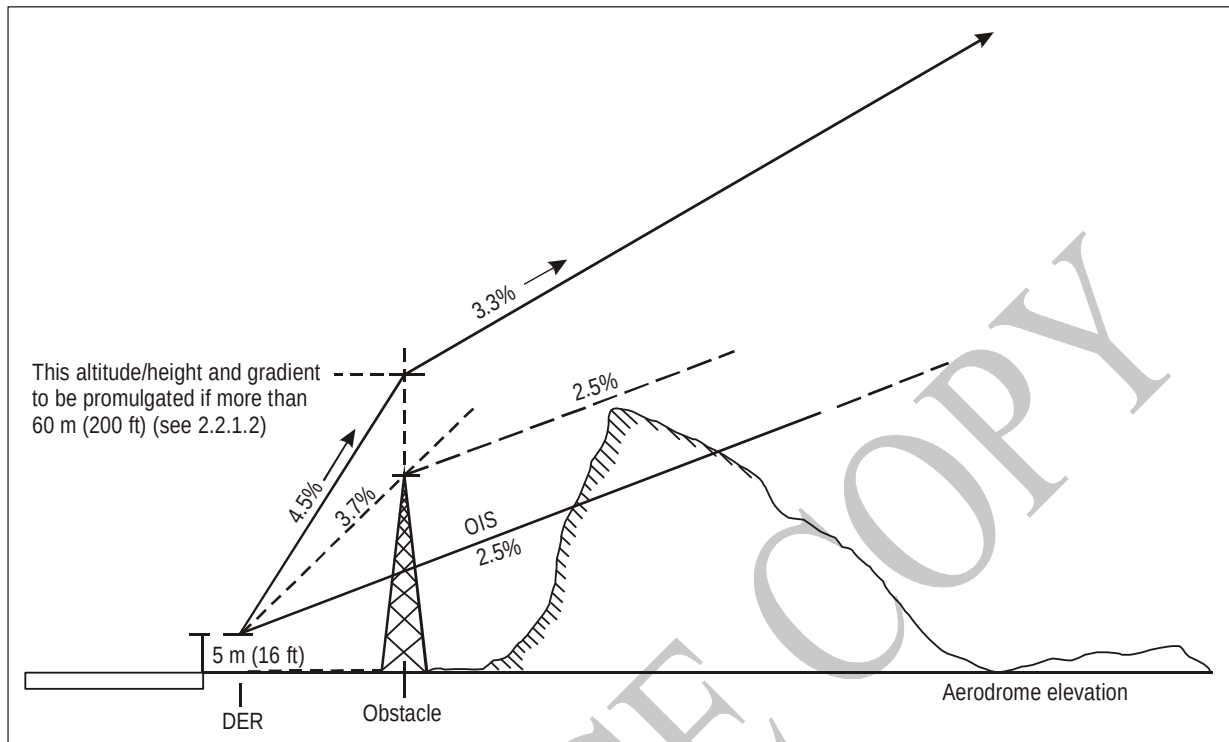


Figure I-3-2-2. Procedure design gradient

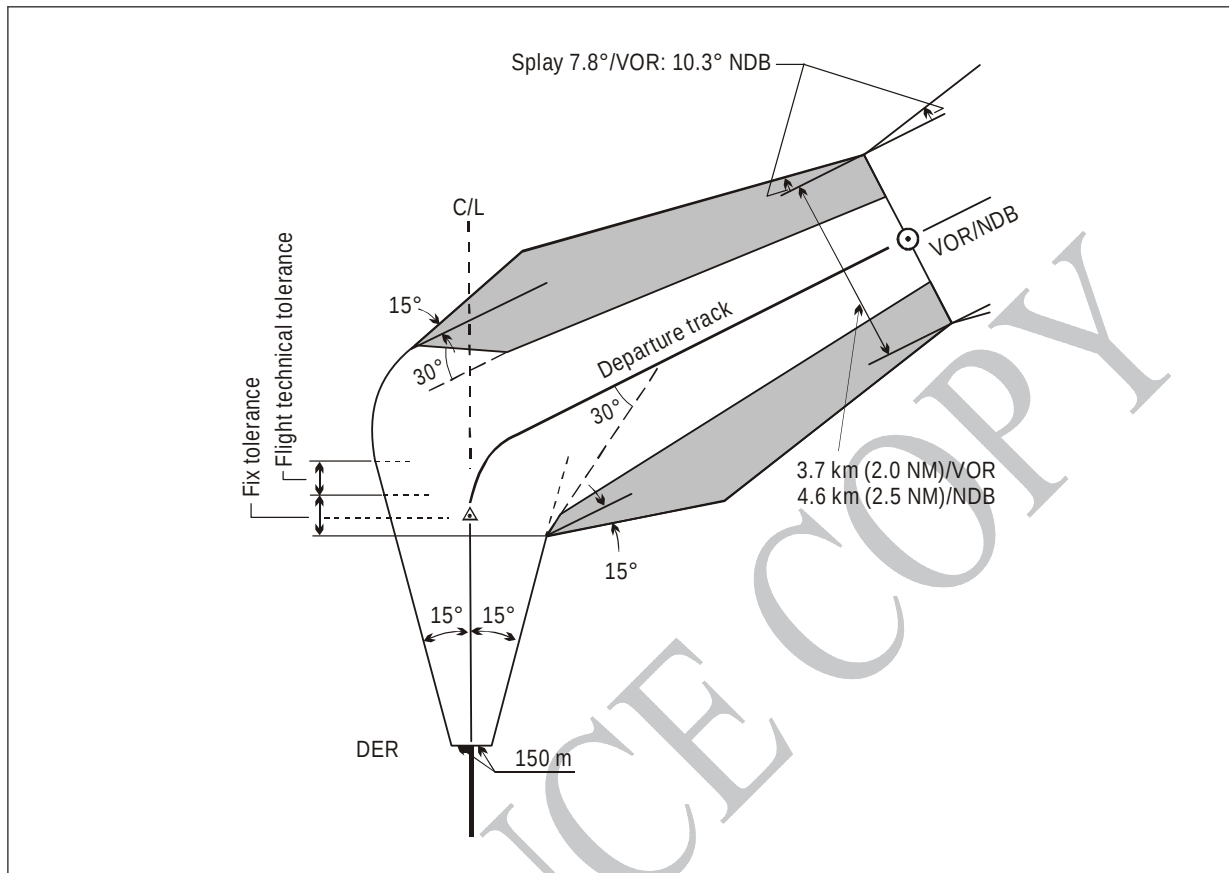


Figure I-3-2-3. Turning departure — turn at a fix

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°”).

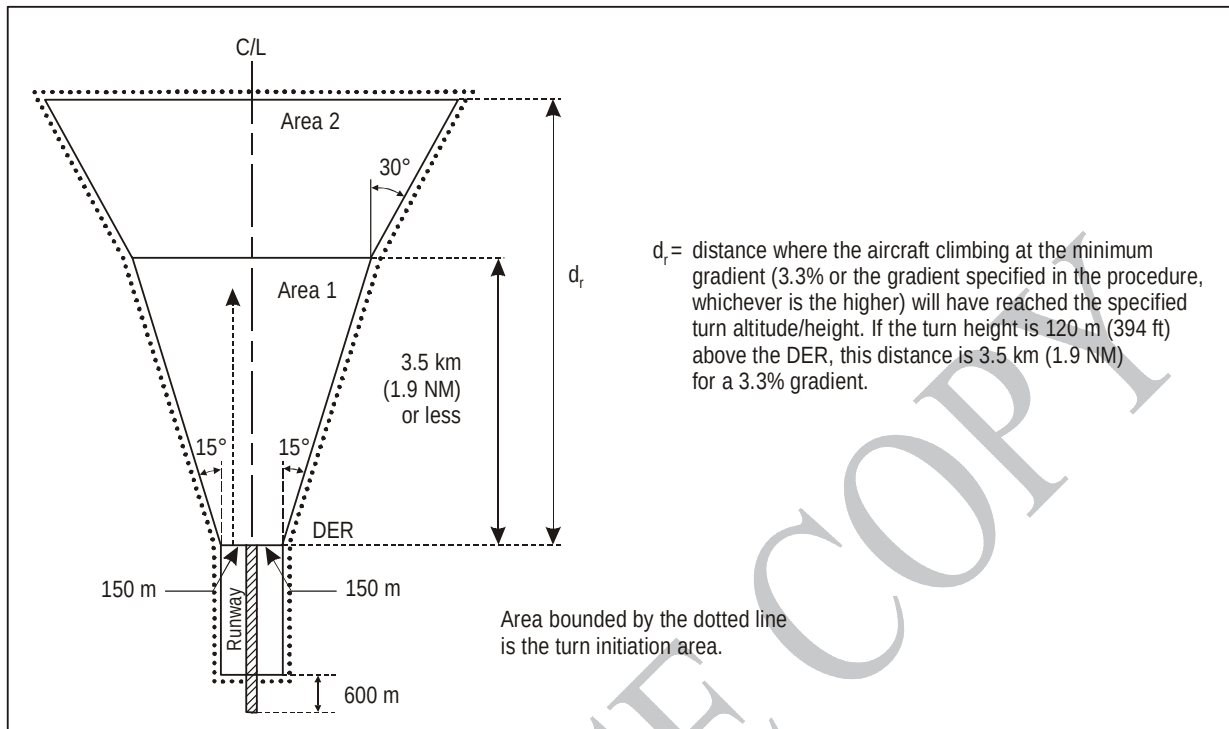


Figure I-3-3-1. Areas 1 and 2 and turn initiation area for omnidirectional departures

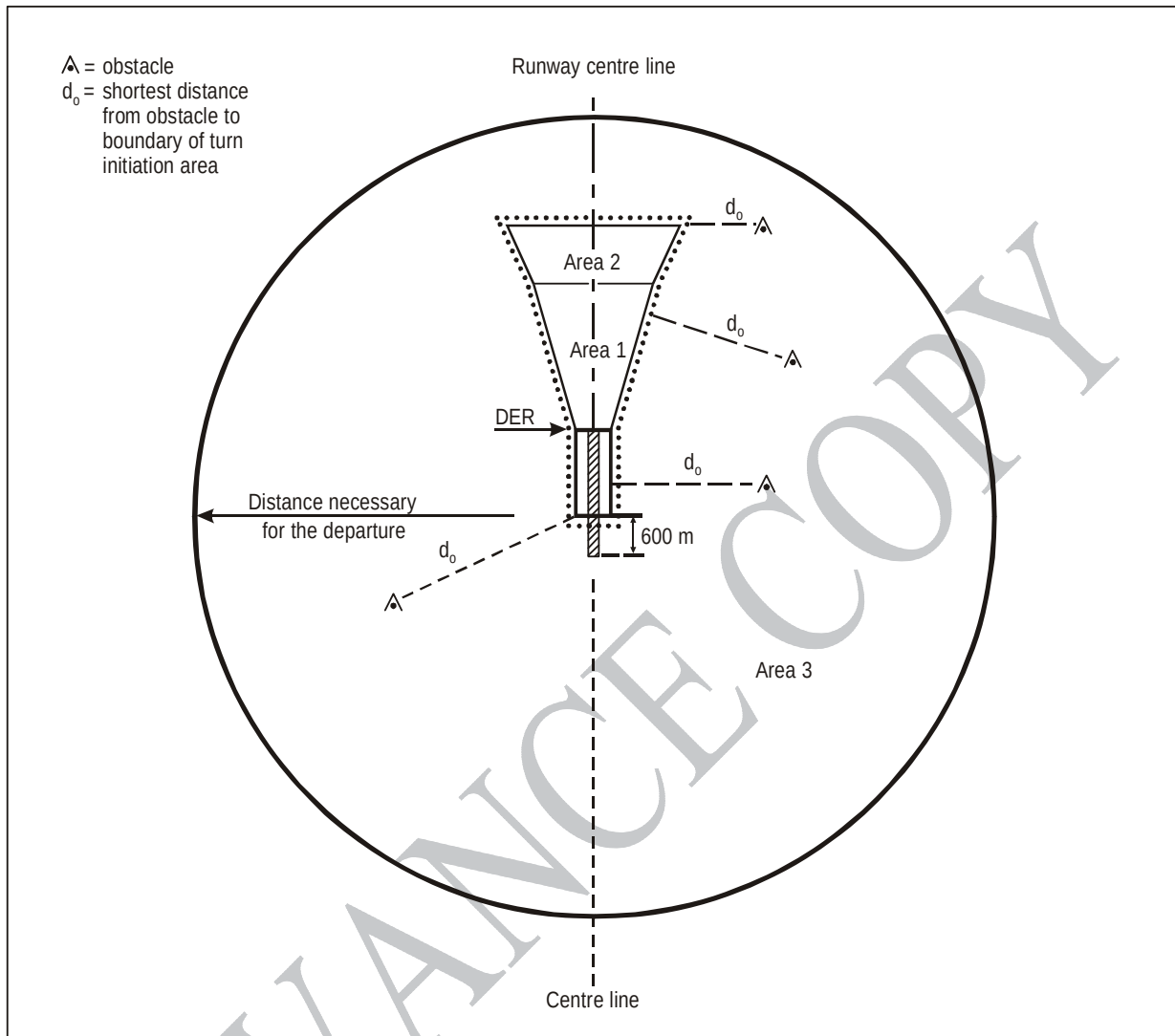


Figure I-3-3-2. Area 3 for omnidirectional departures

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.

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

Altitude/Flight Level “Window”	<u>17 000</u> <u>10 000</u>	<u>FL220</u> <u>10 000</u>
“At or Above” Altitude/Flight Level	<u>5 000</u>	<u>FL60</u>
“At or Below” Altitude/Flight Level	<u>5 000</u>	<u>FL210</u>
“Mandatory” Altitude/Flight Level	<u>3 000</u>	<u>FL50</u>
“Recommended” Procedure Altitude/Flight Level	5 000	FL50
“Expected” Altitude/Flight Level	Expect 5 000	Expect FL50

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:

- Significant obstacles which penetrate the OIS;
- 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;
- The highest obstacle in the departure area, and any significant obstacle outside the area which dictates the design of the procedure;
- A PDG greater than 3.3 per cent. When such a gradient is specified, the altitude/height to which it extends shall be promulgated;
- 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);
- Altitude/heights to be achieved during the departure when overheading significant points that can be identified by means of navigation facilities or fixes;
- 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.

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 V_{at} if approved by the State of the Operator. The category defined for a given aeroplane shall be a permanent value and thus independent of changing day-to-day operations.

1.3.7 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.

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 Table I-4-1-1 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”.

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.

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

<i>Aircraft categories</i>	<i>Rate of descent</i>	
	<i>Minimum</i>	<i>Maximum</i>
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)

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.

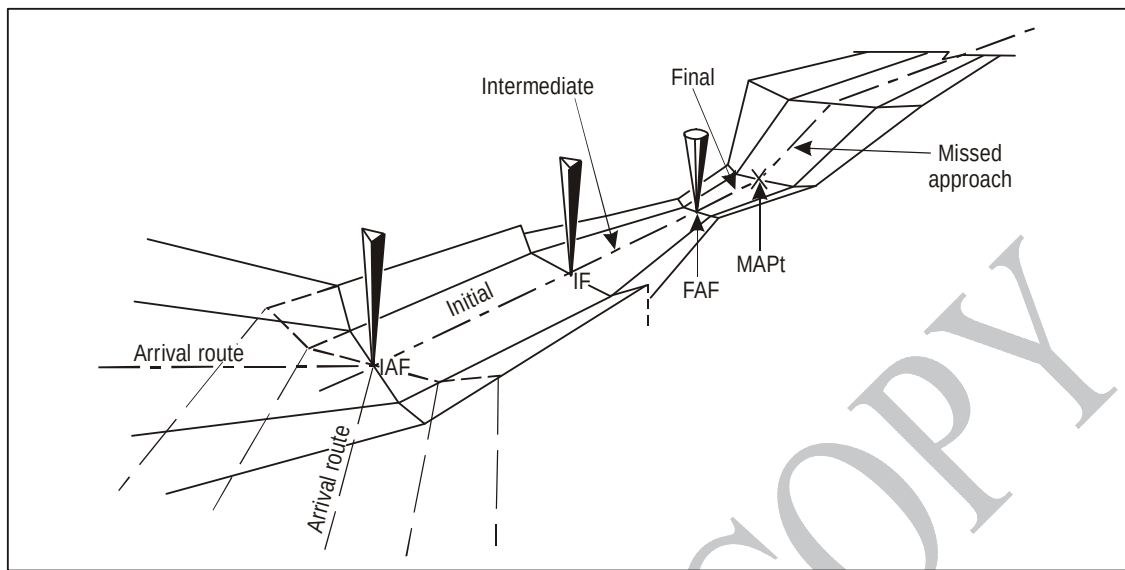


Figure I-4-1-1. Segments of instrument approach

PRECISION APPROACH

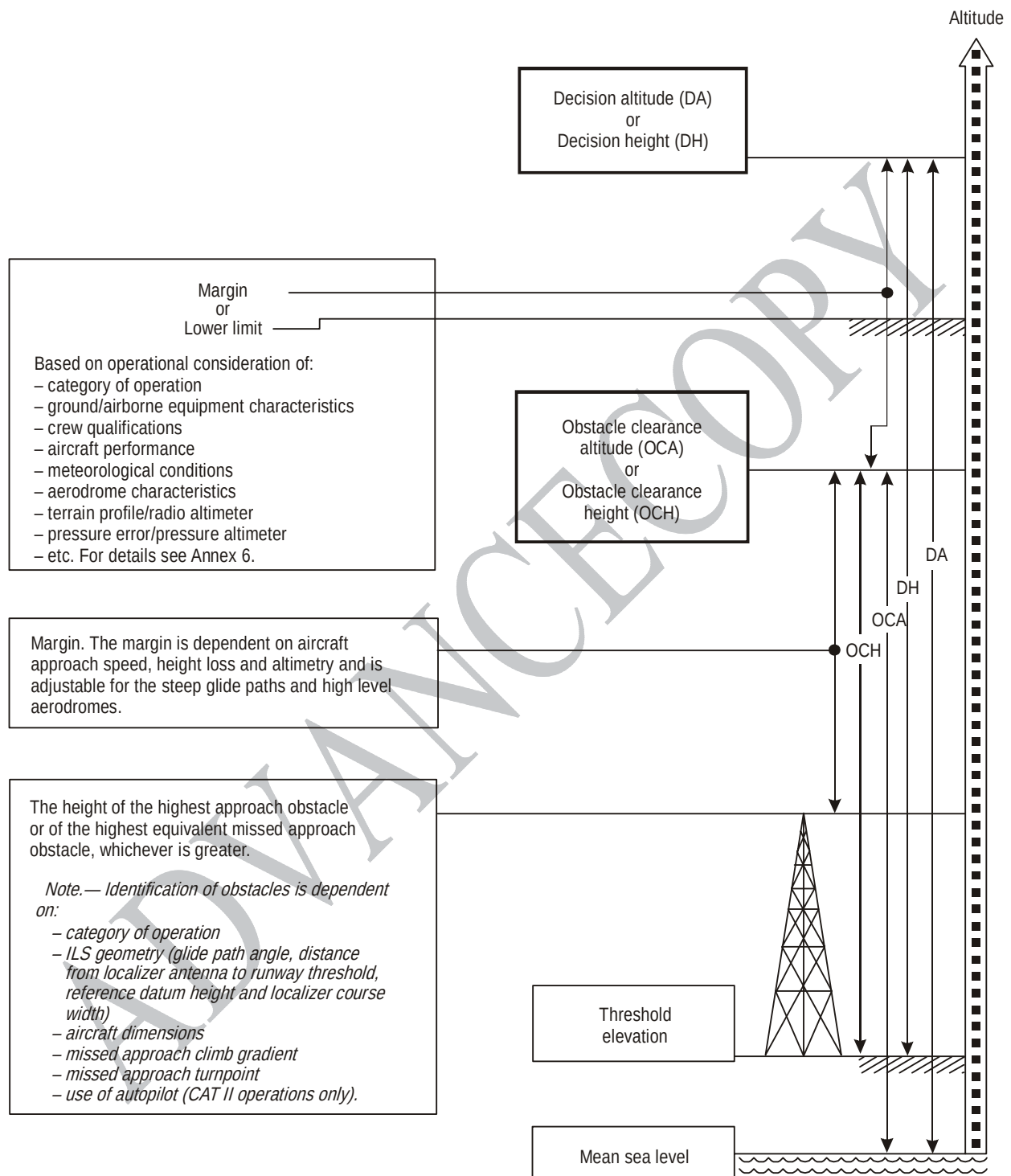


Figure I-4-1-2. Relationship of obstacle clearance altitude/height (OCA/H) to decision altitude/height (DA/H) for precision approaches

NON-PRECISION APPROACH

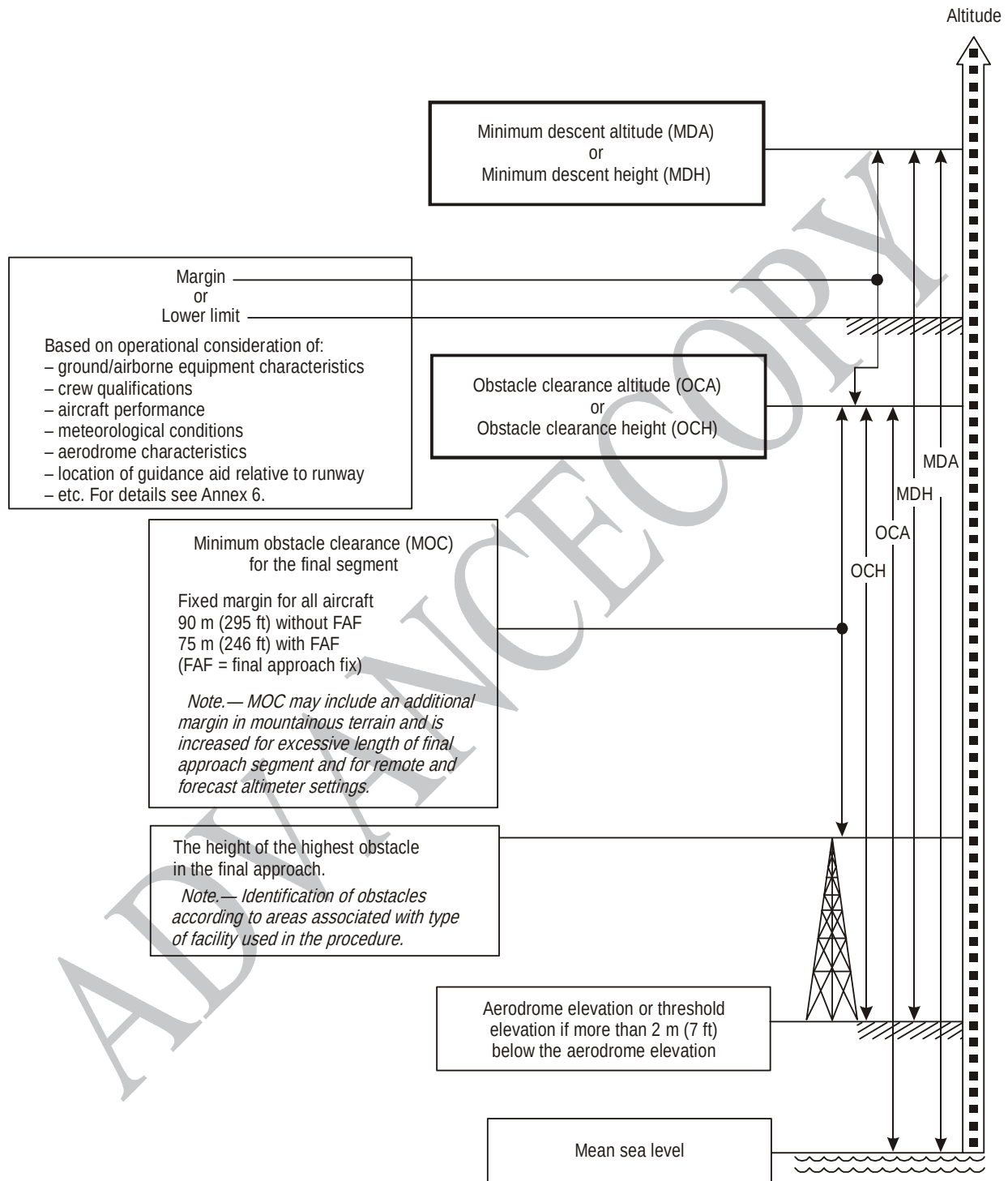


Figure I-4-1-3. Relationship of obstacle clearance altitude/height (OCA/H) to minimum descent altitude/height (MDA/H) for non-precision approaches (example with a controlling obstacle in the final approach)

VISUAL MANOEUVRING (CIRCLING)

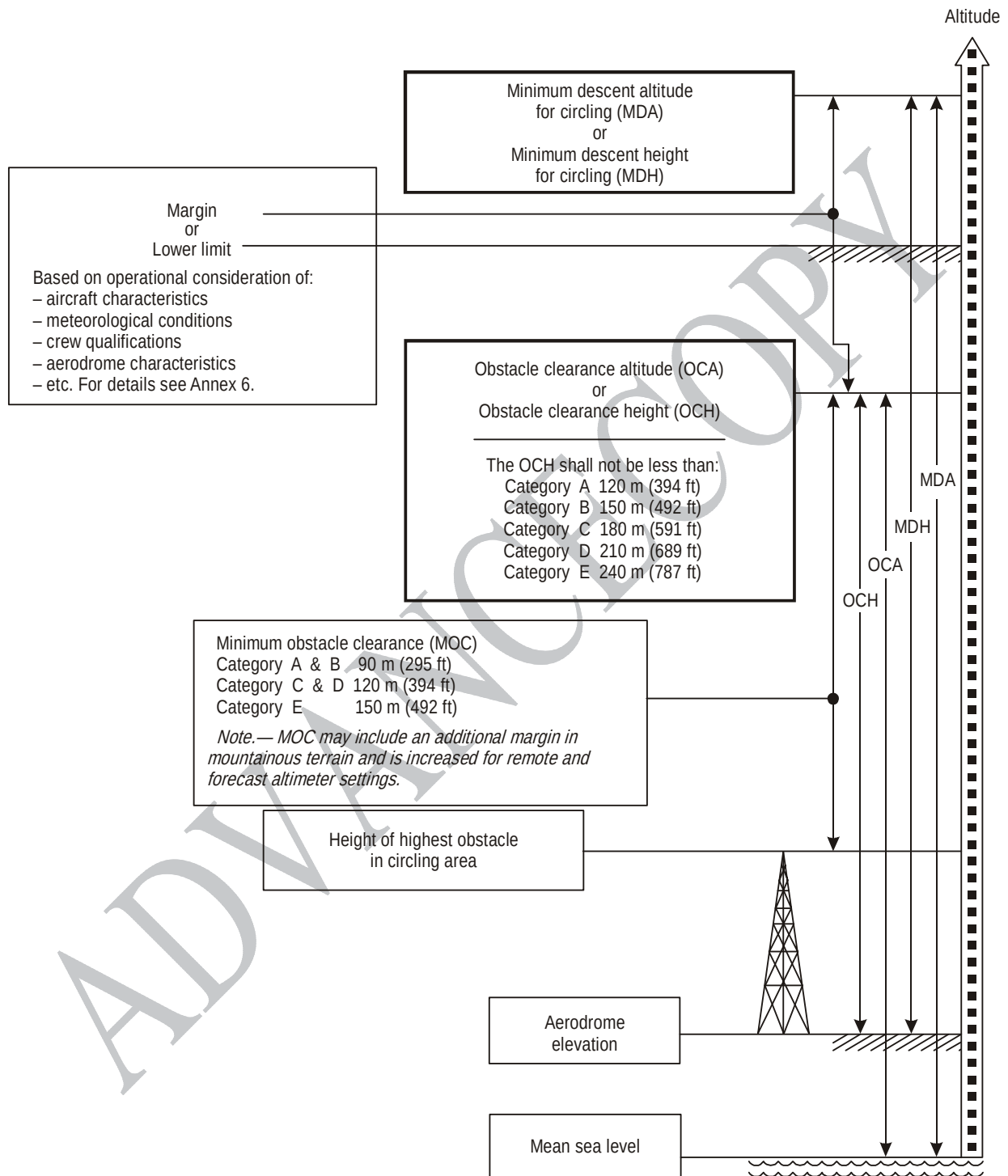


Figure I-4-1-4. Relationship of obstacle clearance altitude/height (OCA/H) to minimum descent altitude/height (MDA/H) for visual manoeuvring (circling)

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:

- a straight leg with track guidance. This straight leg may be timed or may be limited by a radial or DME distance;
- a 45° turn;
- a straight leg without track guidance. This straight leg is timed. It is:
 - 1 minute from the start of the turn for Category A and B aircraft; and
 - 1 minute 15 seconds from the start of the turn for Category C, D and E aircraft; and
- 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:

- a straight leg with track guidance. This straight leg may be timed or may be limited by a radial or DME distance;
- an 80° turn;
- 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:

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

- 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 $\pm 30^\circ$ of the outbound track of the reversal procedure. However, for base turns, where the $\pm 30^\circ$ 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 $3^\circ/\text{second}$, 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 $\pm 5^\circ$ 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.

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

<i>Outbound track</i>	<i>Maximum*</i>	<i>Minimum*</i>
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
<i>Inbound track</i>	<i>Maximum*</i>	<i>Minimum*</i>
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).

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.

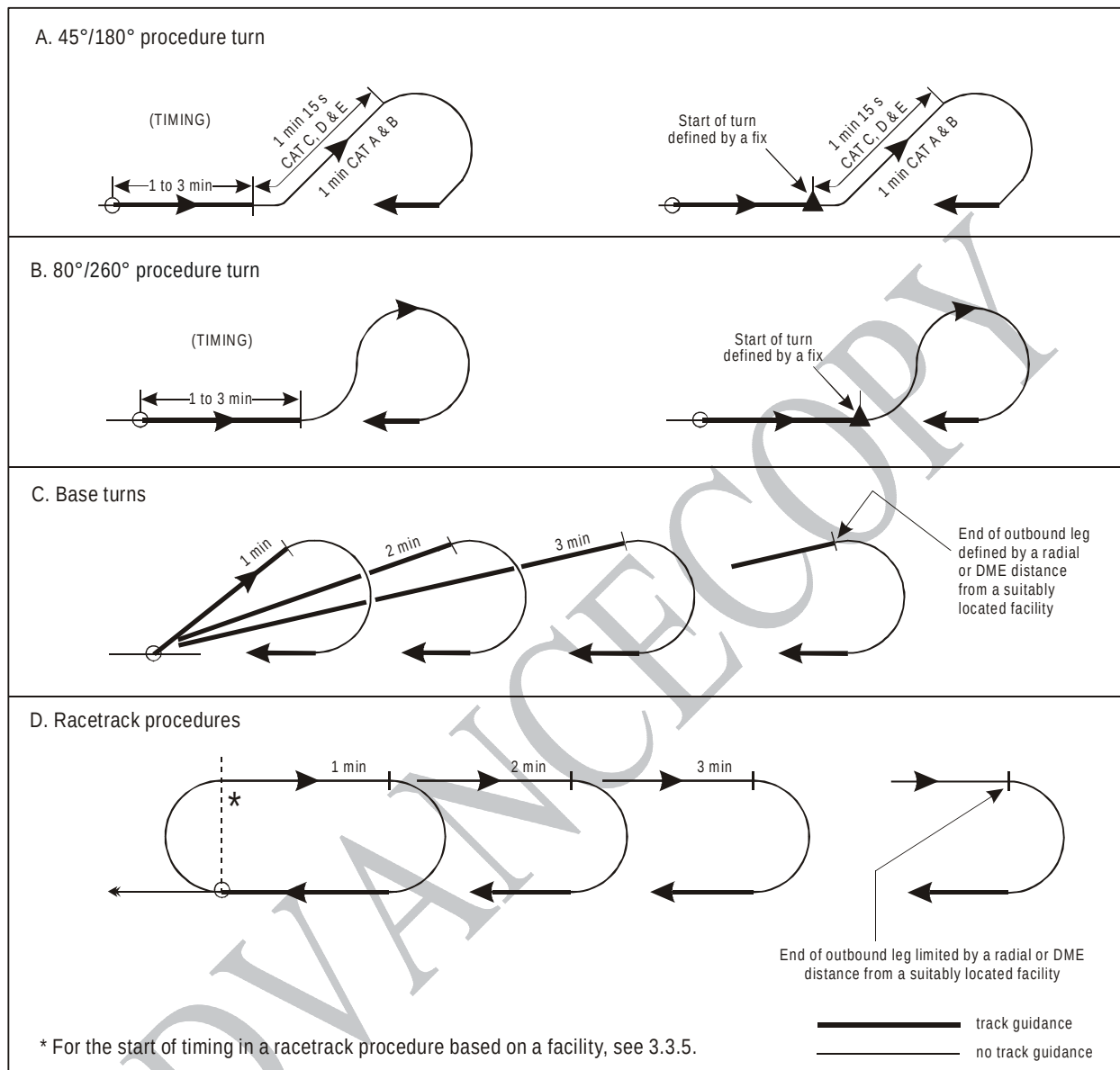
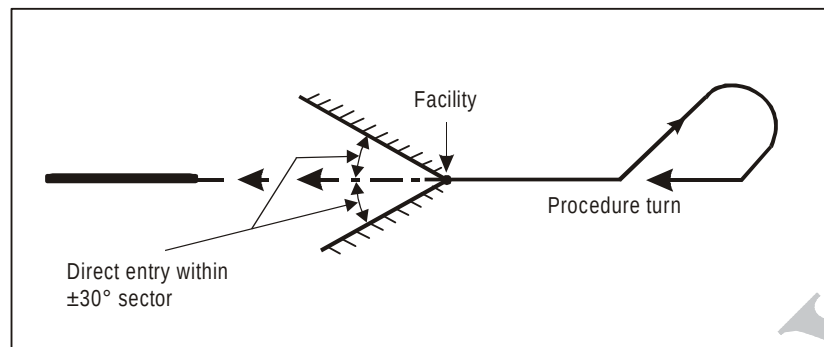
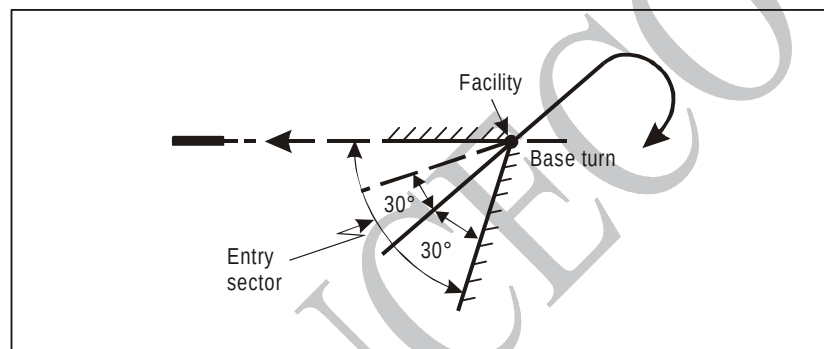


Figure I-4-3-1. Types of reversal and racetrack procedures

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

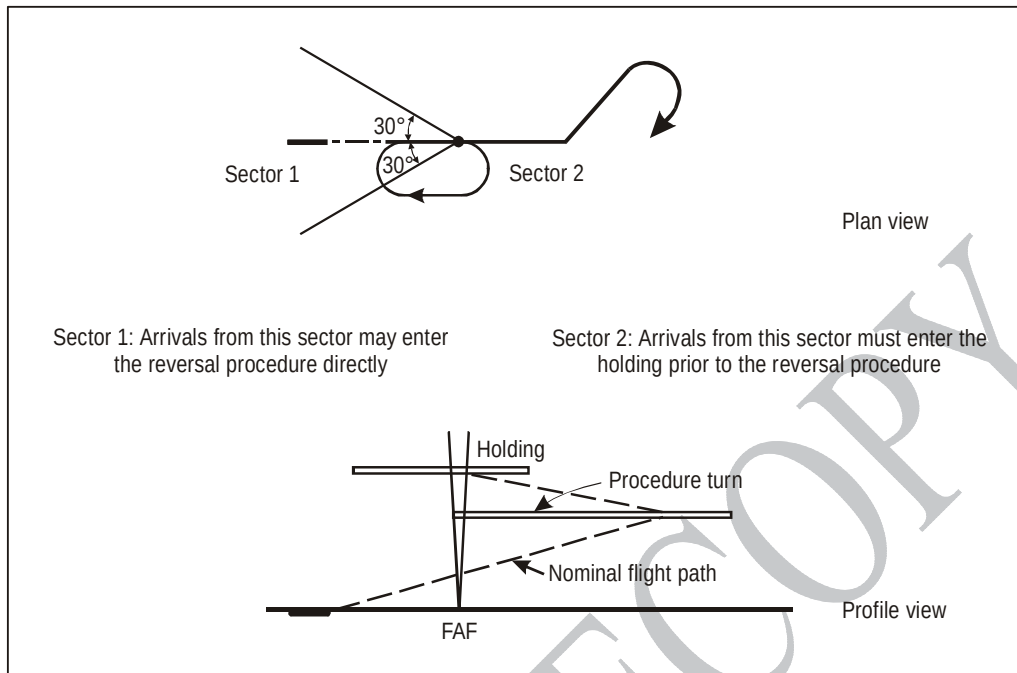


Figure I-4-3-4. Example of omnidirectional arrival using a holding procedure in association with a reversal procedure

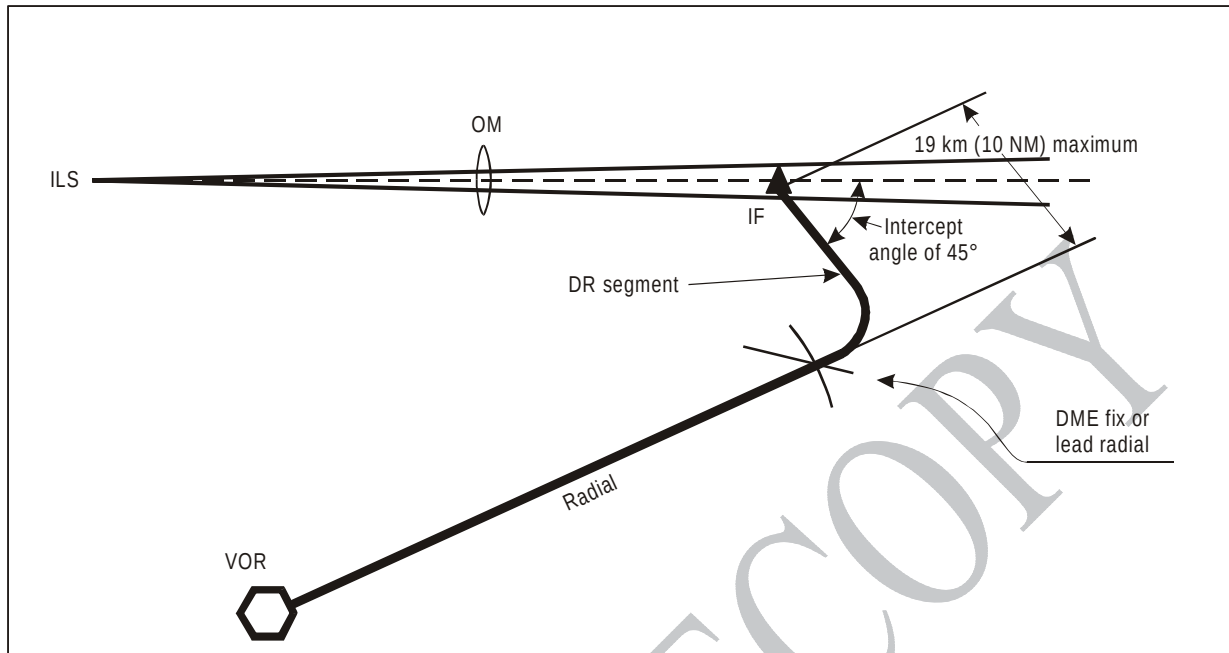


Figure I-4-3-5. Dead reckoning segment

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.

