

**Section 6**  
**HOLDING PROCEDURES**

# Chapter 1

## HOLDING CRITERIA

### 1.1 GENERAL

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

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

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

### 1.2 SHAPE AND TERMINOLOGY ASSOCIATED WITH HOLDING PATTERN

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

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

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

#### 1.3.1 Speeds

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

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

#### 1.3.2 Bank angle/rate of turn

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

#### 1.3.3 Allowance for known wind

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

### 1.3.4 Start of outbound timing

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

### 1.3.5 Outbound leg length based on a DME distance

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

### 1.3.6 Limiting radials

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

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

### 1.3.7 ATC notification

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

## 1.4 ENTRY

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

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

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

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

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

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

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

#### 1.4.4 Sector 1 entry

*Sector 1 procedure (parallel entry):*

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

#### 1.4.5 Sector 2 entry

*Sector 2 procedure (offset entry):*

- a) at the fix, the aircraft is turned onto a heading to make good a track making an angle of 30° from the reciprocal of the inbound track on the holding side; then
- b) the aircraft will fly outbound:
  - 1) for the appropriate period of time (see 1.4.9, “Time/distance outbound”), where timing is specified; or
  - 2) until the appropriate limiting DME distance is reached, where distance is specified. If a limiting radial is also specified, then the outbound distance is determined either by the limiting DME distance or the limiting radial, whichever comes first;
- c) the aircraft is turned right to intercept the inbound holding track; and
- d) on second arrival over the holding fix, the aircraft is turned right to follow the holding pattern.

#### 1.4.6 Sector 3 entry

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

#### 1.4.7 DME arc entry

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

#### 1.4.8 Special entry procedure for VOR/DME holding

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

##### 1.4.8.1 Definition of entry areas

- a) Arrival to a VOR/DME holding pattern may be:
  - 1) along the axis of the inbound track;

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

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

1.4.8.3 The radius of a DME arc used as guidance for arrival at a VOR/DME holding should be not less than 18.5 km (10 NM).

#### 1.4.8.4 *Minimum length for the last segment of the arrival track*

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

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

Where the entry point is the holding fix:

- a) *Arrival on the VOR radial for the inbound leg, on the same heading as the inbound track* (see Figure I-6-1-3 A). The arrival path (or its last segment) is aligned with the inbound track and follows the same heading. The entry consists of following the holding pattern.
- b) *Arrival on the VOR radial for the inbound leg, on a heading reciprocal to the inbound track* (see Figure I-6-1-3-B).
  - 1) On arrival over the holding fix, the aircraft turns onto the holding side on a track making an angle of 30° with the reciprocal of the inbound track, until reaching the DME outbound limiting distance.
  - 2) At this point it turns to intercept the inbound track.
  - 3) In the case of a VOR/DME holding entry away from the facility with a limiting radial, if the aircraft encounters the radial ahead of the DME distance, it must turn and follow it until reaching the DME outbound limiting distance, at which point it turns to join the inbound track.
- c) *Arrival on the DME arc defining the holding fix, from the non-holding side* (see Figure I-6-1-3 C).
  - 1) On arrival over the holding fix, the aircraft turns and follows a track parallel to and on the same heading as the outbound track.

- 2) When it reaches the DME outbound limiting distance, the aircraft turns to intercept the inbound track.
- d) *Arrival on the DME arc defining the holding fix, from the holding side.* An arrival track leading to this type of entry should not be specified if possible, particularly in the case of a VOR/DME holding procedure away from the facility. If an appropriate DME distance is chosen, this type of arrival can actually be replaced by one on a DME arc terminating in the extension of the inbound track (see a) above and Figure I-6-1-3 D).

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

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

#### 1.4.9 Time/distance outbound

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

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

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

### 1.5 HOLDING

#### 1.5.1 Still air condition

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

### 1.5.2 Corrections for wind effect

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

### 1.5.3 Departing the pattern

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

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

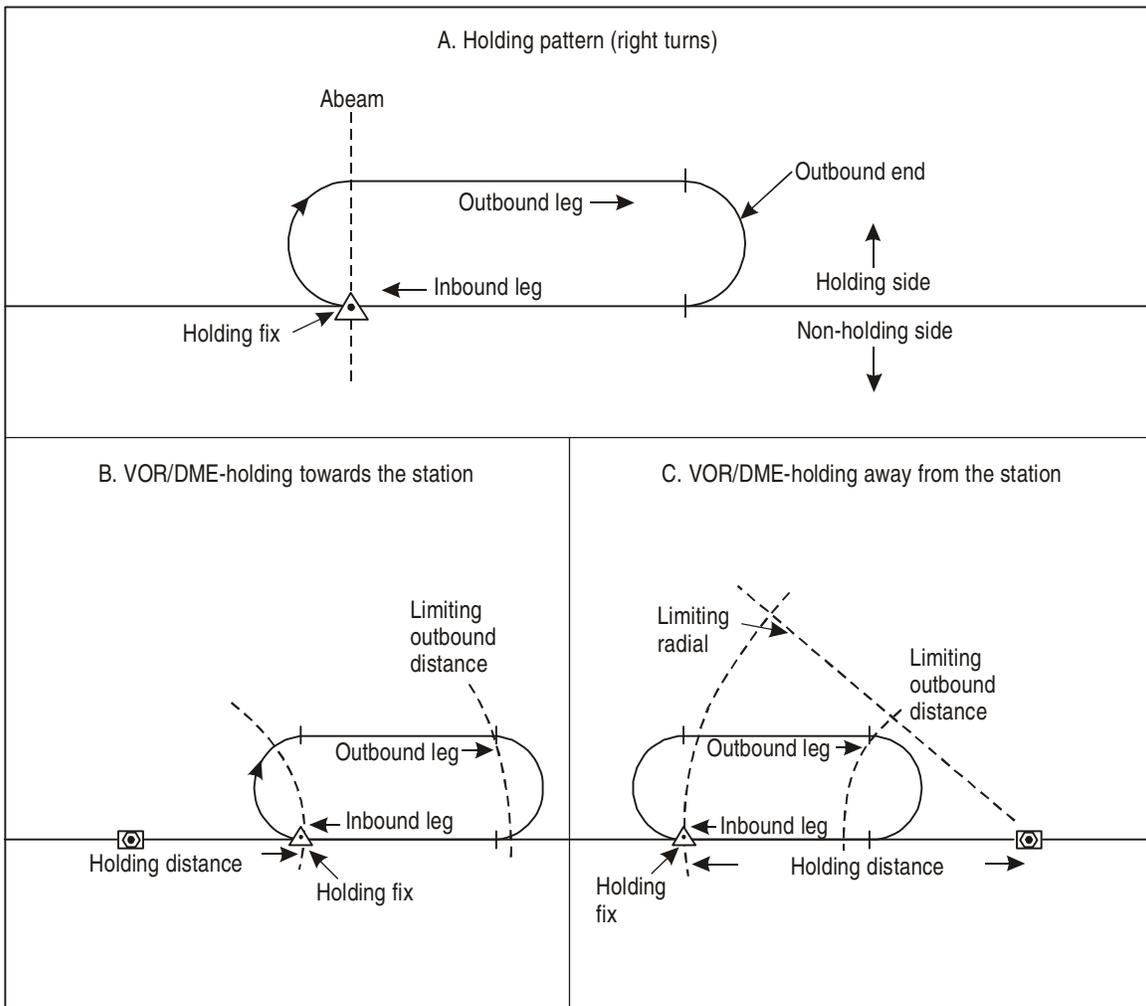
| <i>Levels<sup>1</sup></i>  | <i>Normal conditions</i>   | <i>Turbulence conditions</i>   |
|--|--|--|
| Up to 4 250 m (14 000 ft) inclusive  | 425 km/h (230 kt) <sup>2</sup><br>315 km/h (170 kt) <sup>4</sup> | 520 km/h (280 kt) <sup>3</sup><br>315 km/h (170 kt) <sup>4</sup>       |
| Above 4 250 m (14 000 ft) to<br>6 100 m (20 000 ft) inclusive  | 445 km/h (240 kt) <sup>5</sup>                                   | 520 km/h (280 kt)<br>or<br>0.8 Mach,<br>whichever is less <sup>3</sup> |
| Above 6 100 m (20 000 ft) to<br>10 350 m (34 000 ft) inclusive   | 490 km/h (265 kt) <sup>5</sup>                                   |  |
| Above 10 350 m (34 000 ft)   | 0.83 Mach  | 0.83 Mach  |
| <ol style="list-style-type: none"> <li>The levels shown represent <i>altitudes</i> or corresponding <i>flight levels</i> depending upon the altimeter setting in use.</li> <li>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.</li> <li>The speed of 520 km/h (280 kt) (0.8 Mach) reserved for turbulence conditions shall be used for holding only after prior clearance with ATC, unless the relevant publications indicate that the holding area can accommodate aircraft flight at these high holding speeds.</li> <li>For holdings limited to CAT A and B aircraft only.</li> <li>Wherever possible, 520 km/h (280 kt) should be used for holding procedures associated with airway route structures.</li> </ol> |  |  |

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

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

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

| $\theta$                 | 0° to 70°  | 71° to 90° | 91° to 105° | 106° to 120° |
|--------------------------|------------|------------|-------------|--------------|
| Minimum distance km (NM) | 7.4<br>(4) | 9.3<br>(5) | 13.0<br>(7) | 16.7<br>(9)  |



