

1 GENERAL

1.1

This section describes operational procedures and outlines the parameters on which the criteria of ICAO Document 8168, Volume II – **Construction of Visual and Instrument Flight Procedures**, are based, so as to illustrate the need for pilots to adhere strictly to the published procedures.

1.1.1

With the exception of this introductory material, paragraphs have been extracted in whole or in part from PANS-OPS. The PANS-OPS paragraph numbers are used beginning with Part II.

1.2 PANS-OPS VERSUS PREVIOUS EDITIONS TO PANS-OPS

1.2.1 Instrument Departure and Approach Procedures

1.2.1.1

There are instrument departure and approach procedures published that were developed prior to the ICAO procedures initially established with ICAO Document 8168, Volume I, First and Second Editions. These procedures may have applied different procedure criteria.

1.2.1.2

Procedures developed in accordance with the ICAO Procedures are indicated with a margin notation "PANS-OPS", "PANS-OPS 3" or "PANS-OPS 4".

PANS-OPS

indicates that the State has specified that the approach procedure complies with ICAO Document 8168, Volume II, First or Second Edition.

PANS-OPS 3

further indicates that holding speeds to be used are those specified in ICAO Document 8168, Volume II, Third Edition.

NOTE:

For applying the correct holding speed, refer to the respective State RULES AND PROCEDURES page.

PANS-OPS 4

further indicates that the acceleration segment criteria have been deleted, as formerly published in ICAO Document 8168, Volume II, First, Second and Third Editions.

NOTE:

Acceleration Segment criteria published in previous editions of Document 8168 are contained in Appendix 1.

1.2.2 Obstacle Clearance Limit — OCL

1.2.2.1

A few approach charts which still show an OCL in the profile section have not been converted to the PANS-OPS standard. The airspace protected for the IAP is smaller, and normally the speed is restricted to a maximum 150 KTAS with an omnidirectional wind of 60 kt.

1.3 STATE PAGES — RULES AND PROCEDURES

1.3.1

On RULES AND PROCEDURES pages, the conversion status of the IAPs applicable for the individual States is explained under the subtitle "Flight Procedures".

1 GENERAL CRITERIA

1.1 INTRODUCTION

1.1.1

The criteria in this part 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 which include but are not limited to standard instrument departure routes and associated procedures.

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. Omnidirectional departures may specify sectors to be avoided.

1.2 THE INSTRUMENT DEPARTURE PROCEDURE

1.2.1

The design of an instrument departure procedure is, in general, dictated by the terrain surrounding the aerodrome, but may also be required to cater for ATC requirements in the case of standard instrument departure 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.

1.2.2

At many aerodromes, a prescribed departure route is not required for ATC purposes. Nevertheless, there may be obstacles in the vicinity of the aerodrome that will 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 will be published as described in Chapter 4.

1.2.4

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

1.2.5

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.

1.2.6

Wherever possible a straight departure will be specified which is aligned with the runway centerline.

1.2.7

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 II-2-1 (see 2.3.3). Wherever other limiting speeds than those specified in Table II-2-1 are promulgated, they must be complied with to remain within the appropriate areas. If an aeroplane operation requires a higher speed, then an alternative departure procedure must be requested.

1.2.8 Establishment of a Departure Procedure

1.2.8.1

A departure procedure will be established for each runway where instrument departures are expected to be used and will define a departure procedure for the various categories of aircraft based on all-engines PDG (procedure design gradient) of 3.3 per cent or an increased PDG if required to achieve minimum obstacle clearance.

NOTE:

Development of contingency procedures is the responsibility of the operator.

1.2.8.2

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

1.3 OBSTACLE CLEARANCE

1.3.1

Obstacle clearance is a primary safety consideration in the development of instrument departure procedures. The protected areas and obstacle clearance applicable to individual types of departure are specified in subsequent chapters.

1.3.2

Unless otherwise promulgated, a PDG of 3.3 per cent is assumed. The PDG is made up of:

- a. 2.5 per cent gradient of obstacle identification surfaces or the gradient based on the most critical obstacle penetrating these surfaces, whichever is the higher gradient (see Figures II-3-2 and II-4-1); and
- b. 0.8 per cent increasing obstacle clearance.

1.3.3

Gradients published will be 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 II-4-1). For conversion of climb gradient for cockpit use see Figure II-4-2. The final PDG continues until obstacle clearance is ensured for the next phase of flight (i.e., enroute, holding or approach). At this point the departure procedure ends and is marked by a significant point.

1.3.4

The minimum obstacle clearance equals zero at the DER (departure end of runway) and thereafter will increase by 0.8 per cent of the horizontal distance in the direction of flight assuming a maximum divergence of 15°.

1.3.5

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

1.3.7

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

1.3.8

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.

2 STANDARD INSTRUMENT DEPARTURES

2.1 GENERAL

2.1.1

A SID is normally developed to accommodate as many aircraft categories as possible. Departures which are limited to specific aircraft categories are clearly annotated.

2.1.2

The SID terminates at the first fix / facility / way-point of the enroute phase following the departure procedure.

2.1.3

There are two basic types of departure route: straight and turning. Departure routes are based on track guidance acquired within 20 km (10.8 NM) from the departure end of the runway (DER) on straight departures and within 10 km (5.4 NM) after completion of turns on departures requiring turns. The design of instrument departure routes and the associated obstacle clearance criteria are based on the definition of tracks to be followed by the aeroplane. When flying the published track, the pilot is expected to correct for known wind to remain within the protected airspace.

2.2 STRAIGHT DEPARTURES

2.2.1

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

2.2.2

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

2.2.3

When obstacles exist affecting the departure route, procedure design gradients greater than 3.3 per cent are promulgated to an altitude / height after which the 3.3 per cent gradient is considered to prevail. Gradients to a height of 60m (200 ft) or less, caused by close-in obstacles, are not specified. In such cases, the corresponding obstacles are published as indicated in Chapter 4. See Figure II-2-2.

Figure II-2-1. Area for Straight Departure with Track Guidance

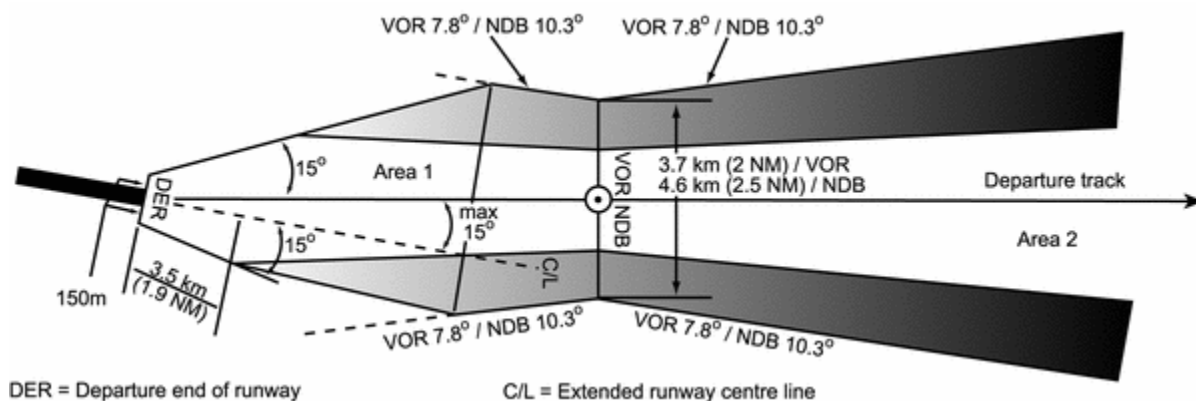
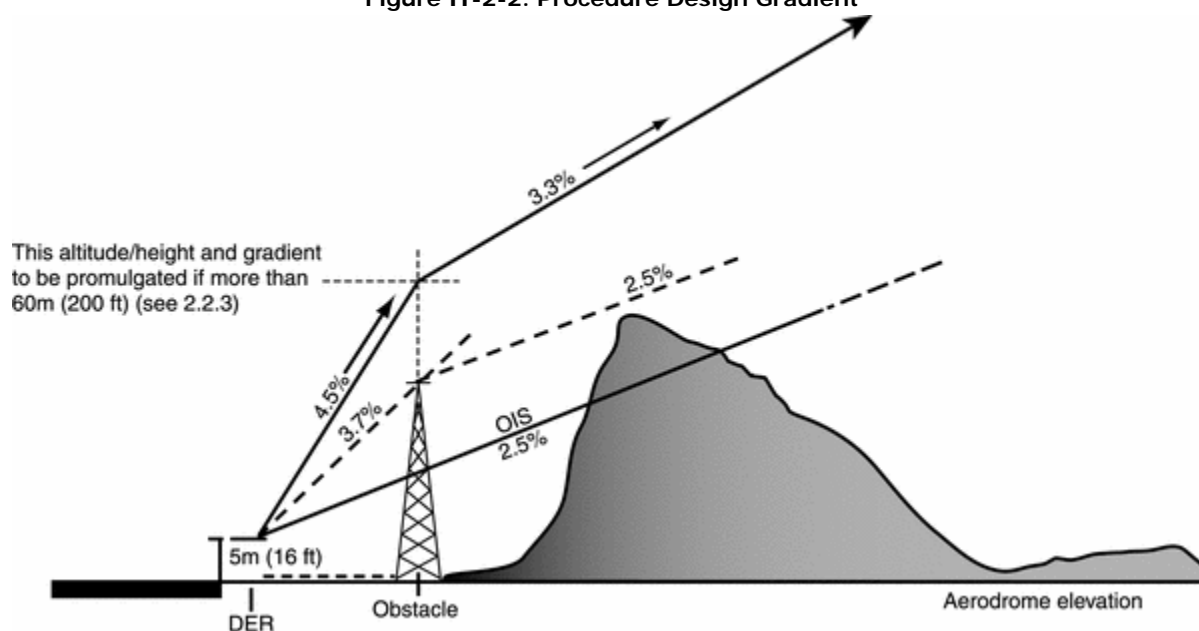


Figure II-2-2. Procedure Design Gradient



2.3 TURNING DEPARTURES

2.3.1

When a departure route requires a turn of more than 15°, a turning area is constructed. Turns may be specified at an altitude / height, at a fix, and at a facility. Straight flight is assumed until reaching an altitude / height of at least 120m (394 ft), or 90m (295 ft) for helicopters, above the elevation of the DER. No provision is made in this document for turning departures requiring a turn below 120m (394 ft), or 90m (295 ft) for helicopters, above the elevation of the DER. Where the location and/or height of obstacles precludes the construction of turning departures which satisfy the minimum turn height criterion, departure procedures should be developed on a local basis in consultation with the operators concerned.

2.3.3

Turn areas at a facility or DME distance (see Figure II-2-3) are constructed in the same manner, and using the same parameters as for the missed approach, except that the speeds employed are the final missed approach speeds listed in Tables III-1-1 and III-1-2, increased by 10 per cent to account for increased aeroplane mass in departure (see Table II-2-1). 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, in such cases the procedure is annotated with a cautionary note (see 2.3.4 c.).

Table II-2-1. Maximum Speeds for Turning Departures

1. **turn designated at an altitude/height:** turn altitude/height;
 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. **temperature:** ISA + 15° C corresponding to a. above;
 - c. **indicated airspeed:** the speed tabulated for "final missed approach" in Tables III-1-1 and III-1-2 for the speed category for which the departure procedure is designed, increased by 10 per cent to account for the increased aircraft mass at departure. However, where operationally required to avoid obstacles, reduced speeds as slow as the IAS tabulated for "intermediate missed approach" in Tables III-1-1 and III-1-2, increased by 10 per cent may be used, provided the procedure is annotated "Departure turn limited to _____ km/h (kt) IAS maximum".
 - d. **true air speed:** the IAS in c. above adjusted for altitude a. and temperature b.;
 - e. **wind:** maximum 95 per cent probability wind on an omnidirectional basis, where statistical wind data are available. Where no wind data are available, an omnidirectional 56 km/h (30 kt) is used;
 - f. **bank angle:** 15° average achieved;
 - g. **fix tolerance:** as appropriate for the type of fix;
 - h. **flight technical tolerances:** pilot reaction time 3 seconds and bank establishment time 3 seconds (total 6 seconds; see Figure II-2-3);
 - i. **turn boundary:** calculated as shown in PANS-OPS, Volume II Part III, 7.3.3 (not published herein); and
 - j. **secondary areas:** secondary areas are specified when track guidance is available.

2.3.5

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

2.5 CONTINGENCY PROCEDURES

2.5.1

Development of contingency procedures, required to cover the case of engine failure or an emergency in flight which occurs after V₁ is the responsibility of the operator, in accordance with Annex 6. Where terrain and obstacles permit, these procedures should follow the normal departure route.

2.5.2

When it is necessary to develop turning procedures to avoid an obstacle which would have become limiting, then the procedure should be detailed 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.

3 OMNIDIRECTIONAL DEPARTURES

3.1

Where no track guidance is provided in the design, the departure criteria are developed by using the omnidirectional method.

3.2

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

3.3

Unless otherwise specified, departure procedures are developed on the assumption of a 3.3 per cent procedure design gradient (PDG) and a straight climb on the extended runway centerline until reaching 120m (394 ft) above the aerodrome elevation.

3.4

The basic procedure ensures:

- a. the aircraft will climb on the extended runway centerline to 120m (394 ft) before turns can be specified; and
- b. at least 90m (295 ft) of obstacle clearance will be provided before turns greater than 15° can be specified.

3.5

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 OIS (obstacle identification surface), and 90m (295 ft) of obstacle clearance prevails, a 3.3 per cent climb to 120m (394 ft) will satisfy the obstacle clearance requirements for a turn in any direction (see Figure II-3-1 — Area 1).

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

3.6

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

- a. fly a departure route; or
- b. ensure that ceiling and visibility will permit obstacles to be avoided by visual means.

Figure II-3-1. Areas 1 and 2 and Turn Initiation Area for Omnidirectional Departure

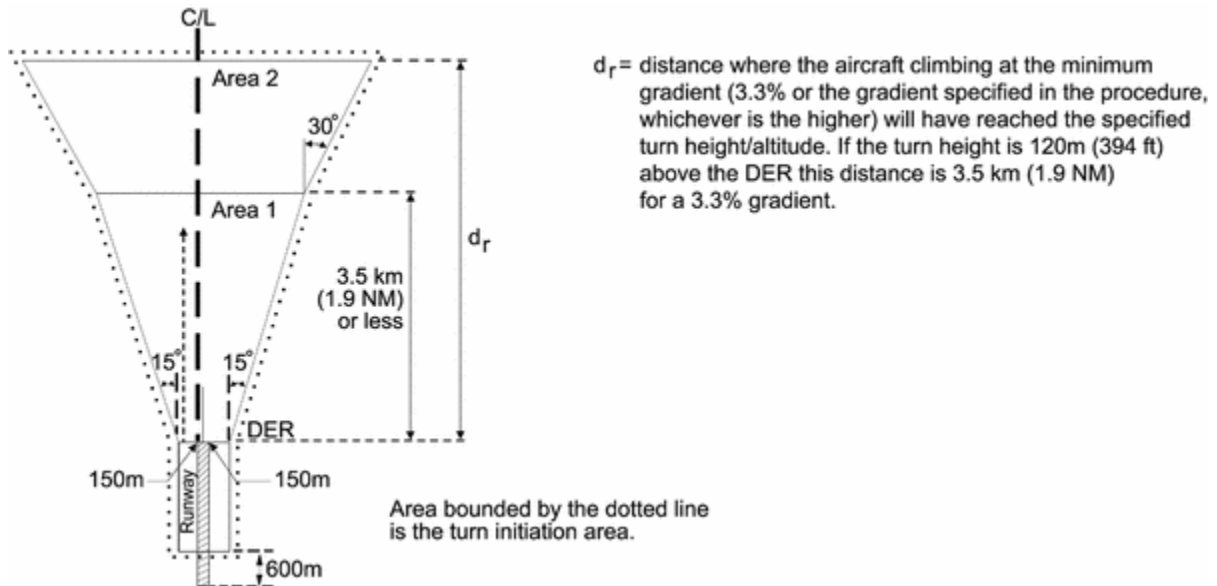
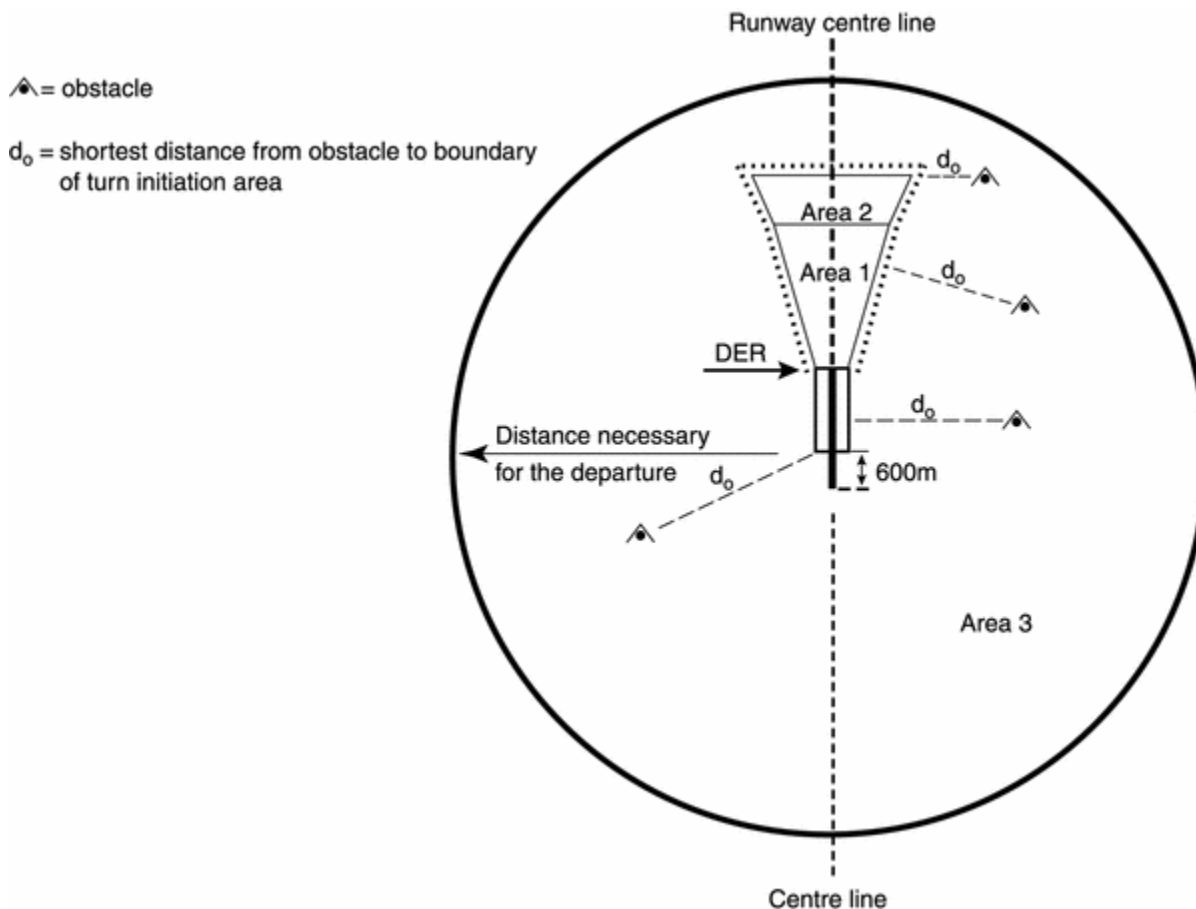


Figure II-3-2. Area 3 for Omnidirectional Departures



4 PUBLISHED INFORMATION

4.1

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

4.2

For departure routes, the following information is 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;
- The altitude / height at which a gradient in excess of 3.3 per cent is not longer used. A note is included whenever the published procedure design gradient is based only on airspace restriction (i.e., PDG based only on airspace restriction).
- All navigation facilities, fixes or waypoints, radials and DME distances depicting route segments are clearly indicated on the SID chart.

4.3

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

4.4

For omnidirectional departures, the restrictions will be expressed as sectors to be avoided or sectors in which minimum gradients and/or minimum altitudes are specified to enable an aeroplane to safely overfly obstacles.

4.5

The published minimum gradient will be the highest in any sector that may be expected to be overflown. The altitude to which the minimum gradient is specified will permit the aircraft to continue at the 3.3 per cent minimum gradient through that sector, a succeeding sector, or to an altitude authorized for another phase of flight (i.e., enroute, holding or

approach). See Figure II-4-1. A fix may also be designated to mark the point at which a gradient in excess of 3.3 per cent is no longer required.

4.6

When it is necessary, after a turn, to fly a heading to intercept a specified radial / bearing, the procedure will specify the turning point, the track to be made good and the radial / bearing to be intercepted (e.g., "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").

4.7

Departures which are limited to specific aircraft categories will be clearly annotated.