Table I-4-5-1. Aircraft dimensions

<i>Aircraft category</i>	<i>Wing span (m)</i>	<i>Vertical distance between the flight paths of the wheels and the GP antenna (m)</i>
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.

5.5.2.2 **ILS:**

- Category I flown with pressure altimeter;
- Category II flown with radio altimeter and flight director;
- 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.

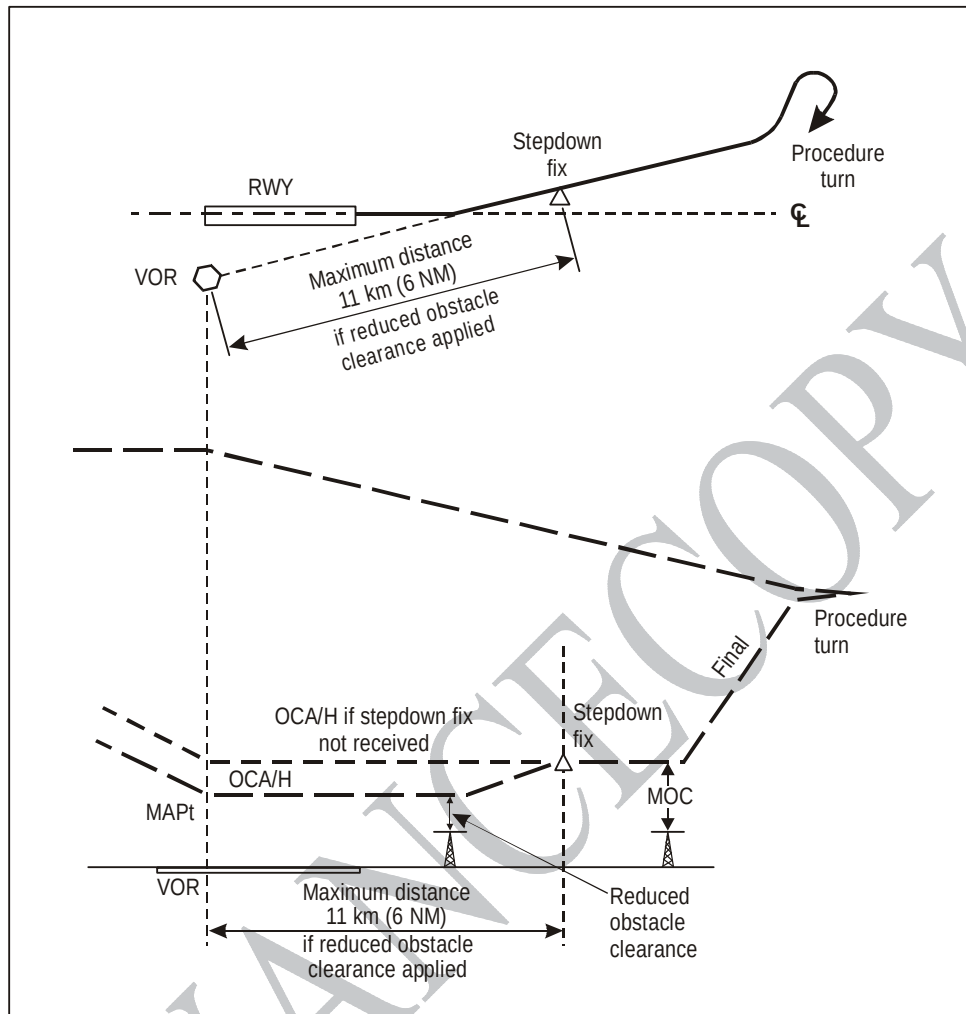
5.5.7 Unless otherwise noted on the instrument approach chart, the nominal missed approach climb gradient is 2.5 per cent.

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

<i>Aircraft category (V_{at})</i>	<i>Margin using radio altimeter</i>		<i>Margin using pressure altimeter</i>	
	<i>Metres</i>	<i>Feet</i>	<i>Metres</i>	<i>Feet</i>
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.

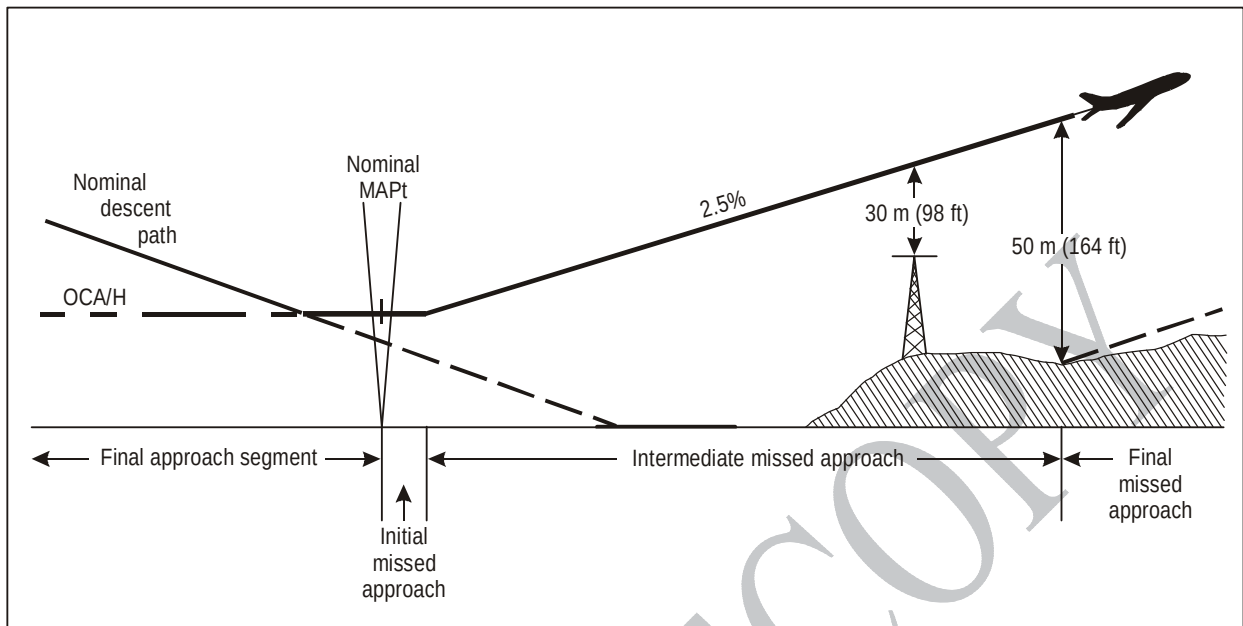


Figure I-4-6-1. Missed approach phases

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)

<i>Category of aircraft/IAS (km/h)</i>	<i>A/185</i>	<i>B/250</i>	<i>C/335</i>	<i>D/380</i>	<i>E/445</i>
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)

<i>Category of aircraft/IAS (kt)</i>	<i>A/100</i>	<i>B/135</i>	<i>C/180</i>	<i>D/205</i>	<i>E/240</i>
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

<i>Aircraft category</i>	<i>Obstacle clearance m (ft)</i>	<i>Lowest OCH above aerodrome elevation m (ft)</i>	<i>Minimum visibility km (NM)</i>
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

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

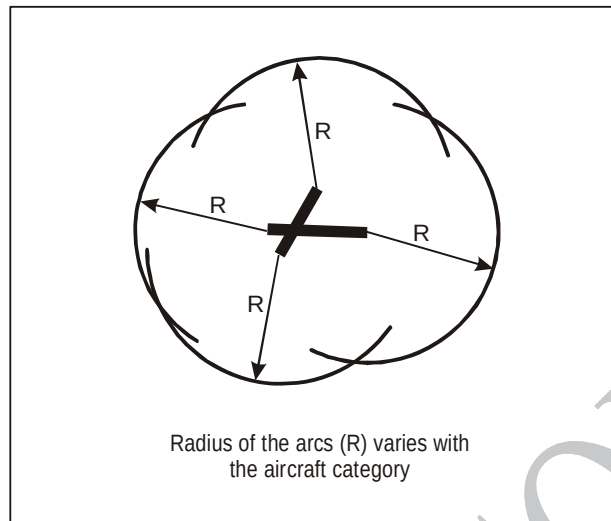


Figure I-4-7-1. Visual manoeuvring (circling approach) area

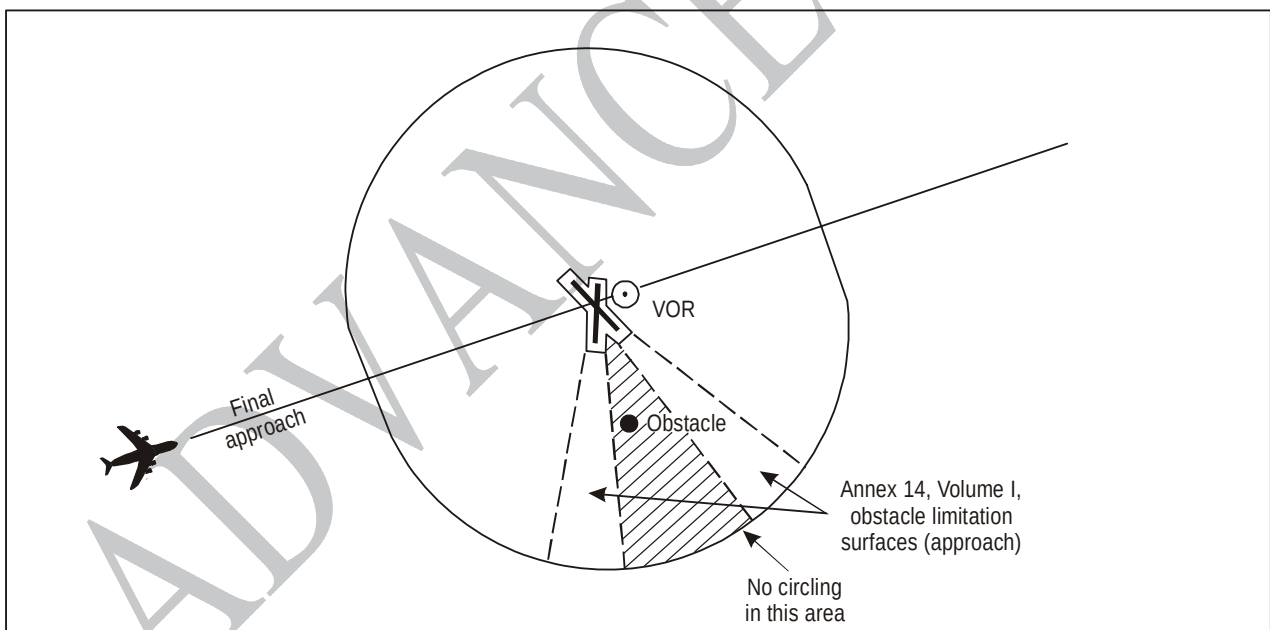


Figure I-4-7-2. Visual manoeuvring (circling) area — prohibition on circling

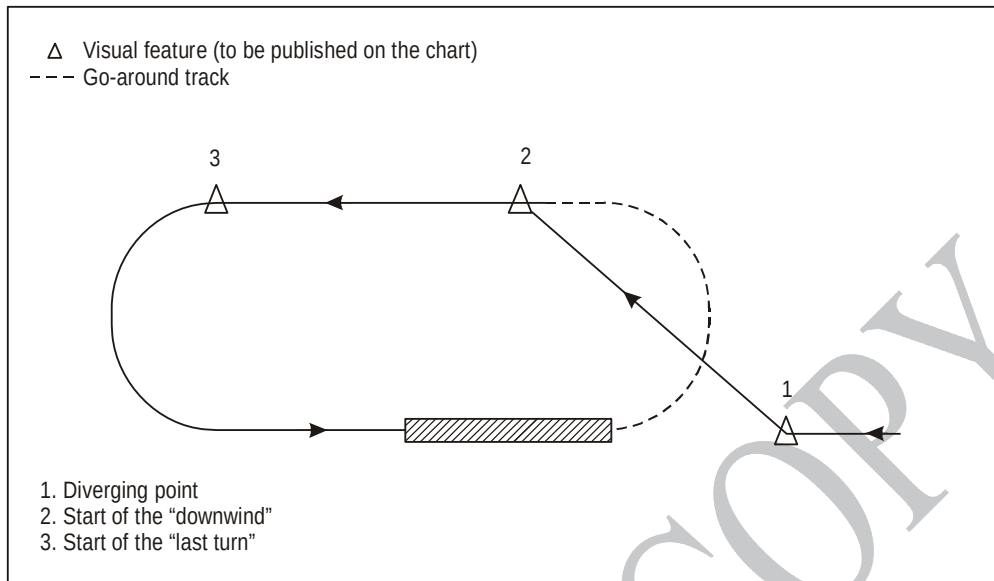


Figure I-4-7-3. Standard track general case

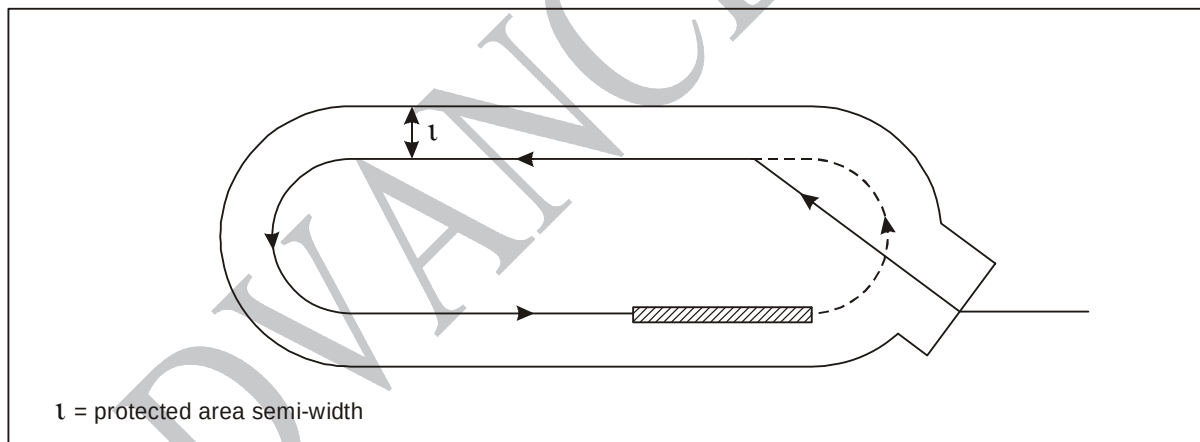


Figure I-4-7-4. Area

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 1-4-8-1.)

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

Altitude/Flight Level “Window”	<u>17 000</u> <u>10 000</u>	<u>FL220</u> <u>10 000</u>
“At or Above” Altitude/Flight Level	<u>7 000</u>	<u>FL60</u>
“At or Below” Altitude/Flight Level	<u>5 000</u>	<u>FL50</u>
“Mandatory” Altitude/Flight Level	<u>3 000</u>	<u>FL30</u>
“Recommended” Procedure Altitude/Flight Level	5 000	FL50
“Expected” Altitude/Flight Level	Expect 5 000	Expect FL50

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)

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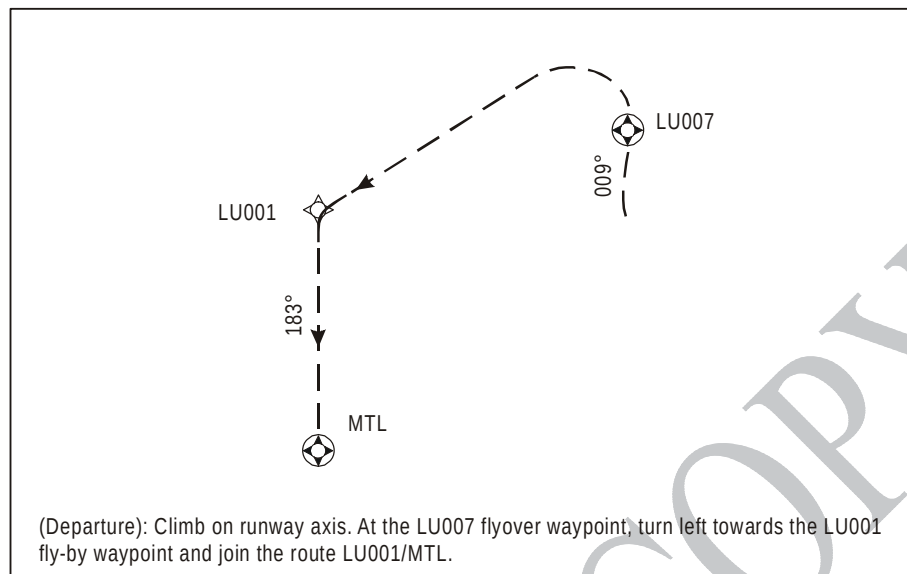
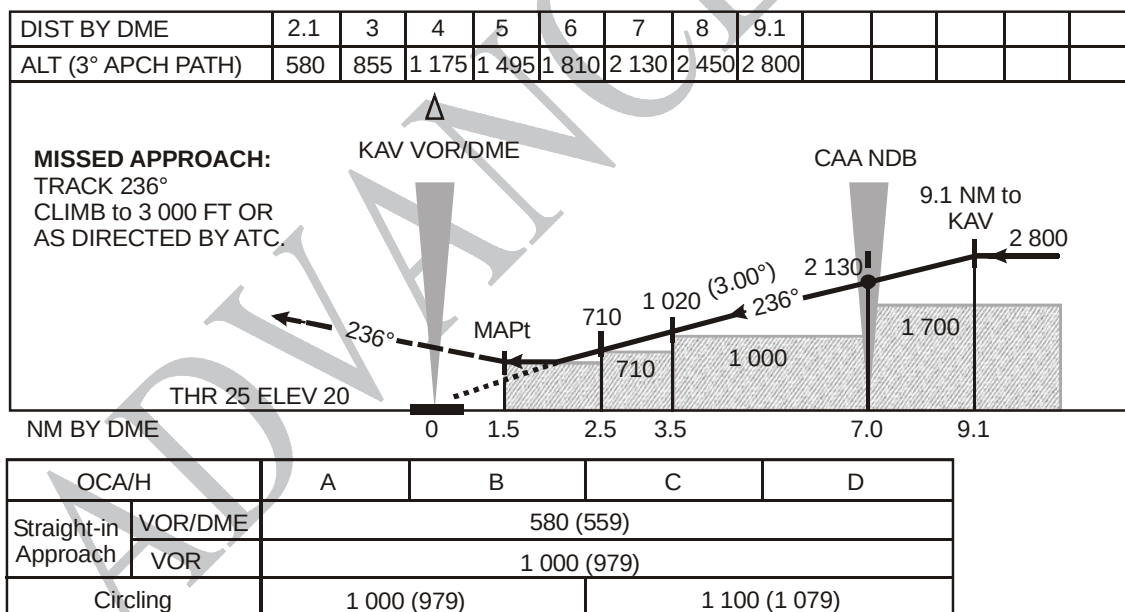


Figure I-4-8-1. Text description

DATE OF AERONAUTICAL
INFORMATION

PRODUCING ORGANIZATION

RWY 25VOR

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

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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:

<i>Variation in terrain elevation</i>	<i>MOC</i>
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.

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Section 6

HOLDING PROCEDURES

Chapter 1

HOLDING CRITERIA

1.1 GENERAL

1.1.1 To ensure that aircraft remain in the protecting holding areas, pilots shall use established error check procedures to reduce the effects of operating errors, data errors or equipment malfunction.

1.1.2 Guidance on parameters relating to holding areas for supersonic transport (SST) aeroplanes is contained in the “Statement of Operational Requirements” in *Guidance Material on SST Aircraft Operations* (Circular 126).

1.1.3 The procedures described in this chapter are related to right turn holding patterns. For left turn holding patterns, the corresponding entry and holding procedures are symmetrical with respect to the inbound holding track.

1.2 SHAPE AND TERMINOLOGY ASSOCIATED WITH HOLDING PATTERN

The shape and terminology associated with the holding pattern are given in Figure I-6-1-1.

Note.— For helicopter holding procedures, the buffer area is 3.7 km (2 NM) wide and only applies below 1 830 m (6 000 ft).

1.3 SPEEDS, RATE OF TURN, TIMING, DISTANCE AND LIMITING RADIAL

1.3.1 Speeds

Holding patterns shall be entered and flown at or below the airspeeds given in Tables I-6-1-1 and I-6-1-2.

Note.— The speeds given in Tables I-6-1-1 and I-6-1-2 are rounded to the nearest multiple of five for operational reasons. From the standpoint of operational safety, these speeds are considered to be equivalent to the unrounded originals.

1.3.2 Bank angle/rate of turn

All turns are to be made at a bank angle of 25° or at a rate of 3° per second, whichever requires the lesser bank.

1.3.3 Allowance for known wind

All procedures depict tracks. Pilots should attempt to maintain the track by making allowance for known wind by applying corrections both to heading and timing. This should be done during entry and while flying in the holding pattern.

Table I-6-1-1. Holding speeds — Categories A through E

<i>Levels¹</i>	<i>Normal conditions</i>	<i>Turbulence conditions</i>
Up to 4 250 m (14 000 ft) inclusive	425 km/h (230 kt) ² 315 km/h (170 kt) ⁴	520 km/h (280 kt) ³ 315 km/h (170 kt) ⁴
Above 4 250 m (14 000 ft) to 6 100 m (20 000 ft) inclusive	445 km/h (240 kt) ⁵	520 km/h (280 kt) or 0.8 Mach, whichever is less ³
Above 6 100 m (20 000 ft) to 10 350 m (34 000 ft) inclusive	490 km/h (265 kt) ⁵	
Above 10 350 m (34 000 ft)	0.83 Mach	0.83 Mach
- The levels shown represent <i>altitudes</i> or corresponding <i>flight levels</i> depending upon the altimeter setting in use. - When the holding procedure is followed by the initial segment of an instrument approach procedure promulgated at a speed higher than 425 km/h (230 kt), the holding should also be promulgated at this higher speed wherever possible. - The speed of 520 km/h (280 kt) (0.8 Mach) reserved for turbulence conditions shall be used for holding only after prior clearance with ATC, unless the relevant publications indicate that the holding area can accommodate aircraft flight at these high holding speeds. - For holdings limited to CAT A and B aircraft only. - Wherever possible, 520 km/h (280 kt) should be used for holding procedures associated with airway route structures.		

Table I-6-1-2. Holding speeds — for helicopter procedures

<i>Maximum speed up to 1 830 m (6 000 ft)</i>	185 km/h (100 kt)
<i>Maximum speed above 1 830 m (6 000 ft)</i>	315 km/h (170 kt)
<i>Note.— MOC in secondary area for helicopter holding procedures is linear from zero to full MOC.</i>	

1.3.4 Start of outbound timing

Outbound timing begins over or abeam the fix, whichever occurs later. If the abeam position cannot be determined, start timing when the turn to outbound is completed.

1.3.5 Outbound leg length based on a DME distance

If the outbound leg length is based on a DME distance, then the outbound leg terminates as soon as the limiting DME distance is reached.

1.3.6 Limiting radials

1.3.6.1 In the case of holding away from the station (see Figure I-6-1-1 C), where the distance from the holding fix to the VOR/DME station is short, a limiting radial may be specified. A limiting radial may also be specified where airspace conservation is essential.

1.3.6.2 If the limiting radial is reached before the limiting DME distance, this radial should be followed until a turn inbound is initiated. The turn should be initiated at the latest where the limiting DME distance is reached.

1.3.7 ATC notification

If for any reason a pilot is unable to conform to the procedures for normal conditions, air traffic control should be advised as early as possible.

1.4 ENTRY

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

1.4.1 The entry into the holding pattern shall be according to heading in relation to the three entry sectors shown in Figure I-6-1-2, recognizing a zone of flexibility of 5° on either side of the sector boundaries.

1.4.2 For holding on a VOR intersection, the entry track is limited to the radials forming the intersection.

1.4.3 For holding on a VOR/DME fix, the entry track is limited to:

- a) the VOR radial;
- b) the DME arc; or

Note.— A DME arc entry procedure is specified only when there is a specific operational difficulty which makes the use of other entry procedures impossible.

- c) the entry radial to a VOR/DME fix at the end of the outbound leg, as published.

1.4.4 Sector 1 entry

Sector 1 procedure (parallel entry):

- a) at the fix, the aircraft is turned left onto an outbound heading for the appropriate period of time (see 1.4.9, "Time/distance outbound"); then
- b) the aircraft is turned left onto the holding side to intercept the inbound track or to return to the fix; and then
- c) on second arrival over the holding fix, the aircraft is turned right to follow the holding pattern.

1.4.5 Sector 2 entry

Sector 2 procedure (offset entry):

- a) at the fix, the aircraft is turned onto a heading to make good a track making an angle of 30° from the reciprocal of the inbound track on the holding side; then
- b) the aircraft will fly outbound:

- 1) for the appropriate period of time (see 1.4.9, “Time/distance outbound”), where timing is specified; or
- 2) until the appropriate limiting DME distance is reached, where distance is specified. If a limiting radial is also specified, then the outbound distance is determined either by the limiting DME distance or the limiting radial, whichever comes first;
- c) the aircraft is turned right to intercept the inbound holding track; and
- d) on second arrival over the holding fix, the aircraft is turned right to follow the holding pattern.

1.4.6 Sector 3 entry

Sector 3 procedure (direct entry): Having reached the fix, the aircraft is turned right to follow the holding pattern.

1.4.7 DME arc entry

DME arc entry: At the fix, the aircraft shall enter the holding pattern in accordance with either the Sector 1 or Sector 3 entry procedure.

1.4.8 Special entry procedure for VOR/DME holding

Note.— Where a special entry procedure is used, the entry radial is clearly depicted.

1.4.8.1 Definition of entry areas

- a) Arrival to a VOR/DME holding pattern may be:
 - 1) along the axis of the inbound track;
 - 2) along a published track; and
 - 3) by radar vectoring, when aircraft must be established on prescribed protected flight paths.
- b) The entry point may be either of the following two options:
 - 1) the holding fix: In this case, the aircraft will arrive at the entry point by means of:
 - i) the VOR radial for the inbound leg; or
 - ii) the DME arc defining the holding fix.
 - 2) the fix at the end of the outbound leg: In this case, the aircraft will arrive at the entry point by means of the VOR radial passing through the fix at the end of the outbound leg.

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

1.4.8.3 The radius of a DME arc used as guidance for arrival at a VOR/DME holding should be not less than

18.5 km (10 NM).

1.4.8.4 Minimum length for the last segment of the arrival track

The minimum length for the last segment of the arrival track, which terminates at the entry point, depends on the angle (θ) between that segment and the preceding segment (or radar path). The various values are shown in Table I-6-1-3.

Table I-6-1-3. Minimum length for the last segment of the arrival track

θ	0° to 70°	71° to 90°	91° to 105°	106° to 120°
Minimum distance km (NM)	7.4 (4)	9.3 (5)	13.0 (7)	16.7 (9)

1.4.8.5 Method of arrival at a VOR/DME holding and the corresponding entry procedures

Where the entry point is the holding fix:

- a) *Arrival on the VOR radial for the inbound leg, on the same heading as the inbound track* (see Figure I-6-1-3 A). The arrival path (or its last segment) is aligned with the inbound track and follows the same heading. The entry consists of following the holding pattern.
- b) *Arrival on the VOR radial for the inbound leg, on a heading reciprocal to the inbound track* (see Figure I-6-1-3-B).
 - 1) On arrival over the holding fix, the aircraft turns onto the holding side on a track making an angle of 30° with the reciprocal of the inbound track, until reaching the DME outbound limiting distance.
 - 2) At this point it turns to intercept the inbound track.
 - 3) In the case of a VOR/DME holding entry away from the facility with a limiting radial, if the aircraft encounters the radial ahead of the DME distance, it must turn and follow it until reaching the DME outbound limiting distance, at which point it turns to join the inbound track.
- c) *Arrival on the DME arc defining the holding fix, from the non-holding side* (see Figure I-6-1-3 C).
 - 1) On arrival over the holding fix, the aircraft turns and follows a track parallel to and on the same heading as the outbound track.
 - 2) When it reaches the DME outbound limiting distance, the aircraft turns to intercept the inbound track.
- d) *Arrival on the DME arc defining the holding fix, from the holding side*. An arrival track leading to this type of entry should not be specified if possible, particularly in the case of a VOR/DME holding procedure away from the facility. If an appropriate DME distance is chosen, this type of arrival can actually be replaced by one on a DME arc terminating in the extension of the inbound track (see a) above and Figure I-6-1-3 D).

However, space problems may rule out this solution. Criteria are therefore provided for an arrival on the DME arc defining the holding fix, coming from the holding side:

- 1) On arrival over the holding fix, the aircraft turns and follows a track parallel and reciprocal to the inbound track, until reaching the DME limiting outbound distance. It then turns to intercept the inbound track (see Figure I-6-1-3 E).
- 2) If the entry point is the fix at the end of the outbound leg, arrival (or last segment thereof) is effected along the VOR radial passing through the outbound fix. On arrival over the fix at the end of the outbound leg, the aircraft turns and follows the holding pattern (see Figure I-6-1-3 F and G).

1.4.9 Time/distance outbound

The still air time for flying the outbound entry heading should not exceed:

- a) one minute if at or below 4 250 m (14 000 ft); or
- b) one and one-half minutes if above 4 250 m (14 000 ft).

Where DME is available, the length of the outbound leg may be specified in terms of distance instead of time.

1.5 HOLDING

1.5.1 Still air condition

- a) Having entered the holding pattern, on the second and subsequent arrivals over the fix, the aircraft turns to fly an outbound track which will most appropriately position the aircraft for the turn onto the inbound track;
- b) It continues outbound:
 - 1) where timing is specified:
 - i) for one minute if at or below 4 250 m (14 000 ft); or
 - ii) for one and one-half minutes if above 4 250 m (14 000 ft);
 - or
 - 2) where distance is specified until the appropriate limiting DME distance is reached; then
- c) the aircraft turns so as to realign itself on the inbound track.

1.5.2 Corrections for wind effect

Due allowance should be made in both heading and timing to compensate for the effects of wind to ensure the inbound track is regained before passing the holding fix inbound. In making these corrections, full use should be made of the indications available from the navaid and estimated or known wind.

1.5.3 Departing the pattern

When clearance is received specifying the time of departure from the holding point, the pilot should adjust the pattern within the limits of the established holding procedure in order to leave the holding point at the time specified.

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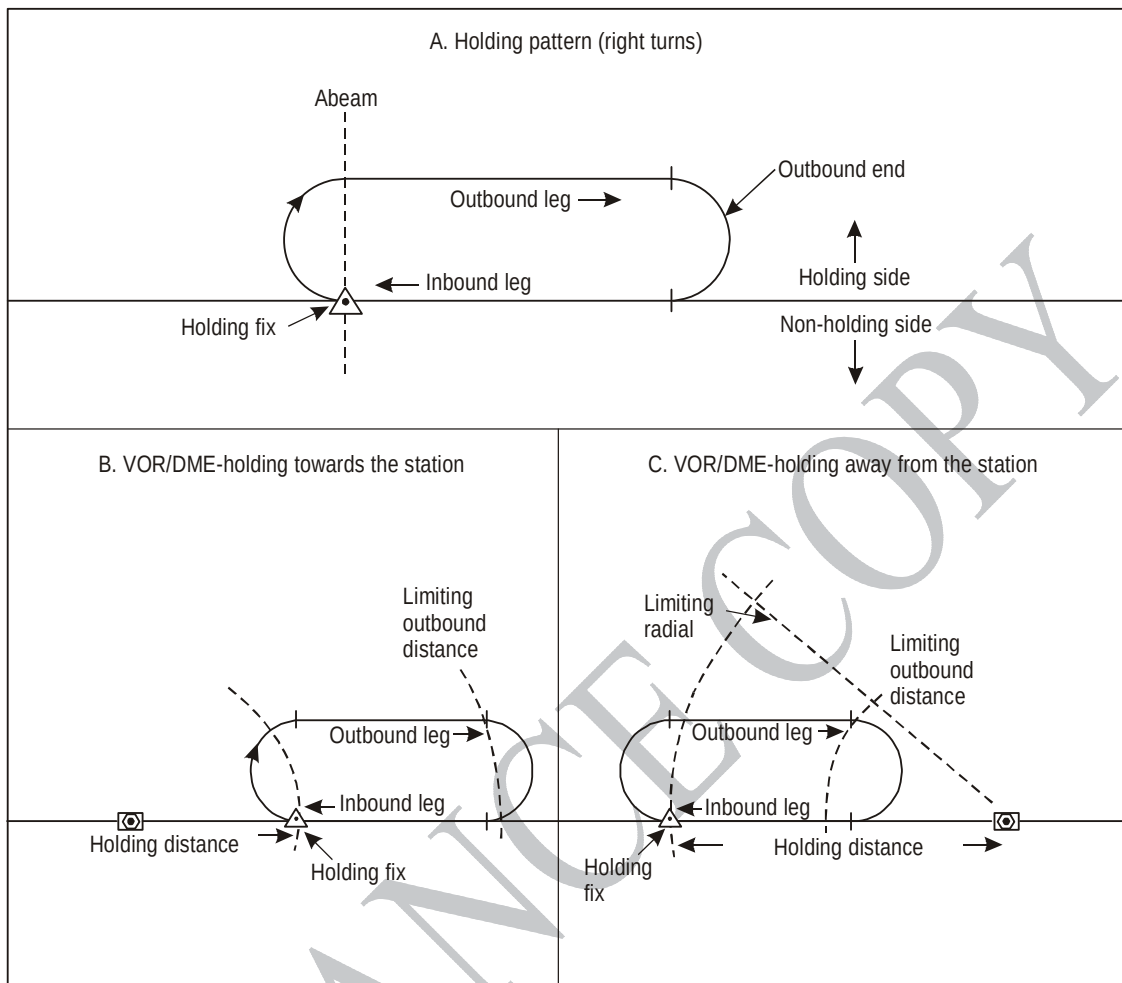


Figure I-6-1-1. Shape and terminology associated with right turn holding pattern

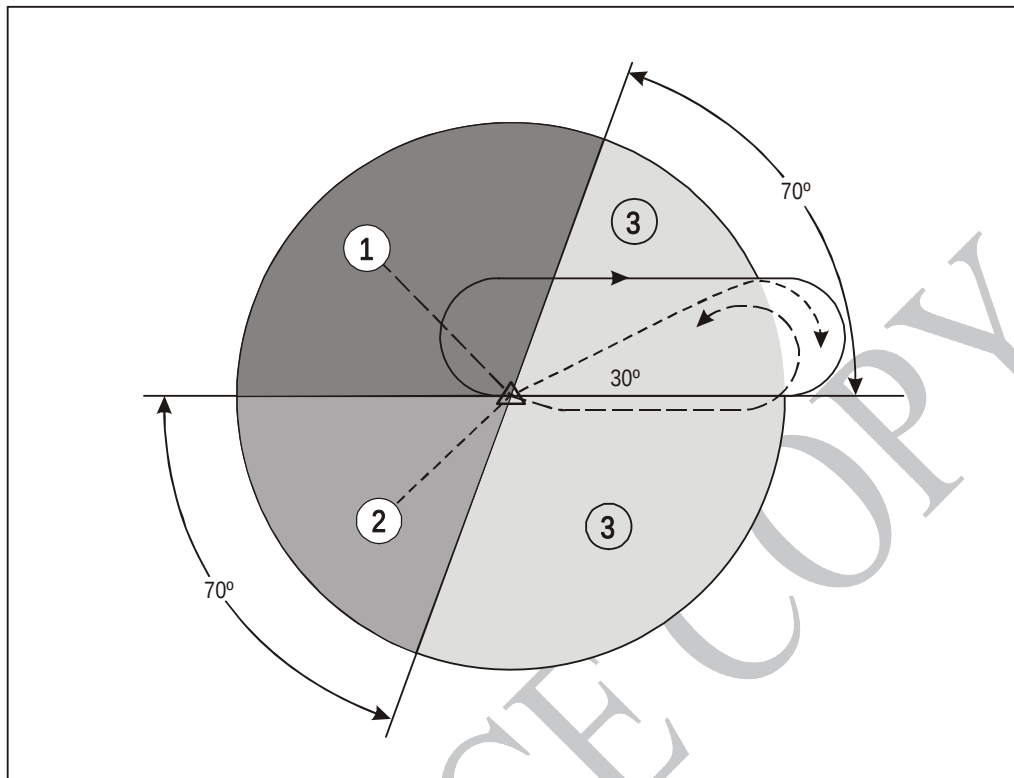


Figure I-6-1-2. Entry sectors

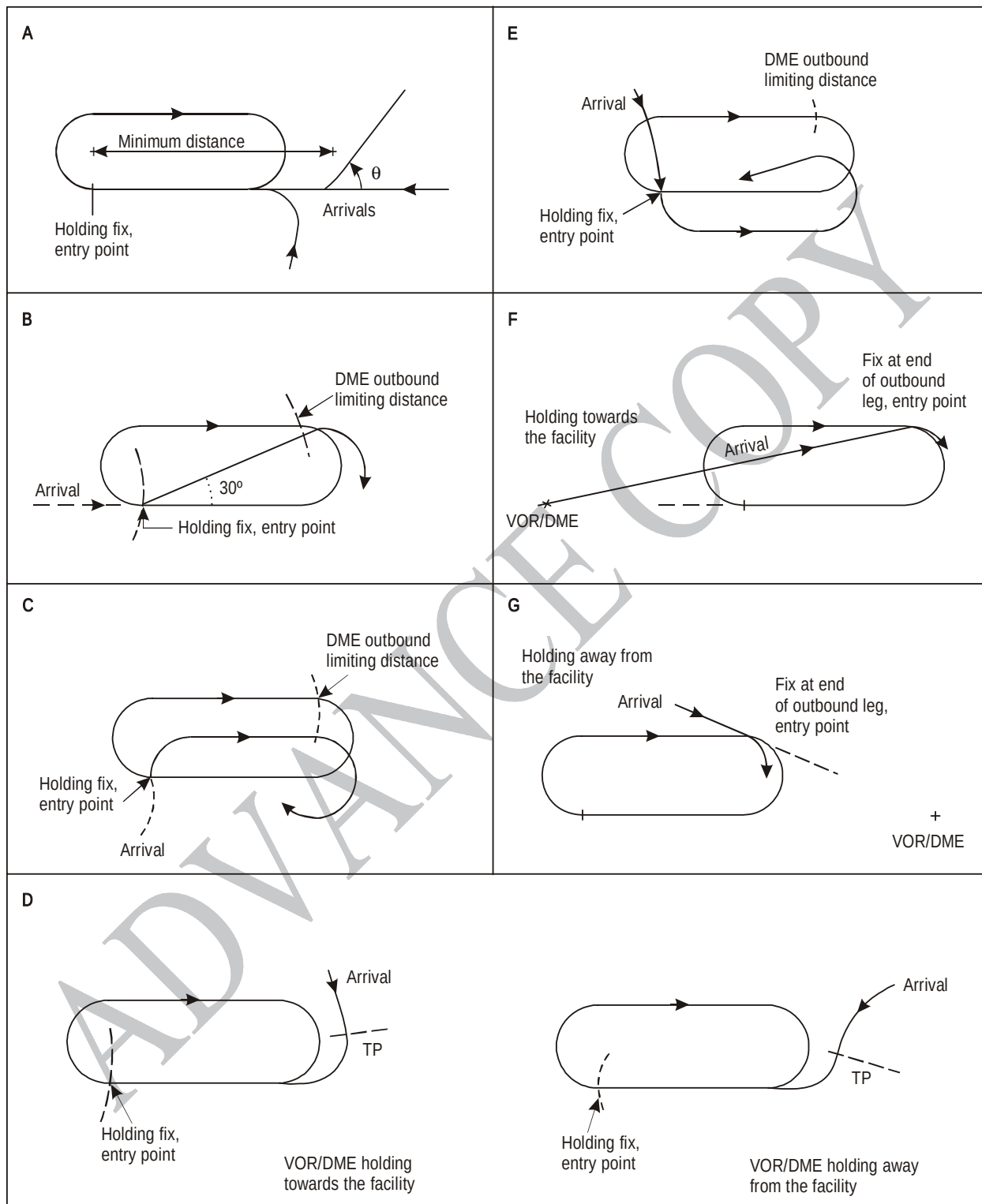


Figure I-6-1-3. VOR/DME holding entry procedures

Chapter 2

OBSTACLE CLEARANCE

2.1 HOLDING AREA

The holding area includes the basic holding area and the entry area. The basic holding area is the airspace required for a holding pattern at a specific level, based on the allowances for aircraft speed, wind effect, timing errors, holding fix characteristics, etc. The entry area is the airspace required for the entry procedure.