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

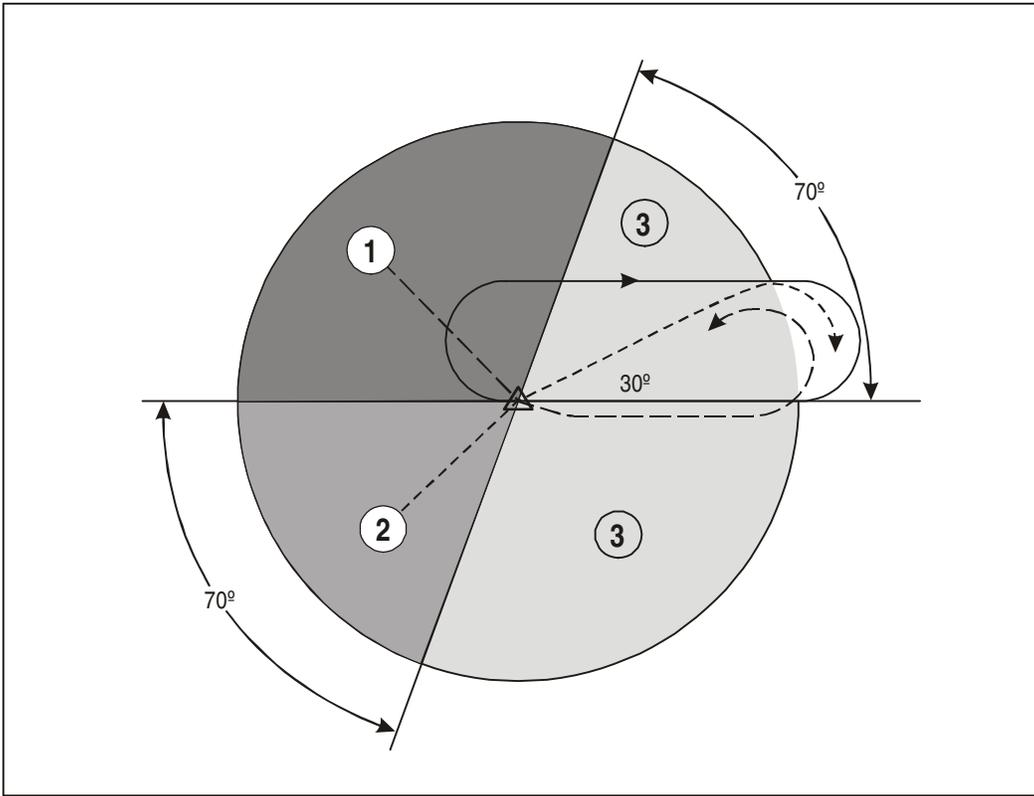


Figure I-6-1-2. Entry sectors

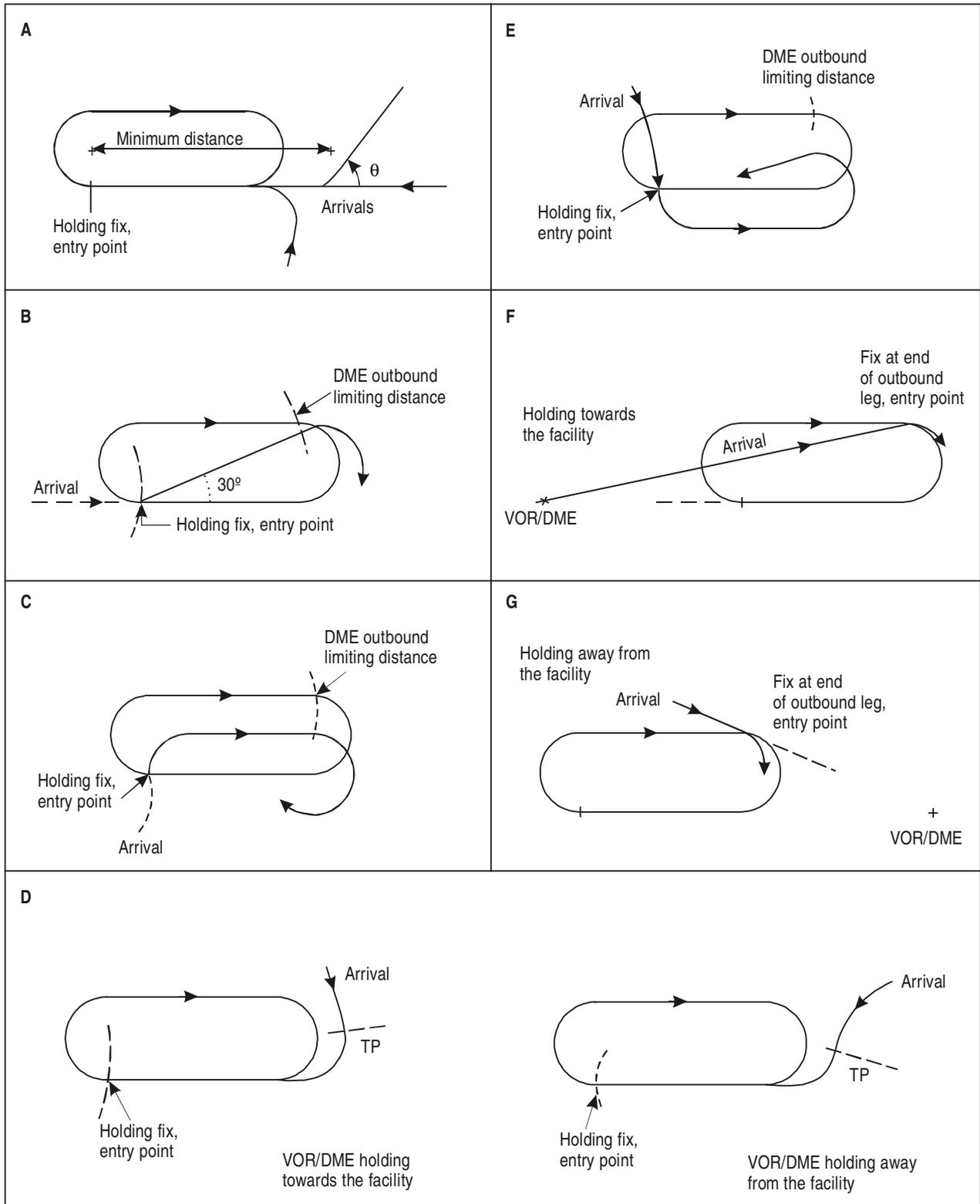


Figure I-6-1-3. VOR/DME holding entry procedures

## **Chapter 2**

# **OBSTACLE CLEARANCE**

### **2.1 HOLDING AREA**

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

### **2.2 BUFFER AREA**

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

### **2.3 MINIMUM HOLDING LEVEL**

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

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

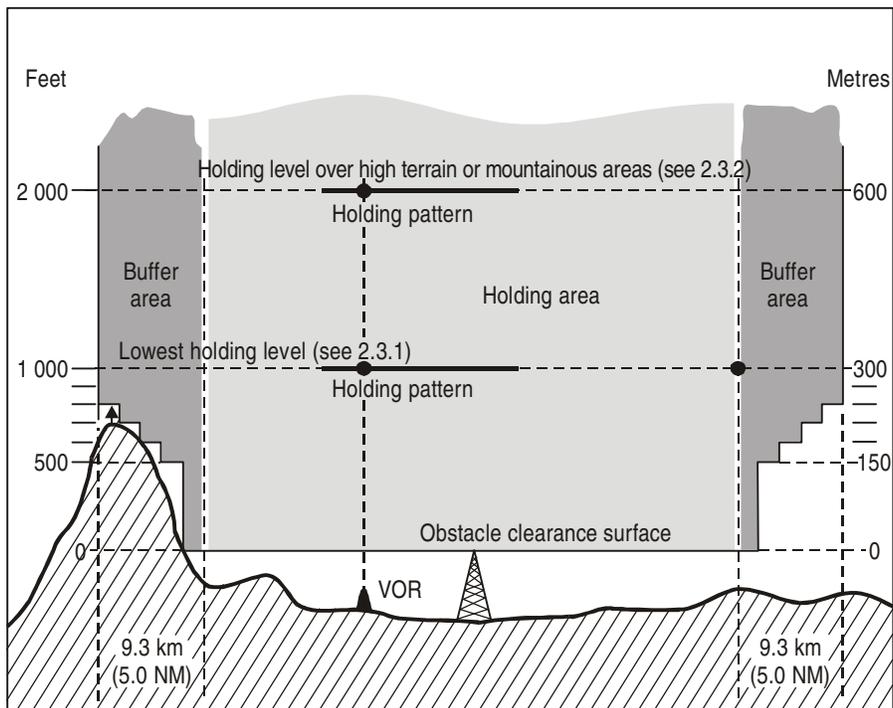
The minimum holding altitude to be published shall be rounded up to the nearest 50 m or 100 ft as appropriate.

#### **2.3.2 Obstacle clearance over high terrain or in mountainous areas**

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

**Table I-6-2-1. 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                |
| <i>Category H</i>                                |  |                    |
| 0 to 3.7 km (0 to 2.0 NM)                        | Linear<br>300 to 0                               | Linear<br>984 to 0 |



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

**Section 7**

**NOISE ABATEMENT PROCEDURES**

## Chapter 1

### GENERAL NOISE ABATEMENT INFORMATION

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

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

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

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

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

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## Chapter 2

### NOISE PREFERENTIAL RUNWAYS AND ROUTES

#### 2.1 NOISE PREFERENTIAL RUNWAYS

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

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

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

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

#### 2.2 NOISE PREFERENTIAL ROUTES

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

2.2.2 In establishing noise preferential routes:

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

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

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

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

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

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

- a) in the case of a departing aeroplane, it has attained the altitude or height which represents the upper limit for noise abatement procedures; or
  - b) it is necessary for the safety of the aeroplane (e.g. for avoidance of severe weather or to resolve a traffic conflict).
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# **Chapter 3**

## **AEROPLANE OPERATING PROCEDURES**

### **3.1 INTRODUCTION**

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

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

### **3.2 OPERATIONAL LIMITATIONS**

#### **3.2.1 General**

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

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

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

#### **3.2.2 Take-off**

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

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

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

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

### 3.2.3 Departure climb

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

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

### 3.3 DEVELOPMENT OF PROCEDURES

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

### 3.4 AEROPLANE OPERATING PROCEDURES — APPROACH

3.4.1 In noise abatement approach procedures which are developed:

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

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

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

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

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

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

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

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

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

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

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

### 3.5 AEROPLANE OPERATING PROCEDURES — LANDING

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

### 3.6 DISPLACED THRESHOLDS

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

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

### 3.7 CONFIGURATION AND SPEED CHANGES

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

### 3.8 UPPER LIMIT

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

### 3.9 COMMUNICATIONS

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

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## Appendix to Chapter 3

### NOISE ABATEMENT DEPARTURE CLIMB GUIDANCE

#### 1. General

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

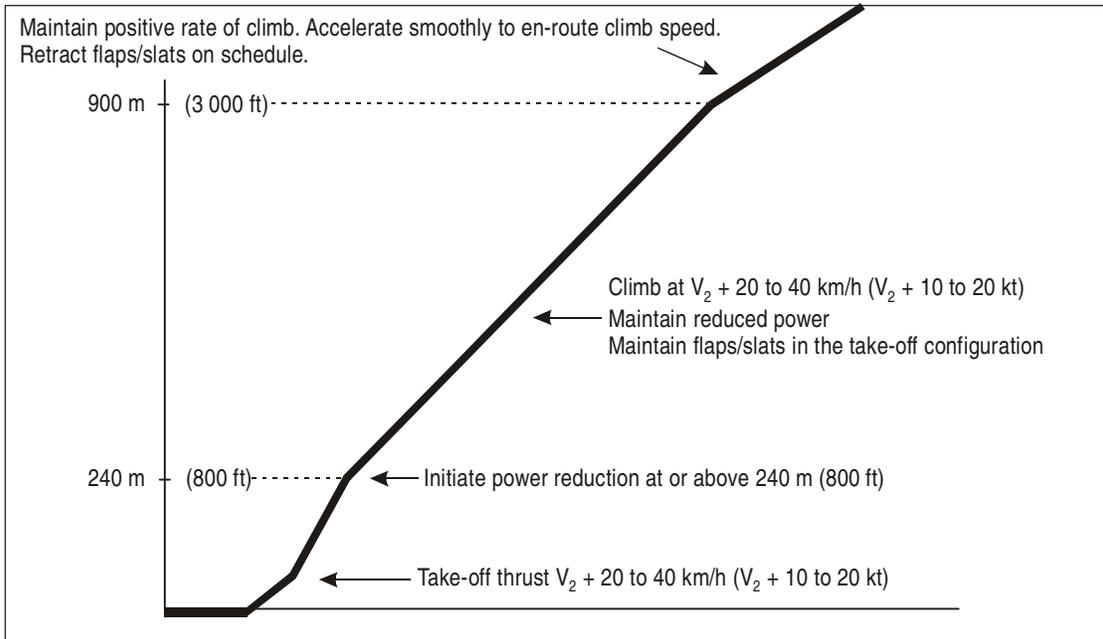
- a) reduce power with the initiation of the first flap/slat retraction; or
- b) reduce power after flap/slat retraction.

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

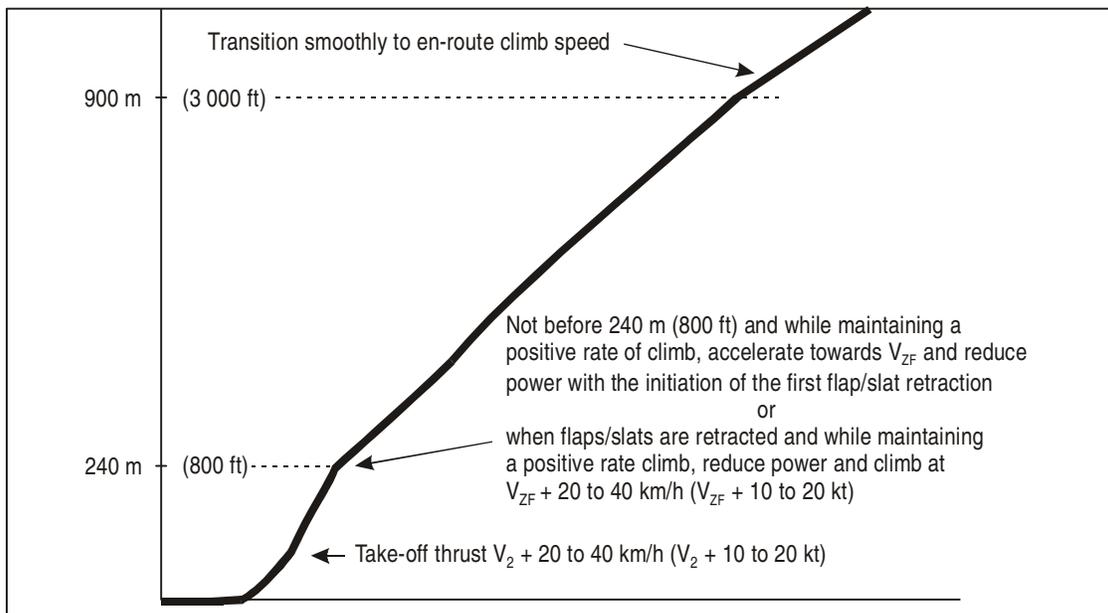
3.6 On reaching 900 m (3 000 ft) above aerodrome elevation, transition to normal en-route climb speed.

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

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



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



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

**Section 8**  
**PROCEDURES FOR USE**  
**BY HELICOPTERS**

# Chapter 1

## INTRODUCTION

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

1.2 For flight operations using Category A procedures, the primary requirement is to manoeuvre the helicopter within the Category A airspeed tolerances as prescribed in Table I-8-3-1 and Table I-4-1-1 or Table I-4-1-2. Failure to maintain the minimum speed could lead to an excursion of the protected airspace provided because of high drift angles or errors in turning point determinations. Similarly, high vertical speeds could hazard the helicopter when over a stepdown fix (see PANS-OPS, Volume II, Part I, Section 2, Chapter 2, 2.7.4), or could result in the helicopter on departure initiating a turn at a height of 120 m (394 ft), but prior to reaching the departure area.

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

## Chapter 2

# JOINT HELICOPTER/AEROPLANE PROCEDURES

### 2.1 GENERAL

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

### 2.2 DEPARTURE CRITERIA

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

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

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

### 2.3 INSTRUMENT APPROACH CRITERIA

#### 2.3.1 Categorization

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

#### 2.3.2 Operational constraints

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

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

aerodrome” NDB or VOR procedure). In these cases (if the FAF to MAPt distance exceeds certain values dependent on aerodrome elevation), a slower speed when combined with a tailwind may cause the helicopter to reach start of climb (SOC) after the point calculated for Category A aeroplanes. This will reduce the obstacle clearance in the missed approach phase. Conversely, a slower speed combined with a headwind could cause the helicopter to reach the MAPt and any subsequent turn altitude before the point calculated for Category A aeroplanes, and hence depart outside the protected area. Therefore, for helicopters, speed should be reduced below 130 km/h (70 kt) only after the visual references necessary for landing have been acquired and the decision has been made that an instrument missed approach procedure will not be performed.

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

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## Chapter 3

### PROCEDURES SPECIFIED FOR USE BY HELICOPTERS ONLY

#### 3.1 GENERAL

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

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

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

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

| <i>PANS-OPS,<br/>Volume II<br/>reference</i>  | <i>Criteria</i>                        | <i>CAT H</i>                                       | <i>CAT A</i>      |
|---|--|--|-------------------|
| <b>Part II Conventional procedures</b>  |  |  |                   |
| <i>Section 4 — Holding criteria</i>   |  |  |                   |
| <i>Chapter 1 — Holding criteria</i>   |  |  |                   |
| Table II-4-1-2  | <i>Holding</i>                         |  |                   |
|   | Maximum speed up to 1 830 m (6 000 ft) | 185 km/h (100 kt)                                  | 315 km/h (170 kt) |
|   | Maximum speed above 1 830 m (6 000 ft) | 315 km/h (170 kt)                                  | 315 km/h (170 kt) |
| 3.12.1  | Buffer area                            | 3.7 km (2 NM)<br>(only below 1 830 m<br>(6000 ft)) | 9km (5 NM)        |
| Table II-4-1-2  | <i>MOC (ft)</i>                        | Linear from 0 to full<br>MOC                       | Steps             |
| * Helicopter point-in-space procedures based on basic GNSS may be designed using maximum speeds of 120 KIAS for initial and intermediate segments and 90 KIAS on final and missed approach segments, or 90 KIAS for initial and intermediate segments and 70 KIAS on final and missed approach segments based on operational need. Refer to Part IV, Chapter 1. |  |  |                   |

**Section 9**

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

*(To be developed)*

**Procedures for  
Air Navigation Services**

**AIRCRAFT OPERATIONS**

**Part II**

**FLIGHT PROCEDURES — RNAV AND SATELLITE-BASED**

**Section 1**  
**GENERAL**

## **Chapter 1**

### **GENERAL INFORMATION FOR RNAV SYSTEMS**

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

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

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

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## Chapter 2

# TERMINAL ARRIVAL ALTITUDE (TAA)

### 2.1 GENERAL

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

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

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

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

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

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

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

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

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

#### 2.1.9 Stepdown arcs

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

#### 2.1.10 TAA icons

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

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

## **2.2 FLIGHT PROCEDURES**

### **2.2.1 Establishment**

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

### **2.2.2 Manoeuvring**

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

### **2.2.3 Transitioning between TAAs**

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

### **2.2.4 Entry to procedure**

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

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

### **2.2.5 Reversal procedures**

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

### 2.2.6 Holding

A racetrack holding procedure will normally be located at an IAF or the IF. When one or more of the initial segments are not provided, the holding pattern will normally be located to facilitate entry to the procedure (see Figure II-1-2-7).

