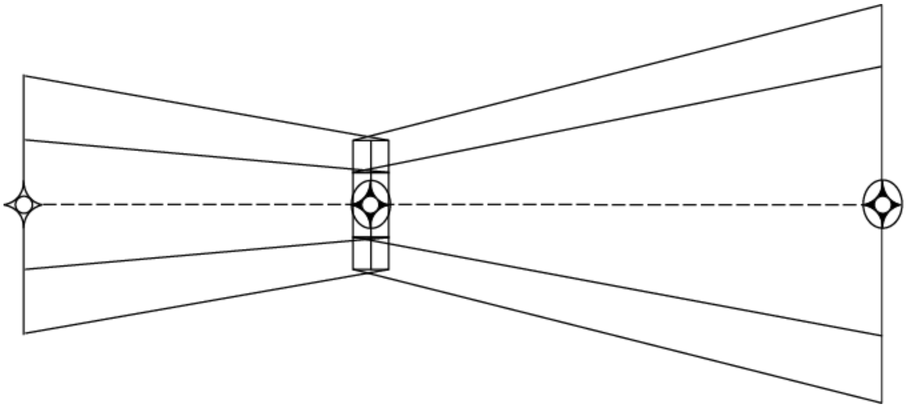
CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 5.3



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15 Dec 2011

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RECORD OF AMENDMENTS

AMENDMENT NO.	EFFECTIVE DATE	DATE ENTERED	ENTERED BY
Change 1	01 July 1996	1 July 1996	Incorporated
Change 2	30 November 2001	30 November 2001	Incorporated
Change 3	15 May 2006	15 May 2006	Incorporated
Change 4	01 January 2008	01 January 2008	Incorporated
Change 5	01 January 2009	01 January 2009	Incorporated
Change 5.2	11 February 2010	11 February 2010	Incorporated
Change 5.3	15 December 2011		

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FORWARD

This publication prescribes standardized methods for use in designing instrument flight procedures. It is to be used by personnel charged with the responsibility for the preparation, approval and promulgation of instrument procedures. Compliance with criteria contained herein is not a substitute for sound judgment and common sense. These criteria do not relieve procedure designers and supervisory personnel from exercising initiative or taking appropriate action in recognizing both the capabilities and limitations of aircraft and navigational aid performance. These criteria are predicated on normal aircraft operations for considering obstacle clearance requirements.

Obstacle clearance is the primary safety consideration in the development of instrument procedures. Obstruction clearances quoted in this publication are the lowest or smallest values that can be accepted consistent with flight safety.

In the event of a conflict or disaccord between English and French versions of this criteria, the English version is considered the authority.

Recommendations concerning changes or additions should be provided to one of the following:

Division Instrument Check Pilot (DICP)
1 Canadian Air Division Headquarters
P.O. Box 17000
Station Forces
Winnipeg, MB R3J 3Y5

Transport Canada
Director
Aerodromes and Air Navigation Branch
(AARTAC)
Transport Canada Building
Place de Ville, Tower "C",
Ottawa, ON K1A 0N8

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CHANGE 5.3 REVISION—CHANGE PAGE

Change 5.3 to the *Criteria for the Development of Instrument Procedures* (TP308/GPH209) reintroduces new Criteria for the design of Radar, as well as Area Navigation (RNAV) procedures.

CARs 803.02(b) states that no person shall publish or submit for publishing in the Canada Air Pilot an instrument procedure unless the procedure has been developed by a person who has successfully completed training in the interpretation and application of the standards and criteria specified in the manual entitled Criteria for the Development of Instrument Procedures, which training has been accepted by the Minister.

TP308/GPH209 will be amended on a yearly basis (if warranted), otherwise updated through Advisory Circulars (ACs), posted at:

http://www.tc.gc.ca/eng/civilaviation/opssvs/managementservices-referencecentre-acs-menu-455.htm

ADVISORY CIRCULARS

Publication of Change 5.3 cancels the following TP 308/GPH 209 ADVISORY CIRCULARS:

- Advisory Circular (AC) 803-001, Issue 2, dated 2009-03-10 – TP308/GPH209 – Change 5.2 – Criteria for the Development of Instrument Procedures.

EFFECTIVE DATE

15 December 2011

EXPLANATION OF CHANGES

The volume and chapter numbers are identified on the inside top right corner of the page. The chapter and page numbers (example 1-1) are on the bottom centre of the page. The revision number (Change 5.3) is on the bottom left corner and the date of issue is bottom right.

For administrative purposes, all table and figure numbers have continued to be revised to be compatible with the FAA’s Terminal Instrument Procedures Criteria (TERPs).

Significant areas of new direction, guidance, and policy included in this change are as follows:

Volume 1, General Criteria

(1) Chapter 2 – General Criteria, para 216 Governing Obstacle – Revised.

(2) Chapter 10 – RADAR Procedures – Entire chapter revised.

(3) Chapter 16 – Global Positioning System (GPS) (Non-Precision) – Revoked

Volume 2, Non Precision Approach Procedure (NPA) Construction

(1) NO CHANGE

Volume 3, Precision Approach (PA) & Baro VNAV Approach Procedure Construction

(1) **General**

  (a) Volume renamed – Precision Approach Procedure Construction

(2) **Chapter 4 – Baro VNAV**

  (a) Chapter Revoked

Volume 4, Non Precision Approach Procedure (NPA) Construction

(1) NO CHANGE

Volume 5, Helicopter Instrument Procedure Construction

(1) NO CHANGE

Volume 6, Supplemental Criteria Construction

(1) **Document 1 – Flight Management System (FMS)**

  (a) Document 1 – Re-issued with textual changes and several chapters removed

(2) **Document 4 – Wide Area Augmentation System (WAAS)**

  (a) Document 4 – Revoked

(3) **Document 5 – Required Navigation Performance (RNP)**

  (a) Document 5 – Revoked

(4) **Document 7 – Area Navigation (RNAV)**

  (a) Document 7 – Added

Annexes

(1) **Annex J – Terrain and Obstacle Data (TOD)**

  (a) New Document Added

PAGE CONTROL CHART

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		Annex J – TOD	
		Entire Annex J	15/12/2011

A3 Aerospace and
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1 Canadian Air Division Headquarters
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Attention: DICP

Transport Canada
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Aerodromes and Air Navigation (AARTA)
Transport Canada Building
Place de Ville, Tower "C",
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CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 5.3

VOLUME 1

GENERAL CRITERIA

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CHAPTER 1. ADMINISTRATION

100. Purpose

This manual contains the criteria that shall be used to formulate, review, approve and publish instrument procedures within Canada.

101. ICAO Annexes

Where ICAO Annexes 4 & 15 refers to PANS-OPS Doc 8168, reference shall be made to TP308/GPH209. Should any uncertainty exist as to the appropriate TP308 reference, Transport Canada, Airspace Standards & Procedures (AARTA) should be contacted for clarification.

102. Reserved

103. Cancellation

This document supersedes all previous editions of TC TP 308/DND GPH 209, Criteria for the Development of Instrument Procedures.

104. Existing Procedures

Existing procedures shall be revised to comply with these standards and criteria. New procedures shall be developed in accordance with these standards and criteria. Approval of nonstandard procedures, as required, is specified in Para 141.

105. Types Of Procedures

Criteria are provided for the following types of authorized terminal instrument procedures:

a. Precision Approach (PA)

   (1) Straight-In. A descent in an approved procedure where the final approach course alignment is normally on the runway centreline and vertical guidance information is provided. For example, Precision Approach Radar (PAR) and Instrument Landing System (ILS) procedures are Precision Approaches.

   (2) Simultaneous. A procedure that provides for approaches to parallel runways. This procedure typically uses two precision approach equipped parallel runways. Simultaneous approaches shall be radar monitored. Military commanders may approve simultaneous approaches based upon dual precision radar.

   (3) Simultaneous Converging Instrument Approach (SCIA). A procedure for conducting simultaneous instrument approaches to converging runways. This procedure uses two or more precision converging approaches.

b. Non-Precision Approach (NPA)

   (1) Straight-In. A descent in an approved procedure other than a precision approach in which the final approach course alignment and descent gradient permit authorization of straight-in landing minima.

c. Circling. A descent in an approved precision or non-precision approach procedure to circling minima from which a circle-to-land manoeuvre is performed, or an approach procedure that does not meet criteria for authorizing straight-in landing minima.

d. IFR Departure Procedure. Procedures designed to provide obstacle clearance during instrument departures.

106—119. Reserved

120. Procedure Development Requirements

Prior to the development of any instrument procedure, the following associated minimum standards shall be met:

a. Aerodrome. Table 1-1 represents the type of instrument procedure, associated minima and application (public or restricted use) authorized for any combination of NAVAID/approach system capability versus the landing surface and applicable aerodrome design standards or aerodrome authorization. Table 1-1 does not apply to PINSA procedures or Heliports/Helipads.

b. Navigation Facility. All electronic and visual navigation facilities used shall meet appropriate standards and the requirements of a flight inspection and calibration.

c. Obstruction Marking and Lighting. Buildings, structures and objects, including objects of natural growth shall be marked and lighted in accordance with CAR 621.19, Standards *Obstruction Markings* or DND CETO C-98-01 0-003/MG-004.

d. Altimeter Setting Source. All instrument approach procedures shall be predicated on the availability of an approved altimeter-setting source. See Para 323(b).

e. Communications. In controlled airspace air-to-ground communications with an ATS facility shall be available at the initial approach fix minimum altitude and at the missed approach clearance limit altitude. At lower altitudes communications shall be required where essential to the safe and efficient use of airspace. Air-to-ground communication normally consists of UHF or VHF radio, but other communications may be approved at locations that have a special need and capability.

f. Flight Check. All instrument approach procedures, departure procedures, airways and air routes shall be flight checked prior to approval to verify the governing obstacle for each segment. Instrument approach procedures and departure procedures shall also be flight checked for flyability prior to approval. This flight check shall be conducted by a person who has successfully completed training in the interpretation and application of the criteria found in this manual. All approved instrument approach procedures, departure procedure routes, airways and air routes shall be periodically checked to verify the governing obstacle for each segment.

121. Retention And Cancellation

Before an instrument procedure is cancelled, coordination with civil and military users shall be effected. Care shall be taken not to cancel procedures required by the military or required by air carrier operators at provisional or alternate airports. Military procedures shall be retained or cancelled as required by the appropriate military authority.

122—129. Reserved

Certified Aerodromes		**TP 308**		
NAVAID/ Approach System Capability	**Landing Surface**	**Type of Procedure**	**Minima Authorized**	**Application**
Precision	Precision	PA CAT I, II, III, NPA or APV	Applicable Minima	Public or Restricted
Precision	Non-Precision	PA, NPA or APV	250 feet HAA/HAT	Public or Restricted
Precision	Non-Instrument	PA, NPA or APV	500 feet HAA/HAT	Public or Restricted
Non-Precision/ APV	Precision	NPA or APV	250 feet HAA/HAT	Public or Restricted
Non-Precision/ APV	Non-Precision	NPA or APV	250 feet HAA/HAT	Public or Restricted
Non-Precision/ APV	Non-Instrument	NPA or APV	500 feet HAA/HAT	Public or Restricted

Non-Certified Aerodromes		**TP 308**		
NAVAID/ Approach System Capability	**Aerodrome Authorization Landing Surface**	**Type of Procedure**	**Minima Authorized**	**Application**
Precision	Non-Precision	PA, NPA or APV	250 feet HAA/HAT	Restricted
Precision	Non-Instrument	PA, NPA or APV	500 feet HAA/HAT	Restricted
Non-Precision/ APV	Non-Precision	NPA or APV	250 feet HAA/HAT	Restricted
Non-Precision/ APV	Non-Instrument	NPA or APV	500 feet HAA/HAT	Restricted
NAVAID/ Approach System Capability	**Aerodrome Operator Attestation (1)**	**Type of Procedure**	**Minima Authorized**	**Application**
Precision	Non-Precision	PA, NPA or APV	250 feet HAA/HAT	Public or Restricted
Precision	Non-Instrument	PA, NPA or APV	500 feet HAA/HAT	Public or Restricted
Non-Precision/ APV	Non-Precision	NPA or APV	250 feet HAA/HAT	Public or Restricted
Non-Precision/ APV	Non-Instrument	NPA or APV	500 feet HAA/HAT	Public or Restricted

NAVAID/ Approach System Capability	**No Aerodrome Status**	**Type of Procedure**	**Minima Authorized**	**Application**
Precision, APV Non-Precision	Landing surface designed to no standards	PA, NPA or APV	500 feet HAA/HAT	Restricted

Note: (1) Operational note providing wingspan advisory information shall be published on the instrument procedure approach plate.

Table 1-1: Instrument Procedure & Minima Authorized Versus Aerodrome Status, Para 120.a.

130. Responsibility

a. Military Aerodromes. The DND shall establish and approve terminal instrument procedures for aerodromes under their jurisdiction and be responsible for the publication of these procedures.

b. Civil Procedures at Military Aerodromes. At those military aerodromes where a need for civil approach procedures is identified, the appropriate civil authority shall formulate, coordinate with the DND, approve and publish such procedures. DND shall be informed prior to cancellation of any of these civil procedures.

c. Civil Aerodromes. The appropriate civil authority shall establish terminal instrument procedures for civil aerodromes in accordance with this publication and be responsible for the publication of these procedures.

d. Military Procedures at Civil Aerodromes. At those civil aerodromes where the DND has a special requirement for approach or departure procedures the DND shall formulate, coordinate with the appropriate civil authorities, approve and publish such procedures. The civil authority shall be informed prior to cancellation of any of these DND procedures.

131. Establish And Revise Instrument Procedures

DND or the appropriate civil authority shall establish or revise terminal instrument procedures when:

a. new facilities are installed;

b. changes to existing facilities necessitate a change to an approved procedure;

c. additional procedures are necessary;

d. new obstacles dictate revision of existing procedures.

e. there is a cyclical review to a procedure (See Para 140);

f. an operational assessment dictates;

g. there is a change to standards or criteria that may affect flight safety; or

h. there is a change to airspace structure.

132—139. Reserved

140. Formulation

Procedures shall be prepared in accordance with this publication as determined by the types of navigation facility and procedure to be used. To permit use by aircraft with limited navigational equipment the complete procedure should be, whenever possible, formulated on the basis of a single navigation facility. However, the use of an additional facility in the procedure may be considered if its use would provide an operational advantage.

141. Non-Standard Procedures

The standards contained in this publication are based on reasonable assessment of the factors that contribute to flight technical errors in aircraft navigation and maneuvering, and errors in airborne and ground facility accuracy. They are designed primarily to assure the safety of all users. The dimensions of obstacle assessment areas are influenced by the need to provide for a smooth transition to and from the en route system. Every effort shall be made to formulate procedures in accordance with these standards and criteria; however, peculiarities of terrain, navigation information, obstacles, etc. may require special consideration. In such cases, Transport Canada AARTA, or 1 Canadian Air Division/A3 Aerospace and Force Protection, as appropriate, may approve nonstandard procedures provided the deviations are fully documented and an equivalent level of safety exists. A nonstandard procedure is not a substandard procedure, but is one that has been approved after special study of the local problems has demonstrated that no degradation of safety is involved. Special civil or military procedures, which deviate from the standard because of operational necessity, and in which an equivalent level of safety is not provided, may also be approved by Transport Canada AARTA or 1 Canadian Air Division/A3 Aerospace and Force Protection, as appropriate. However, the approval will be for limited use only and the procedures shall not be published in the CAP or GPH 200. These procedures must also include a cautionary note identifying the divergence from the standards or criteria.

142—149. Reserved

150. Coordination

It is necessary to coordinate terminal instrument procedures to protect the interests of all users of airspace.

a. Military Aerodromes. Procedures shall be coordinated with the appropriate base authorities. When a procedure may conflict with other military or civil activities it shall also be coordinated with the appropriate authorities concerned with those activities. Complete coordination will be indicated by the appropriate signatures being included on the (TC) form 26-0176, “Instrument Approach Procedure”. Normally the signatures required are the procedure designer, WICP, WATCO, WOPSO, ICP Flt Comd, DICP and, where necessary, the appropriate civil authority.

b. Civil Aerodromes. Prior to establishing or revising terminal instrument procedures related to aircraft performance, e.g., descent profiles, the appropriate civil authority shall coordinate with the appropriate users as considered necessary. Coordination with DND is required when a military operating unit is based at a civil aerodrome or when the proximity of a military aerodrome may cause a procedural conflict. New or revised military procedures at civil aerodromes shall be coordinated by the appropriate WICP; with the appropriate Regional civil authority. Complete coordination will be evidenced by the appropriate signatures being included in the Instrument Procedure Design File (IPDF), (sample - TC form 26-0176, see Annex E). Required signatures include, the procedure designer, independent reviewer, flight check pilot, and applicable Air Traffic Services (ATS) representative.

c. Air Traffic Control. Prior to establishing or revising terminal instrument procedures for a military or civil aerodrome, the initiating office shall coordinate with the appropriate Air Traffic Control office.

d. Airspace Action. Where action to designate or restructure controlled airspace for a procedure is planned, such action shall be approved by Transport Canada AARTA and should be initiated sufficiently in advance so that effective dates of the procedure and the airspace action coincide. Effective dates should also coincide with approved AIRAC dates.

e. NOTAM. A NOTAM to change minimum altitudes may be issued in case of emergencies, i.e., facility outages, facility out of tolerance, new penetrations of critical surfaces, etc. However, a complete new procedure may not be issued by NOTAM, except where military requirements dictate.

151. Coordination Conflicts

Coordination conflicts, which cannot be resolved at the Regional level, shall be submitted to the Transport Canada AARTA HQ for resolution. If the problem involves a military procedure, 1 Canadian Air Division/A3 Aerospace and Force Protection and Transport Canada AARTA will take the appropriate action.

152. – 159. Reserved

160. Identification Of Procedures

Terminal instrument procedures shall be identified to be meaningful to the pilot and to permit ready identification by air traffic controllers. VOR/DME procedures predicated upon the use of a VORTAC facility may be designated “VOR/DME” or “TACAN” provided a flight inspection has determined that the TACAN and VOR components will support the procedure. These procedures require DME. The missed approach clearance limit shall be established at a radial/DME fix in lieu of the VORTAC facility to accommodate aircraft equipped with only TACAN. Holding procedures utilizing the VORTAC facility as the holding fix are not authorized for TACAN only equipped aircraft.

Provision may be made for TACAN only equipped aircraft to use VOR/DME approach procedures when requested by the appropriate military authority, and procedure design and facility performance will permit. Where approval can be authorized, VOR/DME procedures based on VORTAC facilities will be identified with the following examples: “VOR/DME or TACAN RWY 30” or “VOR/DME or TACAN A”. Before this identification can be used, a flight inspection must determine that the TACAN azimuth alignment is satisfactory and the procedure will be reviewed and modified as necessary to fully support its use by TACAN equipped aircraft to include the following:

a. establish the missed approach clearance limit at a combination VHF/DME fix;

b. add DME fix capability to VHF intersections where required for TACAN use;

c. ensure that the procedure can be flown satisfactorily by reference to TACAN only equipment;

d. ensure that the procedure can be flown satisfactorily by reference to VOR only equipment; and

e. ensure that holding is not authorized for TACAN equipped aircraft at the VORTAC facility.

161. Straight-In Procedure Identification

Procedures which meet criteria for authorization of straight-in landing minima shall be identified by a prefix describing the navigation system providing the final approach guidance and the runway to which the final approach is aligned. A slash (/) shall indicate that more than one type of equipment is required to execute the final approach. When procedures are combined, the word "or" shall indicate that either type of equipment may be used to execute the final approach.

Examples:

a. ILS RWY 18, LOC (BC) RWY 26, TACAN RWY 36, NDB RWY 21, VOR RWY 25, MLS RWY 06.

b. VOR/DME RWY 23, ILS/DME RWY 35, ILS/TACAN RWY 07.

c. VOR/DME or TACAN RWY 18, ILS or NDB RWY 36.

Where a step-down fix permits descent to a lower MDA than one based only on the navigation aid providing final approach guidance, the procedure shall be identified by that navigation aid. In addition the approach shall also be identified by that aid and the aid defining the step-down fix, e.g., VOR/DME or VOR. The minima shall be specified for both with and without the step-down fix. See Para 288.

Where the procedure is within the Northern Domestic Airspace the procedure identification shall be suffixed with "TRUE" or "GRID", e.g., VOR RWY 18 TRUE, TACAN RWY 18 GRID.

Where the same final approach guidance is used to the same runway, the procedures shall be identified as follows: VOR 1 RWY 18, VOR 2 RWY 18. In the case of GNSS based procedures, the procedures would be named RNAV (GNSS) Z RWY 16, RNAV (GNSS) Y RWY 16.

162. Circling Procedure Identification

When a procedure does not meet the criteria for straight-in landing minima authorization it shall be identified by the type of navigational aid that provides the final approach guidance and an alphabetical suffix. The first procedure formulated shall bear the suffix "A" even though there may be no intention to formulate additional procedures. If additional procedures are formulated they shall be identified alphabetically in sequence, e.g., VOR A, VOR/DME B, NDB C. A revised procedure will bear its original identification.

Where the procedure is within the Northern Domestic Airspace the procedure identification shall be suffixed with "TRUE" or "GRID", e.g., VOR A TRUE, TACAN A GRID.

163. Differentiation

Where high altitude procedures are required the procedure identification shall be prefixed with the letters "HI", e.g., HI TACAN RWY 15.

164. – 169. Reserved

170. Submission

Instrument procedures shall be submitted on forms as detailed in Annex E.

a. DND procedures shall be submitted by the designer in accordance with GPH 209 and 1 Cdn Air Div Orders, Vol 2, 2-009, instruction for Developing and Revising Instrument Procedures. A proper and complete submission shall include copies of all maps and calculations used in the development of the procedure and a sufficient number of copies of the completed draft to provide all intermediate agencies with at least one copy.

b. Civil procedures (public or restricted) shall be submitted in accordance with the information contained in NAV CANADA's, AIS Procedures Manual (AISPM).

c. When a procedure is submitted it shall show the name and signature of the Designer, Independent Reviewer, Flight Check Pilot, and the individual responsible for ATS coordination.

171. Issuance

a. DND is responsible for the release of military approved instrument procedures.

b. NAV CANADA is responsible for the release and distribution of all other instrument procedures.

172. Effective Date

Instrument procedures and revisions thereto shall be processed in sufficient time to permit publication and distribution in advance of the effective ICAO, Aeronautical Information Regulation and Control (AIRAC) date. Effective dates should normally coincide with scheduled airspace changes except when safety or operational effectiveness is jeopardized. In this case the originator shall specify an appropriate effective date.

173—179. Reserved

180. GPH 209/TP 308 Amendment Procedures

Amendments to GPH 209/TP 308 should normally be produced once per year. Bases/Agencies may submit amendment proposals to DICP/Transport Canada AARTA at anytime. DICP and Transport Canada AARTA staffs shall meet to review proposals for incorporation as appropriate. DND/TC Aviation will liaise with the DOD/FAA regarding U.S. TERPS.

181. Amendment Printing/Distribution

DICP and TC AARTA shall incorporate the adopted amendments into GPH 209/TP 308. Transport Canada AARTA shall prepare the amendment directive and coordinate the publishing requirements.

182. Computation/Submission Forms

Forms detailed in this manual may be reproduced locally either by photocopy or a facsimile computer generation.

183—199. Reserved

CHAPTER 2. GENERAL CRITERIA

200. Scope

This chapter contains only that information common to all types of terminal instrument procedures. Criteria that do not have general application are located in the individual chapters concerned with the specific types of facilities.

SECTION 1. COMMON INFORMATION

201. TP308/GPH209 Criteria

a. TP308/GPH209 specifies the minimum measure of obstacle clearance that is considered by Transport Canada, to supply a satisfactory level of vertical protection. The validity of the protection is dependent, in part, on assumed aircraft performance. In the case of TP308/GPH209, it is assumed that aircraft will perform within certification requirements.

b. The following is an excerpt from the foreword of this document: "These criteria are predicated on normal aircraft operations for considering obstacle clearance requirements." Normal aircraft operation means all aircraft systems are functioning normally, all required navigational aids (NAVAID's) are performing within flight inspection parameters, and the pilot is conducting operations utilizing instrument procedures based on TP308/GPH209 standards to provide the required obstacle clearance (ROC). While the application of TP308/GPH209 criteria indirectly addresses issues of flyability and efficient use of NAVAID's, the major safety contribution is the provision of obstacle clearance standards. This facet of TP308/GPH209 allows aeronautical navigation in instrument meteorological conditions (IMC) without fear of collision with unseen obstacles. ROC is provided through application of level and sloping Obstacle Clearance Surfaces (OCS).

202. Level OCS.

The level OCS concept is applicable to “level flight” segments. These segments are level flight operations intended for en route, initial, intermediate segments, and non-precision final approaches. A single ROC value is applied over the length of the segment. These values were determined through testing and observation of aircraft and pilot performance in various flight conditions. Typical ROC values are: for en route procedure segments, 1,000 feet (1,500 or 2,000 over mountainous terrain), as designated in TP1820 - Designated Airspace Handbook; and for initial segments, 1,000 feet, 500 feet in intermediate segments, and 350/300/250 feet in final segments.

a. This method of applying ROC results in a horizontal band of airspace that cannot be penetrated by obstacles. Since obstacles always extend upward from the ground, the bottom surface of the ROC band is mathematically placed on top of the highest obstacle within the segment. The depth (ROC value) of the band is added to the obstacle height to determine the minimum altitude authorized for the segment. The bottom surface of the ROC band is referred to as the level OCS. Therefore, level flight segments are evaluated by the level OCS application standard (see Figure 2-1-1).

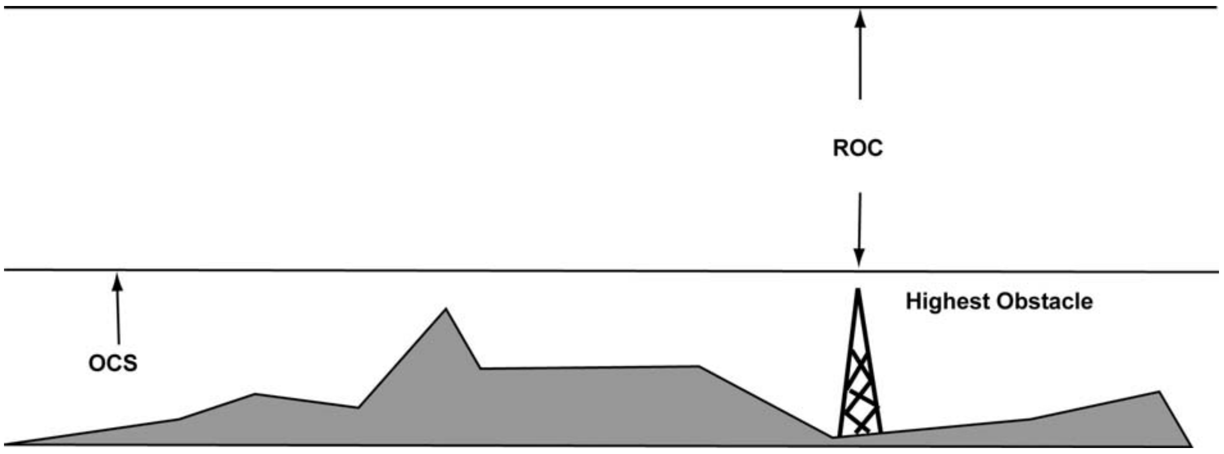
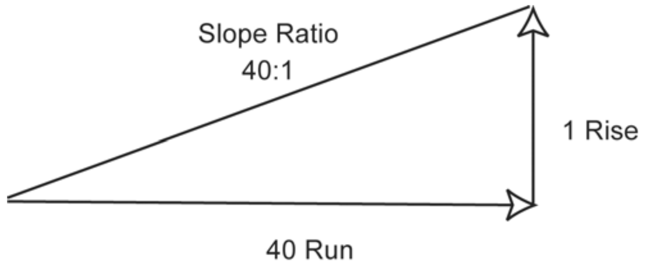


Figure 2-1-1: Minimum Segment Altitude. Para 202.a.

203. Sloping Obstacle Clearance Surfaces (OCS).

The method of applying ROC, in segments dedicated to descending on a glidepath or climbing in a departure or missed approach segment, requires a different obstacle clearance concept than the level OCS because the ROC value must vary throughout the segment. The value of ROC near the runway is relatively small, and the value at the opposite end of the segment is sufficient to satisfy one of the level surface standards as per Para 202. It follows then, that a sloping OCS is a more appropriate method of ROC application.



Note: Slope ratios are normally expressed in terms of rise over run in engineering and professional technical jargon. However, TP308/GPH209 has traditionally expressed slope ratios in terms of run over rise; e.g., 34:1, 40:1 (see Figure 2-1a).

Figure 2-1a: Slope Ratio. Para 203.a.

a. Descending on a Precision Glidepath. The obstacle evaluation method for descent on a glidepath is the application of a descending OCS below the glidepath. The vertical distance between the glidepath and the OCS is ROC; i.e., ROC = (glidepath height) - (OCS height). The ROC decreases with distance from the FAF as the OCS and glidepath converge on the approach surface baseline (ASBL) height (see Figure 2-1-2). The OCS slope and glidepath angle values are interdependent: OCS Slope = 102 ÷ glidepath angle; or glidepath angle = 102 ÷ OCS slope. This relationship is the standard that determines the ROC value since ROC = (glidepath height)-(OCS height).

(1) If the OCS is penetrated, the OCS slope may be adjusted upward, thereby increasing the glidepath angle. The glidepath angle would increase because it is dependent on the required slope.

(2) Descent on a glidepath generated by systems that do not meet the system precision requirements of ICAO Annex 10, such as barometric vertical navigation (Baro-VNAV), provide ROC through application of a descending sloping surface based on standards using differing formulas, but the concept is the same.

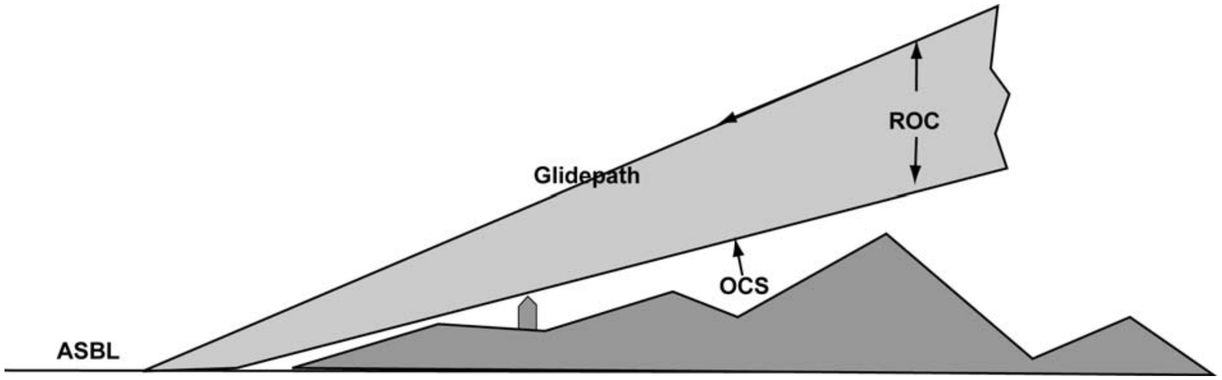


Figure 2-1-2: Precision Glide Path Descent. Para 203.a.

b. Climbing on departure or missed approach. The concept of providing obstacle clearance in the climb segment, in instrument procedures, is based on the aircraft maintaining a minimum climb gradient. The climb gradient must be sufficient to increase obstacle clearance along the flightpath so that the minimum ROC for the subsequent segment is achieved prior to leaving the climb segment (see Figure 2-1-3). For TP308/GPH209 purposes, the MINIMUM climb gradient that will provide adequate ROC in the climb segment is 200 ft/NM.

(1) The obstacle evaluation method for a climb segment is the application of a rising OCS below the minimum climbing flightpath. Whether the climb is for departure or missed approach is immaterial. The vertical distance between the climbing flightpath and the OCS is ROC. ROC for a climbing segment is defined as ROC = 0.24CG. This concept is often called the 24% rule. Altitude gained is dependent on climb gradient (CG) expressed in feet per NM. The minimum ROC supplied by the 200 ft/NM CG is 48 ft/NM (0.24 x 200 = 48). Since 48 of the 200 feet gained in 1 NM is ROC, the OCS height at that point must be 152 feet (200 – 48=152), or 76% of the CG (152 ÷ 200=0.76). The slope of a surface that rises 152 over 1 NM is 40 (6076.11548 ÷ 152 = 39.97 = 40).

(2) Where an obstruction penetrates the OCS, a non-standard climb gradient (greater than 200 ft/NM) is required to provide adequate ROC. Since the climb gradient will be greater than 200 ft/NM, ROC will be greater than 48 ft/NM (0.24 x CG>200=ROC>48). The non-standard ROC expressed in ft/NM can be calculated using the formula: (0.24h) ÷ (0.76d) where "h" is the height of the obstacle above the altitude from which the climb is initiated, and "d" is the distance in NM from the initiation of climb to the obstacle. Normally, instead of calculating the non-standard ROC value, the required climb gradient is calculated directly using the formula: h ÷ (0.76d).

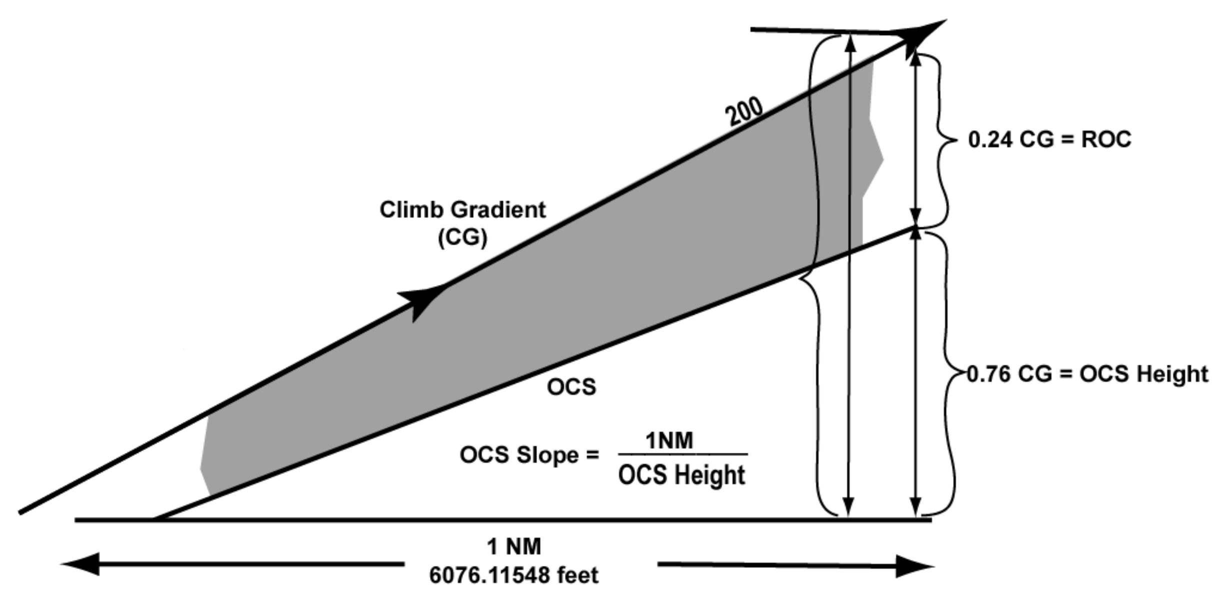


Figure 2-1-3: Climb Segment. Para 203.b.

c. In the case of an instrument departure, the OCS is applied during the climb until at least the minimum en route value of ROC is attained. The OCS begins at the departure end of runway, at the elevation of the runway end. It is assumed aircraft will cross the departure end-of-runway at a height of at least 35 feet. However, for TP308/GPH209 purposes, aircraft are assumed to lift off at the runway end (unless the procedures state otherwise). The ROC value is zero at the runway end, and increases along the departure route until the appropriate ROC value is attained to allow en route flight to commence.

d. In the case of a missed approach procedure, the climbing flight path starts at the height of MDA or DA minus height loss. The OCS starts approximately at the MAP/DA point at an altitude of MDA/DA minus the final segment ROC and adjustments. Therefore, the final segment ROC is assured at the beginning of the OCS, and increases as the missed approach route progresses. The OCS is applied until at least the minimum initial or en route value of ROC is attained, as appropriate.

e. Extraordinary circumstances, such as a mechanical or electrical malfunction, may prevent an aircraft from achieving the 200 ft/NM minimum climb gradient assumed by TP308/GPH209. In these cases, adequate obstacle clearance may not be provided by published instrument procedures. Operational procedures contained outside TP308/GPH209 guidelines are required to cope with these abnormal scenarios.

204—209. Reserved

210. Units Of Measurement

a. Bearings, Courses and Radials.

(1) Bearings and courses shall be expressed in degrees magnetic, except that true and/or grid shall be used within the Northern Domestic Airspace;

(2) Radials. VOR/TACAN radials shall normally be identified as the magnetic bearing FROM the facility and shall be prefixed with the letter "R" (e.g., R-130). When the facility is within the Northern Domestic Airspace and is oriented with grid (DND) or true north, radials shall be so indicated (e.g., R-130G, R-130T).

b. Altitudes. The unit of measure for altitude in this publication is feet

(1) Published altitudes in the areas of the Altimeter Setting Region shall be expressed in feet above MSL, e.g. 17,900 feet. Published altitudes above the transition level (18,000 ft.) shall be expressed as flight levels (FL); e.g. FL190. Normally, altitudes at the transition level will not be used.

(2) MDAs shall be rounded off to the next higher 20-foot increment;

(3) all other altitudes expressed in the approach shall be rounded off to the next higher 20-foot increment, except the ILS glide path check altitude which shall be rounded off to the nearest 10-foot increment.

(4) DA and DH values shall be rounded off to the next higher 1-foot increment (see Para 322, Note 1).

c. Distances. Distances are to be expressed in nautical miles (6,076.11548 feet or 1852.0 meters per NM) and hundredths thereof), except:

(1) Where feet are required,

(2) Visibilities are expressed in statute miles (5280 feet per SM) and fractions thereof; and

(3) Runway Visual Range (RVR) is expressed in multiples of one hundred feet by increments of:

(a) 200 feet from 600 feet to 3,000 feet; and

(b) 500 feet from 3,000 feet to 6,000 feet.

Use the following formulas for feet and meter conversions:

$$\text{feet} = \frac{\text{meters}}{0.3048} \qquad \text{meters} = \text{feet} \times 0.3048$$

d. Speeds. Aircraft speeds shall be expressed in knots indicated airspeed (KIAS).

211. Positive Course Guidance (PCG)

Positive course guidance shall be provided for feeder routes, initial (except as provided for in Para 233.b), intermediate, and final approach segments. The segments of a procedure wherein positive course guidance is provided should be within the service volume of the facility(ies) used. Positive course guidance may be provided by one or more of the navigation systems for which criteria has been published herein.

212. Aircraft Categories

Aircraft performance directly affects the amount of airspace and the visibility, which is required for maneuvering during instrument procedures. The varying performance is acknowledged by the following system of aircraft speed categories.

Category A — speed less than 91 knots
Category B — speed 91 knots or more but less than 121 knots
Category C — speed 121 knots or more but less than 141 knots
Category D — speed 141 knots or more but less than 166 knots
Category E — speed 166 knots and greater

213. Aircraft Category Application

The approach category operating characteristics shall be used to determine turning radii, minimums, and obstacle clearance areas for circling, missed approach and certain departure procedures. When designing an instrument procedure, Category A, B, C and D normally will be considered for civil procedures and Category B, C, D and E will be considered for military procedures.

214. Procedure Construction

An instrument approach procedure (IAP) may have four separate segments. They are the initial, the intermediate, the final, and the missed approach segments. In addition, an area for circling the airport under visual conditions shall be considered. An approach segment begins and ends at the plotted position of the fix; however, under some circumstances certain segments may begin at specified points where no fixes are available. The fixes are named to coincide with the associated segment. For example, the intermediate segment begins at the intermediate fix (IF) and ends at the final approach fix (FAF). The order in which this chapter discusses the segments is the same order in which the pilot would fly them in a completed procedure; that is from an initial, through an intermediate, to a final approach. Only those segments that are required by local conditions need to be included in a procedure. In constructing the procedure, the final approach course (FAC) should be identified first because it is the least flexible and most critical of all the segments. When the final approach has been determined, the other segments should be blended with it to produce an orderly maneuvering pattern that is responsive to the local traffic flow. Consideration shall also be given to any accompanying controlled airspace to the extent it is feasible (see Figure 2-1-4).

215. Instrument Procedures And Class "F" Airspace

Instrument procedures may come in conflict with Class “F” airspace. Normally, the primary area obstacle clearance surface shall not penetrate the Class “F” airspace, however, instrument approach procedures may exist within Class “F” airspace when it is established for security reasons.

The vertical clearance from Class “F” airspace will vary depending upon the activity within the Class “F” airspace and the potential for conflict. The ROC for the instrument approach procedure segment overlying the Class “F” should be used as a guideline to establish obstacle clearance. In no case shall the ROC be less than 100 feet.

a. Where Class “F” restricted or advisory airspace has been established for military purposes or flight training activities, then the maximum ROC shall be applied.

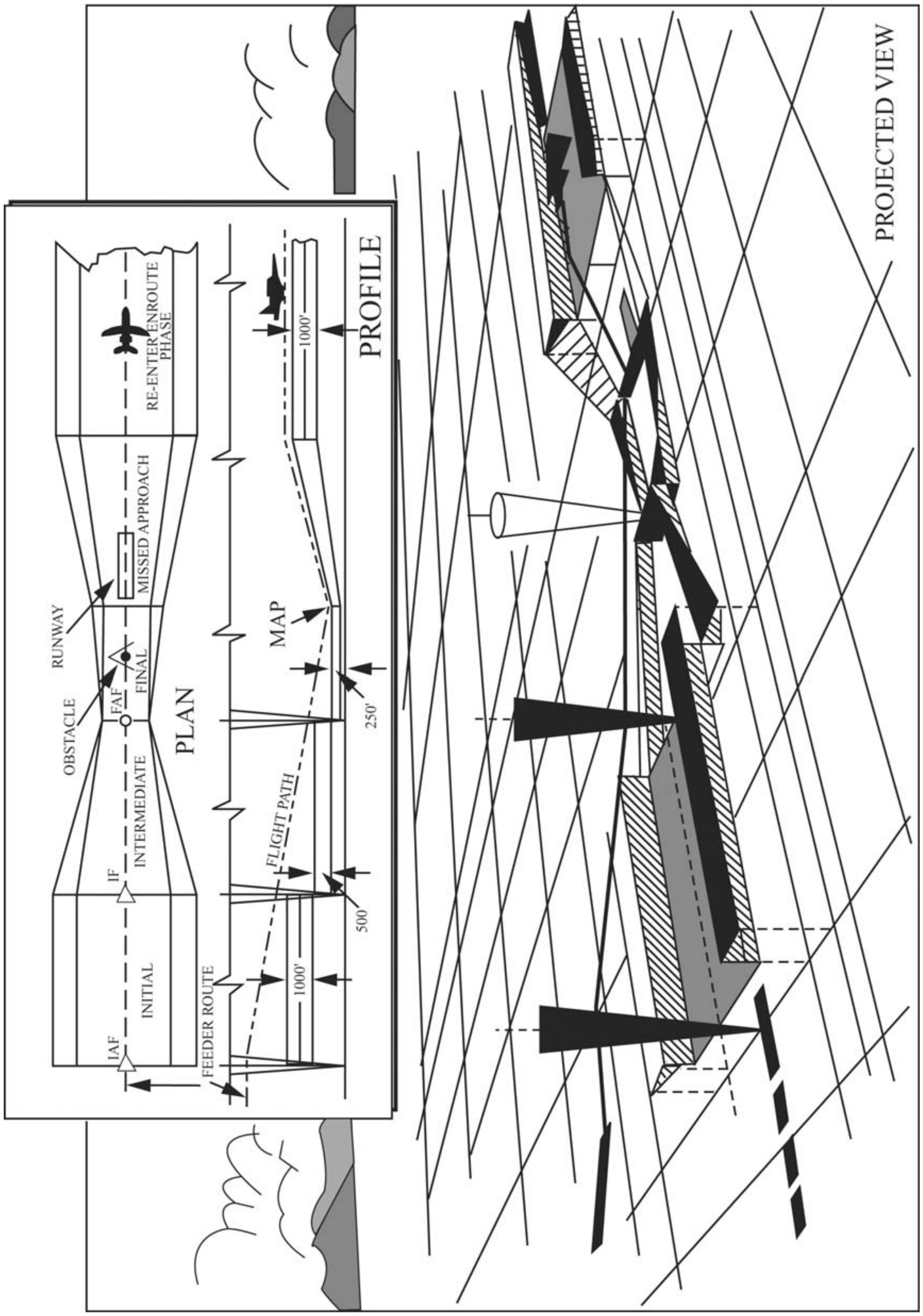


Figure 2-1-4: Segments Of An Approach Procedure. Para 214.

b. Where Class “F” restricted airspace has been established for security reasons e.g. over a prison, the instrument procedure designer may elect to use a minimum of 100 feet of ROC.

c. Where Class “F” restricted airspace has been established for security reasons, e.g. visiting dignitaries, instrument procedures may exist within the Class “F”, and authorization to fly the procedure may be given by the Controlling Agency.

d. For missed approach and departure procedures Class F airspace shall not penetrate the OCS.

Note: Where Class “F” airspace influences an instrument procedure, the type of activity within the Class “F” shall be documented, as well as the amount of ROC that has been applied. Other known areas that could constitute a hazard, such as known blasting areas, should be treated as Class “F” airspace and documented.”

216. Controlling Obstacle(s)

The controlling obstacle in each segment of the procedure shall be identified in the documentation submitted with the procedure. The minimum accuracy standards (Annex J) apply to all controlling obstacles. When assessing contour lines on a topographical map to determine obstacle height, the accepted method is to use the contour that is on or in the trapezoid being assessed. To this figure, add the next contour interval MINUS one contour unit (foot/metre, as appropriate). If the area is treed, then the average tree height (determined from local forestry authorities) is added to the terrain elevation. A survey or a well-documented flight check process may confirm controlling obstacle elevations that are questionable.

In determining the height of mobile objects, the following standard shall be used:

a. 15.5 feet for mobile obstacles traversing multi-lane controlled access highways where over crossings are designed for a maximum of 15.5 feet vertical distance;

b. 15 feet for any other public roadway;

c. for a private roadway, 10 feet or the height of the highest mobile object, whichever is greater, that would normally traverse the road;

d. 23 feet for a railroad; and

e. for a waterway or any other traverse way not previously mentioned, an amount equal to the height of the highest mobile object that would normally traverse it.

217—219. Reserved

SECTION 2. EN ROUTE OPERATIONS

220. Feeder Routes

When the Initial Approach Fix (IAF) is part of the en route structure, there may be no need to designate additional routes for aircraft to proceed to the IAF. In some cases, however, it is necessary to designate feeder routes from the en route structure to the IAF. Only those feeder routes, which provide an operational advantage, shall be established and published. These should coincide with the local air traffic flow. The length of the feeder route shall not exceed the operational service volume of the facilities that provide navigational guidance, unless additional frequency protection is provided. En route airway obstacle clearance criteria normally apply to feeder routes, however feeder routes that are 25 NM or less may have 1,000 feet ROC applied. Feeder routes greater than 25 NM shall have en route airway obstacle clearance (Chapter 17) criteria applied. The minimum altitude established on feeder routes shall not be less than the altitude established at the IAF.

a. Construction of a feeder route connecting to a course reversal segment. The area considered for obstacle evaluation is oriented along the feeder route at a width appropriate to the type of route (VOR or NDB). The area terminates at the course reversal fix, and is defined by a line perpendicular to the feeder course through the course reversal fix.

b. The angle of intersection between the feeder route course and the next straight segment (feeder/initial) course shall not exceed 120°.

Descent Gradient. The OPTIMUM descent gradient of the feeder route is 250 feet per NM. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 500 feet per NM. The OPTIMUM descent gradient for high altitude penetrations is 800 feet per NM. Where a higher descent gradient is necessary, the MAXIMUM permissible is 1000 feet per NM.

221. Safe Altitude/Minimum Sector Altitude (MSA)

A minimum safe altitude is the minimum altitude which provides at least 1,000 feet of obstacle clearance for emergency use, within a specified distance from the RNAV WP/primary navigation facility upon which a procedure is predicated or the aerodrome geographic centre (safe altitude 100 NM). These altitudes shall be rounded to the next higher 100-foot increment. Such altitudes will be identified as minimum sector altitudes or safe altitudes and shall be established as follows:

a. Minimum Sector Altitude (MSA). Establish an MSA for all procedures within a 25-mile radius of the WP/ facility, including the area 4 NM beyond the outer boundary. When the distance from the facility to the airport exceeds 25 NM, the radius shall be expanded to include the airport landing surfaces up to a maximum distance of 30 NM (see Figure 2-2-1). When the procedure does not use an omnidirectional facility, e.g. LOC [BC] with a fix for the FAF, use the primary omnidirectional facility in the area. If necessary to offer relief from obstacles, establish sector divisions, or a common safe altitude (no sectors) for the entire area around the facility. Sectors shall not be less than 90° in spread. Sector altitudes should be raised and combined with adjacent higher sectors when a height difference does not exceed 300 feet. A sector altitude shall also provide 1,000 feet of obstacle clearance in the adjacent sector or periphery area within 4 NM of the sector boundary line. For area navigation (RNAV) procedures, establish a common altitude within the specified radius of the runway waypoint (RWY WP), (normally the MAWP), for straight-in approaches; the airport waypoint (APT WP) for circling procedures; or for GPS approaches, from the WP used for the MSA centre (see Figure 2-2-2). APT WP is the same as the geographic centre of aerodrome.

b. Safe Altitude 100 NM. A safe altitude shall be established within a 100-NM radius of the geographic centre of the aerodrome. Where a requirement exists for these altitudes, these shall be established with a common altitude for the entire area. Where these altitudes are established in designated mountainous regions, they shall provide the appropriate obstacle clearance, either 1,500 or 2,000 feet. These altitudes shall be identified in published procedures as "Safe Altitude 100 NM".

222—229. reserved

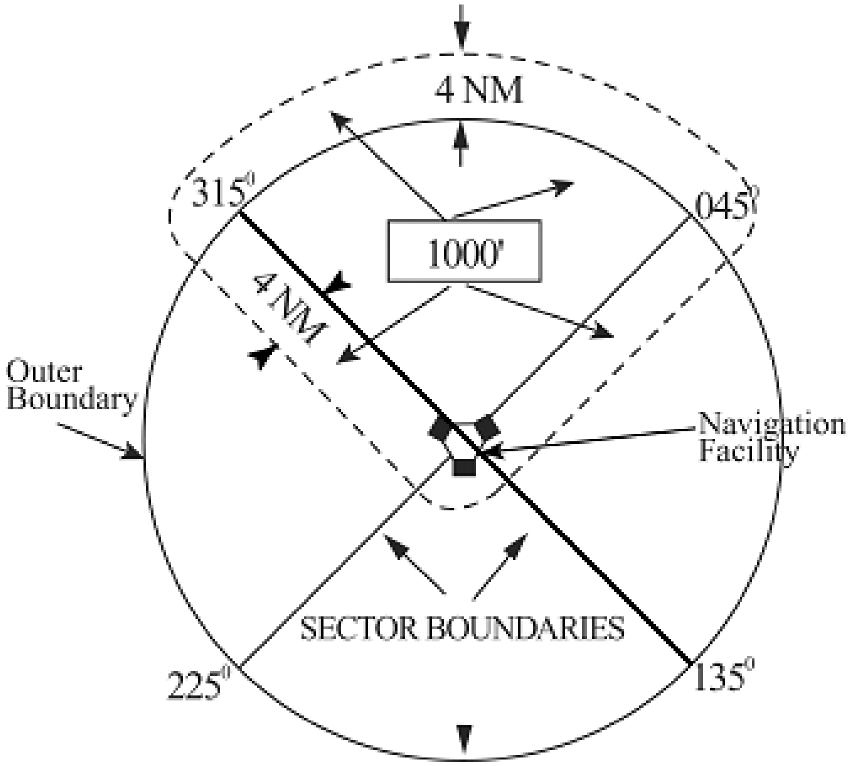


Figure 2-2-1: Non-RNAV MSA. Para 221.

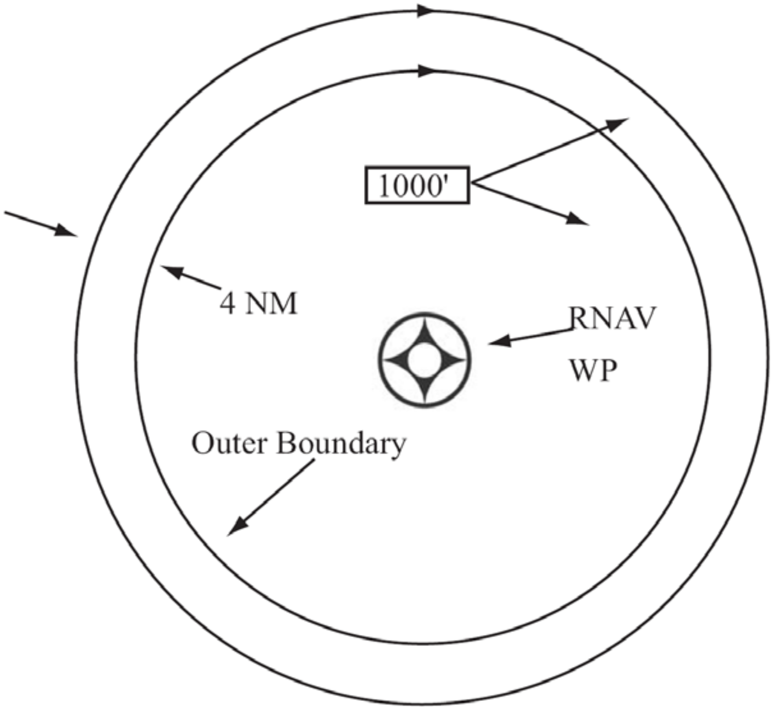


Figure 2-2-2: RNAV MSA. Para 221.

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SECTION 3. INITIAL APPROACH

230. Initial Approach Segment

The instrument approach commences at the IAF. In the initial approach the aircraft has departed the en route phase of flight, and is maneuvering to enter the intermediate segment. When the IF is part of the en route structure, it may not be necessary to designate an initial approach segment. In this case the approach commences at the IF and intermediate segment criteria apply. An initial approach may be made along an arc, radial, course, heading, or radar vector, or a combination thereof. Procedure turns, holding pattern descents, and high altitude penetrations are initial segments. Positive course (track) guidance is required except when dead reckoning courses can be established over limited distances. Although more than one initial approach may be established for a procedure, the number should be limited to that which is justified by traffic flow or other operational requirements. Where holding is required prior to entering the initial approach segment, the holding fix and IAF should coincide. When this is not possible the IAF shall be located within the holding pattern on the inbound holding course.

231. Altitude Selection

Minimum altitudes in the initial approach segment shall be established in 100-foot increments; i.e., 1,549 feet may be shown as 1,500 feet as long as the ROC is not violated and 1,550 shall be shown as 1,600 feet. The altitude selected shall not be below the PT altitude where a PT is required. In addition, altitudes specified in the initial approach segment must not be lower than any altitude specified for any portion of the intermediate or final approach segments.

232. Initial Approach Segments Based On Straight Courses And Arcs With Positive Course Guidance (PCG)

a. Alignment.

(1) Courses. The angle of intersection between the initial approach course and the intermediate course shall not exceed 120°. When the angle is 90° or greater, a lead radial/bearing, which provides 2 NM of lead, shall be identified to assist in leading the turn onto the intermediate course (see Figure 2-3).

(2) Arcs. An arc may provide course guidance for all or a portion of an initial approach. The minimum arc radius shall be 7 NM, except for high altitude procedures, in which the minimum radius shall be at least 15 NM. When an arc of less than 15 NM radius is used in high altitude procedures, the descent gradient along the arc shall not exceed the criteria in Para 232.d and Table 2-1. An arc may join a course at or before the IF. When joining a course on or before the IF, the angle of intersection of the arc and the fix course shall not exceed 120°. When the angle is 90° or greater, a fix, lead radial or lead bearing which provides at least 2 NM of lead shall be identified to assist in leading the turn onto the intermediate course. DME arc courses should be predicated on collocated VOR/DME, NDB/DME or TACAN facilities. Where an operational advantage can be achieved non-collocated facilities may be used providing the two facilities are within 4 NM of each other and the angle subtended by the line joining the aircraft to the DME source and the bearing to the track guidance facility does not exceed 8°.

MILES (nm)	Max Ft. Per nm
15	1,000
14	720
13	640
12	560
11	480
10	400
9	320
8	240
7	160

Table 2-1: Descent Gradient On High Altitude Arc Of Less Than 15 NM. Para 232a(2).

$$D_{ARC} = \frac{RadiusXAngle}{57.3}$$

D_{ARC} = Distance flown along arc

Lead Radial (LR) or Lead Bearing (LB) = (2 x 57.3)/ radius of the arc

Angle = number of degrees of arc flown

b. Area. The initial approach segment has no standard length. The length shall be sufficient to permit the altitude change required by the procedure and shall not exceed 50 NM unless an operational requirement exists. The total width of the initial approach segment shall be 6 NM on each side of the initial approach course. This width is divided into a primary area, which extends laterally 4 NM on each side of the course, and a secondary area, which extends laterally 2 NM on each side of the primary area (see Figure 2-10). When any portion of the initial approach is more than 50 NM from the navigation facility, the criteria for en route airways shall apply to that portion.

c. Obstacle Clearance. The obstacle clearance in the initial approach primary area shall be a minimum of 1,000 feet. In the secondary area 500 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge (see Figure 2-6a). The minimum obstacle clearance required at any given point in the secondary area is shown in Annex C, Figure C-3. Allowance for precipitous terrain should be made, as specified in Para 323.a. The altitudes selected by application of the obstacle clearance specified in this paragraph shall be rounded to the next higher 100-foot increment (see Para 231).

d. Descent Gradient. The OPTIMUM descent gradient in the initial approach is 250 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 500 feet per mile. The OPTIMUM descent gradient for high altitude penetrations is 800 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 1,000 feet per mile. The maximum descent gradient for a high altitude arc of less than 15-mile radius is found in Table 2-1.

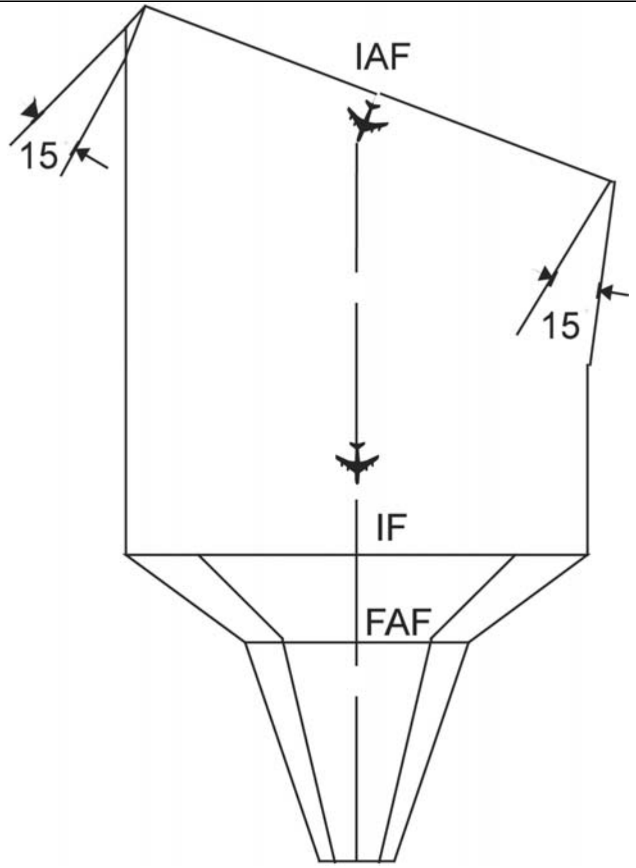


Figure 2-4-1: Most Common DR Segment. Para 233.b.

233. Initial Approach Segment Based On Dead Reckoning (DR)

a. Alignment. Each DR course shall intercept the extended intermediate course. For LOW altitude procedures the intercept point shall be at least 1 mile from the IF for each 2 NM of DR flown. For HIGH altitude procedures the intercept point shall be 1 mile prior to the IF for each 3 NM of DR flown. The intercept angle shall:

   (1) not exceed 90°; and

   (2) not be less than 45° except when DME is used or the DR distance is 3 NM or less.

b. Area. The MAXIMUM length of the DR portion of the initial segment is 10 NM (except Para 232.b applies for HIGH altitude procedures where DME is available throughout the DR segment). Where the DR course begins, the width is 6 NM on each side of the course, expanding outward by 15° until joining the points as depicted in Figures 2-4-1, 2-4-2, 2-4-3, 2-4-4, and 2-4-5.

c. Obstacle Clearance. The obstacle clearance in the DR initial approach segment shall be a minimum 1,000 feet. There is no secondary area. Allowance for precipitous terrain should be considered as specified in Para 323.a. The altitudes selected by application of the obstacle clearance specified in this paragraph shall be rounded in accordance with Para 231.

d. Descent Gradient. The OPTIMUM descent gradient in the initial approach is 250 feet per mile. Where a higher descent gradient is necessary, the maximum permissible gradient is 500 feet per mile. The OPTIMUM descent gradient for high altitude penetrations is 800 feet per mile. Where a higher descent gradient is necessary, the maximum permissible gradient is 1,000 feet per mile.

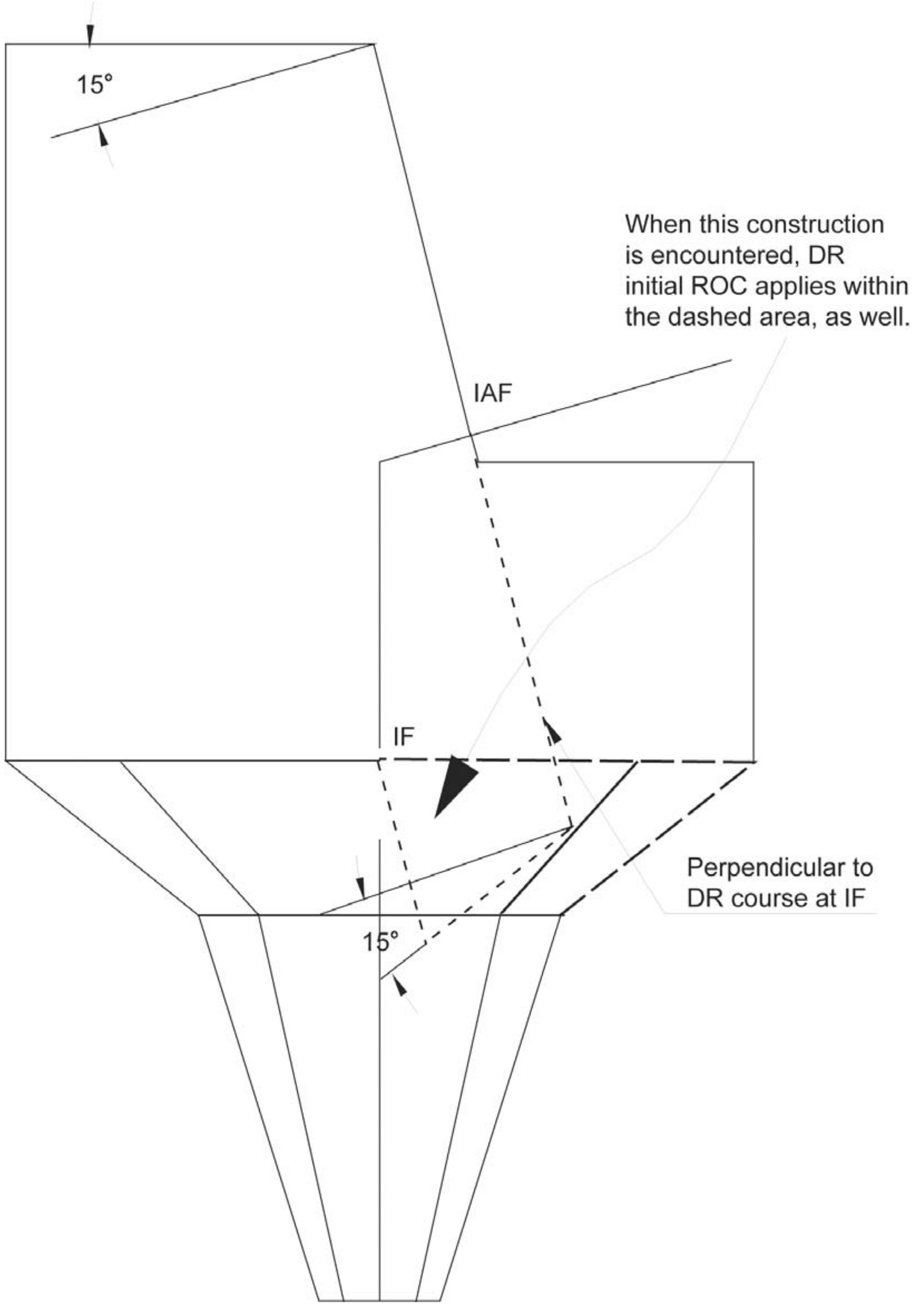


Figure 2-4-2: DR Segment With Boundary Inside The Intermediate Segment. Para 233.b.

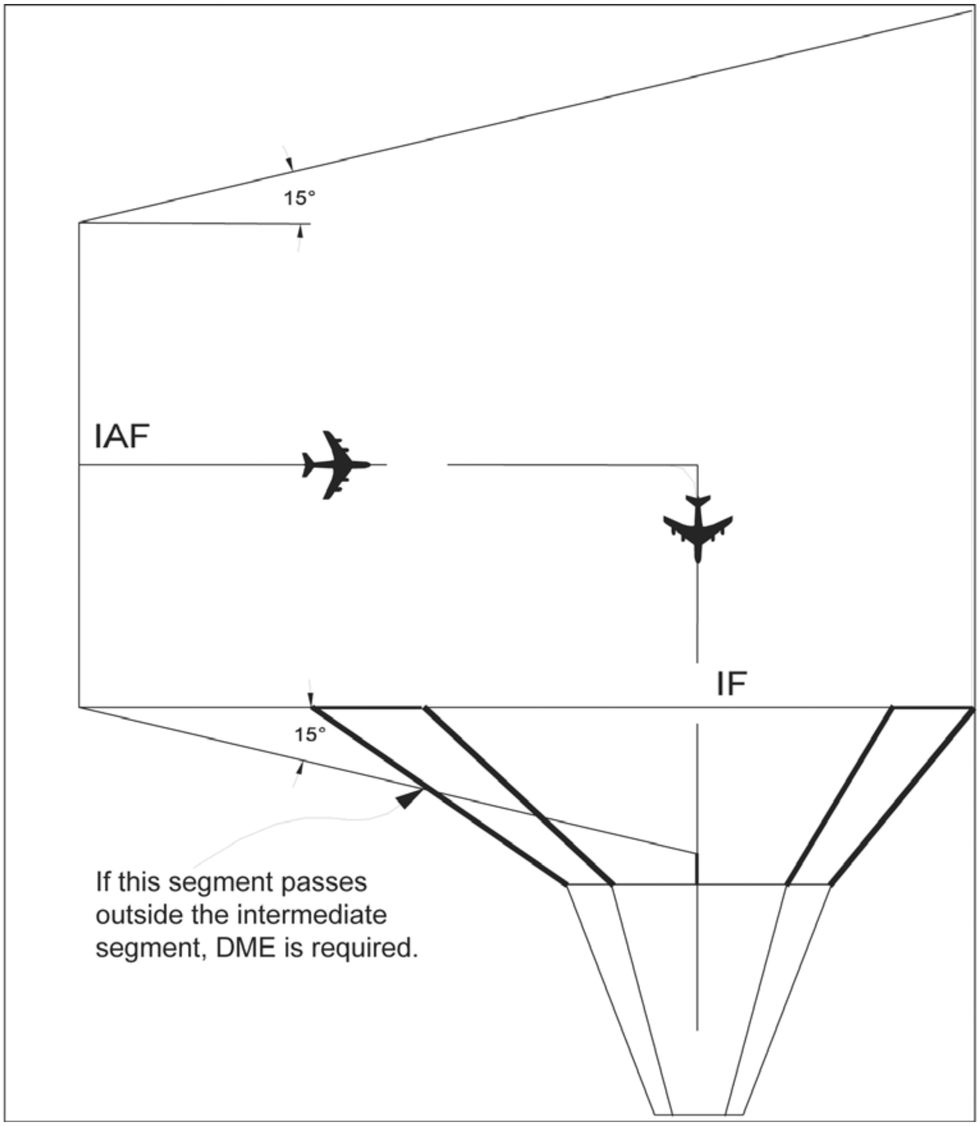


Figure 2-4-3: DR Segment With Boundary Intercepting The Intermediate Segment. Para 233.

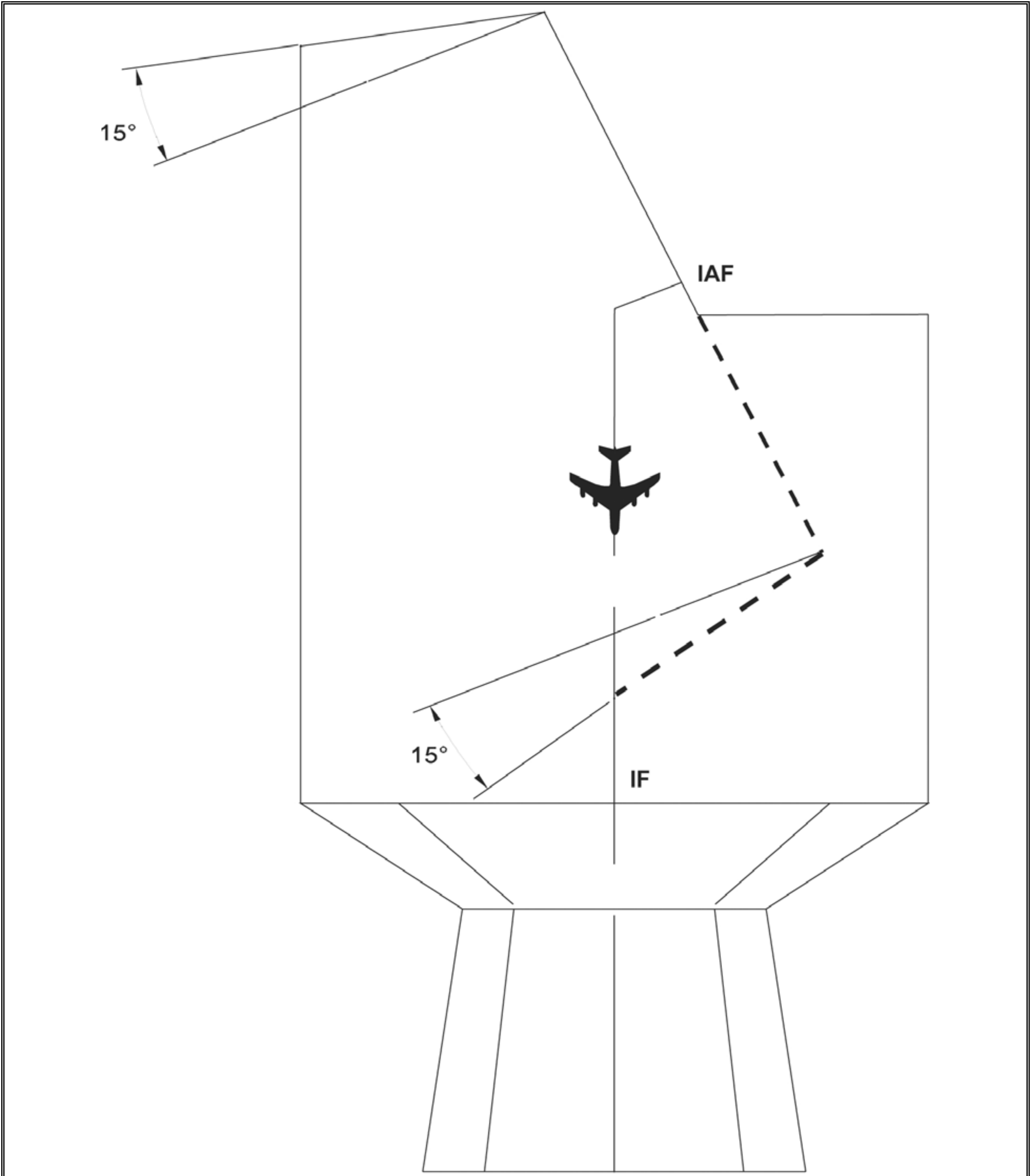


Figure 2-4-4: DR Initial Segment With Boundary Inside The Straight Initial Segment. Para 233.b.

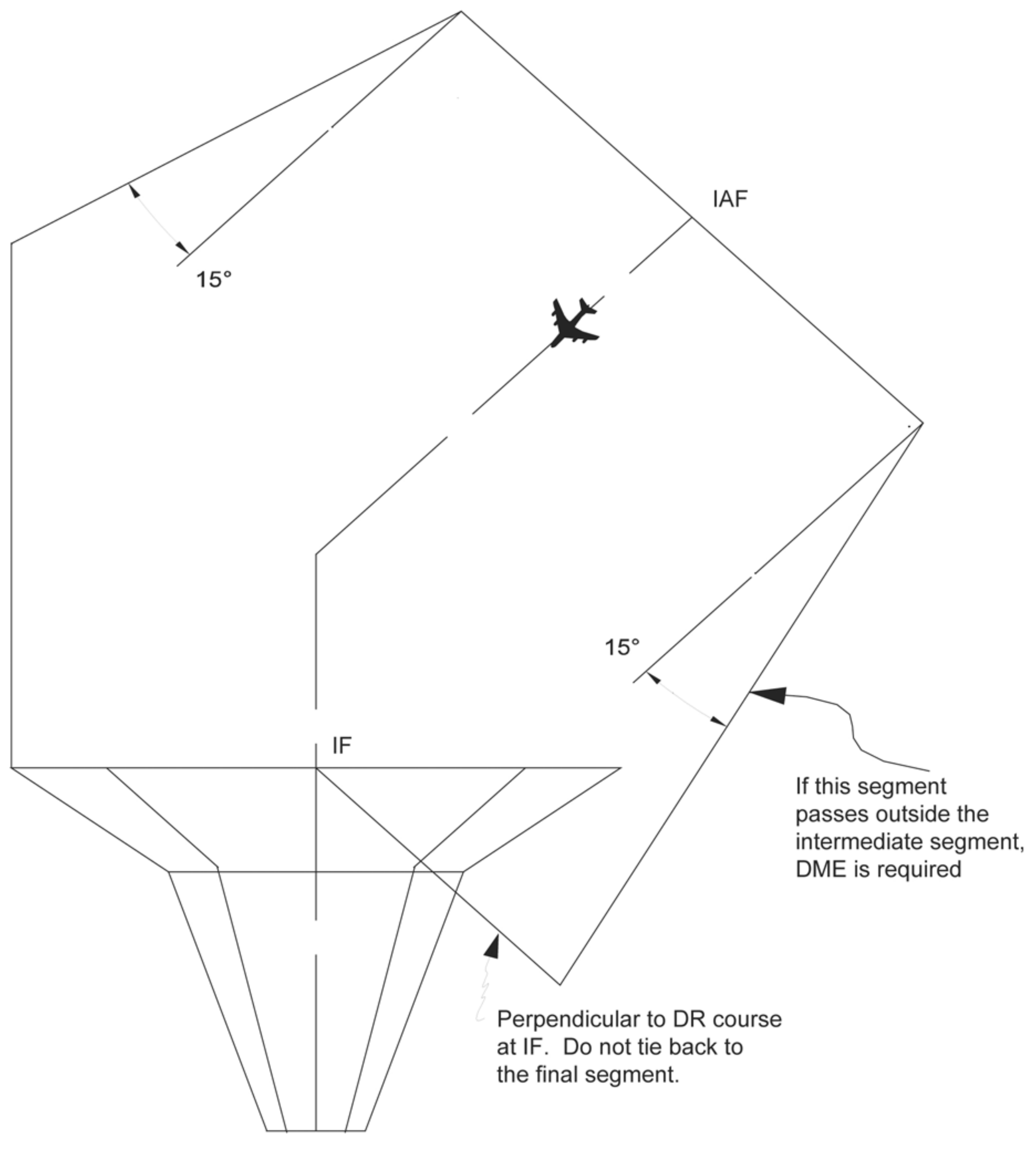


Figure 2-4-5: DR Initial Segment With Boundary Outside The Intermediate Segment. Para 233.b.

234. Initial Approach Segment Based On A Procedure Turn (PT)

A PT shall be specified when it is necessary to reverse direction to establish the aircraft on an intermediate or final approach course (FAC) except as specified in Para 234.e. A PT begins by overheading a facility or fix which meets the criteria for a holding fix (see Para 287.b) or for a FAF (see Para 287.c). The procedure shall specify the PT fix, the outbound and inbound course, the distance within which the PT shall be completed, and the direction of the PT. When a teardrop turn is used, the angle of divergence between the outbound course and the reciprocal of the inbound course shall be a MINIMUM of 15° or a MAXIMUM of 30° (see Para 235.a for high altitude teardrop penetrations). When the beginning of the intermediate or final approach segment associated with the PT is marked by no fix, the segment is deemed to begin on the inbound PT course at the maximum distance specified in the procedure. Where neither segment is marked by a fix, the final segment begins at the maximum distance specified in the procedure.

a. Alignment. When the inbound course of the procedure turn becomes the intermediate course it must meet the intermediate course alignment criteria. (See Para 242.a.) When the inbound course becomes the final approach course it must meet the final approach course alignment criteria. (See Para 250.) The wider side of the procedure turn area shall be oriented in the same direction as that prescribed for the procedure turn.

b. Area. The procedure turn areas are depicted in Figure 2-5. The normal procedure turn distance is 10 NM, (see Table 2-1A). Decrease this distance to 5 NM where only CAT "A" aircraft or helicopters are to be operating, and increase to 15 NM to accommodate operational requirements, or as specified in Para 234d. No extension of the PT is permitted without a FAF. When a procedure turn is authorized for use by Category "E" aircraft, a 15-mile PT distance shall be used. The PT segment is made up of the entry and maneuvering zones. The entry zone terminates at the inner boundary which extends perpendicular to the PT inbound course at the PT fix. The remainder of the procedure turn segment is the maneuvering zone. The entry and maneuvering zones are made up of primary and secondary areas. The PT primary area dimensions are based on the PT completion altitude, or the highest feeder route altitude, whichever is greater. To allow additional maneuvering area as the true airspeed increases at higher altitudes, the dimension of the PT primary area increases (see Table 2-1A). The PT secondary area is 2 NM on the outside of the primary area.

≤ 6,000

PT Length	Offset	R_1	R_2	R_3	R_4
5	2	4	6	5	7
>5-10	2	5	7	6	8
>10-15	β-4	5	7	β	β+2

$\beta = 0.1 \times (d - 10) + 6$

Where d = PT Length (nm)

> 6,000 ≤ 10,000

PT Length	Offset	R_1	R_2	R_3	R_4
5	2	4	6	5	7
>5-10	2	6	8	7	9
>10-15	β-5	6	8	β	β+2

$\beta = 0.1 \times (d - 10) + 7$

Where d = PT Length (nm)

> 10,000

PT Length	Offset	R_1	R_2	R_3	R_4
5	2	4	6	5	7
>5-10	2	7	9	8	10
>10-15	β-6	7	9	β	β+2

$\beta = 0.1 \times (d - 10) + 8$

Where d = PT Length (nm)

Table 2-1A: Procedure Turn Variables According To ASL Altitude, Para 234b.

Type of PT	Altitude Difference
15 nm PT from FAF	Within 3,000 ft of ALT over FAF
10 nm PT from FAF	Within 2,000 ft of ALT over FAF
5 nm PT from FAF	Within 1,000 ft of ALT over FAF
15 nm PT, no FAF	Not Authorized
10 nm PT, no FAF	With 1,500 ft of MDA on Final
5 nm PT, no FAF	With 1,000 ft of MDA on Final

Table 2-1B: PT Completion Altitude Difference. Para 234d.

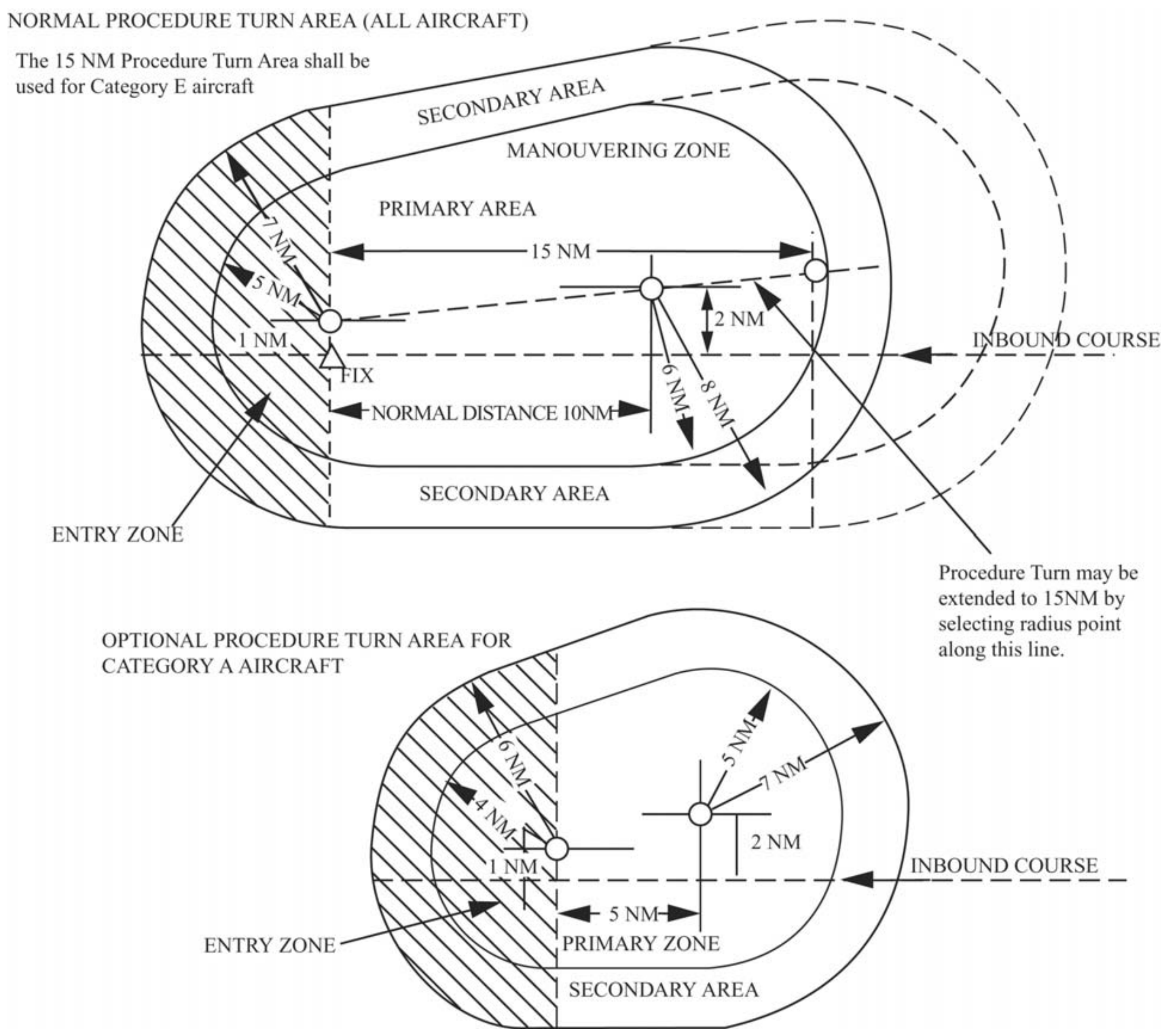
c. Obstacle Clearance. A minimum of 1,000 feet of clearance shall be provided in the primary area. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge (see Figure 2-6 and 2-6a). Allowance for precipitous terrain should be considered as specified in Para 323.a. The primary and secondary areas determine obstacle clearance in both the entry and maneuvering zones. The use of entry and maneuvering zones provides further relief from obstacles. The entry zone is established to control the obstacle clearance until proceeding outbound from the procedure turn fix. The maneuvering zone is established to control obstacle clearance AFTER proceeding outbound from the procedure turn fix. (see Figure 2-5). The altitudes selected by application of the obstacle clearance specified in this paragraph shall be rounded to the next higher 100 feet increment (see Para 231).

d. Descent Gradient. The OPTIMUM descent gradient in the initial approach is 250 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient is 500 feet per mile. Where a PT is established over a FAF, the PT completion altitude should be as close as possible to the FAF altitude. The difference between the PT completion altitude and the altitude over the FAF shall not be greater than those shown in Table 2-1b. If greater differences are required for a 5 or 10-mile PT, the PT distance limits and maneuvering zone shall be increased at the rate of 1 mile for each 200 feet of required altitude.

e. Elimination of PT. A PT is NOT required when an approach can be made direct from a specified IF to the FAF. The abbreviation "No PT" is used to denote that no procedure is necessary and will normally be shown adjacent to the IF. However, if the minimum altitude IF to FAF is not readily apparent, the No PT abbreviation will be shown at some point between the fix and the FAF. Design criteria outlined in Para 240-244 applies. Publishing an IF to permit a No PT approach does not preclude the publishing of a procedure turn as well, where operationally appropriate. A PT NEED NOT be established when an approach can be made from a properly aligned holding pattern. See Para 1820.a. In this case, the holding pattern in lieu of a PT, shall be established over a final or intermediate approach fix and the following conditions apply:

(1) If the holding pattern is established over the FAF (not applicable to RNAV procedures), an intermediate segment is not constructed. Ideally, establish the minimum holding altitude at the FAF altitude. In any case, the published holding altitude shall not be more than 300 feet above the FAF altitude.

(2) If the holding pattern is established over the IF, the minimum holding altitude (MHA) shall permit descent to the FAF altitude within the descent gradient tolerances prescribed for the intermediate segment (see Para 242d).



Note: In the **normal** PT area example above:
R1 = 5 NM, R2 = 7 NM, R3 = 6 NM, and R4 = 8 NM.
In the **optional** PT area example above:
R1 = 4 NM, R2 = 6 NM, R3 = 5 NM, and R4 = 7 NM.

Figure 2-5: Procedure Turn Areas. Para 234.b.

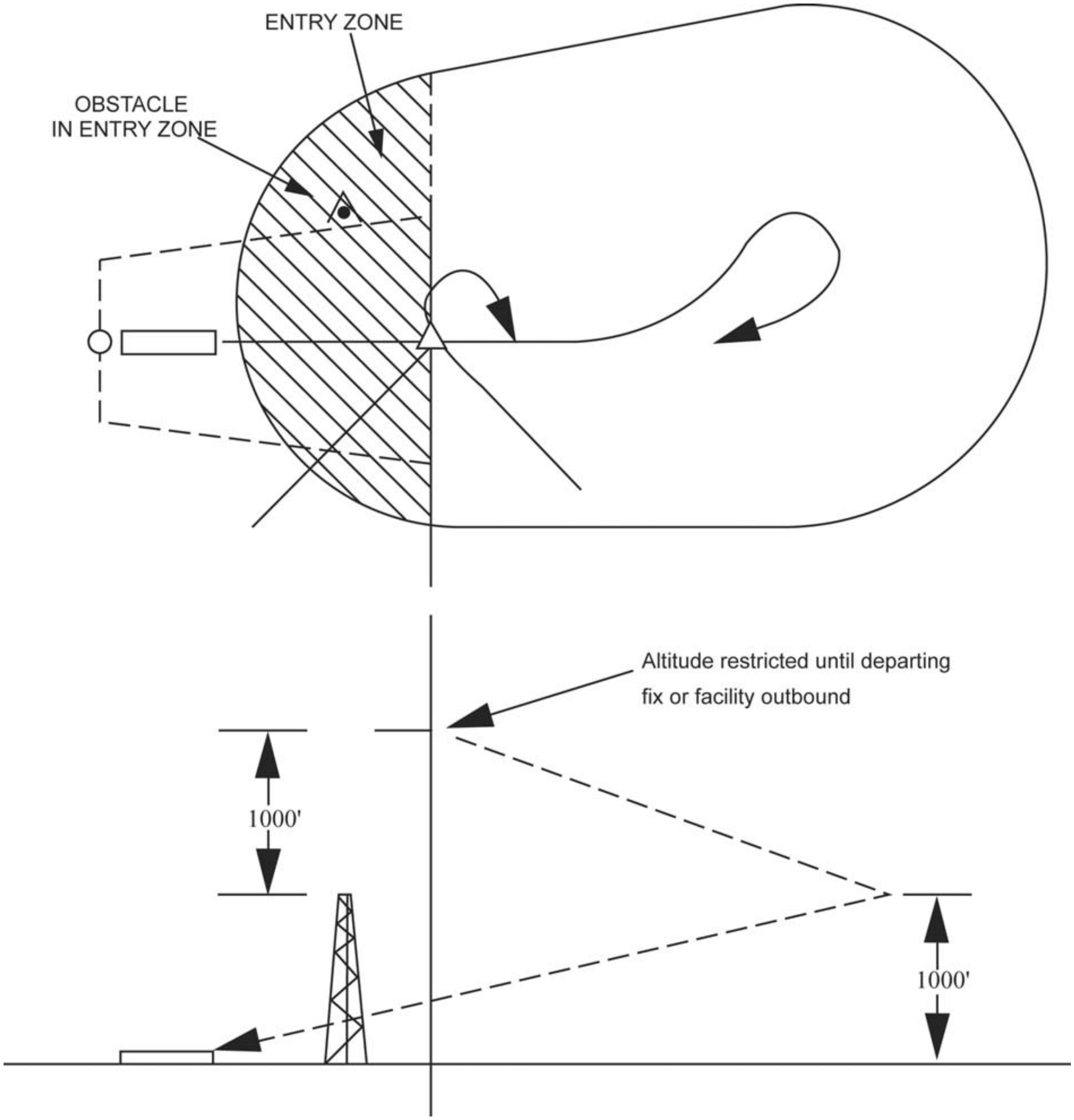


Figure 2-6: Procedure Turn Initial Approach Area. Para 234.c.

235. Initial Approach Based On High Altitude Teardrop Penetration

A teardrop penetration consists of departure from an IAF on an outbound course, followed by a turn toward and intercepting the inbound course at or prior to the IF or point. Its purpose is to permit an aircraft to reverse direction and lose considerable altitude within reasonably limited airspace. Where no IF is available to mark the beginning of the intermediate segment, it shall be assumed to commence at a point 10 NM prior to the FAF. When the facility is located on the airport, and no fix is available to mark the beginning of the final approach segment the criteria in Para 423 applies.

a. Alignment. The outbound penetration course shall be between 18 and 26° to the left or right of the reciprocal of the inbound course. The actual angular divergence between the courses will vary inversely with the distance from the facility at which the turn is made (see Table 2-2).

ALT to be Lost Prior to Commencing Turn (ft)	Distance Turn Commences (nm)	Course Divergence (Degrees)	Specified Penetration Turn Distance (nm)
12,000	24	18	28
11,000	23	19	27
10,000	22	20	26
9,000	21	21	25
8,000	20	22	24
7,000	19	23	23
6,000	18	24	22
5,000	17	25	21
4,000	16	26	20

Table 2-2: Penetration Turn Distance/Divergence. Para 235a.

b. Area.

(1) Size. The size of the penetration turn area must be sufficient to accommodate both the turn and the altitude loss required by the procedure. The penetration turn distance shall not be less than 20 NM from the facility. The penetration turn distance depends on the altitude to be lost in the procedure and the point at which the descent is started (see Table 2-2). The aircraft should lose half the altitude or 5,000 ft., whichever is greater, outbound prior to starting the turn. The penetration turn area has a width of 6 NM on both sides of the flight track up to the IF or point, and shall encompass all the areas within the turn (see Figure 2-7).

(2) Penetration Turn Table. Table 2-2 should be used to compute the desired course divergence and penetration turn distances, which apply when a specific altitude loss outbound is required. It is assumed that the descent begins at the plotted position of the fix. When the procedure requires a delay before descent of more than 5 NM, the distance in excess of 5 NM should be added to the distance the turn commences. The course divergence and penetration turn distance should then be adjusted to correspond to the adjusted turn distance. Extrapolations may be made from the table.

(3) Primary and Secondary Areas. All of the penetration turn area, except the outer 2 NM of the 6-mile obstacle clearance area on the outer side of the penetration track, is primary area (see Figure 2-7). The outer 2 NM is secondary area. The outer 2 NM on both sides of the inbound penetration course should be treated as secondary area.

c. Obstacle Clearance. Obstacle clearance in the initial approach primary area shall be a MINIMUM of 1,000 feet. Obstacle clearance at the inner edge of the secondary area shall be 500 feet, tapering to zero feet at the outer edge (see Figure 2-6a). Where no IF is available, a 10 NM intermediate segment is assumed and normal obstacle clearance is applied to the controlling obstacle. The controlling obstacle, as well as the minimum altitude selected for the intermediate segment, may depend on the availability of an IF (see Figure 2-8). Allowance for precipitous terrain should be considered in the penetration turn area as specified in Para 323.a. The altitudes selected by application of the obstacle clearance specified in this paragraph shall be rounded to the next higher 100 feet increment. (See Para 231.)

d. Descent Gradient. The OPTIMUM descent gradient is 800 feet per mile. The MAXIMUM gradient is 1,000 feet per mile.

e. Penetration Turn Altitude. When an IF is NOT provided, the penetration turn completion altitude shall not be more than 4,000 feet above the FAF altitude.

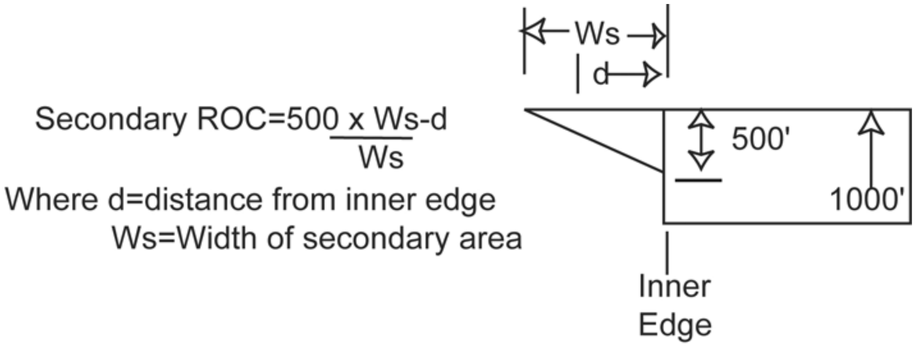


Figure 2-6a: Obstacle Clearance Areas. Paras 234.c and 235.c.

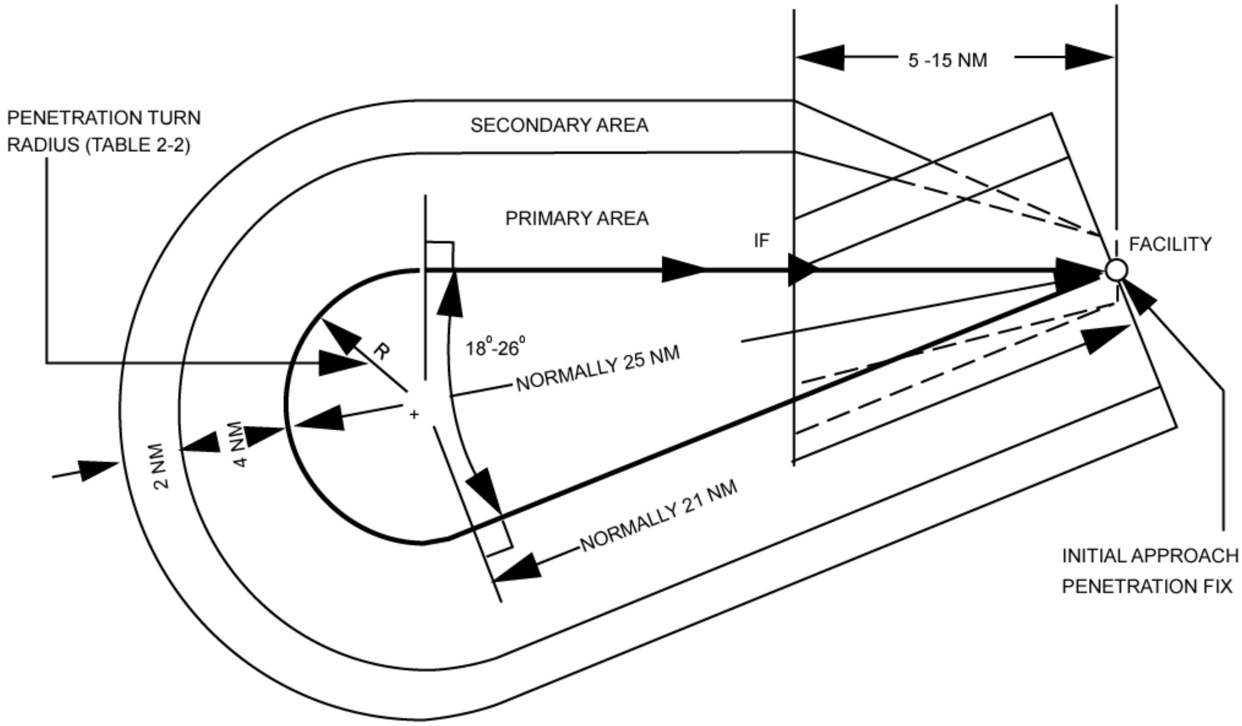


Figure 2-7: Typical Penetration Turn Initial Approach Area. Para 235.

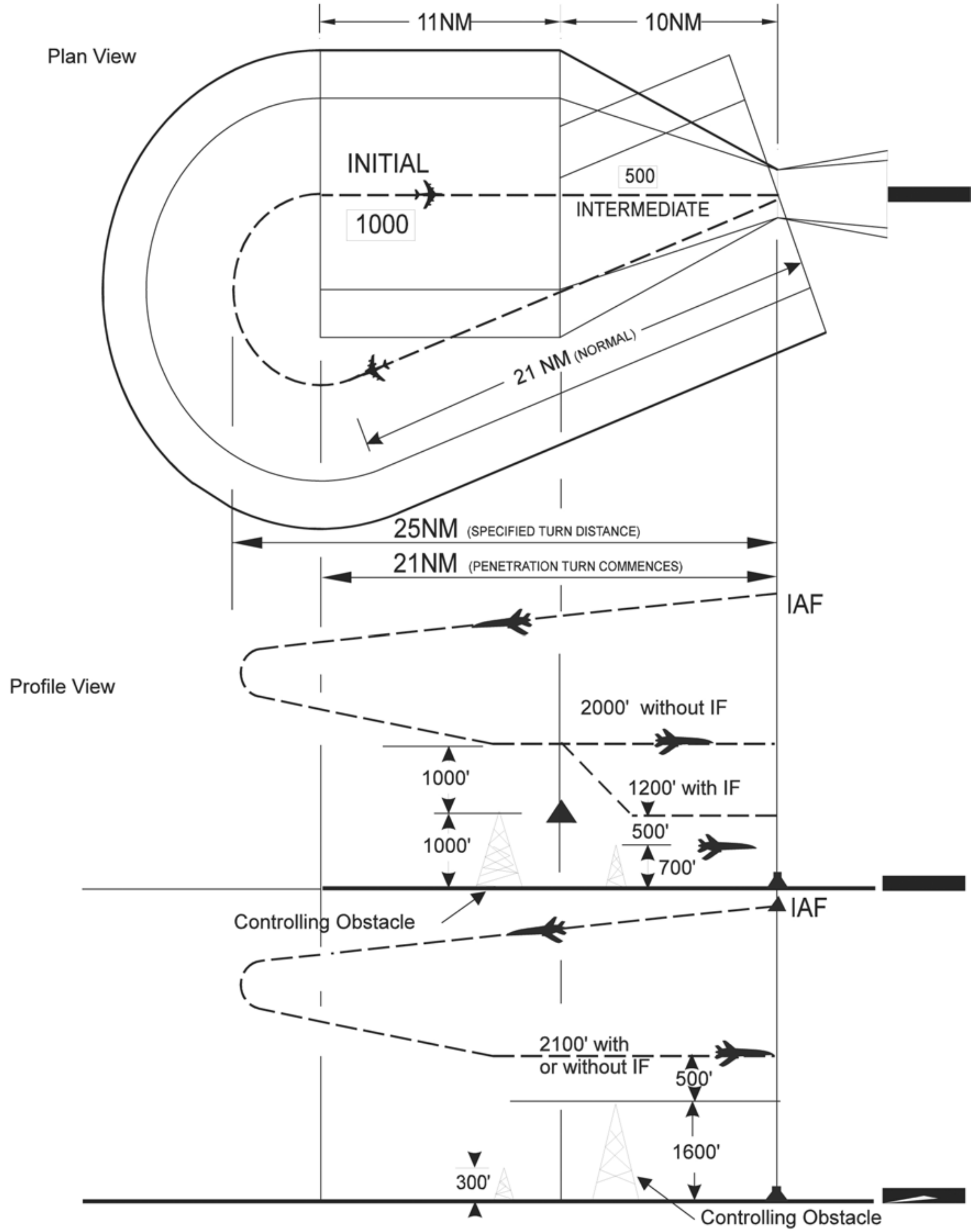


Figure 2-8: Penetration Turn Initial Approach Obstacle Clearance. Para 235.c.

236. Initial Approach Course Reversal Using Non-Collocated Facilities And A Turn Of 120° Or Greater To Intercept The Inbound Course (see Figures 2-9-1, 2-9-2, and 2-9-3)

a. Common Criteria.

(1) A turn point (TP) fix shall be established as shown in the figures. The fix error shall meet section 8 criteria, and shall not exceed plus-or-minus 2 NM.

(2) A flight path radius of 2.8 NM shall be used for procedures where the altitude at the TP fix is at or below 10,000 feet MSL, or 4 NM for procedures where the altitude at the TP fix is above 10,000 feet MSL.

(3) Descent Gradient. Para 232.d applies.

(4) Obstacle Clearance. Para 235.c applies.

(5) Initial Distance. When the course reversal turn intercepts the extended intermediate course, and when the course reversal turn intercepts a straight segment prior to intercepting the extended intermediate course, the minimum distance between the rollout point and the FAF is 10 NM.

(6) ROC Reduction. No reduction of secondary ROC is authorized in the course reversal area unless the TP fix is DME.

b. Figures 2-9-1 and 2-9-2. The rollout point shall be at or prior to the intermediate fix/point.

(1) Select the desired rollout point on the inbound course.

(2) Place the appropriate flight path arc tangent to the rollout point.

(3) From the outbound facility, place the outbound course tangent to the flight path arc. The point of tangency shall be the TP fix.

c. Figure 2-9-3.

(1) The point of intersection shall be at or prior to the IF/point (Para 242 applies). The angle shall be 90° or less.

(2) The distance between the rollout point and the point of intersection shall be no less than the distance shown in Table 2-2A.

Angle "a" (Degrees)	NM
0 – 15	1
> 15 – 30	2
> 30 – 45	3
> 45 – 60	4
> 60 – 75	5
> 75 – 90	6

Table 2-2A: Minimum Distance From Roll Out Point To Point Of Intersection. Para 236c(2).

(3) Para 235 and Table 2-2 should be used for high altitude procedures up to the point of intersection of the two inbound courses.

(4) Select the desired point of intersection. From the outbound facility draw a line through the point of intersection.

(5) At the outbound facility, measure the required number of degrees course divergence (may be either side of the line through the point of intersection) and draw the outbound course out the required distance. Connect the outbound course and the line through the point of intersection with the appropriate arc.

(6) Determine the desired rollout point on the line through the point of intersection.

   (a) Place the appropriate flight path arc tangent to the rollout point.

   (b) From the outbound facility draw the outbound course tangent to the flight path arc. The point of tangency is the TP fix.

237—239. Reserved

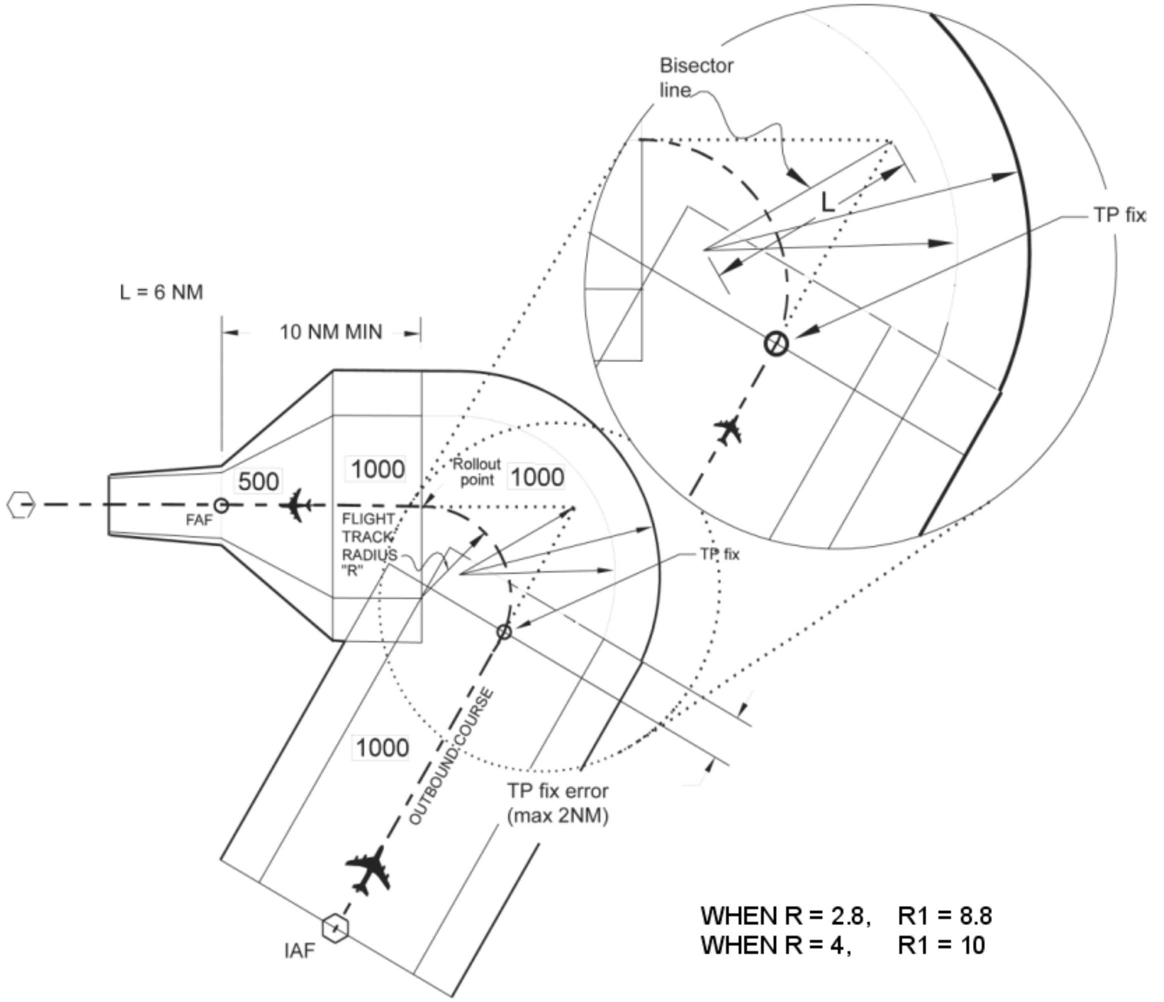


Figure 2-9-1: Example Of Initial Course Reversal. Para 236.

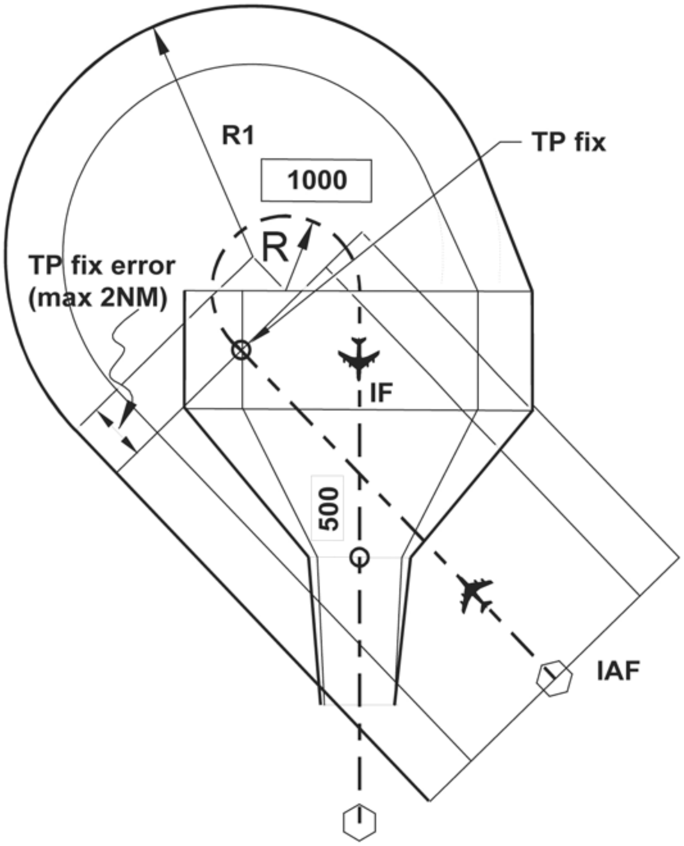


Figure 2-9-2: Example Of Initial Approach Course Reversal. Para 236.

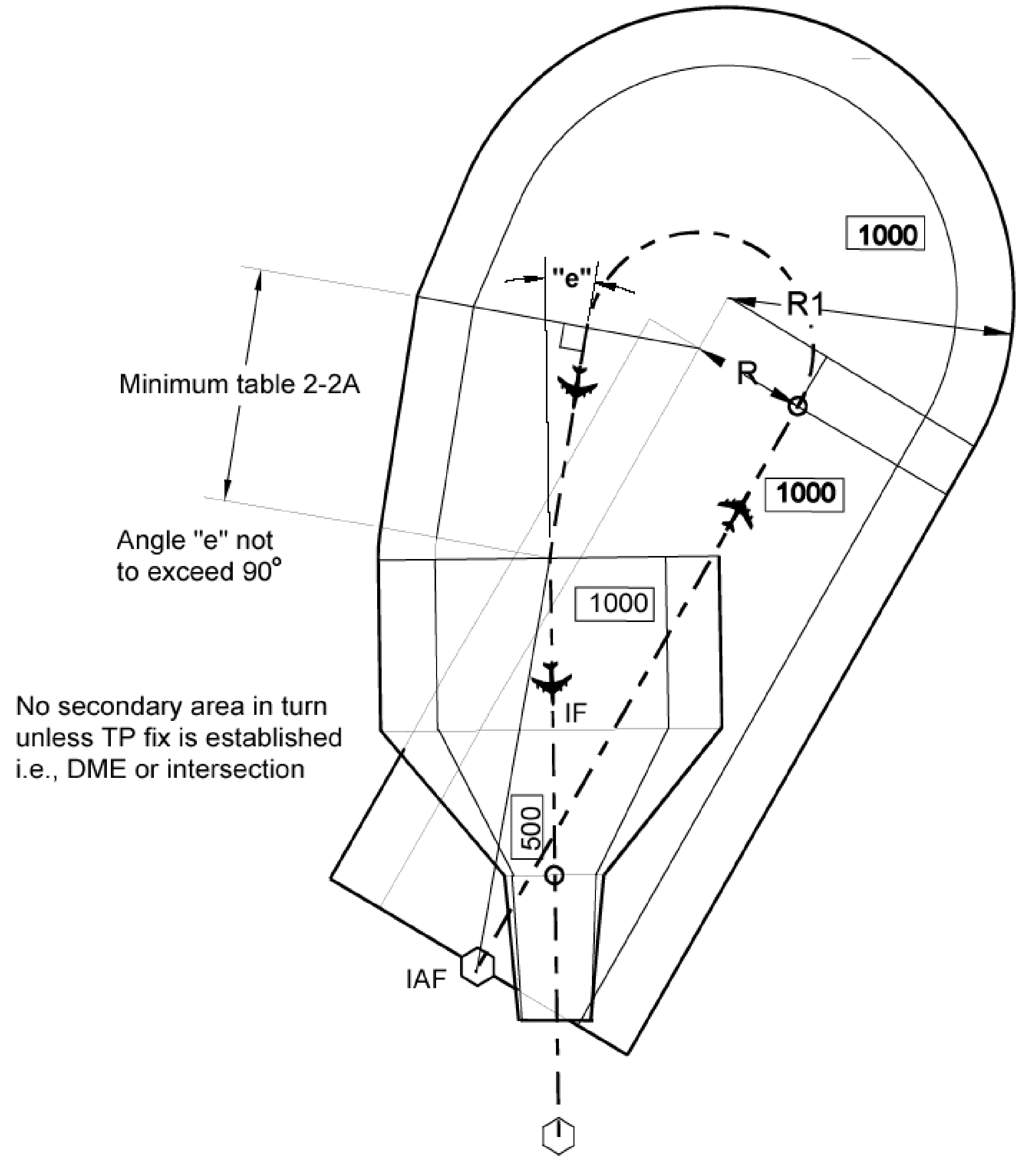


Figure 2-9-3: Example Of Initial Approach Course Reversal. Para 236.

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SECTION 4. INTERMEDIATE APPROACHES

240. Intermediate Approach Segment

This is the segment which blends the initial approach segment into the final approach segment. It is the segment in which aircraft configuration, speed, and positioning adjustments are made for entry into the final approach segment. The intermediate segment begins at the IF point, and ends at the FAF. There are two types of intermediate segments: the "radial" or " course" intermediate segment and the "arc" intermediate segment. In either case, positive course guidance (PCG) shall be provided. See Figure 2-10 for typical approach segments.

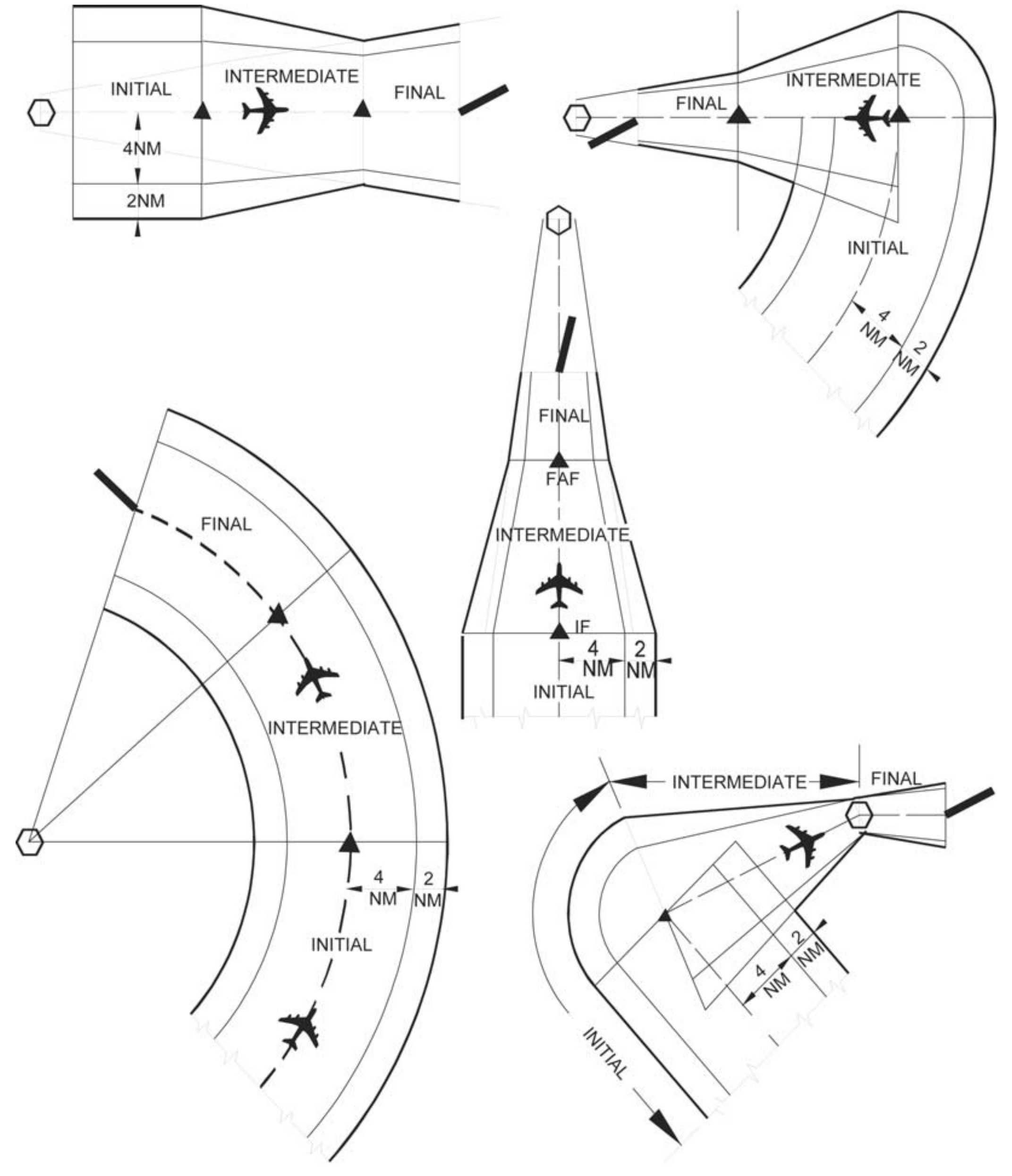


Figure 2-10: Typical Approach Segments. Paras 232.b and 240.

241. Altitude Selection

The MINIMUM altitude in the intermediate segment shall be established in 100-foot increments, without violating the ROC; i.e., 749 feet may be shown as 700 feet and 750 feet shall be shown as 800. In addition, the altitude selected for arrival over the FAF should be low enough to permit descent from the FAF to the airport for a straight-in landing whenever possible.

242. Intermediate Approach Segment Based On Straight Courses

a. Alignment. The course to be flown in the intermediate segment shall be the same as the final approach course, except when the final approach fix is the navigation facility and it is not practical for the course to be identical. In such cases, the intermediate course shall not differ from the final approach course by more than 30° (see Figure 2-10).

b. Area.

(1) Length. The length of the intermediate segment is measured along the course to be flown. Where the initial segment joins the intermediate segment at angles up to 90°, the MINIMUM length is 5 nm for CAT A/B, and 6 nm for CAT C/D/E (except as specified in Volume 1, chapter 10 and 16, and Volume 3, chapter 2). Table 2-3 lists the minimum segment length where the initial approach course joins the intermediate course at an angle greater than 90° (see Figure 2-3). The MAXIMUM segment length is 15 nm. The OPTIMUM length is 10 nm. A distance greater than 10 nm should not be used unless an operational requirement justifies a greater distance.

Angle (Degrees)	Minimum Length (nm)
91 – 96	6
> 96 – 102	7
> 102 – 108	8
> 108 – 114	9
> 114 – 120	10

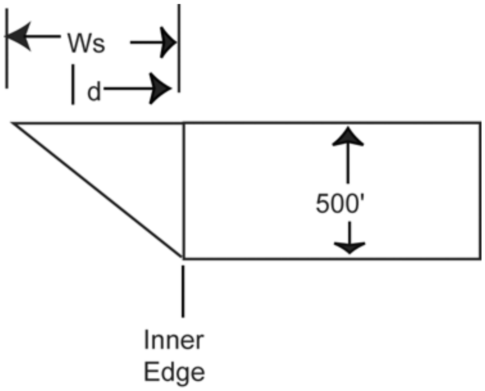
Table 2-3: Minimum Intermediate Course Length (nm). Para 242.b(1).

(2) Width. The width of the intermediate segment is the same as the width of the segment it joins. When the intermediate segment is aligned with the initial or final approach segments, the width of the intermediate segment is determined by joining the outer edges of the initial segment with the outer edges of the final segment. When the intermediate segment is not aligned with the initial or final approach segments, the resulting gap on the outside of the turn is part of the preceding segment is closed by the appropriate arc (see Figure 2-10). For obstacle clearance purposes the intermediate segment is divided into a primary and a secondary area.

c. Obstacle Clearance. A minimum of 500 feet of obstacle clearance shall be provided in the primary area of the intermediate approach segment. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge (see Figure 2-10a). The minimum obstacle clearance required at any point in the secondary area may be determined by using the graph in Annex C, Figure C-3. Allowance for precipitous terrain should be considered as specified in Para 323.a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet, provided the ROC is not violated (see Para 241).

d. Descent Gradients. Because the intermediate segment is used to prepare the aircraft speed and configuration for entry into the final approach segment, the gradient should be as flat as possible. The OPTIMUM descent gradient is 150 feet per mile. The MAXIMUM gradient is 318 feet per mile, except for a localizer approach published in conjunction with an ILS procedure. In this case, a higher descent gradient equal to the commissioned GS angle (provided it does not exceed 3°) is permissible. Higher gradients resulting from arithmetic rounding are also permissible.

Note: When the descent gradient exceeds 318 feet per mile, the procedure specialist should assure an initial segment is provided prior to the intermediate segment to prepare the aircraft speed and configuration for entry into the final segment. This segment should be a minimum length of 5 NM and its descent gradient should not exceed 318 feet per mile.



$$\text{Secondary ROC} = \frac{500 \times \text{Ws-d}}{\text{Ws}}$$

Where d=distance from inner edge
Ws=Width of secondary area

Figure 2-10a: Obstacle Clearance Area. Paras 242.c and 243.c.

243. Intermediate Approach Segment Based On An Arc

Arcs with a radius of less than 7 NM or more than 30 NM from the navigation facility shall NOT be used. DME arc courses shall be predicated only on a DME collocated with a facility providing omnidirectional course information.

a. Alignment. The same arc shall be used for the intermediate and the final approach segments. No turns shall be required over the FAF.

b. Area.

  (1) Length. The intermediate segment shall NOT be less than 5 NM or more than 15 NM in length, measured along the arc. The OPTIMUM length is 10 NM. A distance greater than 10 NM should not be used unless an operational requirement justifies the greater distance.

  (2) Width. The total width of an arc intermediate segment is 6 NM on each side of the arc. For obstacle clearance purposes, this width is divided into a primary and a secondary area. The primary area extends 4 NM laterally on each side of the arc segment. The secondary areas extend 2 NM laterally on each side of the primary area (see Figure 2-10).

c. Obstacle Clearance. A minimum of 500 feet of obstacle clearance shall be provided in the primary area. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge (see Figure 2-10a). Allowance for precipitous terrain should be considered as specified in Para 323.a. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet, provided the ROC is not violated. (See Para 241.)

d. Descent Gradients. Criteria specified in Para 242.d apply.

244. Intermediate Approach Segment Within A PT Segment

a. PT Over a FAF. When the FAF is a Facility (see Figure 2-11).

  (1) The MAXIMUM intermediate length is 15 NM, the OPTIMUM is 10 NM, and the MINIMUM is 5 NM. Its width is the same as the final segment at the facility and expanding uniformly to 6 NM on each side of the course at 15 NM from the facility.

  (2) The intermediate segment considered for obstacle clearance shall be the same length as the PT distance; e.g., if the procedure requires a PT to be completed within 5 NM, the intermediate segment shall be only 5 NM long, and the intermediate approach shall begin on the intermediate course 5 NM from the FAF.

  (3) When establishing a step down fix within intermediate segment underlying a PT area:

    (a) Table 2-1a shall be applied.

    (b) Only one step down fix is authorized within the intermediate segment that underlies the PT maneuvering area.

    (c) The distance between the PT fix/facility and a SDF underlying the PT area shall not exceed 4 NM.

    (d) The MAXIMUM descent gradient from the IF point to the SDF is 200 feet/NM. The MAXIMUM descent gradient from the SDF to the FAF is 318 feet/NM.

b. PT Over a FAF When the FAF is Not a Facility (see Figure 2-12).

  (1) The intermediate segment shall be 6 NM wide each side of the intermediate course at the PT distance.

  (2) When establishing a step down fix within intermediate/initial segment underlying a PT area:

    (a) Table 2-1a shall be applied.

    (b) Only one step down fix is authorized within the intermediate segment that underlies the PT maneuvering area.

    (c) The distance between the PT fix/facility and a SDF underlying the PT area shall not exceed 4 NM.

    (d) The MAXIMUM descent gradient from the IF point to the SDF is 200 feet/NM. The MAXIMUM descent gradient from the SDF to the FAF is 318 feet/NM.

c. PT Over a Facility/Fix After the FAF (see Figure 2-13).

  (1) The PT facility/fix to FAF distance shall not exceed 4 NM.

  (2) The MAXIMUM PT distance is 15 NM.

  (3) The length of the intermediate segment is from the start of the PT distance to the FAF and the MINIMUM length shall be 5 NM.

  (4) Intermediate Segment Area.

    (a) PT Over a Facility. The intermediate segment starts 15 NM from the facility at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

    (b) PT Over a Fix (NOT a Facility). The intermediate segment starts at the PT distance at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

  (5) The MAXIMUM descent gradient in the intermediate segment is 200 feet/NM. The PT distance may be increased in 1 NM increments up to 15 NM to meet descent limitations.

  (6) When establishing a step down fix within intermediate/initial segment underlying a PT area:

    (a) Only one step down fix is authorized within the intermediate segment that underlies the PT maneuvering area.

    (b) The distance between the PT fix/facility and a stepdown fix (SDF) underlying the PT area shall not exceed 4 NM.

    (c) The MAXIMUM descent gradient from the IF point to the SDF is 200 feet/NM. The MAXIMUM descent gradient from the SDF to the FAF is 318 feet/NM.

d. PT Over a Facility/Fix PRIOR to the FAF (see Figures 2-14-1 and 2-14-2).

  (1) The MINIMUM PT distance is 5 NM.

  (2) The length of the intermediate segment is from the start of the PT distance to the FAF and the MAXIMUM length is 15 NM.

  (3) Intermediate Segment Area.

(a) PT Over a Facility. The intermediate segment starts 15 NM from the facility at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

(b) PT Over a Fix (NOT a Facility). The intermediate segment starts at the PT distance at a width of 6 NM each side of the inbound course and connects to the width of the final segment at the FAF. The area considered for obstacle clearance is from the start of the PT distance to the FAF.

(4) The MAXIMUM descent gradient is 200 feet/NM. If the PT facility/fix is a step-down fix, the descent gradient from the step-down fix to the FAF may be increased to a maximum of 318 feet/NM (see Figure 2-14-2). The PT distance may be increased in 1 NM increments up to 15 NM to meet descent limitations.

(5) When establishing a step down fix within an intermediate/initial segment underlying a PT area:

(a) When the PT fix is over a facility/fix prior to the FAF, the facility/fix is the SDF in the intermediate/initial area, and another SDF within this segment is not authorized.

(b) The MAXIMUM descent gradient from the IF point to the SDF is 200 feet/NM. The MAXIMUM descent gradient from the SDF to the FAF is 318 feet/NM.

e. PT Facility/Fix Used as an Intermediate Fix (see Figure 2-14-3).

(1) When the PT inbound course is the same as the intermediate course, either Para 244.d may be used, or a straight initial segment may be used from the start of the PT distance to the PT fix.

(2) When the PT inbound course is NOT the same as the intermediate course, an intermediate segment within the PT area is NOT authorized; ONLY a straight initial segment shall be used from the start of the PT distance to the PT fix.

(3) When a straight initial segment is used, the MAXIMUM descent gradient within the PT distance is 318 feet/NM, the PT distance may be increased in 1 NM increments up to 15 NM to meet descent limitations.

(4) When establishing a step down fix within an intermediate/initial segment underlying a PT area:

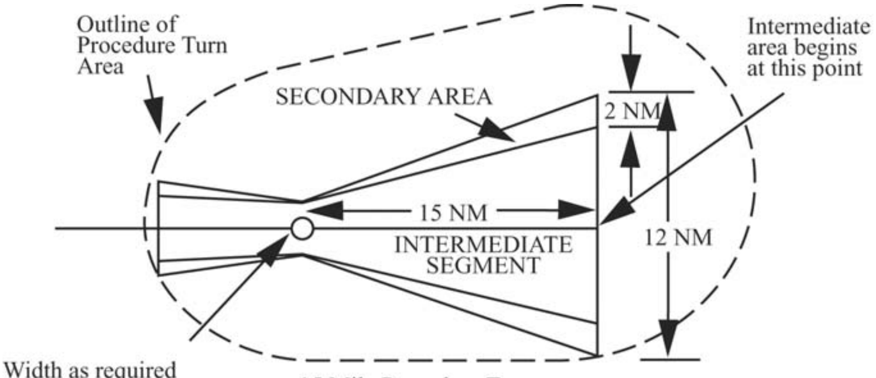
(a) Only one step down fix is authorized within the initial segment that underlies the PT maneuvering area.

(b) The distance from the PT fix/facility and a SDF underlying the PT area shall not exceed 4 NM.

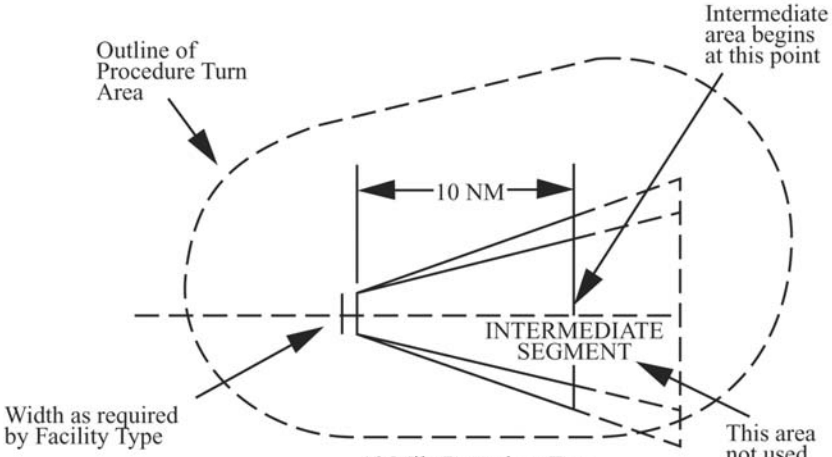
(c) The MAXIMUM descent gradient from the PT completion point (turn distance) to the SDF, and from the SDF to the IAF is 318 feet/NM.

f. When a PT from a facility is required to intercept a localizer course, the PT facility is considered on the localizer course when it is located within the commissioned localizer course width.

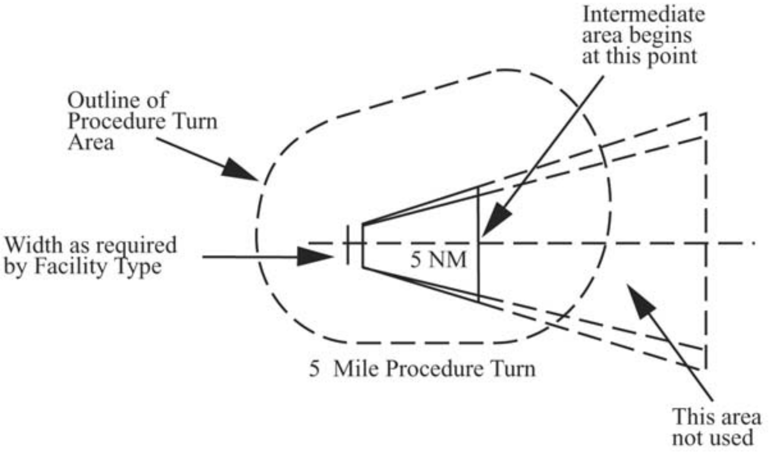
245—249. Reserved



15 Mile Procedure Turn



10 Mile Procedure Turn



5 Mile Procedure Turn

Figure 2-11: Intermediate Area Within A Procedure Turn Area. FAF Is The Facility. Para 244.a.

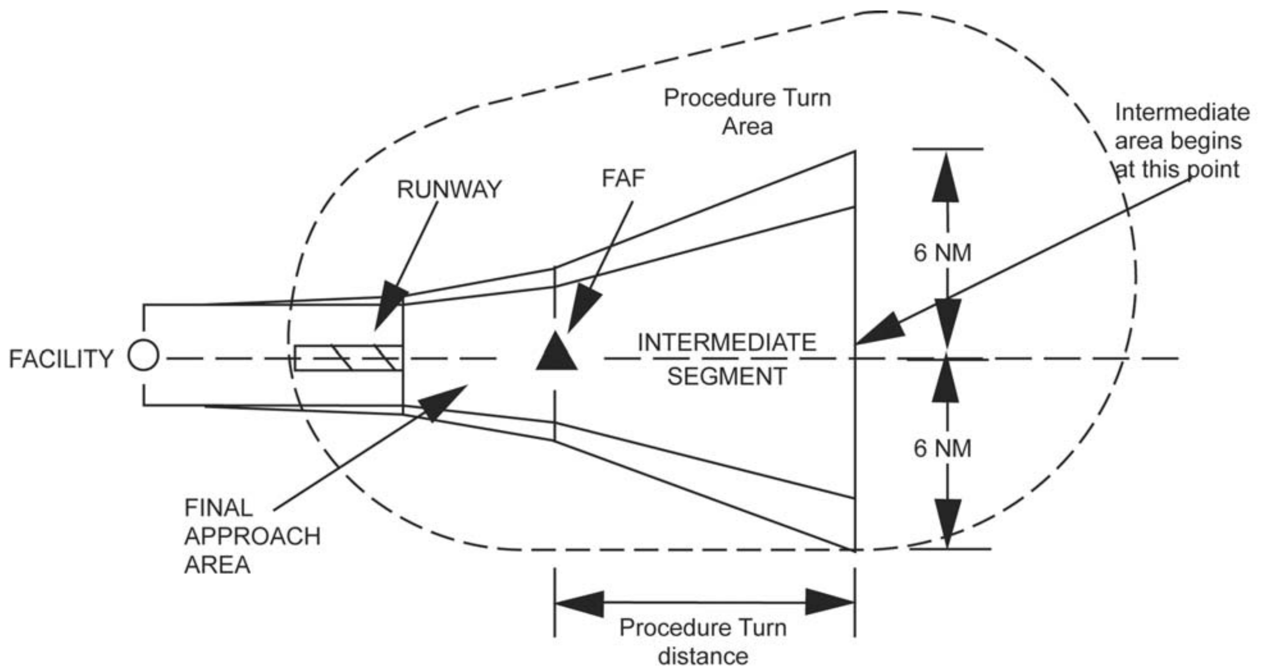


Figure 2-12: Intermediate Area Within The Procedure Turn Area. FAF Is Not The Facility. Para 244.b.

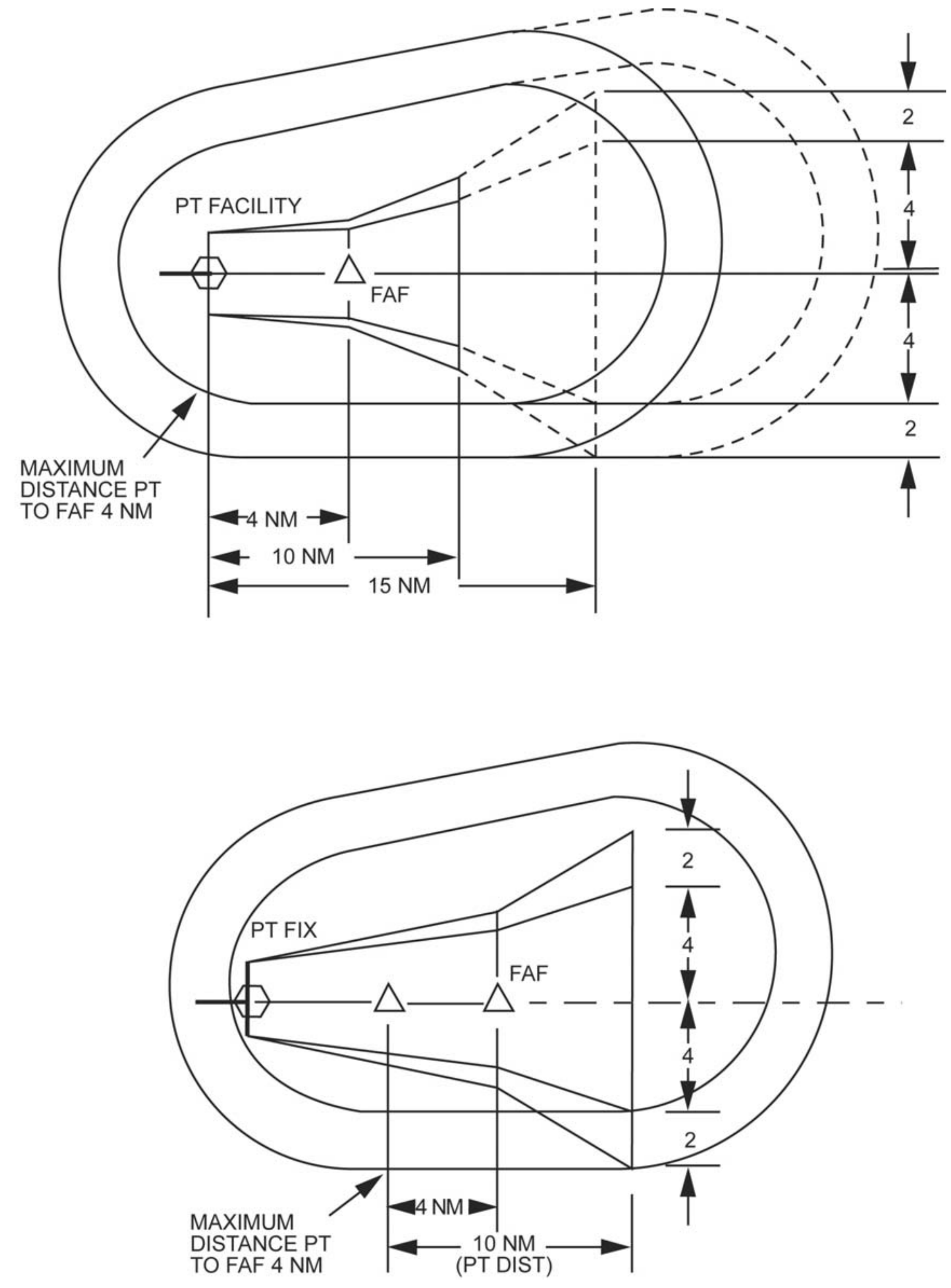


Figure 2-13: Intermediate Area Within The Procedure Turn. PT Over The Facility/Fix After The FAF. Para 244.c.

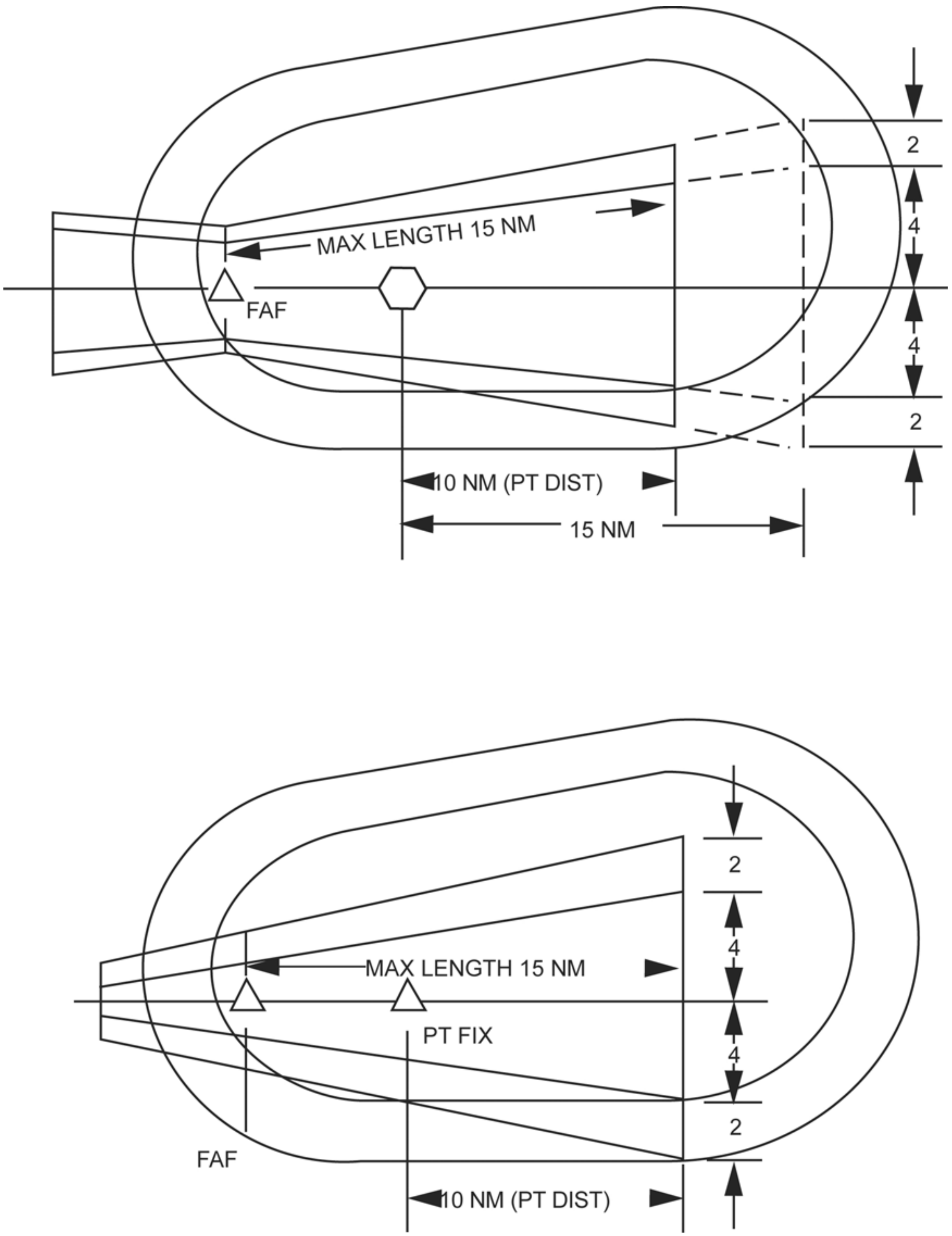


Figure 2-14-1: Intermediate Area Within The Procedure Turn Area. PT Over The Facility/Fix Prior To The FAF. Para 244.d.

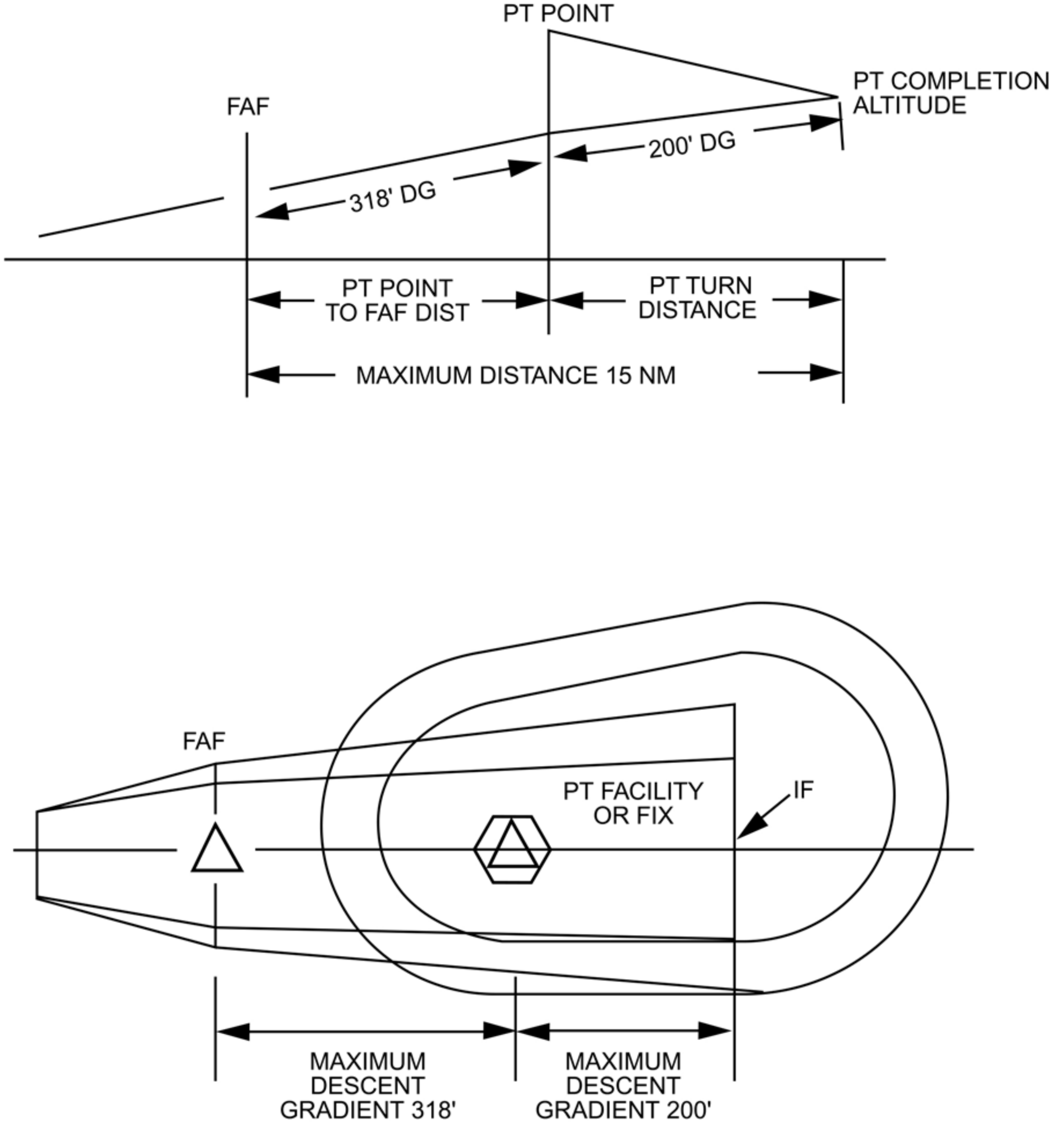


Figure 2-14-2: Intermediate Area Within The Procedure Turn Area. PT Facility/Fix Used As A Stepdown Fix. Para 244.d.(4).

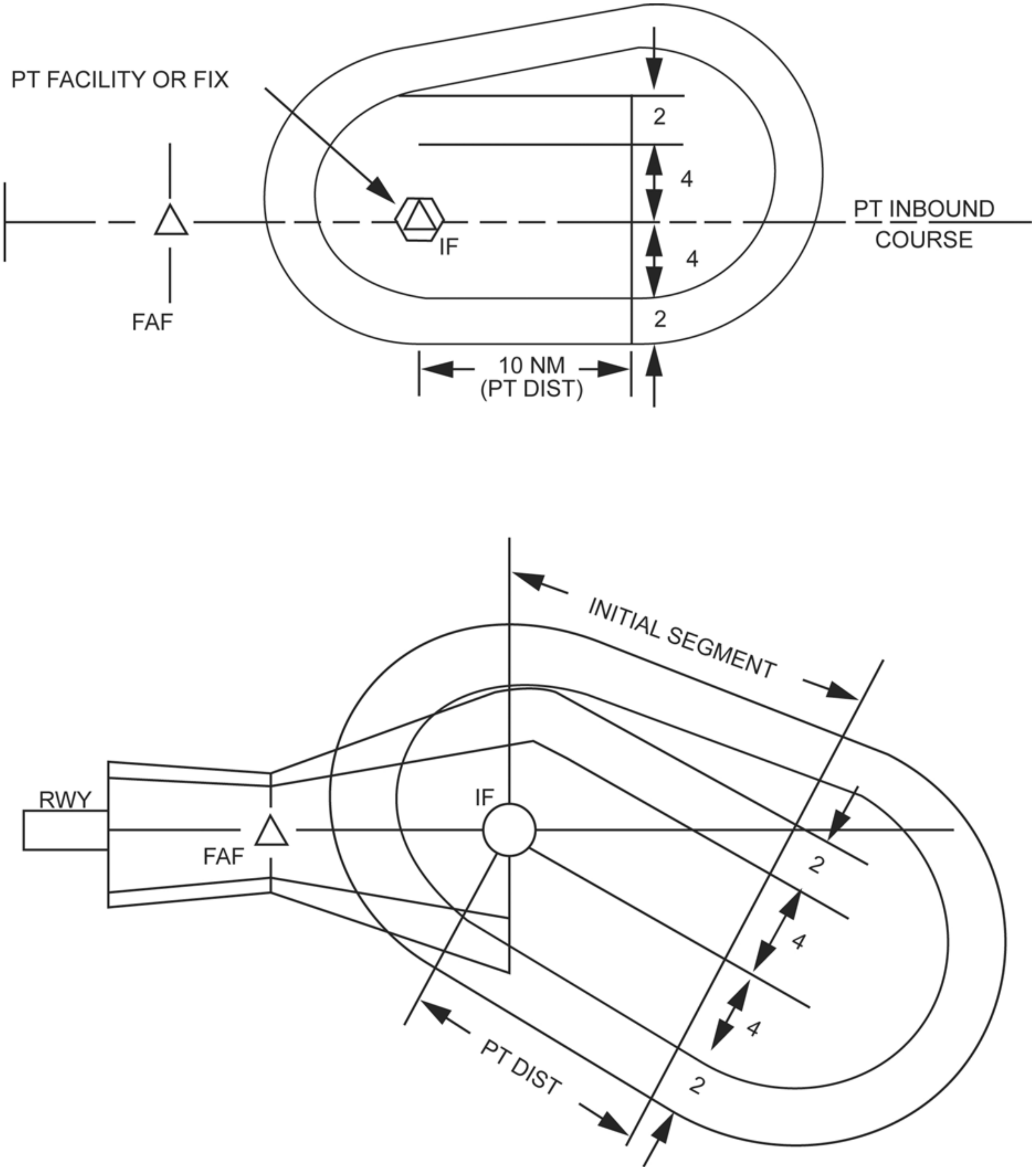


Figure 2-14-3: Use Of PT Fix For IF. Para 244.e.

Figure 2-14-4 to 2-14-6: Reserved

SECTION 5. FINAL APPROACH

250. Final Approach Segment

This is the segment in which alignment and descent for landing are accomplished. The final approach segment considered for obstacle clearance begins at the FAF or points and ends at the runway or missed approach point (MAP), whichever is encountered last. Final approach may be made to a runway for straight-in landing, or to an airport for a circling approach. Since the alignment and dimensions of the non-visual portions of the final approach segment vary with the location and type of navigation facility, applicable criteria are contained in chapters designated for specific navigation facilities.

251. Reserved

252. Descent Angle/Gradient.

The OPTIMUM non precision final segment descent gradient is 318 FT/NM, which approximates a 3.00° angle. The MAXIMUM descent gradient is 400 ft/NM, which approximates a descent angle of 3.77°. Calculate descent gradient from the plotted position of the FAF or SDF to the plotted position of the SDF or final endpoint (FEP) as appropriate (see Figure 2-14-7). The FEP is formed by the intersection of the FAC and a line perpendicular to the FAC that extends to the runway threshold (first useable landing surface for circling only procedures). When the maximum descent gradient is exceeded, straight-in minimums are NOT authorized; however, circling only minimums may be authorized if the maximum circling descent gradient is not exceeded (see Para 252.d). In these cases, publish the actual descent gradient to threshold crossing height (TCH) rather than to circling minimum descent altitude (CMDA).

a. Non-RNAV approaches. FAF and/or last SDF) location and altitude should be selected to provide a descent angle and TCH coincident (±0.20°, ±3’) with the lowest published visual glideslope indicator (VGSI) glideslope angle, when feasible; or, when VGSI is not installed, the FAF and/or last SDF location and altitude should be selected so as to achieve a near optimum final segment descent gradient. To determine the FAF or SDF altitude necessary to align the descent angle with the lowest VGSI, calculate the altitude gain of a plane with the slope of the lowest published VGSI glideslope angle emanating from the lowest published VGSI TCH to the FAF or SDF location. To determine the OPTIMUM FAF or SDF altitude, calculate the altitude gain of a 318 FT/NM gradient (3° angle) extending from the visual TCH to the FAF or SDF location. Round this altitude up or down to the 100’ increment for the FAF or 20’ increment for the SDF. Ensure that ROC requirements are not violated during the rounding process. If the gradient from TCH to SDF is greater than the gradient from TCH to FAF, continue the greater gradient to the FAF and adjust the FAF altitude accordingly. If application of hold-in-lieu of PT criteria in Para 234.e.1, or intermediate segment obstacles prohibit this altitude, consider relocating the FAF to achieve an altitude that will satisfy both the VGSI or optimum descent gradient (see Figure 2-14-8).

b. RNAV Approaches. If feasible, place the FAF waypoint where the optimum descent angle, or the lowest published the VGSI (if installed) glidepath angle intersects the intermediate altitude or the altitude determined by application of hold-in-lieu of PT criteria in Para 234.e.1. When an SDF is used, the SDF altitude should be at or below the published VGSI glideslope angle (lowest angle for multi-angle systems) (see Figure 2-14-9).

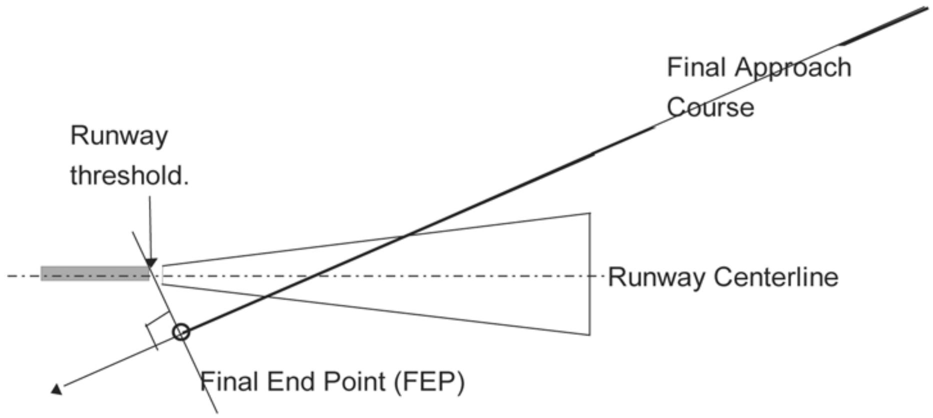
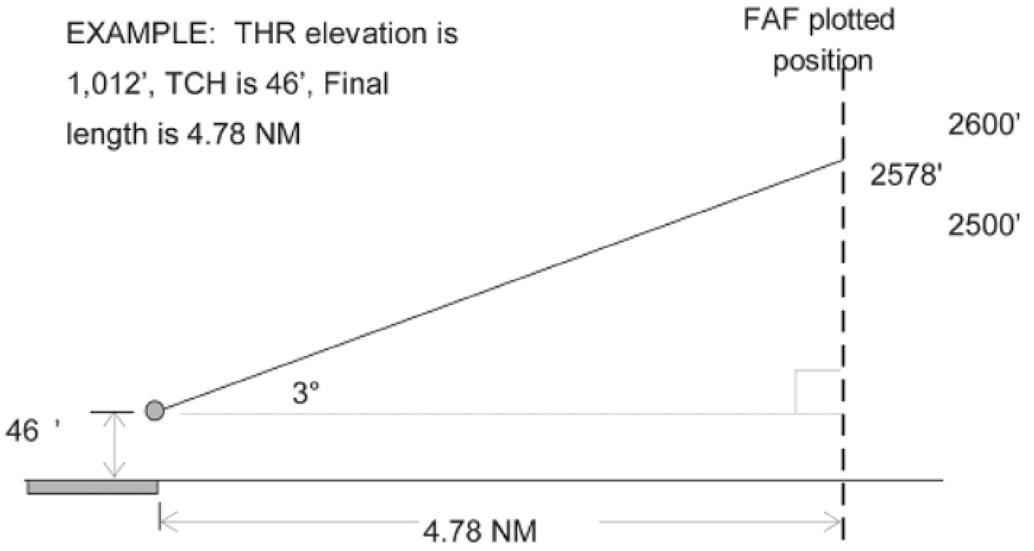


Figure 2-14-7: Final End Point. Para 252.

SL in NM;
FAF Altitude = THRe + TCH = (318 x SL)
SL in feet;
FAF Altitude = THRe + TCH + (Tan (VGSI Angle) x SL x 6076.11548)
Where:
THRe = THR Elevation
SL = Segment Length

EXAMPLE: THR elevation is 1,012', TCH is 46', Final length is 4.78 NM

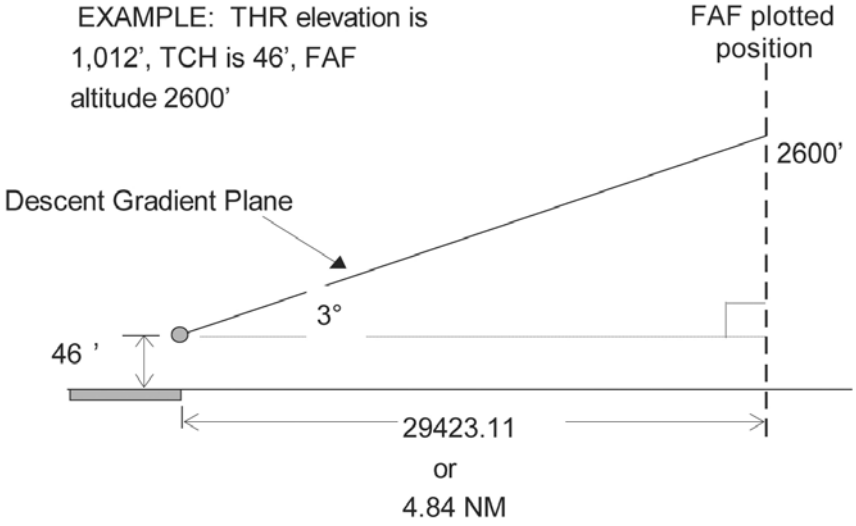


2578.04 = 1012 + 46 + (318 x 4.78)
or
2580.12 = 1012 + 46 + Tan (3°) x (4.78 x 6067.11548)

Figure 2-14-8: FAF Activities Given Final Length. Para 252.a.

$$SL = \frac{\left(\text{FAF Altitude} - \left[\text{THRe} + \text{TCH}\right]\right)}{\tan\left(3^\circ \text{ or VGSI angle}\right)}$$

where: SL = Segment Length in feet
THRe = Threshold Elevation



$$29423.11 = \frac{2600 - \left(1012 + 46\right)}{\tan\left(3^\circ\right)}$$

Figure 2-14-9: Final Length Given FAF Altitude. Para 252.b.

c. Determining Final Segment Descent Gradient and Angle.

(1) Final Without SDF's. Calculate the final descent gradient by dividing the height loss from FAF to TCH by the segment length in NM.

$$\text{Descent Gradient} = \frac{\mathit{HeightLoss}}{\mathit{SegmentLength(NM)}}$$

The descent gradient divided by 6076.11548 is the arc tangent of the segment descent angle (Ɵ).

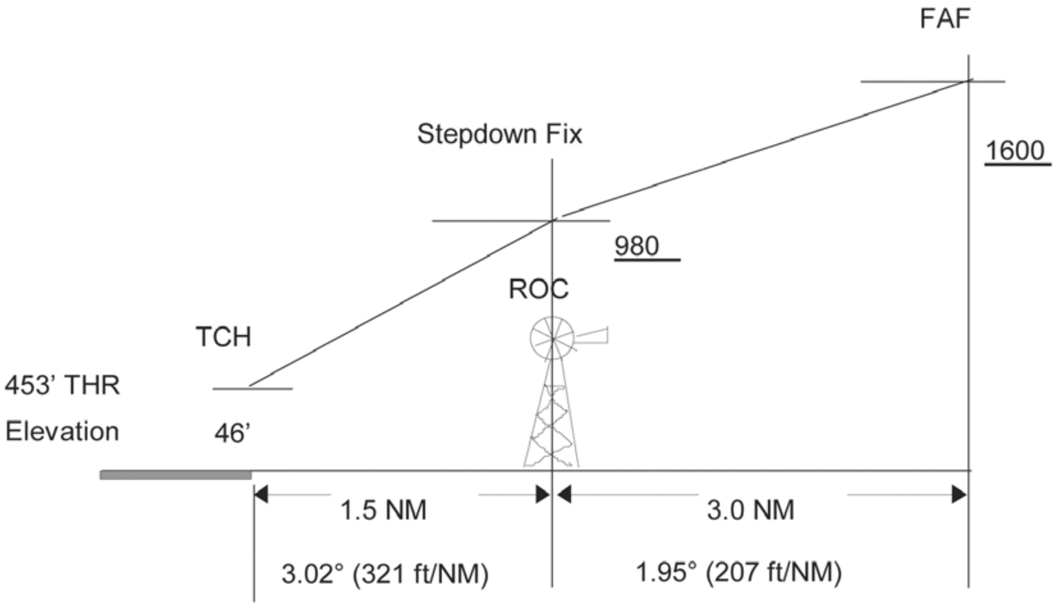
$$\text{Tan}(\Theta) = \frac{\mathit{DescentGradient}}{6076.11548}$$

For RNAV standard instrument approach procedures (SIAP), this angle is the glideslope computer setting.

(2) Final With SDF. The maximum descent angle is calculated using the difference between the FAF/stepdown altitudes and the stepdown/TCH altitudes as appropriate. Descent gradient and angle computations apply to each stepdown segment. Height loss in the last segment flown is from the SDF minimum altitude to the TCH (see Figure 2-14-10).

d. Circling Approaches. The maximum descent angle is calculated using the difference between the FAF/stepdown altitudes and stepdown/lowest CMDA as appropriate (see Figure 2-14-11).

253—259. Reserved



$$\text{Descent Gradient} = \frac{(1600 - 980)}{3.0}$$

$$\text{Descent Gradient} = 207 \text{ ft / NM}$$

$$\text{Tan}(q) = \frac{207}{6076.11548}$$

$$q = 1.95^\circ$$

$$\text{Descent Gradient} = \frac{(980 - (453 + 46))}{1.5}$$

$$\text{Descent Gradient} = 321 \text{ ft / NM}$$

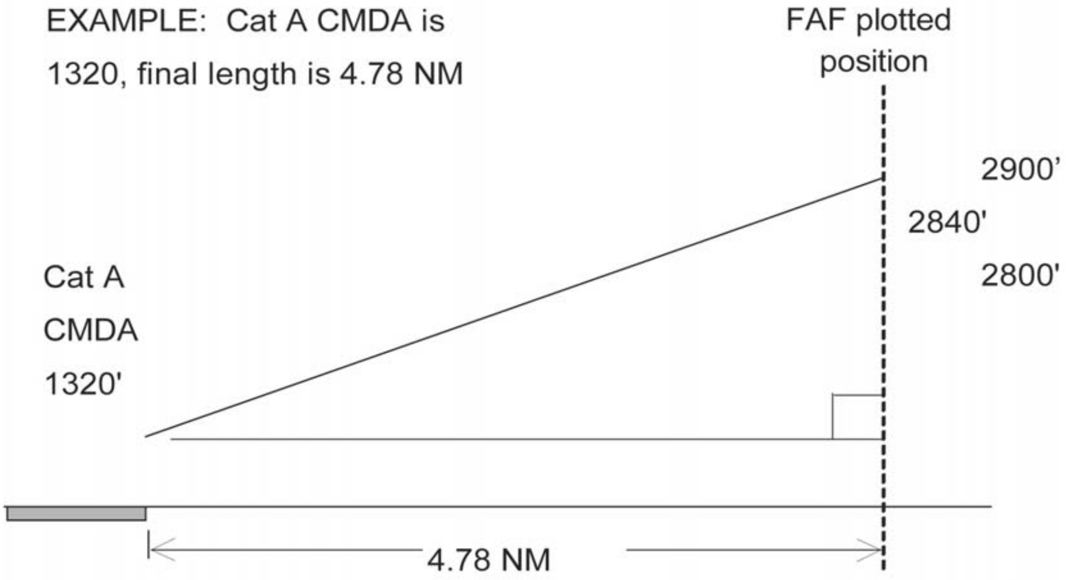
$$\text{Tan}(q) = \frac{321}{6076.11548}$$

$$q = 3.02^\circ$$

Figure 2-14-10: Descent Gradient And Angle. Para 252.c.(2).

FAF Altitude = CMDA + (318 x Seg. Len. in NM)

EXAMPLE: Cat A CMDA is 1320, final length is 4.78 NM



To calculate the FAF altitude for a given descent gradient:
2840.04 = 1320 + (318 x 4.78)

To calculate Descent Gradient and Angle given a FAF altitude and final length:

$$\text{Descent Gradient} = \frac{(2900-1320)}{4.78}$$

Descent Gradient = 331 ft/NM

$$\tan(\theta) = \frac{331}{6076.11548}$$

$\theta = 3.12^\circ$

Figure 2-14-11: FAF Net Given Segment Length. Para 252.d.

SECTION 6. CIRCLING APPROACH

260. Circling Approach Area

This is the obstacle clearance area, which shall be considered for aircraft maneuvering to land on a runway, which is not aligned with the FAC of the approach procedures, or for an approach where the final segment descent gradient does not meet criteria.

a. Alignment and Area. The size of the circling area varies with the approach category of the aircraft, as shown in Table 2-4. To define the limits of the circling area for the appropriate category, draw an arc of suitable radius from the centre of the end of each usable runway. Join the extremities to the adjacent arcs with lines drawn tangent to the arcs. The area thus enclosed is the circling approach area (see Figure 2-15).

Approach Category	Radius (nm)
A	1.3
B	1.5
C	1.7
D	2.3
E	4.5

Table 2-4: Circling Approach Area Radii (nm). Para 260a.

b. Obstacle Clearance. A minimum of 300 feet of obstacle clearance shall be provided in the circling approach area. There is no secondary obstacle clearance for the circling approach. See Para 322 for standard circling MDA.

261. Circling Approach Area Not Considered For Obstacle Clearance

It is permissible to eliminate from consideration, a particular sector where prominent obstacles exist in the circling approach area, provided the landing can be made without maneuvering over this sector and further provided that a note to this effect is included in the procedure. When a sector is eliminated from the obstacle clearance area, the area within which circling is permitted will be expanded to include a portion of the sector eliminated. The expanded portion of the obstacle clearance area shall begin at the threshold and splay 10° from the runway edge. Sectors within which circling is not permitted shall be clearly identified by runway centrelines, and where necessary, illumination of certain runway lights may be required. Circling restrictions shall be noted on the procedure.

262—269. Reserved

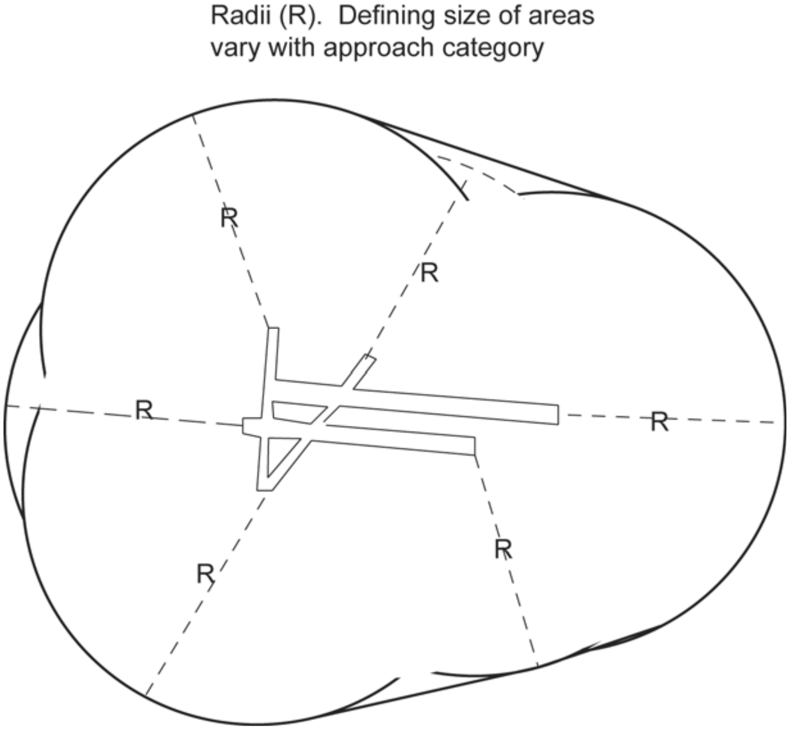


Figure 2-15: Construction Of Circling Approach Area. Para 260.a.

SECTION 7. MISSED APPROACH

270. Missed Approach Segment

(See ILS and PAR chapters for special provisions). A missed approach procedure shall be established for each IAP. The missed approach shall be initiated at the decision height (DH) in precision approaches or missed approach point (MAP) in non-precision approaches. The missed approach procedure must be simple, specify an altitude, and a clearance limit. The missed approach altitude specified in the procedure shall be sufficient to permit holding or en route flight. This means that the missed approach altitude must provide sufficient ROC to allow the pilot to hold at the missed approach holding fix (using the appropriate holding template), or must provide sufficient ROC to allow the pilot to proceed enroute. Where the missed approach altitude is below an initial approach altitude or enroute altitude, the 40:1 OIS must be assessed beyond the missed approach holding fix. If a climb in hold is required, it shall be assessed in accordance with Chapter 18, Holding Criteria. A note indicating that a shuttle is required prior to proceeding on course shall be included in the missed approach instructions. Example: Shuttle climb to 5000' BPOC.

Design alternate missed approach procedures using the criteria in this section. The area considered for obstacles has a width equal to that of a final approach area at the MAP and expands uniformly to the width of the initial approach segment at a point 15 nautical miles from the MAP (see Figure 2-16). When PCG is available, a secondary area for the reduction of obstacle clearance is identified within the missed approach area, which has the same width as the final approach segment area at the MAP, and which expands uniformly to a width of 2 NM at a point 15 NM from the MAP (see Figure 2-16). Where PCG is not available beyond this point, expansion of the area continues until PCG is achieved or segment terminates. Where PCG is available beyond this point, the area tapers at a rate of 30° inward relative to the course until it reaches initial segment width.

Note: Only the primary missed approach procedure shall be included on the published chart.

271. Missed Approach Alignment

Wherever practical, the missed approach course should be a continuation of the FAC. Turns are permitted, but should be minimized in the interest of safety and simplicity.

272. Missed Approach Point (MAP)

The MAP specified in the procedure may be the point of intersection of an electronic glide path with a DH, a navigation facility, a fix, or a specified distance from the FAF. The specified distance may not be more than the distance from the FAF to the usable landing surface. Specific criteria for the MAP are contained in the appropriate facility chapters.

273. Straight Missed Approach Area

When the missed approach course is within 15° of the final approach course, it is considered a straight missed approach (see Figure 2-16). The area considered for obstacle clearance is specified in Para 270.

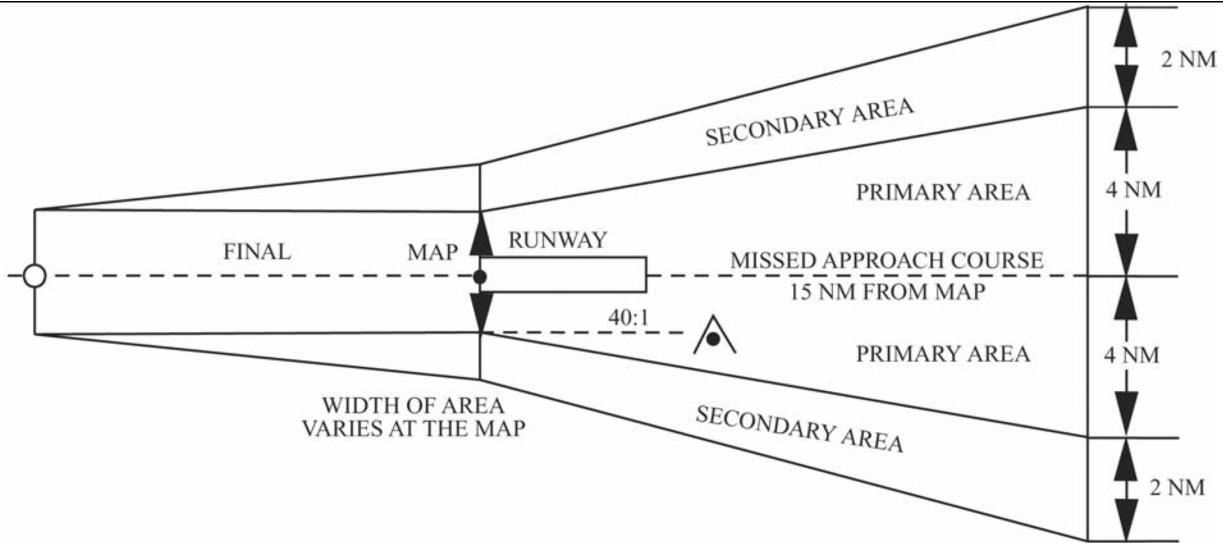


Figure 2-16: Straight Missed Approach Area. Para 273.