2.2 BUFFER AREA

An additional buffer area extends 9.3 km (5.0 NM) beyond the boundary of the holding area. Significant obstacles in the buffer area are taken into consideration when determining the minimum holding level.

2.3 MINIMUM HOLDING LEVEL

2.3.1 The minimum permissible holding level (see Figure I-6-2-1) provides a clearance of at least:

- a) 300 m (984 ft) above obstacles in the holding area;
- b) one of the values shown in Table I-6-2-1 above obstacles in the buffer area.

The minimum holding altitude to be published shall be rounded up to the nearest 50 m or 100 ft as appropriate.

Table I-6-2-1. Obstacle clearance increment

<i>Distance beyond the boundary of the holding area</i>	<i>Minimum obstacle clearance over low flat terrain</i>	
	<i>Metres</i>	<i>Feet</i>
0 to 1.9 km (0 to 1.0 NM)	300	984
1.9 to 3.7 km (1.0 to 2.0 NM)	150	492
3.7 to 5.6 km (2.0 to 3.0 NM)	120	394
5.6 to 7.4 km (3.0 to 4.0 NM)	90	295
7.4 to 9.3 km (4.0 to 5.0 NM)	60	197
<i>Category H</i>		
0 to 3.7 km (0 to 2.0 NM)	Linear 300 to 0	Linear 984 to 0

2.3.2 Obstacle clearance over high terrain or in mountainous areas

Over high terrain or in mountainous areas, additional obstacle clearance up to a total of 600 m (1 969 ft) is provided to accommodate the possible effects of turbulence, down drafts and other meteorological phenomena on the performance of altimeters. Guidance material on the consideration of these effects is contained in PANS-OPS, Volume II, Appendix B to Part II, Section 4, Chapter 1.

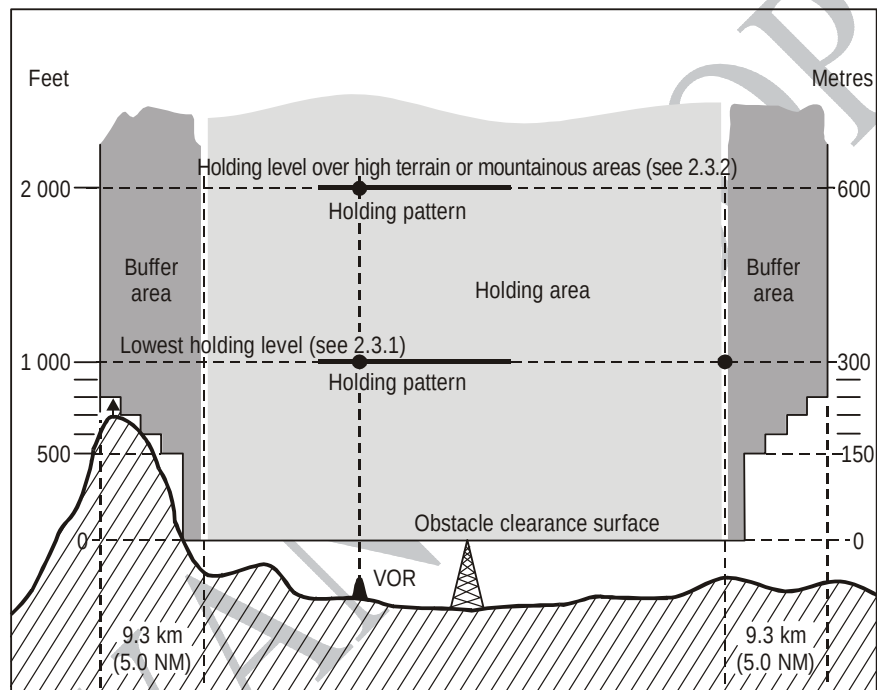


Figure I-6-2-1. Minimum holding level as determined by the obstacle clearance surface related to the holding area and the buffer area

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Section 7

NOISE ABATEMENT PROCEDURES

Chapter 1

GENERAL NOISE ABATEMENT INFORMATION

1.1 Nothing in these procedures shall prevent the pilot-in-command from exercising authority for the safe operation of the aeroplane.

1.2 Noise abatement procedures shall not be implemented except where a need for such procedures has been determined. (See Annex 16, Volume I, Part V.)

1.3 The procedures herein describe the methods for noise abatement when a problem is shown to exist. They have been designed for application to turbojet aeroplanes. They can comprise any one or more of the following:

- a) use of noise preferential runways to direct the initial and final flight paths of aeroplanes away from noise-sensitive areas;
- b) use of noise preferential routes to assist aeroplanes in avoiding noise-sensitive areas on departure and arrival, including the use of turns to direct aeroplanes away from noise-sensitive areas located under or adjacent to the usual take-off and approach flight paths; and
- c) use of noise abatement take-off or approach procedures, designed to minimize the overall exposure to noise on the ground and at the same time maintain the required levels of flight safety.

1.4 For the purpose of these procedures, the heights given in metres and feet and speeds given in kilometres/hour and knots are considered to be operationally acceptable equivalents.

Chapter 2

NOISE PREFERENTIAL RUNWAYS AND ROUTES

2.1 NOISE PREFERENTIAL RUNWAYS

2.1.1 Preferred runway directions for take-off and landing, appropriate to the operation, are nominated for noise abatement purposes, the objective being to utilize whenever possible those runways that permit aeroplanes to avoid noise-sensitive areas during the initial departure and final approach phases of flight.

2.1.2 Runways should not normally be selected for preferential use for landing unless they are equipped with suitable glide path guidance, e.g. ILS, or a visual approach slope indicator system for operations in visual meteorological conditions.

2.1.3 Noise abatement should not be the determining factor in runway nomination under the following circumstances:

- a) if the runway surface conditions are adversely affected (e.g. by snow, slush, ice or water, mud, rubber, oil or other substances);
- b) for landing in conditions when the ceiling is lower than 150 m (500 ft) above aerodrome elevation, or for take-off and landing when the horizontal visibility is less than 1.9 km (1 NM);
- c) when the crosswind component, including gusts, exceeds 28 km/h (15 kt);
- d) when the tailwind component, including gusts, exceeds 9 km/h (5 kt); and
- e) when wind shear has been reported or forecast or when adverse weather conditions, e.g. thunderstorms, are expected to affect the approach or departure.

2.2 NOISE PREFERENTIAL ROUTES

2.2.1 Noise preferential routes are established to ensure that departing and arriving aeroplanes avoid over-flying noise-sensitive areas in the vicinity of the aerodrome as far as practicable.

2.2.2 In establishing noise preferential routes:

- a) turns during take-off and climb should not be required unless:
 - 1) the aeroplane has reached (and can maintain throughout the turn) a height of not less than 150 m (500 ft) above terrain and the highest obstacles under the flight path;

Note.— PANS-OPS, Volume II, permits turns after take-off at 120 m (400 ft) and obstacle clearance of at least 90 m (300 ft) during the aeroplane's turn. These are minimum requirements for noise abatement purposes.

- 2) the bank angle for turns after take-off is limited to 15° except where adequate provision is made for an acceleration phase permitting attainment of safe speeds for bank angles greater than 15°;
- b) no turns should be required coincident with a reduction of power associated with a noise abatement procedure; and
- c) sufficient navigation guidance should be provided to permit aeroplanes to adhere to the designated route.

2.2.3 In establishing noise preferential routes, the safety criteria of standard departure and standard arrival routes regarding obstacle clearance climb gradients and other factors should be taken into full consideration (see PANS-OPS, Volume II).

2.2.4 Where noise preferential routes are established, these routes and standard departure and arrival routes should be compatible (see Annex 11, Appendix 3).

2.2.5 An aeroplane should not be diverted from its assigned route unless:

- a) in the case of a departing aeroplane, it has attained the altitude or height which represents the upper limit for noise abatement procedures; or
- b) it is necessary for the safety of the aeroplane (e.g. for avoidance of severe weather or to resolve a traffic conflict).

Chapter 3

AEROPLANE OPERATING PROCEDURES

3.1 INTRODUCTION

3.1.1 This chapter provides the aeroplane operating procedures to be taken into account when developing noise abatement take-off and climb procedures. In the appendix to this chapter, two examples of noise abatement climb procedures are given, one which alleviates noise close to the aerodrome, Noise Abatement Departure Procedure 1 (NADP 1), and one which alleviates noise more distant from the aerodrome, NADP 2.

3.1.2 The State in which the aerodrome is located is responsible for ensuring that noise abatement objectives are specified by aerodrome operators. The noise abatement objectives should enable operators to develop safe procedures in accordance with this chapter. The State of the Operator is responsible for the approval of safe flight procedures developed by the aircraft operators.

3.2 OPERATIONAL LIMITATIONS

3.2.1 General

3.2.1.1 Noise abatement procedures based on this document should not be selected if noise benefits cannot be expected.

3.2.1.2 Noise abatement climb procedures that do not comply with the minimum requirements of the procedures in this document shall not be approved by the State of the Operator.

3.2.1.3 The pilot-in-command has the authority to decide not to execute a noise abatement departure procedure if conditions preclude the safe execution of the procedure.

3.2.2 Take-off

Noise abatement procedures in the form of reduced power take-off should not be required in adverse operating conditions such as:

- a) if the runway surface conditions are adversely affected (e.g. by snow, slush, ice or water, mud, rubber, oil or other substances);
- b) when the horizontal visibility is less than 1.9 km (1 NM);
- c) when the crosswind component, including gusts, exceeds 28 km/h (15 kt);
- d) when the tailwind component, including gusts, exceeds 9 km/h (5 kt); and

- e) when wind shear has been reported or forecast or when adverse weather conditions, e.g. thunderstorms, are expected to affect the departure.

Note.— Some operating manuals (or the flight manual) may impose restrictions on the use of reduced take-off power while engine anti-icing systems are operating.

3.2.3 Departure climb

Aeroplane operating procedures for the departure climb shall ensure that the safety of flight operations is maintained while minimizing exposure to noise on the ground. The following requirements need to be satisfied:

- a) Noise abatement procedures shall not be executed below a height of 240 m (800 ft) above aerodrome elevation.
- b) The noise abatement procedure specified by an operator for any one aeroplane type should be the same for all aerodromes.
- c) To minimize the impact on training while maintaining some flexibility to address variations in the location of noise-sensitive areas, sufficient commonality shall exist between the departure procedures specified by the operator. There will be no more than two departure procedures to be used by one operator for an aeroplane type, one of which should be identified as the normal departure procedure, and the other as the noise abatement departure procedure.
- d) Normal departure procedures typically include general noise reduction measures that encompass one of the two examples shown in the appendix to this chapter — Noise Abatement Departure Climb Guidance.
- e) Conduct of noise abatement climb procedures is secondary to the satisfaction of obstacle requirements.
- f) All necessary obstacle data shall be made available to the operator, and the procedure design gradient shall be observed.
- g) The power settings to be used subsequent to the failure or shutdown of an engine or any other apparent loss of performance, at any stage in the take-off or noise abatement climb, are at the discretion of the pilot-in-command, and noise abatement considerations no longer apply.
- h) The minimum level of thrust for the flap/slat configuration, after power reduction, is defined as the lesser of the maximum climb power and that level necessary to maintain the specified engine inoperative minimum net climb gradient (1.2, 1.5 or 1.7 per cent for 2, 3 or 4 engines) for the flap/slat configuration of the aeroplane, in the event of loss of an engine, without a throttle position increase by the pilot-in-command. The minimum thrust level varies as a function of flap setting, altitude, and aeroplane weight; therefore, this information must be provided in the aircraft operating manual.
- i) The power settings specified in the aircraft operating manual are to take account of the need for engine anti-icing when applicable.
- j) Noise abatement climb procedures are not to be used in conditions where wind shear warnings exist, or the presence of wind shear or downburst activity is suspected.
- k) The maximum acceptable body angle specified for an aeroplane type shall not be exceeded.

3.3 DEVELOPMENT OF PROCEDURES

A noise abatement procedure shall be developed by the operator for each aeroplane type (with advice from the aeroplane manufacturer, as needed) and agreed to by the State of the Operator. The departure procedure to be used on a specific departure should satisfy the noise objectives of the State of the Aerodrome.

3.4 AEROPLANE OPERATING PROCEDURES — APPROACH

3.4.1 In noise abatement approach procedures which are developed:

- a) the aeroplane shall not be required to be in any configuration other than the final landing configuration at any point after passing the outer marker or 5 NM from the threshold of the runway of intended landing, whichever is earlier; and
- b) excessive rates of descent shall not be required.

Note.— Design criteria for descent gradients are contained in PANS-OPS, Volume II, Part I, Section 4, 3.3.5, 3.7.1, 4.3.3 and 5.3.

3.4.2 When it is necessary to develop a noise abatement approach procedure based on currently available (1982) systems and equipment, the following safety considerations shall be taken fully into account:

- a) glide path or approach angles should not require an approach to be made:
 - 1) above the ILS glide path angle;
 - 2) above the glide path angle of the visual approach slope indicator system;
 - 3) above the normal PAR final approach angle; and
 - 4) above an angle of 3° except where it has been necessary to establish, for operational purposes, an ILS with a glide path angle greater than 3°;

Note 1.— New procedures will need to be developed as and when the introduction of new systems and equipment makes the use of significantly different approach techniques possible.

Note 2.— The pilot can accurately maintain a prescribed angle of approach only when provided with either continuous visual or radio navigation guidance.

- b) the pilot should not be required to complete a turn on to final approach at distances less than will:
 - 1) in the case of visual operations, permit an adequate period of stabilized flight on final approach before crossing the runway threshold; or
 - 2) in the case of instrument approaches, permit the aircraft to be established on final approach prior to interception of the glide path, as detailed in Section 4, Chapter 5, 5.2.4, “FAF crossing”.

3.4.3 Within the constraints necessary at some locations to maintain efficient air traffic services, noise abatement descent and approach procedures utilizing continuous descent and reduced power/reduced drag techniques (or a combination of both) have proved to be both effective and operationally acceptable. The objective of such procedures is to achieve uninterrupted descents at reduced power and with reduced drag, by delaying the extension of wing flaps and

landing gear until the final stages of approach. The speeds employed during the application of these techniques tend, accordingly, to be higher than would be appropriate for descent and approach with the flaps and gear extended throughout, and such procedures must therefore comply with the limitations in this section.

3.4.4 Compliance with published noise abatement approach procedures should not be required in adverse operating conditions such as:

- a) if the runway is not clear and dry, i.e. it is adversely affected by snow, slush, ice or water, mud, rubber, oil or other substances;
- b) in conditions when the ceiling is lower than 150 m (500 ft) above aerodrome elevation, or when the horizontal visibility is less than 1.9 km (1 NM);
- c) when the crosswind component, including gusts, exceeds 28 km/h (15 kt);
- d) when the tailwind component, including gusts, exceeds 9 km/h (5 kt); and
- e) when wind shear has been reported or forecast or when adverse weather conditions, e.g. thunderstorms, are expected to affect the approach.

3.5 AEROPLANE OPERATING PROCEDURES — LANDING

Noise abatement procedures shall not contain a prohibition of use of reverse thrust during landing.

3.6 DISPLACED THRESHOLDS

The practice of using a displaced runway threshold as a noise abatement measure shall not be employed unless aircraft noise is significantly reduced by such use and the runway length remaining is safe and sufficient for all operational requirements.

Note.— Reduction of noise levels to the side of and at the beginning of a runway can be achieved by displacing the commencement of the take-off, but at the expense of increased noise exposures under the flight path. Displacement of the landing threshold will, in the interests of safety, involve clearly marking the threshold to indicate the displacement and relocation of the approach aids.

3.7 CONFIGURATION AND SPEED CHANGES

Deviations from normal configuration and speeds appropriate to the phase of flight shall not be made mandatory.

3.8 UPPER LIMIT

Noise abatement procedures shall include information on the altitude/height above which they are no longer applicable.

3.9 COMMUNICATIONS

In order not to distract flight crews during the execution of noise abatement procedures, air/ground communications should be kept to a minimum.

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Appendix to Chapter 3

NOISE ABATEMENT DEPARTURE CLIMB GUIDANCE

1. General

1.1 Aeroplane operating procedures for the take-off climb shall ensure that the necessary safety of flight operations is maintained while minimizing exposure to noise on the ground. The following two examples of operating procedures for the climb have been developed as guidance and are considered safe when the criteria in 3.2 are satisfied. The first procedure (NADP 1) is intended to provide noise reduction for noise-sensitive areas in close proximity to the departure end of the runway (see Figure I-7-3-App-1). The second procedure (NADP 2) provides noise reduction to areas more distant from the runway end (see Figure I-7-3-App-2).

1.2 The two procedures differ in that the acceleration segment for flap/slat retraction is either initiated prior to reaching the maximum prescribed height or at the maximum prescribed height. To ensure optimum acceleration performance, thrust reduction may be initiated at an intermediate flap setting.

Note 1.— For both procedures, intermediate flap transitions required for specific performance-related issues may be initiated prior to the prescribed minimum height; however, no power reduction can be initiated prior to attaining the prescribed minimum altitude.

Note 2.— The indicated airspeed for the initial climb portion of the departure prior to the acceleration segment is to be flown at a climb speed of $V_2 + 20$ to 40 km/h (10 to 20 kt).

2. Noise abatement climb — Example of a procedure alleviating noise close to the aerodrome (NADP 1)

2.1 This procedure involves a power reduction at or above the prescribed minimum altitude and the delay of flap/slat retraction until the prescribed maximum altitude is attained. At the prescribed maximum altitude, accelerate and retract flaps/slats on schedule while maintaining a positive rate of climb, and complete the transition to normal en-route climb speed.

2.2 The noise abatement procedure is not to be initiated at less than 240 m (800 ft) above aerodrome elevation.

2.3 The initial climbing speed to the noise abatement initiation point shall not be less than $V_2 + 20$ km/h (10 kt).

2.4 On reaching an altitude at or above 240 m (800 ft) above aerodrome elevation, adjust and maintain engine power/thrust in accordance with the noise abatement power/thrust schedule provided in the aircraft operating manual. Maintain a climb speed of $V_2 + 20$ to 40 km/h (10 to 20 kt) with flaps and slats in the take-off configuration.

2.5 At no more than an altitude equivalent to 900 m (3 000 ft) above aerodrome elevation, while maintaining a positive rate of climb, accelerate and retract flaps/slats on schedule.

2.6 At 900 m (3 000 ft) above aerodrome elevation, accelerate to en-route climb speed.

3. Noise abatement climb — Example of a procedure alleviating noise distant from the aerodrome (NADP 2)

3.1 This procedure involves initiation of flap/slat retraction on reaching the minimum prescribed altitude. The flaps/slats are to be retracted on schedule while maintaining a positive rate of climb. The power reduction is to be performed with the initiation of the first flap/slat retraction **or** when the zero flap/slat configuration is attained. At the prescribed altitude, complete the transition to normal en-route climb procedures.

3.2 The noise abatement procedure is not to be initiated at less than 240 m (800 ft) above aerodrome elevation.

3.3 The initial climbing speed to the noise abatement initiation point is $V_2 + 20$ to 40 km/h (10 to 20 kt).

3.4 On reaching an altitude equivalent to at least 240 m (800 ft) above aerodrome elevation, decrease aircraft body angle/angle of pitch while maintaining a positive rate of climb, accelerate towards V_{ZF} and either:

- a) reduce power with the initiation of the first flap/slat retraction; or
- b) reduce power after flap/slat retraction.

3.5 Maintain a positive rate of climb, and accelerate to and maintain a climb speed of $V_{ZF} + 20$ to 40 km/h (10 to 20 kt) to 900 m (3 000 ft) above aerodrome elevation.

3.6 On reaching 900 m (3 000 ft) above aerodrome elevation, transition to normal en-route climb speed.

3.7 An aeroplane should not be diverted from its assigned route unless:

- a) in the case of a departing aeroplane it has attained the altitude or height which represents the upper limit for noise abatement procedures; or
- b) it is necessary for the safety of the aeroplane (e.g. for avoidance of severe weather or to resolve a traffic conflict).

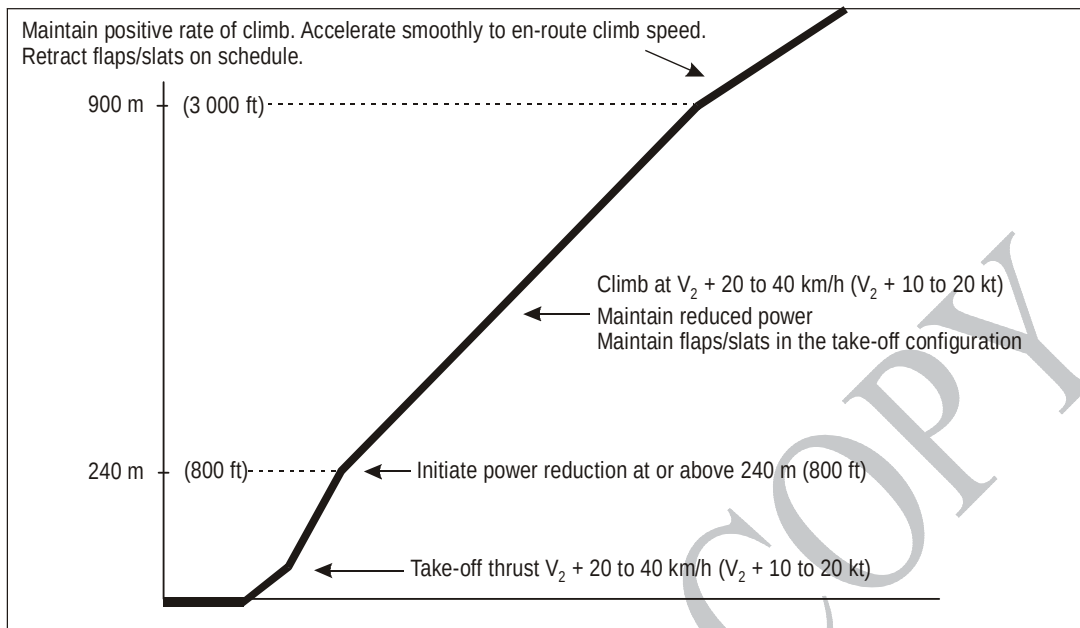


Figure I-7-3-App-1. Noise abatement take-off climb — Example of a procedure alleviating noise close to the aerodrome (NADP 1)

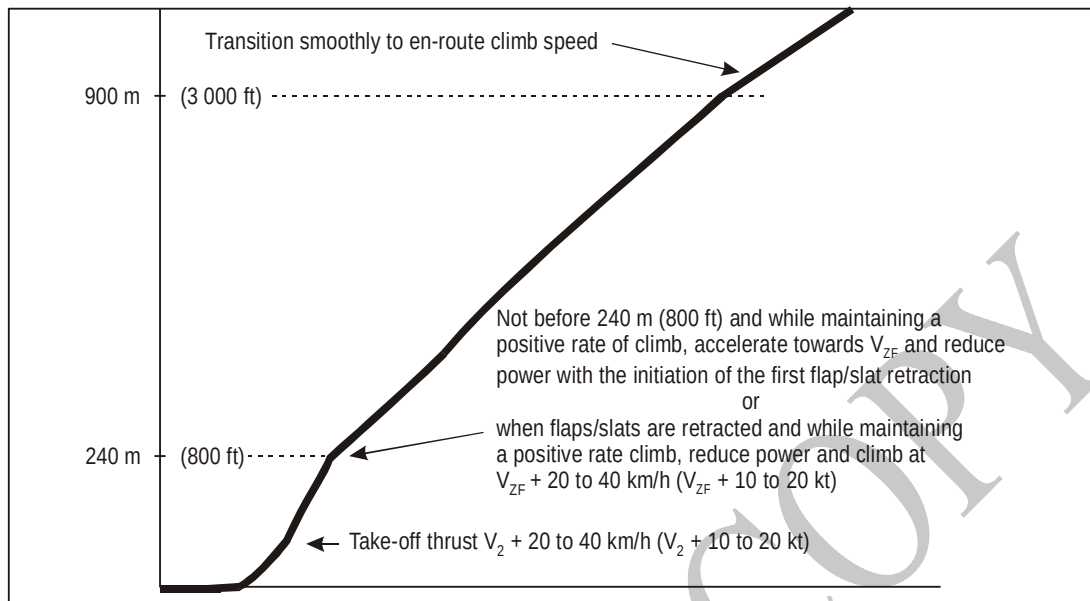


Figure I-7-3-App-2. Noise abatement take-off climb — Example of a procedure alleviating noise distant from the aerodrome (NADP 2)

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Section 8

**PROCEDURES FOR USE
BY HELICOPTERS**

Chapter 1

INTRODUCTION

1.1 In order to capitalize on the capabilities of helicopters, helicopter-only procedures may be designed and authorized for airspeeds lower than those established for Category A aeroplanes. Those procedures which have been designed under the special criteria for helicopter-use only are identified by the letter H and refer to the category of aircraft as Category H.

1.2 For flight operations using Category A procedures, the primary requirement is to manoeuvre the helicopter within the Category A airspeed tolerances as prescribed in Table I-8-3-1 and Table I-4-1-1 or Table I-4-1-2. 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 PANS-OPS, Volume II, Part I, Section 2, Chapter 2, 2.7.4), 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.

1.3 It should also be remembered that circling procedures are not applicable to helicopters. Rather than executing a circling procedure, it is considered that a helicopter manoeuvres visually to a suitable landing area. Helicopter pilots using a Category A procedure which authorizes both straight-in and circling minima may manoeuvre at the straight-in minimum descent height (MDH) if visibility permits. However, the pilot must be alert to operational notes regarding ATS requirements while manoeuvring to land.

Chapter 2

JOINT HELICOPTER/AEROPLANE PROCEDURES

2.1 GENERAL

The criteria specified in Section 3, “Departure Procedures”, Section 4, “Arrival and Approach Procedures” and Section 6, “Holding Procedures” may be applied for helicopter operations provided that the helicopter is operated as an aeroplane, especially in regard to the items noted in 2.2, “Departure Criteria” and 2.3, “Instrument Approach Criteria”. For helicopter-only procedures, refer to Chapter 3 of this section.

2.2 DEPARTURE CRITERIA

When helicopters use a procedure designed for aeroplanes and when no special helicopter procedure has been promulgated, the following operational constraints must be considered:

- *straight departures*: It is important that helicopters cross the DER within 150 m laterally of the runway centre line when using departure procedures designed for aeroplanes.
- *turning or omnidirectional departures*: Straight flight is assumed until reaching an altitude/height of at least 120 m (394 ft) above the elevation of the DER.

For a turn designated at an altitude/height, the turn initiation area begins at a point located 600 m from the beginning of the runway. However, when it is unnecessary to accommodate turns initiated as early as 600 m from the beginning of the runway, the turn initiation area begins at the DER and this information shall be noted on the departure chart.

2.3 INSTRUMENT APPROACH CRITERIA

2.3.1 Categorization

Helicopters may be classified as Category A aeroplanes for the purpose of designing instrument approach procedures and specifications (including the height loss/altimeter margins in Table I-4-5-2).

2.3.2 Operational constraints

When helicopters use procedures designed for Category A aeroplanes, and when no special helicopter procedure has been promulgated, the following operational constraints must be considered:

- a) *Range of final approach speeds*. The minimum final approach speed considered for a Category A aeroplane is 130 km/h (70 kt). This is only critical when the MAPt is specified by a distance from the 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. 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. 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.

- b) *Rate of descent after fixes.* 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 minimum obstacle clearance (MOC). Helicopters are capable of nominal descent gradients which could penetrate this plane. Therefore, for helicopters, rates of descent after crossing the final approach and any stepdown fix should be limited accordingly.

Chapter 3

PROCEDURES SPECIFIED FOR USE BY HELICOPTERS ONLY

3.1 GENERAL

For flight operations and procedures based on helicopter-only criteria, Table I-8-3-1 provides a comparison between selected Category H helicopter criteria and the corresponding Category A aeroplane criteria. Awareness of the differences between the two criteria is essential to the safety of helicopter IFR operations.

Table I-8-3-1. Comparison between selected helicopter-only criteria and the corresponding aeroplane criteria

<i>PANS-OPS, Volume II reference</i>	<i>Criteria</i>	<i>CAT H</i>	<i>CAT A</i>
Part I			
<i>Section 2 — General principles</i>			
<i>Chapter 2 — Terminal area fixes</i>			
2.7.4	Stepdown fix gradient (per cent)	15 to 25	15
<i>Section 3 — Departure procedures</i>			
<i>Chapter 2 — General concepts</i>			
2.3	Minimum height to initiate a turn	90 m (over the DER elevation)	120 m (over the DER elevation)
2.7	Procedure design gradient	5%	3.3%
<i>Chapter 3 — Departure routes</i>			
3.2	Straight departures		
3.2.3	Track adjustments will take place no further than a point corresponding to _____ above the DER, or at a specified track adjustment point	90 m	120 m
3.3	Turning departures		
3.3.1	Straight flight assumed until reaching a height of at least	90 m (295 ft)	120 m (394 ft)

<i>PANS-OPS, Volume II reference</i>	<i>Criteria</i>	<i>CAT H</i>	<i>CAT A</i>
3.3.2	Turn initiation area start point	See earliest limit for DER	600 m from beginning of runway
3.3.4	Turn parameters, max speed	165 km/h (90 kt)	225 km/h (121 kt)
3.3.4	Reduced speed limitation for obstacle avoidance (from Table I-4-1-2)	130 km/h (70 kt)	204 km/h (110 kt)
<i>Chapter 4 — Omnidirectional departures</i>			
4.1	Initial straight ahead climb	90 m (295 ft)	120 m (394 ft)
4.2.1	Turn initiation area	beginning of the FATO	600 m from beginning of runway
<i>Chapter 5 — Published information</i>			
5.1	Procedure design gradient	5%	3.3%
<i>Section 4 — Arrival and approach procedures</i>			
<i>Chapter 1 — General information</i>			
Table I-4-1-2	<i>Speeds (kt)</i>		
	Initial approach		
	a) general	70/120*	90/150
	b) reversal, racetrack below 6 000 ft MSL	100	110
	c) reversal, racetrack above 6 000 ft MSL	110	110
	Final approach	60/90*	70/100
	Circling	N/A	100
	Intermediate missed approach	90	100
	Final missed approach	90	110
<i>Chapter 5 — Final approach segment</i>			
5.3.1.2	Maximum descent gradient	10%	6.5%
5.3.2	Origin of descent gradient	(above the beginning of the LDAH)	(above the threshold)
<i>Chapter 6 — Missed approach segment</i>			
6.2.3.2	Final phase MOC	40 m (130 ft)	50 m (164 ft)
6.4.3	Reduced turning speed	130 km/h (70 kt)	185 km/h (100 kt)

PANS-OPS, Volume II reference		Criteria	CAT H	CAT A
Part II		Conventional procedures		
Section 4 — Holding criteria				
Chapter 1 — Holding criteria				
Table II-4-1-2 Holding				
	Maximum speed up to 1 830 m (6 000 ft)		185 km/h (100 kt)	315 km/h (170 kt)
	Maximum speed above 1 830 m (6 000 ft)		315 km/h (170 kt)	315 km/h (170 kt)
3.12.1	Buffer area		3.7 km (2 NM) (only below 1 830 m (6000 ft))	9km (5 NM)
Table II-4-1-2 MOC (ft)			Linear from 0 to full MOC	Steps
* 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 Part IV, Chapter 1.				

Section 9

**PROCEDURES FOR THE ESTABLISHMENT
OF AERODROME OPERATING MINIMA**

(To be developed)

**Procedures for
Air Navigation Services**

AIRCRAFT OPERATIONS

Part II

FLIGHT PROCEDURES — RNAV AND SATELLITE-BASED

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Section 1
GENERAL

Chapter 1

GENERAL INFORMATION FOR RNAV SYSTEMS

1.1 In RNAV guidance systems, a computer converts navigation data inputs into aircraft position, calculates track and distance and provides steering guidance to the next waypoint. The limitations of RNAV systems are those of the computers on which they are based.

1.2 The computer is programmed so that calculation errors are minimal and do not affect the accuracy of the output significantly. The computer, however, cannot identify data input errors.

1.3 Since the waypoint and, in some cases, data contained in the navigation database, have been calculated and promulgated by States and inserted by the operator or crew, the actual computed position will contain any errors that they have introduced into the navigation database.

Chapter 2

TERMINAL ARRIVAL ALTITUDE (TAA)

2.1 GENERAL

2.1.1 The purpose of the terminal arrival altitude (TAA) is to provide a transition from the en-route structure to an RNAV approach procedure.

2.1.2 TAAs are associated with an RNAV procedure based upon the “T” or “Y” arrangement described in Section 3, Chapter 1.

2.1.3 An RNAV-equipped aircraft approaching the terminal area and intending to conduct an RNAV approach is required to track via the appropriate IAF associated with the procedure. If a 46 km (25 NM) MSA is published, once the IAF is selected as the next waypoint, the MSA reference is unavailable unless the aircraft is equipped with additional navigation systems or the reference point for the 46 km (25 NM) MSA is reselected. The publication of TAAs avoids the requirement for distance and/or azimuth information in relation to the MSA reference point and provides obstacle clearance while tracking direct to an IAF.

2.1.4 Where published, TAAs replace the 46 km (25 NM) MSA.

2.1.5 The standard TAA arrangement consists of three areas defined by the extension of the initial legs and the intermediate segment course. These areas are called the straight-in, left base, and right base areas.

2.1.6 TAA area boundaries are defined by a radial RNAV distance from, and magnetic bearings to, the TAA reference point. The TAA reference point is normally the associated IAF but in some cases may be the IF.

Note.— In this chapter, the standard “T” or “Y” arrangement incorporating three IAFs will be assumed. Where one or more of the initial segments are not employed, the TAA reference point may be the IF.

2.1.7 The standard TAA radius is 46 km (25 NM) from the IAF, and the boundaries between TAAs are normally defined by the extension of the initial segments (see Figure II-1-2-1).

2.1.8 Minimum altitudes charted for each TAA shall provide at least 300 m (1 000 ft) obstacle clearance.

2.1.9 Stepdown arcs

TAAs may contain stepdown arcs defined by an RNAV distance from the IAF (see Figure II-1-2-2).

2.1.10 TAA icons

TAAs are depicted on the plan view of approach charts by the use of “icons” which identify the TAA reference point (IAF or IF), the radius from the reference point, and the bearings of the TAA boundaries. The icon for each TAA will be located and oriented on the plan view with respect to the direction of arrival to the approach procedure, and will show minimum altitudes and stepdowns. The IAF for each TAA is identified by the waypoint name to help the pilot

orient the icon to the approach procedure. The IAF name and the distance of the TAA boundary from the IAF are included on the outside arc of the TAA icon. TAA icons also identify, where necessary, the location of the intermediate fix by the letters “IF” and not the IF waypoint identifier to avoid misidentification of the TAA reference point and to assist in situational awareness (see Figures II-1-2-3 to II-1-2-5).

2.2 FLIGHT PROCEDURES

2.2.1 Establishment

Prior to operating at the TAA, the pilot must determine that the aircraft is located within the TAA boundary by selecting the relevant IAF and measuring the bearing and distance of the aircraft to the IAF. That bearing should then be compared with the published bearings that define the lateral boundaries of the TAA. This is critical when approaching the TAA near the extended boundary between the left and right base areas, especially where TAAs are at different levels.

2.2.2 Manoeuvring

An aircraft may be manoeuvred at the TAA provided the flight path is contained within the TAA boundaries by reference to bearings and distance to the IAF.

2.2.3 Transitioning between TAAs

An aircraft may transition from one TAA to another provided that the aircraft does not descend to, or has climbed to, the next TAA prior to crossing the boundary between TAAs. Pilots must exercise caution in transitioning to another TAA to ensure that reference is made to the correct IAF and that the aircraft is contained within the boundaries of both TAAs.

2.2.4 Entry to procedure

An aircraft established within a TAA area may enter the associated approach procedure at the IAF without conducting a procedure turn provided the angle of turn at the IAF does not exceed 110°. In most cases, the design of the TAA will not require a turn in excess of 110° unless the aircraft is located close to the intermediate segment or is transitioning from one TAA to another. In such cases, the aircraft may be manoeuvred with the TAA to establish the aircraft on a track prior to arrival at the IAF that does not require a procedure turn (see Figure II-1-2-6).

Note. — The maximum 110° requirement ensures that the segment length of the approach procedure is adequate to provide turn anticipation and to permit interception of the following segment at the maximum airspeed permitted for the procedure.

2.2.5 Reversal procedures

Where entry cannot be made to the procedure with a turn at the IAF less than 110°, a reversal procedure shall be flown.