4.8

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

Figure II-4-1. Climb Gradient Reduction in Departure

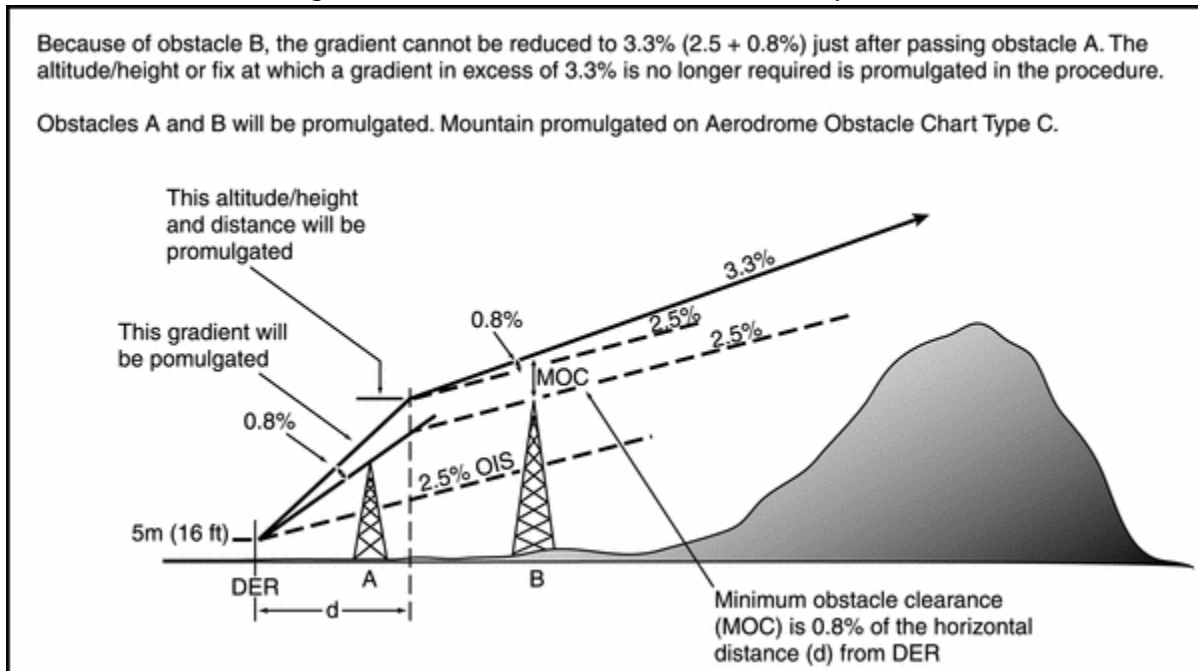
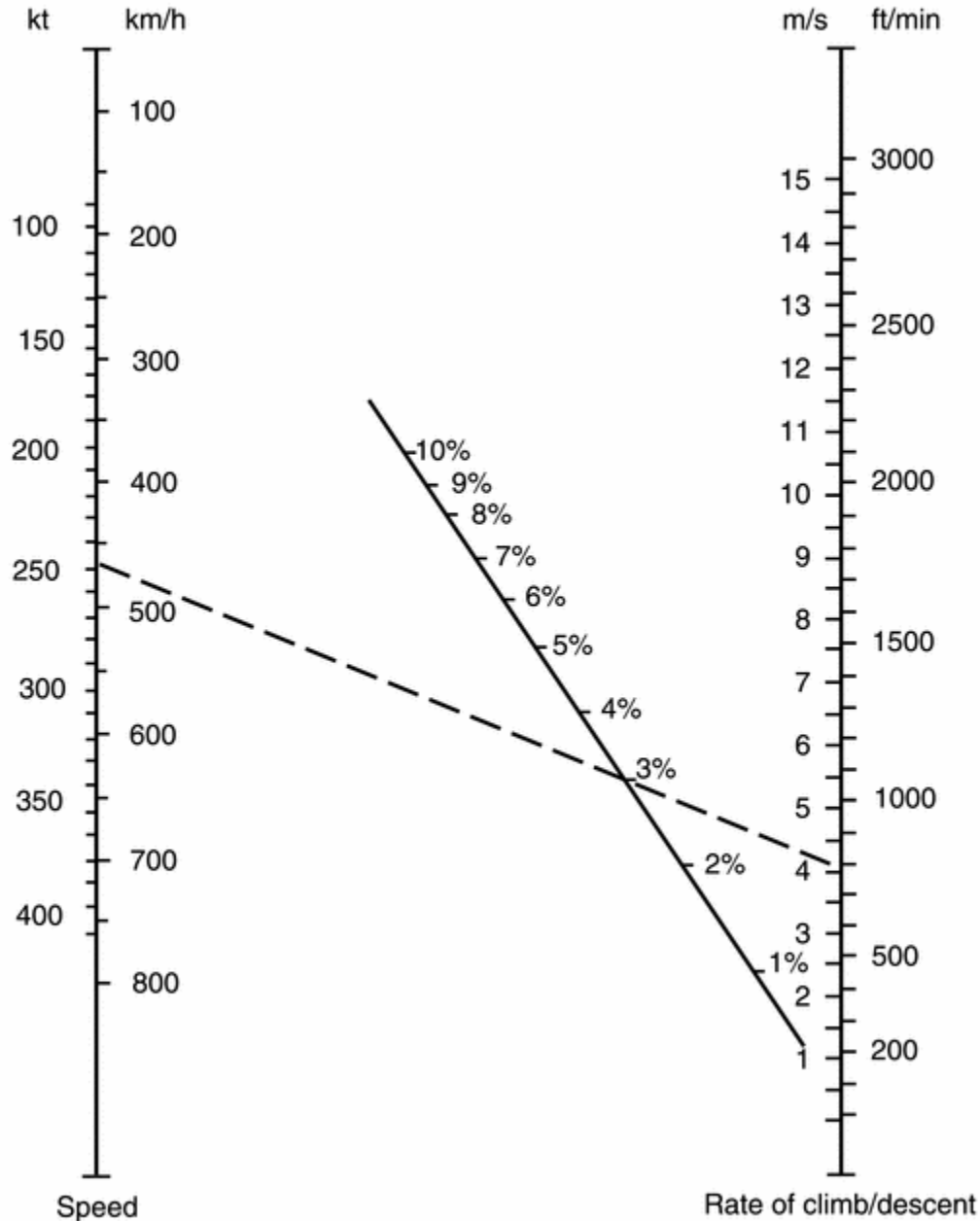


Figure II-4-2. Conversion Nomogram

Climb/descent gradient (%) vs. rate of climb/descent in m/s and ft/min at speed in km/h (kt)



Example: At a speed of 470 km/h (250 kt) a gradient of 3 per cent corresponds to a rate of 4 m/s (760 ft/min)

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

5.1

The general principles of RNAV approach procedures apply also to RNAV departure procedures.

5.2

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. To follow a procedure based on RNP, the RNAV system must be approved for the promulgated RNP and it is assumed that all nav aids on which the RNP procedure is based are in service (see NOTAMs related to DME stations, GNSS, etc.). A route may consist of segments where different RNP values are applicable. It should be noted 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 will be able to meet the RNP requirement specified for each segment.

In some cases this may require the pilot to manually update the aircraft's navigation system immediately prior to take-off. During the flight, the pilot must check that the system complies with the RNP requirements of the segment concerned and must check in particular the RNP changes along the route.

5.3

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

5.4

There are four kinds of turns:

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

6 USE OF FMS / RNAV EQUIPMENT TO FOLLOW CONVENTIONAL DEPARTURE PROCEDURES

6.1

Where FMS / RNAV equipment is available, it may be used when flying the conventional departure procedures defined in PANS-OPS, Volume II, Part II, 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.

6.2

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

7 AREA NAVIGATION (RNAV) DEPARTURE PROCEDURES FOR BASIC GNSS

7.1 BACKGROUND

7.1.1

This chapter describes GNSS departures based on the use of area navigation systems that may exist in different avionics implementations, ranging from either a basic GNSS stand-alone receiver to a multi-sensor area navigation (RNAV) system that utilizes information provided by a basic GNSS sensor.

7.2 GNSS RNAV

7.2.1 General

7.2.1.1

Introduction. Section 7.2 describes GNSS departures based on the use of basic GNSS receivers. Basic GNSS receivers must include integrity monitoring routines and be capable of turn anticipation. Flight crews should be familiar with the specific functionality of the equipment.

7.2.1.2

Operational approval. Aircraft equipped with basic GNSS receivers, which have been approved by the State of the Operator for departure and non-precision approach operations, may use these systems to carry out basic GNSS procedures provided that before conducting any flight the following criteria are met:

- a. the GNSS equipment is serviceable;
- b. the pilot has 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 navaids must be selected; and
- e. the procedure must be retrievable from an airborne navigation database.

7.2.1.3

Flight Plan. Aircraft relying on basic GNSS receivers are considered to be RNAV-equipped. Appropriate equipment suffixes are assigned to each type for inclusion in the flight plan. Where the basic GNSS receiver becomes inoperative, the pilot should immediately advise ATC and amend the equipment suffix for subsequent flight plans.

7.2.1.4

Navigation database. Departure and approach waypoint information are contained in a navigation database. If the navigation database does not contain the departure or approach procedure, then the basic GNSS receiver cannot be used for these procedures.

7.2.1.5

Performance integrity. The basic GNSS receiver verifies the integrity (usability) of the signals received from the satellite constellation through receiver autonomous integrity monitoring (RAIM). 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. RAIM generates an alert indicating the possibility of an unacceptable position error if it detects an inconsistency amongst 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. 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 arrival 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 approach navigation system, select another destination or delay the flight until RAIM is predicted to be available. RAIM outages will be more frequent for approach mode than for enroute 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.

7.2.1.6

Equipment operation. There are a number of manufacturers of basic GNSS receivers on the market, and each employs a different method of interface. It is expected that flight crews will become thoroughly familiar with the operation of their particular receiver prior to using it in flight operations. The equipment shall be operated in accordance with the provisions of the applicable aircraft operating manual. It is also strongly recommended to have one of the appropriate checklists available on board the aircraft for easy reference in the sequential loading and operation of the equipment.

7.2.1.7

Operating modes and alert limits. The basic GNSS receiver has three modes of operation - enroute, terminal and approach mode - based upon manual flight of the aircraft. The RAIM alert limits are automatically coupled to the receiver modes and are set to ± 3.7 , 1.9, and 0.6 km (± 2.0 , 1.0 and 0.3 NM) respectively.

7.2.1.8

Course deviation indicator (CDI) sensitivity. The CDI sensitivity is automatically coupled to the operating mode of the receiver and is set to ± 9.3 , 1.9 or 0.6 km (± 5.0 , 1.0 or 0.3 NM) for enroute, terminal and approach respectively. Although a manual selection for CDI sensitivity is available, overriding an automatically selected CDI sensitivity during an approach will cancel the approach mode.

7.2.2 Pre-flight

7.2.2.1

All basic GNSS IFR operations shall be conducted in accordance with the aircraft operating manual. Prior to the conduct of IFR flight operations using basic GNSS receivers, the operator shall 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.

7.2.2.2

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.

7.2.2.3

The pilot/operator shall follow the specific start-up and self-test procedures for the equipment as outlined in the aircraft operation manual.

7.2.3 Departure

7.2.3.1

Equipment capabilities. Basic GNSS receivers differ widely in their capabilities. The basic GNSS receiver operating manual must be checked to ascertain:

- the correct annunciation for the receiver departure mode. If the departure mode is not available, then a mode appropriate for the GNSS equipment used during departure must be selected to ensure the required integrity, or the GNSS equipment must not be used during departure;
- whether 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 SIDs in their databases at all; and
- whether 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).

7.2.3.2

Equipment set-up. The basic GNSS receiver must be selected to 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 7.2.3.1) with CDI sensitivity of ± 1.9 km (± 1.0 NM). 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 radar vectored to a track or when required to intercept a specific track to a waypoint.

7.2.3.3

Straight departures. Where the alignment of the initial departure track is determined by the position of the first waypoint located after the DER, there are no unique requirements for the basic GNSS receiver.

7.2.3.4

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.

7.3 MULTI-SENSOR RNAV

7.3.1 General

7.3.1.1

Introduction. For GNSS procedures, multi-sensor RNAV systems such as a flight management computer (FMC) must include a basic GNSS sensor that includes integrity monitoring routines supporting 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) that may be used individually or in combination with each other. The FMC will provide an automatic selection of the best (most accurate) source, as well as a capability to deselect or inhibit from use in calculating position, a sensor type or specific navigation aid. The FMC may be the source of flight director cues or may also be connected to an autoflight system for automatic flight operations. With this type of avionics, the pilot typically interfaces with the FMC through a control and display unit. Flight crews should be familiar with the functionality of the FMC, specific when GNSS is the primary positioning source.

NOTE:

For text simplicity in this section, the term FC is used to denote the general category of multi-sensor RNAV systems.

7.3.1.2

Operational approval. Aircraft equipped with an FMC system that has been approved by the State of the Operator for departure and non-precision approach operations may use the system to carry out RNAV procedures based on GNSS providing that before conducting any flight the criteria in 7.2.1.2 are met.

7.3.1.3

Flight plan. Aircraft relying on FMCs using GNSS are considered to be RNAV-equipped. Appropriate equipment suffixes are assigned to each type for inclusion in the flight plan. Where a GNSS sensor for the FMC becomes inoperative and the resulting equipment configuration is insufficient for the conduct or continuation of the procedures, the pilot should immediately advise ATC and request an available alternative procedure consistent with the capability of the RNAV system. It should be noted that depending on the type of certification of the FMC being used, the FMC being used, the manufacturer's aircraft flight manuals and data may allow for continued operation.

7.3.1.4

Navigation database. The criteria of 7.2.1.4 apply for an FMC system.

7.3.1.5

Performance integrity. 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 aircraft autonomous integrity monitoring (AAIM). RAIM relies only on satellite signals to perform the integrity function whereas 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.

7.3.1.6

Equipment operation. The criteria of 7.2.1.6 apply for an FMC system.

7.3.1.7

Operating modes and alert limits. An FMC using GNSS will contain either the three system modes of operation described in 7.2.1.7, or will be equivalent (for example, be required to be operated in conjunction with a flight director system or coupled autopilot system to ensure the required level of performance is provided).

7.3.1.8

CDI sensitivity. The criteria of 7.2.1.8 apply 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, auto-pilot or enhanced guidance displays.

7.3.2 Pre-flight

The criteria of 7.2.2.1 apply for an FMC system.

7.3.3 Departure

7.3.3.1

Equipment capabilities. The criteria of 7.2.3.1 apply for an FMC system. Some FMC installations may not provide the terminal RAIM alarm alert but should provide an equivalent capability appropriate to the operation.

7.3.3.2

Equipment set-up. The criteria of 7.2.3.2 apply for an FMC system. 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 the operation based upon the CDI.

7.3.3.3

The criteria of 7.2.3.3 and 7.2.3.4 apply for an FMC system.

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

8.1 GENERAL CRITERIA

8.1.1

Introduction. 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.

8.1.1.1

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.

8.1.1.2

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** (currently in preparation).

8.1.2

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).

8.2 DEPARTURE

8.2.1

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.

8.2.2

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.

8.2.2.1

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.

8.2.3

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 is as described in 8.2.2. 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.

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

9.1 DEPARTURE OPERATIONS

No departure criteria specifically designed for GBAS exist. 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 7, "Area Navigation (RNAV) Departure Procedures for Basic GNSS" and Chapter 8, "Area Navigation (RNAV) Departure Procedures for Satellite-based Augmentation System (SBAS)".)

1 GENERAL CRITERIA

1.2 THE INSTRUMENT APPROACH PROCEDURE

1.2.1

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

An instrument approach procedure may have five separate segments. They are the arrival, initial, intermediate, final and missed approach segments. 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; e.g., the final approach segment of a precision approach may originate at the point of intersection of the designated intermediate flight altitude with the nominal flight path.

1.2.3

Whenever possible, a straight-in approach will be specified which is aligned with the runway centerline. 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 centerline is 30° or less.

1.2.4

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, a circling approach will be specified. 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.

1.2.5

Minimum sector altitudes/terminal arrival altitudes. Minimum sector altitudes or terminal arrival altitudes are established for each aerodrome and provide at least 300 m (984 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.

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.

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 MAP. 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 15m (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 MAP 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. If a greater height is used, ATC clearance should be obtained to ensure separation.

2. When using the "stabilized approach" technique in a non-precision approach, the height/altitude at which the missed approach maneuver 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.
3. In all cases, regardless of the flight technique used, cold temperature correction must be applied to all minimum altitudes (see Part VI, Chapter 3, 3.3).

The following ICAO tables indicate the specified range of handling speeds for each category of aircraft to perform the maneuvers specified. This speed ranges have been assumed for use in calculating airspace and obstacle clearance requirements for each procedure.

Table III-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	Max speeds for visual maneuvering (circling)	Max speeds for missed approach	
					Intermediate	Final
A	<169	165/280 (205*)	130/185	185	185	205
B	169/223	220/335 (260*)	155/240	250	240	280
C	224/260	295/445	215/295	335	295	445
D	261/306	345/465	240/345	380	345	490
E	307/390	345/467	285/425	445	425	510
H	N/A	130/220**	110/165***	N/A	165	165
CAT H (PinS)***	N/A	130/220	110/165	N/A	130 or 165	130 or 165

Vat - Speed at threshold based on 1.3 times stall speed V_{S0} 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 6000 ft is 185 km/h, and maximum speed for reversal and racetrack procedures above 6000 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.

Table III-1-2. Speeds for procedure calculations in knots (kt)

Aircraft category	V at	Range of speeds for initial approach	Range of final approach speeds	Max speeds for visual maneuvering (circling)	Max speeds for missed approach	
					Intermediate	Final
A	<91	90/150 (110*)	70/100	100	100	110
B	91/120	120/180 (140*)	85/130	135	130	150
C	121/140	160/240	115/160	180	160	240
D	141/165	185/250	130/185	205	185	265

E	166/210	185/250	155/230	240	230	275
H	N/A	70/120**	60/90***	N/A	90	90
CAT H	N/A	70/120	60/90	N/A	70 or 90	70 or 90
(PinS)***						

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 6000 ft is 100 kt and maximum speed for reversal and racetrack procedures above 6000 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.

NOTE:

The V_{at} speeds given in Column 1 of Table III-1-1 are converted exactly from those in Table III-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.

1.7 PROMULGATION

1.7.1

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 RDH in specific chapters). Earth curvature is not considered in determining the descent gradient/angle.

1.7.2

Descent angles for database coding. Paragraph 1.7.1 applies, except only to descent angles and that the angles shall be published to the nearest one-hundredth of a degree.

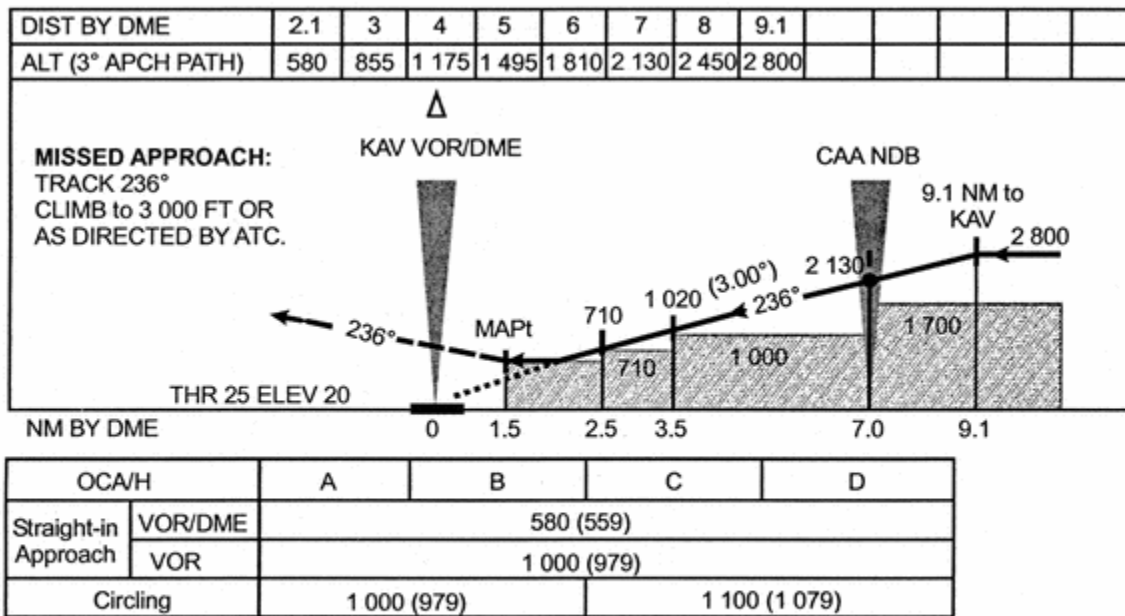
1.7.3

FAF altitude-procedure altitude/height. 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 III-1-4.

1.7.4

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.

Figure III-1-4. Procedure altitude/height vs. minimum altitudes with stepdown fix



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2 APPROACH PROCEDURE DESIGN

2.1 INSTRUMENT APPROACH AREAS

2.1.4

Non-precision approach procedures and procedures with vertical guidance will be developed to include not only the minimum altitudes/heights to ensure obstacle clearance, but also procedure altitudes/heights. Procedure altitude/heights will be 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. In no case will a procedure altitude/height be less than any OCA/H.

2.4 DESCENT GRADIENT

2.4.1

In designing instrument approach procedures, 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.

2.4.2

Adequate space for descent is provided by establishing a maximum allowable descent gradient for each segment of the procedure. The minimum descent gradient/angle in the final approach of a non-precision procedure with FAF is 4.3 per cent/2.5° (43 m/km (260 ft/NM)). The 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 Cat A and B aircraft, 6.1 per cent/3.5° (61 m/km (370 ft/NM)) for Cat C, D and E aircraft, and 10 per cent (5.7°) for CAT H. For procedures with VOR or NDB on aerodrome and no FAF, rates of descent in the final approach phase are given in Table III-2-1. 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.

2.4.3

In certain cases the maximum descent gradient of 6.5 per cent (65 m/km (400 ft/NM)) results in descent rates which exceed the recommended rates of descent for some aircraft; e.g. at 280 km/h (150 kt) it results in a 5 m/s (1000 ft/min) rate of descent. Pilots should consider carefully the descent rate required for non-precision final approach segments before starting the approach.

2.4.4

Any constant descent angle shall clear all step-down fix minimum crossing altitudes within any segment.

Table III-2-1. Rate of Descent in the Final Approach Segment of a Procedure with no FAF

Aircraft Categories	Rate of descent	
	Minimum	Maximum
A, B	120 m/min (394 ft/min)	200 m/min (655 ft/min)
C, D, E	180 m/min (590 ft/min)	305 m/min (1000 ft/min)

3 ARRIVAL AND APPROACH SEGMENTS

3.1 GENERAL

3.1.3

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.

3.2 STANDARD INSTRUMENT ARRIVALS

3.2.1

When necessary or where an operational advantage is obtained, arrival routes from the enroute phase to a fix or facility used in the procedure are published. When arrival routes are published, the width of the associated area decreases from the "enroute" value until the "initial approach" value with a convergence angle of 30° each side of the axis. This convergence begins at 46 km (25 NM) before the 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). The arrival route normally ends at the initial approach fix. Omnidirectional or sector arrivals can be provided taking into account minimum sector altitudes (MSA).

3.2.2

Terminal radar is a suitable complement to published arrival routes. When terminal 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 through reference to the instrument approach chart.

3.2.3

Arrival 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 requirement, but are developed to separate arriving and departing air traffic procedurally. These altitudes/flight levels shall be charted as indicated in Table III-3-1. The method of charting of altitudes/flight levels to correctly depict the designed procedure may differ between avionics manufacturers.

Table III-3-1. Charted altitudes/flight levels

Altitude/Flight Level "Window"	<u>17000</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>3000</u>	<u>FL30</u>
"Recommended" Procedure Altitude/Flight Level	5 000	FL50
"Expected" Altitude/Flight Level	Expect 5 000	Expect FL50

3.3 INITIAL APPROACH SEGMENT

3.3.1 General

3.3.1.1

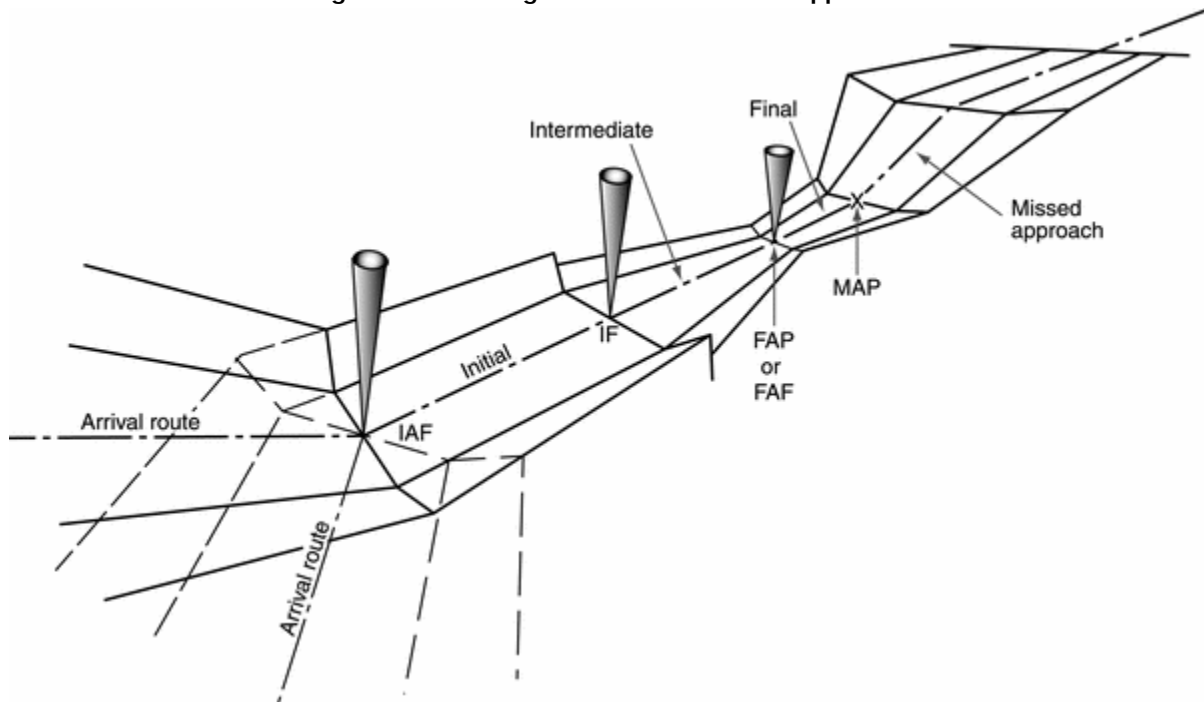
The initial approach segment commences at the initial approach fix (IAF) and ends at the intermediate fix (IF). In the initial approach, the aircraft has departed the enroute structure and is maneuvering to enter the intermediate approach

segment. Aircraft speed and configuration will depend on the distance from the aerodrome, and descent required. The initial approach segment provides at least 300m (984 ft) of obstacle clearance in the primary area.

3.3.1.3

Where no suitable initial approach fix or intermediate fix is available to construct the instrument procedure in the form shown in Figure III-3-1, a reversal procedure, racetrack or holding pattern is required.