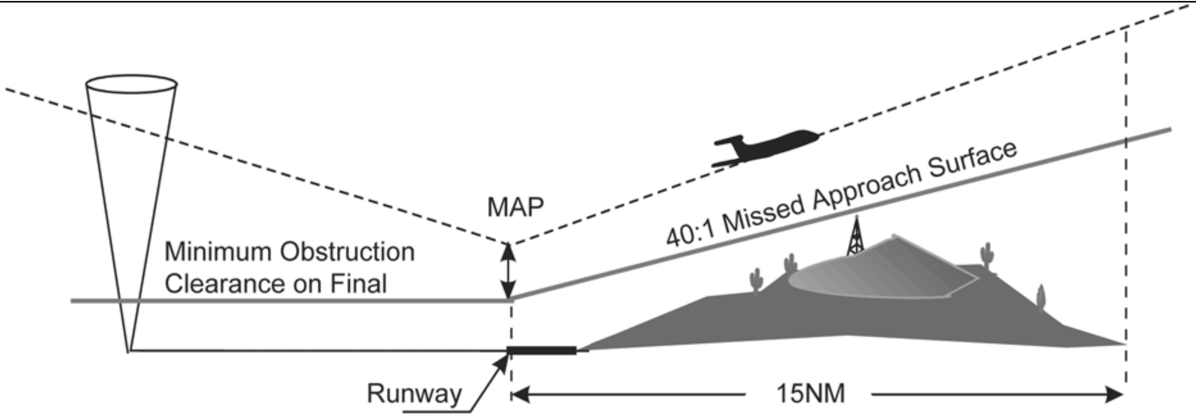
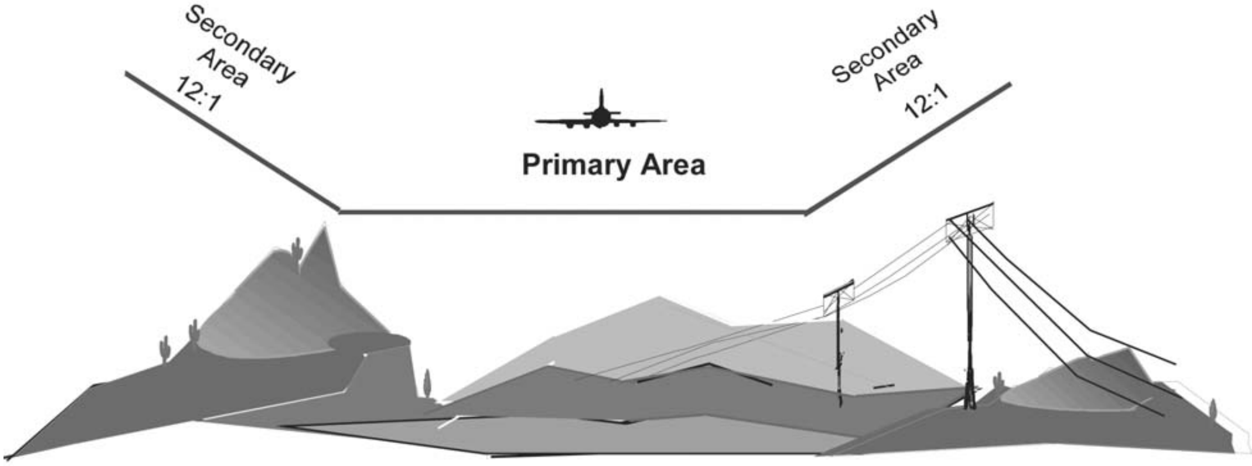


Figure 2-17: Straight Missed Approach Obstacle Clearance. Para 274.



WHEN COURSE GUIDANCE IS AVAILABLE

Figure 2-18: Missed Approach Cross-Section. Para 274.

274. Straight Missed Approach Obstacle Clearance

Within the primary missed approach area, no obstacle shall penetrate the missed approach surface. This surface begins over the MAP at a height determined by subtracting the required final approach primary area ROC and any minima adjustments, in accordance with Para 323, from the MDA. It rises uniformly at a rate of 1 foot vertically for each 40 feet horizontally (40:1) (see Figure 2-17). Where the 40:1 surface reaches a height of 1,000 feet below the missed approach altitude (Para 270), further application of the surface is not required. In the secondary area, no obstacle shall penetrate a 12:1 slope that extends outward and upward from the 40:1 surface at the inner boundaries of the secondary area (see Figure 2-18). Evaluate the missed approach segment to ensure obstacle clearance is provided.

a. Evaluate the 40:1 surface from the MAP to the clearance limit (end of the missed approach segment). The height of the missed approach surface over an obstacle is determined by measuring the straight-line distance from the obstacle to the nearest point on the line defining the origin of the 40:1 surface. If obstacles penetrate the surface, take action to eliminate the penetration.

b. The preliminary charted missed approach altitude is the highest of the minimum missed approach obstruction altitude, minimum holding altitude (MHA) established in accordance with Para 1820.a, or the lowest airway minimum en route altitude (MEA) at the clearance limit. To determine the minimum missed approach obstruction altitude for the missed approach segment, identified the highest obstacle in the primary area; or if applicable, the highest equivalent obstacle in the secondary area. Then add the appropriate ROC (plus adjustments), for holding or en route to the highest obstacle elevation. Round the total value to the nearest hundred-foot value, provided the ROC is not penetrated.

c. Determine if a climbing in holding pattern (climb-in-hold) evaluation is required (see Para 1822). If a climb in hold is intended at the clearance limit, a climb-in-hold evaluation is mandatory.

    (1) Calculate the elevation of the 40:1 surface at the end of the segment (clearance limit). The 40:1 surface starts at the same elevation as it does for obstacle evaluations. Compute the 40:1 rise from a point on the line defining the origin of the 40:1 surface in the shortest distance and perpendicular to the end-of-segment line at the clearance limit.

    (2) Compute the ROC surface elevation at the clearance limit by subtracting the appropriate ROC (plus adjustments) from the preliminary charted missed approach altitude.

    (3) Compare the ROC surface elevation at the clearance limit with the 40:1 surface elevation.

        (a) If the computed 40:1 surface elevation is equal to or greater than the ROC surface elevation, a climb-in-hold evaluation is NOT required.

        (b) If computed 40:1 surface elevation is less than the ROC surface elevation, a climb-in-hold evaluation IS required. TP308/GPH209, Chapter 18, Holding Pattern Criteria, Para 1820 specifies higher speed groups and, therefore, larger template sizes are usually necessary for the climb-in-hold evaluation. These templates may require an increase in minimum holding altitude (MHA) under TP308/GPH209 Chapter 18, Para 1801.c. Minimum Holding Altitude (MHA). If this evaluation requires an increase in the MHA, evaluate the new altitude using the higher speed group specified in Para 1822. This sequence of review shall be used until the MHA does not increase, then the 40:1 surface is re-evaluated. If obstacles penetrate the 40:1 surface, take action to eliminate the penetration.

(c) The charted missed approach altitude is the higher of the preliminary charted missed approach altitude or the MHA established under Para 274.c.3.b.

275. Turning Missed Approach Area

(See Volume 3 for special provisions.) If a turn of more than 15° from the FAC is required, a turning missed approach area must be constructed.

Note: If the HAT value associated with the DH/MDA is less than 400 feet, construct a combination straight and turning missed approach (see Para 277) to accommodate climb to at least 400 feet above the TDZE or Airport elevation prior to turn.

a. The dimensions and shape of this area are affected by three variables:

(1) Width of final approach area at the MAP.

(2) All categories of aircraft authorized to use the procedure (the obstacle area for each aircraft category, authorized to fly the procedure, shall be assessed); and

(3) Number of degrees of turn required by the procedure.

b. Secondary areas for the reduction of obstacle clearance are permitted when PCG is provided. The secondary area begins where a line perpendicular to the straight flightpath, originating at the point of completion of the turn, intersects the outer boundaries of the missed approach segment. The width of the secondary area expands uniformly from 0 (zero) to 2 NM at the 15 NM flight track point.

c. Primary areas. Figures 2-19 to 2-24 show the manner of construction of some typical turning missed approach areas. The following radii are used in the construction of these areas:

(1) 90° Turn or Less. Narrow final approach area at MAP (see Figure 2-19). To construct the area:

(a) Draw an arc with the radius (R_1) from the MAP. This line is then extended outward to a point 15 NM from the MAP, measured along the line. This is the assumed flight path. (see Table 2-5).

Approach Category	Obstacle Clearance Radius (R)	Flightpath Radius (R_1)
A	2.6	1.30
B	2.8	1.40
C	3.0	1.50
D	3.5	1.75
E	5.0	2.50

Table 2-5: Turning Missed Approach Radii (Nautical Miles). Para 275.

(a) Establish Points "A_2" and "B_1" by measuring 6 NM perpendicular to the flight path at the 15 mile point.

(b) Now connect "A_2" and "B_1" with a straight line.

(c) Draw an arc with the radius (R) from Point "A" to "A_1". ("A_1" is defined as the point where a line from "A_2" becomes tangent to the obstacle clearance "R" radius.) This is the edge of the obstacle clearance area.

(d) Establish Point "B" by measuring backward on the edge of the final approach secondary area a distance of 1 mile or a distance equal to the fix error PRIOR to the FAF, whichever is greater.

(e) Connect Points "A_1" and "A_2", and Points "B" and "B_1" with straight lines.

(2) 90° Turn or Less. Wide final approach area at MAP (see Figure 2-20). To construct the area:

(a) Draw an arc with the appropriate radius (R_1) from the MAP. This line is then extended outward to a point 15 NM from the MAP, measured along the line. This is the assumed flight path.

(b) Establish Points "A_2" and "B_1" by measuring 6 NM perpendicular to the flight path at the 15-mile point.

(c) Now connect Points "A_2" and "B_1" with a straight line.

(d) Draw an arc with the appropriate radius (R) from Point "A" to "A_1". ("A_1" is defined as the point where a line from "A_2" becomes tangent to the obstacle clearance "R" radius.) This is the edge of the obstacle clearance area.

(e) Establish Point "B" by measuring backward on the edge of the final approach secondary area a distance of 1 mile or a distance equal to the fix error PRIOR to the FAF, whichever is greater.

(f) Connect Points "A_1", and "A_2" and Points "B" and "B_1" with straight lines.

(3) More Than a 90° Turn. NARROW FINAL approach area at MAP (see Figure 2-21). To construct the area:

(a) Draw an arc with the radius (R_1) from the MAP through the required number of degrees and then continue outward to a point 15 NM from the MAP, measured along this line, which is the assumed flight path.

(b) Establish Points "A_2" and "C_1" by measuring 6 NM on each side of the assumed flight path and perpendicular to it at the 15 mile point.

(c) Now connect Points "A_2" and "C_1" with a straight line.

(d) Draw an arc with the radius (R) from Point "A" to Point "A_1" (Figure 2-21 uses 135°). ("A_1" is defined as the point where a line from "A_2" becomes tangent to the obstacle clearance "R" radius.) This is the outer edge of the obstacle clearance area.

(e) Locate Point "C" at the inner edge of the final approach secondary area opposite the MAP. (Point "A" and Point "C" will be coincident when the MAP is the facility.)

(f) Connect Points "A_1" and "A_2" and Points "C" and "C_1" with straight lines.

(4) More Than 90° Turn. WIDE FINAL approach area at MAP (see Figure 2-22). To construct the area:

(a) Draw the assumed flightpath, which is an arc with the radius (R_1), from the MAP the required number of degrees to the desired flightpath or course.

(b) Establish Points "A_4" and "C_1" by measuring 6 NM on each side of the assumed flight path and perpendicular to it at the 15-mile point.

(c) Connect Points "A_4" and "C_1" with a straight line.

(d) Draw a 90° arc with the appropriate radius (R) from Point "A" to Point "A_1". Note that when the width of the final approach area at the MAP is greater than the appropriate radius (R), the turn is made in two increments when constructing the obstacle clearance area.

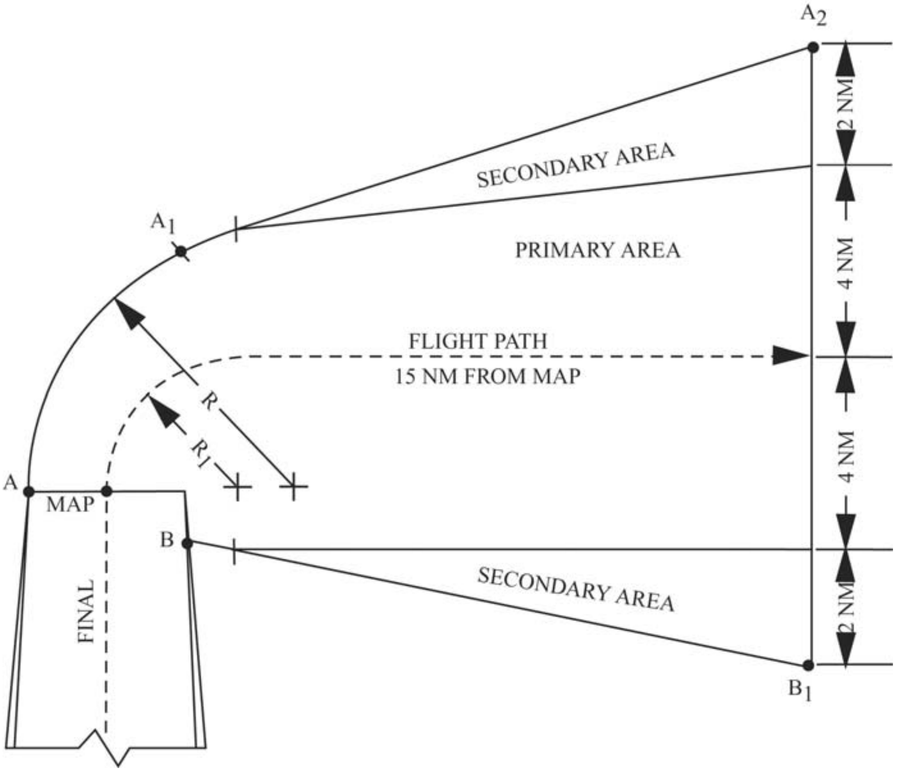


Figure 2-19: Turning Missed Approach Area. 90 Degree Turn Or Less. Narrow Final Approach At MAP. Para 275.c.(1).

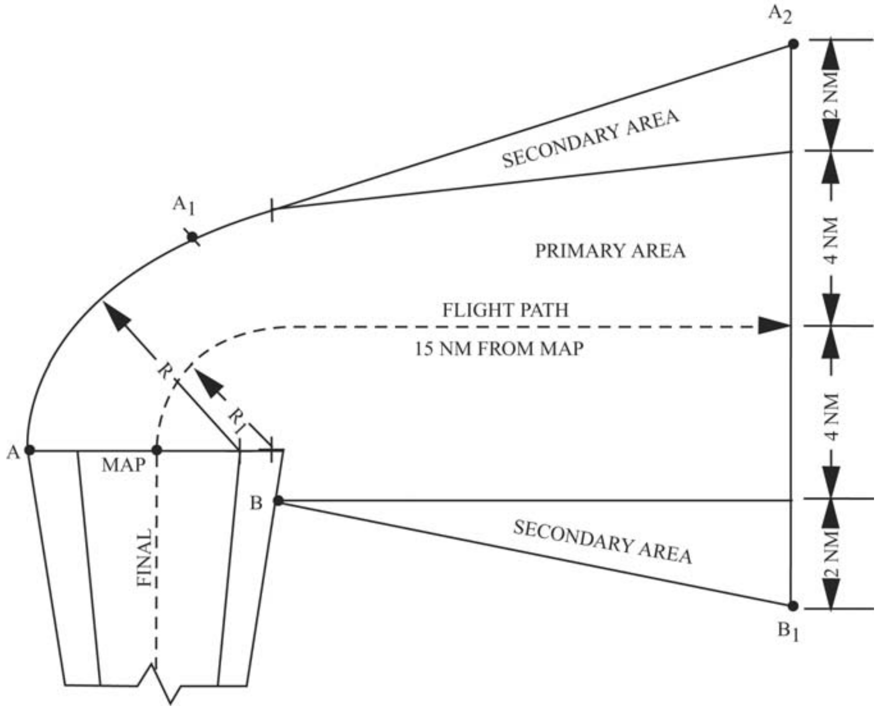


Figure 2-20: Turning Missed Approach Area. 90 Degree Turn Or Less. Wide Final Approach Area At MAP. Para 275.c.(2).

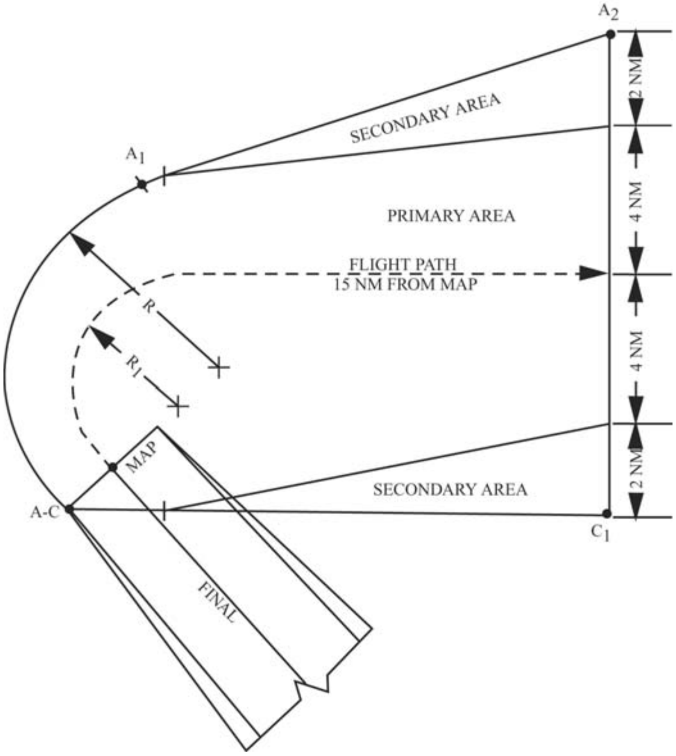


Figure 2-21: Turning Missed Approach Area. More Than 90 Degree Turn. Narrow Final Approach At MAP. Para 275.c.(3).

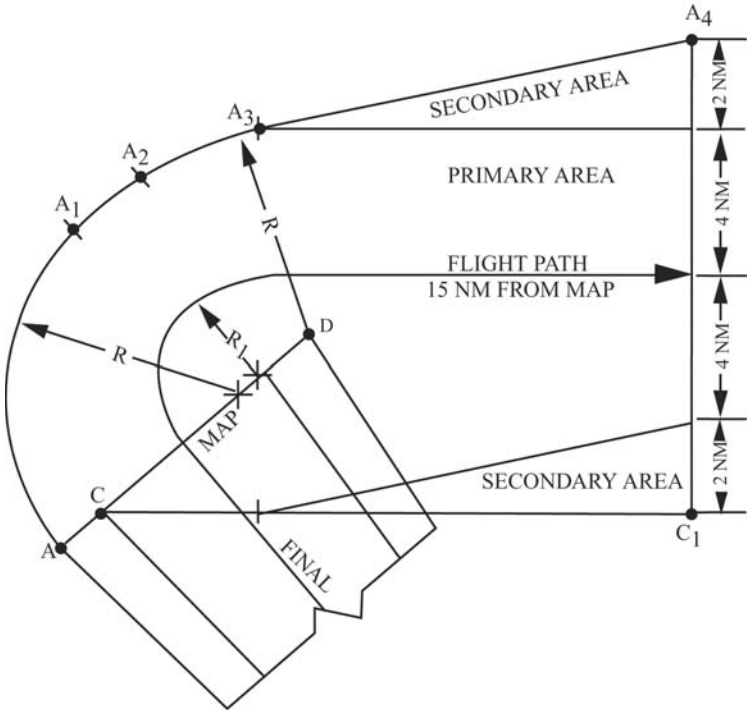


Figure 2-22: Turning Missed Approach Area. More Than 90 Degree Turn. Wide Final Approach At MAP. Para 275.c.(4).

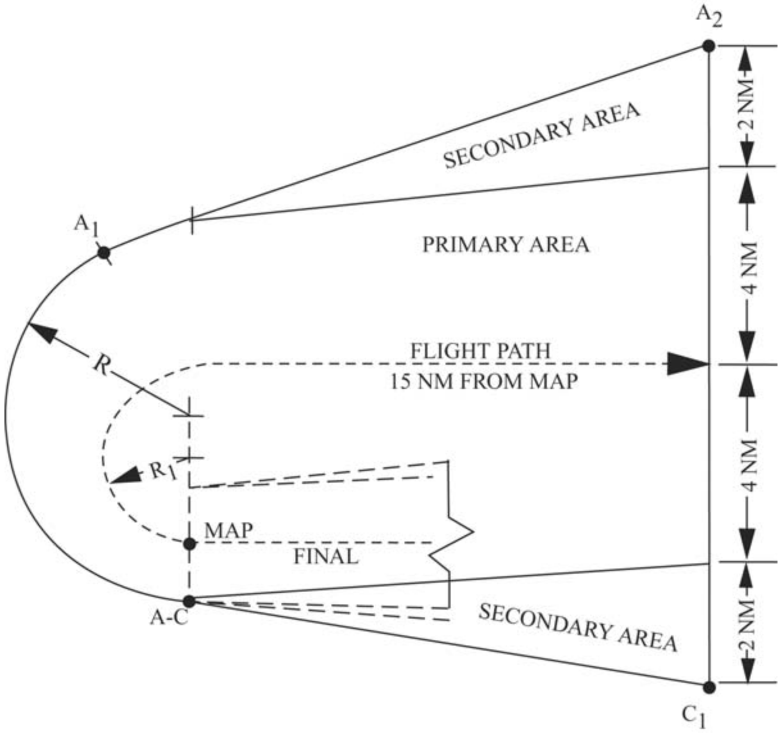


Figure 2-23: Turning Missed Approach Area. 180 Degree Turn. Narrow Final Approach Area At MAP. Para 275.

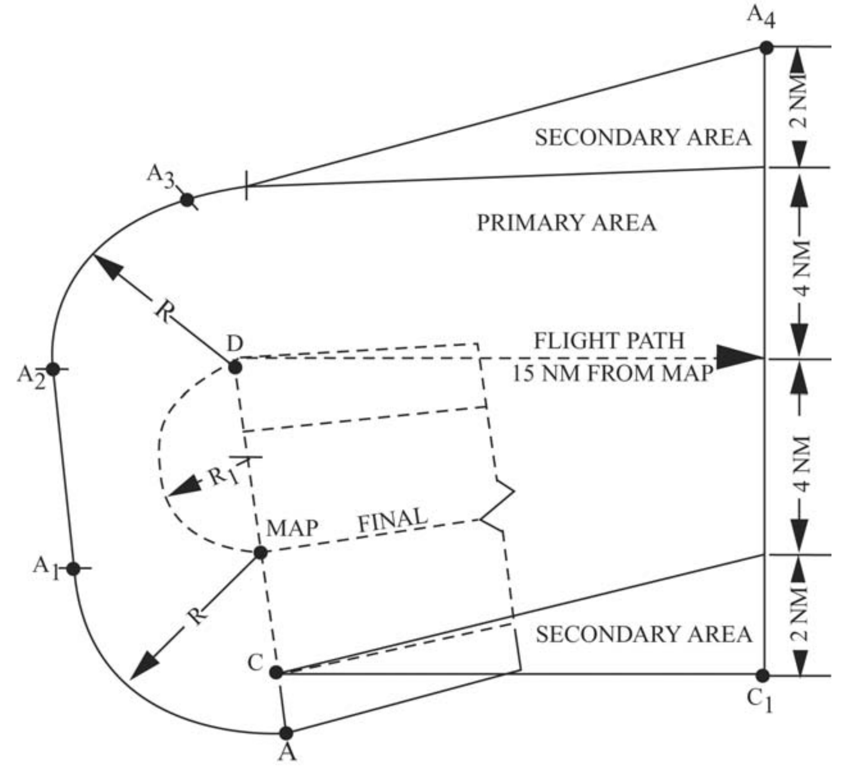


Figure 2-24: Turning Missed Approach Area. 180-Degree Turn. Wide Final Approach Area At MAP. Para 275.c.(6).

(e) Draw an arc with the radius (R) from Point "D" (edge of final approach secondary area opposite MAP) the required number of degrees from Point "A_2" to Point "A_3". (Point “A_3”is defined as the point where a line from "A_4" becomes tangent to the obstacle clearance "R" radius from Point "D"). Compute the number of degrees by subtracting 90° from the total turn magnitude.

(f) Connect Points "A_1" and "A_2" with a straight line.

(g) Locate Point "C" at the inner edge of the final approach secondary area opposite the MAP.

(h) Connect Point "A_3" with Point "A_4" and connect Point "C" with Point "C_1" using straight lines.

(5) 180° Turn. Narrow final approach area at MAP (see Figure 2-23). To construct the area:

(a) Draw an arc with the radius (R_1) from the MAP through 180°, and then continue outward to a point 15 NM from the MAP, measured along this line, which is the assumed flight path.

(b) Establish Points "A_2" and "C_1" by measuring 6 NM on each side of the assumed flight path, and perpendicular to it at the 15 mile point.

(c) Now connect Point "A_2" and Point "C_1" with a straight line.

(d) Locate Point "C" at the inner edge of the final approach secondary area opposite the MAP. (Point "A" and Point "C" will be coincident when the MAP is the facility.)

(e) Draw an arc with the radius (R) from Point "A" to Point "A_1" (180°). This is the outer edge of the obstacle clearance area.

(f) Connect Points "A_1" and "A_2" and Points "C" and "C_1" by straight lines. (The line "A_1-A_2" joins the arc tangentially.)

(6) 180° Turn. Wide Final Approach area at MAP (see Figure 2-24). To construct the area:

(a) Draw the flightpath arc with the radius (R_1) from the MAP and then continue the line outward to a point 15 NM from the MAP, measured along the assumed flightpath.

(b) Establish Points "A_4" and "C_1" by measuring 6 NM on each side of the flight path and perpendicular to it at the 15-mile point.

(c) Now connect Points "A_4" and "C_1" with a straight line.

(d) Draw a 90° arc with the appropriate radius (R) from Point "A" to Point "A_1". Note that when the width of the final approach area at the MAP is greater than the appropriate radius (R), the turn is made in two increments when constructing the obstacle clearance area.

(e) Draw an arc with the radius (R) from Point "D" (edge of final approach secondary area opposite MAP) the required number of degrees from Point "A_2" to Point "A_3". Compute the number of degrees by subtracting 90° from the total turn magnitude.

(f) Connect Points "A_1" and "A_2" with a straight line.

(g) Locate Point "C" at the inner edge of the final approach secondary area opposite the MAP.

(h) Connect Points "A_3" and "A_4" and Points "C" and "C_1" with straight lines. (The line "A_3-A_4" joins the arc tangentially.)

276. Turning Missed Approach Obstacle Clearance

The methods of determining the height of the 40:1 missed approach surface over obstacles in the turning missed approach area vary with the amount of turn involved. Evaluate the missed approach segment to ensure the 40:1 obstacle identification surface (OIS) is not penetrated.

a. 90° Turn or Less (see Figure 2-25). Zone 1 is a 1.6-mile continuation of the final approach secondary area, and has identical obstacle clearance requirements. Zone 2 is the area in which the height of the missed approach surface over an obstacle must be determined. To do this, first identify line "A-D-B". Point "B" is located by measuring backward on the edge of the final approach area a distance of 1 mile or a distance equal to the fix error prior to the MAP, whichever is greater. This is to safeguard the short-turning aircraft. Thus, the height of the missed approach surface over an obstacle in Zone 2 is determined by measuring the straight-line distance from the obstacle to the nearest point on line "A-D-B" and computing the height based on the 40:1 ratio. The height of the missed approach surface over the MAP is the same as specified in Para 274. When an obstacle is in a secondary area, measure the straight-line distance from the nearest point on the line "A-D-B" to the point on the inner edge of the secondary area which is nearest the obstacle. Compute the height of the missed approach surface at this point, using the 40:1 ratio. Then apply the 12:1 secondary area ratio from the height of the surface for the remaining distance to the obstacle.

b. More than 90° Turn (see Figure 2-26). In this case a third zone becomes necessary. Zone 3 is defined by extending a line from Point "B" to the extremity of the missed approach area perpendicular to the FAC. Zone 3 will encompass all of the missed approach area not specifically within Zones 1 and 2. All distance measurements in Zone 3 are made from point "B". Thus the height of the missed approach surface over an obstacle in Zone 3 is determined by measuring the distance from the obstacle to point "B" and computing the height based on the 40:1 ratio. The height of the missed approach surface over Point "B" for Zone 3 computations is the same as the height of the MDA. For an obstacle in the secondary area, use the same measuring method prescribed in Para 276.a except that the original measuring point shall be point "B".

c. Secondary Area. In the secondary area no obstacles may penetrate a 12:1 slope, which extends outward and upward from the 40:1 surface from the inner to the outer boundary lines of the secondary area.

d. Evaluate the missed approach segment from the MAP to the clearance limit. Terminate the 40:1 obstacle clearance surface (OCS) at an elevation corresponding to enroute ROC below the missed approach altitude.

(1) If the 40:1 0CS terminates prior to the clearance limit, continue the evaluation using a level OIS at the height that the 40:1OCS was terminated.

(2) If the clearance limit is reached before the 40:1 OCS terminates, continue a climb-in-hold evaluation at the clearance limit.

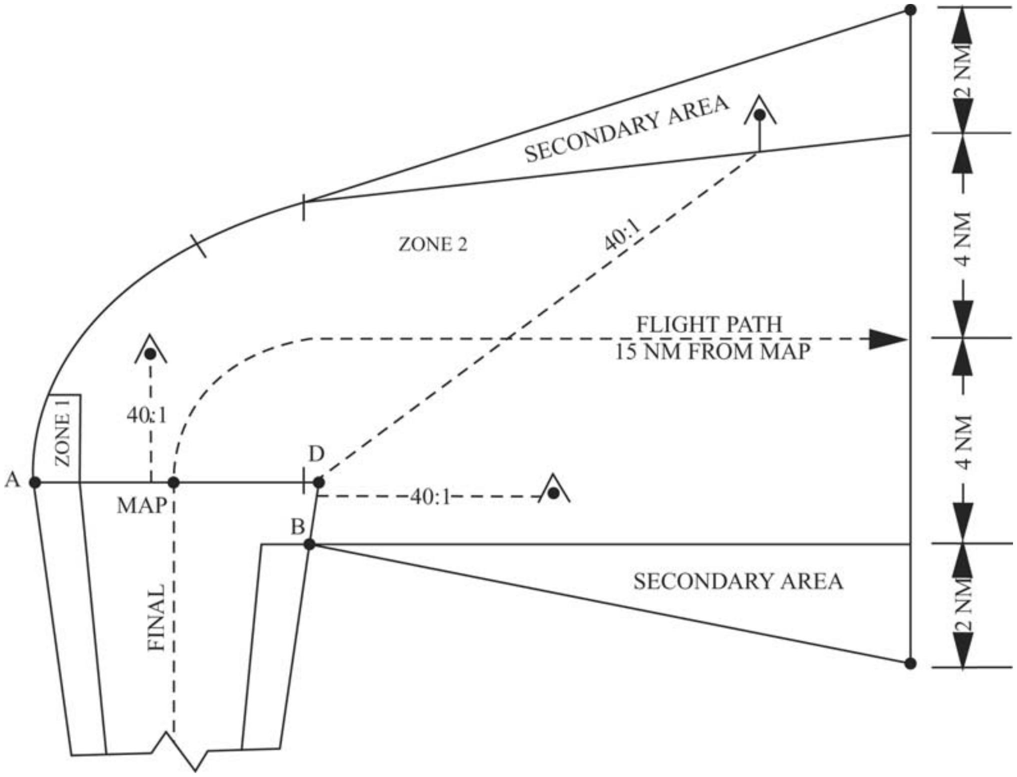


Figure 2-25: Turning Missed Approach Obstacle Clearance. 90 Degree Turn Or Less. Para 276.

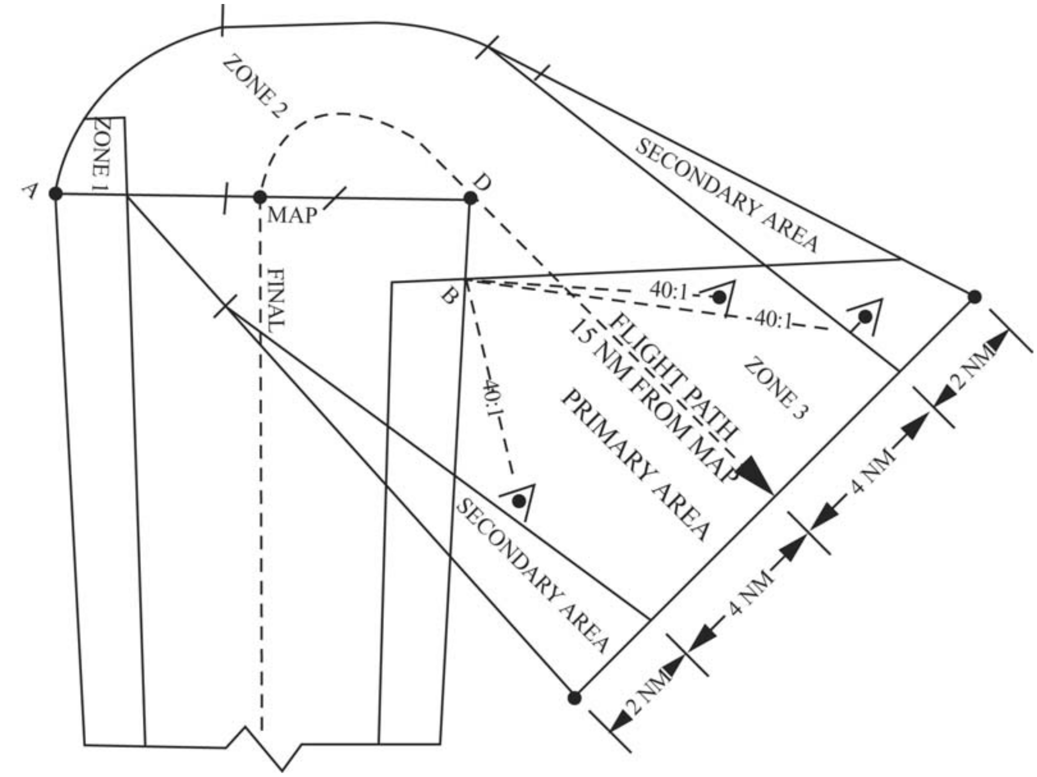


Figure 2-26: Turning Missed Approach Obstacle Clearance. More Than 90 Degree Turn. Para 276.

e. The preliminary charted missed approach altitude is the highest of the minimum missed approach obstruction altitude, MHA established in accordance with Chap 18, Para 1820.c, or lowest airway MEA at the clearance limit. To determine the minimum missed approach obstruction altitude for the missed approach segment, identify the highest obstacle in the primary area; or if applicable, the highest equivalent obstacle in the secondary area. Then add the appropriate ROC (plus adjustments) for holding or en route to the highest obstacle elevation. Round the total value to the nearest hundred-foot level, provided the ROC is not violated.

f. Determine if a climb-in-hold evaluation is required (see Chap 18, Para 1822.a(2)).

  (1) Calculate the elevation of the 40:1 surface at the end of the segment (clearance limit). The 40:1 surface starts at the same elevation as it does for obstacle evaluations. Compute the 40:1 rise from a point on the “A-D-B" line in the shortest distance to the end-of-segment line at the clearance limit.

  (2) Compute the ROC surface elevation at the clearance limit by subtracting the appropriate ROC (plus adjustments) from the preliminary charted missed approach altitude.

(3) Compare the ROC surface elevation at the clearance limit with the 40:1 surface elevation.

(a) If the computed 40:1 surface elevation is equal to our greater than the ROC surface elevation, a climb hold evaluation is NOT required.

(b) If the computed 40:1 surface elevation is less than the ROC surface elevation, a climb-in-hold evaluation IS required. Chap 18 Holding Criteria, Para 1822, specifies higher speed groups and therefore, larger template sizes are usually necessary for the climb-in-hold evaluation. These templates may require an increase in MHA under Para 1801.c. If this evaluation requires an increase in the MHA, evaluate the new altitude using the higher speed group specified in Para 1822. This sequence of review shall be used until the MHA does not increase, then the 40:1 surface is re-evaluated. If obstacles penetrate the 40:1 surface, take action to eliminate the penetration.

g. The charted missed approach altitude is the higher of the preliminary charted missed approach altitude or the MHA established under Para 274.c.3.b.

277. Combination Straight And Turning Missed Approach Area

If a straight climb to a specific altitude followed by a turn is necessary to avoid obstacles, a combination straight and turning missed approach area must be constructed. The straight portion of this missed approach area is Section 1. The portion in which the turn is made is Section 2. Evaluate the missed approach segment to ensure obstacle clearance is provided.

a. Straight Portion. Section 1 is a portion of the normal straight missed approach area and is constructed as specified in Para 273. Obstacle clearance is provided as specified in Para 274 except that secondary area reductions do not apply. The length of Section 1 is determined as shown in Figure 2-27 and relates to the need to climb to a specified altitude prior to commencing the turn. Point A_1 marks the end of Section 1. Point B_1 is one mile from the end of Section 1 (see Figure 2-27).

b. Turning Portion. Section 2 is constructed as specified in Para 275 except that it begins at the end of Section 1 instead of at the MAP. To determine the height, which must be attained before commencing the missed approach turn, first identify the controlling obstacle on the side of Section 1 to which the turn is to be made. Then measure the distance from this obstacle to the nearest edge of the Section 1 area. Using this distance as illustrated in Figure 2-27, determine the height of the 40:1 slope at the edge of Section 1. This height plus the appropriate final ROC, (the sum rounded up to the next higher 100-foot increment) is the height at which the turn should be started. Obstacle clearance requirements in Section 2 are the same as those specified in Para 276 except that Zone 1 is not considered and Section 2 is expanded to start at point “B” if no fix exists at the end of Section 1, or if no course guidance is provided in Section 2 (see Figure 2-27).

c. Evaluate the 40:1 surface from the MAP to the clearance limit (end of the missed approach segment). If obstacles penetrate the surface, take action to eliminate the penetration.

d. The preliminary charted missed approach altitude is the lowest of the minimum missed approach obstruction altitude, MHA established in accordance with Chapter 18, Para 1820.c, or lowest airway MEA at the clearance limit. To determine the minimum missed approach obstruction altitude for the missed approach segment, identify the highest obstacle in the primary area; or if applicable, the highest equivalent obstacle in the secondary area. Then add the appropriate ROC (plus adjustments) for holding or en route to the highest obstacle elevation. Round the total value to the next higher hundred-foot level.

e. Determined if a climb-in-hold evaluation is required (see Chapter 18, Para 1822).

   (1) Calculate the elevation in the 40:1 surface at the end of the segment (clearance limit). The 40:1 surface starts at the same elevation as it does for obstacle evaluations, plus minima adjustments in accordance with Para 323.

   (2) Compute the ROC surface elevation at the clearance limit by subtracting the appropriate ROC (plus adjustments) from the preliminary charted missed approach altitude.

   (3) Compare the ROC surface elevation at the clearance limit with the 40:1 surface elevation.

      (a) If the computed 40:1 surface elevation is equal to or greater than the ROC surface elevation, a climb-in-hold evaluation is NOT required.

      (b) If the computed 40:1 surface elevation is less than the ROC surface elevation, a climb-in-hold evaluation IS required. TP 308 Holding Criteria, Para 1822, specifies higher speed groups and therefore, larger template sizes are usually necessary for the climb-in-hold evaluation. These templates may require an increase in MHA under Para 1801.c. If this evaluation requires an increase in the MHA, evaluate the new altitude using the higher speed group specified in Para 1822. This sequence of review shall be used until the MHA does not increase, then the 40:1 surface is re-evaluated. If obstacles penetrate the 40:1 surface, take action to eliminate the penetration.

f. The charted missed approach altitude is the higher of the preliminary charted missed approach altitude or the MHA established under Para 274.c.3.b.

EXAMPLE

GIVEN

1. MDA 360' MSL
2. Obstacle height: 1098' MSL
3. Obstacle in section 2 = 3 NM from near edge of section

Find:

1. Required length of Section 1
2. Minimum altitude at which aircraft can start turn

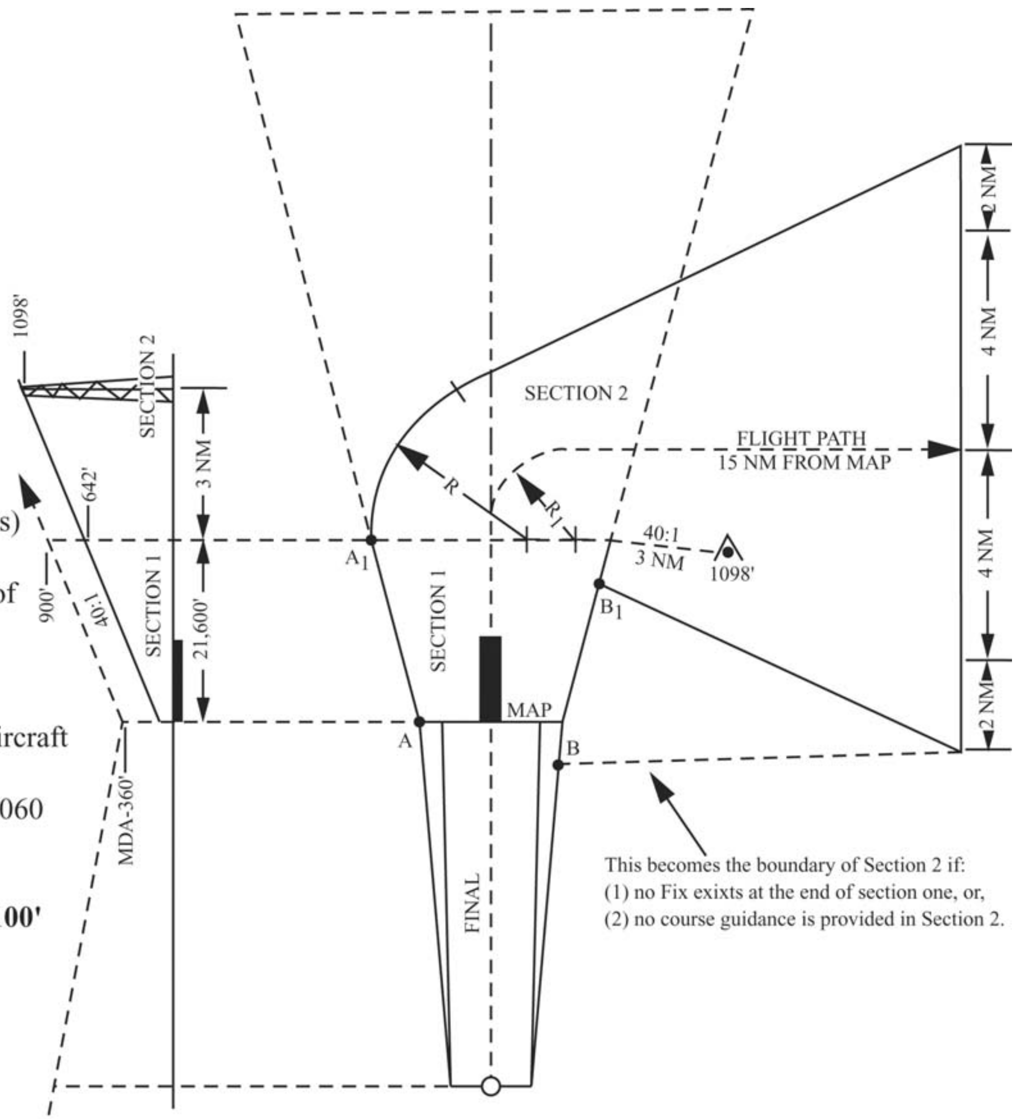
Solution:

1. Find height MSL at near edge:
   1098-(3x6076/40)=642
2. Find HMAS=MDA-(ROC+Adjustments)
   360-250=110
3. Find the rise from the MAP to the end of Section 1: 642-110=532

ANSWER 1: Length of Section 1:
532x40=21280

ANSWER 2: Minimum altitude at which aircraft can turn:
((21280/6076)x200)+360=1060
Round result to next higher 100 foot increment.

Missed approach instructions:"**Climb to 1100'** before starting right turn to...etc."



This becomes the boundary of Section 2 if:
(1) no Fix exixts at the end of section one, or,
(2) no course guidance is provided in Section 2.

NOTE:
Section 1 must be lengthened to accomodate the rounding up to **1100'.** In this example the aircraft will climb an extra *40' (from 1060'to1100')* at **200'/NM**, therfore, traveling an extra *1200' (40x30)* from the previous section 1 calculations. The required length of section 1 for the turn at **1100' MSL** is **22480' (21280 + 1200).**

Figure 2-27: Combined Missed Approach Area. Para 277.a.

278. Missed Approach Area Tracking To A Facility

A missed approach may track to a facility. The opening segment area is a portion of the normal missed approach area. The closing segment area may be constructed using the appropriate approach area criteria for the facility used (see Figure 2-30). To use this option, the missed approach shall meet the following conditions:

a. a track to the facility must be specified,

b. the area must be constructed centered on the published track,

c. the missed approach must be a straight missed approach in accordance with Para 273, and

d. the missed approach facility must be within 15 NM of the MAP.

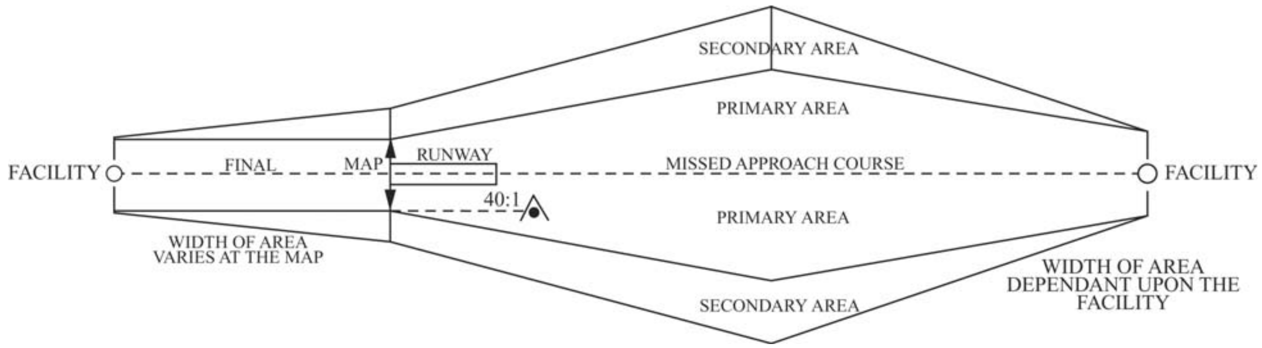


Figure 2-30: Missed Approach Area Tracking To A Facility. Para 278.

279. End Of Missed Approach

Aircraft shall be assumed to be in the initial approach or en route environment upon reaching minimum obstacle clearance altitude (MOCA) or minimum en route altitude (MEA). Thereafter, the initial approach or the en route obstacle clearance criteria apply. This means that the missed approach altitude must provide sufficient ROC to allow the pilot to hold at the missed approach holding fix (using the appropriate holding template), or must provide sufficient ROC to allow the pilot to proceed enroute. Where the missed approach altitude is below an initial approach altitude or enroute altitude, the 40:1 OIS must be assessed beyond the missed approach holding fix. If a climb in hold is required, it shall be assessed in accordance with Chapter 18, Holding Criteria. A note indicating that a shuttle is required prior to proceeding on course shall be included in the missed approach instructions. Example: Shuttle climb to 5000' BPOC.

SECTION 8. TERMINAL AREA FIXES

280. General

Terminal area fixes include, but are not limited to the FAF, the IF, the IAF, the holding fix, and when possible, a fix to mark the MAP. Each fix is a geographical position on a defined course. Terminal area fixes should be based on similar navigation systems. For example, TACAN, VORTAC, and VOR/DME facilities provide Radial/DME fixes. NDB facilities provide bearings. VOR facilities provide VOR radials. The use of integrated (VHF/NDB) fixes shall be limited to those intersection fixes where no satisfactory alternative exists.

281. Fixes Formed By Intersection

A geographical position can be determined by the intersection of courses or radials from two stations. One station provides the course the aircraft is flying and the other provides a crossing indication that identifies a point along the course that is being flown. Because all stations have accuracy limitations, the geographical point which is identified is not precise, but may be anywhere within a quadrangle which surrounds the plotted point of intersection. Figure 2-28 illustrates the intersection of an arc and a radial from the same DME facility, and the intersection of two radials or courses from different navigation facilities. The area encompassed by the sides of the quadrangle formed in these ways is referred to in this publication as the "fix displacement area".

282. Course/Distance Fixes

A DME fix is formed by a DME reading on a positive navigational course. The information should be derived from a single facility with collocated azimuth and DME antennas. However, when a unique operational requirement indicates a need for DME information from other than collocated facilities, an individual IAP that specifies DME may be approved, provided the angular divergence between the signal sources at the fix does not exceed 23° (see Figure 2-28). For limitation on use of DME with ILS, see Volume 3, Para 2.9.1.

283. Fixes Formed By Radar

Where ATC can provide the service, Airport Surveillance Radar (ASR) may be used for any terminal area fix. PAR may be used to form any fix within the radar coverage of the PAR system. Air Route Surveillance Radar (ARSR) may be used for initial approach and intermediate approach fixes.

284. Fix Displacement Area

The areas portrayed in Figure 2-28 extend along the flight course from Point "A" to Point "C". The fix error is a plus-or-minus value, and is represented by the lengths from "A" to "B" and "B" to "C". Each of these lengths is applied differently. The fix error may cause the fix to be received early (between "A" and "B"). Because the fix may be received early, protection against obstacles must be provided from a line perpendicular to the flight course at point “A".

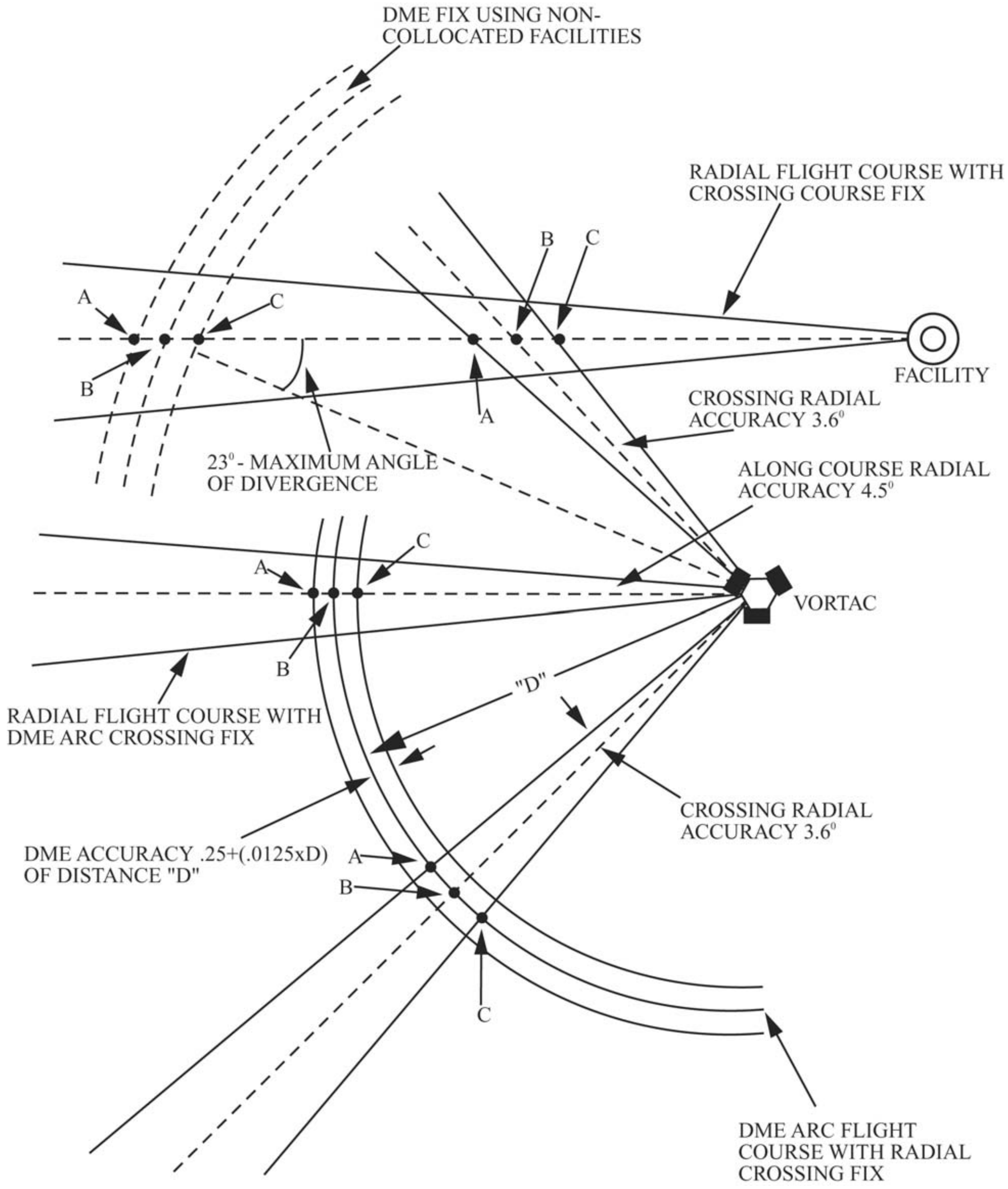


Figure 2-28: Intersection Fix Displacement. Paras 281, 282, and 284.

285. Intersection Fix Displacement Factors

The intersection fix displacement area is determined by the system use accuracy of the navigation fixing systems (see Figure 2-28). The system use accuracy in VOR and TACAN type systems is determined by the combination of ground station error, airborne receiving system error, and flight technical error (FTE). En route VOR data have shown that the VOR system accuracy along radial 4.5°, 95 percent of occasions, is a realistic, conservative figure. Thus, in normal use of VOR or TACAN intersections, fix displacement factors may conservatively be assessed as follows:

a. Along-Course Accuracy.

  (1) VOR/TACAN radials, plus-or-minus 4.5°.

  (2) Localizer course, plus-or-minus 1°.

  (3) NDB courses or bearings, plus-or-minus 5°.

  Note: The plus-or-minus 4.5° (95 percent) VOR/TACAN figure is achieved when the ground station course signal error, the FTE, and the VOR airborne equipment error are controlled to certain normal tolerances. Where it can be shown that any of the three error elements is consistently different from these assumptions (for example, if flight inspection shows a consistently better VOR signal accuracy or stability than the one assumed, or if it can be shown that airborne equipment error is consistently smaller than assumed), VOR fix displacement factors smaller than those shown above may be utilized under Para 141.

b. Crossing Course Accuracy.

  (1) VOR/TACAN radials, plus-or-minus 3.6°.

  (2) Localizer course, plus-or-minus 0.5°.

  (3) NDB courses or bearings, plus-or-minus 5°.

  Note: The plus-or-minus 3.6° (95 percent) VOR/TACAN figure is achieved when the ground station course signal error and the VOR airborne equipment error are controlled to certain normal tolerances. Since the crossing course is not flown, FTE is not a contributing element. Where it can be shown that either of the error elements is consistently different, VOR displacement factors smaller than those shown above may be utilized in accordance with Para 141.

286. Other Fix Displacement Factors

a. Radar. Plus-or-minus 500 feet or 3 percent of the distance to the antenna, whichever is greater.

b. DME. Plus-or-minus .25 NM plus 0.0125 of the distance to the antenna.

c. Overheading a Station. The fix error involved in station passage is not considered significant in terminal applications. The fix is therefore considered to be at the plotted position of the navigation facility. The use of TACAN station passage as a fix is NOT acceptable for holding fixes or high altitude IAF’s.

287. Satisfactory Fixes

a. Intermediate, Initial or Feeder Fix. To be satisfactory as an intermediate or initial or feeder approach fix, the fix error must not be larger than 50 percent of the appropriate segment distance that follows the fix. Measurements are made from the plotted fix position (see Figure 2-29).

b. Holding Fixes. Any terminal area fix except overheading a TACAN may be used for holding. The following conditions shall exist when the fix is an intersection formed by courses or radials:

(1) The angle of divergence of the intersecting courses or radials shall not be less than 45°.

(2) If the facility that provides the crossing course, is NOT an NDB, it may be as much as 45 NM from the point of intersection.

(3) If the facility that provides the crossing course is an NDB, it must be within 30 NM of the intersection point.

(4) If distance stated in Para 287.b.(2) or (3) are exceeded, the minimum angle of divergence of the intersecting courses must be increased at the following rate:

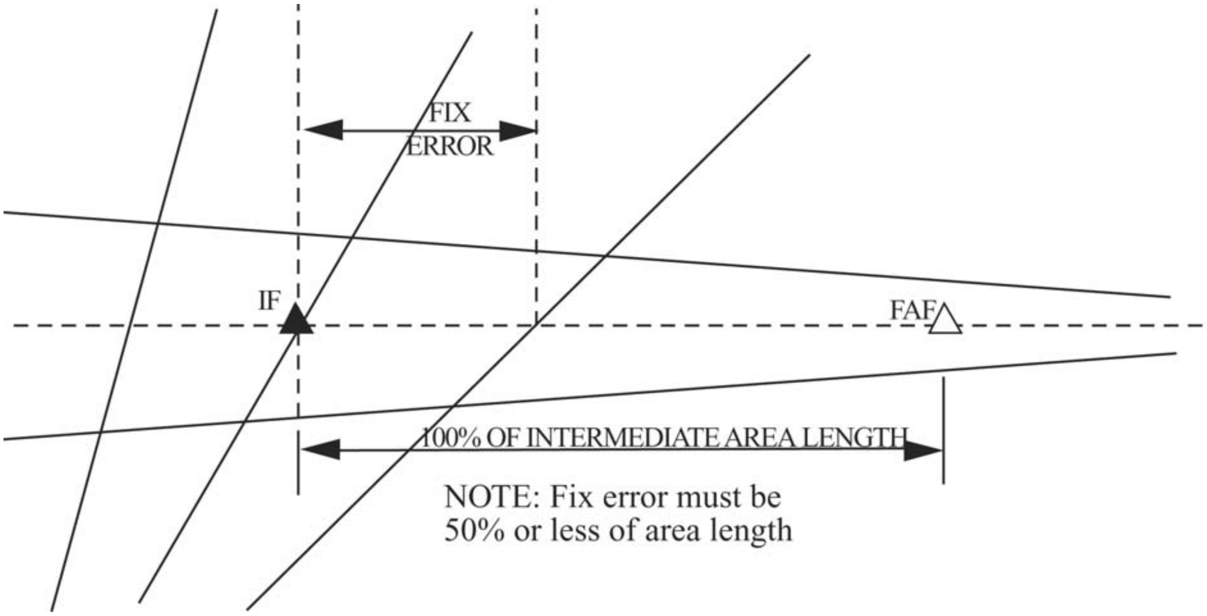
(a) If an NDB facility is involved, 1° for each mile over 30 NM.

(b) If an NDB facility is NOT involved, ½° for each mile over 45 NM.

c. FAF. For a fix to be satisfactory for use as a FAF, the fix error should not exceed plus-or-minus 1 mile (see Figures 2-31-1 and 2-31-2). It may be as large as plus-or-minus 2 NM when:

(1) The MAP is marked by overheading an air navigation facility; OR

(2) A buffer of equal length to the excessive fix error is provided between the published MAP and the point where the missed approach surface begins (see Figure 2-32)



NOTE: Fix error must be 50% or less of area length

Figure 2-29: Intermediate Or Initial Approach Fix Errors. Para 287.

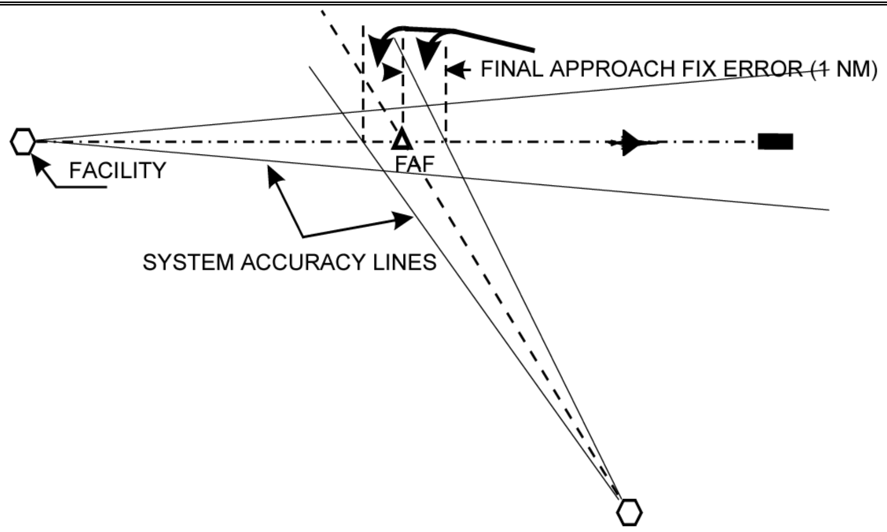
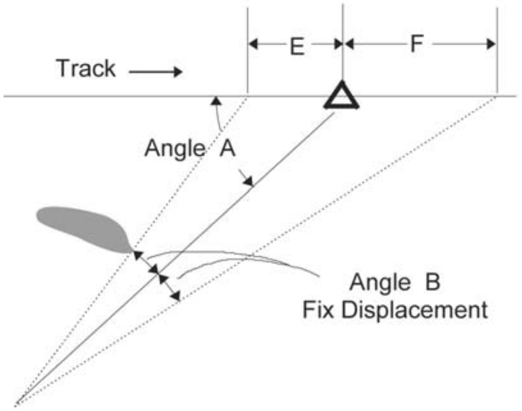


Figure 2-31-1: Measurement Of FAF Error. Para 287.c.

Calculate fix displacement using the following formulas:



Formula	Example
$E = \dfrac{6076.11548 \times D \times \sin B}{\sin (A + B)}$	$E = \dfrac{6076\text{-}11548 \times 30 \times \sin 3.6^\circ}{\sin (50^\circ + 3.6^\circ)}$ $E = 14220.10$
$F = \dfrac{6076.11548 \times D \times \sin B}{\sin (A - B)}$	$F \quad \dfrac{6076.11548 \times 30 \times \sin 3.6^\circ}{\sin (50^\circ - 3.6^\circ)}$ $F = 15805.19$

Figure 2-31-2: Fix Displacement Calculations. Para 287.c.

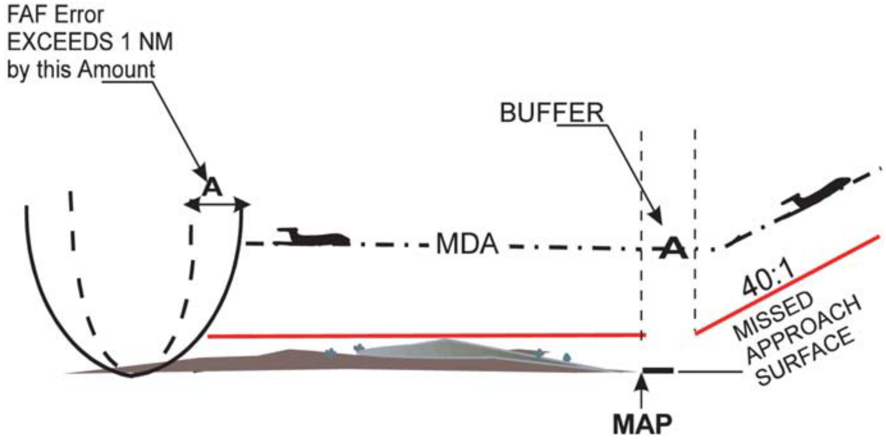


Figure 2-32: FAF Error Buffer. Para 287.c.(2).

288. Using Fixes For Descent

a. Distance Available for Descent. When applying descent gradient criteria applicable to an approach segment (initial, intermediate or final approach areas), the measuring point is the plotted position of the fix (see Figure 2-33).

b. Obstacle Clearance After Passing a Fix. It is assumed that descent will begin at the earliest point the fix can be received. Full obstacle clearance shall be provided from this point to the plotted point of the next fix. Therefore, the altitude to which descent is to be made at the fix must provide the same clearance over obstacles in the fix displacement area as it does over those in the approach segment that is being entered (see Figures 2-34-1 and 2-34-2).

c. Step-down Fixes (see Figure 2-35).

(1) DME or Radar Fixes. Except in the intermediate segment within a procedure turn (see Para 244), there is no maximum number of step-down fixes in any segment when DME or radar is used. DME may be denoted in tenths of a mile. The distance between fixes shall not be less than 1 mile.

(2) Intersection Fixes.

(a) Only one step-down fix is permitted in the final and intermediate segments.

(b) If an intersection fix forms a FAF, IF, or IAF:

(i) The same crossing facility shall be used for the step-down fix(es) within that segment.

(ii) All fixes from the IF to the last step-down fix in final shall be formed using the same crossing facility.

(c) Table 2-5A shall be used to determine the number of step-down fixes permitted in the initial segment. The distance between fixes shall not be less than 1 mile.

Length of Segment	Number of Fixes
5 – 10 NM	1 stepdown fix
over 10 – 15 NM	2 stepdown fixes
over 15 NM	3 stepdown fixes

Table 2-5A: Stepdown Fixes In Initial Segment. Para 288c(2)(c).

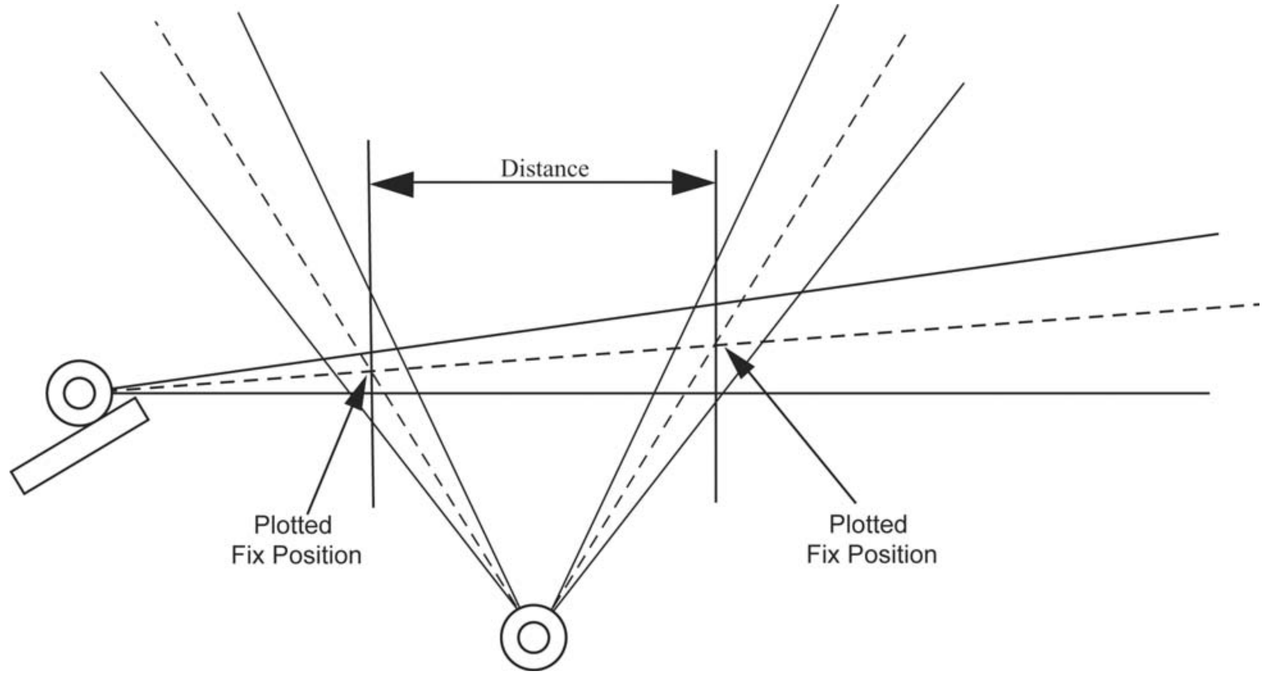


Figure 2-33: Distance For Descent Gradient Application. Para 288.a.

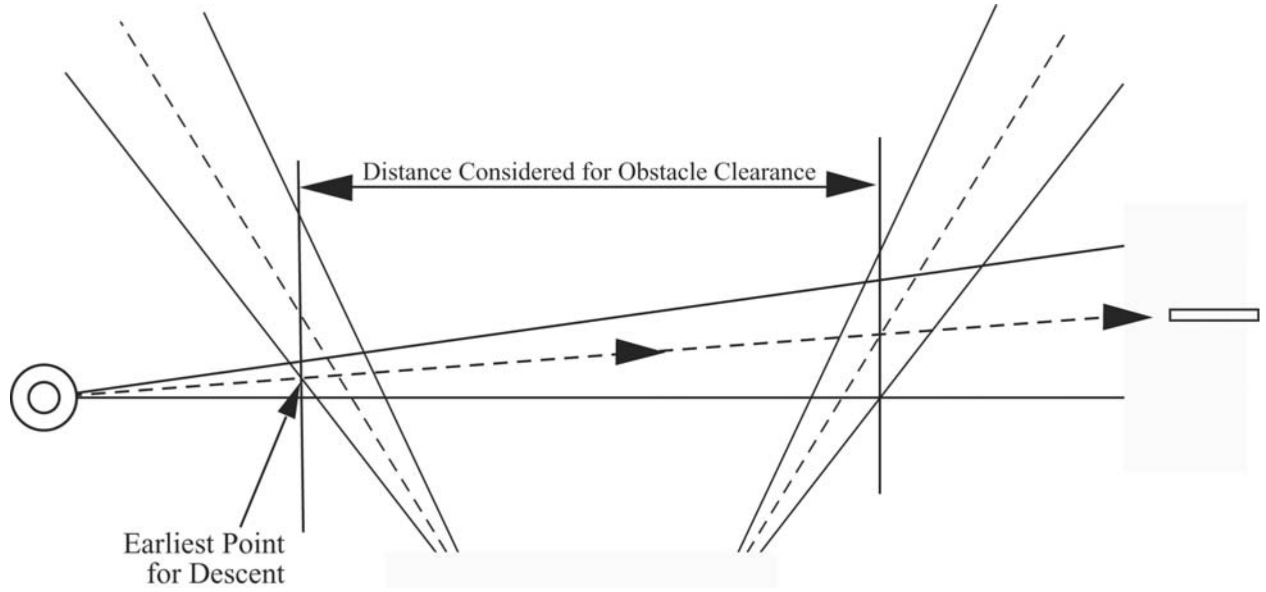
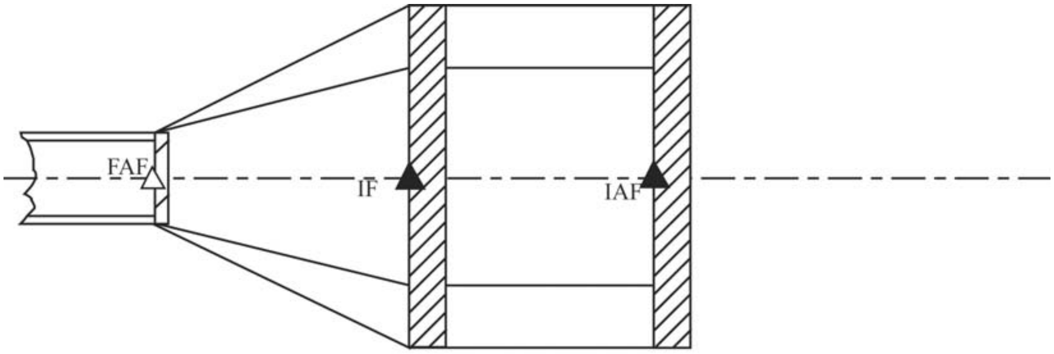
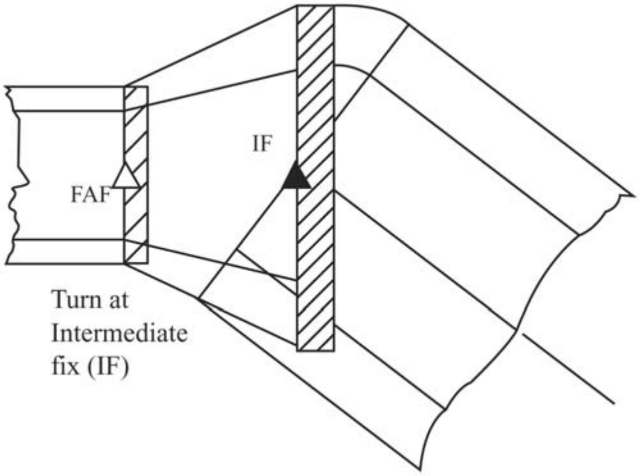


Figure 2-34-1: Obstacle Clearance Area Between Fixes. Para 288.b.



Straight Initial, Intermediate, and Final Segments



Turn at Intermediate fix (IF)

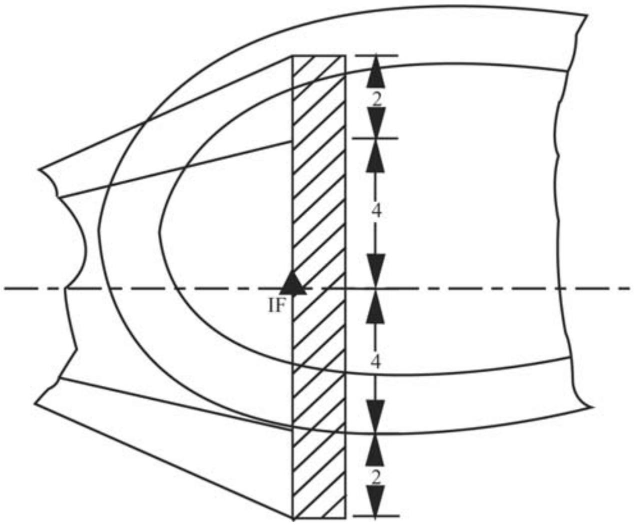


Figure 2-34-2: Construction Of Fix Displacement Area For Obstacle Clearance. Para 288.b.

(3) Altitude at the Fix. The minimum altitude at each step-down fix shall be specified in 100-foot increments, except the altitude at the last step-down fix in the final segment may be specified in a 20-foot increment.

(4) In the Final Segment:

(a) A step-down fix shall not be established unless a decrease of at least 60 feet in MDA or a reduction in the visibility minimum is achieved.

(b) The last step-down fix error shall not exceed plus-or-minus 2 NM or the distance to the MAP whichever is less. The fix error for other step-down fixes in final shall not exceed 1 NM.

(c) Minimums shall be published both with and without the last step down fix, except for procedures requiring DME or NDB procedures that use a VOR radial to define the step down fix.

289. Obstacles Close To An IF, FAF, OR SDF

Existing obstacles close to an IF, FAF, or SDF may be eliminated from consideration if the following conditions are met:

a. The obstacle is in the intermediate segment or final approach trapezoid within 1 NM past the point the IF/FAF/SDF can first be received, AND

b. The obstacle does not penetrate the 7:1 obstacle identification surface (OIS). The surface begins at the earliest point the fix can be received and extends toward the MAP 1 NM. The beginning surface height is determined by subtracting the intermediate segment ROC (and adjustments from Para 323.a, b, or c, as applicable) from the minimum altitude required at the fix. The surface slopes downward 1 foot vertically for each 7 feet horizontally toward the MAP.

c. Obstacles eliminated from consideration by application of this paragraph shall be noted on the procedure.

d. The following formulas may be used to determine the OIS height at the obstacle or the minimum fix altitude based on applying the surface to an obstacle, which must be eliminated.

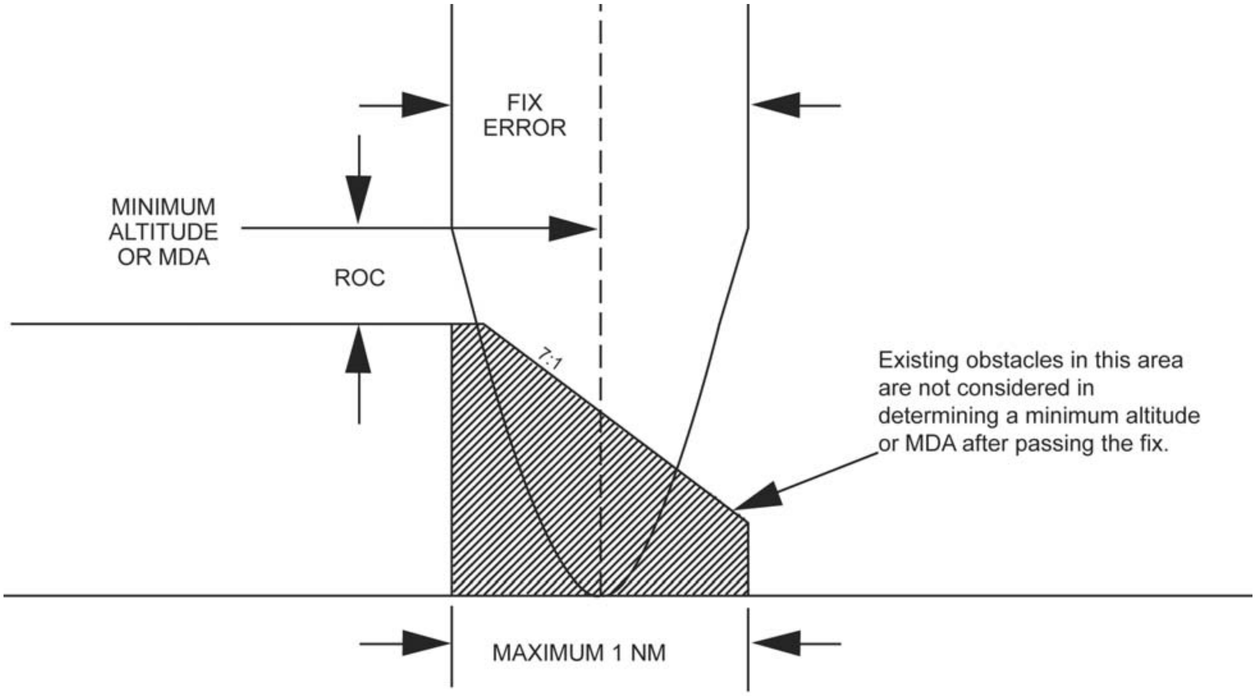
Fix Alt = MSL altitude at the fix (round up in accordance with Para 288.c.3)
Obst Dist = Distance from earliest fix reception to obstacle
ROC = Required Obstacle Clearance (plus adjustments)
Obst Elev = MSL obstacle elevation

$$OISHeight = FixAlt - ROC - \left(\frac{ObstDist}{7}\right)$$

$$MinFixAlt = ObstElev + ROC + \left(\frac{ObstDist}{7}\right)$$

See Figures 2-36a, b and c. To determine fix error, see Para 284, 285, and 286.

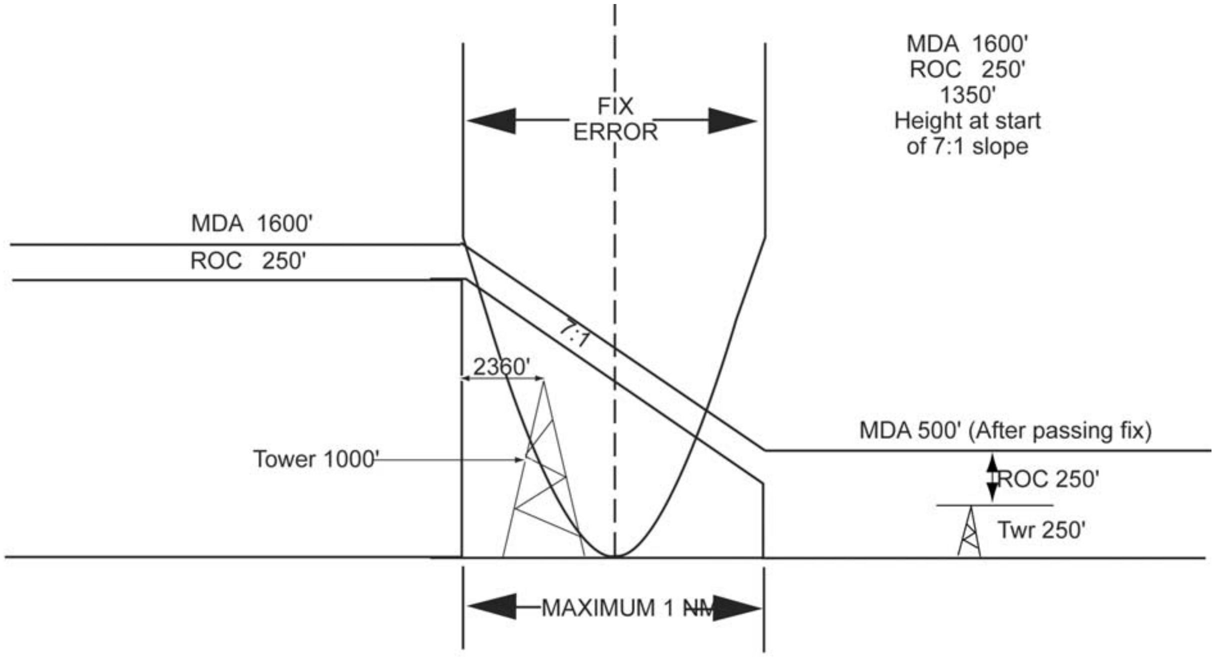
290—299. Reserved



Obstacles close to a fix (FAF or stepdown) may be eliminated from consideration as an obstacle when the following conditions exist:

1. Must be located in the intemediate or final approach area, within 1 mile past the point where the fix can be first received,
2. Obstacle does not penetrate a 7:1 descent gradient which starts at the point where the fix is first received. (7:1 means 1 foot vertically for each 7 feet horizontally.),
3. The height at the start of the 7:1 slope is determined by subtracting the ROC from the minimum altitude required, and
4. Any obstacle eliminated because of the 7:1 descent gradient will be noted on the procedure.

Figure 2-36a: Obstacle Close-In To A Fix. Para 289.



1350' Height at start of 7:1 slope.
\- 337' 7:1 descent gradient at 2360' from the start of the 7: slope.
1013' Height of 7:1 slope at obstacle does not penetrate 7:1 slope.

Figure 2-36b: Example Of Obstacle Close In To Fix. Para 289.

PRIMARY	
Obstacle #	**Result**
A.1 MDA at WP	
A.2 ROC	
A.3 (MDA – ROC) [(A.1)-(A.2)] =	
A.4 Distance (d)	
A.5 Distance (d) divided by 7 [(d) / 7] =	
A.6 Descent [(A.3)-(A.5)] =	
A.7 Obstacle Height (ASL)	
A.8 Result [(A.6)-(A.7)] =	
≤ 0 is Yes Penetration > 0 is No Penetration	Yes / No

SECONDARY	
Obstacle #	**Result**
B.1 MDA at WP	
B.2 Distance (d)	
B.3 Distance (d) divided by 7 [(d) / 7] =	
B.4 ALT over the Obstacle [(B.1)-(B.3)] =	
B.5 ROC	
B.6 Width of Secondary	
B.7 Dist from the Obstacle $\frac{\text{ROC (B.5) x Dist (B.7)}}{\text{Width (B.6)}} =$	
B.8 ROC over the Obstacle	
B.9 Obstacle height (ASL)	
B.10 Obstacle + ROC [(B.8)-(B.9)] =	
B.11 Result [(B.4)-(B.10)] =	
≤ 0 is Yes Penetration > 0 is No Penetration	Yes / No
7:1 Slope Zone Coverage To Verify: D = (MDA^1 – MDA^2) x 7, and E = D + (ROC^2) x 7	

Figure 2-36c: 7:1 Slope Worksheet, Para 289.

CHAPTER 3. TAKE-OFF AND LANDING MINIMA

300. Application

The minima specified in this section are the lowest that can be approved at any location for the type of facility concerned.

301—309. Reserved

SECTION 1. GENERAL INFORMATION

310. Establishment

The minimums established for a particular airport shall be the lowest permitted by the criteria contained in this document. Each procedure shall specify minima for the various conditions stated in the procedure; i.e., straight-in, circling and take-off, as required. The elements of minima are the Minimum Descent Altitude (MDA) or Decision Altitude (DA) and a visibility. The minima shall include the visibility required by the procedure. The height of the MDA or DA above the highest elevation in the touchdown zone (or above the aerodrome elevation for circling approaches) shall be shown on the procedure. Alternate and take-off minima may be specified in separate directives established by the appropriate authority.

Note: For approach procedures, the visibility published is advisory only.

311. Publication

Minima shall be published for each approach category that can be accommodated at the aerodrome. Where the aerodrome landing surface is not adequate, or other restrictions exist which prohibit certain approach categories, "Not Authorized" or "NA" shall be entered in lieu of minima values. Approach Category "E" minima should normally be published only on high altitude procedures, except where special requirements exist for their publication on other procedures.

312—319. Reserved

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SECTION 2. ALTITUDES

320. Minimum Descent Altitude (MDA)

The MDA is the lowest altitude to which descent shall be authorized in procedures not using a glide slope. The MDA shall be expressed in feet above MSL and is determined by adding the required obstacle clearance to the MSL height of the controlling obstacle in the final approach segment and circling approach area for circling procedures.

321. MDA For Straight-In Approach

The MDA for a straight-in approach shall provide at least the minimum required clearance over obstacles in the final approach segment. It shall also be established high enough to ensure that obstacles in the missed approach area do not penetrate the 40:1 missed approach surface (see Vol 1, Para 274). The MDA shall be rounded off to the next higher 20-foot increment. Example: 2,104 feet becomes 2,120.

322. MDA For Circling Approach

The height of the circling MDA above the aerodrome (HAA) shall not be less than the minima referred to in Para 351. In addition, the MDA shall provide at least the minimum required final obstacle clearance in the final approach segment and the minimum required circling obstacle clearance in the circling approach area. It shall also meet the missed approach requirements specified in Para 321. The MDA shall be rounded to the next higher 20-foot increment. For example, 2,109 feet shall become 2,120. The published circling MDA shall not be above the FAF altitude or below the straight-in MDA.

323. Minima Adjustments

Raising the MDA or DA above that required for obstacle clearance may be necessary under the following conditions:

a. Precipitous Terrain. When procedures are designed for use in areas characterized by precipitous terrain, in or outside of designed mountainous areas, consideration must be given to induced altimeter errors and pilot control problems which result when winds of 20 knots or more move over such terrain. Where these conditions are known to exist, required obstacle clearance in the final approach segment should be increased. Procedure specialists and approving authorities should be aware of such hazards involved and make appropriate addition, based on their experience and good judgment, to limit the time in which an aircraft is exposed to lee-side turbulence and other weather phenomena associated with precipitous terrain. This may be done by increasing the minimum altitude over the intermediate and final approach fixes so as to preclude prolonged flight at low altitudes. User comments should be solicited to obtain the best available local information.

b. Remote Altimeter Setting Source (RASS). When the altimeter setting is obtained from a source more than 5 NM from the airport reference point (ARP) for an airport, or the heliport reference point (HRP) for a heliport or vertiport, the ROC shall be increased by the amount of RASS adjustment for the final (except precision final), step-down, circling and intermediate segments. For precision finals, the DH shall be increased by the amount of RASS adjustment. When two altimeter sources are used, RASS shall be applied to the missed approach climb-to-altitude. RASS adjustment does not apply to MSAS, initials, en route, feeder routes or segment/areas based upon en route criteria. A remote altimeter-setting source is not authorized for a remote distance that is greater then 75 NM or for an elevation differential between the RASS and the landing area that is greater than 6,000 feet. To determine which adjustment shall apply, evaluate the terrain between the RASS and the airport/heliport/vertiport for adverse atmospheric pressure pattern effects. Comments should be solicited from Environment Canada in order to obtain the best available climatological information.

(1) Where intervening terrain does not adversely influence atmospheric pressure patterns, the following formula shall be used to compute the basic adjustment in feet:

RASS Adjustment = $2.3\ d_R + 0.14e$

where: "d_R" = the horizontal distance in nautical miles from the altimeter source to the ARP/HRP, and

"e" = the elevation differential in feet between the elevation of the RASS and the elevation of the airport/heliport/vertiport. (see Figure 3-37B).

(2) Where intervening terrain adversely influences atmospheric pressure patterns, an elevation differential area (EDA) shall be evaluated. The EDA is defined as the area within 5 NM each side of a line connecting the ARP/HRP and the RASS, and includes a circular area enclosed by a 5 NM radius at each end of this line. (see Figure 3-37C. The following formulas shall be used to compute the basic adjustment:

RASS Adjustment = $2.3\ d_R + 0.14E$

where: "d_R" = the horizontal distance in nautical miles from the altimeter source to the ARP/HRP, and

"E" = the terrain elevation differential in feet between the lowest and the highest terrain elevation points contained with the EDA. (see Figure 3-37C).

(3) For the intermediate segment, use 60 per cent of the basic adjustment from Para 323.b (1) or (2), and increase the intermediate segment ROC by the amount this value exceeds 200 feet.

(4) For a missed approach climb-to-altitude when two altimeter sources are available and the climb-to-altitude is less than the missed approach clearance limit altitude, apply RASS adjustment to the climb-to-altitude or to Section 2 and Zone 2/3 40:1 surface height as follows:

(a) Decrease the starting height of the 40:1 surface for Section 2 and Zone 2/3 by the difference between the RASS adjustments for the two remote altimeter sources. (Where one altimeter is local, subtract the full RASS adjustment.) Do not decrease these surface-starting heights to less than the height of the 40:1 surface at the MAP.

(b) If the application of Para 323.b(4)(a) results in a 40:1 surface penetration that cannot be resolved by other methods, provide a second climb-to-altitude using the least accurate altimeter source by adding the difference between the RASS adjustments to the climb-to-altitude and rounding to the next higher 20-foot increment. DO NOT lower the Section 2 and Zone 2/3 40:1 surfaces. This application shall not increase the climb-to-altitude above the missed approach clearance limit altitude.

For example: "MISSED APPROACH: Climb to 5,900 (6,100 when using Kelowna altimeter setting) then

(5) Point-In-Space Approach (PINSA). When the MAP is more than 5 NM from the PINSA altimeter-setting source, RASS adjustment shall be applied. For application of the RASS formula, define "d_R" as the distance from the altimeter setting source to the MAP, and define "e" or "E" as in Para 323.b.(1) or (2).

(6) Minimum Reception Altitude (MRA). Where a minimum altitude is dictated by the MRA, the MRA shall be increased by the amount of the RASS adjustment factor.

(7) When the procedure is based on a remote altimeter source, the procedure shall be annotated, as follows:

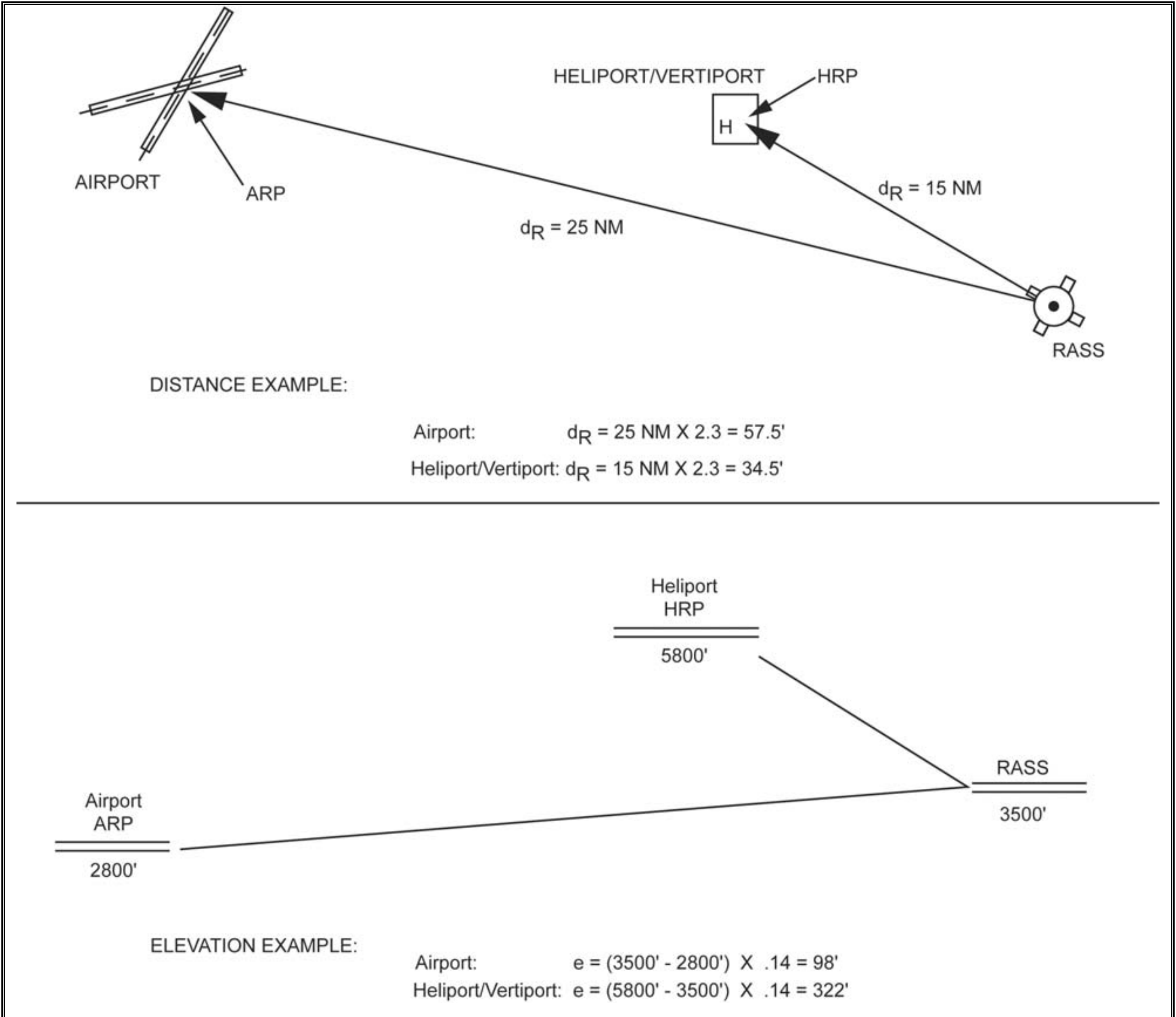
(a) Full Time Remote - "Use Ottawa Intl altimeter setting." In this case, the adjustment shall be included in the published altitudes.

(b) Part Time Remote - "When using Ottawa Intl altimeter setting, add XXX feet to all procedure altitudes."

(8) The calculated RASS adjustment value shall be rounded to the nearest 10-foot increment.

c. Excessive Length of Final Approach. When a final approach fix is incorporated in the procedure, and the distance from that fix to the nearest landing surface exceeds 6 NM, the required obstacle clearance in the final approach segment shall be increased at the rate of 5 feet for each one-tenth NM over 6 miles. Where a step-down fix is incorporated in the final approach segment, the basic obstacle clearance may be applied between the step-down fix and the MAP, provided the fix is within 6 NM of the landing surface. These criteria are applicable to non-precision approach procedures only.

Figure 3-1 TO 3-37a: Reserved



DISTANCE EXAMPLE:

Airport: d_R = 25 NM X 2.3 = 57.5'

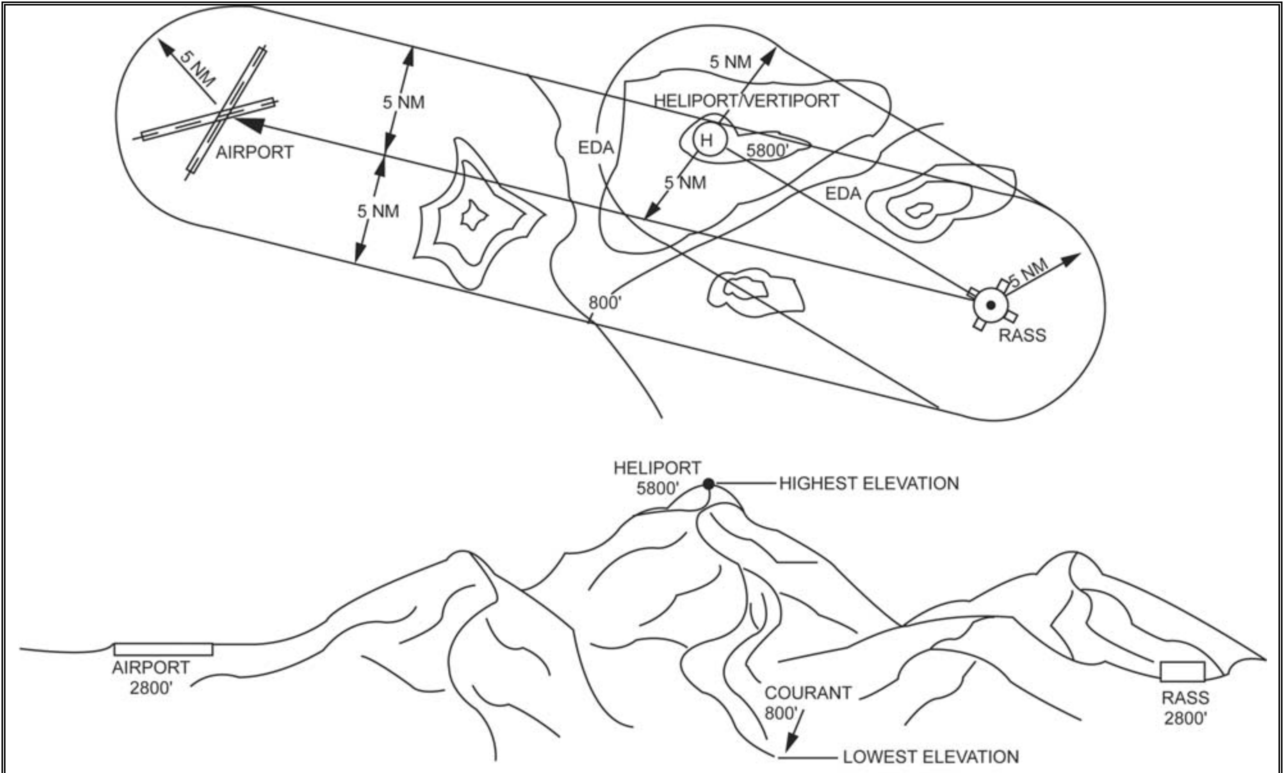
Heliport/Vertiport: d_R = 15 NM X 2.3 = 34.5'

ELEVATION EXAMPLE:

Airport: e = (3500' - 2800') X .14 = 98'

Heliport/Vertiport: e = (5800' - 3500') X .14 = 322'

Figure 3-37b: Distance Remoted (d_R) And Elevation. Para 323.b.



EXAMPLE - ELEVATION DIFFERENCE:

AIRPORT - E = 5800' - 800' = 5000' X .14 = 700'
HELIPORT/VERTIPORT - E = 5800' - 800' = 5000' X .14 = 700'

Figure 3-37c: Elevation Differential Area (EDA) Where Intervening Terrain Influences Atmospheric Pressure Patterns. Para 323.b.

324. Decision Altitude (DA)

The DA applies to approach procedures where the pilot is provided with glidepath deviation information; e.g., ILS, MLS, TLS, GLS, LNAV/VNAV, Baro VNAV, or PAR. The DA is the barometric altitude, specified in feet above MSL, at which a missed approach shall be initiated if the required visual reference has not been established. DA’s shall be established with respect to the approach obstacle clearance and HAT requirements specified in TP308 Volume 3.

325. Decision Height (DH)

The DH is the value of the DA expressed in feet above the highest runway elevation in the touchdown zone. This value is also referred to as **HAT**.

326—329. Reserved

SECTION 3. VISIBILITIES

330. Establishment Of Visibility Minima

a. Straight-in minima for NON-PRECISION approaches shall be established for an approach category when:

(1) The final approach course-runway alignment criteria have been met; AND

(2) The height of the MDA above the touchdown zone (TDZ) and the associated visibility are within the tolerances specified in Para 331; AND

(3) The descent gradient from the final approach fix to the runway does not exceed the maximum specified in the applicable facility chapter of this document.

b. Straight-in minima for PRECISION approaches shall be established for an approach category when the final approach course alignment criteria have been met.

c. The minimum visibility prior to applying credit for lights shall not be less than;

(1) the visibility required in Para 331; or

The MAP to threshold distance (where the MAP is reached before the threshold), whichever is greater.

d. When straight-in minima are not authorized, only circling MDAs and visibilities will be established. In establishing circling visibility minima, Para 331 applies. These minima shall be no lower than those specified in Para 351.

e. Circling minima shall NOT be lower than straight-in landing minima.

331. Effect Of HAA/HAT And Facility Distance On Straight-In And Circling Visibility Minima/Advisory Visibility

The minimum standard visibility required for the pilot to establish visual reference in time to descend safely from the MDA is dependent upon the HAT/HAA. The minimum standard visibility is specified in Table 3–2.

HAT/HAA RANGE	VISIBILITY (SM)
Up to 347’	1
348’ – 434’	1 ¼
435’ – 521’	1 ½
522’ – 608’	1 ¾
609’ – 695’	2
696’ – 782’	2 ¼
783’ – 869’	2 ½
870’ – 956’	2 ¾
957’ and above	3

Note: If the landing runway is served by an operational high intensity (HAIL), MALSR (AM) or SSALR (AN) approach lighting system, the visibility may be reduced by ½ SM, but at no time to a value less than that shown in Table 3-1. On circling approaches, no visibility credit will be given for approach lights.

Table 3-2: Non-Precision Approach Visibility Minima. Para 331 and 343.

332. Effect Of DA On Precision Visibility Minima/Advisory Visibility

The minimum standard visibility required for the pilot to establish reference in time to descent safely from the DA is dependent upon the HAT. The minimum standard visibility is specified in Table 3–3.

HAT	VISIBILITY (SM)
100‘ – 199’	RVR down to 1200
200’ – 249’	½
250’	¾
> 250’	use Table 3-2

Table 3-3: Precision Approach Visibility Matrix. Para 332.

333. Runway Visual Range (RVR)

An RVR sensor system is used for measuring the visibility along the runway. It is an instrumentally derived value that represents the horizontal distance a pilot will see down the runway from the approach end. It is based on the sighting of either high intensity runway lights or the visual contrast of other targets; whichever yields the greater visual range.

334. Reserved

335. Comparable Values Of RVR And Ground Visibility

If RVR minima for take-off or landing are prescribed in an instrument approach procedure but RVR is not reported for the runway of intended operation, the RVR minima shall be converted to ground visibility in accordance with Table 3–4, and observed as the applicable visibility minimum for take-off or landing on that runway.

RVR	VISIBILITY (SM)
1400	¼
2600	½
4000	¾
5000	1

Table 3-4: Comparable Values Of RVR And Ground Visibility. Para 335.

336—339. Reserved

SECTION 4. VISIBILITY CREDIT FOR LIGHTS

340—342. Reserved

343. Visibility Reduction

Standard visibility requirements are computed by applying the criteria contained in Para 331. These requirements may be reduced by giving credit for appropriate light systems as shown in Table 3–2.

Note: No credit is given for approach light systems for circling approaches.

344—349. Reserved

SECTION 5. STANDARD MINIMA

350. Standard Straight-In Minima

Table 3–1 specifies the lowest minima which may be prescribed for various combinations of electronic and visual navigation aids. Lower minima based on special equipment or aircrew qualifications may be authorized only by TC HQ or DND HQ, as applicable. Higher minima shall be specified where required by application of criteria contained elsewhere in this document.

351. Standard Circling Minima

Table 3–1 specifies the lowest minima which may be prescribed for circling approaches. See also Para 330.c. The MDA established by application of the minima specified in this paragraph shall be rounded to the next higher 20-foot increment.

352—359. Reserved

SECTION 6. ALTERNATE MINIMA

360. Alternate Weather Minima

Determining the weather requirements for an alternate is the responsibility of the pilot-in-command based upon criteria detailed in the Canada Air Pilot and A.I.P. Canada. For military procedures, see BGA-100-001/AA-000.

361—369. Reserved

SECTION 7. DEPARTURES

370. Take-Off Minima

All take-off minima shall be determined by applying Vol 1, Chap 12 of this document to all conventional departure procedures and Standard Instrument Departures (SIDs). The appropriate RNAV criteria shall be applied for all RNAV Departures and SIDs. Published minima are detailed in the Canada Air Pilot and appropriate Military publications.

371—399. Reserved

TYPE OF APPROACH		MINIMA		
		HEIGHT	VISIBILITY (SM)	RVR
ILS CAT II		HAT 100 FT		12
PAR, ILS CAT I		HAT 200 FT	1/2	26
HAIL INOP		HAT 200 FT	3/4	40
RNAV	- GNSS	HAT 250 FT	1	50
	- BARO/VNAV	HAT 250 FT	1	50
	- LPV	HAT 250 FT	1	50
	- RNP	HAT 250 FT	1	50
LOC		HAT 250 FT	1	50
LOC BACK COURSE		HAT 250 FT	1	50
VOR/DME		HAT 250 FT	1	50
TACAN		HAT 250 FT	1	50
VOR WITH FAF		HAT 250 FT	1	50
VOR WITHOUT FAF		HAT 300 FT	1	50
NDB WITH FAF		HAT 300 FT	1	50
NDB WITHOUT FAF		HAT 350 FT	1	50
CIRCLING	CAT A and B	HAT 500 FT	1 1/2	
	CAT C	HAT 500 FT	2	
	CAT D and E	HAT 600 FT	2	

Note: All calculated minima values shall be rounded to whole number increments a follows:

Precision: DH – next higher 1’ increment (i.e., 196.2’ = 197’)
TCH – next lower 1’ increment (i.e., 46.75’ = 46’)
Non-Precision: MDAs – next higher 20-foot increment (i.e., 414’ = 420’)
Sector Altitudes – next higher 100-foot increments (i.e., 2036’ = 2100’)
HAT – next higher 1-foot increment (i.e., 257.2’ = 258’)

Table 3-1: Standard Straight-In And Circling Minima. Para 350 and 351.

CHAPTER 4. ON-AIRPORT VOR (NO FAF)

400. General

This chapter is divided into two sections; one for low altitude procedures and one for high altitude teardrop penetration procedures. These criteria apply to procedures based on a VOR facility located on an airport in which no final approach fix (FAF) is established. These procedures must incorporate a procedure or a penetration turn. An ON-AIRPORT facility is one that is located:

a. For Straight-in Approach. Within one mile of the nearest portion of the landing runway.

b. For Circling Approach. Within one mile of the nearest portion of the usable landing surface of the airport.

401—409. Reserved

SECTION 1. LOW ALTITUDE PROCEDURES

410. Feeder Routes

Criteria for feeder routes are contained in Para 220.

411. Initial Approach Segment

The initial approach fix is received by overheading the navigation facility. The initial approach is a procedure turn. The criteria for the procedure turn areas are contained in Para 234.

412. Intermediate Approach Segment

This type of procedure has no intermediate segment. Upon completion of the procedure turn, the aircraft is on final approach.

413. Final Approach Segment

The final approach begins where the procedure turn intersects the final approach course inbound.

a. Alignment. The alignment of the final approach course with the runway centreline determines whether a straight-in or circling approach may be established.

   (1) Straight-in. The angle of convergence of the final approach course and the extended runway centreline shall not exceed 30 degrees. The final approach course should be aligned to intersect the extended runway centreline 3,000 feet outward from the runway threshold. When an operational advantage can be achieved this point of intersection may be established at any point between the runway threshold and a point 5,200 feet outward from the runway threshold. Also, where an operational advantage can be achieved, a final approach course which does not intersect the runway centreline, or intersects it at a distance greater than 5,200 feet from the threshold, may be established provided such a course lies within 500 feet laterally of the extended runway centreline at a point 3,000 feet outward from the runway threshold. Straight-in category C, D, and E minimums are not authorized when the final approach course intersects the extended runway centreline at an angle greater than 15° and a distance less than 3,000 feet (see Figure 4-38).

(2) Circling Approach. When the final approach course alignment does not meet the criteria for straight-in landing, only a circling approach shall be authorized, and the course alignment should be made to the centre of the landing area. When an operational advantage can be achieved, the final approach course may be aligned to pass through any portion of the usable landing surface. See Figure 4-39.

b. Area. Figure 4-40 illustrates the final approach primary and secondary areas. The primary area is longitudinally centred on the final approach course, and is 10 miles long. The primary area is 2 miles wide at the facility and expands uniformly to 6 miles at 10 mile from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility and expands uniformly to 1.34 miles on each side of the primary area at 10 miles from the facility. When the 5 mile procedure turn is used, only the inner 5 miles of the final approach area need be considered.

c. Obstacle Clearance.

(1) Straight-in. The minimum obstacle clearance in the primary area is 300 feet. In the secondary area, 300 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. The minimum required obstacle clearance at any given point in the secondary area is found in Annex C, Figure C-6.

(2) Circling Approach. In addition to the minimum requirements specified in Para 413.c.(1), obstacle clearance in the circling area shall be as prescribed in Chapter 2, Section 6.

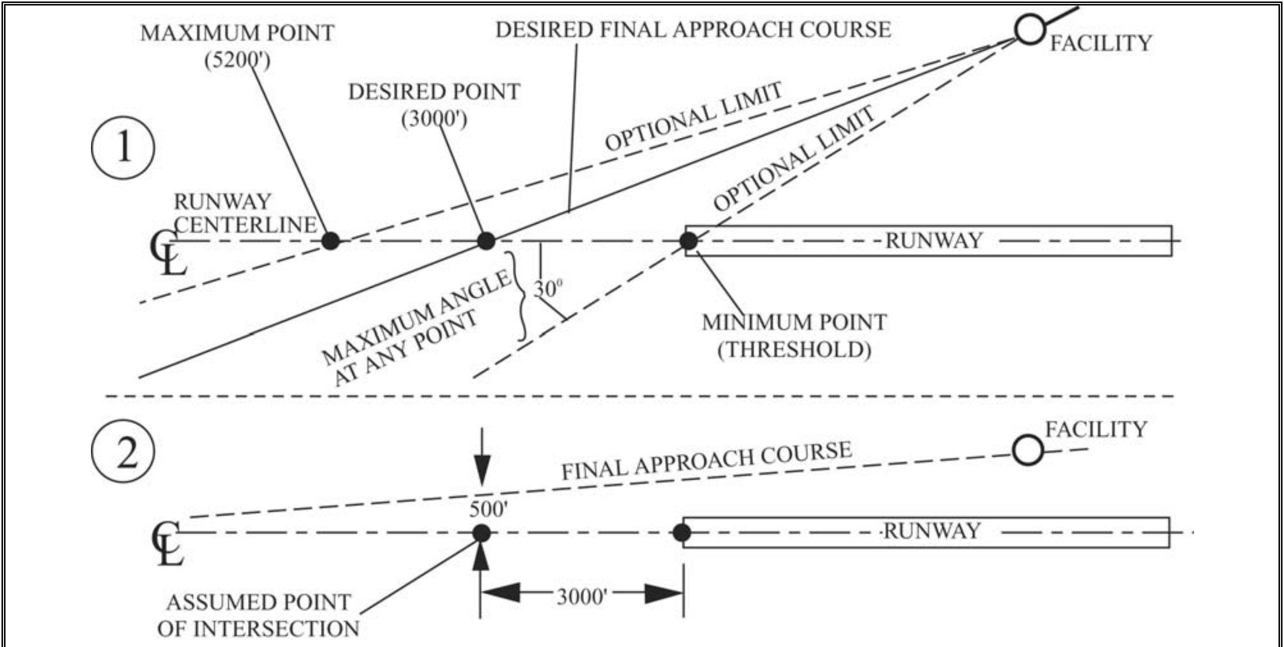
d. Procedure Turn Altitude (Descent Gradient). The procedure turn completion altitude shall be within 1,500 feet of the MDA (1,000 feet with a 5-mile procedure turn), provided the distance from the facility to the point where the final approach course intersects the runway centreline (or the first usable portion of the landing area for "circling only" procedures) does not exceed 2 miles. When this distance exceeds 2 miles, the maximum difference between the procedure turn completion altitude and the MDA shall be reduced at the rate of 25 feet for each one tenth of a mile in excess of 2 miles. See Figure 4-41.

Note: For those procedures in which the final approach does NOT intersect the extended runway centreline within 5,200 feet of the runway threshold (see Para 413.a.(1)) the assumed point of intersection for computing the distance from the facility shall be 3,000 feet from the runway threshold. See Figure 4-38.

e. Use of Step-down Fix. Use of the step-down fix (Para 288.c) is permitted provided the distance from the facility to the step-down fix does not exceed 4 miles. The descent gradient between PT completion altitude and stepdown altitude shall not exceed 150 ft/NM. The descent gradient will be computed based upon the difference in PT completion altitude minus stepdown fix altitude, divided by the specified PT distance, minus the facility to stepdown fix distance. Obstacle clearance may be reduced to 250 feet from the stepdown fix to the MAP/FEP. See Figure 4-42, Para 252.

f. Minimum Descent Altitude. Criteria for determining the MDA are contained in Chapter 3.

Figure 4-1 TO 4-37: Reserved



Note: Note: Straight-in category C, D, and E minimums are not authorized when the final approach course intersects the extended runway centerline at an angle greater than 15° and a distance less than 3,000 feet.

Figure 4-38: Alignment Options For Final Approach Course. On-Airport VOR, No FAF, Straight-In Approach Procedure. Para 413.a.(1).

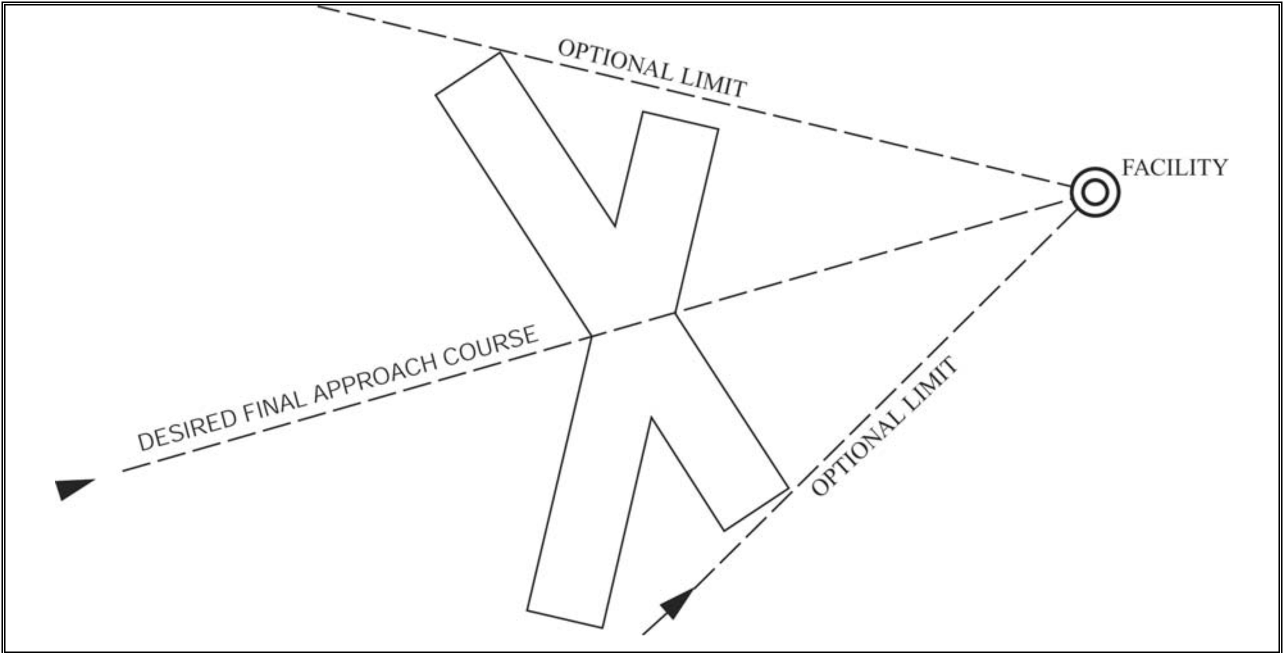


Figure 4-39: Alignment Options For Final Approach Course. On Airport VOR, No FAF, Circling Approach Procedure. Para 413.a.(2).

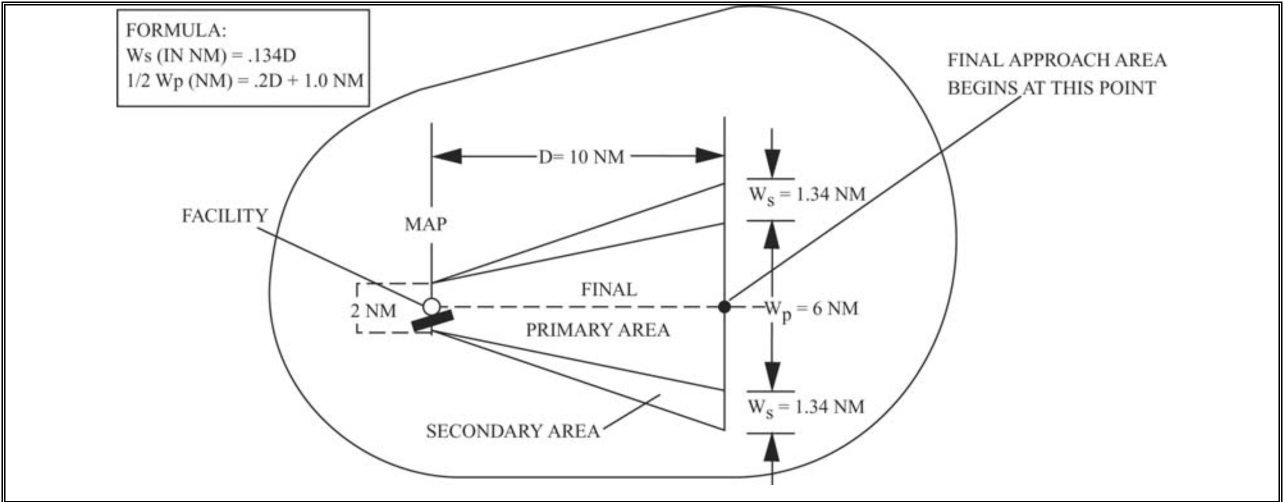


Figure 4-40: Final Approach Primary And Secondary Areas. On-Airport VOR, No FAF. Para 413.b.

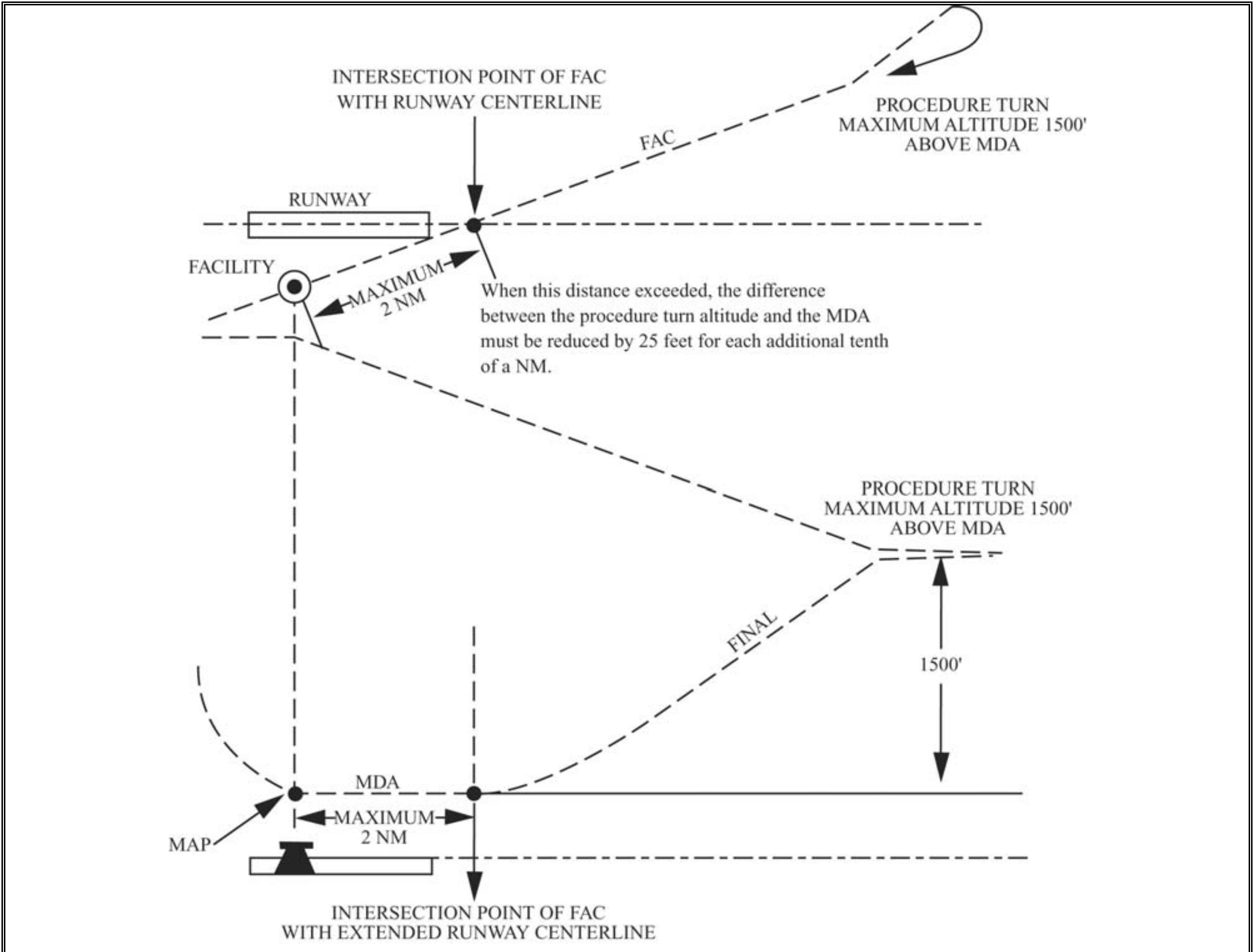


Figure 4-41: Procedure Turn Altitude. On-Airport VOR, No FAF. Para 413.d.

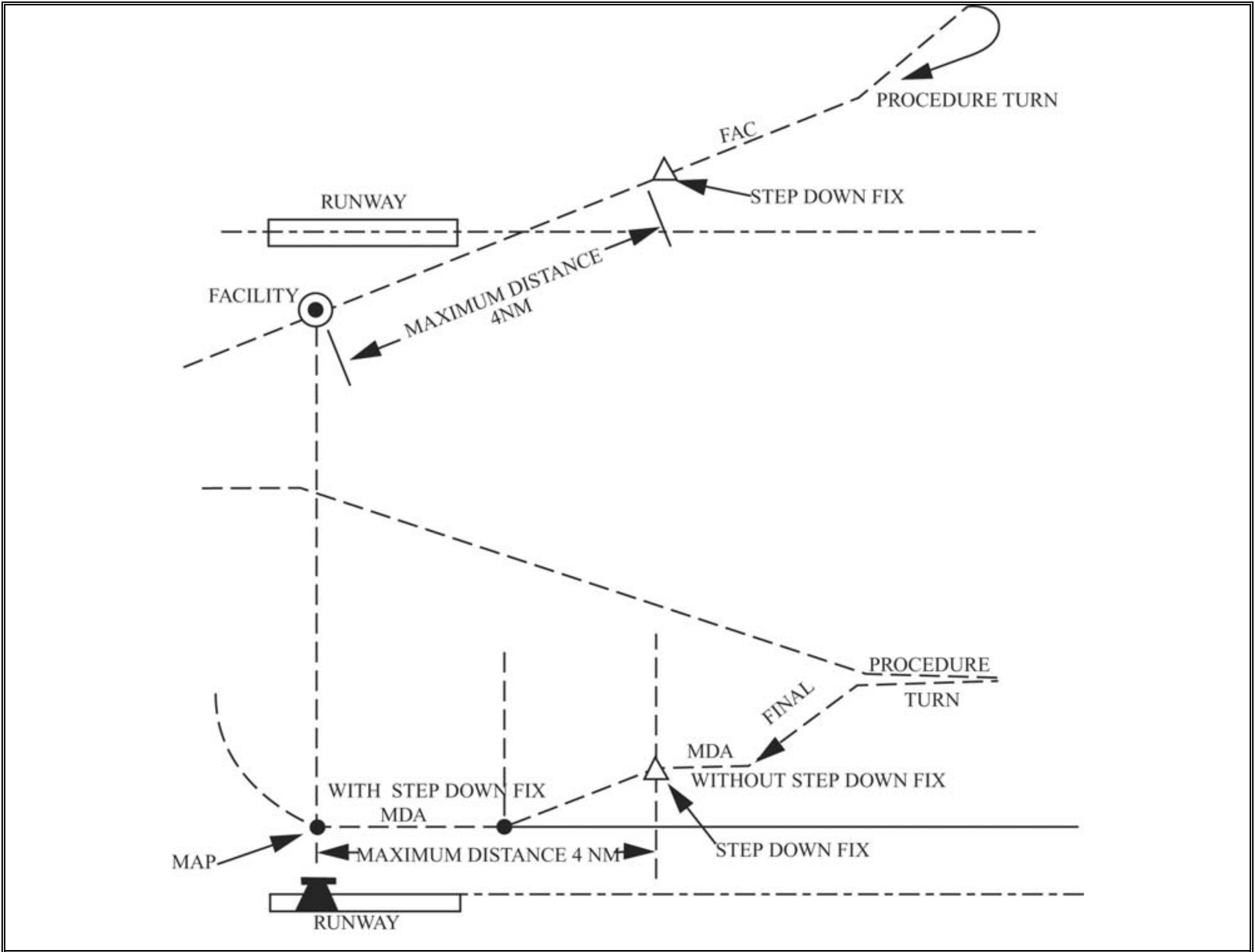


Figure 4-42: Use Of Step-Down Fix. On-Airport VOR, No FAF. Para 413.e.

414. Missed Approach Segment

Criteria for the missed approach segment are contained in Chapter 2, Section 7. The missed approach point is the facility. See Figure 4-42. The missed approach surface shall commence over the facility at the required height. See Para 274.

415—419. Reserved

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SECTION 2. HIGH ALTITUDE TEARDROP PENETRATIONS

420. Feeder Routes

Criteria for feeder routes are contained in Para 220.

421. Initial Approach Segment

The initial approach fix is received by overheading the navigation facility. The initial approach is a teardrop penetration turn. The criteria for the penetration turn are contained in Para 235.

422. Intermediate Approach Segment

This procedure has no intermediate segment. Upon completion of the penetration turn, the aircraft is on final approach.

423. Final Approach Segment

An aircraft is considered to be on final approach upon completion of the penetration turn. However, the final approach segment begins on the final approach course 10 miles from the facility. That portion of the penetration procedure prior to the 10-mile point is treated as the initial approach segment. See Figure 4-6.

a. Alignment. Same as low altitude (Para 413.a).

b. Area. Figure 4-6 illustrates the final approach primary and secondary areas. Theprimary area is longitudinally centred on the final approach course, and is 10 miles long. The primary area is 2 miles wide at the facility, and expands uniformly to 8 miles at a point 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility, and expands uniformly to 2 miles each side of the primary area at a point 10 miles from the facility.

c. Obstacle Clearance.

   (1) Straight-in. The minimum obstacle clearance in the primary area is 500 feet. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. The minimum required obstacle clearance at any given point in the secondary area is shown in Annex C, Figure C-3.

   (2) Circling Approach. In addition to the minimum requirements specified in Para 423.c.(1), obstacle clearance in the circling area shall be as prescribed in Chapter 2, Section 6.

d. Penetration Turn Altitude (Descent Gradient). The penetration turn completion altitude shall be at least 1,000 feet, but not more than 4,000 feet, above the MDA on final approach.

e. Use of Step-down Fix. The use of the step-down fix is permitted provided the distance from the facility to the step-down fix does not exceed 10 miles. See Para 288.c.

f. Minimum Descent Altitude. In addition to the normal obstacle clearance requirement of the final approach segment (see Para 423.c), the MDA specified shall provide at least 500 feet of clearance over obstacles in the portion of the initial approach segment between the final approach segment and the point where the assumed penetration turn track intercepts the inbound course. See Figure 4-43.

424. Missed Approach Segment

Criteria for the missed approach segment are contained in Chapter 2, Section 7. The missed approach point is the facility. See Figure 4-43. The missed approach surface shall commence over the facility at the required height. See Para 274.

425—499. Reserved

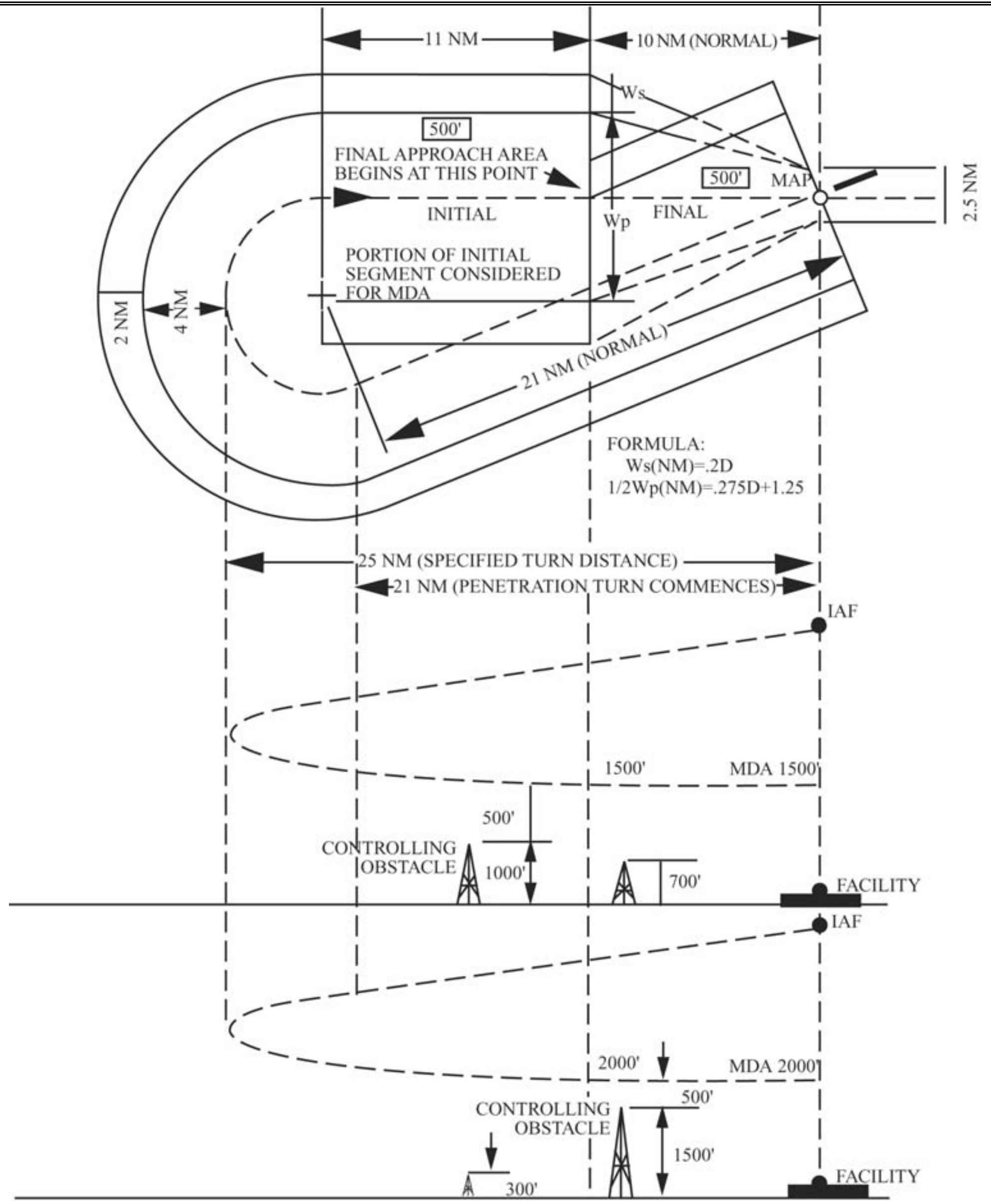

Figure 4-43: Penetration Turn. On Airport VOR, No FAF. Para 423.

CHAPTER 5. TACAN, VOR/DME AND VOR WITH FAF

500. General

This chapter applies to approach procedures based on VOR, VOR/DME, VORTAC or TACAN facilities in which a final approach fix (FAF) is established. The chapter is divided into two sections; Section 1 for VOR procedures that do not use DME as the primary method for establishing fixes, and Section 2 for VOR/DME and TACAN procedures, which use collocated, frequency, paired DME as the sole method of establishing fixes. When both the VOR and TACAN azimuth elements of a VORTAC station will support it, a single procedure, identified as a VOR/DME or TACAN shall be published. Such a procedure may be flown using either a VOR/DME or TACAN airborne receiver and shall satisfy TACAN terminal area fix requirements. See Para 286.d.

501—509. Reserved

SECTION 1. VOR WITH FAF

510. Feeder Routes

Criteria for feeder routes are contained in Para 220.

511. Initial Approach Segment

Criteria for the initial approach segment are contained in Chapter 2, Section 3. (see Figures 5-44a, 5-44b and 5–45.)

512. Intermediate Approach Segment

Criteria for the intermediate approach segment are contained in Chapter 2, Section 4. (see Figures 5–44a, 5-44b and 5–45.)

513. Final Approach Segment

The final approach may be made either FROM or TOWARD the facility. The final approach segment begins at the final approach fix and ends at the runway or missed approach point, whichever is encountered last.

a. Alignment. The alignment of the final approach course with the runway centreline determines whether a straight-in or circling-only approach may be established. The alignment criteria differ depending on whether the facility is OFF or ON the airport. See definitions in Para 400.

  (1) Off-airport Facility.

    (a) Straight-in. The angle of convergence of the final approach course and the extended runway centreline shall not exceed 30 degrees. The final approach course should be aligned to intersect the runway centreline at the runway threshold. However, when an operational advantage can be achieved, the point of intersection may be established to as much as 3,000 feet outward from the runway threshold. (see Figure 5–46.)

Figure 5-1 TO 5-44: Reserved

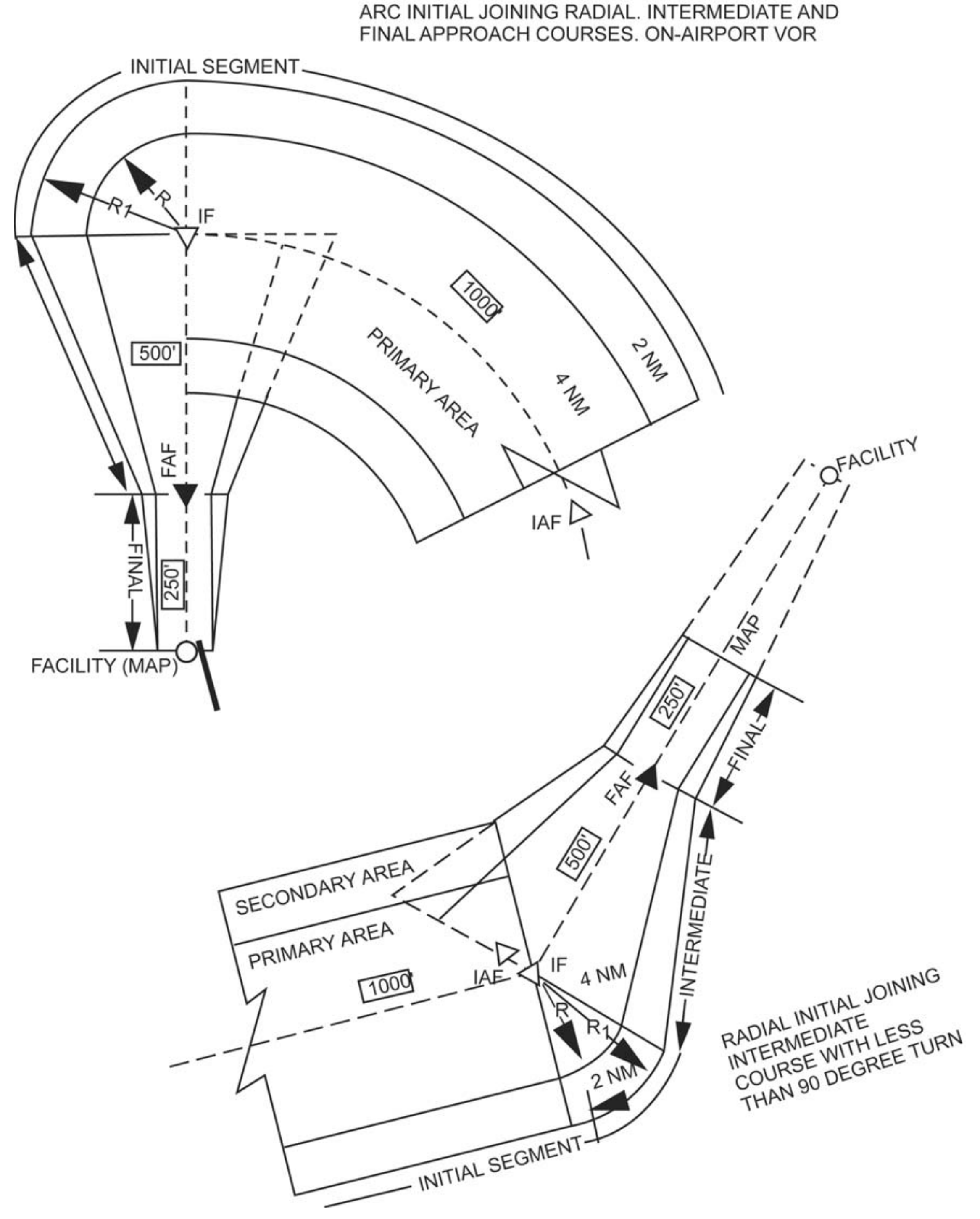

Figure 5-44a: Typical Low Alt Approach Segments. VOR with FAF. Para 511 & 512.

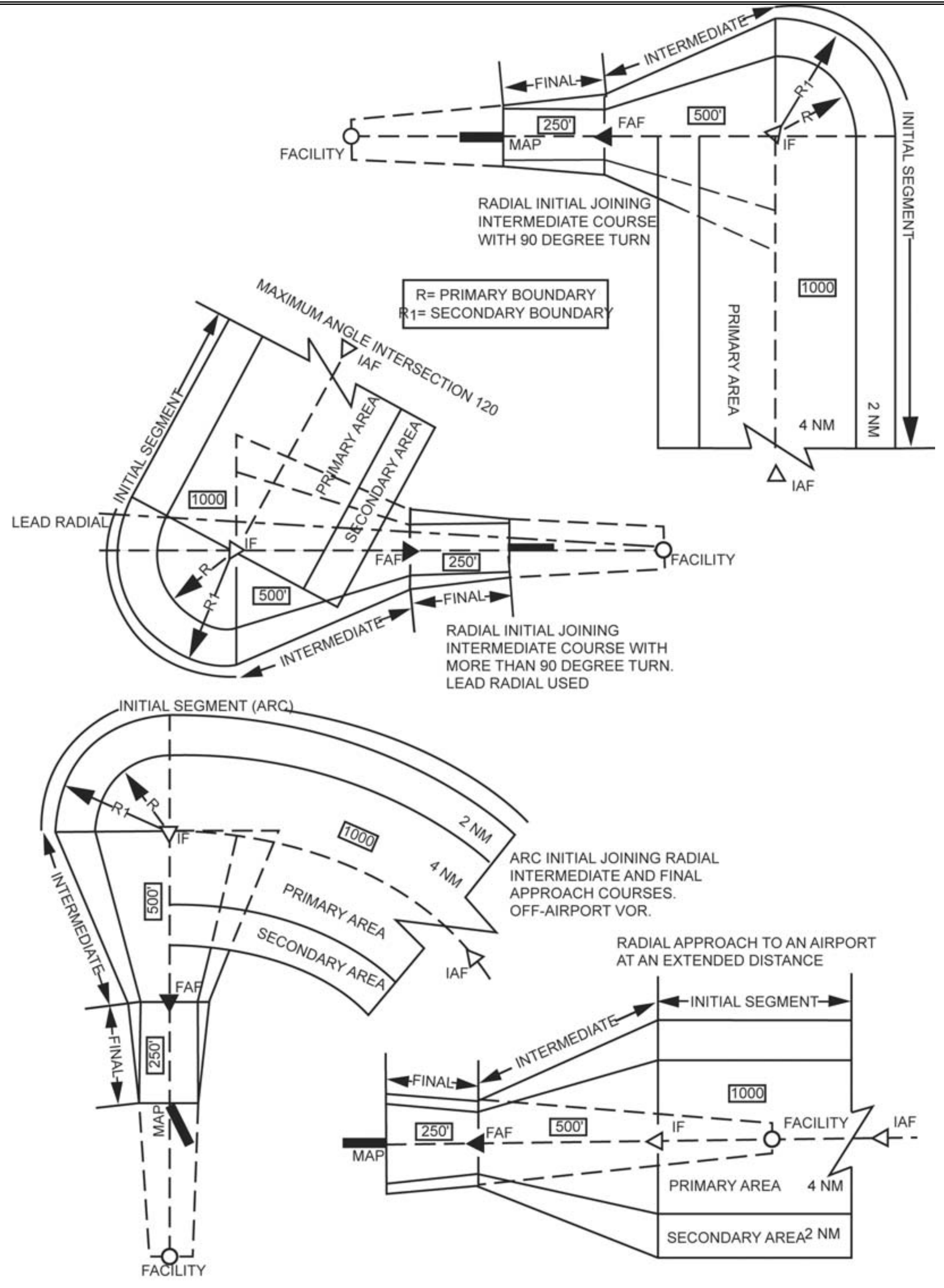

Figure 5-44b: Typical Low Alt Approach Segments. VOR with FAF. Para 511 & 512.

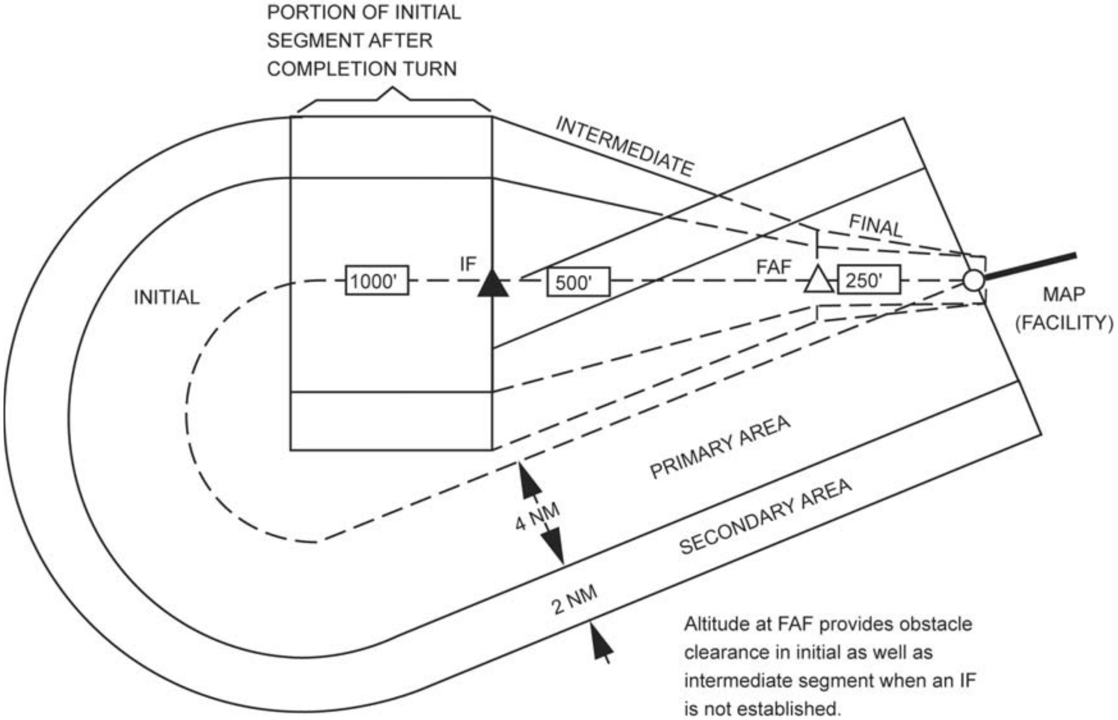

Figure 5-45: Typical High Altitude Segments. VOR with FAF. Para 511 & 512.

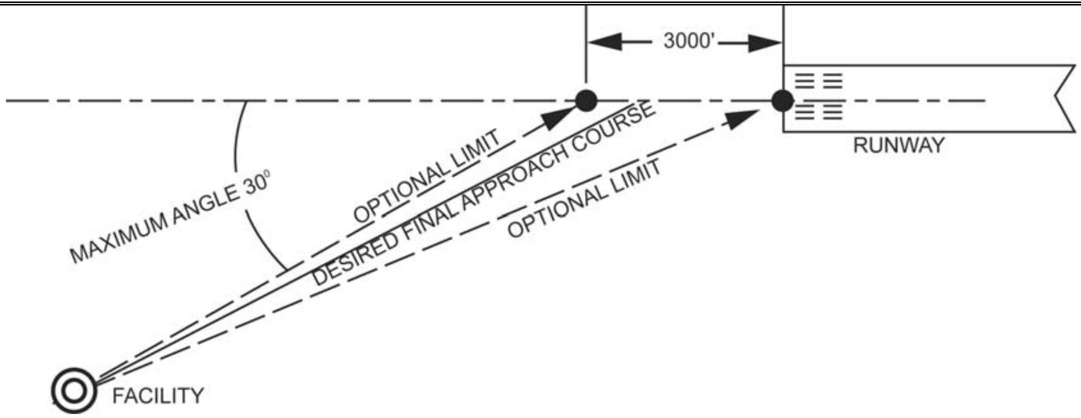

Figure 5-46: Alignment Options For Final Approach Course. Off-airport VOR with FAF. Straight-in approach. Off-airport Para 513.1.(1)(a).

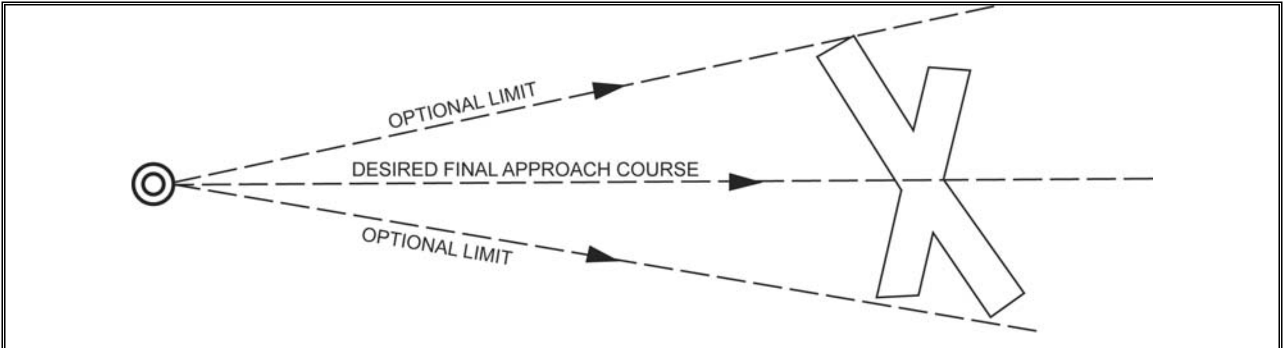

Figure 5-47: Alignment Options For Final Approach Course. Off-airport VOR with FAF. Circling Approach. Para 513.a.(1)(b).

(b) Circling Approach. When the final approach course alignment does not meet the criteria for a straight-in landing, only a circling approach shall be authorized, and the course alignment should be made to the centre of the landing area. When an operational advantage can be achieved, the final approach course may be aligned to any portion of the usable landing surface. (see Figure 5–47.)

(2) On-airport Facility.

(a) Straight-in. The angle of convergence of the final approach course and the extended runway centreline shall not exceed 30 degrees. The final approach course should be aligned to intersect the extended runway centreline 3,000 feet outward from the runway threshold. When an operational advantage can be achieved, this point of intersection may be established at any point between the threshold and a point 5,200 feet outward from the threshold. Also, where an operational advantage can be achieved a final approach course which does not intersect the runway centreline, or which intersects it at a distance greater than 5,200 feet from the threshold, may be established, provided that such a course lies within 500 feet laterally of the extended runway centreline at a point 3,000 feet outward from the runway threshold. (see Figure 5–48.)

(b) Circling Approach. When the final approach course alignment does not meet the criteria for a straight-in landing, only a circling approach shall be authorized, and the course alignment should be made to the centre of the landing area. When an operational advantage can be achieved, the final approach course may be aligned to any portion of the usable landing surface. (see Figure 5–49.)

b. Area. The area considered for obstacle clearance in the final approach segment starts at the final approach fix and ends at the runway or missed approach point, whichever is encountered last. It is a portion of a 30-mile long trapezoid (see Figure 5–50), which is made up of primary and secondary areas. The primary area is centred longitudinally on the final approach course. It is 2 miles wide at the facility, and expands uniformly to 5 miles wide at 30 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility and expands uniformly to 1 mile on each side of the primary area at 30 miles from the facility. Final approaches may be made to airports, which are a maximum of 30 miles from the facility. (see Figure 5–51.) The OPTIMUM length of the final approach segment is 5 miles. The MAXIMUM length is 10 miles. The MINIMUM length of the final approach segment shall provide adequate distance for an aircraft to make the required descent, and to regain course alignment when a turn is required over the facility. Table 5–14 shall be used to determine the minimum length needed to regain the course.

Tables 5–1 TO 5–13: Reserved

Approach Category	Magnitude of Turn over the Facility (Degrees)		
	10°	20°	30°
A	1.0	1.5	2.0
B	1.5	2.0	2.5
C	2.0	2.5	3.0
D	2.5	3.0	3.5
E	3.0	3.5	4.0

Note: This table may be interpolated. If turns of more than 30° are required, or if the minimum lengths specified in the table are not available, straight-in minima are not authorized. See Figure 5-51 for typical straight-in final approach areas.

Table 5-14: Minimum Length Of Final Approach Segment - VOR (nm). Para 513.b.

c. Obstacle Clearance.

(1) Straight-in Landing. The minimum obstacle clearance in the primary area is 250 feet. In the secondary area 250 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. (see Figure 5-51a for the minimum obstacle clearance at any given point in the secondary area. (see also Annex C, Figure C–5).

(2) Circling Approach. In addition to the minimum requirements specified in Para 513.c.(1) above, obstacle clearance in the circling area shall be as prescribed in Chapter 2, Section 6.

d. Descent Gradient. Para 252 applies.

e. Use of Fixes. Criteria for the use of radio fixes are contained in Chapter 2, Section 8. Where a procedure is based on a procedure turn and an on-airport facility is the procedure turn fix, the distance from the facility to the FAF shall not exceed 4 miles.

f. Minimum Descent Altitudes. Criteria for determining the MDA are contained in Chapter 3, Section 2.

514. Missed Approach Segment

Criteria for the missed approach segment are contained in Chapter 2, Section 7. For VOR procedures, the missed approach point and surface shall be established as follows:

a. Off-airport Facilities.

   (1) Straight-in. The missed approach point is a point on the final approach course, which is not farther from the final approach fix than the runway threshold. (see Figure 5-52.) The missed approach surface shall commence over the missed approach point at the required height. (See Para 274.)

   (2) Circling Approach. The missed approach point is a point on the final approach course, which is not farther from the final approach fix than the first usable portion of the landing area. The missed approach surface shall commence over the missed approach point at the required height. (See Para 274.)

b. On-airport Facilities. The missed approach point is a point on the final approach course, which is not farther from the final approach fix than the facility. The missed approach surface shall commence over the missed approach point at the required height. (See Para 274.)

515—519. Reserved

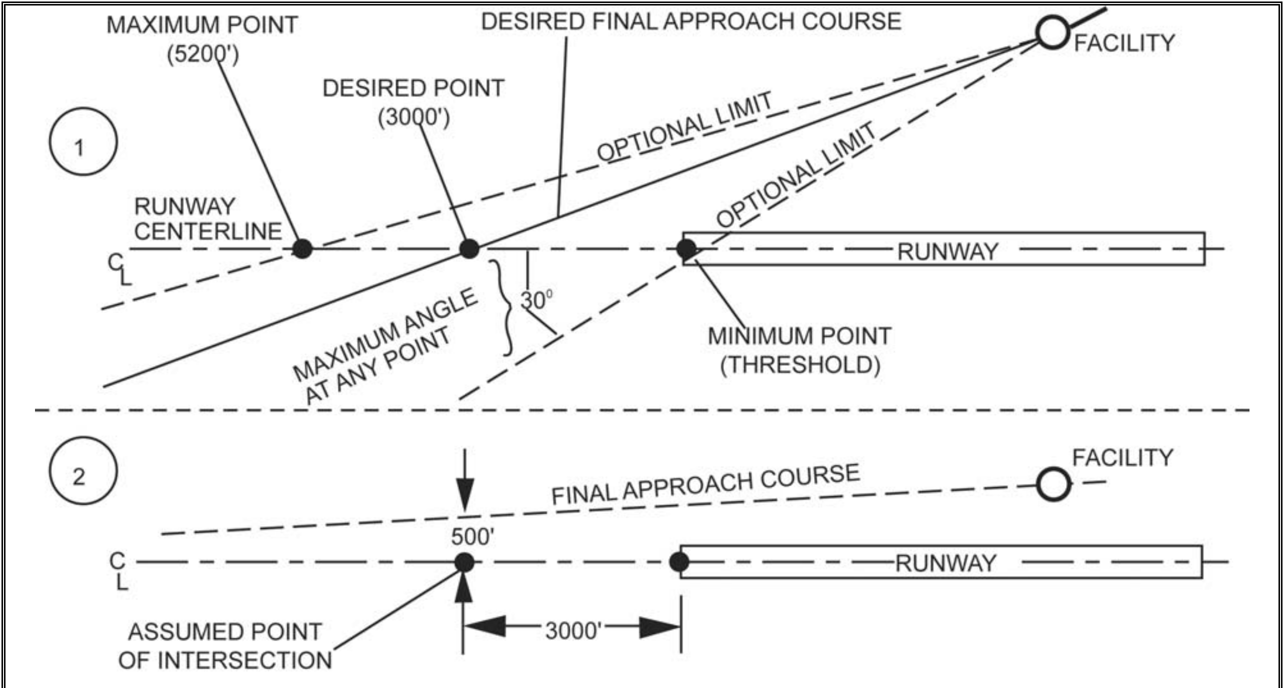

Figure 5-48: Alignment Options For Final Approach Course. On-Airport VOR, with FAF, Straight-In Approach Procedure. Para 513.a.(2)(a).

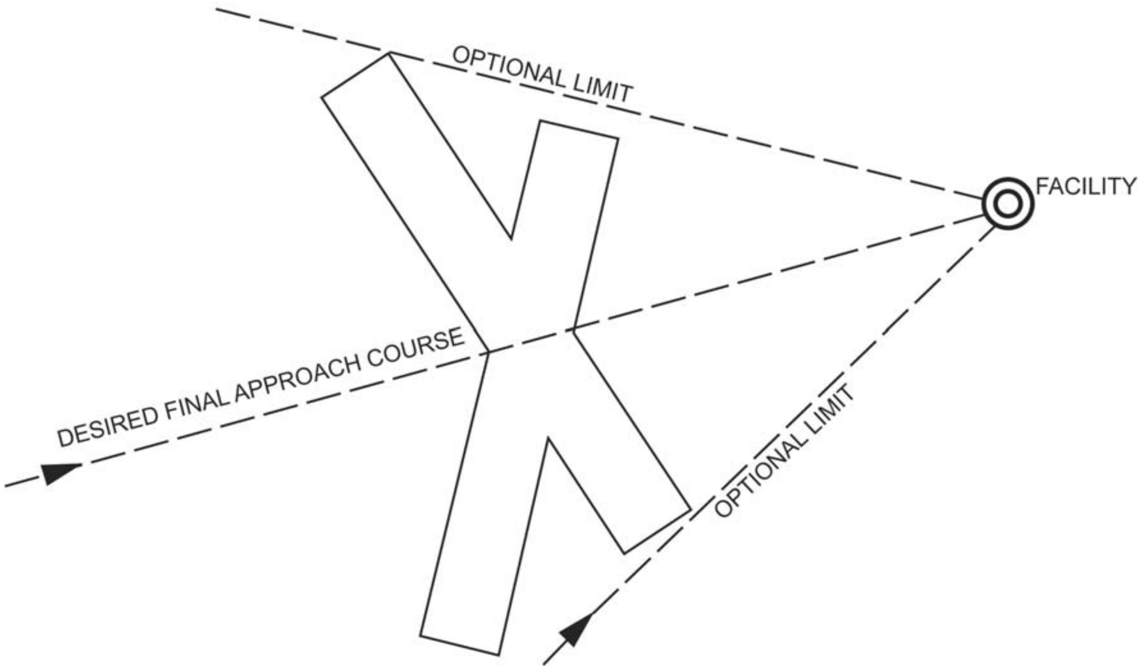

Figure 5-49: Alignment Options For Final Approach Course. On Airport VOR with FAF, Circling Approach Procedure. Para 513.a.(2)(b).

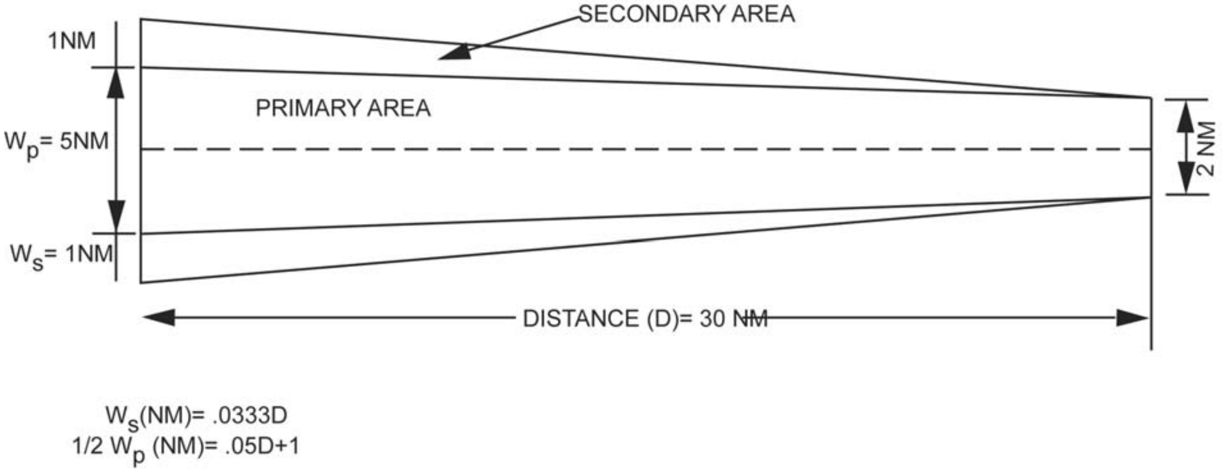

Figure 5-50: Final Approach Trapezoid. VOR with FAF. Para 513.b.

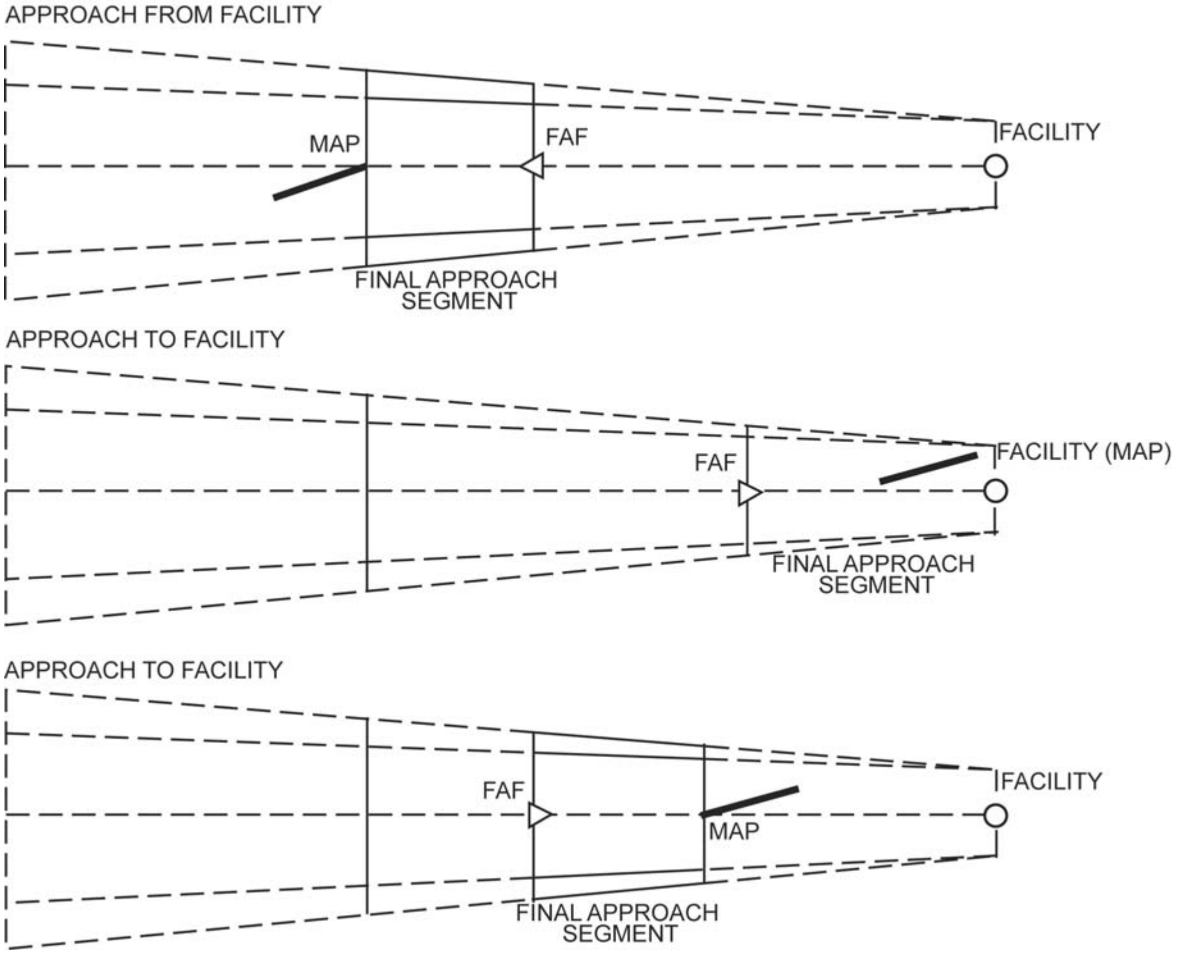

Figure 5-51: Typical Straight -In Final Approach. VOR with FAF. Para 513.b.

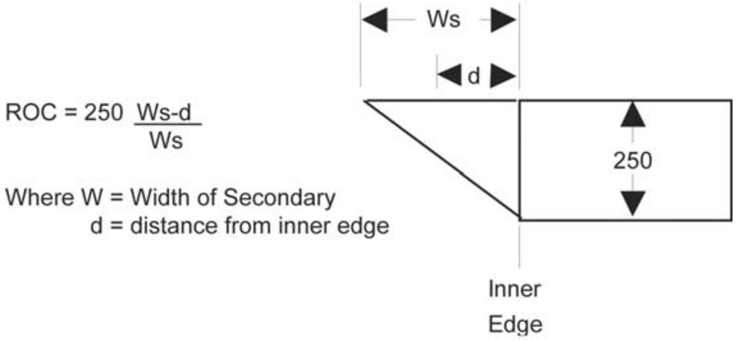

Figure 5- 51a: Minimum Obstacle Clearance. Para 513.c(1).

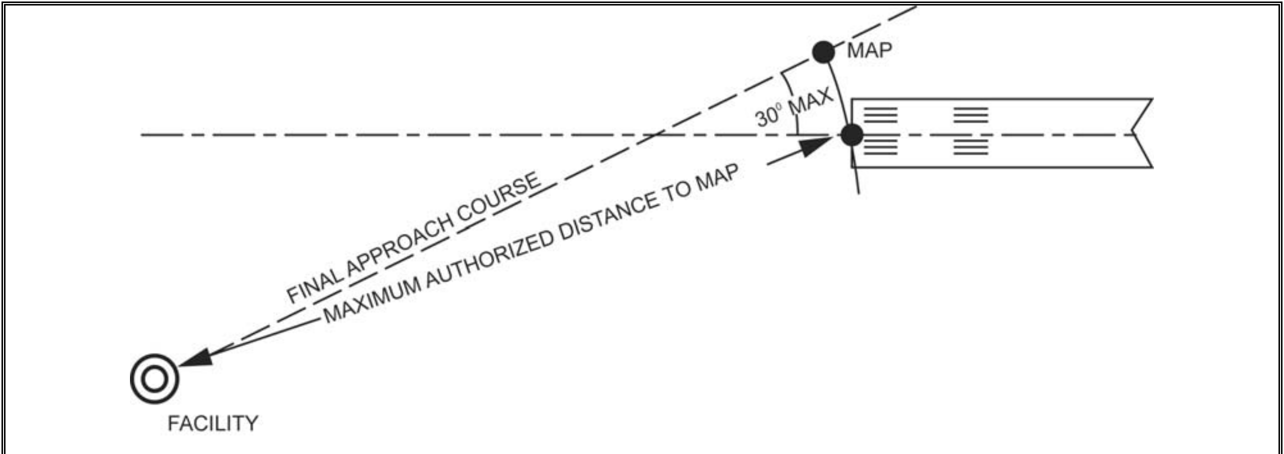

Figure 5-52: Missed Approach Point. Off-Airport VOR with FAF. Para 514.a.(1).

SECTION 2. TACAN AND VOR/DME

520. Feeder Routes

Criteria for feeder routes are contained in Para 220.

521. Initial Approach Segment

Due to the fixing capability of TACAN and VOR/DME a procedure turn initial approach may not be required. Criteria for initial approach segments are contained in Chapter 2, Section 3.

522. Intermediate Approach Segment

Criteria for the intermediate segment are contained in Chapter 2, Section 4.

523. Final Approach Segment

TACAN and VOR/DME final approaches may be based either on arcs or radials. The final approach begins at a final approach fix and ends at the missed approach point. The missed approach point is always marked with a fix.

a. Radial Final Approach. Criteria for the radial final approach are specified in Para 513.

b. Arc Final Approach. The final approach arc shall be a continuation of the intermediate arc. It shall be specified in nautical miles and tenths thereof. Arcs closer than 7 miles (15 miles for high altitude procedures) and farther than 30 miles from the facility shall not be used for final approach. No turns are permitted over the final approach fix.

   (1) Alignment. For Straight-in approaches, the final approach arc shall pass through the runway threshold when the angle of convergence of the runway centreline and the tangent of the arc does not exceed 15 degrees. When the angle exceeds 15 degrees the final approach arc shall be aligned to pass through the centre of the airport and only circling minimums shall be authorized. (see Figure 5–53.)

   (2) Area. The area considered for obstacle clearance in the arc final approach segments starts at the final approach fix and ends at the runway or missed approach point, whichever is encountered last. It should not be more than 5 miles long. It shall be divided into primary and secondary areas. The primary area is 8 miles wide, and extends 4 miles on either side of the arc. A secondary area is on each side of the primary area. The secondary areas are 2 miles wide on each side of the primary area. (see Figure 5–54.)

   (3) Obstacle Clearance. The minimum obstacle clearance in the primary area is 500 feet. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. See Figure 5-54a for the minimum required obstacle clearance at any point in the secondary area. (see also Annex C, Figure C–3.)

   (4) Descent Gradient. Criteria for descents are specified in Para 252.

   (5) Use of Fixes. Fixes along an arc are restricted to those formed by radials from the VORTAC facility which provides the DME signal. Criteria for such fixes are contained in Chapter 2, Section 8.

   (6) Minimum Descent Altitude. Straight-in MDAs shall not be specified lower than circling for arc procedures. Criteria for determining the circling MDA are contained in Chapter 3, Section 2.

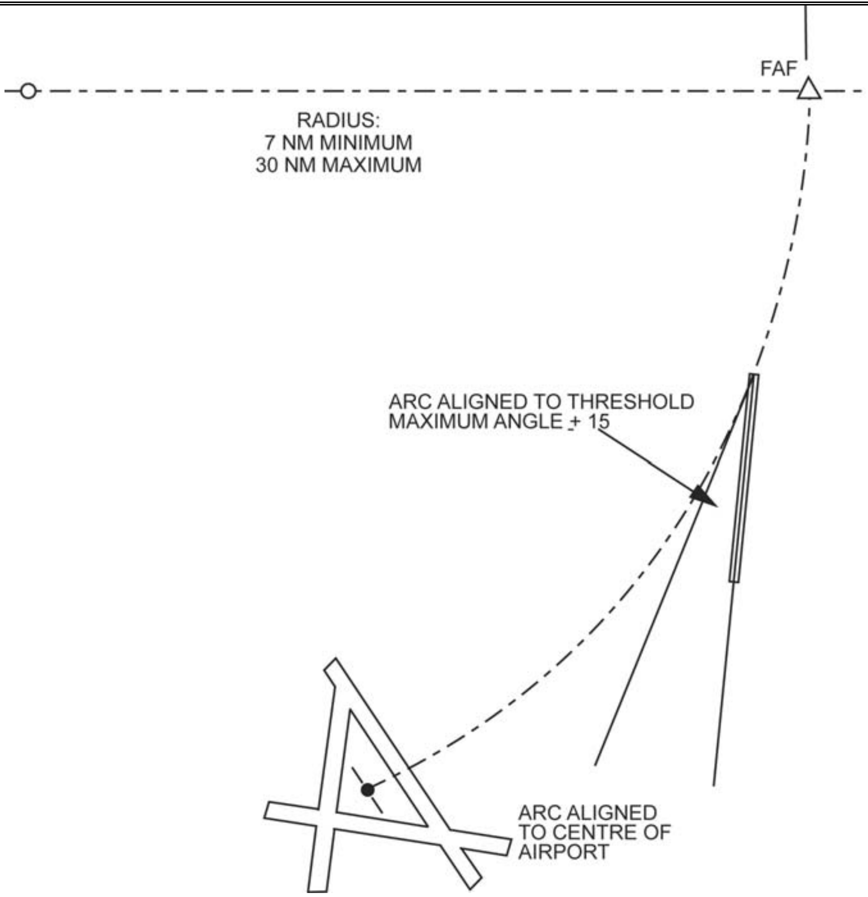

Figure 5-53: Arc Final Approach Alignment. Arc Aligned To Threshold. TACAN or VOR/DME. Para 523.b.(1).

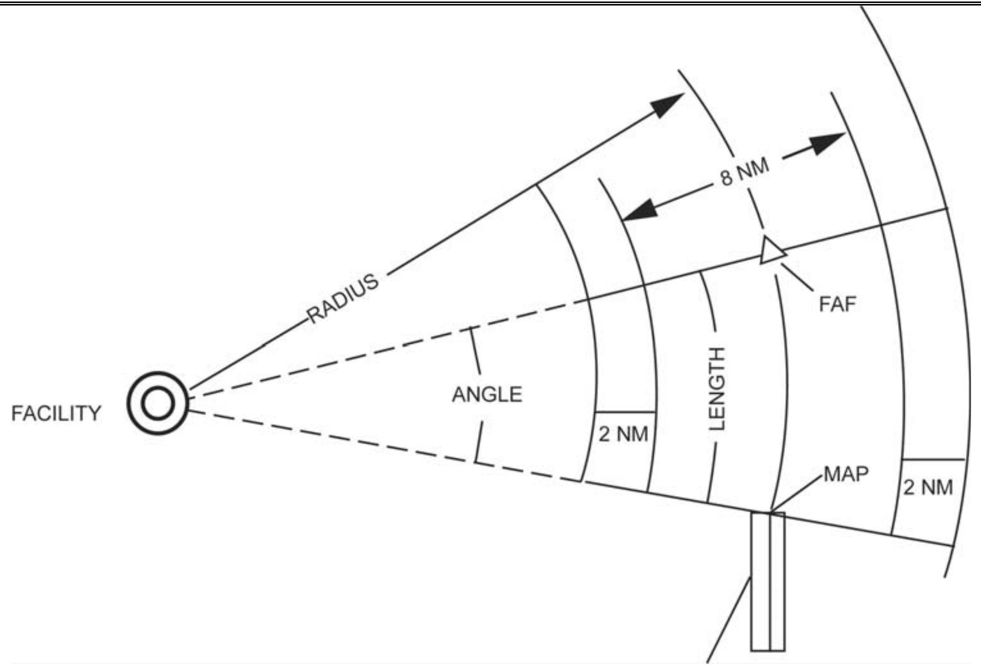

Figure 5-54: Arc Final Approach Area. TACAN or VOR/DME. Para 523.b.(2).

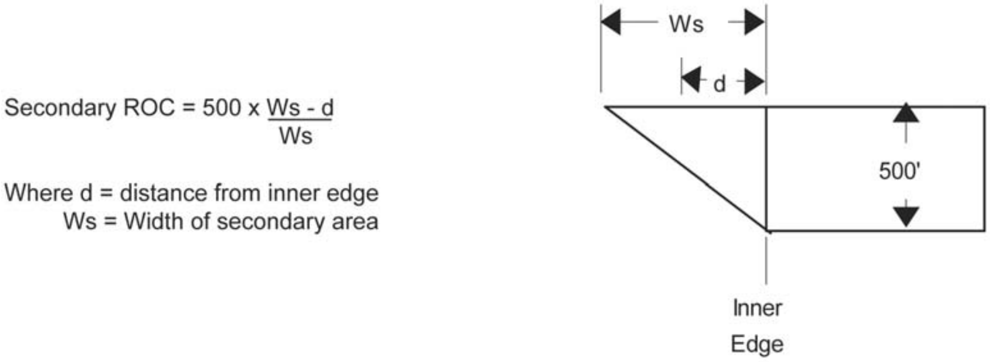

Figure 5- 54a: Minimum Obstacle Clearance. Para 523.b(3).