2.2.6 Holding

A racetrack holding procedure will normally be located at an IAF or the IF. When one or more of the initial segments

are not provided, the holding pattern will normally be located to facilitate entry to the procedure (see Figure II-1-2-7).

2.3 NON-STANDARD TAA

2.3.1 Modification to the standard TAA design may be necessary to accommodate operational requirements. Variations may eliminate one or both of the base areas or modify the angular size of the straight-in area. In cases where the left or right base area is eliminated, the straight-in area is modified by extending its 46 km (25 NM) radius to join the remaining area boundary (see Figure II-1-2-7).

2.3.2 If both the left and right base areas are eliminated, the straight-in area is constructed on the straight-in IAF or IF with a 46 km (25 NM) radius, through 360° of arc (see Figure II-1-2-8).

2.3.3 For procedures with a single TAA, the TAA area may be subdivided by pie-shaped sectors with the boundaries identified by magnetic bearings to the IAF, and may have one stepdown arc (see Figure II-1-2-9).

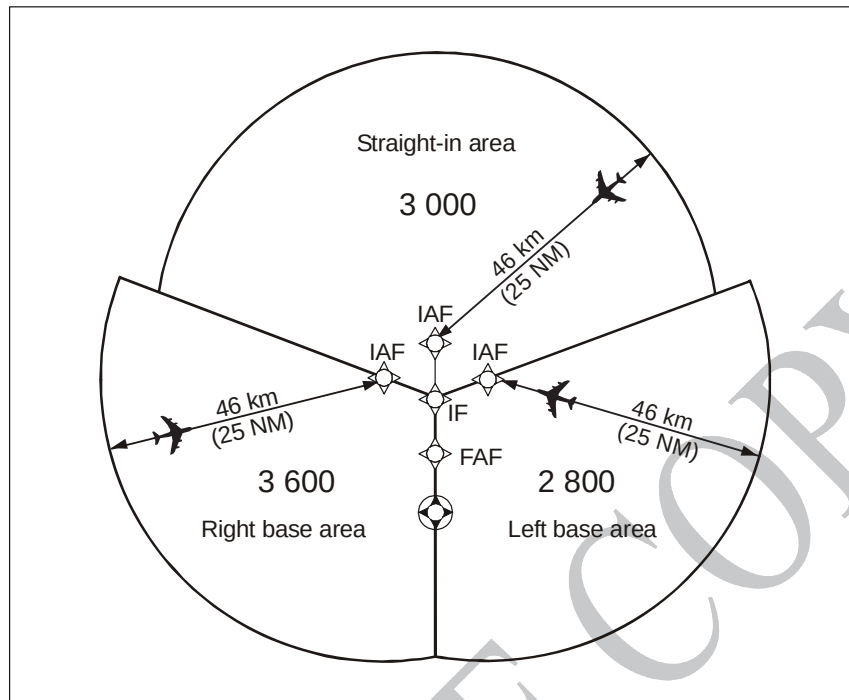


Figure II-1-2-1. Typical TAA arrangement

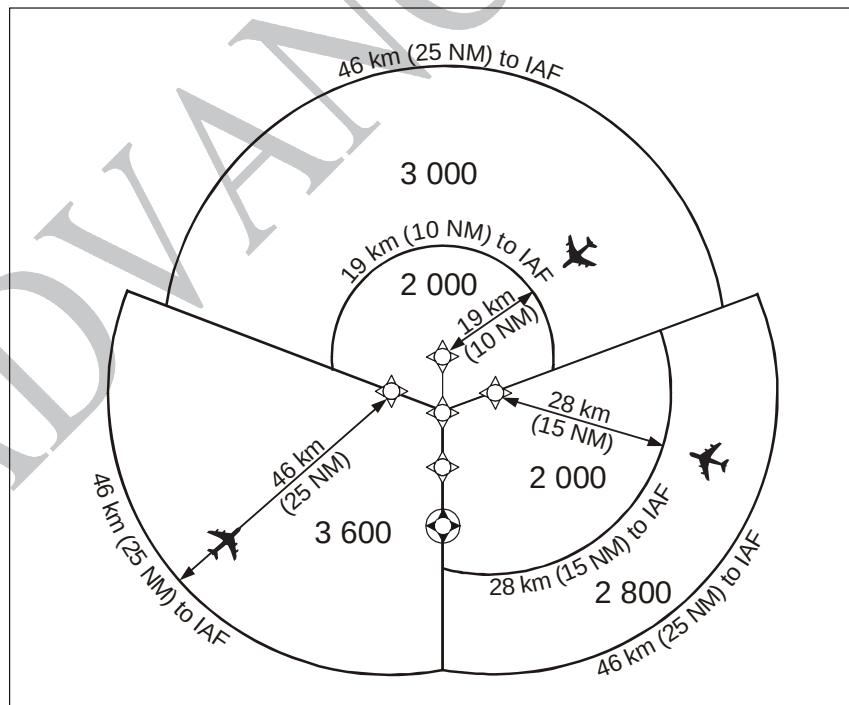


Figure II-1-2-2. TAA with stepdown arcs

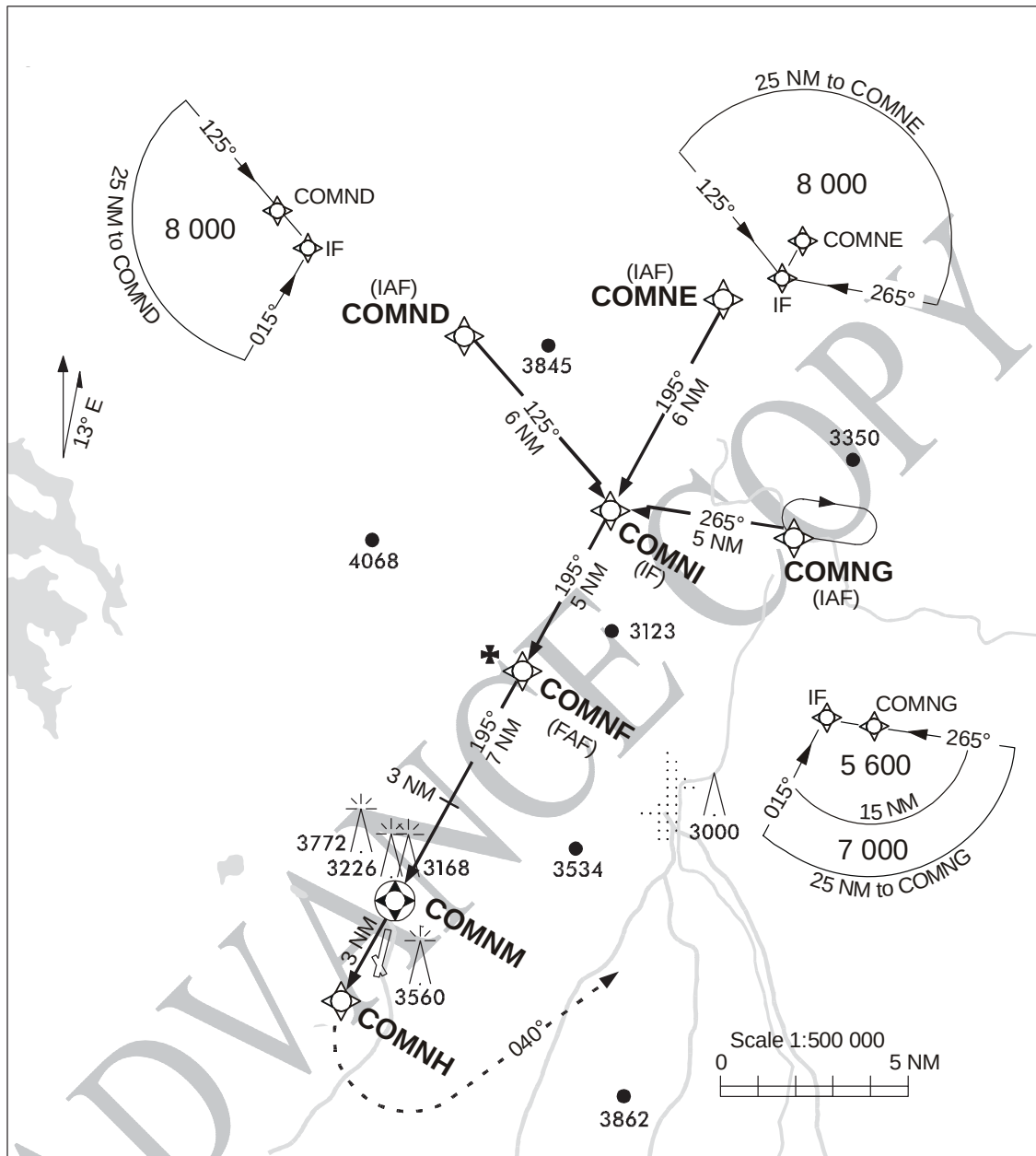


Figure II-1-2-3. TAA "Y" bar icon arrangement

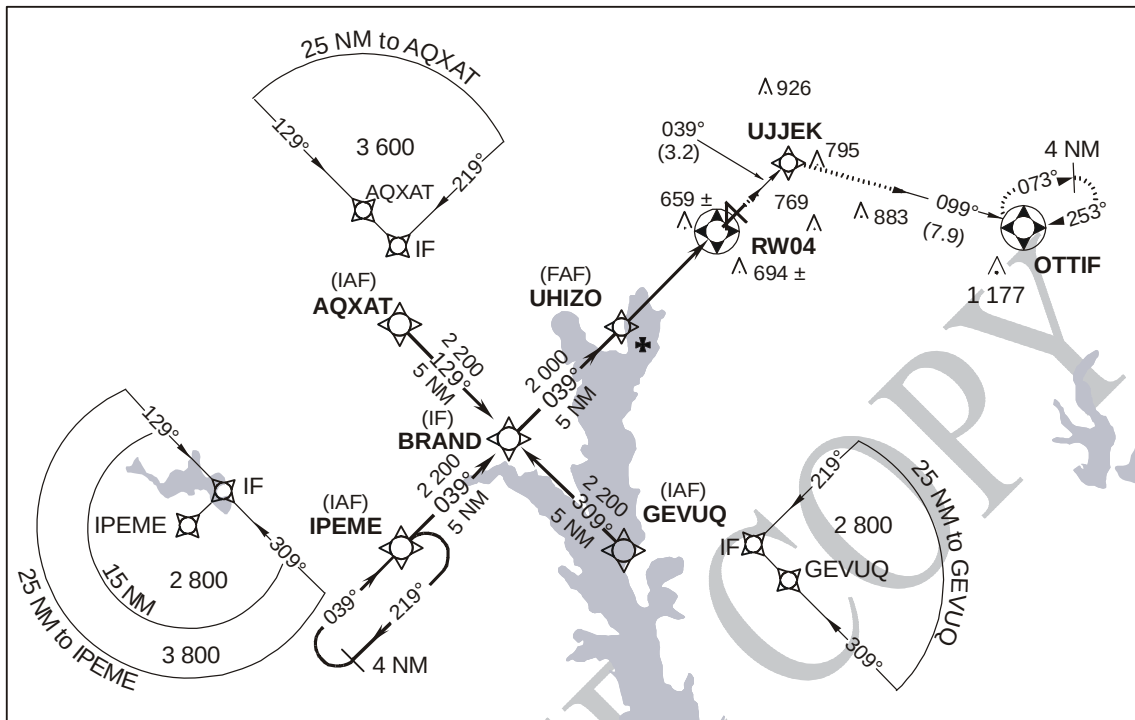


Figure II-1-2-4. "T" bar icon arrangement

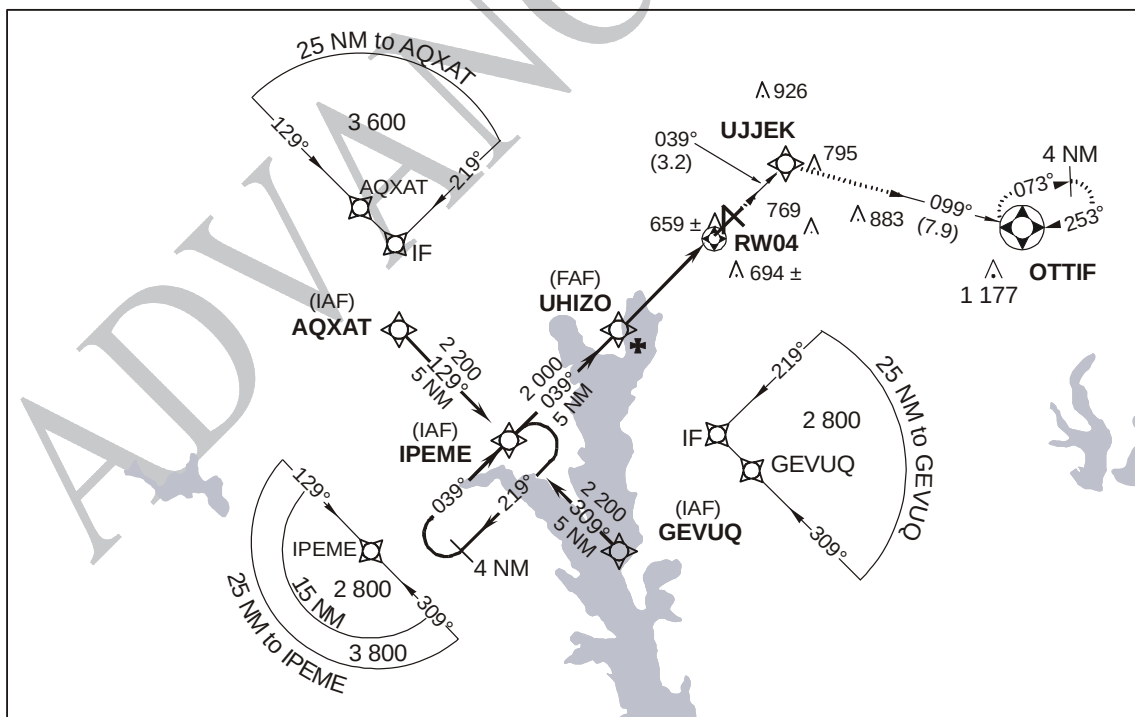
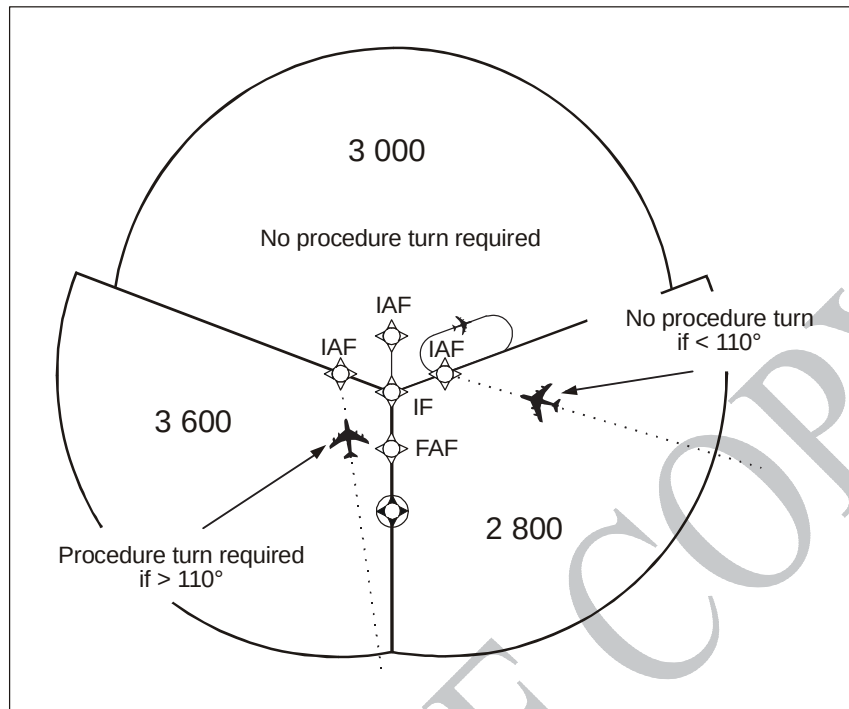
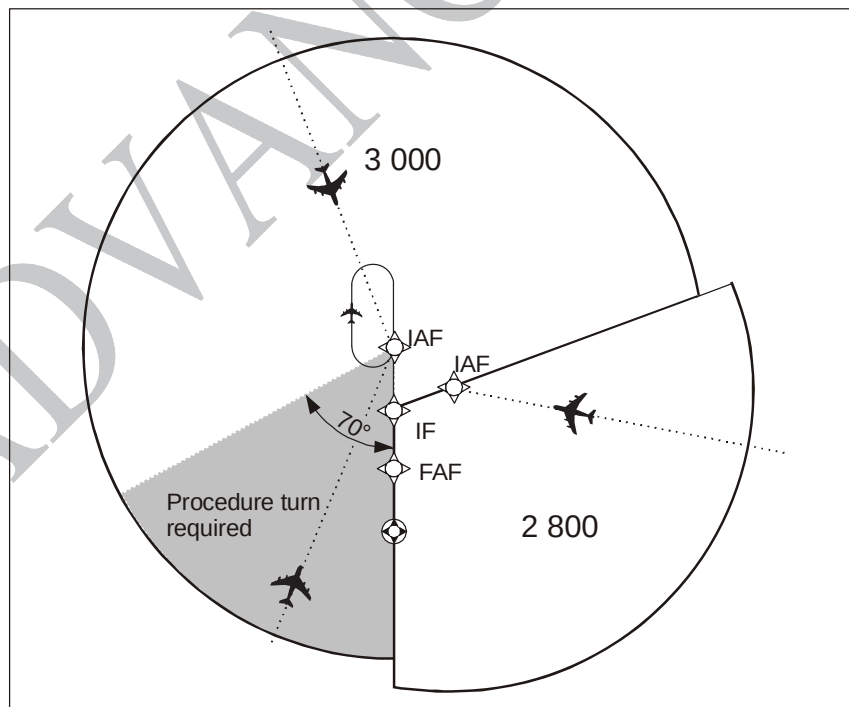


Figure I-2-3-5. "T" bar icon arrangement without centre initial approach fix

**Figure II-1-2-6. Procedure entry****Figure II-1-2-7. TAA arrangement without right base**

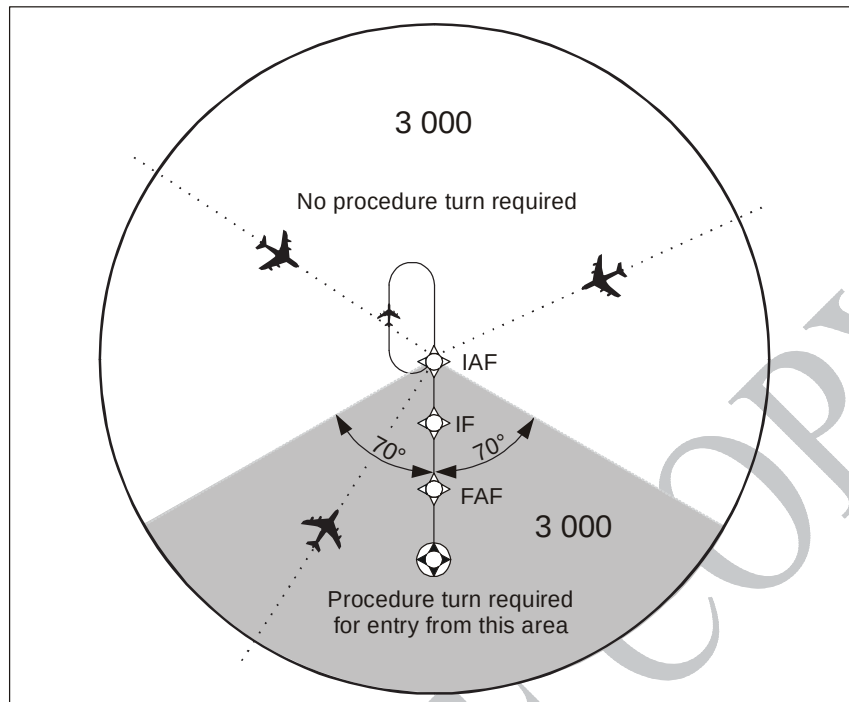


Figure II-1-2-8. TAA arrangement without left and right base

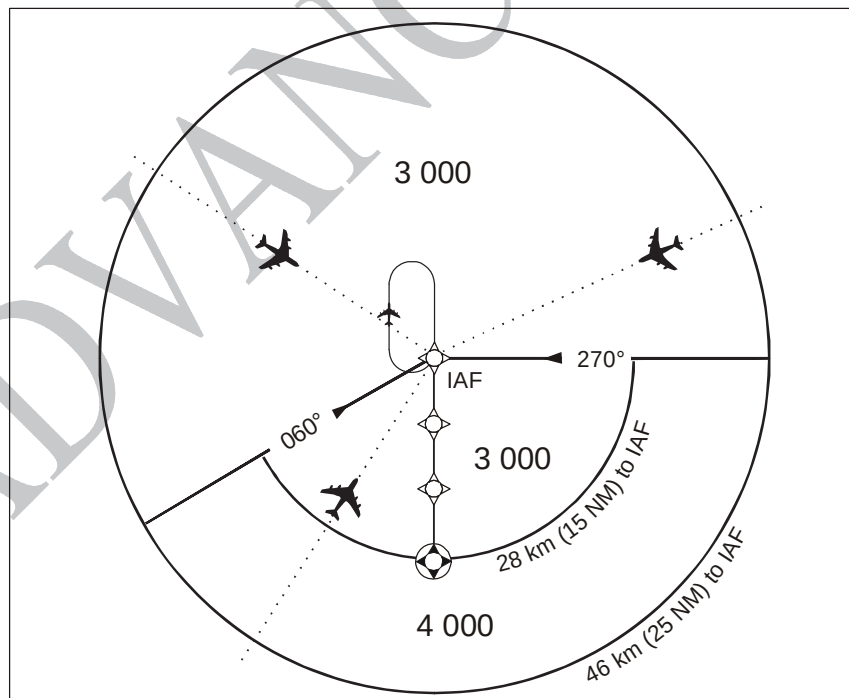


Figure II-1-2-9. Single TAA with sectorization and stepdown

Chapter 3

GENERAL INFORMATION FOR BASIC GNSS

3.1 BASIC GNSS RECEIVER SPECIFICATIONS

3.1.1 The term “basic GNSS receiver” was developed to describe first generation GNSS receivers that at least meet RTCA DO 208, SC-181 and JAA TGL 3, and equivalent IFR certification standards, for example TSO-C129.

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

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

- a) integrity monitoring routines, for example, receiver autonomous integrity monitoring (RAIM);
 - b) turn anticipation; and
 - c) capability for procedures retrieved from the read-only electronic navigation database.
-

Chapter 4

GENERAL INFORMATION FOR SATELLITE-BASED AUGMENTATION SYSTEM (SBAS)

(To be developed)

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Chapter 5

GENERAL INFORMATION FOR GROUND-BASED AUGMENTATION SYSTEM (GBAS)

5.1 GENERAL CRITERIA

5.1.1 GBAS receiver

A GBAS receiver is a type of GNSS avionics that at least meets requirements for a GBAS receiver in Annex 10, Volume I, and specifications of RTCA DO-253A and DO-246B as amended by the respective FAA TSO (or equivalent).

5.1.2 GBAS avionics requirements

Minimum GBAS avionics requirements do not include provisions for RNAV. GBAS may provide a position, velocity and time (PVT) vector output. When the GBAS ground station supports this service, it is called GBAS positioning service. The PVT vector is intended to be used as input to existing on-board navigation equipment. However, there is no requirement that the aircraft be RNAV-equipped. There is no requirement that GBAS avionics provide missed approach guidance. Minimum display functionality is an ILS look-alike and includes display of course deviation indications, vertical deviation indications, distance to threshold information, and failure flags. Without on-board navigation equipment, the pilot is not provided with position and navigation information. Only guidance information relative to the final approach course and glide path is provided.

5.1.3 A more detailed description of GBAS and the performance levels supported by GBAS is provided in Annex 10, Volume I, Attachment D, Section 7, and the *Global Navigation Satellite System (GNSS) Manual* (Doc 9849).

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Section 2

DEPARTURE PROCEDURES

Chapter 1

AREA NAVIGATION (RNAV) DEPARTURE PROCEDURES FOR NAVIGATION SYSTEMS USING BASIC GNSS RECEIVERS

1.1 BACKGROUND

1.1.1 Introduction

This chapter describes GNSS departures based on the use of basic GNSS as a stand-alone receiver or in a multi-sensor RNAV environment. Flight crews should be familiar with the specific functionality of the equipment.

Note.— For text simplicity in this section, the term “flight management computer (FMC)” is used to denote the general category of multi-sensor RNAV systems.

1.1.2 GNSS standards

1.1.2.1 The term “Basic GNSS receiver” designates the GNSS avionics that at least meet the requirements for a GPS receiver as outlined in Annex 10, Volume I, and the specifications of RTCA/DO-208 or EUROCAE ED-72A, as amended by United States Federal Aviation Administration FAA TSO-C129A or European Aviation Safety Agency ETSO-C129A (or equivalent). These documents specify the minimum performance standards that GNSS receivers must meet in order to comply with en-route, terminal area and non-precision approach procedures developed specifically for GNSS.

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

- a) integrity monitoring routines, for example, receiver autonomous integrity monitoring (RAIM);
- b) turn anticipation; and
- c) capability for procedures retrieved from the read-only electronic navigation database.

1.1.2.3 For an FMC, the integrity monitoring routines shall support system sensor selection and usage, as well as status and alerting indications. In this type of implementation, GNSS is just one of several different navigation positioning sources (e.g. IRS/INS, VOR/DME and DME/DME) that may be used individually or in combination with each other.

1.1.2.4 The FMC automatically selects the best (most accurate) source. It also permits the user to deselect or inhibit a sensor type or specific navigation aid from use in calculating position.

1.1.2.5 The FMC may be the source of guidance cues for flight or may also be connected to an autoflight system that provides guidance cues for automatic flight operations. With this type of avionics, the pilot typically interacts with the FMC through a control and display unit. Flight crews should be familiar with the functionality of the FMC,

specifically when GNSS is the primary positioning source.

1.2 GENERAL

1.2.1 Operational approval

Aircraft equipped with basic GNSS receivers (either as stand-alone equipment or in a multi-sensor environment) that have been approved by the State of the Operator for departure and non-precision approach operations may use these systems to carry out RNAV procedures provided that before conducting any flight, the following criteria are met:

- a) the GNSS equipment is serviceable;
- b) the pilot has a current knowledge of how to operate the equipment so as to achieve the optimum level of navigation performance;
- c) satellite availability is checked to support the intended operation;
- d) an alternate airport with conventional nav aids has been selected; and
- e) the procedure is retrievable from an airborne navigation database.

1.2.2 Flight plan

1.2.2.1 Aircraft relying on basic GNSS receivers are considered to be RNAV-equipped. The appropriate equipment suffix shall be included in the flight plan.

1.2.2.2 Where the basic GNSS receiver (whether stand-alone equipment or in a multi-sensor environment) becomes inoperative, the pilot should immediately:

- a) advise ATC;
- b) request an available alternative procedure consistent with the capability of the FMC system; and
- c) amend the equipment suffix, where possible, for subsequent flight plans.

1.2.2.3 It should be noted that depending on the type of certification of the FMC being used, the manufacturers' aircraft flight manuals and data may allow for continued operation.

1.2.3 Navigation database

Departure and approach waypoint information is contained in a navigation database. If the navigation database does not contain the departure or approach procedure, then the basic GNSS stand-alone receiver or FMC shall not be used for these procedures.

1.2.4 Performance integrity

1.2.4.1 The basic GNSS receiver verifies the integrity (usability) of the signals received from the satellite

constellation through RAIM to determine if a satellite is providing corrupted information.

1.2.4.2 Aircraft equipped with a multi-sensor RNAV capability may utilize aircraft autonomous integrity monitoring (AAIM) to perform the RAIM integrity function. AAIM integrity performance must be at least equivalent to RAIM.

1.2.4.3 RAIM generates an alert indicating the possibility of an unacceptable position error if it detects an inconsistency among the set of satellite range measurements currently in use. The RAIM function will be temporarily unavailable when an insufficient number of satellites are being tracked or the satellite geometry is unsuitable.

1.2.4.4 Since the relative positions of the satellites are constantly changing, prior experience with the airport does not guarantee reception at all times so a RAIM availability prediction for the expected departure time should always be checked pre-flight. When RAIM is unavailable, the GNSS procedure must not be used. In this case, the pilot must use another type of navigation system, select another destination or delay the flight until RAIM is predicted to be available.

1.2.4.5 RAIM outages will be more frequent for approach mode than for en-route mode due to the more stringent alert limits. Since factors such as aircraft attitude and antenna location may affect reception of signals from one or more satellites, and since, on infrequent occasions, unplanned satellite outages will occur, RAIM availability predictions cannot be 100 per cent reliable.

1.2.4.6 Most air carrier and corporate aircraft GNSS implementations employ FMCs that rely on the integrity capability of the GNSS sensors incorporating RAIM, as well as FMCs relying on both GNSS sensor RAIM and AAIM. RAIM relies only on satellite signals to perform the integrity function. AAIM uses information from other on-board navigation sensors in addition to GNSS signals to perform the integrity function to allow continued use of GNSS information in the event of a momentary loss of RAIM due to an insufficient number of satellites or the satellite constellation. AAIM integrity performance must be at least equivalent to RAIM performance.

1.2.5 Equipment operation

1.2.5.1 There are a number of manufacturers of basic GNSS receivers and of FMCs using GNSS sensors on the market, and each employs a different pilot interface. Flight crews shall be thoroughly familiar with the operation of their particular system prior to using it in flight operations.

1.2.5.2 The equipment must be operated in accordance with the provisions of the applicable aircraft operating manual. An appropriate checklist shall be available on board the aircraft for easy reference during the sequence of loading information into the system and when operating the equipment.

1.2.6 Operating modes and alert limits

The basic GNSS receiver has three modes of operation: en-route, terminal and approach mode. The RAIM alert limits are automatically coupled to the receiver modes and are set to:

- a) ± 3.7 km (2.0 NM) in en-route mode;
- b) ± 1.9 km (1.0 NM) in terminal mode; and
- c) ± 0.6 km (0.3 NM) in approach mode.

An FMC using GNSS will contain either the three system modes of operation described above, or be required to operate in conjunction with a flight director system or coupled autopilot system to ensure the required level of performance is provided.

1.2.7 Course deviation indicator (CDI) sensitivity

1.2.7.1 The CDI sensitivity is automatically coupled to the operating mode of the receiver. Its settings are:

- a) ± 9.3 km (5.0 NM) in en-route mode;
- b) ± 1.9 km (1.0 NM) in terminal mode; and
- c) ± 0.6 km (0.3 NM) in approach mode.

1.2.7.2 Although a manual selection for CDI sensitivity is available, overriding an automatically selected CDI sensitivity during an approach will cancel the approach mode.

1.2.7.3 The above criteria also applies for an FMC system. Some FMC GNSS implementations may incorporate different display sensitivities for departure operations. These different display sensitivities may be used when guidance is provided by a flight director, autopilot or enhanced guidance displays.

1.3 PRE-FLIGHT

1.3.1 Prior to IFR flight operations using basic GNSS receivers, the operator should ensure that the equipment and the installation are approved and certified for the intended IFR operation, as not all equipment is certified for approach and/or departure procedures.

1.3.2 Prior to any basic GNSS IFR operation, a review of all the NOTAMs appropriate to the satellite constellation should be accomplished.

Note.— Some GNSS receivers may contain the capability to deselect the affected satellite.

1.3.3 The pilot/operator must follow the specific start-up, initialization, and self-test procedures for the GNSS receiver as outlined in the aircraft operating manual.

1.4 DEPARTURE

1.4.1 Equipment capabilities

1.4.1.1 Basic GNSS receivers differ widely in their capabilities. The basic GNSS receiver operating manual must be checked to ensure that:

- a) the correct annunciation for the receiver departure mode is available. If departure mode is not available, then either:
 - 1) a mode appropriate for the GNSS equipment used during departure must be selected to ensure the required integrity; or
 - 2) the GNSS equipment must not be used during departure;

- b) the database contains the required transitions and departures. Databases may not contain all of the transitions or departures from all runways, and some basic GNSS receivers do not contain standard instrument departures (SIDs) in their databases at all; and
- c) terminal RAIM alarm alert limits are automatically provided by the receiver (terminal RAIM alarm alert limits may not be available unless the waypoints are part of the active flight plan).

1.4.1.2 Some FMC installations may not provide the terminal RAIM alarm alert but should provide an equivalent capability appropriate to the operation.

1.4.2 Equipment set-up

1.4.2.1 The basic GNSS receiver must be selected to the appropriate mode for use in departure, as indicated for the departure procedure (for example, the charted procedure may indicate that terminal mode is appropriate if departure mode is not available, see 1.4.1.1) with CDI sensitivity of ± 1.9 km (1.0 NM).

1.4.2.2 The departure navigation routes must be loaded into the active flight plan from a current navigation database in order to fly the published SID. Certain segments of a SID may require some manual intervention by the pilot, especially when the aircraft is radar vectored to a track or required to intercept a specific track to a waypoint.

1.4.2.3 Some FMC installations will rely on a combination of indications and situation information on electronic map displays and primary flight displays, in conjunction with required operating configurations (for example, conduct of procedures using the flight director), providing equivalency to conduct of the operation based upon the CDI.

1.4.3 Straight departures

Where the alignment of the initial departure track ($\alpha < 15^\circ$) is determined by the position of the first waypoint located after the DER, there are no unique requirements for the basic GNSS receiver.

1.4.4 Turning departures

Turns are specified as a “turn at a fly-by waypoint”, “turn at a flyover waypoint” or “turn at an altitude/height”. For some systems, turns at an altitude/height cannot be coded in the database, and in this case, such turns must be executed manually.

Chapter 2

AREA NAVIGATION (RNAV) DEPARTURE PROCEDURES FOR SATELLITE-BASED AUGMENTATION SYSTEM (SBAS)

2.1 GENERAL CRITERIA

2.1.1 Introduction

2.1.1.1 An SBAS augments core satellite constellations by providing ranging, integrity and correction information via geostationary satellites. The system comprises a network of ground reference stations that observe satellite signals, and master stations that process observed data and generate SBAS messages for uplink to the geostationary satellites, which broadcast the SBAS message to the users.

2.1.1.2 By providing extra ranging signals via geostationary satellites and enhanced integrity information for each navigation satellite, SBAS delivers a higher availability of service than the core satellite constellations.

2.1.1.3 A more detailed description of SBAS and the performance levels supported by SBAS is provided in Annex 10, Volume I, Chapter 3, and Attachment D, Section 6, and the *Global Navigation Satellite System (GNSS) Manual* (Doc 9849).

2.1.2 SBAS receiver

An SBAS receiver is a type of GNSS avionics that at least meets requirements for an SBAS receiver as laid down in Annex 10, Volume I, and specifications of RTCA DO-229C, as amended by FAA TSO-C145A/146A (or equivalent).

2.2 DEPARTURE

2.2.1 Departure procedure

The entire departure procedure must be selected from the airborne database. Pilot entry of the departure procedure is not authorized. When integrity requirements cannot be met to support the SBAS departure operation, the SBAS receiver will annunciate the procedure is not available.

2.2.2 Straight departure

From the DER to the turn initiation point of the first waypoint in the departure procedure, the SBAS receiver provides a nominal full-scale deflection (FSD) of 0.3 NM. Larger FSDs may be acceptable with augmentations, such as an autopilot, that can control the flight technical error.

2.2.3 Terminal operation mode reversion

At the turn initiation point for the first waypoint in the departure procedure, the SBAS receiver will revert to the terminal operation mode with an FSD of 1 NM. The SBAS receiver will continue to function in the terminal integrity mode until the last waypoint of the departure procedure is sequenced. After this waypoint, the SBAS receiver will provide en-route integrity.

2.2.4 Turning departure

The criteria are dependent on whether the first waypoint is a fly-by or flyover waypoint. For a fly-by waypoint, turn anticipation is always provided. At turn initiation, FSD and integrity performance transitions are as described in 2.2.2, “Straight departure”. For a flyover waypoint, there is no turn anticipation. FSD and integrity performance transitions occur when the waypoint is sequenced. The SBAS receiver will not transition to en-route integrity performance until the final waypoint in the departure procedure is sequenced.

Chapter 3

AREA NAVIGATION (RNAV) DEPARTURE PROCEDURES FOR GROUND-BASED AUGMENTATION SYSTEM (GBAS)

3.1 DEPARTURE OPERATIONS

No departure criteria specifically designed for GBAS exists. Departure operations based upon basic GNSS or SBAS may be flown by aircraft with a GBAS receiver using the optional GBAS positioning service. (See Chapter 1, “Area Navigation (RNAV) Departure Procedures for Navigation Systems using Basic GNSS Receivers” and Chapter 2, “Area Navigation (RNAV) Departure Procedures for Satellite-based Augmentation System (SBAS)”).

Chapter 4

AREA NAVIGATION (RNAV) DEPARTURE PROCEDURES AND RNP-BASED DEPARTURE PROCEDURES

4.1 This chapter describes area navigation (RNAV) departure procedures for VOR/DME, DME/DME and RNP. The general principles of RNAV and RNP-based approach procedures apply also to RNAV and RNP-based departures.

4.2 Departures may be based on RNAV VOR/DME, RNAV DME/DME, basic GNSS or RNP criteria. Most FMS-equipped aircraft are capable of following RNAV procedures based on more than one of the above systems. However, in some cases the procedure may specify constraints on the system used.

4.3 To follow a procedure based on RNP, the RNAV system must be approved for the promulgated RNP and it is assumed that all the nav aids on which the RNP procedure is based are in service (see NOTAMs related to DME stations, GNSS, etc.).

4.4 A route may consist of segments where different RNP values are applicable. Note that the segment with the lowest RNP value is the most demanding one for the flight. Prior to the flight, the pilot must verify that the aircraft is able to meet the RNP requirements specified for each segment. In some cases, this may require the pilot to manually update the aircraft's navigation system immediately before take-off.

4.5 During the flight, the pilot must check that the system complies with the RNP requirements of the current segment. The pilot must also check in particular the RNP changes along the route.

4.6 The pilot will use the system's information to intervene and keep the flight technical error (FTE) to within the tolerances established during the system certification process.

4.7 There are four kinds of turns:

- a) turn at a fly-by waypoint;
- b) turn at a flyover waypoint;
- c) turn at an altitude/height; and
- d) fixed radius turn (generally associated with procedures based on RNP).

Section 3

**ARRIVAL AND NON-PRECISION
APPROACH PROCEDURES**

Chapter 1

AREA NAVIGATION (RNAV) ARRIVAL AND APPROACH PROCEDURES FOR NAVIGATION SYSTEMS USING BASIC GNSS RECEIVERS

1.1 BACKGROUND

1.1.1 Introduction

This chapter describes non-precision approach procedures based on the use of basic GNSS as a stand-alone receiver or in a multi-sensor RNAV environment. Flight crews should be familiar with the specific functionality of the equipment.