Figure III-3-1. Segments of Instrument Approach



3.3.2 Types of Maneuvers

3.3.2.1

Reversal procedure — 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 particular pattern, normally a base turn or procedure turn is prescribed, and to remain within the airspace provided requires strict adherence to the directions and timing specified. It should be noted that the airspace provided for these procedures does not permit a racetrack or holding maneuver to be conducted unless so specified.

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

- a. **45°/180° procedure turn (see Figure III-3-2 A.)** starts at a facility or fix and consists of:
 - a straight leg with track guidance; this straight leg may be timed or 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 categories A and B aircraft and 1 minute 15 seconds from the start of the turn for categories C, D and E aircraft;
 - 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 (paragraph b. below) unless specifically excluded.

- b. **80°/260° procedure turn (see Figure III-3-2 B.)** starts at a facility or fix and consists of:
 - a straight leg with track guidance; this straight leg may be timed or 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 (paragraph 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 over-all length of the protected area.

- 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 III-3-2 C.). The outbound track and/or the timing may be different for the various categories of aircraft.

3.3.2.2

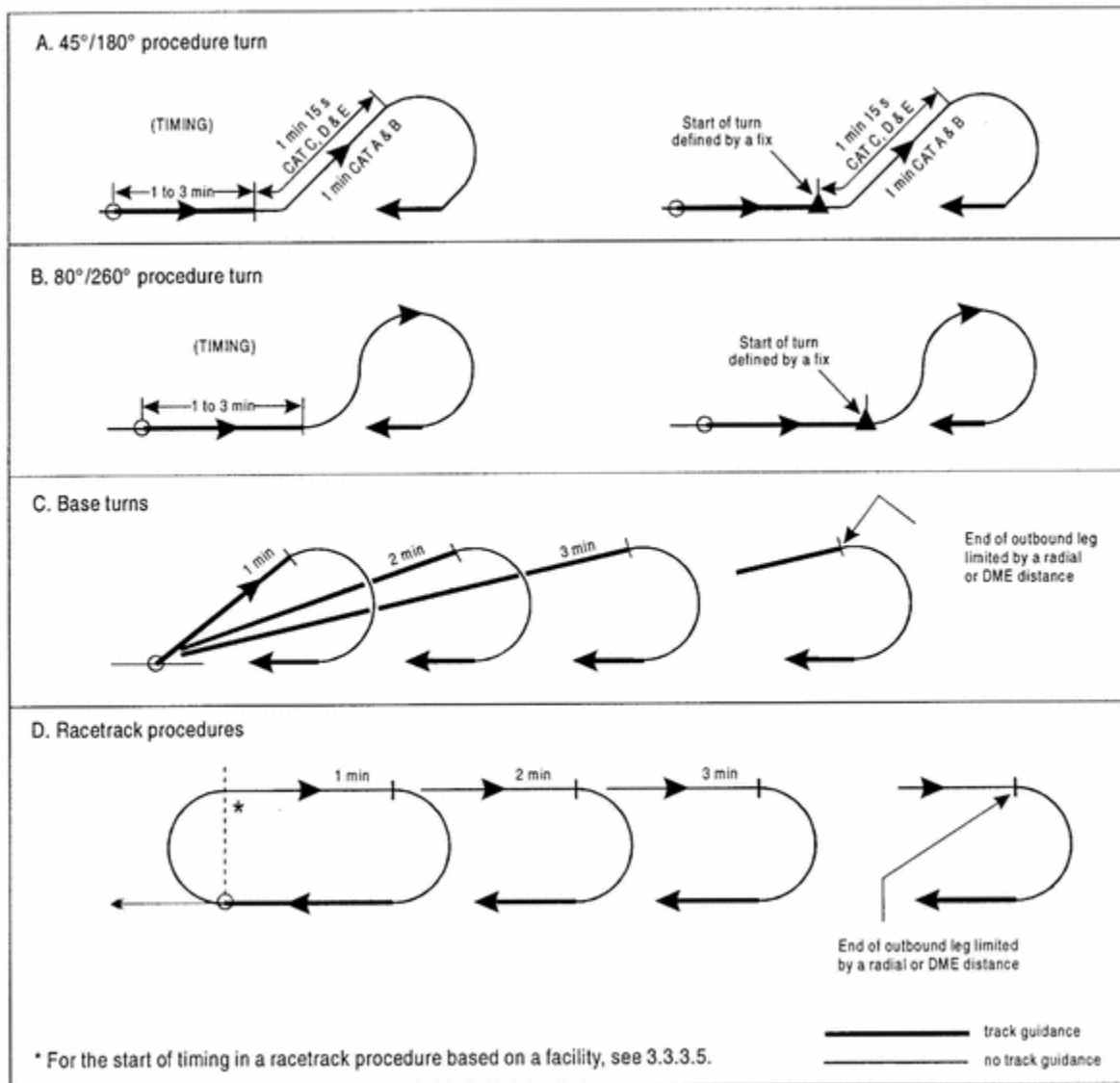
Racetrack procedure — A racetrack procedure consists of a turn from the inbound track through 180° from overhead the facility or fix on to the outbound track, for 1, 2 or 3 minutes, followed by a 180° turn in the same direction to return to the inbound track (see Figure III-3-2 D.). As an alternative to timing, the outbound leg may be limited by a DME distance or intersecting radial / bearing. 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 comparable to that prescribed for holding procedure entry with the following considerations:

- a. Offset entry from sector 2 shall limit the time on the 30° offset track to 1 minute 30 seconds, 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 minute, the time on the 30° offset track shall be 1 minute 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.
- c. All maneuvering shall be done in so far as possible on the maneuvering 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.

Figure III-3-2. Types of Reversal and Racetrack Procedures



3.3.3 Flight Procedures for Racetrack and Reversal Procedures

3.3.3.1

Entry — 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. For racetrack procedures, entry shall be as paragraph 3.3.2.2, unless other restrictions are specified. See Figures III-3-3, III-3-4 and III-3-5.

3.3.3.2

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.

3.3.3.3

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.

3.3.3.4

Descent . The aircraft shall cross the fix or facility and fly outbound on the specified track descending as necessary to the specified altitude. If a further descent is specified after the inbound turn, this descent shall not be started until established on the inbound track ("established" is considered as being within half full scale deflection for the ILS and

VOR, or within $\pm 5^\circ$ of the required bearing for the NDB).

Figure III-3-3. Direct Entry to Procedure Turn

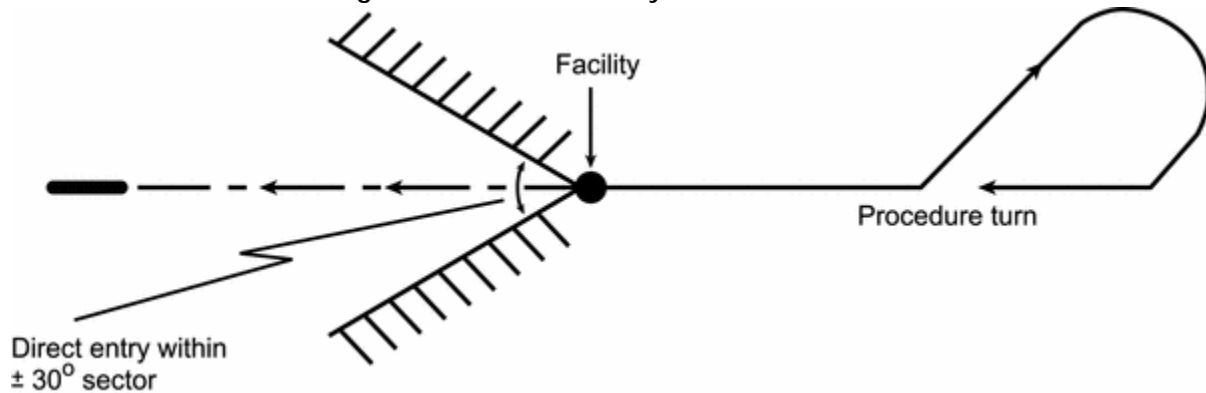


Figure III-3-4. Direct Entry to Base Turn

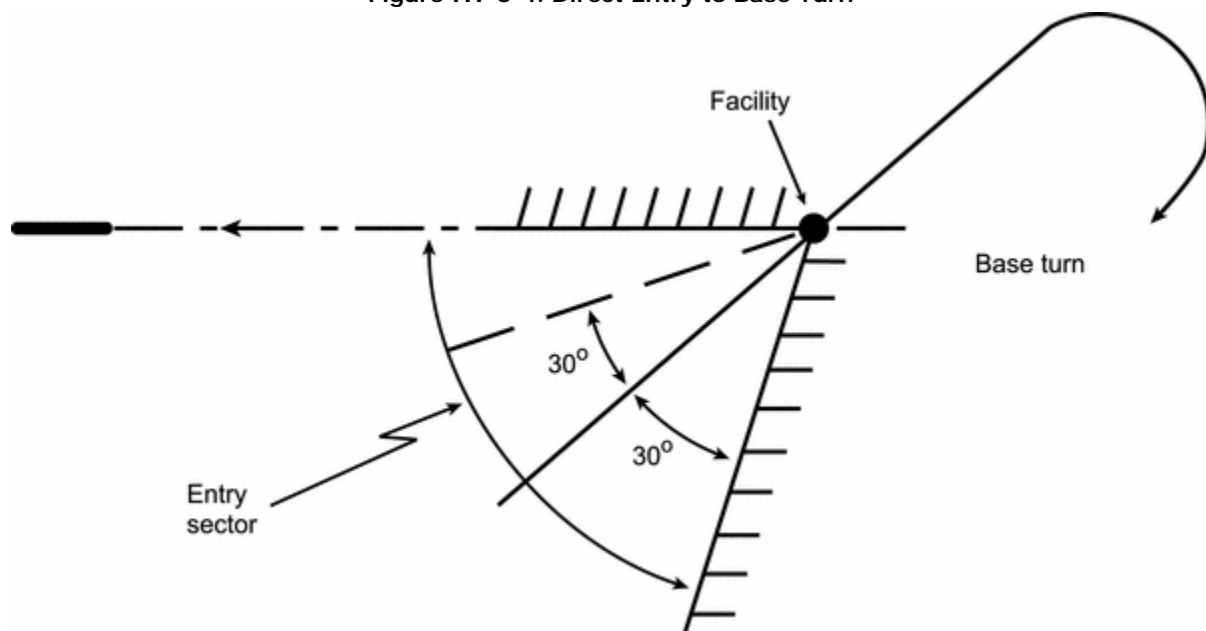
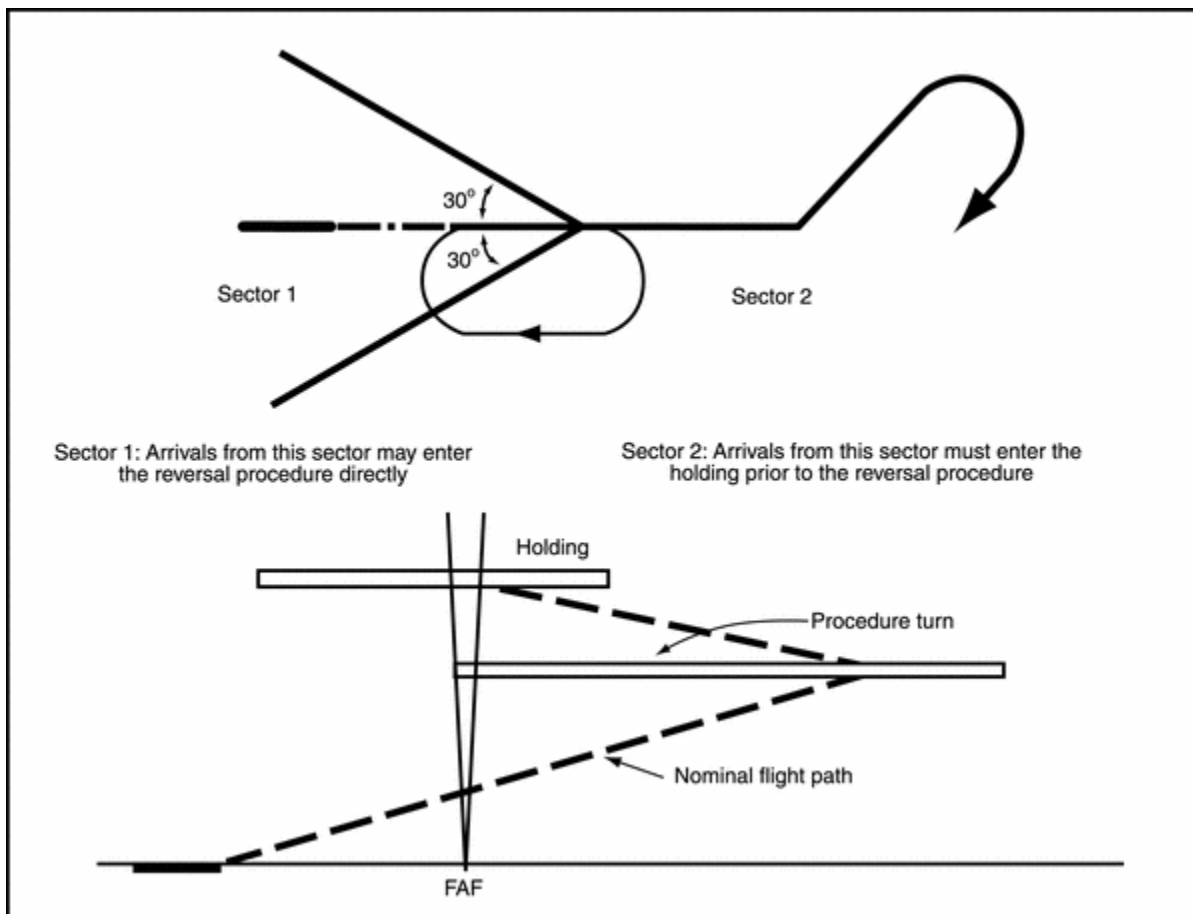


Figure III-3-5. Example of Omnidirectional Arrival Using a Holding Procedure in Association with a Reversal Procedure



3.3.3.5

Outbound timing – racetrack procedure . When the procedure is based on a facility, outbound timing starts from abeam the facility or on attaining the outbound heading, whichever comes later. When the procedure is based on a fix, the outbound timing starts from attaining the outbound heading. The turn on to the inbound track should be started within the specified time (adjusted for wind) or when encountering any DME distance or the radial / bearing specifying a limiting distance, whichever occurs first.

3.3.3.6

Wind effect. Due allowance should be made in both heading and timing to compensate for the effects of wind to regain the inbound track as accurately and expeditiously as possible to achieve a stabilized approach. In making these corrections, full use should be made of the indications available from the aid and estimated or known winds. When a DME distance or radial / bearing is specified it shall not be exceeded when flying on the outbound track.

3.3.3.7

Descent rates. The specified timings and procedure altitudes are based on rates of descent that do not exceed the values shown in Table III-3-2.

3.3.3.8

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 III-3-2.

NOTE:

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

Table III-3-2. Maximum/minimum descent to be specified on a reversal or racetrack procedure

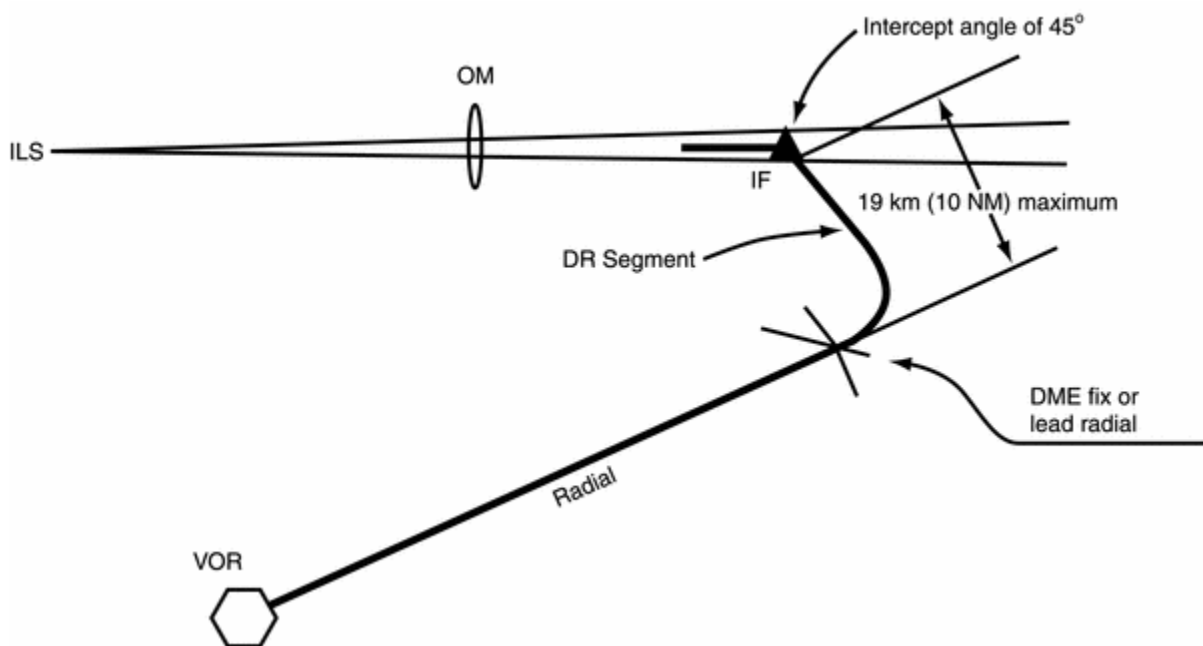
OUTBOUND TRACK	MAXIMUM*	MINIMUM*
----------------	----------	----------

CAT A/B	245m (804 ft)	N/A
CAT C/D/E	365m (1,197 ft)	N/A
INBOUND TRACK	MAXIMUM*	MINIMUM*
CAT A/B	200m (655 ft)	120m (394 ft)
CAT C/D/E	305m (1,000 ft)	180m (590 ft)
* Maximum/minimum descent for 1 minute nominal outbound time (m (ft)).		

3.3.3.9

Dead reckoning segment — Where an operational advantage can be obtained, an ILS procedure may include a dead reckoning segment from a fix to the localizer (see Figure III-3-6). 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 III-3-6. Dead Reckoning Segment



3.4 INTERMEDIATE APPROACH SEGMENT

3.4.1 General

3.4.1.1

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

3.4.1.2

Where a final approach fix 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.

NOTE:

Where no final approach fix is specified, the inbound track is the final approach segment.

3.5 FINAL APPROACH SEGMENT

3.5.1 General

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 maneuver.

3.5.2 Final Approach – Non-precision with Final Approach Fix

3.5.2.1

This segment begins at a facility or fix, called the final approach fix (FAF) and ends at the missed approach point (MAP) (see Figure III-3-1). 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 MDA/H applicable 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).

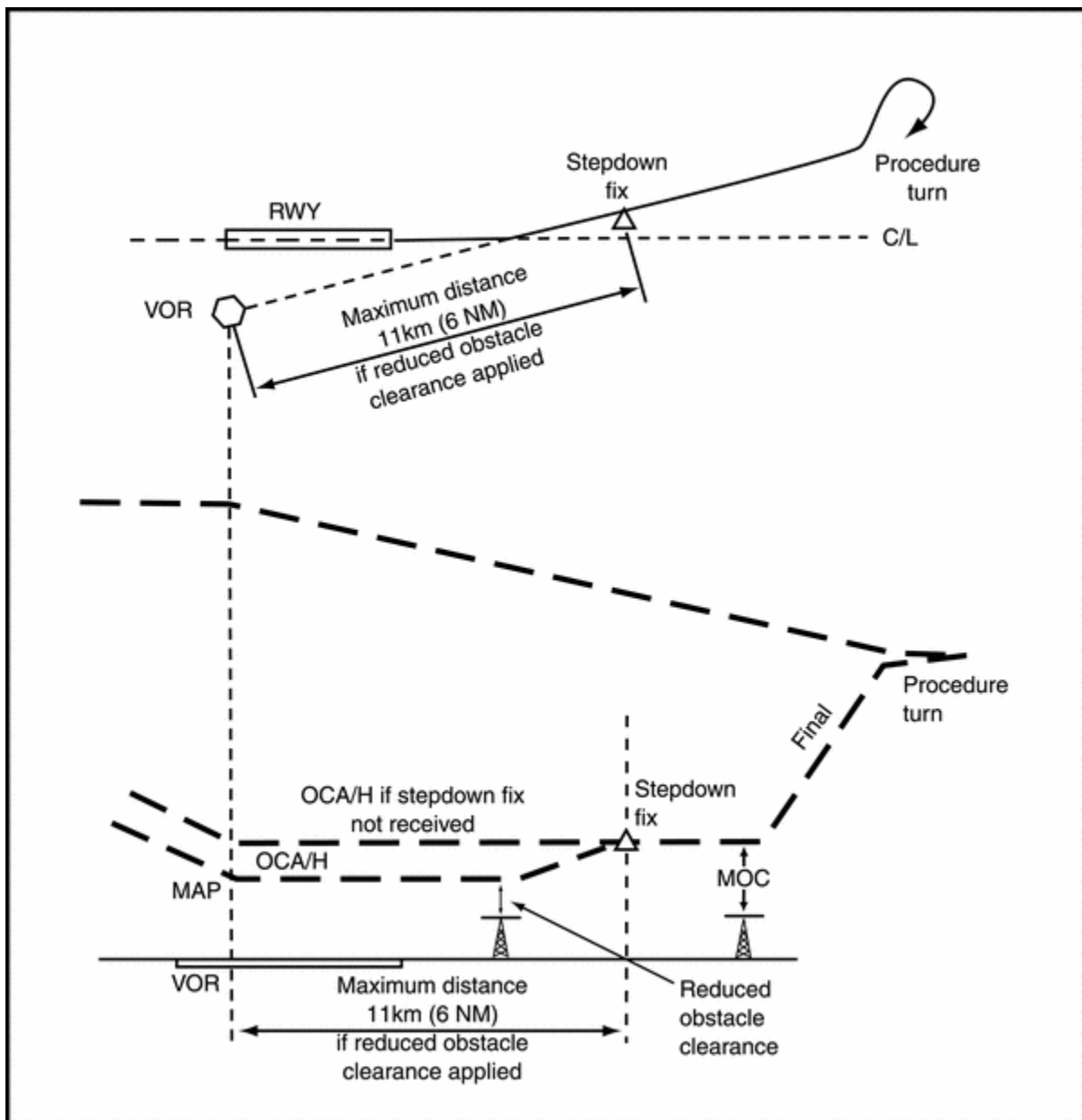
3.5.2.2

The FAF is crossed at the procedure altitude/height in descent but no lower than the minimum crossing altitude associated with FAF under 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 in one-tenth of a degree for chart presentation and in one-hundredth of a degree for database coding purposes. Where range information is available, descent profile information is provided.

3.5.2.3

A stepdown fix may be incorporated in some non-precision approach procedures, in which case two OCA/H values will be published: a higher value applicable to the primary procedure, and a lower value applicable only if the stepdown fix is positively identified during the approach (see Figure III-3-7). Normally only one stepdown fix is specified, but in the case of a VOR/DME procedure, several DME fixes may be depicted, each with its associated minimum crossing altitude.

Figure III-3-7. Stepdown Fix



3.5.2.3.1

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

NOTE:

The use of DME distance provides an additional check for enroute radar descent distances.

3.5.3 Final Approach — Non-precision with no Final Approach Fix

3.5.3.1

When 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, a procedure may be designed where the facility is both the IAF and the MAP.

3.5.3.2

These procedures will indicate a minimum altitude/height for a reversal procedure or racetrack, and an OCA/H for final approach. 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.

3.5.3.3

In procedures of this type, the final approach track cannot normally be aligned on the runway centerline. 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.

3.5.4 Final Approach Segment — Non-Precision Approaches — Constant Approach Slope

3.5.4.1

Compatible with the primary safety consideration of obstacle clearance, non-precision approach design shall provide the optimum final approach descent gradient of 5.2 per cent, or constant approach slope of 3° , providing a rate of descent of 50m per km (318 ft per NM). Consistent with 3.5.2.2, information provided in approach charts shall display the optimum constant approach slope.