524. Missed Approach Segment

Criteria for the missed approach segment are contained in Chapter 2, Section 7. The missed approach point shall be a radial/DME fix. The missed approach surface shall commence over the fix and at the required height. (Also see Para 514.)

Note: The arc missed approach course may be a continuation of the final approach arc.

525—599. Reserved

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CHAPTER 6. NDB PROCEDURES ON-AIRPORT FACILITY, NO FAF

600. General

This chapter is divided into two sections: one for low altitude procedures and one for high altitude teardrop penetration procedures. These criteria apply to NDB procedures based on a facility located on the airport in which no final approach fix is established. These procedures must incorporate a procedure turn or a penetration turn. An on-airport facility is one that is located:

a. For Straight-in Approach. Within 1 mile of any portion of the landing runway.

b. For Circling Approach. Within 1 mile of any portion of the usable landing surface on the airport.

601—609. Reserved

SECTION 1. SLOW ALTITUDE PROCEDURES

610. Feeder Routes

Criteria for feeder routes are contained in Para 220.

611. Initial Approach Segment

The initial approach fix is received by overheading the navigation facility. The initial approach is a procedure turn. Criteria for the procedure turn areas are contained in Para 234.

612. Intermediate Approach Segment

This type of procedure has no intermediate segment. Upon completion of the procedure turn the aircraft is on final approach.

613. Final Approach Segment

The final approach begins where the procedure turn intersects the final approach course.

a. Alignment. The alignment of the final approach course with the runway centreline determines whether a straight-in or circling-only approach may be established.

(1) Straight-in. The angle of convergence of the final approach course and the extended runway centreline shall not exceed 30 degrees. The final approach course should be aligned to intersect the extended runway centreline 3,000 feet outward from the runway threshold. When an operational advantage can be achieved, this point of intersection may be established at any point between the runway threshold and a point 5,200 feet outward from the runway threshold. Also, where an operational advantage can be achieved a final approach course which does not intersect the runway centreline, or intersects it at a distance greater than 5,200 feet from the threshold, may be established provided that such course lies within 500 feet laterally of the extended runway centreline at a point 3,000 feet outward from the runway threshold. Straight-in category C, D, and E minimums are not authorized when the final approach course intersects the extended runway centerline at an angle greater than 15° and a distance less than 3,000 feet. (See Figure 6-55.)

Figure 6-1 TO 6-54: Reserved

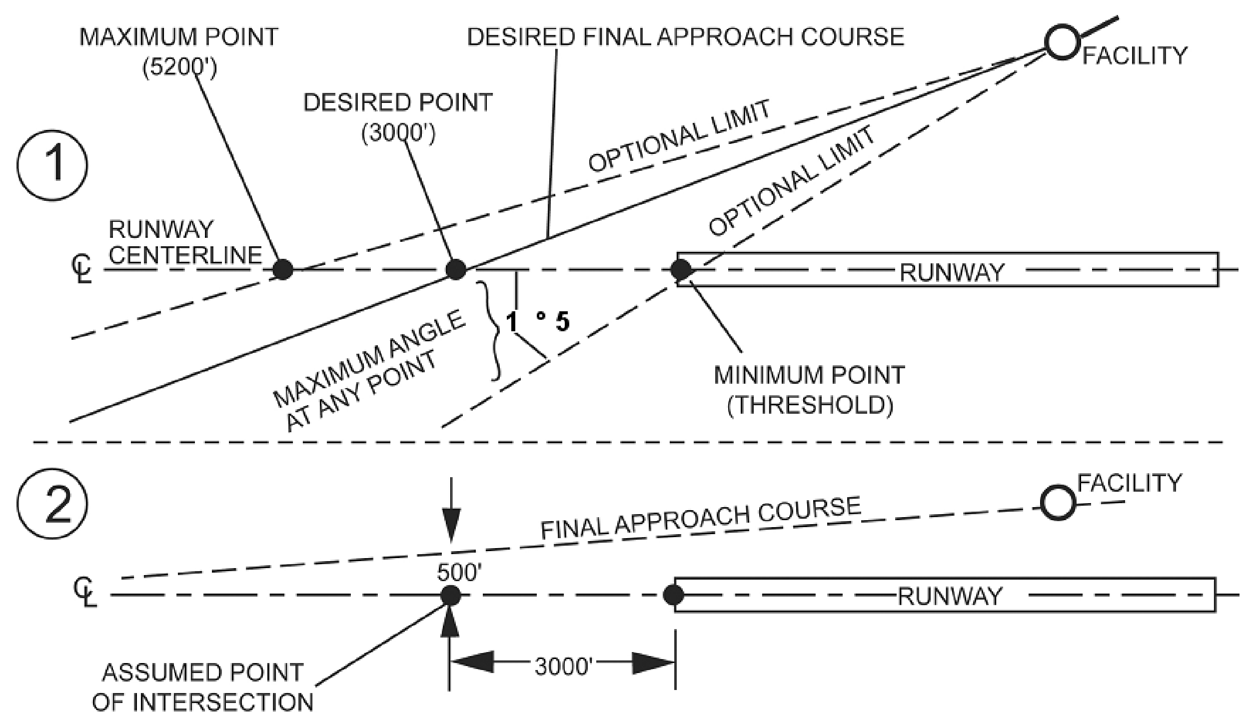


Figure 6-55: Alignment Options For Final Approach Course. On-Airport NDB, No FAF, Straight-In Procedure. Para 613.a.(1).

(2) Circling Approach. When the final approach course alignment does not meet the criteria for straight-in landing, only a circling approach shall be authorized, and the course alignment should be made to the centre of the landing area. When an operational advantage can be achieved, the final approach course may be aligned to pass through any portion of the usable landing surface. (See Figure 6-56.)

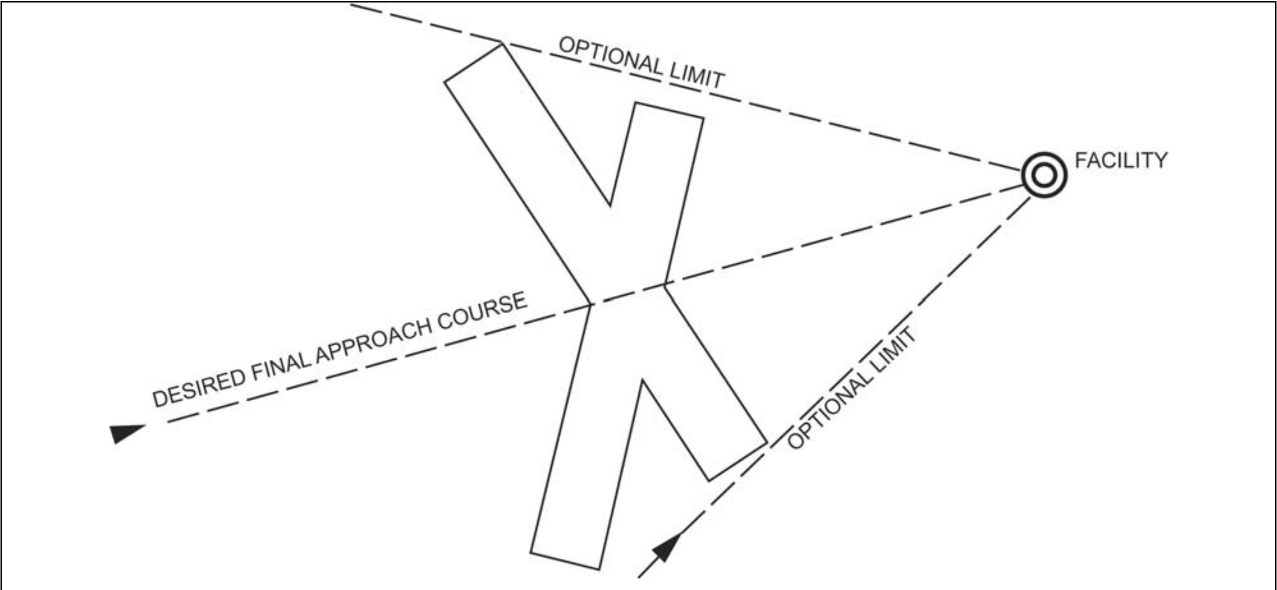


Figure 6-56: Alignment Options For Final Approach Course. On Airport NDB, No FAF, Circling Approach. Para 613.a.(2)

b. Area. Figure 6-57 illustrates the final approach primary and secondary areas. The primary area is longitudinally centred on the final approach course, and is 10 miles long. The primary area is 2.5 miles wide at the facility, and expands uniformly to 6 miles wide at 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility, and expands uniformly to 1.34 miles on each side of the primary area at 10 miles from the facility. When the 5-mile procedure turn is used, only the inner 5 miles of the final approach area need be considered.

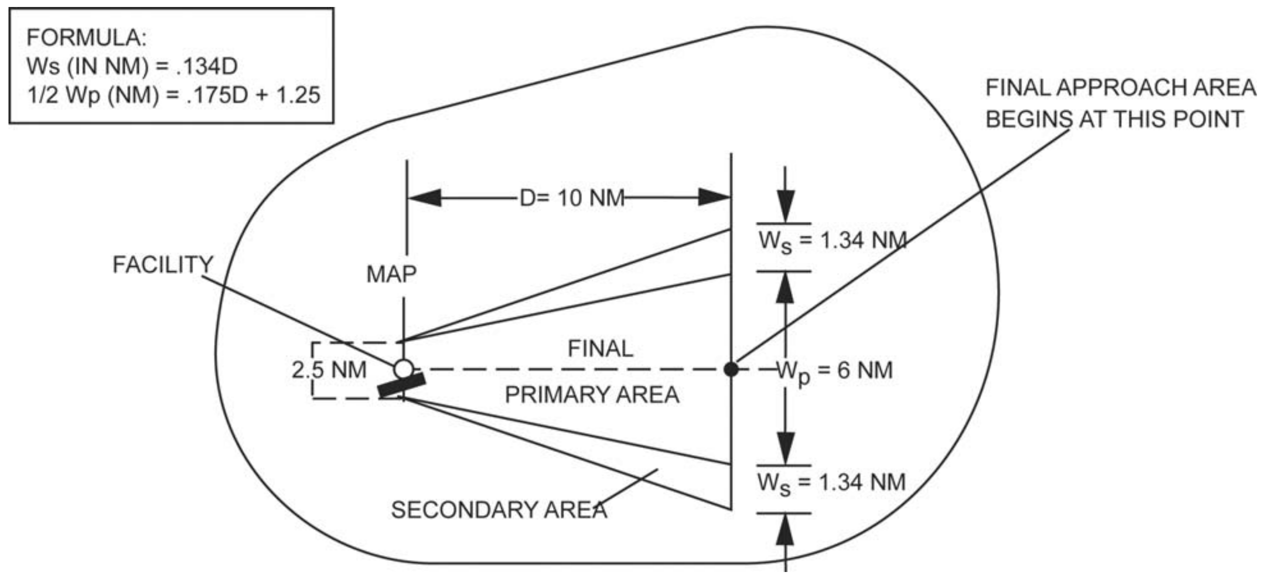


Figure 6-57: Final Approach Primary And Secondary Areas. On-Airport NDB, No FAF. Para 613.b.

c. Obstacle Clearance.

(1) Straight-in. The minimum obstacle clearance in the primary area is 350 feet. In the secondary area, 350 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. To determine ROC in the secondary area, see Figure 6-57a.

$$ROC = 350' \ \frac{Ws - d}{Ws}$$

Where Ws = Width of Secondary

d = distance from inner edge

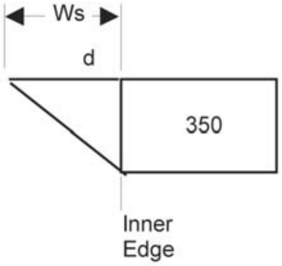


Figure 6-57a: Secondary ROC. Para 6-13.c.

(2) Circling Approach. In addition to the minimum requirements specified in Para 613.c.(1), obstacle clearance in the circling area shall be as prescribed in Chapter 2, Section 6.

d. Procedure Turn Altitude (Descent Gradient). The procedure turn completion altitude shall be within 1,500 feet of the MDA (1,000 feet with a 5-mile procedure turn), provided the distance from the facility to the point where the final approach course intersects the runway centreline (or the first usable portion of the landing area for "circling only" procedures) does not exceed 2 miles. When this distance exceeds 2 miles, the maximum difference between the procedure turn completion altitude and the MDA shall be reduced at the rate of 25 feet for each one-tenth of a mile in excess of 2 miles. (see Figure 6-58.)

Note: For those procedures in which the final approach course does not intersect the extended runway centreline within 5,200 feet of the runway threshold (Para 613.a.(1)), the assumed point of intersection for computing distance from the facility shall be 3,000 feet from the runway threshold. (See Figure 6-55.)

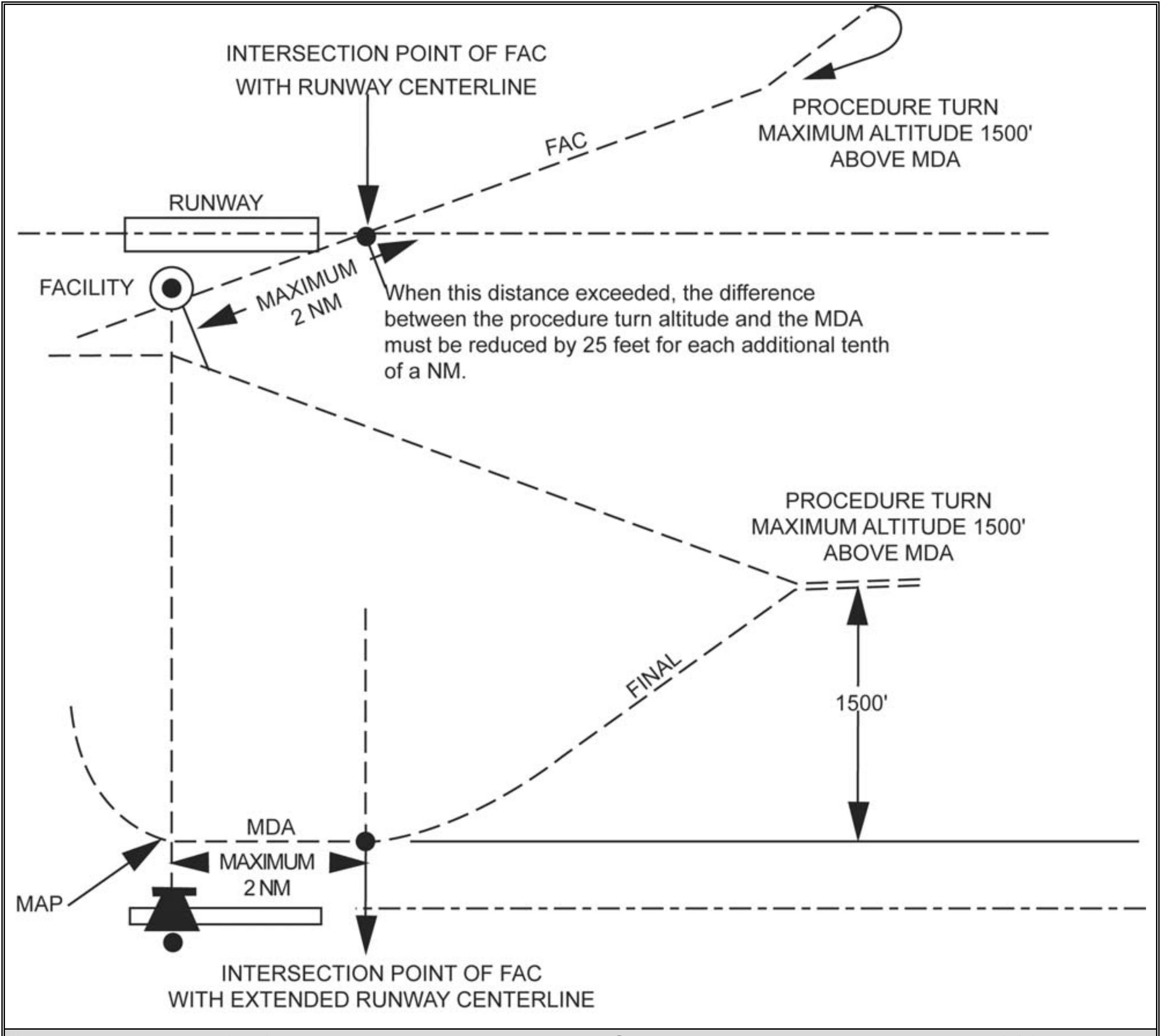


Figure 6-58: Procedure Turn Altitude. On-Airport NDB, No FAF. Para 613.d.

e. Use of Step-down Fix. Use of the step-down fix (Para 288.c) is permitted provided the distance from the facility to the step-down fix does not exceed 4 miles. The descent gradient between PT completion altitude and stepdown fix altitude shall not exceed 150 ft/NM. The descent gradient will be computed based upon the difference in PT completion altitude minus stepdown fix altitude, divided by the specified PT distance, minus the facility to stepdown fix distance. Obstacle clearance may be reduced to 300 feet from the stepdown fix to the MAP/FEP (see Figure 6-59, and Paras 251, 252, and 253).

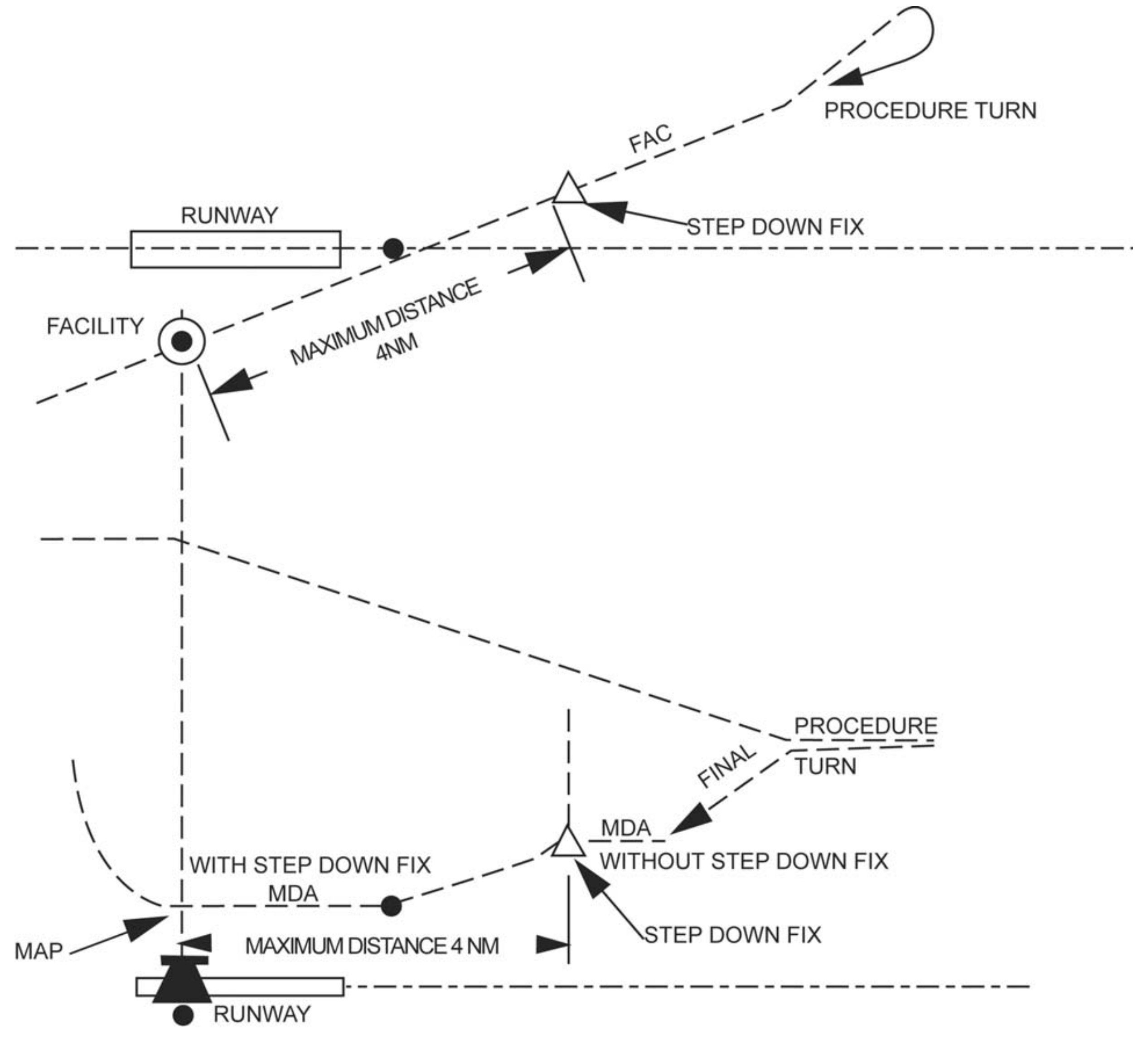


Figure 6-59: Use Of Step-Down Fix. On-Airport NDB, No FAF. Para 613.e.

f. Minimum Descent Altitude. Criteria for determining the MDA are contained in Chapter 3, Section 2.

614. Missed Approach Segment

Criteria for the missed approach segment are contained in Chapter 2, Section 7. The missed approach point is the facility. (see Figure 6-59. The missed approach surface shall commence over the facility at the required height. (See Para 274.)

615—619. Reserved

SECTION 2. HIGH ALTITUDE TEARDROP PENETRATIONS

620. Feeder Routes

Criteria for feeder routes are contained in Para 220.

621. Initial Approach Segment

The initial approach fix is received by overheading the navigation facility. The initial approach is a teardrop penetration turn. The criteria for the penetration turn are contained in Para 235.

622. Intermediate Approach Segment

The procedure has no intermediate segment. Upon completion of the penetration turn, the aircraft is on final approach.

623. Final Approach Segment

An aircraft is considered to be on final approach upon completion of the penetration turn. However, the final approach segment begins on the final approach course 10 miles from the facility. That portion of the penetration procedure prior to the 10-mile point is treated as the initial approach segment. (see Figure 6-60.)

a. Alignment. Same as low altitude criteria. (See Para 613.a.)

b. Area. Figure 6-60 illustrates the final approach primary and secondary areas. The primary area is longitudinally centred on the final approach course, and is 10 miles long. The primary area is 2.5 miles wide at the facility, and expands uniformly to 8 miles at 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility and expands uniformly to 2 miles each side of the primary area at 10 miles from the facility.

c. Obstacle Clearance.

   (1) Straight-in. The minimum obstacle clearance in the primary area is 500 feet. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge. The minimum required obstacle clearance at any given point in the secondary area is shown in Annex C, Figure C–3.

   (2) Circling Approach. In addition to the minimum requirements specified in Para 623.c.(1), obstacle clearance in the circling area shall be as prescribed in Chapter 2, Section 6.

d. Penetration Turn Altitude (Descent Gradient). The penetration turn completion altitude shall be at least 1,000 feet, but not more than 4,000 feet above the MDA on final approach.

e. Use of a Step-down Fix. Use of a step-down fix (see Para 288.c) is permitted, provided the distance from the facility to the step-down fix does not exceed 10 miles.

f. Minimum Descent Altitude. In addition to the normal obstacle clearance requirements of the final approach segment (see Para 623.c), the MDA specified shall provide at least 1000 feet of clearance over obstacles in that portion of the initial approach segment between the final approach segment and the point where the assumed penetration turn track intercepts the inbound course. (See Figure 6-60.)

624. Missed Approach Segment

Criteria for the missed approach segment are contained in Chapter 2, Section 7. The missed approach point is the facility. (See Figure 6-60.) The missed approach surface shall commence over the facility at the required height. (See Para 274.)

625—699. Reserved

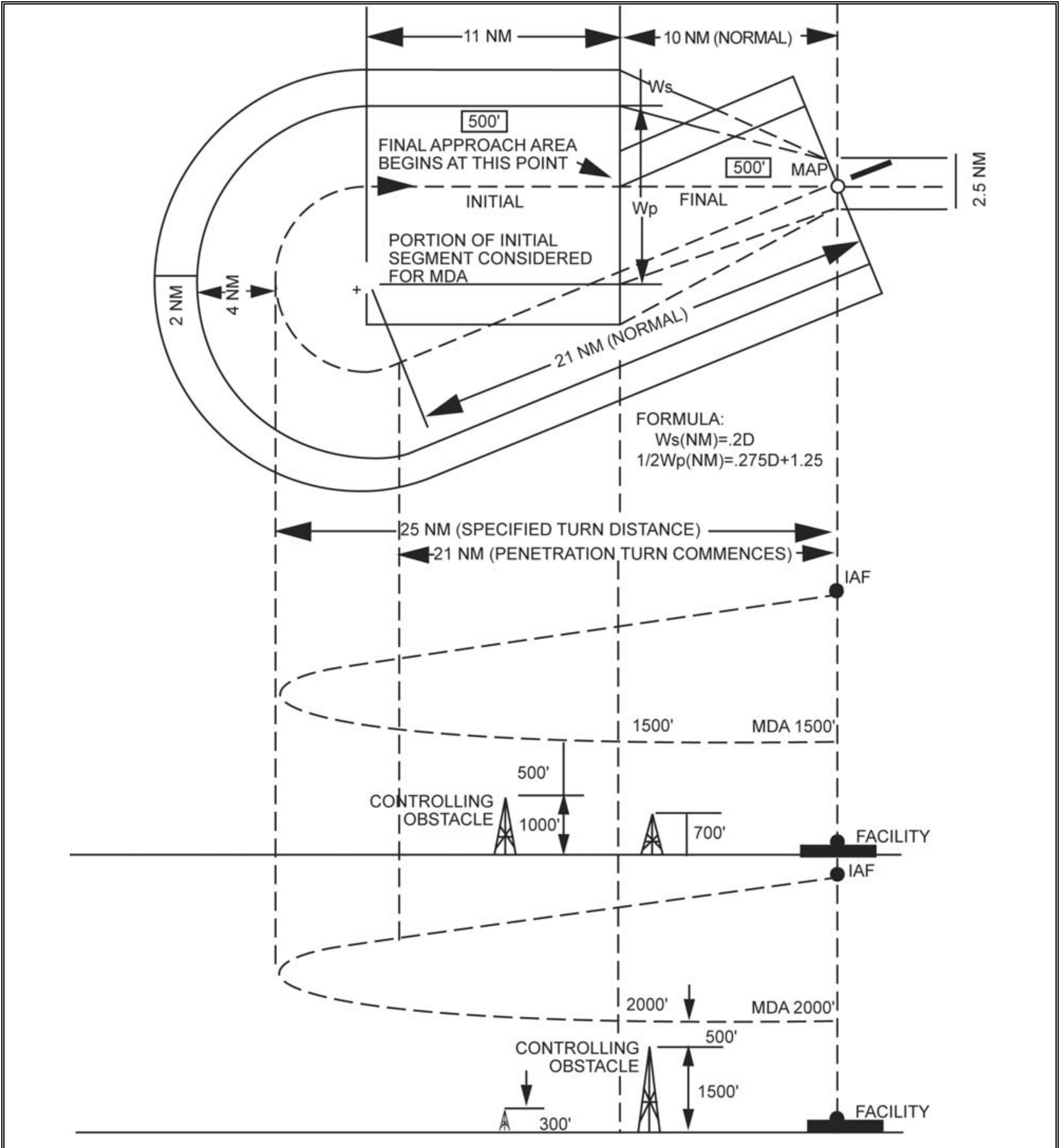


Figure 6-60: Penetration Turn. On Airport VOR, No FAF. Para 623.

CHAPTER 7. NDB WITH FAF

700. General

This chapter prescribes criteria for NDB procedures that incorporate a final approach fix. NDB procedures shall be based only on facilities that transmit a continuous carrier.

701—709. Reserved

SECTION 1. NDB WITH FAF

710. Feeder Routes

Criteria for feeder routes are contained in Para 220.

711. Initial Approach Segment

Criteria for the initial approach are contained in Chapter 2, Section 3.

712. Intermediate Approach Segment

Criteria for the intermediate approach segment are contained in Chapter 2, Section 4.

713. Final Approach Segment

The final approach may be made either FROM or TOWARD the facility. The final approach segment begins at the final approach fix and ends at the runway or missed approach point, whichever is encountered last.

Note: Criteria for the establishment of arc final approaches are specified in Para 523.b.

a. The alignment of the final approach course with the runway centreline determines whether a straight-in or circling-only approach may be established. The alignment criteria differ depending on whether the facility is OFF or ON the airport. See definition in Para 400.

  (1) Off-airport Facility.

    (a) Straight-in. The angle of convergence of the final approach course and the extended runway centreline shall not exceed 30 degrees. The final approach course should be aligned to intersect the runway centreline at the runway threshold. However, when an operational advantage can be achieved, the point of intersection may be established anywhere from the runway threshold to as much as 3,000 feet outward from the runway threshold. (See Figure 7-61.)

    (b) Circling Approach. When the final approach course alignment does not meet the criteria for straight-in landing, only a circling approach shall be authorized, and the alignment should be made to the centre of the landing area. When an operational advantage can be achieved, the final approach course may be aligned to any portion of the usable landing surface. (See Figure 7-62.)

Figure 7-1 TO 7-60: Reserved

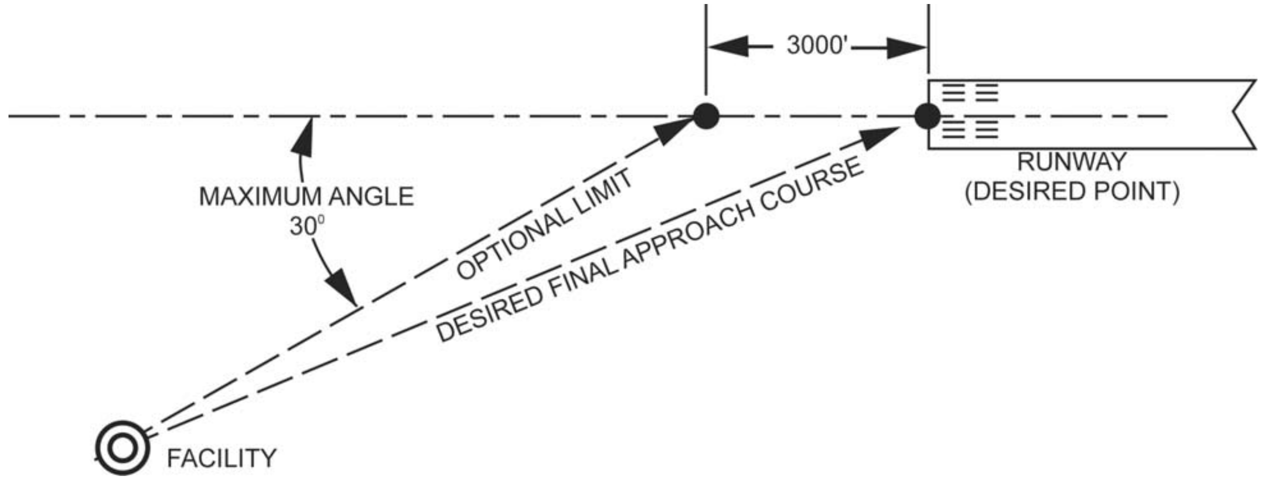


Figure 7-61: Alignment Options For Final Approach Course. Off-Airport NDB with FAF. Straight-In Approach. Para 713.a.(1)(a).

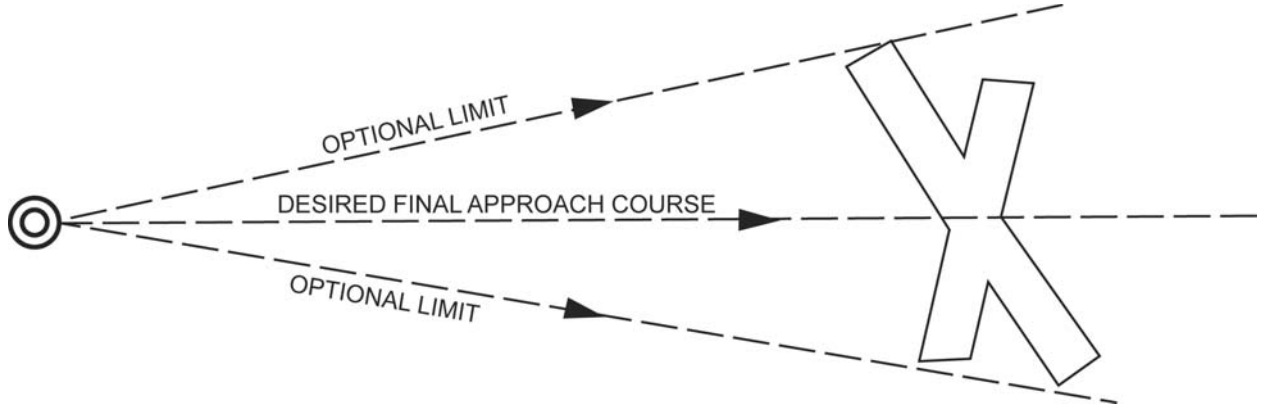


Figure 7-62: Alignment Options For Final Approach Course. Off-Airport NDB with FAF. Circling Approach. Para 713.a.(1)(b).

(2) On-airport Facility.

(a) Straight-in. The angle of convergence between the final approach course and the extended runway centreline shall not exceed 30 degrees. The final approach course should be aligned to intersect the extended runway centreline 3,000 feet outward from the runway threshold. When an operational advantage can be achieved, this point of intersection may be established at any point between the runway threshold and a point 5,200 feet outward from the runway threshold. Also, where an operational advantage can be achieved, a final approach course which does not intersect the runway centreline, or which intersects it at a distance greater than 5,200 feet from the threshold, may be established provided such a course lies within 500 feet laterally of the extended runway centreline at a point 3,000 feet outward from the runway threshold (See Figure 7-63).

(b) Circling Approach. When the final approach course alignment does not meet the criteria for a straight-in landing, only a circling approach shall be authorized, and the course alignment should be made to the centre of the landing area. When an operational advantage can be achieved, the final approach course may be aligned to any portion of the usable landing surface. (See Figure 7-64).

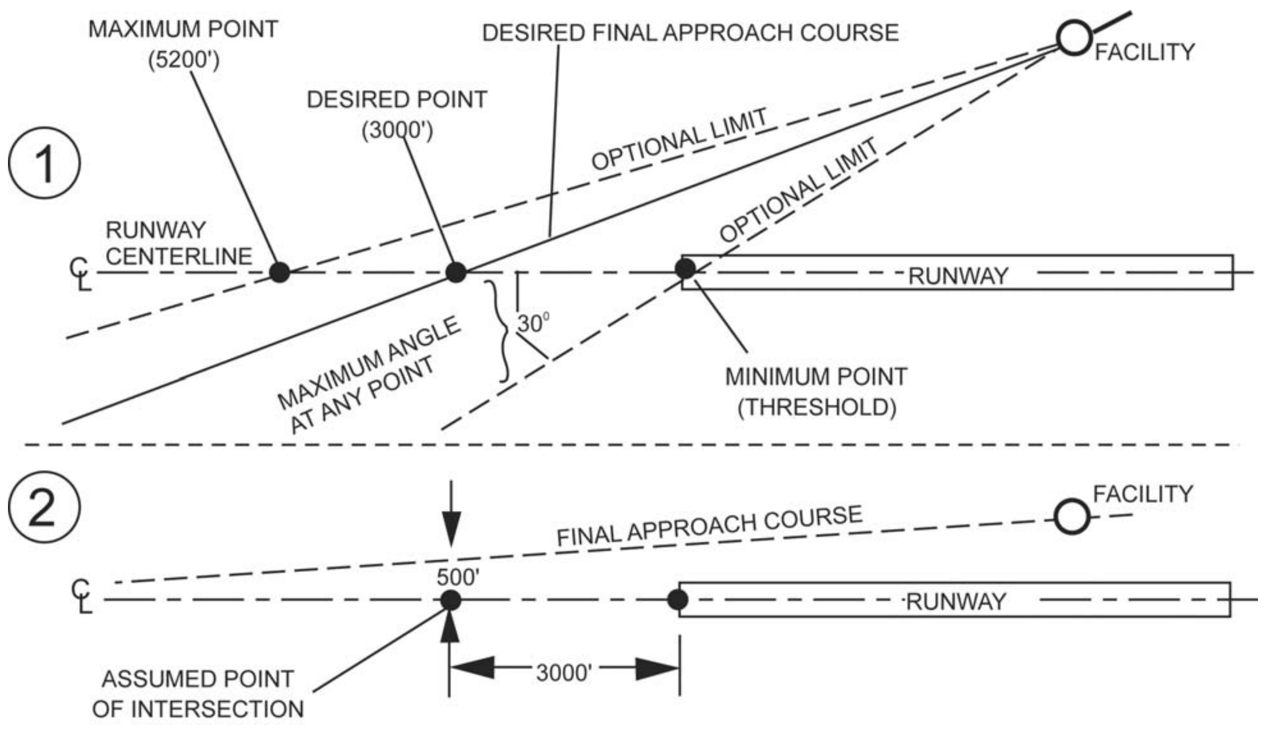


Figure 7-63: Alignment Options For Final Approach Course. On-Airport NDB. Para 713.a.(2)(a).

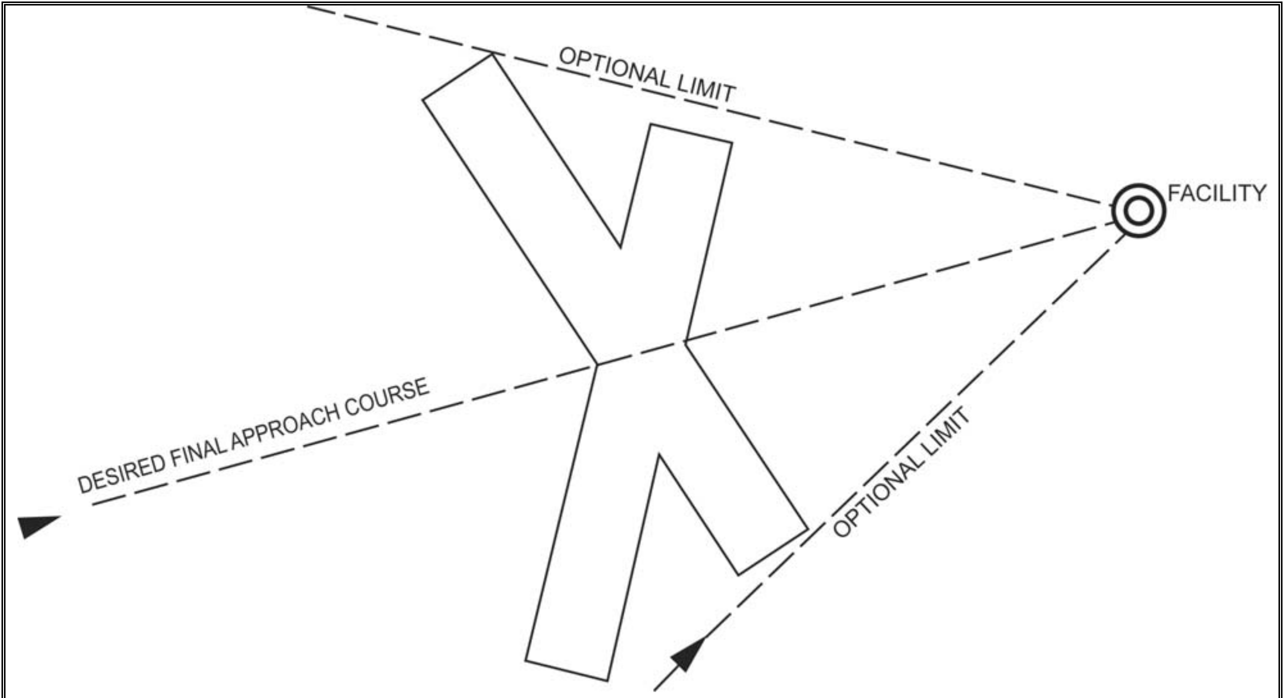


Figure 7-64: Alignment Options For Final Approach Course. On Airport NDB with FAF, Circling Approach. Para 713.a.(2)(b).

b. Area. The area considered for obstacle clearance in the final approach segment starts at the final approach fix and ends at the runway or missed approach point, whichever is encountered last. It is a portion of a 15-mile long trapezoid (see Figure 7-65), which is made up of primary and secondary areas. The primary area is centred longitudinally on the final approach course. It is 2.5 miles wide at the facility and expands uniformly to 5 miles at 15 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility, and expands uniformly to 1 mile each side of the primary area at 15 miles from the facility. Final approaches may be made to airports which are a maximum of 15 miles from the facility. The OPTIMUM length of the final approach segment is 5 miles. The MAXIMUM length is 10 miles. The MINIMUM length of the final approach segment shall provide adequate distance for an aircraft to make the required descent, and to regain course alignment when a turn is required over the facility. Table 7-15 shall be used to determine the minimum length needed to regain the course.

Table 7-1 TO 7-14 : Reserved

Approach Category	Magnitude of Turn over Facility		
	10°	**20°**	**30°**
A	1.0	1.5	2.0
B	1.5	2.0	2.5
C	2.0	2.5	3.0
D	2.5	3.0	3.5
E	3.0	3.5	4.0

Note: This table may be interpolated. If turns of more than 30° are required, or if the minimum lengths specified in the table are not available, straight-in minima are not authorized. See Figure 7-66 for typical final approach areas.

Table 7-15: Minimum Length Of Final Approach Segment — NDB (nm). Para 713.b.

c. Obstacle Clearance.

(1) Straight-in. The minimum obstacle clearance in the primary area is 300 feet. In the secondary area, 300 feet of obstacle clearance shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge. See Figure 6-66a for the minimum obstacle clearance at any given point in the secondary area (see also Annex C, Figure C-6).

(2) Circling Approach. In addition to the minimum requirements specified in Para 713.c.(1), obstacle clearance in the circling area shall be as prescribed in Chapter 2, Section 6.

d. Descent Gradient. Para 252 applies

e. Use of Fixes. Criteria for the use of radio fixes are contained in Chapter 2, Section 8. Where a procedure is based on a procedure turn and an on-airport facility is the procedure turn fix, the distance from the facility to the FAF shall not exceed 4 miles.

f. Minimum Descent Altitude. Criteria for determining the MDA are contained in Chapter 3, Section 2.

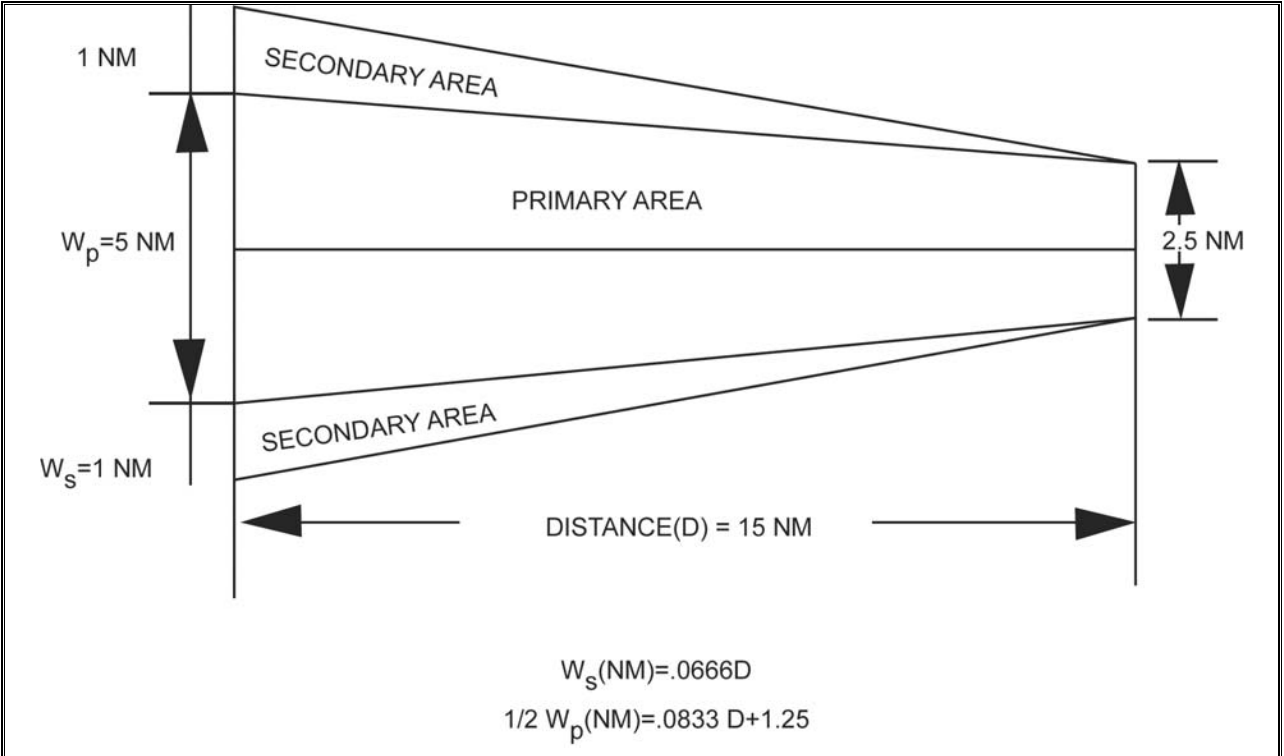
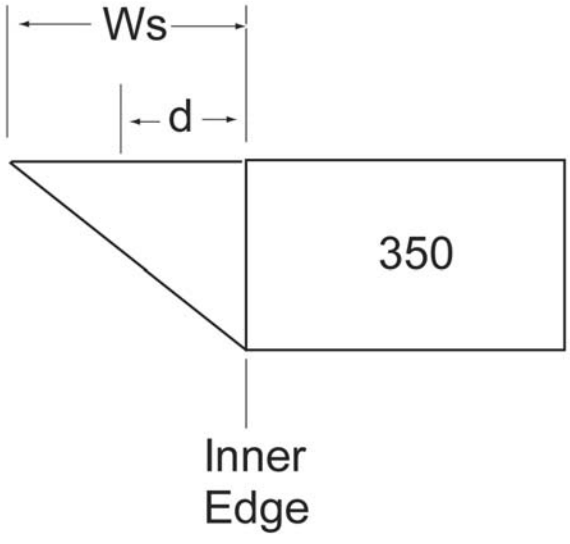


Figure 7-65: Final Approach Trapezoid. NDB with FAF. Para 713.b.



$$ROC = 300' \frac{Ws-d}{Ws}$$

Where Ws= Width of Secondary

d = distance from inner edge

Figure 7-66a: Minimum Obstacle Clearance. Para 713.c.

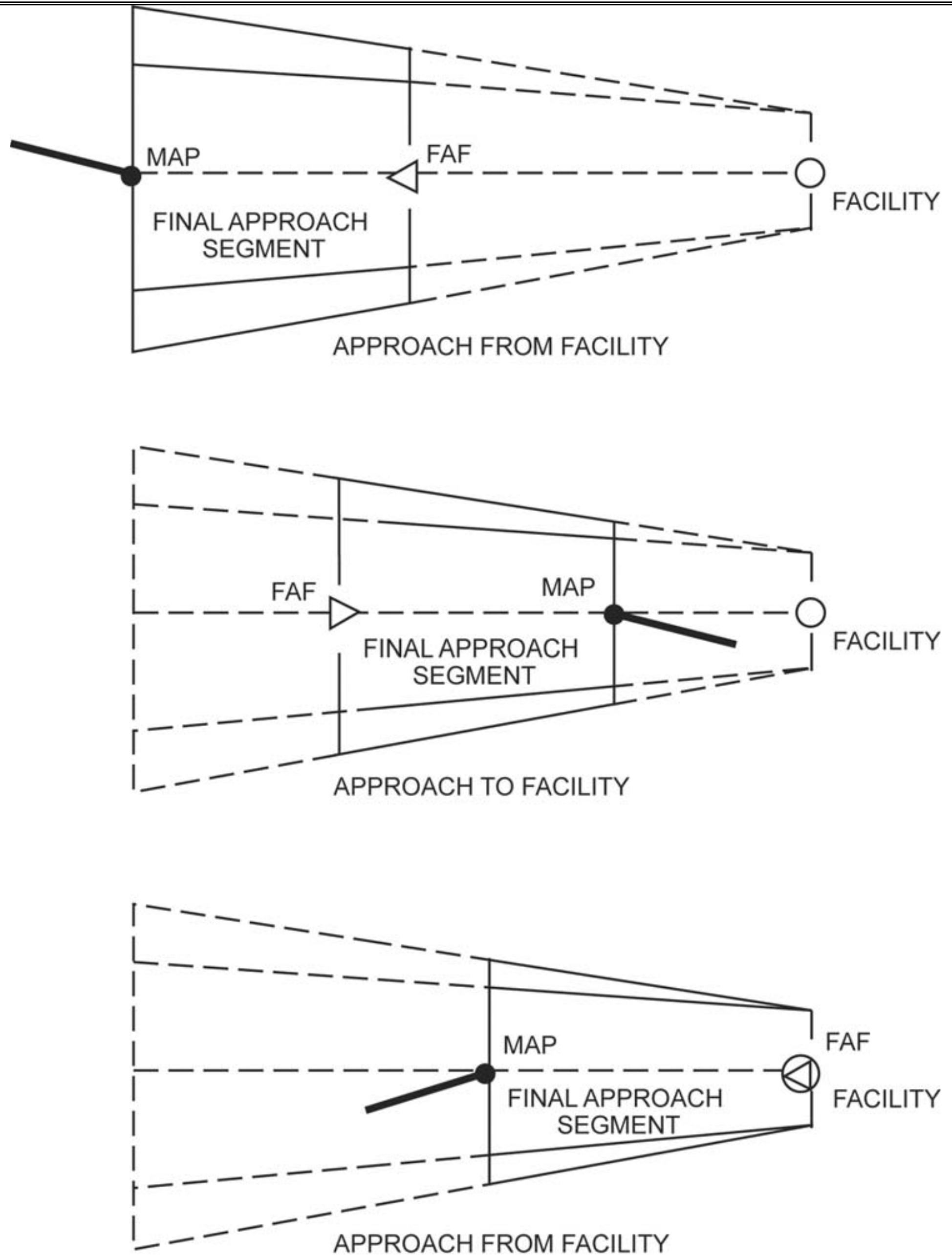


Figure 7-66: Typical Final Approach Areas. NDB with FAF. Para 713.b.

714. Missed Approach Segment

Criteria for the missed approach segment are contained in Chapter 2, Section 7. The missed approach point and surface shall be established as follows:

a. Off-airport Facilities.

(1) Straight-in. The missed approach point is a point on the final approach course which is not farther from the FAF than the runway threshold. The missed approach surface shall commence over the missed approach point at the required height. (See Para 274 and Figure 7-67.)

(2) Circling Approach. The missed approach point is a point on the final approach course which is not farther from the final approach fix than the first usable portion of the landing area. The missed approach surface shall commence over the missed approach point at the required height. (See Para 274.)

b. On-airport Facilities. The missed approach point is a point on the final approach course which is not farther from the final approach fix than the facility. The missed approach surface shall commence over the missed approach point at the required height. (See Para 274.)

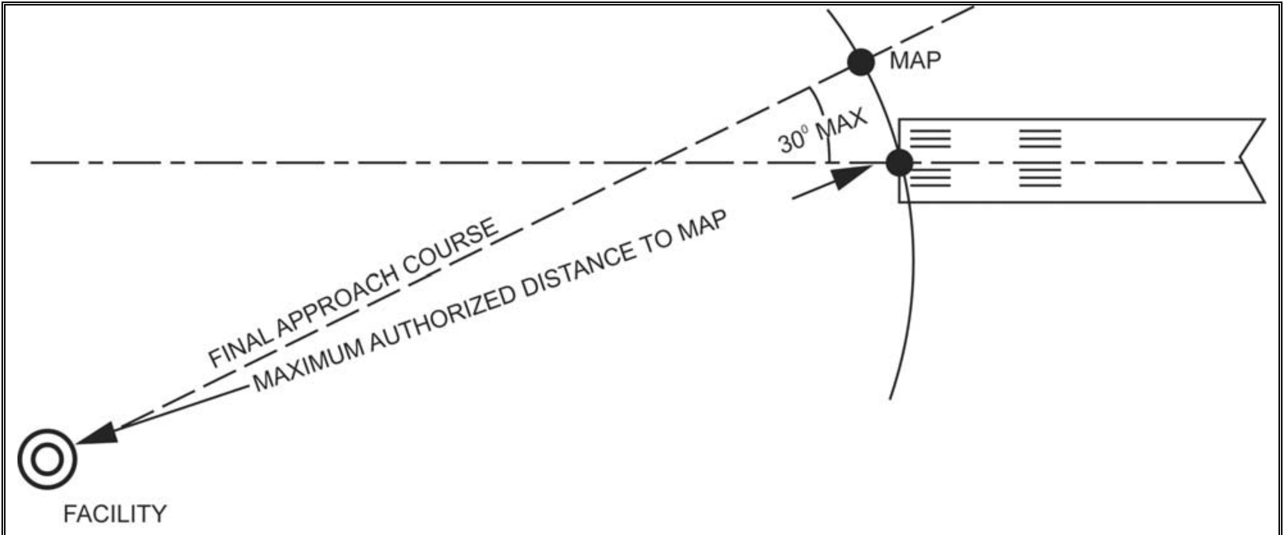


Figure 7-67: Missed Approach Point. Off-Airport NDB with FAF. Para 714.a.(1).

715—799. Reserved

CHAPTER 8. EMERGENCY VHF/UHF DF PROCEDURES

800. General

These criteria apply to Direction Finding (DF) procedures for both high and low altitude aircraft. DF criteria shall be the same as criteria provided for automatic direction finder (ADF) procedures, except as specified herein. As used in this chapter, the word “facility” means the DF antenna site. DF approach procedures are established for use in emergency situations. Detailed operational instructions for Emergency VHF/UHF DF Procedures are contained in Flight Service Station MANOPS 5-10 and 6-70.

801—809. Reserved

SECTION 1. VHF/UHF DF CRITERIA

810. En Route Operations

En route aircraft under DF control follow a course to the DF station as determined by the DF controller. A minimum safe altitude shall be established which provides at least 1,000 feet (1,500 or 2,000 feet in mountainous areas) of clearance over all obstacles within the operational radius of the DF facility. When this altitude proves unduly restrictive, sector altitudes may be established to provide relief from obstacles that are clear of the area where flight is conducted. Where sector altitudes are established, they shall be limited to sectors of not less than 45 degrees in areas BEYOND a 10-mile radius around the facility. For areas WITHIN 10 miles of the facility, sectors of NOT LESS THAN 90 degrees shall be used. Because the flight course may coincide with the sector division line, the sector altitude shall provide at least 1,000 feet (2,000 feet in mountainous terrain) of clearance over obstacles in the adjacent sectors within 6 miles or 20 degrees of the sector division line, whichever is the greater. No sector altitude shall be specified which is lower than the procedure turn altitude or lower than the altitude for area sectors which are closer to the navigation facility.

811. Initial Approach Segment

The initial approach fix is overhead the facility.

a. Area. The initial approach is a low altitude triangular procedure illustrated in Figure 8-1. When the triangular procedure is used, final descent is based on a single heading at 500 feet per minute rate of descent. (See Table 8-1 and Figure 8-2.)

Rate of Descent – 500 Feet per Minute

Aircraft Ground Speed (Knots)	**60**	**70**	**80**	**90**	**100**	**110**	**120**	**Time (Mins)**	**Descent in feet**
Descent (feet per nm)	**500**	**429**	**375**	**330**	**300**	**272**	**250**		
Distance (nm) covered for time flown at estimated compared to descent in feet (Last two columns) **Note: Distances are to nearest tenth of a nautical mile (nm)**	1.0	1.2	1.3	1.5	1.7	1.8	2.0	1	500
	2.0	2.3	2.7	3.0	3.3	3.6	4.0	2	1000
	3.0	3.5	4.0	4.5	5.0	5.5	6.0	3	1500
	4.0	4.6	5.3	6.0	6.6	7.3	8.0	4	2000
	5.0	5.8	6.6	7.5	8.3	9.2	10.0	5	2500
	6.0	7.0	8.0	9.0	10.0	11.0	12.0	6	3000
	7.0	8.1	9.3	10.5	11.7	12.8	14.0	7	3500
	8.0	9.3	10.6	12.0	13.3	14.6	16.0	8	4000
	9.0	10.4	12.0	13.5	15.0	16.5	18.0	9	4500
	10.0	11.6	13.3	15.0	16.7	18.3	20.0	10	5000

Table 8-1: DF Emergency Descent Gradients. Para 811.a.

b. Obstacle Clearance. Obstacle clearance in the initial approach primary area shall be a MINIMUM of 1,000 feet. Obstacle clearance at the inner edge of the secondary area shall be 500 feet, tapering to zero feet at the outer edge. The minimum obstacle clearance at any given point in the secondary area is found by using the graph in Annex C, Figure C–3. The altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet provided the ROC is not violated. (See Para 231.)

812. Intermediate Approach Segment

Except as outlined in this paragraph, criteria for the intermediate segment are contained in chapter 2, section 4. An intermediate segment is used only when the DF facility is located off the airport, and the final approach is made from overhead the facility to the airport or visual contact area.

a. Area. The width of the primary intermediate area is 3.4 miles at the facility expanding uniformly on each side of the course to 8 miles wide 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility expanding along the primary area to 2 miles each side at 10 miles from the facility. (See Figure 8-3.)

b. Obstacle Clearance. A MINIMUM of 500 feet of obstacle clearance shall be provided in the primary area of the intermediate approach segment. In the secondary area, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge. The minimum obstacle clearance required at any given point in the secondary area may be determined by using the graph in Annex C, Figure C-3 or the formula specified in Para 523.b. The altitudes selected by application of the obstacle clearance specified in this paragraph shall be rounded to the nearest 100 feet, provided the ROC is not violated. (See Para 241.)

The obstacle clearance is applied to provide clearance until the inbound aircraft is over the facility. Descent through cloud is commenced at a point as determined by the DF controller, using the DF Emergency Descent Gradients (see Table 8-1). The objective is to have the aircraft descend at a constant rate so as to pass over the facility with at least 500 feet obstacle clearance.

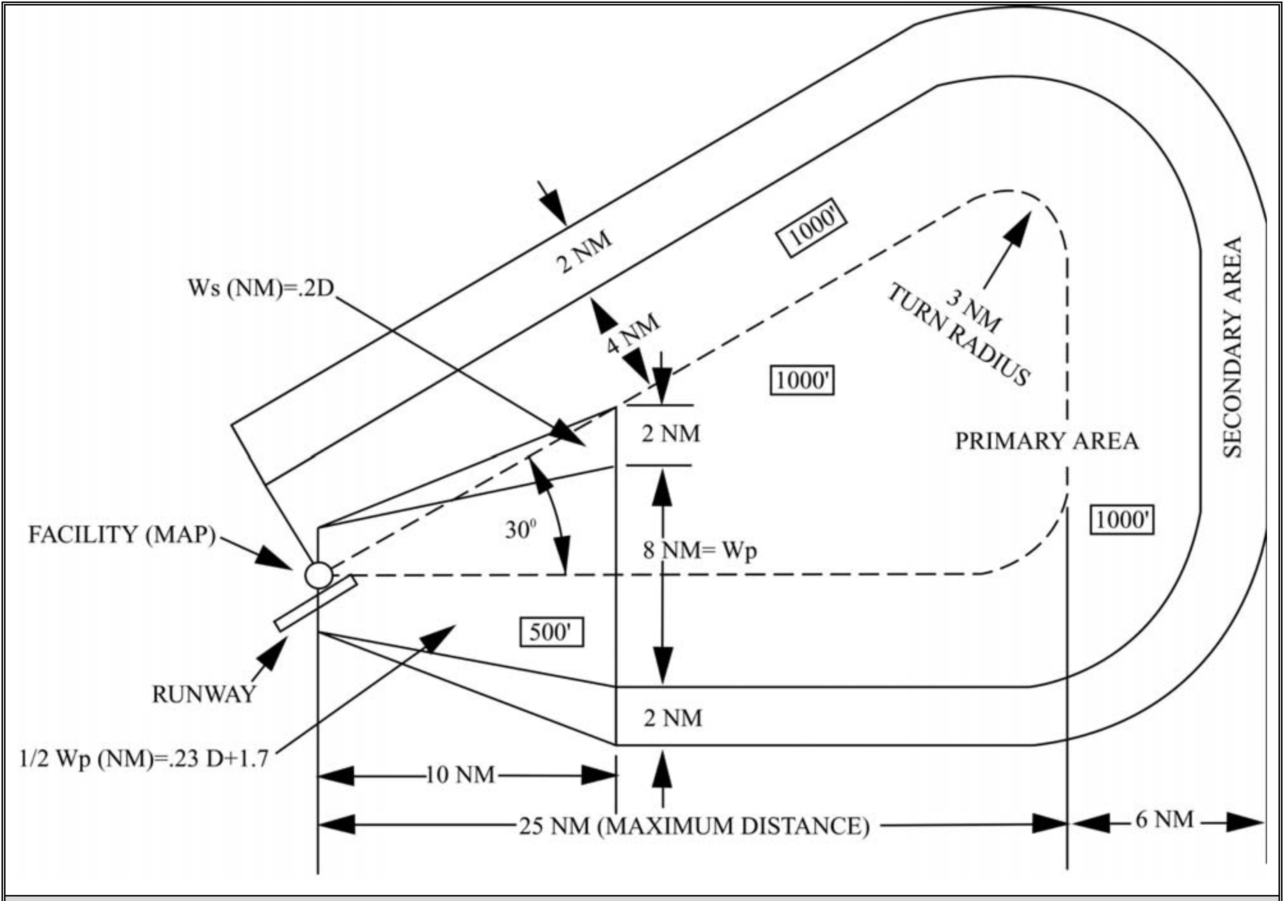


Figure 8-1: Triangular Turn Area. Para 811.a.

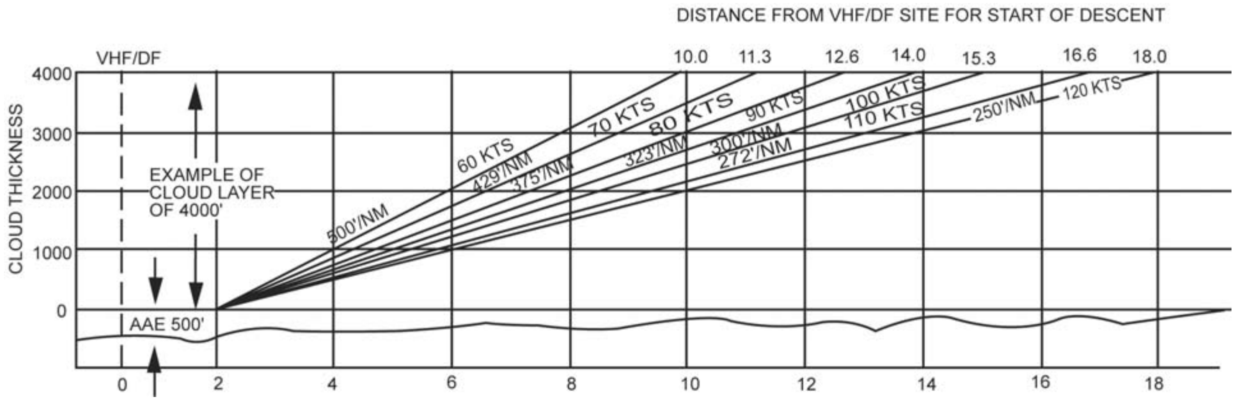


Figure 8-2: DF Descent Distance/ Airspeed Profiles. Para 811.a.

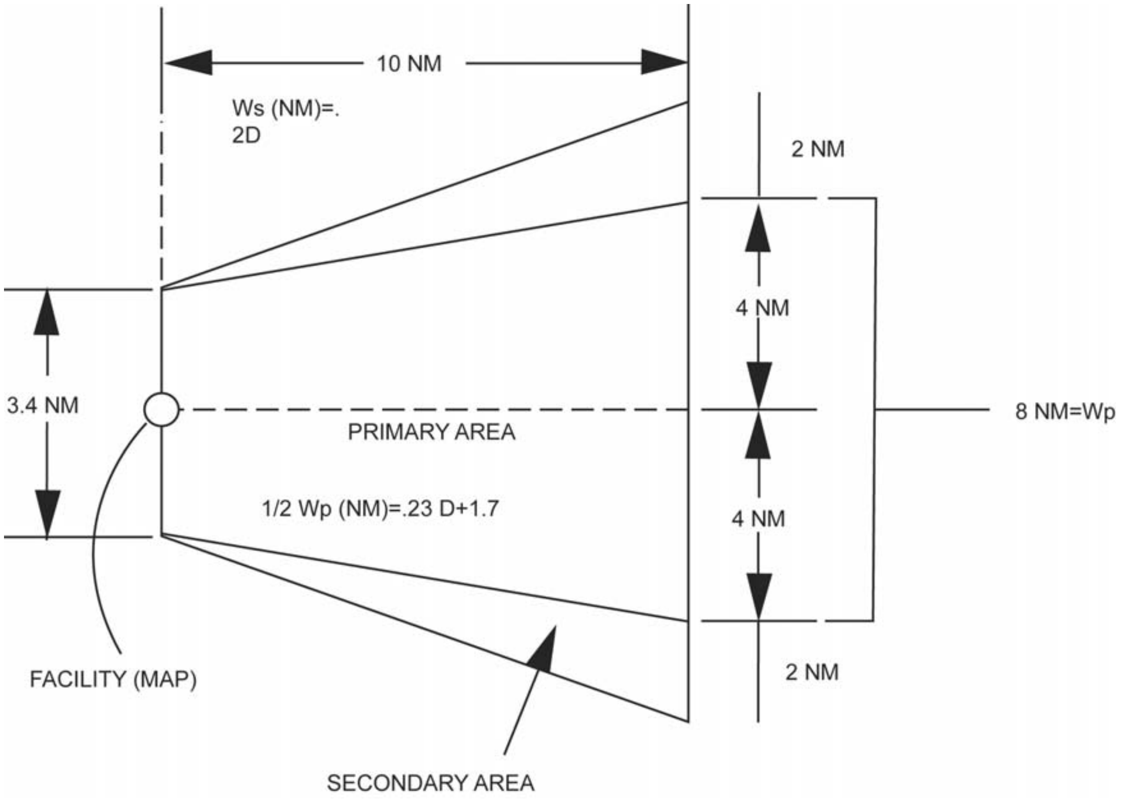


Figure 8-3: Off-Airport DF Intermediate Approach Area On-Airport DF Final Approach Area. Para 812 and 813.

813. Final Approach Segment

The final approach begins at the facility for off-airport facilities or where the procedure turn intersects the final approach course for on-airport facilities (see Para 400 for the definition of on-airport facilities). DF procedures shall not be developed for airports that are more than 10 miles from the DF facility. When a facility is located in excess of 6 miles from an airport, the instrument approach shall end at the facility and flight to the airport shall be conducted in accordance with Visual Flight Rules (VFR).

a. Alignment. Final approach course alignment with the runway is not a consideration in Emergency VHF/UHF DF Procedures.

b. Area.

(1) On-airport Facilities. Figure 8-3 illustrates the final approach primary and secondary areas. The primary area is longitudinally centred on the final approach course and is 10 miles long. The primary area is 3.4 miles wide at the facility and expands uniformly to 8 miles wide at 10 miles from the facility. A secondary area is on each side of the primary area. It is zero miles wide at the facility and expands uniformly to 2 miles on each side of the primary area at 10 miles from the facility.

(2) Off-airport Facilities. The area considered is identical to that described in Para 713a(1)(a) and (b) and Figure 7-65 except that the primary area is 3.4 miles wide at the facility.

(3) Final Approach to Visual Contact Area. (DF site located on or off-aerodrome). Figure 8-4 illustrates the final approach area. The segment starts at the VHF/DF site and ends at the visual contact area that is a portion of a 15-mile long trapezoid located in the best area for emergency descent. The area is centred longitudinally on the final descent course. It is 3.4 miles wide at the facility and expands uniformly to 8 miles at 15 miles from the facility. Final approach should be made within a maximum of 15 miles from the facility. The MINIMUM length of the final approach segment shall provide adequate distance for an aircraft to make a descent at 500 feet per mile from the minimum altitude (1,000 feet obstacle clearance) over the VHF/ DF facility down to 500 feet above the highest centreline elevation of obstacles in the visual contact area. For the MAXIMUM length, descent at 250 feet per mile shall be used. These calculations form the beginning and end of the visual contact area and the width is formed by the boundaries of the trapezoid. (See Table 8-1). The profile in Figure 8-4 illustrates a descent of 3,500 feet, ceiling of 500 feet, rate of descent 500 feet per minute and the visual contact area for ground speeds from 60 to 120 knots.

c. Obstacle Clearance.

(1) Straight-in. The minimum obstacle clearance in the primary area is 500 feet. In the secondary areas, 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge. The minimum required obstacle clearance at any given point in the secondary area can be computed by using the formula specified in para 523.b.

(2) Final Approach to Visual Contact Area. The minimum obstacle clearance in the final approach segment to the visual contact area is 500 feet. An inclined plane is used within the final approach area, originating at the facility with at least 1,000 feet of obstacle clearance and descending at 500 feet per nautical mile to 500 feet above the highest obstacle in the centreline zone of the visual contact area. The centreline

zone boundaries shall be 3,000 feet either side of centreline. The minimum obstacle clearance of 500 feet is maintained between the inclined plane and obstacles in the descending portion of the final approach area. If 500 feet of obstacle clearance from the inclined plane cannot be maintained, the point of origin over the facility is raised accordingly. Example: if the inclined plane originating at the facility with 1,000 feet of obstacle clearance clears the governing obstacle by only 400 feet then the point of origin is raised by 100 feet. (See Figure 8-4.)

814. Missed Approach Segment

Criteria for missed approach is not required for Emergency VHF/UHF/DF Cloud Breaking procedures.

815—819. Reserved

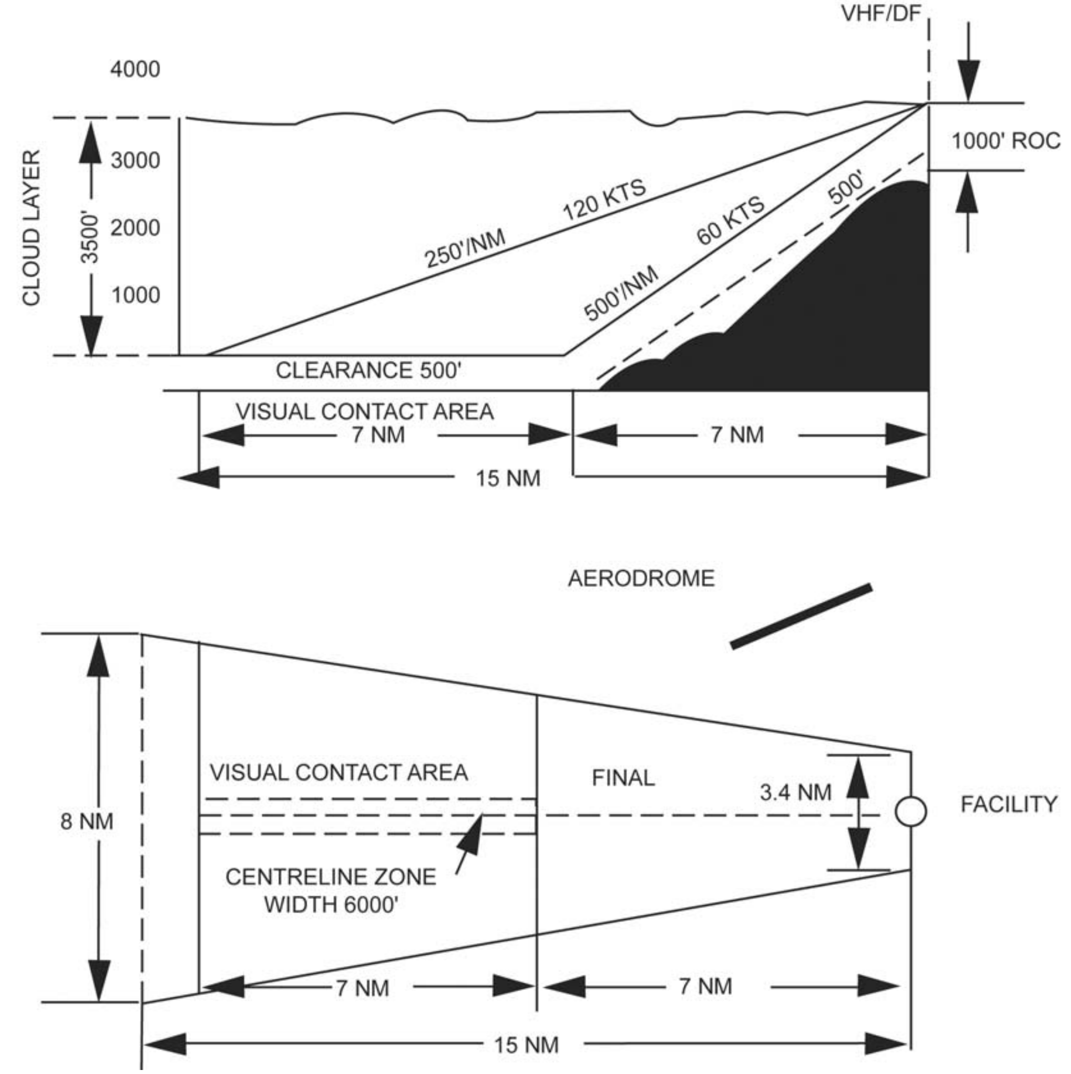


Figure 8-4: Final Approach Segment To Visual Contact Area. Para 813.b.(3) and Para c.(2).

SECTION 2. COMMUNICATIONS

820. Transmission Interval

DF navigation is based on voice transmission of heading and altitude instructions by a ground station to the aircraft. The MAXIMUM interval between transmissions is:

a. En route Operations. 60 seconds.

b. From the Initial Approach Fix to Within an Estimated 30 Seconds of commencement of descent through cloud. 15 seconds.

821—829. Reserved

SECTION 3. MINIMA

830. Approach Minima

No minimum descent altitude (MDA) is given. Prior to final descent the pilot will be informed of the aerodrome elevation. When the outbound type Emergency Cloud-Breaking procedure is used, the pilot will also be informed of the highest elevation of obstacles in the centreline zone of the visual contact area. (See Para 813.c.(2).) The objective is to have the aircraft descend at a constant rate, so as to pass over obstacles in the final approach segment with the required obstacle clearance, until 500 feet above aerodrome elevation is reached. The descent is continued until the aircraft is below cloud.

Note: See the Flight Service Station MANOPS 5-10 and 6-70 for procedure guidelines.

831—899. Reserved

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CHAPTER 9. LOCALIZER

900. Feeder Routes, Initial Approach, And Intermediate Segments.

These criteria are contained in chapter 2, Section 3. When associated with a precision approach procedure, Volume 3, Para 2.3 applies.

901. Use Of Localizer Only.

Where no usable glide slope is available, a localizer-only (front or back course) approach may be approved, provided the approach is made on a localizer from a final approach fix located within 10 miles of the runway threshold. Back course procedures shall not be based on courses that exceed 6 degrees in width and shall not be approved for offset localizers. Back course procedures must be aligned within 3 degrees of the runway alignment.

902. Alignment.

Localizers are normally aligned within 3 degrees of the runway alignment. If the alignment exceeds 3 degrees the alignment shall meet the final approach alignment criteria for VOR on-airport facilities. See Chapter 5, Para 513, and Figure 5–48. Procedures developed utilizing localizers that are offset from the runway centreline up to and including 3° shall have an operational note published identifying the number of degrees of offset. Procedures developed utilizing localizers that are offset more than 3° shall have an operational note published indicating that the procedure is not aligned with the runway.

903. Area.

The final approach dimensions are specified in figure 9-75. However, only that portion of the final approach area that is between the FAF and the runway need be considered as the final approach segment for obstacle clearance purposes. The optimum length of the final approach segment is 5 miles. The MINIMUM length of the final approach segment shall be sufficient to provide adequate distance for an aircraft to make the required descent. The area shall be centered on the FAC and shall commence at the runway threshold. For offset procedures, the final approach area shall commence at the facility and extend to the FAF. The MAP shall not be farther from the FAF than a point adjacent to the landing threshold perpendicular to the FAC. Calculate the width of the area using Vol 3, Chap 3 criteria.

904. Obstacle Clearance.

The minimum ROC in the final approach area is 250 feet in the W and X OCS. In addition, the MDA established for the final approach area shall assure that no obstacles penetrate the 7:1 transitional surfaces (Y OCS).

905. Descent Gradient.

The OPTIMUM gradient in the final approach segment is 318 feet per mile. Where a higher descent gradient is necessary, the MAXIMUM permissible gradient for a straight-in is 400 feet per mile. When maximum straight-in descent gradient is exceeded, then a "circling only" procedure is authorized. When a stepdown fix is incorporated, descent gradient criteria must be met from FAF to SDF and SDF to FEP. See Para 251, 252, and 288a.

Figure 9-1 TO 9-74: Reserved

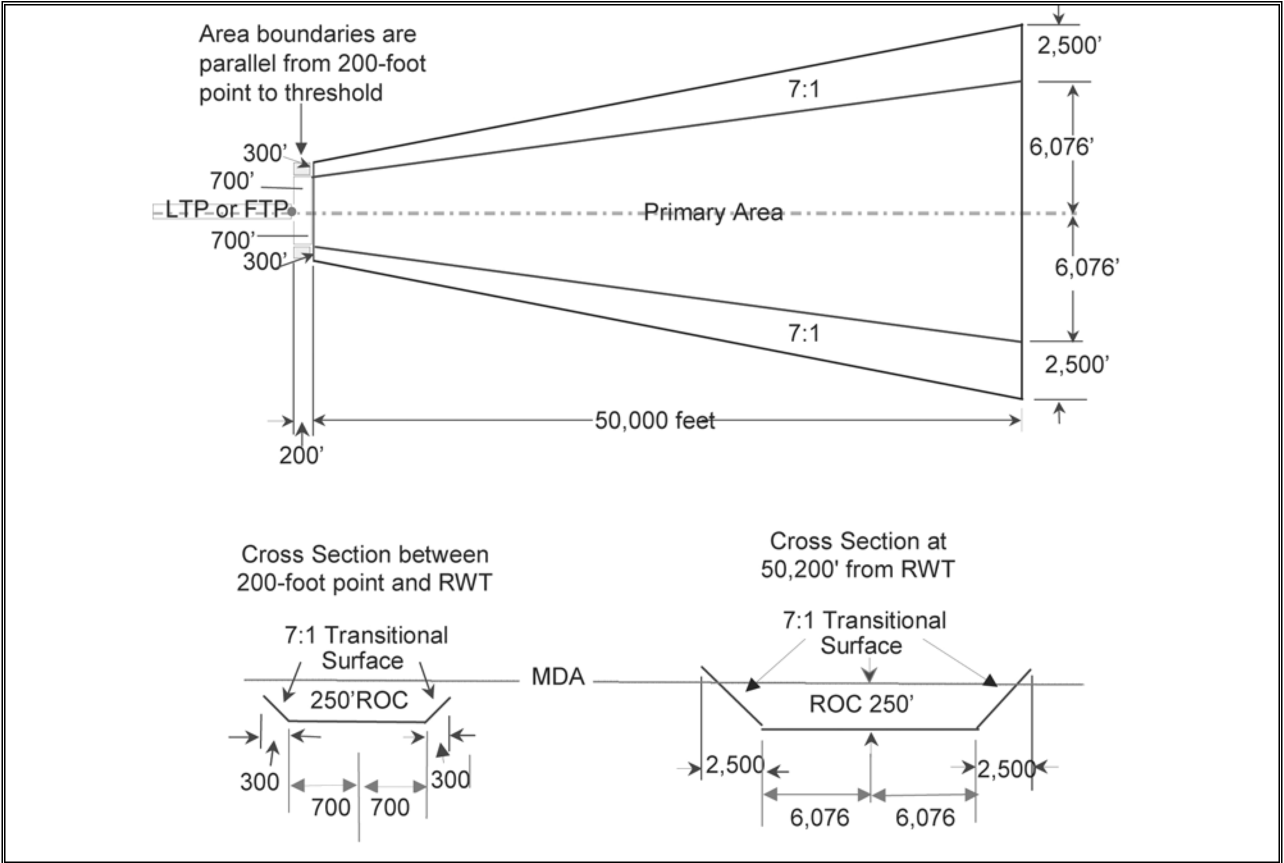

Figure 9-75: Localizer Final Trapezoid. Para 903.

906. MDA.

The lowest altitude on final approach is specified as an MDA. The MDA adjustments specified in para 232 shall be considered.

907. Missed Approach Segment.

The criteria for the missed approach segment are contained in chapter 2, section 7. The MAP is on the FAC not farther from the FAF than the runway threshold (first usable portion of the landing area for circling approach). The missed approach surface shall commence over the MAP at the required height (see para 274).

908—999. Reserved

CHAPTER 10. RADAR APPROACH PROCEDURES AND VECTORING CHARTS

SECTION 1. GENERAL INFORMATION

10.0. GENERAL

This chapter applies to radar approach procedures utilizing ground-based radar.

10.0.1 Precision Approach Radar (PAR)

Precision Approach Radar is a system that graphically displays lateral course, glidepath, and distance from touchdown information of sufficient accuracy, continuity, and integrity to provide precision approach capability to a runway/landing area.

10.0.2 Surveillance Radar

Surveillance Radar is a system that displays direction and distance information with suitable accuracy, continuity, and integrity to safely provide radar vectoring capability for departures, arrivals, and en route operations.

10.0.3 Inoperative Components

Failure of azimuth and range information renders the entire PAR inoperative. When the glide slope feature becomes inoperative, the PAR reverts to a non-precision approach system. In such a case, obstacle clearance shall be as specified in Vol. 1, Chapter 9 for localizer approaches.

10.0.4 Lost Communications Procedures

The PAR procedure shall include instructions for the pilot to follow in the event of a loss of communications with the radar controller.

10.0.5 Minimum Vectoring Altitude Charts

See Annex B. Whenever it is necessary to deviate from established radar patterns, obstacle clearance prescribed in paragraph 10.1.1.a for diverse vectors shall be provided by approved minimum vectoring altitude charts (MVAC's) which depict all controlling obstacle(s) within the maximum range capability of the primary radar system. The chart is based upon the minimum clearance criteria and the maximum radar system range capability. Minimum vectoring altitude charts do not require flight inspection certification.

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SECTION 2. RADAR APPROACHES

10.1 RADAR APPROACHES

PAR procedures may be established where coverage and alignment tolerances are met.

10.1.1 Feeder Routes and Initial Approach Segments

Feeder and initial segments do not need to be established when navigation guidance and obstacle clearance are provided by Air Traffic Control radar vectors, during the transition from the enroute to the terminal phase of flight.

a. **Feeder/Initial Segments based on Routes.** When operationally required, establish feeder routes and/or initial segments based on conventional navigation, Area Navigation (RNAV), or radar routes.

(1) **Conventional/RNAV Feeder/Initial**. Develop in accordance with TP308/GPH209 Volume 1, chapter 2, section 2 and 3 or Volume 6 DOC 7 when Area Navigation (RNAV) is used.

(2) **Radar Feeder/Initial**. The route/segment begins at an established fix that permits positive radar identification and ends at the appropriate termination fix for the segment. Display the course centerline on a radar video map display.

(a) **Alignment**. Design feeder/initial and initial/initial segment intersections with the smallest amount of course change necessary for the procedure. The maximum allowable course change between segments is 90 degrees.

(b) **Area**. The Obstacle Evaluation Area (OEA) begins at the applicable radar fix displacement prior to the route/segment start fix and extends to the segment termination fix. Primary area half-width is equal to the minimum lateral clearance applicable to the radar adaptation (e.g. 3 NM if the aircraft is less than 40 NM from the antenna). There is no secondary area. The primary area has no specified maximum or minimum length; however, the segment must be long enough to permit the required altitude loss without exceeding the maximum authorized descent gradient.

Note: When the minimum lateral clearance changes within a segment (e.g. 5 NM to 3 NM), the OEA half-width also changes without the need to “splay” or “taper”.

(c) **Obstacle Clearance**. Apply the Volume 1, chapter 2 standard applicable to the segment. Volume 1, chapter 3 precipitous terrain adjustments apply.

(d) **Descent Angle**. Apply Volume 1, chapter 2 standard applicable to the segment.

(e) **Altitude Selection**. Apply Volume 1, chapter 2 standard applicable to the segment. Do not publish fix altitudes higher than the minimum required for obstacle clearance or airspace to achieve an "optimum" descent gradient.

10.1.2 Intermediate Approach Segment.

Establish an intermediate segment when necessary (e.g., ATC radar vectors not available or MVA too high to support desired FAF/PFAF altitude). The intermediate segment begins at the intermediate fix and extends to the PFAF. When there is a preceding conventional / RNAV route segment, the applicable conventional/RNAV intermediate segment standards apply, except as specified in paragraph 10.1.2b(2).

a. **Alignment**. The intermediate course is an extension of the final approach course (no course change permitted at the PFAF).

b. **Area**.

(1) **Radar Intermediate**. When radar is used for course guidance (route or vector), the OEA begins at the applicable radar fix displacement prior to the Intermediate Fix (IF) and extends to the PFAF. Primary area half-width is equal to the minimum lateral clearance applicable to the radar adaptation (e.g. 3 NM if the A/C is less than 40 NM from the antenna and 5 NM if the A/C is 40 NM or more from the antenna) until reaching a point 2 NM prior to the PFAF, then tapers to the width of the PAR Final Approach segment (FAS) primary OEA when abeam the PFAF. There are no intermediate secondary areas. See figure 10-1.

Note: When the minimum lateral clearance changes within a segment (e.g. 5 NM to 3 NM), the OEA half-width also changes without the need to "splay" or "taper".

(2) **Non-Radar Intermediate**. When conventional/RNAV navigation is used for course guidance, apply the intermediate OEA criteria from the applicable TP308/GPH209 volume with the following exceptions:

(a) **Connection to PAR Final**. Connect the outer edges of the intermediate primary area abeam the IF to the outer edges precision "X" Obstacle Clearance Surface (OCS) and the intermediate secondary area to the precision "Y" OCS abeam the PFAF.

(3) **Length**. The intermediate segment length is normally 6 NM. The MINIMUM length varies based on course guidance but must always accommodate the required altitude loss. The maximum length is 15 NM.

(a) For conventional/RNAV and radar route course guidance, apply Volume 1, chapter 2 for ASR approaches and Volume 3, chapter 2 for PAR approaches. Radar intermediate segments may not be less than 2 NM.

c. **Obstacle Clearance**. Apply 500 ft ROC over the highest obstacle in the area. Volume 1, chapter 3 precipitous terrain and RASS adjustments apply. For conventional/RNAV course guidance, apply secondary area ROC criteria from the applicable TP308/GPH209 Volume.

d. **Descent gradient**. Apply Volume 1, Chapter 2.

10.1.3 PAR Final Approach Segment (FAS).

a. **Inoperative/unused Components**. Failure of the azimuth component renders the entire PAR system inoperative. When the glide slope feature becomes inoperative, the PAR reverts to a non-precision approach system. In this case, obstacle clearance shall be as specified in Vol. 1, Chapter 9 for localizer approaches.

The missed approach instructions are the same, and the radar missed approach point is identifiable on the PAR scope. NPA minimums are established according to TP308/GPH209, Volume 1, Chapter 3, section 3 and are documented as applicable.

b. **General**. Apply the current basic vertically guided final segment general criteria applicable to Instrument Landing System (ILS) for Glidepath Angle (GPA), Threshold Crossing Height (TCH), Precise Final Approach Fix (PFAF), Glidepath Qualification Surface (GQS), and Precision Obstacle Free Zone (POFZ).

(1) Use the highest applicable MVA to determine the PFAF distance to LTP/coordinates when there is no preceding segment.

(2) ILS Height Above Touchdown/Threshold (HAT/HATh) and Decision Altitude (DA) standards apply (to include Volume 1, chapter 3 adjustments), except the minimum HAT/HATh may be 100 ft for helicopter approaches when the OCS is clear.

Note: Adjusting TCH to reduce/eliminate OCS penetrations is not applicable to PAR FAS evaluations.

c. **Obstacle Evaluation Area (OEA)/Obstacle Clearance Surface (OCS)**. Apply current ILS FAS criteria for alignment, OCS slope, width, height, and OEA/OCS evaluation except the OEA extends to the PFAF (no radar fix tolerance applied). Also, where the PFAF must be located more than 50200 ft from the RWT coordinates, the OEA continues to splay to the PFAF or until reaching the minimum lateral clearance applicable to the radar adaptation.

10.1.4 Missed Approach Segment (MAS).

a. **PAR**. Apply the Volume 3 Category (CAT) I ILS missed approach criteria to approaches with HAT/HATh values greater than or equal to 200 ft. Apply CAT II missed approach criteria for approaches with HAT/HATh values lower than 200 ft.

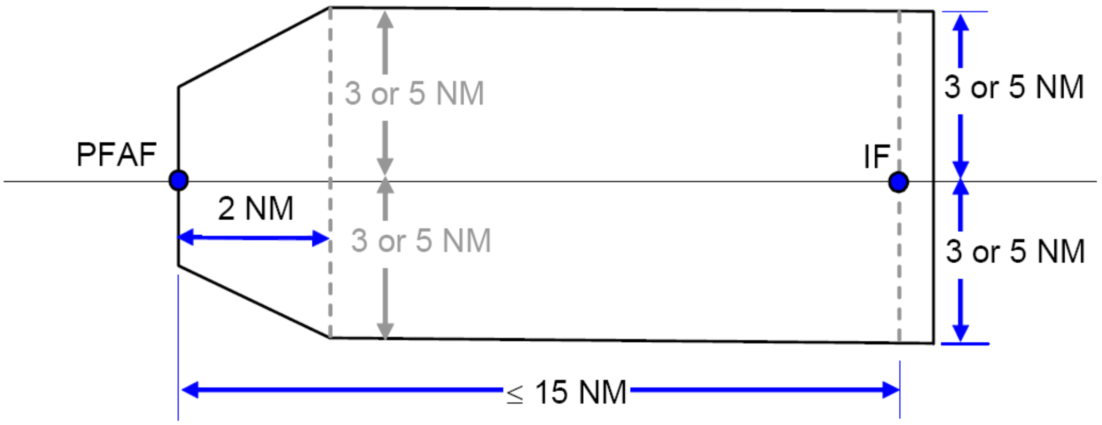

Figure 10-1: Intermediate Segment Area

CHAPTER 11. RESERVED

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CHAPTER 12. DEPARTURE PROCEDURES

1200. General

These criteria specify the obstacle clearance requirements to be applied to diverse departures and departure routes. Obstacle identification surfaces (OIS) of 40:1 are used. A climb gradient of 200 feet per NM will provide at least 48 feet per NM of clearance above objects, which do not penetrate the OIS. Objects which penetrate the OIS are obstacles and shall be considered in the departure procedure by specifying a flight path which will safely avoid the obstacle(s) or by specifying a climb gradient greater than 200 feet per NM that will provide 48 feet (24%) of required obstacle clearance (ROC) for each NM of the flight path. Take-off visibility minima (SPEC VIS) and a "climb visual to" altitude shall be established for those departures specifying a climb gradient.

1201. Application

Diverse departure criteria (Para 1202) shall be applied to all runways authorized by the approving authority for instrument departures. Application of diverse departure criteria may result in the need to develop specific departure routes to avoid obstacles (Para 1203).

1202. Diverse Departures

At many airports, a prescribed departure route is not required for ATC purposes nor as the only suitable route to avoid obstacles. In spite of this, there may be obstacles in the vicinity of the airport that should be considered in determining that restrictions to departures are to be prescribed in a given section(s). The areas and surfaces described herein are to be used to identify such obstacles. Sectors shall be described by bearings and distance from the airport reference point which diverge at least 15° either side of the controlling obstacle. Departure restrictions shall be published as described in Para 1207.a.

a. Zone 1.

   (1) Area. The area begins at the departure end of the runway (DER) and has a beginning width of 1,000 feet (+500 feet from centreline). The area splays 15° on each side of the extended runway centreline for a distance of 2 NM from the DER (see Figure 12–116A).

   (2) Obstacle Identification Surface. A 40:1 OIS overlies Zone 1. It begins at the DER, at the DER altitude and rises in the direction of departure. Obstacle distance measurements shall be made by projecting a line from the obstacle to intersect the extended runway centreline at 90°. The distance from this intersect point to the DER shall be considered the obstacle distance.

b. Zone 2.

   (1) Area. Zone 2 extends radially from a point on the runway centreline located 2,000 feet from the start end of the runway. It is centred on the extended take-off surface centreline and excludes Zone 1. It extends the distance necessary for the 40:1 OIS to reach the minimum altitude authorized for en-route operations (see Figure 12–116B).

   (2) Obstacle Identification Surface. A 40:1 OIS overlies Zone 2 and has a beginning height equal to the height of the OIS at the end of Zone 1. Distance measurements to an obstacle shall be made from the runway edge or edge of Zone 1, whichever in the shorter distance.

c. Zone 3.

(1) Area. Zone 3 covers the area in the direction opposite to the take-off beginning 2,000 feet from the start end of the runway. It provides clearance for 180° turn departures and extends the distance necessary for the 40:1 OIS to reach the minimum altitude authorized for en-route operations (see Figure 12–116C).

(2) Obstacle Identification Surface. A 40:1 OIS overlies Zone 3 and begins 400 feet above airport elevation along the runway edge and rises there from.

Figure 12-1 TO 12-116: Reserved

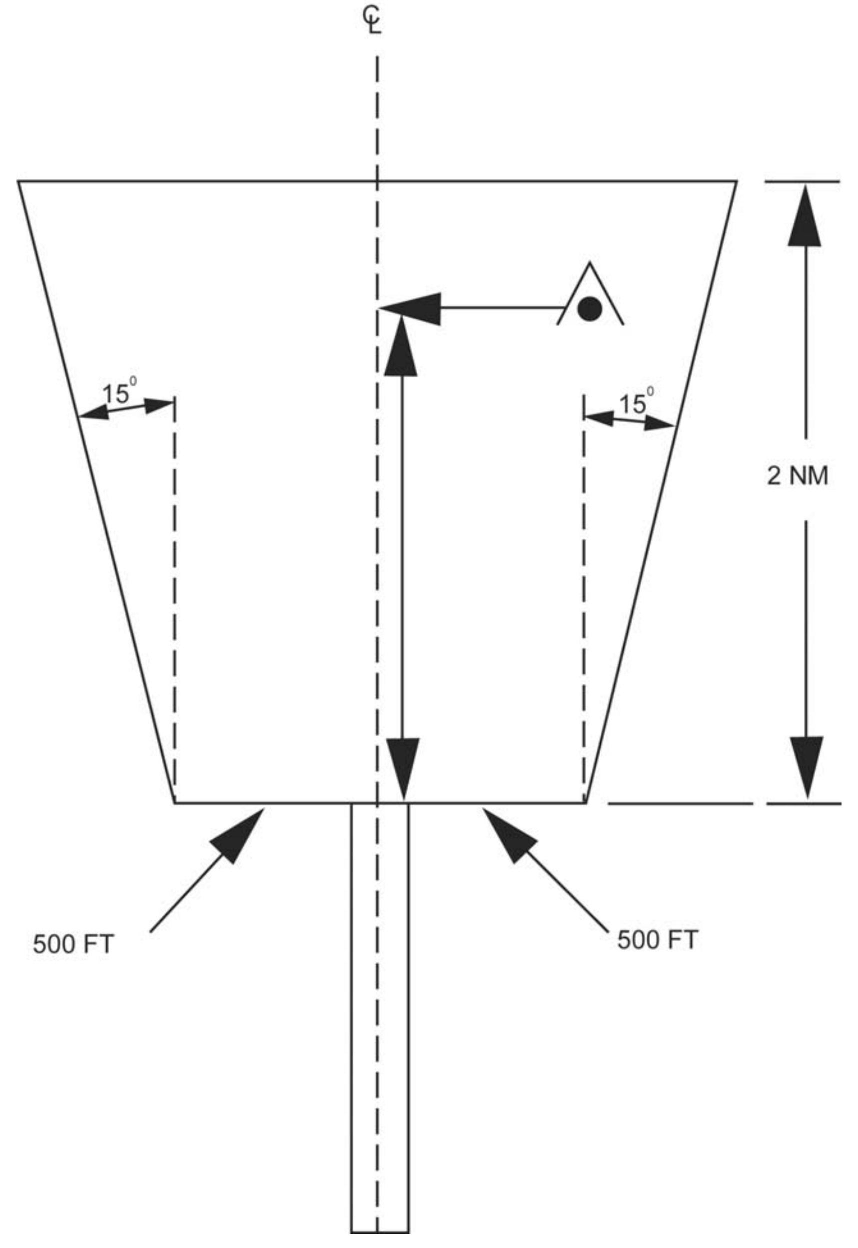


Figure 12-116A: Zone 1 Diverse Departure. Para 1202.a.

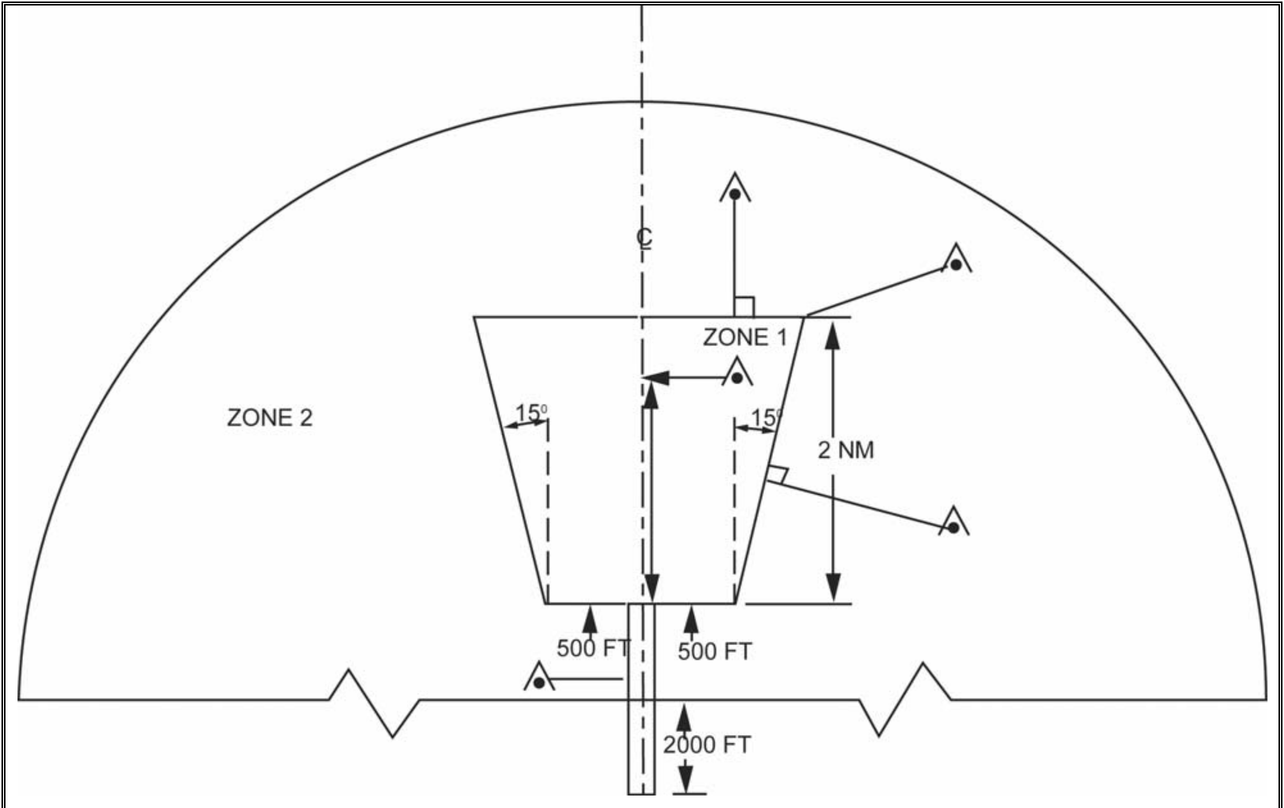


Figure 12-116B: Zone 2 Diverse Departure. Para 1202.b.

Table 12-1 TO 12-30: Reserved

Turn Altitude (feet MSL)	Flight Track Radius (R_1) (nm)		Outer Boundary Radius (R) (nm)	
	CAT A & B	Others	CAT A & B	Others
S.L. to 1,000	1.0	2.5	2.0	5.5
1,001 to 3,500	1.2	2.7	2.4	5.9
3,501 to 6,000	1.3	2.9	2.6	6.3
6,001 to 8,500	1.4	3.1	2.8	6.7
Above 8,501	1.6	3.4	3.2	7.3

Note: These turn radii will accommodate speeds up to 350 KIAS with 30° angle of bank. Outer boundary radius may be reduced ½ nm operational advantage. Procedure must be annotated with airspeed restriction 250 KIAS.

Table 12-31: Departure Turn Radii. Para 1203.a.(1) (b), 1203.b.(1)(b), and 1203.c.(1)(b).

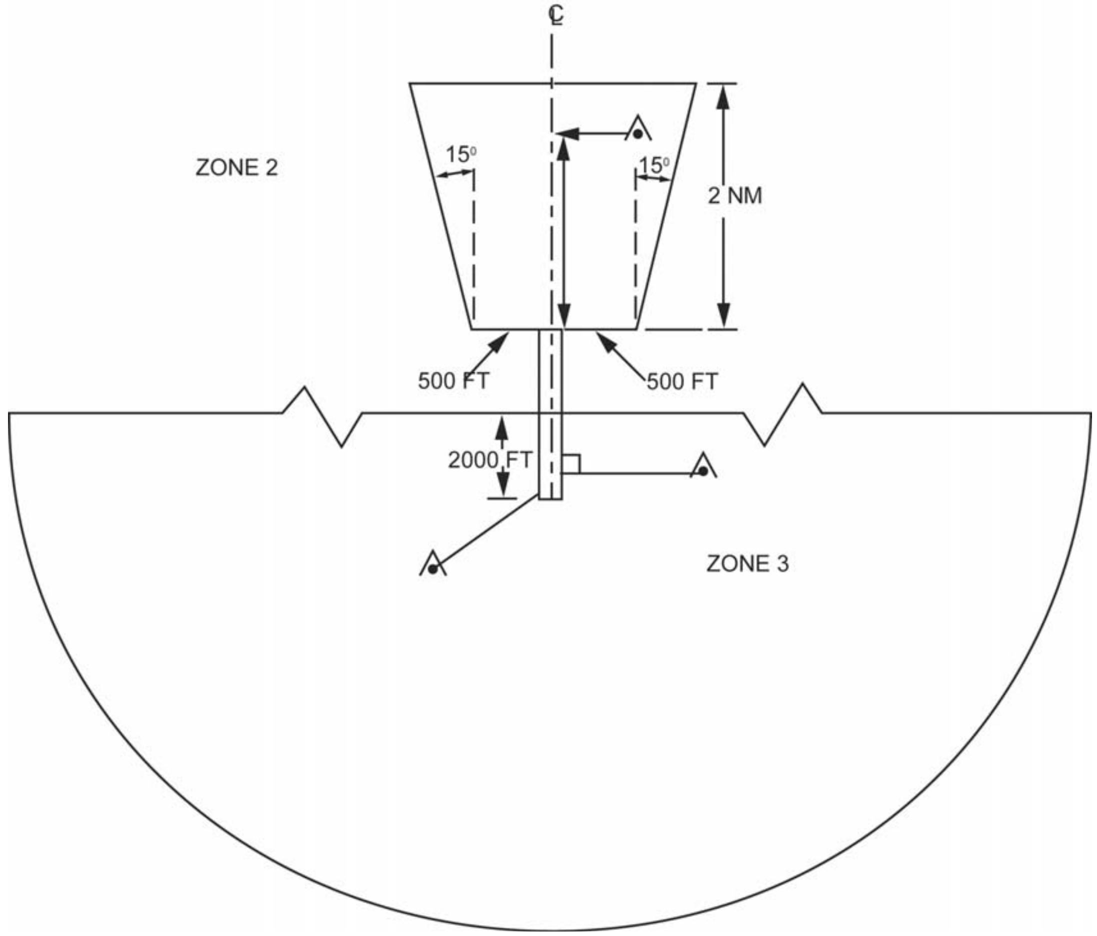


Figure 12-116C: Zone 3 Diverse Departure. Para 1202.c.

1203. Departure Routes

There are three basic types of departure routes: straight, turning, and combination straight and turning. Departure routes shall be based on positive course guidance acquired within 10 NM from the DER on straight departures and within 5 NM after completion of turns on departures requiring turns. Surveillance radar, when available, may be used to provide positive course guidance.

a. Straight Departures. A straight departure is one in which the initial departure course is within 15° of the alignment of the take-off surface. Additionally, the departure course must intersect the runway centreline extended within 2 NM from the DER or the departure course must lie within 500 feet laterally of the runway centreline at the DER (see Figures 12–116D to 12–116H). When the initial departure course is to a facility, a manoeuvring segment is provided under the provisions of Para 1203.a.(1)(b).

(1) Area. The area begins at the departure end of the runway. It is based on the departure course and has a minimum beginning width of 1,000 feet (+500 feet from centreline). The edge of the area shall be no less than 500 feet from the centreline of the runway and the departure course. For example, if the departure course lies 500 feet from the centreline, the beginning width of the area shall be no less than 1,500 feet (see Figure 12–116G). The area splays 15° on each side of the departure course and/or runway centreline extended (whichever protects the greater area) to the point where the boundaries intercept the area associated with the navaid providing course guidance.

(a) When course guidance is provided by a localizer, the area specified in Para 1202.a.(1) shall be used for the first 2 NM of the departure. This area shall be joined to the localizer final approach area stated in Para 903 by lines drawn from the extremities of the area at 2 NM from the departure threshold to the width of the localizer area at 10 NM (see Figure 12–116H). (At certain airports, localizers, although installed, may not be available for use as a departure navaid.)

(b) The area associated with the navaid (other than a localizer) providing course guidance shall have the following dimensions. It shall be 3 NM (±1.5 NM) wide at the facility, it shall have a minimum length of 10 NM and shall splay to a width of 5 NM (±2.5 NM), 6 NM (±3.0 NM) for NDB, at 10 NM from the facility. If additional distance is required, the area may be joined from its extremities to the primary en-route area using 4.5°, 5° for NDB, or splay until primary en-route width is reached.

(i) If a turn of 15° or less is required over the facility, the inbound and outbound areas outer boundaries shall be joined by an arc of 1.5 NM radius.

(ii) If a turn of more than 15° but less than 30° is required over the facility, the turning departure area outer boundary radius (Table 12–31) shall be applied to join the two areas. The outbound area outer boundary shall be applied to join the two areas. The outbound area outer boundary shall be constructed by a line tangent to the arc and drawn to the edge of the outbound area at 10 NM from the facility (see Figure 12–116I).

(iii) If a turn of 30° or more is required over the facility, the area shall be extended a distance of 1 NM beyond the facility aligned with the inbound track at a width of 3 NM (±1.5 NM) and the turning departure area outer boundary radius (Table 12–31) shall be applied to join the extension to the area associated with the outbound track. The outbound area outer boundary shall be constructed by a line tangent to the arc and drawn to the edge of the outbound area at 10 NM from the facility (see Figure 12–116J).

(2) Obstacle Identification Surface. A 40:1 OIS overlies the straight departure area and rises in the direction of departure. The OIS begins at the DER, at the DER elevation.

b. Turning Departures. If the initial departure course does not meet the criteria specified in Para 1203.a, a turning departure shall be constructed. A turning departure is one in which the aircraft climbs straight ahead on the heading of the take-off surface until reaching 400 feet above the airport elevation (within 2 NM) and then immediately begins a turn to intercept a departure course. Positive course guidance is required within 5 NM after completion of the turn (see Figure 12–116K).

(1) Area. The turning departure area is divided into Sections 1 and 2.

(a) Section 1 is identical to the 15° splay area specified in Para 1203.a.(1). It terminates 2 NM from the beginning of the 15° splay area.

(b) Section 2 starts at the end of Section 1. The flight track and outer boundary radii shall be determined from Table 12–31. The outer boundary line shall splay 15° from the departure course beginning at the point abeam the point where the turn is completed. The inner boundary line shall begin at the runway edge 2,000 feet from the start end of the take-off surface on the side in the direction of the turn (Point D). It terminates at the same distance abeam the departure course as the outer boundary does at the end of the departure. The splay of Section 2 terminates when the width reaches that of the primary en-route structure. Thereafter, en-route criteria apply.

(2) Obstacle Identification Surface

(a) Section 1. A 40:1 OIS overlies Section 1 and is identical to the 40:1 specified in Para 1203.a.(2).

(b) Section 2. The dividing line between Sections 1 and 2 are identified as "AB, BC, CD". A 40:1 OIS overlies Section 2 and has an initial height equal to the terminating height of Section 1 at any point along the dividing line and rises in the direction of the departure course. The height of the OIS at any point in Section 2 is determined by measuring the straight line distance from this point to the nearest point on the "AB, BC, CD" dividing line.

c. Combination Straight and Turning Departure. If a straight climb to a height, which is more than 400 feet above the elevation of the DER is necessary prior to beginning the departure turn, a combination straight and turning departure area must be applied. Whenever possible, the point at which the turn commences shall be identified by a fix or by the intersection of the initial dead reckoning departure course with a radial or bearing which provides positive course guidance. When a fix, radial or bearing is not available, the turn may be specified to commence at an altitude based on a climb gradient of 200 feet per NM. For example, a turn 1,000 feet above DER elevation shall be assumed to commence 5 NM from the end of the runway. Positive course guidance is required within 5 NM after completion of the turn.

  (1) Area. The combination straight and turning departure is divided into Sections 1 and 2 (see Figure 12–116L).

    (a) Section 1 is identical to the straight departure area except that it extends to the point at which the turn begins.

    (b) Section 2 starts at the end of Section 1. The flight track and outer boundary radii shall be determined from Table 12–31. The outer boundary radius shall be drawn beginning a distance past the plotted position of the turning point equal to the fix error, along track accuracy, or abeam plotted position; whichever is further from the end of the departure runway. The inner boundary line shall begin at the edge of the 15° splay area at a distance prior to the plotted position of the turning point equal to the fix error or along track accuracy plot plus 1 NM. Where the turn is specified to commence at an altitude, the outer boundary radius begins at the end of Section 1, and the inner boundary line begins at the edge of the 15° splay area abeam the DER. The outer boundary line shall splay 15° from the departure course beginning at the point abeam the point where the turn is completed. The inner boundary line is drawn from the point of beginning to a point which is the same distance abeam the departure course as the outer boundary is at the end of the departure.

    (c) Where a turn is required to intercept a radial/bearing to proceed to or from a facility, alternate area construction is necessary (see Figure 12–116M). The appropriate flight track radius will join the radial/bearing and the runway centreline extended. The arc will be drawn from a point on the bisector of the angle between the runway centreline extended and the plotted position of the radial/bearing. Section 1 ends at the point of tangency of the extended centreline and the arc. The inner boundary begins at the near edge of Section 1 at a point 1 NM prior to the end of that section. The outer boundary begins at the intersection of the extended 15° splay line of Section 1 and the plotted position of the radial/bearing. The splay of Section 2 terminates when the width reaches that of the primary en-route structure. Thereafter, en-route width criteria apply.

  (2) Obstacle Identification Surface.

    (a) Section 1. A 40:1 OIS overlies the straight departure area. It begins at the DER, at the DER elevation, and rises in the direction of departure.

    (b) Section 2. The dividing lines between Sections 1 and 2 are identified as "AB, BC". A 40:1 OIS overlies Section 2. It has the same height as the Section 1 OIS at the dividing line AB and rises in the direction of the departure course.

1204. Reserved

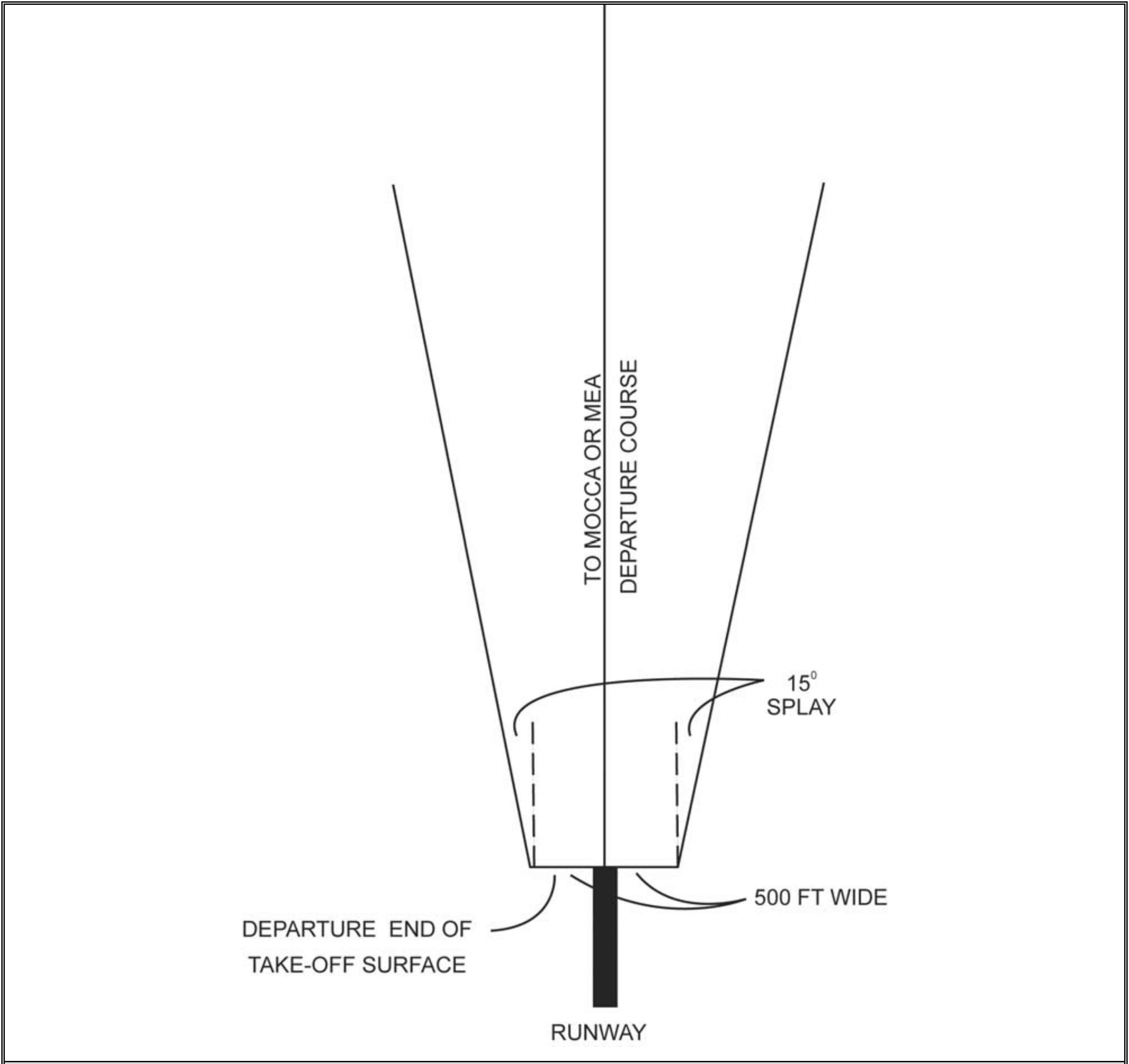


Figure 12-116D: Straight Departure Area Without Course Guidance. Para 1203.

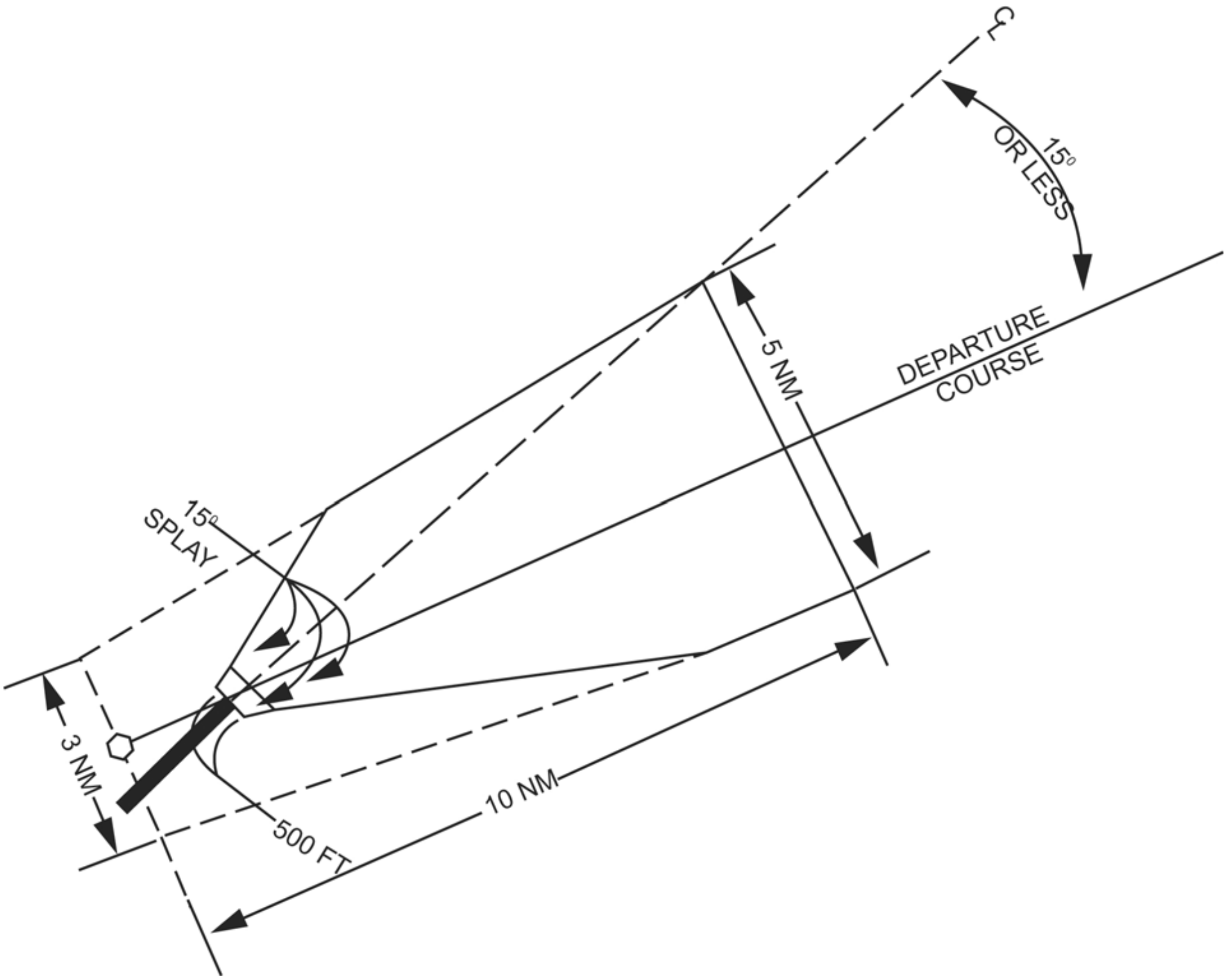


Figure 12-116E: Straight Departure With Course Guidance From On Aerodrome Facility. Para 1203.

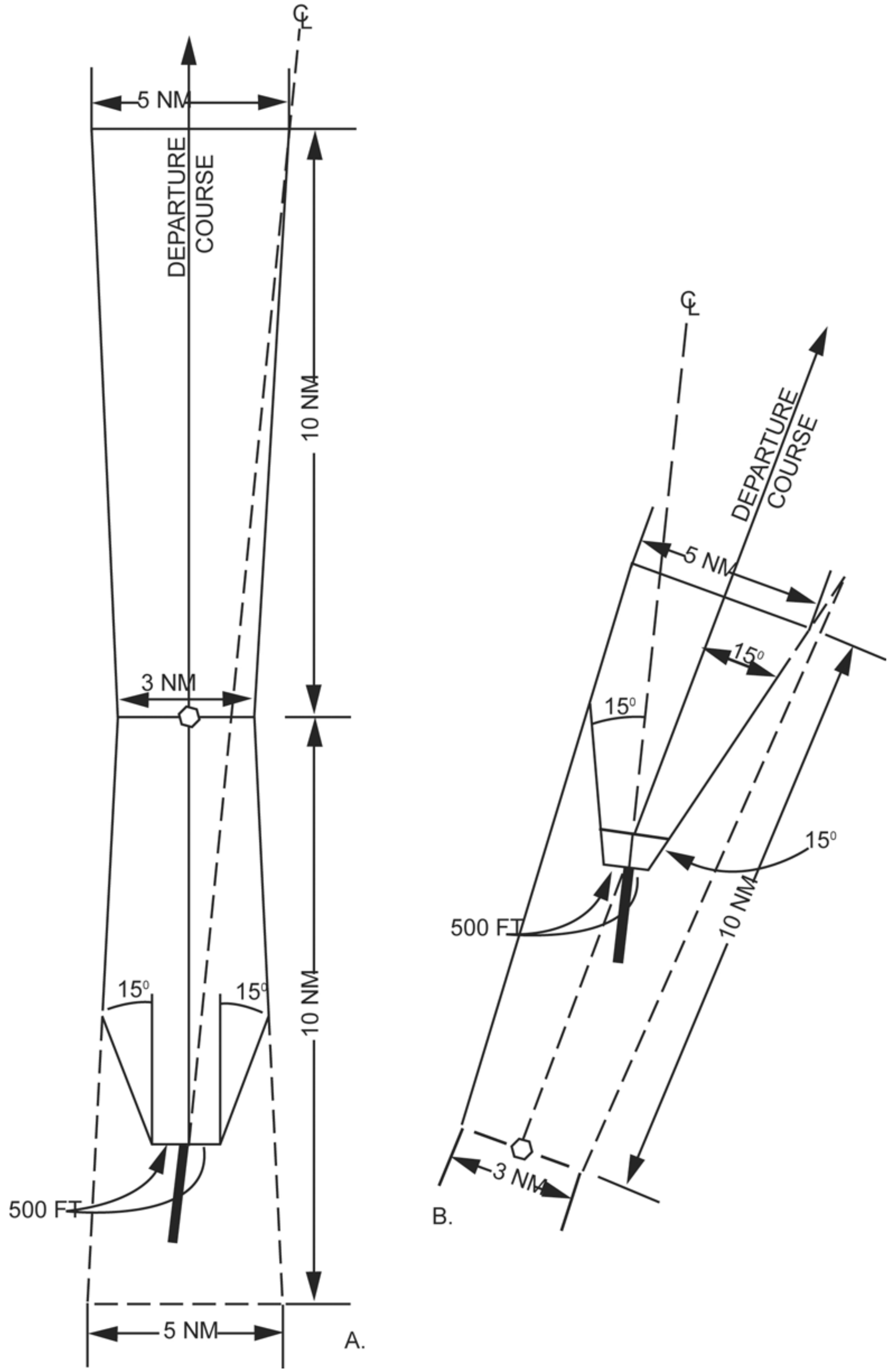


Figure 12-116F: Straight Departure With Course Guidance From Off Aerodrome Facility. Para 1203.

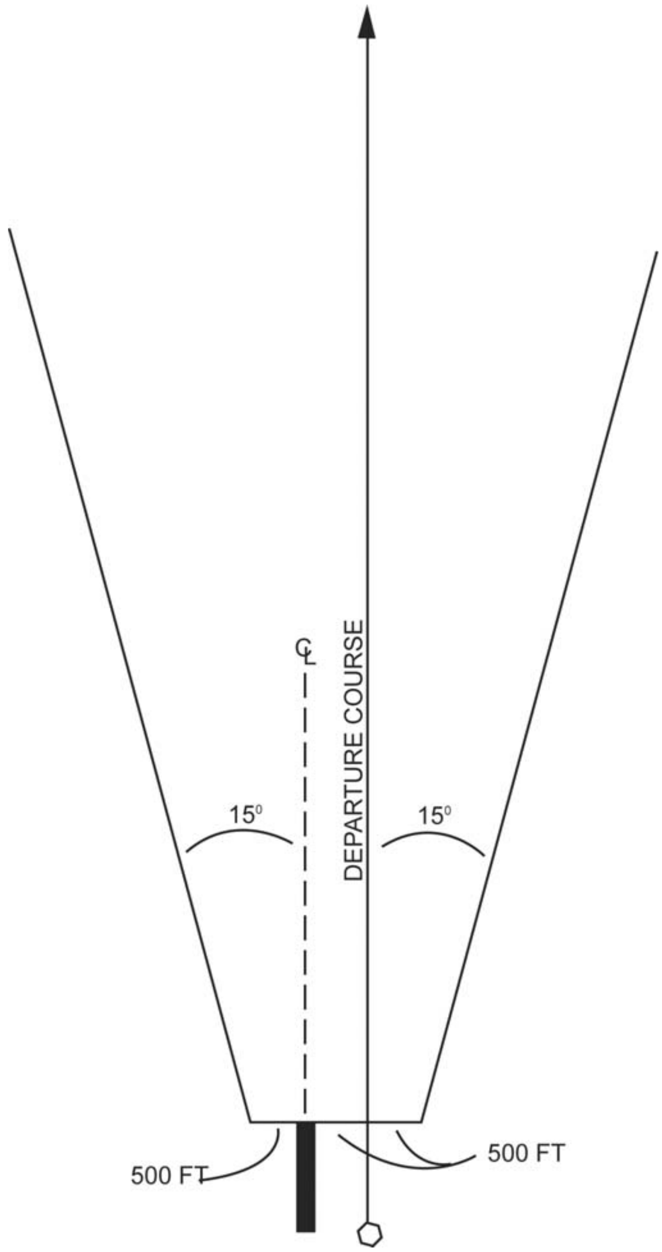
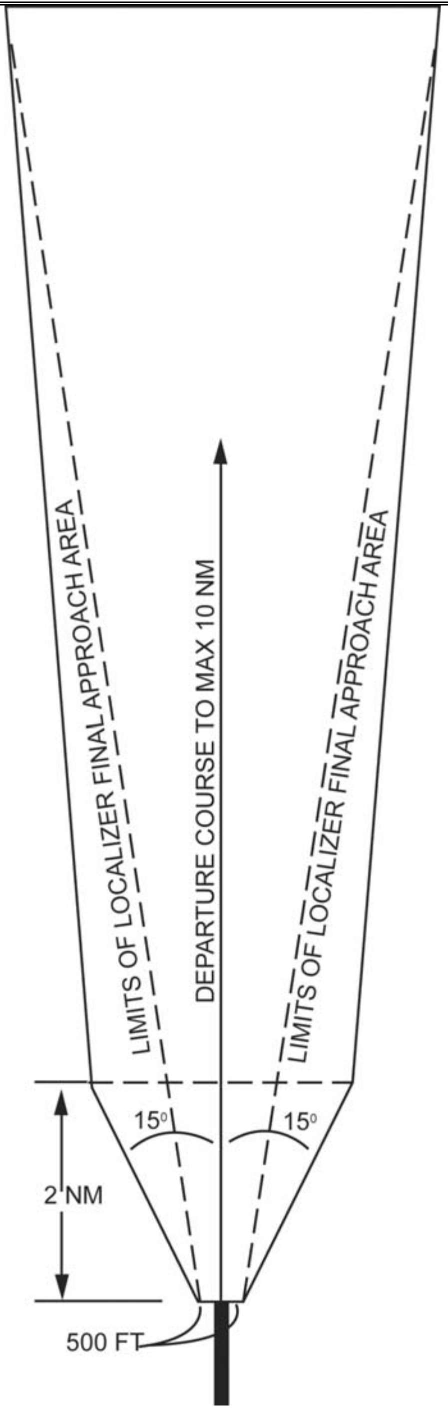
 	

Figure 12-116G: Straight Departure With Offset Departure Course. Para 1203.	**Figure 12-116H: Departure Area When Localizer Is Used For Course Guidance. Para 1203.**

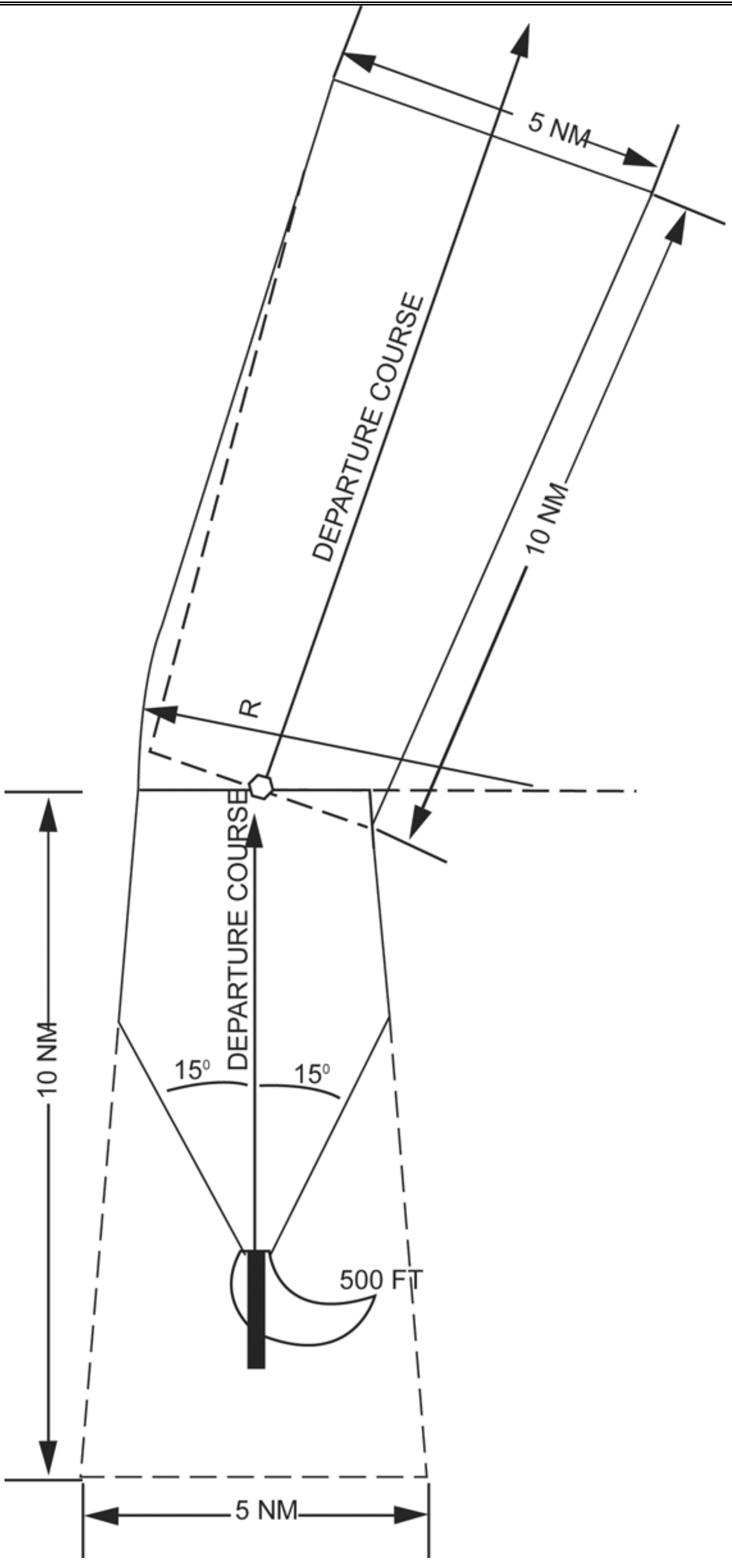


Figure 12-116I: Turn of More Than 15° But Less Than 30° Over Facility. Para 1203.a.

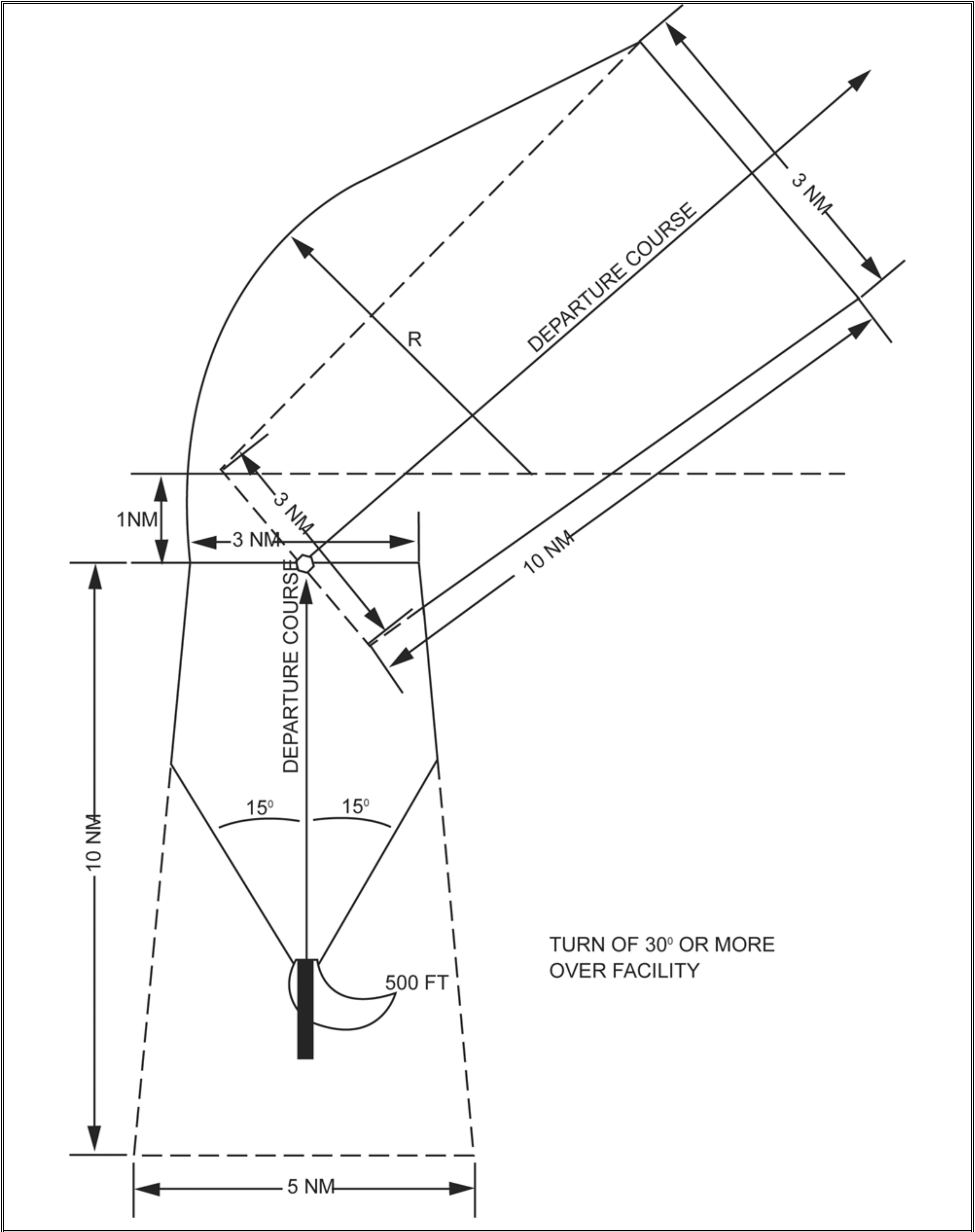


Figure 12-116J: Turn Of 30° Or More Over Facility. Para 1203.a. (1).

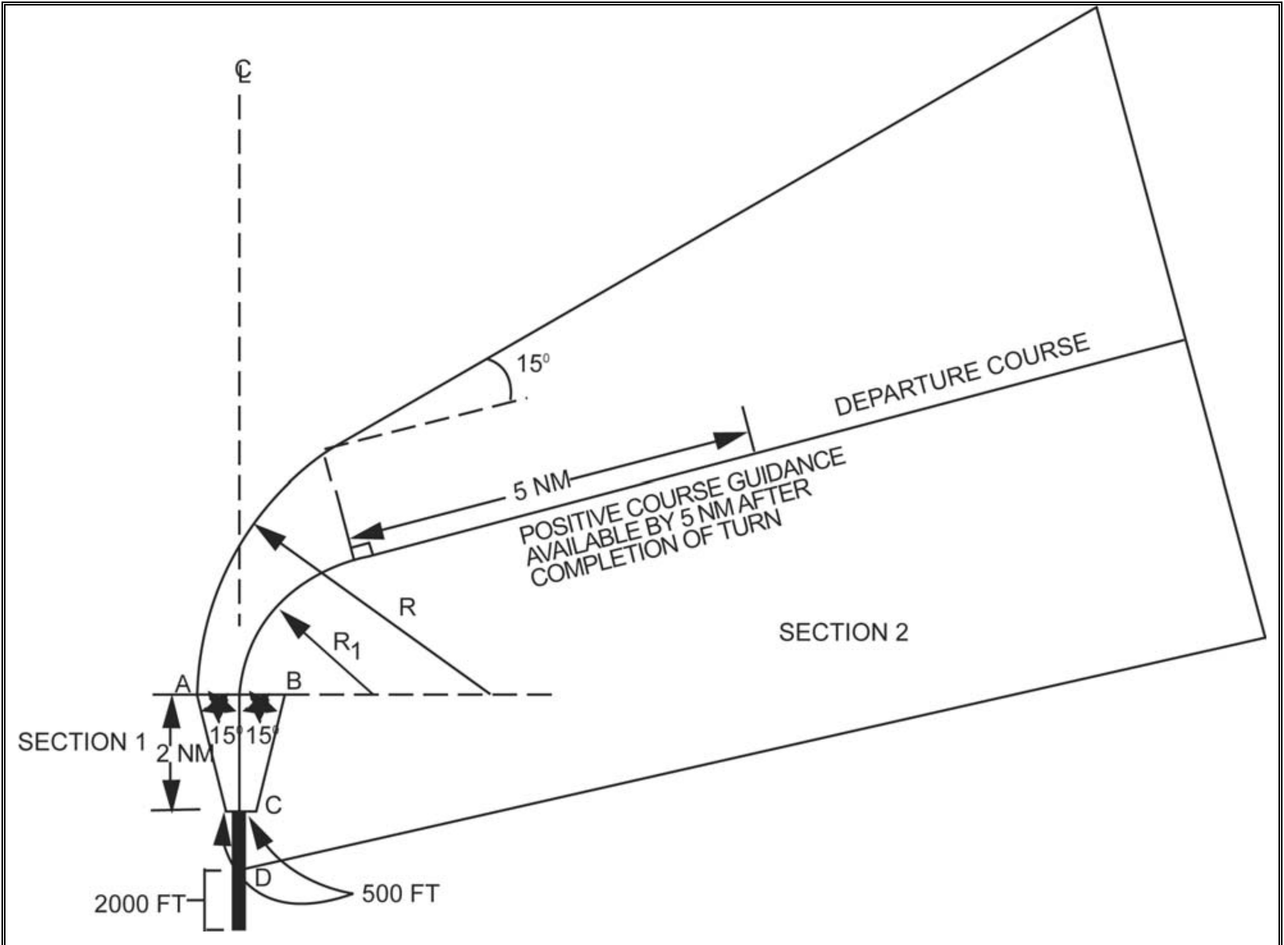


Figure 12-116K: Turning Departure. Para 1203.b.

1205. Climb Gradients

Climb gradients shall include 48 feet per NM (24%) required obstacle clearance. When precipitous terrain is a factor, consideration shall be given to increasing the obstacle clearance (see Para 323.a). Gradients shall be specified to an altitude or fix at which a gradient of more than 200 feet per NM is no longer required.

a. Diverse Departures. In cases where departure routes are not required to avoid obstacles, but obstacles exist in a sector(s) such as a mountain range, the required gradient shall be computed from the origin of the Zone 2 or 3 OIS (as applicable) direct to the obstacle. The altitude to which the climb gradient must be maintained is based on the obstacle plus ROC requiring the highest altitude in that sector.

b. Departure Routes. Climb gradients shall be computed from the elevation of the OIS at the DER along the shortest possible flight path within the obstacle clearance area to the obstacle.

c. Climb gradients to 200 feet above DER elevation or less shall not be specified. These gradients would normally be caused by low, close-in obstacles. A note shall be published stating that the obstacle(s) exist and should be considered by the pilot.

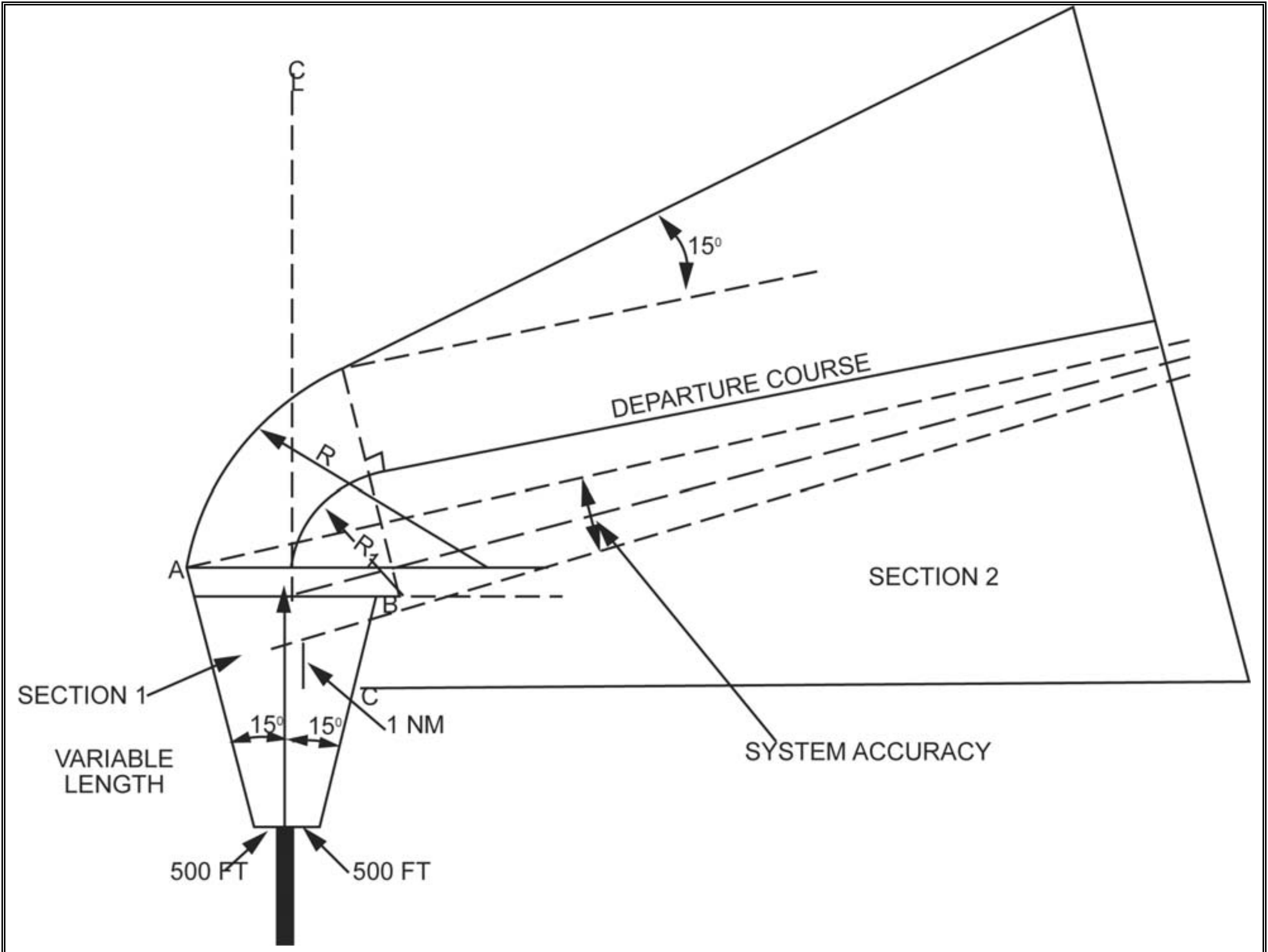


Figure 12-116L: Combination Straight And Turning Departure. Para 1203.c.

1206. End Of Departure

The departure area terminates at a point where the 40:1 OIS, measured along the flight track, reaches the minimum altitude authorized for en-route operations or radar vectoring, whichever is applicable. Where a climb in hold is required to achieve enroute operations, is shall be assessed in accordance with Chapter 18, Holding Criteria. The departure instructions shall specify a climb in hold altitude that is equivalent to an enroute altitude; or the instructions shall specify a climb in hold altitude that will ensure that after leaving the hold and proceeding on course, the 40:1 OIS will be clear until achieving the enroute ROC.

1207. Published Information

The minimum information to be published for departure procedures is specified as follows:

a. Diverse Departures. Departure restrictions shall be expressed as sectors to be avoided or sectors in which climb gradients and/or minimum altitudes are specified to enable an aircraft to safely overfly an obstacle. When more than one sector is involved, the climb gradient selected shall be the highest in any sector that may be expected to be overflown. The altitude to which the gradient is specified must permit the aircraft to continue at 200 feet per NM minimum through that sector, a succeeding sector, or to an en-route altitude. A fix may also be designated to mark the point at which a climb gradient in excess of 200 feet per NM is no longer required.

b. Departure Routes. A departure route must specify all courses, points, fixes, and altitudes required in the procedure. When obstacles must be overflown, minimum crossing altitudes and climb gradient information shall be provided for all departures requiring a climb gradient greater than 200 feet per NM. The altitude or fix at which a climb gradient in excess of 200 feet per NM is no longer required shall also be specified.

c. Minima imposed shall be in accordance with Para 1208 and Chapter 3.

d. When departures are limited to a specific category of aircraft, i.e. Cat A and B, Cat A, B & C, the procedure shall be clearly annotated.

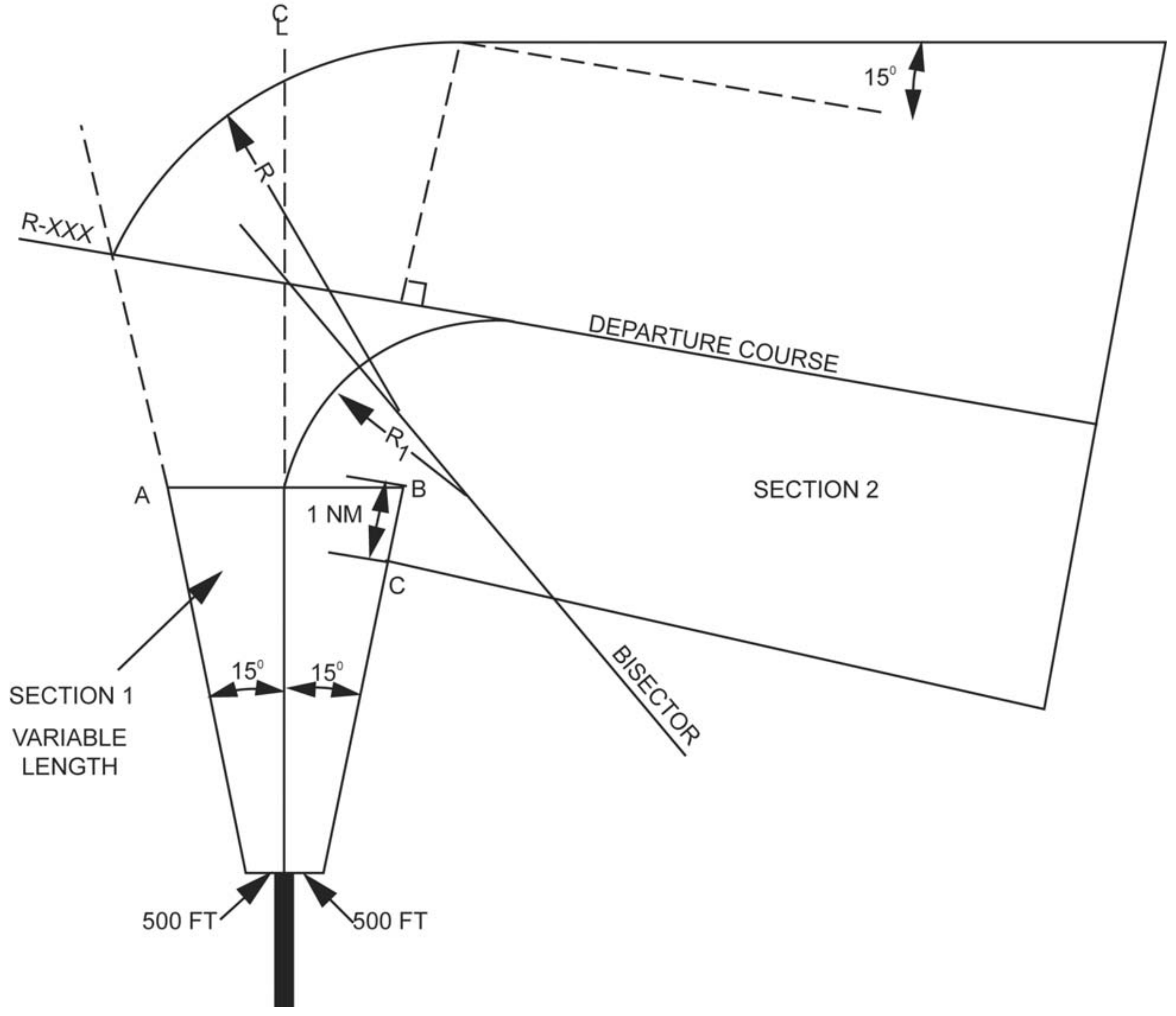


Figure 12-116M: Combination Straight And Turning Departure (To Intercept Radial Or Bearing). Para 1203.c.

1208. Required Minima

IFR departure procedures requiring a climb gradient in excess of 200 feet per NM to meet obstacle clearance requirements shall have published "SPECIFIED VISIBILITY" and a "Climb visual to" altitude to accommodate aircraft that cannot meet the required climb gradient.

1209. Visual Climb Over Airport

Some situations require that the aircraft climb visually to cross the airport (or an on-airport NAVAID) at or above an altitude from which a straight-out climb can be made. Construct a Visual Climb Area, followed by a straight-out instrument climb segment.

1210. Visual Climb Area (VCA)

Construct this area in the same manner as the circling approach area described in Para 260.a, using the radii in Table 12–32.

Category	Radius (nm)
A	2.3
B	2.5
C	2.7
D	3.3
E	5.5

Table 12-32: Visual Climb Area Radii. Para1210.

1211. Establishment Of Altitude For Visual Climb Area

To determine the preliminary climb-to altitude for the VCA, add 264 feet, plus any Para 323.a and b adjustments, to the highest obstacle in the VCA. Round the resultant altitude to the next higher 100-foot increment. If this altitude does not support en-route flight, evaluate a straight departure area using a 40:1 obstacle identification surface.

1212. Straight Departure Area

a. This area begins over the airport reference point (or on-airport navaid). Area width is appropriate to the navaid used, as defined in Para 1203.a.(1)(b).

b. When DR is used, the area has the same width as the VCA abeam the point of beginning. The DR area begins over the airport reference point. The splay begins where a line constructed perpendicular the DR course and through the AGCC intercepts the VCA boundary. It splays 15° each side of and in the direction of the DR course until positive course (track) guidance is acquired (see Figure 12–117).

c. For straight-out segment evaluations, determine the 40:1 surface beginning height by subtracting 264 feet, plus any Para 323.a and b adjustments, from the computer climb-to altitude. The 40:1 surface begins at the VCA boundary, and rises in the shortest distance to the obstacle being evaluated. Where penetrations exist, increase the climb-to altitude by the greatest amount of penetration rounded to the next higher 100-foot increment.

1213. Establishment Of The "Climb Visual To" Altitude

The "Climb visual to" altitude must be high enough to permit the highest obstacle in the VCA to be seen, and to provide an unobstructed visibility at the climb-to altitude. Figure 12–118 illustrates the method of computation, appropriate minimums and departure procedures.

1214—1299. Reserved

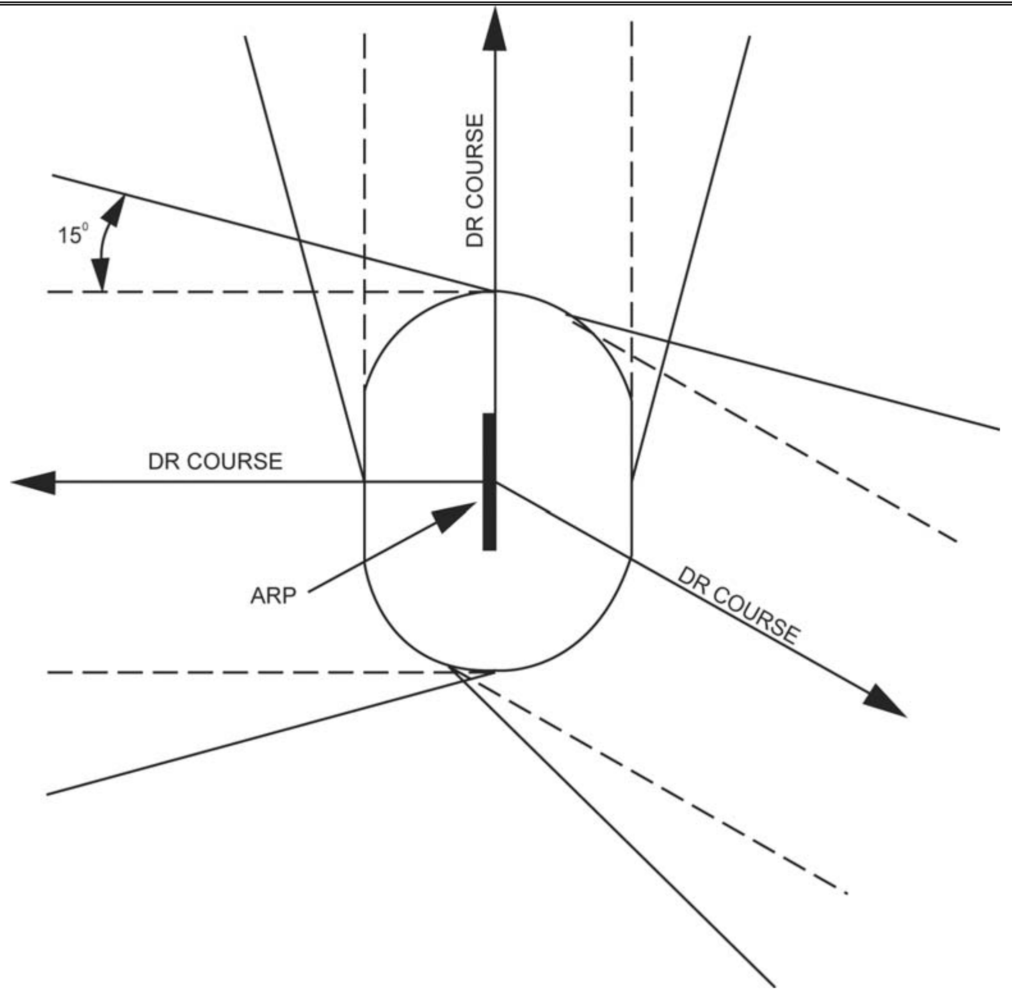
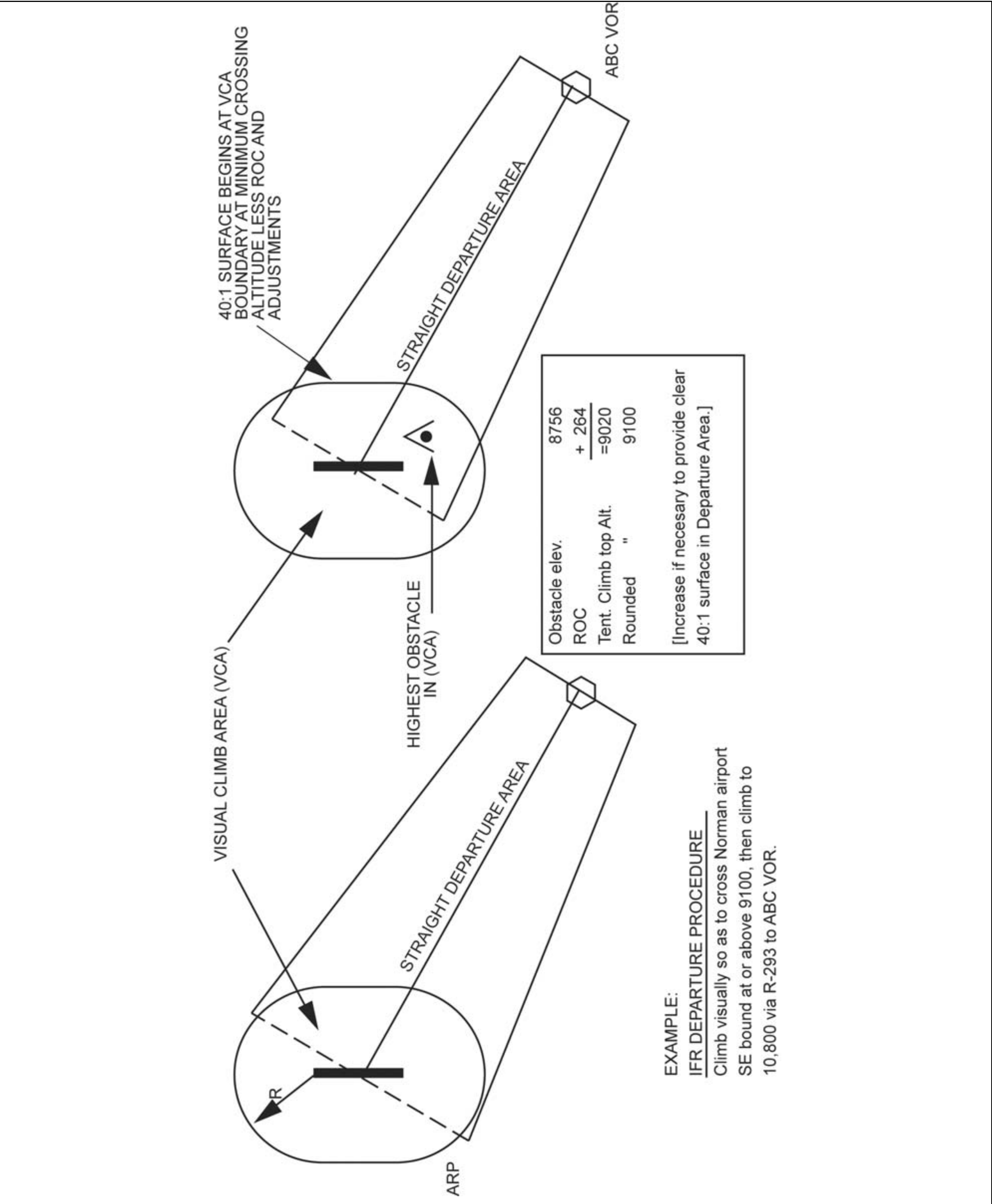


Figure 12-117: Variations Of DR Straight Departure Areas. Para 1212.b.



Obstacle elev.	8756
ROC	+ 264
Tent. Climb top Alt.	=9020
Rounded "	9100

[Increase if necesary to provide clear 40:1 surface in Departure Area.]

EXAMPLE:

IFR DEPARTURE PROCEDURE

Climb visually so as to cross Norman airport SE bound at or above 9100, then climb to 10,800 via R-293 to ABC VOR.

Figure 12-118: Variations Of A Straight Departure Area To A NAVAID. Para 1212 and 1213.

CHAPTER 13. RESERVED

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CHAPTER 15. AREA NAVIGATION (RNAV)

1500. General

This chapter applies to instrument procedures based on airborne area navigation (RNAV) systems. Separate criteria are presented for VOR/DME and non-VOR/DME RNAV systems.

a. VOR/DME Systems. This includes systems based solely on VOR/DME, VORTAC, and TACAN facilities. VOR/DME is synonymous with the terms VORTAC or TACAN.

b. Non-VOR/DME Systems.

  (1) Self-contained systems, including inertial (INS) and Doppler.

  (2) Loran-C and Rho-Rho ground-based systems.

  (3) Multi-sensor systems: those that use a combination of input information.

1501. Terminology

The following terms, peculiar to RNAV procedures, are defined as follows:

a. **Airport (APT) Waypoint (WP).** A waypoint located on the final approach course at or abeam the first useable landing surface, which is used for construction of the final approach area for a circling only approach (LORAN circling approaches only).

b. **Alongtrack Distance (ATD) Fix.** The ATD fix is an alongtrack position defined as a distance in NM, with reference to the next waypoint.

c. **Alongtrack (ATRK) Fix Displacement Tolerance.** Fix displacement tolerance along the flight track.

d. **Crosstrack (XTRK) Fix Displacement Tolerance.** Fix displacement tolerance to the left or right of the flight track.

e. **Instrument Approach Waypoint.** Fixes used in defining RNAV instrument approach procedures, including the feeder waypoint (FWP), the initial approach waypoint (IAWP), the intermediate waypoint (IWP), the final approach waypoint (FAWP), the runway waypoint (RWY WP) and the Airport Waypoint (APT WP), when required.

f. **Missed Approach Holding Waypoint (MAHWP)** is the waypoint designated in the missed approach segment of an instrument approach procedure (IAP) to which the aircraft will automatically fly and, upon reaching the geographic position of the waypoint, enter a specified holding pattern.

g. **Missed Approach Waypoint (MAWP)** is the waypoint on the final approach course that signifies the termination of the final approach segment and the commencement of the missed approach segment. It is normally located at the threshold of the landing runway.

h. **Non-VOR/DME RNAV** is not dependent upon a reference facility and will hereinafter be referred to as non-VOR/DME. Includes the following:

  (1) **Long Range Navigation (Loran-C).** Loran-C is a long-range radio navigation system. A Loran-C "chain" consists of four transmitting facilities, a master and three secondaries, each transmitting in the same group repetition interval (GRI).

  (2) **Inertial Navigation System (INS).** A self-contained system, which utilizes gyros to determine angular motion and accelerometers to determine linear motion. They are

integrated with computers to provide several conditions, which include true heading, true air speed, wind, a glidepath, velocity, and position.

(3) **Doppler.** A self-contained system that determines velocity and position by the frequency shift of a signal transmitted from the aircraft and reflected from the surface back to the aircraft.

(4) **Global Positioning System (GPS).** A system of satellites providing three-dimensional position and velocity information. Position and velocity information is based on the measurement of the transit time of radio frequency (RF) signals from satellites.

(5) **Rho-Rho.** A system based on two or more DME ground facilities.

(6) **Multi-Sensor system.** Based on any VOR/DME or non-VOR/DME RNAV certified approved system or a combination of RNAV certified approved systems. The non-VOR/DME criteria apply.

i. **Reference Facility.** The VOR/DME, VORTAC, or TACAN facility used for the identification and establishment of an RNAV route, waypoint or standard instrument approach procedure.

j. **RNAV Descent Angle.** A vertical angle defining a descending flightpath from the FAF to the RWY WP.

k. **Routes.** Two subsequently related waypoints or ATD fixes define a route segment.

(1) **Jet/Victor routes.**

(2) **Random routes.** Any airway not established under the jet/victor designation. This is normally used to refer to a route that is not based on VOR radials and requires an RNAV system.

l. **Runway WP.** A waypoint located at the runway threshold and used for construction of the final approach area when the final approach course meets straight-in alignment criteria.

m. **Tangent Point (TP).** The point on the VOR/DME RNAV route centreline from which a line perpendicular to the route centreline would pass through the reference facility.

n. **Tangent Point Distance (TPD).** Distance from the reference facility to the tangent point.

o. **Time Difference (TD) Corrections.** Loran-C systems use the time of signal travel from ground facilities to the aircraft to compute distance and position. The time of signal travel varies seasonally within certain geographical areas. The TD correction factor is used to correct these seasonal variations for each geographical area. RNAV criteria assume local TD corrections will be applied.

p. **Turn Anticipation.** The capability of RNAV systems to determine the point along a course, prior to a turn waypoint, where a turn should be initiated to provide a smooth path to intercept the succeeding course, and to annunciate the information to the pilot.

q. **Turn Waypoint.** A waypoint that identifies a change from one course to another.

r. **VOR/DME RNAV.** RNAV that is dependent of VOR/DME, VORTAC or TACAN. It is a system using radials and distances to compute position and flight track and will hereinafter be referred to as VOR/DME.

s. **Waypoint (WP).** A predetermined geographical position used for route definition and/or progress reporting purposes that is defined by the latitude/longitude. For VOR/DME systems, it is defined also by the radial/distance of the position from the facility.

t. **Waypoint Displacement Area.** The rectangular area formed around and centred on the plotted position of a waypoint. Its dimensions are plus-and-minus the appropriate alongtrack and crosstrack displacement tolerance values that are found in Tables 15-1, 15-2, and 15-3.

1502. Procedure Construction

RNAV procedural construction requirements are as follows:

a. Reference Facility. An RNAV approach procedure shall be supported by a single reference facility.

b. Waypoints. A WP shall be used to identify the point at which RNAV begins and the point at which RNAV ends, except when the RNAV portion of the procedure terminates at the missed approach point (MAP), and the MAP is an ATD fix.

c. Segment. Approach segments begin and end at the WP or ATD fix.

   (1) The segment area considered for obstacle clearance begins at the earliest point the WP or ATD can be received, and, except for the final approach segment, ends at the plotted position of the fix.

   (2) Segment length is based on the distance between the plotted positions of the WP or ATD fix defining the segment ends.

   (3) Segment widths are specified in appropriate paragraphs of this chapter, but in no case will they be narrower than XTRK fix displacement tolerances for that segment.

   (4) Minimum segment widths are also determined/limited in part according to WP location relative to the reference facility. This limiting relationship is depicted in Figure 15-2 and explained in the note following Figure 15-2.

d. Fix Displacement. Except in the case of the MAP overlapping the RWY WP or APT WP (see Para 1532), the ATRK fix displacement tolerance shall not overlap the plotted position of the adjacent fix. Additionally, except for a turn at a MAP designated by a WP, WP displacement tolerances shall be orientated along the courses leading to and from the respective WP. See Figure 15-17.

e. Turning Areas. Turning area expansion criteria shall be applied to all turns, en route and terminal, where a change of direction of more than 15° is involved. See Para 1510.c and 1520.

f. Cone of Ambiguity. The primary obstacle clearance area at the minimum segment altitude shall not be within the cone of ambiguity of the reference facility. If the primary area for the desired course lies within the cone of ambiguity, the course should be relocated or the facility flight inspected to verify that the signal is adequate within the area. Azimuth signal information permitting satisfactory performance of airborne components is not provided beyond the following ranges:

   (1) VOR - beyond 60° above the radio horizon.

   (2) TACAN - beyond 40° above the radio horizon. See Figure 15-1.

FIX DISTANCE ALONGTRACK FROM TANGENT POINT

DISTANCE FROM TANGENT POINT TO VOR/DME

		0	10	20	30	40	50	51
0	XTRK		1.3	1.7	2.2	2.8	3.4	3.5
	ATRK		0.6	0.6	0.7	0.8	0.9	0.9
10	XTRK	1.2	1.3	1.7	2.2	2.8	3.4	
	ATRK	0.8	0.8	0.9	0.9	1.0	1.1	
20	XTRK	1.2	1.4	1.8	2.3	2.8		
	ATRK	1.3	1.3	1.3	1.4	1.4		
30	XTRK	1.2	1.4	1.8	2.3	2.9		
	ATRK	1.8	1.8	1.9	1.9	2.0		
40	XTRK	1.3	1.5	1.8	2.3			
	ATRK	2.4	2.4	2.4	2.4			
50	XTRK	1.3	1.5					
	ATRK	2.9	3.0					
53	XTRK	1.3						
	ATRK	3.1						

		0	10	20	30	40	50
0	XTRK		1.3	1.7	2.2	2.8	3.4
	ATRK		0.6	0.6	0.7	0.8	0.9
10	XTRK	1.2	1.3	1.7	2.2	2.8	3.4
	ATRK	0.8	0.8	0.9	0.9	1.0	1.1
20	XTRK	1.2	1.4	1.8	2.3	2.8	3.4
	ATRK	1.3	1.3	1.3	1.4	1.4	1.5
30	XTRK	1.2	1.4	1.8	2.3	2.9	3.5
	ATRK	1.8	1.8	1.9	1.9	2.0	2.9
40	XTRK	1.3	1.5	1.8	1.3	2.9	3.5
	ATRK	2.4	2.4	2.4	2.4	2.5	2.5
50	XTRK	1.3	1.5	1.9	2.4	2.9	3.5
	ATRK	2.9	3.0	3.0	3.0	3.0	3.1
60	XTRK	1.4	1.6	1.9	2.4	3.0	3.6
	ATRK	3.5	3.5	3.5	3.6	3.6	3.6
70	XTRK	1.4	1.6	2.0	2.5	3.0	3.6
	ATRK	4.1	4.1	4.1	4.1	4.2	4.2
80	XTRK	1.5	1.7	2.1	2.5	3.1	3.6
	ATRK	4.6	4.7	4.7	4.7	4.7	4.8
90	XTRK	1.6	1.8	2.1	2.6	3.1	3.7
	ATRK	5.2	5.2	5.3	5.3	5.3	5.3
100	XTRK	1.7	1.8	2.2	2.6	3.2	3.7
	ATRK	5.8	5.8	5.8	5.9	5.9	5.9
110	XTRK	1.7	1.9	2.2	2.7	3.2	3.8
	ATRK	6.4	6.4	6.4	6.4	6.5	6.5
120	XTRK	1.8	2.0	2.3	2.8	3.3	3.8
	ATRK	6.9	7.0	7.0	7.0	7.0	7.1

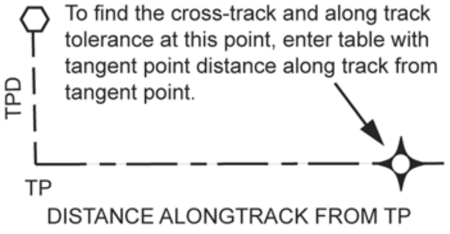
J/V ENROUTE

RANDOM EN ROUTE

Table may be interpolated -- or use next higher value
XTRK/ATRK values are ±

Table application per segment

Segment	Table 15-1		
	J/V En Route	Random En Route	Terminal
En route	X		
Feeder		X	
Feeder S/D		X	
IAWP			X
Initial S/D			X
IWP			X
Intermediate S/D			X
MA/Holding			X



To find the cross-track and along track tolerance at this point, enter table with tangent point distance along track from tangent point.

Table 15-1: VOR/DME En Route And Terminal Fix Displacement Tolerance. Para 1505.b.(1).

FIX DISTANCE ALONGTRACK FROM TANGENT POINT

TANGENT POINT DISTANCE (TPD) FINAL / MISSED		0	1	2	3	4	5	10	15	20	25	30
0	XTRK		0.7	0.7	0.7	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK		0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7
1	XTRK	0.7	0.7	0.7	0.7	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7
2	XTRK	0.7	0.7	0.7	0.7	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7
3	XTRK	0.7	0.7	0.8	0.8	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7
4	XTRK	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8
5	XTRK	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7	0.7	0.8	0.8
10	XTRK	0.8	0.8	0.8	0.8	0.8	0.8	1.0	1.2	1.5	1.8	2.1
	ATRK	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9
15	XTRK	0.8	0.8	0.8	0.8	0.8	0.9	1.0	1.2	1.5	1.8	2.1
	ATRK	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.2
20	XTRK	0.8	0.8	0.8	0.8	0.9	0.9	1.0	1.3	1.5	1.8	2.1
	ATRK	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.4	1.4
25	XTRK	0.8	0.9	0.9	0.9	0.9	0.9	1.1	1.3	1.6	1.8	2.1
	ATRK	1.5	1.5	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.6
30	XTRK	0.9	0.9	0.9	0.9	0.9	0.9	1.1	1.3	1.6	1.9	2.1
	ATRK	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.9	1.9	1.9

INTERPOLATE TO THE NEAREST 0.1 MILE

XTRK/ATRK values are ±

Table application per segment

Segment	Table 15-2
En route	
Feeder	
Feeder S/D	
IAWP	
Initial S/D	
IWP	
Intermediate S/d	
FAWP / ATD Fix	X
Final S/D	X
MAWP / ATD Fix	X
RWY WP / APT WP	X
MA Turn Point	X
MA / Holding	

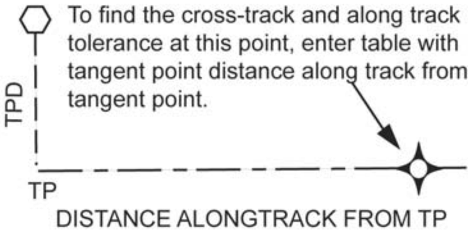

To find the cross-track and along track tolerance at this point, enter table with tangent point distance along track from tangent point.

Table 15-2: VOR/DME Final/Missed Area Fix Displacement Tolerance. Para 1523.b.

g. Use of ATD Fixes. ATD fixes are normally used in lieu of approach WP's when no course change is required at that point. An ATD fix shall not be used in lieu of a RWY WP. The FAF, MAP, and any stepdown fixes may be defined by ATD fixes. Consistent with operational need, flyability, and fix displacement tolerance overlap restrictions, there is no maximum number of stepdown fixes in any segment. Multiple stepdown fixes shall be defined in whole nautical mile (NM) increments.

h. Positive Course Guidance. All RNAV segments shall be based on positive course guidance, except that a missed approach segment without positive course guidance may be developed when considered to provide operational advantages and can be allowed within the obstacle environment.

1503. Reserved

1504. Reference Facilities

Reference facilities shall have collocated VOR and DME components. For terminal procedures, components within 100 feet of each other are defined as collocated. For en route procedures, components within 2,000 feet of each other are defined as collocated.