Note.— For text simplicity in this section, the term “flight management computer (FMC)” is used to denote the general category of multi-sensor RNAV systems.

1.1.2 GNSS standards

1.1.2.1 The term “basic GNSS receiver” designates GNSS avionics that at least meet requirements for a GPS receiver in Annex 10, Volume I, and specifications of RTCA DO 208, or EUROCAE ED-72A, as amended by FAA TSO-C129A or JAA TSO C129 (or equivalent). These documents specify the minimum performance standards that GNSS receivers must meet in order to comply with en-route, terminal area and non-precision approach procedures developed specifically for GNSS.

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

- a) integrity monitoring routines, for example, receiver autonomous integrity monitoring (RAIM);
- b) turn anticipation; and
- c) capability for procedures retrieved from the read-only electronic navigation database.

1.1.2.3 For an FMC, the integrity monitoring routines shall support system sensor selection and usage, as well as status and alerting indications. In this type of implementation, GNSS is just one of several different navigation positioning sources (e.g. IRS/INS, VOR/DME, DME/DME, and localizer) that may be used individually or in combination with each other.

1.1.2.4 The FMC automatically selects the best (most accurate) source. It also permits the user to deselect or inhibit a sensor type or specific navigation aid from use in calculating position.

1.1.2.5 The FMC may be the source of guidance cues for flight or may also be connected to an autoflight system that provides guidance cues for automatic flight operations. With this type of avionics, the pilot typically interacts with the FMC through a control and display unit. Flight crews should be familiar with the functionality of the FMC,

specifically when GNSS is the primary positioning source.

1.2 GENERAL

1.2.1 Operational approval

Aircraft equipped with basic GNSS receivers (either as stand-alone equipment or in a multi-sensor environment) that have been approved by the State of the Operator for approach operations may use these systems to carry out RNAV procedures provided that before conducting any flight, the following criteria are met:

- a) the GNSS equipment is serviceable;
- b) the pilot has a current knowledge of how to operate the equipment so as to achieve the optimum level of navigation performance;
- c) satellite availability is checked to support the intended operation;
- d) an alternate airport with conventional nav aids has been selected; and
- e) the procedure is retrievable from an airborne navigation database.

1.2.2 Flight plan

1.2.2.1 Aircraft relying on basic GNSS receivers are considered to be RNAV-equipped. The appropriate equipment suffix shall be included in the flight plan.

1.2.2.2 Where the basic GNSS receiver (whether stand-alone equipment or in a multi-sensor environment) becomes inoperative, the pilot should immediately:

- a) advise ATC;
- b) request an available alternative procedure consistent with the capability of the FMC system; and
- c) amend the equipment suffix, where possible, for subsequent flight plans.

1.2.2.3 It should be noted that depending on the type of certification of the FMC being used, the manufacturers' aircraft flight manuals and data may allow for continued operation.

1.2.3 Navigation database

Departure and approach waypoint information is contained in a navigation database. If the navigation database does not contain the departure or approach procedure, then the basic GNSS stand-alone receiver or FMC shall not be used for these procedures.

1.2.4 Performance integrity

1.2.4.1 The basic GNSS receiver verifies the integrity (usability) of the signals received from the satellite

constellation through RAIM to determine if a satellite is providing corrupted information.

1.2.4.2 Aircraft equipped with a multi-sensor RNAV capability could rely on the integrity capability of the GNSS sensors incorporating RAIM, as well as AAIM. RAIM relies only on satellite signals to perform the integrity function. AAIM uses information from other on-board navigation sensors in addition to GNSS signals to perform the integrity function to allow continued use of GNSS information in the event of a momentary loss of RAIM due to an insufficient number of satellites or the satellite constellation. AAIM integrity performance must be at least equivalent to RAIM performance.

1.2.4.3 RAIM outages may occur due to an insufficient number of satellites or due to unsuitable satellite geometry which causes the error in the position solution to become too large. Loss of satellite reception and RAIM warnings may also occur due to aircraft dynamics (changes in pitch or bank angle). Antenna location on the aircraft, satellite position relative to the horizon, and aircraft attitude may affect reception of one or more satellites.

1.2.4.4 Since the relative positions of the satellites are constantly changing, prior experience with the airport does not guarantee reception at all times, and RAIM availability should always be checked. If RAIM is not available, another type of navigation and approach system must be used, another destination selected or the flight delayed until RAIM is predicted to be available on arrival. On longer flights, pilots should consider rechecking the RAIM prediction for the destination during the flight. This may provide early indications that an unscheduled satellite outage has occurred since take-off.

1.2.4.5 RAIM outages will be more frequent for approach mode than for en-route mode due to the more stringent alert limits. Since factors such as aircraft attitude and antenna location may affect reception of signals from one or more satellites, and since, on infrequent occasions, unplanned satellite outages will occur, RAIM availability predictions cannot be 100 per cent reliable.

1.2.5 Equipment operation

1.2.5.1 There are a number of manufacturers of basic GNSS receivers and of FMCs using GNSS sensors on the market, and each employs a different method of interface. While most utilize a user interface known as a control and display unit, there are systems that also utilize a graphical user interface. Flight crews shall be thoroughly familiar with the operation of their particular system prior to using it in flight operations.

1.2.5.2 The equipment must be operated in accordance with the provisions of the applicable aircraft operating manual. An appropriate checklist shall be available on board the aircraft for easy reference during the sequence of loading information into the system and when operating the equipment.

1.2.6 Operating modes and alert limits

The basic GNSS receiver has three modes of operation: en-route, terminal and approach mode. The RAIM alert limits are automatically coupled to the receiver modes and are set to:

- a) ± 3.7 km (2.0 NM) in en-route mode;
- b) ± 1.9 km (1.0 NM) in terminal mode; and
- c) ± 0.6 km (0.3 NM) in approach mode.

An FMC using GNSS will contain either the three system modes of operation described above, or be required to operate in conjunction with a flight director system or coupled autopilot system to ensure the required level of performance is provided.

1.2.7 Course deviation indicator (CDI) sensitivity

1.2.7.1 The CDI sensitivity is automatically coupled to the operating mode of the receiver. Its settings are:

- a) ± 9.3 km (5.0 NM) in en-route mode;
- b) ± 1.9 km (1.0 NM) in terminal mode; and
- c) ± 0.6 km (0.3 NM) in approach mode.

1.2.7.2 Although a manual selection for CDI sensitivity is available, the pilot may only manually select a CDI sensitivity other than ± 0.6 km (0.3 NM). Overriding an automatically selected CDI sensitivity during an approach will cancel the approach mode and approach mode annunciation.

1.2.7.3 Some FMC GNSS implementations may incorporate different display sensitivities for approach operations from those shown above. These different display sensitivities may be used when guidance is provided by a flight director or autopilot. Regardless of the approach display sensitivity differences between FMC GNSS implementations, equivalent integrity must still be provided.

1.3 PRE-FLIGHT

1.3.1 Prior to IFR flight operations using basic GNSS receivers, the operator should ensure that the equipment and the installation are approved and certified for the intended IFR operation, as not all equipment is certified for approach and/or departure procedures.

1.3.2 Prior to any basic GNSS IFR operation, a review of all the NOTAMs appropriate to the satellite constellation should be accomplished.

Note.— Some GNSS receivers may contain the capability to deselect the affected satellite.

1.3.3 The pilot/operator must follow the specific start-up, initialization, and self-test procedures for the equipment as outlined in the aircraft operating manual.

1.3.4 For an FMC system, any special conditions or limitations for approach operations and alternatives will be specified in the aircraft operating manual. One type may utilize steps identical to those described above. Other types may require an operations control centre to perform an assessment of RAIM availability and provide this data as part of the flight dispatch information.

1.3.5 For basic GNSS stand-alone receivers, the pilot shall select the appropriate airport(s), runway/approach procedure and initial approach fix on the aircraft's GNSS receiver to determine RAIM availability for that approach. Air traffic services personnel may not be able to provide any information about the operational integrity of the navigation services and approach procedure. This is especially important when the aircraft has been "cleared for the approach". Procedures should be established in the event that GNSS navigation outages are predicted or occur. In these situations, the pilot must revert to an alternative method of navigation.

1.4 GNSS APPROACH PROCEDURES

1.4.1 Usually, flying a basic GNSS non-precision instrument approach procedure is very similar to a traditional approach. The differences include the navigation information displayed on the GNSS equipment control and display unit and the terminology used to describe some of the features.

1.4.2 Flying a basic GNSS approach is normally point-to-point navigation and independent of any ground-based nav aids.

1.4.3 GNSS procedures utilize a straight line (TO-TO) flight from waypoint to waypoint, as sequenced in the database. Slight differences between the published track and the track presented may occur. These differences are usually due to rounding of the track bearing and/or the application of magnetic variation.

1.4.4 The approach cannot be flown unless that instrument approach is retrievable from the avionics database which:

- a) contains all the waypoints depicted in the approach to be flown;
- b) presents them in the same sequence as the published procedure chart; and
- c) is updated for the current AIRAC cycle.

1.4.5 To ensure the correctness of the GNSS database display, pilots should check the data displayed as reasonable for the GNSS approach after loading the procedure into the active flight plan and prior to flying the procedure. Some GNSS avionics implementations provide a moving map display which aids the pilot in conducting this reasonableness check.

1.4.6 Pilots should not attempt to fly any approach unless the procedure is contained in the current navigation database. Flying from one approach waypoint to another waypoint that has not been loaded from a database does not ensure compliance with the published approach procedure. For the basic GNSS receiver, the proper RAIM alert limit will not be selected and the CDI sensitivity will not automatically change to ± 0.6 km (0.3 NM). An FMC using GNSS may contain either the same RAIM alert limits as the basic GNSS receiver, or appropriate navigation performance indications and alerts for ± 0.6 km (0.3 NM). For both basic GNSS and FMCs, manually setting CDI sensitivity does not automatically change the RAIM alert limit on some avionics implementations.

1.4.7 Approaches must be flown in accordance with the aircraft operating manual and the procedure depicted on an appropriate instrument approach chart.

1.4.8 Operators must be familiar with their State's basic GNSS implementation procedures. The aircraft must have the appropriate avionics installed and operational to receive the navigation aids. The operator is responsible for checking NOTAMs to determine the operational status of the alternate airport navigation aids.

1.4.9 Procedures must be established in the event that GNSS outages occur. In these situations, the operator must rely on other instrument procedures. For installations where the FMC includes an AAIM capability, there may be no disruption to the operation unless the outage exceeds the FMC capability to sustain the required level of performance.

1.4.10 To begin the basic GNSS approach, the appropriate airport, runway/approach procedure and initial approach fix (IAF) must first be selected. Pilots must maintain situational awareness to determine the bearing and distance to the GNSS procedure IAF before flying the procedure. This can be critical to ascertain whether entering a right or left base when entering the terminal approach area in the vicinity of the extended runway centre line. All sectors and stepdowns are based on the bearing and distance to the IAF for that area, which the aircraft should be proceeding direct to, unless on radar vectors.

1.4.11 Pilots must fly the full approach from the IAF unless specifically cleared otherwise. Randomly joining an approach at an intermediate fix does not ensure terrain clearance.

1.4.12 When an approach has been loaded in the airborne navigation database, the following actions are required. Depending on the GNSS equipment, some or all of the actions described below may take place automatically. Note that some FMC implementations do not conform to the display sensitivities discussed but instead provide comparable operations as described in the aircraft operating manual.

- a) upon reaching a distance of 56 km (30 NM) to the aerodrome reference point, basic GNSS receivers will give either an “arm” annunciation or where the systems automatically arm the operation, an indication that the aircraft is in the terminal area;
- b) at this annunciation, the pilot must arm the approach mode. Some, but not all, GNSS avionics implementations will arm the approach mode automatically;
- c) if the pilot arms the approach mode early (e.g. where the IAF is beyond a range of 56 km (30 NM) from the aerodrome reference point), no changes to the CDI sensitivity occur until reaching a range of 56 km (30 NM). This does not apply to systems that automatically arm for the operation;
- d) when both the approach mode is armed and the aircraft is within 56 km (30 NM) of the aerodrome reference point, the basic GNSS receiver changes to terminal mode sensitivity at 56 km (30 NM) and the associated RAIM setting. If the pilot fails to ensure the approach is armed at or before a range of 56 km (30 NM) from the aerodrome reference point, the receiver does not change to terminal mode, and obstacle clearance is not ensured. The obstacle clearance criteria assumes the receiver is in terminal mode, and the areas are based on this assumption;
- e) on reaching a distance of 3.7 km (2.0 NM) before the FAF, and provided the approach mode is armed (which it should be, see item c) above), the CDI sensitivity and RAIM ramp to smoothly reach the approach values (0.6 km (0.3 NM)) at the FAF. In addition, the “approach active” annunciation will appear;
- f) the pilot must check the “approach active” annunciator at or before passing the FAF and execute a missed approach if it is not present, or if it is cancelled by overriding an automatically selected sensitivity; and
- g) if the CDI is not centred when the CDI sensitivity changes, any displacement will be magnified and give the incorrect impression that the aircraft is diverging further, although it may be on a satisfactory intercept heading. To avoid this phenomenon, pilots should ensure they are well established on the correct track at least 3.7 km (2.0 NM) before the FAF.

1.4.13 The pilot must be aware of the bank angle/turn rate that the particular GNSS avionics implementation uses to compute turn anticipation, and whether wind and airspeed are included in the calculations. This information must be in the manual describing avionics functionality. Over- or under-banking the turn onto the final approach course may significantly delay achieving course alignment and may result in high descent rates to achieve the next segment altitude.

1.4.14 Pilots must pay particular attention to the exact operation of the basic GNSS avionics implementations for performing holding patterns and, in the case of overlay approaches, operations such as procedure turns and course reversals. These procedures may require manual intervention by the pilot to stop the sequencing of waypoints by the receiver and to resume automatic GNSS navigation sequencing once the manoeuvre is complete. The same waypoint may appear in the route of flight more than once consecutively (IAF, FAF, MAHF on a procedure turn/course reversal).

1.4.15 The pilot shall ensure that the receiver is sequenced to the appropriate waypoint for the segment of the procedure being flown, especially if one or more flyovers are omitted (FAF rather than IAF if the procedure turn is not flown). The pilot may have to bypass one or more flyovers of the same waypoint in order to start GNSS sequencing at the proper place in the sequence of waypoints.

1.4.16 For FMC installations providing a control display unit or graphical user interface and an electronic map display, the pilot should have sufficient situational awareness and means to conveniently monitor and ensure that the procedure to be flown is consistent with the cleared procedure.

1.4.17 GNSS procedures are developed based upon features built into the basic GNSS receiver. These features are provided to permit a reduced flight technical error (FTE) as a result of increasing the sensitivity of the CDI at specific points during the approach.

1.4.18 For FMC installations, the same may be true where pilot tracking performance relies on the CDI. In the cases where flight director guidance cues or FMC/autopilot coupled operation is provided, along with an electronic map display, the FTE is managed and reduced based upon the choice of guidance control as well as the method of displaying the tracking information.

1.4.19 All FMCs and some stand-alone basic GNSS receivers provide altitude information. However, the pilot must still comply with the published minimum altitudes using the barometric altimeter. Where the FMC provides vertical information, flight director guidance cues, or coupled autopilot operation, the pilot should follow the appropriate information or cues along with any necessary cross checks with the barometric altimetry.

1.4.20 The equipment will automatically present the waypoints from the IAF to the MAHF, unless a manual pilot action has already been taken.

1.4.21 Sequencing at the MAPt

1.4.21.1 Basic GNSS equipment may not automatically sequence to the next required waypoint. In this case, it may be necessary to manually sequence the GNSS equipment to the next waypoint.

1.4.21.2 An FMC will provide for automatic sequencing.

1.4.22 Radar vectors

1.4.22.1 With basic GNSS stand-alone equipment, it may be required to manually select the next waypoint so that GNSS is correctly using the appropriate database points and associated flight paths.

1.4.22.2 For FMC installations, the systems typically provide what is known as a “direct-to” capability to support radar vectors under FMC guidance.

1.5 INITIAL APPROACH SEGMENT

1.5.1 Offset IAFs

1.5.1.1 Offset IAFs in procedures based on the “Y” or “T” bar design concept for basic GNSS are aligned such that a course change of 70° to 90° is required at the IF. A capture region is associated with each IAF of the basic GNSS procedure from which the aircraft will enter the procedure. The capture region for tracks inbound to the offset IAFs extends 180° about the IAFs, thus providing a Sector 3 entry in cases where the track change at the IF is 70°. The central IAF is aligned with the final approach track, the angle being identical to the track change at the IF for the corresponding offset IAF. In this way, there are no gaps between the capture regions of all IAFs regardless of the course change at the IF. Its capture region is 70° to 90° either side of the final track. For turns greater than 110° at the IAFs, Sector 1 or 2 entries should be used (see Figures II-3-1-1 and II-3-1-2).

1.5.1.2 When used, the central initial approach segment has no maximum length. The optimum length is 9.3 km (5.0 NM). The minimum segment length is established by using the highest initial approach speed of the fastest category of aircraft for which the approach is designed and the minimum distance between waypoints required by the aircraft avionics in order to correctly sequence the waypoints.

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

1.6 INTERMEDIATE APPROACH SEGMENT

1.6.1 The intermediate segment consists of two components — a turning component abeam the IF followed by a straight component immediately before the final approach fix (FAF). The length of the straight component is variable but will not be less than 3.7 km (2.0 NM) allowing the aircraft to be stabilized prior to overflying the FAF.

1.6.2 The intermediate segment will be contained within the approach procedure contained in the FMC navigation database. It will correspond to the charted procedure.

1.7 FINAL APPROACH SEGMENT

1.7.1 The final approach segment for a GNSS approach will begin at a named waypoint normally located 9.3 km (5.0 NM) from the runway threshold.

1.7.2 Course sensitivity

1.7.2.1 The CDI sensitivity related to GNSS equipment varies with the mode of operation. In the en-route phase, prior to the execution of the instrument approach, the display sensitivity full-scale deflection is 9.3 km (5.0 NM) either side of centre line.

1.7.2.2 For an FMC system, the appropriate course sensitivity may be achieved with the flight crew selection of the appropriate electronic map scale. Where the map scale selections are unsuitable (that is, too large or resolution is insufficient), mitigation may be possible with the use of flight director guidance cues or FMC/autopilot coupled operations.

1.7.2.3 Upon activation of the approach mode, the display sensitivity transitions from a full-scale deflection of 9.3 km (5.0 NM) to 1.9 km (1.0 NM) either side of centre line.

1.7.2.4 At a distance of 3.7 km (2.0 NM) inbound to the FAF, the display sensitivity begins to transition to a full-scale deflection of 0.6 km (0.3 NM) either side of centre line. Some GNSS avionics may provide an angular display between the FAF and MAPt that approximates the course sensitivity of the localizer portion of an ILS.

1.7.3 Stepdown fixes

1.7.3.1 A stepdown fix is flown in the same manner as a ground-based approach. Any required stepdown fixes prior to the missed approach waypoint will be identified by along-track distances.

1.7.3.2 Where the FMC includes a vertical navigation capability, the navigation database procedure may contain a

continuous descent flight path that remains above the stepdown procedure vertical profile. Use of FMC vertical navigation capability will be subject to flight crew familiarity, training and any other requirements of the operational approval.

1.7.4 Descent gradient/angle

The optimum descent gradient/angle is 5.2 per cent/3°, however where a higher gradient/angle is necessary, the maximum permissible is 6.5 per cent/3.7°. The descent gradient/angle is published.

1.8 MISSED APPROACH SEGMENT

1.8.1 CDI sensitivity

1.8.1.1 For basic GNSS receivers, sequencing of the guidance past the MAPt activates transition of the CDI sensitivity and RAIM alert limit to terminal mode (1.9 km (1.0 NM)).

1.8.1.2 While these criteria may apply, some FMCs may incorporate different display sensitivities for missed approach operations. These different display sensitivities may be used when there is guidance provided by flight director cues or autopilot. Regardless of the missed approach display sensitivity differences with the FMC GNSS implementations, equivalent integrity of the operation must still be provided.

1.8.2 A GNSS missed approach requires pilot action to sequence the basic GNSS receiver past the MAPt to the missed approach portion of the procedure. The pilot must be thoroughly familiar with the activation procedure for the particular basic GNSS avionics implementations installed in the aircraft and must initiate appropriate action after the MAPt.

1.8.3 Activating the missed approach prior to the MAPt will cause CDI sensitivity to immediately change to terminal (± 1.0 NM sensitivity), and navigation guidance will continue to the MAPt. The guidance will not be provided beyond MAPt or initiate a missed approach turn without pilot action.

1.8.4 If the missed approach is not activated, the basic GNSS avionics implementation will display an extension of the inbound final course and the along-track distance will increase from the MAPt until it is manually sequenced after crossing the MAPt.

1.8.5 These criteria generally apply to FMCs. There will, however, also be installations, especially those using navigation information on the moving map display, where the FMC path guidance will be continuously displayed for the missed approach.

1.8.6 For the basic GNSS receiver, missed approach routings in which the first track is via a specified course rather than “direct to” the next waypoint requires additional action by the pilot to set the course. Being familiar with all of the inputs required is especially critical during this phase of flight.

1.8.7 The missed approach tracks are typically included in the FMC’s navigation database, such that no pilot action is required.

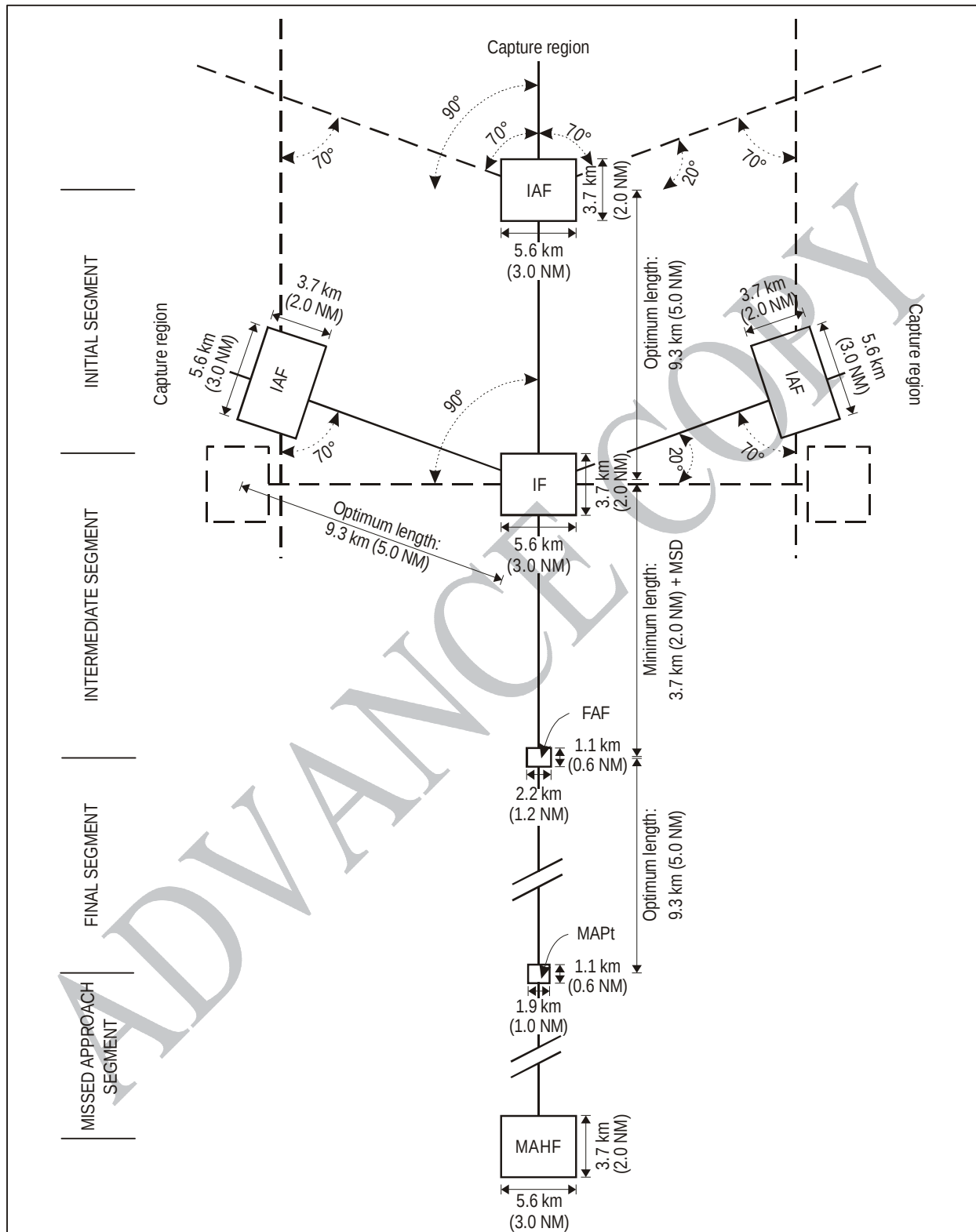


Figure II-3-1-1. Basic GNSS RNAV approach

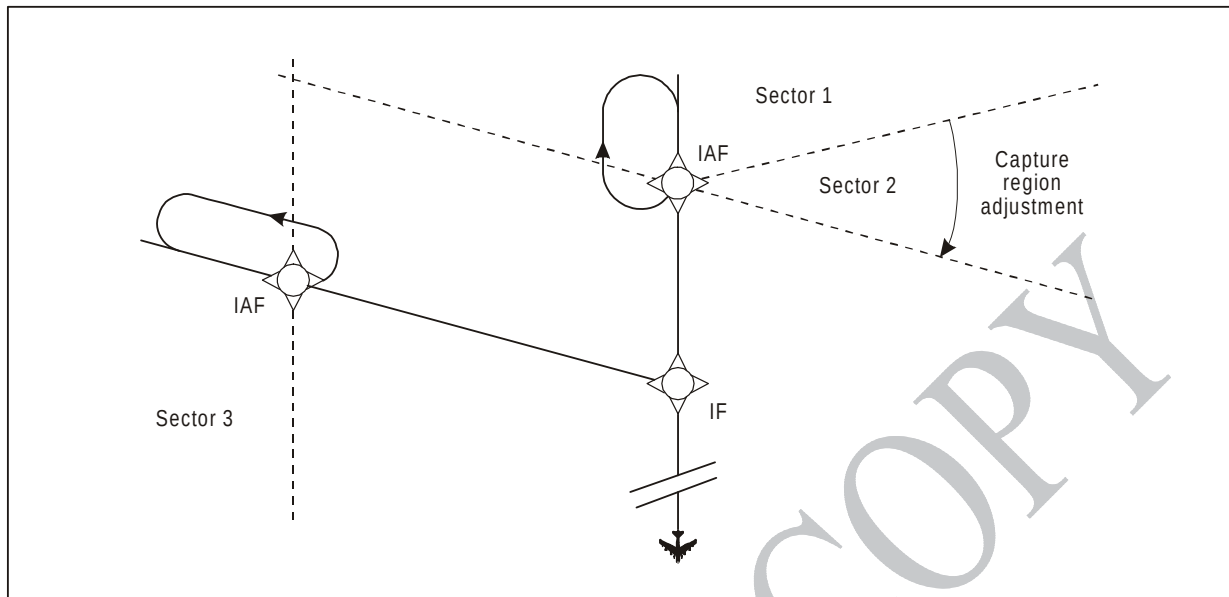


Figure II-3-1-2. Example of implementation of reversal procedures when local conditions prevent an offset leg from being used

Chapter 2

AREA NAVIGATION (RNAV) ARRIVAL AND APPROACH PROCEDURES BASED ON DME/DME

2.1 Area navigation (RNAV) approach procedures based on DME/DME are non-precision approach procedures. These procedures are not required to specify a reference facility, and are based on two different cases:

- a) only two DME stations are available; and
- b) more than two DME stations are available.

2.2 Aircraft equipped with RNAV systems which have been approved by the State of the Operator for the appropriate level of RNAV operations may use these systems to carry out DME/DME RNAV approaches, provided that before conducting any flight it is ensured that:

- a) the RNAV equipment is serviceable; and
- b) the pilot has a current knowledge of how to operate the equipment to optimize navigation accuracy.

2.3 The standard assumptions for airborne and ground equipment on which DME/DME procedures are based are:

- a) If only two DME stations are available, the aircraft is equipped with at least a single flight management computer (FMC) capable of DME/DME navigation, which is approved for operations within the terminal control area (TMA). The FMC must be capable of automatic reversion to updated IRS navigation;
- b) If more than two DME stations are available, the aircraft is equipped with at least a single FMC capable of DME/DME navigation, approved for operations within the TMA;
- c) A navigation database containing the procedures to be flown can automatically be loaded into the FMC flight plan. This database will contain stored waypoints with coordinates based on WGS-84 requirements including speed and vertical constraints; and
- d) Waypoints and DME station coordinates must meet the WGS-84 requirements.

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

- a) DME tolerance based on the specified altitude/height at the waypoints;
- b) flight technical tolerance; and
- c) system computation tolerance.

2.5 For procedures based on two DME stations only, the maximum DME tolerance is factored in order to take into account both the effects of track orientation relative to the DME facilities and the intersect angle between the two DME stations.

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

2.7 If only two DME stations are available, the protected airspace required for obstacle clearance is larger than if more than two DME stations are available.

2.8 ARRIVAL

2.8.1 Standard instrument arrivals (STARs) can be based on required navigation performance (RNP) criteria (limited to RNP 1 or better) or on specific RNAV criteria. When specific RNAV criteria are used, the same principles apply to the protection of all of the arrival phase. The FTT, however, is assumed to be equal to:

- a) 3.7 km (2.0 NM) until at 46 km (25 NM) from the IAF; and
- b) 1.9 km (1.0 NM) after this point.

2.9 The FMS DME/DME navigation sensor may revert to VOR/DME or IRS navigation in a specific order. When this occurs, the following steps must be taken:

- a) the approach procedure must be discontinued;
- b) a missed approach must be initiated; and
- c) ATC must be informed that the navigation accuracy fails to meet the requirements.

2.10 If the FMS reverts to IRS, the route or procedure can be continued for a limited amount of time. This is due to the drift factor inherent in IRS. The exact amount of time that the IRS system may be used depends on its certification and the navigation accuracy to which the procedure has been designed. The maximum flight times which are acceptable for the different phases of flight appear in Table II-3-2-1.

Table II-3-2-1. Maximum flight times under IRS

<i>Flight phase</i>	<i>Time (min.)</i>
En route	50
TMA	25
Approach	12

Chapter 3

AREA NAVIGATION (RNAV) ARRIVAL AND APPROACH PROCEDURES BASED ON VOR/DME

3.1 Area navigation (RNAV) approach procedures based on VOR/DME are assumed to be based on one reference facility composed of a VOR and collocated DME equipment. The reference facility will be indicated.

3.2 The VOR/DME RNAV approach procedure is a non-precision approach procedure.

3.3 OPERATIONAL APPROVAL

Aircraft equipped with RNAV systems which have been approved by the State of the Operator for the appropriate level of RNAV operations may use these systems to carry out VOR/DME RNAV approaches, providing that before conducting any flight it is ensured that:

- a) the RNAV equipment is serviceable;
- b) the pilot has a current knowledge of how to operate the equipment to optimize navigation accuracy; and
- c) the published VOR/DME facility upon which the procedure is based is serviceable.

3.4 The aid used in the construction of the procedure is the reference VOR/DME indicated on the approach chart. The passage of the stipulated fixes shall be verified by means of the reference facility.

3.5 The pilot shall not begin a VOR/DME RNAV approach if either the VOR or DME component of the reference facility is unserviceable.

3.6 NAVIGATION ACCURACY FACTORS

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

- a) ground system tolerance;
- b) airborne receiving system tolerance;
- c) flight technical tolerance;
- d) system computation tolerance; and
- e) distance from the reference facility.

3.6.2 The fixes used in the procedure are indicated as waypoints. These waypoints are referred to by alphanumeric indicators. Their positions are specified in latitude and longitude (degrees, minutes and seconds with an accuracy to the nearest second of arc or equivalent). A radial and DME distance (to an accuracy of 0.18 km (0.1 NM))

from the reference facility are also provided.

3.7 ARRIVAL SEGMENT

Standard instrument arrivals (STARs) can be based on RNP criteria (limited to RNP 1 or better) or on specific RNAV criteria. When specific criteria are used, the same principles apply to the protection of all of the arrival phase. The FTT, however, is assumed to be equal to:

- a) 3.7 km (2.0 NM) until at 46 km (25 NM) from the IAF; and
- b) 1.9 km (1.0 NM) after this point.

3.8 INITIAL APPROACH SEGMENT

When the procedure requires a track reversal, a racetrack pattern may be established.

3.9 FINAL APPROACH SEGMENT

3.9.1 The final approach segment is generally aligned with the runway.

3.9.2 The minimum obstacle clearance in the primary area of the final approach segment is 75 m (246 ft).

3.9.3 Waypoints in the final approach

3.9.3.1 The FAF is defined by a fly-by waypoint.

3.9.3.2 A flyover waypoint is also provided at the runway threshold.

3.10 MISSED APPROACH SEGMENT

3.10.1 The missed approach waypoint (MAPt) is defined by a flyover waypoint. From the earliest MAPt, the area splay at 15° on each side of the missed approach track, at least until the SOC is reached. This allows for the limitations of some RNAV systems, and the pilot's workload at the beginning of the missed approach phase.

3.10.2 A missed approach holding fix (MAHF) defines the end of the missed approach segment. It is located at or after the point where the aircraft, climbing at the minimum prescribed gradient, reaches the minimum altitude for en route or holding, whichever is appropriate.

Chapter 4

AREA NAVIGATION (RNAV) ARRIVAL AND APPROACH PROCEDURES BASED ON SBAS

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Chapter 5

AREA NAVIGATION (RNAV) ARRIVAL AND APPROACH PROCEDURES BASED ON GBAS

No arrival criteria specifically designed for GBAS exist. Arrival operations based upon basic GNSS or SBAS may be flown by aircraft with a navigation system that is compatible with the optional GBAS positioning service. Such operations may not be flown using a navigation system meeting only the minimum GBAS avionics requirements, unless it is also equipped with basic GNSS or SBAS avionics as appropriate.

Chapter 6

AREA NAVIGATION (RNAV) ARRIVAL AND APPROACH PROCEDURES BASED ON RNP

(To be developed)

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Section 4

**APPROACH PROCEDURES WITH
VERTICAL GUIDANCE**

Chapter 1

APV/BARO-VNAV APPROACH PROCEDURES

Note.— Barometric vertical navigation (baro-VNAV) is a navigation system that presents to the pilot computed vertical guidance referenced to a specified vertical path angle (VPA), nominally 3°. The computer-resolved vertical guidance is based on barometric altitude and is specified as a VPA from reference datum height (RDH).

1.1 GENERAL

1.1.1 Procedure classification

1.1.1.1 APV/baro-VNAV approach procedures are classified as instrument approach procedures in support of approach and landing operations with vertical guidance (see Annex 6). Such procedures are promulgated with a decision altitude/height (DA/H). They should not be confused with classical non-precision approach (NPA) procedures, which specify a minimum descent altitude/height (MDA/H) below which the aircraft must not descend.

1.1.1.2 APV/baro-VNAV procedures provide a greater margin of safety than non-precision approach procedures by providing for a guided, stabilized descent to landing. They are particularly relevant to large commercial jet transport aircraft, for which they are considered safer than the alternative technique of an early descent to minimum altitudes.

1.1.1.3 However, the inaccuracies inherent in barometric altimeters, combined with the certificated performance of the specific area navigation (RNAV) mode used, make these procedures less accurate than precision approach systems. In particular, with certain systems the aircraft may not arrive within the Annex 14 obstacle-free surfaces, and the pilot should consider this possibility when making the decision to land at DA/H.

1.1.1.4 The lateral portion of APV/baro-VNAV criteria are based on RNAV non-precision criteria. However, the FAF is not part of the APV/baro-VNAV procedure and is replaced by a final approach point, although the RNAV FAF may be used as a final approach course fix in database design. Similarly, the MAPt is replaced by an aircraft-category-dependent DA/H.

1.1.1.5 The APV/baro-VNAV minimum DH is 75 m (246 ft) plus a height loss margin. However, this minimum DH limit must be increased by the operator to at least 90 m (295 ft) plus a height loss margin when the lateral navigation system is not certificated to ensure the aircraft will arrive within the Annex 14 inner approach, inner transitional and balked landing surfaces (extended as necessary above the inner horizontal surface to OCH) with a high degree of probability.

1.2 SYSTEM PERFORMANCE

1.2.1 The factors upon which the vertical navigational performance of the baro-VNAV procedure depends are outlined below.

1.2.2 Atmospheric effects

1.2.2.1 Atmospheric errors associated with non-standard temperatures are considered in the design of the approach obstacle clearance surface. When temperatures are lower than standard, the aircraft's true altitude will be lower than its barometric indicated altitudes.

1.2.2.2 Most existing VNAV systems do not correct for non-standard temperatures. At temperatures below standard, these errors can be significant and increase in magnitude as altitude above the station increases. The gradient of the approach obstacle clearance surface is reduced as a function of the minimum temperature promulgated for the procedure.

Note.— International Standard Atmosphere (ISA) temperature is 15°C at sea level with a lapse rate of 2°C per 1 000 ft of altitude.

1.2.3 Along-track position uncertainty

All RNAV systems have some amount of along-track error. This along-track uncertainty can mean that the VNAV system will start the descent too early and result in an error in the vertical path. This is compensated for in procedure design by relocating the threshold level origin of the approach obstacle clearance surface.

1.2.4 Flight technical error (FTE)

Flight technical error (FTE) is assumed to be contained within the standard non-precision margin of 75 m (246 ft). This is added below the VPA before the obstacle clearance surface is adjusted for cold temperature and along-track error.

1.2.5 Other system errors

Other errors include static source error, non-homogenous weather phenomena and latency effects. These are insignificant compared with the other errors already addressed and are considered as contained within the existing margin.

1.2.6 Blunder errors

Application of an incorrect or out-of-date altimeter setting, either by air traffic control or the pilot, is possible and must be prevented by appropriate operational techniques.

1.3 EQUIPMENT REQUIREMENTS

1.3.1 APV/baro-VNAV procedures are intended for use by aircraft equipped with flight management systems (FMS) or other RNAV systems capable of computing barometric VNAV paths and displaying the relevant deviations on the instrument display.

1.3.2 Aircraft equipped with APV/baro-VNAV systems that have been approved by the State of the Operator for the appropriate level of lateral navigation (LNAV)/VNAV operations may use these systems to carry out APV/baro-VNAV approaches provided that:

- a) the navigation system has a certificated performance equal to or less than 0.6 km (0.3 NM), with 95 per cent

probability. This includes:

- 1) GNSS navigation systems certified for approach operations;
 - 2) multi-sensor systems using inertial reference units in combination with certified DME/DME or GNSS; and
 - 3) RNP systems approved for RNP 0.3 operations or less;
- b) the APV/baro-VNAV equipment is serviceable;
- c) the aircraft and aircraft systems are appropriately certified for the intended APV/baro-VNAV approach operations;
- d) the aircraft is equipped with an integrated LNAV/VNAV system with an accurate source of barometric altitude; and
- e) the VNAV altitudes and all relevant procedural and navigational information are retrieved from a navigation database whose integrity is supported by appropriate quality assurance measures.