3.5.4.2

Operators shall include in their standard operating procedures specific guidance to utilize on-board technology, combined with ground-based aids such as distance measuring equipment (DME), to facilitate the execution of optimum constant approach slope descents during non-precision approaches.

3.5.5 Final Approach Segment — Precision Approach — ILS / MLS

3.5.5.1

The final approach segment begins at the final approach point (FAP). This is a point in space on the centerline of the localizer or the MLS azimuth specified for the final approach track where the intermediate approach altitude / height intersects the nominal glide path / MLS elevation angle.

3.5.5.2

Generally glide path / MLS elevation angle interception occurs at heights from 300m (984 ft) to 900m (2,955 ft) above runway elevation. In that case, on a 3° glide path / MLS elevation angle, interception occurs between 6 km (3 NM) and 19 km (10 NM) from the threshold.

3.5.5.3

The width of the ILS / MLS final approach 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. The ILS obstacle clearance surfaces assume that the pilot does not normally deviate from the centerline more than half a 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.

3.5.5.4

The intermediate approach track or radar vector has been 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.

3.5.5.5

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 published fix crossing altitude / height.

3.5.5.5.1

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

3.5.5.5.2

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 VI.

NOTE:

Pressure altimeters are calibrated to indicate true altitude under International Standard Atmosphere (ISA) conditions. Any deviation from ISA will therefore result in an erroneous reading on the altimeter. In the case when the temperature is higher than ISA, the true altitude will be higher than the figure indicated by the altimeter; and the true altitude will be lower when the temperature is lower than ISA. The altimeter error may be significant under conditions of extremely cold temperatures.

3.5.5.6

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.

3.5.6 Determination of Decision Altitude (DA) or Decision Height (DH) – ILS/MLS

3.5.6.1

In addition to the physical characteristics of the ILS/MLS 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 3.5.6.3). 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 or OCH values, as appropriate, are promulgated on the instrument approach chart for those categories of aircraft for which the procedure is designed. The values are based amongst others on the following standard conditions:

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

NOTE:

OCA/H for D_L aircraft is published when necessary.

ILS:

- Cat I flown with pressure altimeter;
- Cat II flown with radio altimeter and flight director;
- missed approach climb gradient is 2.5 per cent; and
- glide path angle:
 - minimum: 2.5°
 - optimum: 3.0°
 - maximum: 3.5° (3° for Cat II/III operations).

MLS:

- Cat I flown with pressure altimeter;
- Cat II flown autocoupled / flight director, with radio altimeter;
- missed approach climb gradient is 2.5 per cent; and
- elevation angle:
 - minimum: 2.5°
 - optimum: 3.0°
 - maximum: 3.5° (3° for Cat II/III operations).

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

3.5.6.1.2

Procedures involving glide paths greater than 3.5° or any angle when the nominal rate of descent (V_{at} for the aircraft type x the sine of the glide path angle) exceeds 5 m/sec (1000 ft/min), are non-standard. They require increase of height loss margin (which may be aircraft-type specific), adjustment of the origin of the missed approach surface, the slope of the W surface, re-survey of obstacles, and the application of related operational constraints. They 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.

3.5.6.3

Table III-3-3 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. 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 III-3-3. Height loss / altimeter margin

Aircraft Category (V _{at})	Margin using Radio Altimeter		Margin using Pressure Altimeter	
	Metres	Feet	Metres	Feet
A – 169 km/h (90 kt)	13	42	40	130
B – 223 km/h (120 kt)	18	59	43	142
C – 260 km/h (140 kt)	22	71	46	150
D – 306 km/h (165 kt)	26	85	49	161

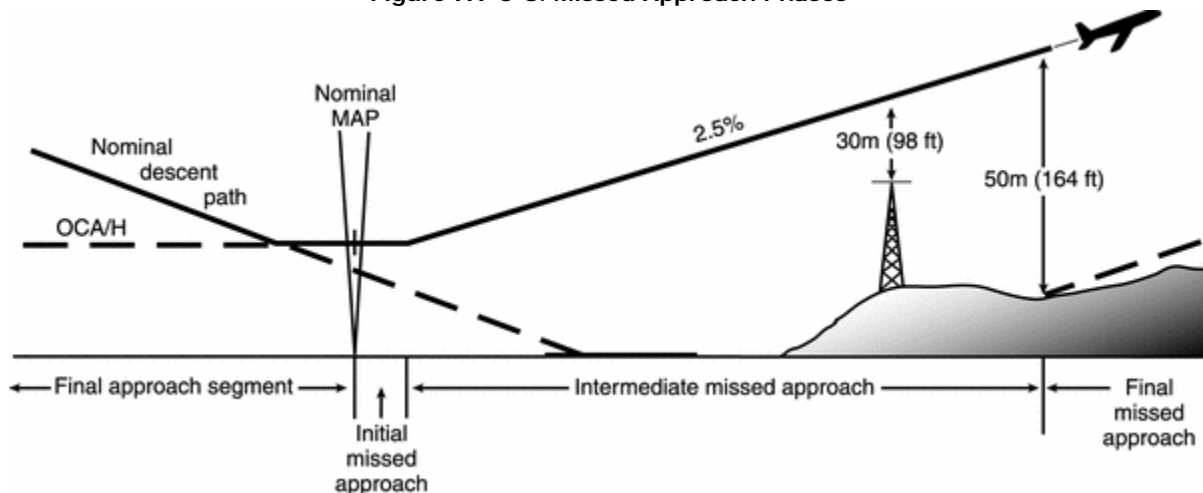
3.6 MISSED APPROACH

3.6.1 General

3.6.1.1

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 III-3-8.

Figure III-3-8. Missed Approach Phases



3.6.1.2

A missed approach procedure, designed to provide protection from obstacles throughout the missed approach maneuver, is established for each instrument approach procedure. It specifies a point where the missed approach begins and a point or an altitude / height where it ends. The missed approach is assumed to be initiated not lower than the DA/H in precision approach procedures, or at a specified point in non-precision approach procedures not lower than the MDA/H.

3.6.1.3

The missed approach point (MAP) in a procedure may be:

- the point of intersection of an electronic glide path with the applicable DA/H; or
- a navigational facility; or
- a fix; or
- a specified distance from the final approach fix (FAF).

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

NOTE:

Timing from the FAF based on ground speed may also be used to assist the planning of a stabilized approach. (See Part III, 3.3.3.6.)

3.6.1.4

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

3.6.1.5

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

3.6.1.6

It is expected that the pilot will fly the missed approach procedure as published. In the event a missed approach is initiated prior to arriving at the missed approach point, it is expected that the pilot will normally proceed to the missed approach point (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 missed approach point (MAP) 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 MAP (or before an equivalent point in the case of a precision approach).

3.6.1.7

Normally procedures are based on a nominal 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 can be 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. When other than a 2.5 per cent gradient is used this will be indicated on the instrument approach chart and, in addition to the OCA/H for the specific gradient used, the OCA/H applicable to the nominal gradient will also be shown.

3.6.1.8

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 such aeroplanes needs special consideration at aerodromes which are critical due to obstacles on the missed approach area and may result in a special procedure being established with a possible increase in the decision altitude / height or minimum descent altitude / height.

3.6.2 Initial Phase

The initial phase begins at the missed approach point (MAP) and ends at the point where the climb is established. The maneuver in this phase necessitates the concentrated attention of the pilot on establishing the climb and the changes in aeroplane configuration. For this reason guidance equipment cannot normally be fully utilized during these maneuvers and therefore no turns should be specified in this phase.

3.6.3 Intermediate Phase

The intermediate phase is the phase within which the climb is continued, normally straight ahead. It extends to the first point where 50m (164 ft) obstacle clearance is obtained and can be maintained. 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 will begin track corrections.

3.6.4 Final Phase

3.6.4.1

General — The final phase begins at the point where 50m (164 ft) obstacle clearance is first obtained and can be maintained. It extends to the point where a new approach, holding or a return to enroute flight is initiated. Turns may be prescribed in this phase.

3.6.4.2

Turning missed approach — Turns in a missed approach procedure are only prescribed where terrain or other factors make a turn necessary. When turns greater than 15° are required in a missed approach procedure, they shall not be prescribed until at least 50m (164 ft) of vertical clearance above obstacles has been ensured. If a turn from the final approach track is made, a specially constructed turning missed approach area is specified. The turning point (TP) is defined in one of two ways:

- a. **at a designated facility or fix** — the turn is made upon arrival overhead the 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.

3.6.4.3

The protected airspace for turns is based on the speed shown in Tables III-1-1 and III-1-2, **final missed approach**. However, where operationally required to avoid obstacles, the IAS as slow as for **intermediate missed approach** in Tables III-1-1 and III-1-2 may be used provided the instrument approach chart is noted "Missed approach turn limited to _____ km/h (kt) IAS maximum". In addition, where an obstacle is located early in the missed approach procedure, the instrument approach chart will be noted "Missed approach turn as soon as operationally practicable to _____ heading".

NOTE:

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

3.6.4.5

Parameters of construction of the turning missed approach area are based on the following assumed conditions:

- a. **bank angle:** 15° average achieved;
- b. **speed:** for each category of aircraft (see Tables III-1-1 and III-1-2);
- c. **wind:** where statistical data are available, a maximum 95 per cent probability on omnidirectional basis is used. Where no data are available, omnidirectional wind of 56 km/h (30 kt) is used;
- d. **pilot reaction time:** -0 to +3 s; and
- e. **bank establishment time:** -0 to +3 s.

3.6.4.6

As with any turning maneuver, 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, which is expected to have an IAS of at least 185 km/h (100 kt) prior to reaching the turning point.

4 VISUAL MANOEUVRING (CIRCLING) IN THE VICINITY OF THE AERODROME

4.1 GENERAL

Visual maneuvering (circling) is the term used to describe the visual phase of flight after completing an instrument approach, to bring an aircraft into position for landing on a runway which is not suitably located for straight-in approach.

4.2 THE VISUAL MANEUVERING (CIRCLING) AREA

4.2.1

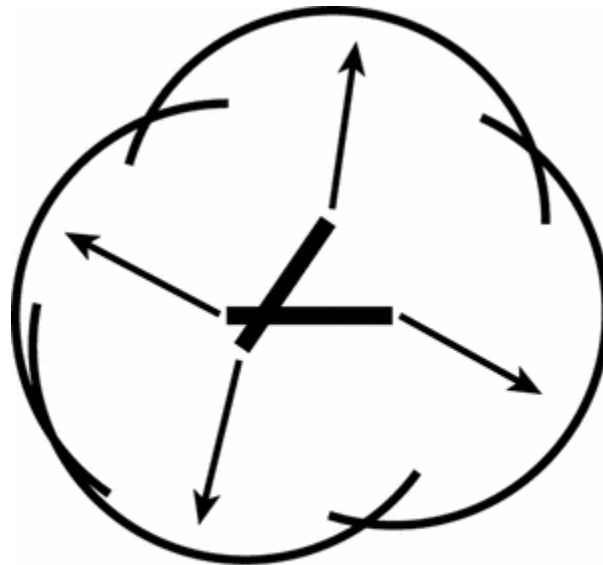
The visual maneuvering area for a circling approach is determined by drawing arcs centered on each runway threshold and joining those arcs with tangent lines (see Figure III-4-1). The radius of the arcs is related to:

- a. aircraft category;
- b. **speed:** speed for each category;
- 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 III-4-1 and III-4-2, and Figure III-4-1.

Figure III-4-1. Visual Maneuvering (Circling Approach) Area



Radius (\bar{R}) varies with
the aircraft category

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

Category of Aircraft/IAS (km/h)	A/185	B/250	C/335	D/380	E/445
TAS at 300m MSL + 46 km/h wind factor	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 (\bar{R}) from threshold (km)	3.12	4.90	7.85	9.79	12.82

Table III-4-2. Example of determining radii for visual maneuvering (circling) area for aerodromes at 1000 ft MSL (non-SI units)

Category of Aircraft/IAS (kt)	A/100	B/135	C/180	D/205	E/240
TAS at 1000 ft MSL + 25 kt wind factor	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 (\bar{R}) from threshold (NM)	1.68	2.66	4.20	5.28	6.94

NOTE:

Radius (\bar{R}) from threshold = $2r$ + straight segment.

Table III-4-3. OCA/H for visual maneuvering (circling) approach

Aircraft Category	Obstacle Clearance	Lowest OCH Above Aerodrome Elevation	Minimum Visibility
-------------------	--------------------	--------------------------------------	--------------------

	m (ft)	m (ft)	Km (NM)
A	90 (295)	120 (394)	1.9 (1.0)
B	90 (295)	150 (492)	2.8 (1.5)
C	120 (394)	180 (591)	3.7 (2.0)
D	120 (394)	210 (689)	4.6 (2.5)
E	150 (492)	240 (787)	6.5 (3.5)

4.3 VISUAL MANEUVERING (CIRCLING) AREA NOT CONSIDERED FOR OBSTACLE CLEARANCE

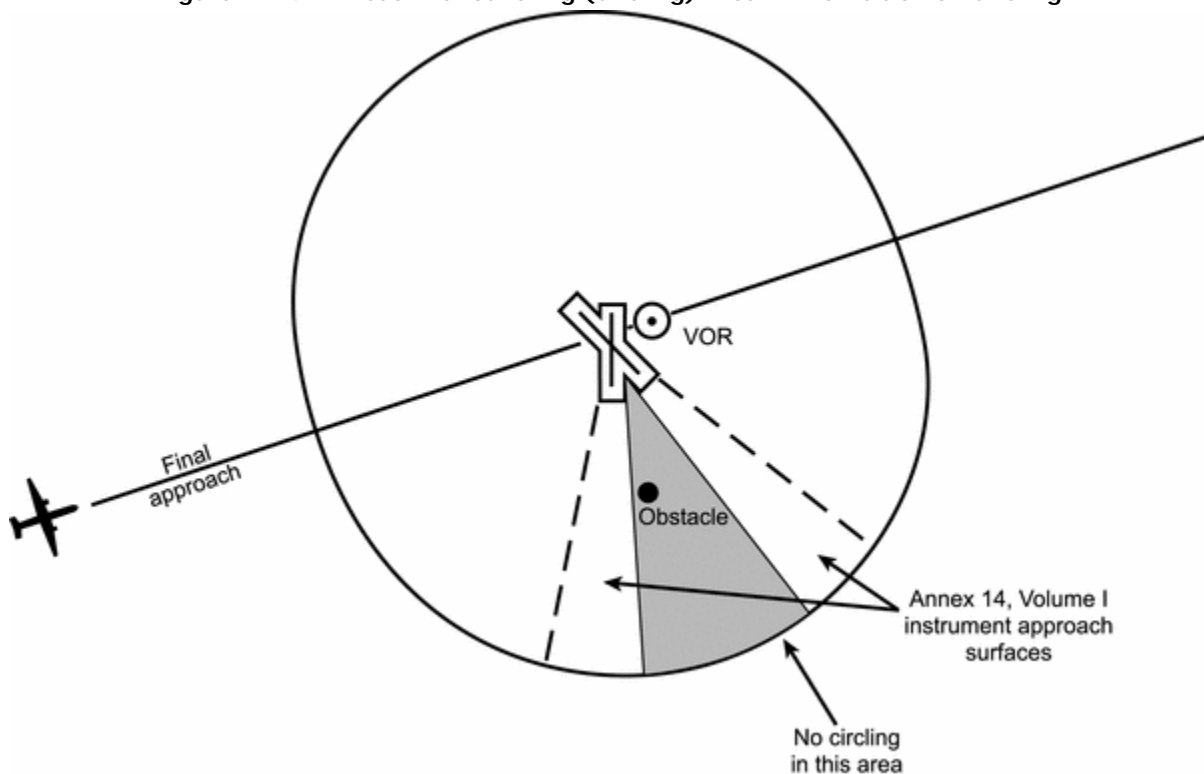
4.3.1

It is permissible to eliminate from consideration a particular sector where a prominent obstacle exists in the visual maneuvering (circling) area outside the final approach and missed approach area.

4.3.2

When this option is exercised, the published procedure prohibits circling within the total sector in which the obstacle exists (see Figure III-4-2).

Figure III-4-2. Visual Maneuvering (Circling) Area — Prohibition on Circling



4.4 OBSTACLE CLEARANCE

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

NOTE:

The information in Table III-4-3 should not be construed as operating minima.

4.5 MINIMUM DESCENT ALTITUDE / HEIGHT (MDA/H)

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.

NOTE:

The procedure does not provide protection from obstacles when the aircraft is below the OCA/H.

4.6 VISUAL FLIGHT MANEUVER

A circling approach is a visual flight maneuver. 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. After initial visual contact, the basic assumption is that the runway environment, (i.e., the runway threshold or approach lighting aids or other markings identifiable with the runway) should be kept in sight while at MDA/H for circling.

4.7 MISSED APPROACH PROCEDURE WHILE CIRCLING

If visual reference is lost while circling to land from an instrument approach, the missed approach specified for that particular procedure must be followed. It is expected that the pilot will make an initial climbing turn toward the landing runway and overhead the aerodrome where the pilot will establish the aircraft climbing on the missed approach track. Inasmuch as the circling maneuver may be accomplished in more than one direction, different patterns will be required to establish the aircraft on the prescribed missed approach course depending on its position at the time visual reference is lost.

4.8 VISUAL MANEUVERING USING PRESCRIBED TRACK

4.8.1 General

4.8.1.1

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

4.8.1.2

This procedure is described, for each aircraft category or group of categories (i.e., A and B) on a special chart on which the visual features used to define the track — or other characteristic features near the track — are shown. Note that:

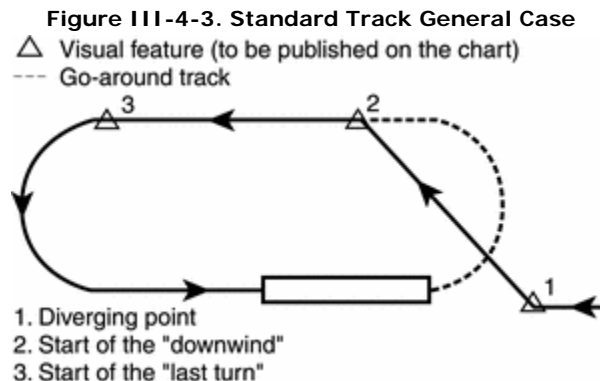
- navigation is primarily by visual reference and any radio navigational information presented is advisory only;
- the missed approach for the normal instrument procedure applies, but the prescribed tracks provide for maneuvering to allow for a go-around and to achieve a safe altitude / height thereafter (joining the downwind leg of the prescribed track procedure or the instrument missed approach trajectory).

4.8.1.3

Since visual maneuvering 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.

4.8.2 Standard Track (General Case)

(see Figure III-4-3)



4.8.2.1

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

4.8.2.2

The length of the final segment is calculated to allow for 30 seconds of flight before the threshold (at IAS for final approach as shown in Tables III-1-1 and III-1-2).

4.8.2.3

When a minimum altitude/height is specified at the beginning of the segment, the length of the final segment has to be adjusted, if necessary, taking into account the descent gradient/angle indicated on the chart.

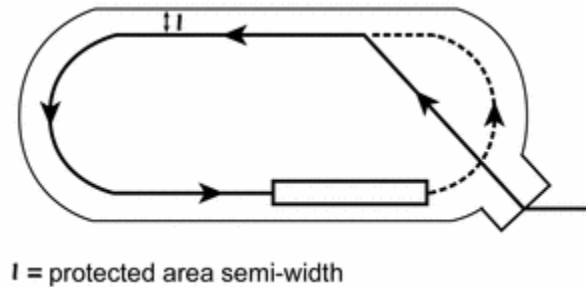
4.8.3 Area Associated with the Prescribed Track

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

Table III-4-4. Semi-width of the Corridor

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

Figure III-4-4. Area



4.8.4 Minimum Obstacle Clearance and OCA/H

The OCA/H for visual maneuvering on prescribed tracks shall provide the minimum obstacle clearance (MOC) over the highest obstacle within the prescribed track area. It shall also conform to the limits specified in Table III-4-3 and be not less than the OCA/H calculated for the instrument approach procedure which leads to the visual maneuver.

4.8.5 Visual Aids

Visual aids associated with the runway used for the prescribed track (i.e., sequenced flashing lights, PAPI, VASIS...) 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.

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

5.1

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.

5.2

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 approaches, providing that before conducting any flight it is ensured that:

- the RNAV equipment is serviceable;
- the pilot has a current knowledge of how to operate the equipment so as to achieve the optimum level of navigation accuracy;
- the published VOR/DME facility upon which the procedure is based is serviceable.

5.3

The accuracy and limitations of RNAV systems are those of a computer employed to convert navigational data inputs into aircraft position, to calculate track and distance and to provide steering guidance to the next way-point. A disadvantage

of this system is that the way-point and, in some cases, data contained in the navigational data base, have been calculated and promulgated by States and inserted by the operator or crew. However, the computer cannot identify data input errors. Furthermore, while the computer is designed so that calculation errors are minimal and do not affect the accuracy of the output significantly, the actual computed position will contain any errors introduced into the navigational database.

5.4

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

5.5

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

5.6

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

- ground station tolerance;
- airborne receiving system tolerance;
- flight technical tolerance;
- system computation tolerance;
- distance from reference facility.

5.7

The fixes used in the procedure are indicated as way-points. These way-points are referred to by alphanumeric indicators and 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.

5.8

Arrival. 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, except that the FTT is assumed to be equal to 3.7 km (2.0 NM) before a point located at 46 km (25 NM) from the IAF and equal to 1.9 km (1.0 NM) after this point.

5.9

The final approach segment is generally aligned with the runway.

5.10

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

5.11

A runway threshold way-point is provided.

5.12

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

5.13

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

5.14

Missed Approach. The missed approach point (MAP) is defined by a flyover waypoint. From the earliest MAP, the area spans at 15° on each side of the missed approach track, at least until the SOC is reached, to take into account the limitations of some RNAV systems, and the pilot's workload at the beginning of the missed approach phase. A missed approach holding fix (MAHF) defines the end of the missed approach segment and is located at or after the point where the aircraft, climbing at the minimum prescribed gradient, reaches the minimum altitude for enroute or holding, whichever is appropriate.

6 USE OF FMS / RNAV EQUIPMENT TO FOLLOW CONVENTIONAL NON-PRECISION APPROACH PROCEDURES

6.1

Where FMS / RNAV equipment is available, it may be used when flying the conventional non-precision approach procedures defined in PANS-OPS, Volume II, Part III, (not published herein) 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.

6.2

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

the FMS.

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

7.1 BACKGROUND

The use of GNSS departures and non-precision approach procedures are based on the use of RNAV systems that may exist in different avionics implementations, ranging from either a basic GNSS stand-alone receiver to a multi-sensor RNAV system that utilizes information provided by a basic GNSS sensor. Flight crews should be familiar with the specific functionality of the equipment.

7.2 GNSS RNAV

7.2.1 General

7.2.1.1

Introduction. Basic GNSS stand-alone receivers must include integrity monitoring routines and provide an RNAV capability that includes turn anticipation. With this type of avionics, the pilot interfaces directly with the receiver. Flight crews should be familiar with the specific functionality of the equipment.

7.2.1.2

Operational approval. Aircraft equipped with basic GNSS receivers, which have been approved by the State of the Operator for departure and non-precision approach operations may use these systems to carry out basic GNSS procedures provided that before conducting any flight the following criteria are met:

- a. the GNSS equipment is serviceable;
- b. the pilot has 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 navaids must be selected; and
- e. the procedure must be retrievable from an airborne navigation database.

7.2.1.3

Flight plan. Aircraft relying on basic GNSS receivers are to be considered to be RNAV-equipped. Appropriate equipment suffixes are assigned to each type for inclusion in the flight plan. Where the basic GNSS receiver becomes inoperative, the pilot should immediately advise ATC and amend the equipment suffix, where possible, for subsequent flight plans.

7.2.1.4

Navigation database. Departure and approach waypoint information is contained in a navigation database. If the navigation database does not contain the departure or approach procedures, then the basic GNSS receiver cannot be used for these procedures.