## 2.3 NON-STANDARD TAA

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

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

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

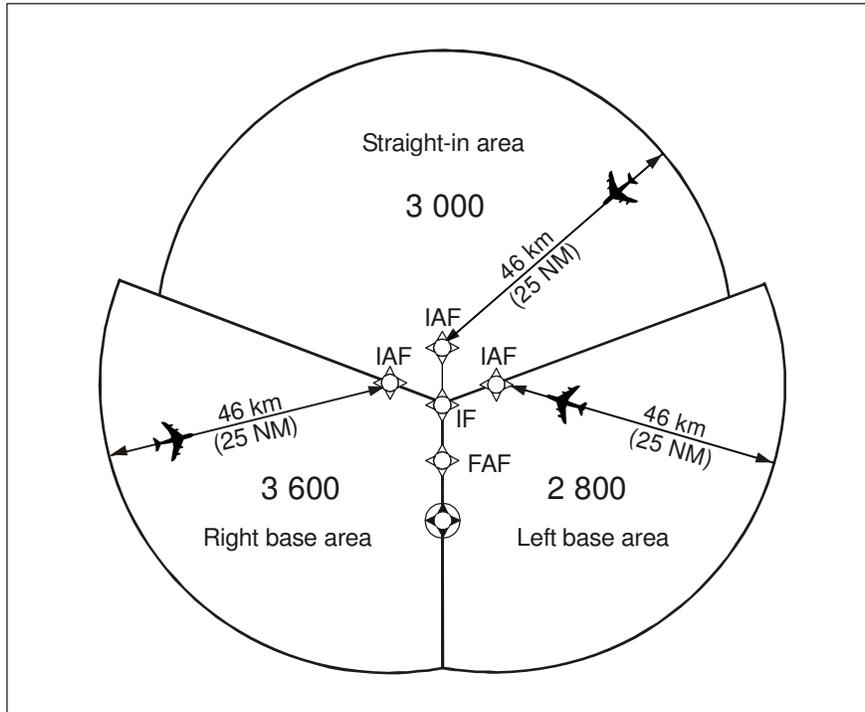


Figure II-1-2-1. Typical TAA arrangement

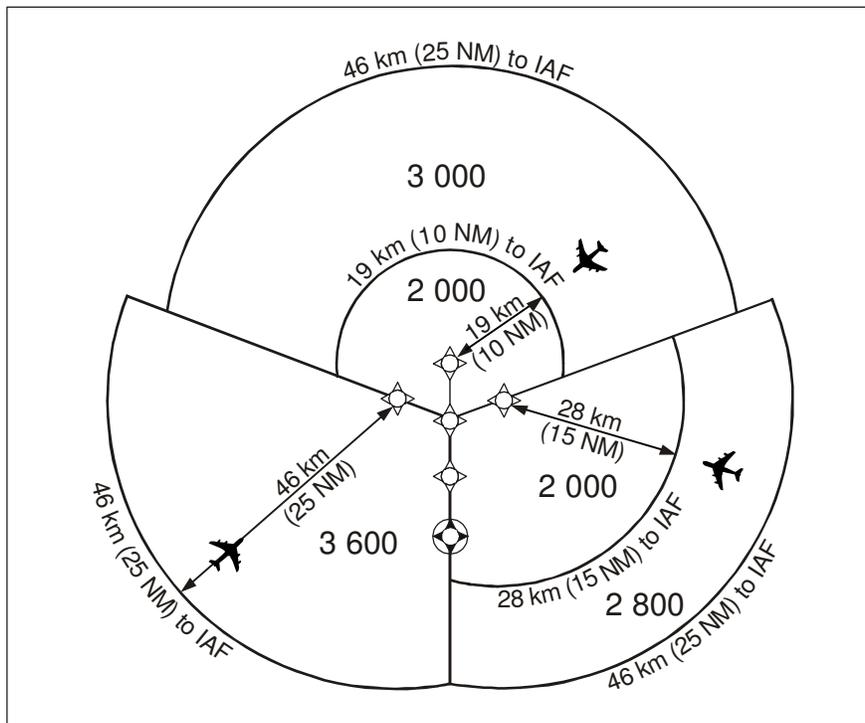


Figure II-1-2-2. TAA with stepdown arcs

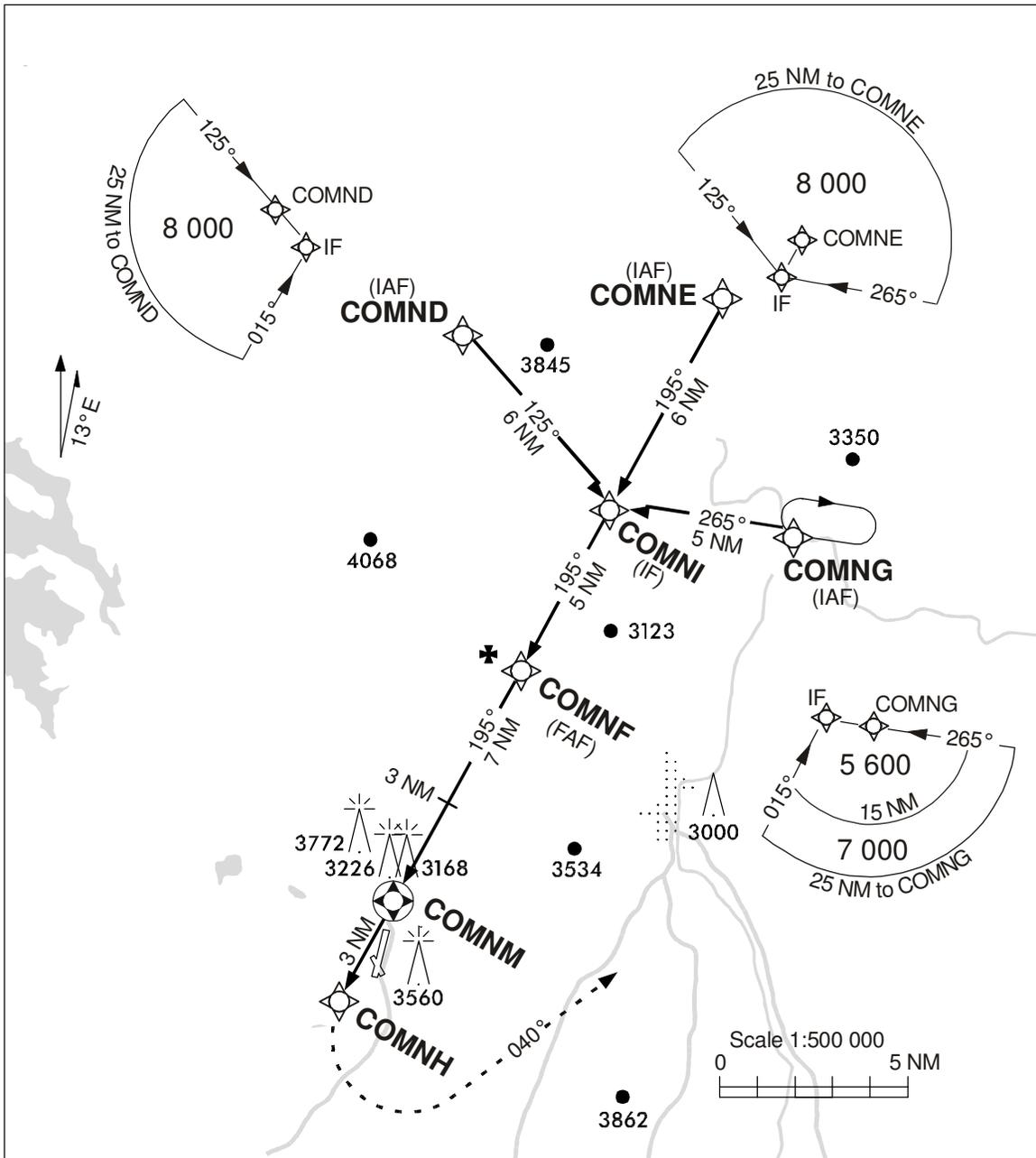


Figure II-1-2-3. TAA “Y” bar icon arrangement

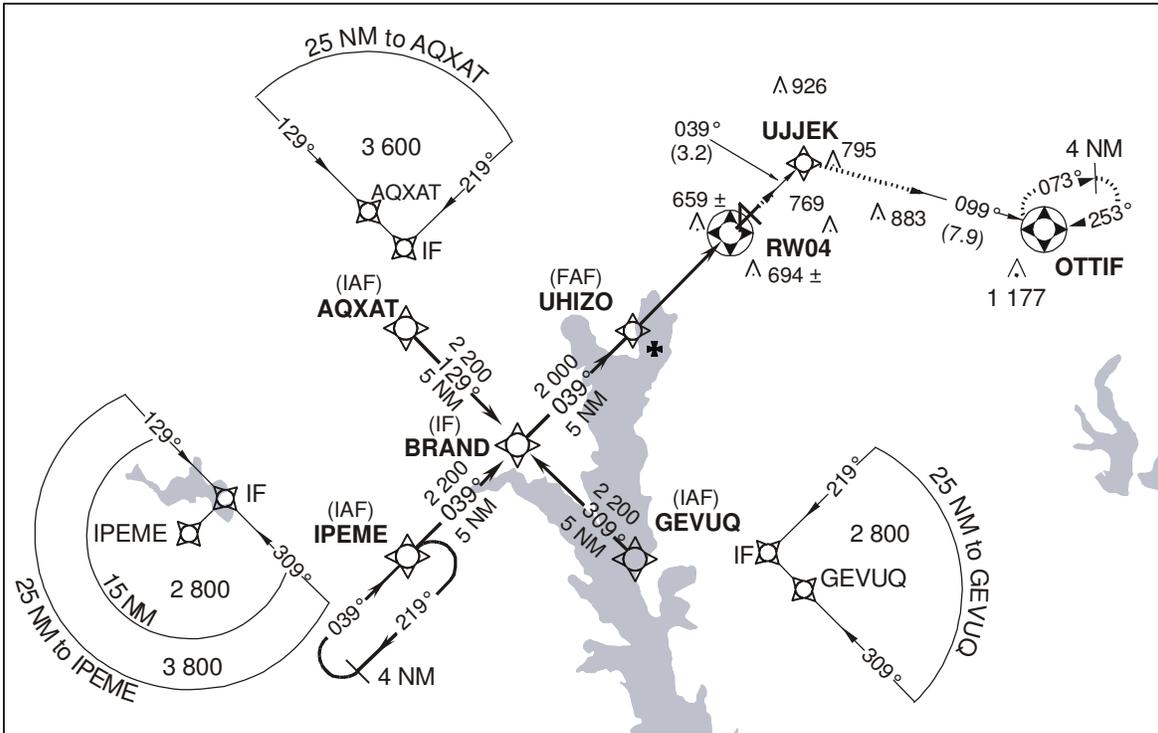


Figure II-1-2-4. "T" bar icon arrangement

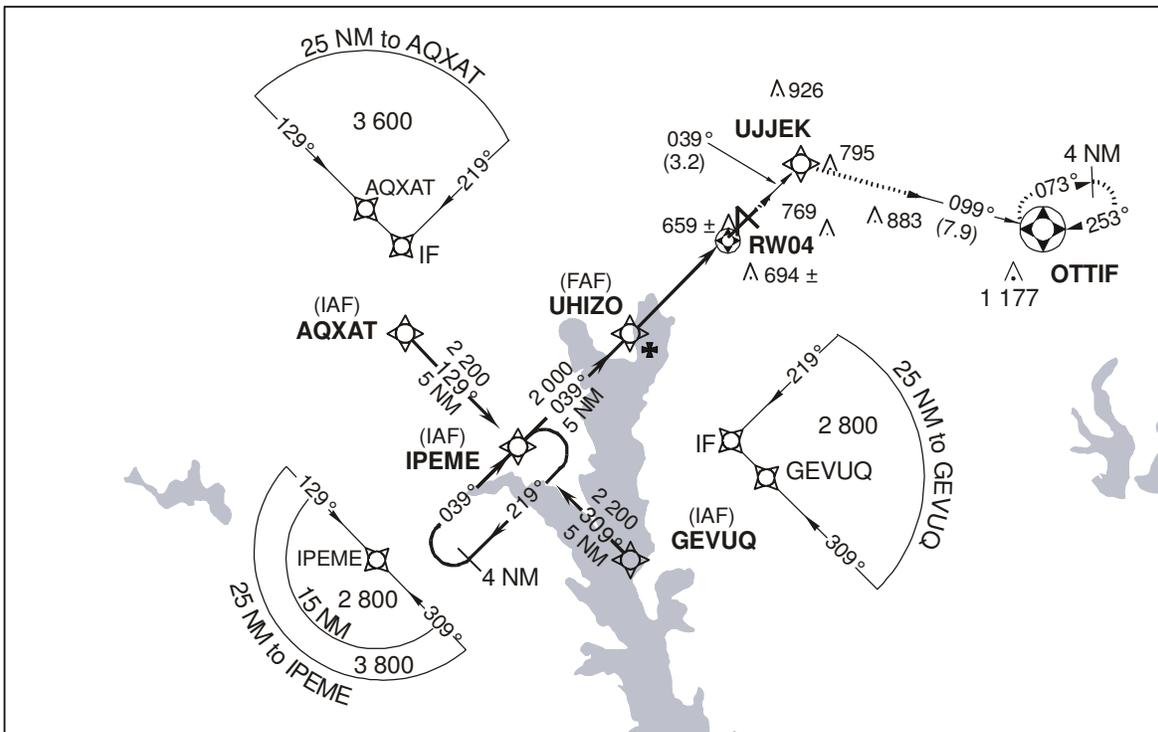


Figure II-1-2-5. "T" bar icon arrangement without centre initial approach fix

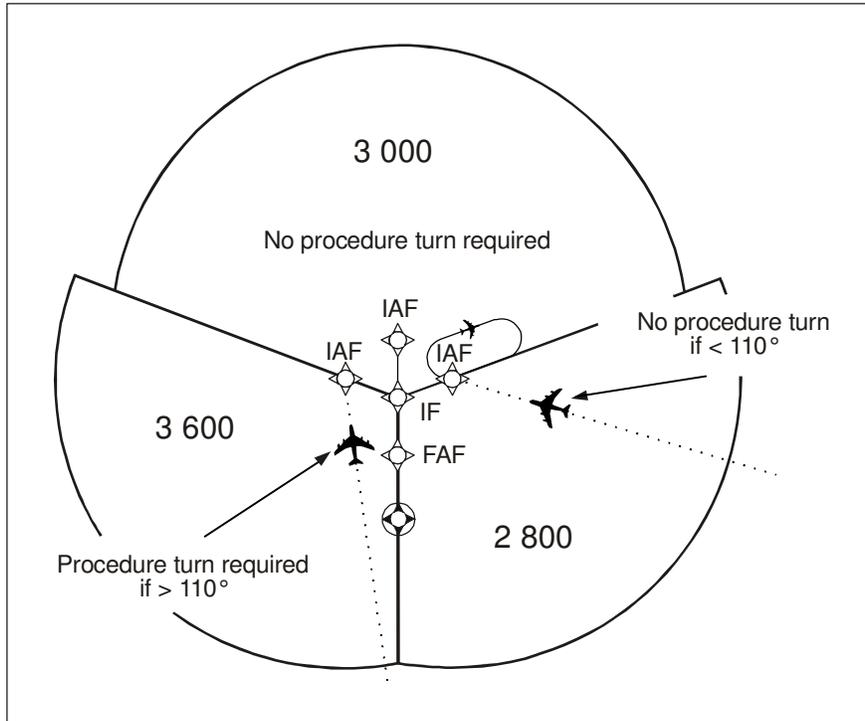


Figure II-1-2-6. Procedure entry

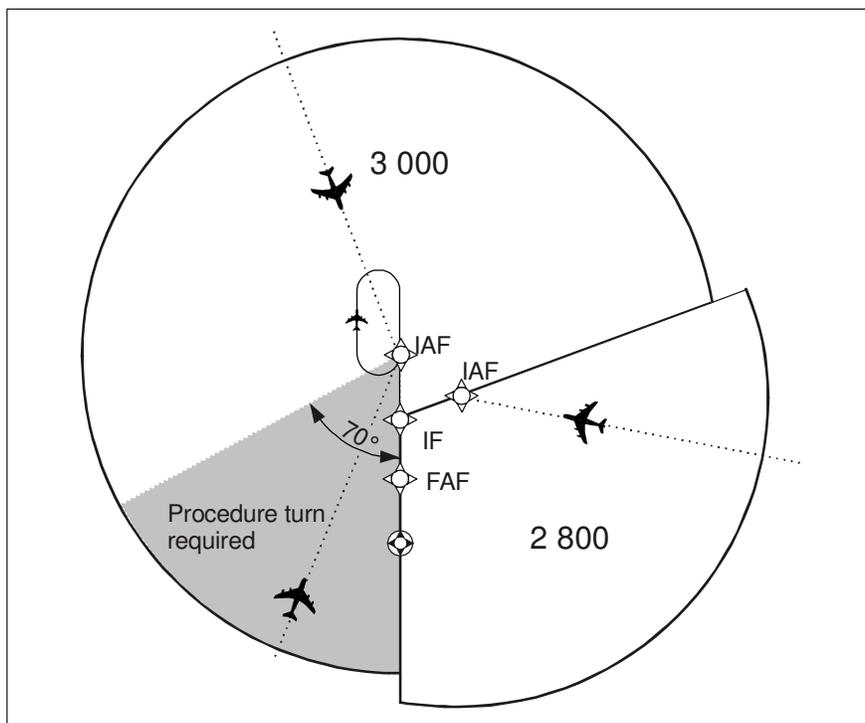


Figure II-1-2-7. TAA arrangement without right base

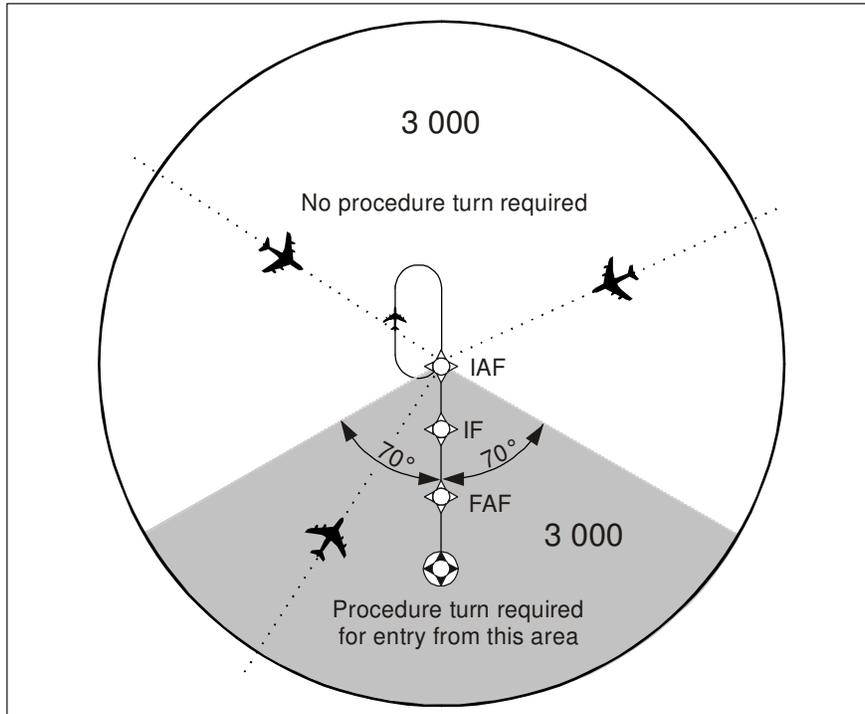


Figure II-1-2-8. TAA arrangement without left and right base

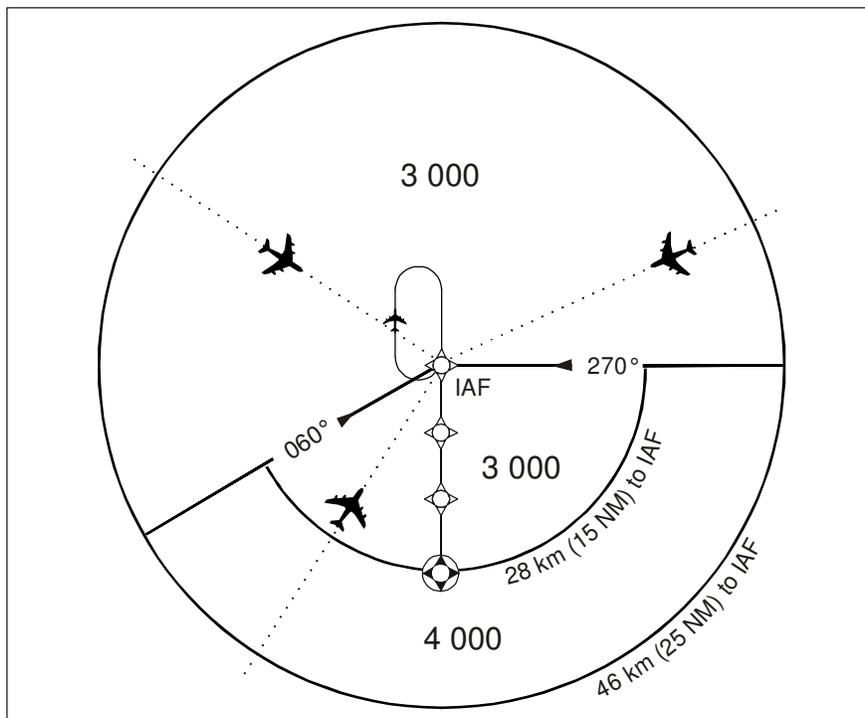


Figure II-1-2-9. Single TAA with sectorization and stepdown

## Chapter 3

### GENERAL INFORMATION FOR BASIC GNSS

#### 3.1 BASIC GNSS RECEIVER SPECIFICATIONS

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

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

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

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

## **Chapter 4**

# **GENERAL INFORMATION FOR SATELLITE-BASED AUGMENTATION SYSTEM (SBAS)**

*(To be developed)*

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## Chapter 5

# GENERAL INFORMATION FOR GROUND-BASED AUGMENTATION SYSTEM (GBAS)

### 5.1 GENERAL CRITERIA

#### 5.1.1 GBAS receiver

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

#### 5.1.2 GBAS avionics requirements

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

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

**Section 2**

**DEPARTURE PROCEDURES**

## Chapter 1

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

### 1.1 BACKGROUND

#### 1.1.1 Introduction

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

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

#### 1.1.2 GNSS standards

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

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

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

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

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

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

## 1.2 GENERAL

### 1.2.1 Operational approval

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

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

### 1.2.2 Flight plan

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

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

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

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

### 1.2.3 Navigation database

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

### 1.2.4 Performance integrity

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

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

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

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

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

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

### 1.2.5 Equipment operation

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

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

### 1.2.6 Operating modes and alert limits

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

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

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

### 1.2.7 Course deviation indicator (CDI) sensitivity

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

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

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

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

## 1.3 PRE-FLIGHT

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

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

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

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

## 1.4 DEPARTURE

### 1.4.1 Equipment capabilities

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

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

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

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

### 1.4.2 Equipment set-up

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

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

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

### 1.4.3 Straight departures

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

### 1.4.4 Turning departures

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

## **Chapter 2**

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

### **2.1 GENERAL CRITERIA**

#### **2.1.1 Introduction**

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

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