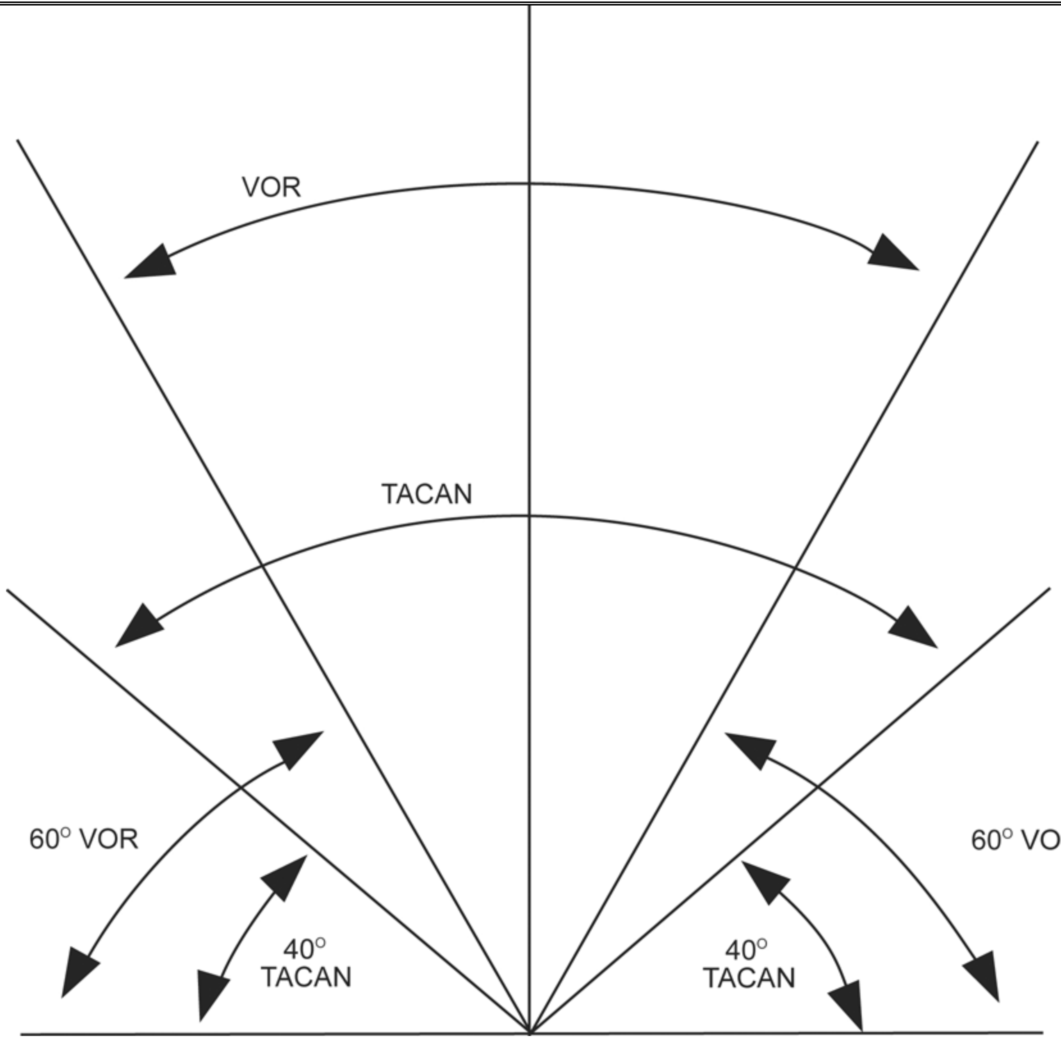


Figure 15-1: Cones Of Ambiguity. Para 1502.

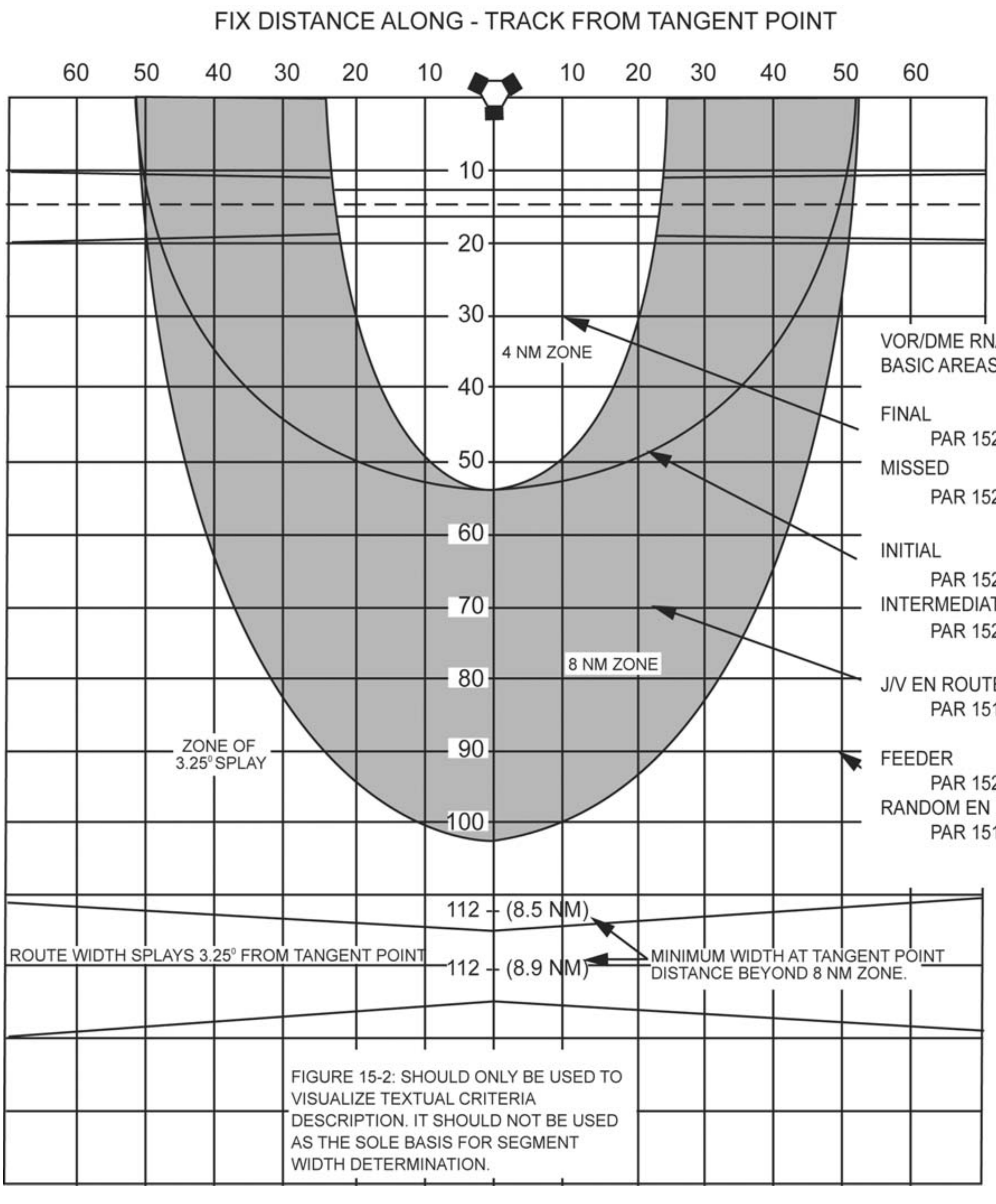


FIGURE 15-2: SHOULD ONLY BE USED TO VISUALIZE TEXTUAL CRITERIA DESCRIPTION. IT SHOULD NOT BE USED AS THE SOLE BASIS FOR SEGMENT WIDTH DETERMINATION.

Figure 15-2: Area Navigation Route Width Summary. Para 1502.

1505. Waypoints

RNAV waypoints are used for navigation reference and for air traffic control operational fixes similarly as VOR/DME ground stations and intersections are used in the conventional VOR structure.

a. Establishment. Waypoints shall be established along RNAV routes at the following points:

   (1) At the end points;

   (2) At points where the route changes course;

   (3) At holding fixes; and

   (4) At other points of operational benefit, such as route junction points which require clarity.

   (5) For VOR/DME WP's, one WP must be associated with each reference facility used for en route navigation requirements. If a segment length exceeds 80 miles and no turning requirement exists along the route, establish a WP at the tangent point.

b. WP. WP placement is limited by the type of RNAV system as follows:

   (1) No VOR/DME waypoints shall be established outside of the service volume of the reference facility and shall be limited to the values contained in Tables 15-1 and 15-2.

   (2) No non-VOR/DME WP's or route segments shall be established outside of the area in which the particular system signal has been approved for IFR operation.

   (3) Self-contained systems such as INS and Doppler do not have limitations on waypoint placement.

   (4) Fix Displacement Tolerances. Tables 15-1 and 15-2 show fix displacement tolerances for VOR/DME systems. Table 15-3 shows fix displacement tolerances for all other systems. When the fix is an ATD fix, the alongtrack fix and crosstrack displacement tolerances are considered to be the same as a WP located at that fix.

c. Defined Waypoint Requirements.

   (1) VOR/DME RNAV Waypoints. Each WP shall be defined by:

      (a) A VOR/DME radial—developed to the nearest hundredth of a degree;

      (b) DME Distance—developed to the nearest hundredth of a mile; and

      (c) Latitude/longitude—in degrees, minutes, and seconds to the nearest hundredth.

   (2) Non-VOR/DME RNAV WP's. Each WP shall be defined by latitude and longitude in degrees, minutes, and seconds developed to the nearest hundredth. Rho-Rho waypoints shall also be developed to the nearest hundredth of a mile.

   (3) Station elevation of the reference facility shall be defined and may be rounded to the nearest 20-foot increment.

1506. RWY WP and APT WP

Straight-in procedures shall incorporate a WP at the runway threshold. Circling procedures shall incorporate an APT WP located at or abeam the first useable landing surface. See Figure 15-3. These waypoints are used to establish the length and width of the final approach area.

	En Route	**Terminal**	**Approach**
XTRK	3.0	2.0	0.6
ATRK	2.8	1.7	0.3

Cross Track (XTRK) and Along Track (ATRK) values are ± values. Table application per segment

Segment	**En Route**	**Table 15-3 Terminal**	**Approach**
En Route	X		
Feeder	X		
Feeder S/D	X		
IAWP		X	
Initial S/D		X	
IWP		X	
Intermediate S/D		X	
FAWP/ ATD Fix			X
Final S/D			X
MAWP/ ATD Fix			X
RWY WP/ APT WP			X
MA Turn Point			X
MA Holding	X		

Table 15-3: Non-VOR/DME Fix Displacement Tolerances. Para 1505.b.(4)

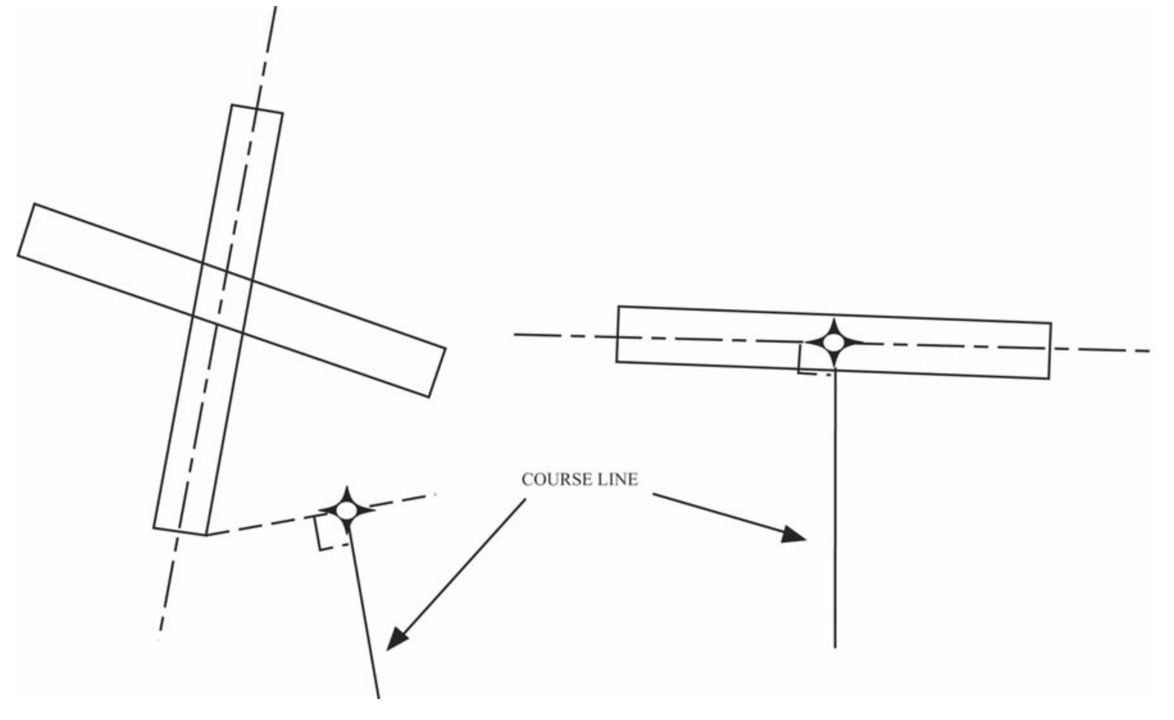


Figure 15-3: Location Of Airport WP. Para 1506.

1507. Holding

Chapter 18 applies. When holding is at an RNAV fix, the selected pattern shall be large enough to contain the entire fix displacement area within the primary area of holding pattern.

a. VOR/DME Pattern Size Selection. For VOR/DME, the distance from the WP to the reference facility shall be applied as the "fix distance". (see Volume 1, Chapter 18, Table 18-2).

b. Non-VOR/DME Pattern Size Selection. For non-VOR/DME, use the "15–29.9 NM" distance column for terminal holding procedures and "30 NM or over" distance column for en route holding (see Volume 1, Chapter 18, Table 18-2).

1508—1509. Reserved

SECTION 1. EN ROUTE CRITERIA

1510. En Route Obstacle Clearance Areas

En route obstacle clearance areas are identified as primary or secondary. These designations apply to straight or turning segment obstacle clearance areas. The required angle of turn connecting en route segments to other en route, feeder, or initial approach segments, shall not exceed 120°. Where the turn exceeds 15°, turning segment criteria in Para 1510.c apply.

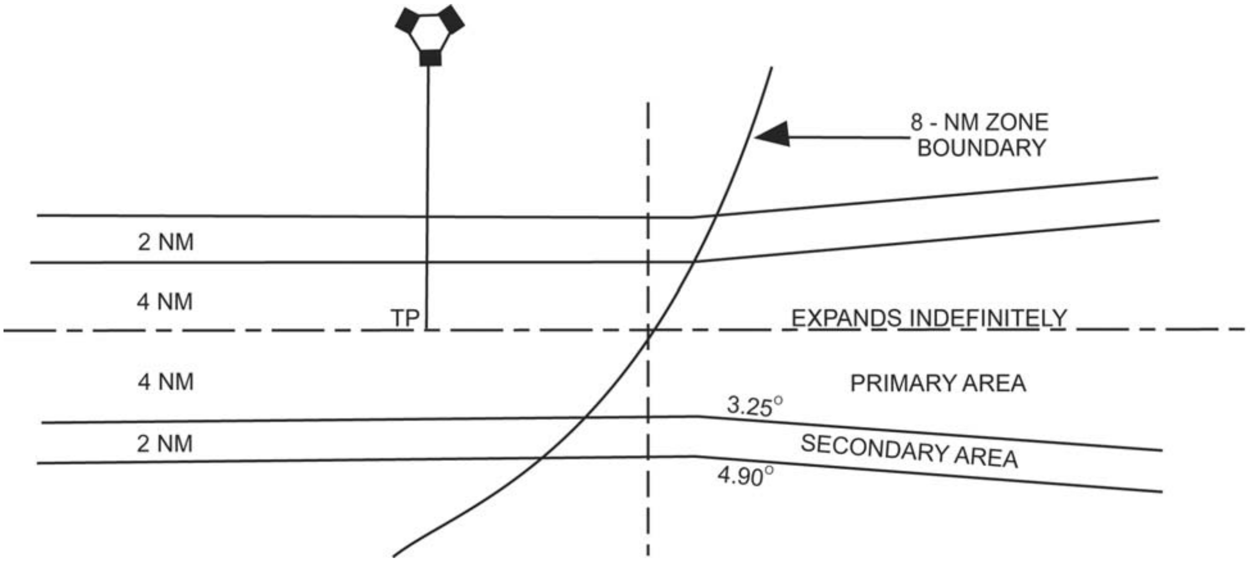


Figure 15-4: VOR/DME Basic Area. Para 1510.a.(1), 1510.b.(1), and 1512.b.(1)(a).

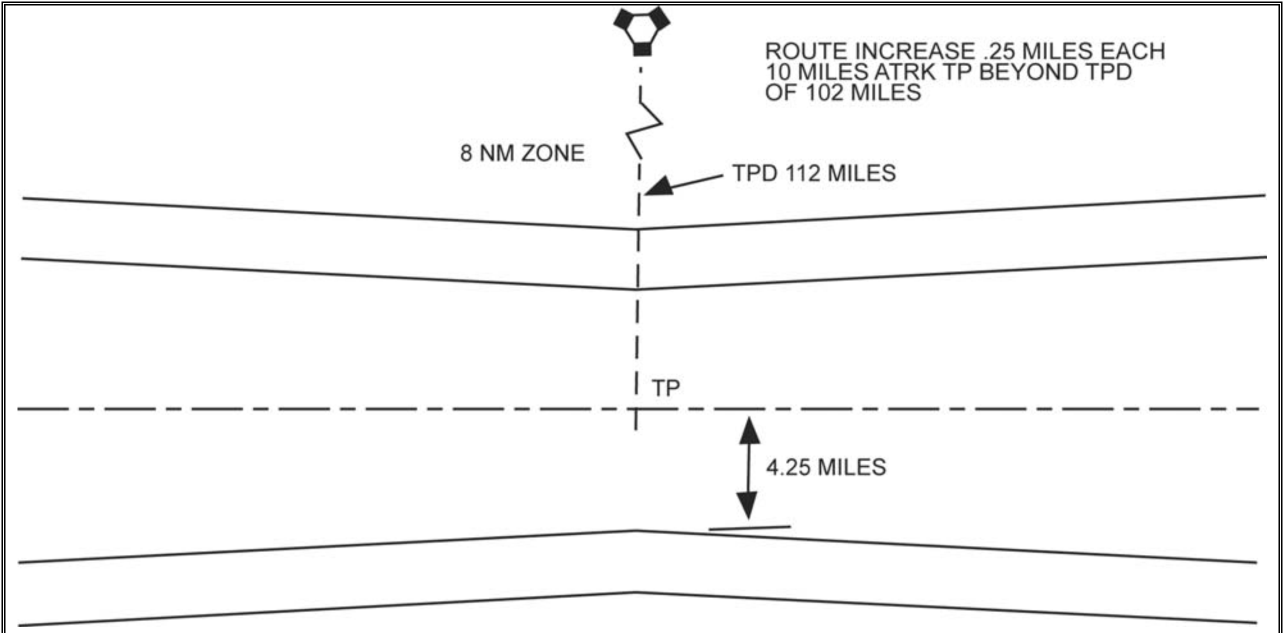


Figure 15-5: VOR/DME Basic Area. Para 1510.a.(1) and b (1).

a. Primary Area. The primary obstacle clearance area is described as follows:

(1) VOR/DME Basic Area. The area is 4 miles each side of the route centreline when the TPD is 102 miles or less and the TPD/ATD values do not exceed the limits of the 8 NM zone. The route width increases at an angle of 3.25° as the ATD increases for that portion of the area where the route centreline lies outside the 8 NM zone. See Figure 15-4. When the TPD exceeds the 102- mile limit, the minimum width at the TPD expands greater than ±4 miles at a rate of 0.25 miles on each side of the route for each 10 miles the TPD is beyond 102 miles. See Figures 15-2 and 15-5, and Table 15-1. When the widths of adjoining route segments are unequal for reasons other than transition of zone boundaries, the following apply:

(a) If the TP of the narrower segment is on the route centreline, the width of the narrower segment includes that additional airspace within the lateral extremity of the wider segment, where the route segments join, thence toward the TP of the narrower route segment, until intersecting the boundary of the narrower segment. See Figure 15-6.

(b) If the TP of the narrower segment is on the route centreline extended, the width of the narrower segment includes that additional airspace within lines from the lateral extremity of the wider segment where the route segments join, thence toward the TP until reaching the point where the narrower segment terminates, or changes direction, or until intersecting the boundary of the narrower segment. See Figure 15-7.

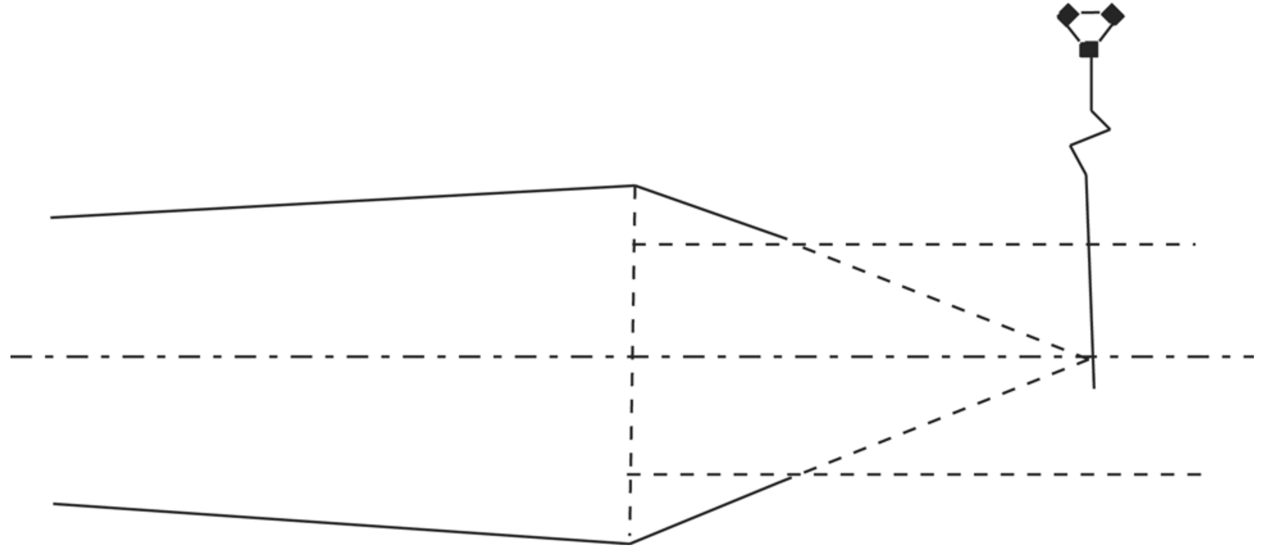


Figure 15-6: Unequal Joining Route Segments. Para 1510.a. (1)(a).

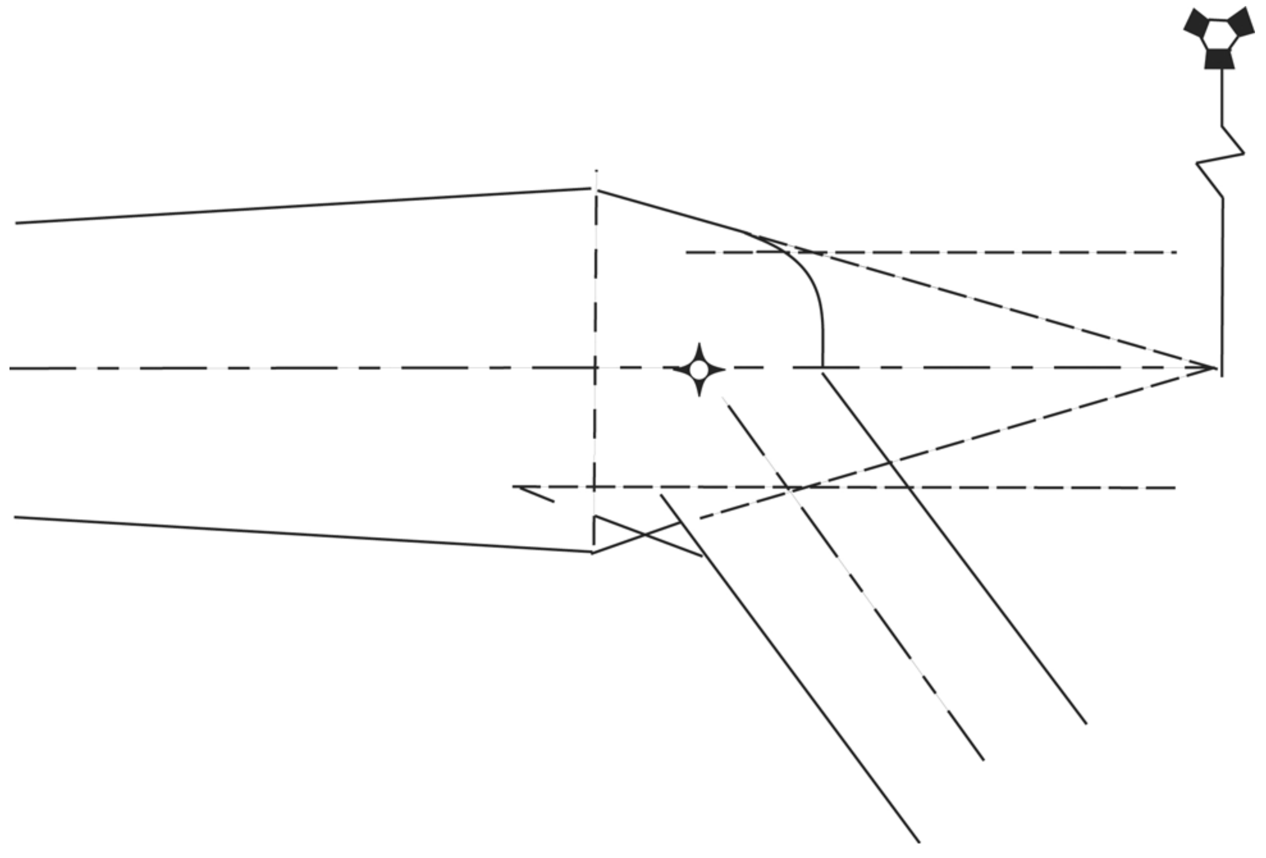


Figure 15-7: Unequal Joining Route Segments With A Turn. Para 1510.a.(1)(b).

(3) Non-VOR/DME Basic Area. The area is 4 miles each side of the route centreline at all points. Non-VOR/DME primary boundary lines do not splay.

(4) Termination Point. An RNAV route termination point shall be at a WP. The primary area extends beyond the route termination point. The boundary of the area is defined by an arc which connects the two primary boundary lines. The centre of the arc is located at the most distant point on the edge of the WP displacement area on the route centreline. See Figure 15-8.

b. Secondary Areas.

(1) VOR/DME Basic Area. The VOR/DME secondary obstacle clearance area extends 2 miles on each side of the primary area and splays 4.9° where the primary area splays at 3.25°. See Figure 15-4. The secondary area beginning width does not increase beyond the 102-mile TPD.

(2) Non-VOR/DME Basic Area. The non-VOR/DME secondary obstacle clearance areas are a constant 2 miles lateral extension on each side of the primary area.

(3) Termination Point. The secondary obstacle clearance area extends beyond the arc, which defines the termination point primary area by an amount equal to the width of the secondary at the latest point the waypoint can be received. See Figure 15-8.

c. Construction of Expanded Turning Areas. Obstacle clearance areas are expanded to accommodate turns of more than 15°. The primary and secondary obstacle clearance turning areas are expanded by outside and inside areas. See Figure 15-9. The inside expansion area is constructed to accommodate a turn anticipation area. Outside expansion area is provided to accommodate overshoot at high speeds and excessive wind conditions. No portion of the primary area at the minimum segment altitude may be in the cone of ambiguity for VOR/DME RNAV routes.

(1) Outside Expansion Area. Determine the expanded area at the outside of the turn as follows:

(a) Construct a line perpendicular to the route centreline 3 miles prior to the latest point the fix can be received or to a line perpendicular to the route centreline at the plotted position of the fix, whichever occurs last. For altitudes 10,000 feet or greater, construct a line perpendicular to the plotted position of the fix. This perpendicular line is a base line for constructing arc boundaries.

(b) From a point of the base line, strike an 8 mile arc from the outer line of the fix displacement area on the outside of the turn to a tangent line to a second 8-mile arc. The second arc is struck from a point on the base line inside the inner line of the fix displacement area to a 30° tangent line to the primary boundary line. From a point where an extension of the box line intersects the primary outer boundary line, connect the 8mile arc with a line tangent to the arc.

(c) Strike arcs from the centre points used for the primary area expansion and provide a parallel expansion of 2 miles of the secondary area at the turn.

(d) Connect the extremities with a straightline tangent to the two associated arcs.

(e) Draw the remaining secondary area boundary 2 miles outside the boundary of the primary area.

(f) If the width of the primary area at the turn point is greater than 8 miles, the expanded area is constructed in the same manner as outlined in Para 1510.c.(1), using the primary area width at the point where the route changes course as the radius of the arc in place of 8 NM and constructing the secondary area of constant width equal to the width of the secondary area at the turn point.

(2) Inside Expansion Area. Determine the expanded area at the inside of the turn as follows:

(a) Determine the fix area by application of the XTRK and ATRK fix displacement tolerances.

(b) Prior to the earliest point the WP (orientated along the course leading to the fix) can be received, locate a point on the primary area boundary at one of the following distances:

(i) 3 miles below 10,000 feet MSL; 3½ miles when the turn exceeds 112°.

(ii) 7 miles for 10,000 feet MSL up to but not including FL180.

(iii) 12 miles for FL180 and above.

(c) From this point, splay the primary area by an angle equal to one-half of the course change.

(d) Draw the secondary area boundary 2 miles outside the boundary of the primary area.

d. TP/WP Limitation. WP's for the Jet/Victor Airway structure shall be limited to the 8 NM zone, a TPD of 70 miles or less, and an ATD fix from the tangent point of 40 miles or less. WP's for random airway structure shall be limited to a TPD of 120 miles or less and an ATD fix from the tangent point of 50 miles.

e. Joining RNAV with Non-RNAV Route Segments.

(1) If the RNAV and non-RNAV segments have the same width at the point of transition, the segments are joined at the location and RNAV criteria are continued in the direction of the RNAV segment.

(2) If the RNAV segment is narrower at the location of the transition, the segments shall be joined according to Para 1512.b.(1)(b).

(3) If the RNAV segment is wider at the location of the transition, the boundaries shall taper from the transition location toward the non-RNAV segment at an angle of 30° until joining the boundaries at the RNAV segments. If the location of the transition includes a turn, the width of the RNAV segment is maintained and the turn area constructed according to this chapter. After the completion of the turn area, the boundaries shall taper at an angle of 30° until passing the non-RNAV boundaries.

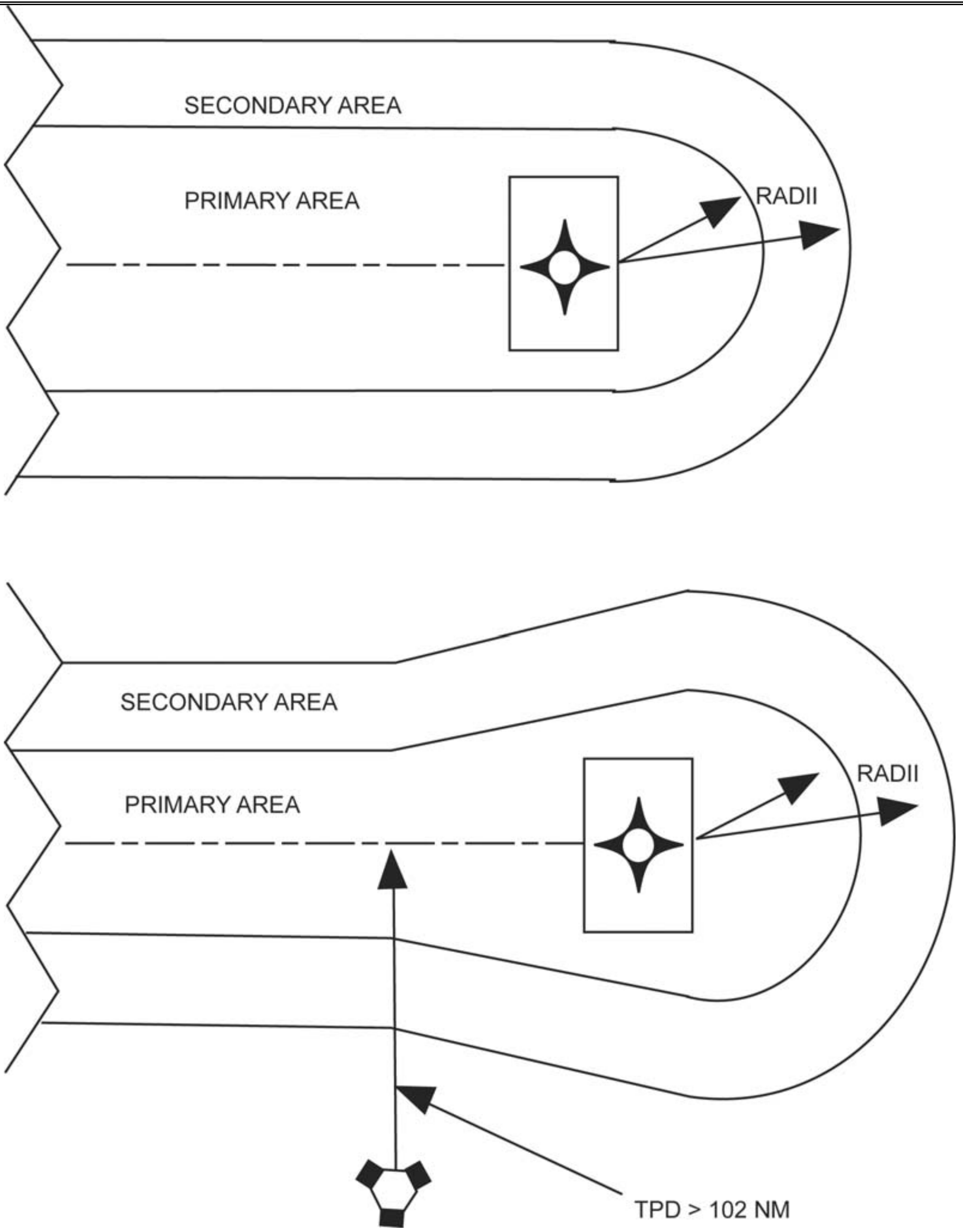


Figure 15-8: Termination Points. Paras 1510.a.(3) and 1510.b.(3).

1511. Obstacle Clearance

Para 1720 and 1721 apply, except that the width of the VOR/DME secondary area is 2 miles at the point of splay initiation and the value 236 feet for each additional mile in Para 1721 is changed 176 feet/NM. Non-VOR/DME systems do not splay. Obstacles in the secondary area are measured perpendicular to the course centreline, except for the expanded turn areas. Obstacles in these areas are measured perpendicular to the primary area boundary, or its tangent, to the obstacle.

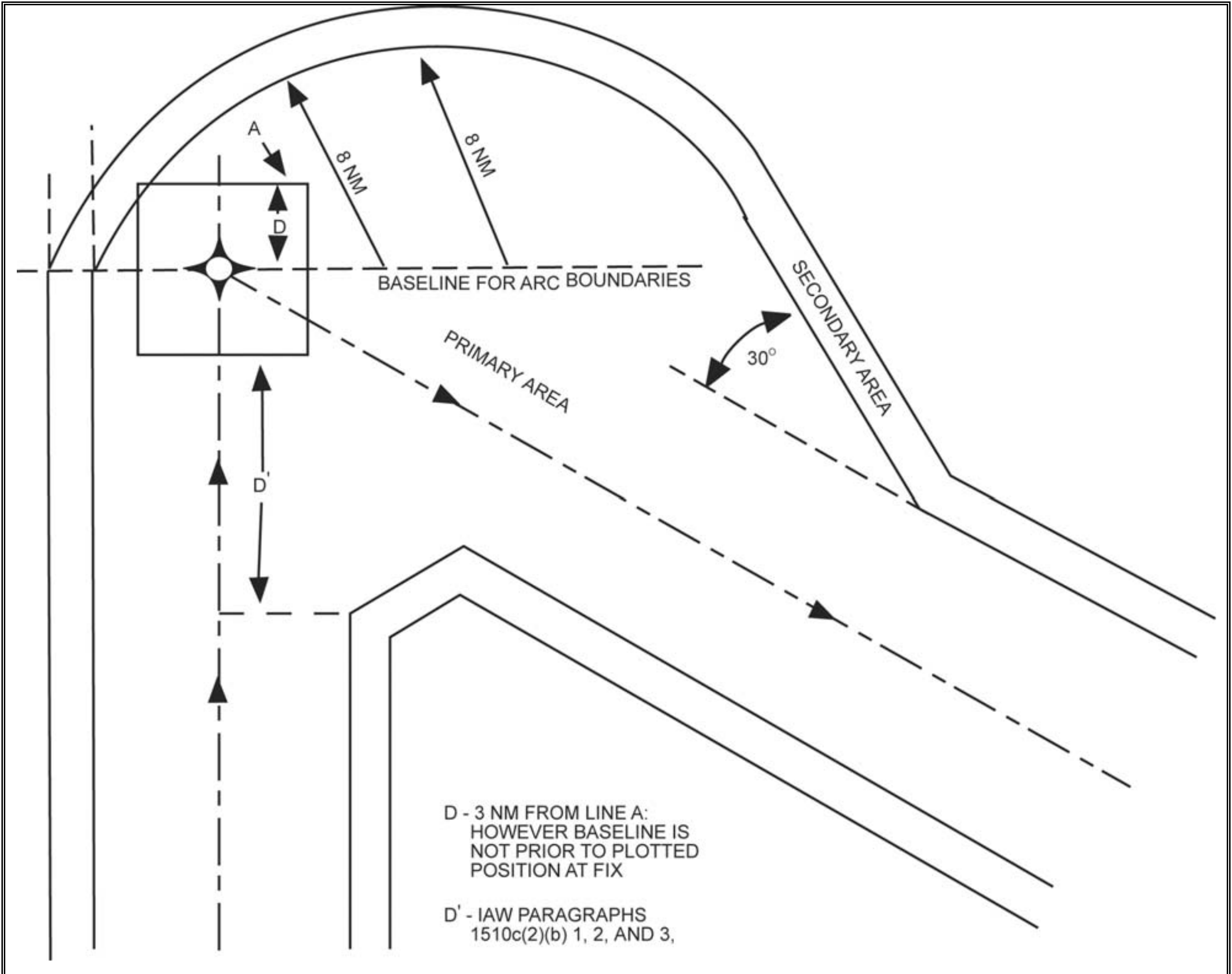


Figure 15-9: Expanded Turning Areas. Para 1520.c.

1512. Feeder Routes

When the initial approach WP is not part of the en route structure, it may be necessary to designate feeder routes from the en route structure to another WP or the IAWP.

a. The required angle of turn for the feeder-to-feeder and feeder-to-initial segment connections shall not exceed 120°. Where the angle exceeds 15°, turning area criteria in Section 2 apply. En route vertical and lateral airway obstacle clearance criteria shall apply to feeder routes. The minimum altitudes established for feeder routes shall not be less than the altitude established at the IAWP. WP's for feeder routes shall be limited to a TPD of 120 miles or less and an ATD fix from the tangent point of 50 miles or less.

b. Obstacle Clearance Areas. Obstacle clearance areas are identified as primary and secondary. These designations apply to straight segment and turning segment obstacle clearance areas.

(1) Primary Area. The primary area obstacle clearance area is derived from Figure 15-2 and the associated formulas. It is described as follows:

(a) VOR/DME Basic Area. The area is 4 miles each side of the route centreline when the TPD is 102 miles or less and the TPD/ATD values do not exceed the limits of the 8 NM zone. The route width increases at an angle of 3.25° as the ATD increases for that portion of the area where the route centreline lies outside the 8 NM zone. See Figure 15-4. When the TPD exceeds the 102-mile limit, the minimum width at the TPD expands at a rate of 0.25 miles on each side of the route for each 10 miles the TPD is beyond 102 miles. Methodology for joining route segments of differing widths is contained in Para 1510.a.(1). See Table 15-2.

(b) Non-VOR/DME Basic Area. The area is 4 miles each side of the course centreline at all points, except for the 20-mile portion of the course just prior to the IAWP where it tapers linearly from 4 miles to 2 miles each side of centreline. Where a WP or a fix is located less than 20 miles prior to the IAWP, the taper begins at that point. See Figure 15-10.

(2) Secondary Areas.

(a) VOR/DME Basic Areas. Secondary obstacle clearance areas extend laterally 2 miles on each side of the primary area and splay 4.9° in the region where the primary area splays at 3.25°. See Figure 15-11 and Para 1512.b.(1)(a).

(b) Non-VOR/DME Basic Area. Non-VOR/DME secondary areas are a constant 2-mile lateral extension on each side of the primary area, except where the basic area tapers as specified in Para 1512.b.(1)(b). Over this area, the secondary area tapers linearly from 2 miles each side of the primary area to 1 mile each side of the primary area.

(3) Obstacle Clearance. Para 232.c applies.

1513—1519. Reserved

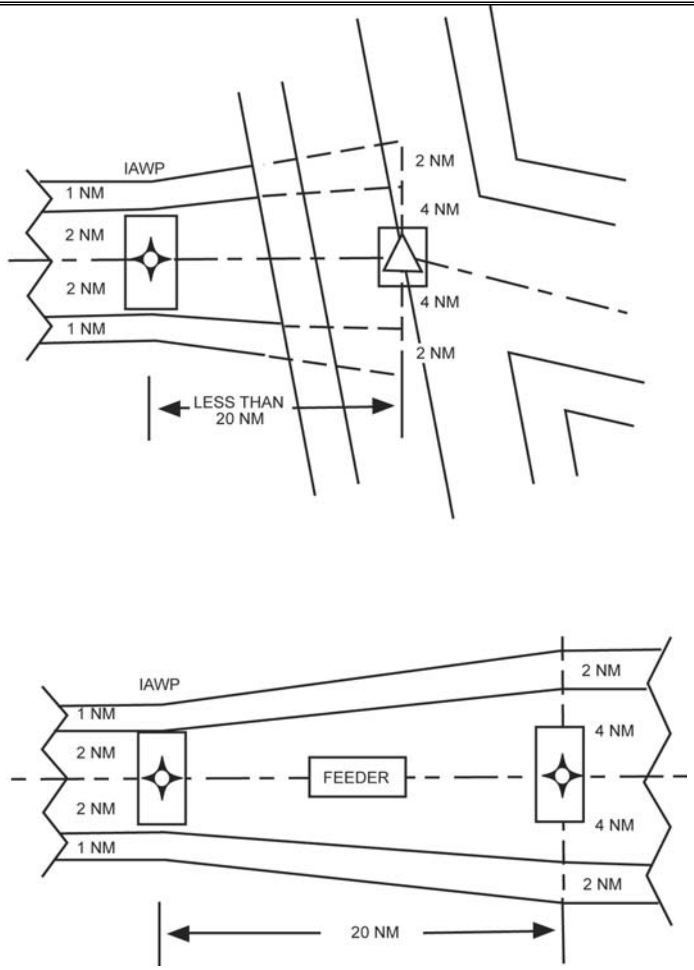


Figure 15-10: Feeder Routes Connecting NON-VOR/DME Basic Areas. Para 1512.b.(1)(b).

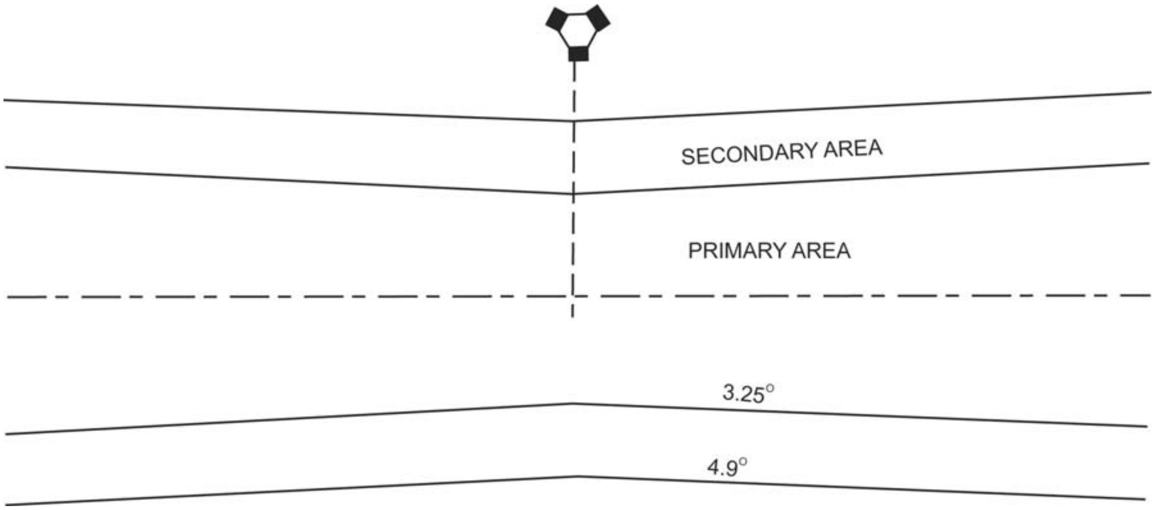


Figure 15-11: VOR/DME Secondary Areas Splay 4.9°. Para 1512.b.(2)(a).

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SECTION 2. TERMINAL CRITERIA

1520. Terminal Turning Area Expansion

Obstacle clearance areas shall be expanded to accommodate turn anticipation. Outside expansion is not required for terminal procedures. Inside expansion applies to all turns of more than 15° within SIAP's, except turns at the MAP. Para 1534 satisfies early turn requirements for the MAP. Determine the expanded area at the inside of the turn as follows:

a. Determine the ATRK Fix Displacement Tolerance.

b. Locate a point on the edge of the primary area at a distance prior to the earliest point the WP can be received. The DTA (distance of turn anticipation) is measured parallel to the course leading to the fix and is determined by the turn anticipation formula:

DTA = 2 x Tan (turn angle / 2)

c. From this point, splay the primary area by an angle equal to one-half of the course change. See Figure 15-12.

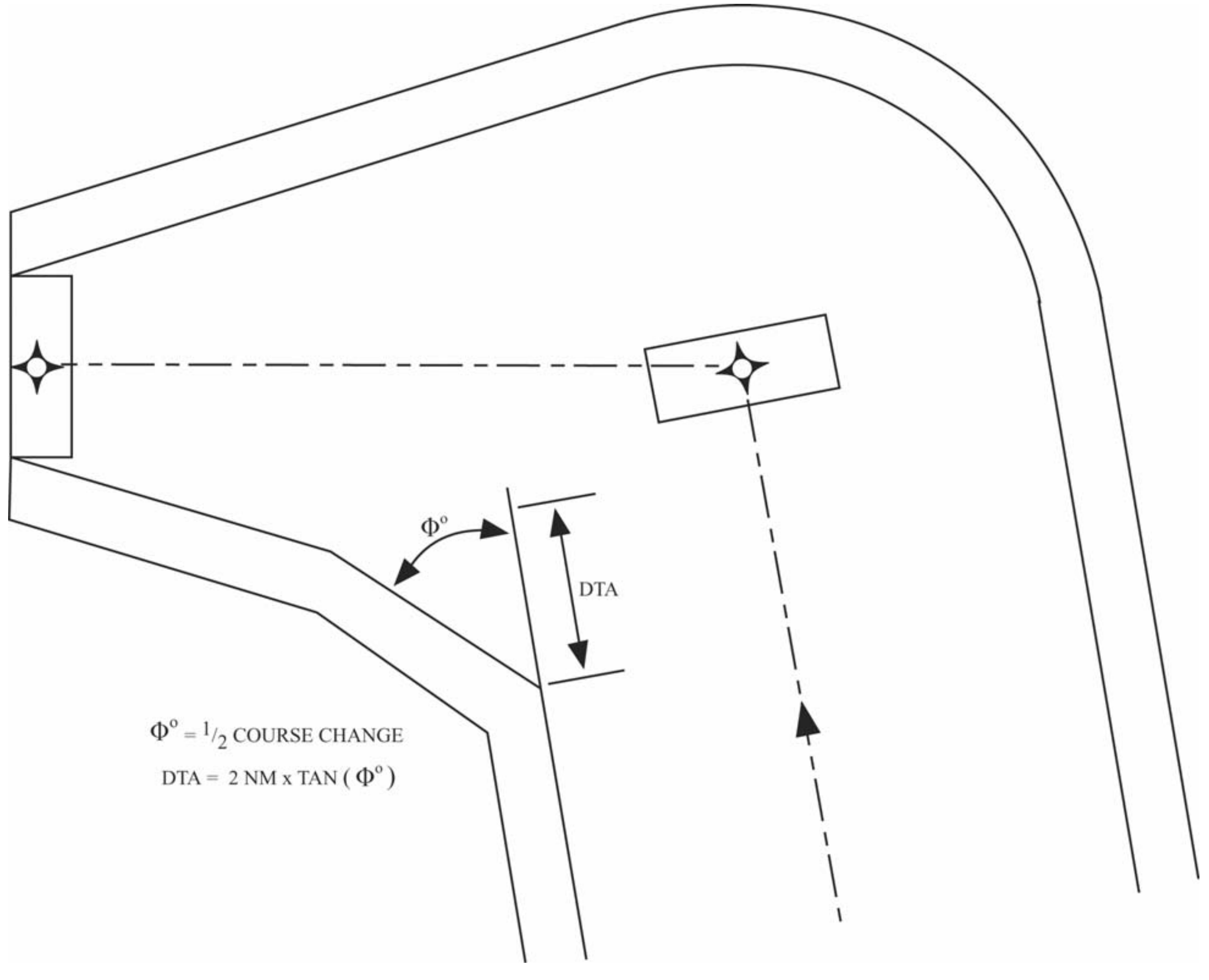


Figure 15-12: Turn Anticipation Splay. Para 1520.

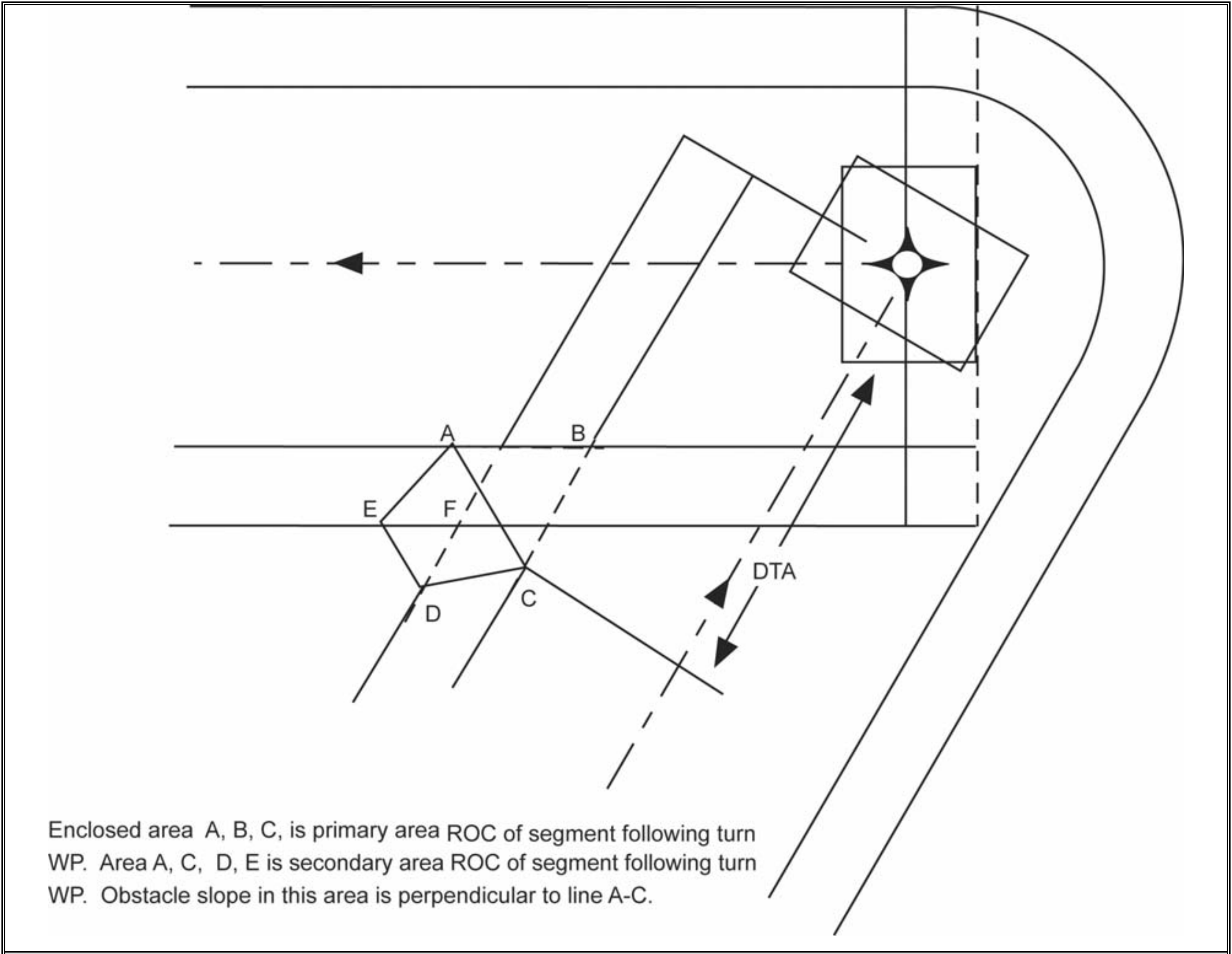
d. Secondary Area Boundary:

   (1) When the obstacle clearance area boundaries of the preceding and following segments of the WP are parallel with the course centreline, construct the secondary boundary, parallel with the expanded turn anticipation primary area boundary, using the width of the preceding segment secondary area.

   (2) When the obstacle clearance area boundaries of the preceding and/or following segments taper, construct the secondary area boundary by connecting the secondary area at points abeam the primary expansion area where it connects to the preceding/following segments of the primary area boundaries.

e. When the boundary of the expanding turn area will not connect with the boundary of the primary area of the following segment, join the expanded area at the boundary abeam the plotted position of the next waypoint or at the latest reception point of the RWY WP or APT WP, as appropriate. See Figure 15-13.

f. Obstacle Evaluation of Expanded Area. Evaluate the primary and secondary expansion areas using the ROC for the segment following the turn waypoint. See Figures 15-13 and 15-14.



Enclosed area A, B, C, is primary area ROC of segment following turn WP. Area A, C, D, E is secondary area ROC of segment following turn WP. Obstacle slope in this area is perpendicular to line A-C.

Figure 15-14: Turn Anticipation Areas. Para 1520.f.

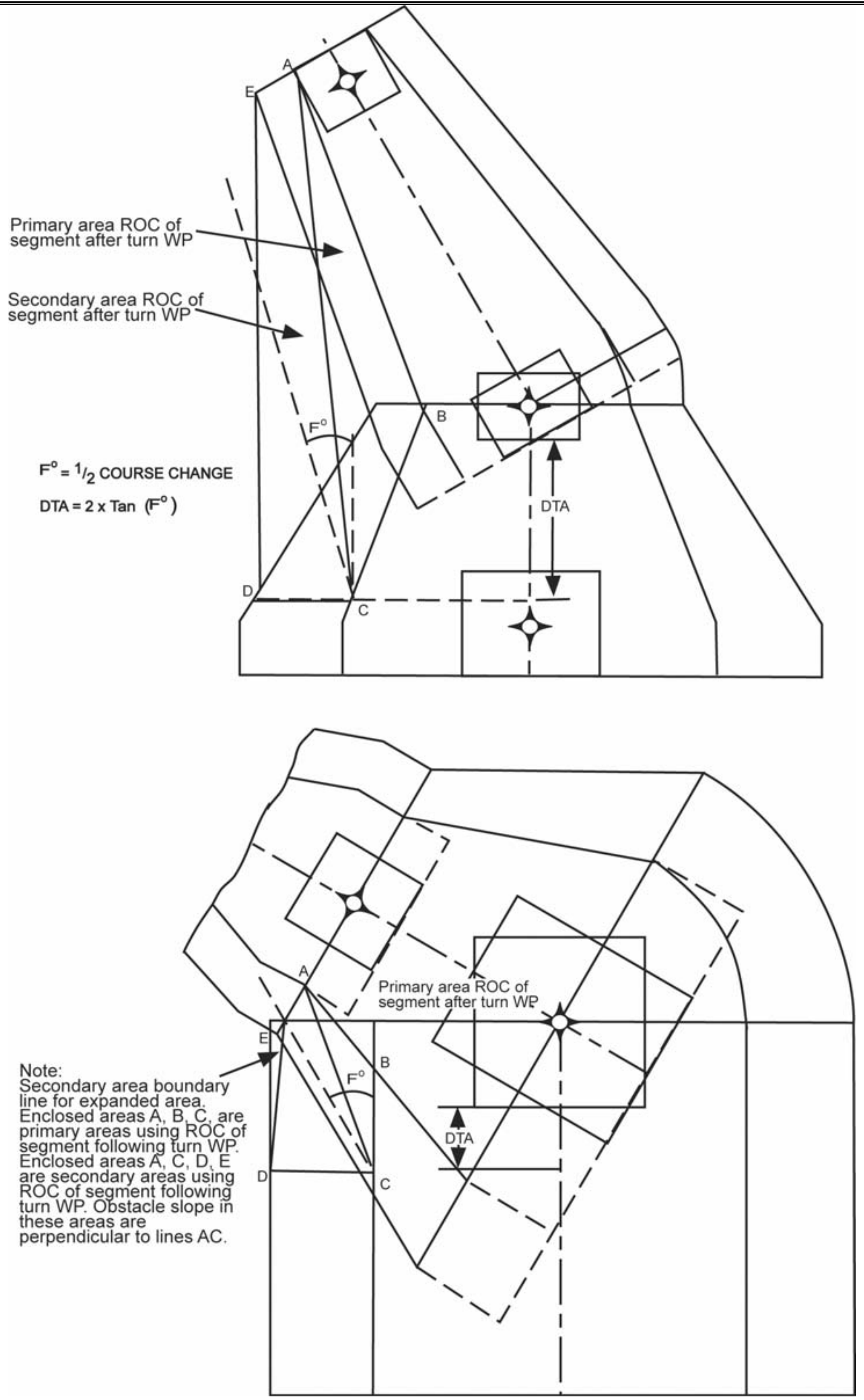


Figure 15-13: Shallow-Angled Turn Anticipation. Tapering Intermediate And Constant Width Segment ROC Applications. Para 1520.e. and f.

1521. Initial Approach Segment

The initial approach segment begins at IAWP and ends at the IWP. See Figures 15-15, 15-16 and 15-17. For VOR/DME systems, the distance from the reference facility to the IAWP shall not exceed 53 miles, nor exceed the TPD or ATD values associated with the limits of the 8 NM Zone shown in Figure 15-2.

a. Alignment. The angle of intercept between the initial and intermediate segment shall not exceed 120°.

b. Course Reversal. When the procedure requires a course reversal, a holding pattern shall be established in lieu of a procedure turn. Para 1507 applies. If holding is established over the FAF, the FAF shall be a WP, and Para 234.e.(1) applies. The course alignment shall be within 15° of the final approach course. If holding is established over the IWP, Para 234.e.(2) applies. The course shall be within 15° of the intermediate course. Where a feeder segment leads to the course reversal, the feeder segment shall terminate at the plotted position of the holding WP. See Figure 15-15.

c. Area.

(1) Length. The initial approach segment has no standard length. It shall be sufficient to permit any altitude changes required by the procedure and shall not exceed 50 miles unless an operational requirement exists.

(2) Width.

(a) Primary Area:

(i) VOR/DME. See Figure 15-18. In the 8 NM zone, the area is 4 NM on each side of the centreline. In the 4 NM zone, the area is 2 NM on each side of the centreline. A 30° splay connects the area boundaries, beginning where the route centreline crosses the 4 NM zone and splaying out as the ATD increases until reaching 4 NM each side of the centreline. In addition:

a) If the splay cuts across an area of the WP fix displacement area, retain the width of the wider area and connect the wider area boundary with the narrower.

b) If a short segment transits the 4 NM zone from the 8 NM zone and re-enters the 8 NM zone, retain the 8 NM zone.

c) If the initial approach and succeeding segments lie within the 4 NM zone, the 4 NM zone may be used throughout.

d) Segments shall not be decreased to 2 NM widths and then increased back to 4 NM widths.

e) The width of the primary area at the earliest point the IAWP can be received is equal to the width at the plotted position.

(ii) Non-VOR/DME. Two miles each side of centreline.

(b) Secondary area:

(i) VOR/DME. The area is 1 mile each side of the primary area where the route centreline lies within the 4 NM zone. The area is 2 miles each side of the primary area where the route centreline lies within the 8 NM zone. The area boundaries are connected by straight lines abeam the same points where the primary area boundaries connect. The width of the secondary area at the earliest point the IAWP can be received is equal to the width at the plotted position.

(ii) Non-VOR/DME. One mile on each side of the primary area.

d. Obstacle Clearance. Para 232.c applies. The note in Annex C, Figure C-3, 2 NM slant range, does not apply to non-VOR/DME.

e. Descent Gradient. Para 232.d and 288.a apply.

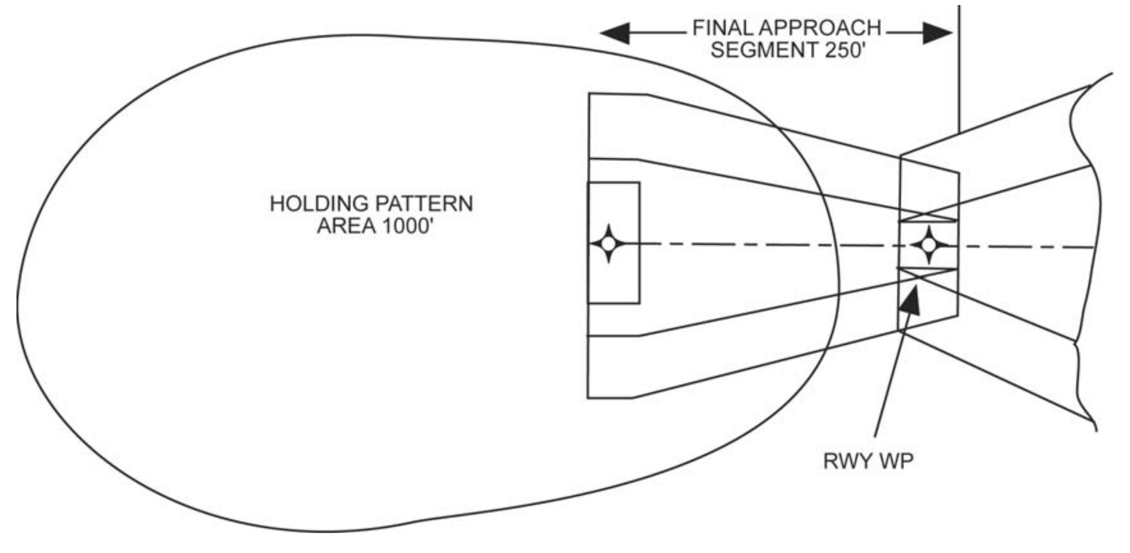


Figure 15-15: Holding Pattern And Final Approach With Associated ROC. Para 1521.b.

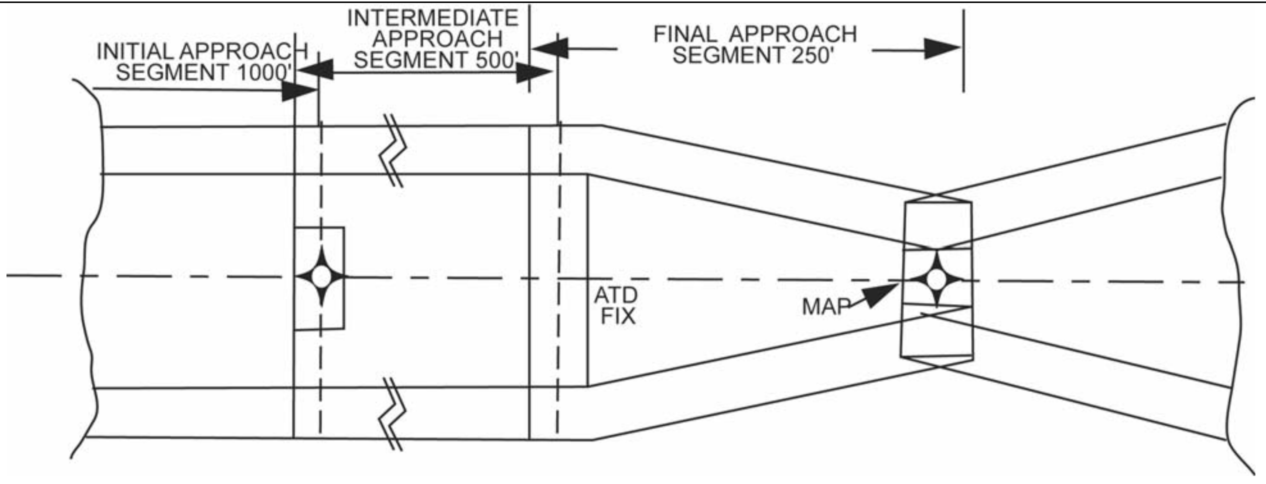


Figure 15-16: Initial, Intermediate, Final Approach With Associated ROC. Para 1521, 1522, and 1523.

1522. Intermediate Segment

The intermediate segment begins at the IWP and ends at the FAWP or ATD fix serving as the FAF. For VOR/DME systems, the distance from the reference facility to the IWP shall not exceed 53 miles, nor exceed the TPD or ATD values associated with the limits of the 8 NM zone shown in Figure 15-2.

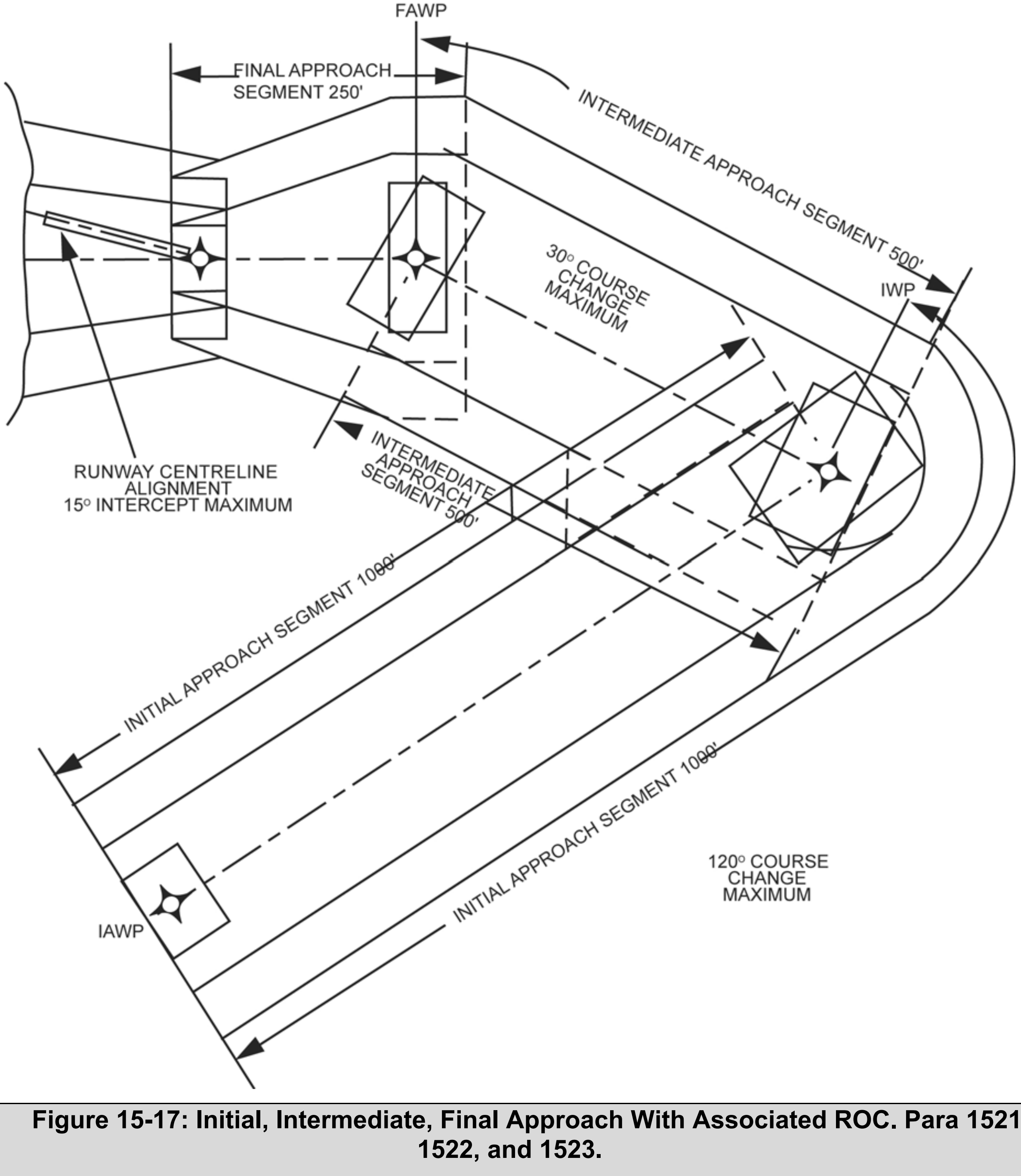


Figure 15-17: Initial, Intermediate, Final Approach With Associated ROC. Para 1521, 1522, and 1523.

a. Alignment. The course to be flown in the intermediate segment should be the same as the final approach course. When this is not practical, the intermediate course shall not differ from the final approach course by more than 30° and an FAWP shall be established at the turn point. See Figure 15-17.

b. Area.

   (1) Length. The intermediate segment shall not be less than 5 miles nor more than 15 miles in length. If a turn is more than 90° at the IWP, Chapter 2, Table 2-5 applies.

   (2) Width.

      (a) Primary area:

         (i) VOR/DME. The width of the intermediate primary area shall equal the width of the initial primary at the IWP. It shall either taper from a point abeam the IWP linearly to + 2 miles at the FAWP or ATD fix or shall be a constant + 2 miles, as appropriate. The width at the earliest point the IWP can be received shall equal the width at the plotted position.

         (ii) Non-VOR/DME. Two miles on each side of centreline.

      (b) Secondary area:

         (i) VOR/DME. The width of the intermediate secondary area shall be equal to the width of the initial secondary at the IWP and shall either taper linearly to ±1 mile at the FAWP or ATD fix or shall be a constant ±1 mile, as appropriate. The width at the earliest point the IWP can be received shall equal the width at the plotted position.

         (ii) Non-VOR/DME One mile on each side of the primary area.

c. Obstacle Clearance. Para 242.c applies.

d. Descent Gradient. Para 242.d applies.

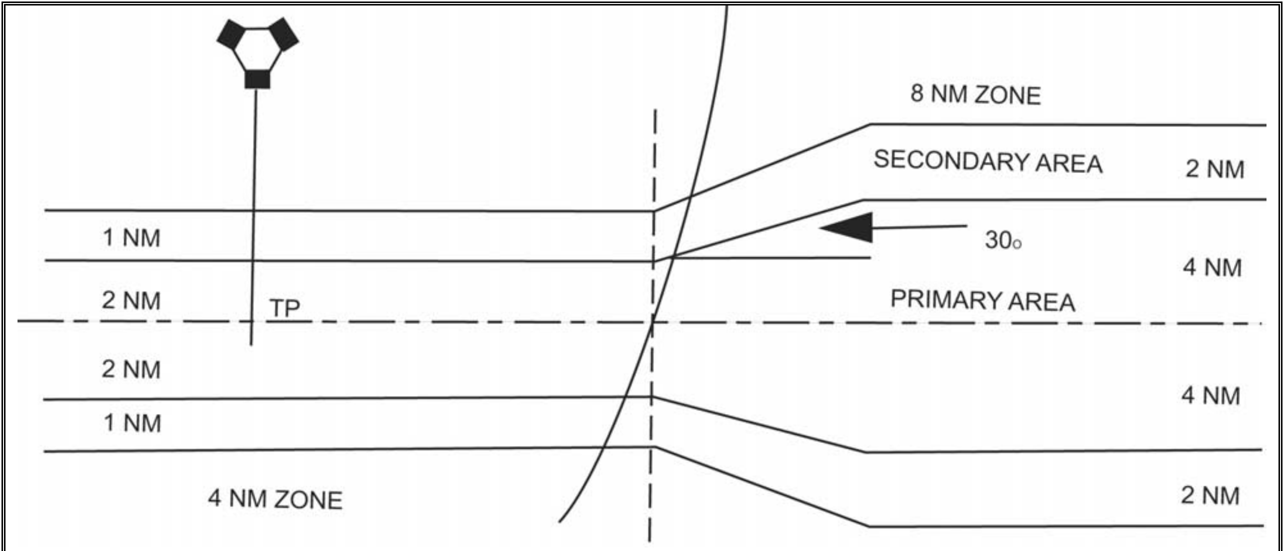


Figure 15-18: VOR/DME Basic Area. Para 1521.c.(2)(a)i.

1523. Final Approach Segment

The final approach segment begins at the FAWP or ATD fix and ends at the MAP. When the final course is a continuation of the intermediate course, an ATD fix should be used in lieu of a FAWP additional ATD fixes established, if necessary, as stepdown fixes or the MAP. For VOR/DME systems, the FAWP/ATD fix waypoint shall be limited to a TPD of 30 miles or less and within the limits of 4 NM zone shown in Figure 15-2.

Approach Category	**Magnitude of Turn over the Final Approach Waypoint (FAWP)**		
	0° - 5°	>5° - 10°	>10° - 30°
A	1.8	1.8	2.0
B	1.8	2.0	2.5
C	2.0	2.5	3.0
D	2.5	3.0	3.5
E	3.0	3.5	4.0

Table 15-4: Minimum Length Of Final Approach Segment (NM). Para 1523.b.1.

a. Alignment. The final approach course shall be aligned through the RWY or APT WP. For a straight- in approach, the alignment should be with the runway centreline. When the alignment exceeds 15°, straight-in minima are not authorized. For a circling approach, the final approach course should be aligned to the centre of the landing area, but may be aligned to any portion of the useable landing surface.

b. Area. The area considered for obstacle clearance starts at the earliest point of the FAWP or ATD fix displacement area, and for straight-in approaches, ends at the latest point of the RWY WP fix displacement area. For circling approaches, the area ends at the latest point of the APT WP fix displacement area.

   (1) Length. The optimum length of the final approach segment, measured between plotted fix positions, is 5 miles. The maximum length is 10 miles. The minimum length shall provide adequate distance for an aircraft to make the required descent and to regain course alignment when a turn is required over the FAWP. Table 15-4 shall be used to determine the minimum length of the final approach segment. Fix displacement area overlap restrictions stated in Para 1502 apply.

   (2) Width.

      (a) The final approach primary area is centred on the final approach course. It is 2 miles wide on each side of course at the earliest position the FAWP/ATD fix can be received. See Figures 15-15 and 15-16. This width remains constant until the latest point the FAWP/ATD fix can be received. It then tapers to the width of the XTRK fix displacement tolerance at the latest point the RWY WP or APT WP can be received. Fix displacement tolerance dimensions are shown in Table 15-2 for VOR/DME systems and in Table 15-3 for non-VOR/DME systems.

      (b) A secondary area 1 mile wide is established on each side of the primary area. See Figures 15-15 and 15-16.

c. Obstacle Clearance.

   (1) Straight-in. The minimum required obstacle clearance (ROC) in the primary area is 250 feet. In the secondary area, the ROC of the primary area is provided at the inner edge, tapering uniformly to zero at the outer edge.

   (2) Circling. A minimum of 300 feet of ROC shall be provided in the circling approach area. Para 260.b applies.

d. Descent Gradient. The optimum descent gradient is 318 feet-per-NM. Where a higher gradient is necessary, the maximum permissible is 400 feet-per-NM.

e. Using Fixes for Descent. Para 288.a, b, c.(3), c.(4)(a) and 289 apply.

f. RNAV Descent Angle Information. Para 252 applies.

1524—1529. Reserved

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SECTION 3. MISSED APPROACH

1530. General

For general criteria, refer to Chapter 2, Section 7. In the secondary areas, no obstacle may penetrate the 12:1 surface extending upward and outward from the 40:1 surface at the edge of the inner boundaries at a right angle to the missed approach course.

1531. Missed Approach Segment

The missed approach segment begins at the MAP and ends at a point designated by the clearance limit. These criteria consider two types of missed approaches. They are identified as RNAV and non-RNAV missed approach procedures and defined as follows:

a. RNAV.

  (1) Route. Positive course guidance provided by RNAV systems is required throughout the missed approach segment. The length of the segment is measured point-to-point between the respective (plotted position) waypoints throughout the missed approach procedure.

    (a) A WP is required at the MAP and at the end of the missed approach procedure. A turn waypoint may be included in the missed approach procedure.

    (b) A straight, turning, or combination straight and turning missed approach procedure may be developed. Waypoints are required for each segment within the missed approach procedure.

    (c) Turns shall not exceed 120°.

    (d) A minimum leg length is required to allow the aircraft's stabilization on course immediately after the MAP. See Table 15-5 for minimum distances required for each category of aircraft based on course changes.

    (e) For the combination straight and turning missed approach, the distance between the latest point the MAP can be received and the earliest point the turn WP can be received shall be sufficient to contain the length of turn anticipation distance required. This segment shall be aligned within 15° or less of the extended FAC.

  (2) Direct. A direct missed approach may be developed to provide a method to allow the pilot to proceed to a waypoint that is not connected to the MAP by a specified course. Positive course guidance is not assumed during the entire missed approach procedure.

    (a) An ATD fix may be specified as the MAP.

    (b) A straight, turning, or combination straight and turning missed approach may be developed.

    (c) The combination straight and turning missed approach procedure shall be a climb from the MAP to a specified altitude. The end of the straight section shall be established by an altitude, and this segment shall be aligned with the final approach course. The length of the straight section shall be determined by subtracting the lowest MDA of the procedure from the height of the turning altitude in the missed approach and multiplying by 40. The distance is measured from the latest point the MAP can be received.

    (d) Turns may exceed angles of 120°.

b. Non-RNAV Missed Approach Procedures. Chapter 2, Section 7 is applicable for non-RNAV missed approach criteria with the following exceptions: the connection for the missed approach area and the origination points of the 40:1 evaluation obstruction slope at the MAP, and the area for early turns begin at the earliest point the WP or ATD fix can be received. The area connects at the MAP as described in Para 1532, 1533, 1534 and 1535. The tie-backs and evaluations are established and conducted as outlined in this chapter of the RNAV missed approach criteria.

	Course Change at MAP				
CAT	**>15° ≤ 30°**	**≤ 45°**	**≤ 60°**	**≤ 90°**	**≤ 120°**
	Minimum Leg Length (nm), between MAP and next WP				
A	3.0	4.0	5.0	5.9	6.9
B	3.0	4.0	5.2	6.2	7.2
C	3.0	4.2	5.5	6.5	7.6
D	3.0	4.5	6.0	7.3	8.5
E	3.0	5.5	7.8	9.5	11.3

Table 15-5: Minimum Leg Length From MAP To Next WP Using RNAV Missed Approach Procedure. Para 1531.a(1)(d).

1532. Missed Approach Point

The MAP shall be located on the final approach course and is normally located at the RWY WP or APT as appropriate. It may be designated by an ATD fix defined relative to the distance from the RWY or WP. The MAP shall be no further from the FAF than the RWY or APT WP, as appropriate. The area of MAP ATD displacement tolerance may overlap the plotted position of the RWY or APT WP. The lateral for the area of the ATD fix are considered the same as the lateral dimensions of the primary area.

1533. Straight Missed Approach

Straight missed approach criteria are applied when the missed approach course does not differ more than 15° from the final approach course.

a. Area.

(1) When the MAP is at the RWY WP or APT WP, the area starts at the earliest point the MAP can be received and has the same width as the area for the WP displacement tolerance at the RWY WP or APT WP, as appropriate. The secondary areas are 1 mile each side of the primary area at the earliest point the MAP can be received. See Figure 15-20.

(2) When the MAP is at an ATD fix, the area starts at the earliest point the MAP can be received and has the same width as the final approach primary and secondary areas at that point. See Figure 15-21.

(3) The area expands uniformly to a width of 6 miles each side of the course line at a point 15 flight track miles from the plotted position of the MAP. When positive course guidance is provided, the secondary areas splay linearly from a width of 1 mile at the MAP to a width of 2 miles at the end of the 15–mile area. The splay of these areas begins at the earliest point the MAP can be received.

(4) When a turn of 15° or less causes the outside edge of the primary missed approach boundary to cross inside the lateral dimensions of the fix displacement area of the MAP, that boundary line is then constructed from the corner of the lateral dimension of the area abeam the latest point the MAP can be received. This point is identified as Point A at the MAP when represented by a WP or an ATD fix is established as the MAP. See Figures 15-22 and 15-23, respectively.

Figure 15-19: Reserved

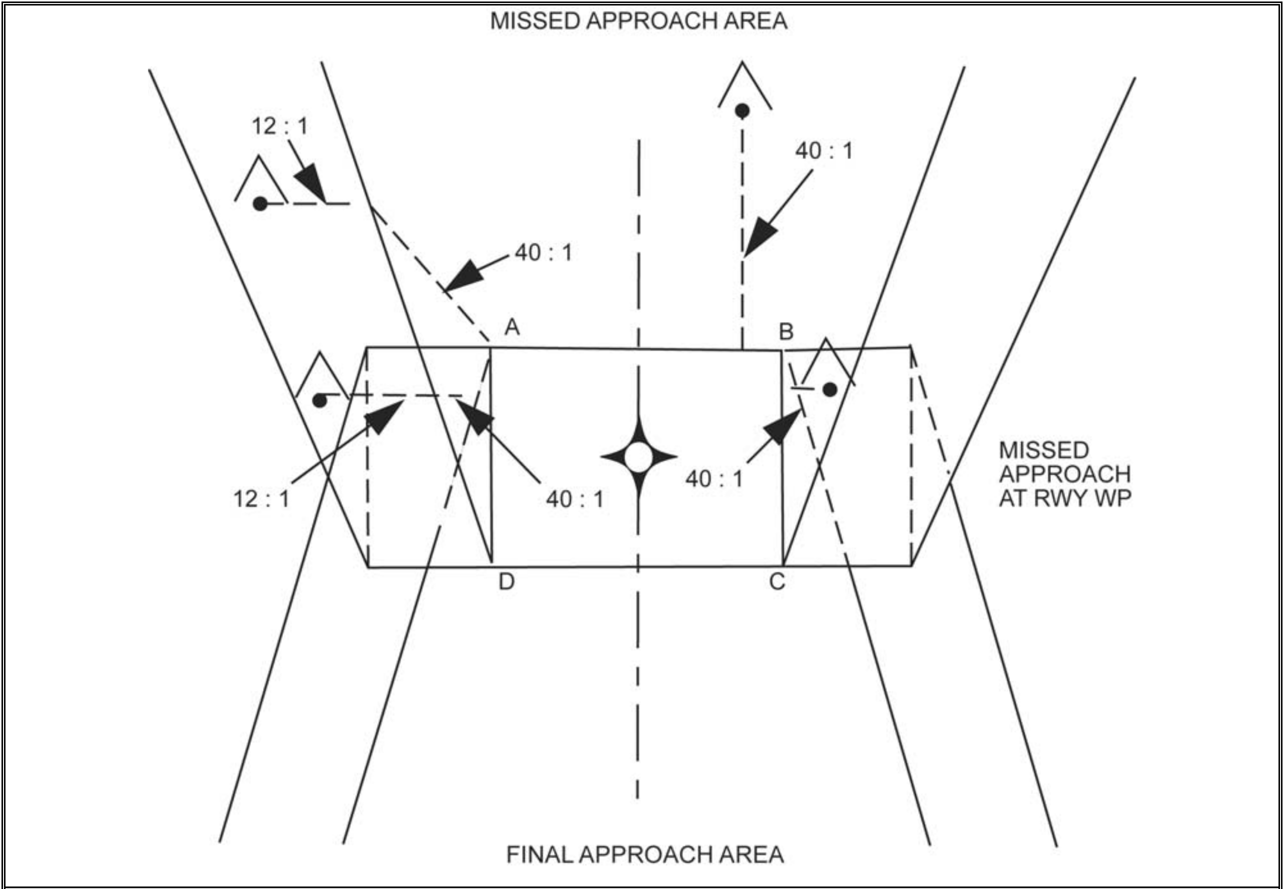


Figure 15-20: Straight Missed Approach At The RWY WP. Para 1533.a.(1).

b. Obstacle Clearance. The 40:1 missed approach surface begins at the edge of the area of the WP displacement tolerance or the displacement area of the ATD fix of the MAP identified as the line D-A-B-C in Figures 15-20 and 15-21. For the triangular area shaded in Figures 15-21 and 15-22 resulting from a skewed course of 15° or less, the 12:1 is measured from Point A. The obstacle slope is established by measuring the shortest distance from the line D-A-B-C to the obstacle. See Figures 15-22 and 15-23. The height of the missed approach surface at the beginning is determined by subtracting the required final approach obstacle clearance and any minima adjustments from the MDA. In the secondary area, no obstacle may penetrate the 12:1 surface extending upward and outward from the surface at the inner boundaries of a right angle to the missed approach course.

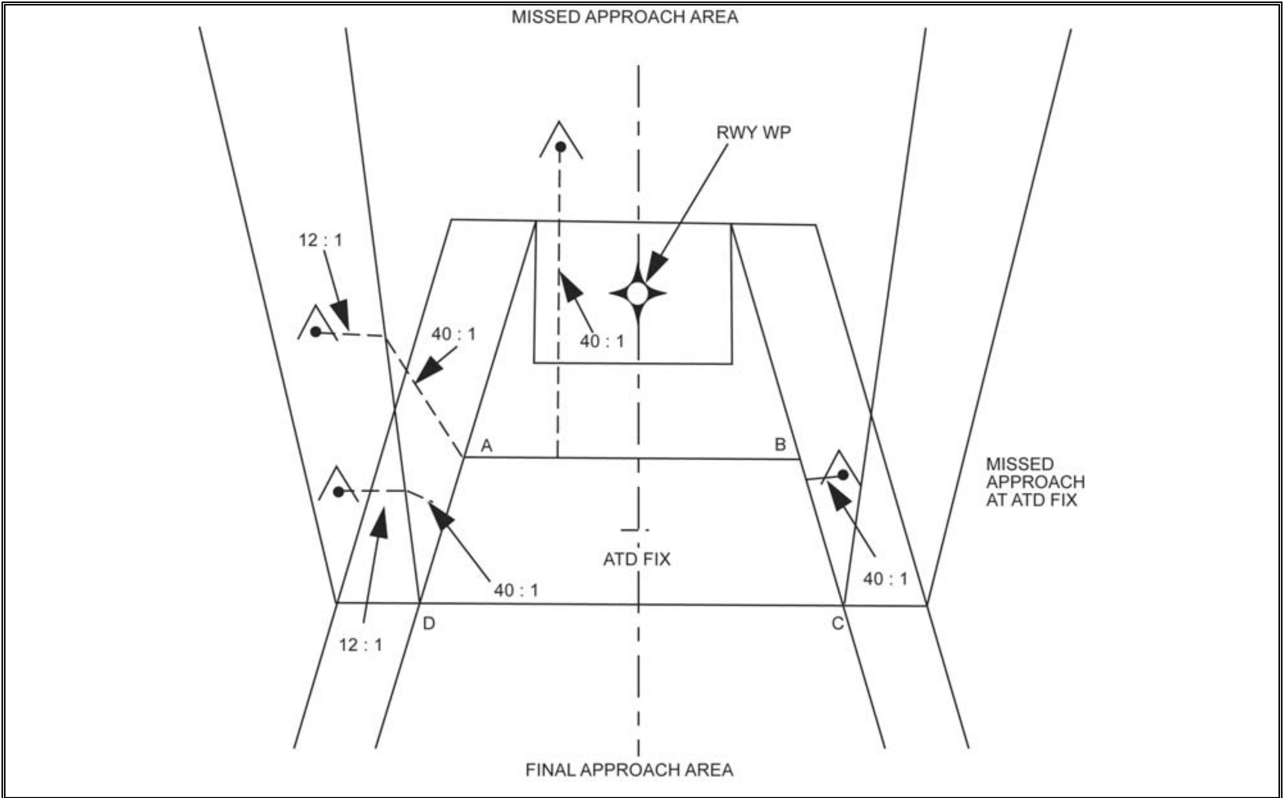


Figure 15-21: Straight Missed Approach At An ATD FIX. Para 1533.a.(2).

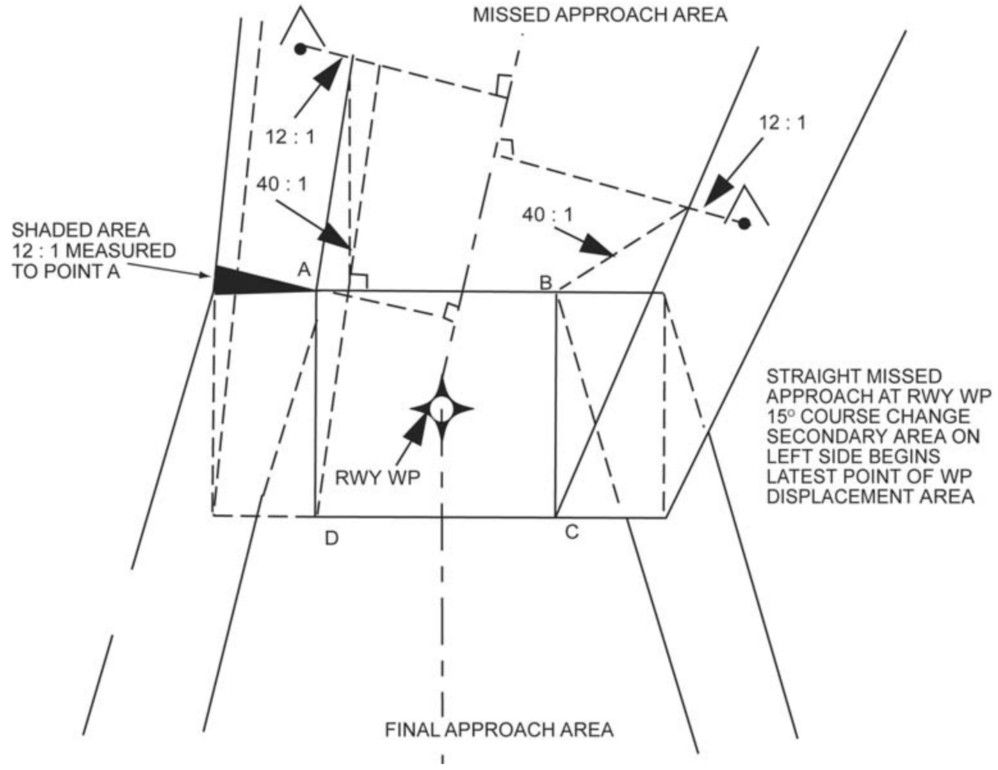


Figure 15-22: Construction Of Straight Missed Approach When Turns ≤ 15° Cause Outside Boundary To Cross Inside MAP Fix Displacement Tolerance At RWY WP. Para 1533.a.(4).

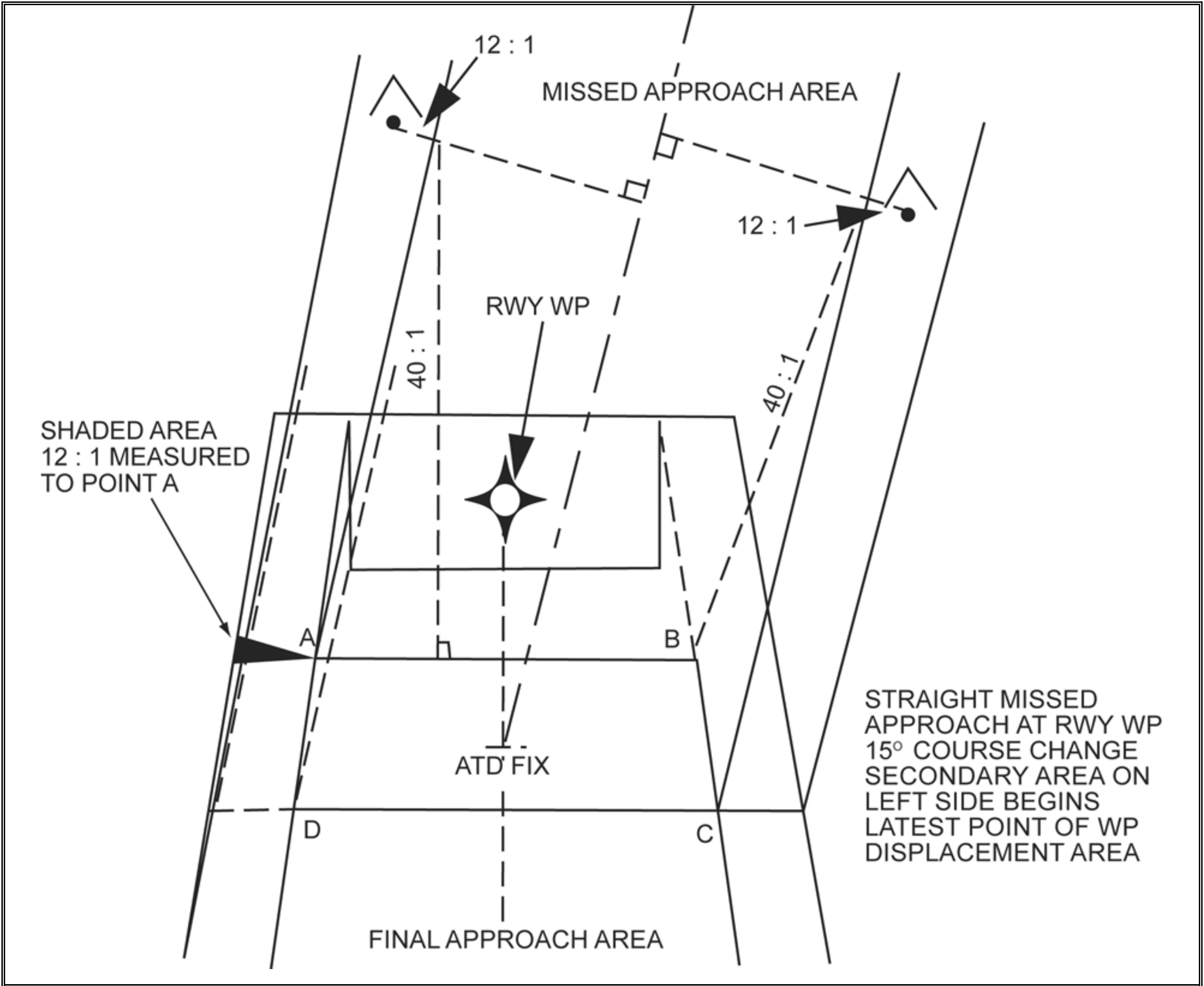


Figure 15-23: Construction Of Straight Missed Approach When Turns ≤ 15° Cause Outside Boundary To Cross Inside MAP Fix Displacment Tolerance At An ATD Fix. Para 1533.a.(4).

1534. Turning Missed Approach

Turning missed approach criteria apply whenever the missed approach course differs by more than 15° from the final approach course.

a. Area.

(1) Zone 1 begins at a point abeam the latest point the MAP can be received. See Figure 15-24.

(2) The turning missed approach area should be constructed by the methods described in Para 275, except as follows:

(a) The radii for the outer boundary is constructed from a baseline at the latest point the MAP can be received.

(b) Where the width "d" of the final approach area at the latest point the MAP can be received exceeds the value of the radius of the outer boundary "R" in Chapter 2, Table 2-5, use "wide final approach area at the MAP" construction methodology. If the width "d" is less than or equal to "R", use "narrow" methodology. See Figure 15-24. Point C_1, for turns of 90° or less, connects to the WP or fix displacement area at Point C, which is located at the earliest point the MAP can be received. See Figures 15-25 and 15-27. Point C_1, for turns more than 90°, connects to the corner of the WP or fix displacement area at the non-turn side at Point D at the earliest point the MAP can be received. See Figures 15-26 and 15-28. Point C_1, for turns which expand the missed approach area boundary beyond line E-D-Z, connects to Point E. See Figure 15-30. Point C_1, for turns beyond line E-Z, (parallel to the final approach course line), connects to Point E_1, a TP of the obstacle boundary arc. See Figures 15-29 and 15-30.

b. Obstacle Clearance. The 40:1 obstacle clearance surface begins at the edge of the WP or fix displacement area of the MAP. The height of the missed approach surface over an obstacle in Zone 2 is determined by measuring a straight-line distance from the obstacle to the nearest point on the A-B-C line and computing the height based on the 40:1 ratio. See Figure 15-25. The height of the missed approach surface in Zone 3 is determined by measuring the distance from the obstacle to Point C as shown in Figure 15-25 and computing the height based on the 40:1 ratio. The height of the missed approach surface over Point C for Zone 3 computations is the same height as the MDA less adjustments specified in Para 323.a, b and c.

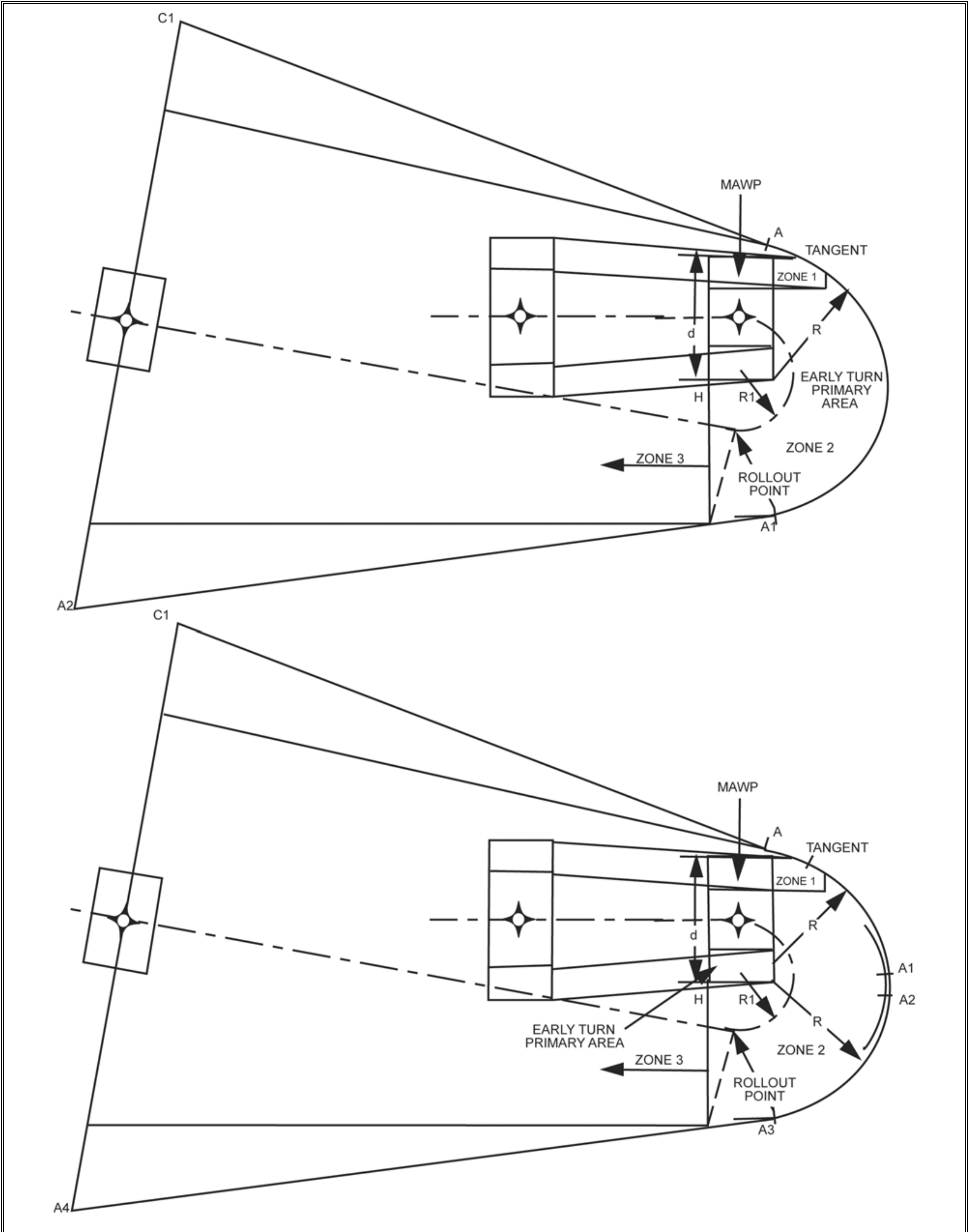


Figure 15-24: Wide And Narrow Missed Approach Methodology. Para 1534.a.(2)(b).

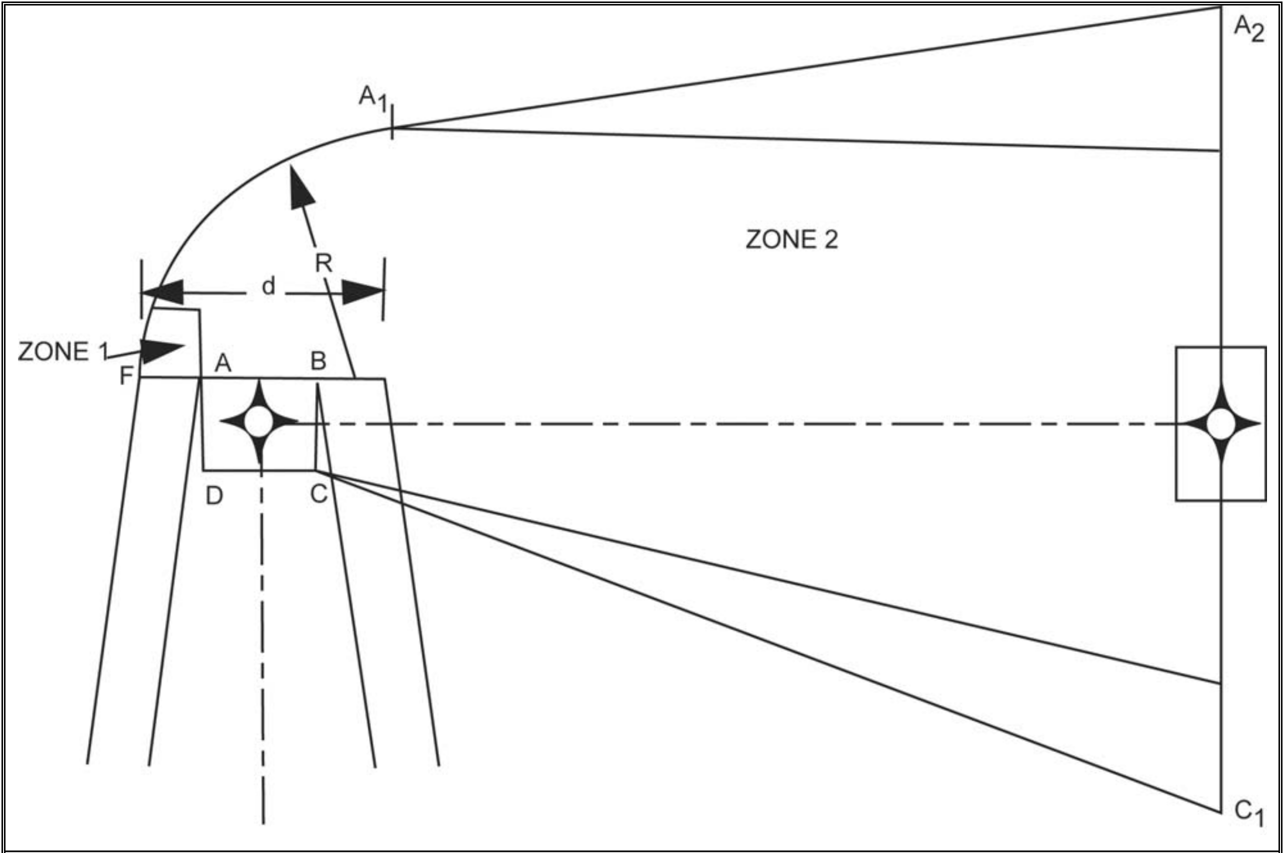


Figure 15-25: RNAV Turning Missed Approach, 90° Or Less. Para 1534.a.(2)(b).

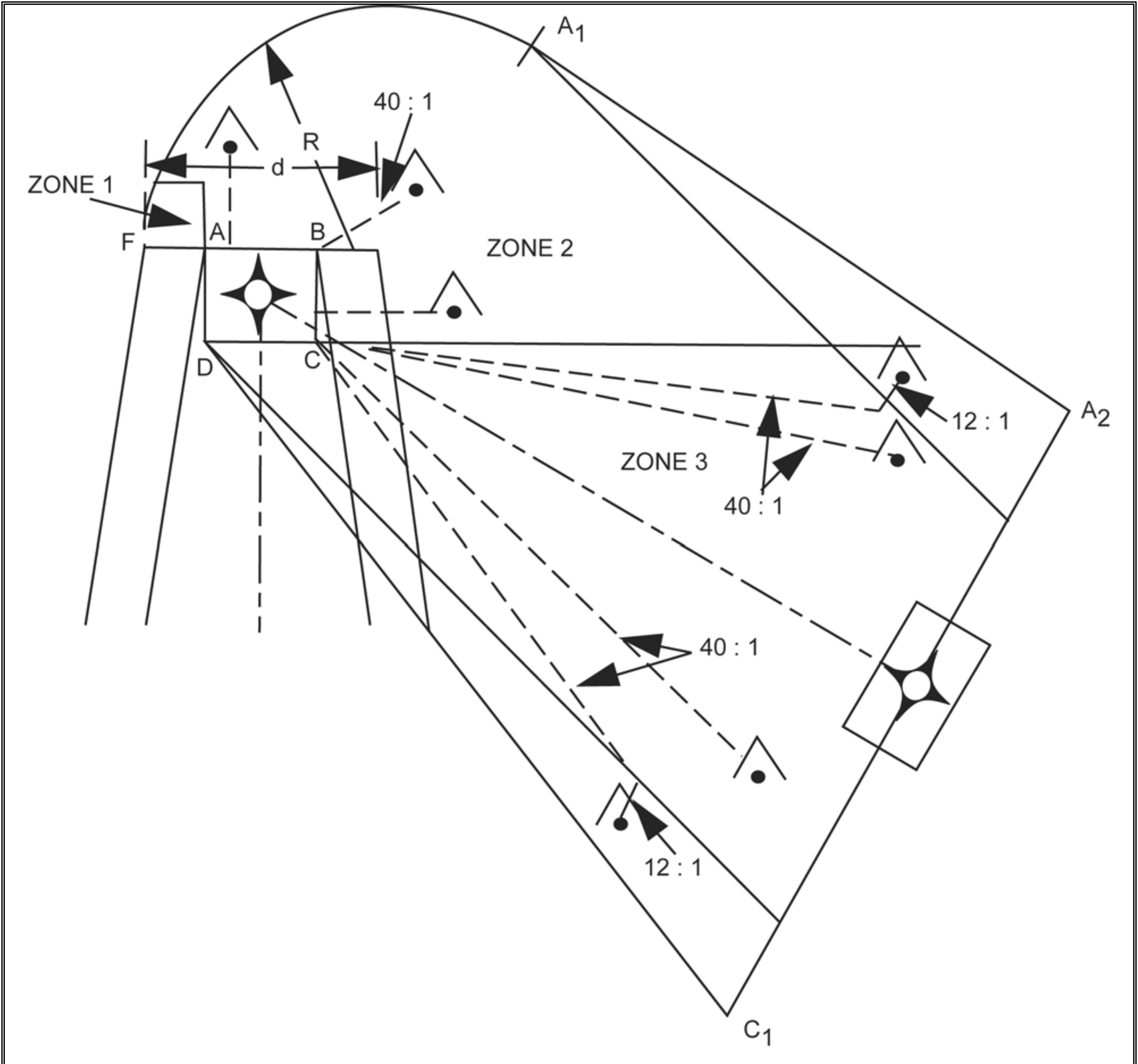


Figure 15-26: RNAV Turning Missed Approach, More Than 90° Up To 120°.
Para 1534.a.(2)(b).

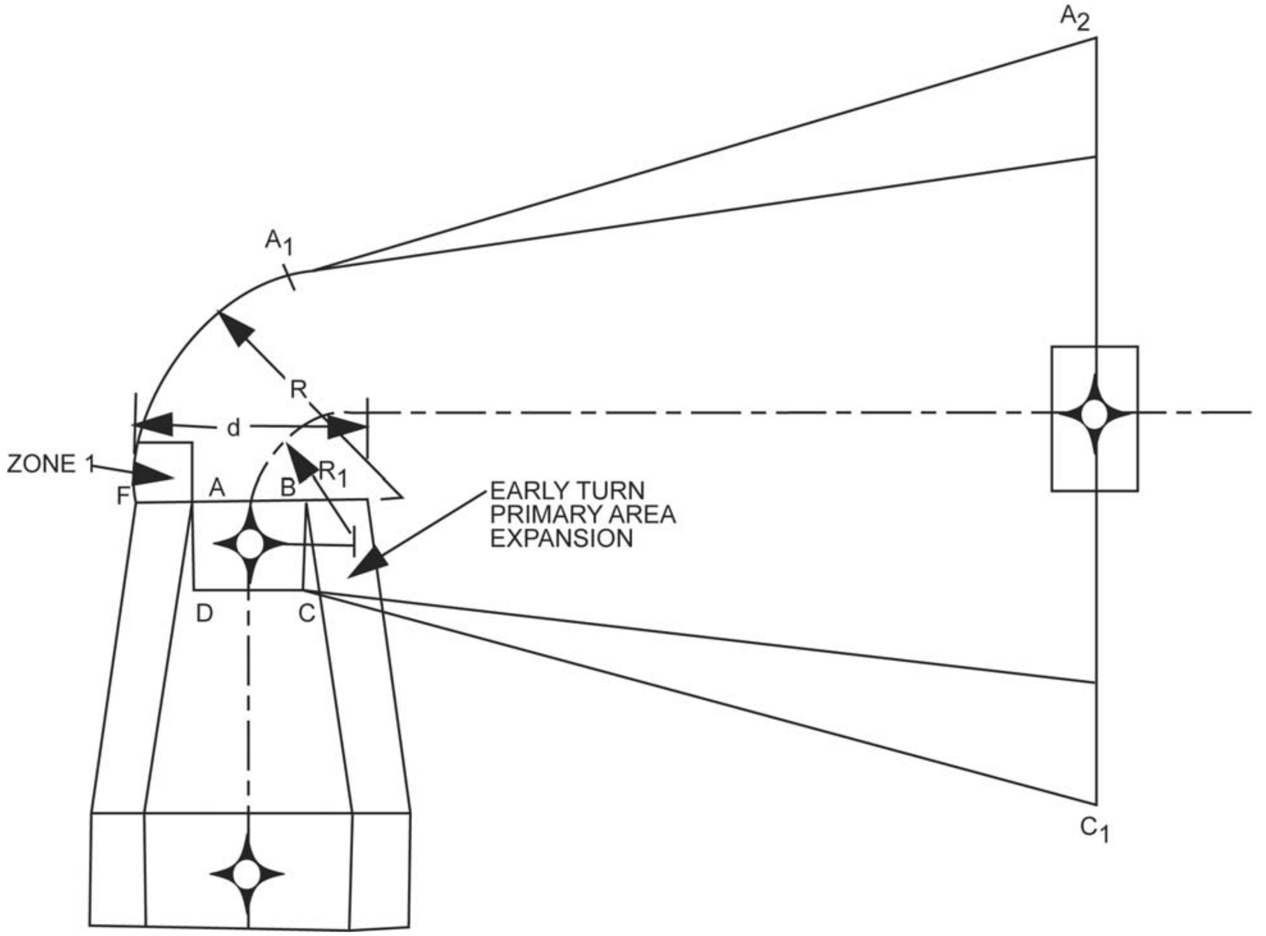


Figure 15-27: Direct Turning Missed Approach, <_ 90° Tie-Back Point C_1 To Point C. Para 1534.a.(2)(b).

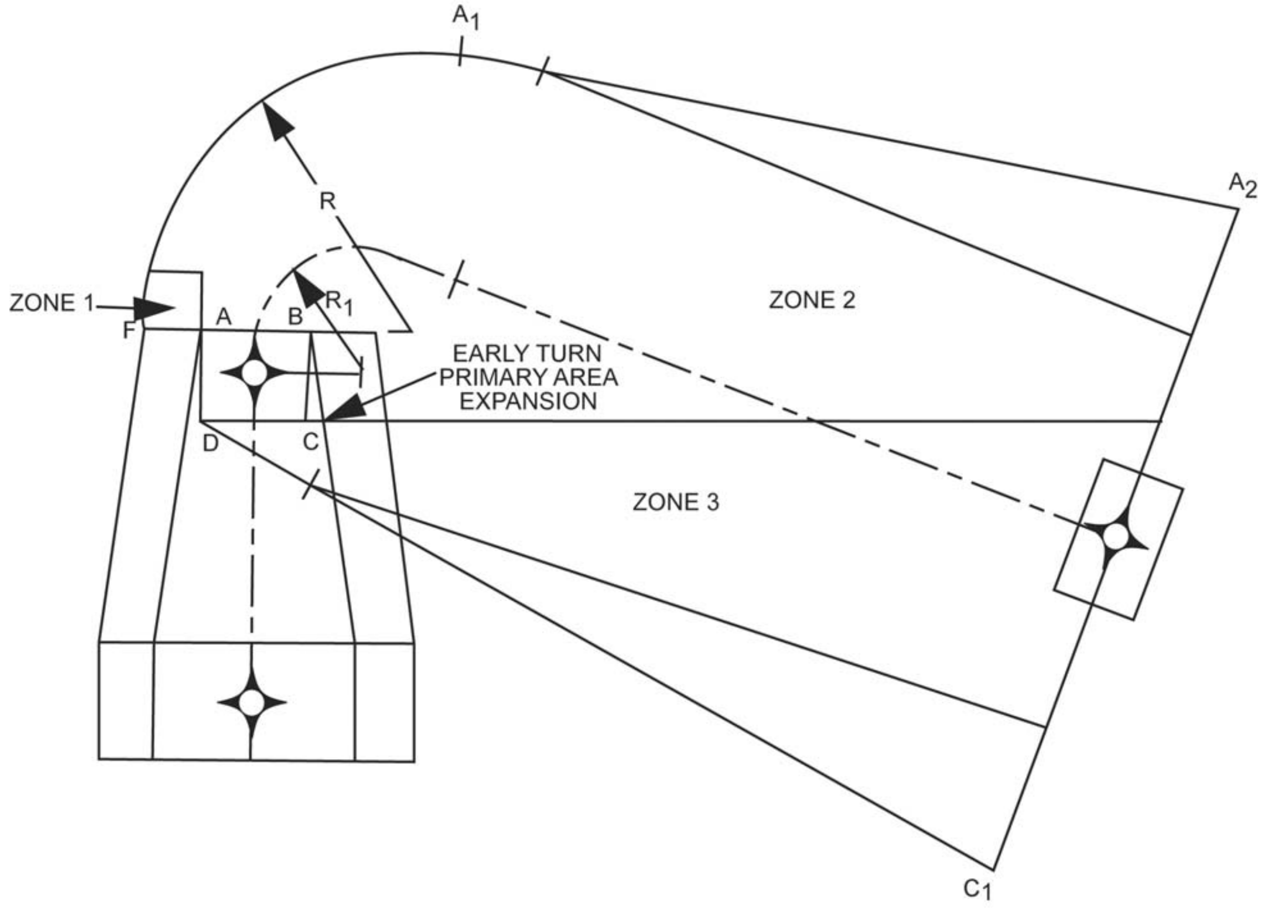
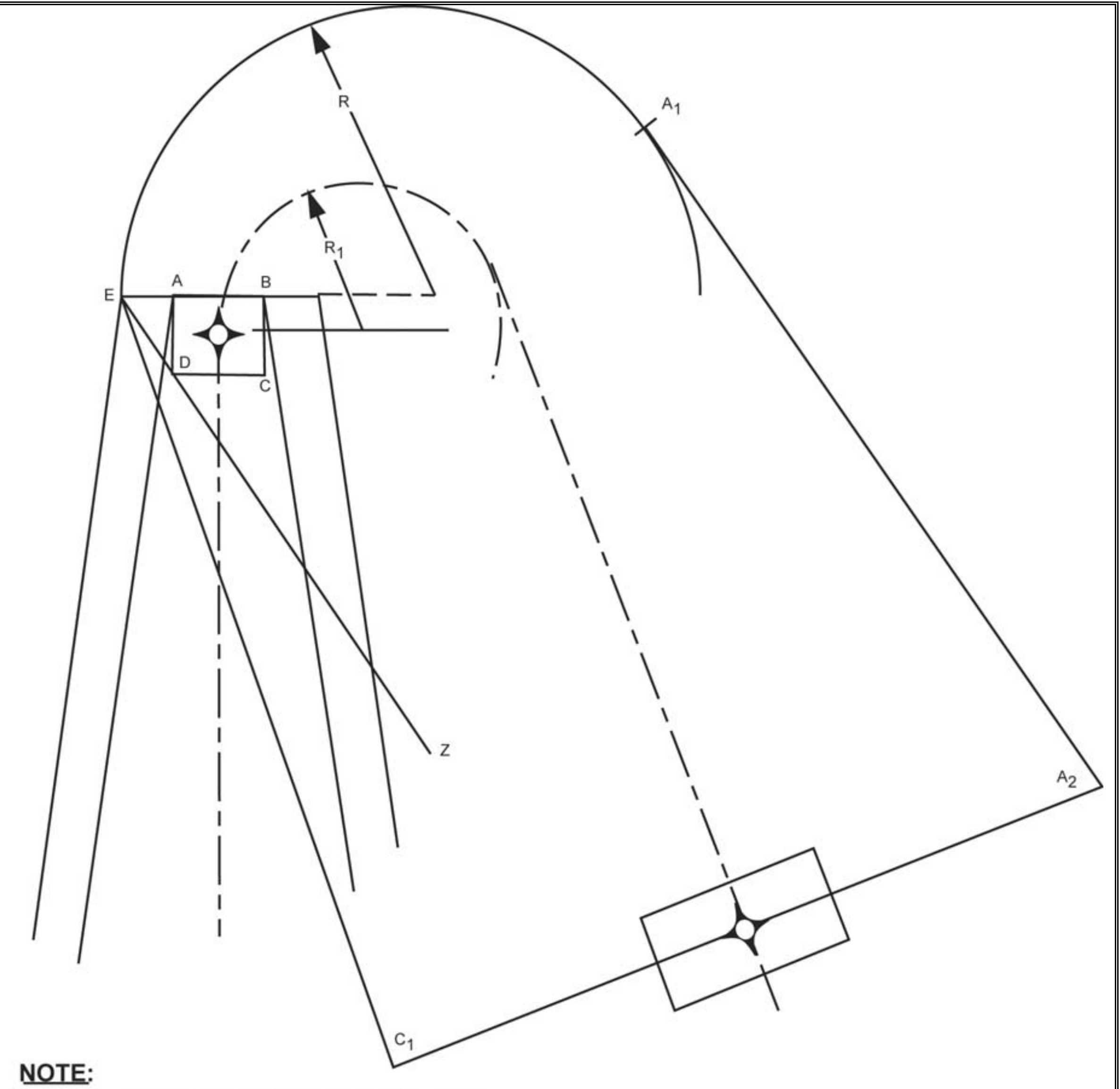
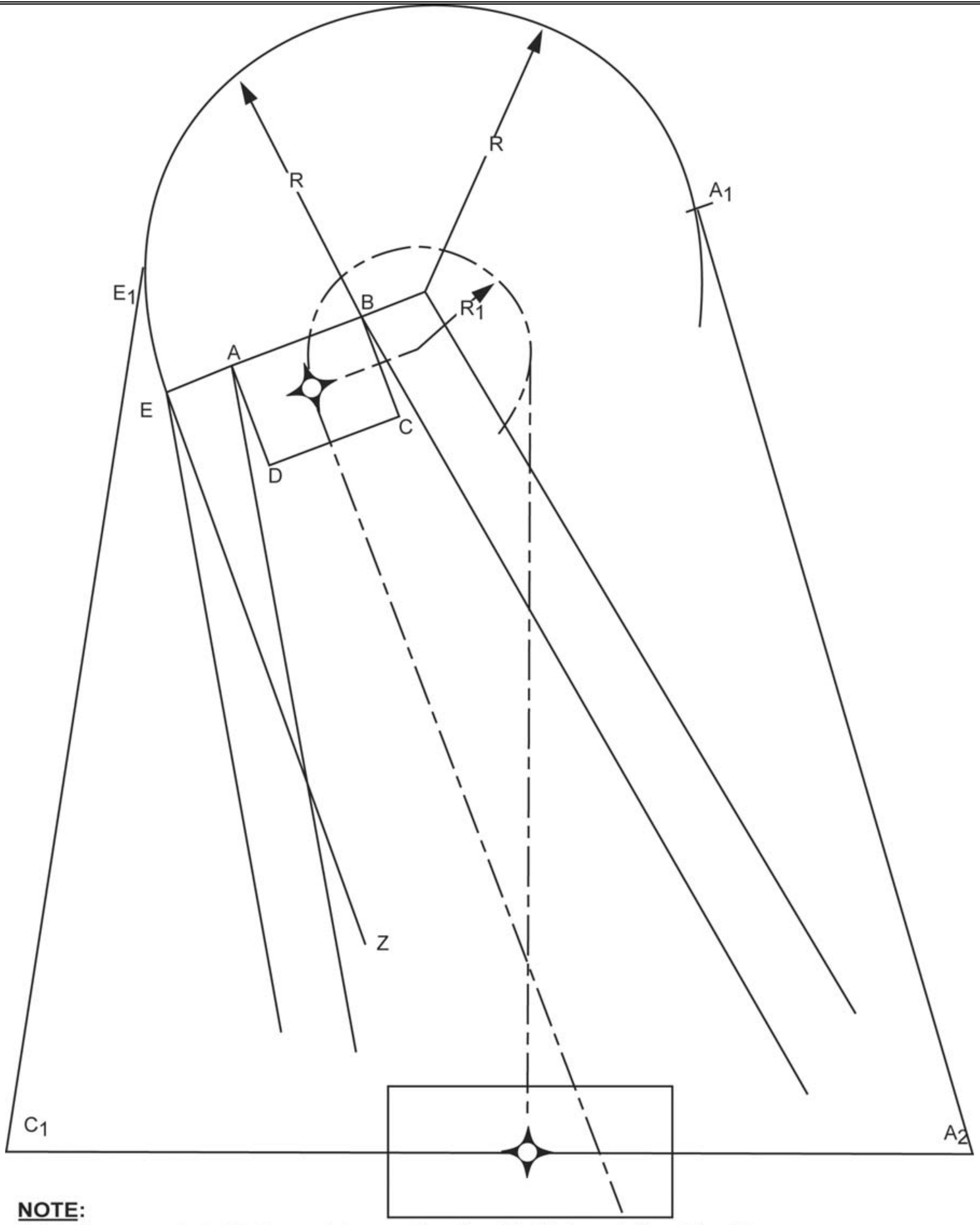


Figure 15-28: Direct Turning Missed Approach, >90° Tie-Back Point C_1 To Point D. Para 1534.a.(2)(b).



NOTE:
Point C_1 connects to point E when C_1-E is outside of line E-Z. E-Z is established by drawing an extended line through D and E.

Figure 15-29: Direct Turning Missed Approach, >90°. Para 1534.a.(2)(b).



NOTE:
Point C_1 connects to E_1 tangent to arc when line C_1-E_1 is outside of line E-Z. E-Z is established parallel to final approach course line.

Figure 15-30: Direct Turning Missed Approach, >180°. Para 1534.a.(2)(b).

1535. Combination Straight And Turning Missed Approach

a. Area.

(1) Section 1 is a portion of the normal straight missed approach area and is constructed as specified in Para 1533. See Figure 15-30. The end of Section 1 is based on a turn at a WP, or a climb to an altitude prior to commencing a turn.

(2) RNAV Route Missed Approach Procedure. A turn WP is used to base the length of Section 1 for a route RNAV missed approach procedure.

(a) Secondary area reductions apply except where the turn exceeds 90°, when the reduction applies only on the non-turning side. See Figure 15-31.

(b) For VOR/DME systems, the turn WP shall be limited to a TPD of 30 NM or less and to within the 4 NM zone.

(c) A turn anticipation area shall be constructed at the turn point.

(d) Construction.

(i) Points F, T_1,T_2, and J represent the end of Section 1. For turns of 90° or less, Point C_1 connects to J. See Figure 15-30. For turns of more than 90°, Point C_1 of Section 3 connects to Point T_2 See Figure 15-31.

(ii) The radius for the obstruction boundary is measured from a base line at the latest point the turn WP can be received.

(iii) The outer boundary line connects tangentially to the outside radius of the boundary arc. Then, the secondary area boundary connects to that line at the point abeam the plotted position of the turn WP. See Figures 15-31 and 15-32.

(3) RNAV Direct Procedure. For an RNAV direct missed approach, the end of Section 1 is based on a climb to altitude, and secondary area reductions are not applied.

(a) The end of Section 1 is established as described in Para 1531.a.(2)(c). Positive course guidance is not assumed, and secondary area obstruction clearance may not be applied. The end of Section 1 is represented by line H-T_3. See Figure 15-32.

(b) Construction.

(i) A base line extension of line G-D-C separates Sections 2 and 3. When Point C1 is established prior to the base line, C1 connects to Point C. See Figure 15-32.

(ii) When C1 is established beyond the base line, but inside line G-Z, C1 connects to Point G. G-Z is established parallel to the FAC line. See Figure 15-33.

(iii) When Point C1 is established beyond an area of line G-Z, C1 connects to Point H. See Figure 15-34.

(iv) When Point C1 is established beyond an area of line H-Z, C1 connects to Point K, a tangent point on the boundary arc. H-Z is established parallel to the final approach course line. See Figure 15-35.

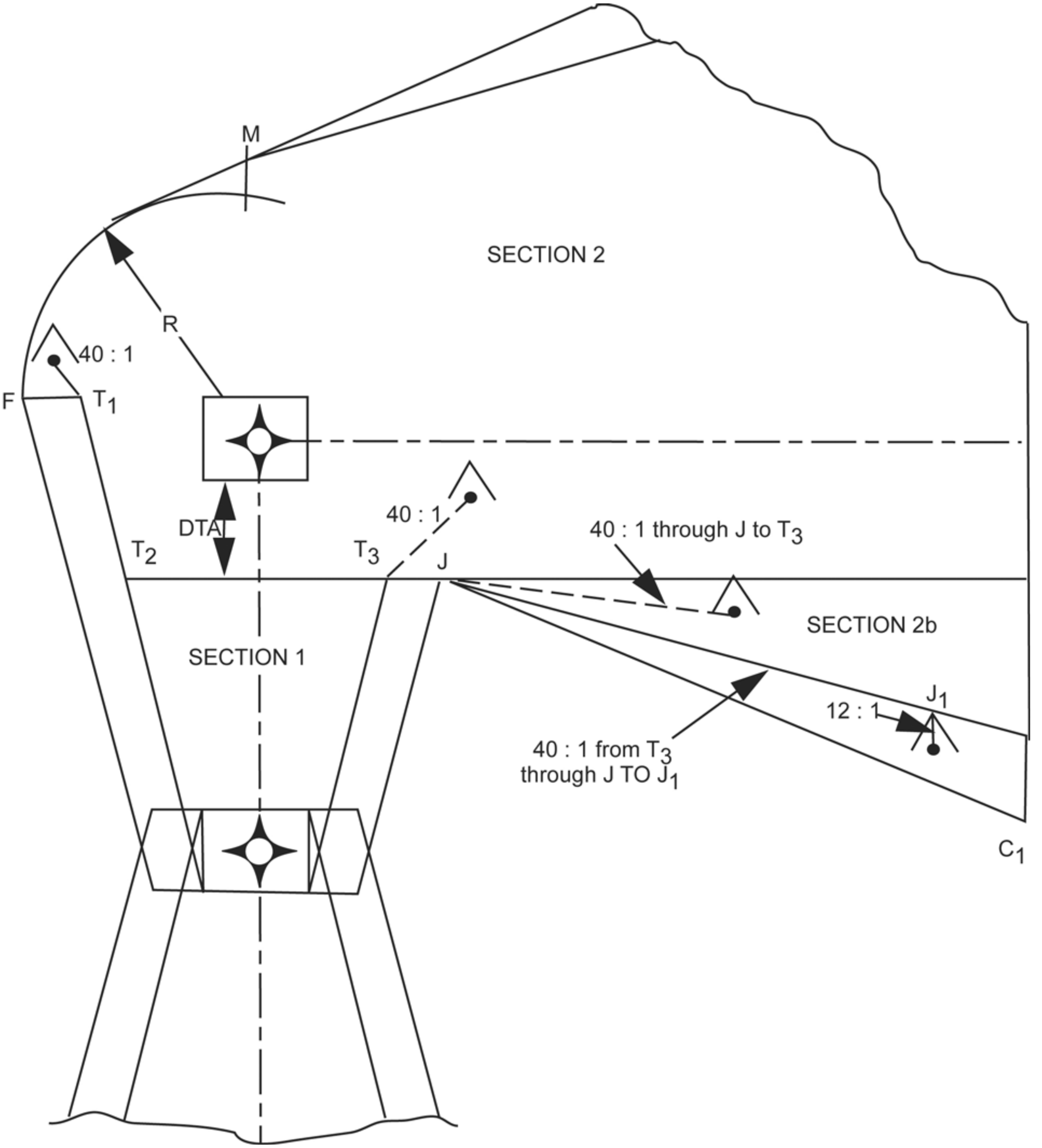


Figure 15-31: RNAV Combination Straight And Turning Missed Approach 90° Or Less. Para 1535.a.(2) and 1535.b.(1)(b).

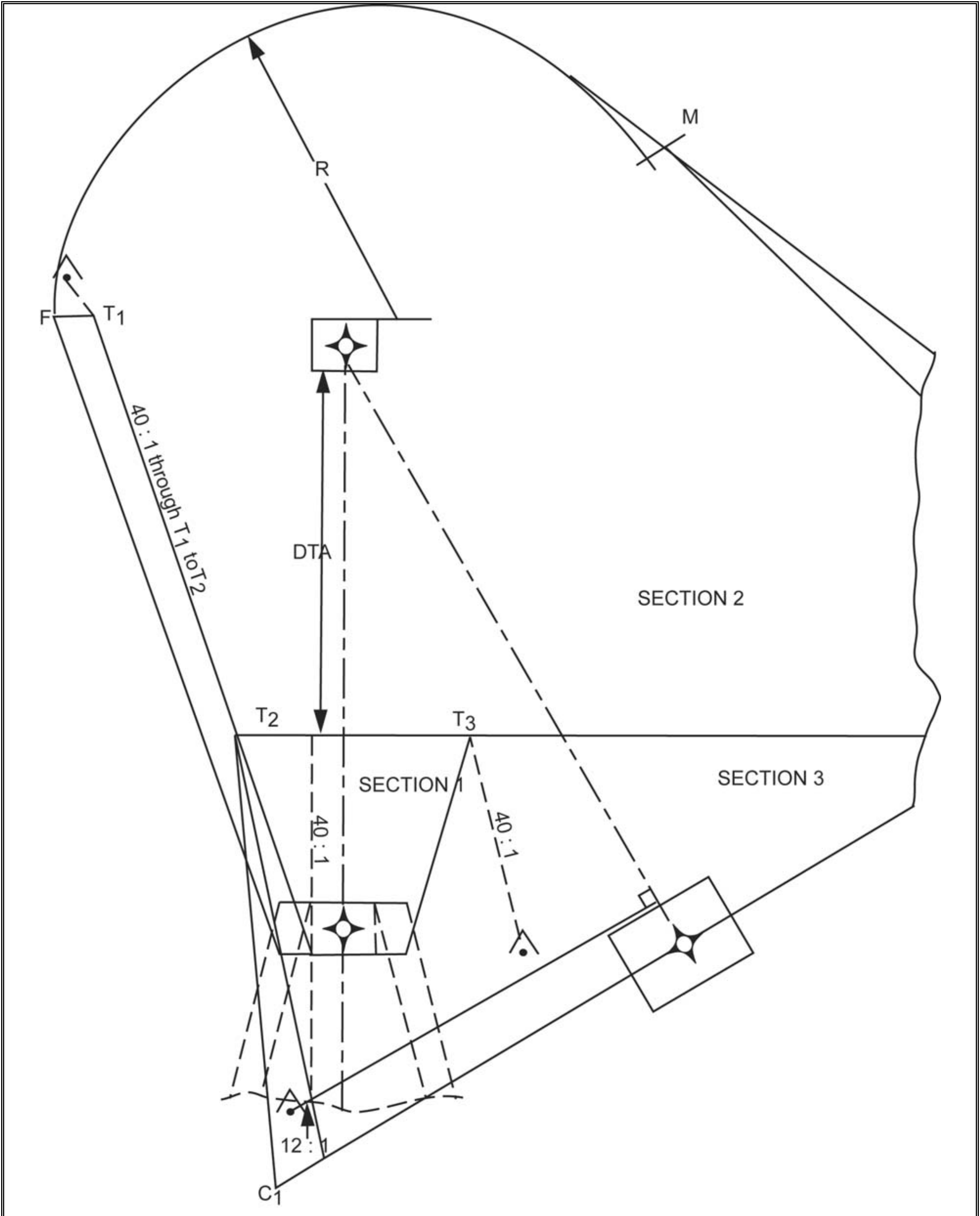


Figure 15-32: RNAV combination straight and turning missed approach. More than 90° up to 120°. Para 1535.a.(2).

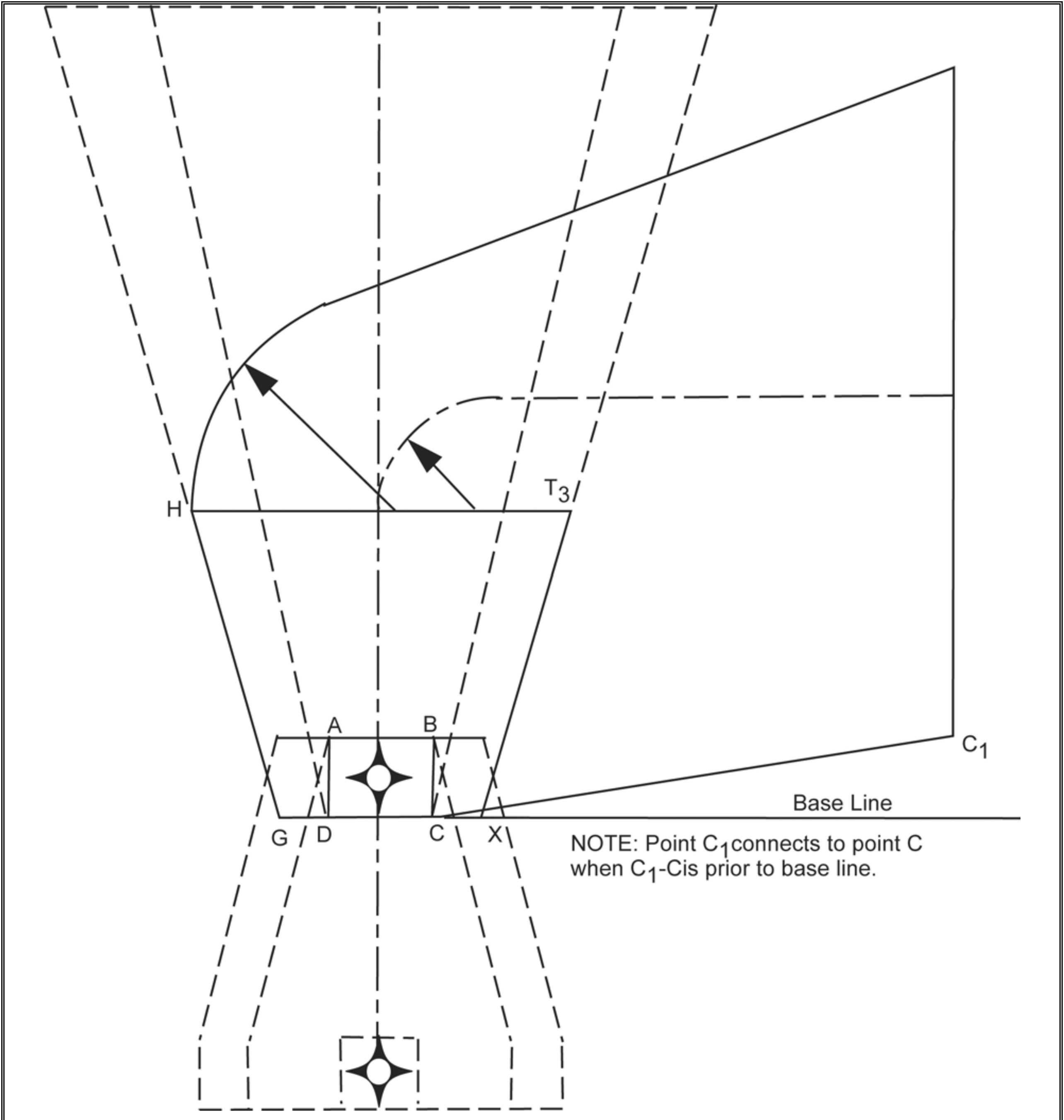


Figure 15-33: Climb To Altitude, Straight And Turning Missed, C_1 Prior To Base Line. Para 1535.a.(3)(a).

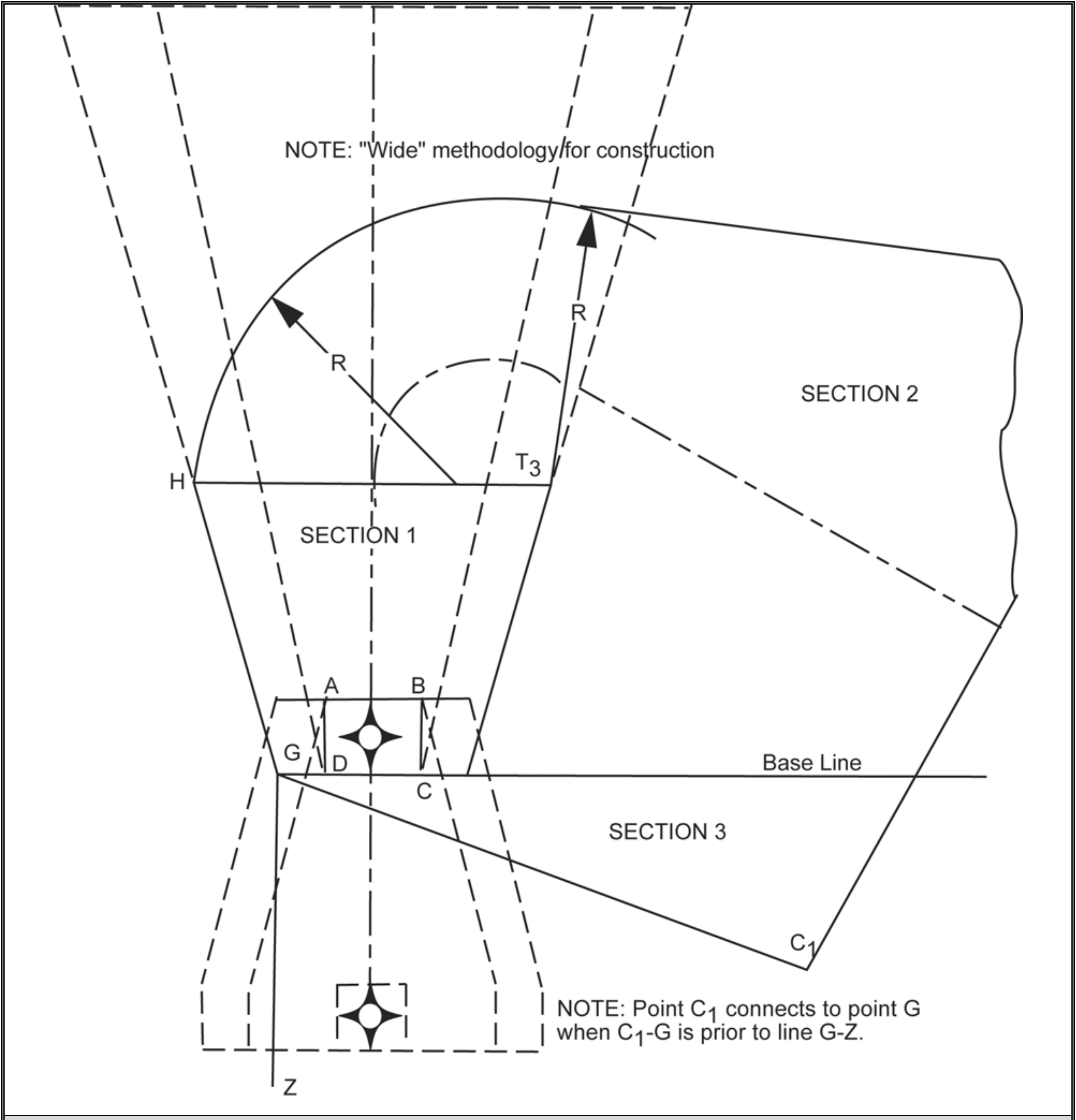
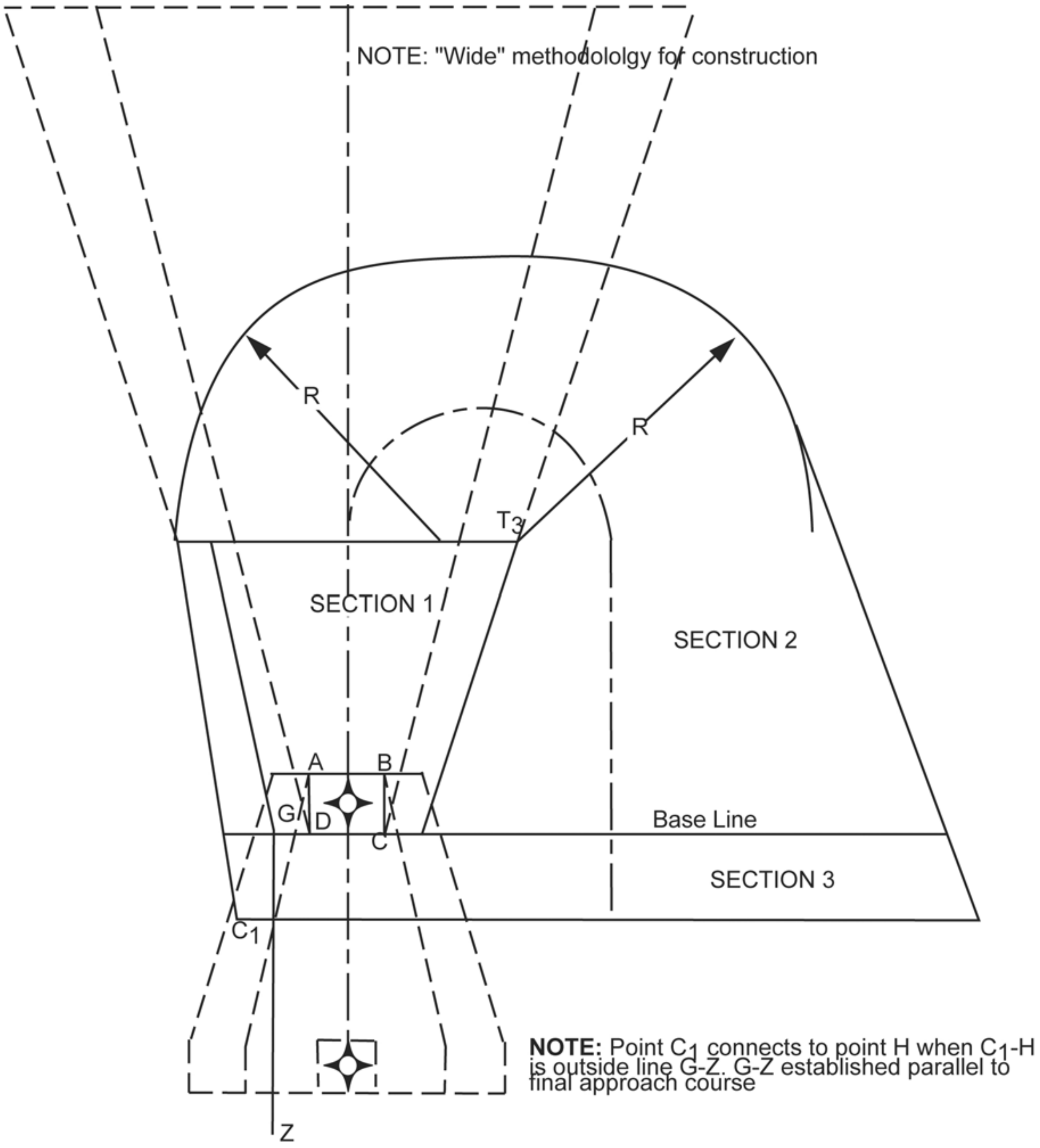


Figure 15-34: Climb To Altitude, Straight And Turning Missed Approach >90°.
Para 1535.a.(3).



NOTE: Point C_1 connects to point H when C_1-H is outside line G-Z. G-Z established parallel to final approach course

Figure 15-35: Climb To Altitude, Straight And Turning Missed Approach >90°. Para 1535.a.(3).

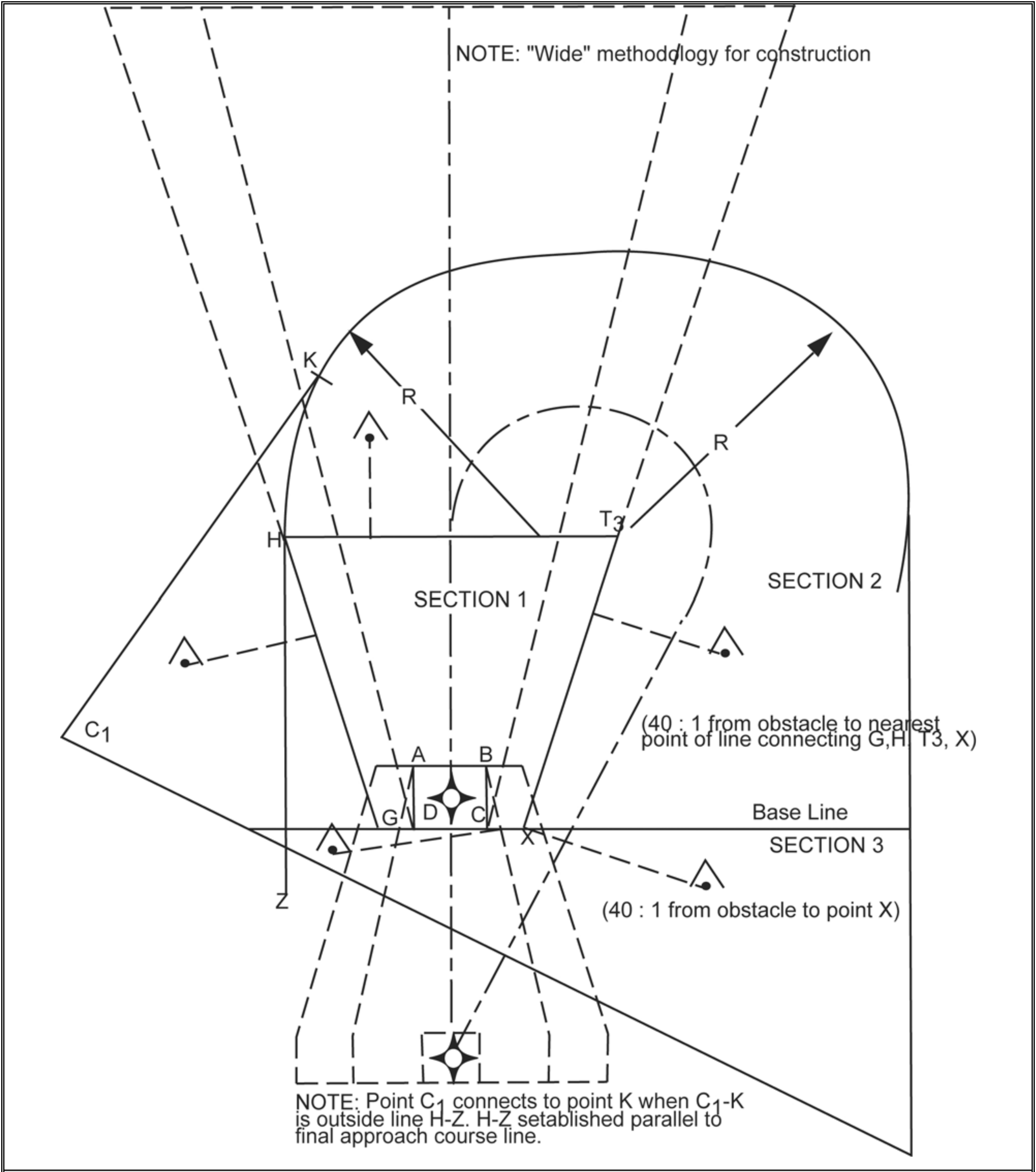


Figure 15-36: Climb To Altitude, Straight And Turning Missed Approach >180°. Para 1535.a.(3).

b. Obstruction Clearance.

(1) RNAV route missed approach of turns 90° or less.

(a) Obstacle in Section 2 are evaluated based on the shortest distance in the primary area from the obstacle to any point on line T_2-T_3 See Figure 15-30.

(b) Obstacles in Section 2b are evaluated based on the shortest distance in the primary area from the obstacle to Point T_3 through Point J. See Figure 15-30.

(2) RNAV Route Missed Approach of Turns More than 90°. Obstacles in Sections 2 and 3 are evaluated based on the shortest distance in the primary area from the obstacle to any point on line T_2-T_3 See Figure 15-31.

(3) RNAV Direct Procedure. Obstacles in Section 2 are evaluated based on the shortest distance from the obstacle to any point on line G-H-T_3-X. Obstacles in Section 3 are evaluated based on the shortest distance from the obstacle to Point X. See Figure 15-35.

(4) The height of the missed approach surface over an obstacle in Section 2 is determined by measuring the shortest distance from the obstacle to the nearest point the T_2-T_3 line for RNAV route missed approach procedures and to the nearest point on the G-H-T_3-X line for RNAV direct missed approach procedures. Compute the height of the surface by using the 40:1 ratio from the height of the missed approach obstacle surface at the end of Section 1. The height of the obstacle surface at the end of Section 1 is determined by computing the 40:1 obstacle surface slope beginning at the height of the missed approach surface measured from the latest point of the MAP. See Figures 15-31 and 15-35.

(5) The height of the missed approach surface over point X for section 3 computations is the height of the MDA less adjustments in Para 323.a, b and c, plus a 40:1 rise in the Section 1as measured from line A-B to end of section 1.

1536. Clearance Limit

The missed approach procedure shall specify an appropriate fix as a clearance limit. The fix shall be suitable for holding. For VOR/DME systems, the clearance limit WP's shall meet terminal fix displacement area criteria from Table 15-1. For non-VOR/DME systems, clearance limit WP's shall meet en route fix displacement tolerance criteria from Table 15-3.

1537—1539. Reserved

SECTION 4. APPROACH MINIMA

1540. Approach Minima

Chapter 3, Section 3, applies except that criteria relating to minimum visibility must account for the effect of crosstrack fix displacement tolerance of the plotted position of the MAP shown in Table 15-6. Crosstrack values in Table 15-2 shall be applied for VOR/DME. A crosstrack value of 0.6 NM shall be applied for non-VOR/DME.

Category	0.6 – 0.8	> 0.8 – 1.0	> 1.0 – 1.2	> 1.2 – 1.6	> 1.6
A	1	1	1	1	1
B	1	1	1	1 ¼	1 ¼
C	1	1	1 ¼	1 ½	1 ½
D	1	1 ¼	1 ½	1 ¾	2
E	1	1 ¼	1 ½	1 ¾	2

Table 15-6: Effect Of Crosstrack Tolerance On Visibility Minima. Para 1540.

1541—1599. Reserved.

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CHAPTER 17. EN ROUTE CRITERIA

1700—1709. Reserved

SECTION 1. VHF OBSTACLE CLEARANCE AREAS

1710. En Route Obstacle Clearance Areas

Obstacle clearance areas for en route planning are identified as "primary", "secondary", and turning areas.

1711. Primary Areas

a. Basic Area. The primary en route obstacle clearance area extends from each radio facility on an airway or route to the next facility. It has a width of 8 NM; 4 NM on each side of the centreline of the airway or route (see Figure 17-1).

b. System Accuracy. System accuracy lines are drawn at a 4.5° angle on each side of the course or route (see Figure 17-1). The apexes of the 4.5° angles are at the facility. These system accuracy lines will intersect the boundaries of the primary area at a point 50.8 NM from the facility. (Normally 51 NM is used.) If the distance from the facility to the change over point (COP) is more than 51 NM, the outer boundary of the primary area extends beyond the 4 NM width along the 4.5° lines (see Figure 17-2). These examples apply when the COP is at mid point. Para 1716 covers the effect of offset COP or dogleg segments.

c. Termination Point. When the airway or route terminates at a navigational facility or other radio fix, the primary area extends beyond that termination point. The boundary of the area may be defined by an arc which connects the two boundary lines. The centre of the arc is, in the case of a facility termination point, located at the geographic location of the facility. In the case of a termination at a radial or DME fix, the boundary is formed by an arc with its centre located at the most distant point of the fix displacement area on course line. Figure 17-8 and its inset show the construction of the area at the termination point.

1712. Secondary Areas

a. Basic Area. The secondary obstacle clearance area extends along a line drawn 2 NM on each side of the primary area (see Figure 17-3).

b. System Accuracy. Secondary area system accuracy lines are drawn at a 6.7° angle on each side of the course or route (see Figure 17-3). The apexes are at the facility. These system accuracy lines will intersect the outer boundaries of the secondary areas at the same point as primary lines, 51 NM from the facility. If the distance from the facility to the COP is more than 51 NM the secondary area extends along the 6.7° line (see Figure 17-4 and Para 1716.c. and d. for offset COP or dogleg airway).

c. Termination Point. Where the airway or route terminates at a facility or radio fix the boundaries are connected by an arc in the same way as those in the primary area. Figure 17-8 and its inset show termination point secondary areas.

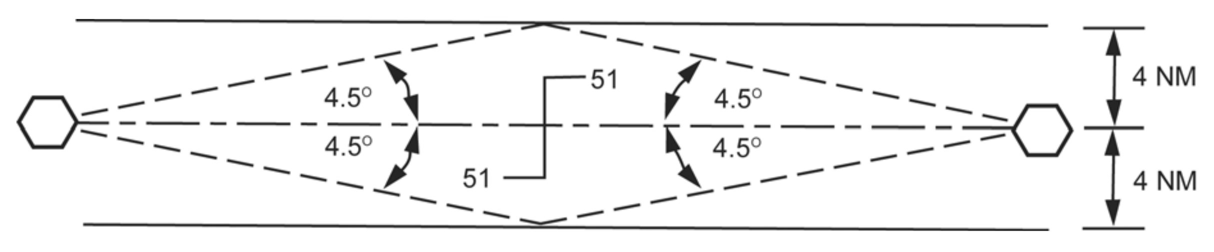

Figure 17-1: Primary Obstacle Clearance Area. Para 1711.a.

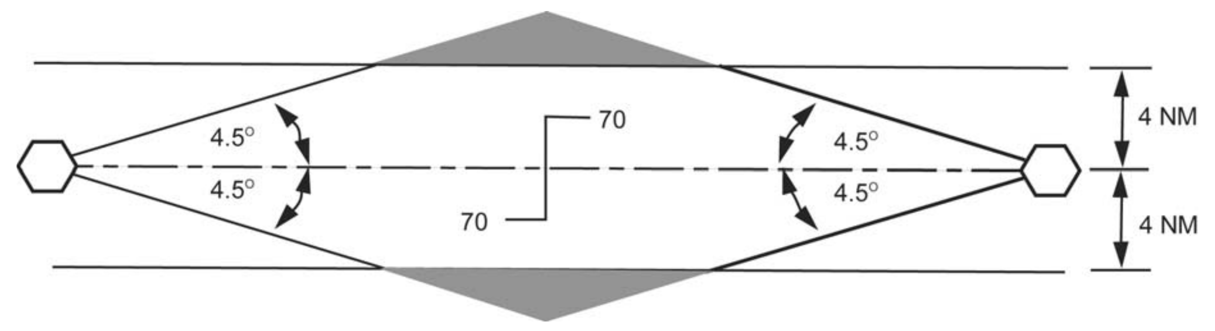

Figure 17-2: Primary Obstacle Clearance Area. Para 1711.b.

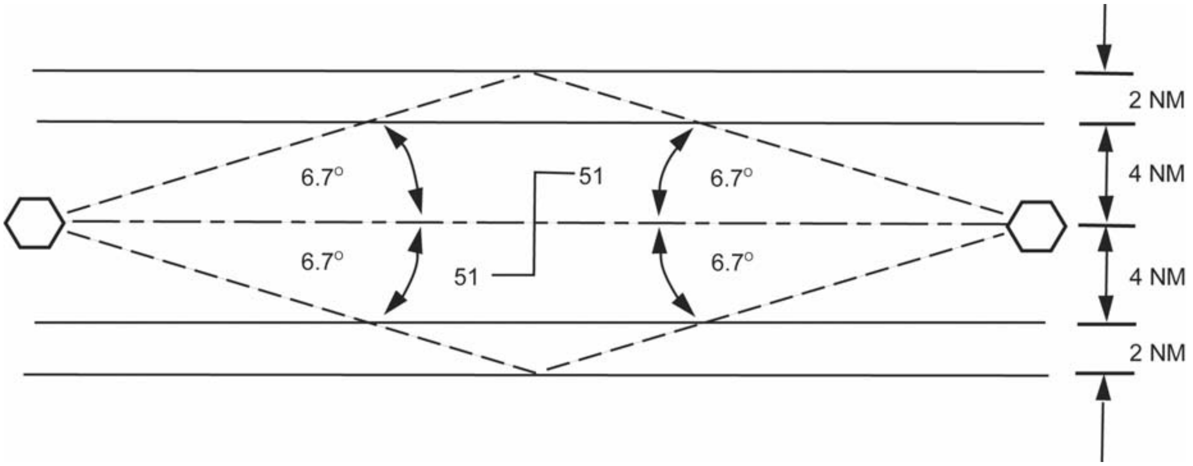

Figure 17-3: Secondary Obstacle Clearance Areas. Para 1712.a.

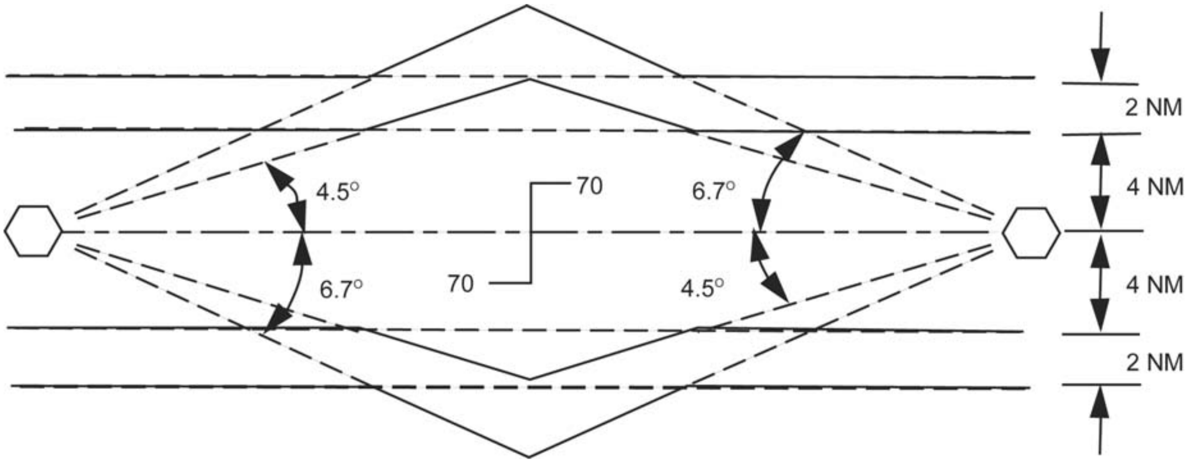

Figure 17-4: secondary obstacle clearance areas. Application of system accuracy lines. Para 1712.b.

1713. Turning Segments

a. Definition. The en route turning area may be defined as an area, which may extend the primary and secondary obstacle clearance areas when a change of course is necessary. The dimensions of the primary and secondary areas will provide adequate protection where the aircraft is tracking along a specific radial, but when the pilot executes a turn, the aircraft may go beyond the boundaries of the protected airspace. The turning area criteria supplements the airway and route segment criteria to protect the aircraft in the turn.

b. Requirement For Turning Segment Criteria. Because of the limitation on aircraft indicated air speeds below 10,000 feet MSL some conditions do not require the application of turning area airspace criteria.

   (1) The graph in Figure 17-5 may be used to determine if the turning segment should be plotted for airways/routes below 10,000 feet MSL. If the point of intersection on the graph of the "amount of turn at intersection" versus "VOR facility to intersection distance" falls outside the hatched area of the graph, the turning segment criteria need not be applied.

   (2) If the "amount of turn" versus "facility distance" values fall within the hatched area or outside the periphery of the graph, then the turning segment criteria must be applied as described in Para 1714.

c. Track. The flight track resulting from a combination of turn delay, inertia, turning rate, and wind effect is represented by a parabolic curve. For ease of application, a radius arc has been developed which can be applied to any scale chart.

d. Curve Radii. A 250-knot IAS, which is maximum allowed below 10,000 feet MSL, results in radii of 2 NM for the primary area and 4 NM for the secondary area up to that altitude. For altitudes at or above 10,000 feet MSL up to but not including 18,000 feet MSL the primary area radius is 6 NM and the secondary area radius is 8 NM. At and above 18,000 feet MSL the radii are 11 NM for primary and 13 NM for secondary.

e. System Accuracy. In drawing turning segments it will be necessary to consider system accuracy factors by applying them to the most adverse displacement of the radio fix or airway/route boundaries at which the turn is made. The 4.5 and 6.7° factors apply to the VOR radial being flown but since no pilot or aircraft factors exist in the measurement of an intersecting radial, a navigation facility factor of plus-or-minus 3.6° is used (see Figure 17-6).

   Note: If a radio fix is formed by intersecting signals from two LF, or one LF and VOR facility, the obstacle clearance areas are based upon accuracy factors of 5.0° (primary) and 7.5° (secondary) each side of the course or route centreline of the LF facilities. If the VOR radial is the intersecting signal, the 3.6° value stated in Para 1713.e applies.

1714. Application Of Turning Segment Criteria

a. Techniques. Figures 17-8, 17-9, and 17-10 illustrate the application of the criteria. They also show areas which may be deleted from considerations when obstacle clearance is the deciding factors for establishing minimum en route altitudes (MEAs) on airways or route segments.

b. Computations. Computations due to obstacles actually located in the turning segments will probably be indicated only in a minority of cases. These methods do, however, add to the flexibility of procedures designers in resolving specific obstacle clearance problems without resorting to the use of deviations to procedures.

c. Minimum Turning Altitude (MTA). Where the application of the turn criteria obviates the use of an MEA with a cardinal altitude, the use of an MTA for a special direction of flight may be authorized.

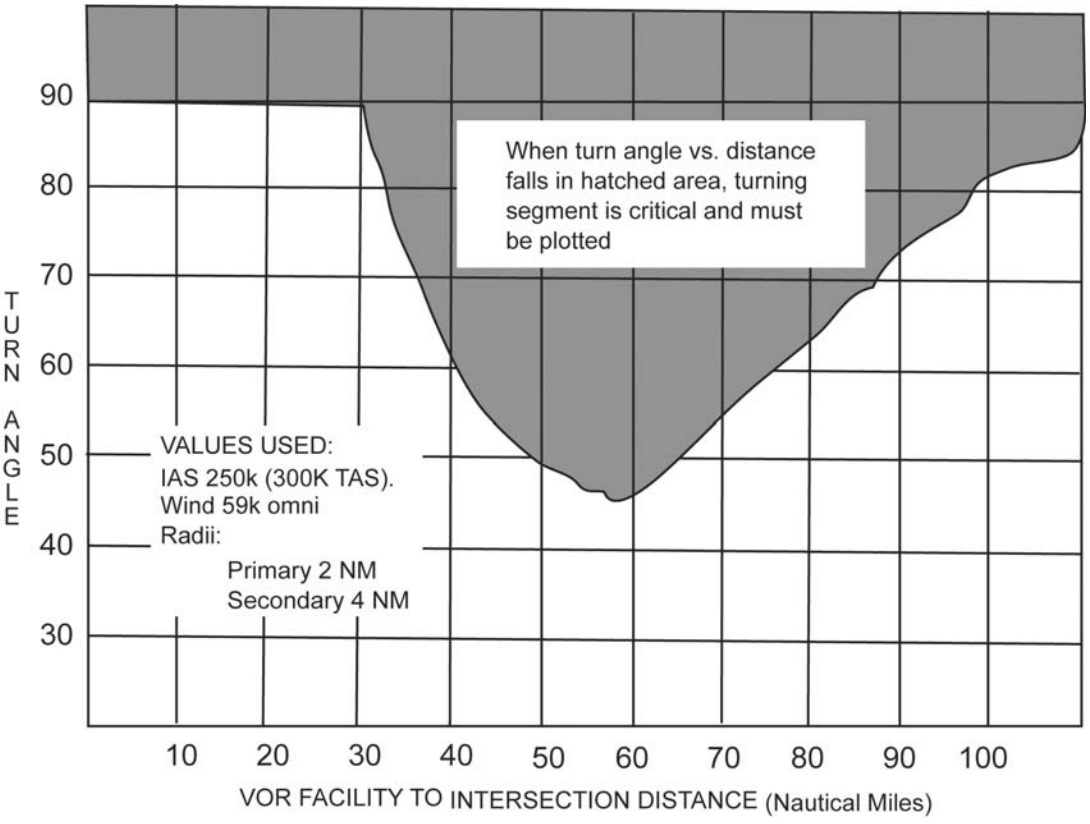

Figure 17-5: Turn Angle vs Distance. Para 1713.b (1) and (2).

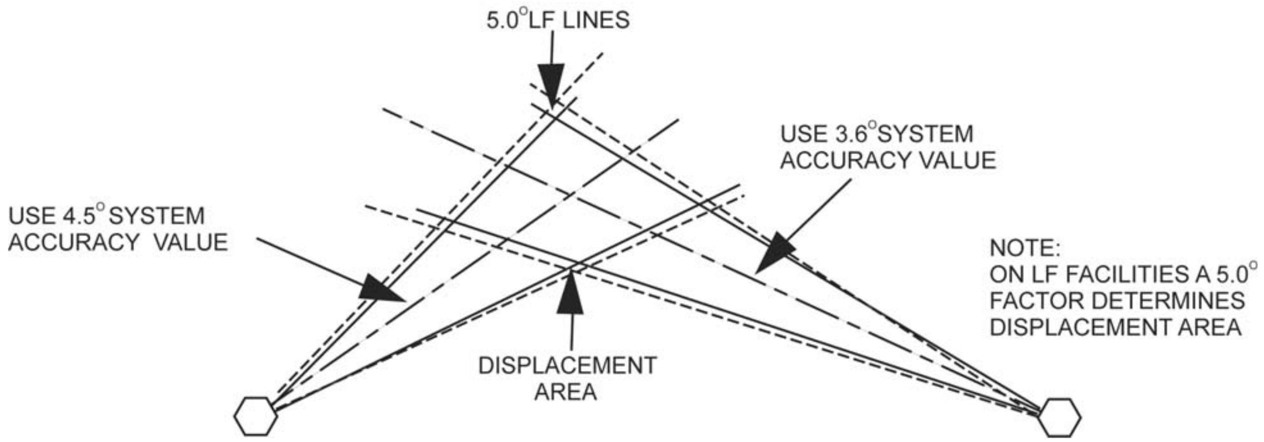

Figure 17-6: Fix Displacement. Para 1713.e.

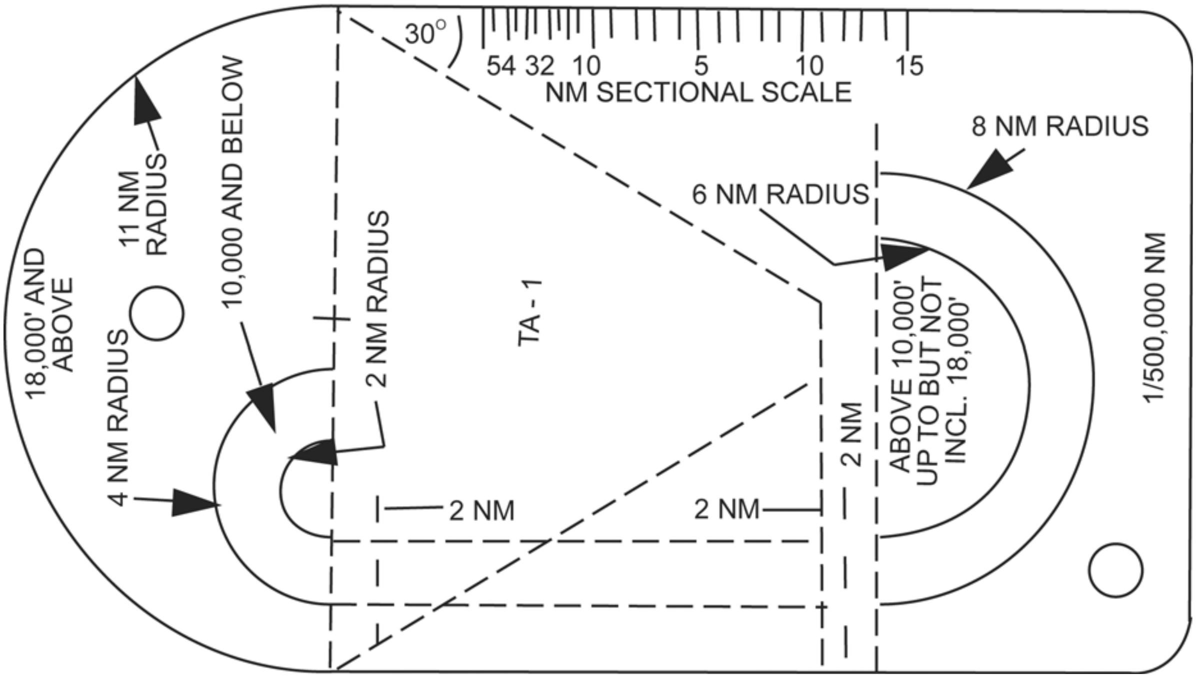

Figure 17-7: Turning Segment Template. Para 1715.

1715. Turn Area Template

A turn area template has been designed for use on charts scaled at 1:500,000 (see Figure 17-7). It is identified as a “TA-1.”

a. Use of Template Intersection Fix.

  (1) Primary Area. At an intersection fix the primary obstacle clearance area arc indexes are placed at the most adverse points of the fix displacement area as determined by the outer intersections of the en route radial 4.5° lines (VOR) and the cross-radial 3.6° lines (VOR) (see Figures 17-8 and 17-9). If LF signals are used the 5.0° system accuracy lines apply. The parallel dashed lines on the turn area template are aligned with the appropriate system accuracy lines and the curves are drawn.

  (2) Secondary Area "Outside" Curve. The outside curve of the secondary area is the curve farthest from the navigation facility that provides the intersecting radial. This curve is indexed to the distance from the fix to the en route facility as follows:

    (a) Where the fix is less than 51 NM from the en route facility, the secondary arc is started at a point 2 NM outside the primary index with the parallel dashed lines of the template aligned on the 4.5° lines (see Figure 17-8).

    (b) Where the fix is farther than 51 NM from the en route station, the arc is started at the point of intersection of the 3.6 and 6.7° lines with the parallel dashed lines of the template aligned on the 6.7° lines (see Figure 17-9).

  (3) Secondary Area "Inside" Curve. The inside curve is the turning segment arc which is nearest the navigation facility which provides the intersecting radial. This arc is begun 2 NM beyond the primary index and on the 3.6° line. The parallel dashed lines on the turning segment template are aligned with the 4.5° lines from the en route station.

    (a) Where the fix is less than 51 NM from the en route facility and the magnitude of the turn is less than 30°, the "inside" curves do not affect the size of the secondary area.

    (b) Where the distance from the en route facility to the fix is more than 51 NM but the magnitude of the turn is less than 45°, the "inside" curves do not increase the size of the secondary area.

    (c) Where the magnitude of the turn is greater than those stipulated in (a) and (b) the "inside" curves will affect the size of the secondary area.

    (d) Whether the secondary area curves affect the size of the secondary obstacle clearance area or not, they must be drawn to provide reference points for the tangential lines described in (4) below.

  (4) Connecting Lines. Tangential straight lines are now drawn connecting the two primary arcs and the two secondary arcs. The outer limits of both curves are symmetrically connected to the respective primary and secondary area boundaries in the direction of flight by lines drawn at a 30° angle to the airway or route centreline (see Figures 17-3 and 17-9).

b. Use of Template When Fix Overheads A Facility (see Figure 17-10). The geographical position of the fix is considered to be displaced laterally and longitudinally by 2 NM at all altitudes.