7.2.1.5

Performance integrity. The basic GNSS receiver verifies the integrity (usability) of the signals received from the satellite constellation through receiver autonomous integrity monitoring (RAIM) to determine if a satellite is providing corrupted information. 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. 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.

7.2.1.7

Operating modes and alert limits. The basic GNSS receiver has three modes of operation: enroute, terminal and approach mode. The RAIM alert limits are automatically coupled to the receiver modes and are set to ± 3.7 , 1.9 and 0.6 km (± 2.0 , 1.0 and 0.3 NM) respectively.

7.2.1.8

Course deviation indicator (CDI) sensitivity. The CDI sensitivity is ± 9.3 , 1.9 or 0.6 km (± 5.0 , 1.0 or 0.3 NM) and is similarly coupled to the operating mode of the receiver. 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.

7.2.2 PRE-FLIGHT

7.2.2.1

All basic GNSS IFR operations should be conducted in accordance with the aircraft operating manual. Prior to an IFR flight using basic GNSS receivers, the operator should ensure that the GNSS equipment and the installation are approved and certified for the intended IFR operation since not all basic GNSS receivers are certified for approach and/or departure procedures.

7.2.2.2

Prior to any 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.

7.2.2.3

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

7.2.2.4

The pilot must 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 "cleaned 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.

7.2.3 GNSS APPROACH PROCEDURES

7.2.3.1

Usually, flying a basic GNSS non-precision instrument approach procedure is very similar to a traditional approach. The differences include the navigational information displayed on the GNSS equipment and the terminology used to describe some of the features. Flying a basic GNSS approach is normally point-to-point navigation and independent of any ground-based nav aids.

7.2.3.2

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 by the GNSS receiver may occur. These differences are usually due to rounding of the track bearing and/or the application of magnetic variation.

7.2.3.3

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.

7.2.3.4

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.

7.2.3.5

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. The proper RAIM alert limit will not be selected, and the CDI sensitivity will not automatically change to ± 0.6 km (± 0.3 NM). Manually setting CDI sensitivity does not automatically change the RAIM alert limit on some GNSS avionics implementations.

7.2.3.6

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

7.2.3.7

Operators must be intimately 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 navigational aids.

7.2.3.8

Procedures must be established in the event that GNSS outages occur. In these situations, the operator must rely on other instrument procedures.

7.2.3.9

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 centerline. 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.

7.2.3.10

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.

7.2.3.11

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 these actions may take place automatically:

- a. upon reaching a distance of 56 km (30 NM) to the aerodrome reference point, basic GNSS receivers will give 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 NM) before the FAWP, and provided the approach mode is armed (which it should be, see item c.), the CDI sensitivity and RAIM ramp to smoothly reach the approach values (0.6 km (0.3 NM)) at the FAWP. In addition, the "approach active" annunciator 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 has been cancelled by overriding an automatically selected sensitivity; and
- g. if the CDI is not centered 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.

7.2.3.12

The pilot must be aware of the bank angle/turn rate the particular receiver 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.

7.2.3.13

Pilots must pay particular attention to the exact operation of the basic GNSS receivers 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 maneuver 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). Care must be exercised to 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.

7.2.3.14

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.

7.2.3.15

Some basic GNSS receivers may provide altitude information. However, the pilot must comply with the published minimum altitudes using the barometric altimeter.

7.2.3.16

The equipment will automatically present the waypoints from the IAF to the missed approach holding fix (MAHF).

7.2.3.17

At the MAP, the 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.

7.2.3.18

With radar vectors, it may be required to manually select the next waypoint so that GNSS is correctly using the appropriate database points and associated flight paths.

7.2.4 Initial approach segment

7.2.4.1

Offset IAFs. 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 III-7-1 and III-7-2).

7.2.4.1.1

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.

7.2.5 Intermediate approach segment

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.

7.2.6 Final approach segment

7.2.6.1

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

7.2.6.2

The course deviation indicator (CDI) sensitivity related to GNSS equipment varies with the mode of operation. In the enroute 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 centerline.

Figure III-7-1. Basic GNSS RNAV Approach

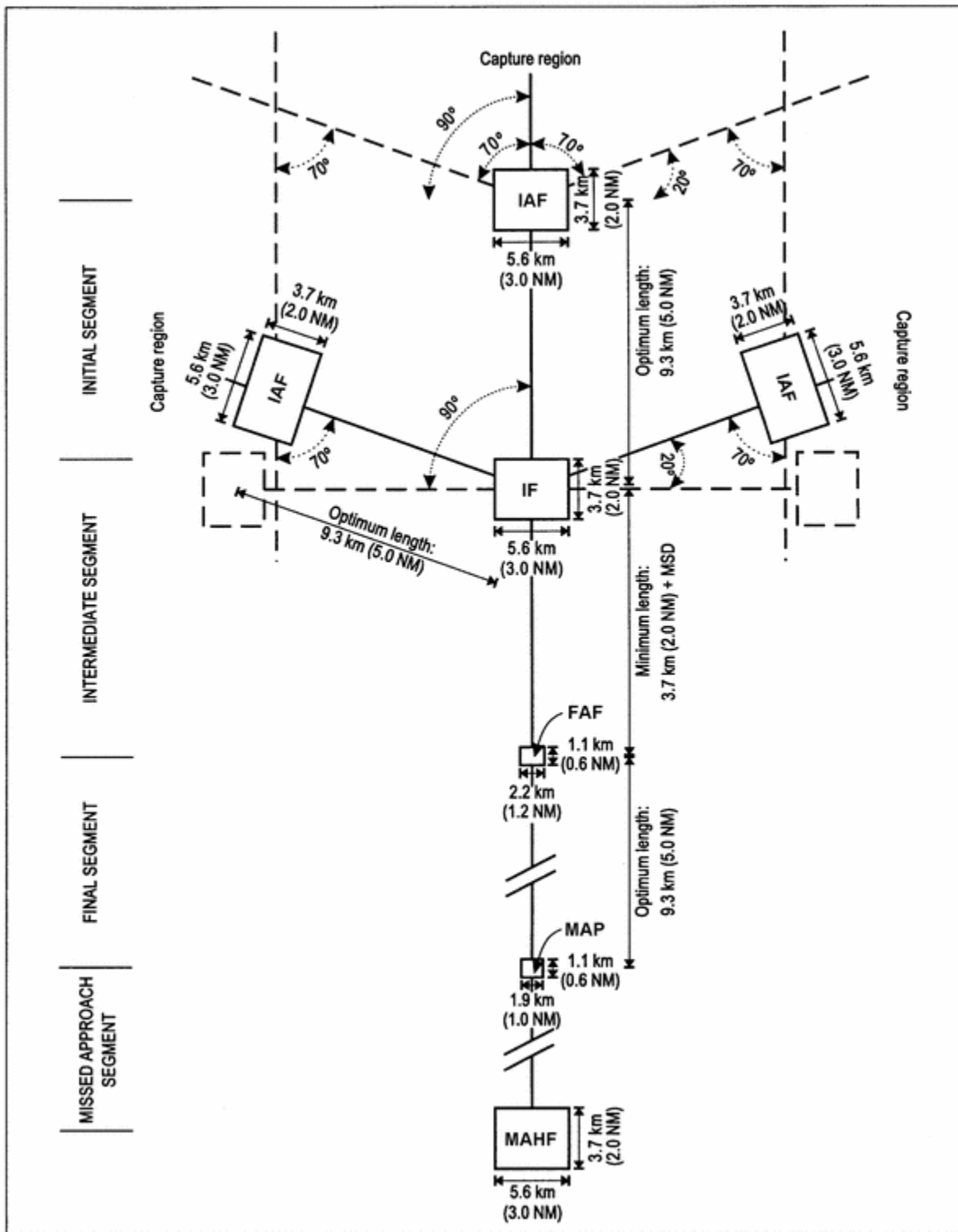
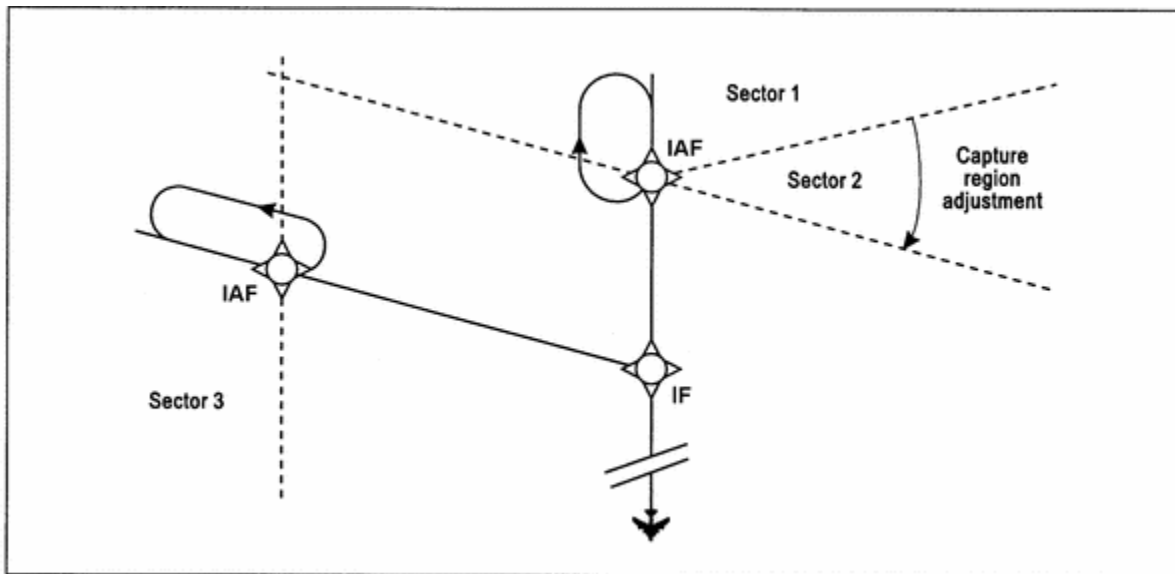


Figure III-7-2. Example of Implementation of Reversal Procedures when Local Conditions Prevent an Offset Leg from being used



7.2.6.2.1

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

7.2.6.2.2

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 the centerline. Some GNSS avionics may provide an angular display between the FAF and MAP that approximates the course sensitivity of the localizer portion of an ILS.

7.2.6.3

Stepdown fixes. 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.

7.2.6.4

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

7.2.7 Missed Approach Segment

7.2.7.1

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

7.2.7.2

A GNSS missed approach requires pilot action to sequence the receiver past the MAP to the missed approach portion of the procedure. The pilot must be thoroughly familiar with the activation procedure for the particular basic GNSS receiver installed in the aircraft and must initiate appropriate action after the MAP. Activating the missed approach prior to the MAP will cause CDI sensitivity to immediately change to terminal (± 1.0 NM sensitivity), and navigation guidance will continue to the MAP. The guidance will not be provided beyond MAP or initiate a missed approach turn without pilot action. 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 MAP until it is manually sequenced after crossing the MAP.

7.2.7.3

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.

7.3 MULTI-SENSOR RNAV

7.3.1 General

7.3.1.1

Introduction. For GNSS non-precision approach procedures and approach procedures with vertical guidance, multi-sensor RNAV systems such as a flight management computer (FMC) must include a basic GNSS sensor that

includes integrity monitoring that supports 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. The FMC will provide an automatic selection of the best (most accurate) source, as well as a capability to deselect or inhibit from use in calculating position, a sensor type or specific navigation aid. 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.

NOTE:

For text simplicity in this section, the term FMC is used to denote the general category of multi-sensor RNAV systems.

7.3.1.2

Operational approval. Aircraft equipped with an FMC system that has been approved by the State of the Operator for departure and non-precision approach operations may use the system to carry out RNAV procedures based on GNSS providing that before conducting any flight the criteria in 7.2.1.2 are met.

7.3.1.3

Flight plan. Aircraft relying on FMCs using GNSS are considered to be RNAV-equipped. Appropriate equipment suffixes are assigned to each type for inclusion in the flight plan. Where a GNSS sensor for the FMC becomes inoperative and the resulting equipment configuration is insufficient for the conduct of the procedures, the pilot should immediately advise ATC and request an available alternative procedure consistent with the capability of the RNAV system. It should be noted that depending on the type of certified FMC being used, the manufacturer's aircraft flight manuals and data may allow for continued operation.

7.3.1.4

Navigation database. The criteria specified in 7.2.1.4 apply for an FMC system.

7.3.1.5

Performance integrity. GNSS implementations could rely on the integrity capability of the GNSS sensors incorporating RAIM, as well as aircraft autonomous integrity monitoring (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.

7.3.1.7

Operating modes and alert limits. An FMC using GNSS will contain either the three systems modes of operation described in 7.2.1.7, "Operating modes and alert limits", 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.

7.3.1.8

CDI sensitivity. Some FMC GNSS implementations may incorporate different display sensitivities for approach operations that differ from those in 7.2.1.8, "Course deviation indicator (CDI) sensitivity". These different display sensitivities may be used when guidance is provided by a flight director or autopilot. Regardless of the approach display sensitivity differences with the FMC GNSS implementations, equivalent integrity must still be provided.

7.3.2 Pre-flight

The pre-flight criteria of 7.2.2.1 through 7.2.2.3 apply for an FMC system. 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 in 7.2.2. Other types may require an operations control center to perform an assessment of RAIM availability and provide this data as part of the flight dispatch information.

7.3.3 GNSS approach procedures

7.3.3.1

The criteria of 7.2.3.1 through 7.2.3.5 apply for an FMC system. 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). Manually setting CDI sensitivity does not automatically change the RAIM alert limit on some avionics implementations.

7.3.3.2

The criteria of 7.2.3.6 through 7.2.3.8 apply for an FMC system. 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.

7.3.3.3

The criteria of 7.2.3.9 through 7.2.3.11 apply for an FMC system. Some FMC implementations do not conform to the

display sensitivities discussed but instead provide comparable operations as described in the aircraft operating manual.

7.3.3.4

The criteria of 7.2.3.12 apply for an FMC system. In installations where an FMC provides navigation information on an electronic map display and/or provides guidance information or cues to the flight crew, pilot familiarization with the displays for their intended use in operations is required.

7.3.3.5

Pilots must pay particular attention to the exact operation of avionics implementations for performing holding patterns and in the case of overlay approaches, operations such as procedure turns and course reversals. 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.

7.3.3.6

The criteria of 7.2.3.14 apply for an FMC system. 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.

7.3.3.7

FMCs provide altitude information. However, the pilot must 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.

7.3.3.8

The criteria of 7.2.3.16 apply for an FMC system.

7.3.3.9

At the MAP, the FMC will provide for automatic sequencing.

7.3.3.10

With radar vectors and for FMC installations, the systems typically provide what is known as a direct-to capability to support radar vectors under FMC guidance.

7.3.4 Initial approach segment

The criteria of 7.2.4 apply for an FMC system.

7.3.5 Intermediate approach segment

The criteria of 7.2.5 apply for an FMC system. The intermediate segment will be contained within the approach procedure contained in the FMC navigation database. It will correspond to the charted procedure.

7.3.6 Final approach segment

7.3.6.1

The criteria of 7.2.6.1 and 7.2.6.2 apply 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.

7.3.6.2

Step-down fixes. The criteria of 7.2.6.3 apply for an FMC system. 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 requirement of the operational approval.

7.3.6.3

Descent angle. Where the FMC provides the capability to define a vertical flight path, it will be specified as an angle. The typical angle will be 3°. When the continuous descent profile is charted, it will be depicted with an angle.

7.3.7 Missed approach segment

7.3.7.1

CDI sensitivity. While the criteria of 7.2.7.1 may apply, some FMC GNSS implementations 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 in the operation must still be provided.

7.3.7.2

The criteria of 7.2.7.2 generally apply. There will 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.

7.3.7.3

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

8 AREA NAVIGATION (RNAV) APPROACH PROCEDURES BASED ON DME/DME

8.1

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

8.2

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, 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 so as to achieve the optimum level of navigation accuracy.

8.3

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

- a. In the case specified in 8.1 a), the aircraft is equipped with at least a single FMC capable of DME/DME navigation and capable of automatic reversion to updated IRS navigation, approved for operations within the TMA;
- b. In the case specified in 8.1 b), the aircraft is equipped with at least a single FMC capable of DME/DME navigation, approved for operations within the TMA; and
- c. Waypoints and DME station coordinates meeting the WGS-84 requirements.

8.4

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

- a. DME tolerance, function of the theoretical maximum radio horizon, based on the specified altitude/height at the way-points;
- b. flight technical tolerance; and
- c. system computation tolerance.

8.5

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

8.6

The protected airspace required for obstacle clearance, where only two DME stations are available, is larger than the case where more than two DME stations are available. In both cases, it is assumed that a navigation database with stored way-points with coordinates based on WGS-84 including speed and vertical constraints containing the procedures to be flown can automatically be loaded into the FMC flight plan.

8.7

Arrival. 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 the arrival phase, except that the FTT is assumed to be equal to 3.7 km (2.0 NM) before a point located at 46 km (25 NM) from the IAF and equal to 1.9 km (1.0 NM) after this point.

8.8

Procedures (approach, departure and arrival routes) may be identified as "RNAV". When this is applied, any of the following navigation sensors ((basic) GNSS), DME/DME or VOR/DME can be used. 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. Many current FMS may downgrade the navigation sensor to VOR/DME or IRS update in a specific order. When this occurs, the approach procedure must be discontinued, a missed approach initiated, and ATC must be informed that the navigation accuracy fails to meet the requirements. In case of infrequent reversions to IRS only, the route or procedure can be continued for a specific amount of time. This time depends on the certification of the IRS and the navigation accuracy to which the procedure has been designed.

NOTE:

The maximum flight time to remain within the protected airspace is based on the lateral protected airspace. The following maximum flight times have been found to be acceptable:

Flight Phase	Time (min.)
Enroute	50
TMA	25
Approach	12

9 RNAV/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 vertical path angle from reference datum height (RDH).

9.1 GENERAL**9.1.1**

RNAV/baro-VNAV approach procedures are classified as instrument approach procedures in support of approach and landing operations with vertical guidance (APV) (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.

9.1.2

RNAV/baro-VNAV procedures are intended for use by aircraft equipped with flight management systems (FMS) or other area navigation (RNAV) systems capable of computing barometric VNAV paths and providing deviations therefrom to an instrument display.

9.1.3

The use of RNAV/baro-VNAV procedures improves the safety of 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. However, the inaccuracies inherent in barometric altimeters, and the certificated performance of the specific RNAV mode used, mean these procedures cannot emulate the accuracy and integrity of precision approach systems. In particular, with certain systems the aircraft may not be delivered within the Annex 14 obstacle free surfaces, and this possibility should be considered in making the decision to land at DA/H.

9.1.4

The baro-VNAV criteria are based on the non-precision criteria described in Chapters 32 and 33 of PANSOPS, Volume II, Part III. However, the FAF is not part of the RNAV/baro-VNAV procedure and is replaced by a final approach point (the RNAV FAF may be used as a final approach course fix in database design). In the same way, the MAP is replaced by an aircraft-category-dependent DA/H.

9.1.5

The RNAV/baro-VNAV minimum DH is 75m (246 ft) plus a height loss margin. However, this minimum DH limit must be increased by the operator to at least 90m (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.

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.

9.2 STANDARD CONDITIONS**9.2.1**

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

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

probability. This is deemed to include GNSS navigation systems certified for approach operations, multi-sensor systems using inertial reference units in combination with certified DME/DME or GNSS, and RNP systems approved for RNP 0.3 operations or less;

- b. the RNAV/baro-VNAV equipment is serviceable;
- c. the aircraft and aircraft systems are appropriately certified for the intended RNAV/baro-VNAV approach operations, and the aircraft is equipped with an integrated LNAV/VNAV system with an accurate source of barometric altitude; and
- d. 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.

9.2.2

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 9.1.5).

9.3 OPERATIONAL CONSTRAINTS

9.3.1

Pilots are responsible for any cold temperature correction required to all published minimum altitudes/heights, including the preceding initial and intermediate segment(s), DA/H and subsequent missed approach heights/altitudes.

NOTE:

The final approach path vertical path angle (VPA) is safeguarded against the effects of low temperature in the design of the procedure.

9.3.2

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 flight management systems 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 RNAV/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.

9.3.3

The pilot shall have current knowledge of how to operate the equipment so as to achieve the optimum level of navigation accuracy.

9.3.4

Baro-VNAV procedures shall only be flown with a current local altimeter setting source available and the QNH/QFE, as appropriate, set on the aircraft's altimeter. Procedures using a remote altimeter setting source cannot support baro-VNAV approach procedures.

9.3.5

The baro-VNAV vertical guidance sensitivity varies with different equipment. However, to ensure obstacle clearance, positive action must be taken to limit vertical path excursions to less than +30m (+100 ft) and -15m (-50 ft) from the VPA.

9.4 SYSTEM PERFORMANCE

9.4.1

The factors upon which the vertical navigational performance of the baro-VNAV procedure depends are as follows:

9.4.1.1

Atmospheric effects. Atmospheric errors associated with non-standard temperatures are considered in the design of the approach obstacle clearance surface. Lower than standard temperatures cause the aircraft's true altitude to be lower than its barometric indicated altitudes. 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.

9.4.1.2

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

9.4.1.3

Flight technical error (FTE). Flight technical error 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.

9.4.1.4

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.

9.4.1.5

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.

9.4.1.6

Vertical path deviation. Cockpit displays showing baro-VNAV vertical path deviation must be suitably located and have sufficient sensitivity to enable the pilot to maintain the path keeping tolerances described in 9.4.1.3. 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. Additionally, this may be mitigated by an appropriate operational alternative that provides for path keeping as specified in 9.4.1.3. Operational alternatives that may be deemed acceptable include baro-VNAV operations with a flight director or autopilot system.

NOTE:

Some existing baro-VNAV vertical path deviation displays are so located and/or 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.

10 GROUND-BASED AUGMENTATION SYSTEM (GBAS)

10.1 GENERAL CRITERIA

10.1.2

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.

10.2 ARRIVAL OPERATIONS USING 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.

10.3 GBAS PRECISION APPROACH OPERATIONS

10.3.1

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.

10.3.2

GBAS approach display criteria. 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.

10.3.3

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.

10.3.4

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.

12 TERMINAL ARRIVAL ALTITUDE (TAA)

12.1 GENERAL

12.1.1

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

12.1.2

TAA's are associated with an RNAV procedure based upon the "T" or "Y" arrangement described in Chapter 7.

12.1.3

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 TAA's 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.

12.1.4

Where published, TAA's replace the 46 km (25 NM) MSA.

12.1.5

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.

12.1.6

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.