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

#### **2.1.2 SBAS receiver**

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

### **2.2 DEPARTURE**

#### **2.2.1 Departure procedure**

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

#### **2.2.2 Straight departure**

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

### **2.2.3 Terminal operation mode reversion**

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

### **2.2.4 Turning departure**

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

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## **Chapter 3**

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

### **3.1 DEPARTURE OPERATIONS**

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

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## Chapter 4

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

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

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

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

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

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

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

4.7 There are four kinds of turns:

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

**Section 3**

**ARRIVAL AND NON-PRECISION  
APPROACH PROCEDURES**

## Chapter 1

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

### 1.1 BACKGROUND

#### 1.1.1 Introduction

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

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

#### 1.1.2 GNSS standards

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

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

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

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

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

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

## **1.2 GENERAL**

### **1.2.1 Operational approval**

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

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

### **1.2.2 Flight plan**

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

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

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

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

### **1.2.3 Navigation database**

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

## 1.2.4 Performance integrity

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

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

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

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

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

## 1.2.5 Equipment operation

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

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

## 1.2.6 Operating modes and alert limits

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

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

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

### 1.2.7 Course deviation indicator (CDI) sensitivity

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

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

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

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

## 1.3 PRE-FLIGHT

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

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

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

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

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

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

## 1.4 GNSS APPROACH PROCEDURES

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

#### **1.4.21 Sequencing at the MAPt**

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

1.4.21.2 An FMC will provide for automatic sequencing.

#### **1.4.22 Radar vectors**

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

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

### **1.5 INITIAL APPROACH SEGMENT**

#### **1.5.1 Offset IAFs**

1.5.1.1 Offset IAFs in procedures based on the “Y” or “T” bar design concept for basic GNSS are aligned such that a course change of 70° to 90° is required at the IF. A capture region is associated with each IAF of the basic GNSS procedure from which the aircraft will enter the procedure. The capture region for tracks inbound to the offset IAFs

extends 180° about the IAFs, thus providing a Sector 3 entry in cases where the track change at the IF is 70°. The central IAF is aligned with the final approach track, the angle being identical to the track change at the IF for the corresponding offset IAF. In this way, there are no gaps between the capture regions of all IAFs regardless of the course change at the IF. Its capture region is 70° to 90° either side of the final track. For turns greater than 110° at the IAFs, Sector 1 or 2 entries should be used (see Figures II-3-1-1 and II-3-1-2).