(1) Primary Arcs. The primary arcs are indexed at points 2 NM beyond the station and 2 NM on each side of the station. The parallel dotted lines on the template are aligned with the airway or route boundaries and the curves drawn.

(2) Secondary Arcs. The secondary arcs are indexed 2 NM outside the primary points, and on a line with them. The parallels dotted lines on the template are aligned with the airway or route boundaries and the curves drawn.

(3) Connection Lines. Tangential straight lines are now drawn connecting the two primary and the two secondary arcs. The outer limits of both curves are connected to the primary and secondary area boundaries by intercept lines, which are drawn 30° to the airway or route centreline. The 30° lines on the template may be used to draw these intercept lines.

c. Deletion Areas. Irregular areas remain on the outer corners of the turn areas (see Figures 17-8, 17-9, and 17-10). These are the areas identified in Para 1714 which may be deleted from consideration when obstacle clearance is the deciding factor for determination of MEA on an airway or route segment.

(1) Where the "outside" secondary area curve is started within the airway or route secondary area boundary (see Figure 17-8), the area is blended by drawing a line from the point where the 3.6° (5.0° with LF facility) line meets the line which forms the en route secondary boundary tangent to the "outside" secondary arc. Another line is drawn from the point where the same 3.6° (or 5.0°) line meets the line, which forms the primary boundary, tangent to the matching primary arc. These two lines now enclose the secondary area at the turn. The corner, which was formerly part of the secondary area, may be disregarded; the part, which was formerly part of the primary area, may now be considered secondary area. These areas are shaded in Figure 17-8.

(2) Where the secondary curve is indexed on the secondary area boundary formed by the 6.7° lines, the arc itself cuts the corner and prescribes the deleted area (see Figure 17-9). This condition occurs when the radio fix is over 51 NM from the en route navigation facility.

(3) When overheading the facility, the secondary area corner deletion area is established by drawing a line from a point opposite the station index at the secondary area boundary, tangent to the secondary "outside" curve (see Figure 17-10). A similar line is drawn from a point opposite the station index at the primary area boundary, tangent to the primary turning arc. The corner formerly part of the primary area now becomes secondary area. Shading in Figure 17-10 shows the deletion areas.

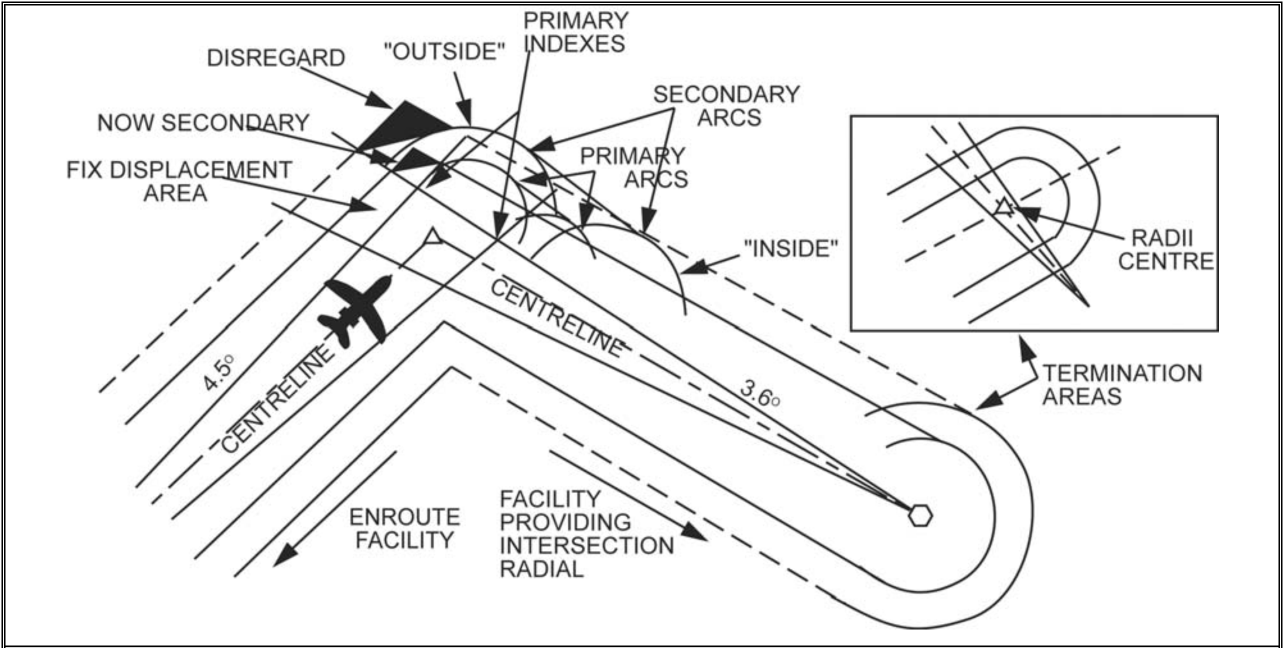

Figure 17-8: turning segment, intersection fix. Facility distance less than 51 nm. Para 1715.a and b.

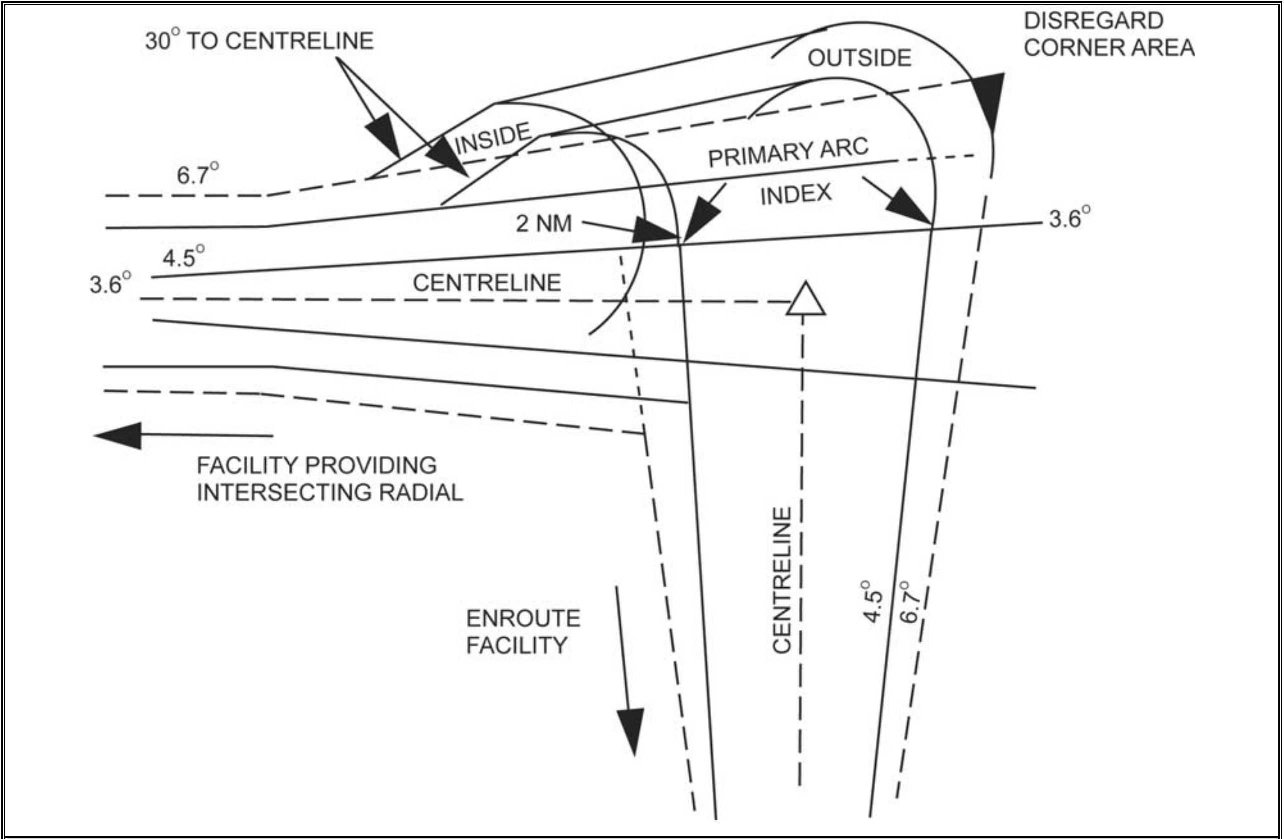

Figure 17-9: turning segment, intersection fix. Facility distance beyond 51 nm. Para 1715.a and b.

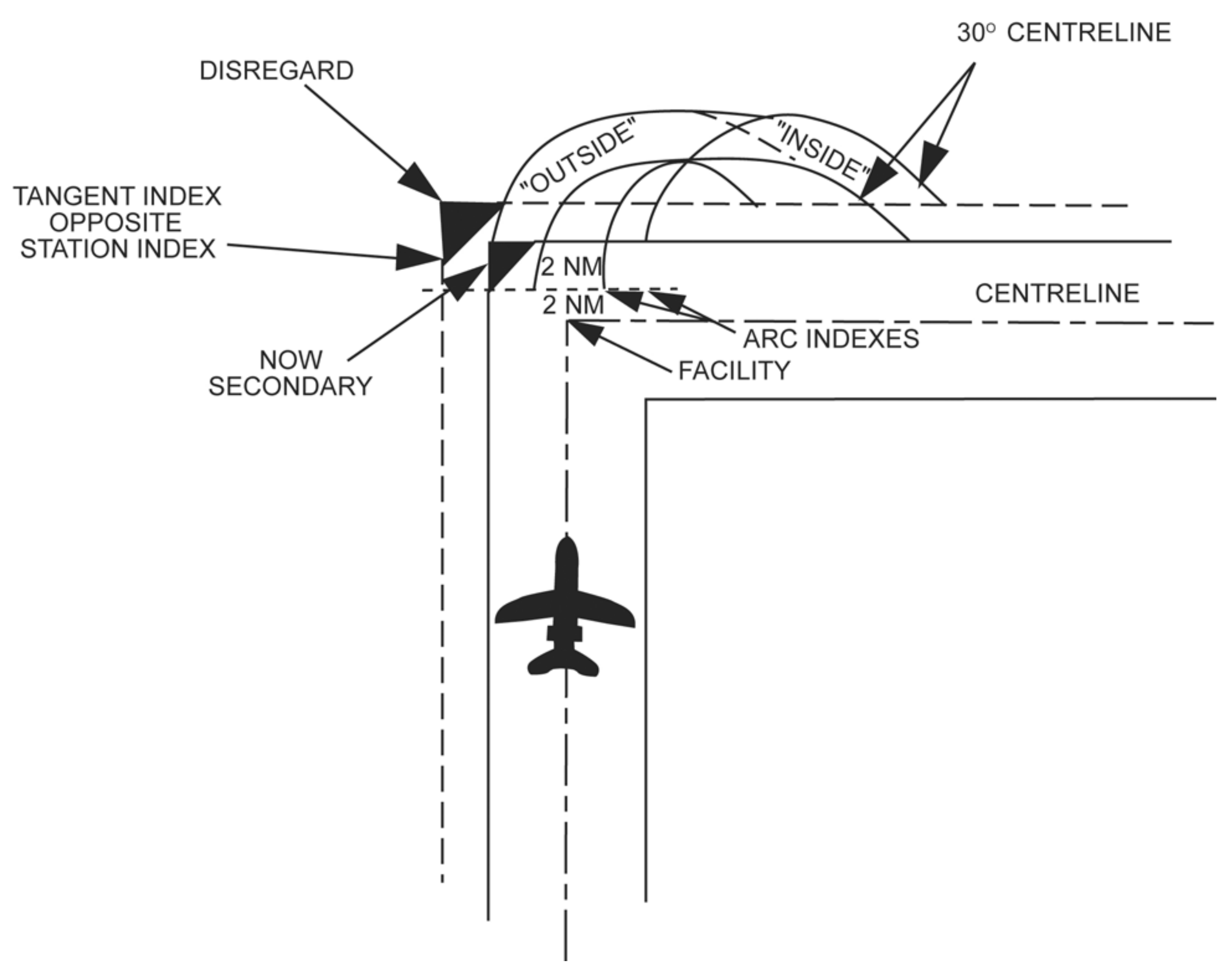

Figure 17-10: Turning Segment Overhead The Facility. Para 1715.b.

1716. Change Over Points (COP)

Points have been defined between navigation facilities along airway/route segments, which are called "change over points (COP)". These points indicate that the pilot using the airway/route should "change over" the navigation equipment to receive course guidance from the facility ahead of the aircraft instead of the one behind. These COP divide a segment and assure continuous reception of navigation signals at the prescribed minimum enroute IFR altitude (MEA). They also assure that aircraft operating within the same portion of an airway or route segment will not be using azimuth signals from two different navigation facilities. Where signal coverage from two facilities overlaps at the MEA, the COP will normally be designated at the mid point, and is not shown on the chart. Where radio frequency interference or other navigation signal problems exist, the COP will be at the optimum location, taking into consideration the signal strength, alignment error, or any other known condition, which affects reception. The effect, of COP on the primary and secondary obstacle clearance areas is as follows:

a. Short Segments. If the airway or route segment is less than 102 NM long and the COP is placed at the mid point, the obstacle clearance areas are not affected (see Figure 17-11).

b. Long Segments. If the distance between two facilities is over 102 NM and the COP is placed at the mid point, the system accuracy lines extend beyond the minimum widths of 8 and 12 NM, and a flare results at the COP (see Figure 17-12).

c. Offset Cop. If the change over point is offset due to facility performance problems, the system accuracy lines must be carried from the farthest facility to a position abeam the change over point, and these lines on each side of the airway or route segment at the COP are joined by lines drawn from the nearer facility. In this case the angles of the lines drawn from the nearer facility have no specific angle (see Figure 17-13).

d. Dogleg Segment. A dogleg airway or route segment may be treated in a manner similar to that given offset COPs. The system accuracy lines will be drawn to meet at a line drawn as the bisector of the dogleg "bend" angle and the boundaries of the primary and secondary areas extended as required (see Figure 17-14).

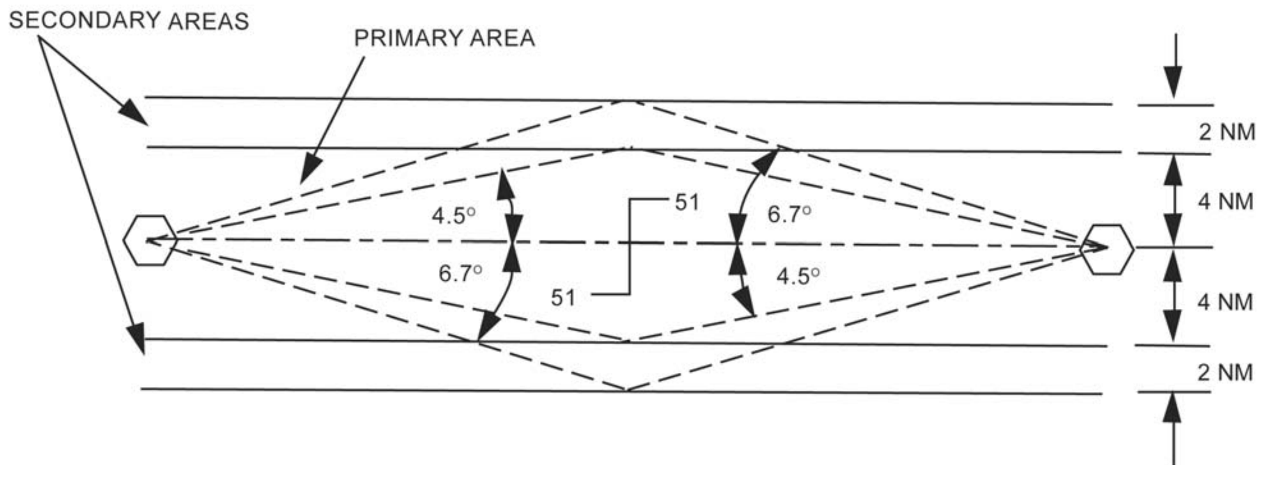

Figure 17-11: COP effect. Short airway or route segment. Para 1716.a.

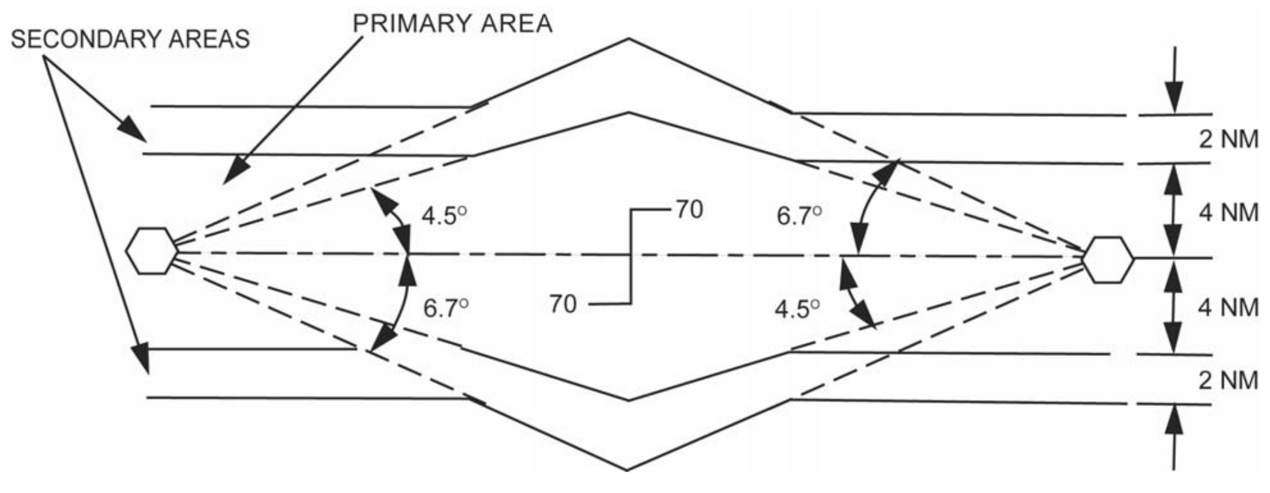

Figure 17-12: COP Effect. Long Airway Or Route Segment. Para 1716.b.

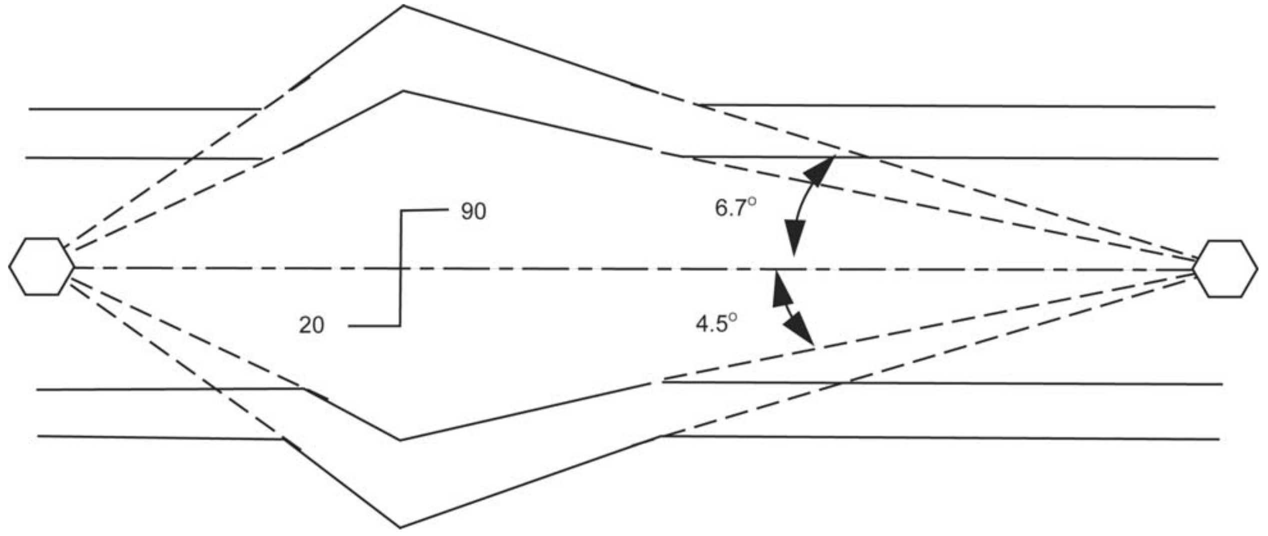

Figure 17-13: Offset COP. Para 1716.c.

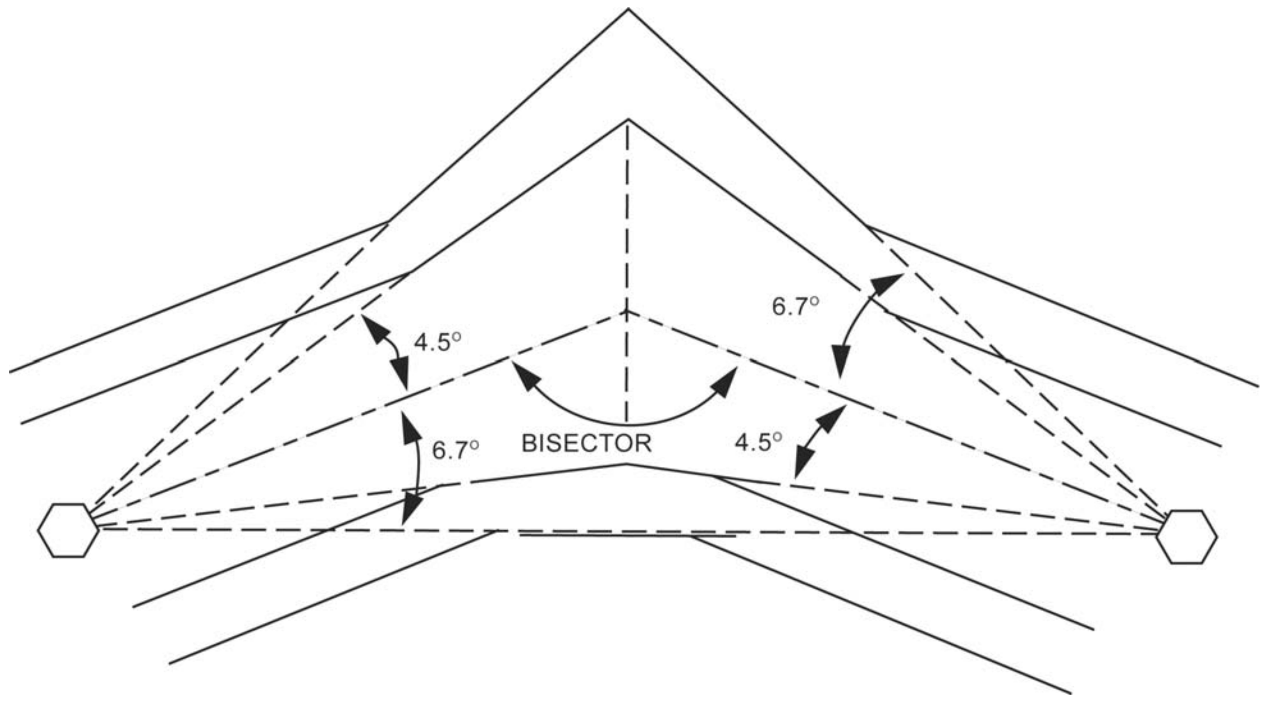

Figure 17-14: Dogleg Segment. Para 1716.d.

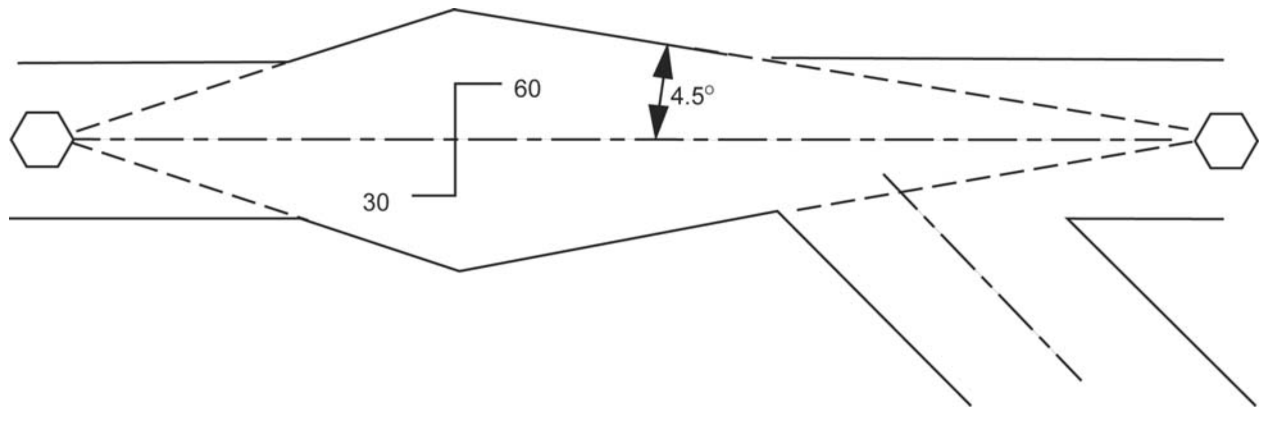

Figure 17-15: Course Change Effect. Para 1717.

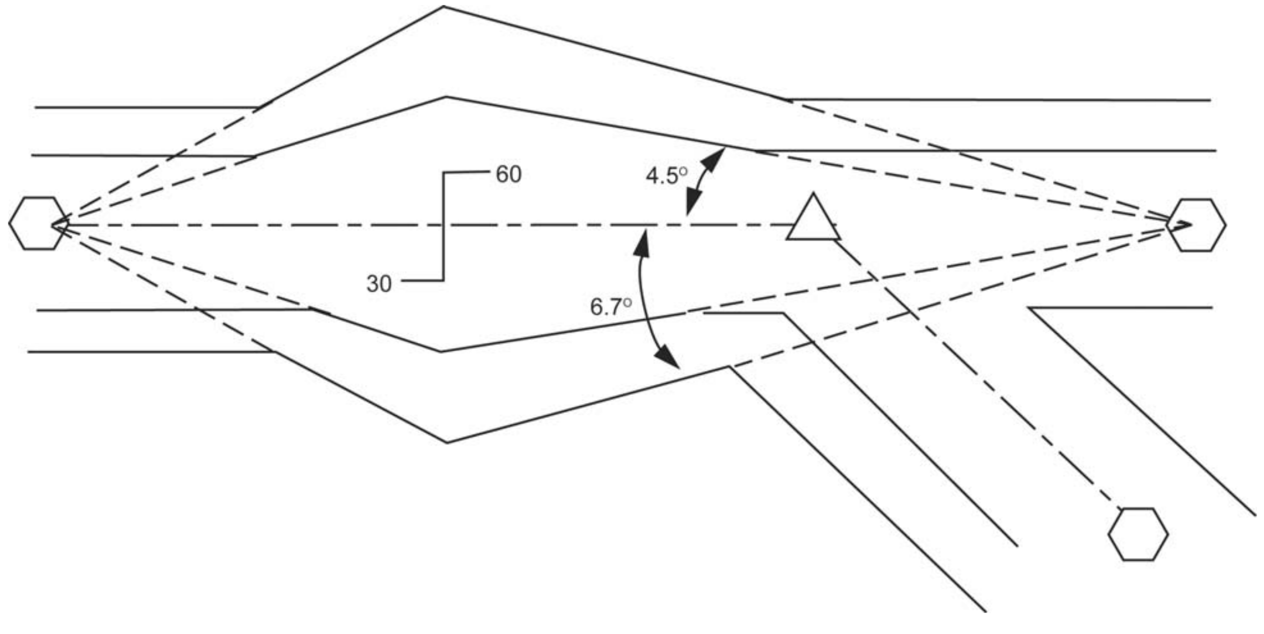

Figure 17-16: Application Of Secondary Areas. Para 1717.

1717. Course Change Effect

The complexity of defining the obstacle clearance areas is increased when the airway or route becomes more complex. Figure 17-15 shows the method of defining the primary area when a radio fix and a COP are involved. Note that the system accuracy lines are drawn from the farthest facility first, and govern the width of the airway or route at the COP. The application of secondary area criteria results in a segment similar to that depicted in Figure 17-16.

1718. Reserved

1719. Protected En Route Areas/Segments

As previously established, the en route areas, which must be considered for obstacle clearance protection, are identified as primary and secondary turn areas. The overall consideration of these areas is necessary when determining obstacle clearances.

SECTION 2. VHF OBSTACLE CLEARANCE

1720. Obstacle Clearance, Primary Area

a. Non-Mountainous Regions. The minimum obstacle clearance over areas not designated as, mountainous will be 1,000 feet over the highest obstacle.

b. Mountainous Areas. Owing to the action of Bernoulli Effect and of atmospheric eddies, vortices, waves, and other phenomena, which occur in conjunction with the disturbed airflow attending the passage of strong winds over mountains, pressure deficiencies manifested as very steep horizontal pressure gradients develop over such regions. Since down drafts and turbulence are prevalent under these conditions, the hazards to air navigation are multiplied. Except as set forth in (1) below, the minimum obstacle clearance over terrain and manmade obstacles, within designated mountainous regions will be 2,000 feet.

(1) Obstacle clearance may be reduced to not less than 1,500 feet above terrain and manmade obstacles within the designated mountainous regions located in eastern Canada which includes part of Quebec, New Brunswick and Newfoundland as described in TP 1820 DAH/GPH 204.

Note: Altitudes of 1,000 feet of obstacle clearance within designated mountainous regions may be provided on airways/routes located within terminal areas. That segment is to be identified by a fix or facility.

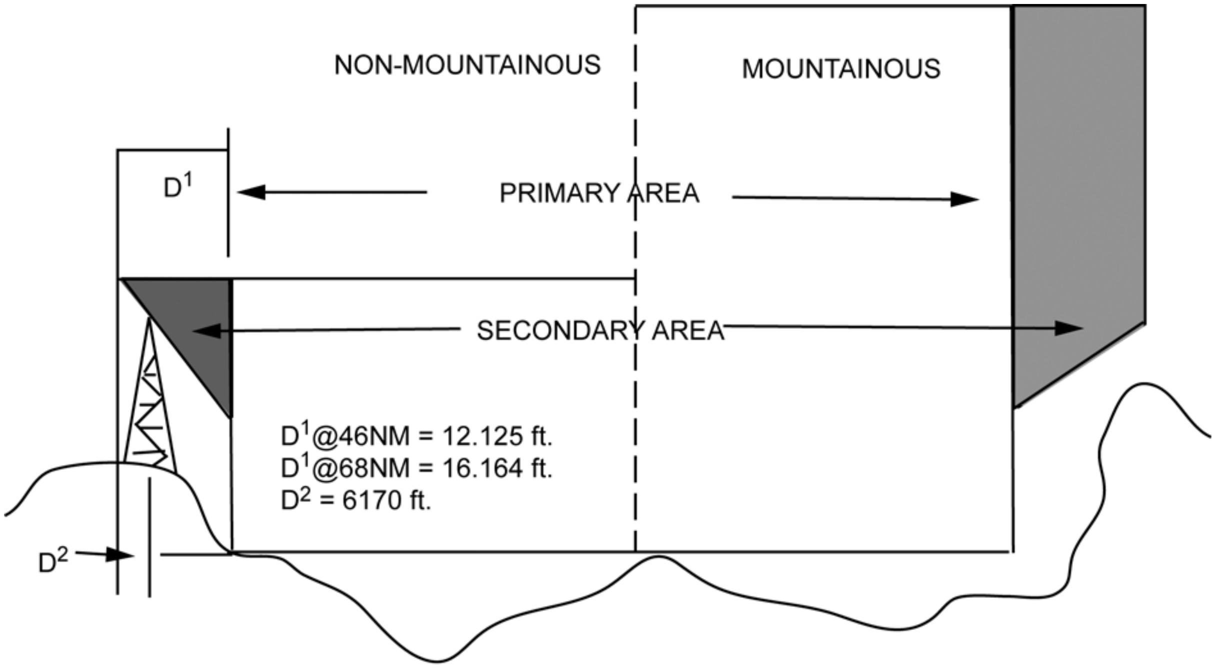

Figure 17-17: Cross Section, Secondary Area Obstacle Clearances. Para 1721.

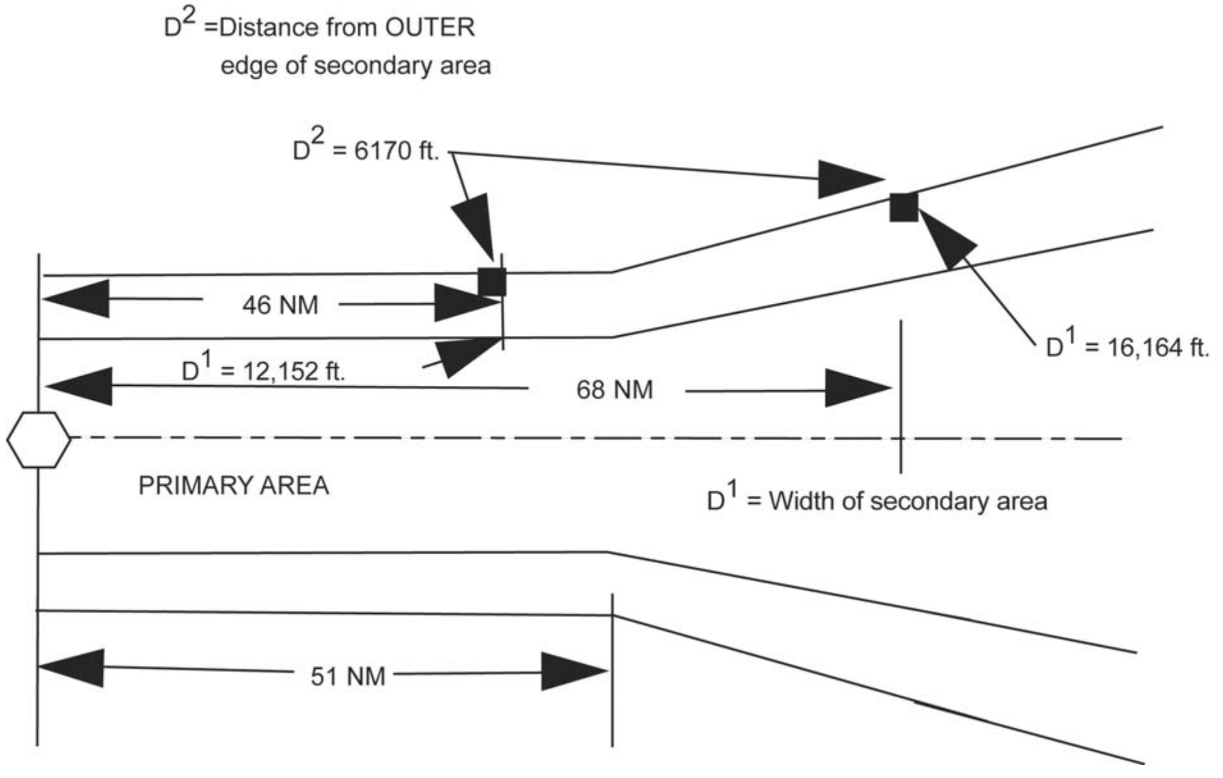

Figure 17-18: Plan View, Secondary Area Obstacle Clearances. Para 1721.

1721. Obstacle Clearance, Secondary Areas

In all areas, mountainous and non-mountainous, obstacles which are located in the secondary areas will be considered as obstacles to air navigation when they extend above the secondary obstacle clearance plane. This plane begins at a point 500 feet above the obstacles upon which the primary obstacle clearance area MOCA is based, and slants upward at an angle which will cause it to intersect the outer edge of the secondary area at a point 500 feet higher (see Figure 17-17). Where an obstacle extends above this plane, the normal MOCA shall be increased by adding to the MSL height of the highest penetrating obstacle in the secondary area the required clearance (C), computed with the following formula:

$$\frac{D^1}{D^2} = \frac{500}{C} \quad \text{or } C = \frac{500 \times D^2}{D^1}$$

D^1 is the total width of the secondary area.

D^2 is the distance from the obstacle to the OUTER edge of the secondary area.

Note: Add an extra 1,000 feet in mountainous regions where 2,000 feet of obstacle clearance is provided and 500 feet in the region where 1,500 feet of obstacle clearance is provided.

D^1 has a total width of 2 NM, or 12,152 feet out to a distance of 51 NM from the en route facility, and then increases at a rate of 236 feet for each additional NM.

Example: An obstacle which reaches 1,875 feet MSL is found in the secondary area 6,170 feet inside the outer secondary area boundary and 46 NM from the facility (see Figures 17-17 and 17-18).

D^1 is 12,152 feet
D^2 is 6,170 feet

$$\frac{500 \times 6{,}170}{12{,}152} = 253.8 \text{ (254 feet)}$$

Obstacle height (1,875) + 254 = 2,129.
MOCA is 2,200 feet.

1722. Obstacle Clearance Graph

Figure 17-19 is a secondary area obstacle clearance graph, designed to allow the determination of clearance requirements without using the formula. The left axis shows the required obstacle clearance; the lower axis shows the distance from the outer edge of the secondary area to the obstacle. The slant lines are facility distance references.

Facility distances, which fall between the charted values, may be found by interpolation along the vertical distance lines.

a. Application. To use the secondary area obstacle clearance chart, enter with the value representing the distance from the outer edge of the secondary area to the obstacle. In the problems above this distance was 6,170 feet. Proceed up to the "51 NM or less" line and read the clearance requirement from the left axis. The chart reads 254 feet, the same as was found using the formula. To solve the second problem, re-enter the chart at 6,170 feet and move vertically to find 68 NM between the 60 and 70 NM facility distance slant lines. The clearance requirement shown to the left is 191 feet, the same as found using the formula.

b. Finding the MOCA. The required clearance, found by using the graph, is now added to the MSL height of the obstacle to get the MOCA.

   (1) 46 NM from facility:

   254 + 1,875 = 2,129 (2,200 MSL).

   (2) 68 NM from facility:

   191 + 1,875 = 2,066 (2,100 MSL).

1723—1729. Reserved

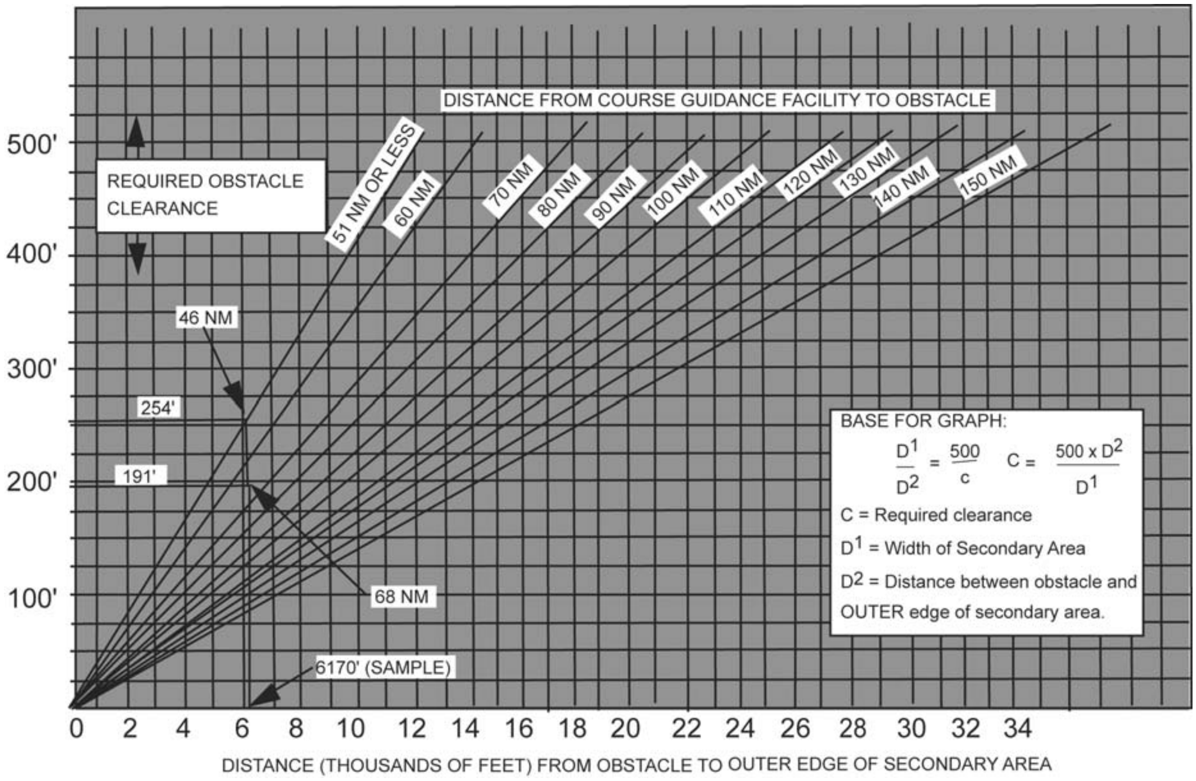

Figure 17-19: Secondary Obstacle Clearance. Para 1722.

Figures 17-20 to 17-22: Reserved

SECTION 3. ALTITUDES

1730. Minimum Reception Altitudes (MRA)

It is necessary to establish MRAs in all cases where designated intersections along airways or routes are formed by intersecting radials that require higher altitudes for the reception of that radial than the established MEA along the airway or route segment.

1731. En Route Minimum Holding Altitudes

The criteria contained herein deal with the clearance of holding aircraft from obstacles.

a. Area. The primary obstacle clearance area for holding shall be based on the appropriate holding pattern airspace area specified in Chapter 18. No reduction in the pattern sizes for "on-entry" procedures is permitted. In addition, when holding is at an intersection fix, the selected pattern shall also be large enough to contain at least 3 corners of the fix displacement area (see Paras 284 and 285, and Figure 18-2). A secondary area 2 NM wide surrounds the perimeter of the primary area.

b. Obstacle Clearance. The minimum obstacle clearance of the route shall be provided throughout the primary area. In the secondary area 500 feet of obstacle clearance shall be provided at the INNER edge, tapering to zero feet at the outer edge. For computation of obstacle clearance in the secondary area, the computational formula specified in Para 1721 shall be applied. Allowance for precipitous terrain should be considered as stated in Para 323.a. The altitudes selected by application of the obstacle clearance specified shall be rounded to the next higher 100-foot increment.

c. Communications. The communications on appropriate ATC frequencies (as determined by ATS) shall be required throughout the entire holding pattern area from the MHA up to and including the maximum holding altitude. If the communications are not satisfactory at the minimum holding obstacle clearance altitude, the MHA shall be authorized at an altitude where the communications are satisfactory.

1732. Minimum En Route Altitudes (MEA)

An MEA will be established for each segment of an airway/route from radio fix to radio fix. The MEA will be established based upon obstacle clearance over the terrain or over manmade objects, adequacy of navigation facility performance, and communications requirements. The MEA shall also be at or above the base of controlled airspace. Segments are designated West to East and South to North. Altitudes will be established to the nearest 100-foot increment; i.e. 4,049 feet becomes 4,000 feet; and 4,050 feet becomes 4,100, as long as the minimum required obstacle clearance is not violated.

Note: Care must be taken to insure that all MEAs based upon flight inspection information have been corrected to and reported as true altitudes above mean sea level (MSL).

1733—1739. Reserved

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SECTION 4. NAVIGATION GAP

1740. Navigational Gap Criteria

Where a gap in course guidance exists, an airway or route segment may be approved in accordance with the criteria set forth in Para 1740.c, provided:

a. Restrictions.

  (1) The gap may not exceed a distance which varies directly with altitude from zero NM at sea level to 65 NM at 45,000 feet MSL;

  (2) Not more than one gap may exist in the airspace structure for the airway/route segment;

  (3) A gap may not occur at any airway or route turning point, except when the provisions of Para 1740.b.(2) are applied; and

  (4) Where the MEA has been established with a gap in navigational signal coverage, the gap area will be identified by distance from the navigation facilities on the chart, depicting the airway/route segments.

b. Authorization. MEAs with gaps shall be authorized only where a specific operational requirement exists. Where gaps exceed the distance in Para 1740.a.(1), or are in conflict with the limitations in Para 1740.a.(2) or (3), the MEA must be increased as follows:

  (1) For straight segments:

    (a) To an altitude which will meet the distance requirement of Para 1740.a.(1), or;

    (b) When in conflict with Para 1740.a.(1) or (2) to an altitude where there is continuous course guidance available.

  (2) For turning segments. Turns to intercept radials with higher MEAs may be allowed provided;

    (a) The increase in MEA does not exceed 1500 feet; and

    (b) The turn does not exceed 90°.

  (3) When in conflict with Para 1740.b.(1) or (2) to an altitude where there is continuous course guidance available.

c. Use Of Steps. Where large gaps exist which require the establishment of altitudes that obviate the effective use of airspace, consideration may be given to the establishment of MEA "steps". These steps may be established at increments of not less than 2,000 feet below 18,000 feet MSL, or not less than 4000 at 18,000 and above, provided that a total gap does not exist for the segment within the airspace structure. MEA steps shall be limited to one step between any two facilities to eliminate continuous or repeated changes to altitude in problem areas. MEA changes shall be identified by designated radio fixes.

d. Gaps. Allowable navigational gaps may be determined by reference to the graph in Figure 17-23.

> EXAMPLE: The problem drawn on the chart shows the method used to determine the allowable gap on a route segment with a proposed MEA of 27,000 feet. Enter the graph at the left edge with the MEA of 27,000 feet. Move to the right to the interception of the diagonal line. Move to the bottom of the graph to read the allowable gap. In the problem drawn, a 39 NM gap is allowable.

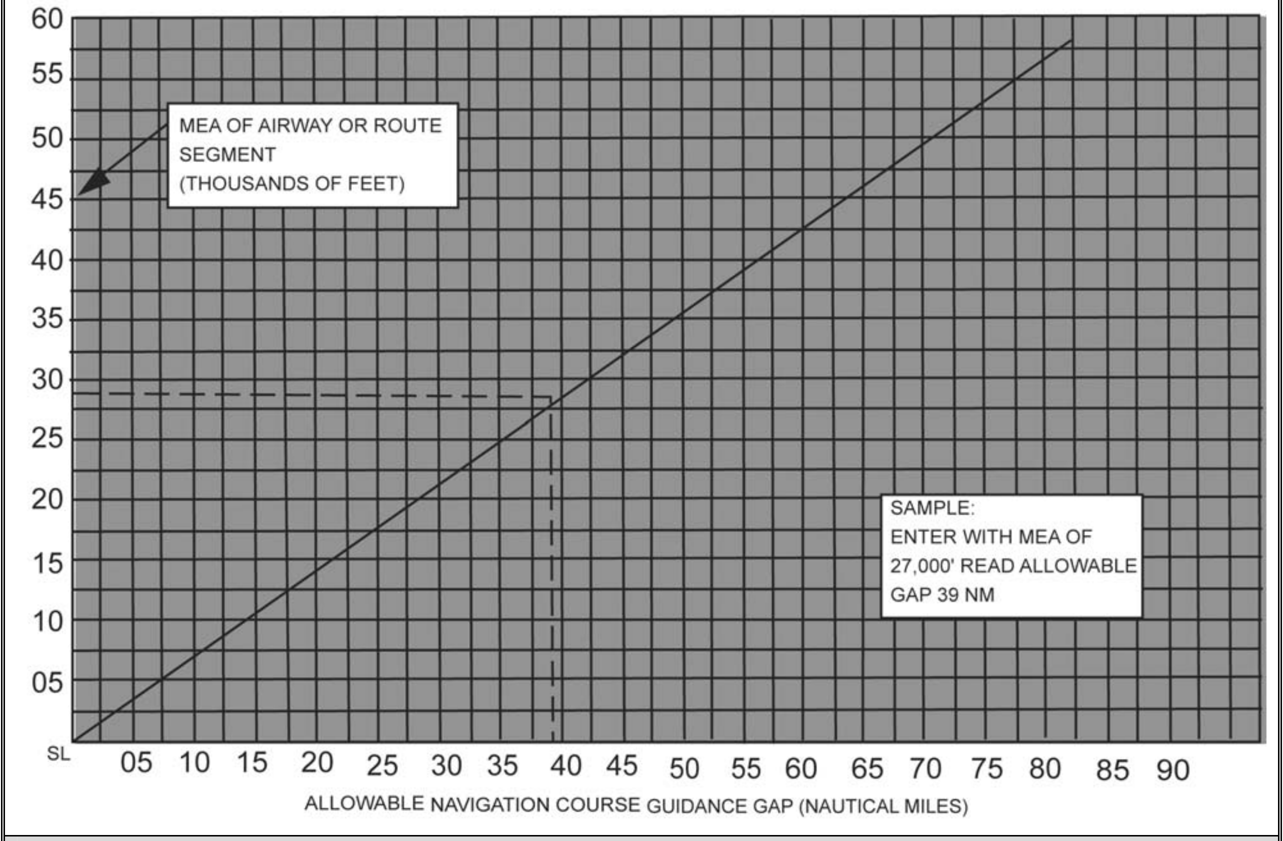

Figure 17-23: Allowable Navigation Course Guidance Gaps. Para 1740.

1741—1749. Reserved

SECTION 5. LOW FREQUENCY AIRWAYS OR ROUTES

1750. LF Airways Or Routes

a. Usage. LF navigation facilities may be used to establish en route airway/route segments.

b. Obstacle Clearance Areas (see Figures 17-24 and 17-25).

(1) The primary obstacle clearance area boundaries of LF segments are lines drawn 4.34 NM (5 statute miles) on each side of and parallel to the segment centreline. These boundaries will be affected by obstacle clearance area factors shown in Para 1750.c.

(2) The LF secondary obstacle clearance areas extend laterally for an additional 4.34 NM on each side the primary area. The boundaries of the secondary areas are also affected by the obstacle clearance areas factors shown in c. below.

c. Obstacle Clearance Area Factors (see Figures 17-24 and 17-25).

(1) The primary of LF segments is expanded in the same way as for VHF airways/routes. Lines are drawn at 5° off the course centreline from each facility. These lines meet at the mid point of the segment. Penetration of the 4.34 NM boundary occurs 49.61(50) NM from the facility.

(2) The secondary areas are expanded in the same manner as the secondary areas for VHF airways/routes. Lines are drawn 7.5° on each side of the segment centreline. These 7.5° lines will intersect the original 8.68 NM secondary area boundaries at 65.93 (66) NM from the facility.

Distance from Primary Boundary	Height added to Obstacle in the Secondary Area
0 – 1 SM (0.00 – 0.87 NM)	500 feet
> 1 – 2 SM (0.87 – 1.74 NM)	400 feet
> 2 – 3 SM (1.74 – 2.61 NM)	300 feet
> 3 – 4 SM (2.61 – 3.48 NM)	200 feet
> 4 – 5 SM (3.48 – 4.34 NM)	100 feet
Note: See Figure 17-23 for cross section view. Also Para 1750.d.(2)(c)	

Table 17-1: Increase To MOCA When 50:1 Obstacle Clearance Plane Penetrated. Para 1750.d.(2)(a)

d. Obstacle Clearance

(1) Obstacle clearance in the primary area of LF airways or routes is the same as that required for VOR airways/routes. The areas over which the clearances apply are different, as shown in Para 1750.c.

(2) Secondary area obstacle clearance requirements for LF segments are based upon distance from the facility and location of the obstacle relative to the inside boundary of the secondary area.

(a) Within 25 NM of the facility the obstacle clearance is based upon a 50:1 plane drawn from the primary area boundary 500 feet above the obstacle, which dictates its MOCA and extending to the edge of the secondary area. When obstacles penetrate this 50:1 plane, the MOCA for the segment will be increased above that dictated for the primary area obstacle as detailed in Table 17-1.

(b) Beyond the 25 NM distance from the facility, the secondary obstacle clearance plane is flat. This plane is drawn from the primary area boundary 500 feet above the obstacle, which dictates its MOCA and extending to the edge of the secondary area. If an obstacle penetrates this surface the MOCA for the segment will be increased so as to provide 500 feet of clearance over the obstacle (see Figure 17-27 and Para 1750.d.(2)(c)).

(c) Obstacle clearance values shown in (a) and (b) above are correct for non-mountainous, areas only. For areas designated as mountainous add 1,000 feet, or 500 feet, as applicable.

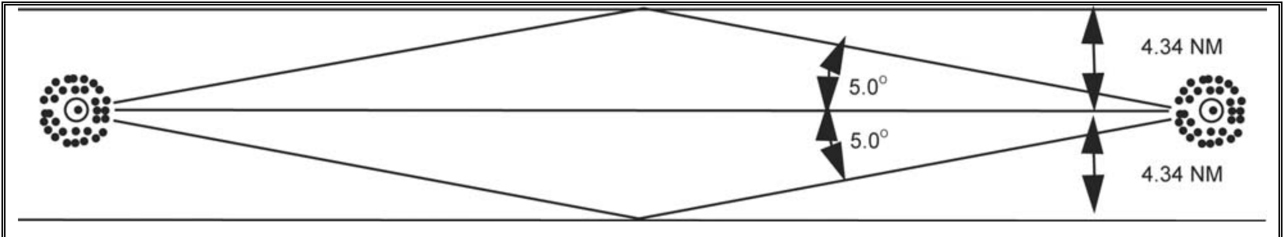

Figure 17-24: LF Segment Primary Obstacle Clearance Area. Para 1750.b.

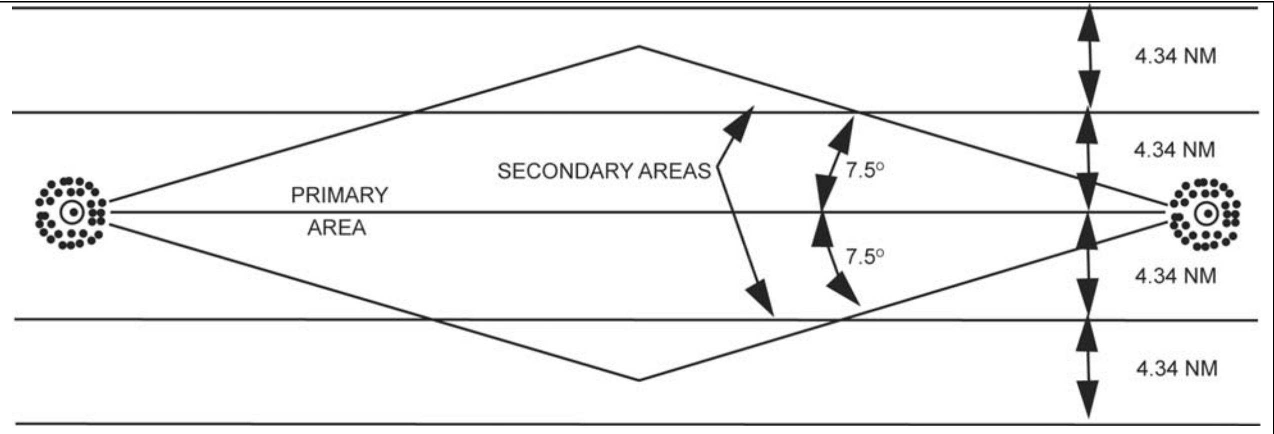

Figure 17-25: LF Segment Secondary Obstacle Clearance Area. Para 1717.B.

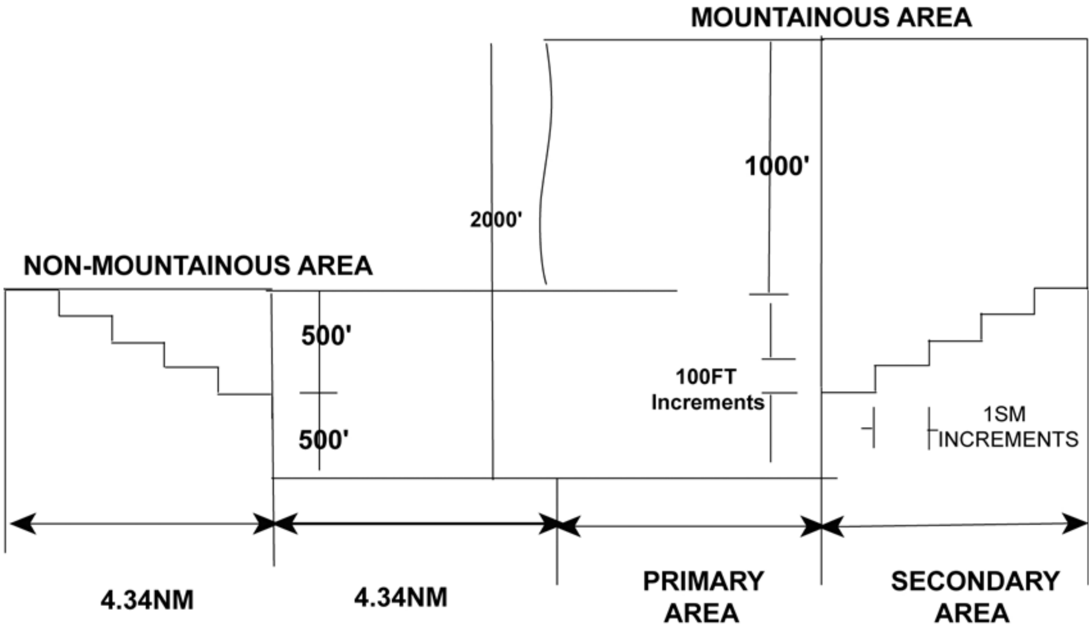

Figure 17-26: LF Segment Obstacle Clearance Within 25nm Of Enroute Facility. Para 1750.d.

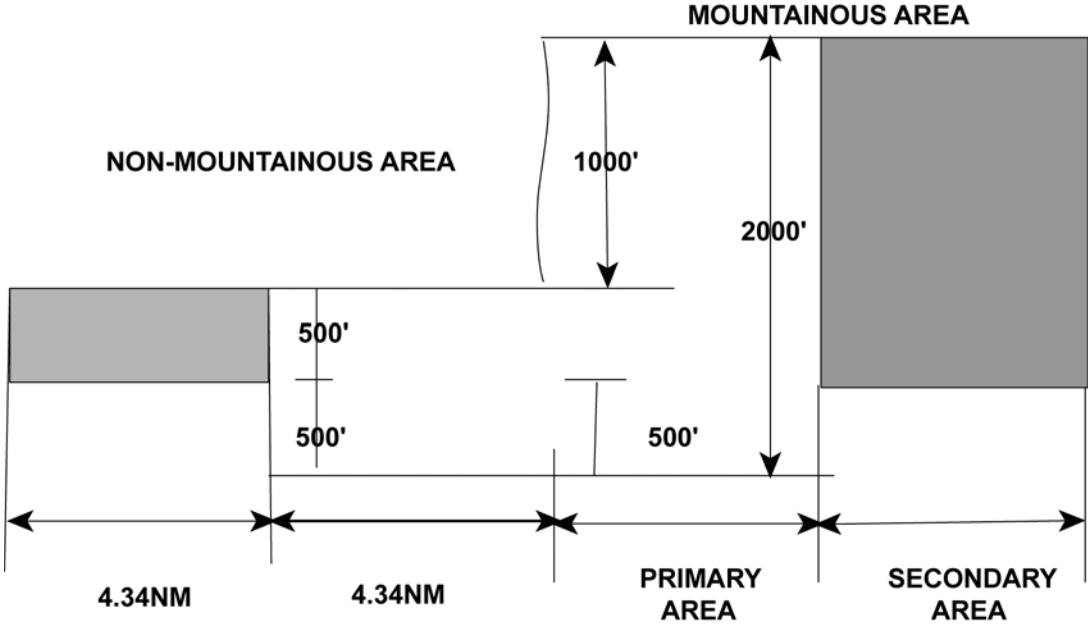

Figure 17-27: LF Segment Obstacle Clearance Area 25nm From Enroute Facility. Para 1750.d.

1751. LF/MF Facility To VHF/UHF Facility Airway Or Air Route

Airways and air routes may be constructed between LF/MF and VHF/UHF facilities. The criteria for area construction and obstacle clearances are contained in the appropriate section within this chapter. However, due to the different system accuracies (primary area 4.5° for VHF/UHF and 5.0° for LF/MF and secondary area 6.7° for VHF/UHF and 7.5° for LF/MF), to ensure proper obstacle assessment for the entire airway or air route, primary and secondary LF/MF system accuracy criteria shall be applied for the entire length of the airway or air route between the LF/MF and VHF/UHF facility.

This means that when constructing the airway or air route, the LF/MF primary obstacle clearance area of 4.34 NM each side of centerline and the secondary obstacle clearance area of 4.34 NM each side of the primary area shall be applied for the entire airway or air route. In addition, the LF/MF primary area shall be expanded 5.0° off the course centerline from each facility and the secondary area shall be expanded 7.5° off the course centerline from each facility for the entire airway or air route.

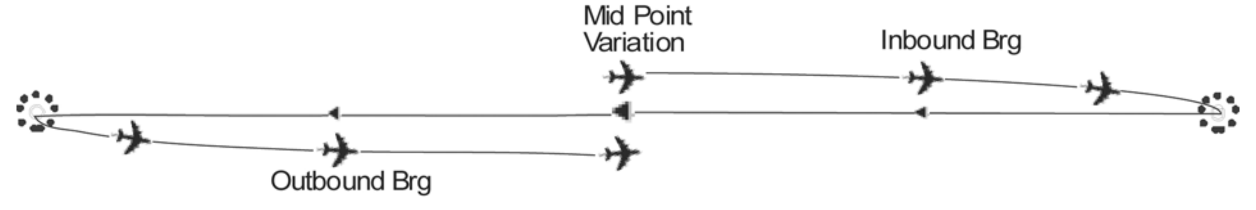

Figure 17-29a: Track Using Midpoint Variation. Para 1752.

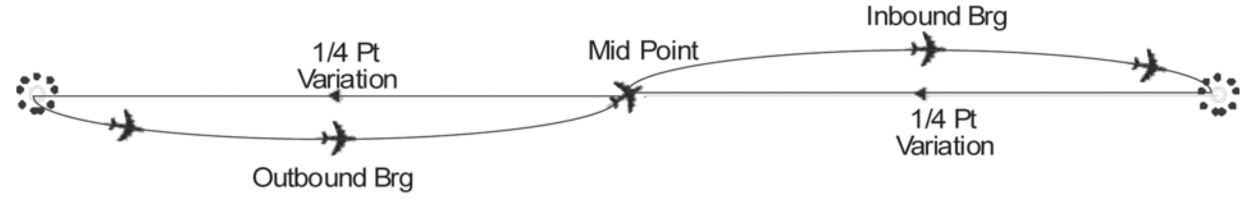

Figure 17-29b: Track Using Quarterpoint Variation. Para 1752.

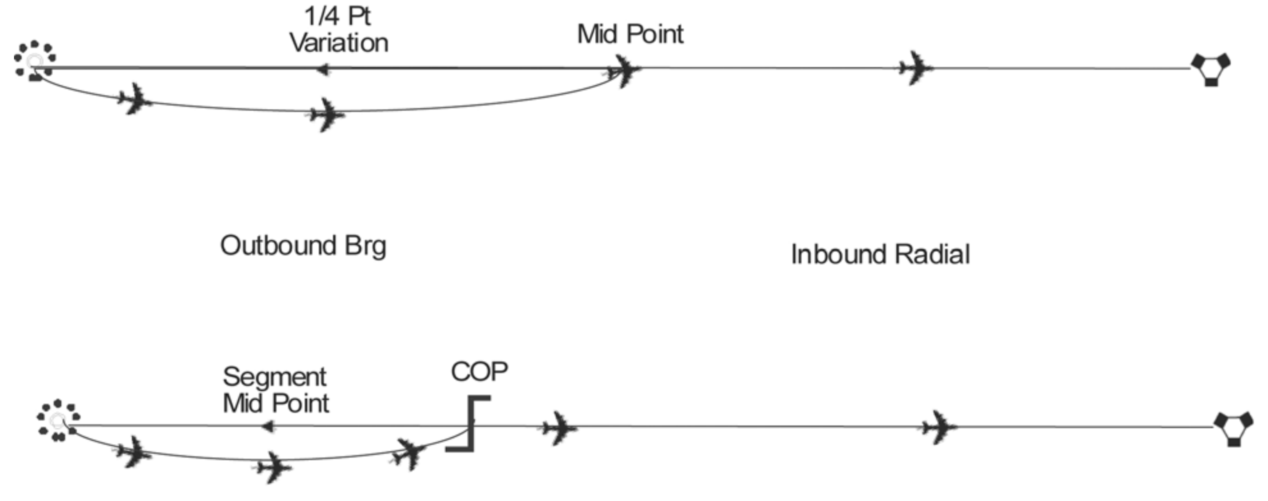

Figure 17-29c: Application Of Quarter point Variation For LF/MF to VHF/UHF Facilities. Para 1752.

1752. Application Of Variation To Calculate LF/MF Tracks

When calculating airway or air route tracks, the appropriate variation shall be applied to the LF/MF segment true bearing to ensure that the aircraft will be positioned on the desired inbound radial at the COP. Proper application of variation is necessary to minimize track error and to ensure the aircraft is positioned on course at the changeover point. This calculation is made from facility to facility and NOT redone for each airway segment between fixes.

If midpoint variation were to be used (see Figure 17-29A) this does not happen. The aircraft heading would initially overcorrect, based on the difference between local variation at the site and the midpoint variation. This over correction will decrease as the aircraft proceeds toward the midpoint, at which time the aircraft would be flying on the proper heading but has not corrected back to the desired track .On a long leg, the resulting track error can be greater than 20nm.

Therefore, to minimize this error and to position the aircraft on the desired track at the midpoint of the airway/air route, ¼ point variation shall be used (see Figure 17-29B). Due to the difference between the local variation at the aircrafts position and the ¼ point variation, the aircraft heading will initially overcompensate, resulting in a track error. As the aircraft proceeds, this error will decrease until at the ¼ point the aircraft will be flying the proper heading but now be just parallel to the desired track. As the aircraft proceeds toward the midpoint it will begin to correct back and ideally be on the desired track at the midpoint (see Figure 17-29B).

Using the same basic rational, in the instance of a dogleg or published COP, the variation to the LF/MF leg shall be the variation at the mid point of that particular segment (see Figure 17-29C).

In summary, the variation(s) to apply to the LF/MF track calculations shall be as follows:

a. LF/MF to LF/MF

   ¼ point variation (see Figure 17-29B).

b. LF/MF to VHF/UHF

   ¼ point variation for the LF/MF segment (see Figure 17-29C).

   The VHF/UHF Radial shall be calculated based on the calibrated variation used for that facility. These values are published in the Canada Flight Supplement, Part D.

c. COP/Dogleg Segment

   Mid-point variation for the LF/MF-COP segment shall be used to calculate the track (see Figure 17-29C).

   The VHF/UHF-COP segment track will be calculated in accordance with Para 1752.b.2.

1753—1759. Reserved

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SECTION 6. MINIMUM DIVERGENCE ANGLES

1760. General

a. Governing Facility. The governing facility for determining the minimum divergence angle depends upon how the fix is determined.

   (1) Where the fix is predicated on an off-course radial or bearing, the distance from the fix to the facility providing the off-course radial or bearing is used.

   (2) Where the fix is predicated on the radials or bearings of two intersecting airways or routes, the distance between the farthest facility and the fix will be used to determine the angle.

b. Holding. Where holding is to be authorized at a fix, the minimum divergence angle is 45°.

1761. VHF Fixes

a. The minimum divergence angle for those fixes formed by intersecting VHF radials are determined as follows:

   (1) When both radio facilities are located within 30 NM of the fix, the minimum divergence is 30°.

   (2) When the governing facility is over 30 NM from the fix, the minimum allowable angle will be increased at the rate of 1° per NM up to 45 NM (45°).

   (3) Beyond 45 NM, the minimum divergence angle increases at the rate of ½° per NM.

   EXAMPLE: Distance from fix to governing facility is 51 NM.

   51 - 45 = 6 NM. x ½ = 3 additional degrees.

   Add this 3° to the 45° required at 45 NM and get 48° minimum divergence angle at 51 NM.

b. Figure 17-28 may be used to define minimum divergence angles. Using the foregoing example, enter the chart at the bottom with the facility distance (51 NM). Move up to the "VHF Fix" conversion line. Then move to the left to read the angle – 48°.

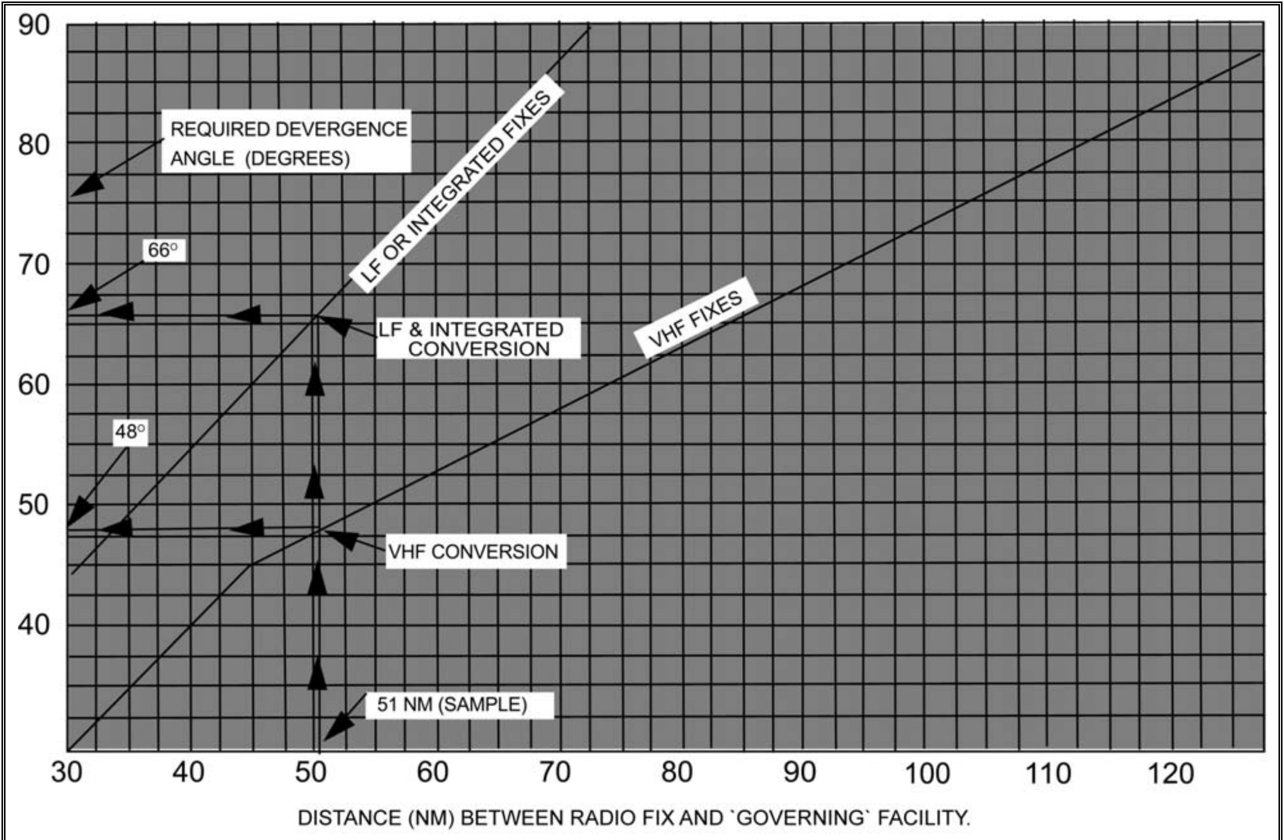


Figure 17-28: Minimum Divergence Angle For Radio Fix. Para 1761.b and 1762.b.

1762. LF or VHF/LF Fixes

a. Minimum divergence angles for LF or integrated (VHF/LF) fixes are determined as follows:

   (1) When the governing facility is within 30 NM of the fix, the minimum divergence angle is 45°.

   (2) Beyond 30 NM the minimum angle must be increased at the rate of 1° for each NM, except for fixes on long over water routes where the fix will be used for reporting purposes and not for traffic separation.

   EXAMPLE: The distance from the governing facility is 51 NM.

   51 - 30 = 21

   Add 21° to 45° required at 30 NM to get the required divergence angle, 66°.

b. Figure 17-28 may be used to define minimum angles for LF or VHF/LF fixes. Using the foregoing example, enter at the bottom of the chart with the 51 NM distance between the facility and fix. Move up to the "LF or INTEGRATED FIX" conversion line, then left to read the required divergence angle, 66°.

1763—1799. Reserved

CHAPTER 18. HOLDING CRITERIA

1800. General

This chapter specifies the criteria for determining the dimensions of airspace to be protected for holding aircraft.

1801. Terminology

a. **Holding Area.** The airspace required at a particular altitude to contain aircraft performing specified entry and holding procedures based on allowances for wind effect, timing errors, fix characteristics, etc.

b. **Holding Pattern.** The race track pattern to be flown by a holding aircraft.

c. **Minimum Holding Altitude (MHA).** The lowest altitude prescribed for a holding pattern, which assures navigational signal coverage, communications, airspace requirements and meets obstacle clearance requirements.

d. **Reduction Area.** For ATC purposes only, that portion of a holding area for which airspace protection may or may not be required, depending upon the direction of entry to the holding pattern, position of the aircraft or length of DME leg used. When assessing a holding pattern for obstacle clearance, the full size of the holding pattern shall be evaluated.

e. **Shuttle Procedure.** A shuttle procedure is a manoeuvre involving a descent or climb in a pattern resembling a holding pattern.

1802. Development Concept

The following factors have been incorporated into the criteria:

a. Winds. An analysis of winds at various levels over a 5 year period led to the adoption of a scale of velocities beginning with 50 knots at 4,000 feet ASL and increasing at a rate of 3 knots for each additional 2,000 feet of altitude to a maximum of 120 knots.

b. Airspeed. Holding patterns are developed based upon the maximum airspeeds shown in Table 18–1.

c. Angle of Bank. The criteria are based upon a bank angle of at least 25° or a rate of turn of 3° per second, whichever requires the lesser bank.

A. Propeller Aircraft (including turbo-prop)	
(1) MHA to 30,000 feet	175 KT IAS
B. Civil Turbo-jet	
(1) MHA to 14,000 feet	230 KT IAS
(2) Above 14,000 feet	265 KT IAS
C. Military Turbo-jet	
(1) all except those aircraft listed below in 2, 3 and 4	265 KT IAS
(2) (USAF) F-4	280 KT IAS
(3) B-1, F-111 and F-5	310 KT IAS
(4) T-37 and CT-114	175 KT IAS

Table 18-1: Maximum Holding Airspeeds. Para 1802.b and 1822.a (1).

1803. Navigation Aid And Airborne System Tolerance

The criteria in this section apply to conventional navigation aids such as VOR, VOR/DME and/or NDB. Allowances have been made for the following factors:

a. Cone of ambiguity. Related to altitude, system error (± 5°) and aircraft track indication (±10° for full instrument deflection). Total tolerance is 15°.

b. Intersection disparity. Related to system error and distance between the holding point and the farthest navigation aid used to form it.

c. Station passage TO-FROM error: ±4°.

d. Delay in recognizing and reacting to fix passage. 6 seconds for entry turn, applied in the direction most significant to protected airspace.

1804. Holding Fixes

Any terminal area fix, except overhead a TACAN, may be used for holding. If that fix is an intersection formed by courses or radials, the following conditions apply:

a. The angle of divergence of the courses or radials shall not be less than 45 degrees. See Figure 18-1.

b. If the facility which provides the crossing course is not an NDB, it may be as much as 45 miles from the point of intersection.

c. If the facility which provides the crossing course is an NDB, it must be within 30 miles of the intersection point.

d. These distances may be exceeded provided the minimum angle of divergence of the intersecting courses is increased at the following rate:

   (1) If an NDB is involved, increase the angle 1 degree for each mile over 30 miles.

   (2) If an NDB is not involved, increase the angle ½ degree for each mile over 45 miles.

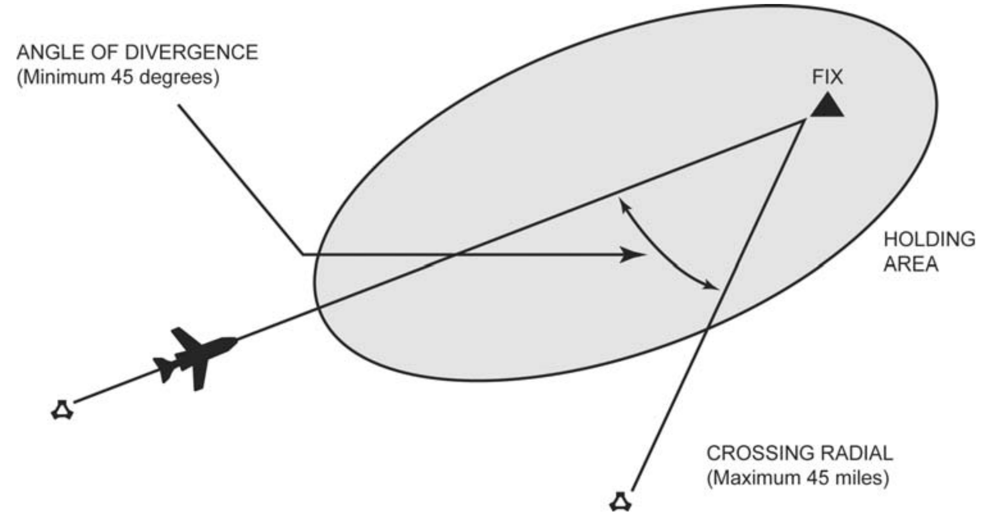


Figure 18-1: Intersections Used For Holding Fixes. Para 1804.a.

1805—1809. Reserved

SECTION 1. RESERVED

1810 – 1819 Reserved

SECTION 2. HOLDING CRITERIA

1820. Level Holding

There are 31 holding airspace sizes. Each area is related to one or more even-numbered altitudes/flight levels and is identified by a template number for easy reference. See Table 18-2.

Templates are drawn to a scale of 1:500,000 (1 inch = approx. 6.9 NM) for use with aeronautical charts having the same scale. Details for tracing templates are contained in Section 3, Para 1831. When use of a different scale is necessary, holding areas may be constructed manually as outlined in Section 3, Para 1832.

a. Alignment. Whenever practical, holding patterns should be aligned to coincide with the flight course to be flown after leaving the holding fix. However, when the flight path to be flown is along an arc, the holding pattern should be aligned on a radial. When a holding pattern is established at a final approach fix and a procedure turn is not used, the inbound course of the holding pattern shall be aligned to coincide with the final approach course unless the final approach fix is a facility. When the final approach fix is a facility, the inbound holding course and the final approach course shall not differ by more than 30 degrees.

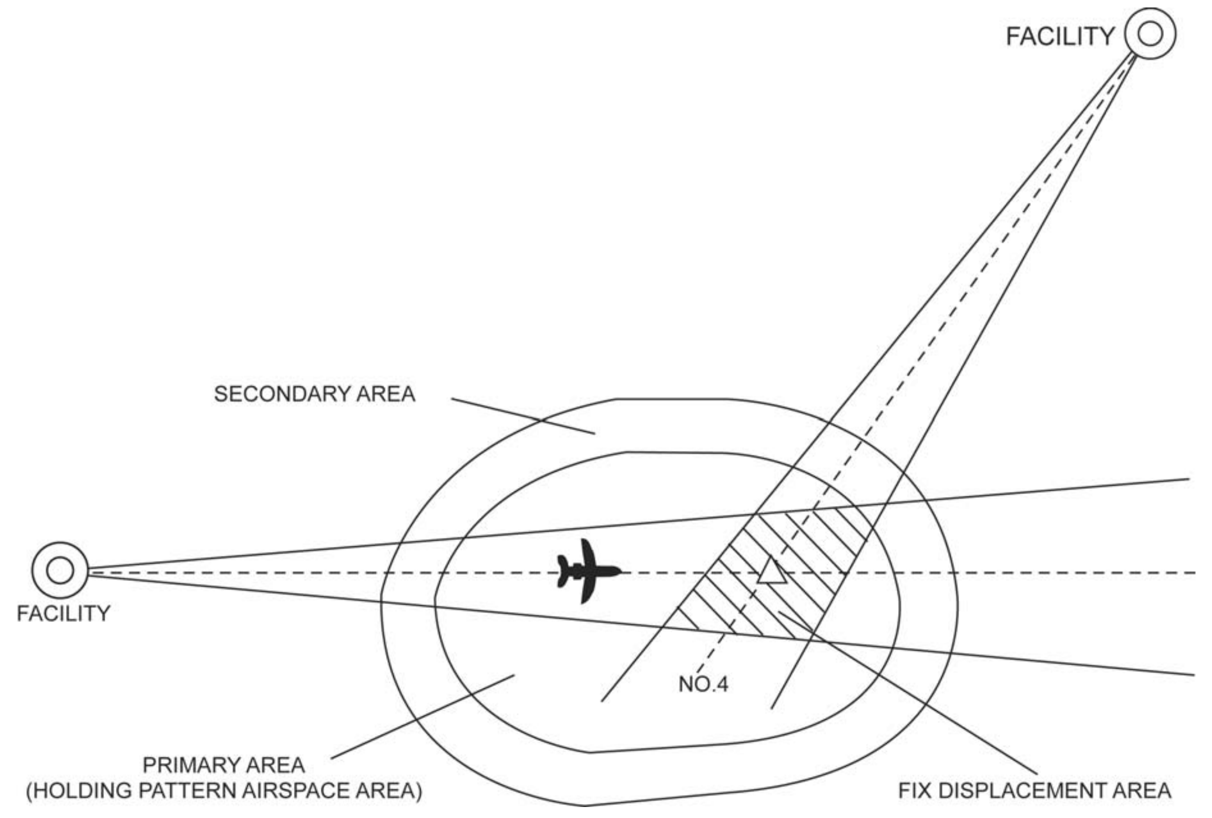


Figure 18-2: Holding Pattern Template Application. Para 1820.b.

b. Area. Pattern number 4 is normally the minimum size authorized for the primary area. When holding is at an intersection fix, the selected pattern primary area shall be large enough to contain at least 3 corners of the fix displacement area. See Chapter 2, Paras 284 and 285, and Figure 18-2. A secondary area 2 miles wide surrounds the perimeter of the primary area. If using a template smaller than pattern number 4, then the appropriate speed restriction shall be published.

   (1) Altitude. Holding altitudes from 2,000 feet ASL to FL480 are listed. Holding at an even altitude requires the use of the appropriately numbered holding area/template shown opposite the altitude. Holding at odd altitudes above 2,000 feet requires use of the numbered holding area/template for the next higher altitude.

   (2) Template Categories. Table 18–2 shall be used to determine the holding template required. Fix distance is the measured ground distance in nautical miles from the holding fix to the NAVAID. Template sizes are shown for three ranges of fix-to-NAVAID distances: 0-14.9 NM, 15-29.9 NM, and 30 NM and over. Holding overhead a NAVAID requires the use of the 0-14.9 NM group. When a fix is based on information from two navigation aids, the greatest fix-to-NAVAID distance shall be used to determine the correct holding area/template size. This applies to any type or combination of navigation aids used to establish a holding fix.

c. Obstacle Clearance. A minimum of 1,000 feet of obstacle clearance shall be provided throughout the primary area. In mountainous regions apply additional obstacle clearance for en route holding. In the secondary area 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge. For computation of obstacle clearance in the secondary area see Annex C, Para 5 and Figure C-3. Allowance for precipitous terrain should be considered as stated in Para 323. Altitudes selected by application of the obstacle clearance specified in this paragraph may be rounded to the nearest 100 feet provided the ROC is not violated. See Para 231.

d. Altitude Selection. If an approach is made from a properly aligned holding pattern, vice from a procedure turn (see Para 234.e), the holding pattern shall be established over a final or intermediate approach fix and the following conditions shall apply:

   (1) If the holding pattern is established over the final approach fix, the minimum holding altitude shall not be more than 300 feet above the altitude specified for crossing the final approach fix inbound; or

   (2) If the holding pattern is established over the intermediate fix, the minimum holding altitude shall permit descent to the final approach fix altitude within the descent gradient tolerances prescribed for the intermediate segment. See Para 243.d.

ALT	175 KIAS			200 KIAS			210 KIAS		
	0 - 14.9 NM	15 - 29.9 NM	30 NM and over	0 - 14.9 NM	15 - 29.9 NM	30 NM and over	0 - 14.9 NM	15 - 29.9 NM	30 NM and over
2	1	1	2	3	4	5			
4	1	2	3	4	5	6			
6	2	3	4	5	6	7			
8	3	4	5				6	7	8
10	4	5	6				7	8	9
12	5	6	7				7	8	9
14	6	7	8				8	9	10
16	7	8	9						
18	8	9	10						
20	8	9	10						
22	9	10	11						
24	10	11	12						
26	11	12	13						
28	12	13	14						
30	13	14	15						
32									

ALT	230 KIAS			265 KIAS			310 KIAS		
	0 - 14.9 NM	15 - 29.9 NM	30 NM and over	0 - 14.9 NM	15 - 29.9 NM	30 NM and over	0 - 14.9 NM	15 - 29.9 NM	30 NM and over
2	5	6	7	7	8	9	11	12	13
4	6	7	8	8	9	10	12	13	14
6	7	8	9	9	10	11	13	14	15
8	8	9	10	10	11	12	14	15	16
10	9	10	11	11	12	13	15	16	17
12	9	10	11	12	13	14	17	18	19
14	10	11	12	13	14	15	18	19	20
16	12	13	14	15	16	17	19	20	21
18	13	14	15	16	17	18	20	21	22
20	14	15	16	17	18	19	21	22	23
22	15	16	17	18	19	20	22	23	24
24	16	17	18	19	20	21	22	23	24
26	17	18	19	20	21	22	24	25	26
28	18	19	20	21	22	23	24	25	26
30	19	20	21	22	23	24	25	26	27
32				23	24	25	26	27	28
34				24	25	26	27	28	29
36				25	26	27	28	29	30
38				26	27	28	29	30	31
40				27	28	29	30	31	
42				28	29	30			
44				28	29	30			
46				29	30	31			
48				31					

Table 18-2: Holding Area Template Selection Chart. Para 1820, 1821.c, and 1824.

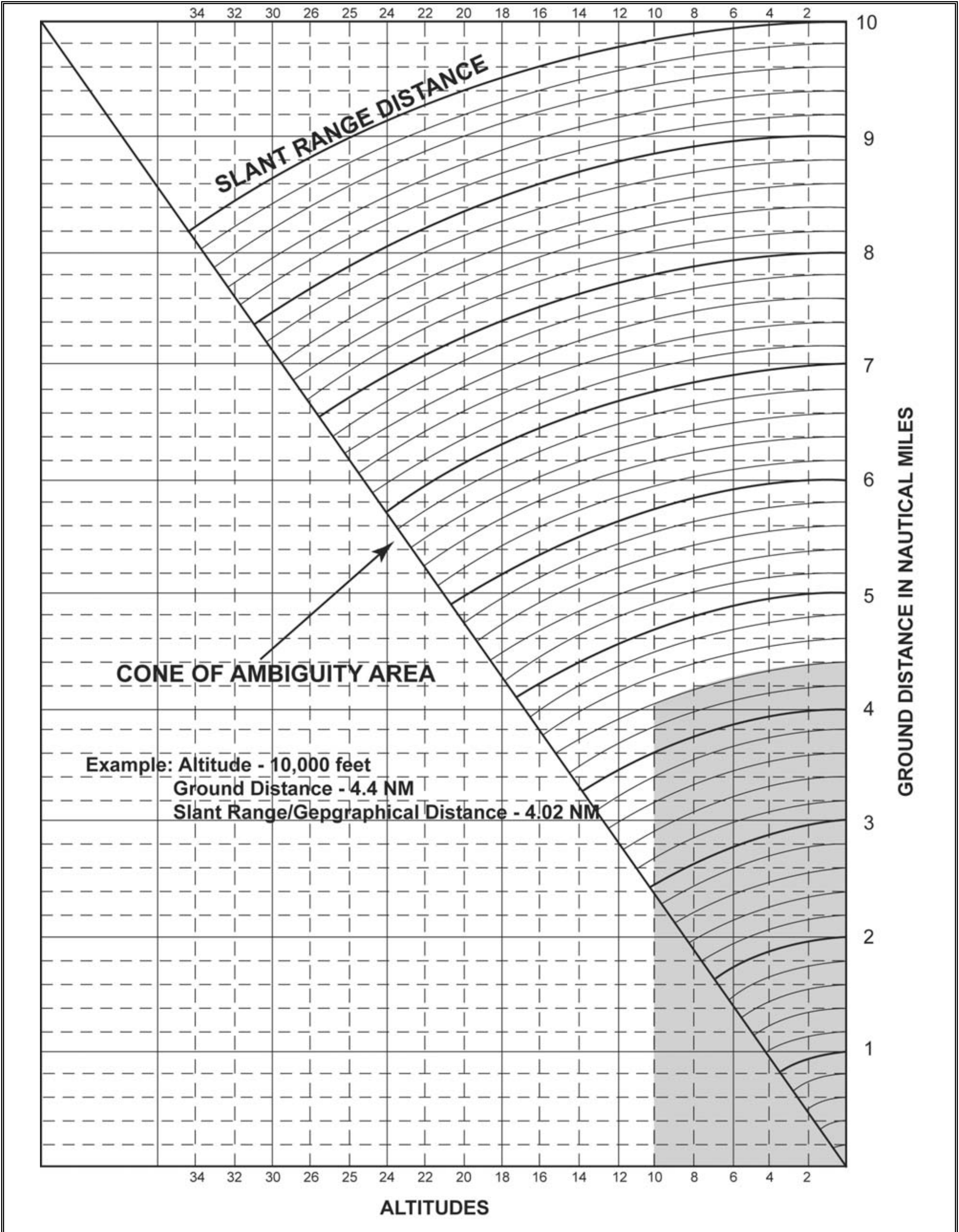


Figure 18-3: DME Slant Range Distance / Cone Of Ambiguity Area Chart. Para 1821.a.

1821. DME Holding

a. Cone of Ambiguity. Cone of ambiguity information is depicted on the DME Slant Range Distance/Cone of Ambiguity Area Chart. See Figure 18-3.

(1) DME fixes shall not be established within the cone of ambiguity above the navigation aid providing DME information.

(2) DME holding may be accomplished either toward or away from a DME navigation aid. When the DME inbound holding track leads toward the navigation aid, the fix end of the holding area, but not the DME fix, may lie within the cone of ambiguity, provided entry to the pattern is normally made from a direction other than through the cone. If entry is usually made through the cone of ambiguity, the entire holding area must lie outside the cone. When the inbound DME holding track leads away from the navigation aid, no part of the holding area may lie within the cone of ambiguity. See Figure 18-4.

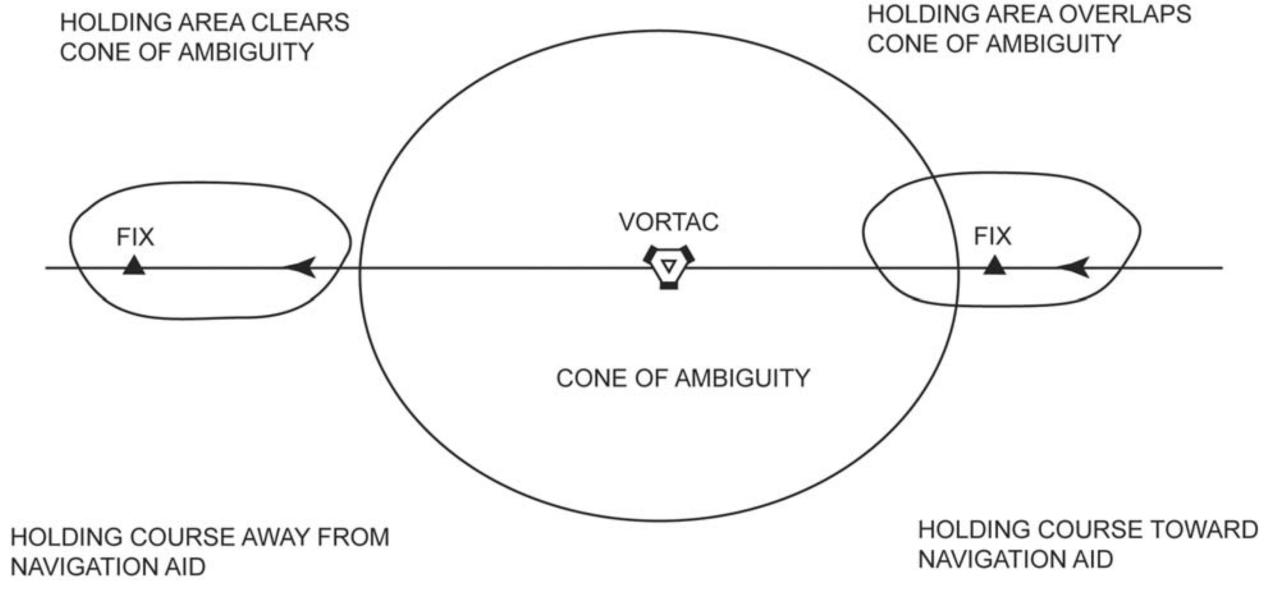


Figure 18-4: DME Holding - Cone Of Ambiguity. Para 1821.a.(2).

b. Effect of Slant Range. An airborne DME reading of 5 NM at 30,000' would indicate that an aircraft is directly over the navigation aid. If the aircraft maintained the 5 NM DME distance during descent, its flight path would form an arc beginning over the navigation aid to a point on the surface 5 NM horizontal distance from the navigation aid. Therefore, near the surface a holding fix could be 5 NM horizontally from the navigation aid, but at 13,000' it would be 4.5 NM horizontally from the navigation aid. In this instance, 5 NM is the fix-to-navigation aid distance, and 4.5 NM is the slant range/geographical distance. See Figure 18-5. When establishing a DME holding fix, the difference between fix-to-navigation aid and slant range/geographical distance shall be determined. DME holding fix distance differences shall be governed by the following:

(1) When establishing a DME hold, fix differences between fix-to-navigation aid and slant range/geographical distance shall be determined using the DME Slant Range Distance/Cone of Ambiguity Area Chart. See Figure 18-3.

(2) Use whole nautical miles for slant range distance. For example: the minimum DME distance to hold an aircraft at 10,000 feet occurs at a slant-range distance of 2.9 NM. Therefore, holding shall be based on a 3 NM DME fix.

(3) When the slant range/geographical distance differs 0.25 NM or less from the fix-to-navigation aid distance at the highest altitude to be used for holding, the difference may be disregarded for altitudes at or below 14,000 feet. A difference of 0.5 NM or less may be disregarded above 14,000 feet.

Example: A DME fix is required for holding at and below 10,000 feet at a geographical distance of 8 NM. Figure 18-3 shows that the 8 NM slant range at 10,000 feet is 7.84 NM horizontally from the navigation aid. The difference of 0.16NM may be disregarded when plotting protected airspace. If the holding altitude in the same example is changed to FL200, the horizontal distance at FL200 would be 7.3 NM, creating a difference of 0.7 NM. In this case, protected airspace should be based on a distance of 7.3 NM.

(4) Collocation of DME and Non-DME fixes. When a DME holding fix is to be collocated with another established fix, and the horizontal distance between the established fix and the navigation aid providing DME information is to be used as the DME slant range distance, significant distance differences may exist. Differences shall be governed by the following:

(a) When it is desirable to use a single distance with respect to both DME and VOR intersection holding, plot the holding area based on the VOR intersection. Then replot the slant range/geographical distance from the navigation aid for the highest holding altitude. The combined perimeter of the two plots determines the airspace to be protected.

(b) When it is desirable to contain DME and non-DME holding within a single pattern size, use a slant range distance different from the distance between the non-DME fix and the navigation aid providing DME information. Select a slant range distance, for the highest altitude to be used for holding, which is coincident with the distance between the non-DME fix and the navigation aid providing DME information. See Figure 18-6.

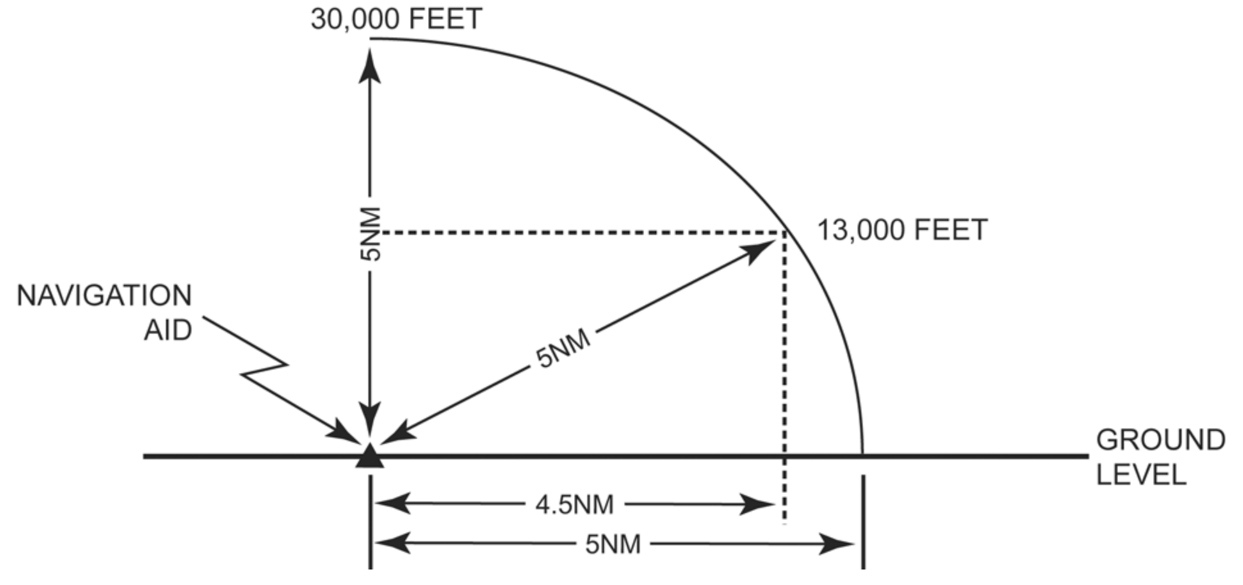


Figure 18-5: Slant Range/Geographical Distance. Para 1821.b.

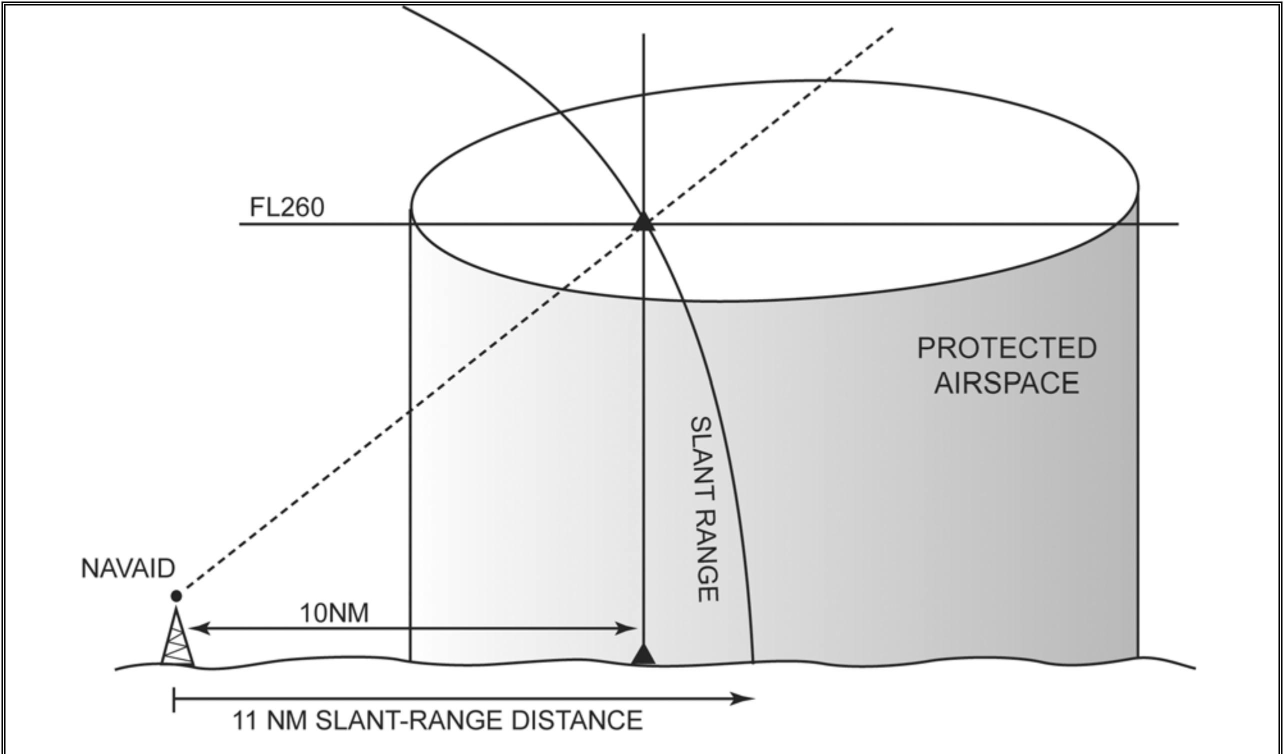


Figure 18-6: Collocated Fix (Single Holding Area). Para 1821.b.(4)(b).

1822. Shuttle Procedures

A shuttle procedure is a manoeuvre involving a descent or climb in a pattern resembling a holding pattern. Shuttles are generally used on procedures located in mountainous areas. In the approach phase, it is normally prescribed where a descent of more than 2,000 feet is required during the initial or intermediate approach segments. In may also be required when flying a missed approach or departure procedure from certain aerodromes.

a. Shuttle Climb.

(1) Area. When a shuttle climb is used, the primary holding area shall encompass the departure or missed approach segment width at the holding fix. See Figure 18-7. A secondary area 2 miles wide surrounds the perimeter of the primary area.

The holding area/speed relationship in Table 18–1 is not adequate for climbing aircraft primarily because climb speeds exceed level holding speeds. Shuttle climb areas may be assessed using the following templates:

(a) If using the 200 KT or 210 KT template, publish a speed restriction of 175 KIAS.

(b) If using the 230 KT template, publish a speed restriction of 200 KIAS.

(c) If using the 265 KT template, publish a speed restriction of 250 KIAS.

(d) If using the 310 KT holding pattern, no speed restriction is required.

Example: A departing turbo-jet aircraft must shuttle climb to 16,000 feet at an NDB. Table 18–2 (310 KT at 16,000 feet) indicates template number 19 will provide the necessary protected airspace.

(e) When developing a shuttle climb, it is acceptable to begin obstacle assessment using the smallest template appropriate for the altitude that the shuttle starts and increase the template size appropriate for altitude as the aircraft climbs and true airspeed increases.

Example: A departure, within mountainous terrain, requires the aircraft to shuttle climb to 16,000 feet before proceeding on course. The field elevation is 2,600 feet. The holding facility is within 5 NM of the departure aerodrome. The speed in the climb will be restricted to 200 KIAS.

Start the obstacle assessment using template number 6, which is appropriate for 4,000 feet and 230 KIAS. Then reassess the procedure using the templates appropriate for 6,000 feet, 8,000 feet, 10,000 feet, 12,000 feet, 14,000 feet and finally 16,000 feet. As the aircraft climbs, the size of the holding area will increase to accommodate the increase in aircraft true airspeed.

(2) Obstacle Clearance. When a shuttle climb is used, as in a departure or missed approach, no obstacle shall penetrate the holding surface. This surface begins at the end of the segment leading to the holding fix. Its elevation is that of the departure OIS or missed approach surface at the holding fix. It rises at a 40:1 rate to the edge of the primary area, then at a 12:1 rate to the outer edge of the secondary area. The distance to any obstacle is measured from the obstacle to the nearest point on the end of the segment at the holding fix. See Figure 18-7.

b. Shuttle Descent.

(1) Alignment. When a holding pattern is established at a final approach fix and a procedure turn is not used, the inbound course of the holding pattern shall be aligned to coincide with the final approach course unless the final approach fix is a facility. When the final approach fix is a facility, the inbound holding course and the final approach course shall not differ by more than 30 degrees.

(2) Area. Shuttle descent areas may be assessed using the following templates:

(a) If using the 200 KT or 210 KT template, publish a speed restriction of 175 KIAS.

(b) If using the 230 KT template, publish a speed restriction of 200 KIAS.

(c) If using the 265 KT template, publish a speed restriction of 250 KIAS.

(d) When assessing a shuttle descent, it is acceptable to reduce the template size appropriate for altitude as the aircraft descends, similar to the shuttle climb.

(3) Obstacle Clearance. A minimum of 1,000 feet of obstacle clearance shall be provided throughout the primary area. In the secondary area 500 feet of obstacle clearance shall be provided at the inner edge, tapering to zero feet at the outer edge.

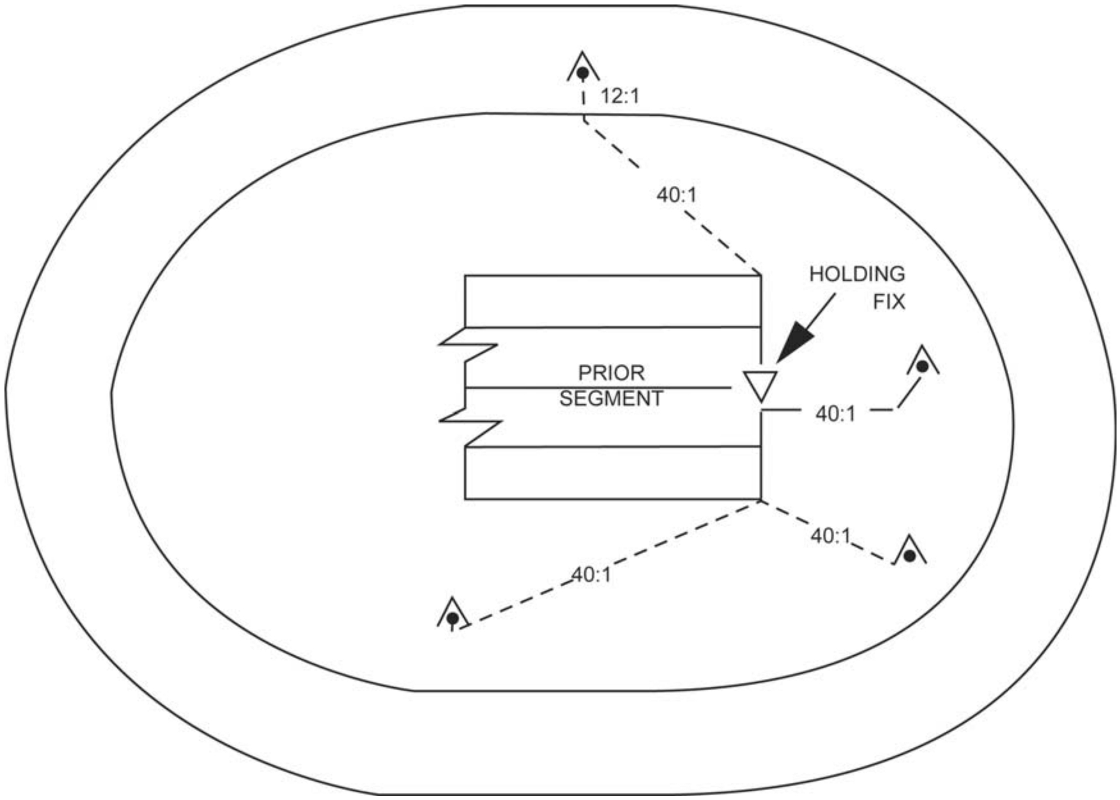


Figure 18-7: Climbing In A Holding Pattern. Para 1822.a.(2).

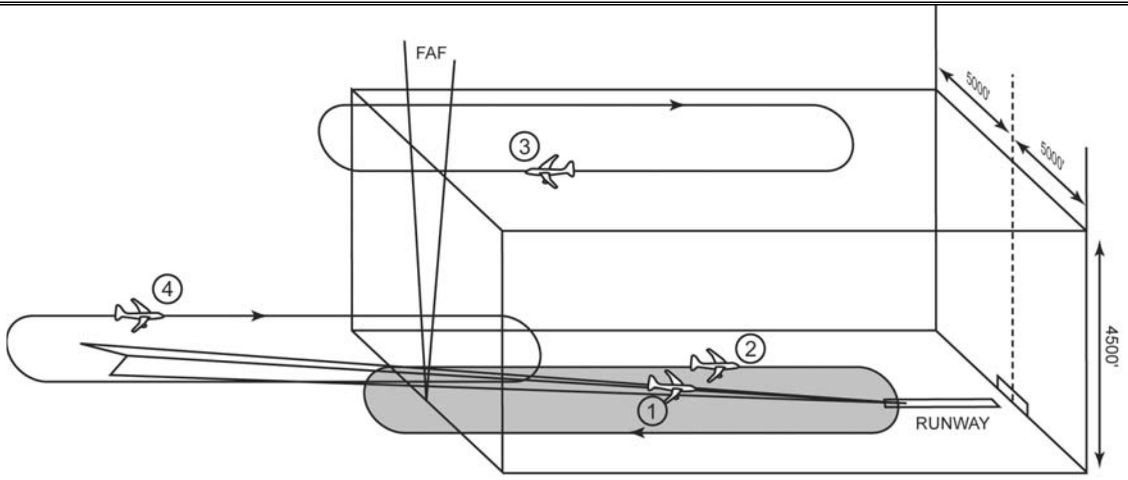
1823. Holding Patterns On ILS Courses

Holding patterns shall not be established inbound on an ILS localizer between the FAF and the localizer antenna below 5,000 feet above the antenna elevation, in order to avoid creating unwanted reflected signals. Holding patterns opposite to the inbound course are acceptable. See Figure 18-8. Ensure localizer signal coverage when establishing the hold.

1824. GPS Holding

The airspace to be protected for GPS holding is the same as per the template areas in Table 18–2. When holding is at a GPS waypoint the primary area of the selected pattern shall be large enough to contain the entire waypoint displacement area (see Table 16–1). Use the 15 NM distance for terminal holding procedures and 30 NM distance for en route holding.

1825—1829. RESERVED



① Aircraft inbound on ILS - OK.

② Inbound holding course is coincident with course of aircraft ① , thus unwanted localizer signals are being reflected - NOT PERMITTED.

③ Inbound holding course is opposite course of aircraft ① - OK.

④ Inbound holding course is outside reflected signal area - OK.

Figure 18-8: Reflected Signal Area. Para 1823.

SECTION 3. CONSTRUCTION OF HOLDING AREAS

1830. Reserved

1831. Tracing Of Templates

a. Primary Area. The perimeter of the template contains four radii and two straight lines. Position the holding fix grommet hole over the fix, and align the solid black line with the inbound holding track. Trace the pattern perimeter. See Figure 18-9.

   (1) Right Turn Pattern. The numbers on the template should be face-up and readable.

   (2) Left Turn Pattern. The numbers on the template should be face-down.

b. Secondary Area. Manually draw the secondary area 2 miles from the edge of the primary area.

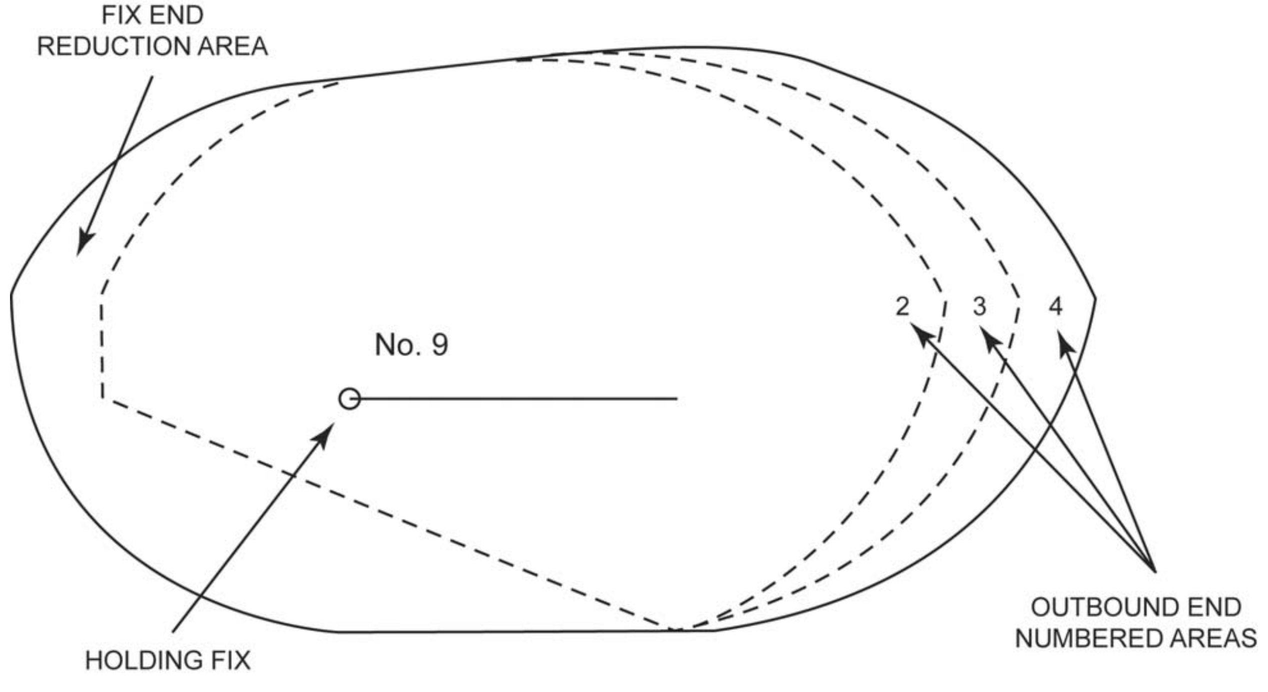


Figure 18-9: Holding Template. Para 1831.a.

1832. Manual Construction Of Holding Areas

Each holding area may be manually constructed by applying the dimensions for the area concerned, as provided in Table 18–3 and using the reference points depicted in Figure 18-10, and in accordance with the following directions:

a. Locate and mark the holding fix with the letter L.

b. Draw the inbound track; A to L, L to M, and M to G.

c. At a 90° angle from the inbound track locate and mark Points B above A, F above G, E above M, H below M and I below L.

d. Connect I and H with a straight line.

e. Set the compass for distance L-B; place the compass center at L and draw an arc from B to beyond C. (Note: C is a general location above L.)

f. Draw a straight line from E tangent to the arc B-C.

g. Set the compass for distance L-B; place the compass center at B and draw a short arc above L; relocate the compass center at I and draw a short arc through the first arc; relocate the compass center at the intersection of the arcs and connect I-B.

h. Set the compass for distance F-M; Place the compass center at F, draw an arc from above H to below E. Place the compass center at E and draw a short arc below M. Place the compass center at H and draw a short arc above M. The arcs formed from E and H intersect the arc formed from F. Place the compass center at the appropriate intersection of these arcs and connect E-F; place the compass center at the other intersection and connect F-H.

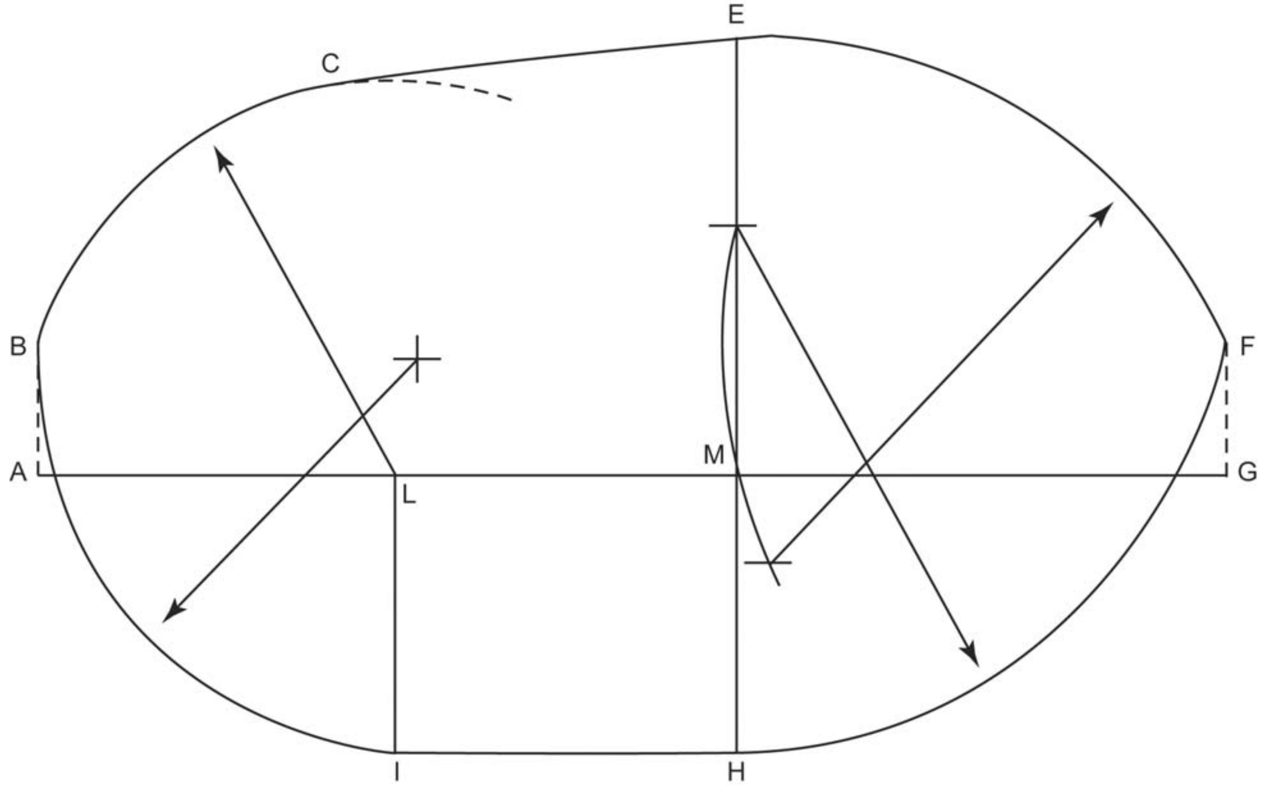


Figure 18-10: Construction Code For Basic Area. Para 1832.

1833—1899. Reserved

Template No.	A-L	L-M	M-G	L-I M-H	M-E	A-B G-F	Total Length	Width
1	3.5	3.7	4.4	2.6	4.1	1.2	11.6	6.7
2	3.8	3.9	4.8	2.9	4.5	1.3	12.5	7.4
3	4.2	4.1	5.2	3.2	4.9	1.4	13.5	8.1
4	4.5	4.3	5.6	3.5	5.3	1.5	14.4	8.8
5	4.9	4.5	6.1	3.8	5.7	1.7	15.5	9.5
6	5.6	4.8	6.5	4.2	6.4	2.0	16.9	10.6
7	6.0	6.6	8.2	4.6	7.2	2.2	20.8	11.8
8	6.5	6.8	9.3	4.9	7.7	2.3	22.6	12.6
9	7.0	7.0	9.7	5.3	8.3	2.5	23.7	13.6
10	7.6	7.3	10.4	5.7	8.9	2.7	25.3	14.6
11	8.0	7.5	11.1	6.2	9.6	2.9	26.6	15.8
12	8.7	7.8	11.7	6.5	10.2	3.1	28.2	16.7
13	9.2	8.6	12.1	7.0	10.9	3.3	29.9	17.9
14	9.9	8.9	12.8	7.5	11.6	3.6	31.6	19.1
15	10.4	9.6	13.1	7.7	12.1	3.8	33.1	19.8
16	11.1	9.9	13.7	8.2	12.8	4.0	34.7	21.0
17	11.9	10.1	14.8	8.6	13.6	4.3	36.8	22.2
18	12.7	10.5	15.7	9.2	14.6	4.5	38.9	23.8
19	13.8	11.1	16.8	9.9	15.7	4.8	41.7	25.6
20	14.5	11.5	18.0	10.5	16.5	5.2	44.0	27.0
21	15.5	11.8	18.8	11.2	17.6	5.5	46.1	28.8
22	16.5	12.1	21.2	11.9	18.8	5.9	49.8	30.7
23	17.6	12.4	21.6	12.7	20.1	6.3	51.6	32.8
24	19.2	12.9	23.4	13.7	21.7	6.9	55.5	35.4
25	21.2	13.3	25.5	14.7	23.4	7.5	60.0	38.1
26	22.9	13.8	27.6	16.1	25.7	8.1	64.3	41.8
27	24.6	14.4	29.5	17.3	27.3	8.8	68.5	44.6
28	26.9	15.2	32.6	18.9	30.2	9.6	74.7	49.1
29	28.0	15.8	34.6	20.1	32.0	10.0	78.4	52.1
30	29.2	16.4	35.3	21.3	33.2	10.4	80.9	54.5
31	30.9	17.0	37.0	22.5	34.5	11.0	84.9	57.0

Table 18-3: Holding Area Airspace Dimensions (nm). Para 1832.

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ALPHABETICAL INDEX

CHAPTER 1. GENERAL INFORMATION

1.0 Purpose

This volume contains final and initial missed approach segment construction criteria applicable to instrument approach procedures that provide positive glidepath guidance. Apply this criteria to approaches based on instrument landing system (ILS), microwave landing system (MLS), precision approach radar (PAR), transponder landing system (TLS), wide area augmentation system (WAAS), local area augmentation system (LAAS), barometric vertical navigation (Baro-VNAV), and future 3-dimensional navigational systems.

1.1 Background

The ILS defined the navigational aid (NAVAID) performance standard for precision vertical and lateral guidance systems. Several different NAVAID's providing positive vertical guidance have evolved since the inception of ILS. NAVAID's capable of supporting Category I landing minimums are: ILS, PAR, MLS, TLS, WAAS, and LAAS. NAVAID's capable of providing Category II/III landing minimums are: ILS, MLS, and LAAS. A NAVAID capable of supporting Category I/II/III minimums does not qualify as a precision approach (PA) system without supporting ground infrastructure. Certain airport and obstruction clearance requirements are mandatory for the system to be considered a PA system and achieve the LOWEST minimums. These requirements are contained in TP 312 Aerodrome Standards, Precision Approach (PA), Barometric Vertical Navigation (Baro-VNAV) Approach Procedure Construction, and appropriate military directives. When mandatory ground infrastructure requirements are not met, these NAVAID's may provide a vertically guided stabilized final approach descent, but command higher landing minimums. Additionally, some flight management system (FMS) avionics suites are equipped with Baro-VNAV systems that provide stabilized descent guidance.

1.2 Definitions

Approach Surface Base Line (ASBL). A horizontal line tangent to the surface of the earth at the runway threshold (RWT) point, aligned with the final approach course (see Figure 1-1).

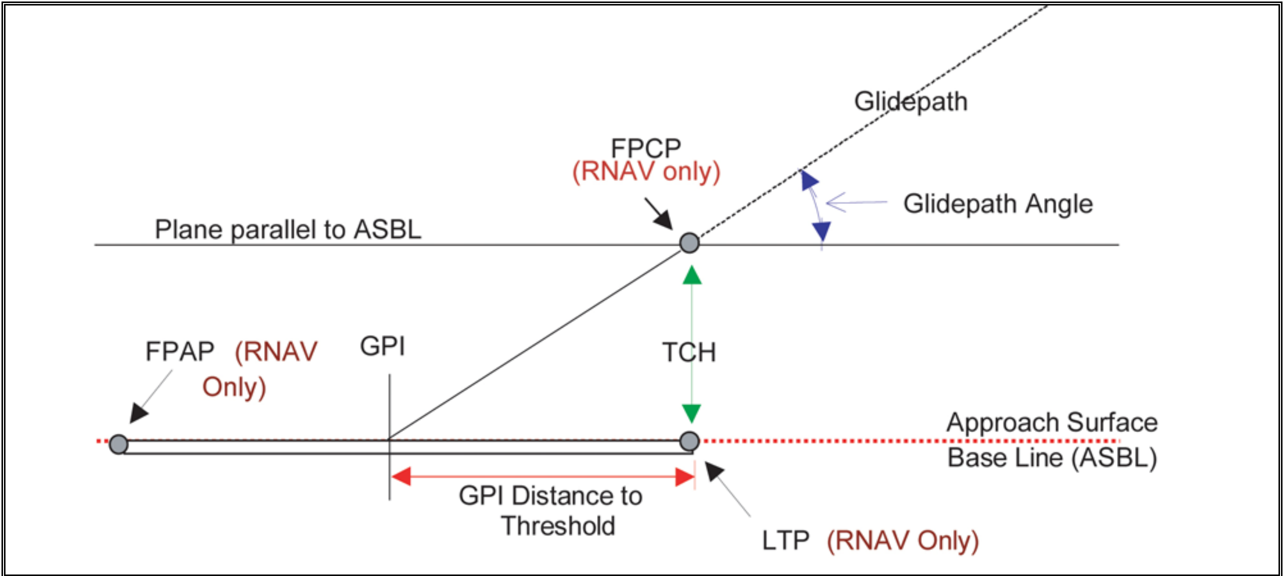


Figure 1-1: Precision Terms. Para 1.2.

Barometric Altitude. Altitude above the orthometric Geoid surface (i.e., mean sea level (MSL), based on atmospheric pressure measured by an aneroid barometer). This is the most common method of determining aircraft altitude.

Barometric Vertical Navigation (Baro-VNAV). RNAV and Non-RNAV. Positive vertical guidance relative to a computed glidepath that is based on the difference between published altitudes at two specified points or fixes.

Decision Altitude (DA). A specified altitude in reference to mean sea level in an approach with vertical guidance at which a missed approach must be initiated if the required visual references to continue the approach have not been established.

Departure End of Runway (DER). The end of the runway that is opposite the landing threshold. It is sometimes referred to as the stop end of runway.

Fictitious Threshold Point (FTP). The equivalent of the landing threshold point (LTP), when the final approach course is offset from runway centreline. It is the intersection of the final course and a line perpendicular to the final course that passes through the LTP. FTP elevation is the same as the LTP (see Figure 1-2).

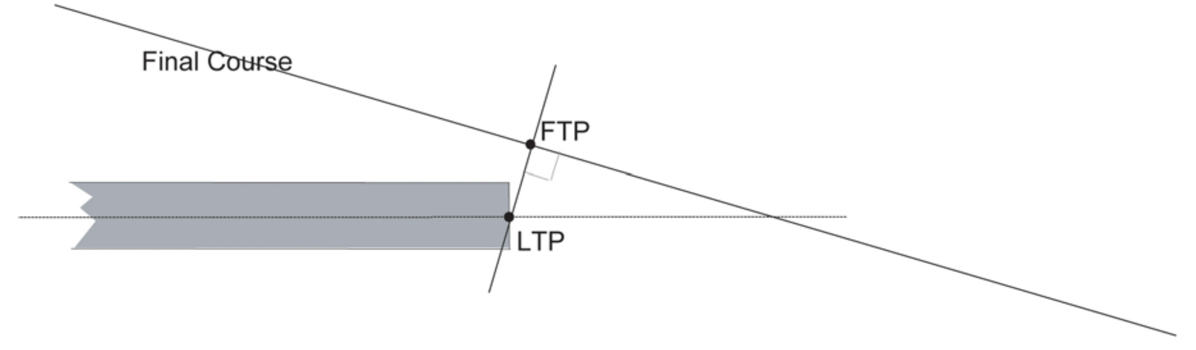


Figure 1-2: Fictitious Threshold Point. Para 1.2.

Flight Path Alignment Point (FPAP) [RNAV Only]. The FPAP is a 3D point defined by World Geodetic System (WGS)-84/North American Datum (NAD)-83 latitude, longitude, MSL elevation (see Figures 1-1 and 1-3). The FPAP is used in conjunction with the LTP and the geometric centre of the WGS-84 ellipsoid to define the vertical plane of a PA RNAV final approach course. The approach course may be offset up to 3° by establishing the FPAP left or right of centreline along an arc centred on the LTP.

Flight Path Control Point (FPCP) [RNAV Only]. An imaginary point above the LTP from which the glidepath mathematically emanates. It is in a vertical plane containing the LTP and FPAP. The FPCP has the same geographic coordinates as the LTP. The elevation of the FPCP is the sum of LTP elevation and the TCH value (see Figure 1-3).

Geoid Height (GH) [RNAV Only]. The height of the Geoid (reference surface for orthometric or MSL heights) relative to the WGS-84 ellipsoid. It is a positive value when the Geoid is above the WGS-84 ellipsoid and negative when it is below. The value is used to convert an MSL elevation to an ellipsoidal or geodetic height - the height above ellipsoid.

Glidepath Angle (GPA). The angular displacement of the glidepath from a horizontal plane that passes through the LTP/FTP. This angle is published on approach charts (e.g., 3.00°, 3.20°, etc.).

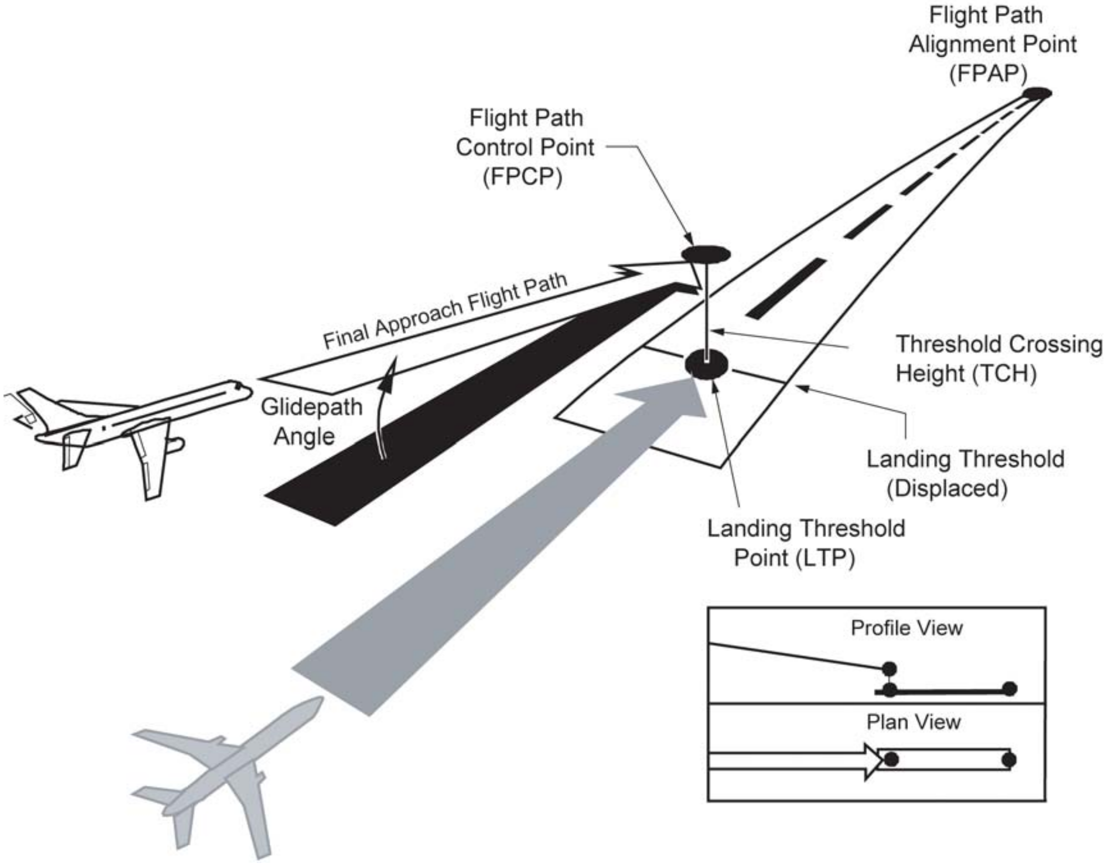


Figure 1-3: Precision Approach Path Points (Straight-In). Para 1.2.

Ground Point of Intercept (GPI). A point in the vertical plane containing the glidepath where the vertical path intercepts the ASBL. GPI is expressed as a distance from RWT (see Figure 1-4).

Height Above Ellipsoid (HAE) [RNAV Only]. A height expressed in feet above the WGS-84 ellipsoid. This value differs from a height expressed in feet above the geoid (essentially MSL) because the reference surfaces (WGS-84 Ellipsoid and the Geoid) do not coincide. To convert an MSL height to an HAE height, algebraically add the geoid height value to the MSL value. HAE elevations are not used for instrument procedure construction, but are documented for inclusion in airborne receiver databases.

EXAMPLE:

Given:	KOUN RWY 35	Runway ID
	N 35 14 31.65	Latitude
	W 97 28 22.84	Longitude
	1177.00MSL	Elevation
	-87.29 feet (-26.606 m)	Geoid Height (GH)

HAE = MSL + GH
HAE = 1177 + (-87.29)
HAE = 1089.71

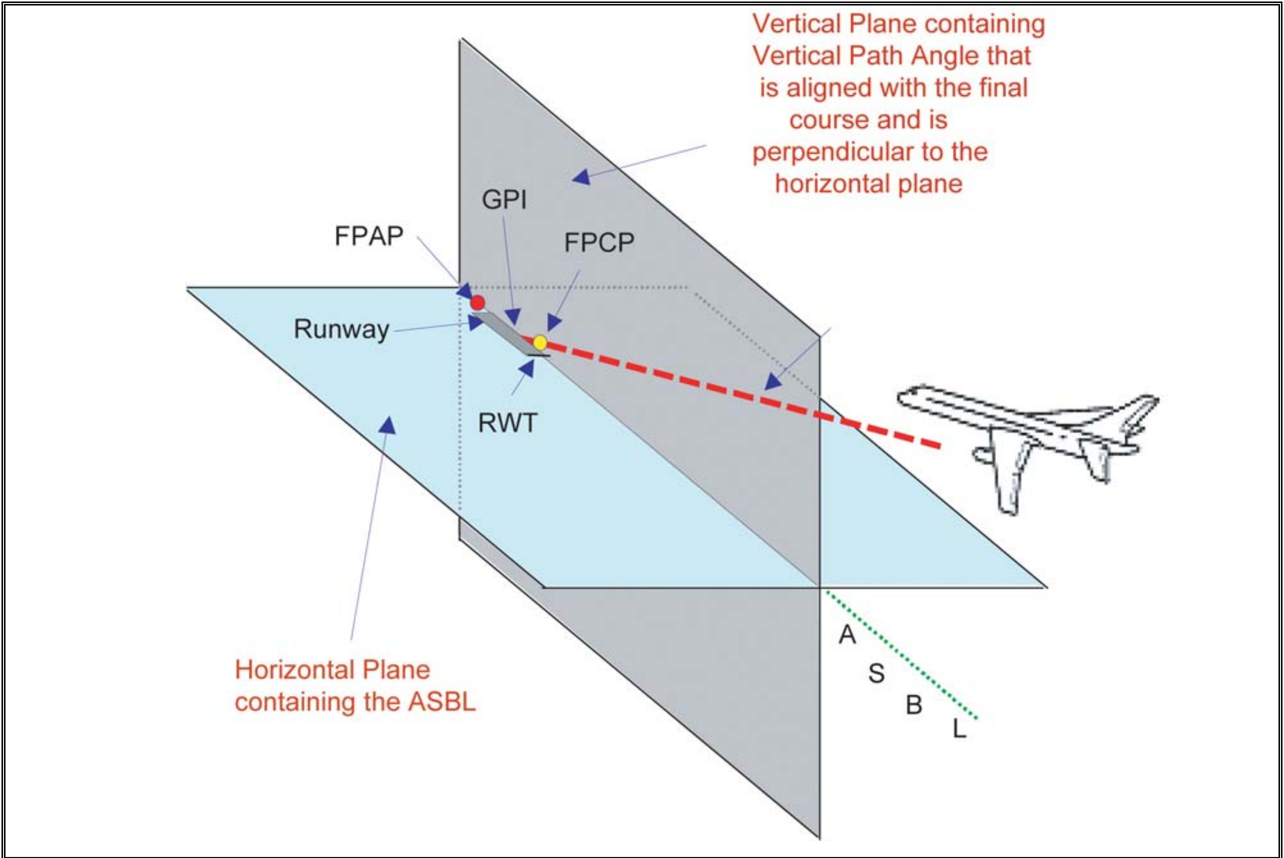


Figure 1-4: 3D Path & Course. Para 1.2.

Height Above Touchdown (HAT). The HAT is the height of the DA above touchdown zone elevation (TDZE).

Inner-Approach Obstacle Free Zone (OFZ). The airspace above a surface centred on the extended runway centreline. It applies to runways with an approach lighting system.

Inner-Transitional OFZ. The airspace above the surfaces located on the outer edges of the runway OFZ and the inner-approach OFZ. It applies to runways with approach visibility minimums less than ¾ statute mile.

Landing Threshold Point (LTP). The LTP is a 3D point at the intersection of the runway centreline and the runway threshold. It is defined by WGS-84/NAD-83 latitude, longitude, MSL elevation, and Geoid height (see Figure 1-1). It is used in conjunction with the FPAP and the geometric centre of the WGS-84 ellipsoid to define the vertical plane of an RNAV final approach course. LTP elevation applies to the FTP when the final approach course is offset from runway centreline.

Lateral Navigation (LNAV) [RNAV Only]. Azimuth navigation without positive vertical guidance. This type of navigation is associated with nonprecision approach procedures.

Microwave Landing System / Mobile Microwave Landing System (MLS/MMLS). MLS/MMLS can be configured in two ways; “Split Site” where the azimuth and elevation antennas are sited the same as an ILS, or “Collocated Site” where the azimuth and elevation antennas are located together along side the runway. “Split Site” is the normal configuration for “fixed” MLS locations to meet the capability of standard MLS avionics receiver equipment. Aircraft that will use MLS/MMLS procedures configured as a “Collocated Site” must have a special MLS avionics receiver capable of computing the offset runway centreline location. These procedures will have the following caveat: “COMPUTED APPROACH: FOR USE BY AIRCRAFT CAPABLE OF COMPUTING OFFSET RUNWAY CENTRELINE ONLY.” Since the MMLS has a selectable azimuth and glide slope, procedures will be published with the caveat: “FLYING OTHER THAN PUBLISHED AZIMUTH AND/OR GS ANGLE RENDERS THE PROCEDURE UNUSABLE.” MMLS equipment computing capability for “collocated” configuration requires that all system components (DME/P, AZ, and EL) must be operating, thus the following caveat must be published: “ALL SYSTEM COMPONENTS MUST BE OPERATIONAL.”

Object Free Area (OFA). An area on the ground centred on a runway, taxiway, or taxi lane centreline provided to enhance the safety of aircraft operations by having the area free of objects, except for objects that need to be located in the OFA for air navigation or aircraft ground manoeuvring purposes.

Obstacle Clearance Surface (OCS). An inclined obstacle evaluation surface associated with a glidepath. The separation between this surface and the glidepath angle at any given distance from GPI defines the MINIMUM required obstruction clearance at that point.

Positive Vertical/Horizontal Guidance. Glidepath or course guidance based on instrumentation indicating magnitude and direction of deviation from the prescribed glidepath or course on which obstruction clearance is based.

Precision Approach (PA). An approach based on a navigation system that provides positive course and vertical path guidance conforming to ILS or MLS system performance standards contained in ICAO Annex 10. To achieve lowest minimums, the ground infrastructure must meet requirements contained in TP312 Aerodrome Standards and TP308/GPH209 Volume 3.

Precision Approach Radar (PAR). A ground radar system displaying an aircraft on final approach in plan and profile views in relation to glidepath and course centrelines. Air traffic controllers issue course line and glidepath information to the pilot. The pilot alters course and rate of descent in response to gain course and glidepath alignment. Military pilots may achieve 100 foot HAT and 1/4 mile visibility minimums with PAR.

Precision Final Approach Fix (PFAF). (Applicable to all PA approach procedures.) A 2D point located on the final approach course at a distance from LTP/FTP where the GPA intercepts the intermediate segment altitude (glidepath intercept altitude). The PFAF marks the outer end of the PA final segment.

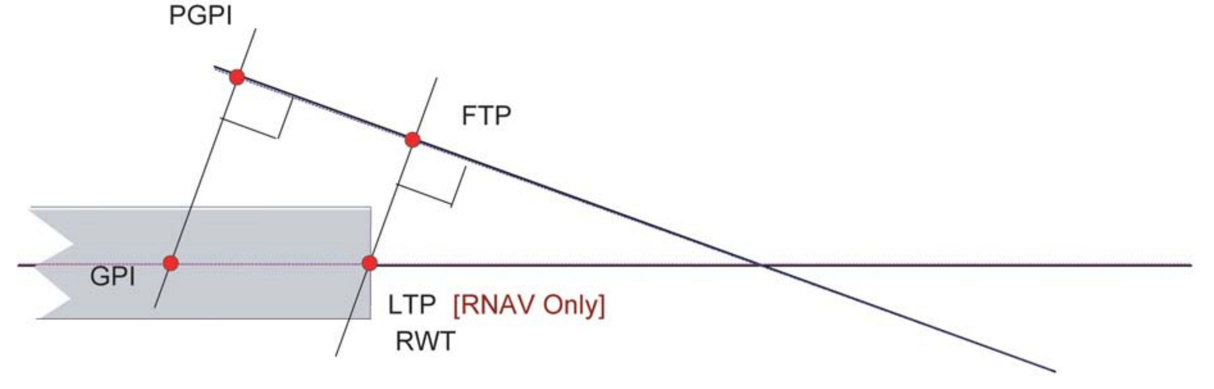


Figure 1-5: PGPI and FTP Locations. Para 1.2.

Pseudo Ground Point of Intercept (PGPI). Phantom location abeam the GPI when the approach course is offset. PGPI elevation is the same as ASBL (see Figure 1-5).

Radio Altimeter Height (RA). An indication of the vertical distance between a point on the nominal glidepath at DA and the terrain directly beneath this point.

Required Navigation Performance (RNP). A statement of the navigation performance accuracy necessary for operation within a defined airspace. Note that there are additional requirements, beyond accuracy, applied to a particular RNP type.

Runway Threshold (RWT). The RWT marks the beginning of that part of the runway usable for landing (see Figure 1-6). It extends the full width of the runway. The RWT geographic coordinates identify the point the runway centreline crosses the RWT.

Figure 1-6: Threshold. Para 1.2.

Three-Dimensional (3D) Point/Waypoint [RNAV Only]. A waypoint defined by WGS-84 latitude and longitude coordinates, MSL elevation, and GH.

Touchdown Zone Elevation (TDZE). The highest elevation in the first 3,000 feet of the landing surface.

Two-Dimensional (2D) Point/Waypoint [RNAV Only]. A waypoint defined by WGS-84 latitude and longitude coordinates.

Wide Area Augmentation System (WAAS) [RNAV Only]. A method of navigation based on the GPS. Ground correction stations transmit position corrections that enhance system accuracy and add VNAV features.

CHAPTER 2. GENERAL CRITERIA

2.0 General

This chapter contains information common to all precision and Baro-VNAV procedures.

2.1 Data Resolution

Perform calculations using at least 0.01 unit of measure. Document latitudes and longitudes to the nearest one hundredth (0.01") arc second; elevations to the nearest hundredth (0.01') foot; courses, descent and glidepath angles to the nearest one hundredth (0.01°) degree, and distances to the nearest hundredth (0.01) unit. Where other publications require different units and/or lesser resolution, use established conversion and rounding methods.

2.2 Procedure Identification

Procedure identification shall be in accordance with ICAO Annex 4 and Annex 11.

2.3 En Route, Initial, And Intermediate Segments

Apply TP308/GPH209 to non-RNAV approaches. Apply criteria in TP308/GPH209, Chapter 16, to construct the RNAV approaches except as noted. If a TAA is desired, apply Order 8260.45, Para 5.

Note: (TLS) Establish an intermediate fix (IF) defined by NAVAID's not associated with the TLS. The IF shall be on the final approach course. Establish a holding pattern at the IF (based on an inbound course to the IF) for use in the event the TLS azimuth course is not acquired.

2.3.1 Minimum Intermediate Segment Length

The intermediate segment blends the initial approach segment into the final approach segment. It begins at the IF and extends along the final approach course extended to the PFAF. Where a turn from the initial course to the final approach course extended is required, the initial course shall intercept at or before the IF.

a. Length. The MINIMUM length of the intermediate segment is 2 NM. Minimum segment length varies where a turn is required at the IF. The length is determined by the magnitude of heading change in the turn on to the final approach course extended (see Figure 2-1A). The maximum angle of intersection is 90° unless a lead radial as specified in TP308/GPH209 Volume 1, Para 232a, is provided and the length of the intermediate segment is increased as specified in TP308/GPH209 Volume 1, Table 2-3.

b. Width. The intermediate trapezoid begins at the width of the initial segment at the latest point the IF can be received, to the width of the final segment at the plotted position of the PFAF (see Figure 2-1B).

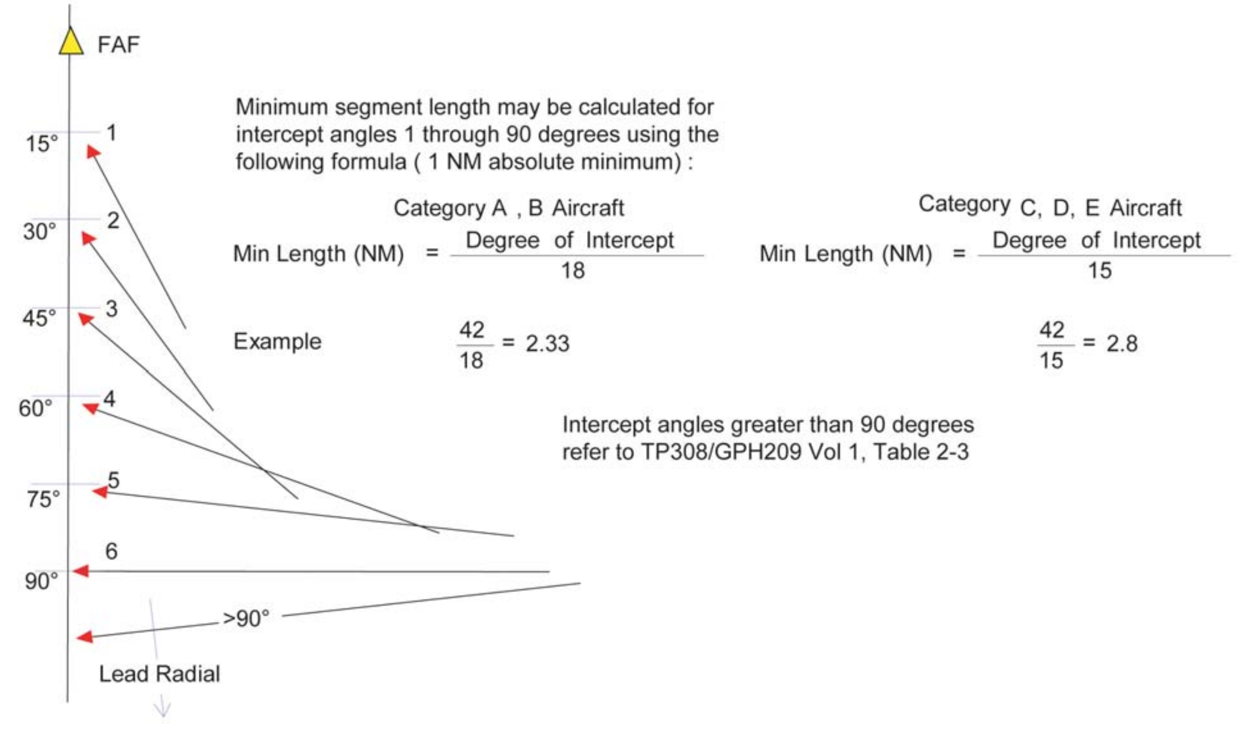


Figure 2-1A: Minimum Intermediate Segment. Para 2.3.1.a.

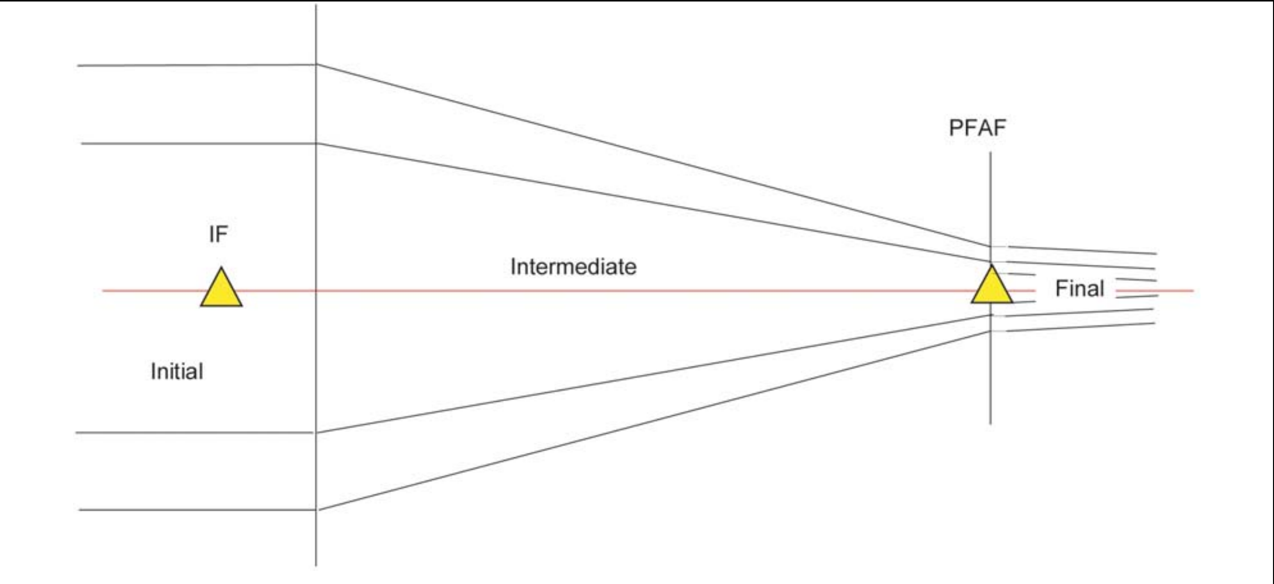


Figure 2-1B: Intermediate Segment Width. Para 2.3.1.b.

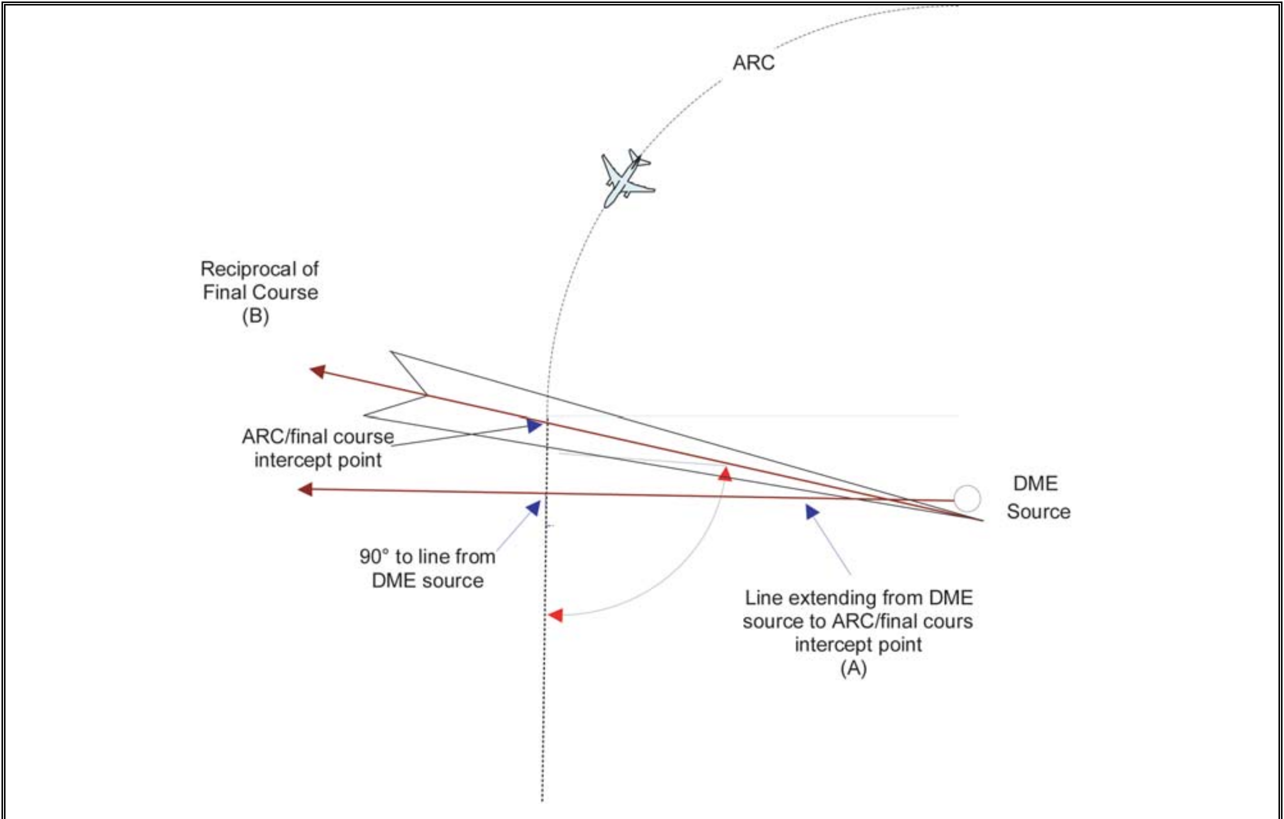


Figure 2-2: Aircraft On The Same Side Of Localizer As DME Sources. Para 2.3.2.a.

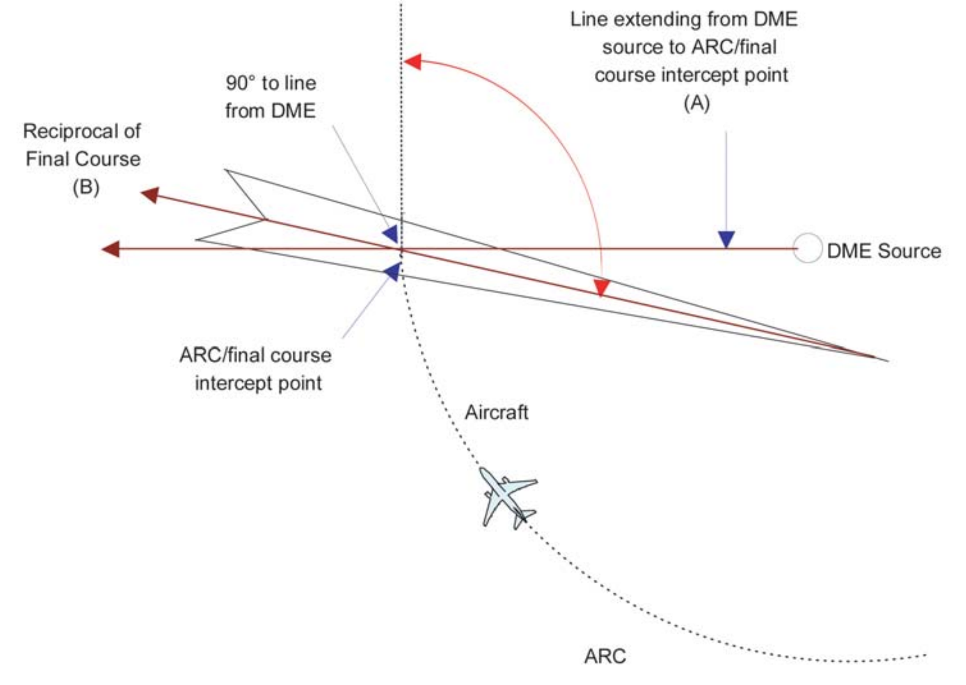


Figure 2-3: Aircraft On The Opposite Side Of Localizer From DME Sources. Para 2.3.2.b.

2.3.2 Determining FAC Intercept Angle Where DME Source Is Not Collocated With FAC facility

Determine the intercept initial/intermediate segment intercept angle on approach procedures utilizing ARC initial segments using the following formulas.

a. DME source on the same side of course as the aircraft (see Figure 2-2).

$90 - | A - B | =$ Intercept Angle

Example: $90 - |270 – 285 | = 75^\circ$

b. DME source on opposite side of course as the aircraft (see Figure 2-3).

$90 + | A - B | =$ Intercept Angle

Example: $90 + |270 – 285 | = 105^\circ$

2.4 RNP Values

Procedures designed under this order may be flown by aircraft with navigation systems certified to RNP values. Each segment of an RNAV procedure has a specific RNP value. Table 2-1 lists RNP values (95% accuracy) by segment type.

Segment	Lateral (NM) RNAV
En Route	2.0
Initial	1.0
Intermediate	0.5
Final	0.30
LNAV	0.30
Missed Approach	1.0

Table 2-1: Segment RNP Values. Para 2.4.

2.5 Maximum Authorized GPA's

Tables 2-2A, 2 2B, and 2-2C list the MAXIMUM allowable GPA's and MINIMUM visibility by aircraft category, and MAXIMUM TCH values for allowing credit for approach lighting systems. Design all approach procedures to the same runway with the same glidepath angle and TCH. Angles above 3.0° require the approval of Chief of Standards, Aerodromes and Air Navigation or the appropriate military authority.

Category	GPA
A (80 knots or less)	6.4
A (81 – 90 knots)	5.7
B	4.2
C	3.6
D & E	3.1

Table 2-2A: Maximum GPA's. Para 2.5 and 3.5.3.

Glidepath Angle (with approach lighting config)		Minimum HAT*	Aircraft Category			
			A	B	C	D & E
			Minimum Visibility			
3.00° - 3.10°	✭	**200**	¾ 4000			
	#	**200**	½ 2600			
	$	**200**	1800			
3.11° - 3.30°	✭	**200**	¾ 4000		**NA**	
	✭	**250**	¾ 4000		1 5000	**NA**
	#	**200**	½ 2600		**NA**	
	#	**250**	½ 2600		¾ 4000	**NA**
	$	**200**	1800		**NA**	
	$	**250**	1800		½ 2600	**NA**
3.31° - 3.60°	✭	**200**	¾ 4000		**NA**	
	✭	**270**	¾ 4000		1 5000	**NA**
	#	**200**	½ 2600		**NA**	
	#	**270**	½ 2600		¾ 4000	**NA**
	$	**200**	2000		**NA**	
	$	**270**	2000		½ 2600	**NA**
3.61° - 3.80°	✭	**200**	¾ 4000		**NA**	
	#	**200**	½ 2600		**NA**	
3.81° - 4.20°	✭	**200**	¾ 4000	**NA**		
	✭	**250**	¾ 4000	1 5000	**NA**	
	#	**200**	½ 2600	**NA**		
	#	**250**	½ 2600	¾ 4000	**NA**	
4.21° - 5.00°	✭	**250**	¾ 4000	**NA**		
	#	**250**	½ 2600	**NA**		
5.01° - 5.70°	✭	**300**	1 5000	**NA**		
	#	**300**	¾ 4000	**NA**		
5.71° - 6.40° Airspeed Max 80 Kts	✭	**350**	1 ¼	**NA**		
	#	**350**	1 5000	**NA**		

* The HAT shall not be less than 200 feet for civil operations, or 100 feet for military operations.

✭ = No Lights
# = MALSR, SSALR, ALSF
NA = Not Authorized
$ = # Plus TDZ/CL Lights

Note: For a HAT higher than the minimum, the visibility (prior to applying credit for lights) shall equal the distance from DA/MAP to RWT, or
(a) ¾ SM up to 5.00°, or
(b) 1 SM 5.01° through 5.70°, or
(c) 1 ¼ SM 5.71° through 6.40°, whichever is the greater.

Table 2-2B: Standard PA Landing Minimums. Para 2.5.

HAT (Feet)	Glide Path Angle (Degrees)	TCH Upper Limit (Feet)	HAT (Feet)	Glide Path Angle (Degrees)	TCH Upper Limit (Feet)
200	3.00 - 3.20	75	**300**	3.00 - 4.90	75
	3.21 - 3.30	70		4.91 - 5.00	71
	3.31 - 3.40	66		5.01 - 5.10	66
	3.41 - 3.50	63		5.11 - 5.20	61
	3.51 - 3.60	59		5.21 - 5.30	56
	3.61 - 3.70	55		5.31 - 5.40	52
	3.71 - 3.80	50		5.41 - 5.50	48
	3.81 - 3.90	47		5.51 - 5.60	43
	3.91 - 4.00	43		5.61 - 5.70	39
	4.01 - 4.10	39			
	4.11 - 4.20	35			
250			**350**		
	3.00 - 4.10	75		3.00 - 5.60	75
	4.11 - 4.20	71		5.61 - 5.70	70
	4.21 - 4.30	67		5.71 - 5.80	65
	4.31 - 4.40	62		5.81 - 5.90	60
	4.41 - 4.50	58		5.91 - 6.00	55
	4.51 - 4.60	54		6.01 - 6.10	50
	4.61 - 4.70	50		6.11 - 6.20	45
	4.71 - 4.80	45		6.21 - 6.30	40
	4.81 - 4.90	41		6.31 - 6.40	35
	4.91 - 5.00	37			
270					
	3.00 - 4.40	75			
	4.41 - 4.50	73			
	4.51 - 4.60	68			
	4.61 - 4.70	64			
	4.71 - 4.80	59			
	4.81 - 4.90	55			
	4.91 - 5.00	51			

Table 2-2C: Threshold Crossing Height Upper Limits For Allowing Visibility Credit For Lights. Para 2.

2.5.1 RNAV Glidepath Angles

If a non-RNAV PA system (ILS, TLS, or PAR) serves the same runway as an RNAV PA system, the RNAV glidepath angle and TCH should match the non-RNAV system.

2.5.2 VGSI Angles

A VGSI is recommended for all runways to which an instrument approach is published. Where installed, the VGSI angle and TCH should match the glidepath angle of vertically guided approach procedures to the runway.

2.6 Glide Slope Threshold Crossing Height Requirements

2.6.1 Category I Threshold Crossing Height (TCH) Requirements

a. Standard. The glide slope should be located considering final approach obstructions and achieving TCH values associated with the greatest Table 2-3 wheel height group applicable to aircraft normally expected to use the runway. The TCH should provide a 30-foot wheel crossing height (WCH).

b. Deviations from Standard. The TCH shall provide a WCH of no less than 20 feet or greater than 50 feet for the appropriate wheel height group. These limits shall not be exceeded unless formally approved by a Ministerial Authorization, or an Exemption issued by Transport Canada, AARN or the appropriate Military Authority.

   Note: 60 feet is the maximum TCH.

c. Displaced Threshold Considerations. The TCH over a displaced threshold can result in a WCH value of 10 feet if the TCH over the beginning of the full strength runway pavement suitable for landing meets Table 2-3 TCH requirements.

2.6.2 Category II and III TCH Requirements

a. Standard. The commissioned TCH shall be between 50 and 60 feet with the optimum being 55 feet.

b. Deviations from the Standard. Any deviation must be formally approved by; a Ministerial Authorization, an Exemption issued by Transport Canada, AART, or the appropriate Military Authority.

2.6.3 Required TCH Values

Publish a note indicating “VGSI not coincident with the procedure GPA” when the VGSI angle is more than 0.2° from the GPA, or when the VGSI TCH is more than 3 feet from the procedure TCH.

2.7 Ground Point Of Intercept (GPI)

Calculate GPI distance using the following formula:

$$\text{GPI} = \frac{\text{TCH}}{\text{Tan (GPA)}}$$

2.8 Determining FPAP Coordinates. (RNAV Only)

The geographic relationship between the LTP and the FPAP determines the final approach ground track. Geodetically calculate the latitude and longitude of the FPAP using the LTP as a starting point, the desired final approach course (OPTIMUM course is the runway bearing) as a forward azimuth value, and an appropriate distance. If an ILS or MLS serves the runway, the appropriate distance in feet is the distance from the LTP to the localizer antenna minus 1,000 feet, or the distance from the LTP to the DER, whichever is greater. Apply Table 2-4 to determine the appropriate distance for runways not served by an ILS.

Representative Aircraft type	Approximate Glidepath to Wheel Height	Recommended TCH +/- 5 Feet	Remarks
Height Group 1 General Aviation, Small Commuters, Corporate Turbojets, T-37, T-38, C-12, C-20, C-21, T-1, Fighter Jets, UC-35, T-3, T-6	10 Feet or less	40 Feet	Many runways less than 6,000 feet long with reduced widths and/or restricted weight bearing which would normally prohibit landings by larger aircraft.
Height Group 2 F-28, CV-340/440/580, B-737, C-9, DC-9, C-130, T-43, B-2, S-3	15 Feet	45 Feet	Regional airport with limited air carrier service.
Height Group 3 B-727/707/720/757, B-52, C-135, C-141, C-17, E-3, P-3, E-8, C-32, A-300/310, A-319/320/321	20 Feet	50 feet	Primary runways not normally used by aircraft with ILS glidepath-to-wheel heights exceeding 20 feet.
Height Group 4 B-747/767/777, L-1011, DC-10, A-330, A-340, A-380 (planned), B-1, KC-10, E-4, C-5, VC-25	25 Feet	55 Feet	Most primary runways at major airports.

Notes:

1. To determine the minimum allowable TCH, add 20 feet to the glidepath-to-wheel height.
2. To determine the maximum allowable TCH, add 50 feet to the glidepath-to-wheel height (PA not to exceed 60 ft.)
3. Publish a note indicating VGSI not coincident with the procedure GPA when the VGSI angle is more than 0.2° from the GPA, or when the VGSI TCH is more than 3 feet from the procedure TCH.

Table 2-3: TCH Requirements. Para 2.3.1.a and 2.6.1.

Runway Length	FPAP Distance from LTP	Splay	± Wdith
≤ 9.023’	9.023’	2.0°	350’
> 9.023’ and ≤ 12,366’	to DER	$ArcTan\left(\frac{350}{RWYLength+1000}\right)$	350’
> 12,366 and ≤ 16,185’	to DER	1.5°	$Tan(1.5)(RWYLength+1{,}000)$
> 16,185’ (AFS or Appropriate Military Agency Approval)	to DER or as specified by approving agency	1.5°	$Tan(1.5)(RWYLength+1{,}000)$

Table 2-4: Runways Not Served By An ILS. Para 2.8.

2.9 Determining PFAF/FAF Coordinates

See Figure 2–4.

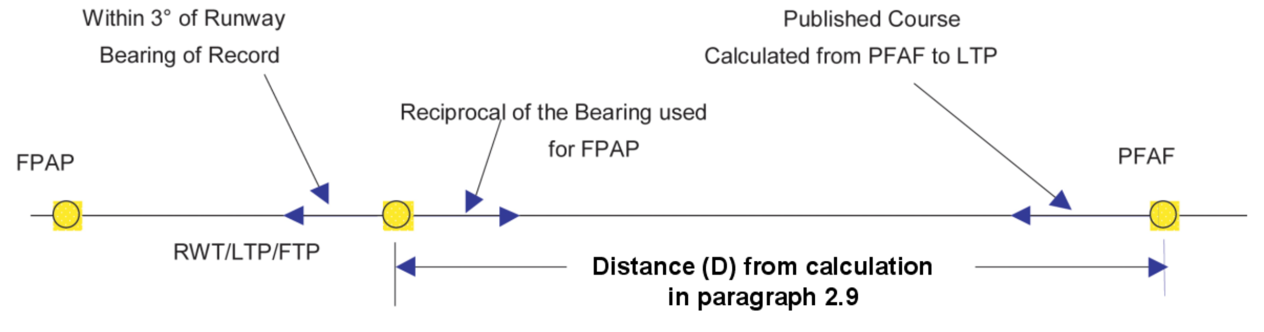


Figure 2-4: Determining PFAF Location. Para 2.9.

Geodetically calculate the latitude and longitude of the PFAF using the horizontal distance (D-GPI) from the LTP or FTP to the point the glidepath intercepts the intermediate segment altitude. Determine D using the following formulas:

Step 1: Formula: $z = A - F$

Example: $z = 2{,}100 - 562.30 = 1{,}537.70$

Step 2: Formula: $$D = 364{,}609 \times \left(90 - \theta - \sin^{-1}\left(\frac{20{,}890{,}537 \sin(90+\theta)}{z + 20{,}890{,}537}\right)\right)$$

Example: $$D = 364{,}609 \times \left(90 - \theta - \sin^{-1}\left(\frac{20{,}890{,}537 \sin(90+\theta)}{z + 20{,}890{,}537}\right)\right)$$

$D = 28{,}956.03$

Where: A = FAF Altitude in feet (example 2,100)
F = LTP elevation in feet (example 562.30)
θ = Glidepath angle (example 3.00°)
z = FAF Alt above ASBL

Note: Step 2 formula includes earth curvature.

2.9.1 Distance Measuring Equipment (DME)

When installed with ILS, DME may be used to designate the FAF. When a unique requirement exists, DME information derived from a separate facility, as specified in TP308/GPH209 Volume 1, Para 282, may also be used to provide ARC initial approaches, a FAF for back course (BC) approaches, or as a substitute for the outer marker. When used as a substitute for the outer marker, the fix displacement error shall NOT exceed ± 1/2 NM and the angular divergence of the signal sources shall NOT exceed 6° (DOD 23°).

2.10 Common Fixes (RNAV Only)

Design all procedures published on the same chart to use the same sequence of charted fixes.

2.11 Clear Areas And Obstacle Free Zones (OFZ)

TC Aerodrome Standards are responsible for maintaining obstruction requirements in accordance with TP 312 Aerodrome Standards. Appropriate military directives apply at military installations. For the purpose of this document, there are two OFZ's that apply: the runway OFZ and the inner approach OFZ. The runway OFZ parallels the length of the runway and extends 200 feet beyond the runway threshold. The inner OFZ overlies the approach light system from a point 200 feet from the threshold to a point 200 feet beyond the last approach light. If approach lights are not installed or not planned, the inner approach OFZ does not apply. When obstacles penetrate either the runway or approach OFZ, visibility credit for lights is not authorized, and the lowest authorized HAT and visibility values are:

For GPA ≤ 4.2°: 250 - ¾

For GPA > 4.2°: 350 -1

Note: Application of TP308/GPH209 Volume 1, Para 251 may require a higher minimum visibility value.

2.12 Glidepath Qualification Surface (GQS)

The GQS extends from the runway threshold along the runway centreline extended to the DA point. It limits the height of obstructions between DA and RWT. When obstructions exceed the height of the GQS, an approach procedure with positive vertical guidance (ILS, MLS, GLS, VNAV, etc.) is not authorized (see Figure 2-5A).

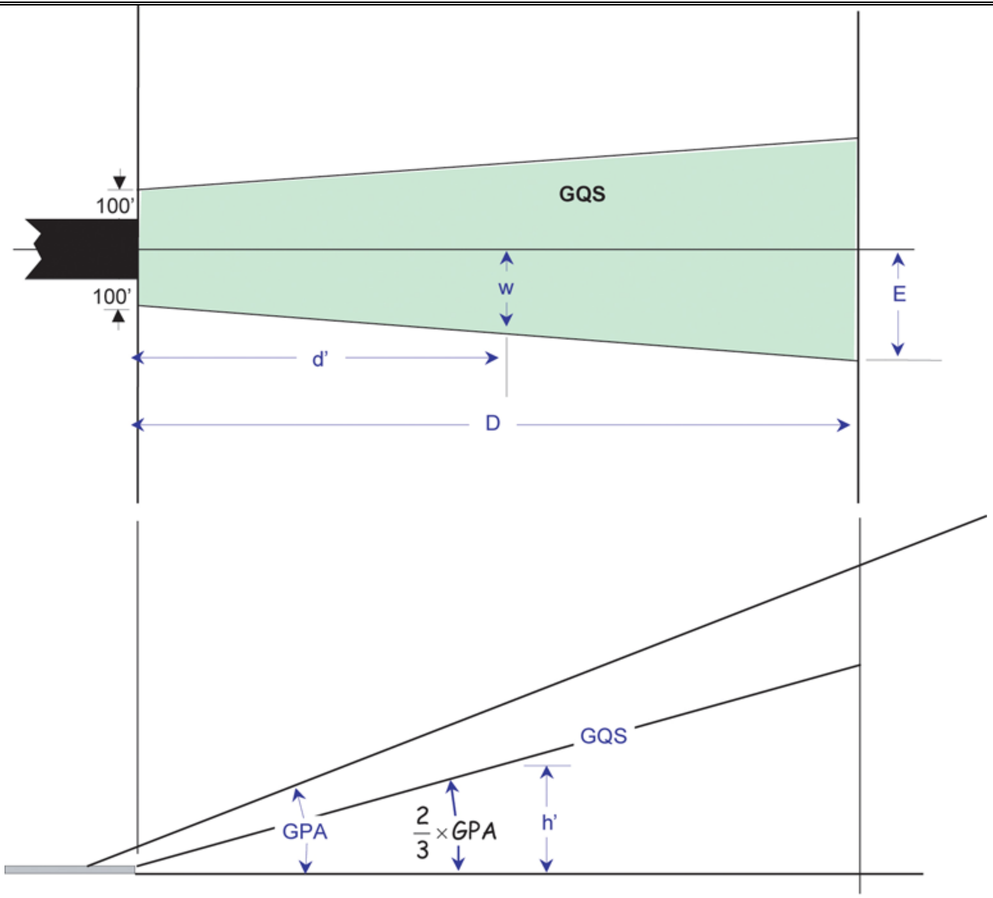


Figure 2-5A: GQS. Para 2.12.

2.12.1 Area

a. Length. The GQS extends from the runway threshold to the DA point.

b. Width. The GQS originates 100 feet from the runway edge at RWT.