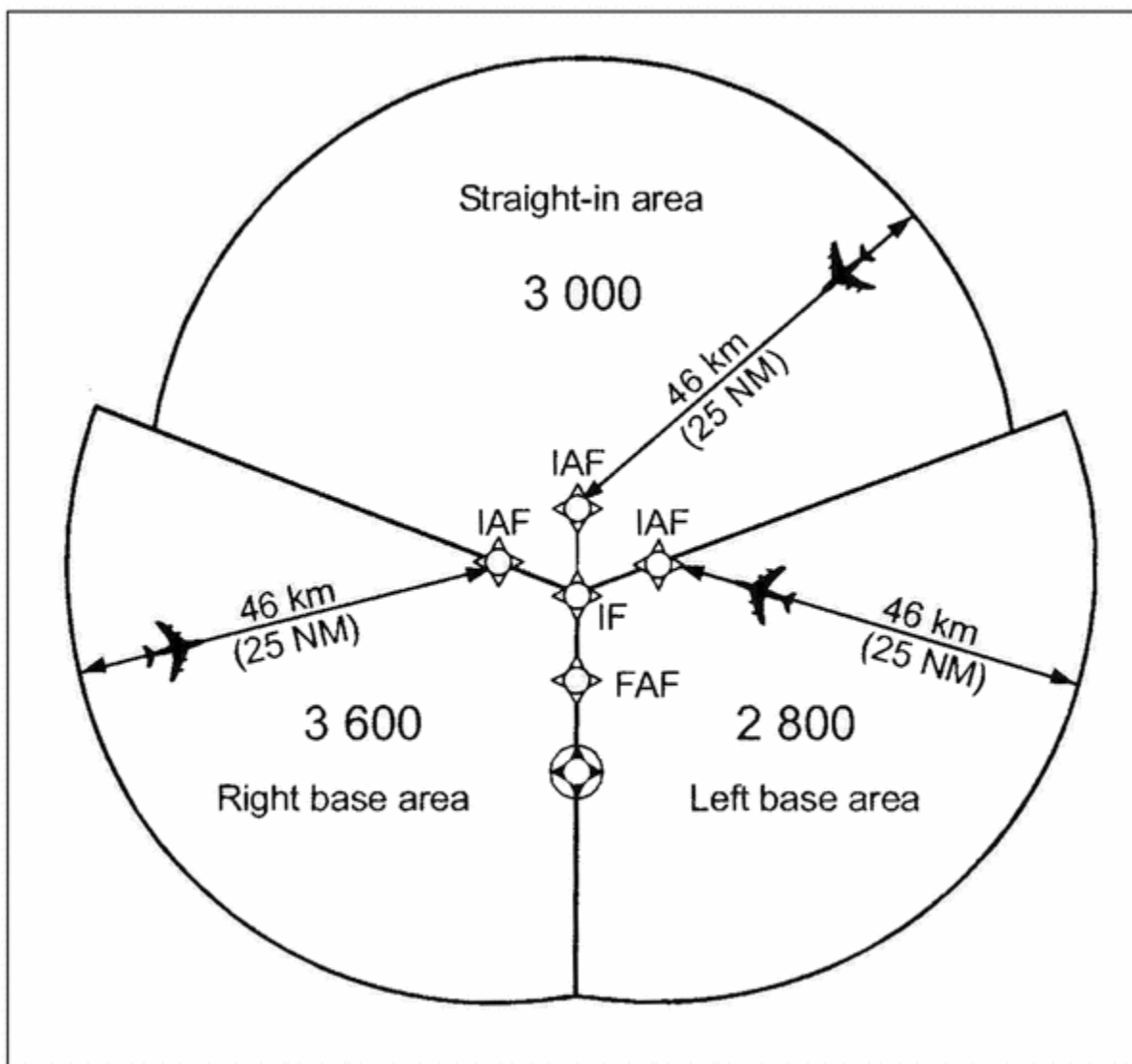
NOTE:

In this chapter, the standard "T" or "Y" arrangement incorporating three IAF's will be assumed. Where one or more of the initial segments are not employed, the TAA reference point may be the IF.

12.1.7

The standard TAA radius is 46 km (25 NM) from the IAF and the boundaries between TAA's are normally defined by the extension of the initial segments (see Figure III-12-1).

Figure III-12-1. Typical TAA arrangement



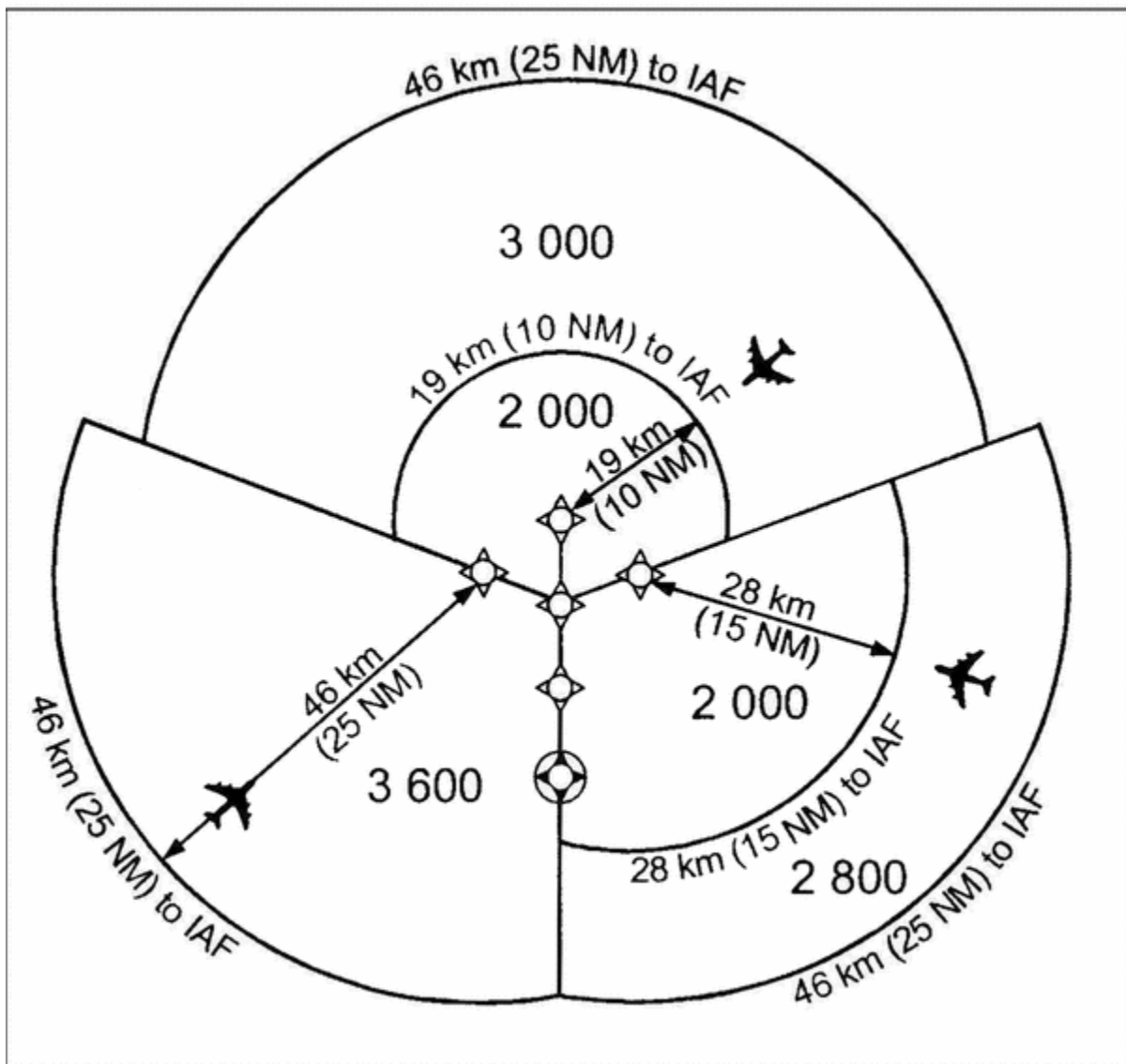
12.1.8

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

12.1.9

Stepdown arcs. TAA may contain stepdown arcs defined by an RNAV distance from the IAF (see Figure III-12-2).

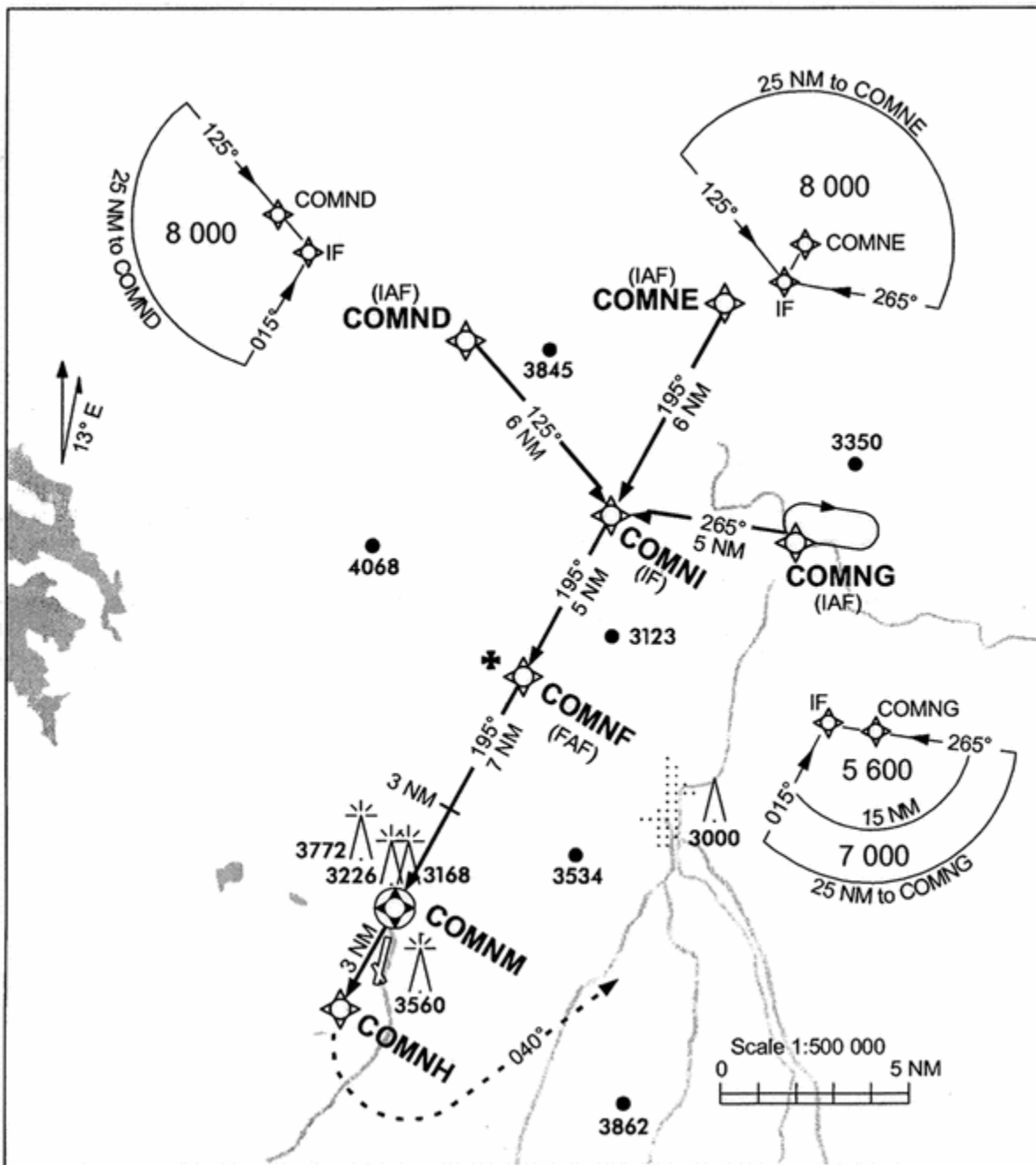
Figure III-12-2. TAA with stepdown arcs



12.1.10

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 step-downs. 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 III-12-3 to III-12-5).

Figure III-12-3. TAA "Y" bar icon arrangement



12.2 FLIGHT PROCEDURES

12.2.1

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 the right base areas, especially where TAAs are at different levels.

12.2.2

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

12.2.3

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.

Figure III-12-4. "T" bar icon arrangement

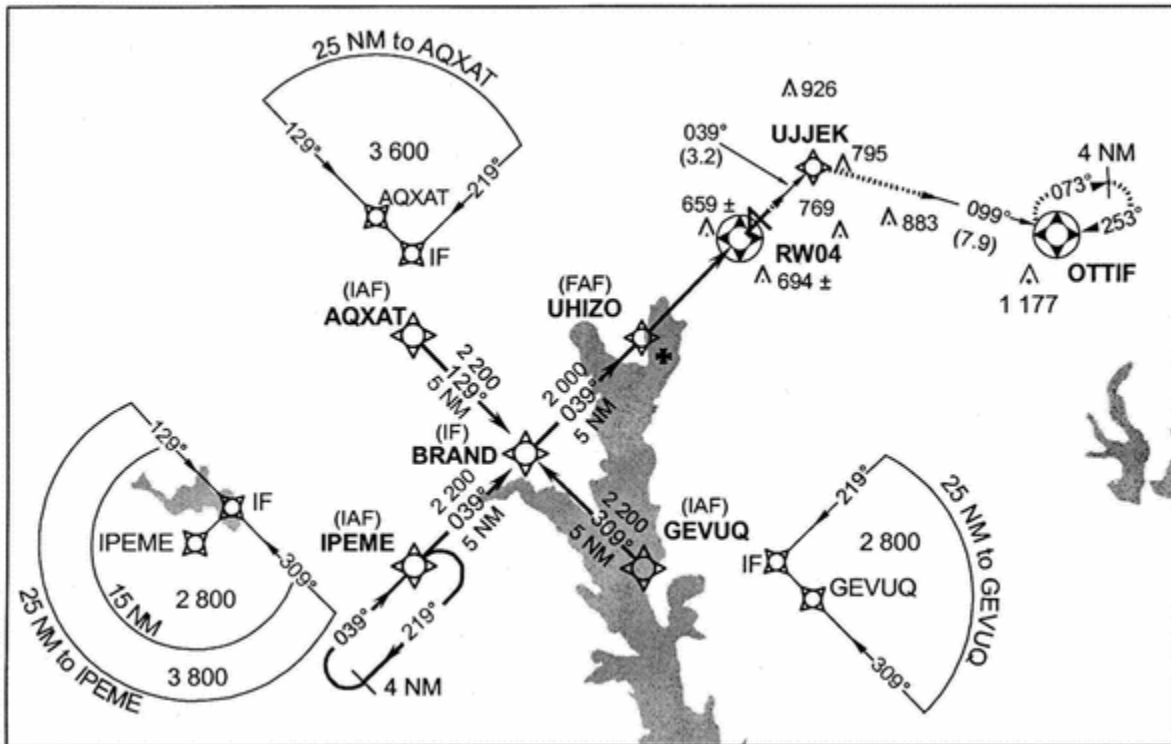
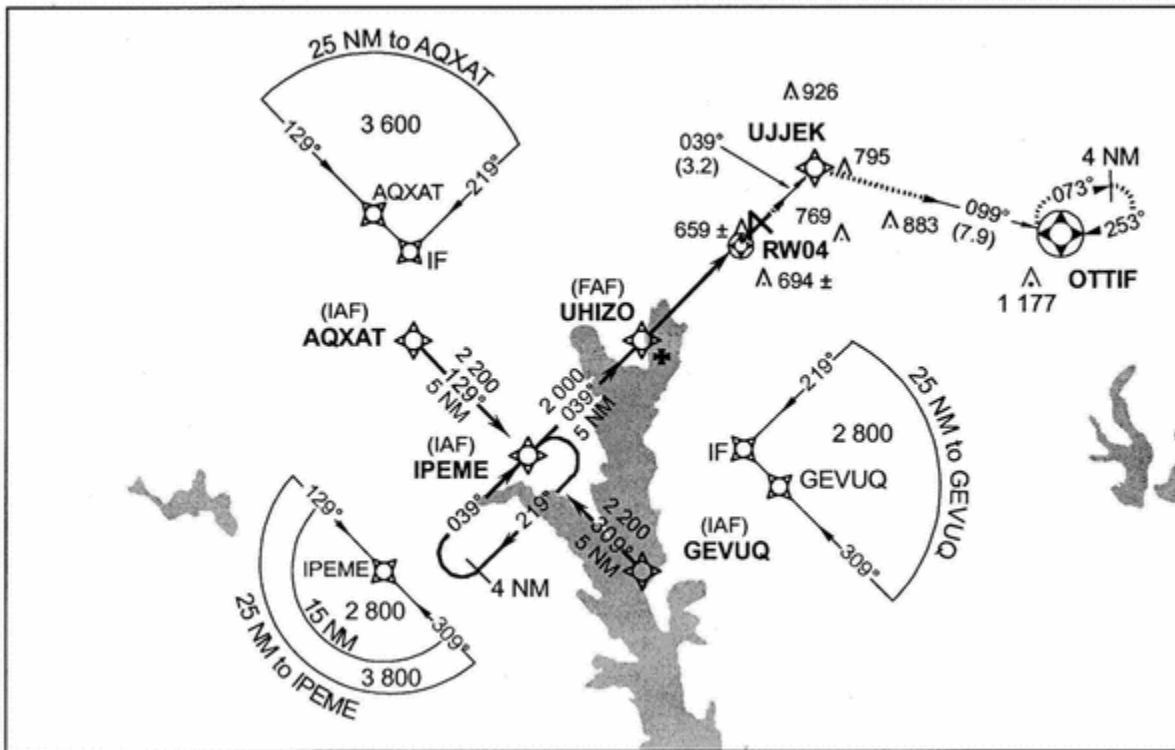


Figure III-12-5. "T" bar icon arrangement without center initial approach fix



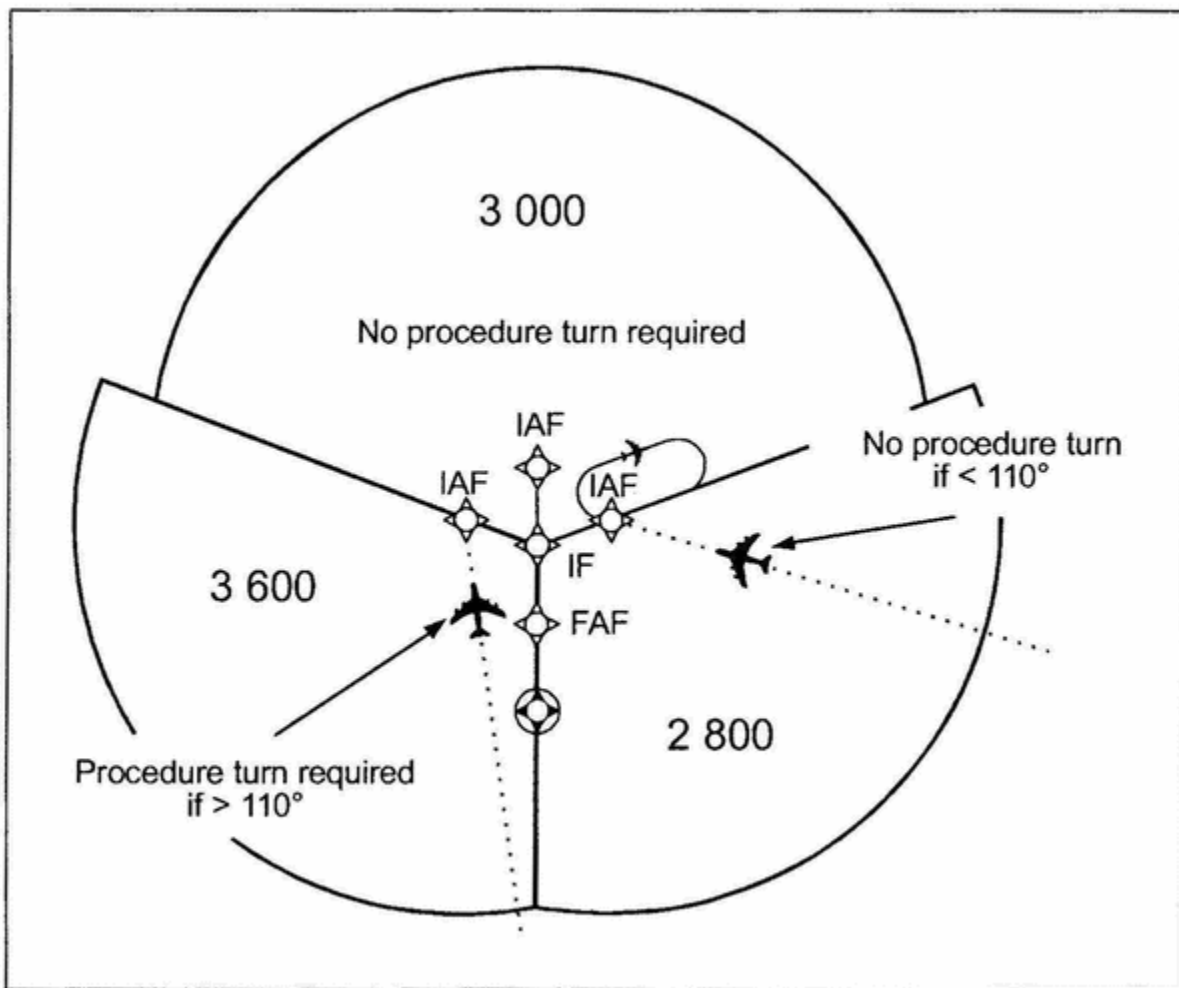
12.2.4

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 maneuvered 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 III-12-6).

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.

Figure III-12-6. Procedure entry



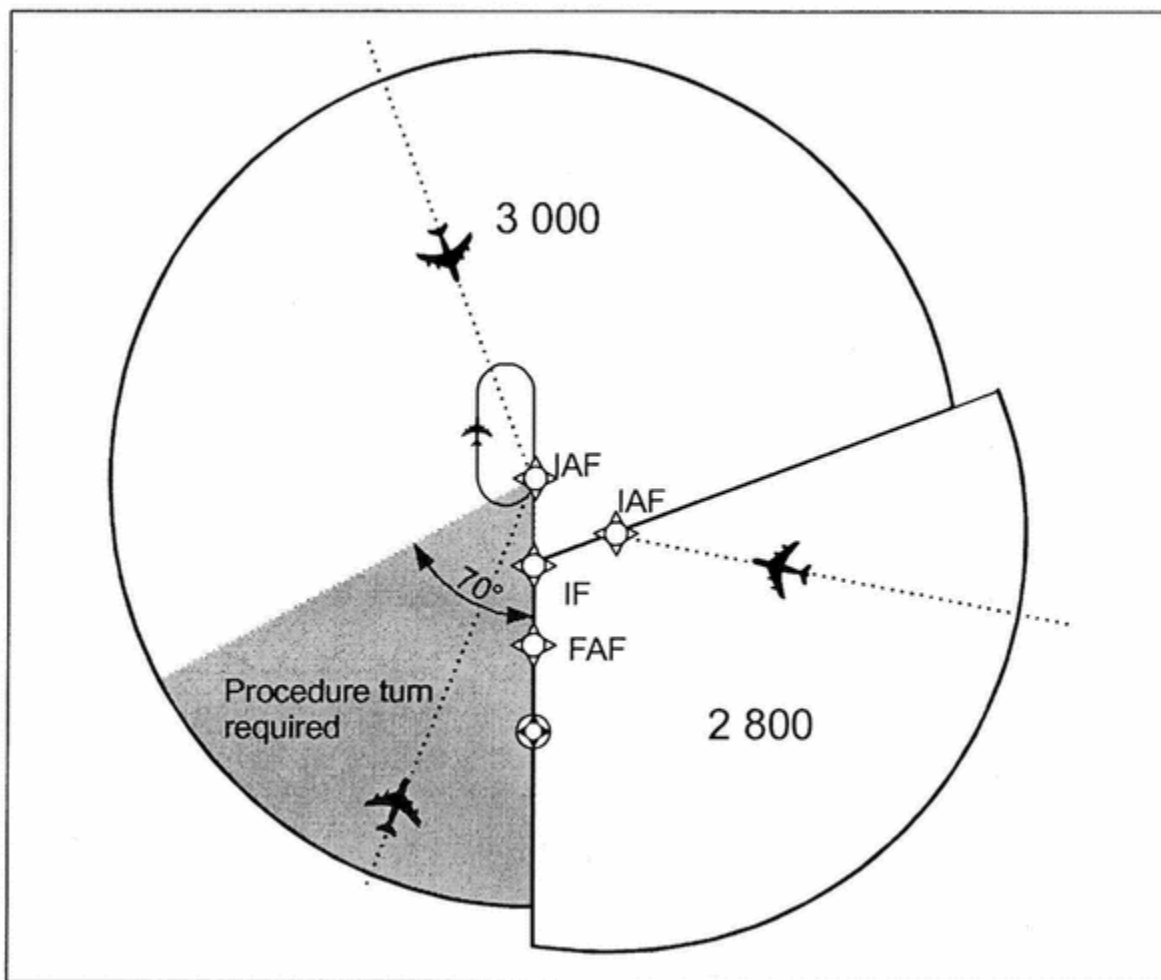
12.2.5

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.

12.2.6

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 III-12-7).