Note.— Acceptable means of compliance can be found in documents such as the United States Federal Aviation Administration (FAA) Advisory Circular (AC) 20-138, AC 20-130A and AC 120-29.

1.3.3 Where LNAV/baro-VNAV procedures are promulgated, the approach area has been assessed for obstacles penetrating the Annex 14 inner approach, inner transitional and balked landing surfaces. If obstacles penetrate these surfaces, a restriction is placed on the minimum value of OCA/H permitted (see 1.1.5).

1.4 OPERATIONAL CONSTRAINTS

1.4.1 Pilots are responsible for any necessary cold temperature corrections to all published minimum altitudes/heights. This includes:

- a) the altitudes/heights for the initial and intermediate segment(s);
- b) the DA/H; and
- c) subsequent missed approach altitudes/heights.

Note.— The final approach path VPA is safeguarded against the effects of low temperature by the design of the procedure.

1.4.2 Temperatures below the promulgated minimum

Baro-VNAV procedures are not permitted when the aerodrome temperature is below the promulgated minimum aerodrome temperature for the procedure, unless the flight management system (FMC) is equipped with approved cold temperature compensation for the final approach. In this case, the minimum temperature can be disregarded provided it is within the minimum certificated temperature limits for the equipment. Below this temperature, and for aircraft that do not have FMCs equipped with approved cold temperature compensation for the final approach, an LNAV procedure may still be used provided that:

- a) a conventional RNAV non-precision procedure and APV/LNAV OCA/H are promulgated for the approach; and

- b) the appropriate cold temperature altimeter correction is applied to all minimum promulgated altitudes/heights by the pilot.

1.4.3 A VPA deviation chart may be published on baro-VNAV instrument procedure charts, correlating an aerodrome temperature with an associated true VPA. This chart is intended to advise flight crews that although the non-temperature compensated aircraft's avionics system may be indicating the promulgated final approach VPA, the actual VPA is different from the information presented to them by the system.

1.4.4 This chart is not intended to have the pilot increase or decrease the VPA flown to achieve the actual promulgated VPA. A sample of the chart is provided in Table II-4-1-1.

Table II-4-1-1. Vertical path angle (VPA) deviation chart

<i>VPA Deviations for Non-temperature Compensated Systems</i>	
<i>A/D Temperature</i>	<i>Actual VPA</i>
+30°C	3.20°
+15°C	3.00°
0°C	2.80°
-15°C	2.68°
-31°C	2.50°

1.4.5 Some baro-VNAV systems have the capability to correctly compensate the VPA of an instrument approach procedure following an input of the aerodrome (altimeter source) temperature by the pilot. Pilots operating aircraft with this feature active are expected to ignore the VPA chart and fly the system-corrected VPA guidance.

1.4.6 Altimeter setting

Baro-VNAV procedures shall only be flown with:

- a) a current local altimeter setting source available; and
- b) the QNH/QFE, as appropriate, set on the aircraft's altimeter.

Procedures using a remote altimeter setting source cannot support a baro-VNAV approach.

1.4.7 Vertical guidance sensitivity

1.4.7.1 The baro-VNAV vertical guidance display sensitivity varies with different equipment. However, cockpit displays showing vertical path deviation must be suitably located and have sufficient sensitivity to enable the pilot to limit vertical path excursions to less than:

- a) +30 m (+100 ft); and

- b) -15 m (50 ft)

from the VPA.

1.4.7.2 Vertical path deviation

Where equipment does not meet these criteria, an operational assessment and specific flight crew procedures may be required for the approval of baro-VNAV operations. This may include requirements for the availability and use of a flight director or autopilot system.

Note.— Some existing baro-VNAV vertical path deviation displays have a graphic scale where 2.5 cm (1 inch) represents 121 m (400 ft), and such arrangements make it difficult for a pilot to meet the path keeping tolerance requirements.

1.4.8 The LNAV FAF and MAPt are used for coding purposes for the baro-VNAV procedure and are not intended to inhibit descent at the FAP or to restrict DA/H.

Chapter 2

APV I and II

(To be developed)

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Section 5

PRECISION APPROACH PROCEDURES

Chapter 1

GBAS PRECISION APPROACH PROCEDURES

1.1 APPROACH CONDUCT

A precision approach using GBAS is selected by use of a channel number in the airborne equipment. The GBAS precision approach is carried out in a manner very similar to an ILS precision approach by using lateral guidance on the intermediate segment until intercepting the glide path, whereupon vertical guidance is initiated and continued, along with lateral guidance, for landing.

1.2 GBAS APPROACH DISPLAY CRITERIA

1.2.1 GBAS provides precision approach service equivalent to ILS Category I approach service. Minimum required GBAS display functionality is equivalent to ILS. GBAS continuously provides very accurate distance to landing threshold information. System failure display and annunciation are equivalent to ILS.

1.2.2 The GBAS path is defined differently from an ILS path. Data defining the path, including the glide path, lateral sector width, lateral sensitivity and other characteristics of the guidance sector, are transmitted by ground equipment to the airborne system using a high-integrity digital data message. The digital message defines the final approach segment (FAS) path and guidance characteristics. The airborne system geometrically calculates the path and defines the guidance characteristics specified in the transmitted digital data. The airborne system generates guidance with characteristics similar to other precision approach systems such as ILS that transmit electronic beams for the aircraft equipment to track. A complete description of the FAS data block and an example of the format are contained in PANS-OPS, Volume II, Part III, Section 3, Chapter 6, Appendix (to be developed).

1.3 GBAS CHANNEL SELECTION

The detailed information on pilot selection of the GBAS channel can be found in Annex 10, Volume I, Attachment D, 7.7.

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Section 6

RNAV HOLDING

Chapter 1

GENERAL

1.1 The general criteria in Part I, Section 6, “Holding Criteria”, are applied except as modified or amplified by the material in this chapter.

1.2 Aircraft equipped with RNAV systems which have been approved by the State of the Operator for the appropriate level of RNAV operations may use these systems to carry out VOR/DME RNAV holding, provided that before conducting any flight it is ensured that:

- a) the aircraft is fitted with serviceable RNAV equipment;
- b) the pilot has a current knowledge of how to operate the equipment to optimize navigation accuracy; and
- c) the published VOR/DME facility upon which the procedure is based is serviceable.

1.3 The accuracy and limitations of RNAV systems are those of the computer. The computer is designed so that calculation errors are minimal and do not affect the accuracy of the output significantly. However, the computer cannot identify data input error.

1.4 Waypoint and, in some cases, data contained in the navigation database, have been calculated, promulgated by States and input by the operator or crew. Any errors introduced into the navigation database will affect the actual computed position.

1.5 Conventional holding patterns may be flown with the assistance of an RNAV system. In this case, the RNAV system has no other function than to provide guidance for the autopilot or flight director. The pilot remains responsible for ensuring that the aircraft complies with the speed, bank angle, timing and distance assumptions contained in Part I, Section 6, Chapter 1, 1.3.

1.6 PILOT RESPONSIBILITIES

1.6.1 When RNAV equipment is used for non-RNAV holding procedures, the pilot shall verify positional accuracy at the holding fix on each passage of the fix.

1.6.2 Pilots shall ensure that speeds used to fly the RNAV holding procedures comply with Tables I-6-1-1 and I-6-1-2.

Chapter 2

HOLDING PATTERNS

2.1 Some RNAV systems can fly non-RNAV holding patterns without strict compliance with the PANS-OPS, Volume II, assumptions. Before these systems are used operationally, they must have demonstrated, to the satisfaction of the appropriate authority, that their commands will contain the aircraft within the basic holding area defined by PANS-OPS, Volume II, for the environmental conditions assumed by those criteria. The pilot shall verify overflight of the stipulated fixes by means of the reference facility.

2.2 RNAV holding may be conducted in specifically designed holding patterns. These holding patterns utilize the criteria and flight procedure assumptions of conventional holding with orientations that may be referenced either by an overhead position or by radial and DME distance from a VOR/DME facility. These holding patterns assume:

- a) that automatic radio navigation updating is utilized. This ensures that the navigation tolerance stays within the limits assumed by the procedure designer;
- b) that the pilot is provided with tracking information in a suitable form such as HSI and/or EFIS presentation or cross-track error data; and
- c) that the pilot confirms the holding waypoints by cross-reference to the published VOR/DME fixes.

2.3 RNAV holding procedures may be constructed using one or two waypoints (see Figures II-6-2-1 A and B). Area holding may also be provided (see Figure II-6-2-1 C).

2.4 RNP holdings are characterized by a maximum track geometrically defined by the length of the inbound track and diameter of the turn (see Figure II-6-2-1 E).

2.5 An RNP approved RNAV system is assumed to be able to remain within the RNP limit for 95 per cent of the time spent in the holding pattern.

2.6 RNAV area holding is specified by an area holding waypoint and an associated circle. The radius of this circle is always such that the pilot may select any inbound track to the fix and join and follow a standard left or right holding pattern based on the fix and selected track. Alternatively, any other pattern may be flown which will remain within the specified area. See Figure II-6-2-1 C.

2.7 The waypoints for VOR/DME RNAV holding are defined by radio navigation fixes which determine the minimum accuracy required to fly the procedure.

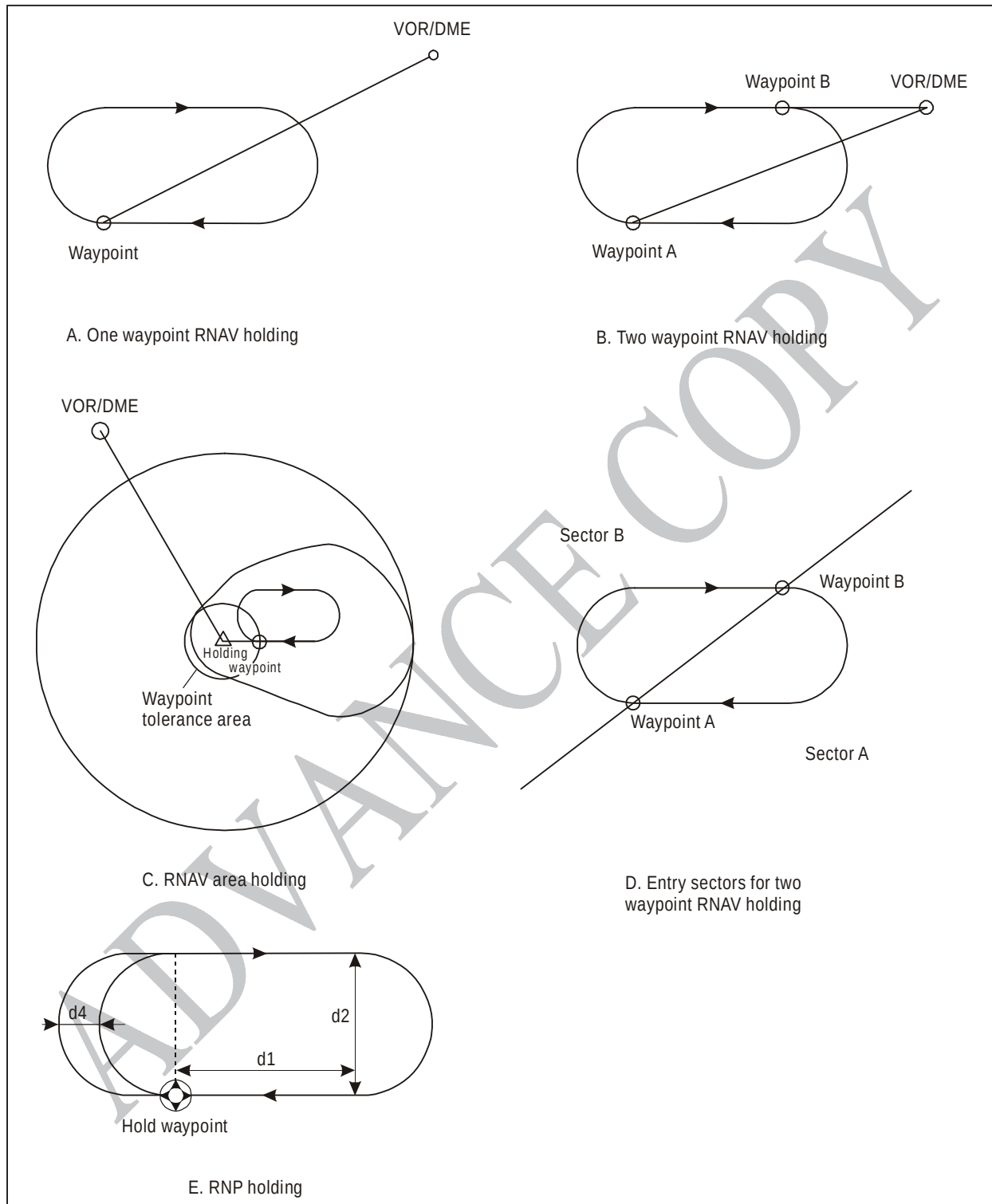


Figure II-6-2-1. RNAV/RNP holding procedures

Chapter 3

HOLDING ENTRY

3.1 Except where it is published that specific entries are required, entries into a one waypoint RNAV holding are the same as for conventional holding.

Note.— Future RNAV systems able to enter into a one waypoint RNAV holding without overflying the holding point may use specific holding patterns based on this assumption. They may also use conventional or RNAV holding.

3.2 Sectors for entry to an RNAV two waypoint holding procedure are separated by the line which passes through the two waypoints. Entries from either sector shall be made through the associated waypoint. (See Figure II-6-2-1 D.) After passing the waypoint, the aircraft shall turn to follow the procedure.

Note.— Flight management systems designed only for single waypoint holding procedures will not normally be able to use two waypoint procedures without a software modification. Alternatives to two waypoint procedures will be provided for aircraft with single waypoint flight management systems.

3.3 For area holding, any entry procedure which is contained within the given area is permissible.

Chapter 4

ALTERNATIVE RNAV HOLDING ENTRIES FOR REDUCED HOLDING ENTRY AREAS

4.1 Conventional entries described in Part I, Section 6, Chapter 1, 1.4, “Entry”, are based on the fact that for VOR or NDB procedures, it is necessary to overfly the station or holding fix at the beginning of the entry. Such manoeuvres require additional protection for entry procedures or a holding fix at the beginning of the entry.

4.2 With a suitable RNAV system, it is no longer necessary to overfly the station or holding waypoint. This chapter gives an example of alternative entries which are less “space consuming” than the conventional ones. This material is presented for the purpose of information to manufacturers. A date for operational use will be established in the future.

4.3 DEFINING ENTRY SECTORS

The holding pattern is composed of two half circles and two straight segments, as shown in Figure II-6-4-1.

4.4 ENTRY MANOEUVRES

4.4.1 Sector 1 entry (see Figure II-6-4-2)

1. Turn along the arc of any arbitrary circle centred on a line between the centres of C1 and C2.
2. Intercept the inbound track of the holding pattern in the reverse direction.
3. Follow the perimeter of circle C2.
4. Continue on the tangent between C1 and C2 until the aircraft reaches circle C1.
5. Follow the perimeter of circle C1 until the aircraft reaches holding point A.

4.4.2 Sector 2 entry (see Figure II-6-4-3)

1. Overfly point A.
2. Intercept circle C2 tangentially.
3. Follow circle C2 until intercepting the inbound track.

4.4.3 Sector 3 entry (see Figure II-6-4-4)

Inbound track continues through holding point A, until intersecting the holding pattern as shown.

4.4.4 Sector 4 entry (see Figure II-6-4-5)

1. Continue on the inbound track toward holding point A until intersecting a circle centred on the extended line between the centres of C1 and C2.
2. Follow that circle until intersecting the outbound track.

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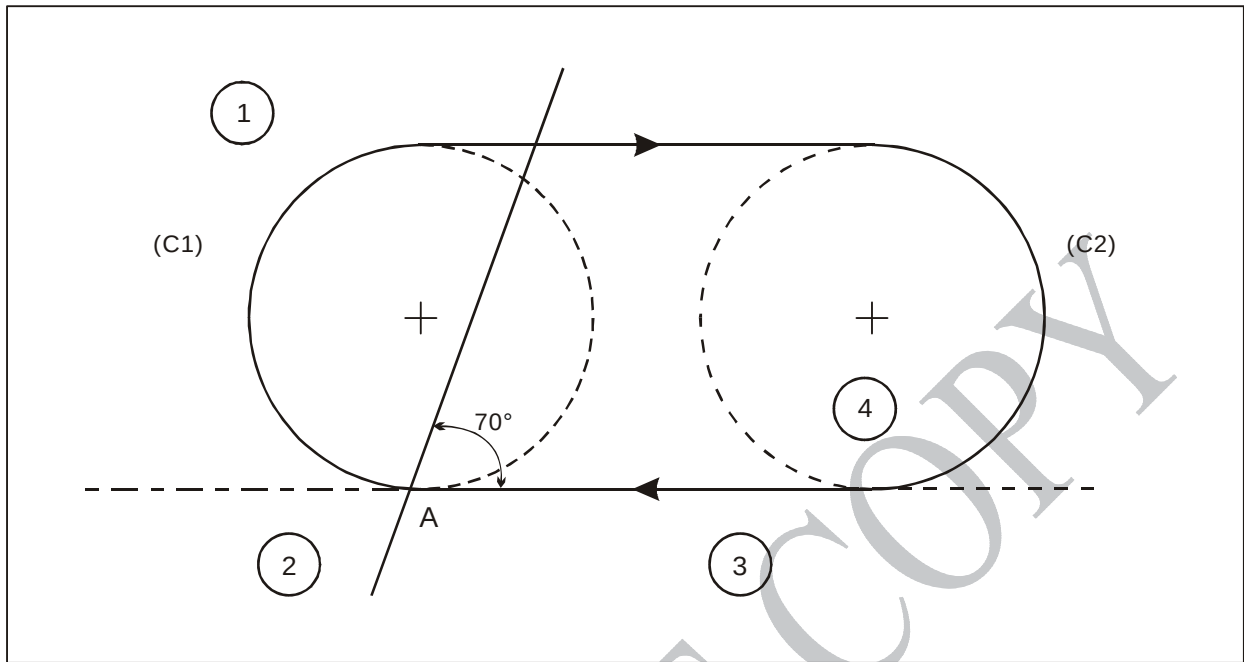


Figure II-6-4-1. Entry sectors

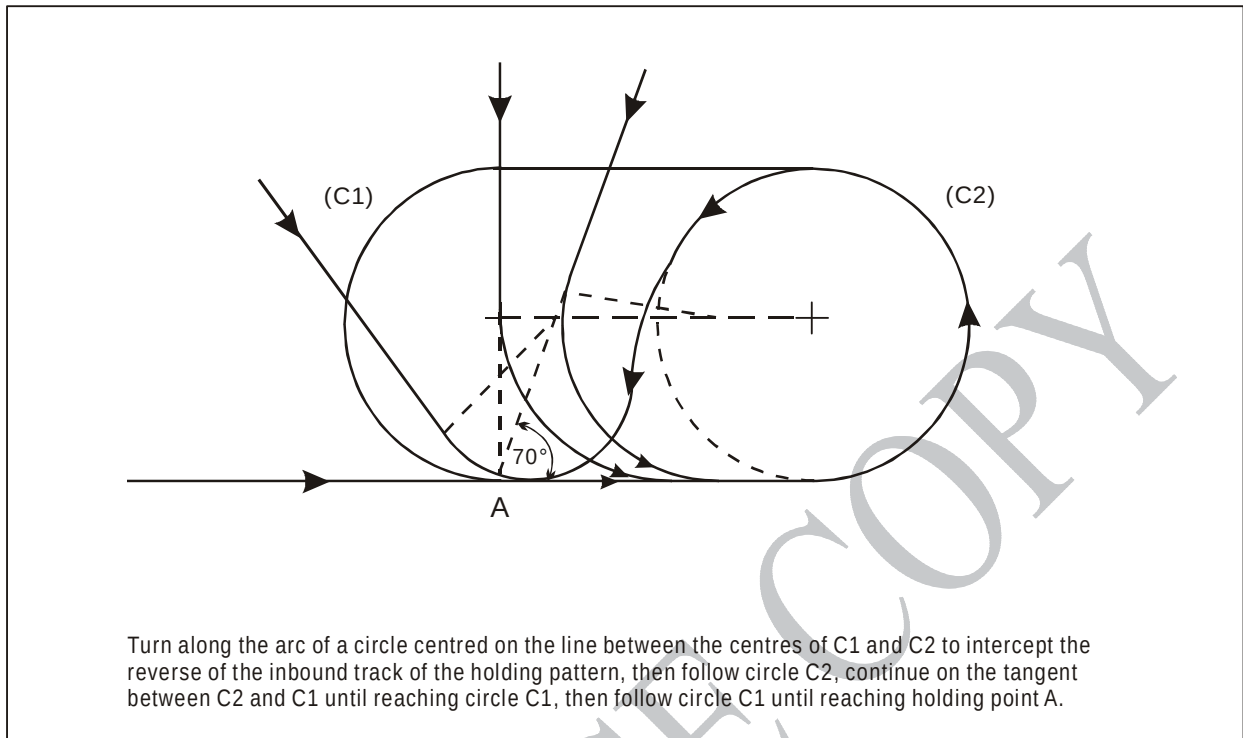


Figure II-6-4-2. Sector 1 entry

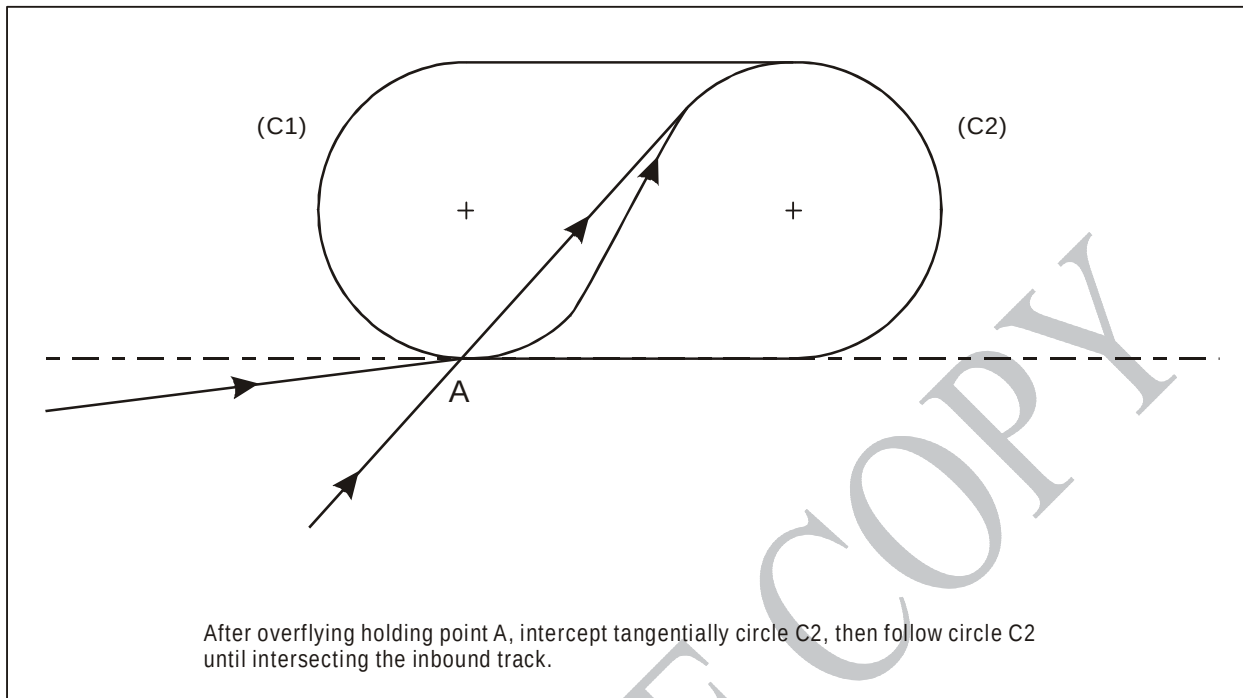


Figure II-6-4-3. Sector 2 entry

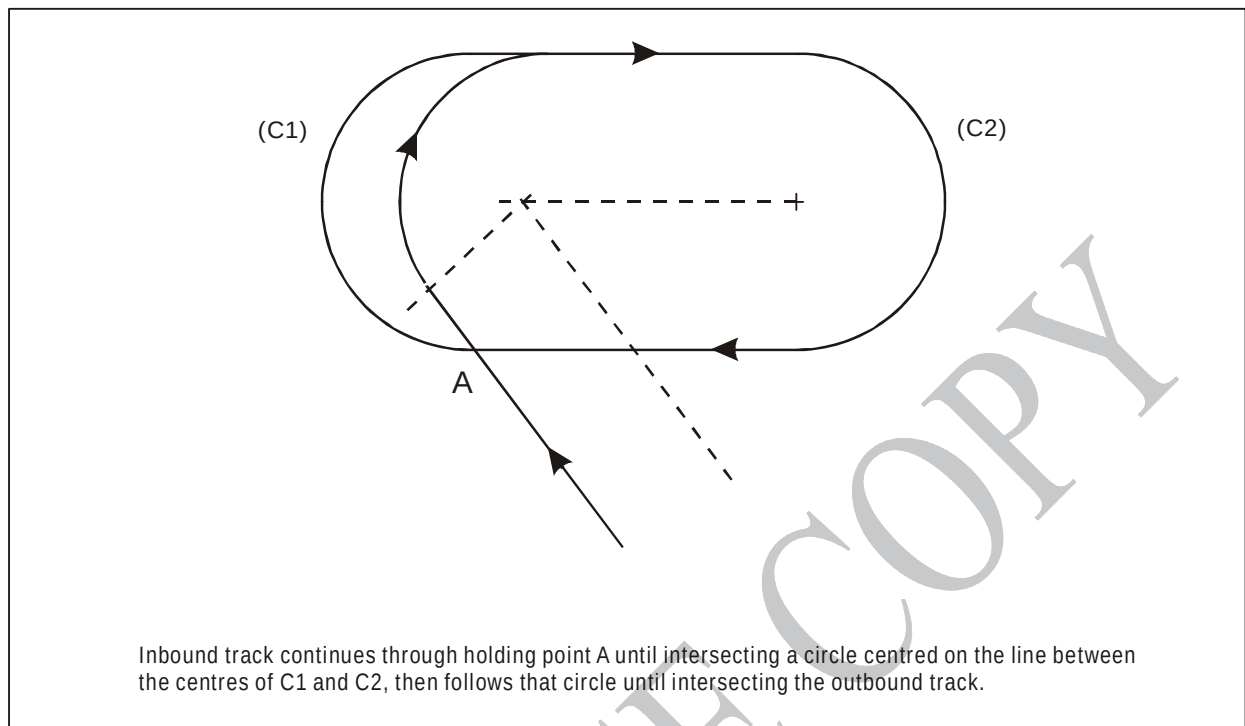


Figure II-6-4-4. Sector 3 entry

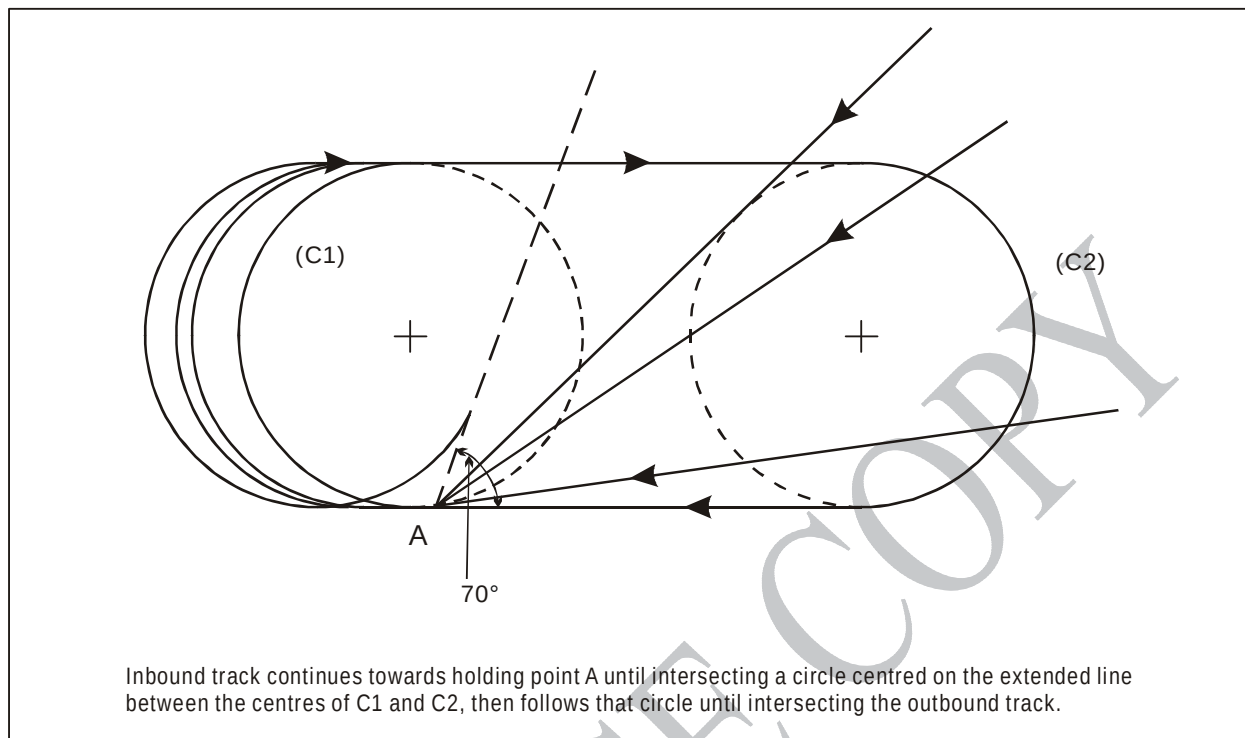


Figure II-6-4-5. Sector 4 entry

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Section 7
EN ROUTE

Chapter 1

AREA NAVIGATION (RNAV) AND RNP-BASED EN-ROUTE PROCEDURES

1.1 STANDARD CONDITIONS

1.1.1 The general criteria for VOR and NDB routes apply except that the area has a constant width and no angular limits.

1.1.2 The standard assumptions on which en-route RNAV/RNP procedures are developed are:

- a) the fix tolerance area of the waypoint is a circle of radius equal to the en-route RNP;
- b) the system provides information which the pilot monitors and uses to intervene and thus limit excursions of the FTT to values within those taken into account during the system certification process; and
- c) en-route procedures are normally based on RNP 4 or higher. Where necessary and appropriate, they may be based on RNP 1.

1.2 DEFINITION OF TURNS

1.2.1 Turns in an RNAV route only allow the use of fly-by waypoints.

1.2.2 There are two kinds of turns for RNP routes:

- a) the turn at a fly-by waypoint; and
- b) the controlled turn. For this kind of turn, used on RNP 1 routes, the radius of turn is:
 - 28 km (15 NM) at and below FL 190; and
 - 41.7 km (22.5 NM) at and above FL 200.

**Procedures for
Air Navigation Services**

AIRCRAFT OPERATIONS

Part III

AIRCRAFT OPERATING PROCEDURES

Section 1

ALTIMETER SETTING PROCEDURES

Chapter 1

INTRODUCTION TO ALTIMETER SETTING PROCEDURES

1.1 These procedures describe the method for providing adequate vertical separation between aircraft and for providing adequate terrain clearance during all phases of a flight. This method is based on the following basic principles:

- a) States may specify a fixed altitude known as the transition altitude. In flight, when an aircraft is at or below the transition altitude, its vertical position is expressed in terms of altitude, which is determined from an altimeter set to sea level pressure (QNH).
- b) In flight above the transition altitude, the vertical position of an aircraft is expressed in terms of flight levels, which are surfaces of constant atmospheric pressure based on an altimeter setting of 1 013.2 hPa.
- c) The change in reference from altitude to flight levels, and vice versa, is made:
 - 1) at the transition *altitude*, when climbing; and
 - 2) at the transition *level*, when descending.
- d) The transition level may be nearly coincident with the transition altitude to maximize the number of flight levels available. Alternatively, the transition level may be located 300 m (110 ft) above the transition altitude to permit the transition altitude and the transition level to be used concurrently in cruising flight, with vertical separation ensured. The airspace between the transition level and the transition altitude is called the transition layer.
- e) Where no transition altitude has been established for the area, aircraft in the en-route phase shall be flown at a flight level.
- f) The adequacy of terrain clearance during any phase of a flight may be maintained in any of several ways, depending upon the facilities available in a particular area. The recommended methods in the order of preference are:
 - 1) the use of current QNH reports from an adequate network of QNH reporting stations;
 - 2) the use of such QNH reports as are available, combined with other meteorological information such as forecast lowest mean sea level pressure for the route or portions thereof; and
 - 3) where relevant current information is not available, the use of values of the lowest altitudes or flight levels, derived from climatological data.
- g) During the approach to land, terrain clearance may be determined by using:
 - 1) the QNH altimeter setting (giving altitude); or
 - 2) under specified circumstances (see Chapter 2, 2.4.2 and Chapter 3, 3.5.4), a QFE setting (giving height above the QFE datum).

1.2 This method provides flexibility to accommodate variations in local procedures without compromising the fundamental principles.

1.3 These procedures apply to all IFR flights and to other flights which are operating at specific cruising levels in accordance with the *Rules of the Air* (Annex 2) or the *Procedures for Air Navigation Services, Air Traffic Management* (PANS-ATM, Doc 4444) or the *Regional Supplementary Procedures* (Doc 7030).

ADVANCE COPY

Chapter 2

BASIC ALTIMETER SETTING REQUIREMENTS

2.1 GENERAL

2.1.1 System of flight levels

2.1.1.1 Flight level zero shall be located at the atmospheric pressure level of 1 013.2 hPa. Consecutive flight levels shall be separated by a pressure interval corresponding to at least 500 ft (152.4 m) in the standard atmosphere.

Note.— This does not preclude reporting intermediate levels in increments of 30 m (100 ft). (Refer to Section 3, Chapter 1, 1.2, “Use of Mode C”.)

2.1.1.2 Flight levels shall be numbered according to Table III-1-2-1 which indicates the corresponding height in the standard atmosphere in feet and the approximate equivalent height in metres.

Table III-1-2-1. Flight level numbers

Flight level number	Height in standard atmosphere		Flight level number	Height in standard atmosphere	
	Metres	Feet		Metres	Feet
10	300	1 000	50	1 500	5 000
15	450	1 500	...	...	...
20	600	2 000	100	3 050	10 000
25	750	2 500	...	...	...
30	900	3 000	150	4 550	15 000
35	1 050	3 500	...	...	...
40	1 200	4 000	200	6 100	20 000
45	1 350	4 500	...	...	...
			500	15 250	50 000

Note.— The heights shown in metres correspond to those in the table of cruising levels given in Appendix 3 to Annex 2.

2.1.2 Transition altitude

2.1.2.1 A transition altitude shall normally be specified for each aerodrome by the State in which the aerodrome is located.

2.1.2.2 Where two or more closely spaced aerodromes are located so that coordinated procedures are required, a common transition altitude shall be established. This common transition altitude shall be the highest that would be required if the aerodromes were considered separately.

2.1.2.3 As far as possible, a common transition altitude should be established:

- a) for groups of aerodromes of a State or all aerodromes of that State;
- b) on the basis of an agreement, for:
 - 1) aerodromes of adjacent States;
 - 2) States of the same flight information region; and
 - 3) States of two or more adjacent flight information regions or one ICAO region; and
- c) for aerodromes of two or more ICAO regions when agreement can be obtained between these regions.

2.1.2.4 The height above the aerodrome of the transition altitude shall be as low as possible but normally not less than 900 m (3 000 ft).

2.1.2.5 The calculated height of the transition altitude shall be rounded up to the next full 300 m (1 000 ft).

2.1.2.6 Despite the provisions in 2.1.2, “Transition altitude”, a transition altitude may be established for a specified area on the basis of regional air navigation agreements.

2.1.2.7 Transition altitudes shall be published in aeronautical information publications and shown on the appropriate charts.

2.1.3 Transition level

2.1.3.1 States shall make provision for the determination of the transition level to be used at any given time at each of their aerodromes.

2.1.3.2 Where two or more closely spaced aerodromes are located so that coordinated procedures and a common transition altitude are required, a common transition level shall also be used at those aerodromes.

2.1.3.3 Appropriate personnel shall have available at all times the number of the flight level representing the current transition level for an aerodrome.

Note.— The transition level is normally passed to aircraft in the approach and landing clearances.

2.1.4 References to vertical position

2.1.4.1 The vertical position of aircraft operating at or below the transition altitude shall be expressed in terms of

altitude. Vertical position at or above the transition level shall be expressed in terms of flight levels. This terminology applies during:

- a) climb;
- b) en-route flight; and
- c) approach and landing (except as provided for in 2.4.3, “References to vertical positioning after approach clearance”).

Note.— This does not preclude a pilot using a QFE setting for terrain clearance purposes during the final approach to the runway.

2.1.4.2 Passing through the transition layer

While passing through the transition layer, vertical position shall be expressed in terms of:

- a) flight levels when climbing; and
- b) altitude when descending.

2.2 TAKE-OFF AND CLIMB

A QNH altimeter setting shall be made available to aircraft in taxi clearances prior to take-off.

2.3 EN ROUTE

2.3.1 When complying with the specifications of Annex 2, an aircraft shall be flown at altitudes or flight levels (as applicable) corresponding to the magnetic tracks shown in the table of cruising levels in Appendix 3 to Annex 2.

2.3.2 Terrain clearance

2.3.2.1 QNH altimeter setting reports should be provided from sufficient locations to permit determination of terrain clearance with an acceptable degree of accuracy.

2.3.2.2 For areas where adequate QNH altimeter setting reports cannot be provided, the appropriate authorities shall provide the information required to determine the lowest flight level which will ensure adequate terrain clearance. This information shall be made available in the most usable form.

2.3.2.3 Appropriate services shall at all times have available the information required to determine the lowest flight level which will ensure adequate terrain clearance for specific routes or segments of routes. This information shall be made available for flight planning purposes and for transmission to aircraft in flight, on request.

2.4 APPROACH AND LANDING

2.4.1 The QNH altimeter setting shall be made available to aircraft in approach clearances and in clearances to enter the traffic circuit.

2.4.2 A QFE altimeter setting, clearly identified as such, should be made available in approach and landing clearances. This should be available on request or on a regular basis, in accordance with local arrangements.

2.4.3 References to vertical positioning after approach clearance

After approach clearance has been issued and the descent to land is begun, the vertical positioning of an aircraft above the transition level may be by reference to altitudes (QNH) provided that level flight above the transition altitude is not indicated or anticipated.

Note.— This applies primarily to turbine engine aircraft for which an uninterrupted descent from a high altitude is desirable and to aerodromes equipped to control such aircraft by reference to altitudes throughout the descent.