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

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

## 1.6 INTERMEDIATE APPROACH SEGMENT

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

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

## 1.7 FINAL APPROACH SEGMENT

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

### 1.7.2 Course sensitivity

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

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

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

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

### 1.7.3 Stepdown fixes

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

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

### 1.7.4 Descent gradient/angle

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

## 1.8 MISSED APPROACH SEGMENT

### 1.8.1 CDI sensitivity

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

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

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

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

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

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

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

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

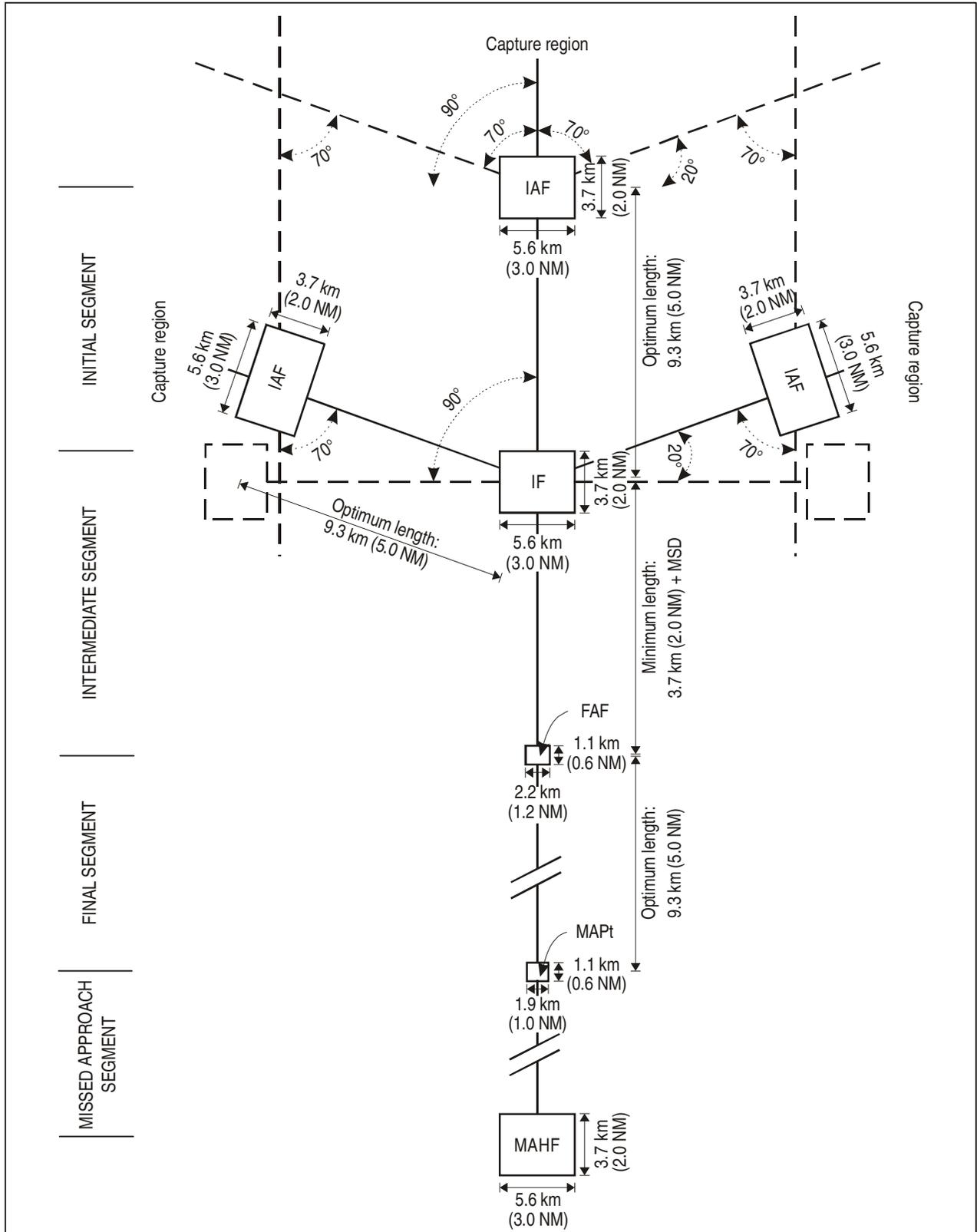
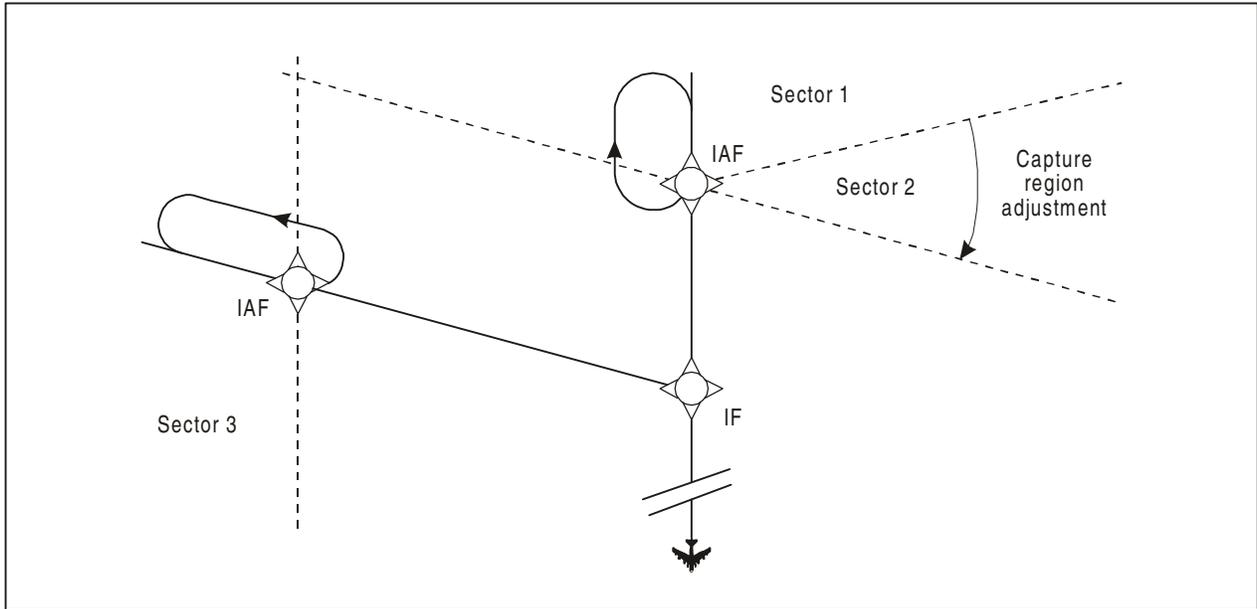


Figure II-3-1-1. Basic GNSS RNAV approach



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

## Chapter 2

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

## **Chapter 3**

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

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

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

#### **3.3 OPERATIONAL APPROVAL**

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

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

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

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

#### **3.6 NAVIGATION ACCURACY FACTORS**

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

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

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

### 3.7 ARRIVAL SEGMENT

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

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

### 3.8 INITIAL APPROACH SEGMENT

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

### 3.9 FINAL APPROACH SEGMENT

- 3.9.1 The final approach segment is generally aligned with the runway.
- 3.9.2 The minimum obstacle clearance in the primary area of the final approach segment is 75 m (246 ft).

#### 3.9.3 Waypoints in the final approach

- 3.9.3.1 The FAF is defined by a fly-by waypoint.
- 3.9.3.2 A flyover waypoint is also provided at the runway threshold.

### 3.10 MISSED APPROACH SEGMENT

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

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

## **Chapter 4**

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

*(To be developed)*

## **Chapter 5**

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

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

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## **Chapter 6**

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

*(To be developed)*

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**Section 4**

**APPROACH PROCEDURES WITH  
VERTICAL GUIDANCE**

# Chapter 1

## APV/BARO-VNAV APPROACH PROCEDURES

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

### 1.1 GENERAL

#### 1.1.1 Procedure classification

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

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

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

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

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

### 1.2 SYSTEM PERFORMANCE

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

## 1.2.2 Atmospheric effects

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

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

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

## 1.2.3 Along-track position uncertainty

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

## 1.2.4 Flight technical error (FTE)

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

## 1.2.5 Other system errors

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

## 1.2.6 Blunder errors

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

## 1.3 EQUIPMENT REQUIREMENTS

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

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

- a) the navigation system has a certificated performance equal to or less than 0.6 km (0.3 NM), with 95 per cent probability. This includes:
  - 1) GNSS navigation systems certified for approach operations;
  - 2) multi-sensor systems using inertial reference units in combination with certified DME/DME or GNSS; and
  - 3) RNP systems approved for RNP 0.3 operations or less;
- b) the APV/baro-VNAV equipment is serviceable;
- c) the aircraft and aircraft systems are appropriately certified for the intended APV/baro-VNAV approach operations;
- d) the aircraft is equipped with an integrated LNAV/VNAV system with an accurate source of barometric altitude; and
- e) the VNAV altitudes and all relevant procedural and navigational information are retrieved from a navigation database whose integrity is supported by appropriate quality assurance measures.

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

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

## 1.4 OPERATIONAL CONSTRAINTS

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

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

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

### 1.4.2 Temperatures below the promulgated minimum

Baro-VNAV procedures are not permitted when the aerodrome temperature is below the promulgated minimum aerodrome temperature for the procedure, unless the flight management system (FMS) 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 FMSs equipped with approved cold temperature compensation for the final approach, an LNAV procedure may still be used provided that:

- a) a conventional RNAV non-precision procedure and APV/LNAV OCA/H are promulgated for the approach; and
- b) the appropriate cold temperature altimeter correction is applied to all minimum promulgated altitudes/heights by the pilot.

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

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

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

#### 1.4.6 Altimeter setting

Baro-VNAV procedures shall only be flown with:

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

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

#### 1.4.7 Vertical guidance sensitivity

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

- a) +30 m (+100 ft); and
- b) -15 m (50 ft)

from the VPA.

##### 1.4.7.2 Vertical path deviation

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

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

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

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

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

## **Chapter 2**

### **APV I and II**

*(To be developed)*

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**Section 5**

**PRECISION APPROACH PROCEDURES**

# Chapter 1

## GBAS PRECISION APPROACH PROCEDURES

### 1.1 APPROACH CONDUCT

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

### 1.2 GBAS APPROACH DISPLAY CRITERIA

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

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

### 1.3 GBAS CHANNEL SELECTION

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

**Section 6**  
**RNAV HOLDING**

# Chapter 1

## GENERAL

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

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

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

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

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

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

### 1.6 PILOT RESPONSIBILITIES

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

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

## Chapter 2

### HOLDING PATTERNS

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

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

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

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

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

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

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

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

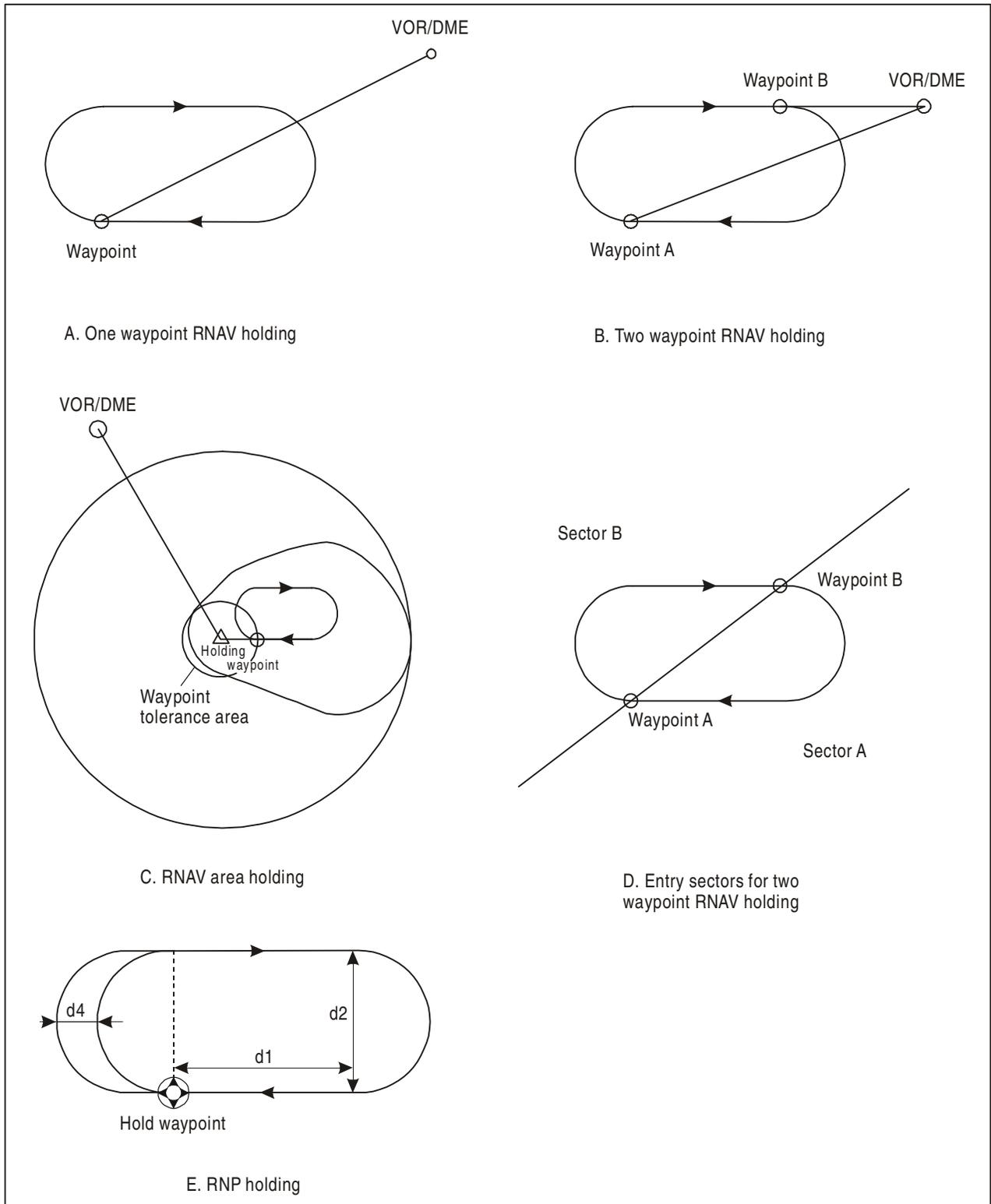


Figure II-6-2-1. RNAV/RNP holding procedures

## Chapter 3

### HOLDING ENTRY

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

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

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

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

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

## Chapter 4

### ALTERNATIVE RNAV HOLDING ENTRIES FOR REDUCED HOLDING ENTRY AREAS

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

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

#### 4.3 DEFINING ENTRY SECTORS

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

#### 4.4 ENTRY MANOEUVRES

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

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

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

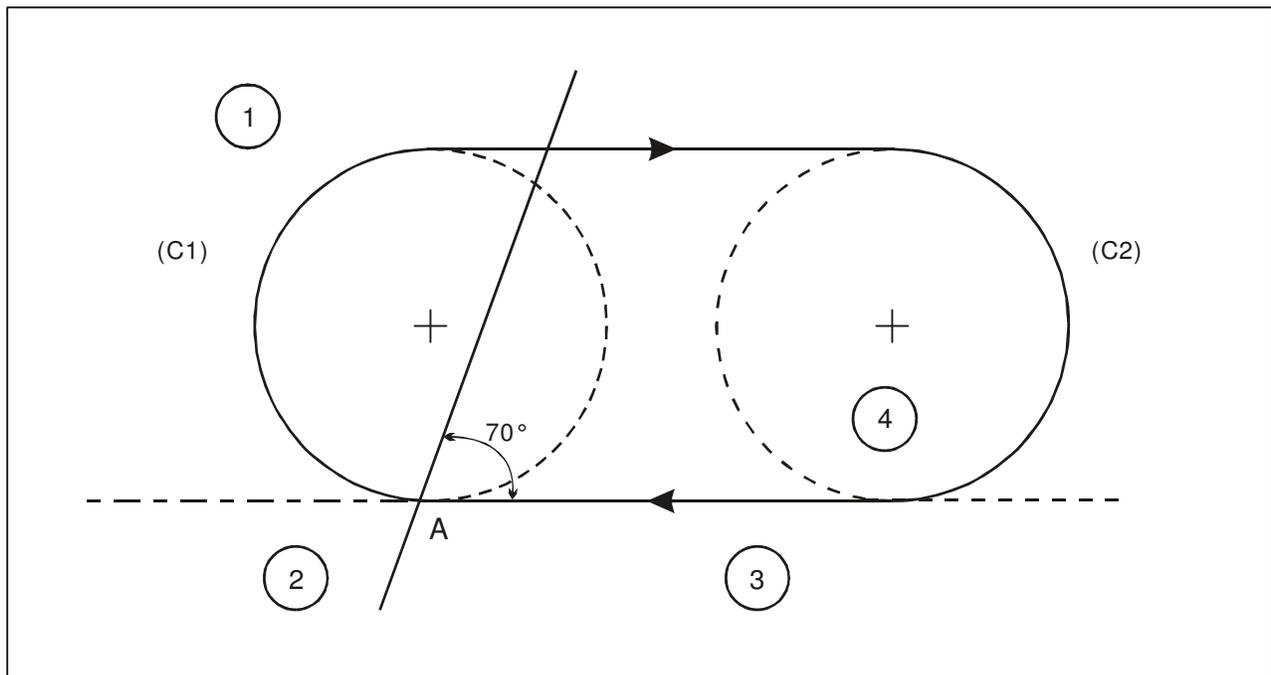
1. Overfly point A.
2. Intercept circle C2 tangentially.
3. Follow circle C2 until intercepting the inbound track.