Calculate the half-width of the GQS (E) from the runway centreline extended at the DA point using the following formula:

$$E = 0.036(D - 200) + 400$$

Where: D = the distance (ft) measured along RCL extended from RWT to the DA point
E = GQS half-width (ft) at DA

c. If the course is offset from the runway centreline more than 3°, expand the GQS area on the side of the offset as follows referring to Figure 2-5B:

STEP 1. Construct line **BC**. Locate point "**B**" on the runway centreline extended perpendicular to course at the DA point. Calculate the half-width (E) of the GQS for the distance from point "**B**" to the RWT. Locate point "**C**" perpendicular to the course distance "E" from the course line. Connect points "**B**" and "**C**."

STEP 2. Construct line **CD**. Locate point "D" 100 feet from the edge of the runway perpendicular to the LTP. Draw a line connecting point "C" to point "D."

STEP 3. Construct line **DF**. Locate point "F" 100 feet from the edge of the runway perpendicular to the LTP. Draw a line connecting point "D" to point "F."

STEP 4. Construct line **AF**. Locate point "A" distance "E" from point "B" perpendicular to the runway centreline extended. Connect point "A" to point "F."

STEP 5. Construct line **AB**. Connect point "A" to point "B."

Calculate the half-width of the GQS at any distance "d" from RWT using the following formula:

$$w = \left(\frac{E - k}{D} d\right) + k$$

Where: D = distance (ft) from RWT to the DA point

d = desired distance (ft) from RWT

w = GQS half-width at distance d

E = GQS half-width at DA from step 1 above

$$k = \left(\frac{\text{RWT Width}}{2}\right) + 100$$

d. OCS. Obstructions shall not penetrate the GQS. Calculate the height of the GQS above ASBL at any distance "d" measured from RWT along RCL extended to a point abeam the obstruction (see Figure 2-5B) using the following formula:

$$h = \tan\left(\frac{2\theta}{3}\right) d$$

Where: d = distance from RWT (ft)

θ = glidepath angle

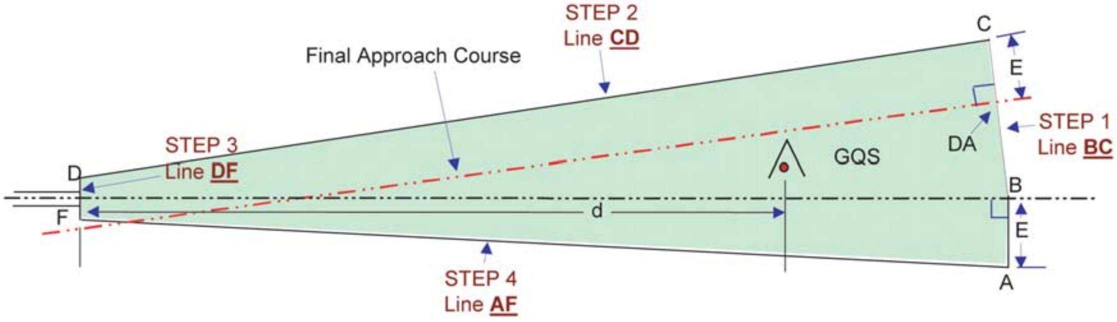
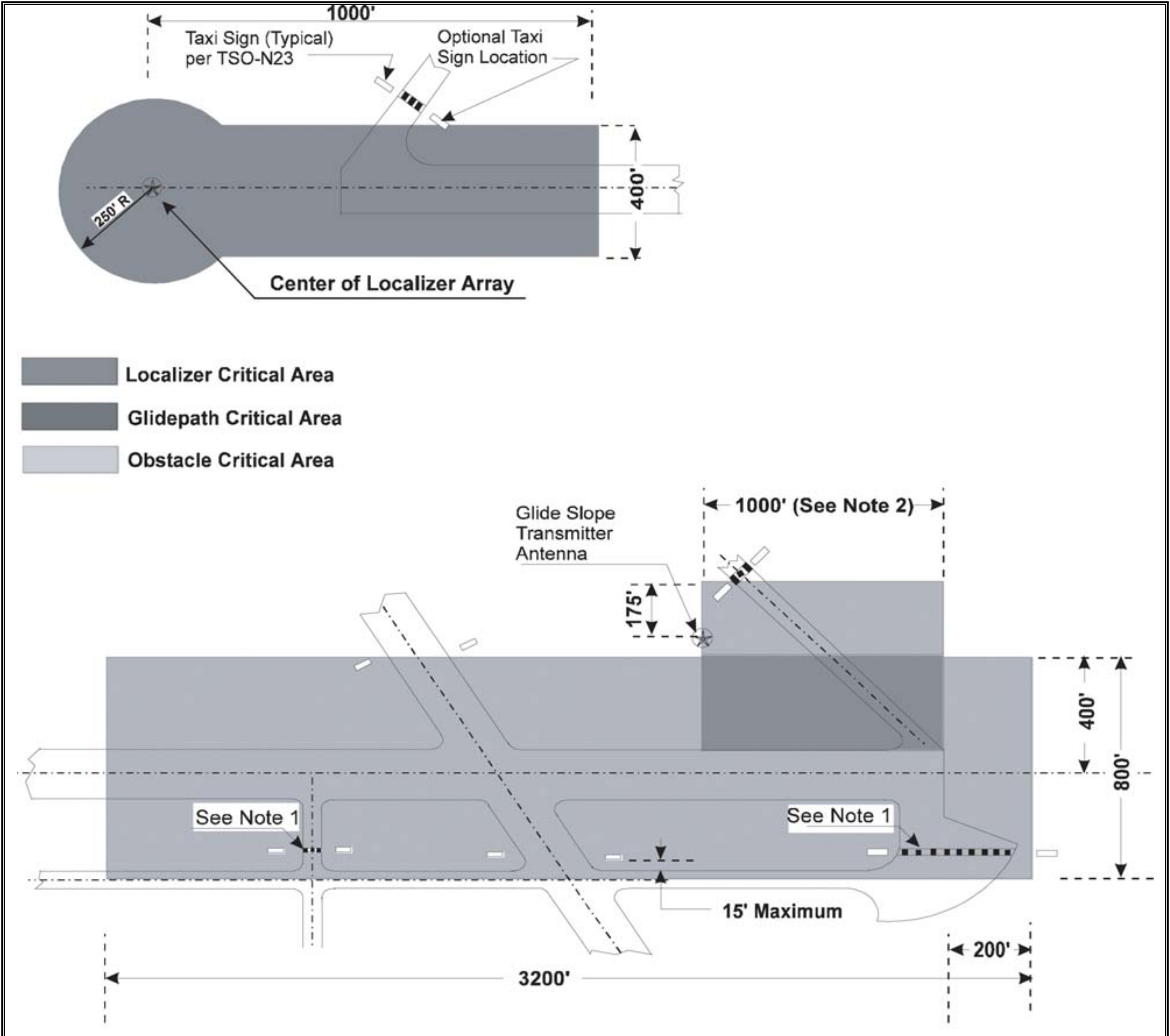


Figure 2-5B: Final Approach Course Offset > 3 Degrees, Para 2.12.1.c

2.13 ILS Critical Areas

Figure 2-6 identifies the critical area that must be clear during IFR ILS approach operations.



NOTES: 1. Location of hold lines when operations are permitted on a 400-foot parallel taxiway.
2. Or to the end of the runway, whichever is greater.

Figure 2-6: Category II Critical Areas. Para 2.13.

2.14 ILS Antenna Mast Height Limitations For Obstacle Clearance

The standard for locating the ILS antenna mast or monitor is a MINIMUM distance of 400 feet from the runway, measured perpendicular to RCL. The antenna mast should not exceed 55 feet in height above the elevation of the runway centreline nearest it (see Figure 2-7). At locations where it is not feasible for technical or economic reasons to meet this standard, the height and location of the antenna is restricted according to Figure 2-7.

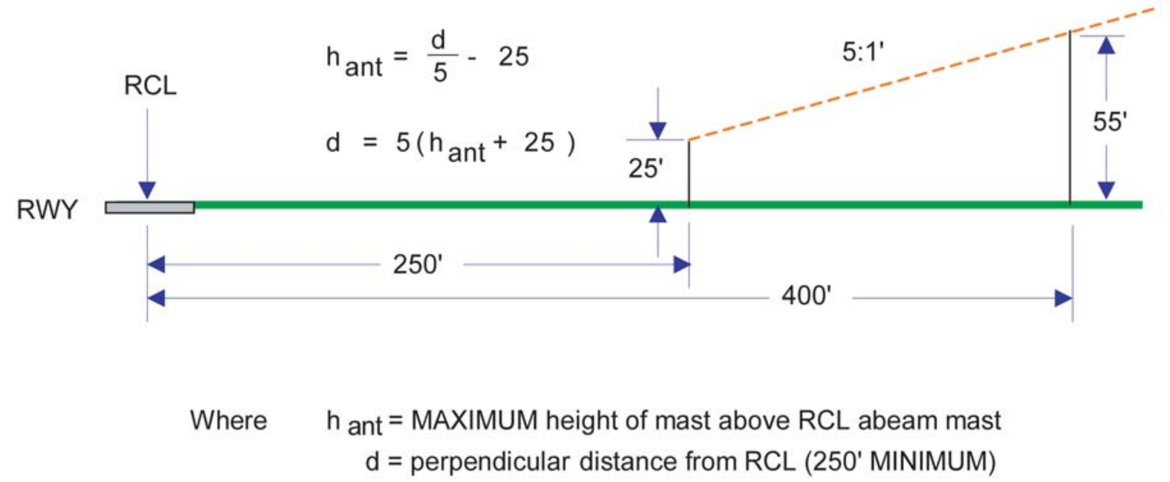


Figure 2-7: ILS Antenna Mast Limitations. Para 2.14.

CHAPTER 3. PRECISION FINAL AND MISSED APPROACH SEGMENTS

3.0 Final Segment

The area originates 200 feet from LTP or FTP and ends at the PFAF (see Figure 3-1). The primary area consists of the W and X OCS, and the secondary area consists of the Y OCS.

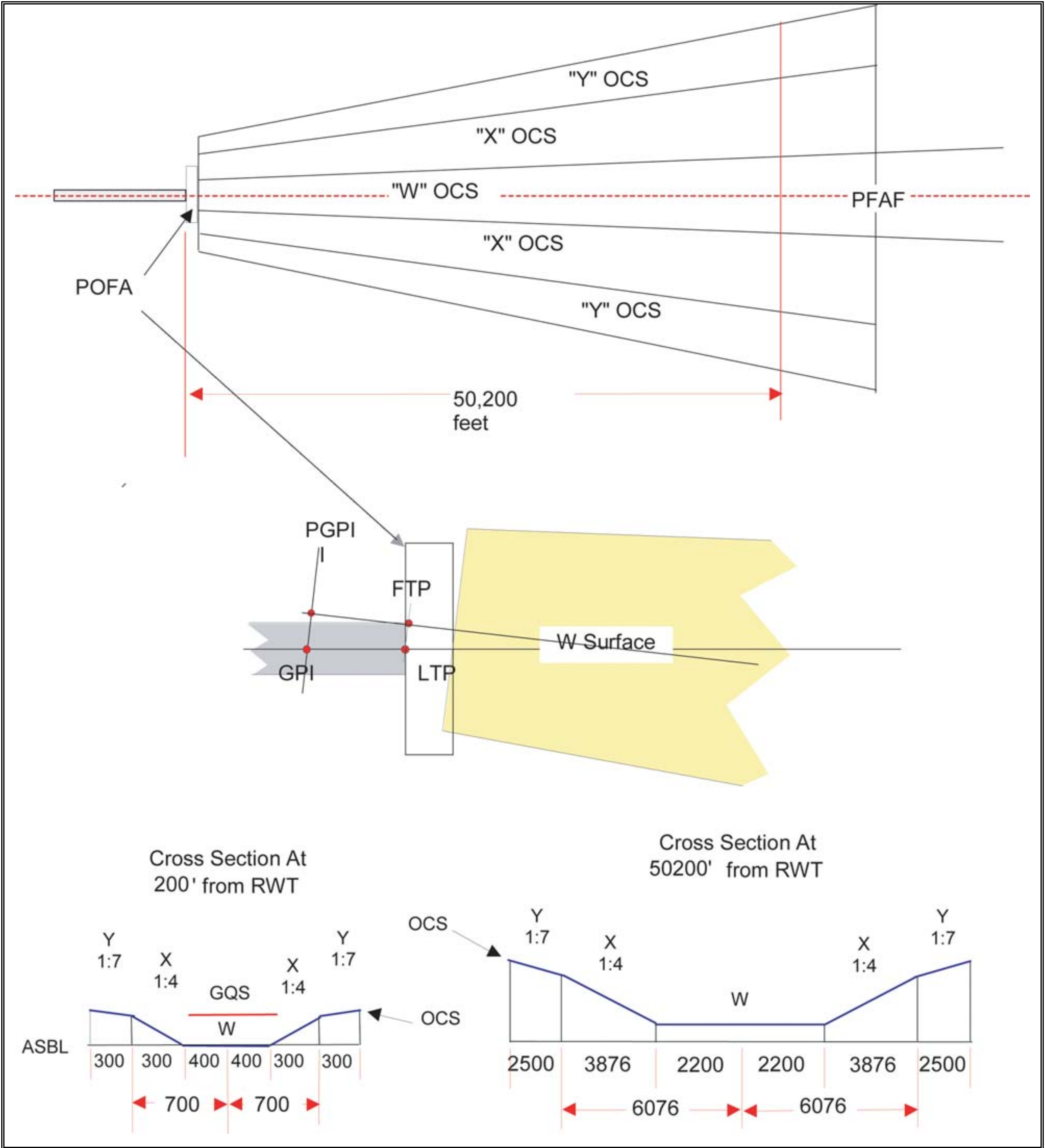


Figure 3-1: Precision Obstacle Clearance Area. Para 3.0.

3.1 Alignment

The final course is normally aligned with the runway centreline extended (± 0.03°) through the LTP/RWT (± 5 feet). Where a unique operational requirement indicates a need for an offset course, it may be approved provided the offset does not exceed 3°. Where the course is not aligned with the RCL, the MINIMUM HAT is 250 feet, and MINIMUM RVR is 2,600 feet. Additionally, the course must intersect the runway centreline at a point 1,100 to 1,200 feet toward the LTP/RWT from the DA point (see Figure 3-2).

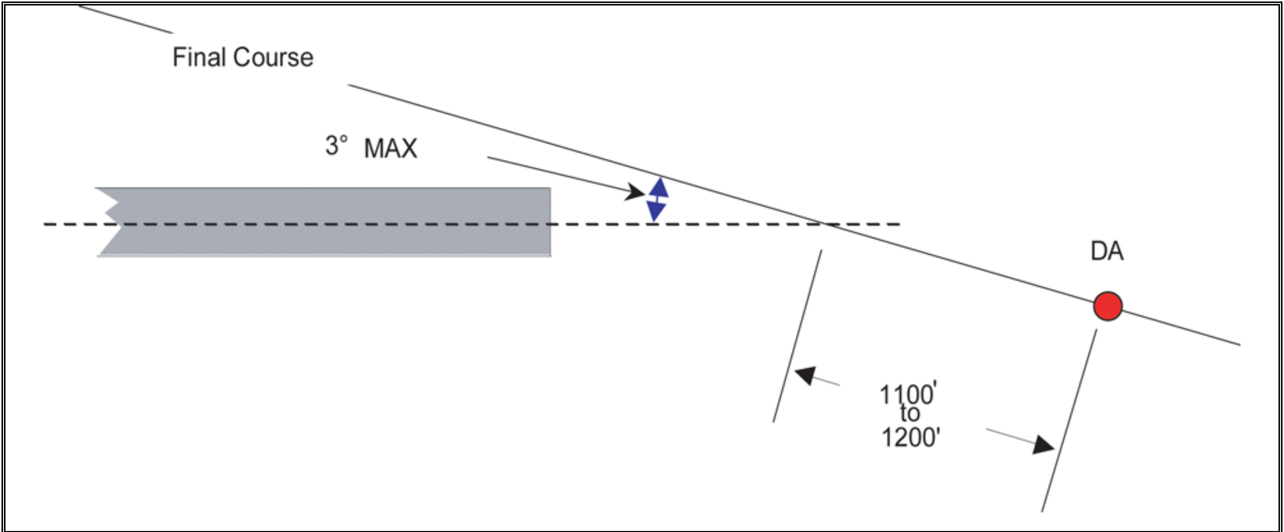


Figure 3-2: Offset Final. Para 3.1.

3.2 OCS Slopes

In this document, slopes are expressed as rise over run; e.g., 1:34. Determine the OCS slope associated with a specific GPA using the following formula:

$$S = \frac{102}{GPA} \qquad \text{Example: } \frac{102}{3} = 34$$

3.2.1 Origin

The OCS begins at 200 feet from LTP or FTP, measured along course centreline and extends to the PFAF. The rising slope normally begins at the OCS origin. However, when the GPI to RWT distance is less than 954 feet, the slope is zero from its origin to distance ‘d’ from the origin. The slope associated with the glidepath begins at this point (see Figure 3-3). Use the following formula to determine distance ‘d’:

Where $d = 954 - GPI$
$GPI = 801.41$ ft

Example: $d = 954 - 801.41 = 152.59$ ft

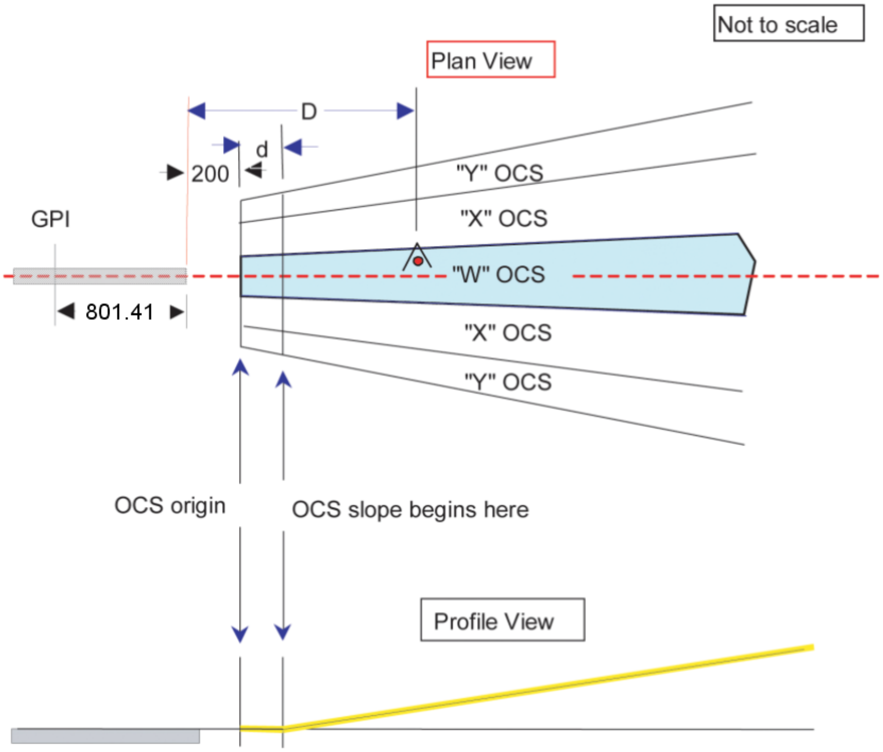


Figure 3-3: OCS Slope When GPI <954'. Para 3.2.

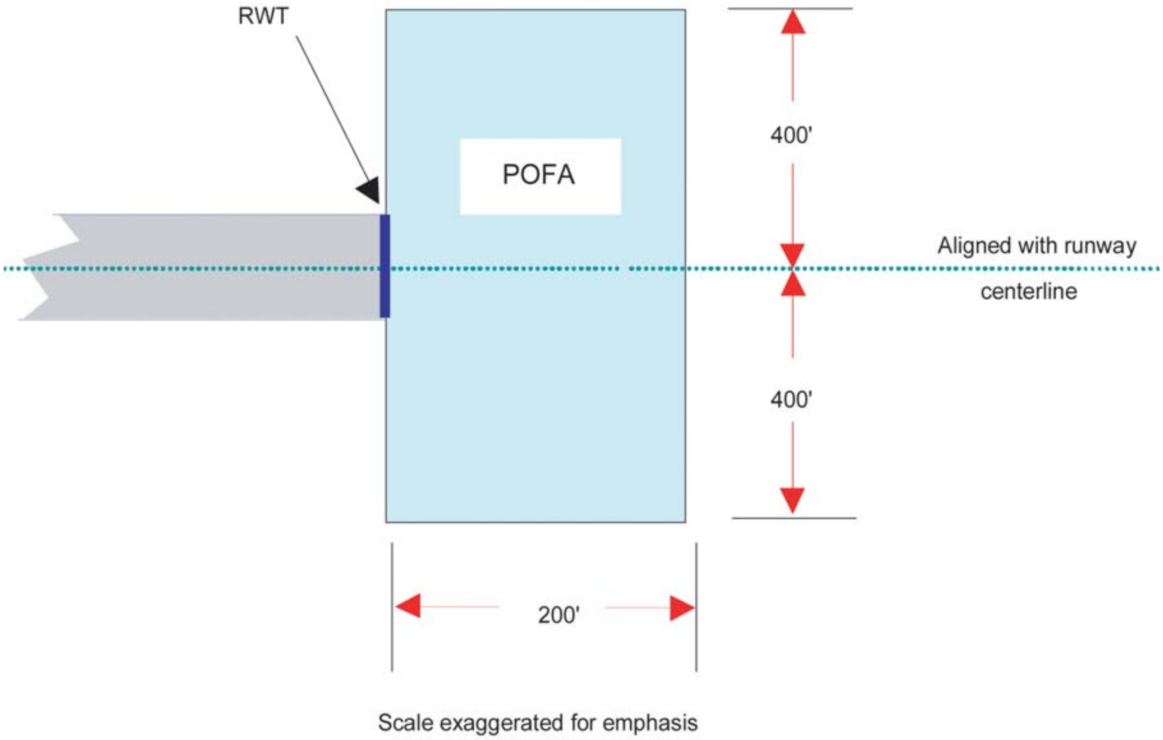


Figure 3-4: POFA. Para 3.3.

3.2.2 Revising GPA for OCS Penetrations

Raising the glidepath angle may eliminate OCS penetrations. To determine the revised minimum glidepath angle, use the following formula:

$$\text{Revised Angle} = \frac{102\left(\dfrac{D-(200+d)}{S}+p\right)}{D-(200+d)}$$

Where : D = distance (ft) from RWT
d = d from para 3.2.1 for GPI less than 954’, 0 for GPI 954’ or greater
S = W surface slope
p = penetration in feet

Example:

$$\frac{102\left(\dfrac{2200-(200+0)}{34}+2.18\right)}{2200-(200+0)} = 3.12°$$

Where: D = 2 200
d = 0
S = 34
p = 2.18

*Actual answer is 3.1118°. Always round to the next higher hundredth (0.01) degree. This prevents rounding errors in amount of penetration causing miniscule penetration values using the revised angle.

3.3 Precision Object Free Area (POFA)

The POFA is an area centre on the runway centreline extended, beginning at the RWT, 200 feet long, and ± 400 feet wide. The airport sponsor is responsible for maintaining POFA obstruction requirements in TP312 Aerodrome Standards (see Figure 3-4). If the POFA is not clear, the minimum HAT/visibility is 250 ft/ 3/4 SM.

3.4 W OCS

See Figure 3-5.

3.4.1 Width

The width is 400 feet either side of course at the beginning (edge of POFA), and expands uniformly to 2,200 feet either side of course 50,200 feet from LTP or FTP, as defined by the formula:

$$D_W = 0.036\,(D - 200) + 400$$

Where D = the distance in feet from LTP or FTP
D_W = Perpendicular distance in feet from course centerline to W surface outer boundary

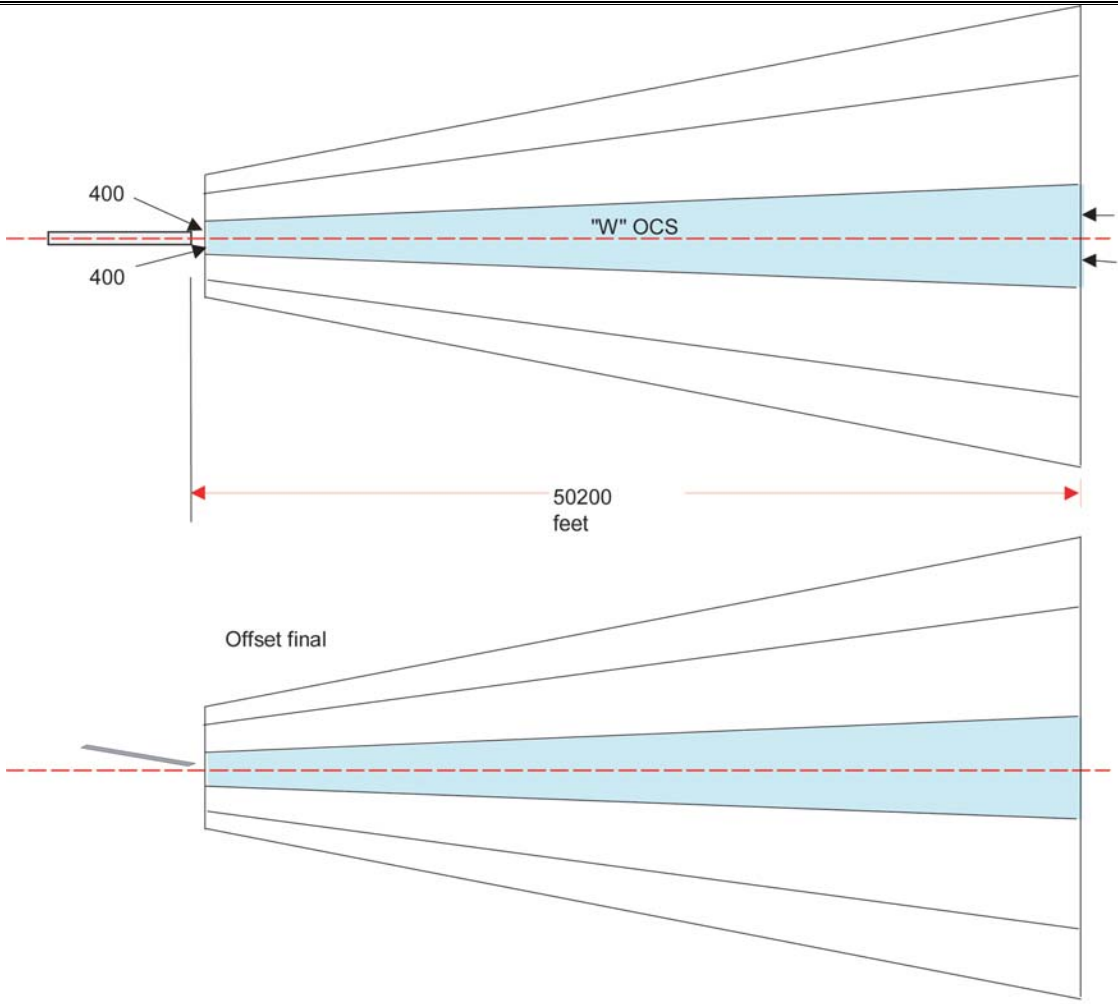


Figure 3-5: W OCS. Para 3.4.

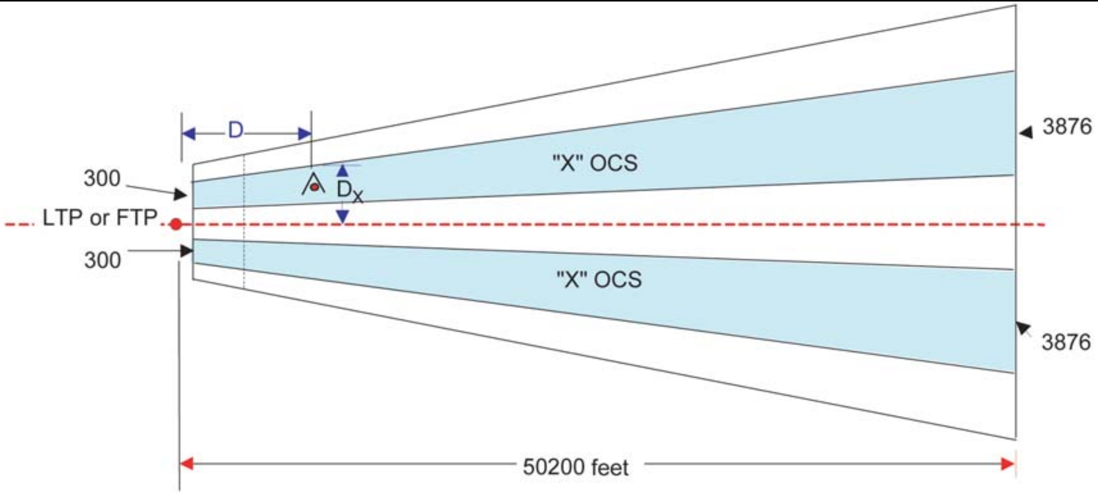


Figure 3-6: W OCS. Para 3.5.

3.4.2 Height

The height (Z_W) of the W OCS above ASBL is defined by the formula:

$$Z_W = \frac{D - (200 + d)}{S}$$

Where D = the distance in feet from RWT

d = d from para 3.2.1 for GPI less than 954’, or greater

S = W surface slope

3.4.3 W OCS Penetrations

Lowest minimums are achieved when the W surface is clear. If an existing obstacle penetrates the surface, adjust obstruction height, raise the GPA (see Para 3.2.2), or displace the RWT to eliminate the penetration. If the penetration cannot be eliminated, adjust the DA (see Para 3.8).

3.5 X OCS

See Figure 3-6.

3.5.1 Width

The perpendicular distance (D_X) from the course to the outer boundary of the X OCS is defined by the formula:

$$D_X = 0.10752\,(D - 200) + 700$$

Where D = distance (ft) from LTP or FTP

3.5.2 Height

The X OCS begins at the height of the W surface at distance D from LTP or FTP, and rises at a slope of 1:4 in a direction perpendicular to the final approach course. Determine the height (Z_X) above ASBL for a specific location of the X OCS using the following formula:

$$Z_X = \overset{\substack{\text{Height of}\\ \text{W Sfc}}}{\frac{D - (200 + d)}{S}} + \overset{\substack{\text{Rise of}\\ \text{X Sfc}}}{\frac{D_O - D_W}{4}}$$

Where D = the distance in feet from LTP or FTP

d = d from para 3.2.1 for GPI less than 954’, 0 for GPI 954’ or greater

D_O = the perpendicular distance in feet between course centreline and a specific point in the X surface

D_W = the perpendicular distance in feet between course centreline and the W surface boundary

S = the slope associated with GPA $\left(\frac{102}{\text{GPA}}\right)$

3.5.3 X OCS Penetrations

Lowest minimums can be achieved when the X OCS is clear. To eliminate, avoid, or mitigate a penetration, take one of the following actions listed in the order of preference.

a. Remove or adjust the obstruction location and/or height.
b. Displace the RWT.
c. Raise the GPA (see Para 3.2.2) within the limits of table 2-2A.
d. Adjust DA (for existing obstacles only) (see Para 3.8).

3.6 Y OCS

See Figure 3-7.

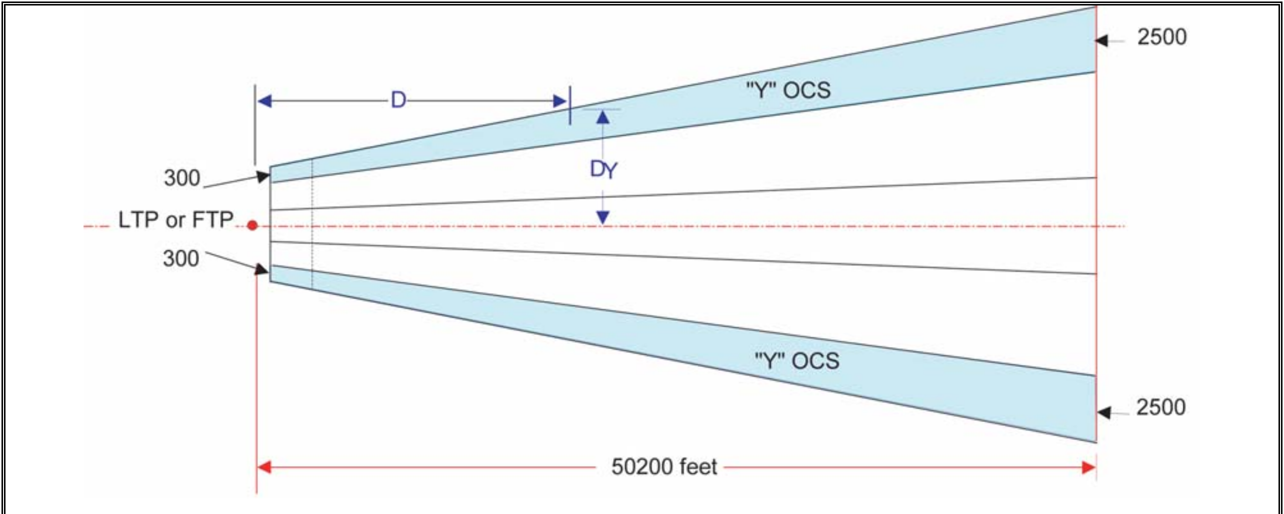


Figure 3-7: Y OCS. Para 3.6.

3.6.1 Width

The perpendicular distance (D_Y) from the runway centreline extended to the outer boundary of the Y OCS is defined by the formula:

$D_Y = 0.15152 (D - 200) + 1000$

Where $D =$ distance (ft) from LTP or FTP

3.6.2 Height

The Y OCS begins at the height of the X surface at distance D from LTP or FTP, and rises at a slope of 1:7 in a direction perpendicular to the final approach course. The height (Z_Y) of the Y surface above ASBL is defined by the formula:

$$Z_Y = \overset{\substack{\text{Height of} \\ \text{W Sfc}}}{\frac{D - (200 + d)}{S}} + \overset{\substack{\text{Rise of} \\ \text{X Sfc}}}{\frac{D_X - D_W}{4}} + \overset{\substack{\text{Rise of} \\ \text{Y Sfc}}}{\frac{D_O - D_X}{7}}$$

Where D = the distance in feet from LTP or FTP

d = d from Para 3.2.1 for GPI less than 954’, 0 for GPI 954’ or greater

D_X = the perpendicular distance in feet between course centreline and the X surface outer boundary

D_O = the perpendicular distance in feet between course centreline and an obstruction in the Y surface

3.6.3 Y OCS Penetrations

Lowest minimums can be achieved when the Y OCS is clear. When the OCS is penetrated, remove the obstruction or reduce its height to clear the OCS. If this is not possible, a subjective evaluation is necessary. Consider the obstruction's physical nature, the amount of penetration, obstruction location with respect to the X surface boundary, and density of the obstruction environment to determine if the procedure requires adjustment. If an adjustment is required, take the appropriate actions from the following list:

a. Adjust DA for existing obstacles (see Para 3.8).

b. Displace threshold.

c. Offset final course.

d. Raise GPA (see Para 3.2.2).

e. If an adjustment is not required, CHART the obstruction.

3.7 Decision Altitude (DA) And Height Above Touchdown (HAT)

The DA value may be derived from the HAT. The MINIMUM HAT for Category I operations is 200 feet. Calculate the DA using the formula:

DA = HAT + TDZE

3.8 Adjustment Of DA For Final Approach OCS Penetrations

See Figure 3-8.

The distance from GPI to the DA may be increased to ensure DA occurs at a height above ASBL providing sufficient obstruction clearance. This adjustment is available for existing obstacles only. Proposed obstructions shall not penetrate the OCS.

3.8.1 GPI Distance

Determine the distance from LTP to the adjusted DA point using the formula:

$$DA_{adjusted} = \frac{102h}{GPA} + (200 + d)$$

Where $DA_{adjusted}$ = adjusted distance (ft) from LTP to DA
d = d from Para 3.2.1 for GPI < 954’, 0 for GPI ≥ 954’
h = obstacle height (ft) above ASBL

Note: If obstacle is in the X surface, subtract X surface rise from h.
If obstacle is in the Y surface, subtract X and Y surface rise from h.

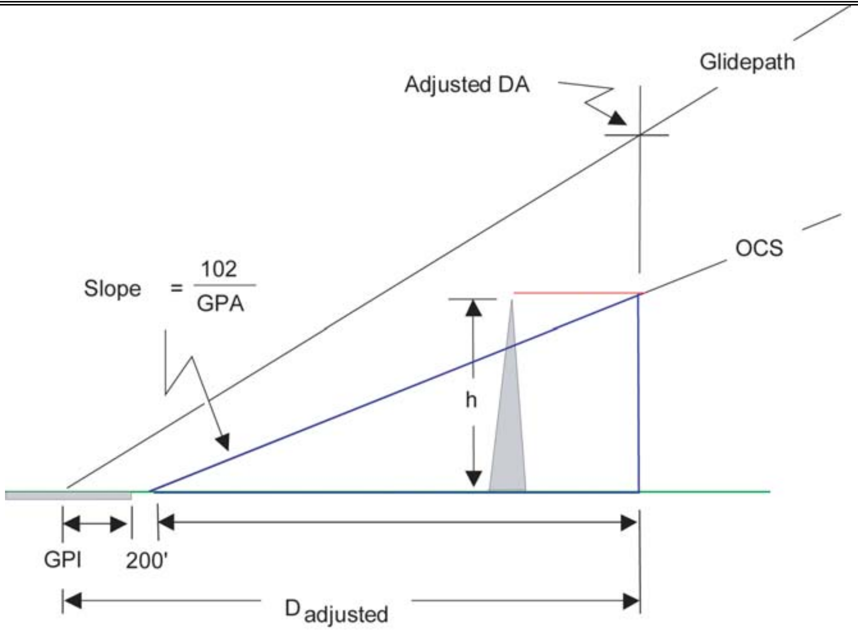


Figure 3-8: DA Adjustment. Para 3.8.1.

3.8.2 Calculate The Adjusted DA and HAT

Calculate the adjusted DA and HAT using the formula:

$$\text{DA} = \tan \text{GPA} \left(\left(\frac{102h}{\text{GPA}} + (200 + d)\right) + \frac{\text{TCH}}{\tan(\text{GPA})}\right) + \text{LTP}_{\text{elevation}}$$

3.8.3 Calculate The Revised Minimum HAT/ Maximum ROC

Calculate the revised minimum HAT and maximum ROC using the formula:

$$\text{Min HAT and Max ROC} = \frac{\text{GPA}}{3}\ 250$$

3.8.4 Compare HAT and Minimum HAT

Compare the HAT and the minimum HAT and publish the higher of the two values.

3.8.5 Mark And Light

Initiate action to mark and light obstructions that would require DA adjustment when they are located between the DA and the LTP/FTP. These obstacles shall also be noted and identified on the IAP chart.

3.9 Missed Approach

The missed approach segment begins at DA and ends at the clearance limit. It is comprised of Section 1 (initial climb) and Section 2 (from end of Section 1 to the clearance limit). Section 2 is constructed under criteria contained in FAA Order 8260.44 for RNAV procedures. Section 2 beginning width is ± 0.5 NM. The 40:1 OCS begins at the elevation of Section 1b at centreline. The MA procedure is limited to two turn fixes (see Figure 3-9A).

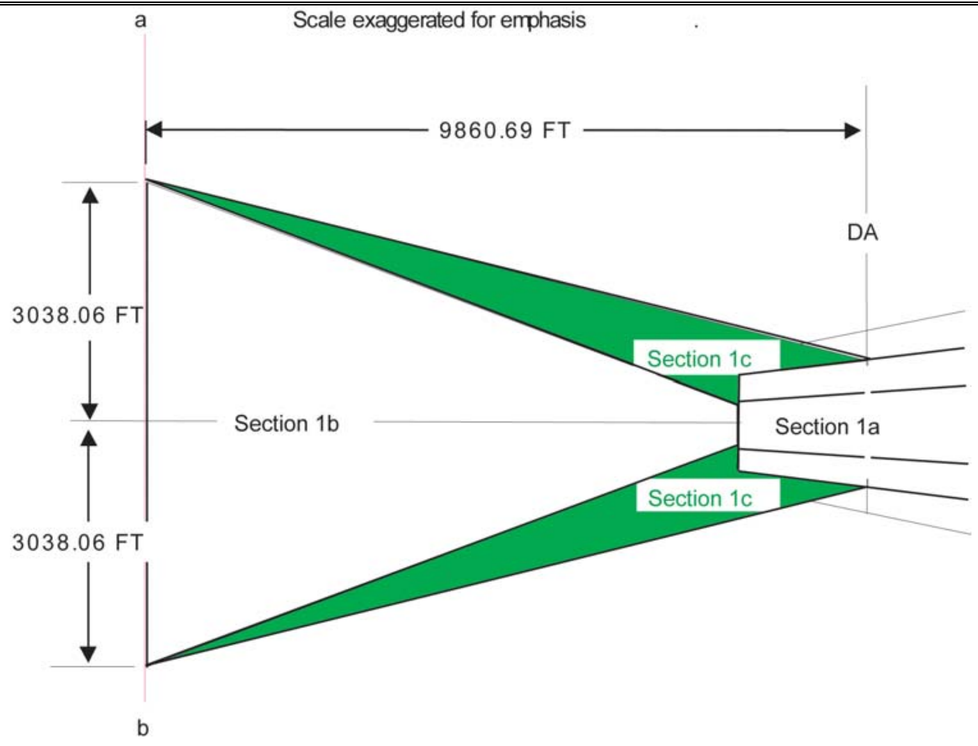


Figure 3-9a: Section 1a, 1b, 1c. Para 3.9.1.

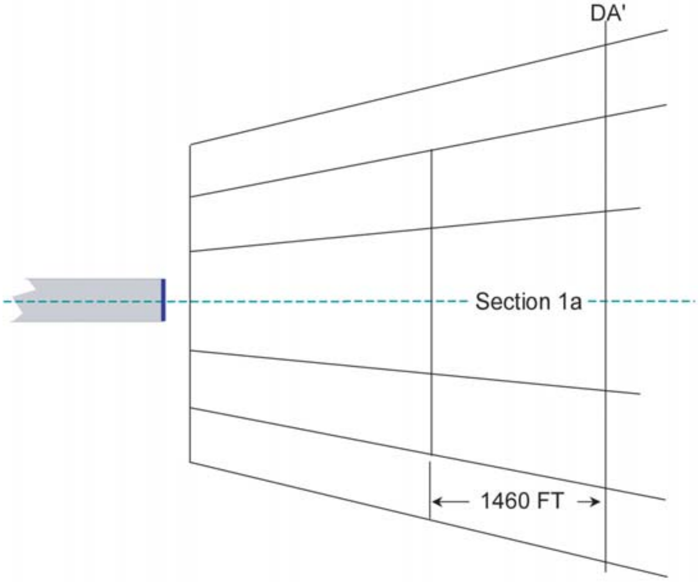
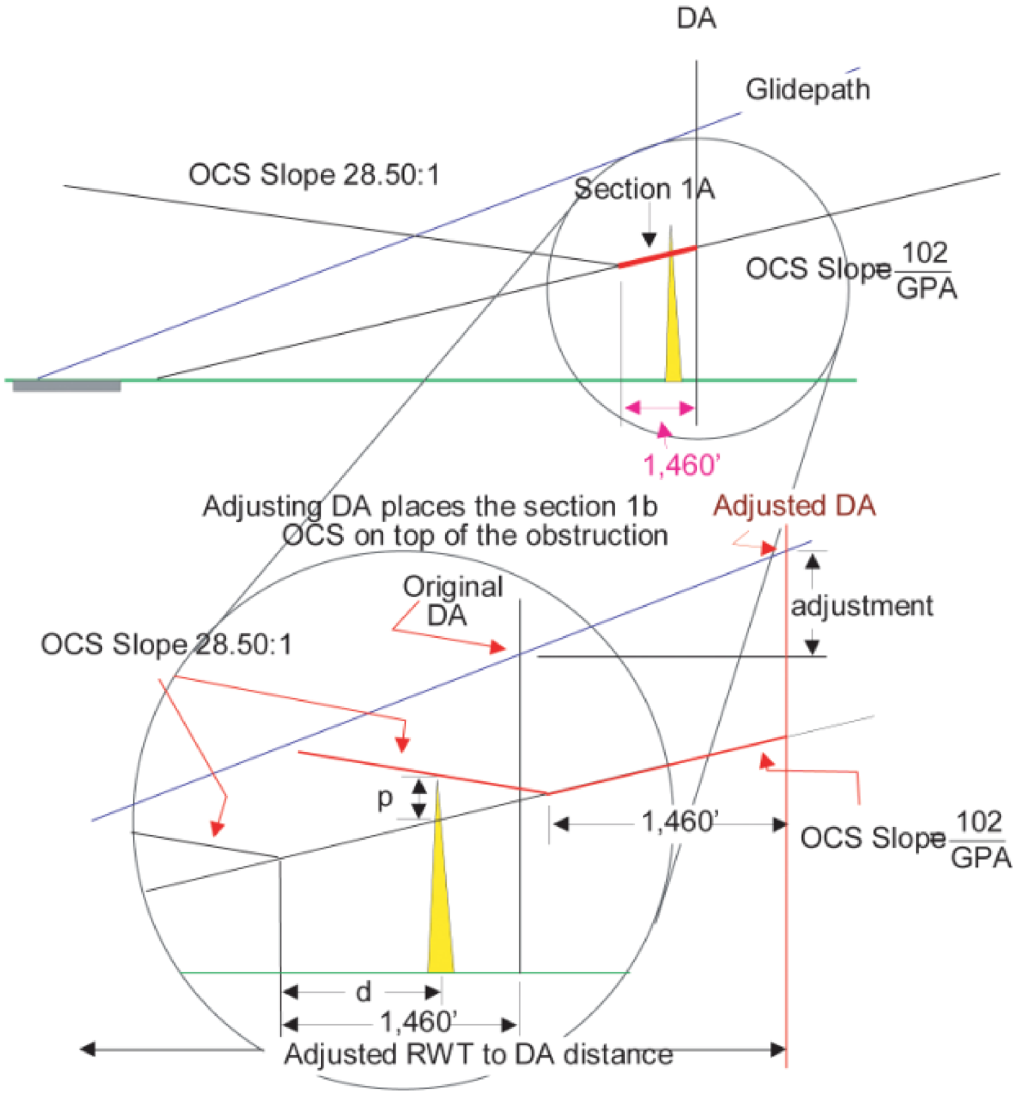


Figure 3-9B: Section 1a. Para 3.9.1.



$$d = X_O - (\text{RWT to DA Distance} - 1{,}460)$$

$$\text{adjustment} = \text{Tan (GPA)} \left[\left(\frac{p}{\frac{1}{28.50} + \frac{\text{GPA}}{102}} \right) + d \right]$$

$$\text{adjusted DA (MSL)} = \text{original DA} + \text{adjustment}$$

$$\text{adjusted RWT to DA Dist} = \frac{\text{adjusted DA (MSL)} - (\text{RWT MSL elevation} + \text{TCH})}{\tan(\text{GPA})}$$

Where
p = penetration (ft)
GPA = glide path angle
X_O = distance from RWT to obstruction (ft)
d = distance (ft) from obstruction to point where the 28.5:1 OCS originates

Figure 3-9C: Penetration Of Section 1a OCS. Para 3.9.1.

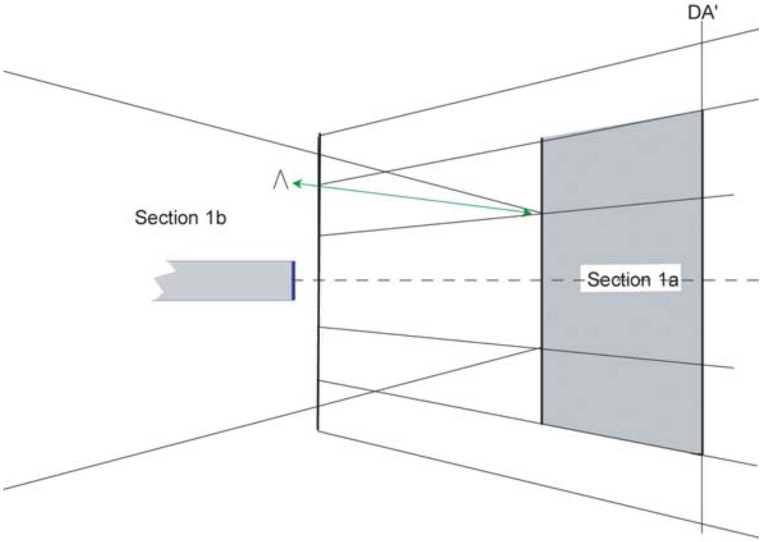


Figure 3-9D: Section 1b. Para 3.9.1.b.

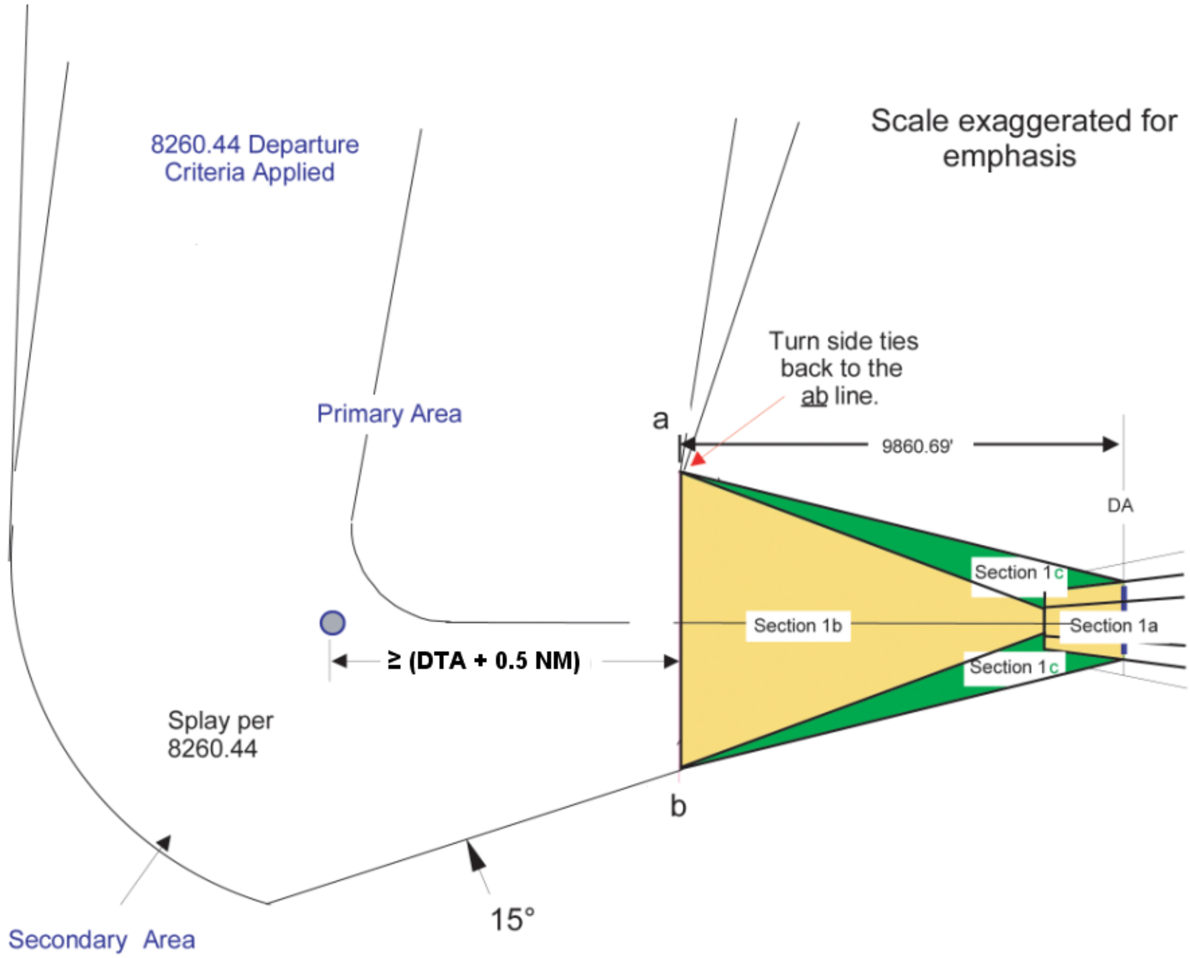


Figure 3-10A: Turning Missed Approach With Turning Fix At The Minimum Required Distance. Para 3.9.1.d.

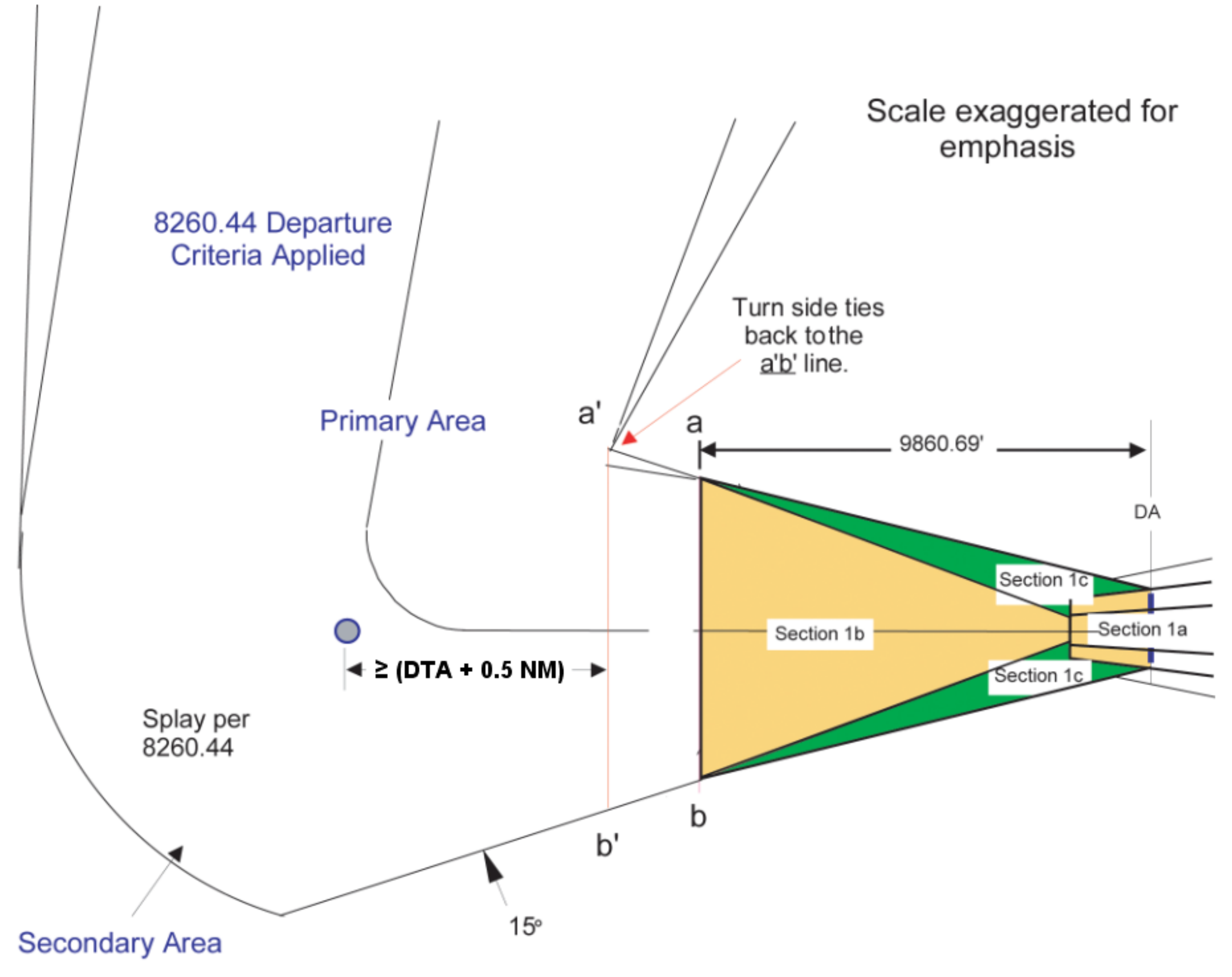


Figure 3-10B: Turning Missed Approach With Turn Fix At Greater Than Minimum Distance. Para 3.9.1.d.

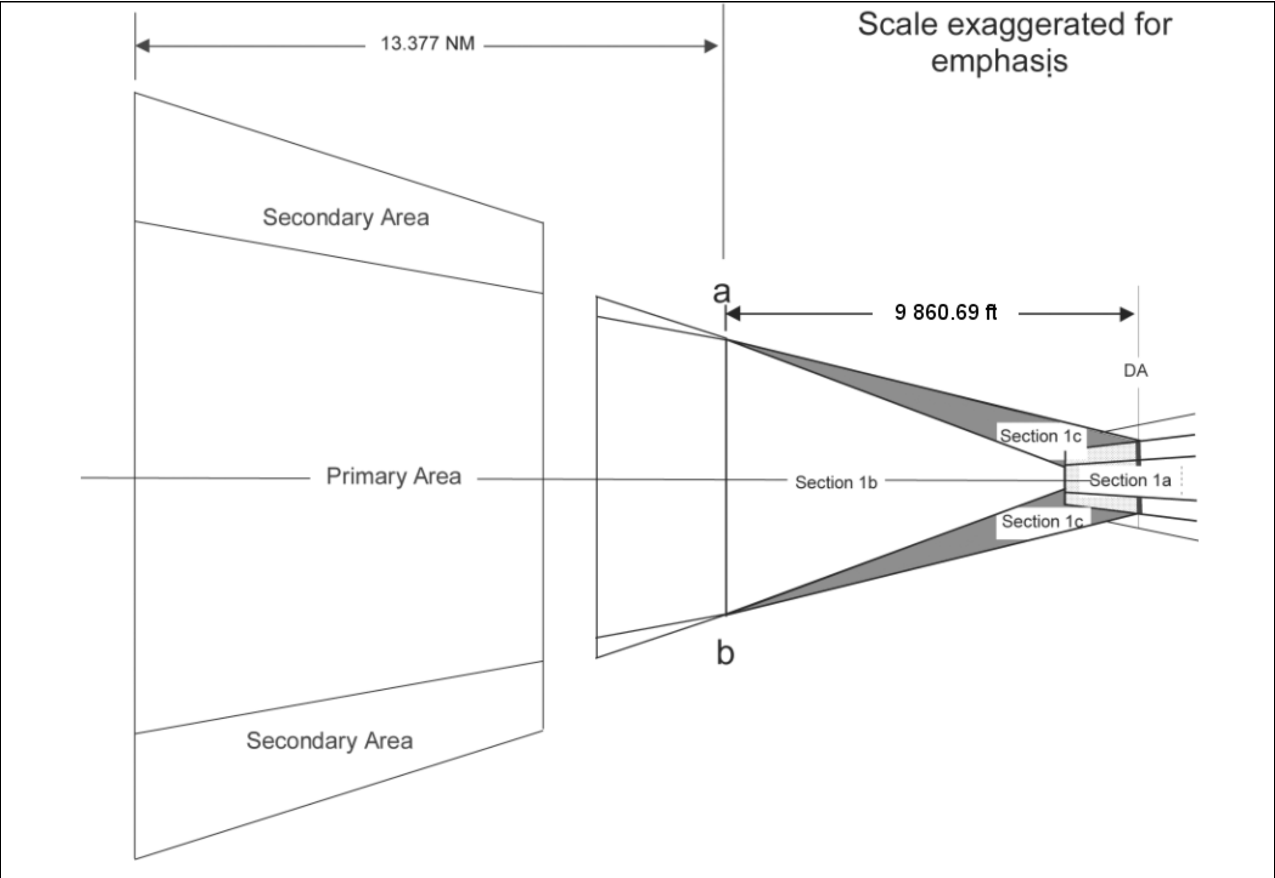


Figure 3-11A: Straight Missed Approach. Para 3.9.1.e.

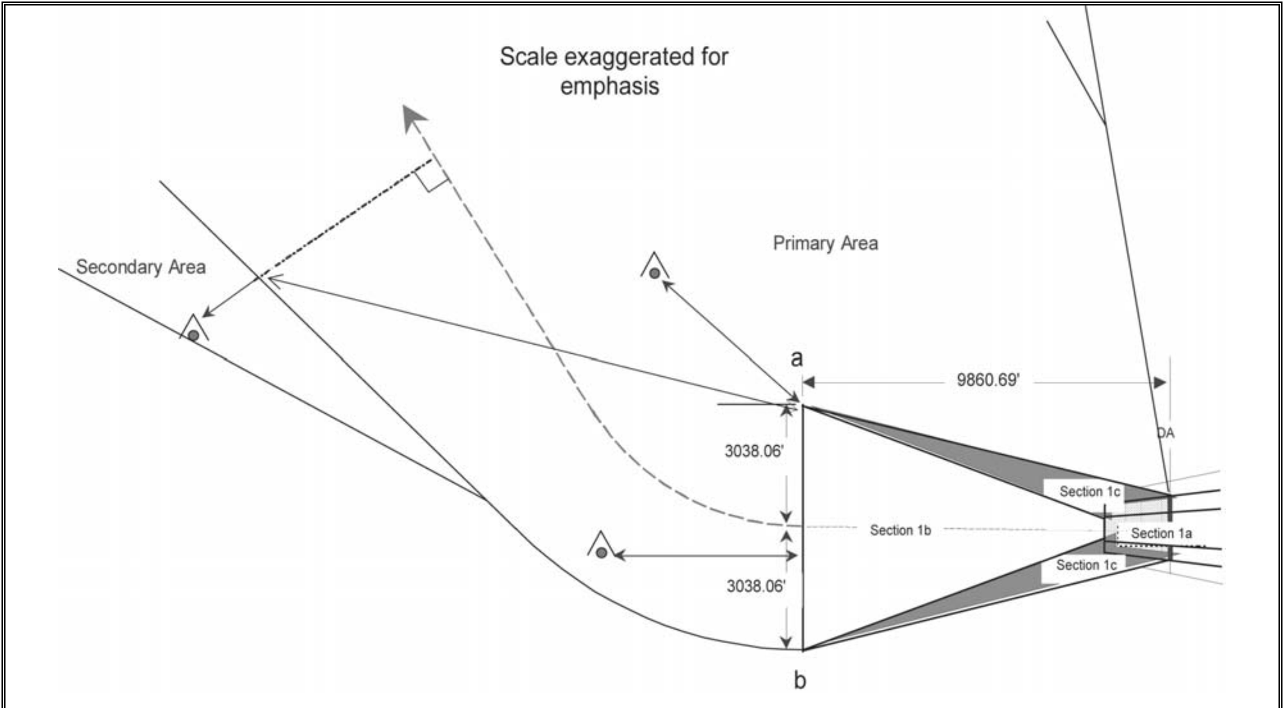


Figure 3-11B: Turning Missed Approach. Para 3.9.1.e.

3.9.1 Section 1

Section 1 is aligned with the final approach course. It is comprised of 3 subsections, beginning at DA and extending 9860.69 feet.

a. Section 1a.

   (1) Area. Section 1a begins at the DA point and overlies the final approach primary (W and X surfaces) OCS, extending 1,460 feet in the direction of the missed approach. This section is always aligned with the final approach course (see Figures 3-9B and 3-9C).

   (2) OCS. The height of the Section 1a surface is equal to the underlying W or X surface as appropriate. If this section is penetrated, adjust DA per Figure 3-9C to mediate the penetration.

b. Section 1b.

   (1) Area. Section 1b begins at the end of section 1a, extends to a point 9860.69 feet from DA, and splays along the extended final course to a total width of 1 NM. This section is always aligned with the final approach course (see Figures 3-9A, 3-9D).

   (2) OCS. Section 1b OCS is a 1:28.5 inclined plane rising in the direction of the missed approach. The height of the beginning of section 1b is equal to the height of the W OCS at the end of Section 1a (see Figure 3-9D). Evaluate obstructions using the shortest distance of the obstruction from the end of Section 1a. Adjust DA per Figure 3-9E to mediate penetrations in this section.

c. Section 1c (see Figure 3-9F).

(1) Area. These are 1:7 secondary areas that begin at the DA point. These sections splay to a point on the edge and at the end of Section 1b.

(2) OCS. An inclined plane starting at the DA point and sloping 1:7, perpendicular to the MA course. The inner boundaries originate at the elevation of the outer edges of the W surface at the beginning of Section 1b. The outer boundaries originate at the elevation of the outer edges of the X surfaces at the DA point. These inner and outer boundaries converge at the end of Section 1b (9860.69 feet from the DA point). Obstacles in Section 1c, adjacent to the X surfaces, are evaluated with a 1:7 slope from the elevation of the outer boundaries of the X surfaces. Obstacles in Section 1c, adjacent to Section 1b, are evaluated using the 1:7 slope, beginning at the elevation at the outer edge of Section 1b (see Figures 3-9A and 3-9F). Reduce the obstruction height by the amount of 1:7 surface rise from the edge of Section 1a or 1b (measured perpendicular to Section 1 course). Then evaluate the obstruction as if it were in Section 1a or 1b.

d. Section 2 (RNAV Only). Apply FAA Order 8260.44 criteria in this section. Instead of the departure trapezoid originating at DER altitude at the DER, it originates at the elevation of the end of Section 1b OCS at centreline, with a width of ± 0.5 NM (along the ab line). It ends at the plotted position of the clearance limit. The primary and secondary widths shall be the appropriate width from the distance flown. Establish a fix on the continuation of the final approach course at least 0.5 NM from the end of Section 1 (ab line). If the fix is a fly-by turning waypoint, locate the fix at least DTA+0.5 NM from the ab line (see Figures 3-10A and 3-10B). Use table 3-1 airspeeds to determine turn radii from FAA Order 8260.44, table 3. Establish the outer boundary radius of a turning procedure based on the highest category aircraft authorized to use the approach.

Category	**MA Altitude <10,000’ MSL**	**MA Altitude 10,000’ MSL**
A, B	200 KIAS	200 KIAS
C,D,E	250 KIAS	310 KIAS

Table 3-1: Turn Radius. Para 3.9.1.d.

e. Section 2 (Non-RNAV).

(1) Straight-Ahead (15° or less of final course heading). Section 2 is a 40:1 OCS that starts at the end of Section 1 and is centred on the missed approach course. The width increases uniformly from 1 NM at the beginning to 12 NM at a point 13.377 NM from the beginning. A secondary area for reduction of obstacle clearance is identified within Section 2. The secondary area begins at zero miles wide and increases uniformly to 2 NM wide at the end of Section 2. PCG is required to reduce obstacle clearance in the secondary areas (see Figure 3-11A). Use TP308/GPH209, Volume 1, Chapter 18, to determine if a climb-in-holding evaluation is required.

(2) Turning Missed Approach. Where turns of MORE than 15° are required, design the procedure to begin the turn at an altitude at least 400 feet above the elevation of the TDZ. Assume the aircraft will be 200 feet above DA at the end of Section 1b. Extend Section 1b 30.39 feet for each additional foot of altitude necessary before a turn can commence. This point is where Section 2 40:1 OCS begins. If the 40:1 OCS of Section 2 is penetrated, adjust DA according to the following formula:

$$\text{DA adjustment} = \left(\frac{p}{\frac{1}{40} + \frac{\text{GPA}}{102}} \right) \times \tan(\theta)$$

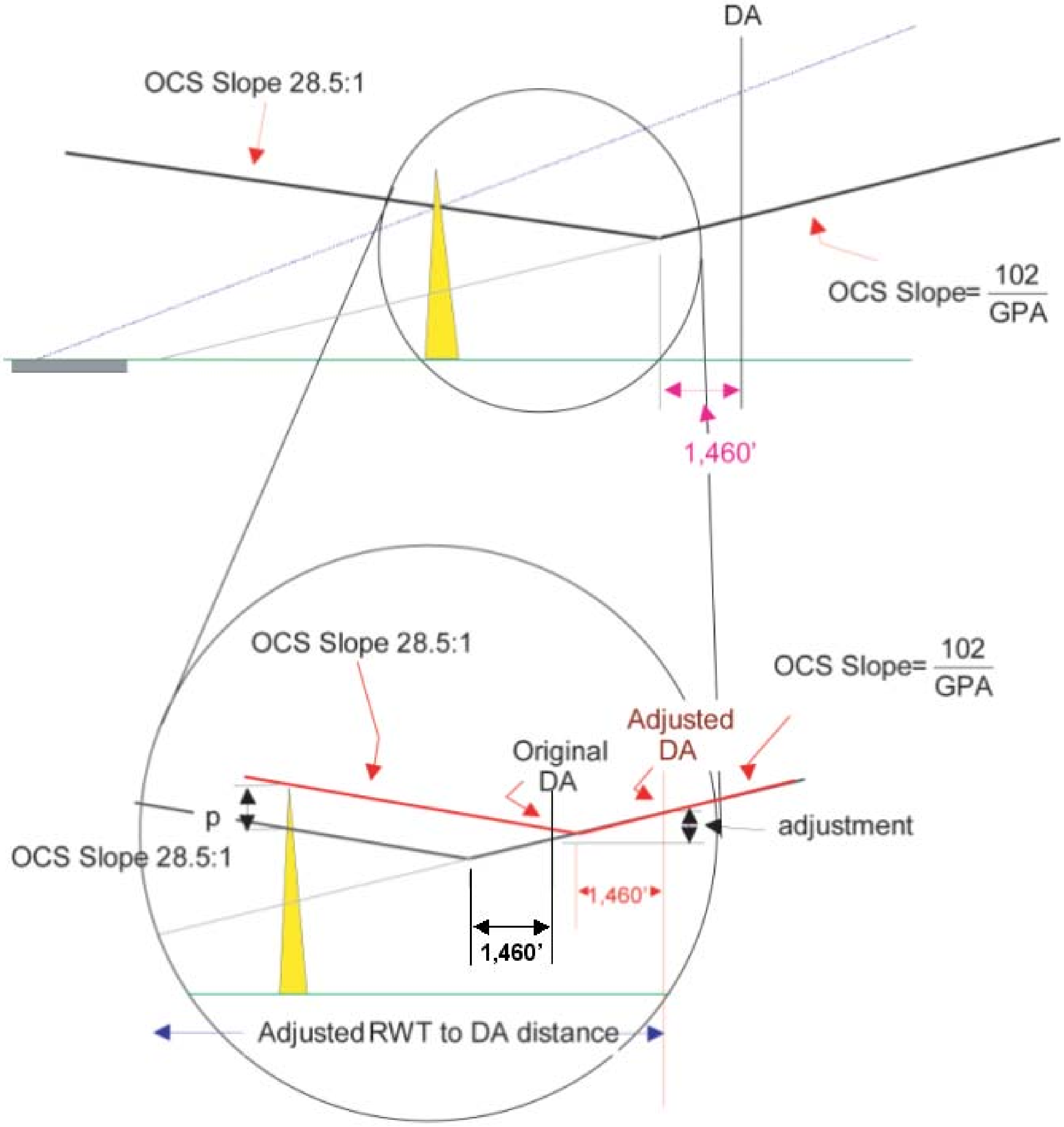
Where p = amount of penetration from Section 2 in feet

θ = Glide Path angle

Adjusted DA = DA adjustment + Original DA (rounded to next higher foot).

Specify the "climb to" altitude in the published missed approach procedure. The flight track and outer boundary radii used shall be as specified in TP308/GPH209 Volume 1, Para 275, Table 2-7. The inner boundary line shall commence at the edge of Section 1 opposite the MAP. The outer and inner boundary lines shall expand to the width of the initial approach area 13.377 NM from the beginning of Section 2. Secondary areas for reduction of obstacle clearance are identified within Section 2. The secondary areas begin after completion of the turn (see Figure 3-11B). They begin at zero NM wide and increase uniformly to 2 NM wide at the end of Section 2. PCG is required to reduce obstacle clearance in the secondary area.

(3) Combination Straight-Turning Missed Approach Procedures. Use TP308/GPH209 Volume 1, Paras 277d and f to establish the charted missed approach altitude. Use TP308/GPH209 Volume 1, Para 293 to determine if a climb-in-holding evaluation is required.



$$\text{adjustment} = \text{Tan (GPA) x} \left(\frac{p}{\frac{1}{28.5} + \frac{GPA}{102}} \right)$$

adjusted DA (MSL) = original DA + adjustment

$$\text{adjusted RWT to DA Dist} = \frac{\text{adjusted DA (MSL)} - \text{(RWT MSL elevation + TCH)}}{\tan \text{(GPA)}}$$

Where p = penetration (ft)
GPA = glide path angle

Figure 3-9E: Penetration Of Section 1b OCS. Para 3.9.1.b.

3.9.2 Missed Approach Climb Gradient (DOD Only)

Where the 40:1 OCS is penetrated and the lowest HAT is required, a mandatory missed approach climb gradient may be specified to provide ROC over the penetrating obstruction. Use the following formula to calculate the climb gradient (CG) in feet per NM:

$$\frac{o - (DA - \tan(\theta)(1460) + 276.52)}{0.76d} = CG$$

Example:

$$\frac{1849 - (613 - \tan(3)(1460) + 276.52)}{(0.76)(5.26)} = 256.15 \approx 260$$

Where
o = MSL height of obstruction
d = shortest distance (NM) from end of Section 1B to obstacle
θ = glidepath angle

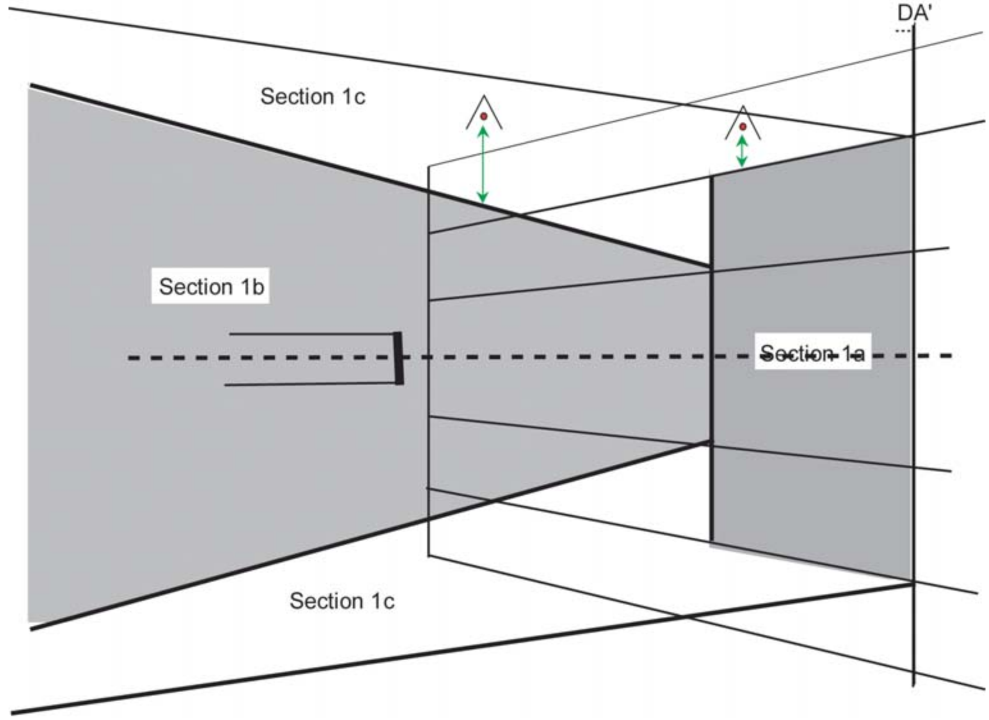


Figure 3-9F: Section 1c. Para 3.9.1.c.

3.9.3 Missed Approach ROC Rationale

The obstacle clearance concept applied to the departure and missed approach climb manoeuvre in instrument procedures design is to enable the aircraft to gain sufficient altitude to supply at least the minimum ROC for the subsequent level surface segments of the procedure. The obstacle evaluation method for a climb manoeuvre is the application of a rising OCS below the minimum climbing flight path. The vertical distance between the climbing flight path and the OCS is ROC. The ROC and OCS slope values are dependent on a minimum aircraft climb performance of 200 ft/NM (see Figure 3-12). Whether the climb is for departure or missed approach is immaterial. The standard for determining OCS slope is that 76% (19/25) of the altitude gained defines the OCS slope; 24% (6/25) of the altitude gained defines the ROC value.

The amount of ROC increases as the aircraft climbs until the point en route or initial segment ROC (1,000/2,000 feet as appropriate) is realized. After this point, application of a sloping surface for obstacle clearance purposes is not required. Where an obstacle penetrates the OCS, a greater than normal climb gradient (greater than 200 ft/NM) is required to provide adequate ROC. Since the climb gradient will be greater than 200 ft/NM, the ROC requirement will be greater than 48 ft/NM (0.24 x [Y > 200] = [Z > 48]).

The ROC expressed in ft/NM can be calculated using the formula:

$$\frac{0.24h}{0.76d} \quad \text{or} \quad \frac{6h}{19d}$$

Where h = the height of the obstacle in feet above the altitude from which the climb is initiated

d = the distance in NM from the initiation of climb to the obstacle

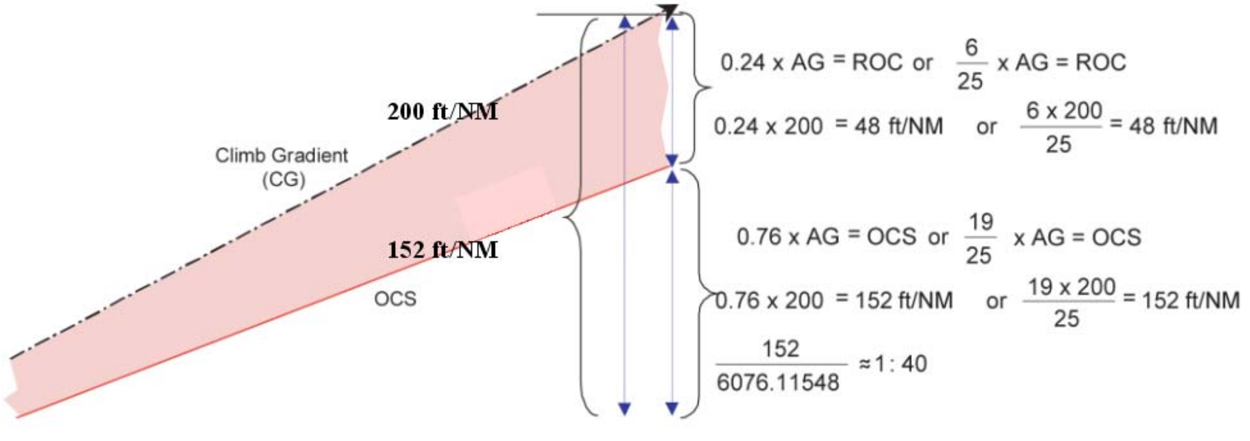


Figure 3-12: ROC and OCS Slope Values. Para 3.9.3.

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CHAPTER 4. RESERVED

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APPENDIX 1. CATEGORY (CAT) II AND III PRECISION MINIMUMS REQUIREMENTS

1.0 Reserved

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APPENDIX 2. SIMULTANEOUS ILS PROCEDURES

1.0 General

Simultaneous dual and triple ILS approach procedures using ILS installations with parallel courses may be authorized when the minimum standards in this appendix and chapter 2 of this Volume are met.

2.0 System Components

Simultaneous ILS approach procedures require the following basic components:

2.1. An ILS Is Specified In Chapter 2 Of This Volume For Each Runway

Adjacent markers of the separate systems shall be separated sufficiently to preclude interference at altitudes intended for use.

2.2 ATC Approved RADAR For Monitoring Simultaneous Operations

3.0 Inoperative Components

When any component specified in Para 2.0 becomes inoperative, simultaneous ILS approaches are not authorized on that runway.

4.0 Feeder Routes And Initial Approach Segment

The criteria for feeder routes and the initial approach segment are contained in TP308/GPH209 Volume 1, chapter 2, Para 2.3. The initial approach shall be made from a facility or satisfactory radio fix by radar vector. Procedure and penetration turns shall not be authorized.

4.1 Altitude Selection

In addition to obstacle clearance requirements, the altitudes established for initial approach shall provide the following vertical separation between glide slope intercept altitudes:

4.1.1 Dual

Simultaneous dual ILS approaches shall require at least 1,000 feet vertical separation between glide slope intercept altitudes for the two systems (see Figure A2-1).

4.1.2 Triple

Simultaneous triple ILS approaches shall require at least 1,000 feet vertical separation between GS intercept altitudes for any combination of runways. No two runways share the same GS intercept altitude (see Figure A2-2).

4.2 Localizer Intercept Point

The localizer intercept point shall be established UNDER chapter 2, Para 2.3 of this volume. Intercept angles may not exceed 30°; 20° is optimum.

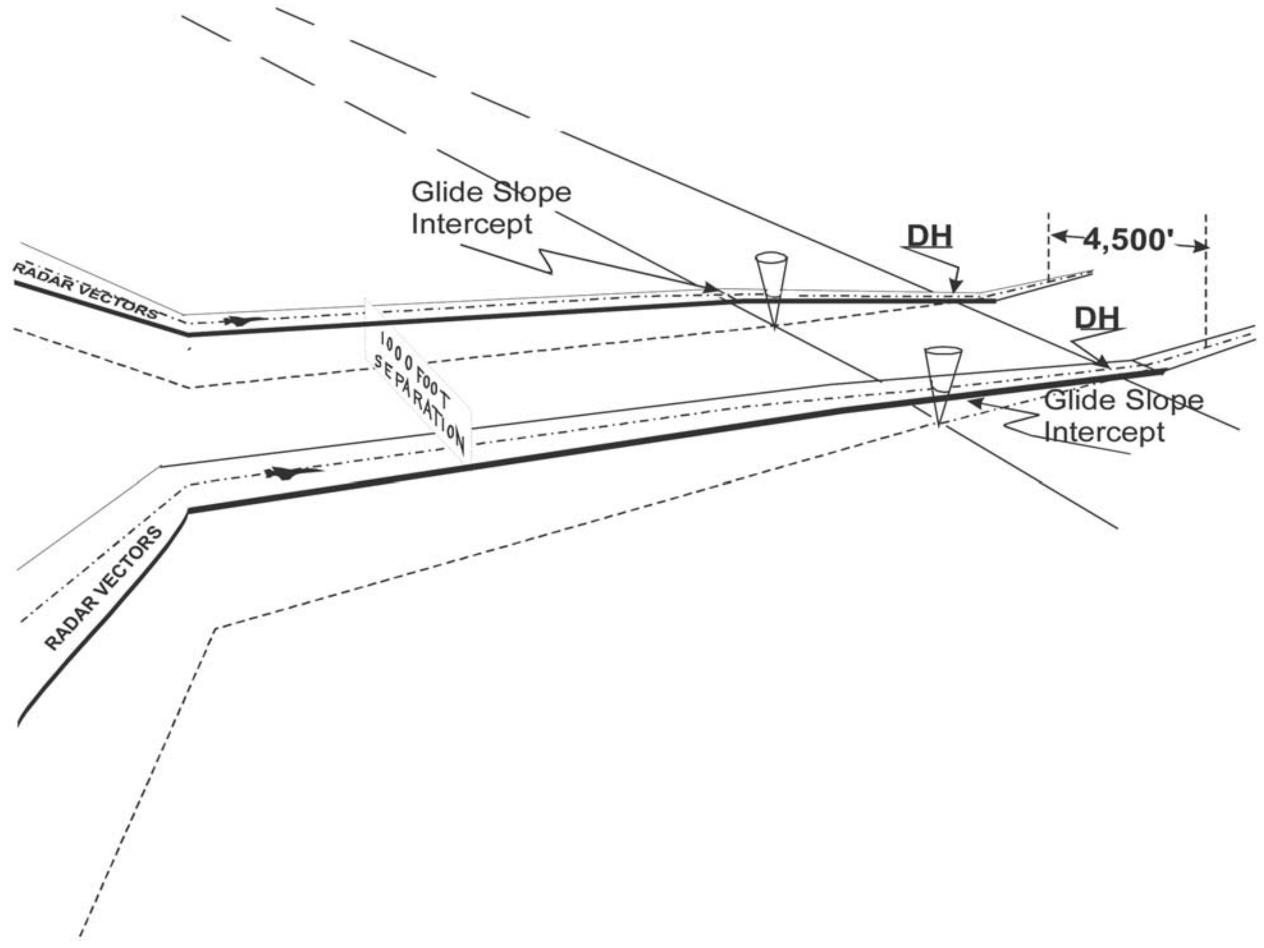


Figure A2-1: Initial Approach Segment, Simultaneous ILS. App 2, Para 4.1.1.

5.0 Intermediate Approach Segment

Criteria for the intermediate segment are contained in TP308/GPH209 Volume 1, Paras 241 and 242, except that simultaneous ILS procedures shall be constructed with a straight intermediate segment aligned with the final approach course (FAC), and the minimum length shall be established in accordance with chapter 2, Para 2.3.1 of this volume. The intermediate segment begins at the point where the initial approach intercepts the FAC. It extends along the inbound course to the GLIDE SLOPE intercept point.

6.0 Final Approach Segment

Criteria for the final approach segment are contained in chapter 3 of this Volume.

7.0 Final Approach Course (FAC) Standards

The FACs for simultaneous ILS approaches require the following:

7.1. Dual Approaches

The MINIMUM distance between parallel FACs is 4,300 feet.

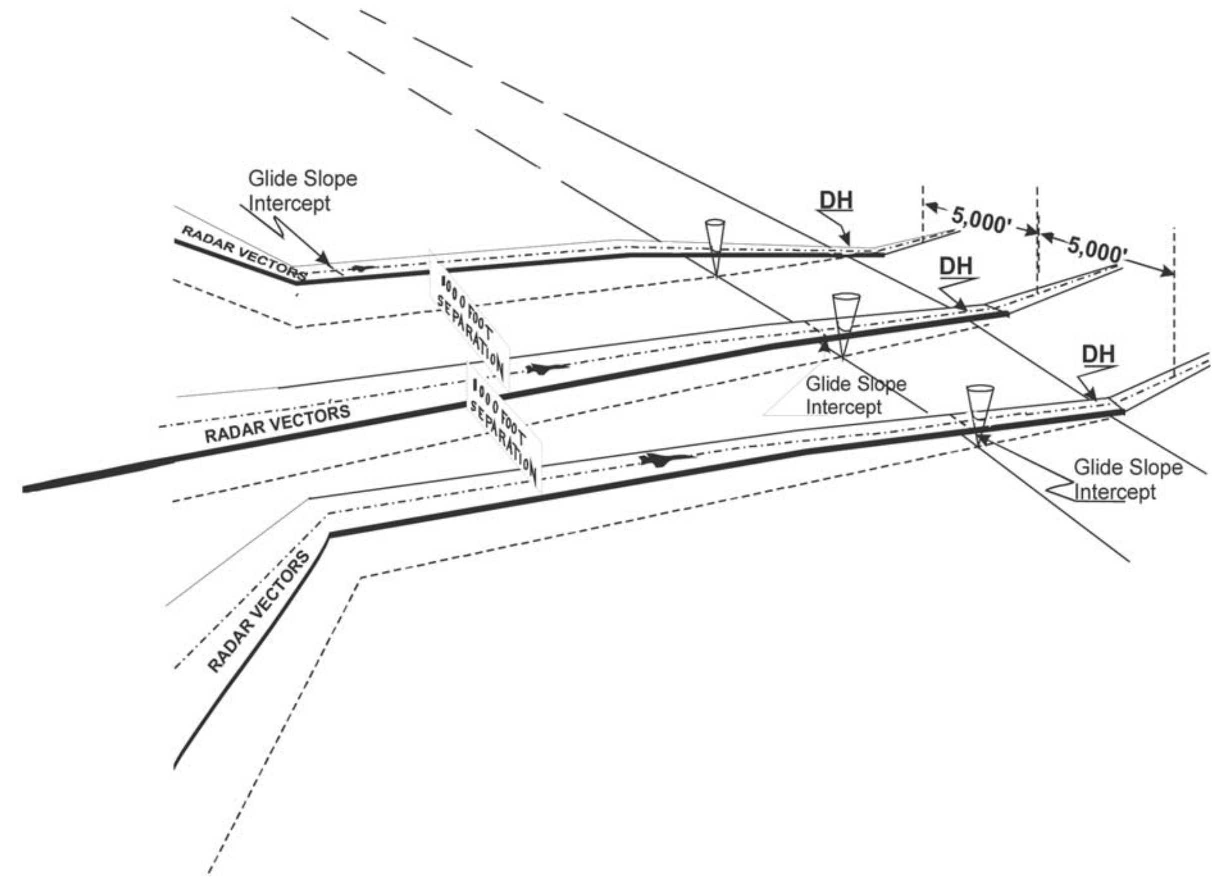


Figure A2-2: Initial Approach Segment For Triple Simultaneous ILS. Appendix 2, Para 4.1.2.

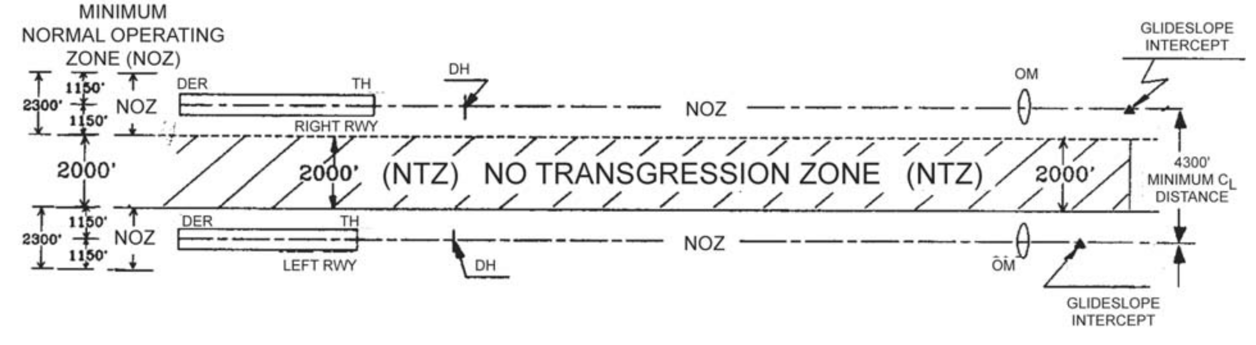


Figure A2-3: Dual Simultaneous ILS, “No Transgression And Normal Operating Zones.” Appendix 2, Para 7.4.1.

7.2. Triple Approaches

The MINIMUM distance between parallel FACs is 5,000 feet. For triple parallel approach operations at airport elevations above 1,000 feet MSL, ASR with high-resolution final monitor aids or high update radar with associated final monitor aids is required.

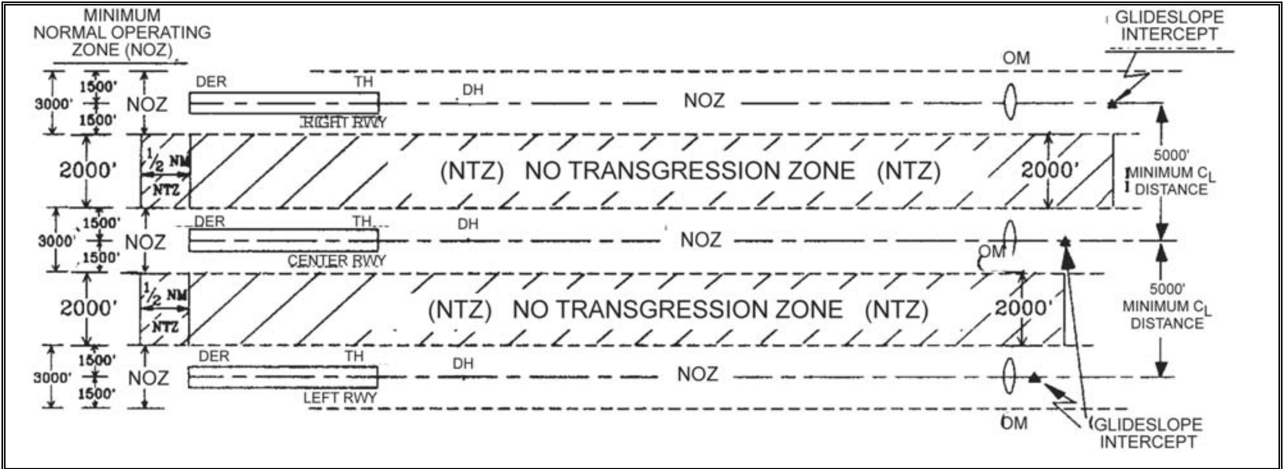


Figure A2-4: Triple Simultaneous ILS, "No Transgression And Normal Operating Zones." Appendix 2, Para 7.4.2.

7.3. No Transgression Zone (NTZ)

The NTZ shall be 2,000 feet wide equidistant between FACs.

7.4. Normal Operating Zone (NOZ)

The area between the FAC and the NTZ is half of the NOZ.

7.4.1 NOZ For Dual Simultaneous ILS Approaches

The NOZ for dual simultaneous ILS approaches shall not be less than 1,150 feet in width each side of the FAC (see Figure A2-3).

7.4.2 NOZ For Triple Simultaneous Ils Approaches

The NOZ for triple simultaneous ILS approaches shall not be less than 1,500 feet in width each side of the FAC (see Figure A2-4).

8.0 Missed Approach Segment

Except as stated in this paragraph, the criteria for missed approach are contained in chapter 3 of this Volume. A missed approach shall be established for each of the simultaneous systems. The minimum altitude specified for commencing a turn on a climb straight ahead for a missed approach shall not be less than 400 feet above the TDZE.

8.1 Dual

Missed approach courses shall diverge a minimum of 45°.

8.2 Triple

The missed approach for the centre runway should continue straight ahead. A minimum of 45° of divergence shall be provided between adjacent missed approach headings. At least one outside parallel shall have a turn height specified that is not greater than 500 feet above the TDZE for that runway.

APPENDIX 3. CLOSE PARALLEL ILS/MLS APPROACHES

1.0 Background

Extensive tests have disclosed that under certain conditions, capacity at the nation's busiest airports may be significantly increased with independent simultaneous parallel approaches to runways that are more closely spaced than the minimum of 4,300 feet. Tests have shown that a reduction in minimum separation between parallel runways may be achieved by use of high update radar with high-resolution displays and automated blunder alerts.

2.0 Terminology

Automated Alert. A feature of the PRM that provides visual and/or audible alerts to the monitor controller, when an aircraft is projected to enter, or has entered the NTZ. Para 3.1.2 defines the precision runway monitor (PRM) systems alerts.

Breakout. A technique to direct aircraft out of the approach stream. In the context of close parallel operations, a breakout is used to direct threatened aircraft away from a deviating aircraft.

Close Parallels. Two parallel runways whose extended centrelines are separated by at least 3,400 feet, but less than 4,300 feet, having a precision runway monitoring system that permits simultaneous independent ILS/MLS approaches. Runways are separated by less than 3,400 to 3,000 feet with a localizer offset of not more than 3.0°.

E-Scan Radar. An electronically scanned phased array radar antenna that is cylindrical and stationary. It consists of interrogators and a surveillance processor providing an azimuth accuracy of at least 1 milliradian (0.057°) remote monitoring subsystem (RMS) and an update interval of not more than 1.0 second.

Localizer/Azimuth Offset. An angular offset of the localizer/azimuth from the runway extended centreline in a direction away from the no transgression zone (NTZ) that increases the normal operating zone (NOZ) width.

Monitor Zone. The monitor zone is the volume of airspace within which the final monitor controllers are monitoring close parallel approaches and PRM system automated alerts are active.

No Transgression Zone (NTZ). The NTZ is a 2,000-foot wide zone, located equidistant between parallel runway final approach courses in which flight is not allowed (see Figure A3-1).

Normal Operating Zone (NOZ). The NOZ is the operating zone within which aircraft flight remains during normal independent simultaneous parallel approaches (see Figure A3-1.)

Precision Runway Monitor (PRM). A specialized ATC radar system providing continuous surveillance throughout the monitoring control zone. It includes a high accuracy, high update rate sensor system, and for each runway, a high-resolution colour FMA with automated alerts. The PRM system provides each monitor controller with a clear, precise presentation of aircraft conducting approaches.

3.0 General

Criteria contained in this appendix are designed for independent simultaneous precision ILS or MLS operations to dual parallel runways with centrelines separated by at least 3,000 feet, but less than 4,300 feet. Simultaneous close parallel operations at airport elevations above 1,000 feet MSL and deviations from these criteria or glidepath angles above the U.S. civil standard of 3.0° shall not be established without approval from the Flight Standards Service, FAA, Washington, DC. When runway spacing is less than 3,400 feet, but not less than 3,000 feet, the localizers/azimuth stations in the close runway pair must be aligned at least 2-1/2° divergent from each other, but not more than 3.0°, and an electronically scanned (E-Scan) radar with an update interval of 1.0 second must be employed. All close parallel ILS/MLS operations require final approach radar monitoring, accurate to within 1.0 milliradian, an update interval of 1.0 second, and a final monitor aid (a high resolution display with automated blunder alerts). In these criteria, ILS “glide slope/localizer” terms are synonymous to and may be used interchangeably with MLS “elevation/azimuth” terms. Independent simultaneous close parallel approaches without altitude separation should not be authorized at distances greater than 10 NM from threshold. If Air Traffic Control (ATC) systems and procedures are established which assure minimal NTZ intrusions, this distance may be extended up to 12.5 NM. A separate instrument approach chart described as a special close parallel ILS/MLS procedure shall be published for each runway in the close parallel pair of runways. This special close parallel ILS/MLS procedure is to be identified in accordance with Para 3.1. A standard ILS/MLS procedure may also exist or be published for each of the runways. During close parallel ILS/MLS operations, the close parallel ILS/MLS may overlay the existing standard ILS/MLS procedure, provided that spacing localizer/azimuth alignment is less than 3,400 feet and the missed approaches diverge. A breakout obstacle assessment specified in TP308/GPH209 Volume 3, appendix 4, Obstacle Assessment Surface Evaluation for Simultaneous Parallel Precision Operations, shall be completed as part of the initial evaluation for parallel operations.

3.1 System Components

Simultaneous close parallel approach procedures are not authorized if any component of the PRM system is inoperative. System requirements for simultaneous close parallel approach procedures are:

3.1.1 ILS/MLS

There must be a full ILS or MLS on each runway.

3.1.2 PRM

A PRM system includes the following:

a. Radar. Phased array electronically scanned (E-Scan) antenna; update intervals of 1.0 second.

b. Final Monitor Aid (FMA). Large (not less than 20” x 20”), high resolution (100 pixels/inch minimum), colour monitors with associated visual and audible alerts.

   (1) Caution Alert. A caution alert when the system predicts that an aircraft will enter the NTZ within 10 seconds (e.g., the target symbol and data block change from green to yellow and a voice alert sounds).

   (2) Warning Alert. A warning alert when the aircraft has penetrated the NTZ (e.g., the target symbol and data block change to red).

(3) A Surveillance Alert. A surveillance alert when the track for a monitored aircraft inside the monitor zone has been in a coast state for more than three consecutive updates (e.g., the target symbol and data block change to red).

3.2 Procedure Charting

Volume 1, Para 161, applies, except where a separate procedure is published. In this case, “ILS/MLS PRM” should precede the approach title identification; e.g., “ILS PRM, RWY 27R” (simultaneous close parallel). Notes for approach charts for use in the close parallel operation shall be published in bold and caps as follows: “SIMULTANEOUS CLOSE PARALLEL APPROACHES AUTHORIZED WITH RUNWAYS (NUMBER) L/R” and “LOCALIZER ONLY NOT AUTHORIZED DURING CLOSE-PARALLEL OPERATIONS.” The following shall also be noted: “DUAL VHF COMM REQUIRED,” “MONITOR PRM CONTROLLER (FREQ) ON RWY ( ) L, (FREQ) ON RWY ( ) R,” and “SEE ADDITIONAL REQUIREMENTS ON ADJACENT INFORMATION PAGE.”

4.0 Feeder Routes And Initial Approach Segment

TP308/GPH209 Volume 3, chapter 2, Para 2.3 applies, except as stated in this order. The initial approach shall be made from a NAVAID, fix, or radar vector. Procedure turns and high altitude penetration procedures shall not be authorized.

4.1 Altitude Selection

Altitudes selected shall provide obstacle clearance requirements and a minimum of 1,000 feet vertical separation between aircraft on the two parallel final approach courses in the interval from localizer intercept to glide slope capture.

4.2 Localizer Intercept Point

Apply chapter 2 of this Volume, except optimum localizer intercept angles are 20° or less and the maximum intercept angle shall not exceed 30°.

4.3 NTZ

An NTZ is established and depicted on the FMA as a protected zone 2,000 feet wide, equidistant between parallel runway centrelines, beginning from the point where adjacent inbound aircraft first lose 1,000 feet of vertical separation, and extends to 0.5 NM beyond the farthest departure end of runway (DER), or the point where a combined 45° divergence occurs, whichever is farthest. The beginning of the NTZ for the final segment should begin at the most distant PFAF (see Figure A3-1). Where an offset localizer is determined to provide operational advantage, the NTZ shall be established for the final segment equidistant between adjacent final approach courses beginning and ending as stated above.

4.4 NOZ

An NOZ is established so that the NOZ for each close parallel runway is not less than 700 feet wide on each side of the approach course at any point. The width of the NOZ is equal on each side of the final approach course centreline, and the half-width is defined by the distance from the nearest edge of the NTZ to the final approach course centreline. The length of the NOZ equals the length of the NTZ. Each parallel runway provides an NOZ for the final and missed approach segments that equal the length of the NTZ (see Figure A3-1).

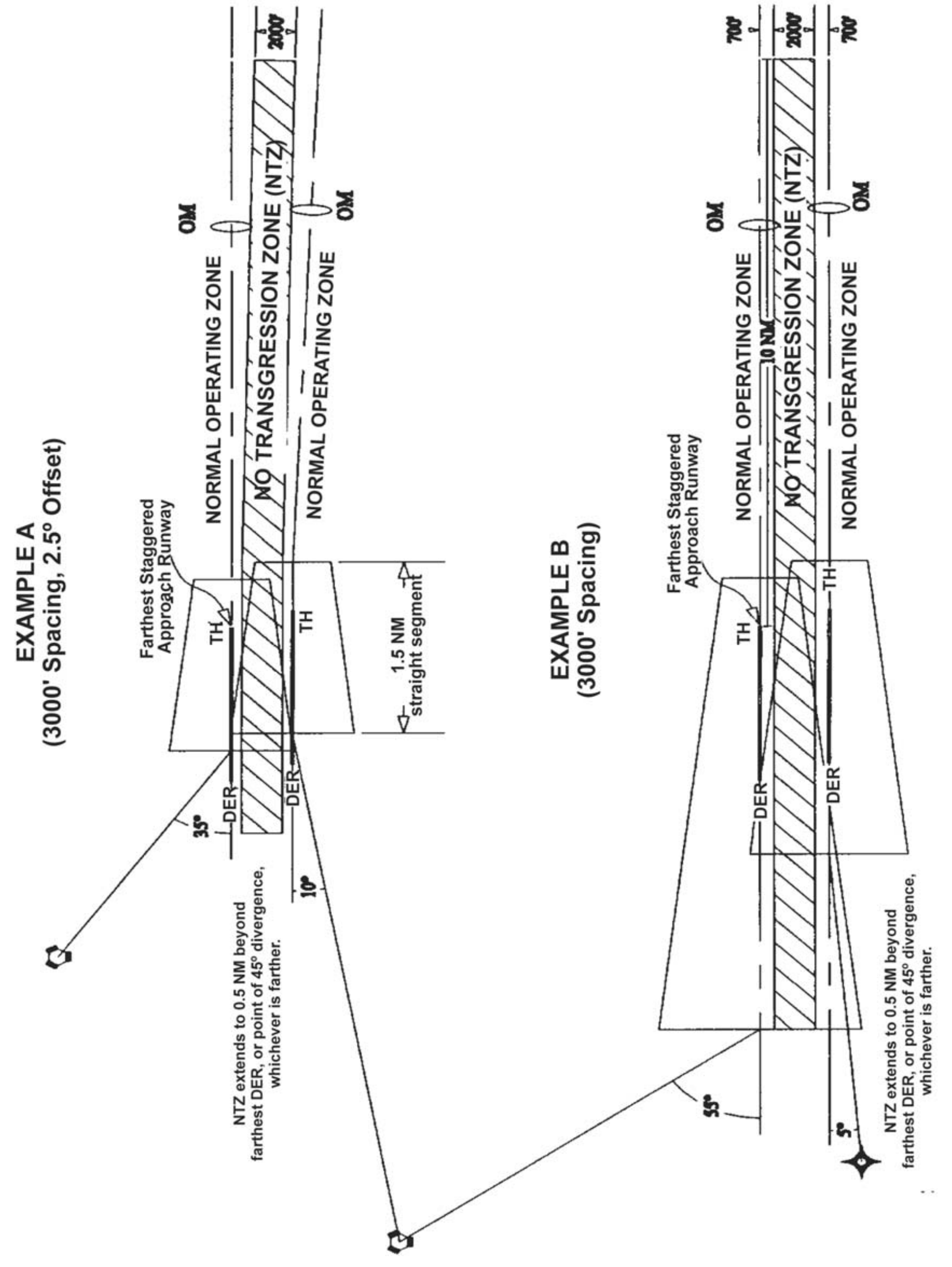


Figure A3-1: Examples Of Close Parallel Finals And Missed Approach Segments, Runway Spacing 3,000’ And 3,400’, Appendix 3. Para 4.2 and 4.4.

Figure A3-1: Examples Of Close Parallel Finals And Missed Approach Segments, Runway Spacing 3,000’ And 3,400’, Appendix 3. Para 4.2 and 4.4.

5.0 Intermediate Approach Segment

Chapter 2, Para 2.3, of this Volume applies, except where close parallel procedures have a straight intermediate segment aligned with the final approach course. Where an existing ILS/MLS procedure is published with a transition intercept angle greater than 30° which cannot be reduced, a separate close parallel procedure shall be established with intercept angles of less than 30°.

6.0 Final Approach Segment

Volume 3, Chap 3 applies. In addition to these criteria, independent simultaneous approaches to close parallels runways require the following:

6.1 Close Parallel Approach Runway Separation

Approaches shall have a minimum of 3,400-foot separation between the parallel final approach courses.

6.2 PRM

A PRM system must be in operation and providing service in accordance with Para 3.1.2.

6.3 NTZ

An appropriate NTZ shall be established between close parallel final approach courses as described in Para 4.3 (see Figure A3-1).

6.4 NOZ

Appropriate NOZ’s shall be established for each parallel final approach segment as described in Para 4.4 (see Figure A3-1).

6.5 Staggered Runway Thresholds

Where thresholds are staggered, the glide slope intercept point from the most distant runway approach threshold should not be more than 10 NM. It is recommended that the approach with the higher intercept altitude be the runway having the most distant approach threshold from the point of view of an aircraft on approach.

6.6 Localizer/ Azimuth Offset

Where an offset localizer is utilized, apply chapter 3 of this Volume. Where approach thresholds are staggered, the offset localizer course should be to the runway having the nearest approach threshold (from the point of view of an aircraft on approach). An offset requires a 50-foot increase in decision height (DH) and is not authorized for Category II and III approaches. (Autopilots with autoland are programmed for localizers to be on runway centreline only.) The NTZ shall be established equidistant between final approach courses.

6.7 Monitor Zone

This zone is a radar-monitored volume of airspace within which the PRM system automated alerts are active. The extent of the monitor zone is as described in the following three subsections.

6.7.1 Monitor Zone Length

The PRM monitor zone begins where aircraft conducting simultaneous parallel approaches reach less than 1,000-foot vertical separation during final approach (typically at glide slope intercept for the higher altitude localizer intercept) and extends to 0.5 NM beyond the farthest DER, or the point where a 45° divergence occurs, whichever generates the greatest length for the monitor zone.

6.7.2 Monitor Zone Width

The PRM monitor zone (automated alerts) includes all of the area between the final approach courses and extends 0.5 NM outboard of each final approach course centreline.

6.7.3 Monitor Zone Height

The PRM monitor zone height may be defined in as many as five separate segments, each having an independent maximum height. Each segment covers the entire monitor zone width, and a portion of the monitor zone length. Within each segment, the monitor zone height extends from 50 feet above ground level to a minimum of 1,000 feet above the highest point within that segment of the glide slope, the runway surface, or the missed approach course, whichever attains the highest altitude.

7.0 Minimums

For close parallel procedures, only straight-in precision minimums apply.

8.0 Missed Approach Segment

Volume 3 chapter 3 applies, except as stated in this appendix. Missed approach procedures for close parallels shall specify a turn as soon as possible after reaching a minimum of 400 feet above the touchdown zone, and diverge at a minimum of 45°. The turn points specified for the two parallel procedures should be established at the end of the straight segment minimum of 1.5 NM. A 45° divergence shall be established by 0.5 NM past the most distant DER. Where an offset localizer is used, the first missed approach turn point shall be established so that the applicable flight track radius (table 5 in Volume 1, chapter 2), constructed in accordance with Volume 1, chapter 2, Section 7, for the fastest category aircraft expected to utilize the offset course, shall not be less than 700 feet from the NTZ.

8.1 NTZ

The NTZ shall be continued into the missed approach segment, as defined in Para 4.3 of this appendix (see Figure A3-1).

8.2 NOZ

The NOZ shall be continued into the missed approach segment, as defined in Para 4.4 of this appendix (see Figure A3-1).

APPENDIX 4. OBSTACLE ASSESSMENT SURFACE EVALUATION FOR SIMULTANEOUS PARALLEL PRECISION OPERATIONS

1.0 Background

One of the major aviation issues is the steady increase in the number and duration of flight delays. Airports have not been able to expand to keep pace with traffic growth. The federal aviation administration (FAA) has taken a variety of measures to increase airport capacity. These include revisions to air traffic control procedures; addition of landing systems, taxiways and runways; and application of new technology. The precision radar monitor (PRM) program is one of these new initiatives. PRM is an advanced radar monitoring system intended to increase the use of multiple, closely-spaced parallel runways in instrument meteorological conditions (IMC) weather by use of high resolution displays with alert algorithms and higher aircraft position update rate. Monitor controllers are required for both standard and closely spaced runway separations. The primary purpose of radar monitoring during simultaneous, independent approach operations is to ensure safe separation of aircraft on the parallel approach courses. This separation may be compromised if an aircraft blunders off course toward an aircraft on the adjacent approach. For close parallel operations (3,400 feet but less than 4,300 feet) and for standard parallel operations (4,300 feet and above), the radar monitoring allows controllers to direct either aircraft off the approach course to avoid a possible collision. Resolution of a blunder is a sequence of events: the monitor alerts and displays the blunder, the controllers intervene, and the pilots comply with controller instructions; thus, increasing the operational safety, flyability, and airport capacity.

2.0 Definitions

Course Width (CW). The angular course deviation required to produce a full scale (±) course deviation indication of the airborne navigation instrument. This width is normally tailored to a parameter of not greater than ±3°. For precision runways longer than 4,000 feet, a linear sector width parameter of ±350 feet each side of centreline at RWT applies. Few category i localizers operate with a course sector width less than 3° (±1½°). Tailored width may be determined by the formula:

$$W = \mathrm{ArcTan}\left(\frac{350}{D}\right) \quad \text{Total Course Width at RWT} = 2 \times W$$

Where W = the half width in degrees at RWT

D = the distance in feet from the localizer antenna to RWT

Parallel Approach Obstruction Assessment (PAOA). An examination of obstruction identification surfaces, in addition to the ILS TP308/GPH209 surfaces in the direction away from the NTZ and adjacent parallel ILS runway, into which an aircraft on an early ILS breakout could fly.

Parallel Approach Obstruction Assessment Surfaces (PAOAs). PAOA assessment surfaces for identifying obstacles that may impact simultaneous precision operations.

Parallel Approach Obstruction Assessment Surface Penetration. One or more obstructions that penetrate the PAOAs.

Parallel Approach Obstruction Assessment Controlling Obstruction (PAOACO). The obstruction within the boundaries of the PAOAs, which constitutes the maximum penetration of that surface.

No Transgression Zone (NTZ). See TP308/GPH209 Volume 3, appendix 3, Para 4.3.

Normal Operational Zone (NOZ). See TP308/GPH209 Volume 3, appendix 3, Para 4.4.

3.0 General

This order characterizes criteria used during the interim test phase of evaluating close parallel operations where early turnout obstacle assessments were accomplished by contractual means using terrestrial photometric techniques combined with survey methods of surface evaluation. This assessment technique is recommended for future evaluations of all independent simultaneous parallel approach operations. Facility information (glidepath angle (GPA), threshold crossing heights (TCH), touchdown zone elevation (TDZE), threshold elevations, etc.) may be obtained from air traffic planning and automation, flight procedures offices, and/or the systems management organizations for the regions in which independent simultaneous parallel operations are planned.

3.1 Parallel Runway Simultaneous ILS Approaches

The procedures for airports with multiple parallel runways must ensure that an aircraft approach on one runway is safely separated from those approaching the adjacent parallel runway. An example of such procedures is depicted in Figure A4-1. Aircraft are directed to the two intermediate segments at altitudes, which differ, by at least 1,000 feet. Vertical separation is required when lateral separation becomes less than 3 NM, as aircraft fly to intercept and stabilize on their respective localizers (LOC). This 1,000-foot vertical separation is maintained until aircraft begin descent on the glidepath.

3.1.1 Lateral RADAR Separation Is Less Than The 3nm and The 1,000 foot Altitude Buffer Is Lost

When lateral radar separation is less than the 3 NM and the 1,000-foot altitude buffer is lost, the aircraft must be monitored on radar. The controllers, on separate and discrete frequencies, will observe the parallel approaches, and if an aircraft blunders from the NOZ into a 2,000-foot NTZ, the monitor controller can intervene so that threatened aircraft on the adjacent approach are turned away in time to prevent a possible encounter. This manoeuvre, on the part of the threatened aircraft, is termed a "breakout" because the aircraft is directed out of the approach stream to avoid the transgressor aircraft. A controller for each runway is necessary so that one can turn the transgressing aircraft back to its course centreline while the other directs the breakout (see Figure A4-1).

3.1.2 Flanking The 2000-Foot NTZ By Two Equal Normal Operational Zones

The 2,000-foot NTZ, flanked by two equal NOZs, provides strong guidance to the monitor controller and manoeuvring room for the aircraft to recover before entering the adjoining NOZ. Aircraft are required to operate on or near the approach course within the limits of the NOZ. If an aircraft strays into the NTZ or turns to a heading that will take it into the NTZ, it is deemed a threat to an aircraft on the adjacent course and appropriate corrective action or breakout instructions are issued (see Figure A4-2).

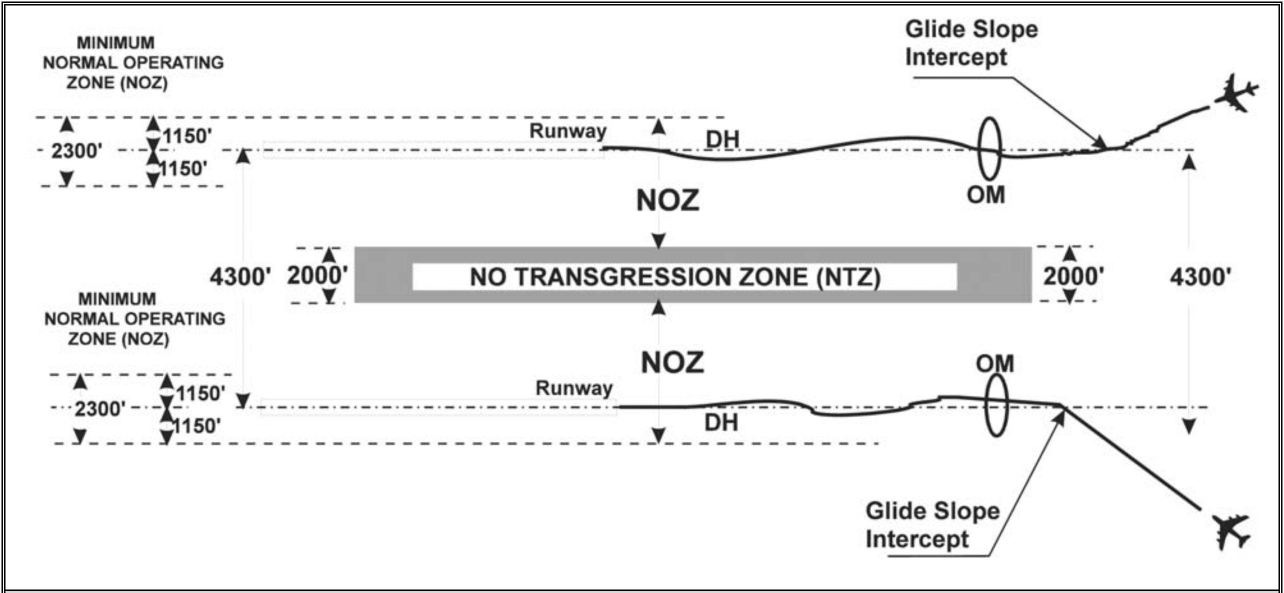


Figure A4-1: Simultaneous Precision Parallel Runway Approach Zones. Appendix 4, Para 3.1.

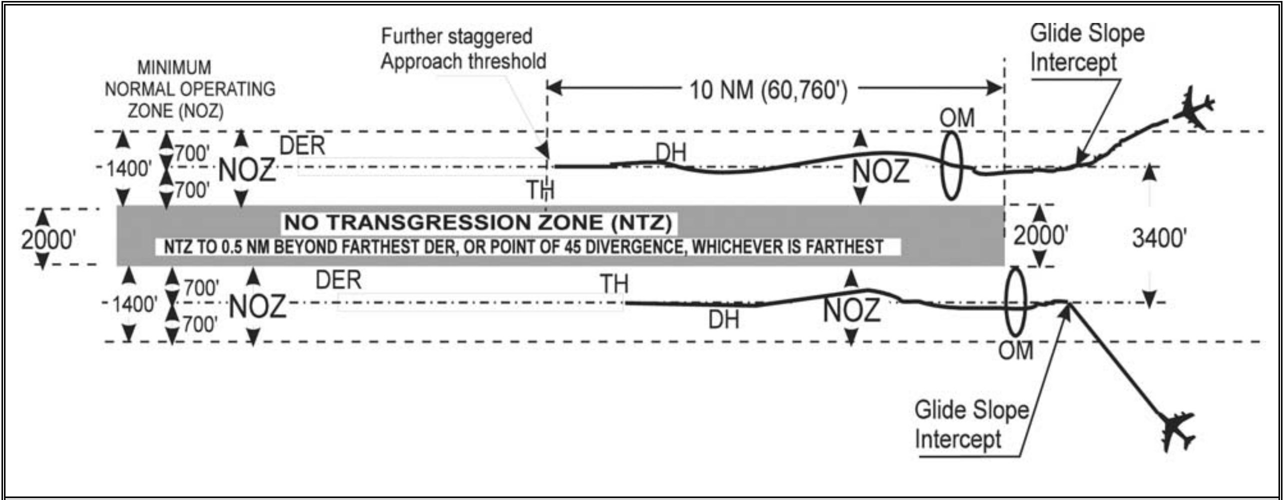


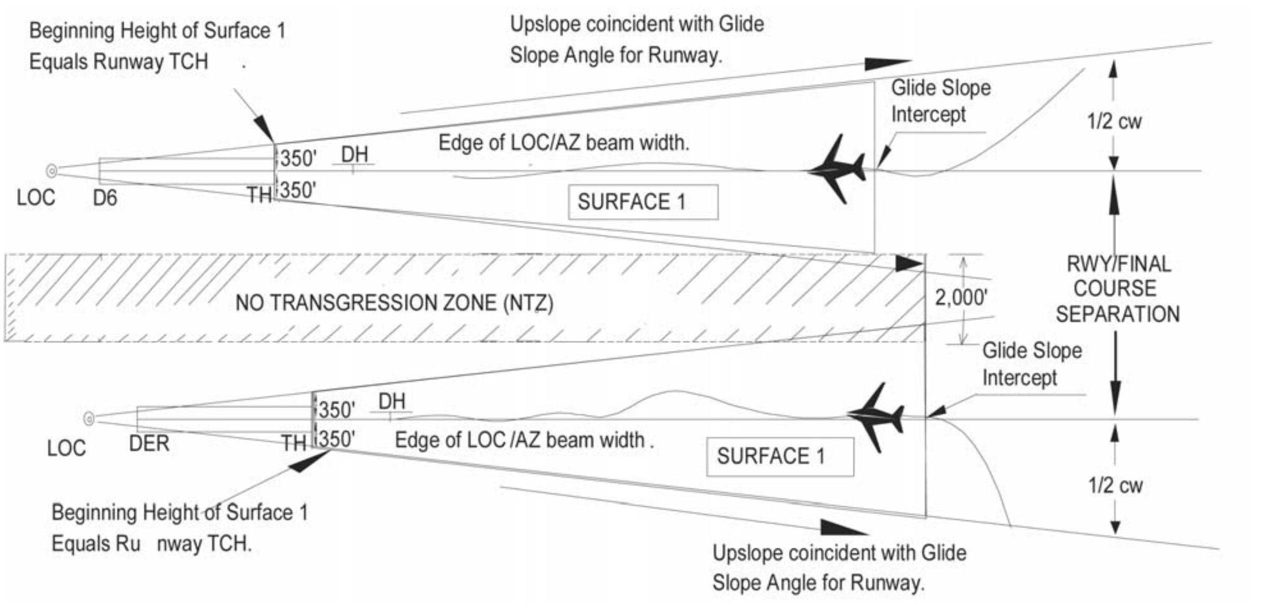
Figure A4-2: Simultaneous ILS No Transgression Zone And Normal Operating Zone. Appendix 4, Paras 3.1.2 and 4.1.2

4.0 PAOA Evaluation

The PAOA evaluation shall be conducted to identify penetrating obstacles as part of a coordinated assessment for all independent simultaneous approach operations to parallel ILS/MLS runways. In these criteria, ILS glidepath/localizer terms are synonymous to and may be used interchangeably with MLS elevation glidepath/azimuth (GP/AZ) terms. The surface dimensions for the obstacle assessment evaluation are defined as follows:

4.1 Surface 1

A final approach course descent surface which is coincident with the glide slope/glidepath (GS/GP) beginning at runway threshold with the width point abeam the threshold 350 feet from runway centreline opposite the NTZ, with lateral boundaries at the outer edge of the LOC/AZ CW, and ending at the farthest GS/GP intercept (see Figure A4-3).



1/2 CW = Perpendicular distance from runway/extended C_L to edge of course beam width.

1/2 CW = Distance from Threshold in feet along C_L X TAN (1/2 Course Beam Angle) + 350'.

OR

1/2 CW = Distance from LOC/AZ Antenna in feet along C_L X TAN ($\frac{\text{LOC/AZ Beam Angle}}{2}$).

Surface 1 Height - Distance from TH in feet along CL X TAN of the GS/GP angle + TCH.

Figure A4-3: Final Descent Surface 1. Appendix 4, Paras 4.1 and 4.5

4.1.1 Length

Surface 1 begins over the runway threshold at a height equal to the TCH for the runway, and continues outward and upward at a slope that is coincident with the GS/GP, to its ending at the GS/GP intercept point.

4.1.2 Width

Surface 1 has a width equal to the lateral dimensions of the LOC/AZ course width. The surface 1 half-width (see Figure A4-2) is calculated using the following formula:

$$\frac{1}{2}\ W = A \times \tan\left(\frac{B}{2}\right) + 350$$

Where W = the width of surface 1 in feet
A = the distance from RWT measured parallel to course in feet
B = the course width beam angle in feet

OR

$$\frac{1}{2}\ W = L \times \tan\left(\frac{B}{2}\right)$$

Where W = the width of surface 1 in feet
L = the distance in feet from azimuth antenna in feet
B = the course width beam angle in feet

4.1.3 Height

Surface height at any given centreline distance (d), may be determined in respect to threshold elevation, by adding the TCH to the product of centreline distance in feet from threshold times the tangent of the GS/GP angle.

$$h1 = \left(d \times \tan(\mathrm{GPA})\right) + \mathrm{TCH}$$

Where h1 = the surface 1 height above ASBL in feet

4.2 Surface 2

4.2.1 Length

Same as Para 4.1.1.

4.2.2 Width And Height

Surface 2 shares a common boundary with the outer edge of surface 1 on the side opposite the NTZ, and slopes upward and outward from the edge of the descent surface 1 at a slope of 11:1, measured perpendicular to the LOC/AZ extended course centreline. Further application is not required when the 11:1 surface reaches a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest (see Figure A4-4).

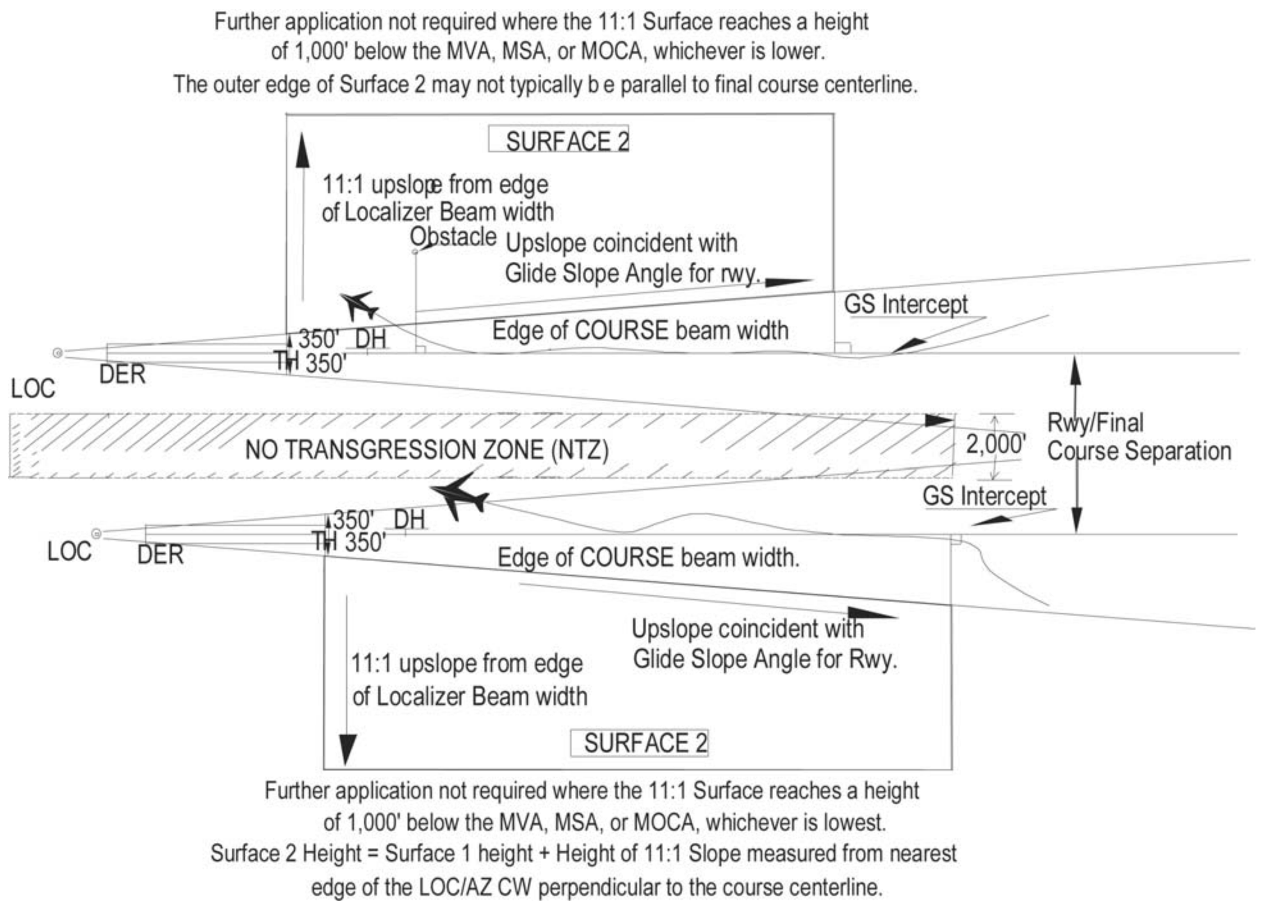


Figure A4-4: Parallel Approach Obstacle Assessment Surface 2. Appendix 4, Para 4.2.2 and 4.5

4.3 Surface 3 (Category I)

4.3.1 Length

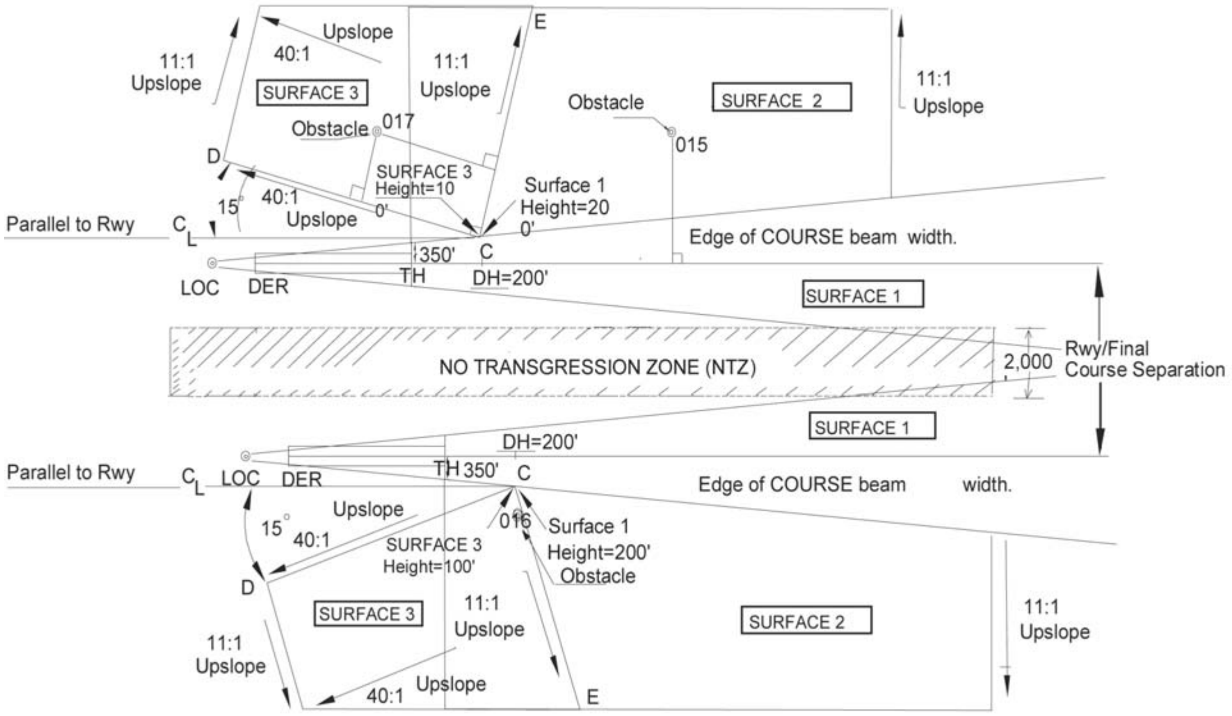
For category I operations, surface 3 begins at the point where surface 1 reaches a height of 200 feet above the TDZE and extends to the point the 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest.

4.3.2 Width

From the beginning point, the edge of surface 3 area splays at a 15° angle from a line parallel to the runway centreline.

4.3.3 Height

Surface 3 begins at a height of 100 feet above TDZE (100 feet lower than surface 1). The surface rises longitudinally at a 40:1 slope along the 15° splay line CD while continuing laterally outward and upward at an 11:1 slope (line CE is perpendicular to the 15° splay line CD). Further application is not required when the 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest (see Figure A4-5).



The outer edges of Surfaces 2 or 3 may not typically be parallel to each other or runway C_L. Further application not required when the 40:1 and 11:1 surfaces reach a height of 1,000' below MVA, MSA or MOCA, whichever is lower.

Further application not required when the 40:1 and 11:1 surfaces reach a height of 1,000' below MVA, MSA, or MOCA, whichever is lower. Surface 3 Height = Height of 11:1 Slope measured (fr. 0bs.) perpendicular to Line CD + Height of 40:1 Slope measured (fr. 0bs.) perpendicular to Line CE + 100 feet.

Figure A4-5: CAT 1 Missed Approach Early Breakout Parallel Approach Obstacle Assessment Surface 3. Appendix 4, Para 4.3.3 and 4.5

4.4 Surface 4 (Category II)

4.4.1 Length

Surface 4 begins at the point where surface 1 reaches a height of 100 feet above the runway TDZE and extends to the point 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest.

4.4.2 Width

From the point of beginning, the edge of surface 4 area splays at a 15° angle from a line parallel to the runway centreline.

4.4.3 Height

Surface 4 begins at the point where surface 1 reaches a height of 100 feet above the runway TDZE and rises longitudinally at a 40:1 slope along the 15° splay line CD, while continuing laterally outward and upward at an 11:1 slope (line CE is perpendicular to the 15° splay line

CD). Further application is not required when the 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest (see Figure A4-6).

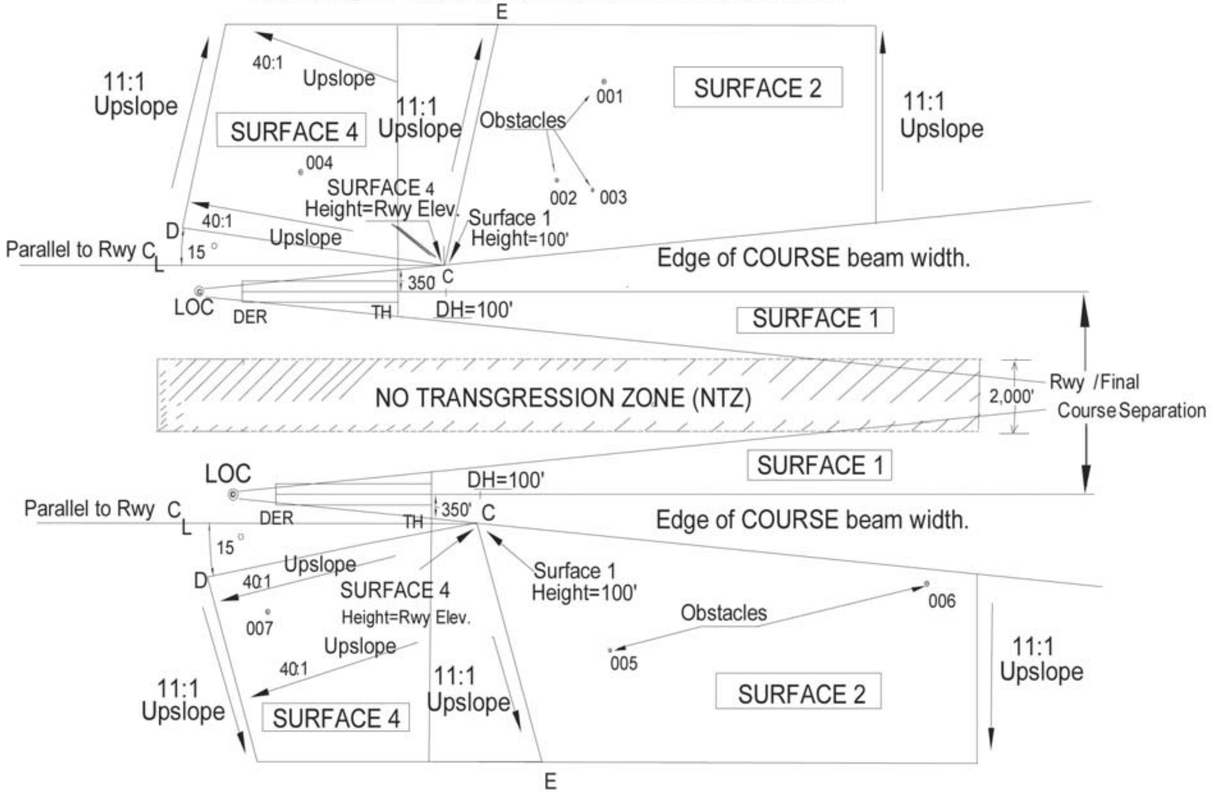
4.5 Latitude-Longitude List

Establish a latitude-longitude list for all obstacles penetrating the PAOA surfaces 2, 3, and 4. Identify locations of surface penetration within the surface areas (see Figures A4-3, A4-4, and A4-5).

4.6 Parallel Operations Application Requirements

PAOA obstacle penetrations shall be identified and, through coordinated actions of those affected, considered for electronic mapping on controller radar displays. If possible, penetrations should be removed by facilities considering independent simultaneous approach operations to parallel precision runways. Where obstacle removal is not feasible, air traffic operational rules shall be established to avoid obstacles. If a significant number of penetrations occur, a risk assessment study shall be required to provide guidance as to whether independent simultaneous ILS/MLS operations to parallel runways should be approved or denied.

The outer edges of Surface 2 or 4 may not typically be parallel to each other or runw ay C_L.
Further application not required when the 40:1 and 11:1 surfaces
reach a height of 1,000' below MVA, MSA, or MOCA, whichever is lower



Further application not required when the 40:1 and 11:1 surfaces reach a height of 1,000' below MVA, MSA, or MOCA, wh ichever is lower. Surface 4 Height = Height of 11:1 Slope measured (fr. Obs.) perpendicular to Line CD + Height of 40:1 Slope measured (fr. Obs.) perpendicular to Line CE.

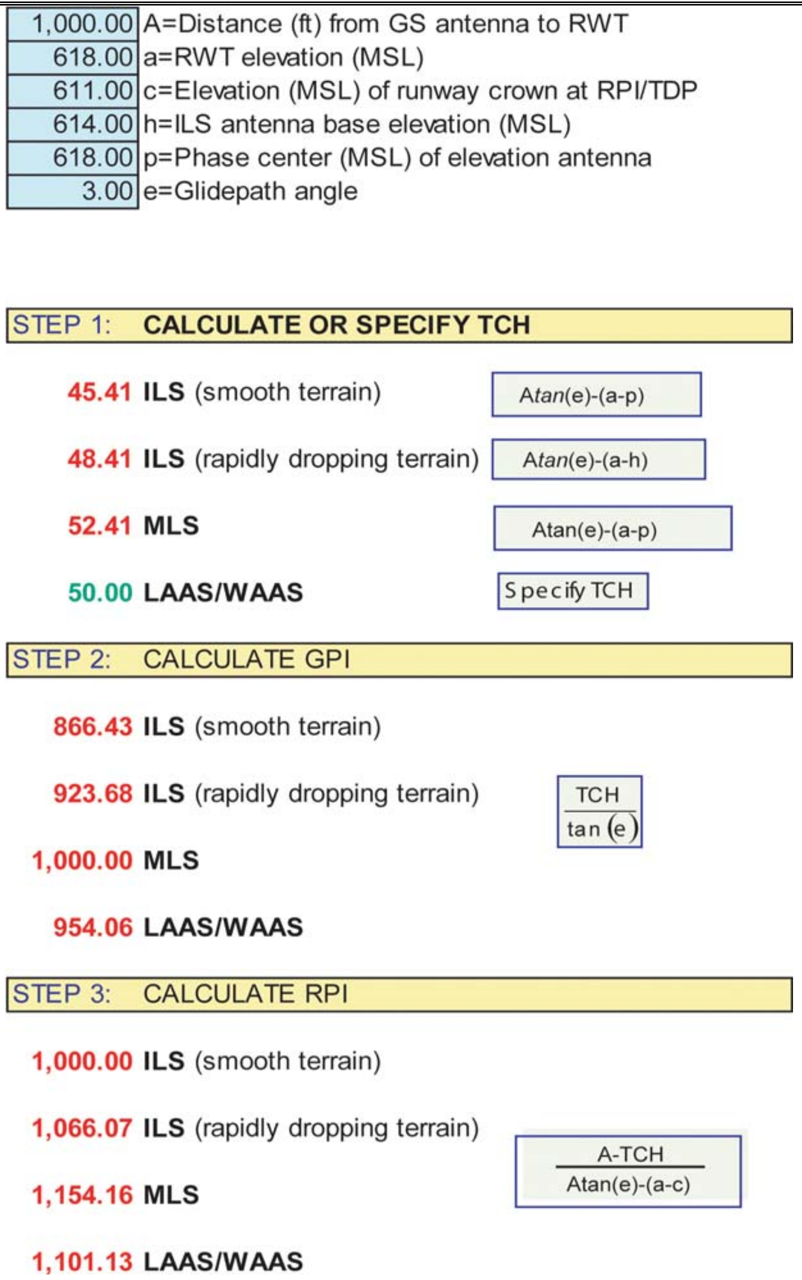
Figure A4-6 CAT II Missed Approach Early Breakout Parallel Approach Obstacle Assessment Surface 4. Appendix 4, Para 4.4.3

APPENDIX 5. THRESHOLD CROSSING HEIGHT (TCH), GROUND POINT OF INTERCEPT (GPI), AND RUNWAY POINT OF INTERCEPT (RPI) CALCULATION

1.0 General

The images in this appendix present examples of the calculation worksheets. These spreadsheets may be used to calculate the applicable values, by filling in the appropriate variables in the blue area of each sheet. The spreadsheets can be found on the Internet on the Transport Canada website.

1.1 Non-RADAR Precision TCH/GPI/RPI Worksheet



1,000.00	A=Distance (ft) from GS antenna to RWT
618.00	a=RWT elevation (MSL)
611.00	c=Elevation (MSL) of runway crown at RPI/TDP
614.00	h=ILS antenna base elevation (MSL)
618.00	p=Phase center (MSL) of elevation antenna
3.00	e=Glidepath angle

STEP 1: **CALCULATE OR SPECIFY TCH**

45.41	**ILS** (smooth terrain)	Atan(e)-(a-p)
48.41	**ILS** (rapidly dropping terrain)	Atan(e)-(a-h)
52.41	**MLS**	Atan(e)-(a-p)
50.00	**LAAS/WAAS**	Specify TCH

STEP 2: CALCULATE GPI

866.43	**ILS** (smooth terrain)
923.68	**ILS** (rapidly dropping terrain)
1,000.00	**MLS**
954.06	**LAAS/WAAS**

$$\frac{TCH}{\tan(e)}$$

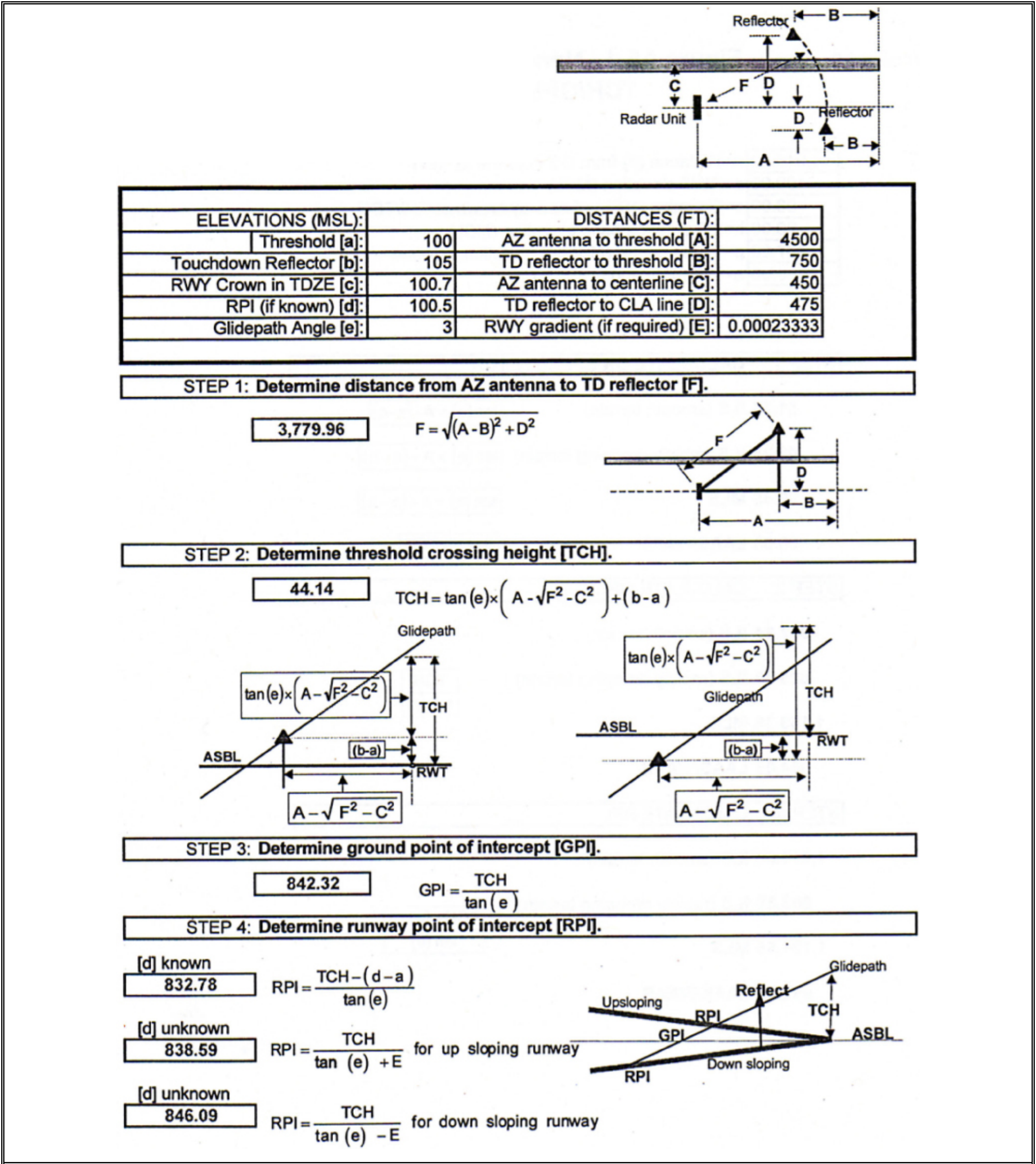
STEP 3: CALCULATE RPI

1,000.00	**ILS** (smooth terrain)
1,066.07	**ILS** (rapidly dropping terrain)
1,154.16	**MLS**
1,101.13	**LAAS/WAAS**

$$\frac{A-TCH}{Atan(e)-(a-c)}$$

Figure A5-1: Non RADAR Precision TCH/GPI/RPI Worksheet

1.2 Precision Approach RADAR (PAR) (Scanning RADAR) Worksheet



ELEVATIONS (MSL):		DISTANCES (FT):	
Threshold [a]:	100	AZ antenna to threshold [A]:	4500
Touchdown Reflector [b]:	105	TD reflector to threshold [B]:	750
RWY Crown in TDZE [c]:	100.7	AZ antenna to centerline [C]:	450
RPI (if known) [d]:	100.5	TD reflector to CLA line [D]:	475
Glidepath Angle [e]:	3	RWY gradient (if required) [E]:	0.00023333

STEP 1: Determine distance from AZ antenna to TD reflector [F].

3,779.96

$$F=\sqrt{(A-B)^2+D^2}$$

STEP 2: Determine threshold crossing height [TCH].

44.14

$$TCH=\tan(e)\times\left(A-\sqrt{F^2-C^2}\right)+(b-a)$$

STEP 3: Determine ground point of intercept [GPI].

842.32

$$GPI=\frac{TCH}{\tan(e)}$$

STEP 4: Determine runway point of intercept [RPI].

[d] known

832.78

$$RPI=\frac{TCH-(d-a)}{\tan(e)}$$

[d] unknown

838.59

$$RPI=\frac{TCH}{\tan(e)+E}$$ for up sloping runway

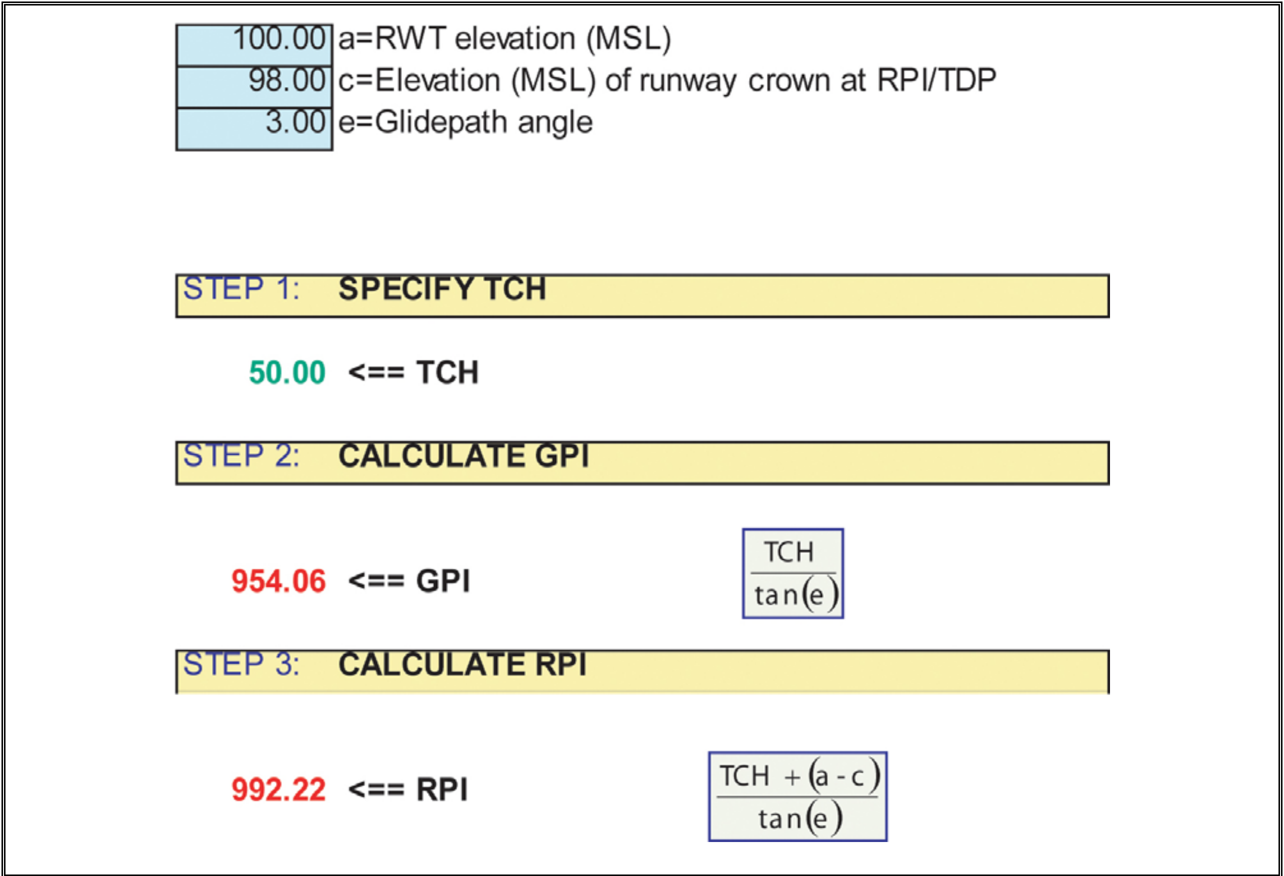
[d] unknown

846.09

$$RPI=\frac{TCH}{\tan(e)-E}$$ for down sloping runway

Figure A5-2: Precision Approach RADAR (PAR) (Scanning RADAR) Worksheet

1.3 Precision RADAR TCH/GPI/RPI Worksheet



100.00	a=RWT elevation (MSL)
98.00	c=Elevation (MSL) of runway crown at RPI/TDP
3.00	e=Glidepath angle

STEP 1: **SPECIFY TCH**

50.00 **<== TCH**

STEP 2: **CALCULATE GPI**

954.06 **<== GPI**

$$\frac{TCH}{\tan(e)}$$

STEP 3: **CALCULATE RPI**

992.22 **<== RPI**

$$\frac{TCH + (a - c)}{\tan(e)}$$

Figure A5-3: Precision RADAR Worksheet

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CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

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CHAPTER 1. HELICOPTER PROCEDURES

SECTION 1. ADMINISTRATION

100. General

This chapter contains criteria for application to “helicopter only” procedures. These criteria are based on the premise that helicopters are approach Category A aircraft with special manoeuvring characteristics. The intent, therefore, is to provide a relief from those portions of other chapters that are more restrictive than the criteria specified herein. However, any criteria contained elsewhere in other chapters of this document may be applied to helicopter only procedures when an operational advantage may be gained.

a. Identification of Inapplicable Criteria. Criteria contained elsewhere in TP308 applies to helicopter procedures, except as detailed in this chapter. Circling approach and high altitude penetration criteria do not apply to helicopter procedures.

b. Use of Existing Facilities. Helicopter-only procedures based on existing facilities may be developed using criteria contained in this chapter.

101. Terminology And Abbreviations

The following terms are peculiar to helicopter procedures and are defined as follows:

HAL. Height above landing area elevation.

Height Above the Surface (HAS). The height of the MDA above the highest terrain/surface within a 5,200-foot radius of the MAP in Point in Space procedures.

Landing Area. As used in helicopter operations, refers to the portion of the heliport or airport runway used, or intended to be used for the landing and take-off of helicopters.

Landing Area Boundary (LAB). The beginning of the landing area of the heliport or runway.

Point in Space Approach (PINSA). An instrument approach procedure to a point in space, identified as a Missed Approach Point, which is not associated with a specific landing area within 2,600 feet of the MAP.

Touchdown Zone (TZ). As used in helicopter procedures, is identical to the landing area.

Touchdown Zone Elevation (TDZE). As used in helicopter procedures, is the highest elevation in the landing area.

102. RESERVED

103. Type Of Procedure

HELICOPTER ONLY PROCEDURES are designed to meet low altitude straight-in requirements ONLY.

104. Facilities For Which Criteria Are Not Provided

This chapter does not include criteria for procedures predicated on VHF/UHF DF, area navigation (RNAV), airborne radar approach (ARA) or microwave landing system (MLS). Procedures utilizing VHF/UHF DF may be developed in accordance with the appropriate chapters of this document. Criteria for RNAV, ARA, and MLS with high glide path angle or selectable glide path angle capability will be developed at a later date.

105. Procedure Identification

Identify helicopter-only procedures using the term “COPTER,” the type of facility or system providing final approach course guidance, and:

a. **For approaches to runways.** The abbreviation RWY, and the runway number; e.g., COPTER ILS or LOC RWY 17; COPTER RNAV (GPS) RWY 31.

b. **For approaches to heliports and a point-in-space.** The magnetic final approach course value and degree symbol; e.g., COPTER ILS or LOC 014°; COPTER TACAN O97°, COPTER RNAV (GPS) 010°.

c. **For approaches based on an ARC final.** The word ARC will be used, and will be followed by a sequential number; e.g., COPTER VOR/DME ARC 1.

d. **For separate procedures at the same location.** Use the same type of facility and same final approach course, add an alpha suffix starting in reverse alphabetical order; COPTER ILS or LOC Z RWY 28L (first procedure), COPTER ILS or LOC Y RWY 28L (second procedure), COPTER ILS or LOC X RWY 28L (third procedure), etc.

SECTION 2. APPLICATION

106. General Criteria

These criteria are based on the unique manoeuvring capability of the helicopter at airspeeds not exceeding 90 knots.

107. Point In Space Approach

Where the centre of the landing area is not within 2,600’ of the MAP, an approach procedure to a point in space may be developed using any of the facilities for which criteria are provided in this chapter. In such procedures the point in space and the missed approach point are identical and upon arrival at this point, helicopters must proceed under visual flight rules (or special VFR in control zone as applicable) to a landing area or conduct the specified missed approach procedure. The published procedure shall be noted to this effect and also should identify available landing areas in the vicinity by noting the course and distance from the MAP to each selected landing area. Point in space approach procedures will not contain alternate minima.

108. Approach Categories

When helicopters use instrument flight procedures designed for fixed wing aircraft, approach Category “A” approach minima shall apply.

109. Procedure Construction

Volume 1, Para 214, applies except for the reference to circling approach.

110. Descent Gradient

The descent gradient criteria specified in other chapters of this document do not apply. The OPTIMUM descent gradient in all segments of helicopter approach procedures is 400 feet per mile. Where a higher descent gradient is necessary, the recommended MAXIMUM is 600 feet per mile. However, where an operational requirement exists a gradient of as much as 800 feet per mile may be authorized provided the gradient used is depicted on approach charts. See special procedure turn criteria in Para 112.

111. Initial Approach Segments Based On Straight Courses And Arcs With Positive Course Guidance

Volume 1, Para 232, is changed as follows:

a. Alignment.

  (1) Courses. The two-mile lead radial specified in Para 232.a.(1) is reduced to 1 mile (see Figure 2–3).

  (2) Arcs. The MINIMUM arc radius specified in Para 232.a.(2) is reduced to 4 NM. The 2-mile lead radial may be reduced to 1 mile (see Figure 2–10).

112. Initial Approach Based On Procedure Turn

Volume 1, Para 234, applies except for all of subparagraph d. and the number 300 in subparagraph e.(1), which is changed to 600. Since helicopters operate at approach Category A speeds, the 5-mile procedure turn will normally be used (see Figure 1-105). However, the larger 10- and 15-mile areas may be used if considered necessary.

Figure 1-1 TO 1-104: Reserved

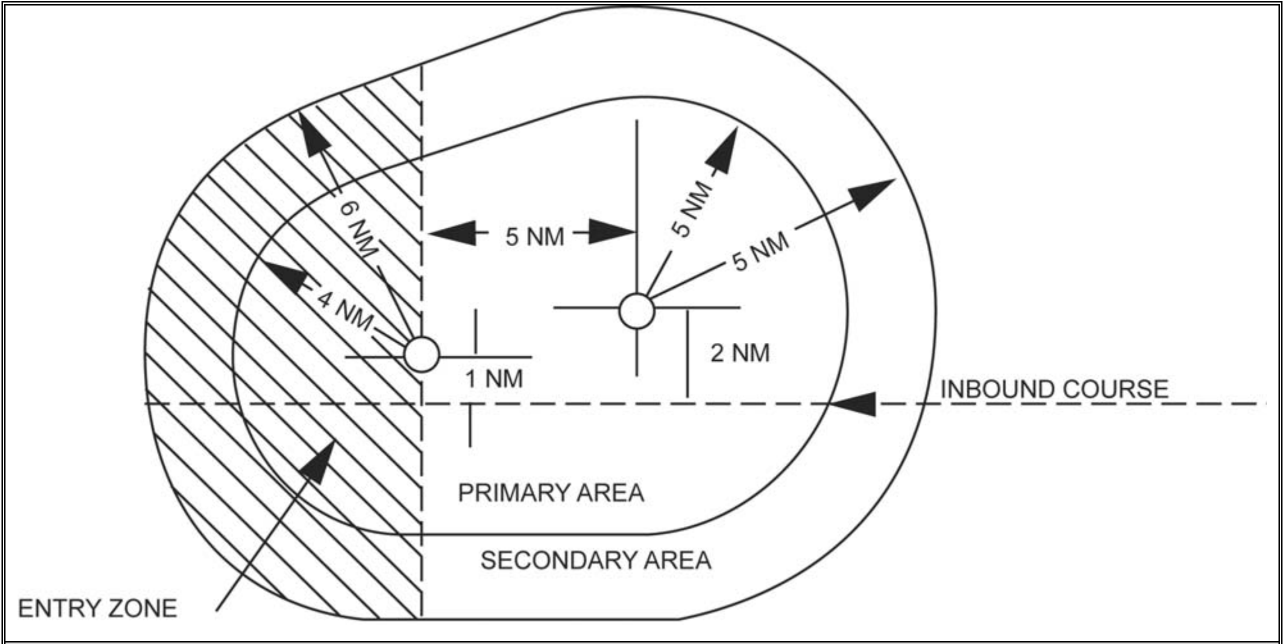


Figure 1-105: Helicopter Procedure Turn Area. Para 112.

Descent Gradient. Because the actual length of the track will vary with environmental conditions and pilot technique it is not practical to specify a descent gradient solely in feet per mile for the procedure turn. Instead the descent gradient is controlled by requiring the procedure turn completion altitude to be as close as possible to the final approach fix altitude. The difference between the procedure turn completion altitude and the altitude over the final approach fix shall not be greater than those shown in Table 1–23.

Table 1-1 TO 1-22: Reserved.

Type Procedure Turn	Altitude Difference
15 NM PT from FAF	Within 6,000 ft of alt over FAF
10 NM PT from FAF	Within 4,000 ft of alt over FAF
5 NM PT from FAF	Within 2,000 ft of alt over FAF
15 NM PT, no FAF	Not Authorized
10 NM PT, no FAF	Within 4,000 ft of MDA on Final
5 NM PT, no FAF	Within 2,000 ft of MDA on Final

Table 1-23: Procedure Turn Completion Altitude Differential. Para 112.

113. Intermediate Approach Segment Based On Straight Courses

Volume 1, Para 242, is changed as follows:

a. Alignment. The provisions of Volume 1, Para 242.a, apply with the exception that the intermediate course shall not differ from the final approach course by more than 60 degrees.

b. Area.

(1) Length. The OPTIMUM length of the intermediate approach segment is 2 NM. The MINIMUM length is 1 mile and the recommended MAXIMUM is 5 NM. A distance greater than 5 NM should not be used unless an operational requirement justifies the greater distance. When the angle at which the initial approach course joins the intermediate course exceeds 30 degrees (see Figure 2–3), the MINIMUM length of the intermediate course is as shown in Table 1–24.

Angle (Degrees)	Minimum Length (NM)
30	1.0
60	2.0
90	3.0
120	4.0

Note: This Table may be interpolated

Table 1-24: Minimum Intermediate Course Length (Not applicable to PAR or ILS). Para 113.

114. Intermediate Approach Segment Based On An Arc

Volume 1, Para 243, is changed as follows: Arcs with a radius of less than 4 NM or more than 30 mile from the navigation facility shall not be used.

a. Area.

(1) Length. The OPTIMUM length of the intermediate approach segment is 2 NM. The MINIMUM length is 1 mile and the recommended MAXIMUM is 5 NM. A distance greater than 5 NM should not be used unless an operational requirement justifies the greater distance. When the angle at which the initial approach course joins the intermediate course exceeds 30 degrees (see Figure 2–3), the MINIMUM length of the intermediate course is as shown in Table 1–24.

115. Intermediate Segment Within A Procedure Turn Segment

Volume 1, Para 244, is changed as follows: The normal procedure turn distance is 5 NM from the fix or from the facility. This produces an intermediate segment 5 NM long. The portion of the intermediate segment considered for obstacle clearance will always have the same length as the procedure turn distance. A distance greater than 5 NM should not be used unless an operational requirement justifies the greater distance (see Figure 2–13, Volume 1, Para 244).

116. Final Approach

Volume 1, Para 250, applies except that the word runway is understood to include landing area and the reference to circling approach does not apply. The final approach course in precision approach procedures shall be aligned as indicated in Paras 152 and 159. For non-precision procedures final approach course alignment shall be as follows:

a. Approaches to a Landing Area. The final approach course should be aligned so as to pass through the landing area. Where an operational advantage can be achieved, a final approach course which does not pass through the landing area may be established, provided such a course lies within 2,600 feet of the centre of the landing area at the MAP.

b. Point in Space Approaches. The final approach course should be aligned to provide for the most effective operational use of the procedure consistent with safety.

117. Missed Approach Point (MAP)

Volume 1, Para 272, is changed to state that the specified distance may not be more than the distance from the final approach fix to a point not more than 2,600 feet from the centre of the landing area. The MAP may be located more than 2,600 feet from the landing area, provided the MINIMUM visibility agrees with the increased distance; e.g., MAP 3,800 feet from the landing area, basic visibility is ¾ mile (see Figure 1-108). For point in space approaches the MAP is on the final approach course at the end of the final approach area.

118. Straight Missed Approach Area

Volume 1, Para 273, applies with the exception that the length of the primary and secondary missed approach area is reduced from 15 NM to 7.5 NM and will have the width of the appropriate airway at termination.

119. Straight Missed Approach Obstacle Clearance

Volume 1, Para 274, applies except that “TDZ or airport elevation” is changed to “landing area elevation”; the slope of the missed approach surface is changed from 40:1 to 20:1 and the secondary area slope is changed from 12:1 to 4:1.

120. Turning Missed Approach Area

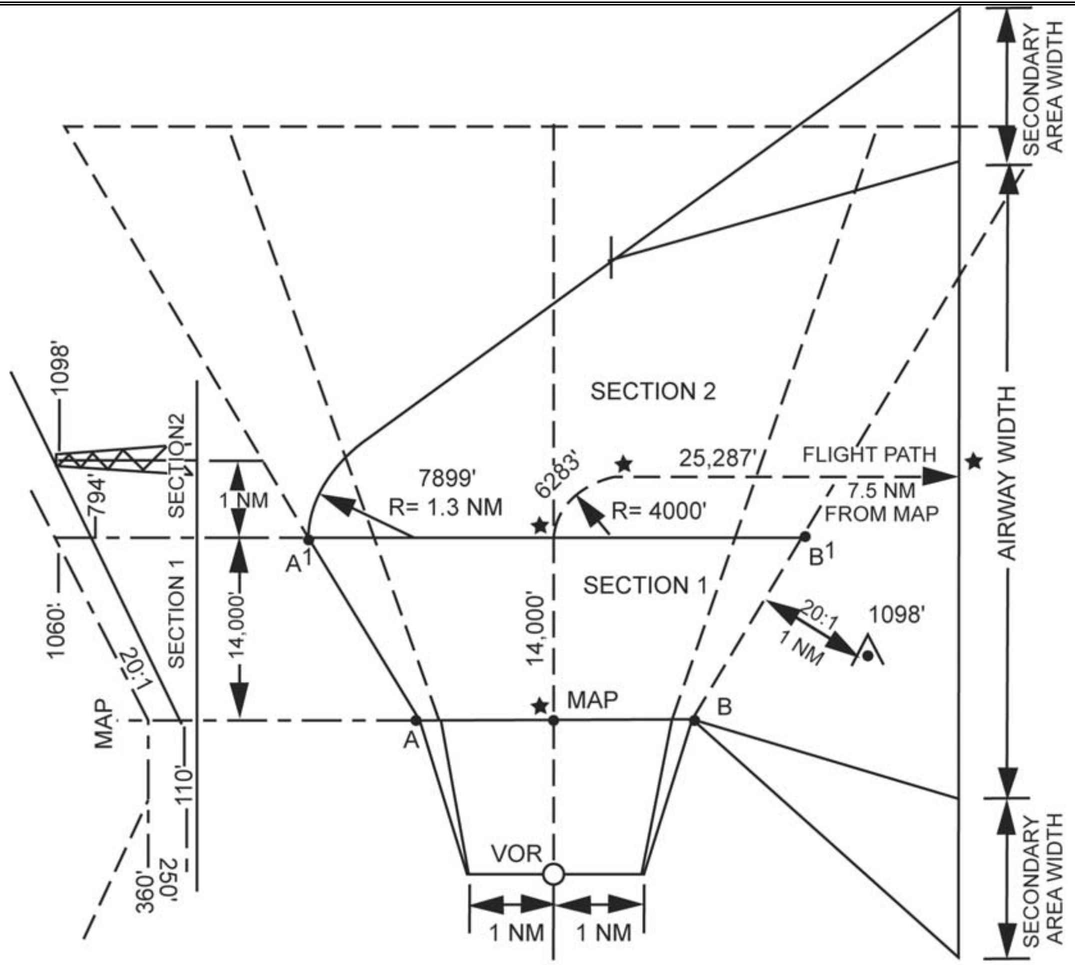
The provisions of Volume 1, Para 275, apply with the exception that when applying missed approach criteria shown in Figures 2–19 through 2–24, and Table 2–5, change all flight path lengths to 7.5 NM, missed approach surface slope to 20:1, secondary slopes to 4:1, obstacle clearance radius (R_1) to 1.3 NM and flight path radius (R_1) to 4,000 feet (66 NM). The area width will expand uniformly to the appropriate airway width.

121. Turning Missed Approach Obstacle Clearance

All missed approach areas described in Volume 1, Para 276, and depicted in Figures 2–25 and 2–26 will be adjusted for helicopter operation using the values shown in Volume 1, Para 120. The area width will expand uniformly to the appropriate airway width.

122. Combination Straight And Turning Missed Approach

Volume 1, Para 277, applies except that the values shown in Volume 5, Para 120, shall be used and point B is relocated to a position abeam the MAP. The area width will expand uniformly to the appropriate airway width (see Figure 1-106).



EXAMPLE:

MDA is 360' MSL based on obstacles in the approach area. A 1098' MSL controlling obstacle is 1 NM (6076') from the near edge of Section 1.

A 20:1 surface that clears the obstacle has a height of 794' MSL at the near edge of Section 1.

6076' ÷ 20 = 304'
1098' - 304' = 794'

To determine minimum altitude at which the missed approach aircraft may start the turn add 250' obstacle clearance and round up the sum to the next higher 20' increment.

794' + 250' = 1044'
Rounded up = 1060'

To climb 700' from MDA 360' MSL to turning altitude (1060' MSL) at the 20:1 climb gradient requires 14,000'. This is the minimum length of Section 1.

Figure 1-106: Combination Missed Approach Area. Para 122.

123. Holding Alignment

The provisions of Volume 1, Para 291, apply with the exception that when the final approach fix is a facility, the inbound holding course shall not differ from the final approach course by more than 90 degrees.

124. Holding Area

Volume 1, Para 292, applies except that the MINIMUM size pattern is No. 1.

SECTION 3. TAKE-OFF AND LANDING MINIMA

125. Application

The minima specified in this section apply to Helicopter Only procedures.

126. Altitudes

Chapter 3 is changed as follows:

a. In Volume 1, Para 321, reference to 40:1 is changed to 20:1.

b. Volume 1, Paras 322 and 351, do not apply.

c. Volume 1, Paras 324, 938, and 1028, apply except that a DH of 100 feet may be approved without approach lights. Table 3-1, referenced in Volume 1, Para 350, does not apply.

d. Table 1–29 in Volume 5, Para 167, governs the establishment of the DH.

127. Visibility

Chapter 3 is changed as follows:

a. Volume 1, Paras 330, 331, 332, and 343, do not apply.

b. Straight-in Minima.

(1) Non-precision Approaches (landing area within 2,600 feet of MAP). The minimum visibility may not be less than the visibility associated with the HAL as specified in Table 1–25.

(2) Precision Approaches. The minimum visibility authorized ¼ mile (1400 RVR).

c. Point in Space Approaches. The minimum visibility prior to applying credit for light is ¾ mile. If the HAS exceeds 800 feet, the minimum no-lights visibility shall be 1 mile. No credit for lights will be authorized unless an approved visual lights guidance system is provided (see also Volume 1, Para 344). Alternate minimums are not authorized. Table 1–25 does not apply.

HAL	**250 – 600 ft**	**601 – 800 ft**	**More than 800 ft**
Visibility (SM) Minima	½ SM	¾ SM	1 SM

Table 1-25: Effect Of HAL On Visibility Minima. Para 127.b.

128. Visibility Credit

Where visibility credit for lighting facilities is allowed for fixed wing operations, the same type credit should be considered for helicopter operations. The approving authority will grant credit on an individual case basis until such time as a standard for helicopter approach light systems is established. The minimum visibility authorized prior to applying credit for lights may be reduced ¼ mile for both precision and non-precision procedures where approved approach light systems are operative. In addition, in precision approach procedures where RVR is approved and minima have been reduced to ¼ mile, 1,400 RVR may also be authorized.

129. Take-Off Minima

Helicopter take-off minima will be in accordance with the appropriate civil or military regulations as applicable.

SECTION 4. ON-HELIPORT VOR, NO FAF

130. General

Volume 1, Para 400, does not apply. These criteria apply to procedures based on a VOR facility located within 2,600 feet of the centre of the landing area in which no final approach fix is established. These procedures must incorporate a procedure turn.

131. Initial And Intermediate Segments

These criteria are contained in Section 2 of this chapter.

132. Final Approach Segment

Volume 1, Para 413, does not apply except as noted below. The final approach begins where the procedure turn intersects the final approach course inbound.

a. Alignment. Volume 1, Para 116.a, applies.

b. Area. The primary area is longitudinally centred on the final approach course. The minimum length is 5 NM. This may be extended if an operational requirement exists. The primary area is 2 NM wide at the facility, and expands uniformly to 4 NM wide at 5 NM from the facility. A secondary area is on each side of the primary area. It is zero NM wide at the facility and expands uniformly to .67 NM on each side of the primary area at 5 NM from the facility (see Figure 1–107).

c. Obstacle Clearance. Volume 1, Para 413.c.(1), applies.

d. Procedure Turn Altitude. The procedure turn completion altitude shall be in accordance with Table 1–23.

e. Use of Step-down Fix. Volume 1, Para 413.e, applies except that 4 NM is changed to 2.5 NM.

f. Minimum Descent Altitude. Criteria for determining MDA are contained in Section 3 of this chapter and Chapter 3.