2.5 MISSED APPROACH

The relevant parts of 2.2, “Take-off and climb”, 2.3, “En route”, and 2.4, “Approach and landing” shall apply in the event of a missed approach.

Chapter 3

PROCEDURES FOR OPERATORS AND PILOTS

3.1 FLIGHT PLANNING

3.1.1 The levels at which a flight is to be conducted shall be specified in a flight plan:

- a) as flight levels if the flight is to be conducted at or above the transition level (or the lowest usable flight level, if applicable); and
- b) as altitudes if the flight is to be conducted at or below the transition altitude.

3.1.2 The altitudes or flight levels selected for flight:

- a) should ensure adequate terrain clearance at all points along the route;
- b) should satisfy air traffic control requirements; and
- c) should be compatible with the table of cruising levels in Appendix 3 to Annex 2, if relevant.

Note 1.— The information required to determine the lowest altitude or flight level which ensures adequate terrain clearance may be obtained from the appropriate services unit (e.g. aeronautical information, air traffic or meteorological).

Note 2.— The choice of altitudes or flight levels depends upon how accurately their vertical position relative to the terrain can be estimated. This in turn depends upon the type of meteorological information available. A lower altitude or flight level may be used with confidence when its position is based on current information which is relevant to the particular route to be flown and when it is known that amendments to this information will be available in flight. See 3.4.2, "Terrain clearance". A higher altitude or flight level will be used when based on information less relevant to the particular route to be flown and the time of the flight. The latter type of information may be provided in chart or table form and may be applicable to a large area and any period of time.

Note 3.— Flights over level terrain may often be conducted at one altitude or flight level. On the other hand, flights over mountainous terrain may require several changes in altitudes or flight levels to account for changes in the elevation of the terrain. The use of several altitudes or flight levels may also be required to comply with air traffic services requirements.

3.2 PRE-FLIGHT OPERATIONAL TEST

The following test should be carried out in an aircraft by flight crew members before flight. Flight crews should be advised of the purpose of the test and the manner in which it should be carried out. They should also be given specific instructions on the action to be taken based on the test results.

QNH setting

1. With the aircraft at a known elevation on the aerodrome, set the altimeter pressure scale to the current QNH setting.
2. Vibrate the instrument by tapping unless mechanical vibration is provided.

A serviceable altimeter indicates the elevation of the point selected, plus the height of the altimeter above this point, within a tolerance of:

- a) ± 20 m or 60 ft for altimeters with a test range of 0 to 9 000 m (0 to 30 000 ft); and
- b) ± 25 m or 80 ft for altimeters with a test range of 0 to 15 000 m (0 to 50 000 ft).

QFE setting

1. With the aircraft at a known elevation on the aerodrome, set altimeter pressure scale to the current QFE setting.
2. Vibrate the instrument by tapping unless mechanical vibration is provided.

A serviceable altimeter indicates the height of the altimeter in relation to the QFE reference point, within a tolerance of:

- a) ± 20 m or 60 ft for altimeters with a test range of 0 to 9 000 m (0 to 30 000 ft); and
- b) ± 25 m or 80 ft for altimeters with a test range of 0 to 15 000 m (0 to 50 000 ft).

Note 1.— If the altimeter does not indicate the reference elevation or height exactly but is within the specified tolerances, no adjustment of this indication should be made at any stage of a flight. Also, any error which was within tolerance on the ground should be ignored by the pilot during flight.

Note 2.— The tolerance of 20 m or 60 ft for altimeters with a test range of 0 to 9 000 m (0 to 30 000 ft) is considered acceptable for aerodromes having elevations up to 1 100 m (3 500 ft) (Standard atmospheric pressure). Table III-1-3-1 indicates the permissible range for aerodromes at different elevations when the atmospheric pressure at an aerodrome is lower than the standard, i.e. when the QNH setting is as low as 950 hPa.

Note 3.— The tolerance of 25 m or 80 ft for altimeters with a test range of 0 to 15 000 m (0 to 50 000 ft) is considered acceptable for aerodromes having elevations up to 1 100 m (3 500 ft) (Standard atmospheric pressure). Table III-1-3-2 indicates the permissible range for aerodromes at different elevations when the atmospheric pressure at an aerodrome is lower than the standard, i.e. when the QNH setting is as low as 950 hPa.

3.3 TAKE-OFF AND CLIMB

3.3.1 Before taking off, one altimeter shall be set on the latest QNH altimeter setting for the aerodrome.

3.3.2 During climb to, and while at the transition altitude, references to the vertical position of the aircraft in air-ground communications shall be expressed in terms of altitudes.

3.3.3 On climbing through the transition altitude, the reference for the vertical position of the aircraft shall be changed from altitudes (QNH) to flight levels (1 013.2 hPa), and thereafter the vertical position shall be expressed in terms of flight levels.

Table III-1-3-1. Tolerance range for altimeters with a test range of 0 to 9 000 m (0 to 30 000 ft)

<i>Elevation of the aerodrome (metres)</i>	<i>Permissible range</i>	<i>Elevation of the aerodrome (feet)</i>	<i>Permissible range</i>
600	581.5 to 618.5		1 940 to 2 060
900	878.5 to 921.5	3 000	2 930 to 3 070
1 200	1 177 to 1 223	4 000	3 925 to 4 075
1 500	1 475.5 to 1 524.5	5 000	4 920 to 5 080
1 850	1 824 to 1 876	6 000	5 915 to 6 085
2 150	2 121 to 2 179	7 000	6 905 to 7 095
2 450	2 418 to 2 482	8 000	7 895 to 8 105
2 750	2 715 to 2 785	9 000	8 885 to 9 115
3 050	3 012 to 3 088	10 000	9 875 to 10 125
3 350	3 309 to 3 391	11 000	10 865 to 11 135
3 650	3 606 to 3 694	12 000	11 855 to 12 145
3 950	3 903 to 3 997	13 000	12 845 to 13 155
4 250	4 199.5 to 4 300.5	14 000	13 835 to 14 165
4 550	4 496.5 to 4 603.5	15 000	14 825 to 15 175

Table III-1-3-2. Tolerance range for altimeters with a test range of 0 to 15 000 m (0 to 50 000 ft)

<i>Elevation of the aerodrome (metres)</i>	<i>Permissible range</i>	<i>Elevation of the aerodrome (feet)</i>	<i>Permissible range</i>
600	569.5 to 630.5	2 000	1 900 to 2 100
900	868 to 932	3 000	2 895 to 3 105
1 200	1 165 to 1 235	4 000	3 885 to 4 115
1 500	1 462 to 1 538	5 000	4 875 to 5 125
1 850	1 809 to 1 891	6 000	5 865 to 6 135
2 150	2 106 to 2 194	7 000	6 855 to 7 145
2 450	2 403 to 2 497	8 000	7 845 to 8 155
2 750	2 699.5 to 2 800.5	9 000	8 835 to 9 165
3 050	2 996.5 to 3 103.5	10 000	9 825 to 10 175
3 350	3 293.5 to 3 406.5	11 000	10 815 to 11 185
3 650	3 590.5 to 3 709.5	12 000	11 805 to 12 195
3 950	3 887.5 to 4 012.5	13 000	12 795 to 13 205
4 250	4 184.5 to 4 315.5	14 000	13 785 to 14 215
4 550	4 481.5 to 4 618.5	15 000	14 775 to 15 225

3.4 EN ROUTE

3.4.1 Vertical separation

3.4.1.1 During en-route flight at or below the transition altitude, an aircraft shall be flown at altitudes. References to the vertical position of the aircraft in air-ground communications shall be expressed in terms of altitudes.

3.4.1.2 During en-route flight at or above transition levels or the lowest usable flight level, whichever is applicable, an aircraft shall be flown at flight levels. References to the vertical position of the aircraft in air-ground communications shall be expressed in terms of flight levels.

3.4.2 Terrain clearance

3.4.2.1 Where adequate QNH altimeter setting reports are available, the latest and most appropriate reports shall be used for assessing terrain clearance.

3.4.2.2 Where the adequacy of terrain clearance cannot be assessed with an acceptable degree of accuracy by means of the QNH reports available or forecast lowest mean sea level pressure, other information shall be obtained for checking the adequacy of terrain clearance.

3.5 APPROACH AND LANDING

3.5.1 Before beginning the initial approach to an aerodrome, the number of the transition level shall be obtained.

Note.— The transition level is normally obtained from the appropriate air traffic services unit.

3.5.2 Before descending below the transition level, the latest QNH altimeter setting for the aerodrome shall be obtained.

Note.— The latest QNH altimeter setting for the aerodrome is normally obtained from the appropriate air traffic services unit.

3.5.3 As the aircraft descends through the transition level, the reference for the vertical position of the aircraft shall be changed from flight levels (1 013.2 hPa) to altitudes (QNH). From this point on, the vertical position of the aircraft shall be expressed in terms of altitudes.

Note.— This does not preclude a pilot using a QFE setting for terrain clearance purposes during the final approach to the runway in accordance with 3.5.4.

3.5.4 When an aircraft which has been given a clearance as number one to land is completing its approach using QFE, the vertical position of the aircraft shall be expressed in terms of the height above the aerodrome datum which was used in establishing obstacle clearance height (OCH) (see Part I, Section 4, Chapter 1, 1.5, “Obstacle clearance altitude/height (OCA/H)”). All subsequent references to vertical position shall be made in terms of height.

Chapter 4

ALTIMETER CORRECTIONS

Note.— This chapter deals with altimeter corrections for pressure, temperature and, where appropriate, wind and terrain effects. The pilot is responsible for these corrections, except when under radar vectoring. In that case, the radar controller issues clearances such that the prescribed obstacle clearance will exist at all times, taking the cold temperature correction into account.

4.1 RESPONSIBILITY

4.1.1 Pilot's responsibility

The pilot-in-command is responsible for the safety of the operation and the safety of the aeroplane and of all persons on board during flight time (Annex 6, 4.5.1). This includes responsibility for obstacle clearance, except when an IFR flight is being vectored by radar.

Note: When an IFR flight is being vectored by radar, air traffic control (ATC) may assign minimum radar vectoring altitudes which are below the minimum sector altitude. Minimum vectoring altitudes provide obstacle clearance at all times until the aircraft reaches the point where the pilot will resume own navigation. The pilot-in-command should closely monitor the aircraft's position with reference to pilot-interpreted navigation aids to minimize the amount of radar navigation assistance required and to alleviate the consequences resulting from a radar failure. The pilot-in-command should also continuously monitor communications with ATC while being radar vectored, and should immediately climb the aircraft to the minimum sector altitude if ATC does not issue further instructions within a suitable interval, or if a communications failure occurs.

4.1.2 Operator's responsibility

The operator is responsible for establishing minimum flight altitudes, which may not be less than those established by States that are flown over (Annex 6, 4.2.6). The operator is responsible for specifying a method for determining these minimum altitudes (Annex 6, 4.2.6). Annex 6 recommends that the method should be approved by the State of the Operator and also recommends the factors to be taken into account.

4.1.3 State's responsibility

Annex 15, Appendix 1 (Contents of Aeronautical Information Publication), indicates that States should publish in Section GEN 3.3.5, "The criteria used to determine minimum flight altitudes". If nothing is published, it should be assumed that no corrections have been applied by the State.

Note.— The determination of lowest usable flight levels by air traffic control units within controlled airspace does not relieve the pilot-in-command of the responsibility for ensuring that adequate terrain clearance exists, except when an IFR flight is being vectored by radar.

4.1.4 Air traffic control (ATC)

If an aircraft is cleared by ATC to an altitude which the pilot-in-command finds unacceptable due to low temperature, then the pilot-in-command should request a higher altitude. If such a request is not received, ATC will consider that the clearance has been accepted and will be complied with. See Annex 2 and the PANS-ATM (Doc 4444), Chapter 6.

4.1.5 Flights outside controlled airspace

4.1.5.1 For IFR flights outside controlled airspace, including flights operating below the lower limit of controlled airspace, the determination of the lowest usable flight level is the responsibility of the pilot-in-command. Current or forecast QNH and temperature values should be taken into account.

4.1.5.2 It is possible that altimeter corrections below controlled airspace may accumulate to the point where the aircraft's position may impinge on a flight level or assigned altitude in controlled airspace. The pilot-in-command must then obtain clearance from the appropriate control agency.

4.2 PRESSURE CORRECTION

4.2.1 Flight levels

When flying at levels with the altimeter set to 1 013.2 hPa, the minimum safe altitude must be corrected for deviations in pressure when the pressure is lower than the standard atmosphere (1 013 hPa). An appropriate correction is 10 m (30 ft) per hPa below 1 013 hPa. Alternatively, the correction can be obtained from standard correction graphs or tables supplied by the operator.

4.2.2 QNH/QFE

When using the QNH or QFE altimeter setting (giving altitude or height above QFE datum respectively), a pressure correction is not required.

4.3 TEMPERATURE CORRECTION

4.3.1 Requirement for temperature correction

The calculated minimum safe altitudes/heights must be adjusted when the ambient temperature on the surface is much lower than that predicted by the standard atmosphere. In such conditions, an approximate correction is 4 per cent height increase for every 10°C below standard temperature as measured at the altimeter setting source. This is safe for all altimeter setting source altitudes for temperatures above -15°C.

4.3.2 Tabulated corrections

For colder temperatures, a more accurate correction should be obtained from Tables III-1-4-1 a) and III-1-4-1 b). These

tables are calculated for a sea level aerodrome. They are therefore conservative when applied at higher aerodromes. To calculate the corrections for specific aerodromes or altimeter setting sources above sea level, or for values not tabulated, see 4.3.3, “Corrections for specific conditions”.

Note 1.— The corrections have been rounded up to the next 5 m or 10 ft increment.

Note 2.— Temperature values from the reporting station (normally the aerodrome) nearest to the position of the aircraft should be used.

4.3.3 Corrections for specific conditions

Tables III-1-4-1 a) and III-1-4-1 b) were calculated assuming a linear variation of temperature with height. They were based on the following equation, which may be used with the appropriate value of t_0 , H , L_0 and H_{ss} to calculate temperature corrections for specific conditions. This equation produces results that are within 5 per cent of the accurate correction for altimeter setting sources up to 3 000 m (10 000 ft) and with minimum heights up to 1 500 m (5 000 ft) above that source.

$$\text{Correction} = H \times \left(\frac{15 - t_0}{273 + t_0 - 0.5 \times L_0 \times (H + H_{ss})} \right)$$

where:

- H = minimum height above the altimeter setting source (setting source is normally the aerodrome unless otherwise specified)
- t_0 = $t_{\text{aerodrome}} + L_0 \times h_{\text{aerodrome}}$. . . aerodrome (or specified temperature reporting point) temperature adjusted to sea level
- L_0 = 0.0065°C per m or 0.00198°C per ft
- H_{ss} = altimeter setting source elevation
- $t_{\text{aerodrome}}$ = aerodrome (or specified temperature reporting point) temperature
- $h_{\text{aerodrome}}$ = aerodrome (or specified temperature reporting point) elevation

4.3.4 Accurate corrections

4.3.4.1 For occasions when a more accurate temperature correction is required, this may be obtained from Equation 24 of the Engineering Sciences Data Unit (ESDU) publication, *Performance*, Volume 2, Item Number 77022¹. This assumes an off-standard atmosphere.

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$$\frac{-\Delta t_{\text{std}}}{L_0} \ln \left(\frac{1 + L_0 \times \Delta h_{\text{PAirplane}}}{t_0 + L_0 \times \Delta h_{\text{PAerodrome}}} \right)$$

where:

- $\Delta h_{\text{PAirplane}}$ = aircraft height above aerodrome (pressure)

$\Delta h_{\text{GAirplane}}$ = aircraft height above aerodrome (geopotential)

Δt_{std} = temperature deviation from the International Standard Atmosphere (ISA) temperature

L_0 = standard temperature lapse rate with pressure altitude in the first layer (sea level to tropopause) of the ISA

t_0 = standard temperature at sea level

Note.— Geopotential height includes a correction to account for the variation of g (average 9.8067 m sec^2) with heights. However, the effect is negligible at the minimum altitudes considered for obstacle clearance: the difference between geometric height and geopotential height increases from zero at mean sea level to -59 ft at $36\,000 \text{ ft}$.

4.3.4.2 The above equation cannot be solved directly in terms of $\Delta h_{\text{GAirplane}}$, and an iterative solution is required. This can be done with a simple computer or spreadsheet programme.

4.3.5 Assumption regarding temperature lapse rates

Both the above equations assume a constant off-standard temperature lapse rate. The actual lapse rate may vary considerably from the assumed standard, depending on latitude and time of year. However, the corrections derived from the linear approximation can be taken as a satisfactory estimate for general application at levels up to $4\,000 \text{ m}$ ($12\,000 \text{ ft}$). The correction from the accurate calculation is valid up to $11\,000 \text{ m}$ ($36\,000 \text{ ft}$).

Note 1.— Where required for take-off performance calculations or wherever accurate corrections are required for non-standard (as opposed to off-standard) atmospheres, appropriate methods are given in ESDU Item 78012, Height relationships for non-standard atmospheres. This allows for non-standard temperature lapse rates and lapse rates defined in terms of either geopotential height or pressure height.

Note 2.— Temperature values are those at the altimeter setting source (normally the aerodrome). En route, the setting source nearest to the position of the aircraft should be used.

4.3.6 Small corrections

For practical operational use, it is appropriate to apply a temperature correction when the value of the correction exceeds 20 per cent of the associated minimum obstacle clearance (MOC).

4.4 MOUNTAINOUS AREAS — EN ROUTE

The MOC over mountainous areas is normally applied during the design of routes and is stated in State aeronautical information publications. However, where no information is available, the margins in Tables III-1-4-2 and III-1-4-3 may be used when:

- a) the selected cruising altitude or flight level or one engine inoperative stabilizing altitude is at or close to the calculated minimum safe altitude; and
- b) the flight is within 19 km (10 NM) of terrain having a maximum elevation exceeding 900 m ($3\,000 \text{ ft}$).

4.5 MOUNTAINOUS TERRAIN — TERMINAL AREAS

4.5.1 The combination of strong winds and mountainous terrain can cause local changes in atmospheric pressure due to the Bernoulli effect. This occurs particularly when the wind direction is across mountain crests or ridges. It is not possible to make an exact calculation, but theoretical studies (CFD Norway, Report 109.1989) have indicated altimeter errors as shown in Tables III-1-4-4 and III-1-4-5. Although States may provide guidance, it is up to the pilot-in-command to evaluate whether the combination of terrain, wind strength and direction are such as to make a correction for wind necessary.

4.5.2 Corrections for wind speed should be applied in addition to the standard corrections for pressure and temperature, and ATC should be advised.

Table III-1-4-1 a). Values to be added by the pilot to minimum promulgated heights/altitudes (m)

Aerodrome temperature (°C)	Height above the elevation of the altimeter setting source (metres)													
	60	90	120	150	180	210	240	270	300	450	600	900	1 200	1 500
0	5	5	10	10	10	15	15	15	20	25	35	50	70	85
−10	10	10	15	15	25	20	25	30	30	45	60	90	120	150
−20	10	15	20	25	25	30	35	40	45	65	85	130	170	215
−30	15	20	25	30	35	40	45	55	60	85	115	170	230	285
−40	15	25	30	40	45	50	60	65	75	110	145	220	290	365
−50	20	30	40	45	55	65	75	80	90	135	180	270	360	450

Table III-1-4-1 b). Values to be added by the pilot to minimum promulgated heights/altitudes (ft)

Aerodrome temperature (°C)	Height above the elevation of the altimeter setting source (feet)													
	200	300	400	500	600	700	800	900	1 000	1 500	2 000	3 000	4 000	5 000
0	20	20	30	30	40	40	50	50	60	90	120	170	230	280
−10	20	30	40	50	60	70	80	90	100	150	200	290	390	490
−20	30	50	60	70	90	100	120	130	140	210	280	420	570	710
−30	40	60	80	100	120	140	150	170	190	280	380	570	760	950
−40	50	80	100	120	150	170	190	220	240	360	480	720	970	1 210
−50	60	90	120	150	180	210	240	270	300	450	590	890	1 190	1 500

Table III-1-4-2. Margin in mountainous areas (SI units)

Terrain variation	MOC
Between 900 m and 1 500 m	450 m
Greater than 1 500 m	600 m

**Table III-1-4-3. Margin in mountainous areas
(non-SI units)**

<i>Terrain variation</i>	<i>MOC</i>
Between 3 000 ft and 5 000 ft	1 476 ft
Greater than 5 000 ft	1 969 ft

**Table III-1-4-4. Altimeter error due to wind speed
(SI units)**

<i>Wind speed (km/h)</i>	<i>Altimeter error (m)</i>
37	17
74	62
111	139
148	247

**Table III-1-4-5. Altimeter error due to wind speed
(non-SI units)**

<i>Wind speed (kt)</i>	<i>Altimeter error (ft)</i>
20	53
40	201
60	455
80	812

Note.— The wind speed values were measured 30 m above aerodrome elevation.

Section 2

**SIMULTANEOUS OPERATIONS ON PARALLEL OR
NEAR-PARALLEL INSTRUMENT RUNWAYS**

Chapter 1

MODES OF OPERATION

1.1 INTRODUCTION

1.1.1 The impetus for considering simultaneous operations on parallel or near-parallel instrument runways in instrument meteorological conditions (IMC) is provided by the need to increase capacity at busy aerodromes. An aerodrome that already has dual parallel precision approach (ILS and/or MLS) runways could increase its capacity if these runways could be safely operated simultaneously and independently under IMC.

1.1.2 However, various factors, such as surface movement guidance and control, environmental considerations, and landside/airside infrastructure, may negate the advantage to be gained from simultaneous operations.

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

1.2 MODES OF OPERATION

1.2.1 There can be a variety of modes of operation associated with the use of parallel or near-parallel instrument runways.

1.2.1.1 Modes One and Two — Simultaneous parallel instrument approaches

There are two basic modes of operation for approaches made to parallel runways:

Mode 1, Independent parallel approaches: In this mode, radar separation minima between aircraft using adjacent ILS and/or MLS are not prescribed.

Mode 2, Dependent parallel approaches: In this mode, radar separation minima between aircraft using adjacent ILS and/or MLS are prescribed.

Note.— For MLS criteria applicable to Category I ILS-type approaches, see PANS-OPS, Volume II, Part II, Section 1, Chapter 3, “MLS”.

1.2.1.2 Mode 3 — Simultaneous instrument departures

Mode 3, Independent parallel departures: In this mode, aircraft are departing in the same direction from parallel runways simultaneously.

Note.— When the minimum distance between two parallel runway centre lines is less than the specified value dictated by wake turbulence considerations, the parallel runways are considered as a single runway in regard to separation between departing aircraft. A simultaneous dependent parallel departure mode of operation is therefore not

used.

1.2.1.3 Mode 4 — Segregated parallel approaches/departures

Mode 4, Segregated parallel operations: In this mode, one runway is used for approaches and one runway is used for departures.

1.2.1.4 Semi-mixed and mixed operations

1.2.1.4.1 In the case of parallel approaches and departures, there may be semi-mixed operations. In this scenario:

- a) one runway is used exclusively for departures while the other runway accepts a mixture of approaches and departures; or
- b) one runway is used exclusively for approaches while the other runway accepts a mixture of approaches and departures.

1.2.1.4.2 There may also be mixed operations, i.e. simultaneous parallel approaches with departures interspersed on both runways.

1.2.1.4.3 Semi-mixed or mixed operations may be related to the four basic modes listed in 1.2.1.1 through 1.2.1.3 as follows:

a) <i>Semi-mixed operations:</i>	<i>Mode</i>
1) One runway is used exclusively for approaches while:	
— approaches are being made to the other runway; or	1 or 2
— departures are in progress on the other runway.	4
2) One runway is used exclusively for departures while:	
— approaches are being made to the other runway; or	4
— departures are in progress on the other runway.	3
b) <i>Mixed operations:</i>	
All modes of operation are possible.	1, 2, 3, 4

1.2.2 Definitions

(see Figure III-2-1-1)

1.2.2.1 Normal operating zone (NOZ)

1.2.2.1.1 This is airspace of defined dimensions extending to either side of an ILS localizer course and/or MLS final approach track centre line. It extends from the runway threshold to the point where aircraft are established on the centre line.

1.2.2.1.2 Only the inner half of the normal operating zone is taken into account in independent parallel approaches.

1.2.2.1.3 The width of the normal operating zone (NOZ) is contingent upon the facilities present at a given airport. See 1.4, “Airport services and facilities”.

1.2.2.2 No transgression zone (NTZ)

In the context of independent parallel approaches, this is a corridor of airspace at least 610 m (2 000 ft) wide located centrally between the two extended runway centre lines. It extends from the nearer runway threshold to the point where 300 m (1 000 ft) vertical separation is reduced. Penetration of the NTZ by an aircraft requires controller intervention to manoeuvre any threatened aircraft on the adjacent approach.

1.3 EQUIPMENT REQUIREMENTS

1.3.1 Airborne avionics

Normal instrument flight rules (IFR) avionics including full ILS or MLS capability are required for conducting parallel approaches.

1.4 AIRPORT SERVICES AND FACILITIES

Independent/dependent parallel approaches may be conducted provided that:

a) the runway centre lines are spaced by the distances specified in Annex 14, Volume I; and

1) for independent parallel approaches:

— if runway centre lines are spaced by less than 1 310 m (4 300 ft) but not less than 1 035 m (3 400 ft). Suitable secondary surveillance radar (SSR) equipment is available, having:

- a minimum azimuth accuracy of 0.06 degrees (one sigma);
- an update period of 2.5 seconds or less; and
- a high resolution display providing position prediction and deviation alert; or

— if runway centre lines are spaced by less than 1 525 m (5 000 ft) but not less than 1 310 m (4 300 ft). SSR equipment with specifications other than those above may be used if the safety of aircraft operations is not adversely affected; or

— where runway centre lines are spaced by 1 525 m (5 000 ft) or more. Suitable surveillance radar is available, having:

- a minimum azimuth accuracy of 0.3 degrees (one sigma); and
- an update period of 5 seconds or less;

- 2) for dependent parallel approaches where runway centre lines are spaced by 915 m (3 000 ft) or more, suitable surveillance radar is available, having:

- a minimum azimuth accuracy of 0.3 degrees (one sigma); and
- an update period of 5 seconds or less;

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

- b) instrument approach charts are available that contain operational notes regarding the parallel approach procedures;
- c) aircraft make straight-in approaches;
- d) an ILS and/or MLS serve(s) each runway, preferably with collocated precision distance measuring equipment (DME);
- e) missed approach procedures provide divergent tracks as prescribed in the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444), Chapter 6;
- f) for independent parallel approaches, an obstacle survey and evaluation has been completed, as appropriate, for the areas adjacent to the final approach segments;
- g) aircraft are advised of the runway identification and ILS localizer and/or MLS frequency;
- h) aircraft are radar vectored to the ILS localizer course or the MLS final approach track;
- i) as early as practicable after an aircraft has established communication with approach control, the aircraft shall be advised that independent parallel approaches are in force. This information may be provided through the automatic terminal information service (ATIS) broadcasts. In addition, the aircraft shall be advised of the runway identification and the ILS localizer and/or MLS frequency to be used;
- j) separate radar controllers dedicated to monitoring the track-keeping of aircraft on parallel approaches (independent parallel approaches only) are provided; and
- k) dedicated radio channels or override capability for the monitoring radar controllers to use for the appropriate voice communication facilities are provided.

1.5 VECTORING TO THE ILS LOCALIZER COURSE OR MLS FINAL APPROACH TRACK

1.5.1 When simultaneous independent parallel approaches are in progress, the following apply:

- a) The main objective is that both aircraft be established on the ILS localizer course or MLS final approach track before the 300 m (1 000 ft) vertical separation is reduced; and
- b) All approaches regardless of weather conditions shall be radar-monitored. Control instructions and information necessary to ensure separation between aircraft and to ensure that aircraft do not enter the NTZ shall be issued. The air traffic control procedure will be to vector arriving aircraft to one or the other of the parallel ILS localizer courses and/or the MLS final approach tracks. When cleared for an ILS or MLS approach, a procedure

turn is not permitted.

- c) When vectoring to intercept the ILS localizer course or MLS final approach track, the final vector shall be such as to:
- 1) allow the aircraft to intercept the ILS localizer course or MLS final approach track at an angle not greater than 30 degrees; and
 - 2) provide at least 2 km (1.0 NM) straight and level flight prior to ILS localizer course or MLS final approach track intercept.

The vector shall also be such as to enable the aircraft to be established on the ILS localizer course or MLS final approach track in level flight for at least 3.7 km (2.0 NM) prior to intercepting the ILS glide path or specified MLS elevation angle.

- d) Each pair of parallel approaches will have a “high side” and a “low side” for vectoring to provide vertical separation until aircraft are established inbound on their respective parallel ILS localizer course and/or MLS final approach track. The low side altitude will normally be such that the aircraft will be established on the ILS localizer course or MLS final approach track well before ILS glide path or specified MLS elevation angle interception. The high side altitude will be 300 m (1 000 ft) above the low side.
- e) When the aircraft is assigned its final heading to intercept the ILS localizer course or MLS final approach track, it shall be advised of:
- 1) its final heading to intercept the ILS localizer course (or MLS final approach track);
 - 2) the altitude to be maintained until both:
 - the aircraft is established on the ILS localizer centre line (or MLS final approach track); and
 - the aircraft has reached the ILS glide path (or specified MLS elevation angle) intercept point; and
 - 3) if required, clearance for the final approach.
- f) If an aircraft is observed to overshoot the ILS localizer course or MLS final approach track during turn-to-final, the aircraft will be instructed to return immediately to the correct track. Pilots are not required to acknowledge these transmissions or subsequent instructions while on final approach unless requested to do so.
- g) Once the 300 m (1 000 ft) vertical separation is reduced, the radar controller monitoring the approach will issue control instructions if the aircraft deviates substantially from the ILS localizer course or MLS final approach track.
- h) If an aircraft that deviates substantially from the ILS localizer course (or MLS final approach track) fails to take corrective action and penetrates the NTZ, the aircraft on the adjacent ILS localizer course (or MLS final approach track) will be instructed to immediately climb and turn to the assigned altitude and heading in order to avoid the deviating aircraft.

1.5.2 Where parallel approach obstacle assessment surfaces (PAOAS) criteria are applied for obstacle assessment, the heading instruction shall not exceed 45° track difference with the ILS localizer course (or MLS final approach track). The air traffic controller shall not issue the heading instruction to the aircraft below 120 m (400 ft) above the runway threshold elevation.

1.5.3 Due to the nature of this break-out manoeuvre, the pilot is expected to arrest the descent and immediately initiate a climbing turn.

1.6 TERMINATION OF RADAR MONITORING

Note.— Provisions concerning the termination of radar monitoring are contained in the PANS-ATM (Doc 4444), Chapter 8.

1.7 TRACK DIVERGENCE

Simultaneous parallel operations require diverging tracks for missed approach procedures and departures. When turns are prescribed to establish divergence, pilots shall begin the turns as soon as practicable.

1.8 SUSPENSION OF INDEPENDENT PARALLEL APPROACHES TO CLOSELY SPACED PARALLEL RUNWAYS

Note.— Provisions concerning the suspension of independent parallel approaches to closely spaced parallel runways are contained in the PANS-ATM (Doc 4444), Chapter 8.

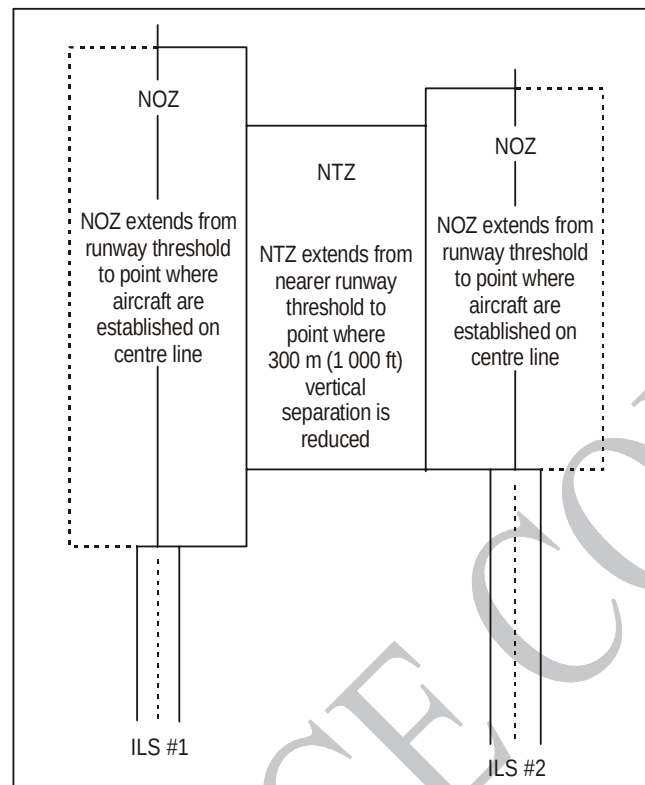


Figure III-2-1-1. Example of normal operating zones (NOZs) and no transgression zone (NTZ)

Section 3

**SECONDARY SURVEILLANCE RADAR (SSR)
TRANSPONDER OPERATING PROCEDURES**

Chapter 1

OPERATION OF TRANSPONDERS

1.1 GENERAL

1.1.1 When an aircraft carries a serviceable transponder, the pilot shall operate the transponder at all times during flight, regardless of whether the aircraft is within or outside airspace where secondary surveillance radar (SSR) is used for ATS purposes.

1.1.2 Except in case of emergency, communication failure or unlawful interference (see 1.4, 1.5 and 1.6), the pilot shall:

- a) operate the transponder and select Mode A codes as directed by the ATC unit with which contact is being made; or
- b) operate the transponder on Mode A codes as prescribed on the basis of regional air navigation agreements; or
- c) in the absence of any ATC directions or regional air navigation agreements, operate the transponder on Mode A Code 2000.

1.1.3 When the aircraft carries serviceable Mode C equipment, the pilot shall continuously operate this mode, unless otherwise directed by ATC.

1.1.4 When requested by ATC to specify the capability of the transponder aboard the aircraft, pilots shall indicate this in item 10 of the flight plan by inserting the appropriate letter prescribed for the purpose.

1.1.5 When requested by ATC to CONFIRM SQUAWK (code), the pilot shall:

- a) verify the Mode A code setting on the transponder;
- b) reselect the assigned code if necessary; and
- c) confirm to ATC the setting displayed on the controls of the transponder.

Note.— For action in case of unlawful interferences, see 1.6.2.

1.1.6 Pilots shall not SQUAWK IDENT unless requested by ATC.

1.2 USE OF MODE C

Whenever Mode C is operated, pilots shall, in air-ground voice communications where level information is required, give such information by stating their level to the nearest full 30 m or 100 ft as indicated on the pilot's altimeter.

1.3 USE OF MODE S

Pilots of aircraft equipped with Mode S having an aircraft identification feature shall set the aircraft identification in the transponder. This setting shall correspond to the aircraft identification specified in item 7 of the ICAO flight plan, or, if no flight plan has been filed, the aircraft registration.

Note.— All Mode S equipped aircraft engaged in international civil aviation are required to have an aircraft identification feature.

1.4 EMERGENCY PROCEDURES

The pilot of an aircraft in a state of emergency shall set the transponder to Mode A Code 7700 unless ATC has previously directed the pilot to operate the transponder on a specified code. In the latter case, the pilot shall continue to use the specified code unless otherwise advised by ATC. However, a pilot may select Mode A Code 7700 whenever there is a specific reason to believe that this would be the best course of action.

1.5 COMMUNICATION FAILURE PROCEDURES

The pilot of an aircraft losing two-way communications shall set the transponder to Mode A Code 7600.

Note.— A controller who observes an SSR response indicating selection of the communications failure code will determine the extent of the failure by instructing the pilot to SQUAWK IDENT or to change code. If it is determined that the aircraft receiver is functioning, further control of the aircraft will be continued using code changes or IDENT transmission to acknowledge receipt of clearances. Different procedures may be applied to Mode S equipped aircraft in areas of Mode S coverage.

1.6 UNLAWFUL INTERFERENCE WITH AIRCRAFT IN FLIGHT

1.6.1 If there is unlawful interference with an aircraft in flight, the pilot-in-command shall attempt to set the transponder to Mode A Code 7500 in order to indicate the situation. If circumstances so warrant, Code 7700 should be used instead.

1.6.2 If a pilot has selected Mode A Code 7500 and has been requested to confirm this code by ATC (in accordance with 1.1.5), the pilot shall, according to circumstances, either confirm this or not reply at all.

Note.— If the pilot does not reply, ATC will take this as confirmation that the use of Code 7500 is not an inadvertent false code selection.

1.7 TRANSPONDER FAILURE PROCEDURES WHEN THE CARRIAGE OF A FUNCTIONING TRANSPONDER IS MANDATORY

1.7.1 In case of a transponder failure after departure, ATC units shall attempt to provide for continuation of the flight to the destination aerodrome in accordance with the flight plan. Pilots may, however, expect to comply with specific restrictions.

1.7.2 In the case of a transponder which has failed and cannot be restored before departure, pilots shall:

- a) inform ATS as soon as possible, preferably before submission of a flight plan;
- b) insert in item 10 of the ICAO flight plan form under SSR the character N for complete unserviceability of the transponder or, in case of partial transponder failure, insert the character corresponding to the remaining transponder capability;
- c) comply with any published procedures for requesting an exemption from the requirements to carry a functioning SSR transponder; and
- d) if required by the appropriate ATS authority, plan to proceed, as directly as possible, to the nearest suitable aerodrome where repair can be carried out.

Chapter 2

PHRASEOLOGY

2.1 PHRASEOLOGY USED BY ATS

The phraseology used by ATS is contained in the PANS-ATM (Doc 4444), Chapter 12.

2.2 PHRASEOLOGY USED BY PILOTS

Pilots shall read back the mode and code to be set when they acknowledge mode/code setting instructions.

Chapter 3

OPERATION OF AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS) EQUIPMENT

3.1 GENERAL

3.1.1 Airborne collision avoidance system (ACAS) indications shall be used by pilots in the avoidance of potential collisions, the enhancement of situational awareness, and the active search for, and visual acquisition of, conflicting traffic.

3.1.2 Nothing in the procedures specified in 3.2, “Use of ACAS indicators”, shall prevent pilots-in-command from exercising their best judgement and full authority in the choice of the best course of action to resolve a traffic conflict or avert a potential collision.

Note 1.— The ability of ACAS to fulfil its role of assisting pilots in the avoidance of potential collisions is dependent on the correct and timely response by pilots to ACAS indications. Operational experience has shown that the correct response by pilots is dependent on the effectiveness of initial and recurrent training in ACAS procedures.

Note 2.— ACAS II Training Guidelines for Pilots are provided in Attachment A to Part III, Section 3, Chapter 3, “ACAS II Training Guidelines for Pilots”.

3.2 USE OF ACAS INDICATORS

The indications generated by ACAS shall be used by pilots in conformity with the following safety considerations:

- a) pilots shall not manoeuvre their aircraft in response to traffic advisories (TAs) only;

Note 1.— TAs are intended to alert pilots to the possibility of a resolution advisory (RA), to enhance situational awareness, and to assist in visual acquisition of conflicting traffic. However, visually acquired traffic may not be the same traffic causing a TA. Visual perception of an encounter may be misleading, particularly at night.