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

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

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

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



**Figure II-6-4-1. Entry sectors**

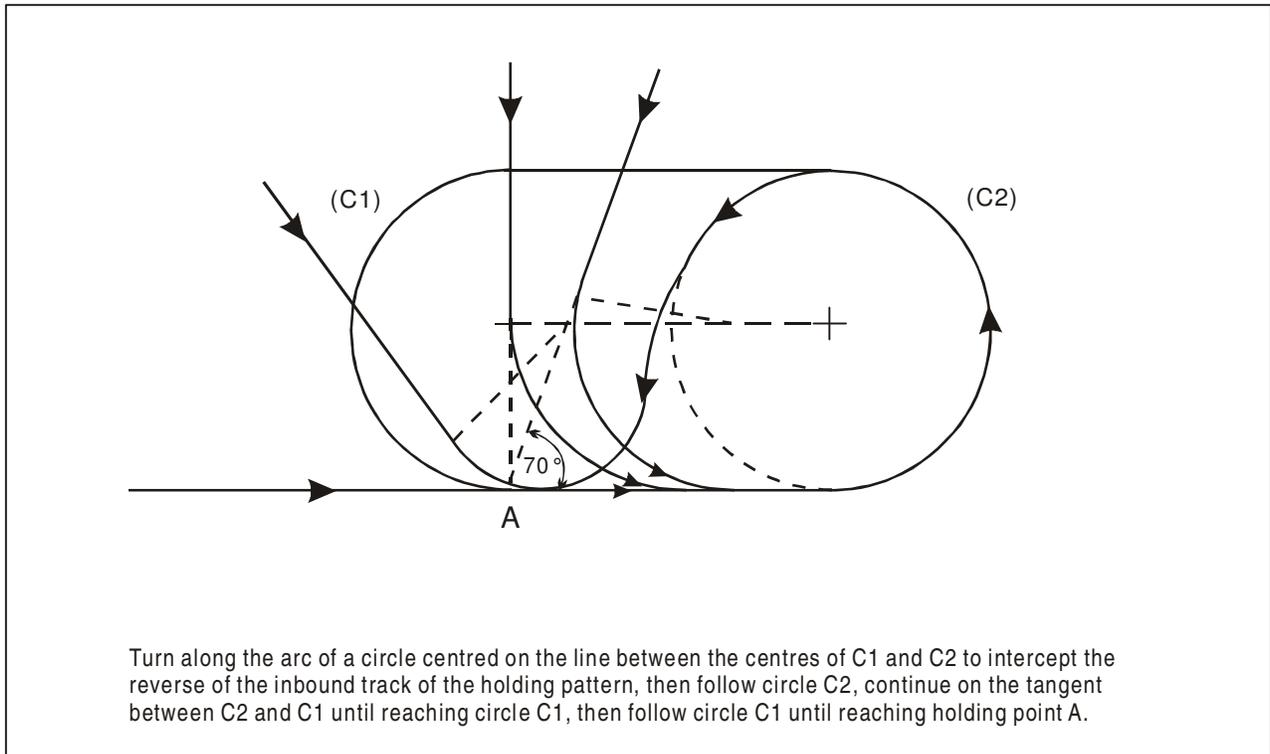


Figure II-6-4-2. Sector 1 entry

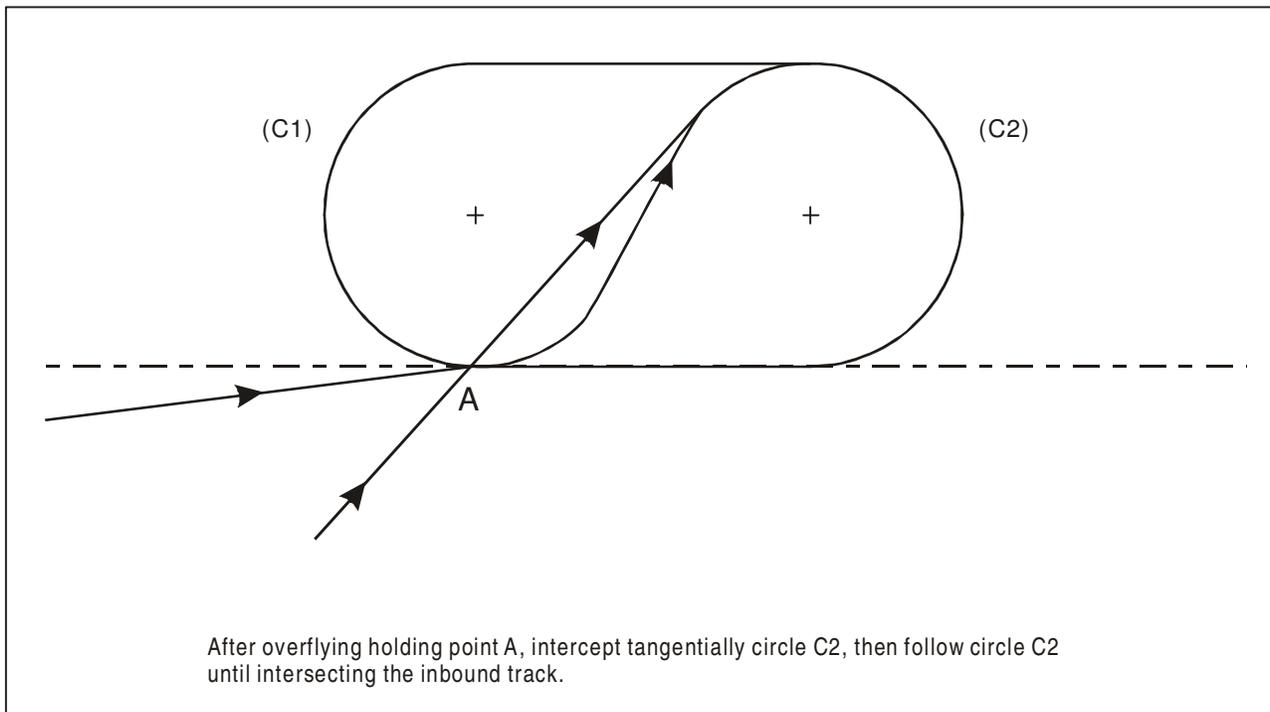
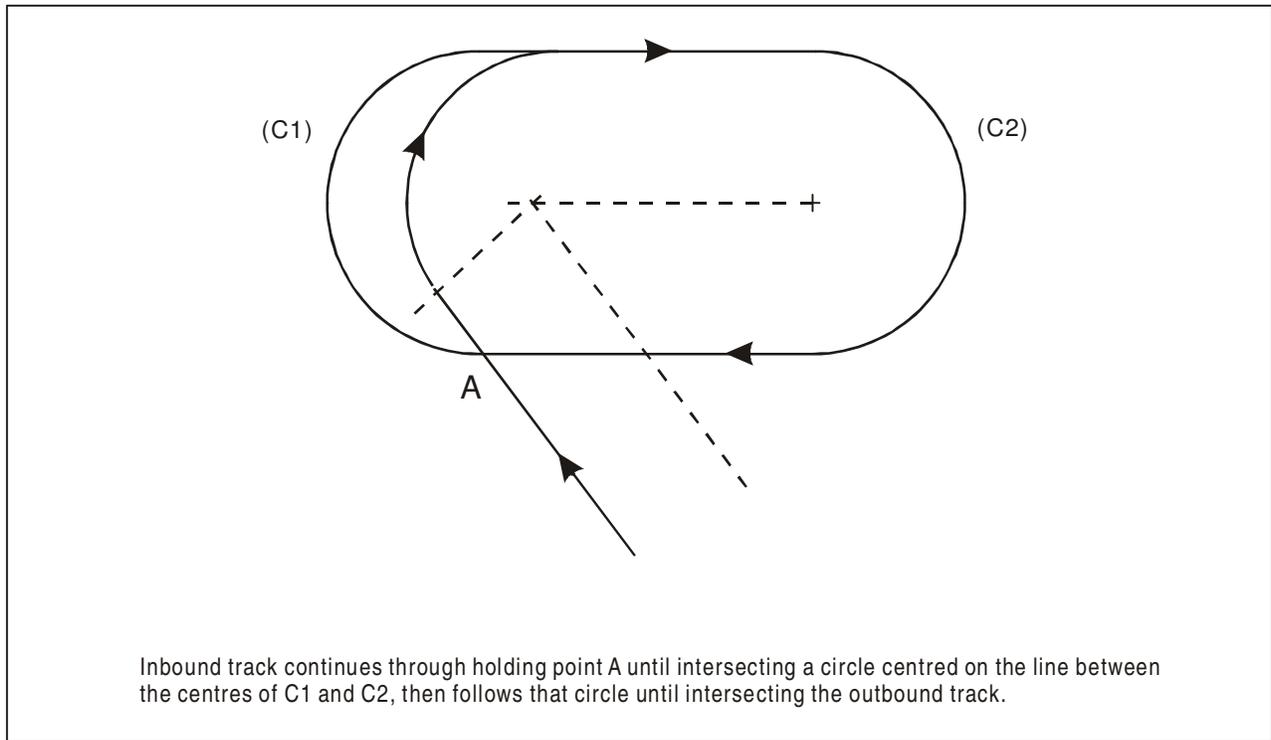
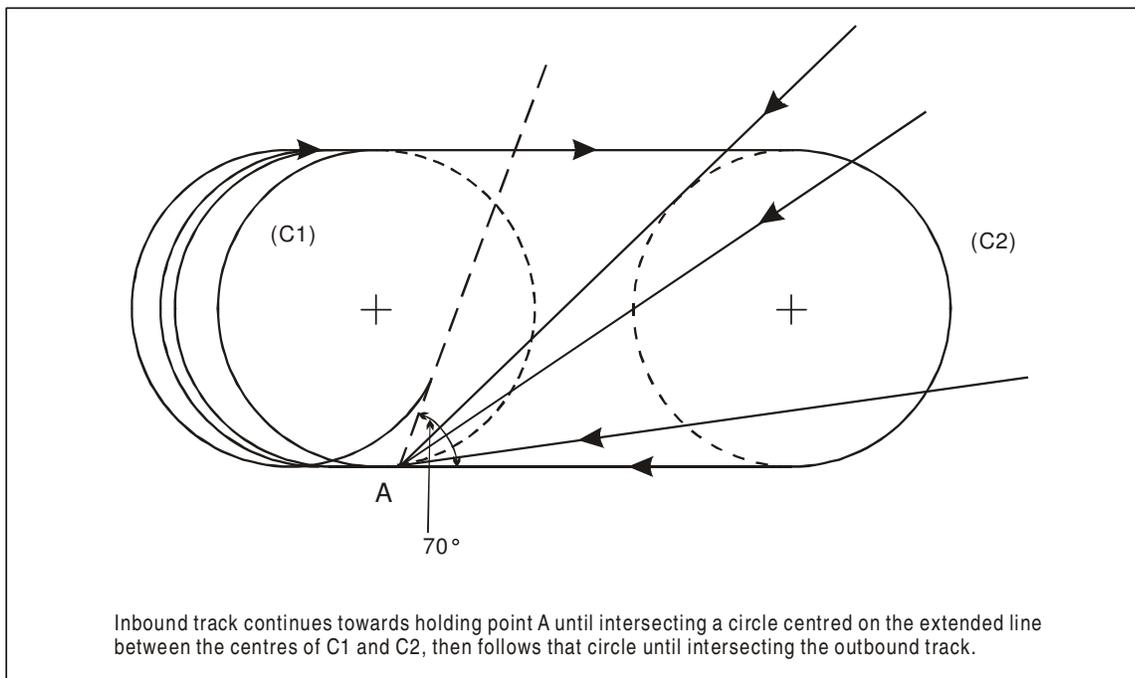


Figure II-6-4-3. Sector 2 entry



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



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

**Section 7**  
**EN ROUTE**

## Chapter 1

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

### 1.1 STANDARD CONDITIONS

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

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

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

### 1.2 DEFINITION OF TURNS

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

1.2.2 There are two kinds of turns for RNP routes:

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

**Procedures for  
Air Navigation Services**

**AIRCRAFT OPERATIONS**

**Part III**

**AIRCRAFT OPERATING PROCEDURES**

**Section 1**

**ALTIMETER SETTING PROCEDURES**

## Chapter 1

### INTRODUCTION TO ALTIMETER SETTING PROCEDURES

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

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

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

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

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## Chapter 2

# BASIC ALTIMETER SETTING REQUIREMENTS

### 2.1 GENERAL

#### 2.1.1 System of flight levels

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

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

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

#### 2.1.2 Transition altitude

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

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

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

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

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

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

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

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

### 2.1.3 Transition level

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

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

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

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

### 2.1.4 References to vertical position

2.1.4.1 The vertical position of aircraft operating at or below the transition altitude shall be expressed in terms of altitude. Vertical position at or above the transition level shall be expressed in terms of flight levels. This terminology applies during:

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

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

#### 2.1.4.2 *Passing through the transition layer*

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

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

## 2.2 TAKE-OFF AND CLIMB

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

## 2.3 EN ROUTE

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

### 2.3.2 Terrain clearance

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

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

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

## 2.4 APPROACH AND LANDING

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

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

### 2.4.3 References to vertical positioning after approach clearance

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

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

## 2.5 MISSED APPROACH

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

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

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

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

## Chapter 3

# PROCEDURES FOR OPERATORS AND PILOTS

### 3.1 FLIGHT PLANNING

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

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

3.1.2 The altitudes or flight levels selected for flight:

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

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

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

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

### 3.2 PRE-FLIGHT OPERATIONAL TEST

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

**QNH setting**

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

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

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

**QFE setting**

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

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

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

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

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

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

**3.3 TAKE-OFF AND CLIMB**

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

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

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

## 3.4 EN ROUTE

### 3.4.1 Vertical separation

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

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

### 3.4.2 Terrain clearance

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

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

## 3.5 APPROACH AND LANDING

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

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

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

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

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

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

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

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

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

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

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

## Chapter 4

### ALTIMETER CORRECTIONS

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

#### 4.1 RESPONSIBILITY

##### 4.1.1 Pilot's responsibility

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

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

##### 4.1.2 Operator's responsibility

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

##### 4.1.3 State's responsibility

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

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

#### **4.1.4 Air traffic control (ATC)**

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

#### **4.1.5 Flights outside controlled airspace**

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

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

### **4.2 PRESSURE CORRECTION**

#### **4.2.1 Flight levels**

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

#### **4.2.2 QNH/QFE**

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

### **4.3 TEMPERATURE CORRECTION**

#### **4.3.1 Requirement for temperature correction**

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

#### **4.3.2 Tabulated corrections**

For colder temperatures, a more accurate correction should be obtained from Tables III-1-4-1 a) and III-1-4-1 b). These tables are calculated for a sea level aerodrome. They are therefore conservative when applied at higher aerodromes. To

calculate the corrections for specific aerodromes or altimeter setting sources above sea level, or for values not tabulated, see 4.3.3, “Corrections for specific conditions”.