Figure III-12-7. TAA arrangement without right base



12.3 NON-STANDARD TAA

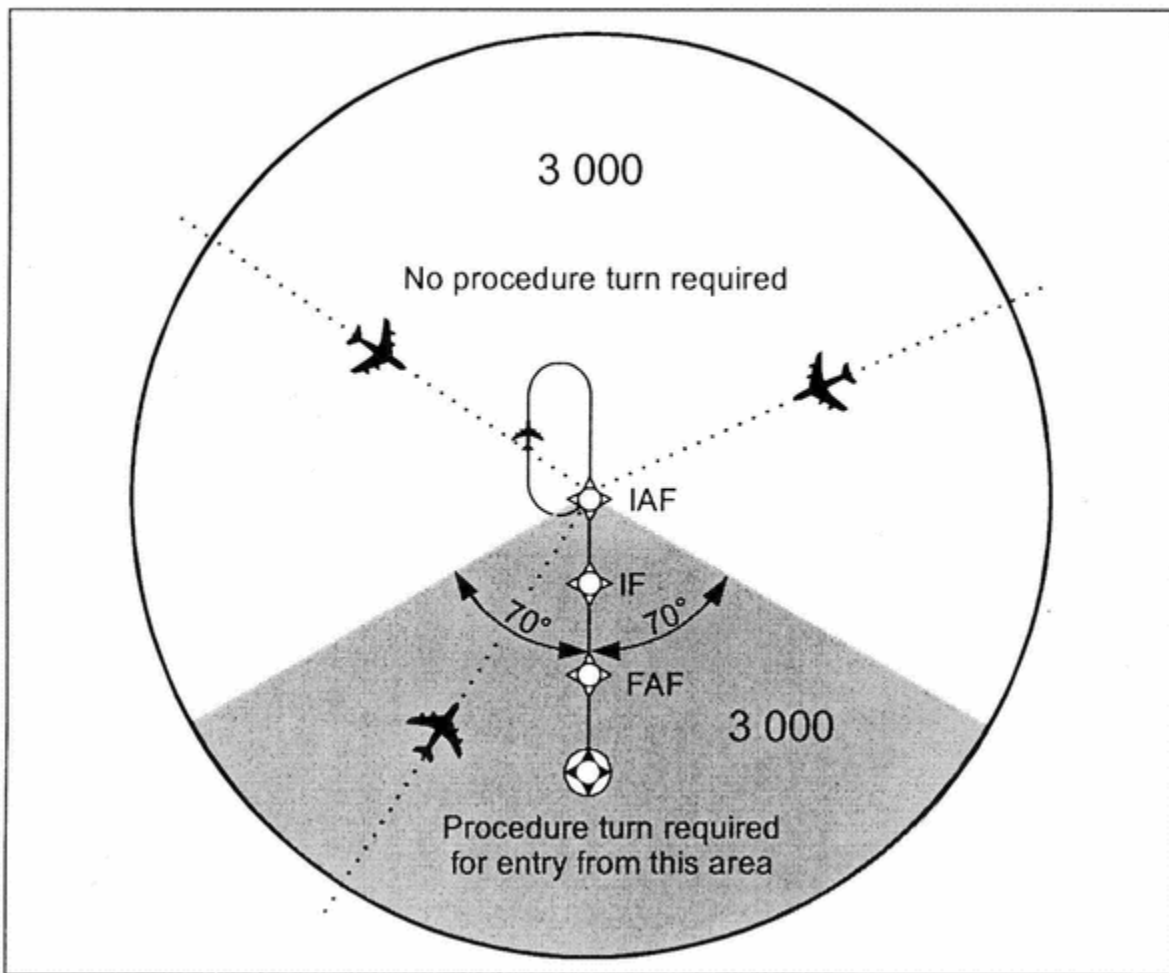
12.3.1

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 III-12-7).

12.3.2

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 III-12-8).

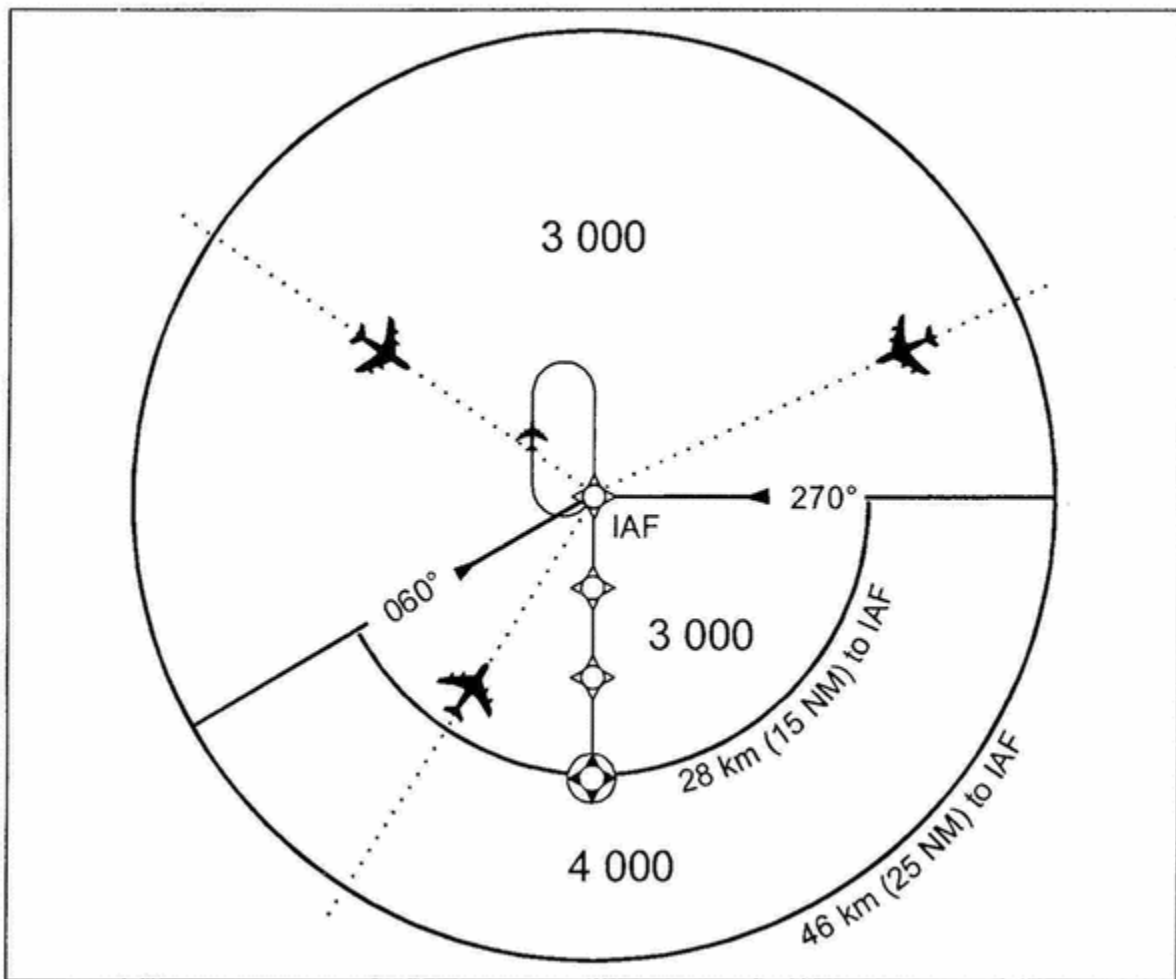
Figure III-12-8. TAA arrangement without left and right base



12.3.3

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 III-12-9).

Figure III-12-9. Single TAA with sectorization and step-down



1 IN-FLIGHT PROCEDURES

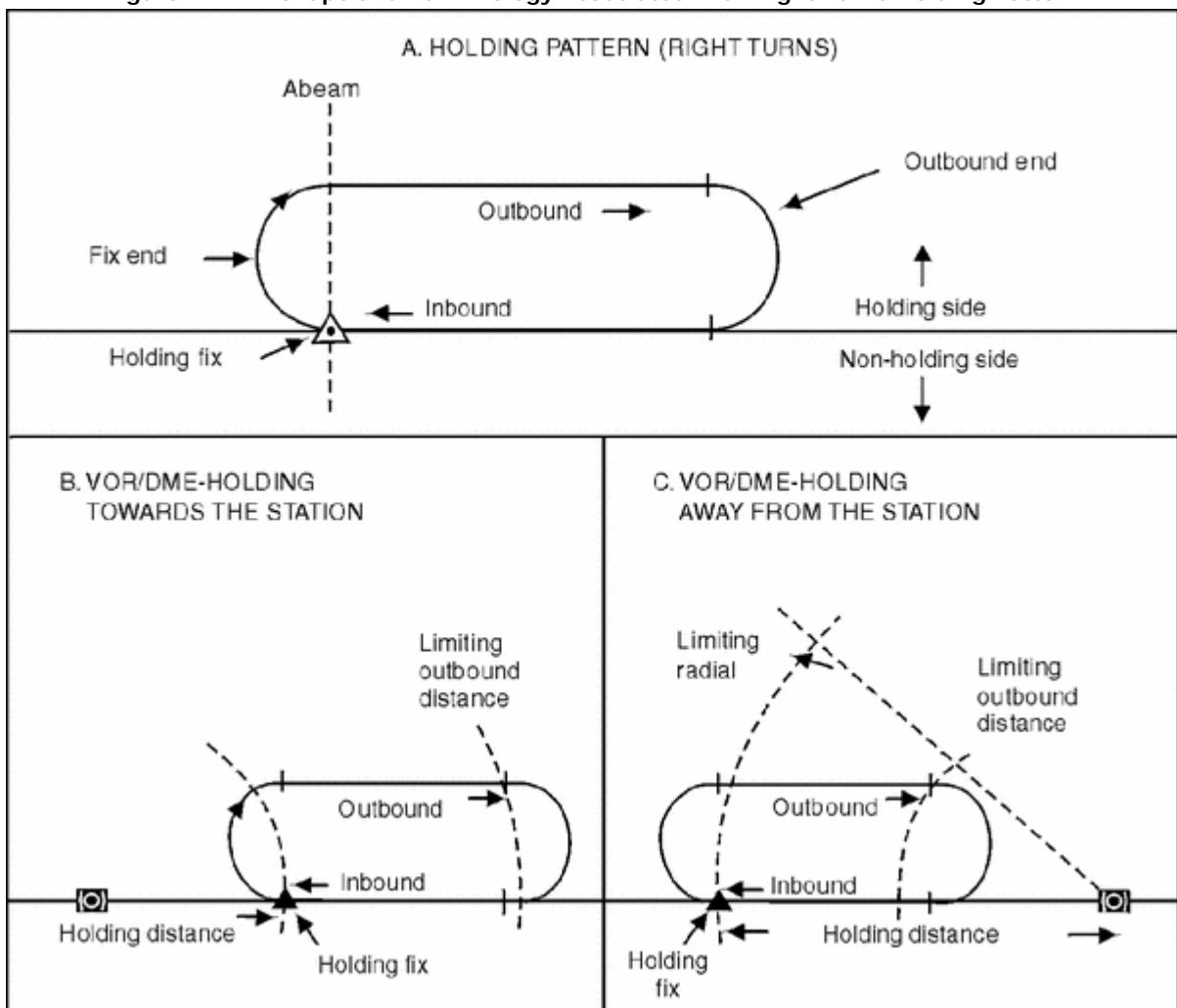
NOTE:

1. Deviations from the in-flight procedures incur the risk of excursions beyond the perimeters of holding areas established.
2. The procedures described in this chapter are related to right turns holding patterns. For left turns holding patterns, the corresponding entry and holding procedures are symmetrical with respect to the inbound holding track.

1.1 SHAPE AND TERMINOLOGY ASSOCIATED WITH HOLDING PATTERN

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

Figure IV-1-1. Shape and Terminology Associated with Right Turns Holding Pattern



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

1.2.1

Holding patterns shall be entered and flown at or below those indicated airspeeds given in Table IV-1-1.

NOTE:

The speeds in Table IV-1-1 are converted and rounded to the nearest multiple of five for operational reasons and, from the standpoint of operational safety, are considered to be equivalent.

1.2.2

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.

1.2.3

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

1.2.4

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

1.2.5

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

1.2.6

In the case of holding away from the station, where the distance from the holding fix to the VOR/DME station is short, a limiting radial may be specified.

1.2.7

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

1.2.8

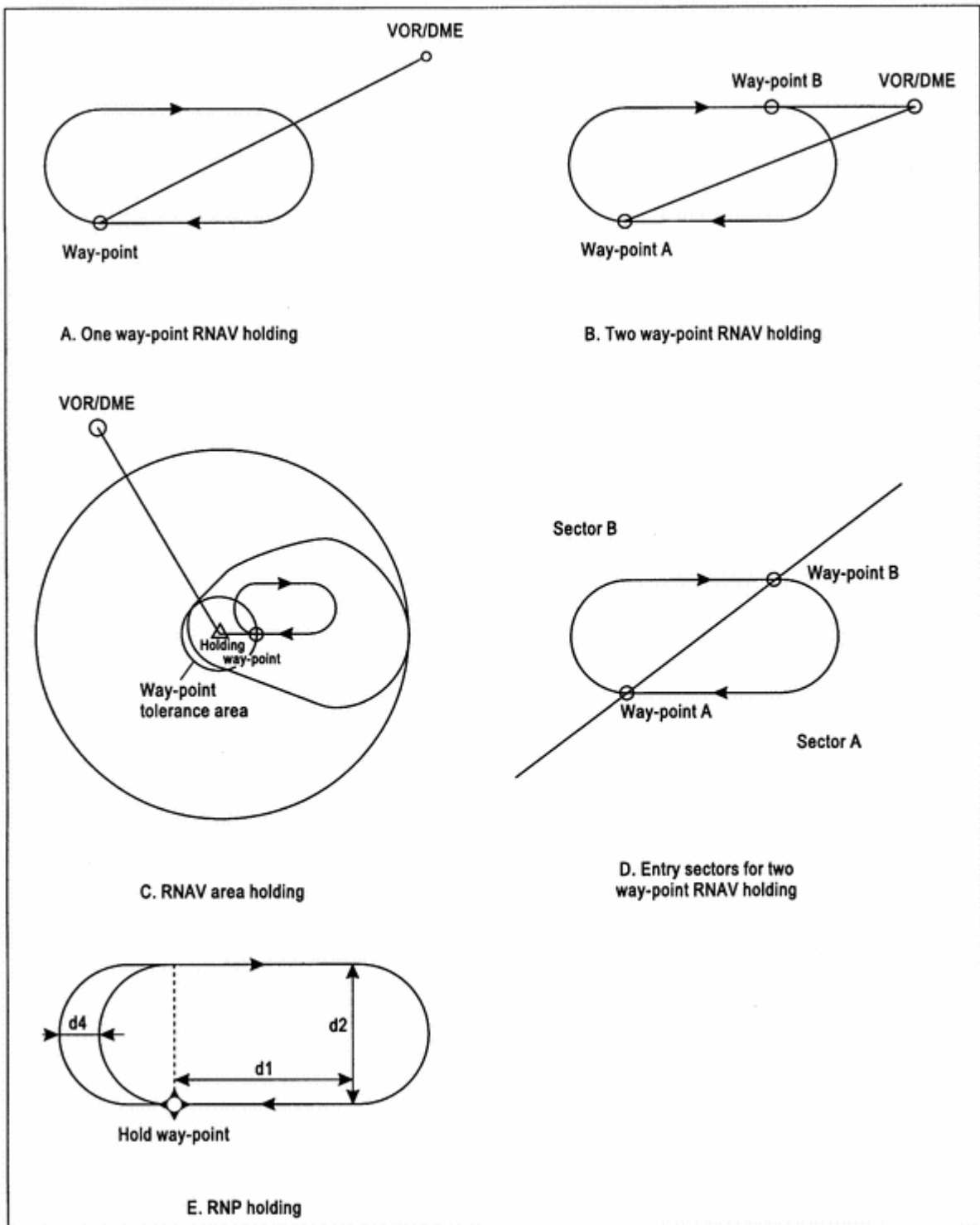
If for any reason a pilot is unable to conform to the procedures for normal conditions laid down for any particular holding pattern, air traffic control should be advised as early as possible.

1.2.9

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 so as to achieve the optimum level of navigational accuracy; and
- c. the published VOR/DME facility upon which the procedure is based is serviceable.

Figure IV-1-2. RNAV/RNP Holding Procedures



1.2.11

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 auto-pilot or flight director. The pilot remains responsible for ensuring that the aircraft complies with the speed, bank angle, timing and distance assumptions.

1.2.13

RNAV holding may be conducted in specifically designed holding patterns. These holding patterns utilize the criteria and

flight procedures 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 so that the navigation tolerance is achieved by all authorized aircraft during the entry maneuver and while in the holding pattern;
- 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 way-points by cross-reference to the published VOR/DME fixes.

1.2.14

RNAV holding procedures may be constructed using one or two way-points. Area holding may also be provided. RNP holdings are characterized by a maximum track geometrically defined by the length of the inbound track and diameter of the turn (see Figure IV-1-2). The 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.

1.2.15

Area holding is specified by an area holding way-point and an associated radius. The value of this radius 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 IV-1-2 C.).

1.2.16

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

1.3 ENTRY

NOTE:

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

1.3.1

The entry into the holding pattern shall be according to heading in relation to the three entry sectors shown in Figure IV-1-3, recognizing a zone of flexibility of 5° on either side of the sector boundaries. For holding on a VOR intersection, the entry track is limited to the radials forming the intersection. For holding on a VOR/DME fix, the entry track is limited to either the VOR radial, DME arc, or alternatively along the entry radial to a VOR/DME fix at the end of the outbound leg, as published.

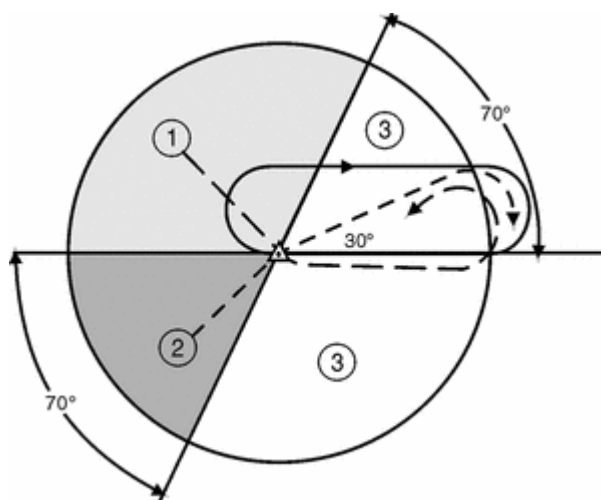
NOTE:

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

1.3.2 Sector 1 Procedure (Parallel Entry):

- a. Having reached the fix, the aircraft is turned left onto an outbound heading for the appropriate period of time (see 1.3.7); 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.

Figure IV-1-3. Entry Sectors



1.3.3 Sector 2 Procedure (Offset Entry):

- a. Having reached 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 1.3.7), where timing is specified, or
 2. until the appropriate limiting DME distance is attained, where distance is specified, or
 3. where a limiting radial is also specified, either until the limiting DME distance is attained or until the limiting radial is encountered, whichever occurs first; then
- c. the aircraft is turned right to intercept the inbound holding track; then
- d. on second arrival over the holding fix, the aircraft is turned right to follow the holding pattern.

1.3.4

Sector 3 Procedures (Direct Entry) — Having reached the fix, the aircraft is turned right to follow the holding pattern.

1.3.5

DME Arc Entry — Having reached the fix the aircraft shall enter the holding pattern in accordance with either the Sector 1 – or Sector 3 – entry procedure.

1.3.6 Special Entry Procedure For VOR/DME Holding:

NOTE:

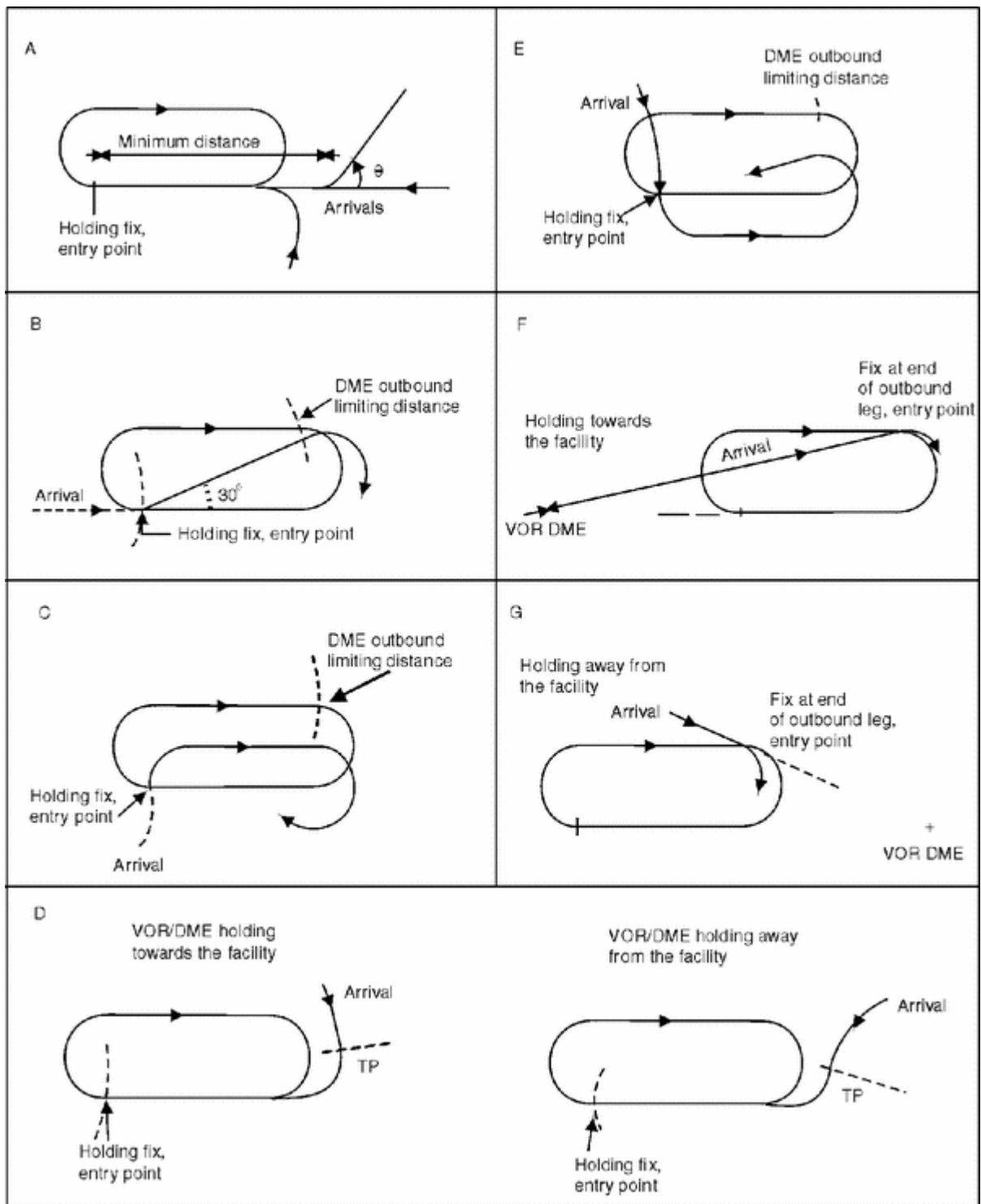
Where a special entry procedure is used, the entry radial is clearly depicted.

1.3.6.5 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.** The arrival path (or last segment thereof) is aligned with the inbound track and follows the same heading. The entry consists of following the holding pattern (see Figure IV-1-4 A).

Figure IV-1-4. VOR/DME Holding Entry Procedures



- b. **Arrival on the VOR radial for the inbound leg, on a heading reciprocal to the inbound track.** On arrival over the holding fix, the aircraft turns onto the holding side on a track making an angle of 30° with the reciprocal of the inbound track, until reaching the DME distance, at which point it turns to intercept the inbound track. In the case of a VOR/DME holding entry away from the facility with a limiting radial, if the aircraft encounters the radial ahead of the DME distance, it must turn and follow it until reaching the DME outbound limiting distance, at which point it turns to join the inbound track (see Figure IV-1-4 B).