Note 2.— The above restriction in the use of TAs is due to the limited bearing accuracy and to the difficulty in interpreting altitude rate from displayed traffic information.

- b) on receipt of a TA, pilots shall use all available information to prepare for appropriate action if an RA occurs; and
- c) in the event of an RA, pilots shall:
 - 1) respond immediately by following the RA as indicated, unless doing so would jeopardize the safety of the aeroplane;

Note 1.— Stall warning, wind shear, and ground proximity warning system alerts have precedence over

ACAS.

Note 2.— Visually acquired traffic may not be the same traffic causing an RA. Visual perception of an encounter may be misleading, particularly at night.

- 2) follow the RA even if there is a conflict between the RA and an air traffic control (ATC) instruction to manoeuvre;
- 3) not manoeuvre in the opposite sense to an RA;

Note.— In the case of an ACAS-ACAS coordinated encounter, the RAs complement each other in order to reduce the potential for collision. Manoeuvres, or lack of manoeuvres, that result in vertical rates opposite to the sense of an RA could result in a collision with the threat aircraft.

- 4) as soon as possible, as permitted by flight crew workload, notify the appropriate ATC unit of the RA, including the direction of any deviation from the current ATC instruction or clearance;

Note.— Unless informed by the pilot, ATC does not know when ACAS issues RAs. It is possible for ATC to issue instructions that are unknowingly contrary to ACAS RA indications. Therefore, it is important that ATC be notified when an ATC instruction or clearance is not being followed because it conflicts with an RA.

- 5) promptly comply with any modified RAs;
- 6) limit the alterations of the flight path to the minimum extent necessary to comply with the RAs;
- 7) promptly return to the terms of the ATC instruction or clearance when the conflict is resolved; and
- 8) notify ATC when returning to the current clearance.

Note.— Procedures in regard to ACAS-equipped aircraft and the phraseology to be used for the notification of manoeuvres in response to an RA are contained in the PANS-ATM (Doc 4444), Chapters 15 and 12 respectively.

Attachment A to Part III, Section 3, Chapter 3

ACAS II TRAINING GUIDELINES FOR PILOTS

Note.—The acronym “ACAS” is used in this attachment to indicate “ACAS II”.

1. INTRODUCTION

1.1 During the implementation of ACAS and the operational evaluations conducted by States, several operational issues were identified that were attributed to deficiencies in pilot training programmes. To address these deficiencies, a set of performance-based training objectives for ACAS pilot training was developed. The training objectives cover: theory of operation; pre-flight operations; general in-flight operations; response to traffic advisories (TAs); and response to resolution advisories (RAs). The training objectives are further divided into the areas of: ACAS academic training; ACAS manoeuvre training; ACAS initial evaluation; and ACAS recurrent qualification.

1.2 ACAS academic training material has been divided into items that are considered essential training and those that are considered desirable. Those items that are deemed to be essential are a requirement for each ACAS operator. In each area, a list of objectives and acceptable performance criteria is defined. All manoeuvre training is considered essential.

1.3 In developing this material, no attempt was made to define how the training programme should be implemented. Instead, objectives were established that define the knowledge a pilot operating ACAS is expected to possess and the performance expected from a pilot who has completed ACAS training. Therefore, all pilots who operate ACAS equipment should receive the ACAS training described below.

2. ACAS ACADEMIC TRAINING

2.1 General

This training is typically conducted in a classroom environment. The knowledge demonstrations specified in this section may be achieved through the successful completion of written tests or providing correct responses to non-real-time computer-based training (CBT) questions.

2.2 Essential items

2.2.1 *Theory of operation.* The pilot must demonstrate an understanding of ACAS operation and the criteria used for issuing TAs and RAs. This training should address the following topics:

2.2.1.1 System operation

OBJECTIVE: Demonstrate knowledge of how ACAS functions.

CRITERIA: The pilot must demonstrate an understanding of the following functions:

a) Surveillance:

- 1) ACAS interrogates other transponder-equipped aircraft within a nominal range of 26 km (14 NM); and
- 2) ACAS surveillance range can be reduced in geographic areas with a large number of ground interrogators and/or ACAS-equipped aircraft. A minimum surveillance range of 8.5 km (4.5 NM) is guaranteed for ACAS aircraft that are airborne.

Note. — If the operator's ACAS installation provides for the use of the Mode S extended squitter, the normal surveillance range may be increased beyond the nominal 14 NM. However, this information is not used for collision avoidance purposes.

b) Collision avoidance:

- 1) TAs can be issued against any transponder-equipped aircraft that responds to the ICAO Mode C interrogations, even if the aircraft does not have altitude-reporting capability;

Note. — SSR transponders having only Mode A capability do not generate TAs. ACAS does not use Mode A interrogations; therefore, the Mode A transponder codes of nearby aircraft are not known to ACAS. In ICAO SARPs, Mode C minus the altitude is not considered Mode A because of the difference in the pulse intervals. ACAS uses the framing pulses of replies to Mode C interrogations and will track and may display aircraft equipped with an operating Mode A/C transponder whether or not the altitude-reporting function has been enabled.

- 2) RAs can be issued only against aircraft that are reporting altitude and in the vertical plane only;
- 3) RAs issued against an ACAS-equipped intruder are coordinated to ensure that complementary RAs are issued;
- 4) failure to respond to an RA deprives the aircraft of the collision protection provided by its ACAS. Additionally, in ACAS-ACAS encounters, it also restricts the choices available to the other aircraft's ACAS and thus renders the other aircraft's ACAS less effective than if the first aircraft were not ACAS-equipped; and
- 5) manoeuvring in a direction opposite to that indicated by an RA is likely to result in further reduction in separation. This is particularly true in the case of an ACAS-ACAS coordinated encounter.

2.2.1.2 Advisory thresholds

OBJECTIVE: Demonstrate knowledge of the criteria for issuing TAs and RAs.

CRITERIA: The pilot must be able to demonstrate an understanding of the methodology used by ACAS to issue TAs and RAs and the general criteria for the issuance of these advisories to include:

- a) ACAS advisories are based on time to closest point of approach (CPA) rather than distance. The time must be short and vertical separation must be small, or projected to be small, before an advisory can be issued. The separation standards provided by air traffic services are different from those against which ACAS issues alerts;
- b) thresholds for issuing a TA or RA vary with altitude. The thresholds are larger at higher altitudes;
- c) TAs generally occur from 20 to 48 seconds prior to CPA. When ACAS is operated in TA-only mode, RAs will be inhibited;

- d) RAs occur from 15 to 35 seconds before the projected CPA; and
- e) RAs are chosen to provide the desired vertical separation at CPA. As a result, RAs can instruct a climb or descent through the intruder aircraft's altitude.

2.2.1.3 ACAS limitations

OBJECTIVE: To verify that the pilot is aware of the limitations of ACAS.

CRITERIA: The pilot must demonstrate a knowledge and understanding of the ACAS limitations including:

- a) ACAS will neither track nor display non-transponder-equipped aircraft, nor aircraft with an inoperable transponder, nor aircraft with a Mode A transponder;
- b) ACAS will automatically fail if the input from the aircraft's barometric altimeter, radio altimeter, or transponder is lost;

Note.— In some installations, the loss of information from other on-board systems such as an inertial reference system (IRS) or attitude and heading reference system (AHRS) may result in an ACAS failure. Individual operators should ensure that their pilots are aware of what types of aircraft system failures will result in an ACAS failure.

- c) some aircraft within 116 m (380 ft) above ground level (AGL) (nominal value) will not be displayed. If ACAS is able to determine that an aircraft below this altitude is airborne, it will be displayed;
- d) ACAS may not display all proximate transponder-equipped aircraft in areas of high-density traffic; however, it will still issue RAs as necessary;
- e) because of design limitations, the bearing displayed by ACAS is not sufficiently accurate to support the initiation of horizontal manoeuvres based solely on the traffic display;
- f) because of design limitations, ACAS will neither display nor give alerts against intruders with a vertical speed in excess of 3 048 m/min (10 000 ft/min). In addition, the design implementation may result in some short-term errors in the tracked vertical speed of an intruder during periods of high vertical acceleration by the intruder; and
- g) stall warnings, ground proximity warning system (GPWS)/enhanced ground proximity warning system (EGPWS) warnings, and wind shear warnings take precedence over ACAS advisories. When either a GPWS/EGPWS or wind shear warning is active, ACAS will automatically switch to the TA-only mode of operation except that ACAS aural annunciations will be inhibited. ACAS will remain in TA-only mode for 10 seconds after the GPWS/EGPWS or wind shear warning is removed.

2.2.1.4 ACAS inhibits

OBJECTIVE: To verify that the pilot is aware of the conditions under which certain functions of ACAS are inhibited.

CRITERIA: The pilot must demonstrate a knowledge and understanding of the various ACAS inhibits including:

- a) increase descent RAs are inhibited below 442 (• 30) m (1 450 (• 100) ft) AGL;
- b) descend RAs are inhibited below 335 (• 30) m (1 100 (• 100) ft) AGL;
- c) all RAs are inhibited below 305 (• 30) m (1 000 (• 100) ft) AGL;
- d) all ACAS aural annunciations are inhibited below 152 (• 30) m (500 (• 100) ft) AGL. This includes the aural

annunciation for TAs; and

- e) altitude and configuration under which climb and increase climb RAs are inhibited. ACAS can still issue climb and increase climb RAs when operating at the aircraft's maximum altitude or certified ceiling. However, if aeroplane performance at maximum altitude is not sufficient to enable compliance with the climb rate required by a climb RA, the response should still be in the required sense but not beyond the extent permitted by aeroplane performance limitations.

Note.— In some aircraft types, climb or increase climb RAs are never inhibited.

2.2.2 *Operating procedures.* The pilot must demonstrate the knowledge required to operate ACAS and interpret the information presented by ACAS. This training should address the following topics:

2.2.2.1 *Use of controls*

OBJECTIVE: To verify that the pilot can properly operate all ACAS and display controls.

CRITERIA: Demonstrate the proper use of controls including:

- a) aircraft configuration required to initiate a self-test;
- b) steps required to initiate a self-test;
- c) recognizing when the self-test is successful and when it is unsuccessful. When the self-test is unsuccessful, recognizing the reason for the failure, and, if possible, correcting the problem;
- d) recommended usage of traffic display range selection. Low ranges are used in the terminal area, and the higher display ranges are used in the en-route environment and in the transition between the terminal and en-route environment;
- e) if available, recommended usage of the "Above/Below" mode selector. "Above" mode should be used during climb, and "Below" mode should be used during descent;
- f) recognition that the configuration of the traffic display, i.e. range and "Above/Below" selection, does not affect the ACAS surveillance volume;
- g) selection of lower ranges on the traffic display to increase display resolution when an advisory is issued;
- h) if available, proper selection of the display of absolute or relative altitude and the limitations of using the absolute display option if a barometric correction is not provided to ACAS; and
- i) proper configuration to display the appropriate ACAS information without eliminating the display of other needed information.

Note.— The wide variety of display implementations makes it difficult to establish more definitive criteria. When the training programme is developed, these general criteria should be expanded to cover specific details for an operator's specific display implementation.

2.2.2.2 *Display interpretation*

OBJECTIVE: To verify that a pilot understands the meaning of all information that can be displayed by ACAS.

CRITERIA: The pilot must demonstrate the ability to properly interpret information displayed by ACAS including:

- a) other traffic, i.e. traffic within the selected display range that is not proximate traffic, or causing a TA or RA to be issued;
- b) proximate traffic, i.e. traffic that is within 11 km (6 NM) and • 366 m (1 200 ft);
- c) non-altitude reporting traffic;
- d) no bearing TAs and RAs;
- e) off-scale TAs and RAs. The selected range should be changed to ensure that all available information on the intruder is displayed;
- f) traffic advisories. The minimum available display range that allows the traffic to be displayed should be selected to provide the maximum display resolution;
- g) resolution advisories (traffic display). The minimum available display range of the traffic display that allows the traffic to be displayed should be selected to provide the maximum display resolution;
- h) resolution advisories (RA display). Pilots should demonstrate knowledge of the meaning of the red and green areas or the meaning of pitch or flight path angle cues displayed on the RA display. For displays using red and green areas, pilots should demonstrate knowledge of when the green areas will and will not be displayed. Pilots should also demonstrate an understanding of the RA display limitations, i.e. if a vertical speed tape is used and the range of the tape is less than 762 m/min (2 500 ft/min), how an increase rate RA will be displayed; and
- i) if appropriate, awareness that navigation displays oriented “Track-Up” may require a pilot to make a mental adjustment for drift angle when assessing the bearing of proximate traffic.

Note.— The wide variety of display implementations will require the tailoring of some criteria. When the training programme is developed, these criteria should be expanded to cover details for an operator’s specific display implementation.

2.2.2.3 Use of the TA-only mode

OBJECTIVE: To verify that a pilot understands the appropriate times to select the TA-only mode of operation and the limitations associated with using this mode.

CRITERIA: The pilot must demonstrate the following:

- a) knowledge of the operator’s guidance for the use of TA-only mode;
- b) reasons for using this mode and situations in which its use may be desirable. These include operating in known close proximity to other aircraft such as when visual approaches are being used to closely spaced parallel runways or taking off towards aircraft operating in a VFR corridor. If TA-only mode is not selected when an airport is conducting simultaneous operations from parallel runways separated by less than 366 m (1 200 ft), and to some intersecting runways, RAs can be expected. If an RA is received in these situations, the response should comply with the operator’s approved procedures; and
- c) the TA aural annunciation is inhibited below 152 m (• 30) m (500 ft (• 100 ft)) AGL. As a result, TAs issued below 152 m (500 ft) AGL may not be noticed unless the TA display is included in the routine instrument scan.

2.2.2.4 Crew coordination

OBJECTIVE: To verify that pilots adequately brief other crew members on how ACAS advisories will be handled.

CRITERIA: Pilots must demonstrate that their pre-flight briefing addresses the procedures that will be used in responding to TAs and RAs including:

- a) division of duties between the pilot flying and the pilot not flying, including a clear definition of whether the pilot flying or the pilot-in-command will fly the aircraft during a response to an RA;
- b) expected call-outs;
- c) communications with ATC; and
- d) conditions under which an RA may not be followed and who will make this decision.

Note 1.— Different operators have different procedures for conducting pre-flight briefings and for responding to ACAS advisories. These factors should be taken into consideration when implementing the training programme.

Note 2.— The operator must specify the conditions under which an RA need not be followed, reflecting advice published by States' Civil Aviation Authorities. This should not be an item left to the discretion of a crew.

Note 3.— This portion of the training may be combined with other training such as crew resource management (CRM).

2.2.2.5 Reporting requirements

OBJECTIVE: To verify that the pilot is aware of the requirements for reporting RAs to the controller and other authorities.

CRITERIA: The pilot must demonstrate the following:

- a) the use of the phraseology contained in the *Procedures for Air Navigation Services — Air Traffic Management* (PANS-ATM, Doc 4444); and
- b) where information can be obtained regarding the need for making written reports to various States when an RA is issued. Various States have different reporting requirements and the material available to the pilot should be tailored to the airline's operating environment.

2.3 Desirable items

2.3.1 Advisory thresholds

OBJECTIVE: Demonstrate knowledge of the criteria for issuing TAs and RAs.

CRITERIA: The pilot must be able to demonstrate an understanding of the methodology used by ACAS to issue TAs and RAs and the general criteria for the issuance of these advisories to include:

- a) the TA altitude threshold is 259 m (850 ft) below FL 420 and 366 m (1 200 ft) above FL 420;
- b) when the vertical separation at CPA is projected to be less than the ACAS-desired separation, an RA requiring a change to the existing vertical speed will be issued. The ACAS-desired separation varies from 91 m (300 ft) at low altitude to a maximum of 213 m (700 ft) above FL 300;
- c) when the vertical separation at CPA is projected to be greater than the ACAS-desired separation, an RA that does not require a change to the existing vertical speed will be issued. This separation varies from 183 to 244 m (600 to 800 ft); and

- d) RA fixed-range thresholds vary between 0.4 km (0.2 NM) at low altitude and 2 km (1.1 NM) at high altitude. These fixed-range thresholds are used to issue RAs in encounters with slow closure rates.

3. ACAS MANOEUVRE TRAINING

3.1 When training pilots to properly respond to ACAS-displayed information, TAs and RAs are most effective when accomplished in a flight simulator equipped with an ACAS display and controls similar in appearance and operation to those in the aircraft. If a simulator is utilized, CRM aspects of responding to TAs and RAs should be practised during this training.

3.2 If an operator does not have access to an ACAS-equipped simulator, the initial ACAS evaluation should be conducted by means of an interactive CBT with an ACAS display and controls similar in appearance and operation to those in the aircraft the pilot will fly. This interactive CBT should depict scenarios in which real-time responses must be made. The pilot should be informed whether or not the responses made were correct. If the response was incorrect or inappropriate, the CBT should show what the correct response should be.

3.3 The scenarios in the manoeuvre training should include initial RAs that require a change in vertical speed; initial RAs not requiring a change in vertical speed; maintain rate RAs; altitude crossing RAs; increase rate RAs; RA reversals; weakening RAs; RAs issued while the aircraft is at a maximum altitude, and multi-aircraft encounters. In all scenarios, excursions should be limited to the extent required by the RA. The scenarios should be concluded with a return to the original flight profile. The scenarios should also include demonstrations of the consequences of not responding to RAs, slow or late responses, and manoeuvring opposite to the direction called for by the displayed RA as follows:

3.3.1 TA responses

OBJECTIVE: To verify that the pilot properly interprets and responds to TAs.

CRITERIA: The pilot must demonstrate:

- a) proper division of responsibilities between the pilot flying and the pilot not flying. The pilot flying should continue to fly the aeroplane and be prepared to respond to any RA that might follow. The pilot not flying should provide updates on the traffic location shown on the ACAS traffic display and use this information to help visually acquire the intruder;
- b) proper interpretation of the displayed information. Visually search for the traffic causing the TA at a location shown on the traffic display. Use should be made of all information shown on the display, note being taken of the bearing and range of the intruder (amber circle), whether it is above or below (data tag), and its vertical speed direction (trend arrow);
- c) other available information is used to assist in visual acquisition. This includes ATC “party-line” information, traffic flow in use, etc.;
- d) because of the limitations described in 2.2.1.3 e), that no manoeuvres are made based solely on the information shown on the ACAS display; and
- e) when visual acquisition is attained, right of way rules are used to maintain or attain safe separation. No unnecessary manoeuvres are initiated. The limitations of making manoeuvres based solely on visual acquisition are understood.

3.3.2 RA responses

OBJECTIVE: To verify THAT the pilot properly interprets and responds to RAs.

CRITERIA: The pilot MUST demonstrate:

- a) proper division of responsibilities between the pilot flying and the pilot not flying. The pilot flying should respond to the RA with positive control inputs, when required, while the pilot not flying is providing updates on the traffic location, checking the traffic display and monitoring the response to the RA. Proper CRM should be used. If the operator's procedures require the pilot-in-command to fly all RAs, transfer of aircraft control should be demonstrated;
- b) proper interpretation of the displayed information. The pilot recognizes the intruder causing the RA to be issued (red square on display). The pilot responds appropriately;
- c) RAs requiring a change in vertical speed, initiation of a response in the proper direction is made within five seconds of the RA being displayed. After initiating the manoeuvre, and as soon as possible, as permitted by flight workload, ATC is notified using the standard phraseology;

Note.— Part III, Chapter 3, 3.2 c) 1), states that in the event of an RA, pilots should respond immediately and manoeuvre as indicated, unless doing so would jeopardize the safety of the aeroplane.

- d) recognition of and the proper response to modifications to the initially displayed RA:
 - 1) for increase rate RAs, the vertical speed is increased within 2 1/2 seconds of the RA being displayed;
 - 2) for RA reversals, the manoeuvre is initiated within 2 1/2 seconds of the RA being displayed;
 - 3) for RA weakenings, the vertical speed is modified to initiate a return towards level flight within 2 1/2 seconds of the RA being displayed; and
 - 4) for RAs that strengthen, the manoeuvre to comply with the revised RA is initiated within 2 1/2 seconds of the RA being displayed;
- e) recognition of altitude crossing encounters and the proper response to these RAs;
- f) for RAs that do not require a change in vertical speed, the vertical speed needle or pitch angle remains outside the red area on the RA display;
- g) for maintain rate RAs, the vertical speed is not reduced. Pilots should recognize that a maintain rate RA may result in crossing through the intruder's altitude;
- h) that if a justified decision is made to not follow an RA, the resulting vertical rate is not in a direction opposite to the sense of the displayed RA;
- i) that the deviation from the current clearance is minimized by levelling the aircraft when the RA weakens and when "Clear of Conflict" is annunciated, executing a prompt return to the current clearance; and notifying ATC as soon as possible, as permitted by flight crew workload;
- j) that when possible, an ATC clearance is complied with while responding to an RA. For example, if the aircraft can level at the assigned altitude while responding to a reduce climb or reduce descent RA, it should be done;
- k) that when simultaneous conflicting instructions to manoeuvre are received from ATC and an RA, the RA is followed and, as soon as possible, as permitted by flight crew workload, ATC is notified using the standard phraseology;

- l) a knowledge of the ACAS multi-aircraft logic and its limitations, and that ACAS can optimize separation from two aircraft by climbing or descending towards one of them. For example, ACAS considers as intruders only aircraft that it finds to be a threat when selecting an RA. As such, it is possible for ACAS to issue an RA against one intruder, which results in a manoeuvre towards another intruder that is not classified as a threat. If the second intruder becomes a threat, the RA will be modified to provide separation from that intruder;
- m) a knowledge of the consequences of not responding to an RA and manoeuvring in the direction opposite to the RA; and
- n) that a prompt response is made when a climb RA is issued while the aircraft is at the maximum altitude.

4. ACAS INITIAL EVALUATION

4.1 The pilot's understanding of the academic training items should be assessed by means of a written test or interactive CBT that records correct and incorrect responses to questions.

4.2 The pilot's understanding of the manoeuvre training items should be assessed in a flight simulator equipped with an ACAS display and controls similar in appearance and operation to those in the aircraft the pilot will fly, and the results assessed by a qualified instructor, inspector, or check pilot. The range of scenarios should include: initial RAs requiring a change in vertical speed; initial RAs that do not require a change in vertical speed; maintain rate RAs; altitude crossing RAs; increase rate RAs; RA reversals; weakening RAs; RAs issued while the aircraft is at the maximum altitude, and multi-aircraft encounters. In all scenarios, excursions should be limited to the extent required by the RA. The scenarios should be concluded with a return to the original flight profile. The scenarios should also include demonstrations of the consequences of not responding to RAs, slow or late responses, and manoeuvring opposite to the direction called for by the displayed RA.

4.3 If an operator does not have access to an ACAS-equipped simulator, the initial ACAS evaluation should be conducted by means of an interactive CBT with an ACAS display and controls similar in appearance and operation to those in the aircraft the pilot will fly. This interactive CBT should depict scenarios in which real-time responses must be made, and a record should be made of whether or not each response was correct. The CBT should include all types of RAs described in 4.2.

5. ACAS RECURRENT TRAINING

5.1 ACAS recurrent training ensures that pilots maintain the appropriate ACAS knowledge and skills. ACAS recurrent training should be integrated into and/or conducted in conjunction with other established recurrent training programmes. An essential item of recurrent training is the discussion of any significant issues and operational concerns that have been identified by the operator.

5.2 ACAS monitoring programmes periodically publish findings from their analyses of ACAS events. The results of these analyses typically discuss technical and operational issues related to the use and operation of ACAS. This information is available from ICAO or directly from the monitoring programmes. ACAS recurrent training programmes should address the results of monitoring programmes in both the academic and simulator portions of recurrent training visits.

Note.—ACAS monitoring programmes are carried out by some States and international organizations including the United States' Federal Aviation Administration (FAA) and the European Organisation for the Safety of Air Navigation (EUROCONTROL).

5.3 Recurrent training should include both academic and manoeuvre training and address any significant issues identified by line operating experience, system changes, procedural changes, or unique characteristics such as the introduction of new aircraft/ display systems or operations in airspace where high numbers of TAs and RAs have been reported.

5.4 Pilots should fly all scenarios once every four years.

5.5 Pilots should complete all scenarios once every two years if CBT is used.

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Section 4

OPERATIONAL FLIGHT INFORMATION

Chapter 1

AERODROME SURFACE OPERATIONS

1.1 Operators shall develop and implement standard operating procedures (SOPs) for aerodrome surface operations. The development and implementation of SOPs shall take into consideration the risk factors (listed in 1.3) associated with the following operations:

- a) runway intersection take-offs;
- b) line-up and wait clearances;
- c) land and hold-short clearances;
- d) take-offs from displaced runway thresholds;
- e) hazards associated with runway crossing traffic; and
- f) hazards associated with runway crossing traffic in the case of closely spaced parallel runways.

Note 1.— The Manual of Surface Movement Guidance and Control Systems (SMGCS) (Doc 9476), Chapter 1, and the Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual (Doc 9830) discuss the safety considerations in aerodrome surface operations.

Note 2.— See Section 5, Chapter 1, for details regarding SOPs design.

Note 3.— Land and hold-short clearances/simultaneous intersecting runway operations are not ICAO procedures.

1.2. The development and implementation of SOPs for aerodrome surface operations should address, but not be limited to, the risk factors listed in 1.3 by means of:

- a) provisions regarding the timely acknowledgement of ground movement instructions;
- b) provisions to ensure the acknowledgement, in standard phraseology, of all clearances to enter, land on, take off from, hold short of, cross or backtrack the runway in use; and

Note.— The proper identification of the runway in use is prescribed in Annex 14, Volume I (Aerodromes), Chapter 5, 5.2.2.4.

- c) provisions for the use of aircraft exterior lights to increase the conspicuity of aircraft manoeuvring on aerodrome surfaces.

Note.— The Manual of Surface Movement Guidance and Control Systems (SMGCS) (Doc 9476), Chapter 4, 4.8, discusses radiotelephony procedures and phraseology in aerodrome surface operations. Chapter 7, 7.3.6, discusses misunderstood clearances.

1.3 Operators should ensure that flight personnel are aware of the risk factors in the aerodrome surface operations

listed in 1.1. Such risk factors should include, but not be limited to:

- a) human error due to excessive workload, loss of vigilance and fatigue;
- b) potential distractions associated with the performance of flight deck tasks; and
- c) failure to use standard phraseology in aeronautical communications.

Note.— The safety of aerodrome surface operations is especially vulnerable to the failure to use standard phraseology in aeronautical communications. Frequency congestion, as well as operational considerations, may adversely affect the issuance and read-back of clearances, leaving flight crews and controllers vulnerable to misunderstandings.

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Chapter 2

READ-BACK OF CLEARANCES AND SAFETY-RELATED INFORMATION

Note.— Provisions on read-back of clearances and safety-related information are included in Annex 11, Chapter 3, 3.7.3, and in the PANS-ATM (Doc 4444), Chapter 4.

Chapter 3

STABILIZED APPROACH PROCEDURE

3.1 GENERAL

The primary safety consideration in the development of the stabilized approach procedure shall be maintenance of the intended flight path as depicted in the published approach procedure, without excessive manoeuvring. The parameters to be considered in the definition of a stabilized approach are listed in 3.2.

3.2 PARAMETERS FOR THE STABILIZED APPROACH

The parameters for the stabilized approach shall be defined by the operator's standard operating procedures (SOPs) (Section 5, Chapter 1). These parameters shall be included in the operator's operations manual and shall provide details regarding at least the following:

- a) range of speeds specific to each aircraft type;
- b) minimum power setting(s) specific to each aircraft type;
- c) range of attitudes specific to each aircraft type;
- d) crossing altitude deviation tolerances;
- e) configuration(s) specific to each aircraft type;
- f) maximum sink rate; and
- g) completion of checklists and crew briefings.

3.3 ELEMENTS OF THE STABILIZED APPROACH

The elements of a stabilized approach (according to the parameters in 3.2) shall be stated in the operator's SOPs. These elements should include as a minimum:

- a) that in instrument meteorological conditions (IMC), all flights shall be stabilized by no lower than 300 m (1 000 ft) height above threshold; and
- b) that all flights of any nature shall be stabilized by no lower than 150 m (500 ft) height above threshold.

3.4 GO-AROUND POLICY

Standard operating procedures should include the operator's policy with regard to the parameters in 3.2 and the elements in 3.3. This policy should state that if an approach is not stabilized in accordance with 3.3, or has become destabilized at any subsequent point during an approach, a go-around is required. Operators should reinforce this policy through training.

Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.13, includes general considerations about stabilized approaches.

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Section 5

**STANDARD OPERATING PROCEDURES (SOPs)
AND CHECKLISTS**

Chapter 1

STANDARD OPERATING PROCEDURES (SOPs)

1.1 GENERAL

Operators shall establish standard operating procedures (SOPs) that provide guidance to flight operations personnel to ensure safe, efficient, logical and predictable means of carrying out flight procedures.

Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.2, includes general considerations about SOPs. The Human Factors Training Manual (Doc 9683), Part 1, Chapter 2, 2.5.11, includes general considerations about SOPs design.

1.2 SOPs OBJECTIVES

SOPs specify a sequence of tasks and actions to ensure that flight procedures can be carried out according to 1.1. To achieve these objectives, SOPs should unambiguously express:

- a) what the task is;
- b) when the task is to be conducted (time and sequence);
- c) by whom the task is to be conducted;
- d) how the task is to be done (actions);
- e) what the sequence of actions consists of; and
- f) what type of feedback is to be provided as a result of the actions (verbal call-out, instrument indication, switch position, etc.).

1.3 SOPs DESIGN

1.3.1 To ensure compatibility with specific operational environments and compliance by flight operations personnel, SOPs design should take into consideration:

- a) the nature of the operator's environment and type of operation;
- b) the operational philosophy, including crew coordination;
- c) the training philosophy, including human performance training;
- d) the operator's corporate culture, including the degree of flexibility to be built into SOPs design;

- e) the levels of experience of different user groups, such as flight crews, aircraft maintenance engineers and cabin attendants;
- f) resource conservation policies, such as fuel conservation or wear on power plants and systems;
- g) flight deck automation, including flight deck and systems layout and supporting documentation;
- h) the compatibility between SOPs and operational documentation; and
- i) procedural deviation during abnormal/unforeseen situations.

1.3.2 Flight operations personnel should be involved in the development of SOPs.

1.4 SOPs IMPLEMENTATION AND USE

Operators should establish a formal process of feedback from flight operations personnel to ensure standardization, compliance and evaluation of reasons for non-compliance during SOPs implementation and use.

Chapter 2

CHECKLISTS

2.1 GENERAL

Operators shall establish checklists as an integral part of standard operating procedures (SOPs). Checklists should describe the actions relevant to specific phases of operations (engine start, taxi, take-off, etc.) that flight crews must perform or verify and which relate to flight safety. Checklists should also provide a framework for verifying aircraft and systems configuration that guards against vulnerabilities in human performance.

2.2 CHECKLIST OBJECTIVES

2.2.1 Normal checklists should aid flight crews in the process of configuring the aircraft and its systems by:

- a) providing logical sequences of coverage of the flight deck panels;
- b) providing logical sequences of actions to meet both internal and external flight deck operational requirements;
- c) allowing mutual monitoring among flight crew members to keep all flight crew members in the information loop; and
- d) facilitating crew coordination to assure a logical distribution of flight deck tasks.

2.2.2 Checklists for use in abnormal situations and those for emergency situations should aid flight crews in coping with malfunctions of aircraft systems and/or emergency situations. They should also guard against vulnerabilities in human performance during high workload situations by fulfilling the objectives in 2.2.1 and, in addition, by:

- a) ensuring a clear allocation of duties to be performed by each flight crew member;
- b) acting as a guide to flight crews for diagnosis, decision making and problem solving, (prescribing sequences of steps and/or actions); and
- c) ensuring that critical actions are taken in a timely and sequential manner.

2.3 CHECKLIST DESIGN

2.3.1 Order of checklist items

2.3.1.1 The following factors should be considered when deciding the order of the items in checklists:

- a) the operational sequence of aircraft systems so that items are sequenced in the order of the steps for activation and operation of these systems;
- b) the physical flight deck location of items so that they are sequenced following a flow pattern;
- c) the operational environment so that the sequence of checklists considers the duties of other operational personnel such as cabin crew and flight operations officers;
- d) operator policies (for example, resource conservation policies such as single-engine taxi) that may impinge on the operational logic of checklists;
- e) verification and duplication of critical configuration-related items so that they are checked in the normal sequence and again immediately before the phase of flight for which they are critical; and
- f) sequencing of critical items in abnormal and emergency checklists so that items most critical are completed first.

2.3.1.2 Critical items should appear no more than twice on a given checklist (see 2.3.1.1 e)). Critical items should be verified by more than one flight crew member.

2.3.2 Number of checklist items

The number of items in checklists should be restricted to those critical to flight safety.

Note.— The introduction of advanced technology in the flight deck, allowing for automated monitoring of flight status, may justify a reduction in the number of items required in checklists.

2.3.3 Checklist interruptions

SOPs should include techniques to ensure a step-by-step, uninterrupted sequence of completing checklists. SOPs should unambiguously indicate the actions by flight crews in case of checklist interruptions.

2.3.4 Checklist ambiguity

Checklist responses should portray the actual status or the value of the item (switches, levers, lights, quantities, etc.). Checklists should avoid non-specific responses such as “set”, “checked” or “completed”.

2.3.5 Checklist coupling

Checklists should be coupled to specific phases of flight (engine start, taxi, take-off, etc.). SOPs should avoid tight coupling of checklists with the critical part of a phase of flight (for example, completing the take-off checklist on the active runway). SOPs should dictate a use of checklists that allows buffers for detection and recovery from incorrect configurations.

2.3.6 Typography

2.3.6.1 Checklist layout and graphical design should observe basic principles of typography, including at least legibility of print (discriminability) and readability under all flight deck lighting conditions.

2.3.6.2 If colour coding is used, standard industry colour coding should be observed in checklist graphical design. Normal checklists should be identified by green headings, system malfunctions by yellow headings, and emergency checklists by red headings.

2.3.6.3 Colour coding should not be the only means of identifying normal, abnormal and emergency checklists.

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Chapter 3

CREW BRIEFINGS

3.1 GENERAL

3.1.1 Operators shall establish crew briefings as an integral part of standard operating procedures (SOPs). Crew briefings communicate duties, standardize activities, ensure that a plan of action is shared by crew members and enhance crew situational awareness.

3.1.2 Operators shall establish both individual and combined crew briefings for flight crew and cabin crew.

Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.8, includes general considerations about briefings.

3.2 OBJECTIVES

Crew briefings should aid crews in performing safety-critical actions relevant to specific phases of flight by:

- a) refreshing prior knowledge to make it more readily accessible in real-time during flight;
- b) constructing a shared mental picture of the situation to support situational awareness;
- c) building a plan of action and transmitting it to crew members to promote effective error detection and management; and
- d) preparing crew members for responses to foreseeable hazards to enable prompt and effective reaction.

Note.— Without briefings, and under the pressure of time constraints and stress, retrieving information from memory may be an extremely unreliable process.

3.3 PRINCIPLES

3.3.1 The following principles should be considered when establishing crew briefings:

- a) crew briefings should be short and should not include more than ten items. If more than ten items are necessary, consideration should be given to splitting the briefing into sequential phases of the flight;
- b) crew briefings should be simple and succinct, yet sufficiently comprehensive to promote understanding of the plan of action among all crew members;
- c) crew briefings should be interactive and where possible should use a question-and-answer format;

- d) crew briefings should be scheduled so as not to interfere with, and to provide adequate time for, the performance of operational tasks; and
- e) crew briefings should achieve a balance between effectiveness and continual repetition of recurring items.

Note.— Crew briefings that become routine recitations do not refresh prior knowledge and are ineffective.

3.3.2 Any intended deviation from SOPs required by operational circumstances should be included as a specific briefing item.

3.4 APPLICATION

3.4.1 Operators shall implement flight and cabin crew briefings for specific phases of operations to include actual conditions and circumstances, as well as special aspects of operations.

3.4.2 Flight crew briefings shall be conducted for, but not be limited to, the following phases of operations:

- a) pre-flight;
- b) departure; and
- c) arrival.

3.4.3 Cabin crew briefings shall be conducted for, but not be limited to, the following phases of operations:

- a) pre-flight; and
- b) first departure of the day.

3.4.4 Cabin crew briefings should be conducted following changes of aircraft type or crew and before flights involving a stop of more than two hours.

3.5 SCOPE

3.5.1 Pre-flight briefings shall include both flight crew and cabin crew.

3.5.2 Pre-flight briefings should focus on crew coordination as well as aircraft operational issues. They should include, but not be limited to:

- a) any information necessary for the flight, including unserviceable equipment or abnormalities that may affect operational or passenger safety requirements;
- b) essential communications, and emergency and safety procedures; and
- c) weather conditions.

3.5.3 Flight crew departure briefings should prioritize all relevant conditions that exist for the take-off and climb. They should include, but not be limited to:

- a) runway in use, aircraft configuration and take-off speeds;
- b) departure procedures;
- c) departure routes;
- d) navigation and communications equipment set-up;
- e) aerodrome, terrain and performance restrictions, including noise abatement procedures (if applicable);
- f) take-off alternates (if applicable);
- g) any item(s) included in the minimum equipment list (if applicable);
- h) review of applicable emergency procedures; and
- i) applicable standard call-outs.

Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.9, includes general considerations about standard call-outs. Attachment F to Chapter 8 contains an example of an operator's guidance on standard call-out procedures.

3.5.4 Flight crew arrival briefings should prioritize all relevant conditions that exist for the descent, approach and landing. They should include, but not be limited to:

- a) terrain restrictions and minimum safe altitudes during descent;
- b) arrival routes;
- c) instrument or visual approach procedures and runway in use;
- d) operational minima, aircraft configuration, and landing speeds;
- e) navigation and communications equipment set-up;
- f) missed approach procedures;
- g) alternate aerodromes and fuel considerations;
- h) review of applicable emergency procedures;
- i) applicable standard call-outs; and

Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.9, includes general considerations about standard call-outs. Attachment F to Chapter 8 contains an example of an operator's guidance on standard call-out procedures.

- j) cold temperature correction (see Section 1, Chapter 4, 4.3).

3.5.5 Cabin crew briefings should prioritize all relevant conditions that exist for the departure. They should include, but not be limited to:

- a) assignment of take-off/landing positions;

- b) review of emergency equipment;
- c) passengers requiring special attention;
- d) the silent review process;

Note.— The silent review process is the self-review of individual actions in the event of emergencies.

- e) review of applicable emergencies;
- f) security or service-related topics that may impact on passenger or crew safety; and
- g) any additional information provided by the operator, including review of new procedures, equipment and systems.

Section 6

**VOICE COMMUNICATION PROCEDURES AND CONTROLLER-PILOT
DATA LINK COMMUNICATIONS PROCEDURES**

(To be developed)