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

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

### 4.3.3 Corrections for specific conditions

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

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

where:

$H$  = minimum height above the altimeter setting source (setting source is normally the aerodrome unless otherwise specified)

$t_0$  =  $t_{\text{aerodrome}} + L_0 \times h_{\text{aerodrome}}$  . . . aerodrome (or specified temperature reporting point) temperature adjusted to sea level

$L_0$  = 0.0065°C per m or 0.00198°C per ft

$H_{ss}$  = altimeter setting source elevation

$t_{\text{aerodrome}}$  = aerodrome (or specified temperature reporting point) temperature

$h_{\text{aerodrome}}$  = aerodrome (or specified temperature reporting point) elevation

### 4.3.4 Accurate corrections

4.3.4.1 For occasions when a more accurate temperature correction is required, this may be obtained from Equation 24 of the Engineering Sciences Data Unit (ESDU) publication, *Performance*, Volume 2, Item Number 77022<sup>1</sup>. This assumes an off-standard atmosphere.

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

where:

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

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

1. Reprinted by permission of ESDU International plc., 27 Corsham Street, London, N1 6UA, UK.

$\Delta t_{\text{std}}$  = temperature deviation from the International Standard Atmosphere (ISA) temperature

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

$t_0$  = standard temperature at sea level

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

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

#### 4.3.5 Assumption regarding temperature lapse rates

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

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

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

#### 4.3.6 Small corrections

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

### 4.4 MOUNTAINOUS AREAS — EN ROUTE

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

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

#### 4.5 MOUNTAINOUS TERRAIN — TERMINAL AREAS

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

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

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

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

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

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

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

| <i>Terrain variation</i>  | <i>MOC</i> |
|---------------------------|------------|
| Between 900 m and 1 500 m | 450 m      |
| Greater than 1 500 m      | 600 m      |

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

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

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

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

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

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

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

**Section 2**

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

# Chapter 1

## MODES OF OPERATION

### 1.1 INTRODUCTION

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

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

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

### 1.2 MODES OF OPERATION

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

#### 1.2.1.1 *Modes One and Two — Simultaneous parallel instrument approaches*

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

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

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

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

#### 1.2.1.2 *Mode 3 — Simultaneous instrument departures*

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

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

### 1.2.1.3 Mode 4 — Segregated parallel approaches/departures

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

### 1.2.1.4 Semi-mixed and mixed operations

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

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

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

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

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

## 1.2.2 Definitions

(see Figure III-2-1-1)

### 1.2.2.1 Normal operating zone (NOZ)

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

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

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

#### 1.2.2.2 *No transgression zone (NTZ)*

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

### 1.3 EQUIPMENT REQUIREMENTS

#### 1.3.1 Airborne avionics

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

### 1.4 AIRPORT SERVICES AND FACILITIES

Independent/dependent parallel approaches may be conducted provided that:

- a) the runway centre lines are spaced by the distances specified in Annex 14, Volume I; and
  - 1) for independent parallel approaches:
    - i) if runway centre lines are spaced by less than 1 310 m (4 300 ft) but not less than 1 035 m (3 400 ft). Suitable secondary surveillance radar (SSR) equipment is available, having:
      - a minimum azimuth accuracy of 0.06 degrees (one sigma);
      - an update period of 2.5 seconds or less; and
      - a high resolution display providing position prediction and deviation alert; or
    - ii) if runway centre lines are spaced by less than 1 525 m (5 000 ft) but not less than 1 310 m (4 300 ft). SSR equipment with specifications other than those above may be used if the safety of aircraft operations is not adversely affected; or
    - iii) where runway centre lines are spaced by 1 525 m (5 000 ft) or more. Suitable surveillance radar is available, having:
      - a minimum azimuth accuracy of 0.3 degrees (one sigma); and
      - an update period of 5 seconds or less;
  - 2) for dependent parallel approaches where runway centre lines are spaced by 915 m (3 000 ft) or more, suitable surveillance radar is available, having:

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

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

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

## **1.5 VECTORED TO THE ILS LOCALIZER COURSE OR MLS FINAL APPROACH TRACK**

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

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

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

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

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

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

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

## **1.6 TERMINATION OF RADAR MONITORING**

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

## **1.7 TRACK DIVERGENCE**

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

## **1.8 SUSPENSION OF INDEPENDENT PARALLEL APPROACHES TO CLOSELY SPACED PARALLEL RUNWAYS**

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

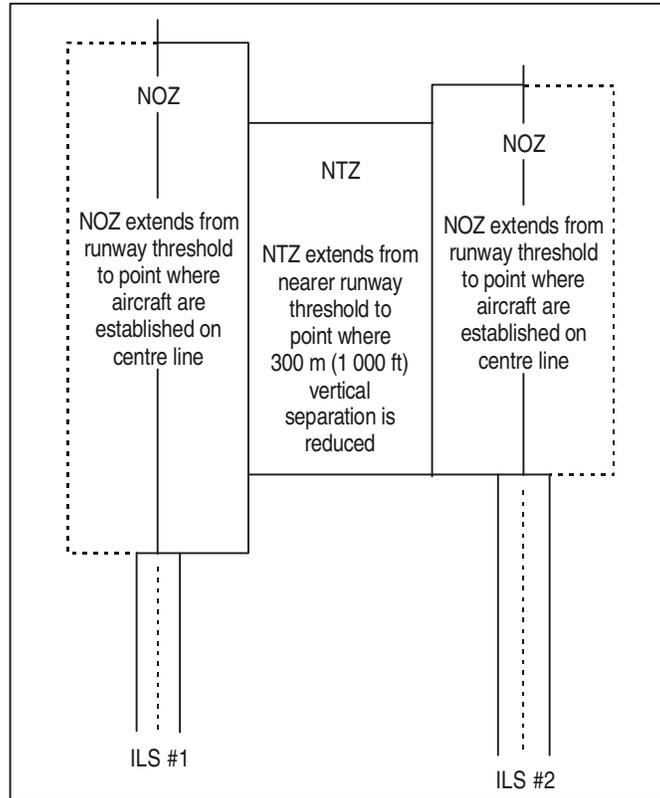


Figure III-2-1-1. Example of normal operating zones (NOZs) and no transgression zone (NTZ)

**Section 3**

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

# Chapter 1

## OPERATION OF TRANSPONDERS

### 1.1 GENERAL

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

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

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

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

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

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

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

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

1.1.6 Pilots shall not SQUAWK IDENT unless requested by ATC.

### 1.2 USE OF MODE C

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

### 1.3 USE OF MODE S

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

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

### 1.4 EMERGENCY PROCEDURES

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

### 1.5 COMMUNICATION FAILURE PROCEDURES

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

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

### 1.6 UNLAWFUL INTERFERENCE WITH AIRCRAFT IN FLIGHT

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

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

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

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

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

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

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

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## **Chapter 2**

### **PHRASEOLOGY**

#### **2.1 PHRASEOLOGY USED BY ATS**

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

#### **2.2 PHRASEOLOGY USED BY PILOTS**

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

---

## Chapter 3

# OPERATION OF AIRBORNE COLLISION AVOIDANCE SYSTEM (ACAS) EQUIPMENT

### 3.1 GENERAL

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

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

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

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

### 3.2 USE OF ACAS INDICATORS

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

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

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

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

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

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

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

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

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

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

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

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

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

## **Attachment to Part III, Section 3, Chapter 3**

### **ACAS II TRAINING GUIDELINES FOR PILOTS**

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

#### **1. INTRODUCTION**

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

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

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

#### **2. ACAS ACADEMIC TRAINING**

##### **2.1 General**

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

##### **2.2 Essential items**

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

###### *2.2.1.1 System operation*

OBJECTIVE: Demonstrate knowledge of how ACAS functions.

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

## a) Surveillance:

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

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

## b) Collision avoidance:

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

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

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

## 2.2.1.2 Advisory thresholds

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

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

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

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

#### 2.2.1.3 ACAS limitations

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

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

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

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

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

#### 2.2.1.4 ACAS inhibits

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

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

- a) increase descent RAs are inhibited below 442 ( $\pm 30$ ) m (1 450 ( $\pm 100$ ) ft) AGL;
- b) descend RAs are inhibited below 335 ( $\pm 30$ ) m (1 100 ( $\pm 100$ ) ft) AGL;
- c) all RAs are inhibited below 305 ( $\pm 30$ ) m (1 000 ( $\pm 100$ ) ft) AGL;

- d) all ACAS aural annunciations are inhibited below 152 ( $\pm 30$ ) m (500 ( $\pm 100$ ) ft) AGL. This includes the aural annunciation for TAs; and
- e) altitude and configuration under which climb and increase climb RAs are inhibited. ACAS can still issue climb and increase climb RAs when operating at the aircraft's maximum altitude or certified ceiling. However, if aeroplane performance at maximum altitude is not sufficient to enable compliance with the climb rate required by a climb RA, the response should still be in the required sense but not beyond the extent permitted by aeroplane performance limitations.

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

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

#### 2.2.2.1 *Use of controls*

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

CRITERIA: Demonstrate the proper use of controls including:

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

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

#### 2.2.2.2 *Display interpretation*

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

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

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

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

#### 2.2.2.3 Use of the TA-only mode

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

CRITERIA: The pilot must demonstrate the following:

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

#### 2.2.2.4 Crew coordination

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

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

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

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

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

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

#### 2.2.2.5 Reporting requirements

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

CRITERIA: The pilot must demonstrate the following:

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

## 2.3 Desirable items

### 2.3.1 Advisory thresholds

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

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

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

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

### 3. ACAS MANOEUVRE TRAINING

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

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

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

#### 3.3.1 TA responses

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

CRITERIA: The pilot must demonstrate:

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

### 3.3.2 RA responses

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

CRITERIA: The pilot MUST demonstrate:

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

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

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

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

#### 4. ACAS INITIAL EVALUATION

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

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

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

#### 5. ACAS RECURRENT TRAINING

5.1 ACAS recurrent training ensures that pilots maintain the appropriate ACAS knowledge and skills. ACAS recurrent training should be integrated into and/or conducted in conjunction with other established recurrent training programmes. An essential item of recurrent training is the discussion of any significant issues and operational concerns that have been identified by the operator.

5.2 ACAS monitoring programmes periodically publish findings from their analyses of ACAS events. The results of these analyses typically discuss technical and operational issues related to the use and operation of ACAS. This information is available from ICAO or directly from the monitoring programmes. ACAS recurrent training programmes should address the results of monitoring programmes in both the academic and simulator portions of recurrent training visits.

*Note.—ACAS monitoring programmes are carried out by some States and international organizations including the United States' Federal Aviation Administration (FAA) and the European Organisation for the Safety of Air Navigation (EUROCONTROL).*

5.3 Recurrent training should include both academic and manoeuvre training and address any significant issues identified by line operating experience, system changes, procedural changes, or unique characteristics such as the introduction of new aircraft/ display systems or operations in airspace where high numbers of TAs and RAs have been reported.

5.4 Pilots should fly all scenarios once every four years.

5.5 Pilots should complete all scenarios once every two years if CBT is used.

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**Section 4**

**OPERATIONAL FLIGHT INFORMATION**

## Chapter 1

### AERODROME SURFACE OPERATIONS

1.1 Operators shall develop and implement standard operating procedures (SOPs) for aerodrome surface operations. The development and implementation of SOPs shall take into consideration the risk factors (listed in 1.3) associated with the following operations:

- a) runway intersection take-offs;
- b) line-up and wait clearances;
- c) land and hold-short clearances;
- d) take-offs from displaced runway thresholds;
- e) hazards associated with runway crossing traffic; and
- f) hazards associated with runway crossing traffic in the case of closely spaced parallel runways.

*Note 1.— The Manual of Surface Movement Guidance and Control Systems (SMGCS) (Doc 9476), Chapter 1, and the Advanced Surface Movement Guidance and Control Systems (A-SMGCS) Manual (Doc 9830) discuss the safety considerations in aerodrome surface operations.*

*Note 2.— See Section 5, Chapter 1, for details regarding SOPs design.*

*Note 3.— Land and hold-short clearances/simultaneous intersecting runway operations are not ICAO procedures.*

1.2. The development and implementation of SOPs for aerodrome surface operations should address, but not be limited to, the risk factors listed in 1.3 by means of:

- a) provisions regarding the timely acknowledgement of ground movement instructions;
- b) provisions to ensure the acknowledgement, in standard phraseology, of all clearances to enter, land on, take off from, hold short of, cross or backtrack the runway in use; and

*Note.— The proper identification of the runway in use is prescribed in Annex 14, Volume I (Aerodromes), Chapter 5, 5.2.2.4.*

- c) provisions for the use of aircraft exterior lights to increase the conspicuity of aircraft manoeuvring on aerodrome surfaces.

*Note.— The Manual of Surface Movement Guidance and Control Systems (SMGCS) (Doc 9476), Chapter 4, 4.8, discusses radiotelephony procedures and phraseology in aerodrome surface operations. Chapter 7, 7.3.6, discusses misunderstood clearances.*

1.3 Operators should ensure that flight personnel are aware of the risk factors in the aerodrome surface operations listed in 1.1. Such risk factors should include, but not be limited to:

- a) human error due to excessive workload, loss of vigilance and fatigue;
- b) potential distractions associated with the performance of flight deck tasks; and
- c) failure to use standard phraseology in aeronautical communications.

*Note.— The safety of aerodrome surface operations is especially vulnerable to the failure to use standard phraseology in aeronautical communications. Frequency congestion, as well as operational considerations, may adversely affect the issuance and read-back of clearances, leaving flight crews and controllers vulnerable to misunderstandings.*

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## **Chapter 2**

# **READ-BACK OF CLEARANCES AND SAFETY-RELATED INFORMATION**

*Note.— Provisions on read-back of clearances and safety-related information are included in Annex 11, Chapter 3, 3.7.3, and in the PANS-ATM (Doc 4444), Chapter 4.*

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## **Chapter 3**

### **STABILIZED APPROACH PROCEDURE**

#### **3.1 GENERAL**

The primary safety consideration in the development of the stabilized approach procedure shall be maintenance of the intended flight path as depicted in the published approach procedure, without excessive manoeuvring. The parameters to be considered in the definition of a stabilized approach are listed in 3.2.