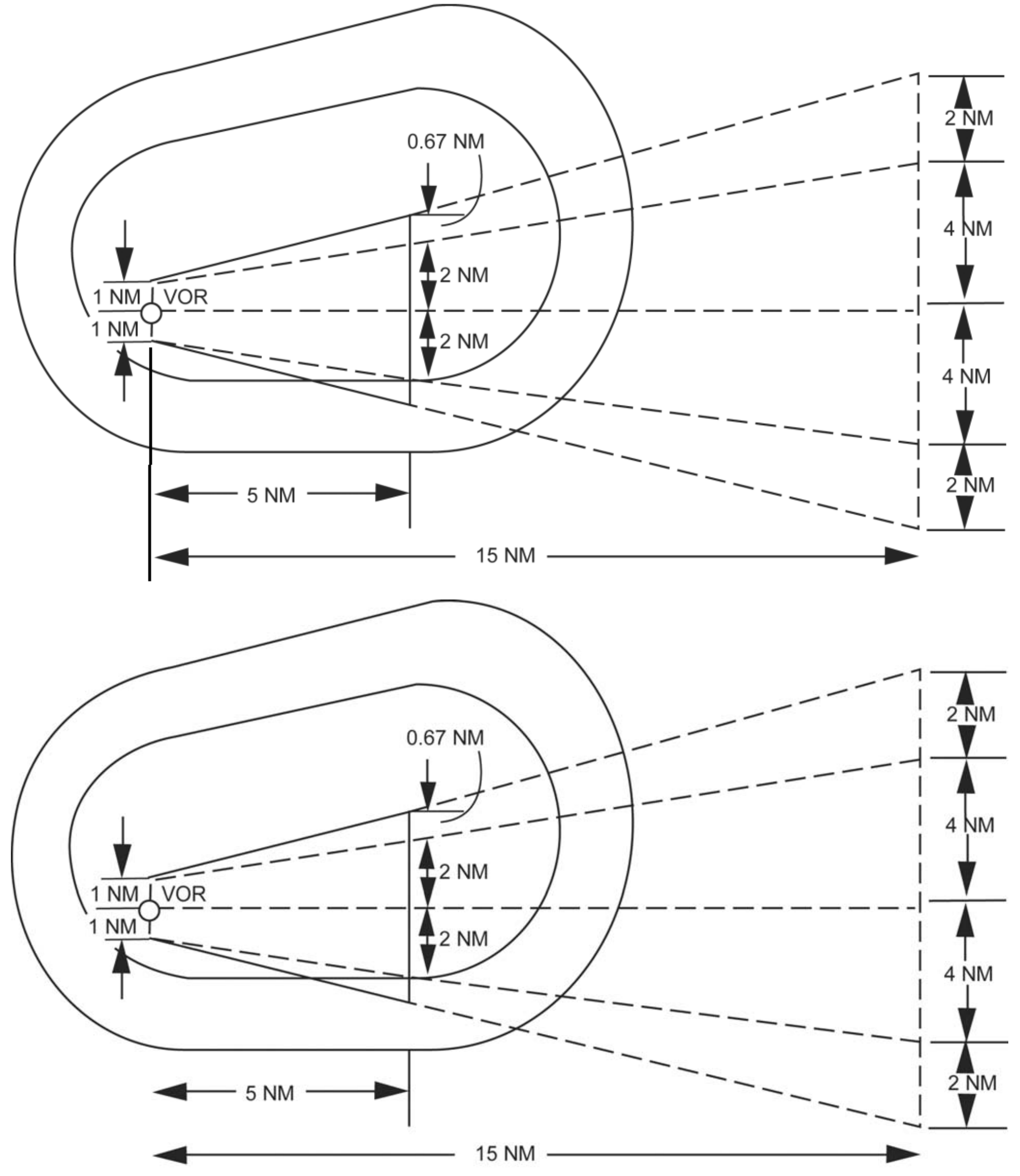


Figure 1-107: Final Approach Primary And Secondary Area. On Heliport VOR, No FAF. Para 132.b and Fig 1 110.

SECTION 5. TACAN, VOR/DME, AND VOR WITH FAF

133. Final Approach Segment

Volume 1, Para 513, does not apply except as noted below.

a. Alignment. Volume 1, Paras 116.a and b, apply.

b. Area. Volume 1, Para 513.b, applies except that portion which refers to the minimum length of the final approach segment. The minimum length of the final approach segment is shown in Table 1–26.

c. Obstacle Clearance. Volume 1, Para 513.c.(1), applies.

134. Reserved

135. Missed Approach Point

The identification of the MAP in Volume 1, Para 514, is changed as follows: The missed approach point is a point on the final approach course which is not farther that 2,600 feet from the centre of the landing area (see Figure 1–108). For point in space approaches the MAP is on the final approach course at the end of the final approach area.

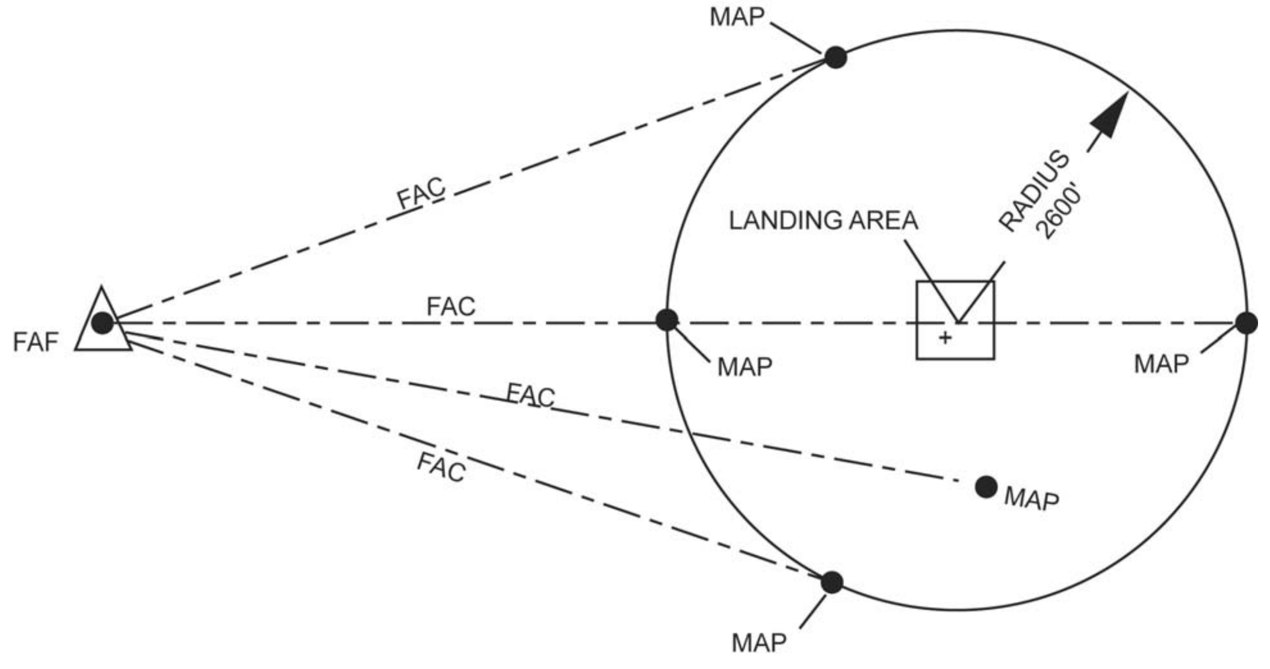


Figure 1-108: Missed Approach Points. Off-Heliport VOR with FAF. Para 135.

136. Arc Final Approach Segment Radius

Volume 1, Para 523.b, does not apply. The final approach arc shall be a continuation of the intermediate arc. It shall be specified in NM and tenths thereof. The minimum arc radius on final approach is 4 NM.

137. Arc Final Approach Segment Alignment

Volume 1, Para 523.b.(1), does not apply. The final approach arc should be aligned so as to pass through the landing area. Where an operational advantage can be achieved, a final approach course, which does not pass through the landing area may be established provided the arc lies 2,600 feet of the landing area at the MAP.

138. Reserved

SECTION 6. ON-HELIPORT NDB, NO FAF

139. General

Volume 1, Para 600, does not apply. These criteria apply to procedures based on an NDB facility located within 2,600 feet of the centre of the landing area in which no final approach fix is established. These procedures must incorporate a procedure turn.

140. Final Approach Segment

Volume 1, Para 613, does not apply except as noted below. The final approach begins where the procedure turn intersects the final approach course inbound.

a. Alignment. Volume 1, Para 116.a, applies.

b. Area. The primary area is longitudinally centred on the final approach course. The minimum length is 5 NM. This may be extended if an operational requirement exists. The primary area is 2.5 NM wide at the facility, and expands uniformly to 4.25 NM wide at 5 NM from the facility. A secondary area is on each side of the primary area. It is zero NM wide at the facility, and expands uniformly to .67 NM wide on each side of the primary area at 5 NM from the facility. Figure 1–109 illustrates the primary and secondary areas.

c. Obstacle Clearance. Volume 1, Para 613.c.(1), applies.

d. Procedure Turn Altitude (Descent Gradient). The procedure turn completion altitude shall be in accordance with Table 1–23.

e. Use of Step-down Fix. Volume 1, Para 613.e, applies except that 4 NM is changed to 2.5 NM.

f. Minimum Descent Altitude. Criteria for determining the MDA are contained in Section 3 of this chapter and Chapter 3.

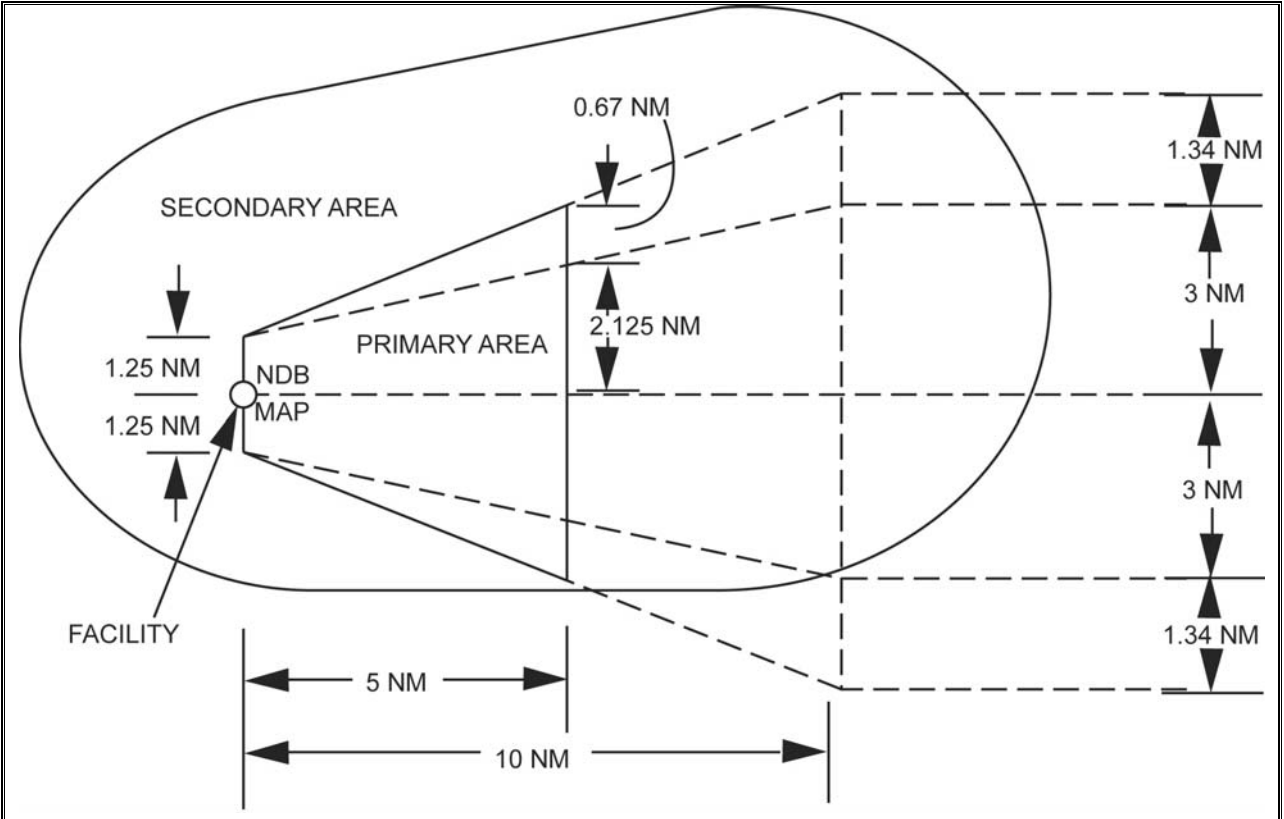


Figure 1-109: Final Approach Primary And Secondary Areas. On-Heliport NDB, no FAF. Para 140.

SECTION 7. NDB PROCEDURES WITH FAF

141. General

These criteria apply to procedures based on an NDB facility that incorporates a final approach fix.

142. Final Approach Segment

Volume 1, Para 713, does not apply except as noted below:

a. Alignment. Volume 1, Paras 116.a and b, apply.

b. Area. Volume 1, Para 713.b, applies except that portion which refers to the minimum length of the final approach segment. The minimum length is specified in Table 1–26.

c. Obstacle Clearance. Volume 1, Para 713.c.(1), applies.

Magnitude of Turn Over the Facility	Minimum Length (NM)
30°	1.0
60°	2.0
90°	3.0

Note: This Table may be interpolated

Table 1-26: Minimum Length Of Final Approach Segment (NM). Para 142.b.

143. Missed Approach Point

The identification of the MAP in Volume 1, Para 714, is changed as follows: The missed approach point is a point on the final approach course which is not farther than 2,600 feet from the centre of the landing area (see Figure 1–108). For point in space approaches, the MAP is on the final approach course at the end of the final approach area.

SECTION 8. RESERVED

144—149. Reserved

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SECTION 9. ILS PROCEDURES

150. General

Chapter 9 is changed as noted in this section. These criteria apply to the present design of instrument landing systems (on airport) only.

151. Intermediate Approach Segment

Volume 1, Para 922, applies with the exception that Table 1–27 specifies the minimum length of the intermediate segment based on the angle of intersection of the initial approach course with the localizer course.

Angle (Degrees)	**Minimum Length (NM)**
30°	1.0
60°	2.0
90°	3.0
Note: This Table may be interpolated	

Table 1-27: Intermediate Segment Angle Of Intercept vs Segment Length. Para 151 & 156

152. Final Approach Segment

Volume 1, Para 930, applies except that glide slope intersection need not occur prior to the FAF normally used for fixed operations.

a. The optimum length of the final approach course is 3.0 NM. The minimum length is 2.0 NM. A distance in excess of 4.0 NM should not be used unless a special operational requirement exists.

b. Final Approach Termination. The final approach shall terminate at a landing point (runway) or at a hover point between the Decision Height and the GPI. Where required, visual hover/taxi routes will be provided to the terminal area.

153. Missed Approach Area

Normally existing missed approach criteria described in Volume 3, Para 3.9, will be utilized for helicopter operations. However, if an operational advantage can be gained, the areas described in Volume 1, Para 168 through 171, may be substituted.

154. Reserved

155. Localizer

Chapter 9 is changed as noted in this paragraph.

a. Alignment. Volume 1, Para 902, applies except that alignment shall be as specified in Para 116.a and b.

b. Area. Volume 1, Para 903, applies except that portion which refers to the minimum length of the final approach segment. The minimum length of the final approach segment is shown in Table 1–26.

c. Missed Approach Point. The identification of the MAP in Volume 1, Para 907, is changed as follows: The missed approach point is a point on the final approach course which is not farther than 2,600 feet from the landing area (see Figure 1–108). For point-in-space approaches, the MAP is on the final approach course at the end of the final

SECTION 10. PRECISION APPROACH RADAR (PAR)

156. Intermediate Approach Segment

Volume 1, Para 1014, applies with the exception that Volume 5, Table 1–27, specifies the MINIMUM length of the intermediate segment based on the angle of intersection of the initial approach course with the intermediate course.

157. Reserved

158. Final Approach Segment

The provisions of Volume 1, Paras 1020.b.(1) and (2), do not apply. The minimum distance from the glide slope intercept point to the GPI is 2 NM.

159. Final Approach Alignment

Volume 1, Para 1020.a, applies with the exception that a final approach course shall be aligned to a landing area. Where required, visual hover/taxi routes shall be established leading to terminal areas.

160. Final Approach Area

a. Length. The final approach area is 25,000 feet long, measured outward along the final approach course from the GPI. Where operationally required for other procedural considerations or for existing obstacles, the length may be increased or decreased symmetrically, except when glide slope usability would be impaired or restricted (see Figure 1–110).

b. Width. The final approach area is centred on the final approach course. The area has a total width of 500 feet at the GPI and expands uniformly to a total width of 8,000 feet at a point 25,000 feet outward from the GPI. The widths are further uniformly expanded or reduced where a different length is required as in Volume 1, Para 160.a above (see Figure 1-110). The width either side of the centreline at a given distance “D” from the point of beginning can be found by using the formula:

$$250 + 0.15D = \tfrac{1}{2} \text{ width.}$$

161. Reserved

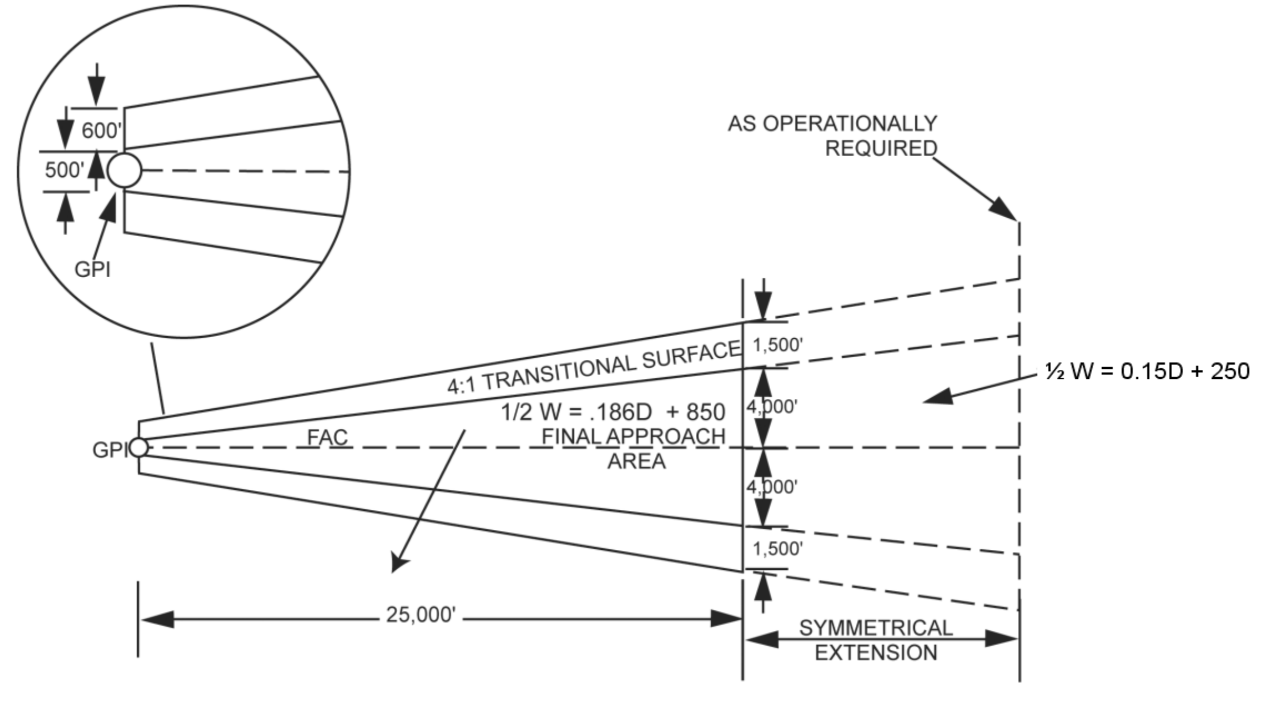


Figure 1-110: PAR Final Approach Area. Para 159 and 160.

162. Final Approach Obstacle Clearance Surface

Volume 1, Para 1021, does not apply. The final approach obstacle clearance surface is divided into two sections.

a. Section 1. This section originates at the GPI and extends for a distance of 775 feet in the direction of the FAF. It is a level plane, the elevation of which is equal to the elevation of the GPI.

b. Section 2. This section originates 775 feet outward from the GPI. It connects with Section 1 at the elevation of the GPI. The gradient of this section varies with the glide path angle used.

(1) To identify the glide slope angle and associated final approach surface gradient to clear obstacles in Section 2:

(a) Determine the distance “D” from the GPI to the controlling obstacle and the height of the controlling obstacle above the GPI.

(b) Enter these values in the formula:

$$\text{TAN ANGLE} = \frac{\text{Obstacle Height}}{\text{D - 775}}$$

(c) Using the TAN table (see Volume 1, Annex D) convert the tangent angle to a degree angle. This is the angle of the Section 2 approach surface gradient that is required to clear the obstacle, measured from the beginning of Section 2 at the height of the GPI.

(d) The minimum glide slope angle required is found in Table 1–28.

Glide Slope Angle (Degrees)	Less Than 3°	3°	4°	5°	6°	7°	8°	12°
Section 2 obstacle clearance surface gradient (degrees)	*	1.65	2.51	3.37	4.23	5.09	5.95	9.39

Note: This Table may be interpolated
* See Para 165.a.

Table 1-28: Final Approach Glide Slope – Surface Slope Angles. Para 162.b.

163. Transitional Surfaces

Volume 1, Para 1022, does not apply. Transitional surfaces for PAR are inclined planes with a slope of 4:1, which extend outward and upward from the edges of the final approach surfaces. They start at the height of the applicable final approach surface, and are perpendicular to the final approach course. They extend laterally 600 feet at the GPI and expand uniformly to a width of 1,500 feet at 25,000 feet from the GPI.

Note: The distance to the outer edge of the 4:1 transitional surface from the final approach course centreline is: ½W = 0.186D + 850. To determine the width of the transitional area, subtract the final approach primary area width found in Para 160.b.

164. Obstacle Clearance

Volume 1, Para 1024, does not apply. No obstacle should penetrate the applicable final approach surface specified in Para 162 or the transitional surfaces specified in Para 163. Obstacle clearance requirements greater than 500 feet need not be applied unless required in the interest of safety due to precipitous terrain or radar system peculiarities (see Figure 1–111).

Note: Provided the surface is free of obstacles, the terrain within Section 1 and 2 may rise at a gradient of 75:1 without adverse effect on minima.. The 75:1 gradient begins at the GPI and extends until it meets the Section 2 obstacle clearance gradient (see Figure 1-111a). This is intended to allow for terrain undulations only, Any vegetation or non-frangible man-made obstructions within this area must be treated in accordance with Para 162.

165. Glide Slope Landing Area

Required obstacle clearance is specified in Para 164. In addition, consideration requirements shall be given to the following in the selection of the glide slope angle:

a. If angles less than 3 degrees are established, the obstacle clearance requirements shall be arrived at in accordance with Volume 1, Paras 1024 and 1025.

b. Angles greater than 6 degrees shall not be established without authorization of the approving authority. The angle selected should be no greater than that required to provide obstacle clearance.

c. Angles selected should be increased to the next higher tenth of a degree, e.g., 4.71 degrees becomes 4.8; 4.69 degrees becomes 4.7.

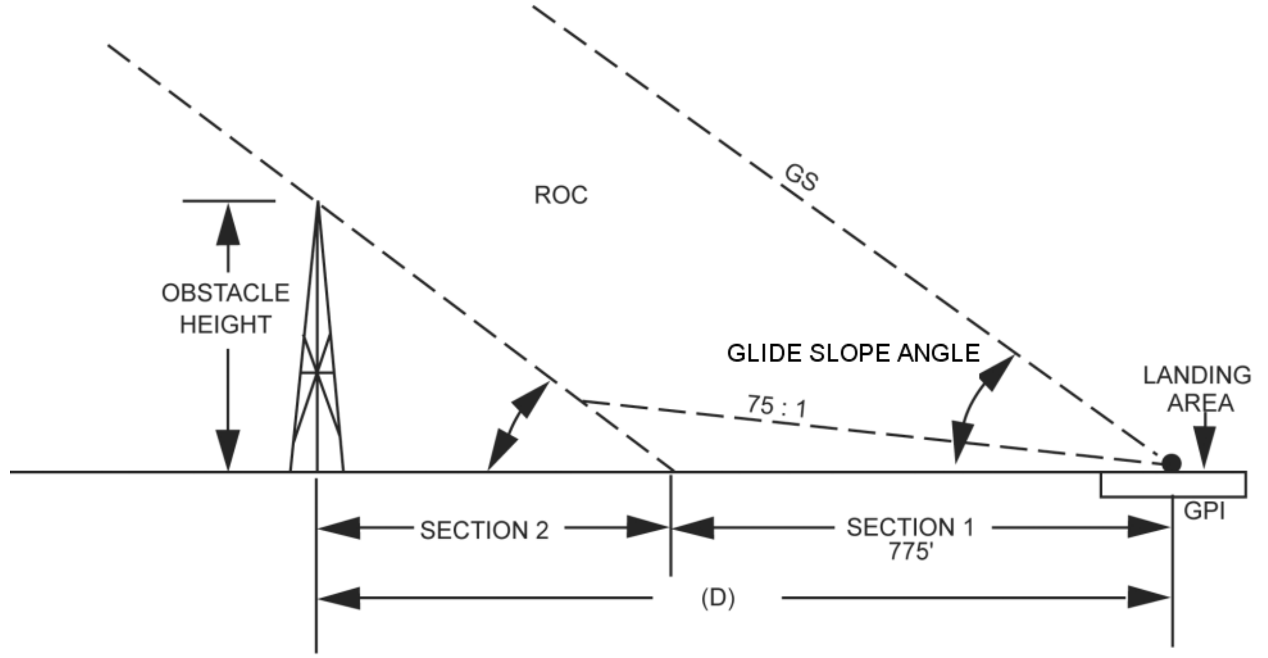


Figure 1-111: Final Approach Area Surface And Obstacle Clearance. Para 162 and 164.

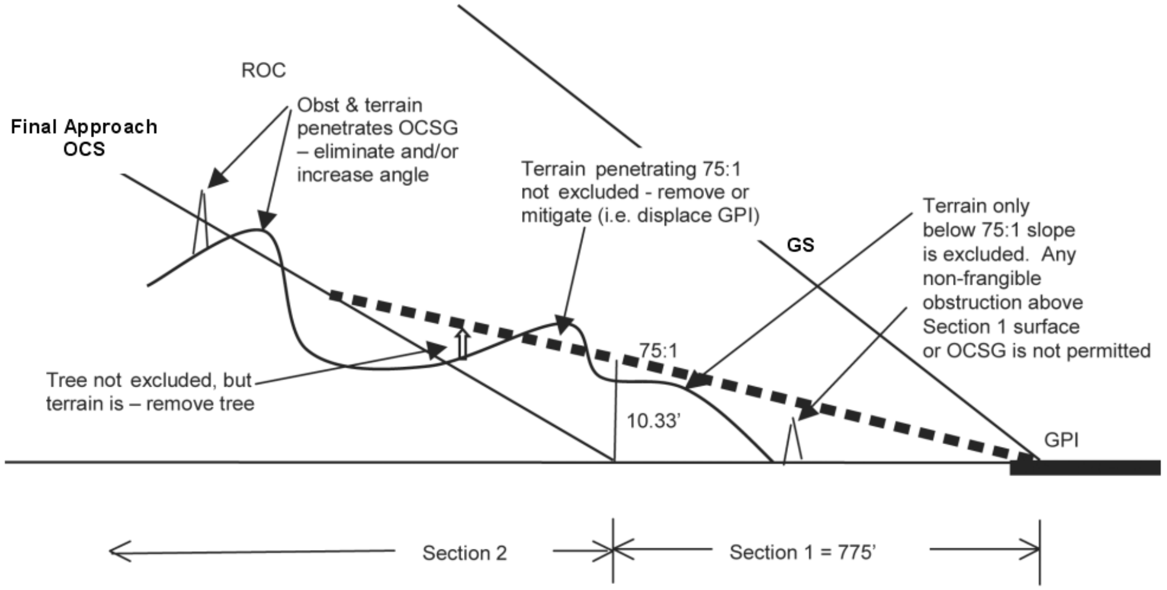


Figure 1-111A: Terrain Exclusion Area. Para 164 Note.

166. Relocation Of The Glide Slope

Volume 1, Para 1027, does not apply. The GPI shall normally be located at the arrival edge of the landing area. If obstacle clearance requirements cannot be satisfied, or if operational advantages will result, the GPI may be moved into the landing area provided sufficient landing area is available forward of the displaced or relocated GPI.

167. Adjustment Of DH

Volume 1, Para 1028, does not apply. An adjustment is required whenever the angle to be used exceeds 3.8 degrees (see Table 1–29). This adjustment is necessary to provide ample deceleration between the DH point and the landing area.

GS Angle (Degrees)	**Up to 3.80**	**3.81 to 5.70**	**Over 5.70**
Minimum DH (Feet)	100	150	200

Table 1-29: Minimum DH – GS Angle Relationship. Para 167.

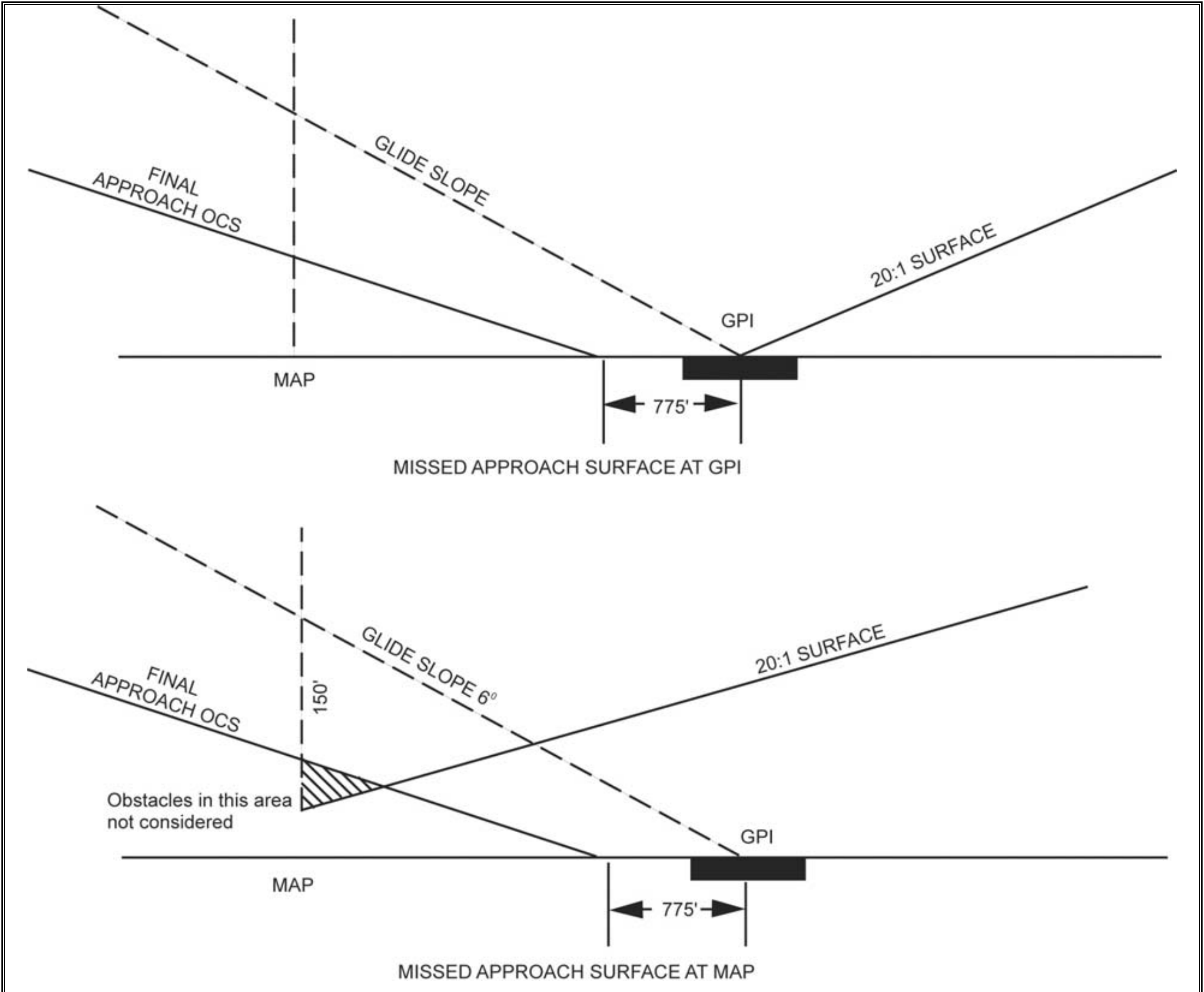


Figure 1-112: Missed Approach Surface Options. Para 168.

168. Missed Approach Obstacle Clearance

No obstacle may penetrate a 20:1 missed approach surface that overlies the missed approach areas illustrated in Figures 1–113, 1–114, and 1–115. The missed approach surface originates at the GPI. However, to gain relief from existing obstacles in the missed approach area the point at which the surface originates may be relocated as far backward from the GPI as a point on the final approach course that is directly below the MAP. In such cases the surface originates at a height below the DH as specified in Table 1–30 (see Figure 1–112).

When penetration of the 20:1 surface originating at the GPI occurs, an upward adjustment to the DH equal to the maximum penetration of the surface should be considered.

GS Angle (Degrees)	**3**	**6**	**9**
Dist. below DH point (Feet)	100	150	200
Note: This Table may be interpolated			

Table 1-30: Beginning Point Of Missed Approach Surface. Para 168.

169. Straight Missed Approach Area

The straight missed approach (maximum of 15 degrees turn from final approach course) area starts at the MAP and extends to 7.5 NM.

a. Primary Area. This area is divided into three sections.

   (1) Section 1A is a continuation of the final approach area. It starts at the MAP and ends at the GPI. It has the same width as the final approach area at the MAP.

   (2) Section 1B is centred on the missed approach course. It begins at the GPI and extends to a point 1 mile from the MAP outward along the missed approach course. It has a beginning width the same as the final approach area at the MAP and expands uniformly to 4,000 feet at 1 mile from the MAP.

   (3) Section 2 is centred on the continuation of the Section 16 course. It begins 1 mile from the MAP and ends 7.5 NM from the MAP. It has a beginning width of 4,000 feet expanding uniformly to a width equal to that of an initial approach area at 7.5 NM from the MAP.

b. Secondary Area. The secondary area begins at the MAP, where it has the same width as the final approach secondary area. In Section 1A the width remains constant from the MAP to the GPI, after which it increases uniformly to the appropriate airway width at 7.5 NM from the MAP (see Figure 1–113).

170. Turning Missed Approach Area

Where turns of more than 15 degrees are required in a missed approach procedure, they shall commence at an altitude that is at least 400 feet above the elevation of the landing area. Such turns are assumed to commence at the point where Section 2 begins. The turning flight track radius shall be 4,000 feet (0.66 NM).

a. Primary Area. The outer boundary of the Section 2 primary area shall be drawn with a 1.3 mile radius. The inner boundary shall commence at the beginning of Section 1B. The outer and inner boundary shall flare to the width of an initial approach area 7.5 NM from the MAP.

b. Secondary Area. Secondary areas for reduction of obstacle clearance are identified with Section 2. The secondary areas begin after completion of the turn. They are zero NM wide at the point of beginning and increase uniformly to the appropriate airway at the end of Section 2. Positive course guidance is required to reduce obstacle clearance in the secondary area (see Figure 1–114).

171. Combination Straight And Turning Missed Approach Area

If a straight climb to an altitude greater than 400 feet is necessary prior to commencing a missed approach turn, a combination straight and turning missed approach area must be constructed. The straight portion of this missed approach area is divided into Section 1 and 2A. The portion in which the turn is made is Section 2B.

a. Straight Portion. Sections 1 and 2A correspond respectively to Section 1 and 2 of normal straight missed approach area and are constructed as specified in Volume 1, Para 169, except that Section 2A has no secondary areas. Obstacle clearance is provided as specified in Volume 1, Para 119. The length of Section 2A is determined as shown in Figure 1–115, and relates to the need to climb to a specified altitude prior to commencing the turn. The line A^1–B^1 marks the end of Section 2A. Point C^1 is 5,300 feet from the end of Section 2A.

b. Turning Portion. Section 2B is constructed as specified in Volume 1, Para 169, except that it begins at the end of Section 2A instead of the end of Section 1. To determine the height which must be attained before commencing the missed approach turn, first identify the controlling obstacle on the side of Section 2A to which the turn is to be made. Then measure the distance from this obstacle to the nearest edge of the Section 2A area. Using this distance as illustrated in Figure 1–115, determine the height of the 20:1 slope at the edge of Section 2A. This height plus 250 feet (rounded off to the next higher 20-foot increment) is the height at which the turn should be started. Obstacle clearance requirements in Section 2B are the same as those specified in Volume 1, Para 121, except that Section 28 is expanded to start at Point C if no fix exists at the end of Section 2A or if no course guidance is provide in Section 2 (see Figure 1–115).

Note: The missed approach areas expand uniformly to the appropriate airway width.

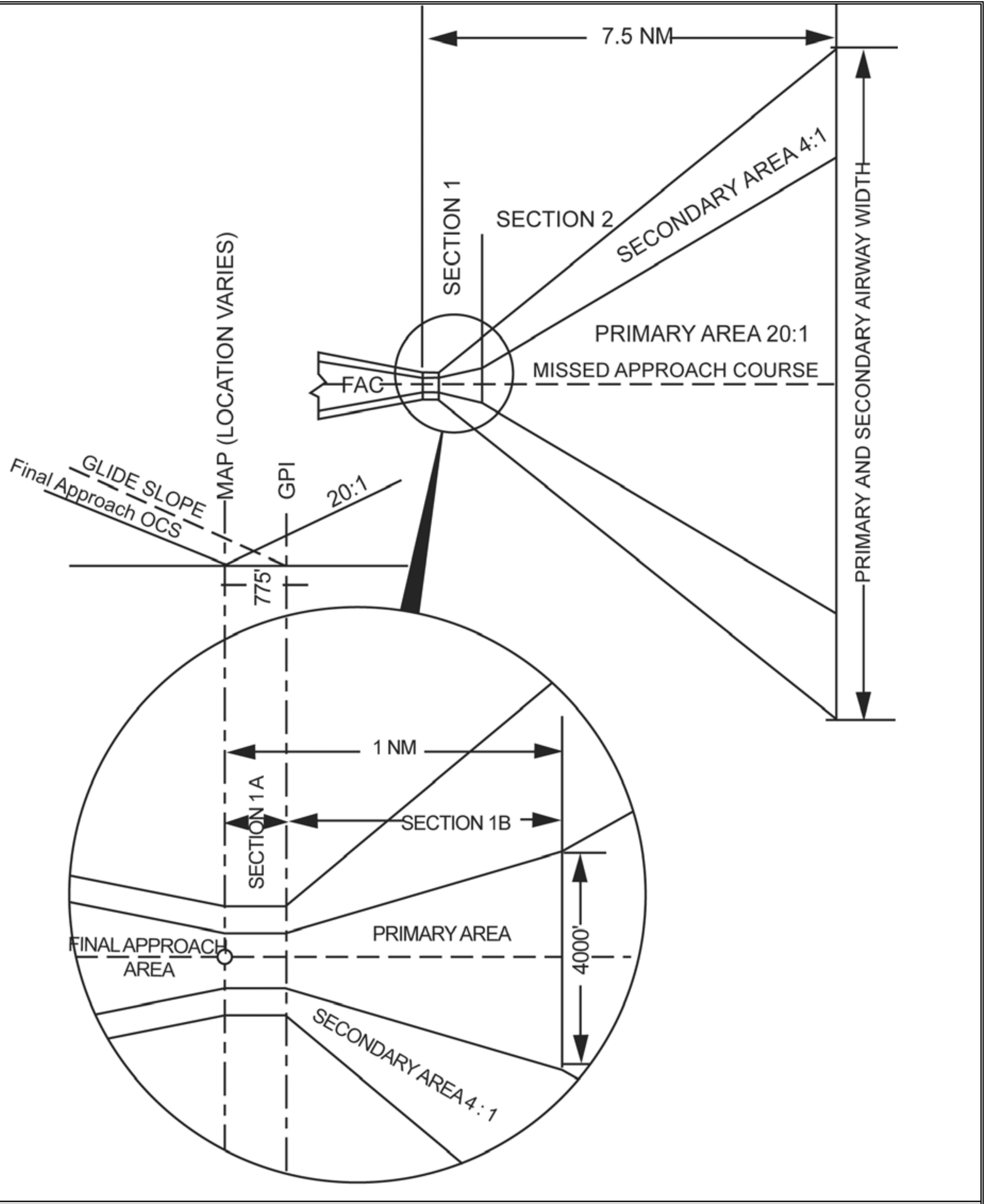


Figure 1-113: Straight Missed Approach. Para 169.

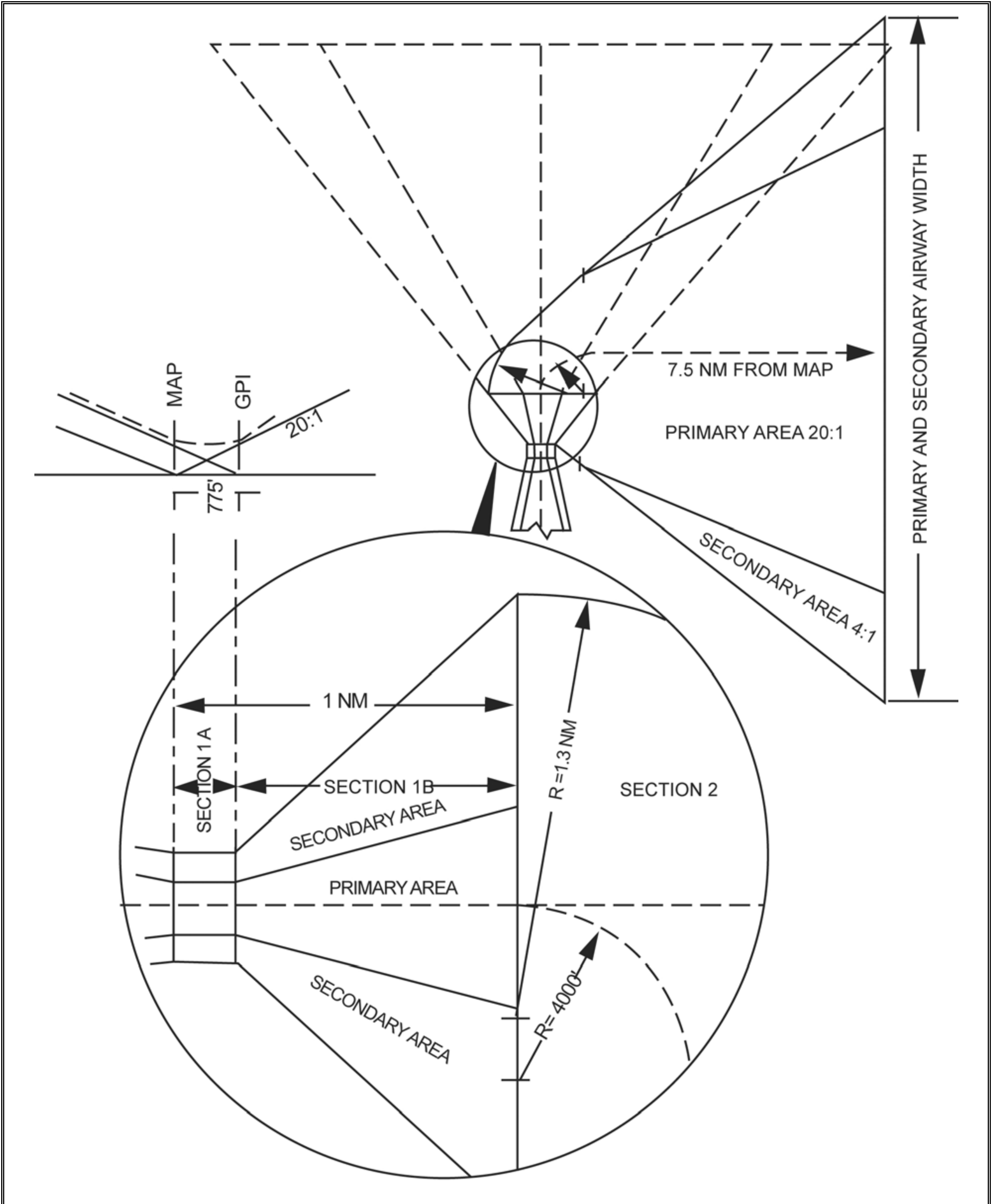
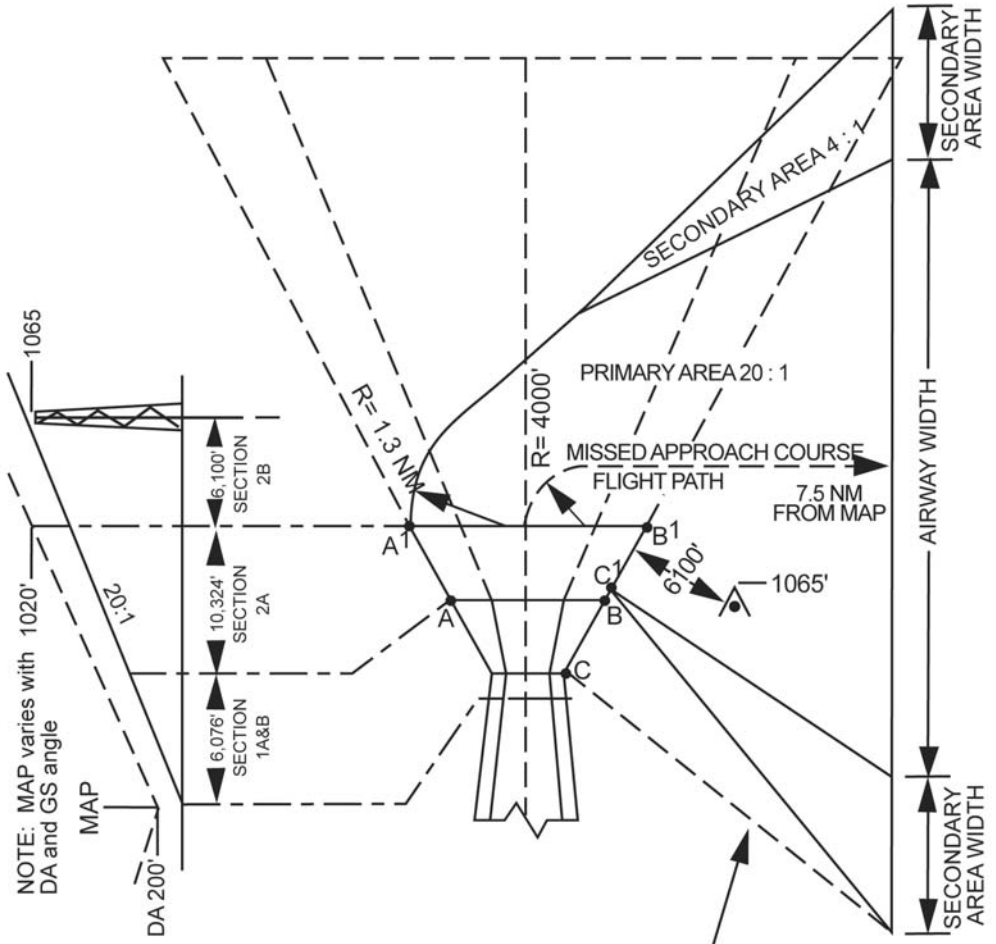


Figure 1-114: Turning Missed Approach Area. Para 170.



This becomes the boundary if no fix exists at the end of Section 2A, or, no course guidance is provided in Section 2B.

EXAMPLE:

DA is 200' MSL. A 1065' controlling obstacle is 6100' from the near edge of Section 2A

A 20:1 surface that clears the obstacle has a height of 760' MSL at the near edge of Section 2A.

6100' ÷ 20 = 305'
1065' - 305' = 760'

To determine minimum altitude at which the missed approach aircraft may start the turn add 250' obstacle clearance and round up the sum to the next higher 20' increment.

760' + 250' = 1010'
Rounded up = 1020'

To climb 820' from DH 200' to the turning altitude (1020' MSL) at the 20:1 climb gradient requires 16,400'. Section 1 is 6076' long; therefore, Section 2A is required to be 10,324' long.

Figure 1-115: Combination Straight And Turning Missed Approach. Para 171.

SECTION 11. AIRPORT SURVEILLANCE RADAR (ASR)

172. Initial Approach Segment

Volume 1, Para 1041.a.(1), applies except that 90 degrees is changed to 120 degrees.

173. Intermediate Approach Segment

Volume 1, Para 1042.b, applies with the exception that the maximum angle of intercept is changed to 120 degrees and Table 1–24 is used to determine the required minimum length of the intermediate segment.

174. Final Approach Segment

Volume 1, Para 1044, applies except for subparagraphs a, c.(2) and d.

a. Alignment. Volume 1, Paras 116.a and b, apply.

175. Missed Approach Point

The identification of the MAP in Volume 1, Para 1048, is changed as follows. The missed approach point is a point on the final approach course that is not farther than 2,600 feet from the centre of the landing area (see Figure 1–108). For point in space approaches the MAP is on the final approach course at the end of the final approach area.

176—199. Reserved

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CHAPTER 2. HELICOPTER GLOBAL POSITIONING SYSTEM (GPS) – NON-PRECISION APPROACH CRITERIA

SECTION 1. ADMINISTRATION

200. General

This chapter contains criteria for formulation, review, approval, and publication of non-precision helicopter instrument approach procedures, based on GPS navigation.

The foundations of these criteria are studies of GPS data from simulation and flight tests conducted by the FAA. A significant difference exists between approach procedures to runways and approach procedures to heliports. Approaches to runways terminate in relatively obstacle free landing environments. Approaches to heliports commonly terminate in areas of dense obstacle populations where executing a missed approach requires higher than average demands on pilot reaction and performance. Speed limitations incorporated in these criteria take advantage of the unique, slow speed capability of helicopters. These speed limitations allow construction of small obstacle clearance areas and yield the lowest possible minimums.

201—205. Reserved

206. Terminology

Final Approach Fix (FAF). A fly-by waypoint (WP) for nonprecision GPS procedures that marks the beginning of the final approach segment.

Height Above Landing Area Elevation (HAL). The height of the minimum descent altitude (MDA) above the helipoint elevation.

Helipoint. The aiming point for the final approach course. It is normally the centre point of the touchdown and lift-off area (TLOF). The helipoint elevation is the highest point on the TLOF.

Heliport. An area of land, water, or structure used or intended to be used for the landing and takeoff of helicopters. It includes buildings and facilities on the area.

Heliport Reference Point (HRP). The geographic centre of a heliport.

Initial Approach Fix (IAF). Normally a fly-by waypoint that marks the beginning of the initial segment and the end of the feeder segment, if applicable.

Intermediate Fix (IF). A fly-by waypoint that marks the end of an initial segment and the beginning of the intermediate segment.

Missed Approach Point (MAP). A fly-over waypoint that marks the end of the final approach segment and the beginning of the missed approach segment.

Touchdown and Lift-Off Area. A TLOF may have any shape. The TLOF is the area of intended landing or takeoffs. See AC 150/5390-2, Heliport Design.

Visual Segment Reference Line (VSRL). A +/- 75-foot line measured perpendicular to the final course at a distance from the helipoint of half the length of the shortest side of the helipad or 75 feet, whichever is smaller.

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SECTION 2. GENERAL CRITERIA

207. General

These criteria assume use of GPS airborne equipment meeting the requirements of TSO-C129a, Airborne Supplemental Navigation Equipment Using GPS. TP 308/GPH 209 applies unless otherwise specified. Heliport design shall meet the requirements of CARs Part III in respect to heliports. Airspeeds shall not exceed 70 knots in the final and missed approach segments. Procedures may be designed for an airspeed not to exceed 90 knots in the final and missed approach segment when specific restriction listed in this chapter are applied. The missed approach airspeed limitation applies until the aircraft is established on the inbound course to the missed approach clearance limit.

a. Publication Requirements

Publish the following notes on the approach:

(1) Publish the final and missed approach maximum airspeed.

(2) Arm the approach mode before approaching closer than 30 nautical miles (NM) from the heliport reference point (HRP) or airport reference point (ARP) (e.g., “Arm approach mode 30 NM prior to the HRP/ARP”).

b. Publish the procedure as a SPECIAL procedure and publish annotations to require special aircrew qualifications when the approach is to a heliport or a point-in-space and one of the following conditions exists:

(1) The course change at the final approach fix (FAF) from the intermediate course to the final approach course exceeds 30°.

(2) Final descent gradient exceeds 600 feet/NM.

(3) The course change at the MAP from the final course to the missed approach course exceeds 30°.

(4) The Visual Segment Descent Angle (VSDA) exceeds 6.0°.

c. Fix Displacement Tolerance.

See Table 2-1.

	EN ROUTE	**TERMINAL**	**APPROACH**
Cross Track	± 2.8 NM	± 1.0 NM	± 0.4 NM
Along Track	± 2.0 NM	± 1.0 NM	± 0.3 NM
Used in the following segments	En Route	IAF	FAF
	Feeder	Initial Step Down Fix	Final Step Down Fix
	Feeder Step Down	IF	MAP
		Intermediate Step Down Fix	
		MA Turn Fix	
		MA Holding Fix	

Table 2-1: Helicopter GPS Fix (WP) Displacement Tolerance. Para 207.c.

208. GPS Approach Course Establishment

Use current guidance contained in Volume 1, Chapter 16. Use “heliport” vice “landing threshold.”

209. Procedure Identification

TP308/GPH209, Volume 5, Chapter 1, Para 105, applies, except:

a. For approaches to a helipoint, NAVAID type is considered GPS (e.g., COPTER GPS 160).

b. For approaches to runways, substitute “RWY (runway numbers)” for final bearing (e.g., COPTER GPS RWY 22, COPTER GPS RWY 31R).

210. Holding.

TP308/GPH209, Volume 5, Chapter 1, Para 124, applies. Locate helicopter holding fixes within 25 NM of the HRP/ARP.

SECTION 3. EN ROUTE CRITERIA

211. General

En route criteria contained in TP308/GPH209, Volume 1, Chapter 15, Non-VOR/DME Basic Area, applies to helicopter GPS en route segments.

212. Feeder Segment Route Width

See Figure 2–1.

a. Construct routes originating 25 NM or less from the HRP/ARP:

  (1) and ending 30 NM or less from the HRP/ARP, with a primary area width of ±1.5 NM and a secondary width of 0.5 NM (terminal size).

  (2) and ending more than 30 NM from the HRP/ARP, with a primary area width of ±4.0 NM and a secondary width of 2.0 NM (en route criteria size).

b. Construct routes originating beyond 25 NM from the HRP/ARP:

  (1) and ending more than 25 NM from the HRP/ARP, with a primary area width of ±4.0 NM and a secondary width of 2.0 NM (en route criteria size).

  (2) and ending 25 NM or less from the HRP/ARP, beginning with standard en route dimensions (primary area width of ±4.0 NM and a secondary width of 2.0 NM) and tapering at a rate 30° inward relative to course to terminal criteria size beginning at the latest point the feeder fix can be received.

    (a) If the route originates beyond 30 NM from the HRP/ARP, the taper begins when the route centreline reaches a point 30 NM from the HRP/ARP or the latest point the feeder fix can be received, whichever is encountered last.

    (b) If the distance from the plotted position of the feeder fix/facility to the plotted position of the next fix is less than 6.33 NM (tapered segment is less than 4.33 NM long), taper from the latest position the feeder fix can be received directly to the appropriate area edges abeam the plotted position of the next fix.

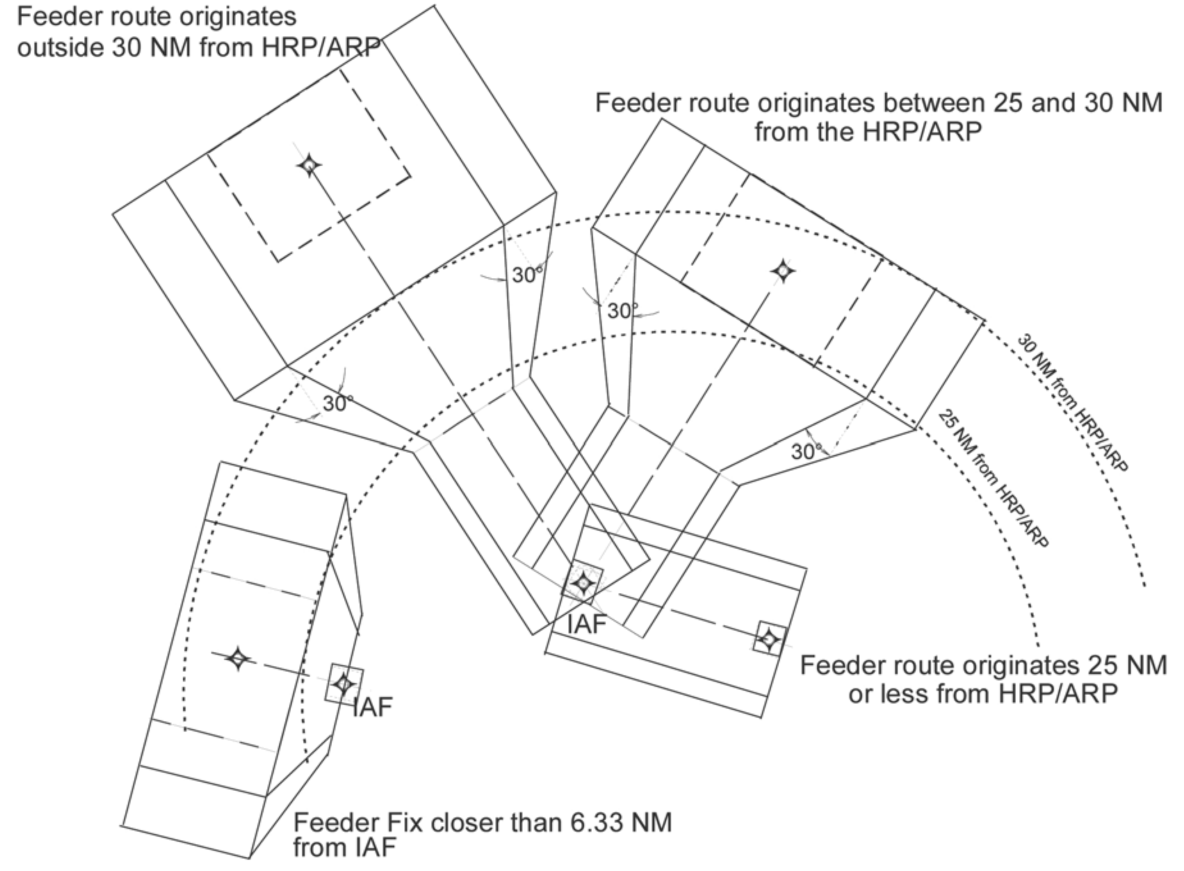


Figure 2-1: Feeder Route Examples. Para 212.

SECTION 4. TERMINAL CRITERIA

213. Approach Configuration

Consider the BASIC “T” approach configuration as the first option in procedure design (see Figure 2-2). It affords flexibility and standardization of procedure design. Use initial and intermediate segment lengths as specified in Table 2-2 as the first option in procedure design. Accommodate deviations from this configuration as operational and air traffic requirements dictate.

Course Intercept Angle (Degrees)	**Minimum Length (NM)**
0 - 30	2.0
> 30 - 90 *****	3.0
> 90 - 120	4.0
***** Final segment 60° maximum intercept angle	

Table 2-2: Helicopter GPS Minimum Initial/Intermediate/Final Segment Lengths. Para 213, 214.b, 215.b, and 216.b.

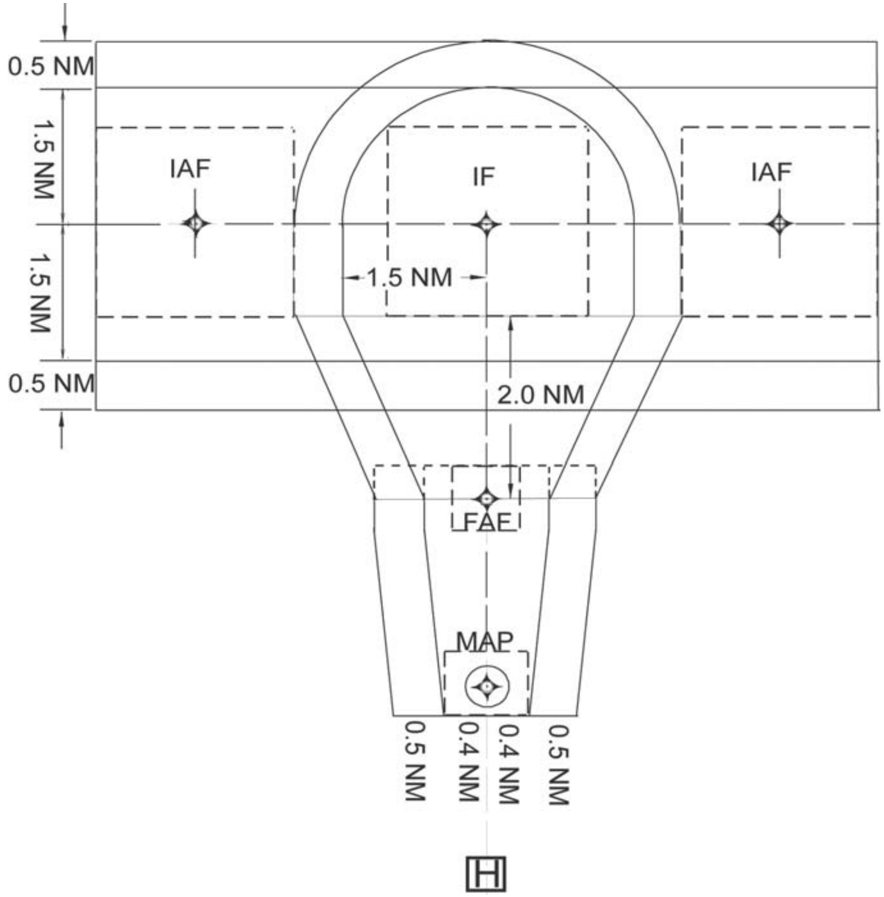


Figure 2-2: Basic T Configuration. Para 213.

214. Initial Approach Segment

The initial approach segment begins at the IAF and ends at the IF or at an IF identified as an along track distance (ATD) from the FAF. Course change at the IF shall not exceed 120°. Turns of 90° or less do not require application of turn anticipation/expansion criteria (see Figures 2-3 and 2-4).

a. Course Reversal. Construct the inbound leg of course reversal holding patterns within 30° of the intermediate segment course, as appropriate

b. Area.

 (1) Length. The initial segment length should not exceed 10 NM, unless operational requirements dictate. Construct IAFs within 25 NM of the ARP/HRP. The minimum length is governed by the magnitude of turn required at the IAF (see Table 2-2).

 (2) Width.

  (a) Primary Area. 1.5 NM each side of the course centreline.

  (b) Secondary Area. 0.5 NM on each side of the primary area.

 (3) Obstacle Clearance. Volume 1, Para 232c, applies.

 (4) Descent Gradient. Optimum descent gradient is 400 feet/NM. Where higher descent gradients are required, Volume 5, Para 110, applies.

215. Intermediate Segment

The intermediate segment begins at the IF or an ATD fix and ends at the FAF (see Figures 2-3 and 2-4)

a. Alignment. The maximum course change at the FAF is 60°; outside and inside turn expansion areas in 8260.38A apply only to procedures designed for maximum airspeeds above 70 KIAS.

b. Area.

 (1) Length. Maximum length is 5 NM. Recommended length is 3 NM. The minimum length is governed by the magnitude of turn required at the IF (see Table 2-2).

 (2) Width. The primary area is 1.5 NM each side of the segment centreline, beginning at the earliest IF position. The segment starts to taper inward 2 NM prior to the plotted position of the FAF to reach a width of ±0.55 NM at the plotted position of the FAF. The secondary area is 0.50 NM each side of the primary area.

 Note: For procedures designed for maximum airspeeds above 70 KIAS: change 0.55 NM to 0.70 NM.

c. Obstacle Clearance. Volume 1, Para 242c, applies.

d. Descent Gradient. The optimum descent gradient is 400 feet/NM. Where higher descent gradients are required, Volume 5, Para 110, applies. For procedures designed for maximum airspeeds above 70 KIAS: If the turn from the initial segment to the intermediate segment exceeds 60°, intermediate descent gradient shall not exceed 600 ft/NM.

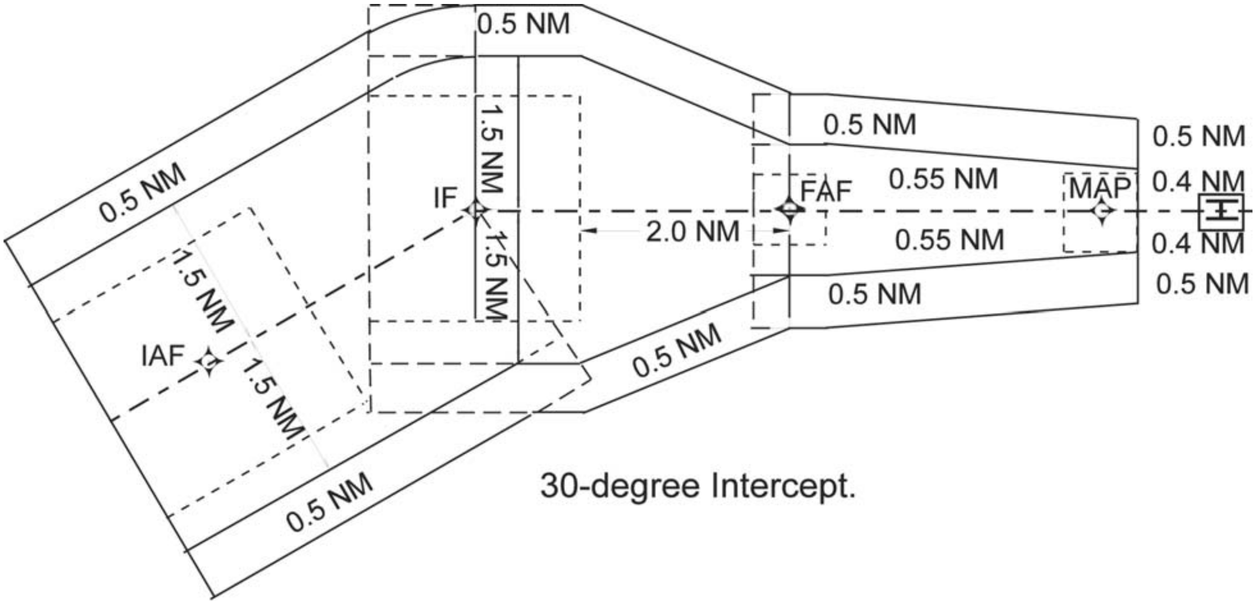


Figure 2-3: Initial/Intermediate Segment Construction. Para 214 and 215.

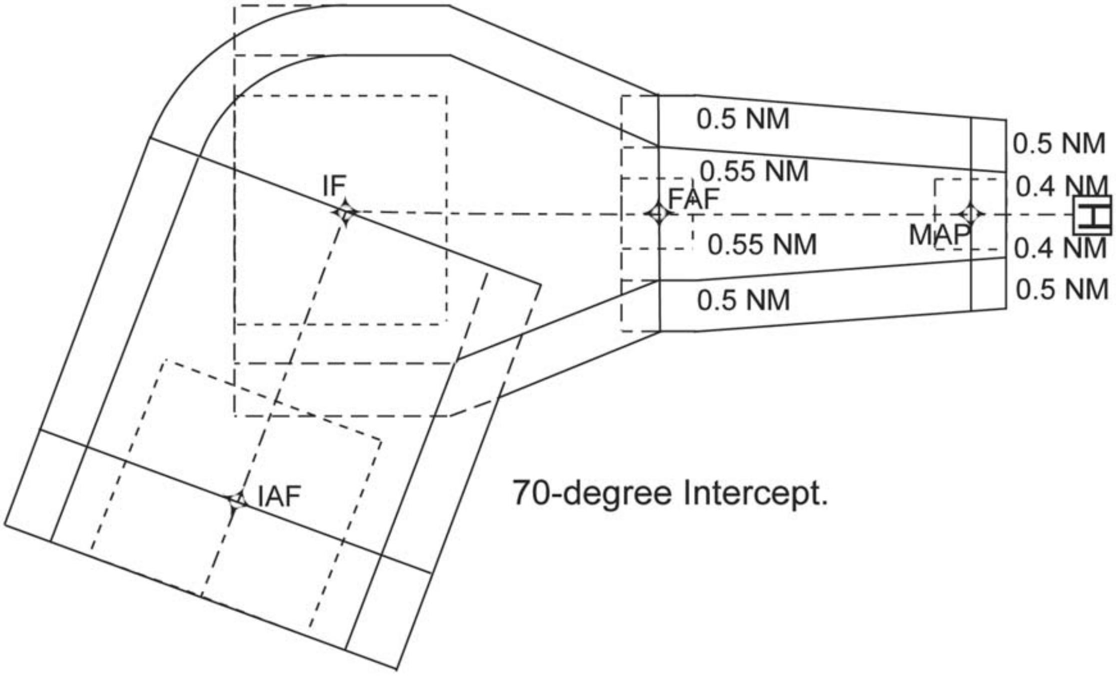


Figure 2-4: Initial/Intermediate Segment Construction. Para 214 and 215.

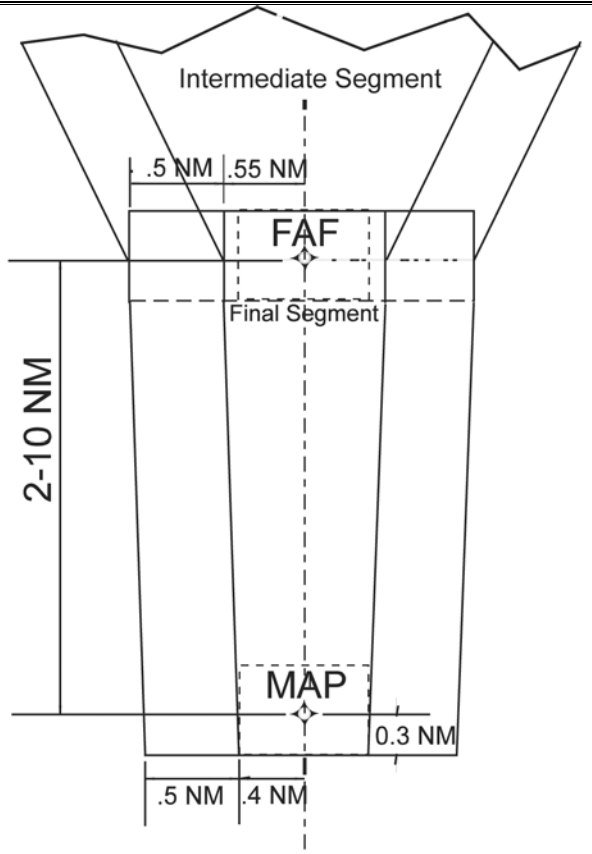


Figure 2-5: Final Segment Construction. Para 216.

216. Final Approach Segment

The final approach segment begins at the FAF and ends at the MAP (see Figure 2-5). Except for point-in-space approaches, apply a visual segment from the MAP to the VSRL (see Para 216.e.). There are three types of final approach segments: approaches aligned to a runway, approaches to a helipoint, and approaches to a point-in-space.

a. Configuration and Alignment.

(1) Approach to a Helipoint and to Runways where Course Alignment is GREATER than 30° from Runway Alignment. Final approach course alignment is from the FAF to the helipoint. The MAP is located on the final approach course between the FAF and a point no closer to the helipoint than 0.3 NM from the VSRL. MAP location should provide the best compromise of lowest visibility and visual segment descent angle.

Note: The minimum distance limitation for locating the MAP guarantees the MAP displacement area will not extend closer than the edge of the helipad/heliport for helipad dimensions less than or equal to 150 x 150 feet.

(2) Approach to a Runway. Volume 1, Chapter 16, Para 1633a, applies, except change reference from 15° to 30°. Para 216e, does not apply.

(3) Point in Space Approach. Volume 5, Chapter 1, Paras 107 and 127c, apply. Para 216.e. does not apply.

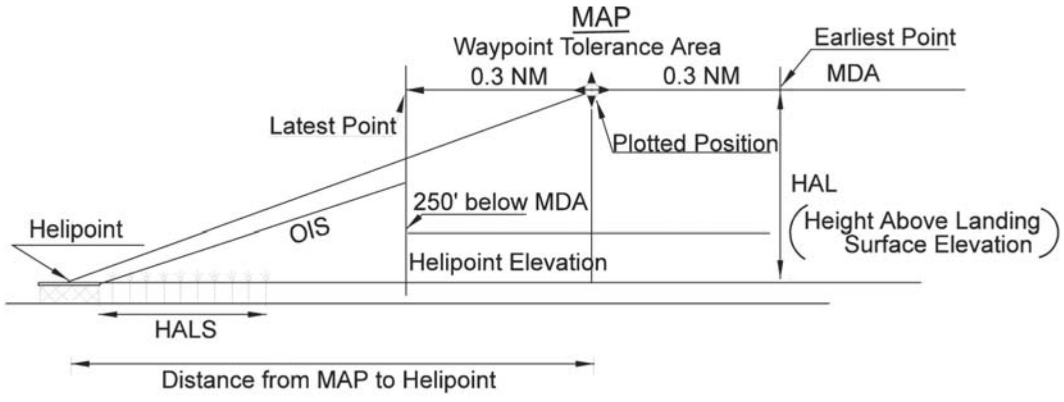
b. Area. The area considered for obstacle clearance begins at the earliest FAF position and ends at the latest MAP position, or the runway threshold, or a point abeam the runway threshold, as appropriate.

(1) Length. The optimum length is 3 NM. The minimum length (FAF to MAP) is governed by the magnitude of turn required at the FAF (see Table 2-2).

(2) Width. The primary area boundary begins 0.55 NM each side of the final segment centerline at the earliest FAF position. The width remains constant until the latest FAF position. It then tapers to 0.4 NM at the latest MAP position. The secondary area boundary is 0.5 NM each side of the primary area.

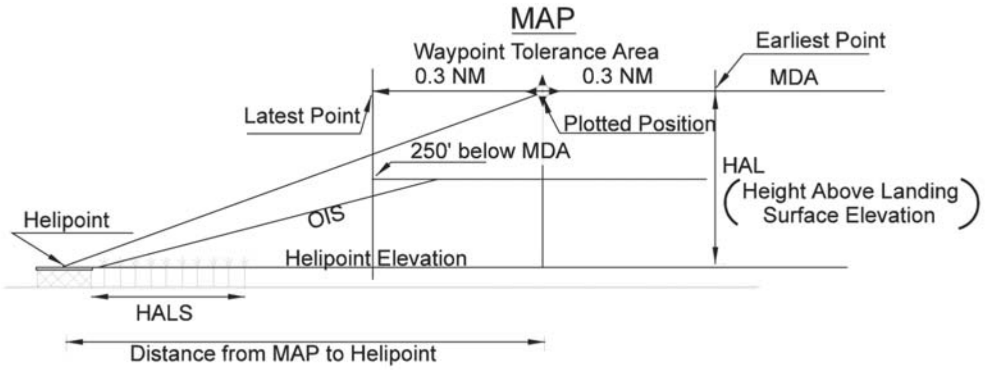
Note: For procedures designed for maximum airspeeds above 70 KIAS: change 0.55 NM to 0.70 NM and 0.40 NM to 0.5 NM in Para 216b(2) above.

c. Obstacle Clearance. Primary area required obstacle clearance (ROC) is 250 feet. Secondary ROC is 250 feet at the edge of the primary area, tapering uniformly to zero at the outer edge.



OIS reaches MDA minus 250 feet first then ends at the latest MAP position

Figure 2-6: Visual Segment OIS Terminating At Latest MAP Position. Para 216.e.(3).



OIS reaches the latest MAP position first then ends at MDA minus 250 feet

Figure 2-7: Visual Segment OIS Terminating At An Altitude 250’ Below The MDA. Para 216.e.(3).

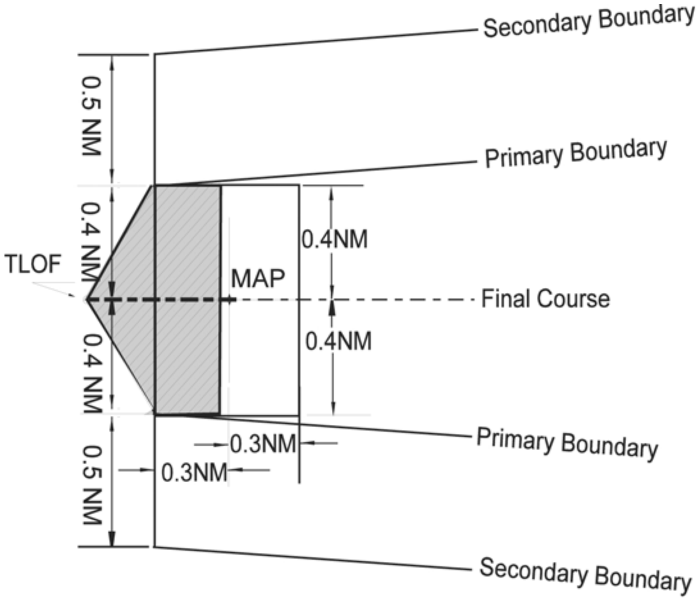


Figure 2-8: Visual Segment Area. Para 216.e.(1).

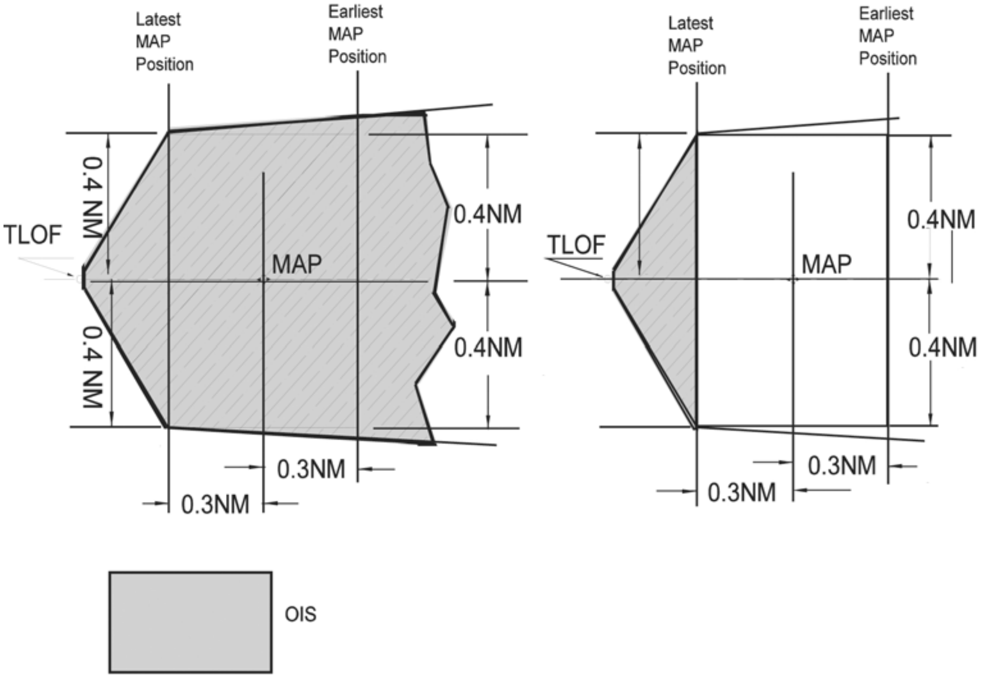


Figure 2-9: Visual Segment Area Showing Splay To Latest MAP Position And Following Final Segment Primary Width. Para 216.e.(1).

d. Descent Gradient. Volume 5, Chapter 1, Para 110, applies, except when the magnitude of turn at the FAF exceeds 30°, the maximum descent gradient authorized is 600 feet per NM. Calculate final segment descent gradient from the FAF altitude at the plotted position of the FAF to the MDA at the plotted position of the MAP.

Note: Minimum Descent Altitude (MDA) is used vice touchdown zone elevation, or helipoint elevation, because it is the approach termination altitude. The helicopter is considered to be in a hover/air-taxi-mode after the MAP when the approach is to a runway. The visual segment descent gradient is considered separately in approaches to helipoints.

e. Visual Segment. The visual segment extends from the plotted position of the MAP to the VSRL and is centred on the final approach course.

Note: For procedures designed for maximum airspeeds above 70 KIAS: minimum visual segment length is 2,500’.

(1) Area (see Figure 2-8 and 2-9).

(a) Length. The area considered for obstacle clearance begins at the VSRL and extends in the direction of the MAP. It extends in the direction of the MAP to the point the visual segment obstacle identification surface (OIS) reaches an altitude 250 feet below the MDA, or the latest MAP position, whichever is further from the helipoint.

(b) Width. The visual segment area begins at the width of ±75 feet, measured perpendicular to the final course and splays to the edges of the final primary area at the latest MAP position. It follows the width of the primary area to the end of the OIS.

(2) Visual Segment Descent Angle. The VSDA is measured from the MDA at the MAP to helipoint elevation at the helipoint. Maximum VSDA is 10.2°, optimum is 6.0°, and the minimum is 3.0°.

(3) Visual Segment OIS. The slope of the OIS is 1.0° less than the computed VSDA. Evaluate obstacles based on the shortest distance, measured along the visual segment centreline, from the obstacle to the surface origin line. Obstacles shall not penetrate the OIS (see Figure 2-6 and 2-7).

(4) Formula. Use the following formulae to calculate HAL, visual segment length from VSRL to a point 250 feet below MDA (VSL250), and VSDA.

$$\text{HAL} = \text{MDA} - \text{Helipoint Elevation}$$

$$\text{VSL250} = \frac{HAL - 250}{\tan(VSDA - 1^\circ)}$$

$$\text{VSDA} = \text{arc tan}\left(\frac{HAL}{D}\right)$$

Where D = MAP to Helipoint Distance in Feet

f. Visual Descent Point (VDP). A VDP may be established for helicopter GPS procedures. The VDP concepts in Volume 5, Chapter 2, Appendix 1 apply, except for: approaches to helipoints, change “runway threshold” and “runway touchdown point” to “helipoint,” and “VASI” to “VGSI, PAPI, or CHAPI.” The recommended VDP on-glideslope angle is 6°. The maximum angle is 10°, and the minimum angle is 3°. Publish the VDP as an ATD from the MAP. Do not publish a VDP if the VDP occurs between the MAP and the helipoint. Locate the VDP on the final course at the point where the visual glideslope indicator (VGSI) on-glideslope beam intersects the MDA. Where lights are not established, the VDP is located on the final course at a distance from the helipoint (threshold for approaches to runways) calculated by the following formula:

$$\text{Distance} = \frac{\text{HAL}}{0.131663}$$

Note: This distance is predicated on a descent gradient of 800 feet/NM.

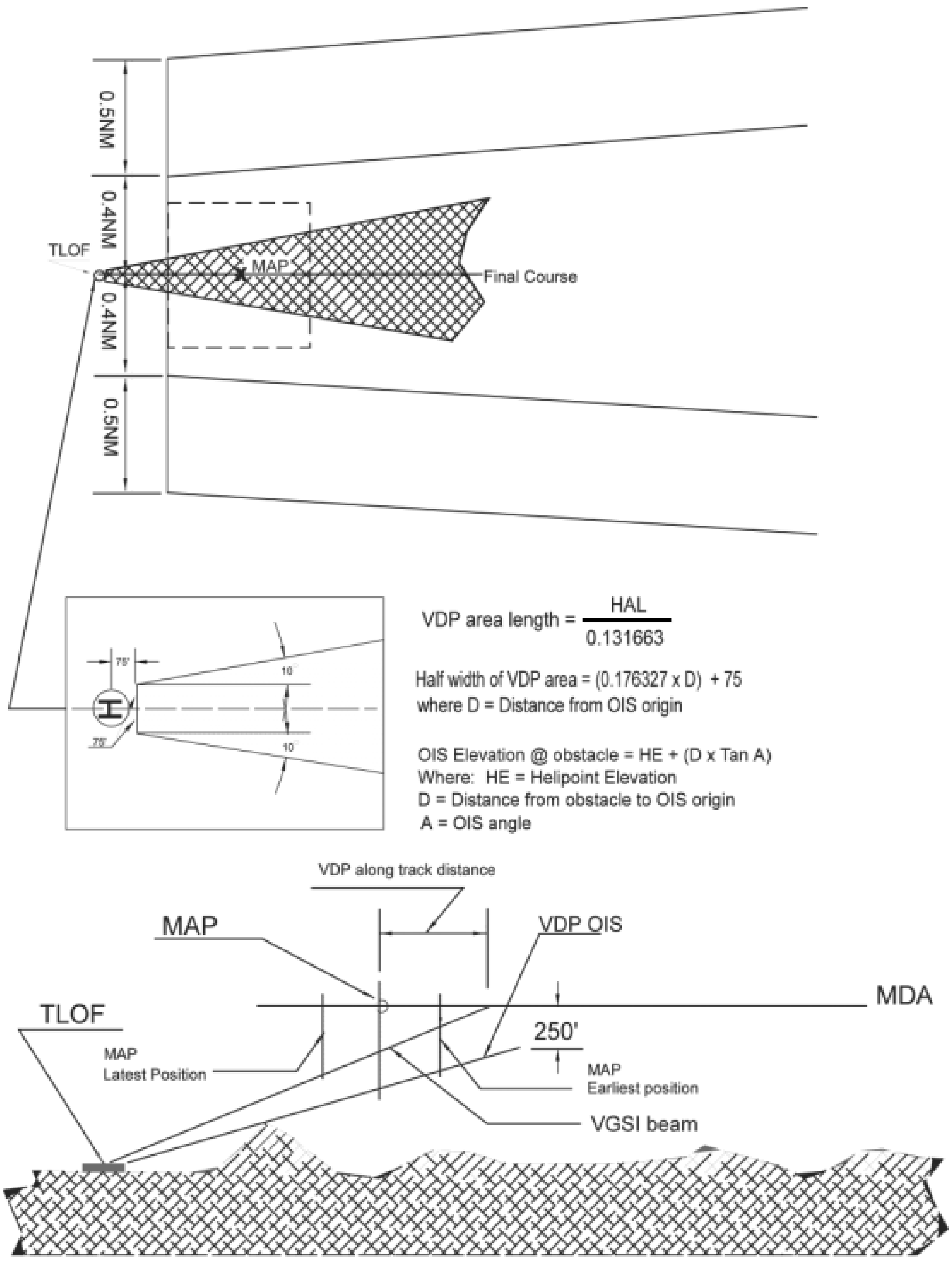
(1) Area.

(a) Straight-In Approaches to Runways. The VDP area for approaches to runways is described in Volume 5, Chapter 2, Appendix 1. Where no VASI is installed, the VDP OIS rises at a 6.5° angle from the threshold to the VDP.

(b) Approaches to Helipoints. Center the VDP area on the final approach course. The VDP OIS origin is VSRL. The surface splays outward at a 10° angle relative to the course line. It ends at the VDP, or where the VDP OIS elevation is equal to the MDA, minus the ROC, whichever occurs first. The VDP OIS inclines upward and outward from its origin at an angle 1° below the aiming angle of the on-glideslope beam. Where no VGSI is installed, the VDP OIS rises at a 6.5° angle from the point of origin.

(2) Obstacle Clearance. No obstacle shall penetrate the VDP OIS (see Figure 2-10). Use the following formula to calculate the OIS elevation above mean sea level (MSL) at a specified obstacle location:

OIS Elevation = HE + (D x tan A)
Where: HE = helipoint elevation
D = distance (ft) from the obstacle to OIS origin
A = OIS angle



$$\text{VDP area length} = \frac{\text{HAL}}{0.131663}$$

Half width of VDP area = $(0.176327 \times D) + 75$
where D = Distance from OIS origin

OIS Elevation @ obstacle = HE + (D x Tan A)
Where: HE = Helipoint Elevation
D = Distance from obstacle to OIS origin
A = OIS angle

Figure 2-10: VDP OIS. Para 216.f.(2).

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SECTION 5. MISSED APPROACH

217. General

The missed approach segment begins at the earliest MAP position and ends at a holding point designated by a missed approach holding fix (MAHF) clearance limit. OPTIMUM routing is straight ahead to a direct entry into holding at the MAHF. TP308/GPH209, Volume 1, Chapter 16, applies, with the following exceptions:

a. The length of the missed approach segment splay is 7.5 NM, vice 15 NM.

b. Segment route width expands to ±1.5 NM (primary) and 0.5 NM (secondary), vice ±4 NM and 2 NM, respectively.

c. Locate the MAHWP within 25 NM of the HRP/ARP.

d. Use a 20:1 primary OIS slope vice a 40:1 slope and a 4:1 secondary OIS slope vice a 12:1 slope.

e. Construct the turning segment outer turn radius boundary using “wide” methodology.

f. For a turning missed approach use an outer boundary radius of 1.3 NM and a flight path radius of 4,000 feet (0.66 NM).

g. Use Table 2-3 for the minimum leg length from the MAP to the next fix when constructing a “route” missed approach.

h. Distance Added for Turn Anticipation (DTA). Volume 1, Chapter 16, Para 1610.b, applies only to the turn at the first fix of a “route” missed approach using the following formula:

$$\text{DTA} = 1.6 \times \tan\left(\frac{\text{turn angle}}{2}\right)$$

Note: For procedures designed for maximum airspeeds above 70 KIAS, the beginning width of the missed approach segment is ±0.5 NM and the formula:

$$\text{DTA} = 2.0 \times \tan\left(\frac{\text{turn angle}}{2}\right)$$

Turn Magnitude	15° – 30°	>30° – 45°	>45° – 60°	>60° – 90°	>90° – 120°
Minimum Length (NM)	1.5	2	2.5	3	3.5

Table 2-3: Missed Approach Initial Leg Length. Para 217.g.

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SECTION 6. MINIMUMS FOR HELICOPTER NONPRECISION GPS APPROACHES

218. Application

Minimums specified in Volume 1, Chapter 3, apply to helicopter GPS procedures, except as follows:

a. General Information. Paras 310 and 311 apply. For helicopter procedures to helipoints, substitute “helipoint elevation” for “airport elevation” or “touchdown zone elevation.”

b. Altitudes. Para 321 applies, except, change 40:1 to 20:1. Para 322 does not apply. Minimums are based on the helipoint elevation.

c. Visibilities.

(1) Approaches to Lighted Heliports. The visibility associated with computed height above landing (HAL), as specified in Table 2-4, is the lowest visibility attainable, prior to applying credit for lights.

(2) Approaches to Runways. See Volume 1, Para 1127a(1).

(3) No-Light Visibility. Minimum visibility shall not be less than the distance from the plotted position of the MAP to the helipoint.

(4) Credit for Lights. Where a helicopter approach lighting system (HALS) (or equivalent) is installed, the visibility may be reduced by ¼ statute mile.

Note: Annotate the procedure to indicate the minimum no-light visibility applicable if HALS fails.

d. Lighting Systems for Helicopter GPS Instrument Approach Procedures.

(1) (Heliport Instrument Lighting System (HILS). A HILS is recommended for all helicopter GPS approach operations. Approved runway lighting is adequate for approaches to runways. When a HILS is installed, the system shall be in alignment with the course from the MAP to the helipoint.

(2) Heliport Approach Lighting System. A HALS is necessary for locations desiring lower minimums for approaches designed to heliports.

HAL	250 – 475 feet	476 – 712 feet	713 – 950 feet	Above 950 feet
Visibility Minimum (SM)	½	¾	1.0	Visibility = HAL ÷ TAN 10.2° from helipoint to plotted position of MAP ÷ 5280’; rounded to next higher ¼ mile visibility increment.

Table 2-4: Effect Of Height Above Landing (HAL) Surface Elevation On Visibility Minimums. Para 218.c.

219. Standard Approach Minimums

Volume 1, Para 350, applies, with the application of Volume 5, Para 127. Para 351 does not apply.

220. Standard Alternate Minimums

A heliport/airport served only by GPS approaches is not suitable for use as an alternate. Nonprecision minimums authorized when a heliport or runway is to be used as an alternate shall be the HIGHER of the following or as specified in the appropriate military directive as necessary:

a. Ceiling 800 feet and visibility 2 SM.

b. Highest published COPTER minimums.

c. Highest published Category A straight-in minimums to a runway.

d. Highest published Category A circling minimums (when straight-in minimums are not published).

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SECTION 7. VISUAL PORTION OF THE FINAL APPROACH SEGMENT

250. Final Approach Segment

A visual portion within the final approach segment may be included for Helicopter GPS approaches (see Para 216.f). Since the alignment and dimensions of the non-visual portions of the final approach segment vary with the location and type of navigation facility, applicable criteria are contained in those sections designated for specific navigation facilities.

251. Visual Portion Of The Final Approach Segment

Evaluate the visual area associated with each usable runway at an airport or helipoint. Apply the STRAIGHT-IN area described in Para 251.a.(2) to runways with approach procedures aligned with the helipoint or runway centerline. Apply the OFFSET visual area described in Para 251.a.(3) to evaluate the visual portion of a straight-in approach that is not aligned with the helipoint or runway centerline. These evaluations determine if night operations must be prohibited because of close-in unlighted obstacles or if visibility minimums must be restricted.

a. Area.

(1) Straight-in. (Need not meet straight-in descent criteria.)

(a) Alignment. Align the visual area with the runway centerline extended or the inbound procedure course to a helipoint.

(b) Length. The visual area begins 200 feet from the threshold (THR) at THR elevation, and extends to the DH point for precision procedures or to the VDP location (even if one is not published) for nonprecision procedures (see Para 253).

Note: When more than one set of minimums are published, use the lowest MDA to determine VDP location.

(c) Width. The beginning width of the visual area is 800 feet (400 feet either side of runway centerline). The sides splay outward relative to runway centerline (see figure 14-6). Calculate the width of the area at any distance "d" from its origin using the following formula:

½ W = (0.138 x d) + 400

Where ½ W = perpendicular distance in feet from centreline to edge of area

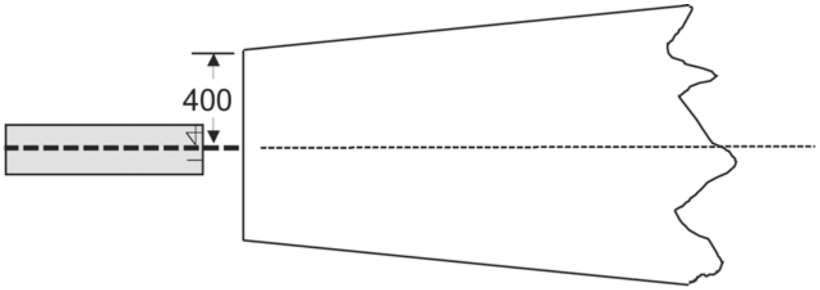


Figure 14-6: visual area origin. Para 251.a.(2).

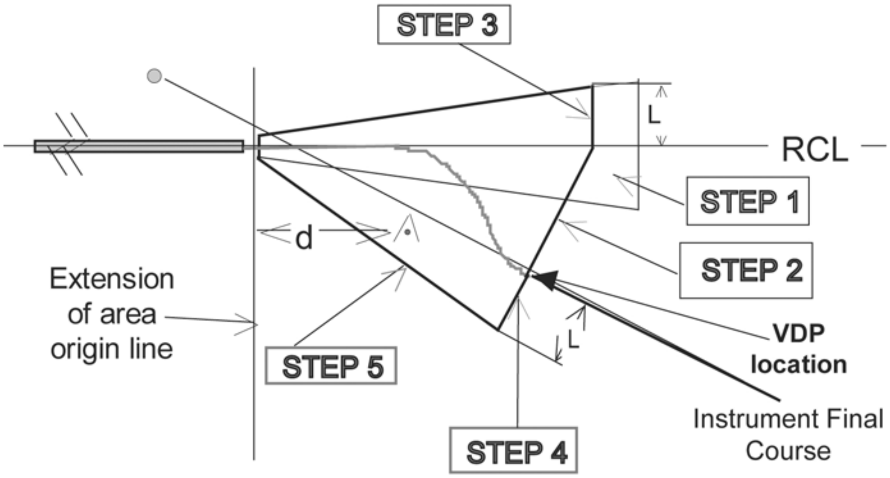


Figure 14-6a: visual segment for offset course. Para 251.a.(3).

(2) Offset. When the final course does not coincide with the helipoint or runway centerline extended (± 0.05°), modify the visual area as follows: (See Figure 14-6a)

(a) STEP 1. Draw the area aligned with the runway centerline as described in Para 251.a.(2).

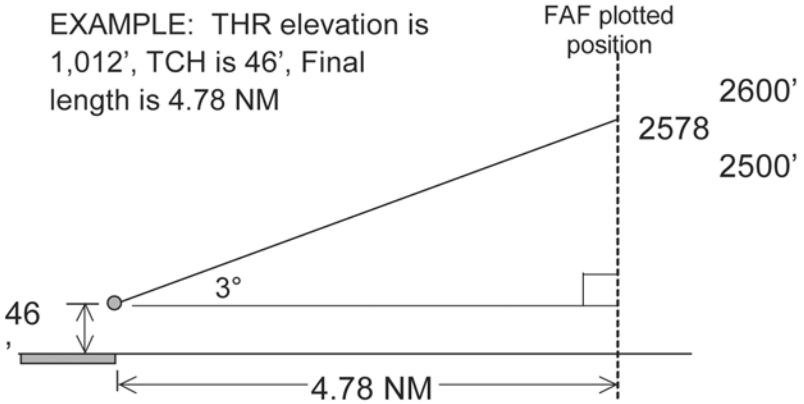
(b) STEP 2. Extend a line perpendicular to the final approach course (FAC) from the visual descent point (VDP) (even if one is not published) to the point it crosses the runway centerline (RCL) extended.

(c) STEP 3. Extend a line from this point perpendicular to the RCL to the outer edge of the visual area, noting the length (L) of this extension.

(d) STEP 4. Extend a line in the opposite direction than the line in Step 2 from the VDP perpendicular to the FAC for the distance (L).

(e) STEP 5. Connect the end of the line constructed in Step 4 to the end of the inner edge of the area origin line 200 feet from runway threshold.

SL in NM:
FAF Altitude = THRe + TCH + (318' SL)
SL in feet:
FAF Altitude = THRe + TCH + (tan (VGSI angle) x SL x 6076.11548)
where: THRe = THR Elevation
SL = Segment Length



$$2578.04 = 1012 + 46 + (318 \times 4.78)$$

or

$$2580.12 = 1012 + 46 + \tan(3°) \times (4.78 \times 6076.11548)$$

Figure 14-8: FAF Activities Given Final Length. Para 252.a.

b. Obstacle Clearance. Two obstacle identification surfaces (OIS) overlie the visual area with slopes of 20:1 and 34:1, respectively. When evaluating a runway for an approach procedure satisfying straight-in alignment criteria, apply the 20:1 and 34:1 surfaces. Calculate the surface height above threshold at any distance “d” from an extension of the area origin line using the following formulae:

$$20 : 1 \text{ Surface Height} = \frac{d}{20}$$

$$34 : 1 \text{ Surface Height} = \frac{d}{34}$$

(1) If the 34:1 surface is penetrated, take **ONE** of the following actions:

(a) Adjust the obstacle height below the surface or remove the penetrating obstacles.

(b) Limit minimum visibility to ¾ mile.

(2) In addition to the 34:1 evaluation, if the straight-in runway's 20:1 surface is penetrated, take **ONE** of the following actions:

(a) Adjust the obstacle height below the surface or remove the penetrating obstacles (see Figure 14-8).

(b) Do not publish a VDP, limit minimum visibility to 1 mile, and take action to have the penetrating obstacles marked and lighted.

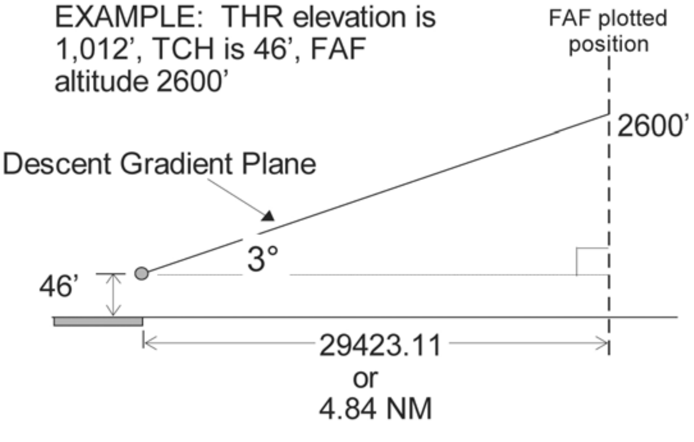
(c) Do not publish a VDP, limit minimum visibility to 1 mile, and publish a note denying the approach (both straight-in and circling) to the affected runway at night.

c. RNAV Approaches. If feasible, place the FAF waypoint where the optimum descent angle, or the lowest published VGSI (if installed) glidepath angle intersects the intermediate altitude or the altitude determined by application hold-in-lieu of PT criteria in Para 234.e.(1). When an SDF is used, the SDF altitude should be at or below the published VGSI glide slope angle (lowest angle for multi-angle systems). See Figure 14–9.

$$SL = \frac{\left(\text{FAF Altitude} - \left[\text{THRe} + \text{TCH}\right]\right)}{\tan\left(3^\circ \text{ or VGSI angle}\right)}$$

where: SL = Segment Length in feet

THRe = Threshold Elevation



$$29423.11 = \frac{2600 - \left(1012 + 46\right)}{\tan\left(3^\circ\right)}$$

Figure 14-9: Final Length Given FAF Altitude. Para 252.b.

252. Visual Descent Point (VDP)

When dual minimums are published, use the lowest minimum descent altitude (MDA) to calculate the VDP distance. **PUBLISH A VDP FOR ALL STRAIGHT-IN NONPRECISION APPROACHES** except as follows:

- Do not publish a VDP associated with an MDA based on part-time or full time remote altimeter settings.
- Do not publish a VDP located prior to a stepdown fix.
- If the VDP is between the MAP and the runway, do not publish a VDP.

a. For runways served by a VGSI, using the VGSI TCH, establish the distance from THR to a point where the lowest published VGSI glidepath angle reaches an altitude equal to the MDA. Use the following formula:

$$\text{VDP Distance} = \frac{\text{MDA} - (\text{TCH} + \text{THR Elevation})}{\tan(\text{VGSI Angle})}$$

b. For runways NOT served by a VGSI, using an appropriate TCH from Table 18A, establish the distance from THR to a point where the greater of a 3° or the final segment descent angle reaches the MDA. Use the following formula:

$$\text{VDP Distance} = \frac{\text{MDA} - (\text{TCH} + \text{THR Elevation})}{\tan(\mathbf{*}\text{Angle})}$$

***** Final segment descent angle or 3°, whichever is higher.

c. Marking VDP Location.

(1) For RNAV SIAP’s, mark the VDP location with an along track distance (ATD) fix to the MAP. Maximum fix error is ± 0.5 NM.

(2) If the final course is not aligned with the runway centerline, use the THR as a vertex, swing an arc of a radius equal to the VDP distance across the final approach course (see Figure 14-12). The point of inter-section is the VDP. (For RNAV procedures, the distance from the point of intersection to the MAP is the ATD for the VDP.)

253—299. Reserved

Figure 14-10 and 14-11: Reserved.

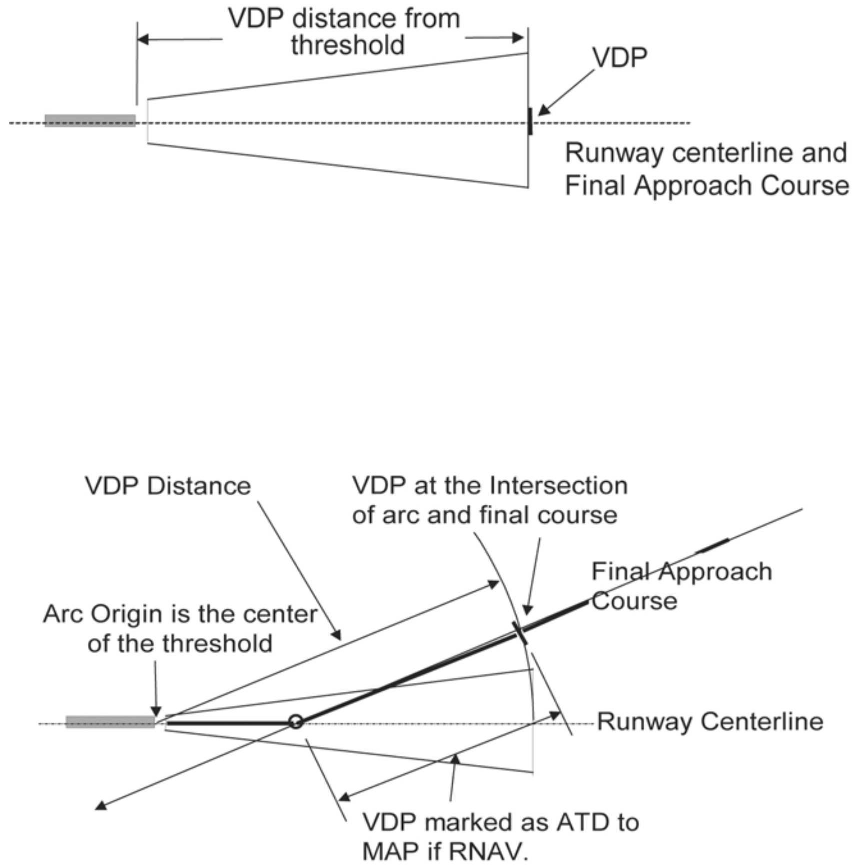


Figure 14-12: VDP Location. Para 252.c.(3).

CRITERIA FOR THE
DEVELOPMENT OF
INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 5.3

VOLUME 6

SUPPLEMENTAL CRITERIA CONSTRUCTION

TRANSPORT CANADA
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15 Dec 2011

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CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 5.3

VOLUME 6

DOC 1

FLIGHT MANAGEMENT SYSTEM (FMS)

TRANSPORT CANADA
NATIONAL DEFENCE

15 Dec 2011

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CHAPTER 1. ADMINISTRATIVE

1.1 PURPOSE

This document provides criteria for establishing instrument area navigation (RNAV) approach, transition to instrument landing system (ILS) precision final approach, in conjunction with TP308/GPH209 *Criteria for the Development of Instrument Procedures*.

Note: All issued and valid deviations, issued by Transport Canada to FAA Order 8260.40B may be considered valid as deviations to TP308 Volume 6 Document 1 Flight Management Systems (FMS)

1.2 – 1.4 RESERVED

1.5 INFORMATION UPDATE

Any deficiencies found, clarification needed, or improvements to be suggested regarding the content of this document, shall be forwarded for consideration to:

Transport Canada Civil Aviation
Chief, Air Navigation & Airspace Standards (AARTA)
Tower C, Place de Ville
330 Sparks St.
Ottawa, Ontario
K1A 0N5

1.6 DEFINITIONS

a. **Approach Operations**. That portion of flight conducted on charted Instrument Approach Procedures (IAP's) commencing at the initial approach waypoint (IAWP) and concluding at landing or the missed approach holding waypoint (MAHWP). All FMS instrument approaches shall be called up from a database contained within the FMS itself.

b. **Departure End of Runway (DER)**. The end of the takeoff run available.

c. **En Route Operations**. That portion of flight conducted on charted VOR routes designated as high or low altitude routes (Jet or Victor) or direct point-to-point operations between defined waypoints.

d. **Flight Management System (FMS)**. An FMS is an onboard computer system, which integrates inputs from various subsystems to aid the pilot in controlling the airplane's lateral and vertical paths. In addition to navigation, the FMS may accomplish performance functions such as thrust management and fuel flow monitoring.

e. **Instrument Approach Waypoints**. Geographical positions, specified in latitude/longitude, used in defining FMS instrument approach procedures. An FMS approach may include some or all of the following waypoints: feeder waypoint (FWP), IAWP, intermediate waypoint (IWP), final approach waypoint (FAWP), missed approach waypoint (MAWP), runway waypoint (RWP) and MAHWP. The terms waypoint and fix are used interchangeably.

f. **Reference Waypoint**. A waypoint of known location used to geodetically compute the location of another waypoint.

g. **Roll Anticipation Distance (RAD)**. The distance traveled by the aircraft while rolling to the bank angle required for a turn.

h. **Runway Waypoint (RWP)**. A waypoint located on the runway centerline at the runway threshold.

i. **Segment**. A segment or leg is the path between two waypoints. A leg is computed and flown by the FMS as a track. All FMS procedures shall be designed using a series of Track to a Fix (TF) legs.

j. **Takeoff Run Available (TORA)**. The runway length declared available for the ground run of an airplane takeoff.

k. **Takeoff Waypoint (TOWP)**. A waypoint located on runway centerline at the beginning of TORA.

l. **Terminal Operations**. That portion of flight conducted on charted Standard Instrument Departures (SID's), on charted Standard Terminal Arrivals (STAR's), or other flight operations between the last en route waypoint and the IAWP (i.e., feeder routes).

m. **Turn Anticipation**. The capability of FMS to determine the point along a course, prior to a fly-by waypoint, where a turn is initiated to provide a smooth path to intercept the succeeding course. Turn distance includes roll anticipation distance as well as the distance necessary to make the required turn.

n. **Waypoint (WP)**. A predetermined geographical position used for route definition and/or progress reporting purposes that is defined by latitude/longitude. A fly-by waypoint requires the use of turn anticipation to avoid overshoot of the next flight segment. A fly-over waypoint precludes any turn until the waypoint is overflown and is followed by an intercept maneuver of the next flight segment.

o. **Waypoint Displacement Area (WPA)**. The rectangular area formed around and centered on the plotted position of the waypoint. This describes the region within which the aircraft could be placed when attempting to fly over the waypoint considering all error components. Its dimensions are plus-and-minus the appropriate along track (ATRK) and crosstrack (XTRK) fix displacement tolerance values found in table 1.

CHAPTER 2. GENERAL CRITERIA

2.1 GENERAL CRITERIA

a. Use of FMS procedures developed in accordance with these criteria shall be limited to aircraft qualifying for the /G or /R equipment suffix. Specific aircraft equipment requirements to qualify using the criteria contained herein are:

(1) At least one (1) RNAV system or FMS certified for terminal use that meets the following standard:

(a) AC 120-138B or later approved, “Airworthiness Approval of Positioning and Navigation Systems” for the airworthiness approval of installed positioning and navigation equipment.

(2) At least one (1) automatic radio-updated inertial reference unit (IRU), if the RNAV system or FMS does not use a GPS sensor;

(3) A current database containing the waypoints for the RNAV STAR to be flown that can be automatically loaded into the RNAV system or FMS active flight plan;

(4) A system capable of following the RNAV system or FMS lateral flight path and limiting the cross-track error deviation to ±½ the navigation accuracy associated with the procedure or route; and

(5) An electronic map display.

b. Do not use this document for instrument procedure altitudes above 15,000 feet MSL.

c. Procedures developed qualify for required navigation performance RNP.3.

2.2 GENERAL PROCEDURE CONSTRUCTION CRITERIA.

General FMS procedural construction requirements are as follows:

a. Waypoints. Except in the case of an ILS final approach segment, a WP shall be used to identify the beginning point and ending point of each segment in an FMS procedure. WP's shall also be established at holding fixes or at other points of operational benefit, such as waypoints associated with altitude and/or airspeed restrictions. (ILS final approach segment is as defined in Volume 1, chapter 9, paragraph 930. The following waypoint guidelines apply:

(1) Fly-by waypoints should be used whenever possible.

(2) Fly-over waypoints should only be used when operationally necessary; e.g., to ensure lateral avoidance of an obstacle on departure, to ensure over fly of the MAWP. Fly-over waypoints shall not be used for the IAWP, IWP, and the FAWP. Table 1 shows which waypoints may be designated as fly-over.

(3) Waypoint displacement tolerances are associated with each waypoint. Displacement tolerance areas for consecutive waypoints shall not overlap. Table 1 contains a summary of waypoint displacement tolerances for each type of waypoint.

(4) Procedures should be designed using the fewest number of waypoints possible.

(5) Waypoints shall be designated where course, speed, or altitude changes occur.

(6) Procedures shall be designed using seamless path construction, and there shall not be any route gaps or discontinuities.

(7) Each WP shall be defined by latitude and longitude in degrees, minutes, and seconds and shall be developed to the nearest hundredth of a second.

b. Segments. FMS RNAV segments begin and end at a WP.

(1) The segment area considered for obstacle clearance begins at the earliest point of the beginning WP displacement area and, except for the final approach segment, ends at the plotted position of the next WP.

(2) Segment length, except for the final approach segment, is based on the distance between the plotted positions of the WP's defining the segment. Final approach segment length is defined in the appropriate section.

(3) Minimum segment lengths are determined using the following guidelines:

(a) Unless otherwise stated, minimum segment lengths are functions of waypoint type, aircraft speed, and amount of course change at the waypoint, and are determined from values contained in table 2 (fly-by waypoints) and table 3 (fly-over waypoints). Figures 1A, 1B, 1C, 1D, and 1E show how to apply tables 2 and 3 to various combinations of waypoint types.

(b) Table 4 contains speed applicability for the various instrument procedure segments, except the final approach segment. Table 4 is used as an entry key to obtain the appropriate data from tables 2, 3, and 5. Table 6 contains the minimum FMS non-precision final approach segment length based on the amount of turn at the FAWP. If it is necessary to restrict airspeed to values less than shown in table 4, select the appropriate speed from tables 2, 3, and 5 and annotate the procedure accordingly. An approach segment shall not be designed using a higher airspeed than the preceding segment; e.g., the initial segment designed using 160 KIAS while the intermediate segment designed using 220 KIAS.

(c) For consecutive fly-by waypoints with turns in the same direction, the minimum turn distance from table 2 may be reduced by the roll anticipation distance from table 5. (See figure 1E.)

(d) In no case will a segment length be less than the sum of the ATRK waypoint displacement tolerances for the respective waypoints. See table 1 for ATRK waypoint displacement tolerances for the various type waypoints.

(e) The following example illustrates these concepts:

(i) **Example**: Given the FMS approach as shown in figure 2, determine the minimum length of each segment. Every waypoint is fly-by and the maximum altitude on the approach is 7,000 feet.

(ii) **En Route Segment (En Route WP - FWP)**. Since FMS navigation is seamless, the angle of turn, if any, at the en route WP must be known before the minimum distance could be determined.

(iii) **Feeder Segment (FWP - IAWP)**. Since this is a feeder segment and the maximum altitude is less than 10,000 feet MSL, table 4 shows that the 250 KIAS column in table 2 is to be used. Since no course change takes place at the FWP, only the 90° course change at the IAWP will figure in the minimum segment length determination. From table 2 for 250 KIAS and 90° course change, the minimum turn distance is 4.91 NM. For this example, this is also the minimum segment length. Remember that the segment length can be no shorter than the sum of the ATRK waypoint displacement tolerances. From table 1, the ATRK waypoint displacement tolerance is 1.7 NM at the FWP and .3 NM at the IAWP. Summing these results in 2.0 NM. Therefore, the 4.91 NM, as previously determined, is the minimum feeder route length for this example.

(iv) **Initial Segment (IAWP-IWP)**. From table 4, the 220 KIAS column of table 2 is to be used for the initial segment. Since there is a course change at both the IAWP and the IWP, two minimum turn distances must be determined. First, from table 2 for 220 KIAS and the 90° course change at the IAWP, the minimum turn distance is 4.06 NM. Second, from table 2 for 220 KIAS and the 60° course change at the IWP, the minimum turn distance is 2.63 NM. Adding these two distances together results in a minimum initial segment length of 6.69 NM.

(v) **Intermediate Segment (IWP - FAWP)**. From table 4, the 175 KIAS column of table 2 is to be used for the intermediate segment. Again, course changes take place at both waypoints, thus two minimum turn distances will be determined. From table 2 for 175 KIAS and the 60° course change at the IWP, the minimum turn distance is 1.93 NM. Notice, however, that the turns at the IWP and the FAWP are in the same direction, so the RAD may be subtracted from the minimum turn distance. From table 5 for 175 KIAS, a fly-by waypoint and a 60° course change, the RAD is .56 NM. Therefore, the minimum turn distance for the course transition at the IWP is 1.93 - .56 = 1.37 NM. The minimum turn distance for the second course transition at the FAWP is determined in a similar manner. From table 2 for 175 KIAS and a 30° course change, the minimum turn distance is 1.37 NM. From table 5 for 175 KIAS, a fly-by waypoint and a 30° course change, the RAD is .37 NM. Therefore, the minimum turn distance for the second transition at the FAWP is 1.37 - .37 = 1.0 NM. The minimum intermediate segment length is then 1.37 + 1.0 = 2.37 NM.

(vi) **Final Segment (FAWP - MAWP)**. From table 6 with a course change of 30° at the FAWP, the minimum final segment length is 3.5 NM.

c. **Waypoint Definition**. When segments are aligned on a straight continuous course with no turns between approach segments prior to the MAWP, construct all preceding WP's using the MAWP as the reference WP. When segments are not aligned on a straight course, use the MAWP as the reference WP to construct the FAWP; use the FAWP to construct preceding WP if preceding segments are on a straight course; or use the IWP as the reference WP to construct the IAWP when there is a turn at the IWP.

d. **Course Change at Waypoints**. The departure course at a WP is the bearing from that WP to the following WP. The arrival course at the WP is the reciprocal of the course from that WP to the preceding WP, and the difference between the departure course and the arrival course at the WP equals the amount of turn at that WP.

e. **Minimum Safe Altitude**. A minimum safe altitude shall be established using the MAWP as the reference center. Develop sectors in accordance with Volume 1, Chapter 2, paragraph 221.

2.3 IDENTIFICATION OF RNAV STAR PROCEDURES

All procedures developed shall be annotated as follows: “FOR USE BY /G OR /R AIRCRAFT ONLY.". Standard Arrival Procedures (STARs), based on FMS, are identified by the bracketed "RNAV," followed by the runway number/letter, as appropriate; i.e., STAR (RNAV) RWYS 15L, 15R.

2.4 HOLDING

Volume 1, chapter 2, section 9, applies, except paragraph 292d. When holding is at an FMS WP, the primary area of the selected pattern shall be large enough to contain the entire waypoint displacement area. To establish the area, refer to Volume 1, Chapter 18, Holding Criteria. Use 15 NM distance for terminal holding procedures and 30 NM distance for en route holding. Obtain leg-length information from Volume 1, Chapter 18, appendix 1, holding course toward the NAVAID. Outbound-end reduction is not authorized.

CHAPTER 3. FMS NON PRECISION APPROACH CRITERIA

3.1 EN ROUTE AND FEEDER ROUTE CRITERIA

Use en route waypoint displacement tolerances for en route waypoints. Use terminal waypoint displacement tolerances for en route waypoints used as feeder waypoints. For all other purposes, use en route criteria for both en route and feeder route construction. En route obstacle clearance areas are identified as primary and secondary. These designations apply to straight and turning segment obstacle clearance areas. The required angle of turn connecting en route segments to other en route, feeder, or initial approach segments shall not exceed 120°. Where the turn exceeds 15°, expanded turning area construction methods as discussed below apply.

a. Primary Area.

(1) Width. Volume 1, chapter 15, paragraphs 1510a(2) and (3) apply.

(2) Length. The minimum length of an en route segment is determined as described in paragraph 2-2b(3). There is no maximum length for an en route segment. The fix displacement areas of consecutive waypoints shall not overlap.

b. Secondary Area. Volume 1, chapter 15, paragraphs 1510b(2) and (3) apply.

c. Construction of Expanded Turning Areas. Obstacle clearance areas shall be expanded to accommodate turns of more than 15°. For fly-by waypoints, inside turn expansion is constructed to accommodate turn anticipation. For fly-over waypoints, outside turn expansion is applied to protect for the fly-over maneuver.

(1) Fly-by Waypoint. Volume 1, chapter 15, paragraph 1510c(2) applies.

(2) Fly-over Waypoint. With reference to figure 3, determine the expanded area at the outside of the turn as follows:

(a) Using the applicable speed (250 KIAS at and below 10,000 feet MSL, 310 KIAS above 10,000 feet MSL) and turn angle, determine the RAD from table 5. Construct a line (ABCD in figure 3) perpendicular to the preceding route centerline the required RAD past the latest point the waypoint can be determined. This line is a baseline for constructing arc boundaries.

(b) Using the applicable speed and turn angle, enter table 3 and determine the radius of turn. From a point (C in figure 3) on the arc base line, strike an outer primary area boundary arc of table 3 radius in the direction of turn beginning at the point (A in figure 3) where an extension of the outer line of the fix displacement area intersects the base line. Strike another arc of the same radius in the direction of turn beginning at the point (B in figure 3) where an extension of the inner line of the fix displacement area intersects the baseline. Connect the two outer primary area boundary arcs with a tangent line.

(c) From table 3 determine the minimum turn distance. From the plotted position of the waypoint, measure along the outbound course centerline the minimum turn distance (E in figure 3). Transfer this point along a line perpendicular to the course line to the outer primary area boundary (F in figure 3). Connect a line from this point tangent to the outermost primary area boundary arc.

(d) From a point (G in figure 3) on the outer primary area boundary perpendicular to the inbound course at the plotted position of the fix, connect a tangent line to the first outer primary area boundary arc.

(e) Establish outer secondary area boundary arcs by striking arcs of table 3 radius plus 2 NM from the center points (C and D in figure 3) used for the primary area expansion. Connect the two outer secondary area boundary arcs with a tangent line.

(f) At the minimum turn distance determined in paragraph 3-1c(2)(c), transfer the turn completion point (E in figure 3) along a line perpendicular to the course line to the outer secondary area boundary (H in figure 3). Connect a tangent line from this point to the outermost secondary area boundary arc.

(g) From a point on the outer secondary area boundary perpendicular to the inbound course at the plotted position of the fix (I in figure 3), connect a tangent line to the first outer secondary area boundary arc.

d. Obstacle Clearance. Volume 1, Chapter 15, paragraph 1511, applies.

3.2 APPROACH CRITERIA

a. Approach Turning Area Expansion. Obstacle clearance areas will be expanded to accommodate turns of more than 15° at the IAWP, IWP (FACF) and FAWP. See figures 4, 5, and 6. Outside turn expansion is not required at these waypoints. MAWP turn expansion criteria is contained in chapter 6 of this document. Construct the approach turning area expansion as follows:

(1) Determine the ATRK displacement tolerance from table 1. Measure this distance from the WP on the inbound course and plot a line perpendicular to the centerline.

(2) Locate a point on the edge of the primary area on the inside of the turn at the distance of turn anticipation (DTA) prior to the ATRK displacement line. The DTA is measured parallel to the course leading to the WP and is determined by the following formulas:

For turns greater than 15° and less than or equal to 90°

DTA = 2 X tan(turn angle ÷ 2)

For turns greater than 90° and less than or equal to 105°

DTA = 2.5 X tan(turn angle ÷ 2)

For turns greater than 105° and less than or equal to 120°

DTA = 3 X tan(turn angle ÷ 2)

(3) From this point, splay the primary area by an angle equal to half the course change until this line intersects the primary area of a succeeding segment. Depending on procedure geometry, this may not be the primary area of the immediately following segment.

(4) Construct the secondary area boundary parallel with the expanded turn anticipation primary area boundary a distance of 1 NM. Extend the secondary area boundary line until it intersects another secondary segment area. Depending on procedure geometry, this may not be the secondary area of the immediately following segment.

(5) In the case of small turn angles, the primary or secondary turn expansion lines may not intersect another primary or secondary area boundary. In this case join the expanded areas at respective points abeam the succeeding WP.

(6) Evaluate primary and secondary areas using the required obstruction clearance (ROC) of the segment(s) following the turn WP. These general guidelines apply:

(a) Working from the primary area turn expansion line back toward the inside of the turn, connect all points which outline secondary area. This area will become primary area for obstacle evaluation purposes. If more than one segment's secondary area is outlined, divide the area for ROC application at the earliest point the second WP can be determined.

(b) To evaluate the secondary turn expansion area, connect the ends of the secondary turn expansion line to the ends of the primary turn expansion line. The area so enclosed will be evaluated as secondary area of the adjacent reevaluated primary segment. ROC for obstacles within this area is evaluated perpendicular to the primary area turn expansion line.

b. Initial Approach Segment. The initial approach segment begins at the IAWP and ends at the IWP. See figure 4.

(1) Segmented Path. A segmented initial approach segment is defined by multiple straight-line legs that begin and end with defined fly-by waypoints. See figure 6. If any of these waypoints are also defined as an IAWP, then paragraph 3-2b(4) applies and a separate evaluation for the newly defined initial segment is required, including all segment legs. The initial approach segment may contain up to four legs. Waypoints shall be located where the course changes and shall be named. Minimum leg lengths are determined as described in paragraph 2-2b(3) using the 220 KIAS column in table 2. Turning area expansion as described in paragraph 3-2a shall be applied to segmented path waypoints. Evaluate the primary and secondary turn expansion areas for the segment or leg following the turn waypoint. See figure 6.

(2) Alignment. The angle of intercept between initial legs and between an initial leg and the intermediate segment shall not exceed 120°.

(3) Length. The initial approach segment has no standard length. It will be sufficient to permit any altitude changes required by the procedure. Total length of the initial segment including all legs of a segmented path shall not exceed 50 miles. Minimum individual segment length is determined as described in paragraph 2-2b(3).

(4) Width. The width of the initial segment shall remain at en route width until the latest position of the IAWP. The primary area tapers 90° abeam this point inward at 30° relative to centerline until reaching a width of 1 NM. The secondary area tapers to a width of 1 NM. The taper begins at the latest position of the IAWP abeam the point of taper of the primary area and tapers to a point abeam the primary area where it reaches its reduced width.

(5) Obstacle Clearance. Refer to Volume 1, Chapter 2, paragraph 232c.

(6) Descent Gradient. Refer to Volume 1, Chapter 2, paragraphs 232d and 288a.

c. Intermediate Approach Segment. The intermediate segment begins at the IWP and ends at the FAWP.

(1) Alignment. The course selected in the intermediate segment should be aligned with the final approach course. When this is not practical, the course change at the FAWP shall not exceed 30°. Paragraph 3-2a applies for turning area expansion.

(2) Length. The minimum intermediate segment length is determined as described in paragraph 2-2b(3). The maximum intermediate length is 15 NM.

(3) Width.

(a) Primary area is 1 NM each side of centerline.

(b) Secondary area is 1 NM on each side of the primary area.

(4) Obstacle Clearance. Volume1, Chapter 2, paragraph 242c, applies.

(5) Descent Gradient. Volume1, Chapter 2, paragraph 242d, applies.

d. Final Approach Segment. The final approach segment begins at the FAWP and ends at the MAWP.

(1) Alignment.

(a) Straight-In. For a straight-in approach, the final approach course (FAC) shall not exceed 15° from the runway centerline (RCL) extended. Optimum FAC is coincident with the RCL. Where the FAC is within 3° of the RCL, the optimum alignment is to the runway threshold. Where the FAC exceeds 3° from the RCL, the optimum alignment is to a point 3,000 feet from runway threshold on the RCL. Where operationally required, optional alignment is authorized to a point between and including the runway threshold and a point 3,000 feet prior to the runway threshold on the RCL, provided alignment is within 15° of the RCL.

1. Except where the alignment is to the runway threshold, the mandatory location of the MAWP is at the intersection of the FAC and the RCL.

2. Where the alignment is to the runway threshold, the optimum location of the MAWP is at the threshold, with optional location of the MAWP anywhere along the FAC between the threshold and the FAWP.

(b) Circling Alignment. The optimum FAC alignment is to the center of the landing area, but may be to any portion of the usable landing surface. The optional location of the MAWP is anywhere along the FAC between the FAWP and the point abeam the nearest landing surface.

(2) Area. The area (straight and circling) considered for obstacle clearance starts at the earliest point of the FAWP displacement area and ends at the latest point of the MAWP displacement area or the runway threshold or a point abeam the runway threshold, whichever is encountered last. See figure 7. The area extended to the threshold beyond the MAWP, when required, has a constant width for both primary and secondary areas and those dimensions equal the lateral dimensions at the MAWP (see figure 8).

(3) Length. The length of the final approach segment is measured from the plotted position of the FAWP to the runway threshold or a point abeam the threshold, whichever is encountered last. The optimum length is 5 NM. The maximum length is 10 NM. The minimum length shall provide adequate distance for an aircraft to meet the required descent and to regain course alignment when a turn is required over the FAWP. Table 6 is used to determine the minimum length of the final approach segment.

(4) Width.

(a) The final approach primary area is centered on the final approach course. It is 1 NM wide on each side of the course at the earliest point of the FAWP displacement area. This width remains constant until the latest point of the FAWP displacement area. It then tapers to the width of the XTRK displacement tolerance (0.6 NM on each side of the final approach course) at the latest point of the MAWP displacement.

(b) A secondary area 1 NM wide is established on each side of the primary area.

(5) Obstacle Clearance.

(a) Straight-In. The minimum required obstruction clearance (ROC) in the primary area is 250 feet. In the secondary area, 250 feet of ROC shall be provided at the inner edge, tapering uniformly to zero feet at the outer edge.

(b) Circling. A minimum of 300 feet of ROC shall be provided in the circling approach area. Volume 1, Chapter 2, paragraph 260, applies.

(6) Descent Gradient. The optimum descent gradient is 318 feet per mile. Where a higher gradient is necessary, the maximum permissible descent gradient is 400 feet per mile.

(7) Vertical Navigation (VNAV) Descent Angle. A final approach VNAV descent angle meeting the criteria in Volume 1, Chapter 2, shall be published.

e. Obstacle Rich Environment (ORE). Due to the high degree of reliance on the FMS for navigation, redundant airborne equipment, surveillance, or special procedures may be required for certain procedures. When a procedure is considered to be in an ORE, a deviation must be issued by Transport Canada Air Navigation & Airspace Standards.

(1) Assessment. Whenever the minimum procedural altitude in an FMS approach procedure containing turns falls below the height of an obstacle located within 6 NM of the course centerline, an ORE assessment shall be made. For each such obstacle there is a “critical point.” The critical point is that point on the outer edge of the secondary area having the shortest distance to the obstacle using a 15° splay from course centerline. The ORE assessment consists of determining whether a 40:1 incline starting from the critical point at the minimum procedural altitude clears the obstacle. Obstacles that have a critical point abeam or after the FAWP or obstacles that have a critical point abeam or prior to the IAWP do not require an ORE assessment.

(2) Method.

(a) Identify each obstacle higher than the minimum procedural altitude and located within 6 NM of the course centerline that requires an ORE assessment.

(b) Locate the critical point for each obstacle identified above. Because the outer edge of the secondary area might not be parallel to the course centerline, the line from the critical point to the obstacle might not be 15° from the edge of the secondary area. However, the line from the critical point to the obstacle is always 105° from a line perpendicular to the course centerline. Consequently, the critical point is located by sliding a 105° template along the outer edge of the secondary area (with its origin, or corner, on the outer edge of the area) until the 105° line touches the closest point of the obstacle (see figure 9).

(c) Determine whether a 40:1 incline starting from the critical point at the minimum procedural altitude clears the obstacle. This is done by measuring the distance in feet between the critical point and the obstacle and dividing that distance by 40. The quotient is added to the elevation of the critical point (i.e., the MINIMUM procedural altitude abeam the critical point) to compute the height of the 40:1 incline at the obstacle. If the elevation of the obstacle is higher than the height of the 40:1 incline, the environment is obstacle rich. A single penetration of the 40:1 incline is sufficient to make the approach environment obstacle rich (see figure 9).

(d) Obstacles A through D in figure 9 are evaluated to determine whether they require an ORE assessment:

1. Obstacle A is below the minimum procedural altitude at its critical point (2,000 feet) and does not require an ORE assessment.
2. Obstacle B is more than 6 NM from initial segment centerline and does not require an ORE assessment.
3. The 2,379-foot obstacle C requires an ORE assessment because it is higher than the minimum procedural altitude abeam its critical point (2,000 feet). The 40:1 incline starts at this same altitude, 2,000 feet, at the critical point. The distance between the critical point and the obstacle is 14,000 feet. 14,000' ¸ 40 = 350' + 2,000' = 2,350' which is 29 feet below the top of the obstacle. The environment is obstacle rich.
4. Although obstacle D is abeam the final approach segment, its critical point is abeam the intermediate segment. In addition, its 1,899-foot height is above the minimum procedural altitude of 1,500 feet. Consequently, it requires an ORE assessment. The 40:1 incline starts at 1,500 feet at the critical point. The distance between the critical point and the obstacle is 15,000 feet. 15,000' ¸ 40 = 375' + 1,500' = 1,875' which is 24 feet below the top of the obstacle. The environment is obstacle rich.

CHAPTER 4.FMS TRANSITION TO ILS FINAL APPROACH SEGMENT

4.1 EN ROUTE AND FEEDER ROUTE CRITERIA PARAGRAPH 3-1 APPLIES.

4.2 APPROACH CRITERIA See figure 10.

a. Approach Turning Area Expansion. Paragraph 3-2a applies.

b. Initial Approach Segment. Paragraph 3-2b applies, with the following exceptions:

(1) Alignment. The maximum angle of intercept between an initial segment and intermediate is 90°.

(2) Width. The width of the initial segment shall remain at en route width until the latest position of the IAWP. The primary area tapers from 90° abeam this point inward at 30° relative to centerline until reaching a width of 1 NM or the maximum half-width of the ILS final approach area, whichever is greater. The ILS final approach area half-width is defined in Volume 1, Chapter 9, paragraph 930, and is found by using the formula 500' + .15(F - 200'), where F is the distance from the threshold to the glide slope intercept point. The secondary area tapers to a width of 1 NM, beginning abeam the point of taper of the primary area and ending at a point abeam the primary area, where it reaches its reduced width.

c. Intermediate Approach Segment. The intermediate segment begins at the IWP and ends at the ILS glide slope intercept point (GSIP).

(1) Alignment. The intermediate segment course shall be an extension of the final approach course.

(2) Length. The minimum length of the intermediate segment depends on the angle of turn at the IWP. Table 7 specifies minimum intermediate segment lengths.

(3) Width. See figure 11. The primary intermediate segment half-width is 1 NM at the earliest point of the IWP displacement area. This width remains constant until the latest point of the IWP displacement area. It then tapers to the half width of the ILS final approach area at the GSIP. In the case where the maximum half width of the ILS final approach area exceeds 1 NM, then the primary intermediate width is constant at the maximum half-width of the ILS final approach area. The width of the secondary intermediate segment is 1 NM each side of the primary area at the earliest point of the IWP displacement area. This width remains constant until the latest point of the IWP displacement area. It then tapers to the width of the ILS secondary area at the GSIP.

(4) Obstacle Clearance. Volume 1, Chapter 2, paragraph 242c, applies.

(5) Descent Gradient. Volume 1, Chapter 2, paragraphs 242d and 923, apply.

(6) Altitude Selection. The intermediate segment altitude shall not be less than the glide slope intercept altitude.

(7) IWP Placement. In order to assure localizer course capture, the IWP shall be laterally located in the center of the localizer course and shall be placed no closer to the runway threshold than explained in this paragraph. For approaches where there is a course change of less than 15° at the IWP, the IWP shall be no closer to the threshold than a point where the localizer course half-width is 0.3 NM. For approaches with course changes at the IWP of more than 15°, additional distance to account for turn anticipation shall be added to determine minimum IWP distance from the runway threshold. The minimum IWP distance from runway threshold is determined as follows:

(a) Compute the distance from the runway threshold to the point where the localizer course half-width is 0.3 NM.

$$D_1 = D \times \left[\frac{0.3}{(\tfrac{1}{2}\,W \text{ at Thld})} - 0.000164578 \right]$$

Where:

D = Runway threshold to localizer antenna distance (ft)

½ W at Thld = Half-width of localizer at runway threshold (ft)

D_1 = Distance in NM from runway threshold to point where localizer course half-width is 0.3 NM.

Where there is a course change of 15° or less at the IWP, D1 is also the minimum IWP distance from the runway threshold.

Example 1: See figure 12. Given a runway length of 10,000 feet, a localizer antenna to runway end distance of 1,000 feet, a localizer course width of ± 350 feet at the runway threshold and no turn at the IWP, compute the minimum IWP distance.

$$D_1 = 11{,}000 \times \left[\frac{0.3}{(350)} - 0.000164578 \right]$$

$$= 7.62 \text{ NM}$$

Where:

D = 10,000' + 1,000' = 11,000

½ W at Thld = 350'

D_1 = **7.62 NM** is the minimum IWP distance

(b) For turns of more than 15° at the IWP, additional distance must be added to D1 to account for the turn. This additional distance, D2, is found by entering table 2 with the IWP course change and reading the minimum turn distance from the 175 KIAS column. D2 is added to D1 to find the minimum IWP distance.

Example 2. See figure 13. The runway length is 7,000 feet, the localizer course width is tailored ± 350 feet at the threshold and the localizer is located 1,000 feet from the end of the runway. The initial and intermediate segments differ by 30°. Compute the minimum IWP distance.

$$D_1 = 8{,}000 \times \left[\frac{0.3}{(350)} - 0.000164578 \right]$$

$$= 5.54 \text{ NM}$$

Where:

D = 7,000' + 1,000' = 8,000

½ W at Thld = 350'

D_1 = 5.54 NM is the minimum IWP distance

D_2 = 1.37 NM (from table 2, 175 KIAS column, turn angle of 30°)

$D_1 + D_2$ = **5.54 + 1.37 = 6.91 NM** is the minimum IWP distance

Example 3. See figure 14. The runway length is 10,000 feet, the localizer course width is tailored ± 350 feet at the threshold and the localizer is located 1,000 feet from the end of the runway. The initial and intermediate segments differ by 90°. Compute the minimum IWP distance.

$$\mathbf{D_1 = 11{,}000 \times \left[\frac{0.3}{(350)} - 0.000164578 \right]}$$

$$\mathbf{= 7.62\ NM}$$

Where:

D = 10,000' + 1,000' = 11,000

½ W at Thld = 350'

D_1 = 7.62 NM is the minimum IWP distance

D_2 = 2.93 NM (from table 2, 175 KIAS column, turn angle of 90°)

$D_1 + D_2$ = **7.62 + 2.93 = 10.55 NM** is the minimum IWP distance

d. ILS Final Approach Segment. Volume 1, Chapter 9, Section 3 applies. See figure 11.

e. Obstacle Rich Environment. Paragraph 3-2e applies.

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APPENDIX 1. FIGURES AND TABLES

FIGURES:

TABLES:

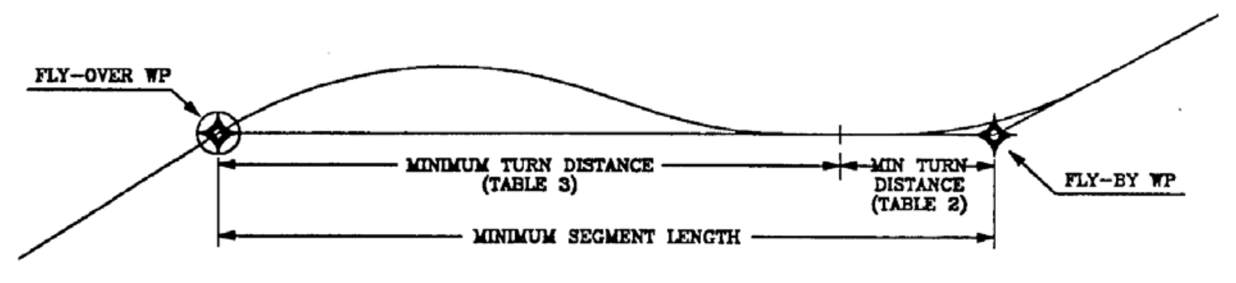


Figure 1A: Minimum Segment Length Fly-Over to fly-By

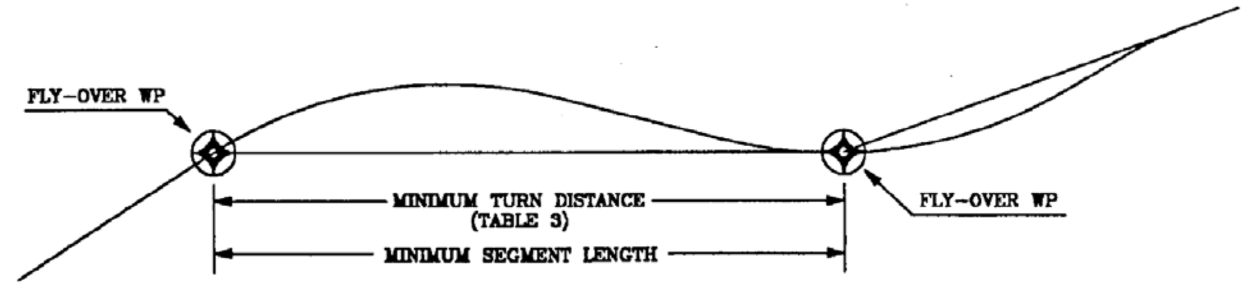


Figure 1B: Minimum segment Length Fly-Over to Fly-Over

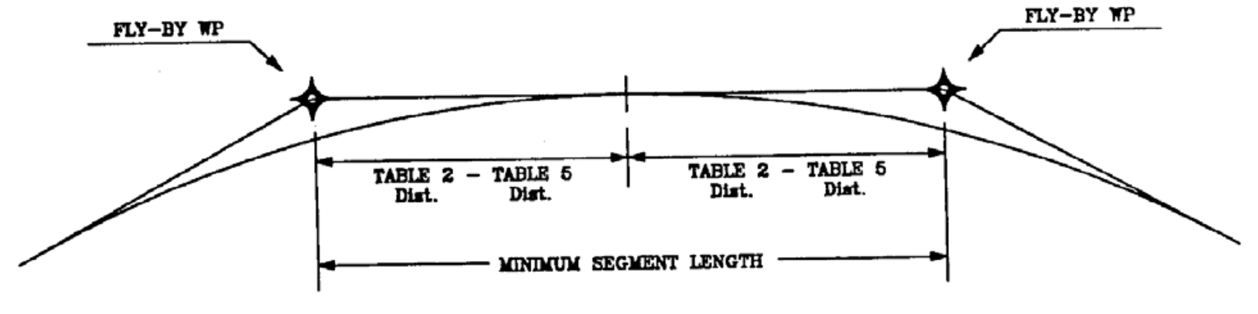


Figure 1C: Minimum segment Length Fly-By to Fly-By

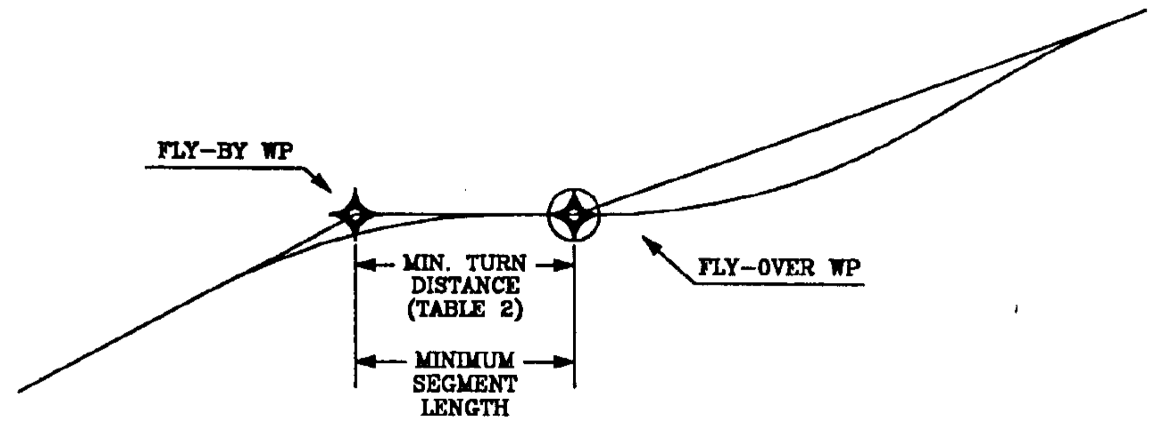


Figure 1D: Minimum Segment Length Fly-By to Fly-Over

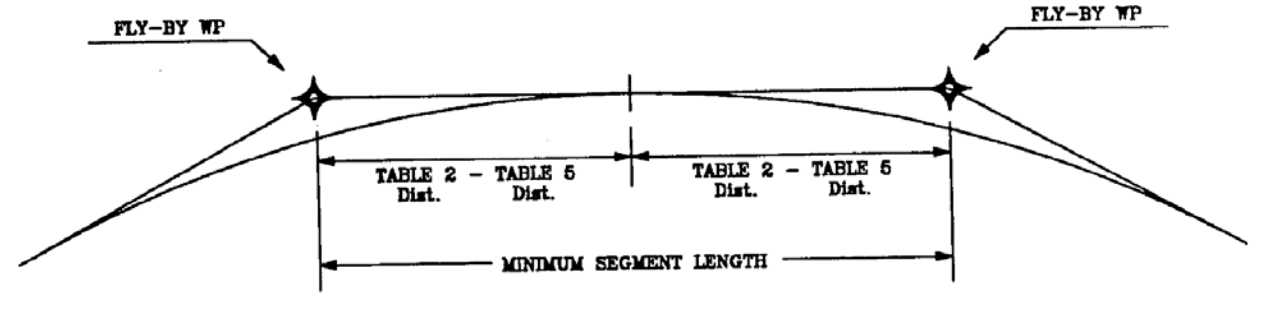


Figure 1E: Minimum Segment Length Fly-By to Fly-By (Turn in Same Direction)

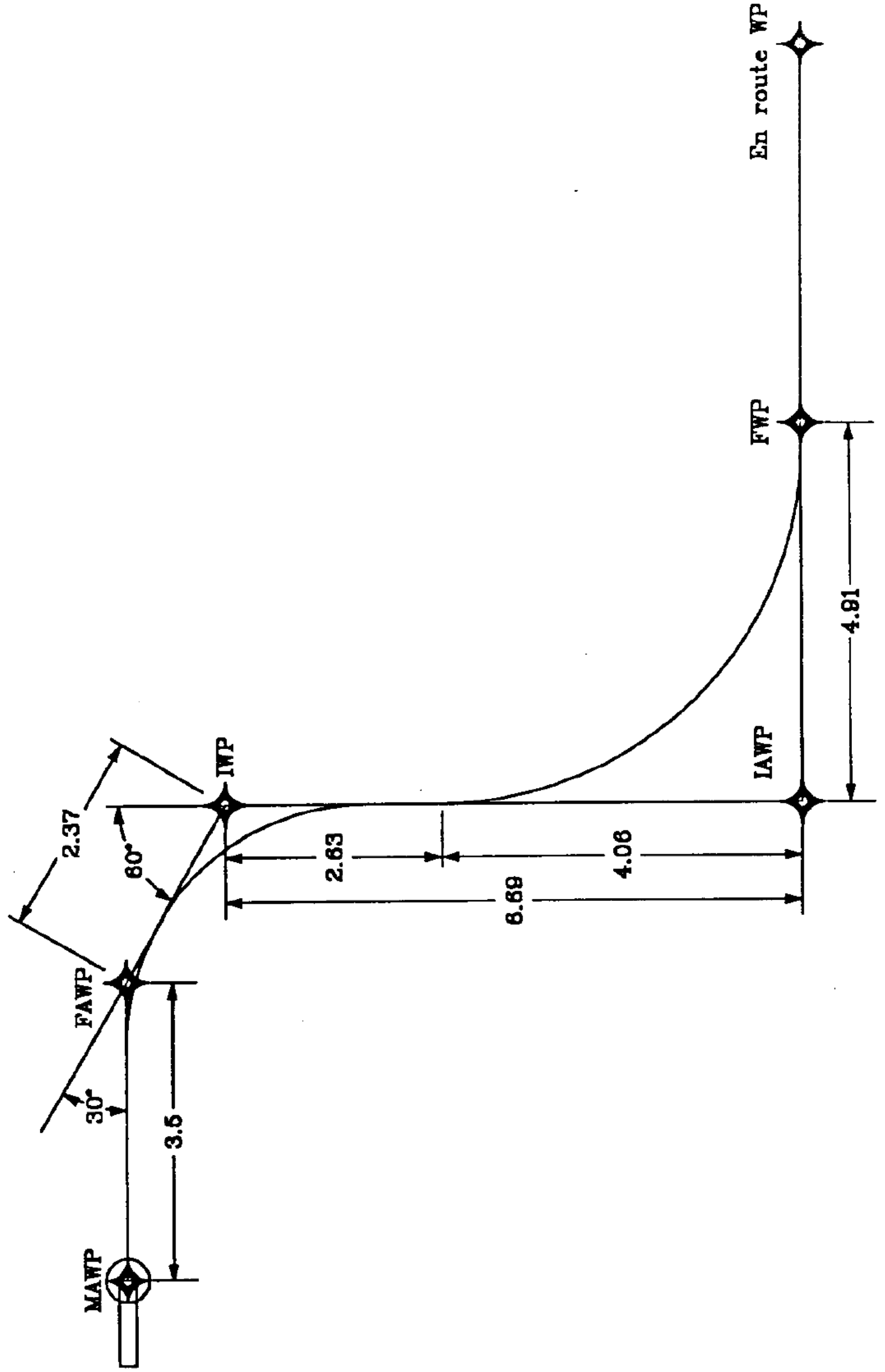


Figure 2: Minimum Segment Length Determination

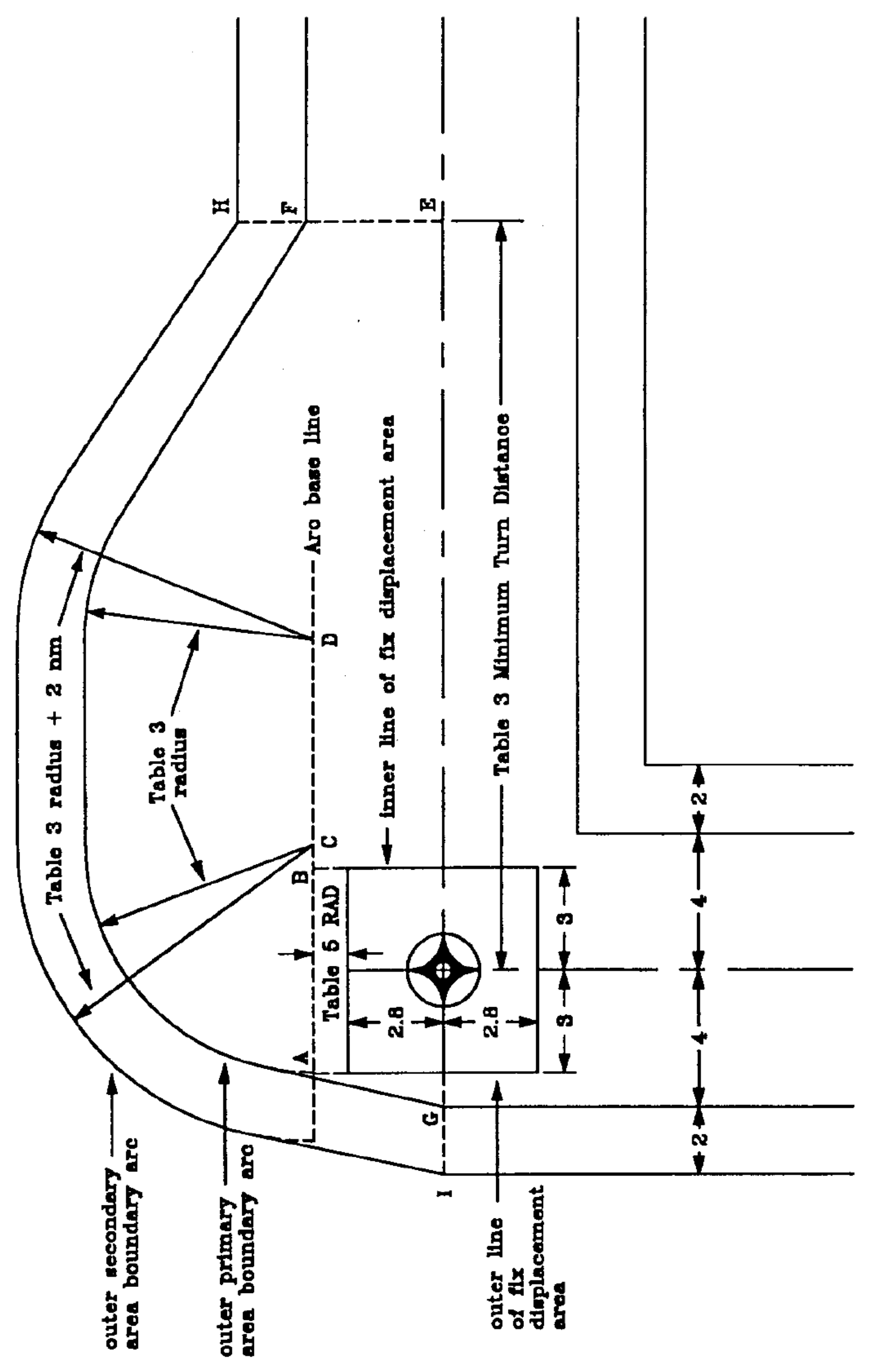


Figure 3: En Route Waypoint Fly-Over Expansion

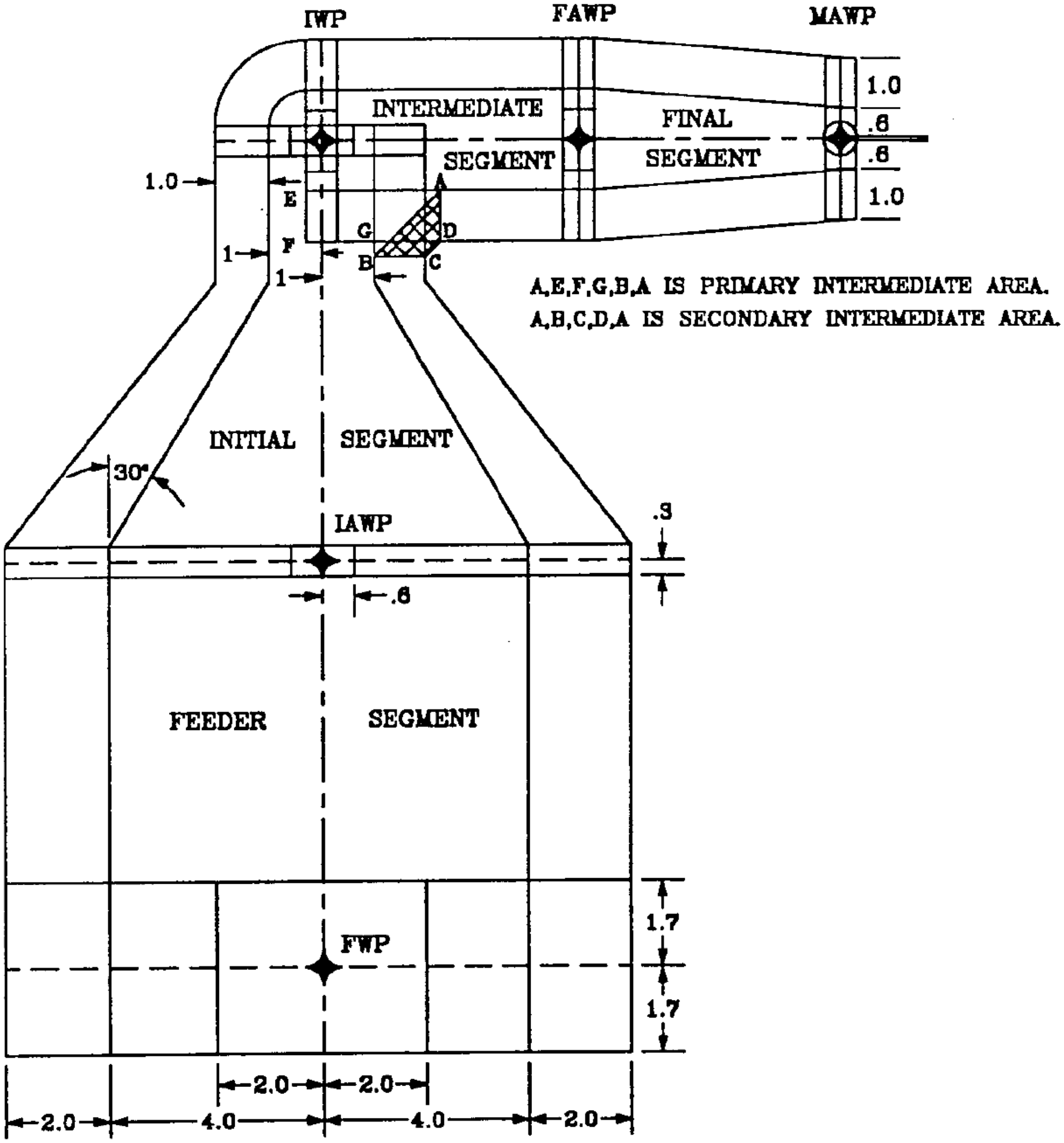
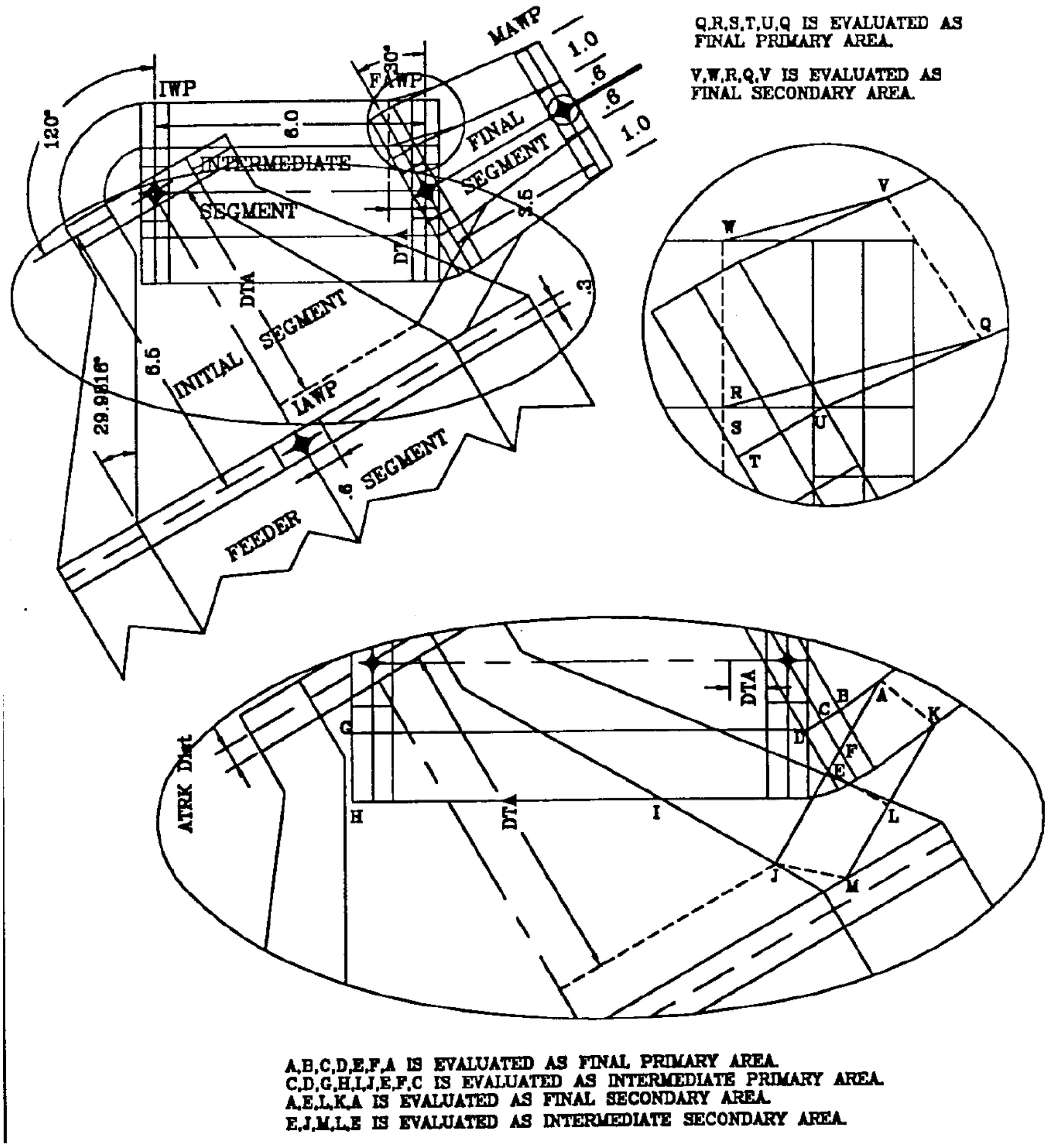


Figure 4: FMS Non Precision Approach Criteria



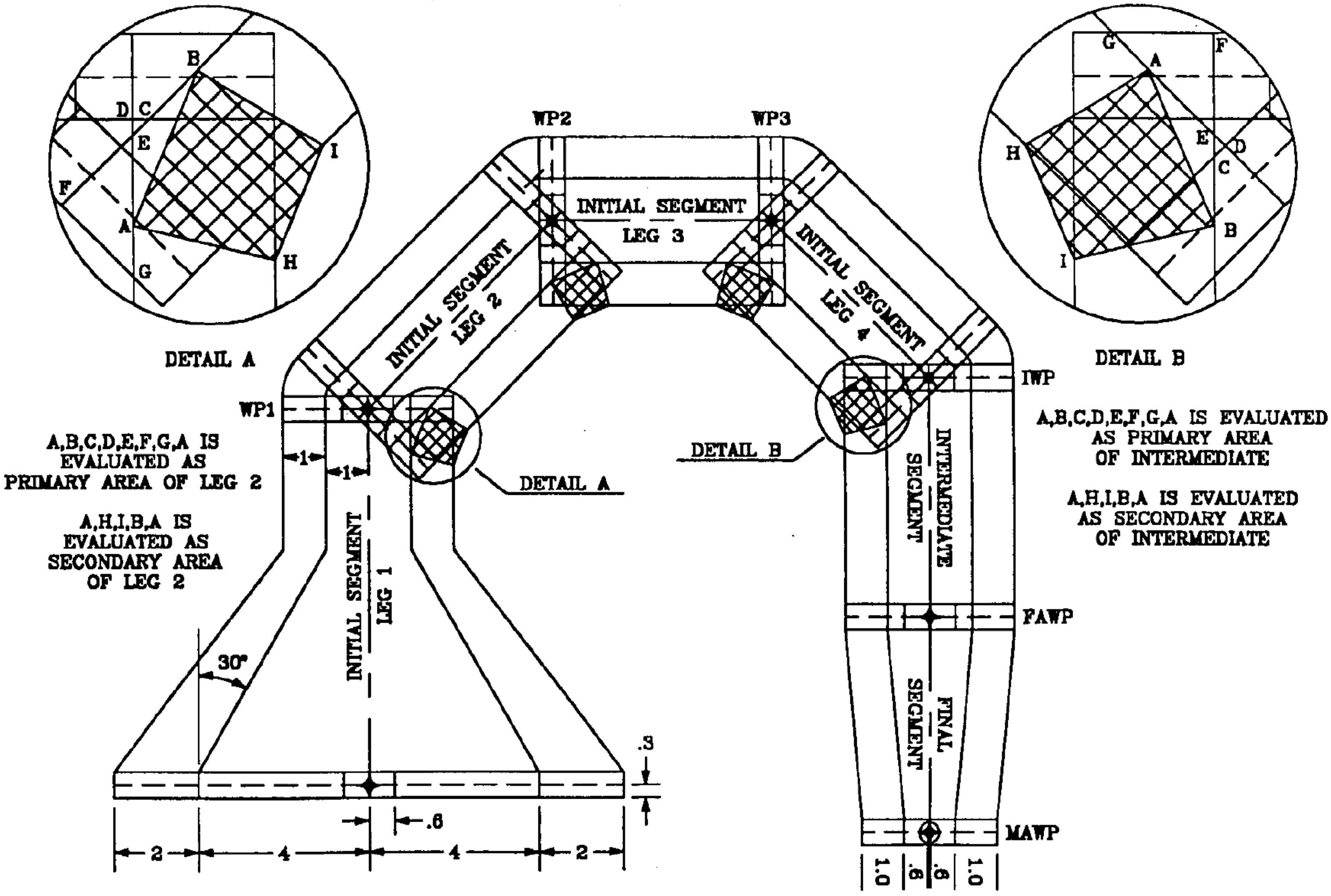
Q,R,S,T,U,Q IS EVALUATED AS FINAL PRIMARY AREA.

V,W,R,Q,V IS EVALUATED AS FINAL SECONDARY AREA.

A,B,C,D,E,F,A IS EVALUATED AS FINAL PRIMARY AREA.
C,D,G,H,I,J,E,F,C IS EVALUATED AS INTERMEDIATE PRIMARY AREA.
A,E,L,K,A IS EVALUATED AS FINAL SECONDARY AREA.
E,J,M,L,E IS EVALUATED AS INTERMEDIATE SECONDARY AREA.

Figure 5: FMS Non Precision Approach Criteria Short Segment Lengths

Figure 6. SEGMENTED PATH INITIAL SEGMENT.



A,B,C,D,E,F,G,A IS EVALUATED AS PRIMARY AREA OF LEG 2

A,H,I,B,A IS EVALUATED AS SECONDARY AREA OF LEG 2

A,B,C,D,E,F,G,A IS EVALUATED AS PRIMARY AREA OF INTERMEDIATE

A,H,I,B,A IS EVALUATED AS SECONDARY AREA OF INTERMEDIATE

Figure 6: Segmented Path Initial Segment

Figure 7 and 8 – Reserved

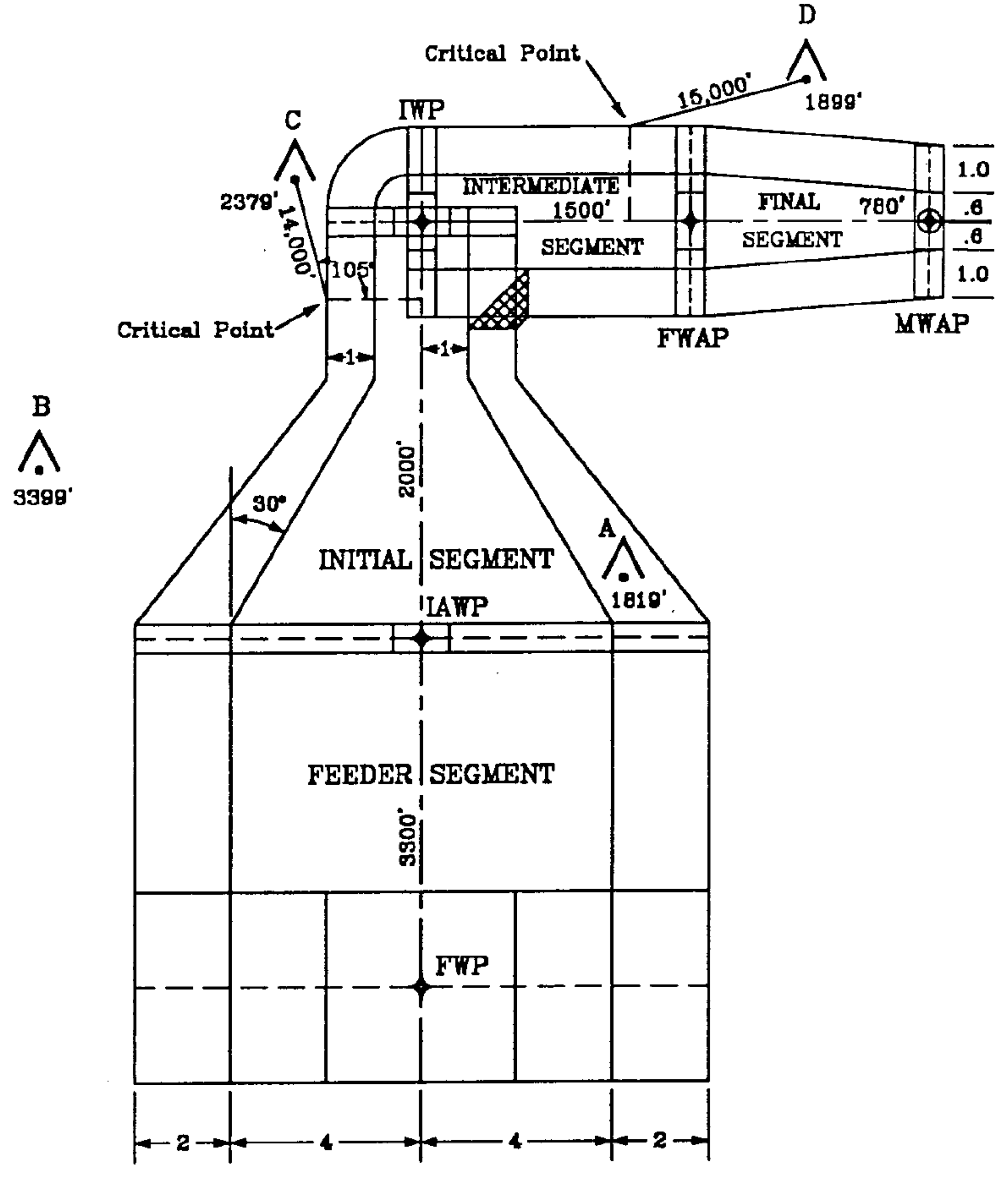


Figure 9: Obstacle Rich Environment Assessment

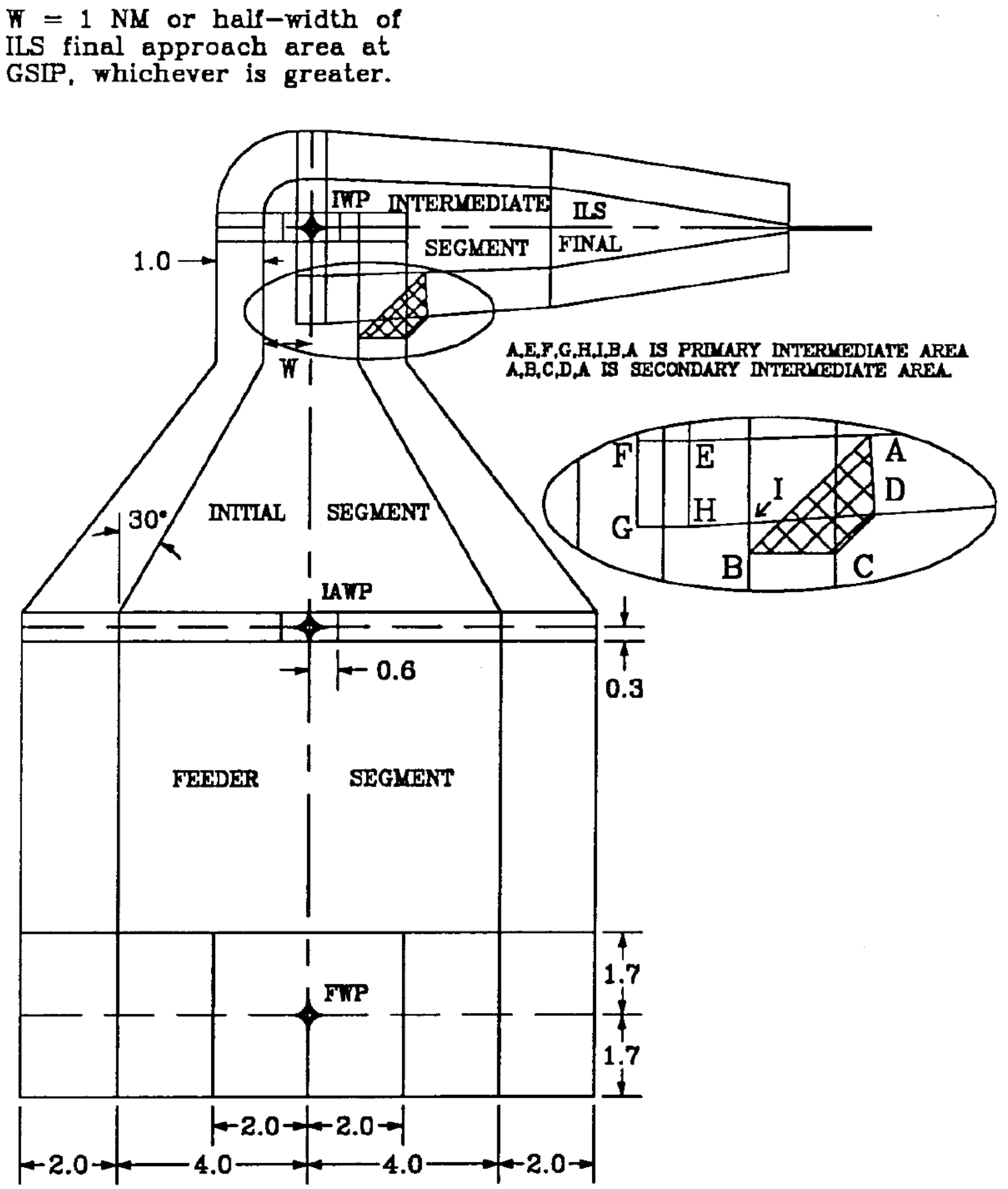
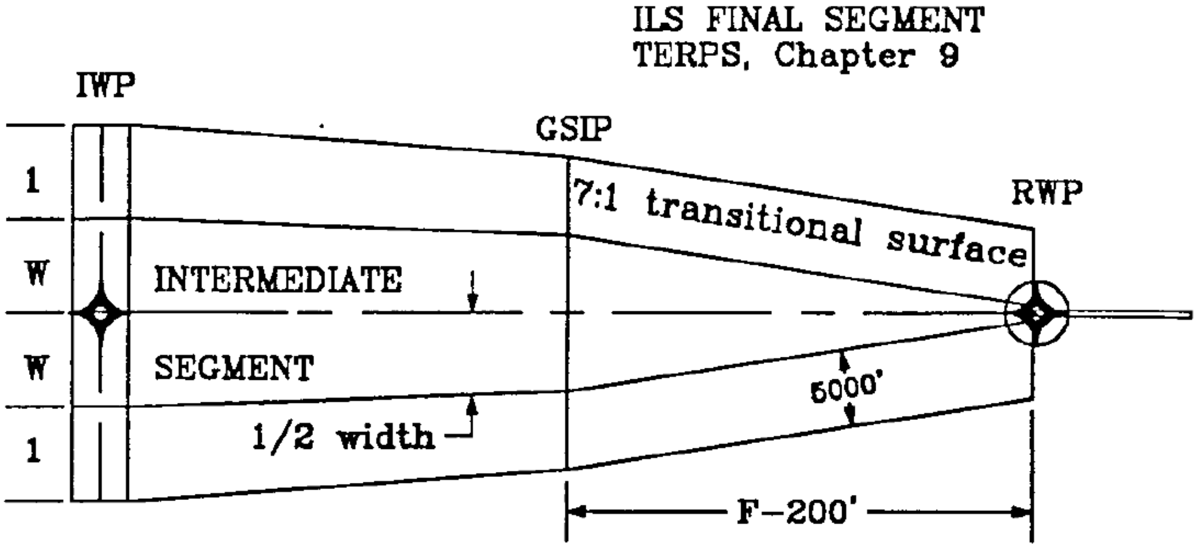


Figure 10: FMS Transition to ILS Final



F = distance from threshold to GSIP

1/2 width = 0.15(F – 200') + 500'

W = 1 NM or half–width of ILS final approach area at GSIP, whichever is greater.