- c. **Arrival on the DME arc defining the holding fix, from the non-holding side.** On arrival over the holding fix, the aircraft turns and follows a track parallel to and on the same heading as the outbound track, until reaching the DME outbound limiting distance, at which point it turns to intercept the inbound track (see Figure IV-1-4 C).
- c. **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 IV-1-4 D).
However, space problems may preclude this solution; criteria are therefore provided for an arrival on the DME arc defining the holding fix, coming from the holding side:
- d. 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, at which point it turns to intercept the inbound track (see Figure IV-1-4 E).
- e. Where 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 Figures IV-1-4 F and G).

1.3.7

Time / Distance Outbound — The still air time for flying the outbound entry heading should not exceed one minute if below or at 4250m (14,000 ft) or one and one half minutes if above 4250m (14,000 ft). Where DME is available, the length of the outbound leg may be specified in terms of distance instead of time.

1.3.8

RNAV holding entries — Except where it is published that specific entries are required, entries into a one way-point RNAV holding are the same as for conventional holding.

NOTE:

Future RNAV systems able to enter into a one way-point RNAV holding without overflying the holding point may use specific holding patterns based on this assumption. They may also use conventional or RNAV holding described above.

1.3.9

Sectors for entry to an RNAV two way-point 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 IV-1-2 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 FMS systems.

1.4 HOLDING

1.4.3

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

1.4.4

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.

1.4.5

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.

1.4.6

Pilots shall ensure that speeds used to fly the RNAV holding procedures comply with Table IV-1-1.

2 OBSTACLE CLEARANCE

2.1 HOLDING AREA

The holding area includes the basic holding area and the entry area:

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

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

2.2 BUFFER AREA

The buffer area is the area extending 9.3 km (5.0 NM) beyond the boundary of the holding area within which the height and nature of obstacles are taken into consideration when determining the minimum holding level usable in the holding pattern associated with the holding area.

2.3 MINIMUM HOLDING LEVEL

2.3.1

The minimum permissible holding level provides a clearance of at least:

- 300m (984 ft) above obstacles in the holding area;
- a value provided in Table IV-2-1 above obstacles in the buffer area.

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

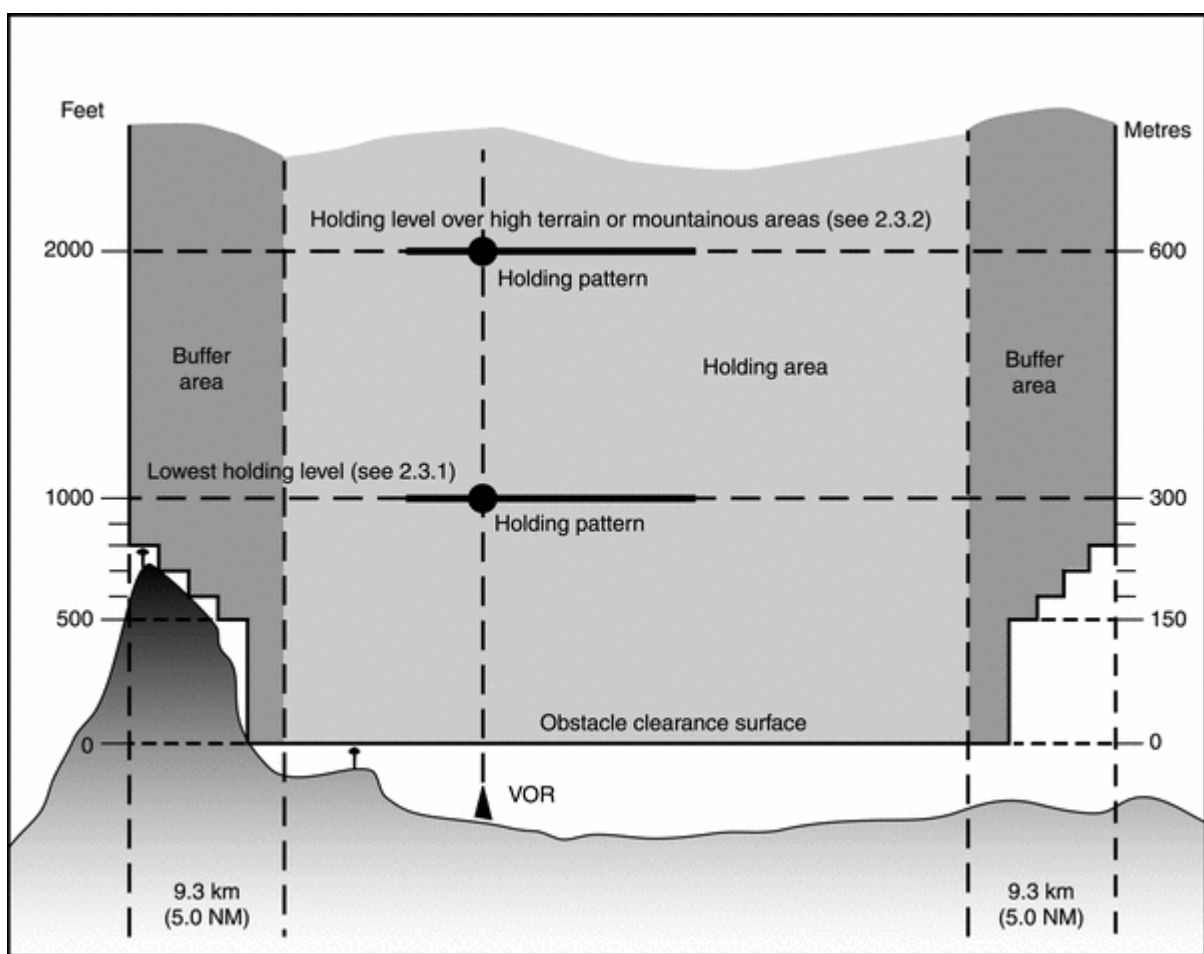
2.3.2

Furthermore, over high terrain or in mountainous areas obstacle clearance up to a total of 600m (1,969 ft) is provided to accommodate the possible effects of turbulence, down drafts and other meteorological phenomena on the performance of altimeters.

Table IV-2-1. Obstacle Clearance Increment

Distance beyond the boundary of the holding area	Minimum obstacle clearance over low flat terrain	
	Metres	Feet
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

Figure IV-2-1. Minimum Holding Level as Determined by the Obstacle Clearance Surface Related to the Holding Area and the Buffer Area



HOLDING SPEEDS AND DEVIATIONS

Holdings should not be misinterpreted as **racetrack** (letdown) patterns which are calculated on criteria for the initial approach segments of an Instrument Approach Procedure. The speeds for initial approach segments are as shown in Table III-1-1 and III-1-2.

Individual Air Traffic Control (ATC) State "Rules and Procedures" pages provide information indicating which of the following holding speed tables, if applicable, is applied by the individual State.

ALL SPEEDS ARE IAS

TABLE IV-1-1. Holding Speeds ICAO Doc 8168, Volume I, Fourth Edition — Flight Procedures

Levels ⁽¹⁾	Normal conditions	Turbulence conditions
up to 4250m inclusive 14,000 ft	425 km/h ⁽²⁾ (230 kt) 315 km/h ⁽⁴⁾ (170 kt)	520 km/h ⁽³⁾ (280 kt) 315 km/h ⁽⁴⁾ (170 kt)
above 4250m to 6100m inclusive 14,000 ft to 20,000 ft	445 km/h ⁽⁵⁾ (240 kt)	520 km/h (280 kt) or 0.8 Mach, whichever is less ⁽³⁾
above 6100m to 10,350m inclusive 20,000 ft to 34,000 ft	490 km/h ⁽⁵⁾ (265 kt)	
above 10,350m 34,000 ft	0.83 Mach	0.83 Mach

Levels (1)	Normal conditions	Turbulence conditions
1.	The levels tabulated represent altitudes or corresponding flight levels depending upon the altimeter setting in use.	
2.	When the holding procedure is followed by the initial segment of an instrument approach procedure promulgated at a speed higher than 425 km/h (230 kt), the holding should also be promulgated at this higher speed wherever possible.	
3.	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 flying at these high holding speeds.	
4.	For holdings limited to CAT A and B aircraft only.	
5.	Wherever possible, 520 km/h (280 kt) should be used for holding procedures associated with airway route structures.	

Attention is drawn to the fact that many holding patterns presently published have been calculated in accordance with the criteria specified in ICAO Doc 8168 Volume II, Second Edition. Many holdings are calculated for lower speeds or other altitudes as shown in the following tables.

TABLE IV-1-2. PANS-OPS Second Edition Holding Speeds Applicable to Many of the Presently Published Holdings

Levels ⁽¹⁾	Propeller ⁽²⁾ aircraft	Jet aircraft	
		Normal conditions	Turbulence conditions
up to 1850m inclusive 6,000 ft	315 km/h (170 kt)	390 km/h (210 kt)	520 km/h (280 kt) or 0.8 Mach whichever is less ⁽³⁾
above 1850m to 4250m inclusive 6,000 ft to 14,000 ft	315 km/h (170 kt)	405 km/h (220 kt)	
above 4250m 14,000 ft	325 km/h (175 kt)	445 km/h (240 kt)	
1	The levels tabulated represent altitudes or corresponding flight levels depending upon the altimeter setting in use.		
2.	Certain types of propeller aircraft may need to hold at higher speeds.		
3.	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 flying at these high holding speeds.		
NOTE: Holdings calculated in accordance with the Second Edition criteria should not be flown at higher holding speeds as the lateral limits of the holding area are larger when the holding speed is higher. The obstacle clearance or separation may not be guaranteed when these holdings are flown at the new higher holding speeds.			

TABLE IV-1-3. Holding Speeds Per U.S. FAA Regulations

Levels	All Aircraft
at 6,000 ft or below	200 kt
above 6,000 ft to and including 14,000 ft	230 kt
above 14,000 ft	265 kt
<ol style="list-style-type: none"> 1. Holding patterns from 6001 ft to 14,000 ft may be restricted to a maximum airspeed of 210 kt. This nonstandard pattern will be depicted by an icon. 2. Holding patterns at all altitudes may be restricted to a maximum airspeed of 175 kt. This nonstandard pattern will be depicted by an icon. 3. Holding patterns at USAF airfields only – 310 kt maximum, unless otherwise depicted. 4. Holding patterns at U.S. Navy fields only – 230 kt maximum, unless otherwise depicted. 	

3 AEROPLANE OPERATING PROCEDURES

3.2 OPERATIONAL LIMITATIONS

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 (i.e., snow, slush, ice or water, or by 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 thunderstorms are expected to affect the approach or 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.

3.4 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 I, Part III, Chapter 2 and in Volume II, Part III, 4.7.1, 5.6 and 6.3.

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, or by mud, rubber, oil or other substances;
- b. in conditions when the ceiling is lower than 150m (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.

NOTE:

Design criteria for descent gradients are contained in PANS-OPS, Volume I, Part III, Chapter 2 and in Volume II, Part III, 4.7.1, 5.6 and 6.3.

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 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 shall issue clearances such that the prescribed obstacle clearance will exist at all times, taking the cold temperature correction into account.

3.2 PRESSURE CORRECTION

3.2.1

Flight levels. When flying at levels with the altimeter set to 1013.2 hPa, the minimum safe altitude must be corrected for deviations in pressure when the pressure is lower than the standard atmosphere (1013 hPa). An appropriate correction is 10m (30 ft) per hPa below 1013 hPa. Alternatively, the correction can be obtained from standard correction graphs or tables supplied by the operator.

3.2.2

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

3.3 TEMPERATURE CORRECTION

3.3.1

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°.

3.3.2

Tabulated corrections. For colder temperatures, a more accurate correction should be obtained from Tables VI-3-1a and VI-3-1b. These tables are calculated for a sea level aerodrome. They are therefore conservative when applied at higher aerodromes.

NOTE 1:

The corrections have been rounded up to the next 5m 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.

Table VI-3-1a. 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 VI-3-1b. 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

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 already having 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. However, various factors, such as surface movement guidance and control, environmental considerations, and land side/air side infrastructure, may negate the advantage to be gained from simultaneous operations. There can be a variety of modes of operation associated with the use of parallel or near-parallel instrument runways.

1.1.1.1 Simultaneous Parallel Instrument Approaches

Two basic modes of operation are possible:

- a. **Mode 1, independent parallel approaches:** approaches which are made to parallel runways where radar separation minima between aircraft using adjacent ILS and/or MLS are not prescribed; and
- b. **Mode 2, dependent parallel approaches:** approaches which are made to parallel runways where radar separation minima between aircraft using adjacent ILS and/or MLS are prescribed.

1.1.1.2 Simultaneous Instrument Departures

Mode 3, independent parallel departures: simultaneous departures for aircraft departing in the same direction from parallel runways.

NOTE:

When the minimum distance between two parallel runway centerlines is lower 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.

1.1.1.3 Segregated Parallel Approaches / Departures

Mode 4, segregated parallel operations: one runway is used for approaches, one runway is used for departures.

1.1.1.4 Semi-mixed and Mixed Operations

In the case of parallel approaches and departures there may be semi-mixed operations; i.e., one runway is used exclusively for departures, while the other runway accepts a mixture of approaches and departures; or, one runway is used exclusively for approaches while the other accepts a mixture of approaches and departures. There may also be mixed operations, i.e. simultaneous parallel approaches with departures interspersed on both runways. Semi-mixed or mixed operations may be related to the four basic modes listed in 1.1.1.1 through 1.1.1.3 above as follows:

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

1.1.2 Definitions (see Figure VII-1-1)

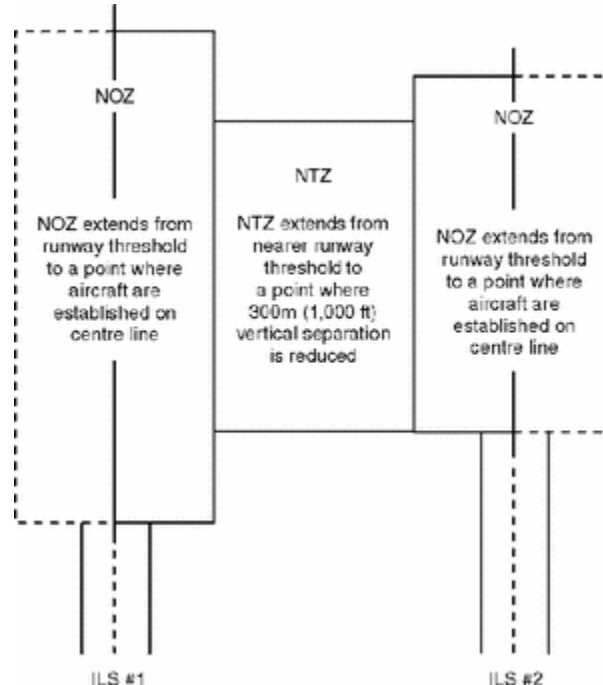
1.1.2.1

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

1.1.2.2

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 centerlines, where a penetration by an aircraft requires a controller intervention to maneuver any threatened aircraft on the adjacent approach.

Figure VII-1-1. Example of Normal Operating Zones (NOZs) and No-Transgression Zone (NTZ)



1.2 EQUIPMENT REQUIREMENTS

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

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

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

- All approaches regardless of weather conditions shall be radar-monitored. Control instructions and information necessary to ensure separation between aircraft and to ensure 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.
- When vectoring to intercept the ILS localizer course or MLS final approach track, the final vector shall be such as to enable the aircraft to intercept the ILS localizer course or MLS final approach track at an angle not greater than 30 degrees and to 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.
- 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 and/or MLS final approach track well before ILS glide path or specified MLS elevation angle interception. The high side altitude will be 300m (1,000 ft) above the low side.

- d. When assigning the final heading to intercept the ILS localizer course or MLS final approach track, the aircraft shall be advised of:
 - 1. its position relative to a fix on the ILS localizer course or MLS final approach track;
 - 2. the altitude to be maintained until established on the ILS localizer course or MLS final approach track to the ILS glide path or MLS elevation angle intercept point; and
 - 3. if required, clearance for the appropriate ILS or MLS approach.
- e. The main objective is that both aircraft be established on the ILS localizer course or MLS final approach track before the 300m (1,000 ft) vertical separation is reduced.
- 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 300m (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. Where parallel approach obstacle assessment surfaces (PAOAS) criteria are applied for obstacle assessment, the air traffic controller shall not issue the heading instruction to the aircraft below 120m (400 ft) above the runway threshold elevation, and the heading instruction shall not exceed 45° track difference with the ILS localizer course or MLS final approach track. Due to the nature of this breakout maneuver, the pilot is expected to arrest the descent and immediately initiate a climbing turn.

1.5 TERMINATION OF RADAR MONITORING

NOTE:

Provisions concerning the termination of radar monitoring are contained in Air Traffic Management (Doc. 4444) , Chapter 8.

1.6 TRACK DIVERGENCE

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

1.7 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 Air Traffic Management (Doc. 4444), Chapter 8.

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 SSR is used for ATS purposes.

1.1.2

Except as specified in 1.4, 1.5 and 1.6 in respect of emergency, radio communication failure, or unlawful interference, the pilot shall:

- a. operate the transponder and select Mode A codes as individually 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 carried aboard the aircraft, pilots shall indicate this by using the characters prescribed for insertion of this information in item 10 of the flight plan.

1.1.5

When requested by ATC to "CONFIRM SQUAWK [code]" the pilot shall verify the Mode A code setting on the transponder, reselect the assigned code if necessary, and 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 wherein the transmission of level information is required, give such information by stating their level to the nearest full 30m 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

1.4.1

The pilot of an aircraft encountering a state of emergency shall set the transponder to Mode A Code 7700 except when previously directed by ATC to operate the transponder on a specified code. In the latter case the pilot shall maintain the specified code unless otherwise advised by ATC.

1.4.2

Notwithstanding the procedures at 1.4.1, 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 observing a response on the radio communications failure code will ascertain the extent of the failure by instructing the pilot to SQUAWK IDENT or to change code. Where 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 issued. 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

Should an aircraft in flight be subjected to unlawful interference, the pilot-in-command shall endeavor to set the transponder to Mode A Code 7500 to give indication of the situation unless circumstances warrant the use of Code 7700.

1.6.2

A pilot, having selected Mode A Code 7500 and subsequently requested to confirm this code by ATC in accordance with 1.1.5 shall, according to circumstances, either confirm this or not reply at all.

NOTE:

The absence of a reply from the pilot will be taken by ATC as an indication that the use of Code 7500 is not due to 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 which occurs after departure, ATC units shall endeavour 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, the character corresponding to the remaining transponder capability;
- c. comply with any published procedures for seeking exemption from the requirements for carriage of a functioning SSR transponder; and
- d. if so required by the appropriate ATS authority, plan to proceed, as directly as possible, to the nearest suitable aerodrome where repair can be effected.

2 PHRASEOLOGY

2.2 USED BY PILOTS

When acknowledging mode/code setting instructions, pilots shall read back the mode and code to be set.

3 OPERATION OF ACAS EQUIPMENT

3.1 GENERAL

3.1.1

The information provided by airborne collision avoidance system (ACAS) is intended to assist pilots in the safe operation of aircraft.

3.1.2

Nothing in the procedures specified in 3.2 hereunder shall prevent pilots-in-command from exercising their best judgment and full authority in the choice of the best course of action to resolve a traffic conflict.

3.2 USE OF ACAS INDICATIONS

ACAS indications are intended to assist the pilots in the active search for, and visual acquisition of, the conflicting traffic, and the avoidance of potential collisions. The indications generated by ACAS shall be used by pilots in conformity with the following safety considerations:

- a. pilots shall not maneuver their aircraft in response to traffic advisories only;

NOTE:

1. Traffic advisories are intended to assist in visual acquisition of conflicting traffic and to alert the pilot to the possibility of a resolution advisory.
2. The above restrictions in the use of traffic advisories is due to the limited bearing accuracy and to the difficulty in interpreting altitude rate from displayed traffic information.

- b. in the event of a resolution advisory to alter the flight path, the search for the conflicting traffic shall include a visual scan of the airspace into which known ACAS aircraft might maneuver;
- c. the alteration of the flight path shall be limited to the minimum extent necessary to comply with the resolution advisories;
- d. pilots who deviate from an air traffic control instruction or clearance in response to a resolution advisory shall promptly return to the terms of the previous air traffic control instruction or clearance when the conflict is resolved and they shall notify the appropriate ATC unit as soon as practicable, of the deviation, including its direction and when the deviation has ended.

NOTE:

1. The ACAS II equipment is mandatory within the airspace of the European Civil Aviation Conference (ECAC) States for all civil fixed-wing turbine-engined aircraft having a MTOW exceeding 15,000kg (33,069 lbs) or approval for more than 30 passengers.
2. The phraseology to be used for the notification of maneuvers in response to a resolution advisory is contained in the PANS-ATM Doc. 4444, Chapter 12.

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, discusses the safety considerations in aerodrome surface operations.
2. Land and hold-short clearances/simultaneous intersecting runway operations are not an ICAO procedure.

1.3

Operators should ensure flight personnel awareness 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 performance vulnerability to error due to workload, vigilance decrement 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.

3 STABILIZED APPROACH PROCEDURE

3.1 GENERAL

Maintenance of the intended flight path as depicted in the published approach procedure, without excessive maneuvering as defined by the parameters in 3.2, shall be the primary safety consideration in the development of the stabilized approach procedure.

3.2 PARAMETERS FOR THE STABILIZED APPROACH

The parameters for the stabilized approach shall be defined by the operator's standard operating procedures (Part XIII, Chapter 1, not published herein). 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 shall be stated in the operator's standard operating procedures. These elements should include as a minimum:

- a. that all flights shall be stabilized according to the parameters in 3.2, by no lower than 300 m (1 000 ft) height above threshold in instrument meteorological conditions (IMC); and
- b. that all flights shall be stabilized according to the parameters in 3.2, by no lower than 150 m (500 ft) height above threshold.

3.4 GO-AROUND POLICY

An operator's policy should be included in the standard operating procedures that in the event of an approach not being stabilized in reference to the parameters in 3.2 or the elements in 3.3, or becoming destabilized at any point during an approach, a go-around is required. Operators should reinforce this policy through training.

1 ENROUTE CRITERIA

1.1 GENERAL

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

Two methods can be used:

- a simplified method, which is the standard method; and
- 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 is intended to correspond to 95 per cent probability of containment (2 SD) and the total width of the area to 99.7 per cent probability of containment (3 SD) plus an angular buffer and an additional fixed width.

1.2.2

Reductions to secondary area widths. Secondary areas for enroute operations may be reduced when justified by factors such as:

- a. when there is 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 navigational 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 secondary area is progressively reduced to zero, ending in an area without track guidance where the full 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 above.

1.3 CHARTING ACCURACIES

Charting accuracies must be taken into account when establishing minimum enroute 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 III, 1.15.

1.4 OBSTACLE CLEARANCE

The MOC value to be applied in the primary area for the enroute phase of an IFR flight is 300 m (1000 ft). In mountainous areas this shall be increased, depending on:

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

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

- simplified method: in the buffer area, the MOC is equal to half the value of the primary area MOC; and
- refined method: in the secondary area, the MOC is reduced linearly from the full clearance at the inner edge to zero at the outer edge.

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 following turn parameters are applied:

- a. altitude - an altitude at or above which the area is designed;
- b. temperature - ISA for the specified altitude plus 15°C;
- c. indicated airspeed - 585 km/h (315 kt);
- d. wind - omnidirectional for the altitude h
 $w = (12 h + 87) \text{ km/h}$, where h is in kilometres,
 $[w = (2 h + 47) \text{ kt}]$, where h is in thousands of feet
or
provided adequate statistical data are available, the maximum 95 per cent probability omnidirectional wind;
- e. average achieved bank angle: 15°;
- f. maximum pilot reaction time: 10 s; and
- g. bank establishment time: 5 s.

1.6 RNAV ROUTES

1.6.1

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

1.6.2

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

1.7 RNP ROUTES

1.7.1 Standard Conditions

The standard assumptions on which enroute RNP procedures are developed are:

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

1.7.2 Definition of Turns

There are two kinds of turns for RNP routes:

- the turn at a fly-by waypoint;
- 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).