#### **3.2 PARAMETERS FOR THE STABILIZED APPROACH**

The parameters for the stabilized approach shall be defined by the operator's standard operating procedures (SOPs) (Section 5, Chapter 1). These parameters shall be included in the operator's operations manual and shall provide details regarding at least the following:

- a) range of speeds specific to each aircraft type;
- b) minimum power setting(s) specific to each aircraft type;
- c) range of attitudes specific to each aircraft type;
- d) crossing altitude deviation tolerances;
- e) configuration(s) specific to each aircraft type;
- f) maximum sink rate; and
- g) completion of checklists and crew briefings.

#### **3.3 ELEMENTS OF THE STABILIZED APPROACH**

The elements of a stabilized approach (according to the parameters in 3.2) shall be stated in the operator's SOPs. These elements should include as a minimum:

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

### 3.4 GO-AROUND POLICY

Standard operating procedures should include the operator's policy with regard to the parameters in 3.2 and the elements in 3.3. This policy should state that if an approach is not stabilized in accordance with 3.3, or has become destabilized at any subsequent point during an approach, a go-around is required. Operators should reinforce this policy through training.

*Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.13, includes general considerations about stabilized approaches.*

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**Section 5**

**STANDARD OPERATING PROCEDURES (SOPs)  
AND CHECKLISTS**

# Chapter 1

## STANDARD OPERATING PROCEDURES (SOPs)

### 1.1 GENERAL

Operators shall establish standard operating procedures (SOPs) that provide guidance to flight operations personnel to ensure safe, efficient, logical and predictable means of carrying out flight procedures.

*Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.2, includes general considerations about SOPs. The Human Factors Training Manual (Doc 9683), Part 1, Chapter 2, 2.5.11, includes general considerations about SOPs design.*

### 1.2 SOPs OBJECTIVES

SOPs specify a sequence of tasks and actions to ensure that flight procedures can be carried out according to 1.1. To achieve these objectives, SOPs should unambiguously express:

- a) what the task is;
- b) when the task is to be conducted (time and sequence);
- c) by whom the task is to be conducted;
- d) how the task is to be done (actions);
- e) what the sequence of actions consists of; and
- f) what type of feedback is to be provided as a result of the actions (verbal call-out, instrument indication, switch position, etc.).

### 1.3 SOPs DESIGN

1.3.1 To ensure compatibility with specific operational environments and compliance by flight operations personnel, SOPs design should take into consideration:

- a) the nature of the operator's environment and type of operation;
- b) the operational philosophy, including crew coordination;
- c) the training philosophy, including human performance training;
- d) the operator's corporate culture, including the degree of flexibility to be built into SOPs design;

- e) the levels of experience of different user groups, such as flight crews, aircraft maintenance engineers and cabin attendants;
- f) resource conservation policies, such as fuel conservation or wear on power plants and systems;
- g) flight deck automation, including flight deck and systems layout and supporting documentation;
- h) the compatibility between SOPs and operational documentation; and
- i) procedural deviation during abnormal/unforeseen situations.

1.3.2 Flight operations personnel should be involved in the development of SOPs.

#### **1.4 SOPs IMPLEMENTATION AND USE**

Operators should establish a formal process of feedback from flight operations personnel to ensure standardization, compliance and evaluation of reasons for non-compliance during SOPs implementation and use.

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## **Chapter 2**

# **CHECKLISTS**

### **2.1 GENERAL**

Operators shall establish checklists as an integral part of standard operating procedures (SOPs). Checklists should describe the actions relevant to specific phases of operations (engine start, taxi, take-off, etc.) that flight crews must perform or verify and which relate to flight safety. Checklists should also provide a framework for verifying aircraft and systems configuration that guards against vulnerabilities in human performance.

### **2.2 CHECKLIST OBJECTIVES**

2.2.1 Normal checklists should aid flight crews in the process of configuring the aircraft and its systems by:

- a) providing logical sequences of coverage of the flight deck panels;
- b) providing logical sequences of actions to meet both internal and external flight deck operational requirements;
- c) allowing mutual monitoring among flight crew members to keep all flight crew members in the information loop; and
- d) facilitating crew coordination to assure a logical distribution of flight deck tasks.

2.2.2 Checklists for use in abnormal situations and those for emergency situations should aid flight crews in coping with malfunctions of aircraft systems and/or emergency situations. They should also guard against vulnerabilities in human performance during high workload situations by fulfilling the objectives in 2.2.1 and, in addition, by:

- a) ensuring a clear allocation of duties to be performed by each flight crew member;
- b) acting as a guide to flight crews for diagnosis, decision making and problem solving, (prescribing sequences of steps and/or actions); and
- c) ensuring that critical actions are taken in a timely and sequential manner.

### **2.3 CHECKLIST DESIGN**

#### **2.3.1 Order of checklist items**

2.3.1.1 The following factors should be considered when deciding the order of the items in checklists:

- a) the operational sequence of aircraft systems so that items are sequenced in the order of the steps for activation and operation of these systems;
- b) the physical flight deck location of items so that they are sequenced following a flow pattern;
- c) the operational environment so that the sequence of checklists considers the duties of other operational personnel such as cabin crew and flight operations officers;
- d) operator policies (for example, resource conservation policies such as single-engine taxi) that may impinge on the operational logic of checklists;
- e) verification and duplication of critical configuration-related items so that they are checked in the normal sequence and again immediately before the phase of flight for which they are critical; and
- f) sequencing of critical items in abnormal and emergency checklists so that items most critical are completed first.

2.3.1.2 Critical items should appear no more than twice on a given checklist (see 2.3.1.1 e)). Critical items should be verified by more than one flight crew member.

### **2.3.2 Number of checklist items**

The number of items in checklists should be restricted to those critical to flight safety.

*Note.— The introduction of advanced technology in the flight deck, allowing for automated monitoring of flight status, may justify a reduction in the number of items required in checklists.*

### **2.3.3 Checklist interruptions**

SOPs should include techniques to ensure a step-by-step, uninterrupted sequence of completing checklists. SOPs should unambiguously indicate the actions by flight crews in case of checklist interruptions.

### **2.3.4 Checklist ambiguity**

Checklist responses should portray the actual status or the value of the item (switches, levers, lights, quantities, etc.). Checklists should avoid non-specific responses such as “set”, “checked” or “completed”.

### **2.3.5 Checklist coupling**

Checklists should be coupled to specific phases of flight (engine start, taxi, take-off, etc.). SOPs should avoid tight coupling of checklists with the critical part of a phase of flight (for example, completing the take-off checklist on the active runway). SOPs should dictate a use of checklists that allows buffers for detection and recovery from incorrect configurations.

### **2.3.6 Typography**

2.3.6.1 Checklist layout and graphical design should observe basic principles of typography, including at least legibility of print (discriminability) and readability under all flight deck lighting conditions.

2.3.6.2 If colour coding is used, standard industry colour coding should be observed in checklist graphical design. Normal checklists should be identified by green headings, system malfunctions by yellow headings, and emergency checklists by red headings.

2.3.6.3 Colour coding should not be the only means of identifying normal, abnormal and emergency checklists.

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## **Chapter 3**

### **CREW BRIEFINGS**

#### **3.1 GENERAL**

3.1.1 Operators shall establish crew briefings as an integral part of standard operating procedures (SOPs). Crew briefings communicate duties, standardize activities, ensure that a plan of action is shared by crew members and enhance crew situational awareness.

3.1.2 Operators shall establish both individual and combined crew briefings for flight crew and cabin crew.

*Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.8, includes general considerations about briefings.*

#### **3.2 OBJECTIVES**

Crew briefings should aid crews in performing safety-critical actions relevant to specific phases of flight by:

- a) refreshing prior knowledge to make it more readily accessible in real-time during flight;
- b) constructing a shared mental picture of the situation to support situational awareness;
- c) building a plan of action and transmitting it to crew members to promote effective error detection and management; and
- d) preparing crew members for responses to foreseeable hazards to enable prompt and effective reaction.

*Note.— Without briefings, and under the pressure of time constraints and stress, retrieving information from memory may be an extremely unreliable process.*

#### **3.3 PRINCIPLES**

3.3.1 The following principles should be considered when establishing crew briefings:

- a) crew briefings should be short and should not include more than ten items. If more than ten items are necessary, consideration should be given to splitting the briefing into sequential phases of the flight;
- b) crew briefings should be simple and succinct, yet sufficiently comprehensive to promote understanding of the plan of action among all crew members;
- c) crew briefings should be interactive and where possible should use a question-and-answer format;

- d) crew briefings should be scheduled so as not to interfere with, and to provide adequate time for, the performance of operational tasks; and
- e) crew briefings should achieve a balance between effectiveness and continual repetition of recurring items.

*Note.— Crew briefings that become routine recitations do not refresh prior knowledge and are ineffective.*

3.3.2 Any intended deviation from SOPs required by operational circumstances should be included as a specific briefing item.

### 3.4 APPLICATION

3.4.1 Operators shall implement flight and cabin crew briefings for specific phases of operations to include actual conditions and circumstances, as well as special aspects of operations.

3.4.2 Flight crew briefings shall be conducted for, but not be limited to, the following phases of operations:

- a) pre-flight;
- b) departure; and
- c) arrival.

3.4.3 Cabin crew briefings shall be conducted for, but not be limited to, the following phases of operations:

- a) pre-flight; and
- b) first departure of the day.

3.4.4 Cabin crew briefings should be conducted following changes of aircraft type or crew and before flights involving a stop of more than two hours.

### 3.5 SCOPE

3.5.1 Pre-flight briefings shall include both flight crew and cabin crew.

3.5.2 Pre-flight briefings should focus on crew coordination as well as aircraft operational issues. They should include, but not be limited to:

- a) any information necessary for the flight, including unserviceable equipment or abnormalities that may affect operational or passenger safety requirements;
- b) essential communications, and emergency and safety procedures; and
- c) weather conditions.

3.5.3 Flight crew departure briefings should prioritize all relevant conditions that exist for the take-off and climb. They should include, but not be limited to:

- a) runway in use, aircraft configuration and take-off speeds;
- b) departure procedures;
- c) departure routes;
- d) navigation and communications equipment set-up;
- e) aerodrome, terrain and performance restrictions, including noise abatement procedures (if applicable);
- f) take-off alternates (if applicable);
- g) any item(s) included in the minimum equipment list (if applicable);
- h) review of applicable emergency procedures; and
- i) applicable standard call-outs.

*Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.9, includes general considerations about standard call-outs. Attachment F to Chapter 8 contains an example of an operator's guidance on standard call-out procedures.*

3.5.4 Flight crew arrival briefings should prioritize all relevant conditions that exist for the descent, approach and landing. They should include, but not be limited to:

- a) terrain restrictions and minimum safe altitudes during descent;
- b) arrival routes;
- c) instrument or visual approach procedures and runway in use;
- d) operational minima, aircraft configuration, and landing speeds;
- e) navigation and communications equipment set-up;
- f) missed approach procedures;
- g) alternate aerodromes and fuel considerations;
- h) review of applicable emergency procedures;
- i) applicable standard call-outs; and

*Note.— The Preparation of an Operations Manual (Doc 9376), Chapter 8, 8.6.9, includes general considerations about standard call-outs. Attachment F to Chapter 8 contains an example of an operator's guidance on standard call-out procedures.*

- j) cold temperature correction (see Section 1, Chapter 4, 4.3).

3.5.5 Cabin crew briefings should prioritize all relevant conditions that exist for the departure. They should include, but not be limited to:

- a) assignment of take-off/landing positions;
- b) review of emergency equipment;
- c) passengers requiring special attention;
- d) the silent review process;

*Note.— The silent review process is the self-review of individual actions in the event of emergencies.*

- e) review of applicable emergencies;
  - f) security or service-related topics that may impact on passenger or crew safety; and
  - g) any additional information provided by the operator, including review of new procedures, equipment and systems.
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**Section 6**

**VOICE COMMUNICATION PROCEDURES AND CONTROLLER-PILOT  
DATA LINK COMMUNICATIONS PROCEDURES**

*(To be developed)*

— END —

## ICAO TECHNICAL PUBLICATIONS

*The following summary gives the status, and also describes in general terms the contents of the various series of technical publications issued by the International Civil Aviation Organization. It does not include specialized publications that do not fall specifically within one of the series, such as the Aeronautical Chart Catalogue or the Meteorological Tables for International Air Navigation.*

**International Standards and Recommended Practices** are adopted by the Council in accordance with Articles 54, 37 and 90 of the Convention on International Civil Aviation and are designated, for convenience, as Annexes to the Convention. The uniform application by Contracting States of the specifications contained in the International Standards is recognized as necessary for the safety or regularity of international air navigation while the uniform application of the specifications in the Recommended Practices is regarded as desirable in the interest of safety, regularity or efficiency of international air navigation. Knowledge of any differences between the national regulations or practices of a State and those established by an International Standard is essential to the safety or regularity of international air navigation. In the event of non-compliance with an International Standard, a State has, in fact, an obligation, under Article 38 of the Convention, to notify the Council of any differences. Knowledge of differences from Recommended Practices may also be important for the safety of air navigation and, although the Convention does not impose any obligation with regard thereto, the Council has invited Contracting States to notify such differences in addition to those relating to International Standards.

**Procedures for Air Navigation Services (PANS)** are approved by the Council for worldwide application. They contain, for the most part, operating procedures regarded as not yet having attained a sufficient degree of

maturity for adoption as International Standards and Recommended Practices, as well as material of a more permanent character which is considered too detailed for incorporation in an Annex, or is susceptible to frequent amendment, for which the processes of the Convention would be too cumbersome.

**Regional Supplementary Procedures (SUPPS)** have a status similar to that of PANS in that they are approved by the Council, but only for application in the respective regions. They are prepared in consolidated form, since certain of the procedures apply to overlapping regions or are common to two or more regions.

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*The following publications are prepared by authority of the Secretary General in accordance with the principles and policies approved by the Council.*

**Technical Manuals** provide guidance and information in amplification of the International Standards, Recommended Practices and PANS, the implementation of which they are designed to facilitate.

**Air Navigation Plans** detail requirements for facilities and services for international air navigation in the respective ICAO Air Navigation Regions. They are prepared on the authority of the Secretary General on the basis of recommendations of regional air navigation meetings and of the Council action thereon. The plans are amended periodically to reflect changes in requirements and in the status of implementation of the recommended facilities and services.

**ICAO Circulars** make available specialized information of interest to Contracting States. This includes studies on technical subjects.