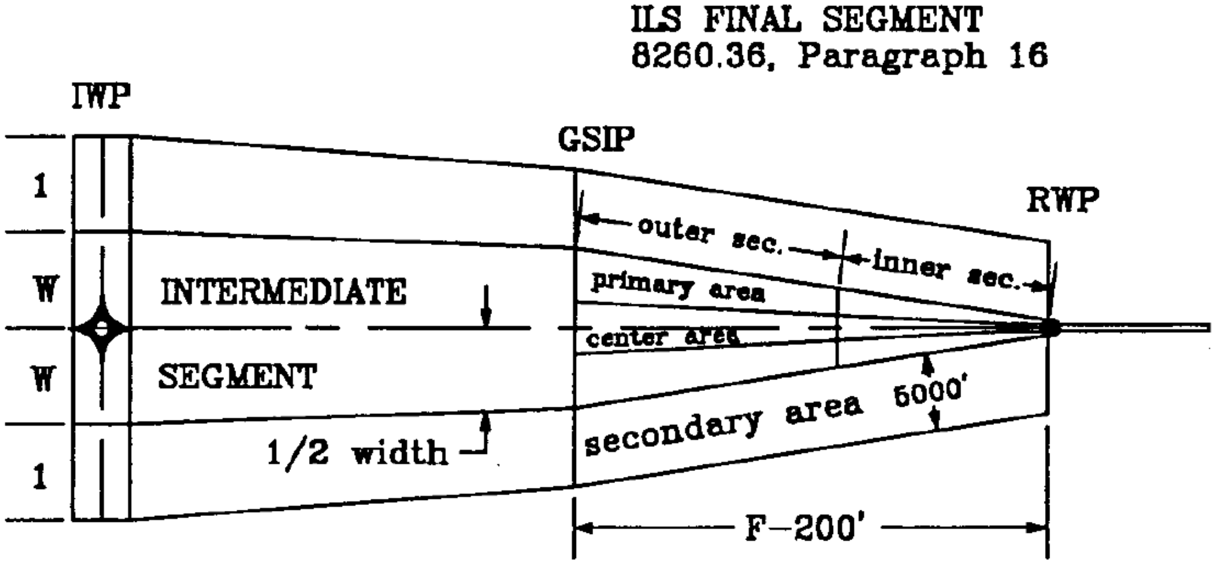


Figure 11: FMS Intermediate segment to ILS Final Segment

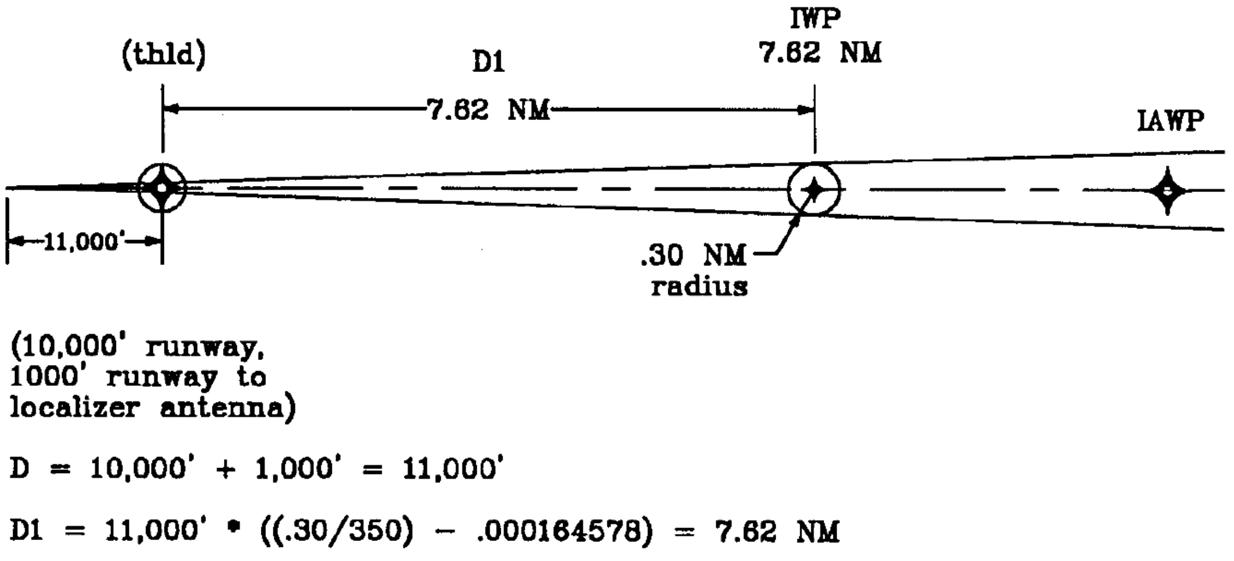


Figure 12: IWP Placement, Example 1

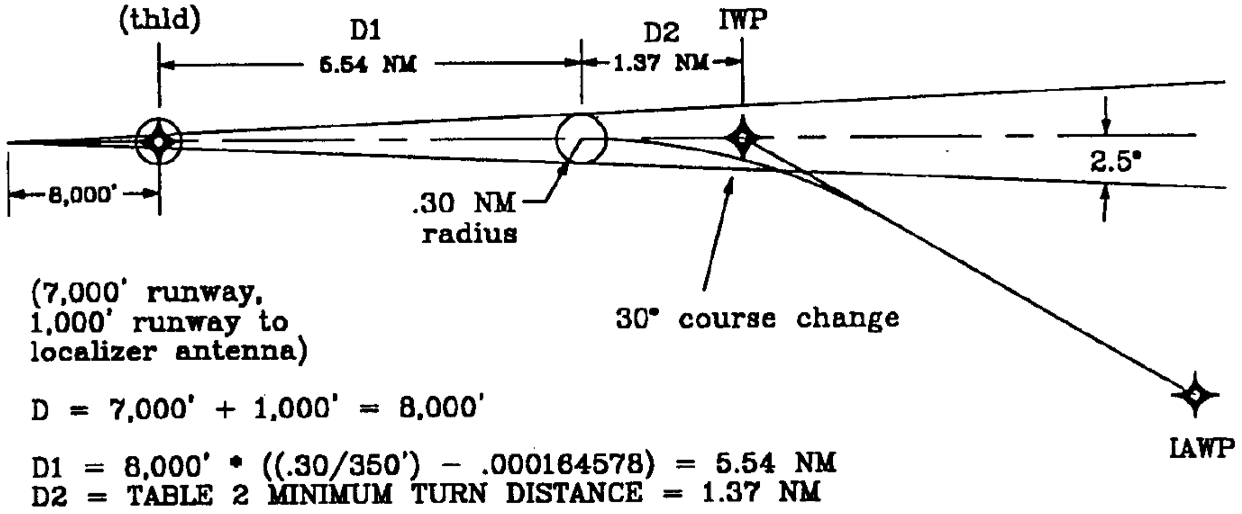


Figure 13: IWP Placement, Example 2

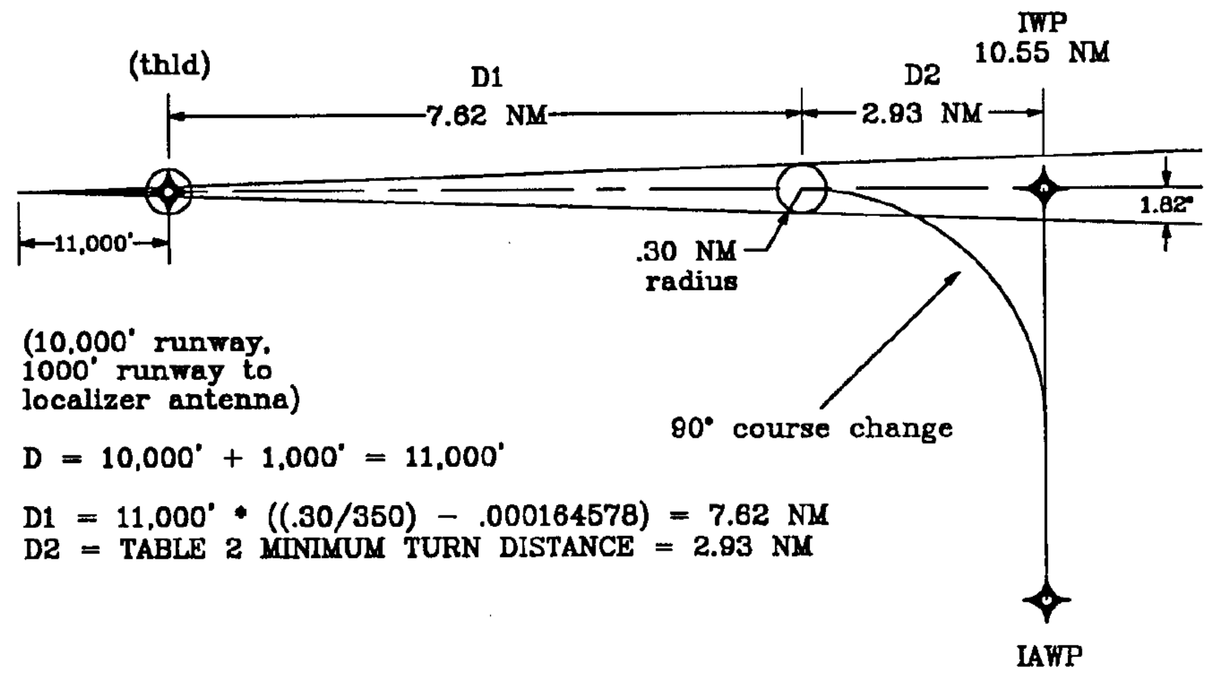


Figure 14: IWP Placement, Example 3

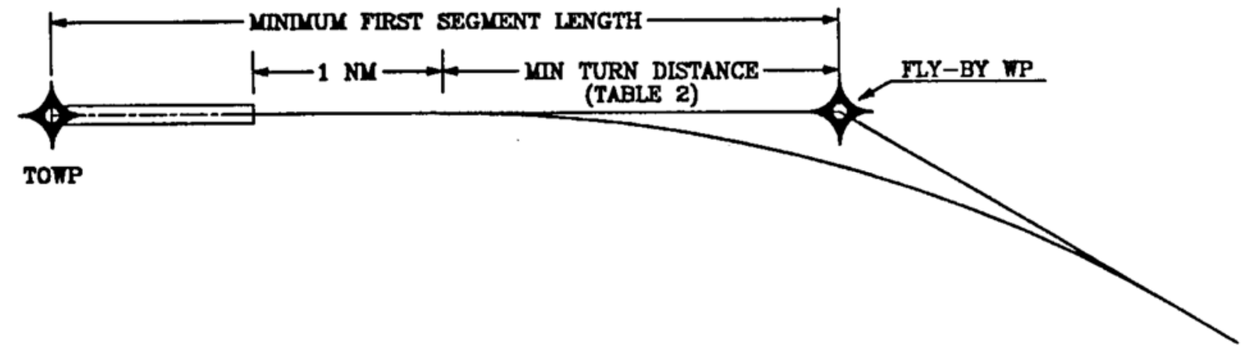


Figure 15: Minimum First Segment Length

Waypoint	Type	ATRK (+/- NM)	XTRK (+/- NM)	Fly-By Allowed	Fly-Over Allowed
En Route	En Route	2.8	3.0	Yes	Yes
FWP	Terminal	1.7	2.0	Yes	Yes
IAWP	Approach	0.3	0.6	Yes	No
IWP	Approach	0.3	0.6	Yes	No
FAWP	Approach	0.3	0.6	Yes	No
MAWP	Approach	0.3	0.6	No	Yes
MAHWP	Approach	0.3	0.6	Yes	Yes

Table 1: Waypoint Design Criteria

	INSIDE TURN EXPANSION									
	160 KIAS		175 KIAS		220 KIAS		250 KIAS		310 KIAS	
Turn Angle (°)	Radius (NM)	Min Turn Dist (NM)	Radius (NM)	Min Turn Dist (NM)	Radius (NM)	Min Turn Dist (NM)	Radius (NM)	Min Turn Dist (NM)	Radius (NM)	Min Turn Dist (NM)
10	10.04	0.99	11.58	1.13	16.46	1.59	20.24	1.93	37.31	3.48
15	6.67	1.05	7.64	1.19	10.94	1.66	13.45	2.01	24.79	3.59
20	4.98	1.11	5.71	1.25	8.17	1.73	10.04	2.09	18.51	3.70
25	3.96	1.16	4.54	1.31	6.5	1.80	7.99	2.17	14.72	3.81
30	3.28	1.22	3.76	1.37	5.37	1.88	6.61	2.25	12.18	3.92
35	3.00	1.32	3.43	1.48	4.91	2.02	6.04	2.43	11.14	4.23
40	2.76	1.41	3.16	1.58	4.52	2.16	5.56	2.59	10.25	4.50
45	2.55	1.49	2.92	1.67	4.18	2.29	5.14	2.74	9.48	4.76
50	2.37	1.57	2.72	1.76	3.89	2.40	4.78	2.88	8.81	5.00
55	2.21	1.64	2.53	1.85	3.63	2.52	4.46	3.02	8.22	5.23
60	2.07	1.72	2.37	1.93	3.39	2.63	4.17	3.15	7.69	5.45
65	2.07	1.84	2.37	2.07	3.39	2.83	4.17	3.40	7.69	5.91
70	2.07	1.97	2.37	2.22	3.39	3.04	4.17	3.66	7.69	6.39
75	2.07	2.11	2.37	2.38	3.39	3.27	4.17	3.94	7.69	6.91
80	2.07	2.26	2.37	2.55	3.39	3.52	4.17	4.24	7.69	7.46
85	2.07	2.42	2.37	2.73	3.39	3.78	4.17	4.56	7.69	8.05
90	2.07	2.59	2.37	2.93	3.39	4.06	4.17	4.91	7.69	8.70
95	2.07	2.78	2.37	3.15	3.39	4.37	4.17	5.29	7.69	9.40
100	2.07	2.99	2.37	3.38	3.39	4.71	4.17	5.71	7.69	10.17
105	2.07	3.22	2.37	3.65	3.39	5.09	4.17	6.18	7.69	11.03
110	2.07	3.48	2.37	3.94	3.39	5.51	4.17	6.70	7.69	11.99
115	2.07	3.77	2.37	4.28	3.39	5.99	4.17	7.29	7.69	13.07
120	2.07	4.11	2.37	4.66	3.39	6.54	4.17	7.96	7.69	14.32

Note: When turn angle falls between values in table, interpolate or use the next larger value.

Table 2. Fly-By Waypoint Minimum Turn Distance and Radius

	INSIDE TURN EXPANSION									
	160 KIAS		175 KIAS		220 KIAS		250 KIAS		310 KIAS	
Turn Angle (°)	Radius (NM)	Min Turn Dist (NM)	Radius (NM)	Min Turn Dist (NM)	Radius (NM)	Min Turn Dist (NM)	Radius (NM)	Min Turn Dist (NM)	Radius (NM)	Min Turn Dist (NM)
10	6.17	4.33	6.60	4.63	7.86	5.60	8.70	6.31	11.67	9.20
15	4.08	4.83	4.35	5.19	5.17	6.36	5.70	7.20	7.69	10.66
20	3.02	5.15	3.22	5.55	3.80	6.84	4.17	7.77	7.69	11.57
25	2.38	5.36	2.53	5.78	3.39	7.15	4.17	8.13	7.69	12.13
30	2.07	5.49	2.37	5.93	3.39	7.34	4.17	8.35	7.69	12.45
35	2.07	5.56	2.37	6.01	3.39	7.44	4.17	8.47	7.69	12.60
40	2.07	5.59	2.37	6.04	3.39	7.48	4.17	8.50	7.69	13.61
45	2.07	5.59	2.37	6.04	3.39	7.66	4.17	8.96	7.69	14.84
50	2.07	5.77	2.37	6.32	3.39	8.18	4.17	9.59	7.69	16.00
55	2.07	6.06	2.37	6.65	3.39	8.65	4.17	10.18	7.69	17.08
60	2.07	6.33	2.37	6.95	3.39	9.09	4.17	10.72	7.69	18.07
65	2.07	6.57	2.37	7.23	3.39	9.49	4.17	11.21	7.69	18.98
70	2.07	6.79	2.37	7.49	3.39	9.85	4.17	11.65	7.69	19.79
75	2.07	6.98	2.37	7.71	3.39	10.17	4.17	12.04	7.69	20.51
80	2.07	7.15	2.37	7.90	3.39	10.44	4.17	12.38	7.69	21.13
85	2.07	7.29	2.37	8.06	3.39	10.67	4.17	12.66	7.69	21.64
90	2.07	7.40	2.37	8.18	3.39	10.85	4.17	12.88	7.69	22.06
95	2.07	7.50	2.37	8.30	3.39	11.02	4.17	13.09	7.69	22.45
100	2.07	7.64	2.37	8.47	3.39	11.26	4.17	13.38	7.69	22.97
105	2.07	7.77	2.37	8.61	3.39	11.46	4.17	13.63	7.69	23.44
110	2.07	7.88	2.37	8.73	3.39	11.64	4.17	13.85	7.69	23.84
115	2.07	7.97	2.37	8.84	3.39	11.78	4.17	14.03	7.69	24.17
120	2.07	8.04	2.37	8.92	3.39	11.90	4.17	14.17	7.69	24.43

Table 3. Fly-Over Waypoint Minimum Turn Distance and Radius

SEGMENT	TABLES 2, 3 & 5 SPEED (KIAS)
Initial Approach	220
Intermediate Approach	175
All others (en route, feeder, missed approach, departure)	
At and below 10,000’ MSL	250
Above 10,000’ MSL	310

Table 4: Segment versus Speed

Turn Angle (°)	ROLL ANTICIPATION DISTANCE (NM)									
	160 KIAS		175 KIAS		220 KIAS		250 KIAS		310 KIAS	
	Fly-By	Fly-Over	Fly-By	Fly-Over	Fly-By	Fly-Over	Fly-By	Fly-Over	Fly-By	Fly-Over
10	0.11	0.18	0.12	0.21	0.15	0.30	0.16	0.37	0.22	0.68
15	0.17	0.28	0.18	0.32	0.22	0.45	0.24	0.56	0.33	1.01
20	0.23	0.37	0.24	0.42	0.29	0.60	0.32	0.74	0.44	1.01
25	0.28	0.46	0.30	0.53	0.36	0.67	0.40	0.74	0.55	1.01
30	0.34	0.52	0.37	0.56	0.44	0.67	0.48	0.74	0.66	1.01
35	0.37	0.52	0.40	0.56	0.48	0.67	0.53	0.74	0.72	1.01
40	0.40	0.52	0.43	0.56	0.51	0.67	0.57	0.74	0.77	1.01
45	0.43	0.52	0.46	0.56	0.55	0.67	0.61	0.74	0.83	1.01
50	0.46	0.52	0.49	0.56	0.59	0.67	0.66	0.74	0.89	1.01
55	0.49	0.52	0.53	0.56	0.63	0.67	0.70	0.74	0.95	1.01
60	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
65	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
70	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
75	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
80	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
85	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
90	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
95	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
100	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
105	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
110	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
115	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01
120	0.52	0.52	0.56	0.56	0.67	0.67	0.74	0.74	1.01	1.01

Table 5. Roll Anticipation Distance (RAD)

APPROACH CATEGORY	MAGNITUDE OF TURN OVER THE FINAL APPROACH WAYPOINT (FAWP)		
	0° - 5°	> 5° - 10°	> 10° - 30°
A	1.8	1.8	2.0
B	1.8	2.0	2.5
C	2.0	2.5	3.0
D	2.5	3.0	3.5
E	3.0	3.5	4.0

Table 6: Minimum Length of FAF Final Approach segment (NM)

TURN ANGLE AT IWP (DEGREES)	**LENGTH (NM)**
15 or less	2.25
30	2.50
45	2.75
60	3.00
75	3.50
90	4.00

Table 7: Minimum Intermediate Segment Length for FMS/ILS Approach

TURN ANGLE (DEGREES)	**OUTSIDE TURN REDUCTION RADIUS (NM)**
10	1.66
15	1.11
20	0.83
25	0.66
30	0.54
35	0.50
40	0.46
45	0.42
50	0.39
55	0.37
60	0.34
65	0.34
70	0.34
75	0.34
80	0.34
85	0.34
90	0.34
95	0.34
100	0.34
105	0.34
110	0.34
115	0.34
120	0.34

Table 8: Fly-By Waypoint Minimum Turn Radius

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Government of Canada Gouvernement du Canada

CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 5

VOLUME 6

DOC 2

RNAV DEPARTURES
(RNAV DEP)

TRANSPORT CANADA
NATIONAL DEFENCE

01 Jan 2009

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CHAPTER 1. AREA NAVIGATION (RNAV) DEPARTURE PROCEDURES

1.1 PURPOSE

This order, in conjunction with Volumes 1, 3 & 5 provides criteria for constructing instrument flight rules (IFR) RNAV departure procedures.

2.0– 5.0 RESERVED

6.1 DEFINITIONS.

6.1.1 Baseline. A line perpendicular to the course line at the latest position of the fix displacement tolerance area, used for construction of turn area expansion arcs.

6.1.2 Climb-in-Hold (CIH). Climbing in holding pattern.

6.1.3 Departure Altitude. An altitude at the end of the departure evaluation area that satisfies the requirements for en route operations. This term is similar in concept to the “missed approach altitude.”

6.1.4 Departure End of Runway (DER). The end of runway declared available for the ground run of an aircraft departure.

6.1.5 Distance of Turn Anticipation (DTA). A distance preceding a fly-by waypoint (WP) at which an aircraft is expected to start a turn to intercept the course of the next segment.

6.1.6 Fly-By WP. A waypoint where a turn is initiated prior to reaching it.

6.1.7 Fly-Over WP. A waypoint over which an aircraft is expected to fly before the turn is initiated.

6.1.8 Initial Climb Area (ICA). A segment starting at the DER, which allows the aircraft sufficient distance to reach an altitude of 400 feet above the DER.

6.1.9 Initial Course. The course established initially after take-off beginning at the DER.

6.1.10 Initial Course Waypoint (ICWP). A waypoint established on the initial course denoting the start of positive course guidance (PCG).

6.1.11 Leg (Segment) Types. The RNAV leg/segment types used in this document are:

a. **Heading to an Altitude (VA).** A segment for aircraft to climb to an altitude on a specified heading (figures 1 and 2). The VA segment terminates at a specified altitude without a terminating position defined. For example, a segment allowing aircraft to make an initial climb to 700 feet MSL after departing Runway 9 on the runway heading of 091° is a VA leg (see figure 1). ARINC Specification 424, attachment 5 states “Heading to an Altitude termination or VA Leg. Defines a specified heading to a specific Altitude termination at an unspecified position.”

Note: VA legs do not provide positive course guidance (PCG) and the aircraft will be subject to wind drift.

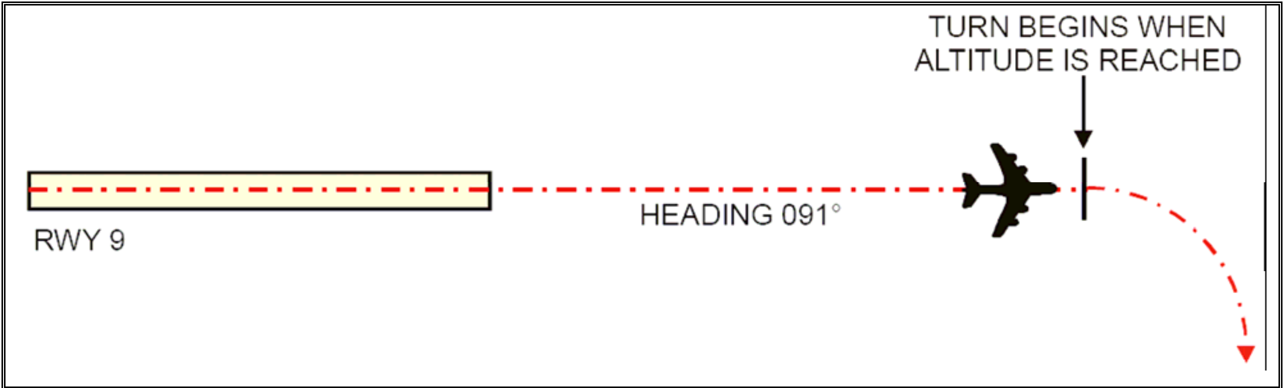


Figure 1: VA Leg Example

b. **Direct to Fix (DF).** A segment following a fly-over fix/WP, climb to an altitude on a specified heading, or radar vector, in which the aircraft’s track is direct to the next fix/WP. A DF route segment begins at an aircraft’s present position, or at an unspecified position, and extends to a specified fix/WP (see figure 2). ARINC Specification 424, attachment 5 states “Direct to a Fix or DF leg. Defines an unspecified track starting from an undefined position to a specific database fix.”

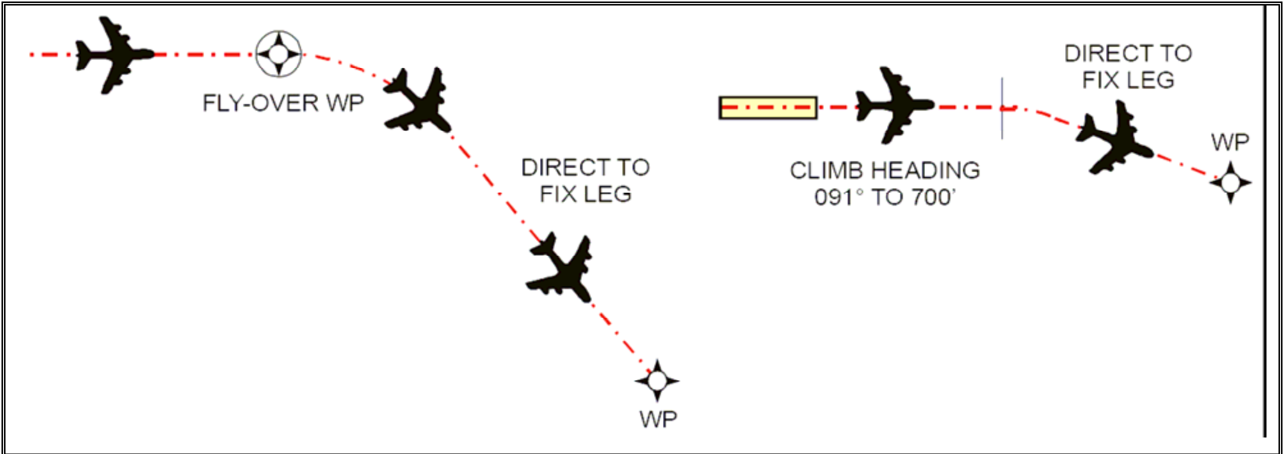


Figure 2: DF Leg Examples

c. **Track to Fix (TF).** A geodesic path, or track, between fixes/WPs which is intercepted and acquired as the flight track to the following fix/WP. TF applies to fly-by and fly-over fixes/WPs as shown in figure 3. ARINC Specification 424, attachment 5 states "Track to a Fix or TF leg. Defines a great circle track over ground between two known database fixes."

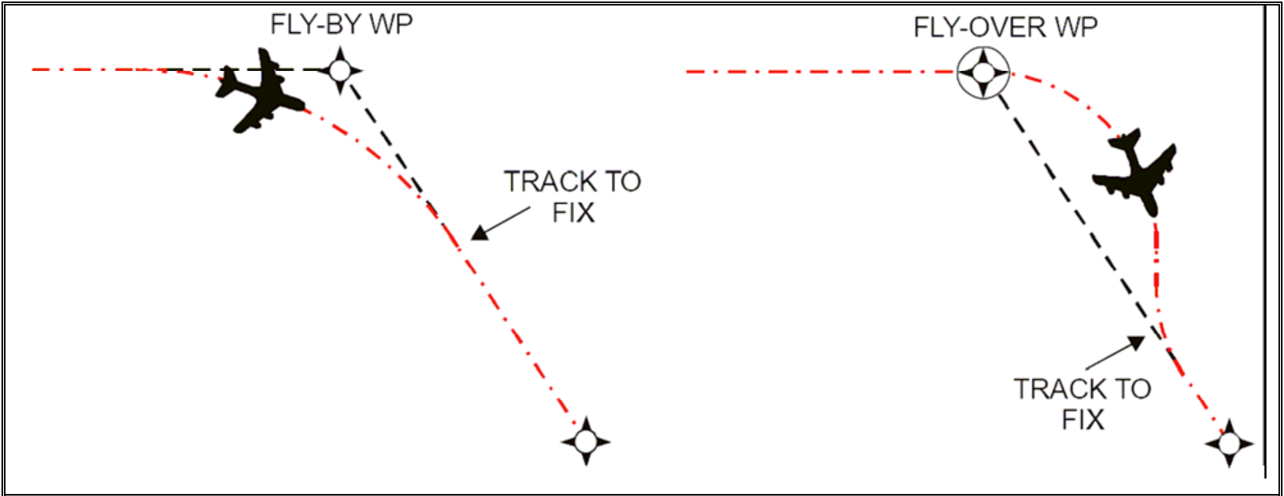


Figure 3: TF Leg Examples

6.1.12 Obstacle Clearance Surface (OCS). A surface, either inclined or level, where obstacle penetrations are not allowed. Also see Volume 1, Chapter 12 that Use Radar Vectors to Join RNAV Routes. Examples of OCS are as follows:

a. **Inclined surface OCS.** For a segment with obstacle penetrations of the standard 40:1 obstacle identification surface (OIS), if a climb gradient of 400 ft/NM is used to mitigate the OIS penetrations, the OCS is an inclined surface at 20:1.

b. **Level surface OCS.** For a segment with a minimum altitude of 3000 MSL and a ROC of 1000, the OCS is a level surface at 2000 MSL.

6.1.13 Reference Line. A line parallel to the course line, following a turn fix/WP, used to construct an additional set(s) of expansion arcs.

6.1.14 Reference Fix/Waypoint. A point of known location used to geodetically compute the location of another fix/WP.

6.1.15 Turn Anticipation. The capability of RNAV airborne equipment to determine the location of the point along a course, prior to a "fly-by" fix/WP which has been designated a turn fix/WP, where a turn is initiated to provide a smooth path to intercept the succeeding course.

6.1.16 Turn Fix/Waypoint (TWP). A fly-by or fly-over fix/WP denoting a course change.

7.1 LEVELS OF CRITERIA.

RNAV departure criteria, for public use procedures, are divided into two levels: Level 1 and Level 2.

7.1.1 Level 1 Criteria. Use of terminal level 1 criteria requires approval from Transport Canada for the following: an en route procedure, the en route portion of a terminal procedure, or for the portion of a departure beyond 30 NM of the departure airport. Approval is based on the navigation system and procedures used. Approval from Flight Standards Service is not required for use of terminal level 1 criteria for a terminal procedure route within 30 NM of the departure airport.

7.1.2 Level 2 Criteria. Level 2 criteria shall be applied unless the use of levels 1 or 3 is required.

7.1.3 Level 3 Criteria. For special use procedures only, an additional level of criteria is level 3, which has narrower evaluation area widths. Level 3 procedures are for navigation systems that update at the runway prior to departure. See Volume 6, Document 1, Flight Management System (FMS) Instrument Procedure Development.

Note: Use of levels 1 or 3 will exclude some RNAV-equipped aircraft.

SECTION 1. GENERAL CRITERIA

8.1 APPLICATION.

8.1.1 Diverse Departure Criteria. Apply diverse departure criteria to determine if departure procedures are required to avoid obstacles. (See Volume 1, Chapter 2).

8.1.2 Develop RNAV departure procedures as needed to satisfy operational, air traffic, obstacle clearance, special use airspace, and/or environmental requirements.

9.1 CRITERIA DESIGN STANDARDS

Use these standards to develop RNAV instrument departure procedures. They provide some flexibility so the procedure designer can select an appropriate level of criteria (see paragraph 7.1), waypoint type (fly-by, fly-over), and leg types (DF, TF, VA, etc.).

9.1.1 **Fix Use**. To the extent practical and efficient, use existing fixes/ WPs/ NAVAIDs.

9.1.2 **Fix Displacement Tolerance (FDT)** values for RNAV departures are in table 1.

Level	FDT	ENROUTE	TERMINAL
Level 1 Criteria	**XTRK**	2.0	1.0
	ATRK	0.5	0.5
Level 2 Criteria	**XTRK**	2.8	2.8
	ATRK	2.0	2.0

Table 1: FIX DISPLACEMENT TOLERANCE (NM)

a. For level 1 criteria, use terminal FDT where the plotted position of the fix is at or within 30 NM straight-line measurement of the departure airport's reference point (ARP). En route FDT applies beyond 30 NM from the ARP, including succeeding fixes/WPs that may lie within 30 NM of the ARP should the route return to the area. When the departure reaches the en route portion of the procedure, en route FDT applies to all fixes/WPs. Also see paragraph 7.1.2 regarding the approved use of levels 1 and 2 criteria.

b. For level 2 criteria, use en route FDT throughout the procedure.

c. For levels 1 and 2 criteria, the fix displacement area must not overlap the plotted position of the adjacent fix/WP along the same route/course. However, the fix displacement area may overlap part of an adjacent fix displacement area.

d. For obstacle clearance area construction, the FDT values must be used for obstacle evaluation as indicated in paragraphs 12 through 17. Fix displacement areas are depicted either as rectangles or as circles. When depicted as a rectangle, the "ATRK" value is used before and after the fix/WP and is measured along the designated flight track. The "XTRK" value is measured perpendicular left and right of the designated flight track. When depicted as a circle, the "ATRK" value is used as the radius and the area is centered on the plotted fix/WP. The depiction as a circle is the new standard and the depiction as a rectangle is planned to be phased out.

e. For minimum segment length, the FDT values are not required to be included in the segment length calculations (see paragraph 9.11.1).

9.1.3. RNAV Fixes/Waypoints. "Fly-By waypoints" are preferred in most situations. Use "Fly-Over waypoints" only when operationally requirements dictate or an advantage is achieved. Establish WPs to designate course restrictions/changes, altitude restricted/changes when necessary.

9.1.4 Guidance for Determining RNAV Minimum Altitudes.

A minimum altitude is required to use RNAV fixes/WPs, TF legs, CF legs, or DF legs. Determine the altitude as the higher of the following:

a. RNAV Engagement Altitude. For "Type A" departure procedures, use a height of 2,000 ft above airport elevation. For "Type B" departure procedures or for "RNAV 1" departure procedures, use a height of 500 ft above airport elevation.

b. Altitude/Height Indicated by a Computer Model Assessment. The current FAA computer model assessment tool is RNAV-Pro. The assessment is not applicable when the procedure is designated as "GPS Required".

c. Altitude Based on Obstacle Clearance. Use inclined required obstacle clearance (ROC) and/or level ROC, as applicable.

d. Altitude Based on Airspace Analysis. Use Order 8260.19, Flight Procedures and Airspace, and Order 7400.2, Procedures for Handling Airspace Matters, to determine the minimum altitude based on airspace analysis.

e. Altitude Based on Other Operational Factors. Other operational factors include air traffic control (ATC) requests, minimum crossing altitude (MCA), radar and/or communications coverage, noise abatement, national security, or environmental.

f. Altitude Based on Flight Inspection. If the flight inspection indicates a higher altitude is required, use that altitude. An example would be to recommend an increase based on precipitous terrain.

9.1.5 Guidance for Rounding RNAV Minimum Altitudes.

a. Within the ICA, round RNAV minimum altitudes to the next higher 1-ft increment, if requested. Otherwise, round to the next higher 20-ft MSL increment.

b. Beyond the ICA, round RNAV Minimum altitudes to the next higher 100-ft MSL increment.

c. An exception to the requirement to round to higher increments may be made when the determining factor in the RNAV Minimum Altitude is airspace (paragraph 9.1.4d) or "other operational factors" (paragraph 9.1.4e). You may round to the nearest increment unless it decreases required obstacle clearance.

9.1.6 Procedure Design Below the RNAV Minimum Altitude.

a. Prior to reaching the RNAV minimum altitude (paragraph 9.1.4), use heading legs or radar vectors. Both ODPs and SIDs allow heading legs, using paragraphs 12.4 and 15. Radar must not be used in ODP design; however, radar may be used in SID design. See Order 8260.53, Standard Instrument Departures that Use Radar Vectors to Join RNAV Routes.

b. Existing SIDs, designed under previous criteria and not meeting the provisions of this paragraph, may remain in effect until a change is needed.

c. ODPs that do not conform with this paragraph must be corrected as soon as possible.

9.2 CHARTING INSTRUCTIONS

Chart all RNAV departures graphically. The following text shall appear on the graphical depiction:

9.2.1 Level 1: “For use by /R (RNP 1.0) and /G equipped aircraft with selectable course deviation indicator (CDI). Set CDI to 1 NM terminal sensitivity. Aircraft without selectable CDI must use flight director."

9.2.2 Level 2: “For use by /R (RNP 2.0) and /G equipped aircraft with selectable course deviation indicator (CDI). Set CDI to 2 NM terminal sensitivity. Aircraft without selectable CDI must use flight director."

9.3 WAYPOINT DEFINITION.

Define departure WPs on runway centerline extended by establishing coordinates using the reciprocal of the opposite direction runway true bearing and the appropriate distance applied from the DER (reference point). Where two or more segments are aligned along a continuous geodetic line, align and construct all succeeding WPs based on a true bearing and distance from the first reference waypoint in the sequence. Where turns are established, use the TWP as the reference WP to construct succeeding WPs and segments aligned on a continuous geodetic line following the turn (see figure 4).

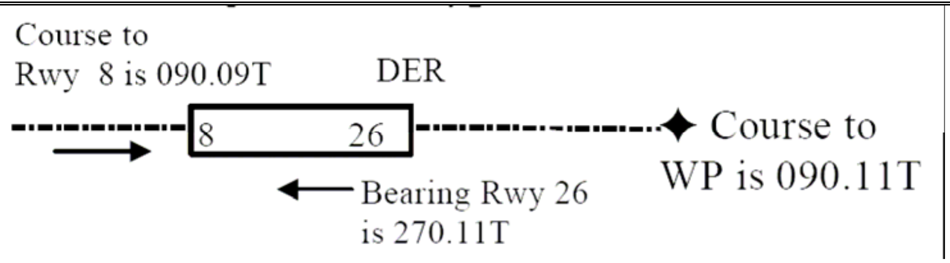


Figure 4: Waypoint definition

9.4 COURSE CHANGE AT WAYPOINTS.

The departure course at a particular WP is the bearing from that WP to the following WP. The arrival course at a particular WP is the 9.11.1 c. In the case of a fly-by to a fly-over WP, the minimum segment length is the DTA of the first WP (see figure 8). For obstacle protection area (see figure 22). departure course and the arrival course at a WP equals the amount of turn at that WP (see figure 5).

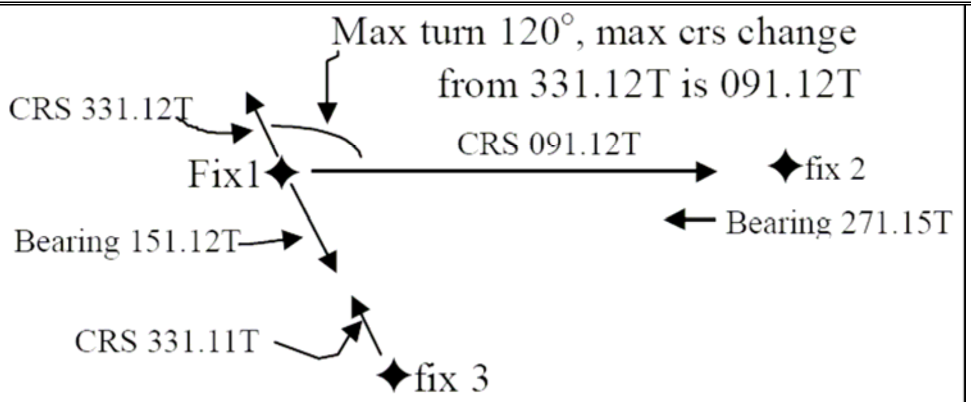


Figure 5: Course Change

9.5 RESERVED.

9.6 ROUTE DESCRIPTION.

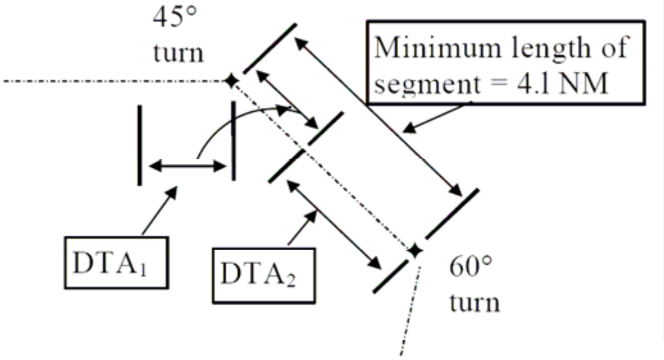
Specify the magnetic courses using the magnetic variation of the departure airport until the departure route joins the en route airway system. Document the names of all WP's or fixes in the order flown with any turns or altitude crossing requirements specified at these points.

9.7-9.10 RESERVED.

9.11 DEPARTURE ROUTE SEGMENTS.

9.11.1 The length of a segment is measured between plotted positions of the WP's. Except for the ICA, the length of a segment shall be sufficient to encompass all turn anticipation and outside turn expansion requirements. Compute values using hundredths or greater, round final computation to the next higher tenth NM.

a. In the case of two successive fly-by turning WP's, the minimum segment length is the DTA of the first waypoint plus DTA of the second waypoint. The DTA's are measured from plotted positions of the fixes (see figure 6). For obstacle protection area (see figure 15).



Example steps of computation:

Given:

Aircraft Speed: 250 KIAS

Altitude: Below 10,000' MSL

First turn angle: 45°

Second turn angle: 60°

Step 1. Determine the radius of turn from table 3: 4.2 NM

Step 2. Determine DTA of first turn:

DTA1 = 4.2 x tangent (45° / 2) = 4.2 x .41 = 1.74 NM

Step 3. Compute the DTA of the second turn:

DTA2 = 4.2 × tangent (60° / 2) = 4.2 × .58 = 2.42 NM

Step 4. Determine minimum total distance between waypoints by adding the dimension in Step 2 to the dimension in Step 3.

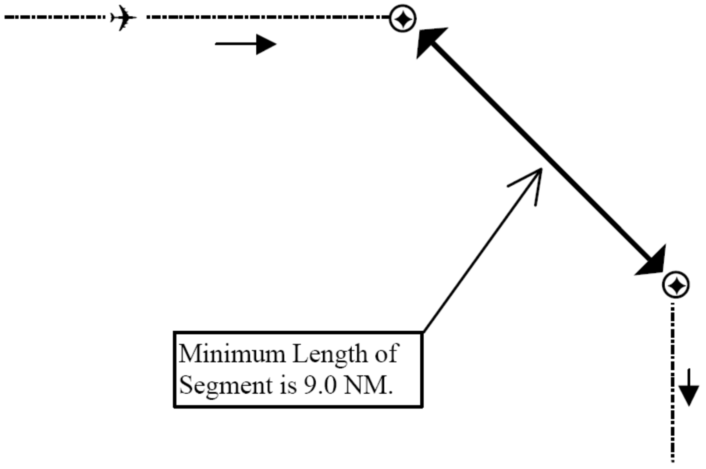
Total distance waypoint to waypoint =

Minimum length of segment = $DTA_1 + DTA_2 = 1.74 + 2.42 = 4.16$ NM

(rounded to next higher tenth) 4.2 NM.

Figure 6: Two successive Fly-By WPs

b. In the case of two successive fly-over WP’s, select the minimum segment length as specified in table 2 (see figure 7). For obstacle protection area (see figure 21).



Using table 2, select applicable airspeed and turn angle.

Example steps of computation:

Given:

Aircraft speed: 250 KIAS

First turn angle: 45°

Second turn angle: (not applicable)

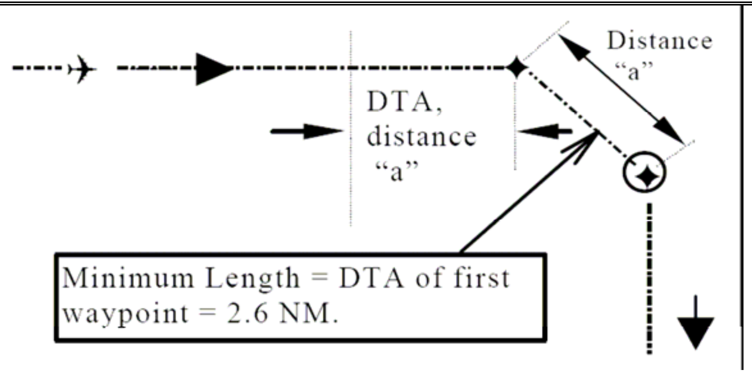
Step 1

Use table 2 and select distance from column under 250 KIAS
and row opposite 45° = 8.96

Minimum length of segment = 8.96 NM (rounded to next higher tenth) 9.0

Figure 7: Two successive Fly-Over WPs

c. In the case of a fly-by to a fly-over WP, the minimum segment length is the DTA of the first WP (see figure 8). For obstacle protection area (see figure 22).



Example steps of computation:

Given:

Aircraft Speed: 250 KIAS
First turn angle: 50°
Second turn angle NA.
Altitude: More than 10,000' MSL

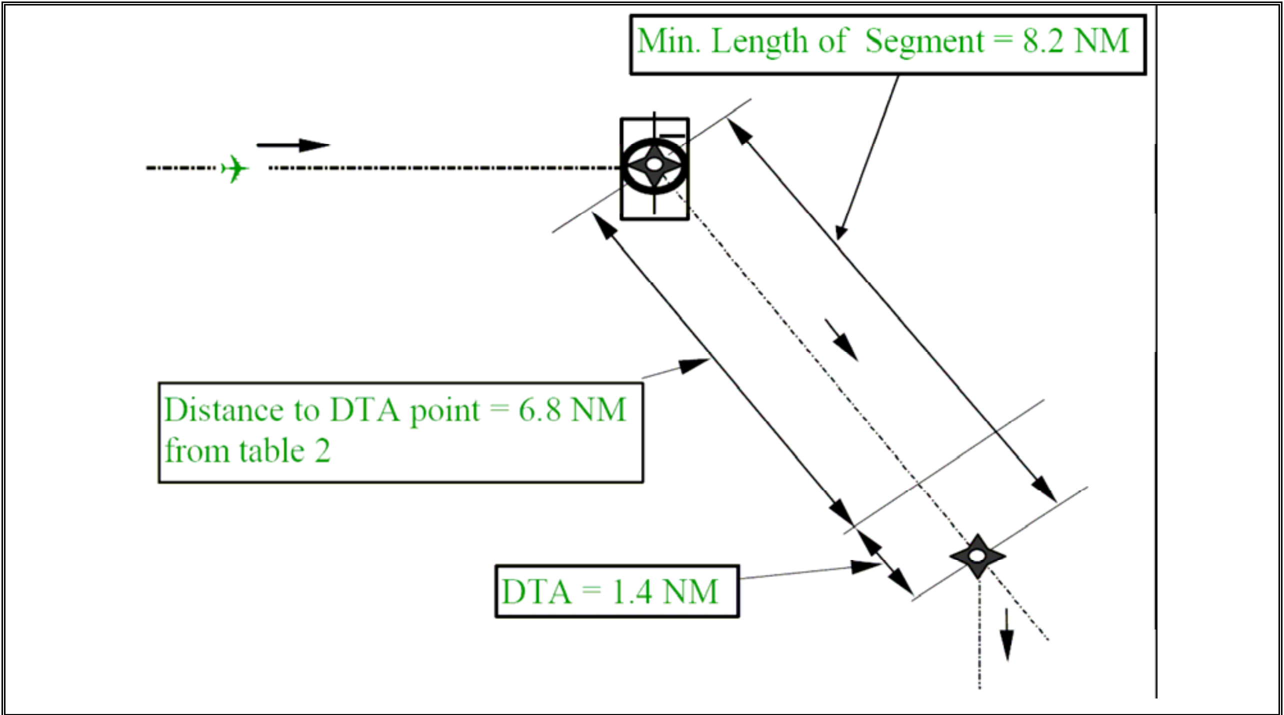
Step 1. Determine the turning radius from table 3: 5.5 NM

Step 2. Determine DTA of first turn:

DTA = 5.5 ´ Tangent (50°¸2) = 2.56 NM
Minimum length of segment = 2.6 NM (rounded to next higher tenth)

Figure 8: Fly to Fly-Over WP

d. In the case of a fly-over to a fly-by WP, the minimum segment length is the minimum distance specified in table 2 plus the DTA for the fly-by WP (see figure 9). For obstacle protection area (see figure 23).



Example steps of computation:

Given:

Aircraft Speed: 200 KIAS
First turn angle: 35°
Second turn angle: 50°
Altitude: Below 10,000’ MSL

Step 1. Use table 2 and select distance from column under 200 KIAS and row opposite 35° = 6.79

Step 2. Determine radius of second turn from table 3: 2.9 NM

Step 3. Determine DTA of second turn:

DTA = 2.9 ´ Tangent (50°¸2) = 2.9 ´ 0.46 = 1.35 NM
Min. Length of Segment = 8.2 NM
Distance to DTA point = 6.8 NM from table 2

Step 4. Determine minimum total distance between waypoints by adding the dimension in step 1 to the dimension in step 3:

Total distance waypoint to waypoint = Minimum length of segment = 6.79 + 1.35 = 8.14 NM. (rounded to next higher tenth) 8.2 NM.

Figure 9: Fly-Over to Fly-By WP

Turn Angle (degree)	140 KIAS	160 KIAS	175 KIAS	200 KIAS	220 KIAS	250 KIAS	310 KIAS	350 KIAS
10	3.95	**4.33**	4.63	**5.16**	5.60	**6.31**	9.20	**10.51**
15	4.37	**4.83**	5.19	**5.83**	6.36	**7.20**	10.66	**12.22**
20	4.65	**5.15**	5.55	**6.25**	6.84	**7.77**	11.57	**13.27**
25	4.82	**5.36**	5.78	**6.52**	7.15	**8.13**	12.13	**13.91**
30	4.93	**5.49**	5.93	**6.69**	7.34	**8.35**	12.45	**14.28**
35	5.00	**5.56**	6.01	**6.79**	7.44	**8.47**	12.60	**14.48**
40	5.03	**5.59**	6.04	**6.82**	7.48	**8.50**	13.61	**16.05**
45	5.03	**5.59**	6.04	**6.87**	7.66	**8.96**	14.84	**17.54**
50	5.09	**5.77**	6.32	**7.31**	8.18	**9.59**	16.00	**18.95**
55	5.33	**6.06**	6.65	**7.72**	8.65	**10.18**	17.08	**20.25**
60	5.55	**6.33**	6.95	**8.10**	9.09	**10.72**	18.07	**21.46**
65	5.75	**6.57**	7.23	**8.44**	9.49	**11.21**	18.98	**22.56**
70	5.93	**6.79**	7.49	**8.75**	9.85	**11.65**	19.79	**23.54**
75	6.09	**6.98**	7.71	**9.02**	10.17	**12.04**	20.51	**24.41**
80	6.23	**7.15**	7.90	**9.26**	10.44	**12.38**	21.13	**25.16**
85	6.34	**7.29**	8.06	**9.45**	10.67	**12.66**	21.64	**25.78**
90	6.43	**7.40**	8.18	**9.61**	10.85	**12.88**	22.06	**26.29**
95	6.52	**7.50**	8.30	**9.76**	11.02	**13.09**	22.45	**26.75**
100	6.63	**7.64**	8.47	**9.96**	11.26	**13.38**	22.97	**27.39**
105	6.74	**7.77**	8.61	**10.13**	11.46	**13.63**	23.44	**27.96**
110	6.82	**7.88**	8.73	**10.28**	11.64	**13.85**	23.84	**28.44**
115	6.90	**7.97**	8.84	**10.41**	11.78	**14.03**	24.17	**28.84**
120	6.96	**8.04**	8.92	**10.51**	11.90	**14.17**	24.43	**29.16**

Note: Distance NM’s
Use 10° line for turns less than 10°
Table may be interpolated or use next higher value

TABLE 2. Fly-Over Waypoint Minimum Turn Distance

9.12 BASIC WIDTHS OF SEGMENTS.

9.12.1 Level 1 criteria.

a. Within and including 30 NM from the ARP.
   (1) Primary area: 2 miles on each side of the segment centerline.
   (2) Secondary area: 1 mile each side of the primary area.

b. Beyond 30 NM from the ARP.
   (1) Primary Area: 3 miles on each side of the segment centerline.
   (2) Secondary Area: 3 miles on each side of the primary area.

9.12.2 Level 2 criteria.

a. Primary Area: 4 miles on each side of the segment centerline.

b. Secondary Area: 2 miles on each side of the primary area.

10.1 INITIAL AREAS.

10.1.1 Initial Climb Area. See figure 10. This segment starts at the DER and proceeds along runway centerline extended to allow the aircraft to reach an altitude of 400 feet above DER and allow establishment of positive course guidance by all navigation systems. Optimum length of the ICA for a fly-over WP is 2 NM and for a fly-by WP is 2 NM plus the DTA distance. Within the ICA, use 2.9 NM for any necessary turn radius (or less as allowed in table 3) to compute a DTA. The maximum length is 5 NM. Exception: When a VA leg is used for the initial climb, maximum length of the ICA does not apply. Specify a WP at the end of its area (except when paragraph 10.1.1c or 12.4.1 is applied (see figures 11 and 26 respectively) to denote the beginning of PCG.

a. Splay the ICA area 15° relative to the course from a point 500 feet each side of runway centerline.

b. To shorten the ICA to less than 2 NM from the DER, publish a fly-over WP, a minimum distance of 1 NM from DER, and specify a climb gradient to that WP.

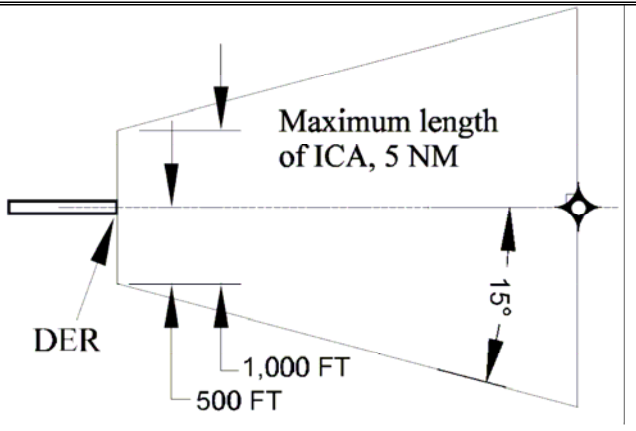


Figure 10: Initial Climb Area

c. To allow a WP less than 2 NM from the DER without a climb gradient imposed, a fly-over WP may be used and published. No turn greater than 15° is permitted at this WP, and a succeeding WP must be established for a DF leg. Locate the WP a minimum distance of ½ NM from DER (see figure 11).

1. Establish a segment aligned with runway centerline a minimum distance of 2 NM from DER to provide an area for the initial climb to 400 feet. A turn for a new course may occur at the first WP. A maximum turn of 15°, relative to runway centerline extended, is permitted and may be used to establish the next WP. No distance limitation is required for the next WP.

2. A secondary area may begin at the first WP provided no turn exists at that WP. If a turn is involved, a secondary area may begin at the first WP on the inside of the turn. Secondary area consideration for the outside area of the turn is not allowed until the end of the 2-mile ICA.

10.1.2 Crosstrack fix displacement tolerances need not be considered during the initial splay boundaries (see figure 12).

10.2 AREAS BEYOND THE ICA.

The 15° splays continue until reaching the total width of the basic primary and secondary areas. This distance from DER is 10.89 NM for Level 1 and 22.09 NM for Level 2. Secondary areas are not designated until the establishment of the first WP. At the first WP, the primary area is manually established by connecting lines from the edges of the area abeam that waypoint to points on a line perpendicular to the course where the width of the basic primary area is reached (see paragraph 9.12 and figure 13).

10.2.1 Once the departure segment splays to the respective primary and secondary area widths, the area widths remain constant except for the following: expansion of areas when a turn is involved; a course in Level 1 criteria reaches a point 30 NM from ARP; and the course in Level 1 reaches the en route structure (see figure 14).

10.2.2 DEVELOP A ROUTE using Level 1 or Level 2 basic primary and secondary areas as outlined in paragraph 9.12. Specify WP's as common fixes (see figure 14).

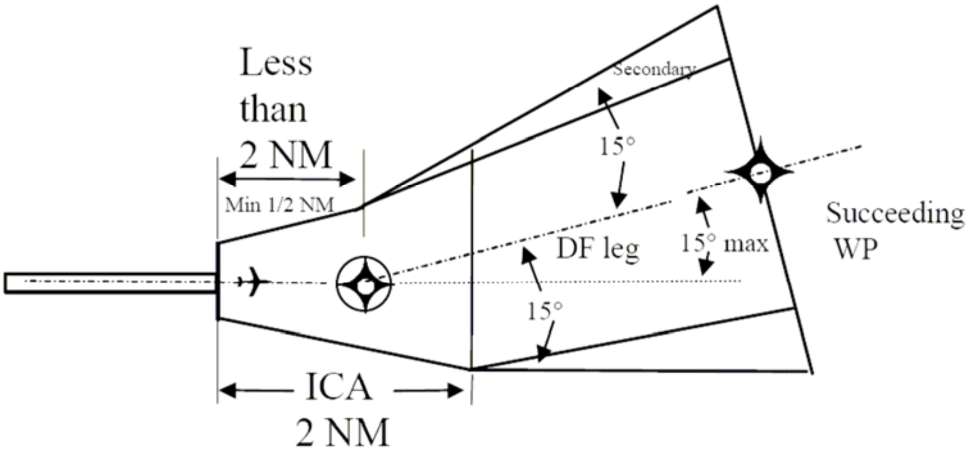


Figure 11: WP Less than 2 NM from DER, without a Climb Gradient Imposed

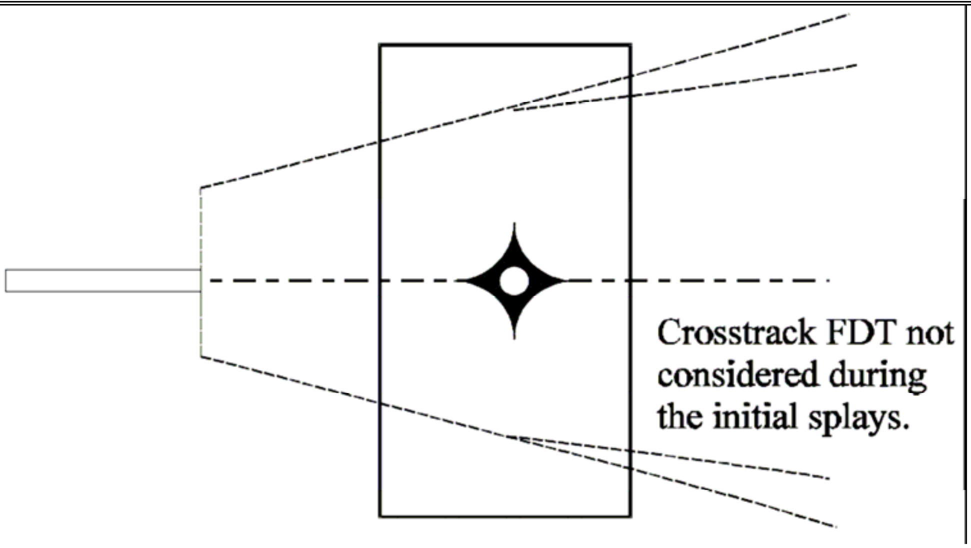


Figure 12: Crosstrack FDT in Initial splay Area

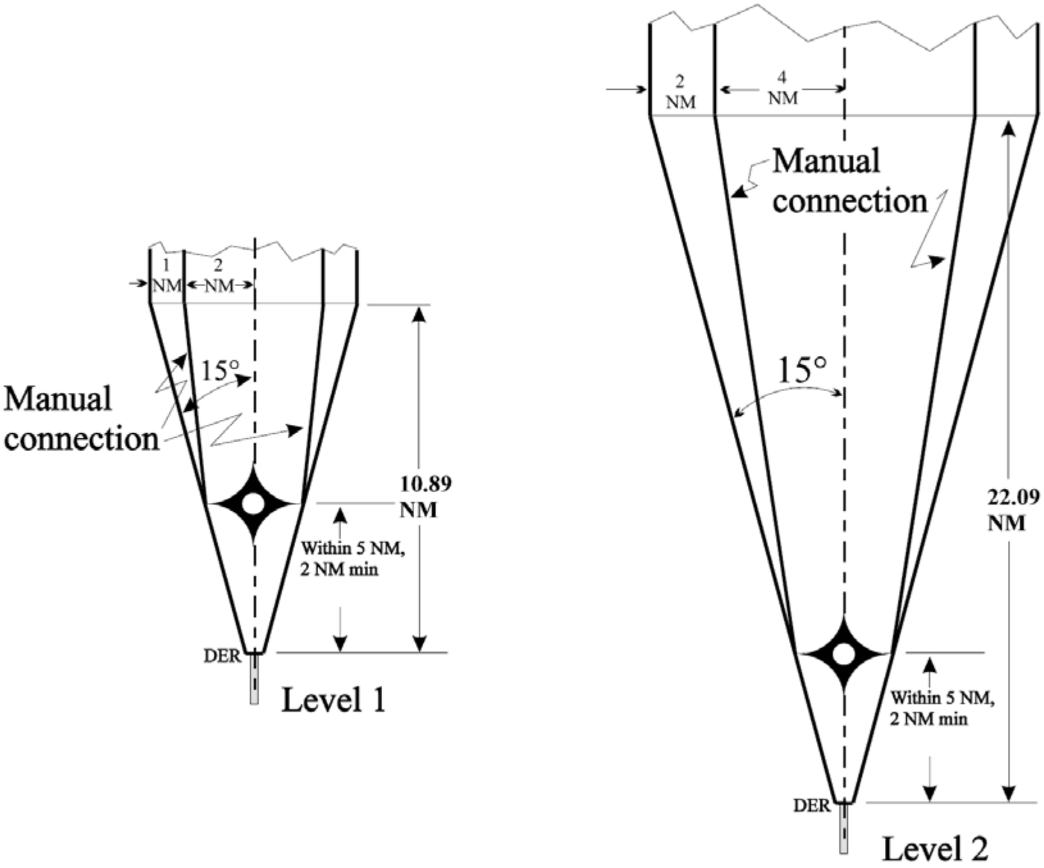


Figure 13: Area Splays to Basic Widths

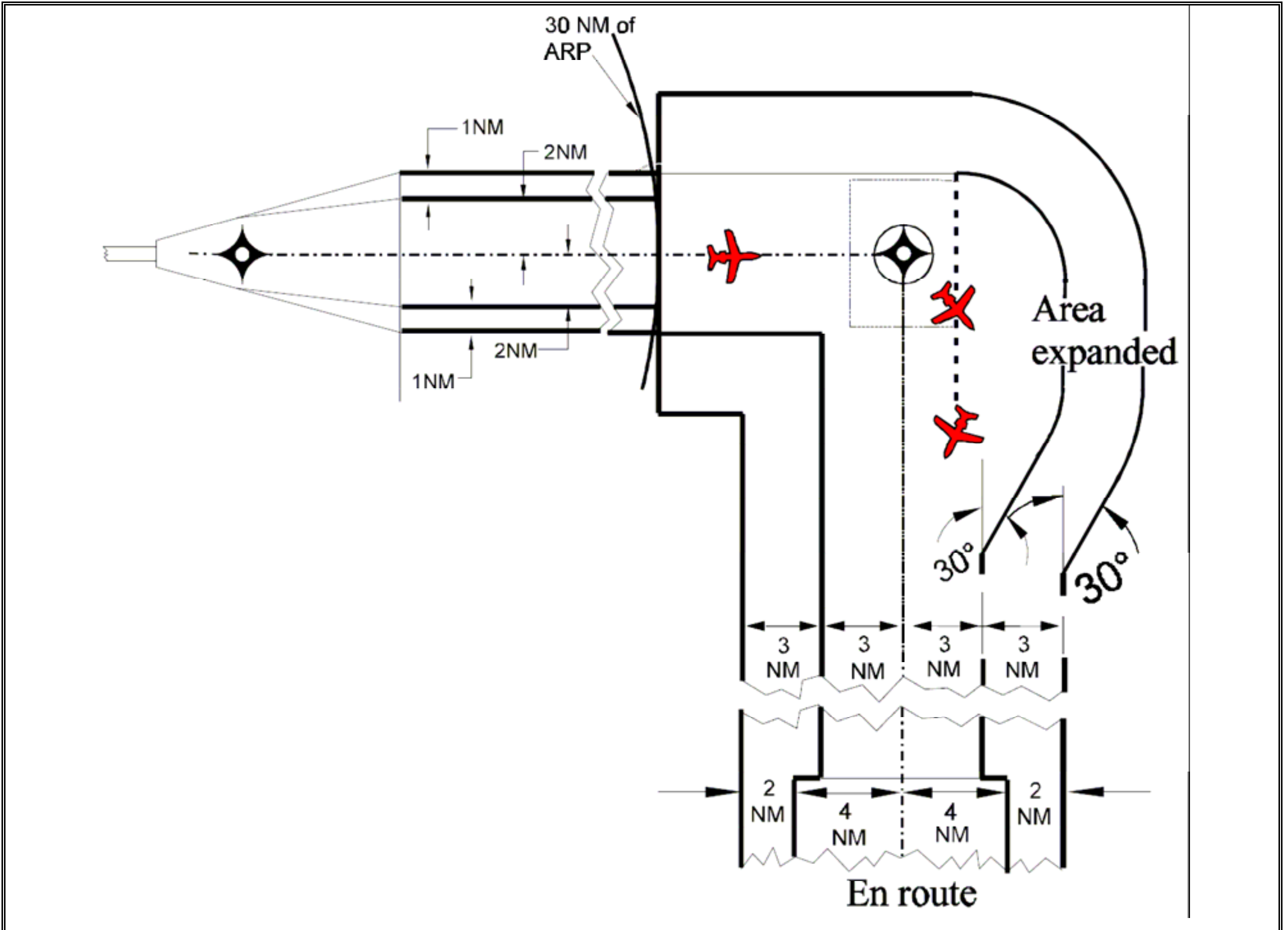


Figure 14: 90° Turn, Fly-Over at more than 30 NM from ARP

11.1 AIRCRAFT SPEEDS AND ALTITUDES. Refer to table 3.

11.1.1 For all turns below 10,000 feet MSL, use 250 knots indicated KIAS unless a lower speed has been authorized by air traffic. If a lower speed is used, the speed restriction shall be noted on the procedure. Do not use a speed less than 200 KIAS for Category C or 220 KIAS for Category D aircraft.

11.1.2 For turns at 10,000 feet MSL and above, use 310 KIAS, unless a higher airspeed has been authorized by air traffic. If a lower speed is used, a speed restriction not less than 250 KIAS above 10,000 through 15,000 feet shall be noted on the procedure for that turn. Above 15,000 feet, no speed reduction below 310 KIAS is permitted.

11.1.3 Where less than the 250 or the 310 KIAS is required, publish a speed restriction. Example: “Do not exceed (a designated speed from table 3) KIAS,” or “Do not exceed (a designated speed from table 3) KIAS until CHUCK WP.”

11.1.4 When an airspeed greater than 250 KIAS is authorized below 10,000 feet MSL or greater than 310 KIAS, 10,000 feet MSL and above, publish that speed from table 3, as appropriate.

	AIRCRAFT SPEEDS			
	140	**160**	**175**	**200**
Turn Radii Below 10,000' MSL	1.7	2.1	2.4	2.9
Turn Radii 10,000' MSL and above	2.4	2.9	3.3	4.0
	AIRCRAFT SPEEDS			
	220	**250**	**310**	**350**
Turn Radii Below 10,000' MSL	3.4	4.2	6.0	7.3
Turn Radii 10,000' MSL and above	4.6	5.5	7.7	9.3

Note: R2 = R1 plus (1 NM, 2 NM, or 3 NM) of secondary area width as applicable: 1 NM for Level 1, 2 NM for Level 2, or 3 NM for Level 1 beyond 30 NM from ARP

Note: Use next higher airspeed for speeds not given

Table 3: Waypoint Turn Radii, NM, According to Aircraft Speeds, (KIAS), (R1)

12.1 TURNS AND AREA EXPANSION.

For turns up to and including 15°, an expansion of the area is not required. The inside and outside boundaries of the segments prior to and after the turn may be connected with no arcs.

12.1.1 For Turns Greater Than 15°, an expansion of the departure area is required. Establish inside expansion area for fly-by WP's. Outside expansion is not required for fly-by WP's. Establish outside expansion areas for fly-over WP's. Inside expansion is

12.1.2 Maximum Course Change Allowable for TF Legs is 120°. No maximum course change is required for DF legs.

12.2 INSIDE EXPANSION AREA FOR A FLY-BY WP.

12.2.1 Expand the primary area by an angle equal to one-half of the course change (see figure 15).

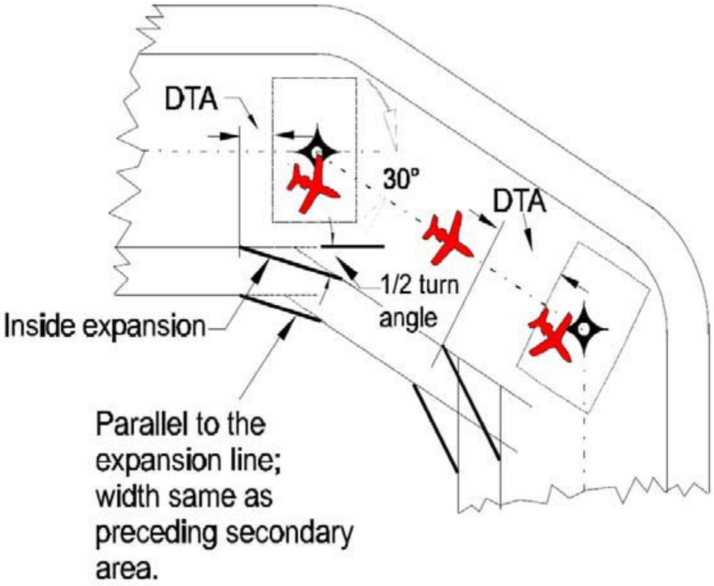


Figure 15: Fly-By WP's

a. Locate a point on the primary area boundary on the inside of a turn a distance equal to the DTA measured back from the earliest point of the FDT area parallel to the course. The length of the DTA is determined by the following formula and it applies to turns of more than 15°.

   DTA = R1 x tan (turn angle / 2)
   See table 3 for R1.

b. Construct the secondary area boundary, parallel with the primary expansion boundary, using the width of the preceding segment secondary area.

12.2.2 Where turns occur during the initial splays, the width of the segment following the TWP begins at the same width the preceding segment ended, and the splays continue as described in paragraph 10.1, except for turn expansion area indicated as follows:

a. Locate point A on the primary area boundary on the inside of the turn as prescribed in paragraph 12.2.1a (see figure 16).

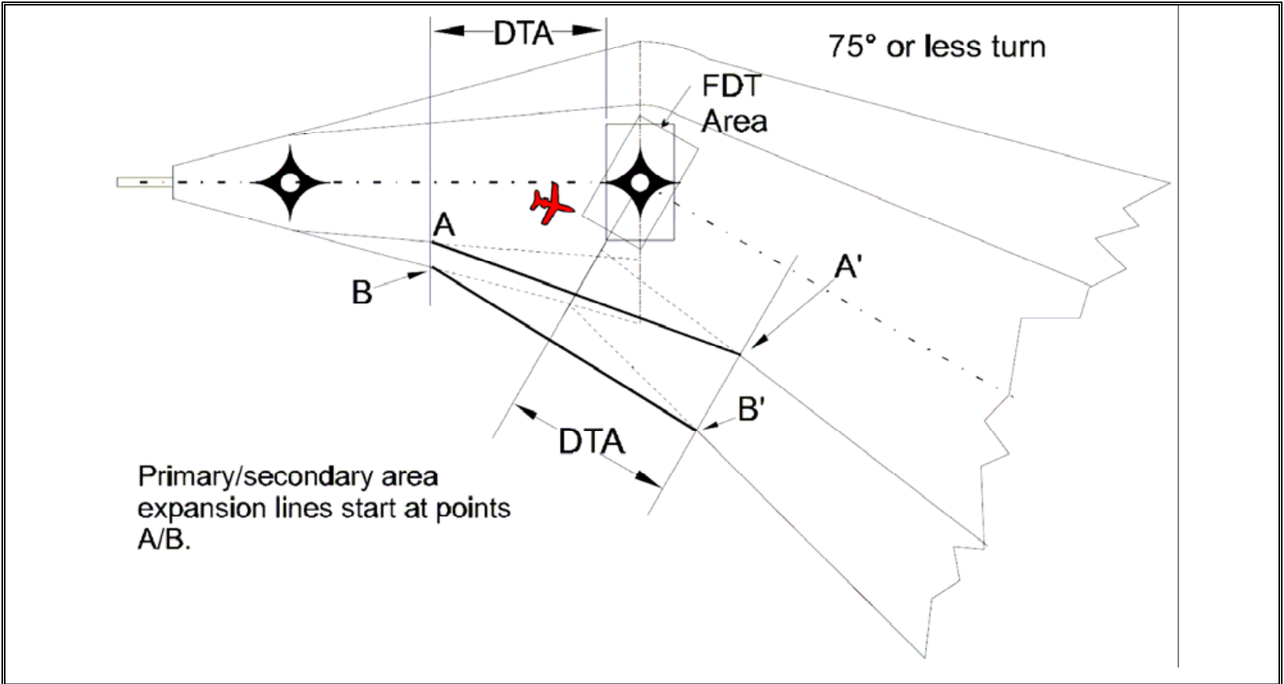


Figure 16: Fly-By WP, Turn 75° or Less

b. Locate point A' on the edge of the primary area at the DTA distance, measured parallel to the course following the plotted position of the WP after completing the turn. Construct the primary boundary area by connecting point A with A' (see figure 16).

c. Locate point B on the edge of the secondary area abeam point A. Locate point B' on the edge of the secondary area abeam point A¢. Construct the secondary area boundary by connecting point B with B' (see figure 16).

d. For turns 75° less, the resulting gap on the outside boundaries of the turn is closed by appropriate radii equal to the distance from the plotted position of the TWP to the edge of the primary or secondary area abeam the TWP (see figure 16).

e. For turns greater than 75°, continue the splay past the TWP and construct an arc from the center of the TWP and connect it to the splay at point E. The radius of this arc is equal to the width of the area at the end of the segment, abeam the plotted position of the fix plus the along track FDT (see figure 17).

  (1) Using tangent lines, join the arc to the points where the splay of the following segment reaches basic dimensions. The beginning width at the TWP, for the splay after the turn, is the width transferred from the TWP's plotted position for the previous segment.

  (2) The inside area is formed by connecting the beginning of the ICA, point A, to the edge of the splay at a distance equal to the DTA of the turn, point A'. Manually connect the point A' to the point where the basic dimensions are reached at point B' to establish the secondary area (see figure 17).

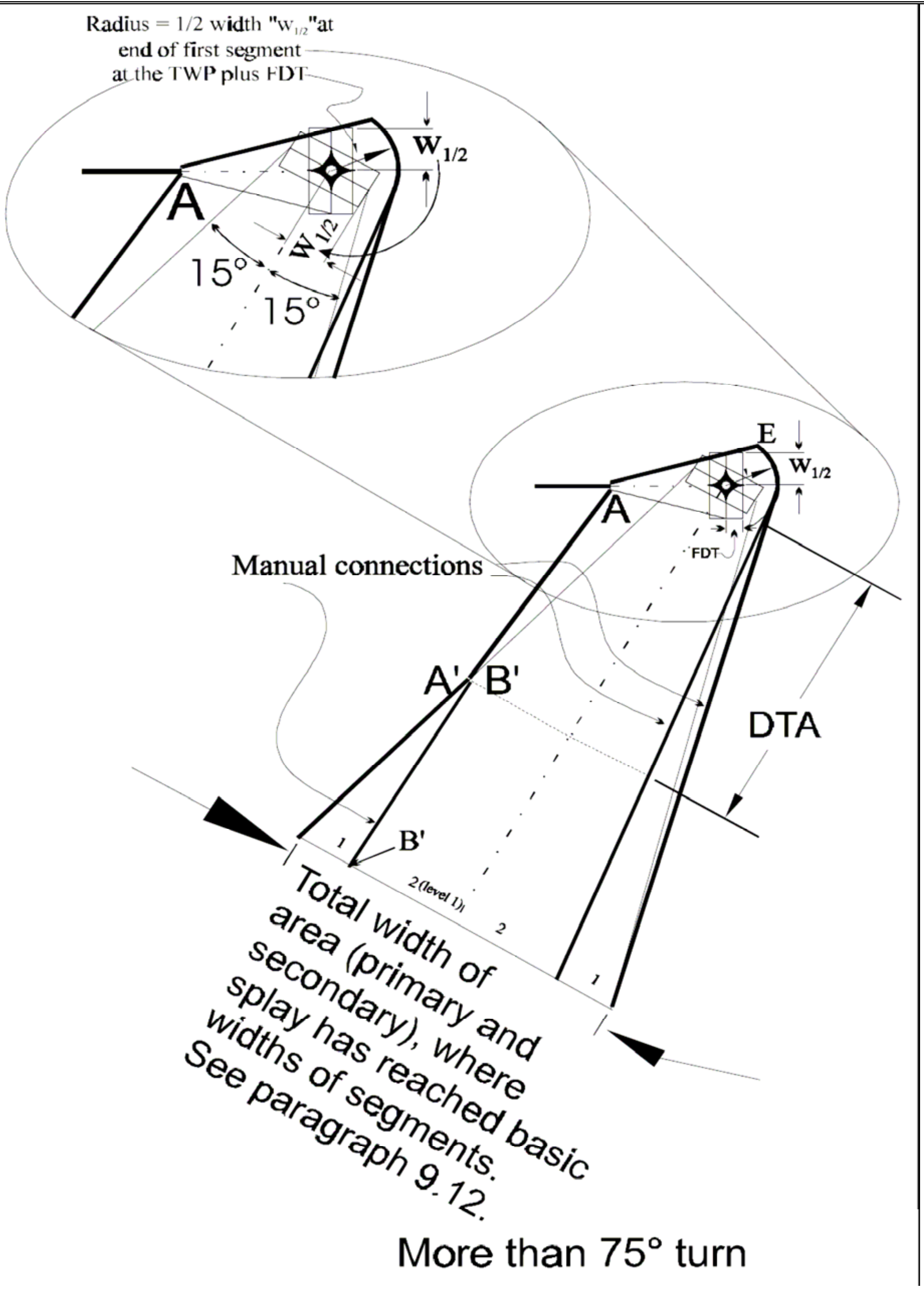


Figure 17: 90° Turn, Fly-Over at more than 30 NM from ARP

12.2.3 Inside expansion area, two successive fly-by WP's, TF legs. Construct inside expansion as prescribed in paragraphs 12.2.1a and 12.2.1b for obstacle clearance areas when boundaries of the segments preceding and following the WP's are parallel with the course centerline. In some cases, example C, the DTA distances may cause the expansion lines to merge, increasing the size of the expanded areas. This construction is permissible (see figures 18A, B, and C).

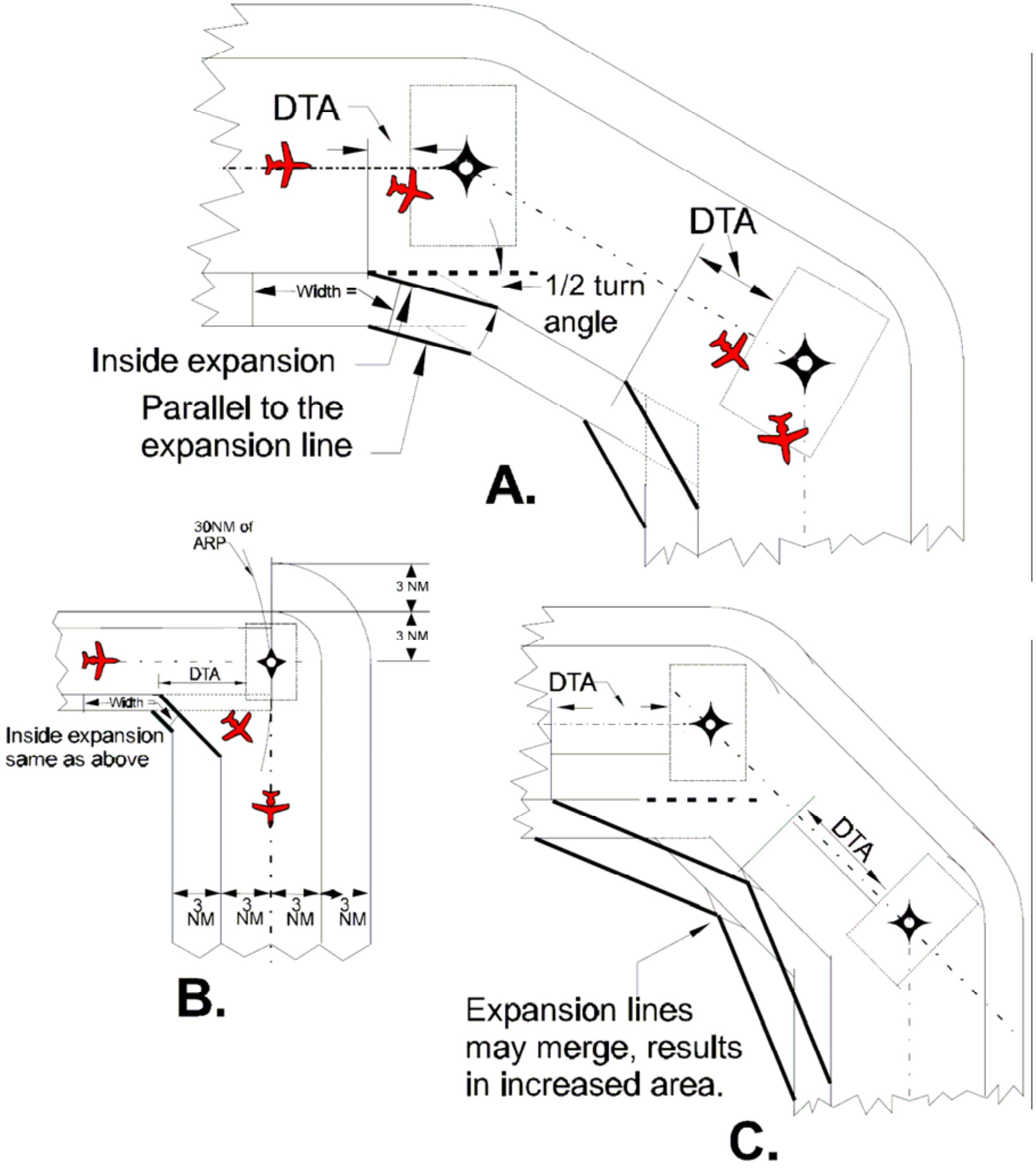


Figure 18: Fly-By WP’s, TF Legs

12.3 OUTSIDE EXPANSION TURNS. Area for a fly-over WP. Track to fix legs.

12.3.1 Aircraft Departure Outer Boundary Radius. Select the outer boundary radius for construction of turning areas from table 3. These radii apply for the primary area boundaries. Use the boundary radius for the airspeed. Radius for the secondary area boundaries adds the applicable secondary width to R1, i.e., 1, 2, 3 NM.

12.3.2 When the first TWP is within 5 NM of DER, use an outer boundary radius of 2.9 NM (or less as allowed in table 3 with the speed restriction) for that area; for any turns thereafter, apply paragraph 11.1. To determine the elevation for application of table 3, use the flight track distance to the WP applying the 200 feet per mile and/or published climb gradient where applicable.

12.3.3 At the latest point of the FDT, construct a baseline, for points C'-C-B. Use this baseline to construct a set of arcs to establish boundaries of the outside expansion areas (see figures 19 and 20).

a. Locate point C at a distance of R1 from the edge of the primary area along the baseline. Using point C on the baseline as a center point, draw an arc with radius R1 on the outside edge of the primary area of the turn. (R1 is a boundary radius selected from table 3.) Draw a second arc with radius R2 (see table 3), using C as a center point, from the outer edge of the secondary area on the outside of the turn (see figures 19 and 20).

b. For turns 90° or greater, locate point B on the baseline at a distance R1 from point C. Draw another set of arcs as outlined in paragraph 12.3.3a. Connect the outside arcs with tangent lines to form the expanded area. The arcs of point B connect tangentially with lines 30° relative to the succeeding course centerline that join with the primary and secondary area boundaries (see figures 19 and 20).

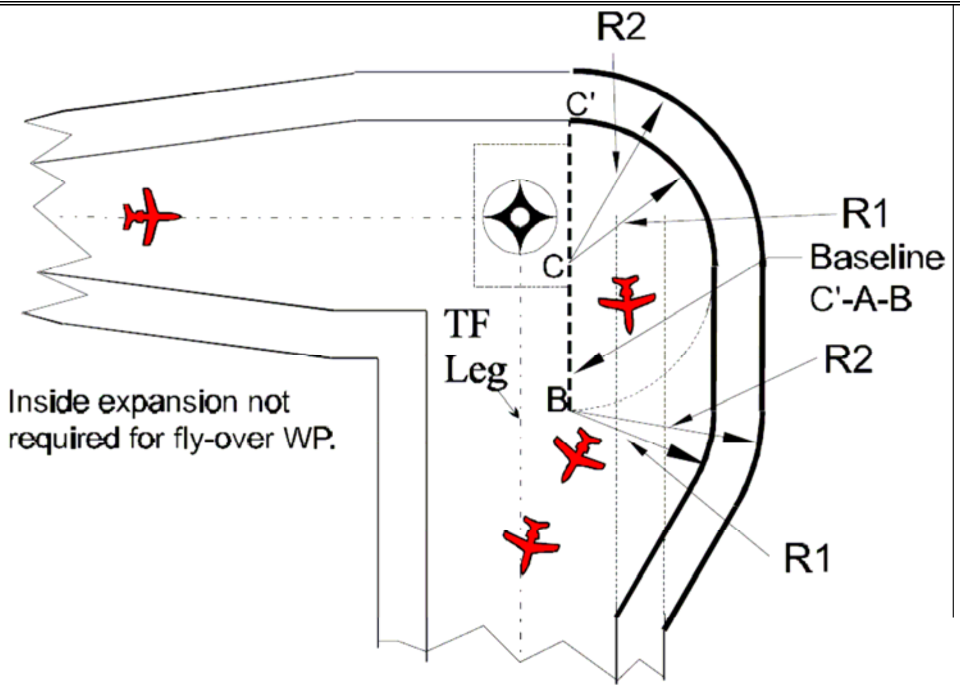


Figure 19: Fly-Over WP Track to Fix Leg

12.3.4 Turns 90° or greater inside 5 NM are illustrated in figure 20. Secondary areas begin abeam the fly-over WP. Where "d" is less than 2 NM, inside splay begins abeam DER as well as secondary area. Locate point "F" on the extended 15° splay using radius R2 from point C. C' is located on the edge of the primary splay and point of intersection with the baseline.

12.3.5 For turns less than 90°, construct a reference line from point C, parallel to the course centerline following the TWP. Locate point D on the reference line at a distance R1 from C and C1 (see figure 21).

a. Using point D as a center point, draw two arcs with radius R1 and R2, respectively. Radius R1 and R2 arcs define the primary and secondary expansion areas, respectively. Connect arcs with tangent lines.

b. Locate E in same manner as locating C in paragraph 12.3.3a (see figure 21). Construct a line on the outside of the turn, parallel to the course line, offset by a distance one-half the segment width. Locate C2 at the intersection of this line and the baseline of this segment. Locate E, a distance of R1 from C2. Using E as a center point, draw arcs R1 and R2. Locate E' in same manner as locating D in paragraph 12.3.5. Connect, via tangents, the arcs centered at C, D, E and E' respectively. The arcs of point E connect tangentially with lines 30° relative to the succeeding course centerline that join with the primary and secondary area boundaries.

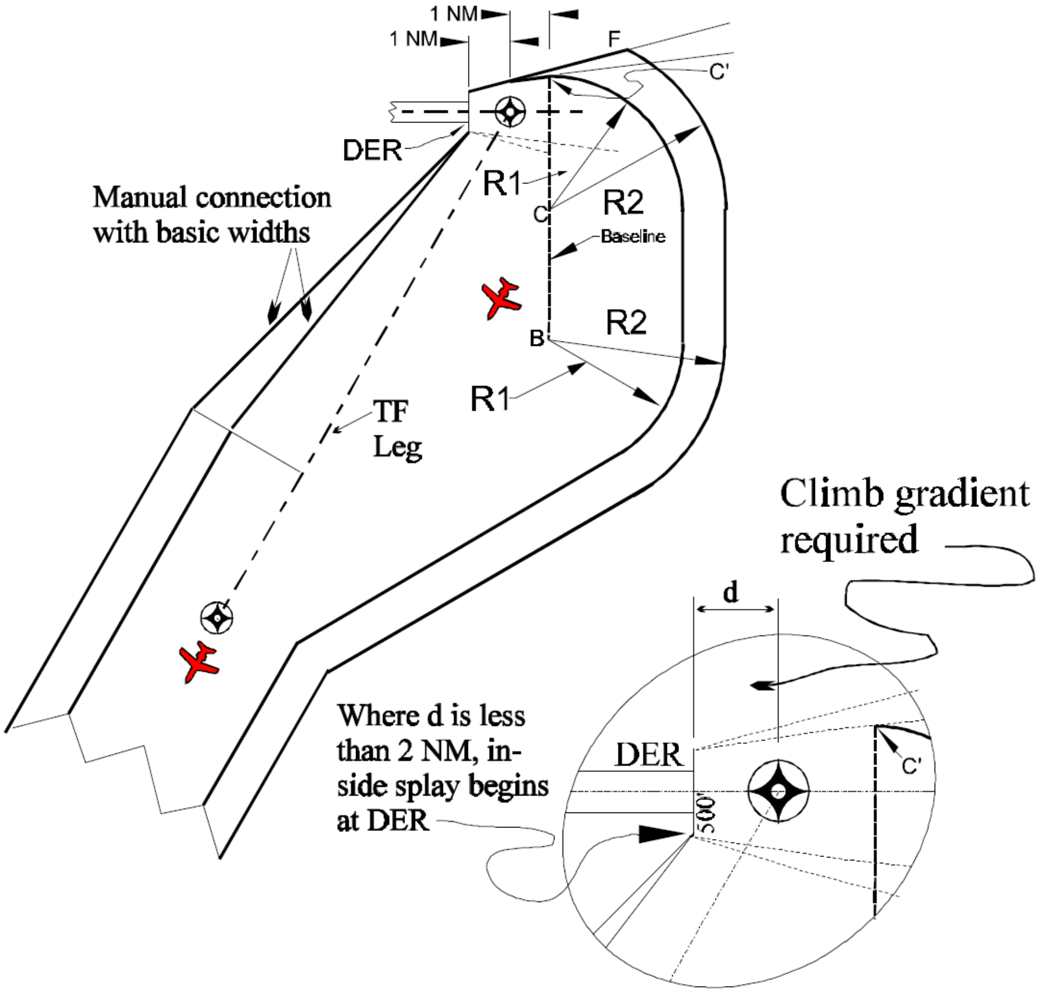


Figure 20: 90° or more Turn, Fly-Over WP Less 2 NM from DER

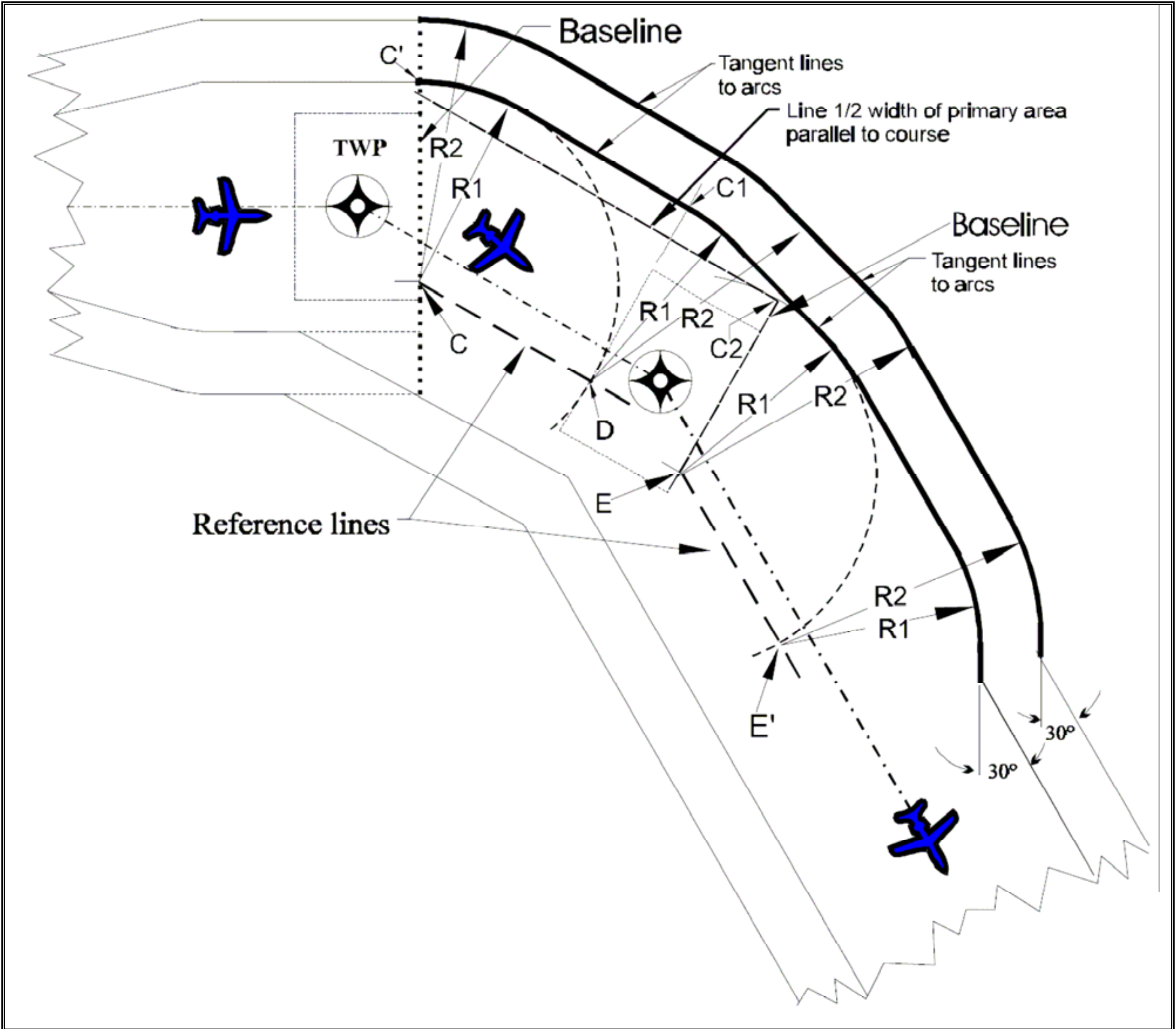


Figure 21: Successive fly-Over WP's

12.3.6 Expansion Areas for Fly-By to Fly-Over WP's. Apply paragraph 12.2.1 for the inside expansion area required for the fly-by WP. Apply paragraph 12.3.5 for the outside expansion required for the fly-over WP (See figure 22).

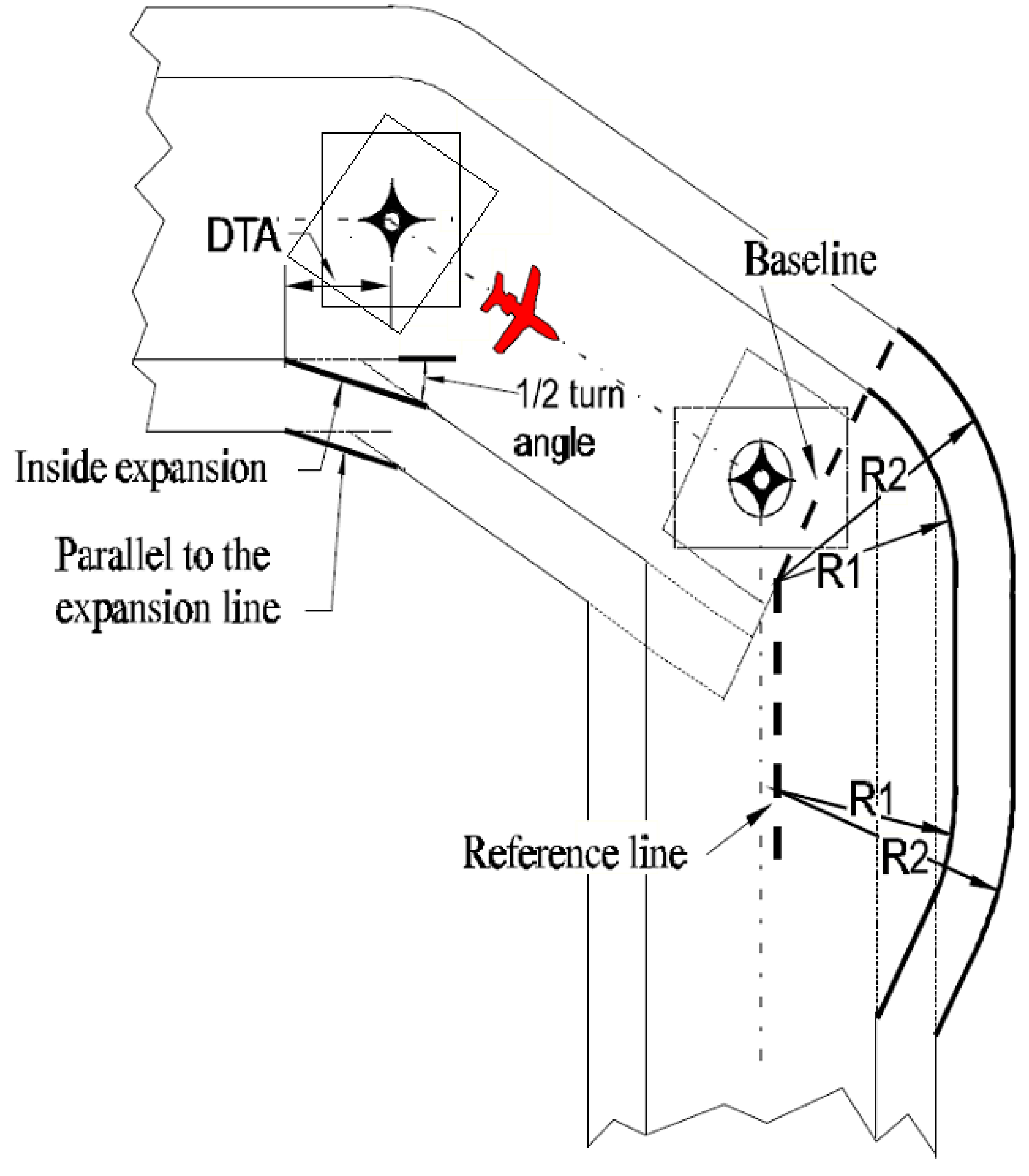


Figure 22: Fly-By to Fly-Over WP's

12.3.7 Expansion Areas for Fly-Over to Fly-By WP's. Apply paragraph 12.2.1 for the inside expansion area required for the fly-by. Apply paragraph 12.3.3b for the outside expansion area, 90° turn or greater, and 12.3.5 turn less than 90°, required for the fly-over WP's (see figure 23).

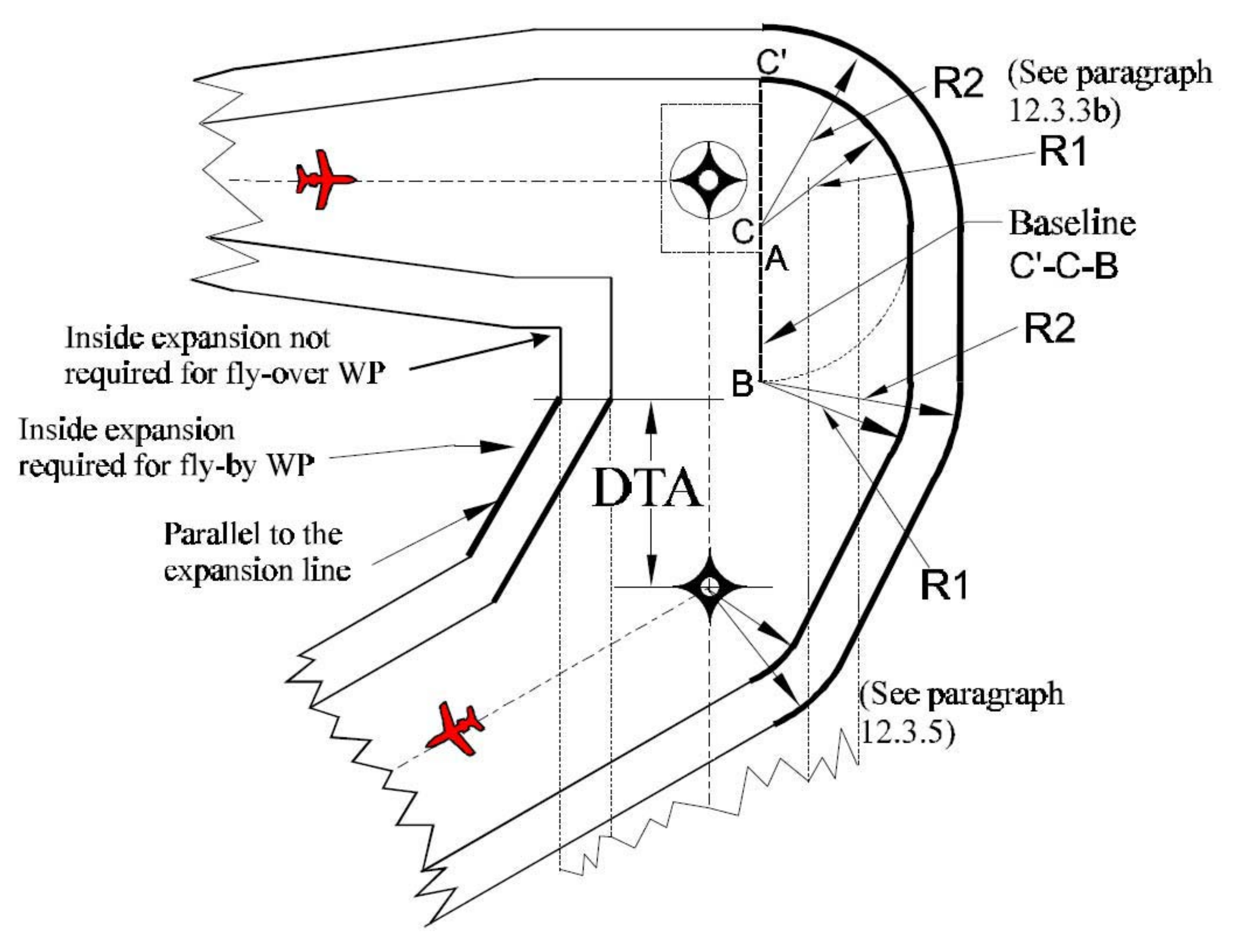
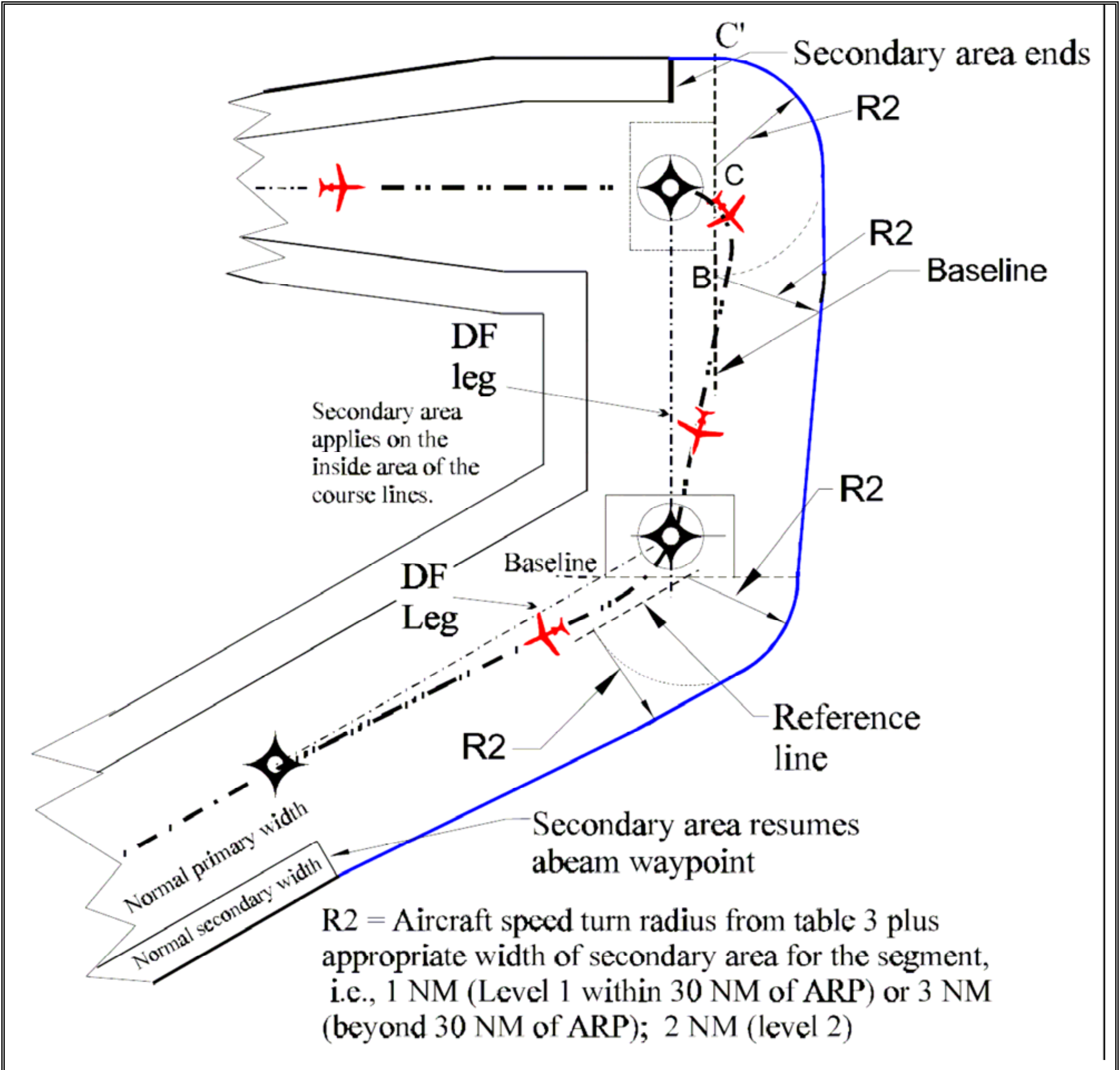


Figure 23: Fly-Over to Fly-By WP's

12.3.8 Direct to Fix Leg, Turns up to 120°. After turning at a fly-over WP, obstacle clearance is provided as if the aircraft rolls out and flies direct from the rollout point to another WP, either fly-by or fly-over. Specify the course change and plot the next WP. A secondary area is not allowed on the outside area of turns abeam the first fly-over WP to abeam the last WP where normal primary and secondary areas can resume. The all-primary area on the outside of the turns encompasses areas of successive fly-over WP's. The dimensions of the arc, to form the outside boundaries of the turning areas, are radii selected from table 3. Add the appropriate secondary dimension width to formulate R2. Baselines and/or reference lines are necessary to construct the outside boundary arcs. Locate C on the baseline from C¢ on the outside of the secondary area's normal boundary width. Swing an arc from C to locate B. Swing an arc from B to form a second expansion arc. Use this expansion method for any successive fly-over WP's (see figure 24).



R2 = Aircraft speed turn radius from table 3 plus appropriate width of secondary area for the segment, i.e., 1 NM (Level 1 within 30 NM of ARP) or 3 NM (beyond 30 NM of ARP); 2 NM (level 2)

Figure 24: Fly-Over to Fly-Over WP, to a Fly-By WP

12.3.9 Direct to Fix Leg, Turns more than 120°, Fly-Over WP. After turning at a fly-over WP, obstacle clearance is provided as if the aircraft rolls out and flies direct from the rollout point to another WP, either fly-by or fly-over. Specify the course change and plot the next WP. A secondary area is not allowed from the TWP to the succeeding WP, but a secondary area is allowed to the TWP. The all-primary area, after the TWP, is made up of primary and secondary width dimensions combined. The dimensions of the arc, to form the outside boundaries of the turning areas, are radii selected from table 3 and adding the appropriate secondary dimension width to formulate R2. In figure 25A, R1 is applied to form the course line that returns to the WP "Y" from TWP "Z." A perpendicular line is then constructed at the end of the segment. Construct a baseline at latest point of the FDT, TWP "Z" to locate vertices to draw the outside obstacle area arcs. Construct an "evaluation" baseline at the earliest point of the FDT, TWP "Z," to evaluate the obstacles in section 2. Locate C on the baseline using R2 from C¢ on the outside of the secondary area's normal boundary width. Swing an arc from C to construct a boundary arc. Continue this arc to form an intersection with the baseline at point D. D might fall short of "B" or overlap it on an extension of the baseline as shown in figure 25B. Point B is at the corner of the secondary area intersecting the baseline. Swing an arc from B (D if it overlaps B as shown in figure 25B) to form a second expansion arc. Join the two arcs by tangents forming the end of section 1 area (see figures 25A and B).

12.4 CLIMB TO ALTITUDE AND TURN.

Use 200 feet per NM to determine distance required from DER to a point on runway centerline extended as the initial course where the turning altitude can be reached. Publish the extended runway centerline starting at the DER as the departure course. The distance measured from the DER to the point shall be sufficient enough to allow the aircraft to reach the designated turning altitude. Publish a climb gradient if a shorter distance is required.

12.4.1 Heading to an Altitude (VA), (Dead Reckoning). Expand the area for the climb by constructing a line 15° relative to the extended runway centerline each side of the course to a point where the altitude for the turn is reached. Select a course and distance to the next waypoint as desired. Expansion of the area is required beyond the first turn similar to the expansion methodology outlined in paragraph 12.3.9. The entire departure area including expanded portion is primary area. Use R2 radius value to construct the turning area around the point where the altitude specified to "climb to" has been reached (see figure 26).

a. For turns 90° or less, construct an inside boundary starting on the edge of the runway at a point 2,000 feet from the take-off roll end of runway, point A' (see figure 26). Extend a line directly to the inside edge of the secondary area abeam the latest point of the FDT area of the waypoint where PCG can be resumed (see figure 26).

12.4.2 VA Followed by Turn More Than 90°. Construct the initial course and area in accordance with paragraph 12.4.1. Use R1 (table 3) as the turn radius to construct a course to the next waypoint. Select distance based on 200 feet/NM to altitude desired. Climb gradient permitted. Expansion of the area is required beyond the first turn, using the wide construction methodology. The entire departure area is primary area (see figure 27).

a. Use R2 at the end of the segment where the turn begins for boundary arcs. Locate point D outside of turn area, construct boundary arc from point D, and join with tangent line to boundary arc for point C¢. Connect boundary arc of point D to point G abeam the waypoint at the edge of the secondary area where the PCG resumes. Connect point C to point F.

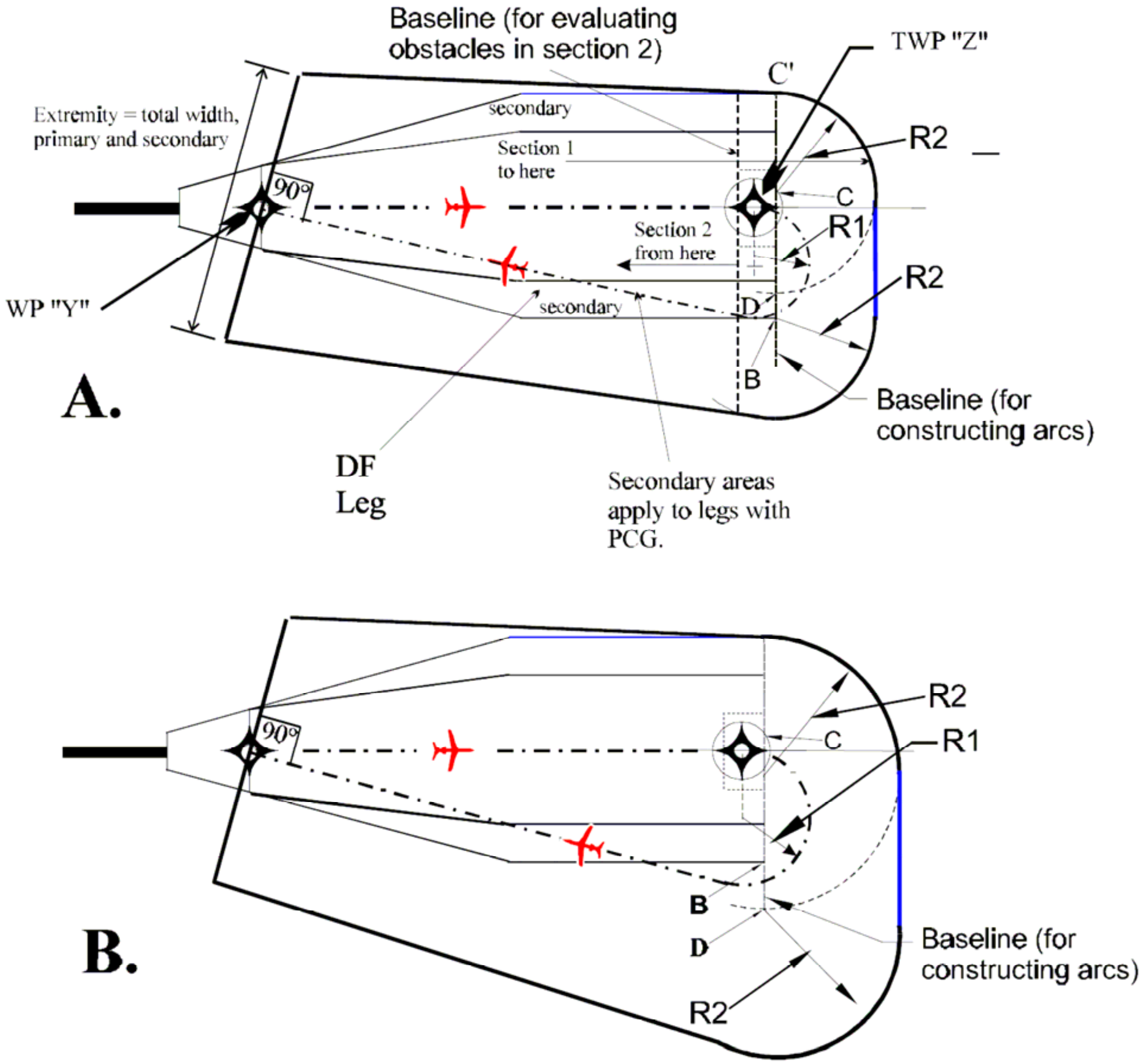


Figure 25: DF, More than 120° turn, Fly-Over WP

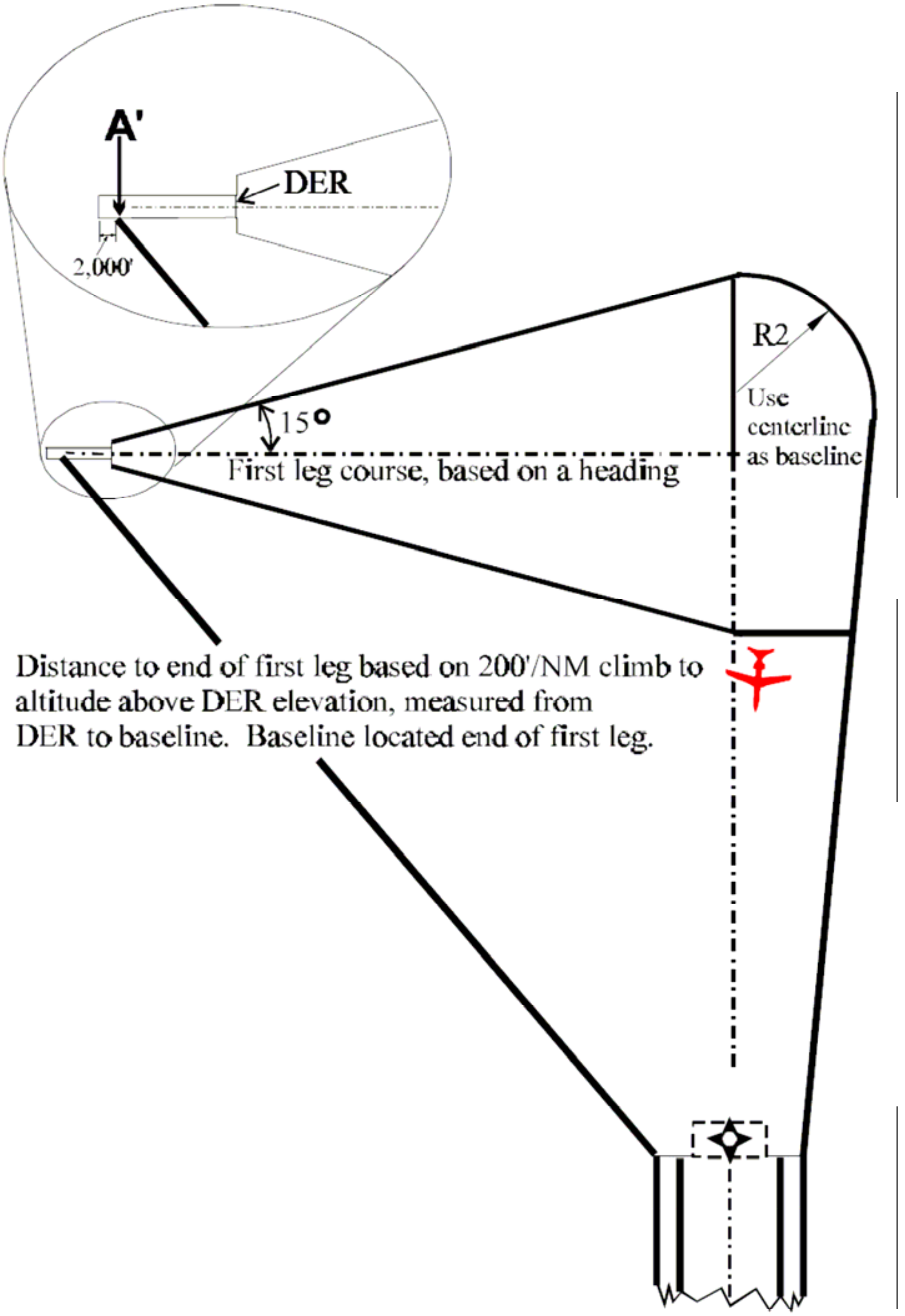

A'
DER
2,000'
R2
15°
Use centerline as baseline
First leg course, based on a heading
Distance to end of first leg based on 200'/NM climb to altitude above DER elevation, measured from DER to baseline. Baseline located end of first leg.

Figure 26: VA

13.1 DEPARTURE AREAS MERGING WITH EN ROUTE AIRWAY STRUCTURE

13.2 FLY-BY WP'S

Inside expansion is not required when departure areas are 4 and 2 NM primary and secondary respectively.

13.2.1 When the departure merges with an airway and departure areas are 2 and 1 NM primary and secondary respectively, the areas do not require any turn expansion (see figure 28).

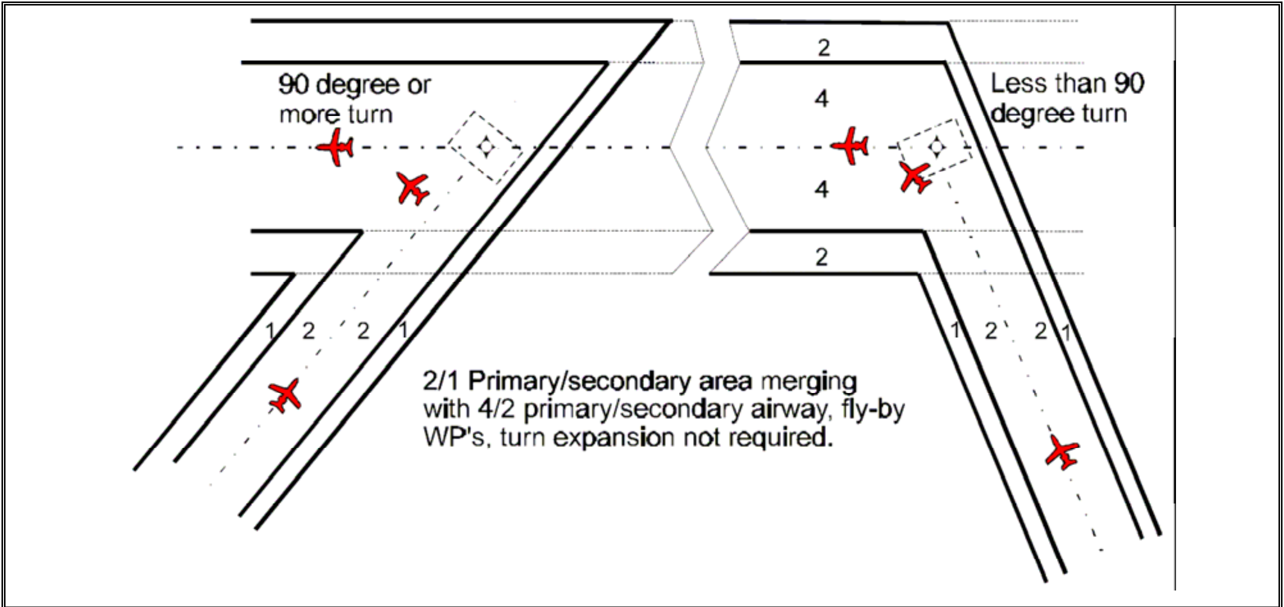


Figure 28: Fly-By WP's, TF Legs

13.2.2 When the departure merges with an airway and the departure areas are 3 and 3 NM primary and secondary respectively, they require inside turn expansion (see figure 29). Paragraph 12.2 provides criteria.

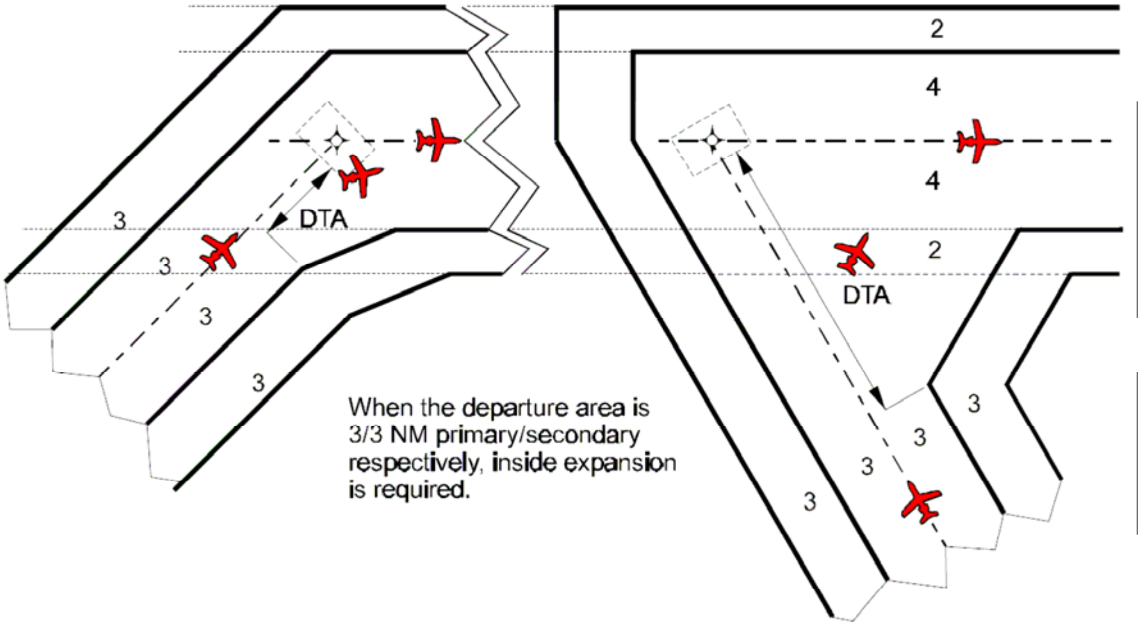


Figure 29: Fly-By WP's, TF Legs

13.2.3 When the departure merges with an airway and departure areas are splaying from 2 and 1 NM areas to 3 and 3 primary and secondary areas respectively, the splay of the outside boundary ends where the two courses intersect. Inside expansion is not required (see figure 30).

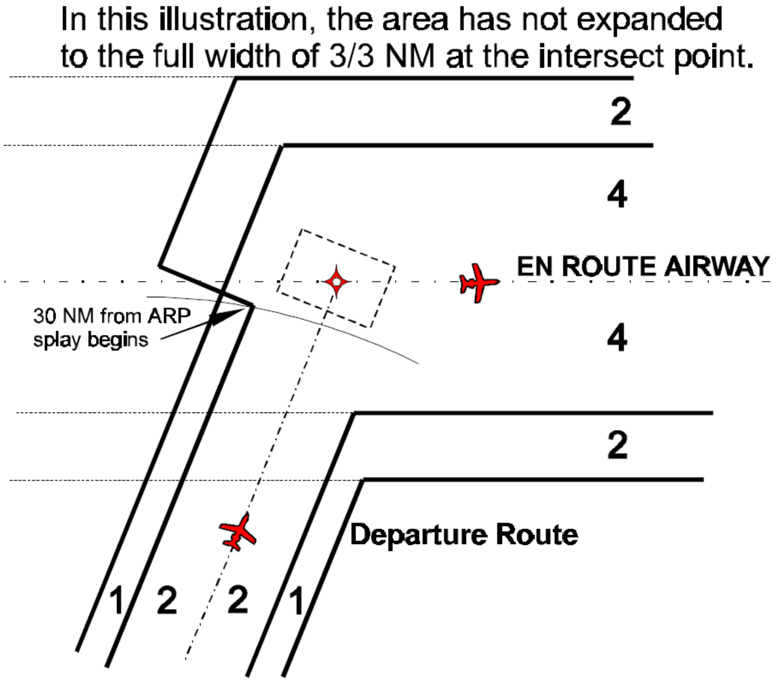


Figure 30: RNAV Departure Joining En Route Airway

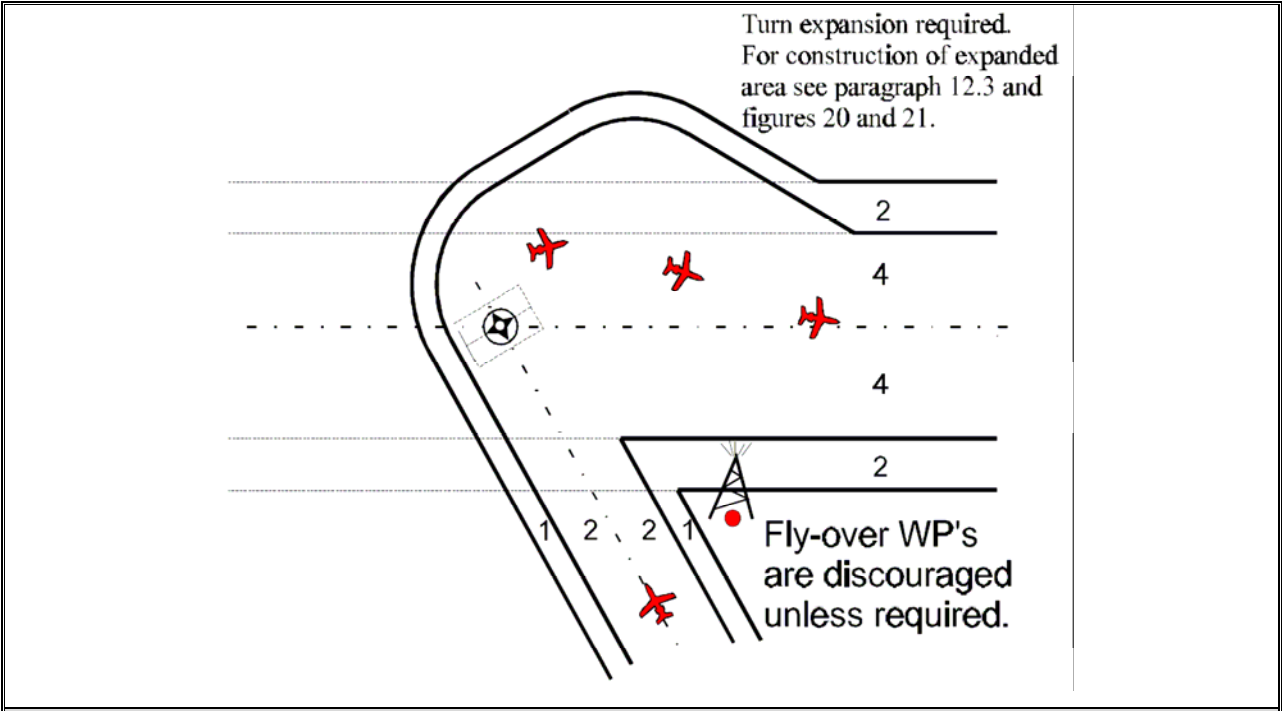


Figure 31: Fly-Over WP, TF Leg

13.3 FLY-OVER WP’S

When the departure area merges with an airway, outside turn expansion is required for all departure areas; i.e., 2 and 1 NM or 3 and 3 NM, primary and secondary areas (see figure 31). Paragraph 12.3 provides criteria.

13.3.1 When the departure areas are 4 and 2 NM primary and secondary respectively, use the criteria in Volume 1, Chapter 17, paragraph 1715b, for outside area expansion for turning areas.

14.1 DEPARTURE ALTITUDE

Establish a departure altitude, which is the highest altitude of: joining an existing airway, off-airway termination, or an air traffic control requirement.

14.2 JOINING AN EXISTING AIRWAY

14.2.1 A level surface evaluation. See paragraph 15.9.

14.2.2 The appropriate MEA or MCA for the direction of flight.

14.3 OFF-AIRWAY TERMINATION

14.3.1 A level surface evaluation.

14.3.2 Altitude where radar services can be provided.

15.1 OBSTACLE EVALUATION

The area considered for obstacle evaluation begins at the departure area, and ends at a point or a WP/FIX/NAVAID defining the end of the departure (see paragraph 18.1). The maximum required obstacle clearance (ROC) for level flight is 1,000 feet in non-mountainous areas and 2,000 feet in designated mountainous areas, except when Order Volume 1, Chapter 17, paragraph 1720, is applied. Do not compute a climb gradient above an altitude that satisfies these ROC's.

15.2 PRIMARY AREA

No obstacle shall penetrate a 40:1 OCS that begins at the DER at DER elevation. Exception: Increase the origin height up to 35' above DER as necessary to clear existing obstacles. The OCS rises above the shortest distance in the primary area from its beginning to the obstacle. For turns, evaluate obstacles on the turning side of the initial climb area by measuring back, within the primary area, the shortest distance to the beginning of the departure area (see figure 32).

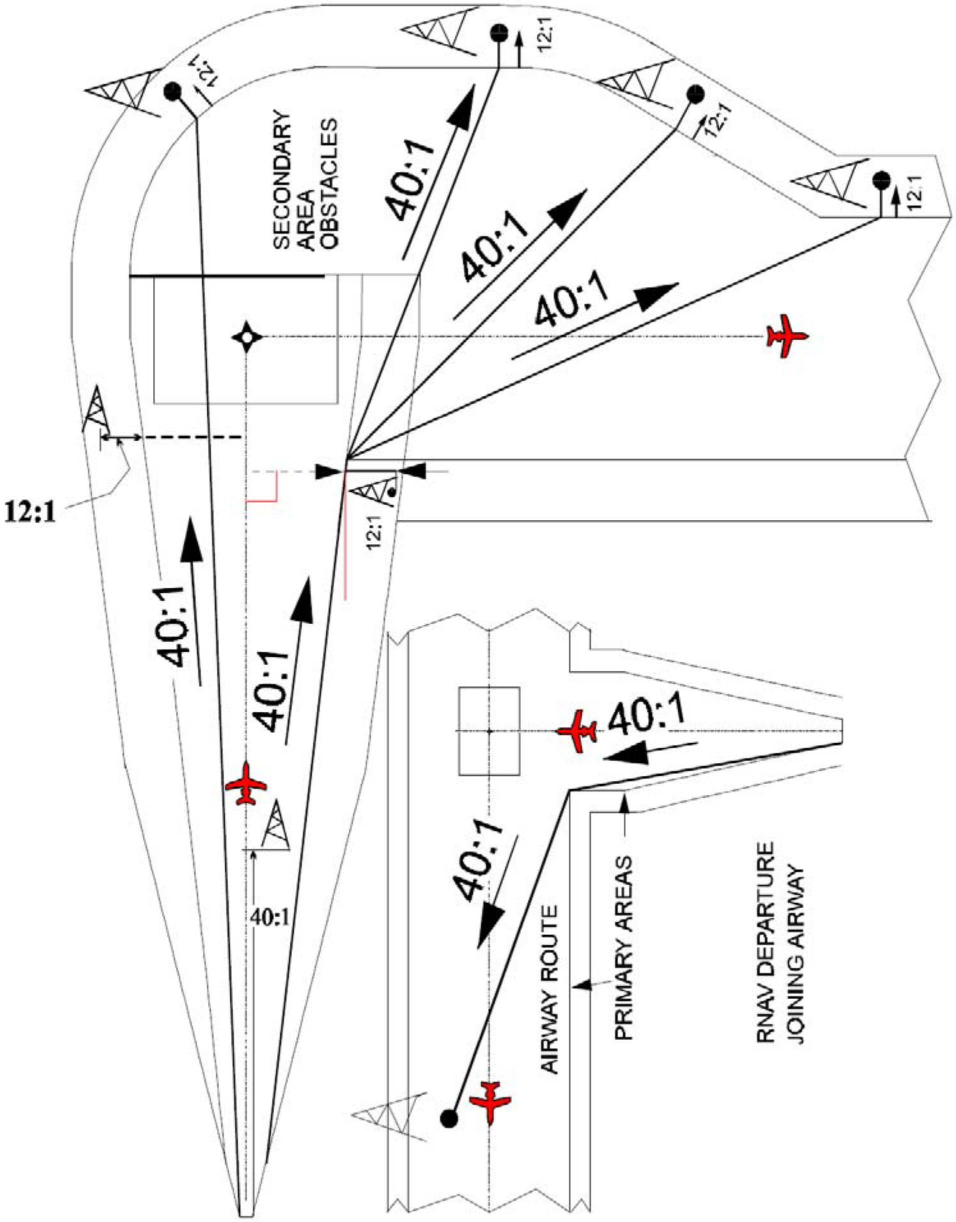


Figure 32: Evaluation of Obstacles

15.2.1 Secondary Area. No obstacle shall penetrate a 12:1 OCS which rises from the edge of the primary area perpendicular to the segment course. In a turn expansion area, the 12:1 OCS rises perpendicular to the edge of the primary area (see figure 32). Determine the height of an equivalent obstacle on the edge of the primary area, and then evaluate the equivalent obstacle relative to the 40:1 OCS at that point.

Example:: A 9,840' MSL obstacle is located in the secondary area, 2,700' from the edge of the primary area.

Step 1. Determine the elevation of an equivalent obstacle (E_E) on the edge of the primary area:

Rise of 12:1 slope to edge of primary area:	2,700' / 12	= 225'
Elevation of obstacle (E_O)		9,840'
Less 12:1 rise		- 225'
Equivalent Obstacle (E_E)		= 9,615'

Step 2. Determine the 40:1 OCS elevation at equivalent obstacle:

D = distance (feet) from beginning of departure area measured along the shortest distance within the primary area = 21,344'

Plus 40:1 rise:	21,344 / 40	= 533.6
DER elevation		7,640.0'
40:1 rise		+ 533.6'
40:1 OCS elevation at equivalent obstacle		= 8,173.6'

15.3 EVALUATE THE DF LEG, TURNS MORE THAN 90°

by measuring shortest distance from the DER to the obstacle within the primary area of section 1. Measure the shortest distance to the "evaluation baseline" from DER and then to the obstacle in section 2 (see figure 33).

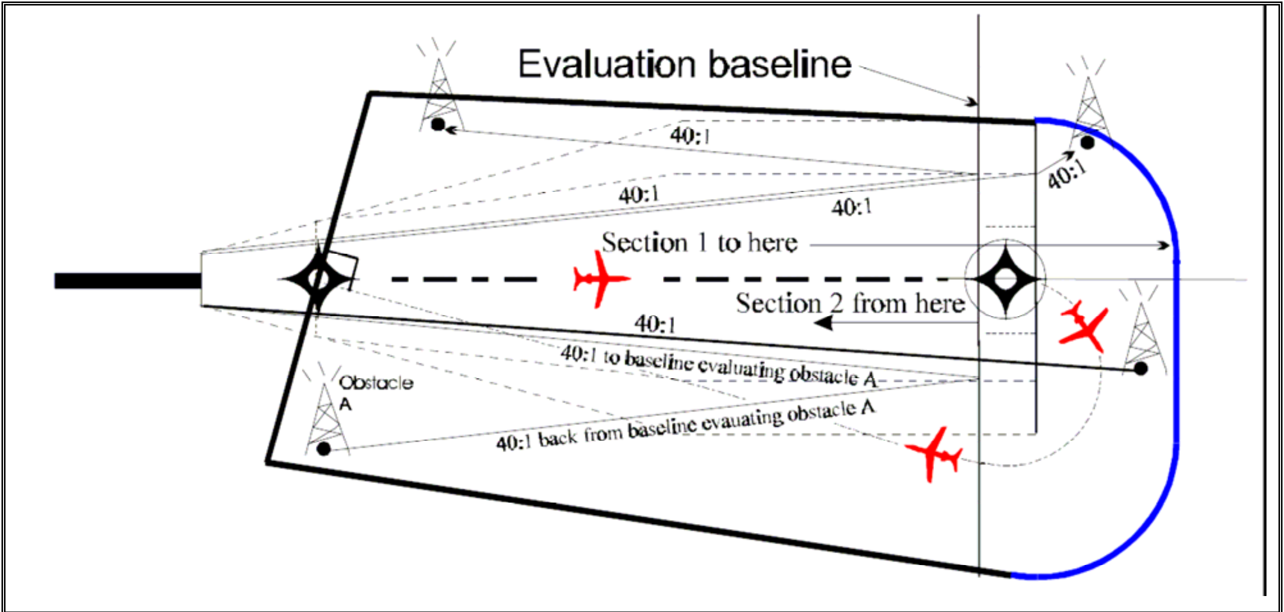


Figure 33: More than 90° Turn, Obstacle Evaluation

15.4 EVALUATE THE CLIMB TO ALTITUDE AND TURN

procedure by measuring shortest distance from the DER to each obstacle within primary area of section 1. Establish an elevation of the A-B-D-C lines by measuring 40:1 from DER to the B-D line. Obstacles beyond the B-D line, section 1A, are measured 40:1 from the DER. Evaluate the shortest distance with a 40:1 slope to the obstacle in section 2 from an edge of the A-B (D-C if applicable) lines starting at their established elevation (see figure 34A). Obstacles in section 3 are evaluated 40:1 from A-C using the elevation established for the A-B-D-C area (see figure 34B).

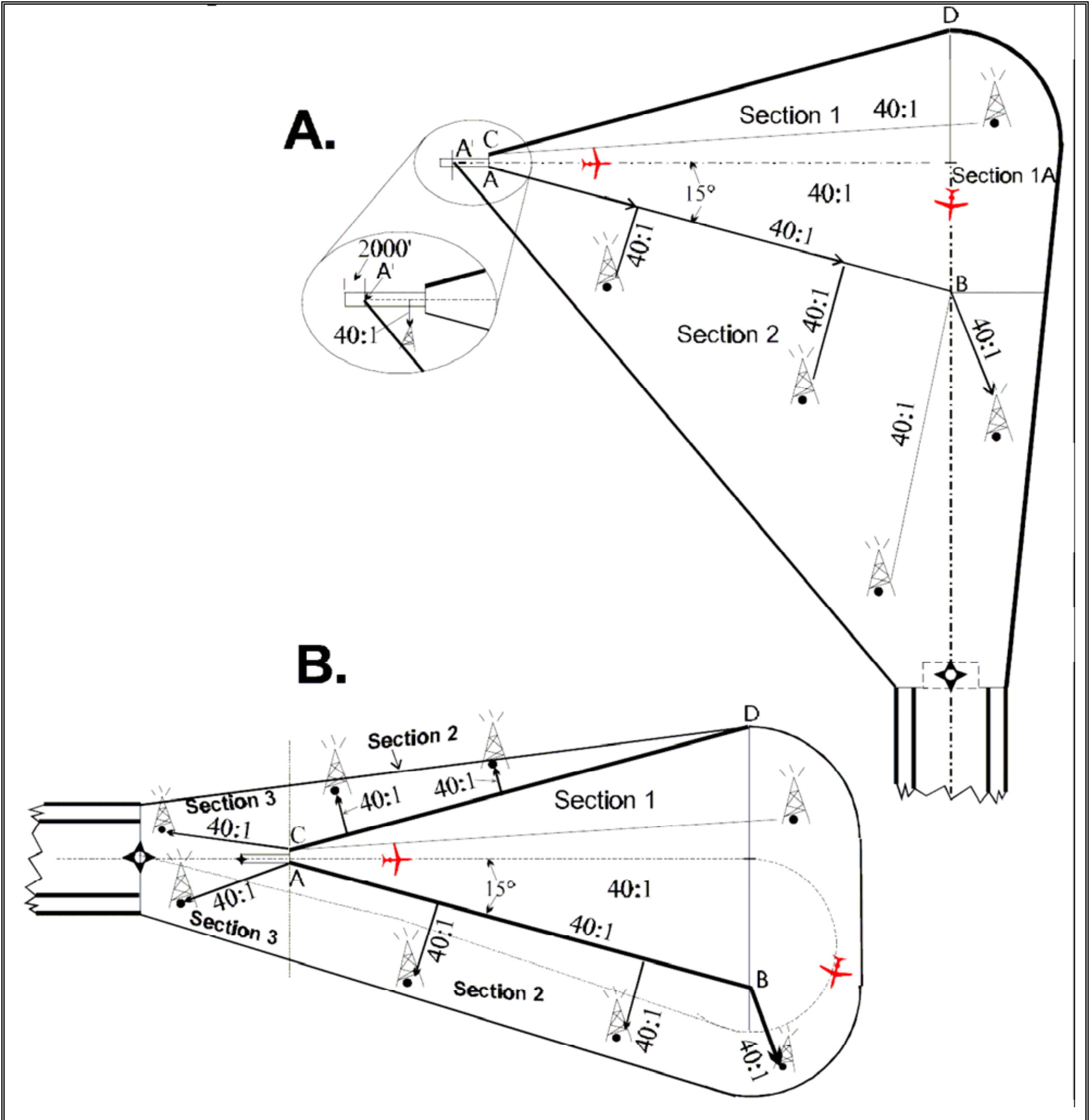


Figure 34: Evaluation of Climb to Altitude and Turn

15.5 WHEN THE DEPARTURE JOINS AN EN ROUTE AIRWAY

normally the departure area ends at the point where the departure course and the en route course intersect. Where the standard climb gradient (200 feet/NM) allows the aircraft to reach the MEA/MCA, further evaluation of the OCS beyond the intersection is not required. Where the standard climb gradient does not allow the aircraft to reach the MEA/MCA, continue the OCS evaluation to the point where the height of the OCS equals the lowest MEA for all directions of flight minus applicable en route ROC.

15.6 WHERE PENETRATIONS OF THE OCS IN PARAGRAPH 15.5 OCCUR

15.6.1 Provide a CIH evaluation to the MEA, see paragraph 17.1, at the departure/airway intersect point (preferred holding pattern alignment is on the airway); or

15.6.2 Provide a climb gradient to MEA at the departure/airway intersect point; or

15.6.3 If during a CIH evaluation an OCS penetration occurs, establish a climb gradient to clear offending obstacles.

15.7 WHERE THE STANDARD CLIMB GRADIENT

will not allow the aircraft to comply with an airway MCA, provide a note indicating climb gradient required. For example: Departures north bound on Victor 240 require a minimum climb of 426 feet/NM to 7,300 feet.

15.8 THE OCS HEIGHT

where the departure course and en route segment intersect is determined by measuring the shortest distance within the primary area to a line drawn perpendicular to the departure course through the point of intersection defined by a WP/FIX/NAVAID.

15.9 APPLY A LEVEL SURFACE EVALUATION

for the entire departure in a similar manner as stated in Volume 1, Chapter 2, paragraph 274.

16.1 CLIMB GRADIENTS

Do not exceed a 500-foot per NM climb gradient without approval from Flight Standards Service.

16.1.1 Climb Gradients to Achieve Operational Requirements. Climb gradients for purposes to achieve operational requirements, such as the initial climb, where the distance to first turn WP is less within 2 NM, calculate a climb gradient to that WP using the following formula:

$$\left(G = \frac{(APT + 400') - DERELEV}{D_1} \right)$$

Where:

G = climb gradient (feet/NM)

APT = airport elevation

DERELEV = DER elevation

DI = distance (NM) from DER measured along the route centerline

NOTE: The 400’ value may be increased by operational/air traffic requirements.

Example:

Where:

APT = 3,000’ (Airport elevation)

DERELEV = 2,950’ (DER elevation)

The first WP is located 1.6 NM beyond the DER.

$$\left(G = \frac{(3{,}000' + 400') - 2{,}950'}{1.6} \right) = \mathbf{281'/NM}$$

16.1.2 Climb Gradients to Achieve Obstacle Clearance. For any segment, including the initial climb area, avoid obstacles (including equivalent obstacles from paragraph 15.2.1) which penetrate the OCS, by specifying a climb gradient that provides 24 percent of the gradient as ROC not to exceed the maximum required obstacle clearance specified in paragraph 15.1 applied over distance (D). Apply the minimum climb gradient required for obstacle clearance. The minimum climb gradient for an obstacle is determined from the formula:

$$G = \frac{H_O}{0.76\ D} \quad \text{or} \quad \frac{H_E}{0.76\ D}$$

Where:

G = climb gradient (feet/NM)

HO= Height (feet) of obstacle above DER (feet) or HE (equivalent obstacle in secondary area) as appropriate.

D = Distance (NM) from DER measured along the shortest distance within the primary area.

Example: Determine minimum climb gradient (G)

Where:

E_E (Equivalent Elevation)	= 9,615’
DER Elevation	<u>= 7,640’</u>
Height (HE) of equivalent obstruction above DER	= 1,975’

D = 3.51 NM

$$G = \frac{H_E}{0.76\ D} = \frac{1{,}975'}{0.76\ (3.51)} = 740.36 \quad = \mathbf{740\ feet/NM}$$

16.1.3 Specify the climb gradient to an altitude where a gradient greater than 200 feet/NM is no longer required. The climb gradient termination altitude (A_T) may be determined by the formula:

$$\mathbf{A_T = DG + DER\ Elevation}$$

Example: Minimum climb gradient termination altitude (A_T)

A_T = [3.51 x 740] + 7,640'

= 10,237.4'

= 10,300' MSL (round to the next higher 100-foot increment)

Using example in paragraph 16.1.2:

“-------with a minimum climb of 740’/NM to10,300’.”

16.1.4 Multiple Climb Gradients. Where multiple climb gradients exist within a segment, (e.g., due to multiple obstacle clearances, and/or as well as air traffic control requirements, or to meet en route MCA requirements) publish the highest computed climb gradient for that segment. When multiple climb gradients result from separate sources, a breakout of each source with the corresponding climb gradient should be published.

16.1.5 Climb Gradients based on an MCA or ATC requirements are calculated using flight track distance. Measurement is between DER and a point where an altitude is required or WP/FIX/NAVAID, or between WP's/FIX's/NAVAID's.

Example: Flight track distance: 12 NM

Altitude	8,000'
Elev DER	-1,200'
.	6,800'

$$G = \frac{6,800'}{12} = 566.66$$ (round to nearest foot) **567' per NM**.

G = climb gradient

17.1 CLIMB IN A HOLDING PATTERN

For a CIH, apply the criteria in Volume 1, Chapter 2, paragraph 293b. Minimum holding shall be at an altitude where radar service can be provided or when joining an airway provides en route operations (see figure 35).

18.1 END OF DEPARTURE.

The departure evaluation terminates at:

18.1.2 A WP/FIX/NAVAID not on an en route structure:

a. Where radar service can be provided.

b. Where a CIH evaluation is required to reach an altitude in which radar service can be provided.

18.1.3 An en route WP/FIX/NAVAID from which the aircraft can continue en route operations.

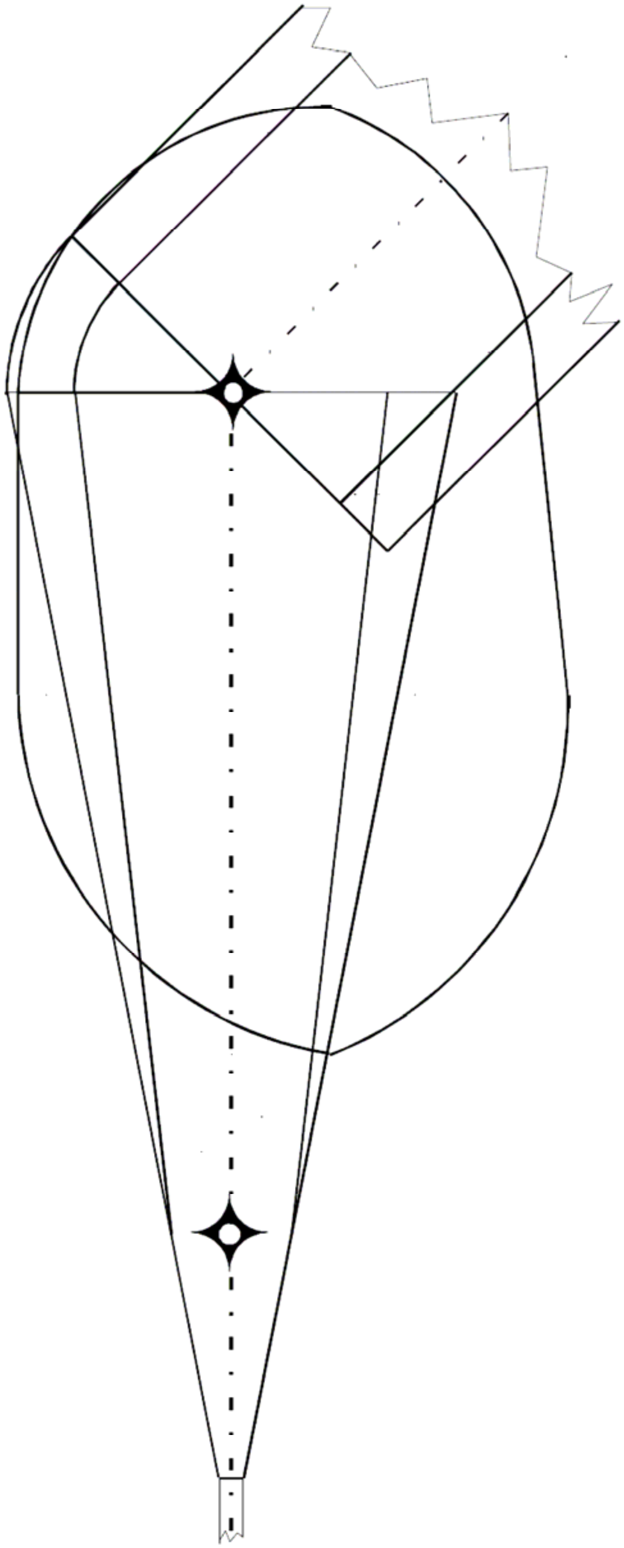


Figure 35: Climb-in-Hold

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CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 5

VOLUME 6

DOC 3

TERMINAL ARRIVAL AREA (TAA)

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CHAPTER 1. TERMINAL ARRIVAL AREAS

SECTION 1. GENERAL

1.0 PURPOSE

To define Terminal Arrival Area (TAA) design criteria and establishes the Basic T segment configuration as standard for area navigation (RNAV) approach procedures within the TAA.

2.0 – 4.0 RESERVED

5.0 BACKGROUND

Historically, transition from en route flight to the terminal environment required specific ground tracks defined by ground based navigational aids (NAVAID's). These transitions were difficult to develop in areas where terrain features interfered with signal propagation and reception. The advent of RNAV navigation systems independent of conventional ground NAVAID's created the possibility of establishing a new transition system. Efforts toward standardization of efficient approach segment configurations generated the TAA random arrival concept.

6.0 RESERVED

7.0 APPLICATION

Minimum Sector Altitudes are not required when TAA is developed.

SECTION 2. TAA AND APPROACH SEGMENT CONSTRUCTION

8.0 MINIMUM SAFE/SECTOR ALTITUDE (MSA)

Do not publish an MSA for an approach with a TAA.

8.1 INITIAL, INTERMEDIATE, FINAL, AND MISSED APPROACH SEGMENTS

The following application guidelines are specific to the TAA. The Basic T approach segment configuration, as described below, is the standard configuration for transition from the en route to the terminal environment. Deviations from the Basic T configuration should be made only when absolutely necessary.

8.1.1 Initial Alignment to the Intermediate Segment.

The OPTIMUM alignment of the initial segment to the intermediate segment is 90°. See figure 1A. Allowable alternative alignment is within 30° of the optimum alignment; however, this deviation should be used only when necessary for obstruction or airspace constraints (see figure 1B). Determine the minimum length of the T initial segments by referring to table 1. Use the value for the highest approach category published on the procedure. Descent gradient considerations may require longer segment lengths. Maximum leg length is 10 NM. If initial segment descent gradient criteria cannot be met, eliminate the T initial approach fix (IAF). Then, aircraft arriving from the direction of the eliminated T IAF will fly the course reversal holding pattern (see figure 1C). For parallel runway configurations, construct T IAF's so that they serve all parallel intermediate segments (see figure 1D).

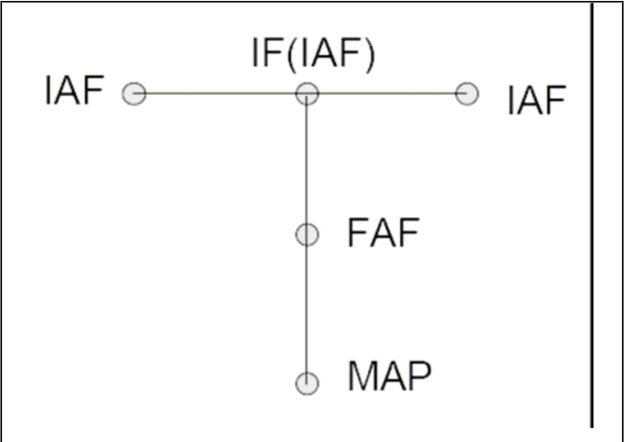


Figure 1A: BASIC T

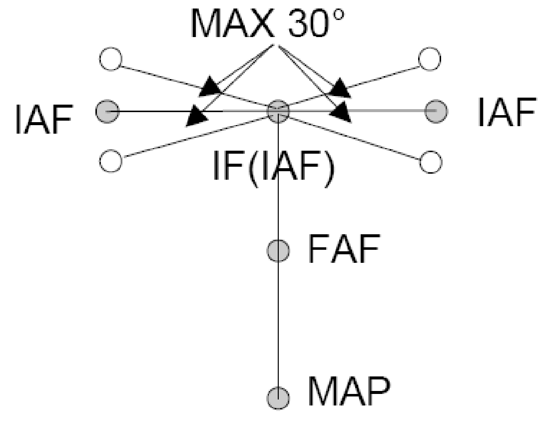


Figure 1B: Basic T Initial Segment Alignment Alternatives

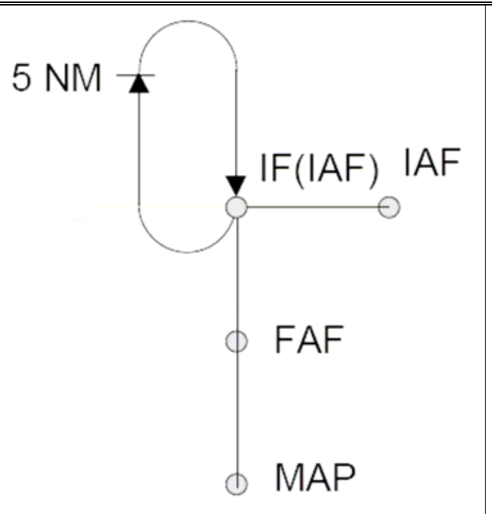
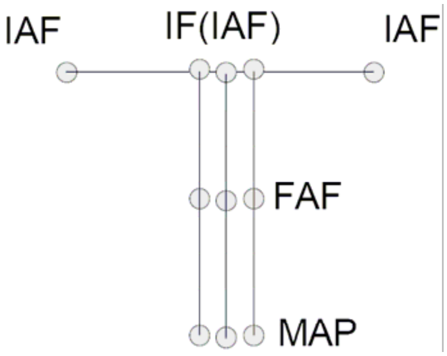


Figure 1C: Basic T With an IAF Eliminated



Note: Scale exaggerated for emphasis. The normal T IAFs serve all parallel runways. Each runway will require a separate IF (IAF). Only one intermediate and final will be depicted on the approach procedure.

Figure 1D: Basic T Parallel Runway Application

Category	Minimum Length (NM)
A	3
B	4
C	5
D	5
E	6

Table 1: Minimum Initial Segment Length

8.1.2 Intermediate Alignment to the Final Segment.

Align the intermediate segment with the final segment; i.e., turns over the final approach fix (FAF) are not allowed.

8.1.3 Establish a holding pattern at the IF(IAF).

The inbound holding course shall be aligned with the inbound intermediate course (see figure 1C). Express all RNAV holding patterns in nautical mile (NM) leg lengths vice timed holding under Order 7130.3, Holding Pattern Criteria.

8.1.4 Missed Approach Segments.

OPTIMALLY, construct missed approach segments to allow a "direct entry" into a missed approach holding pattern as illustrated in figure 2A. If the missed approach routing terminates at a T IAF, OPTIMUM alignment of the missed approach holding pattern is with the initial inbound course, with a direct entry into holding (see figure 2B).

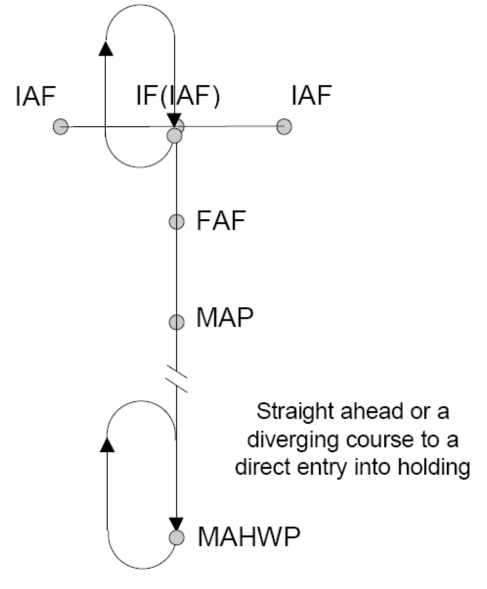


Figure 2A: OPTIMUM Missed Approach Holding

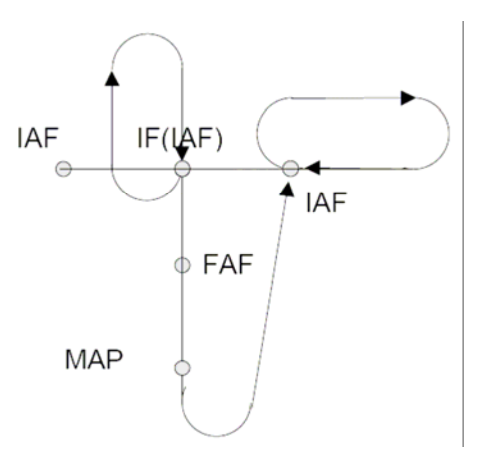


Figure 2B: Missed Approach Holding at an IAF

8.2 STANDARD TAA AREAS

The standard TAA contains three areas defined by the basic T segment centerline extensions: the straight-in area, right base area, and the left base area (see figure 3A). The TAA boundaries shall coincide with procedure flight tracks; e.g., the boundary between the straight-in area and either base area shall be the initial segment centerline extended; and the boundary between base areas shall be the intermediate segment centerline extended.

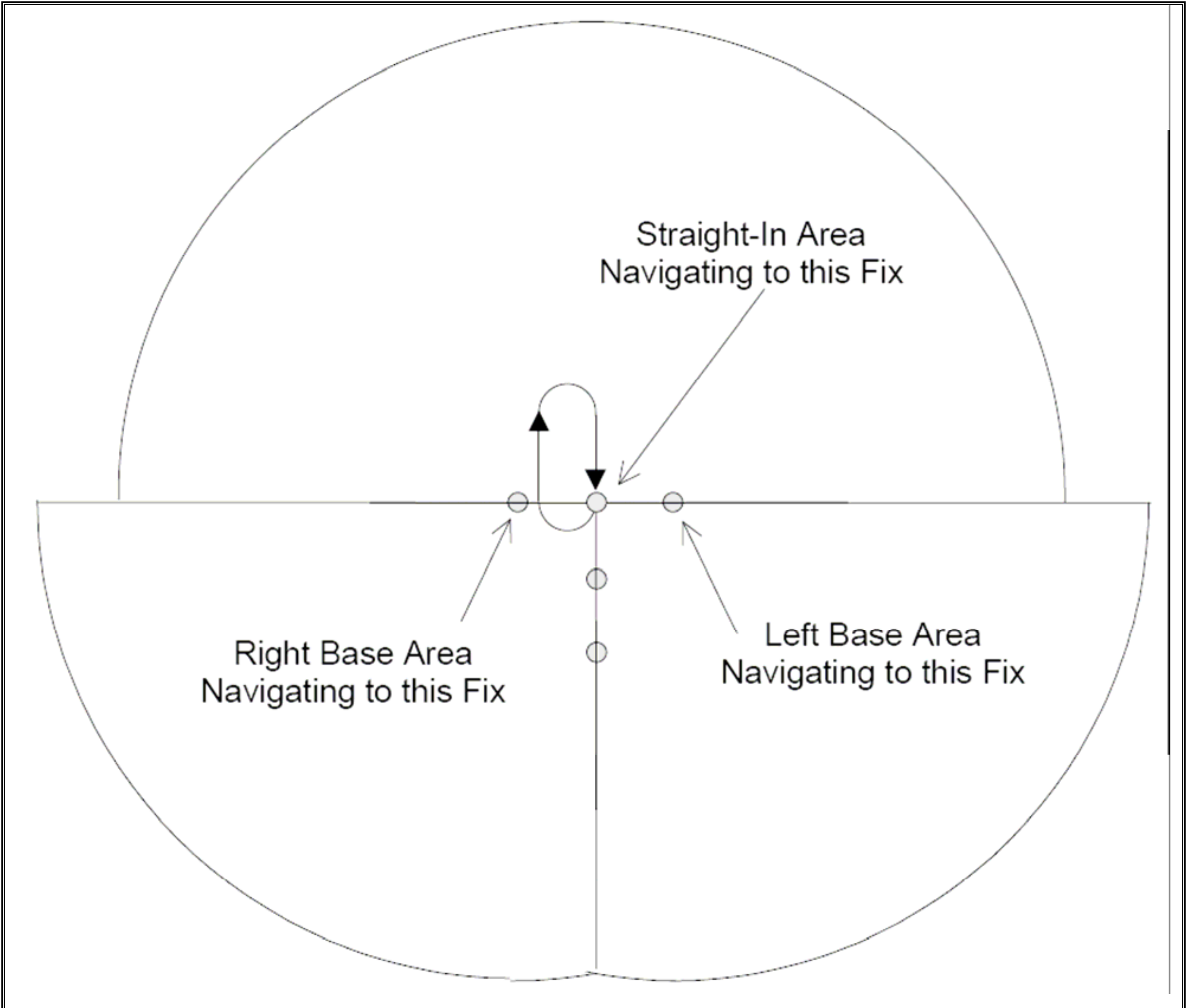


Figure 3A: Standard TAA

8.2.1 Straight-In Area.

The arc boundary of the straight-in area is equivalent to a feeder fix. When crossing the boundary or when released by ATC within the straight-in area, an aircraft is expected to proceed direct to the IF(IAF).

a. 8.2.1 a. Construction. Draw a straight line through the T IAF's, extending 30 NM in each direction from the IF. Then, on the side of the line away from the airport, scribe a 30-NM arc centered on the IF connecting the straight-line end points (see figure 3B).
b. Obstacle Clearance. The area considered for obstacle clearance includes the entire straight-in area and its associated buffer areas (see figure 3B). Vol 1, Chapter 1, Para 1720 applies.

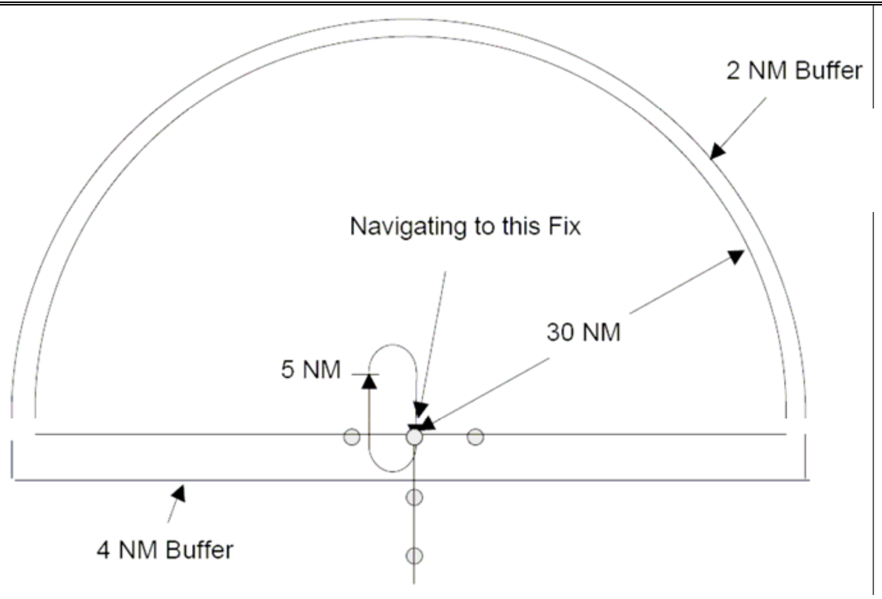


Figure 3B: Straight-In Area

8.2.2 Right Base Area.

The arc boundary of the right base area is equivalent to a feeder fix. When crossing the boundary or when released by ATC within the right base area, an aircraft is considered at the feeder fix and is expected to proceed direct to the IAF.

c. Construction. To construct the top boundary, extend the line from the IF through the T IAF for 30 NM beyond the T IAF. Draw a 30-NM arc, centered on the T IAF, from the end point of the top boundary counter-clockwise to the point it intersects a straight-line extension of the intermediate course (see figure 3C).

d. Obstacle Clearance. The area considered for obstacle clearance includes the entire right base area and its associated buffer areas. Vol 1, Chap 2, Paragraph 1720 applies.

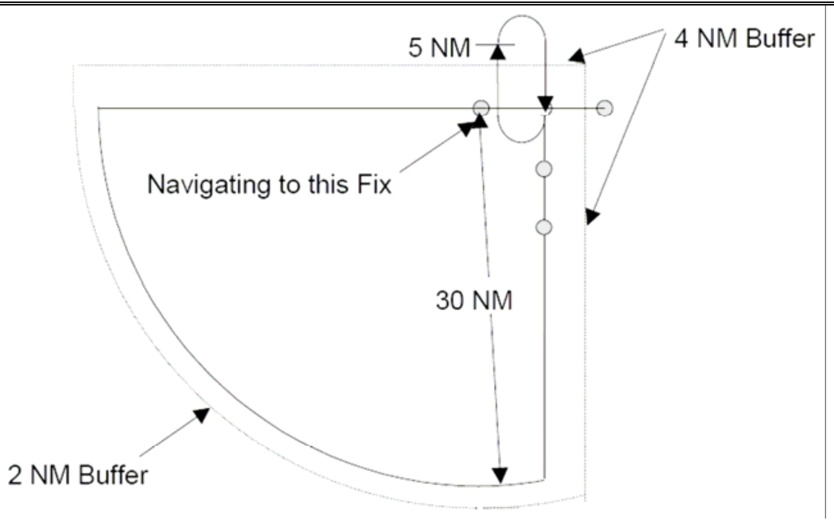


Figure 3C: Right Base Area

8.2.3 Left Base Area.

The arc boundary of the left base area is equivalent to a feeder fix. When crossing the boundary or when released by ATC within the left base area, an aircraft is considered at the feeder fix and is expected to proceed direct to the IAF.

a. Construction. To construct the top boundary, extend the line from the IF through the T IAF for 30 NM beyond the T IAF. Draw a 30-NM arc, centered on the T IAF, from the end point of the top boundary clockwise to the point it intersects a straight-line extension of the intermediate course (see figure 3D).

b. Obstacle Clearance. The area considered for obstacle clearance includes the entire left base area and its associated buffer areas. Vol 1, chap 1, Para 1720 applies.

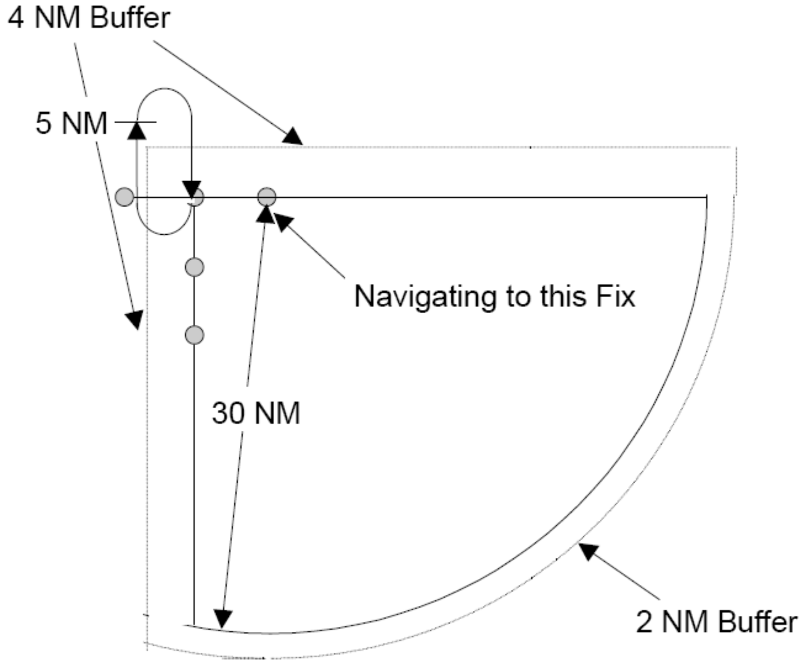


Figure 3D: Left Base Area

8.3 ALTITUDE SELECTION WITHIN THE TAA.

OPTIMALLY, all TAA areas, course reversal holding pattern, and initial segment minimum altitudes should be the same. All NoPT routings shall join the IF(IAF) at a common altitude. When terrain or operational constraints force high area altitudes that do not allow descent within gradient limits, the course reversal pattern at the IF(IAF) shall allow descent from the highest minimum sector altitude to the common IF(IAF) altitude.

8.3.1 Sectors/ Stepdown Arcs.

When necessary to accommodate terrain diversity, operational constraints, or excessive descent gradients, the straight-in, left, and right base areas may be subdivided to gain relief, within the limitations noted below. Stepdown arcs, when used, shall be no closer than 4 NM from the waypoint (WP) upon which the arc is based and must be a minimum of 4 NM from the TAA outer boundary.

a. Straight-in Area. The straight-in area may be divided into as many as three sectors defined radially by magnetic inbound course to the IF(IAF). Each sector may be further sub-divided by a single stepdown arc centered on the IF(IAF). The minimum sector size shall be 30°; except the minimum sector size shall be 45° when the sector contains a stepdown arc and its radial boundaries terminate at the IF(IAF) (see figures 4A through 4D).

b. The left and right base areas may not be radially sectored. Only stepdown arcs (centered on the fix that defines the area) may be used, but are limited to one per sector (see figures 4A through 4D).

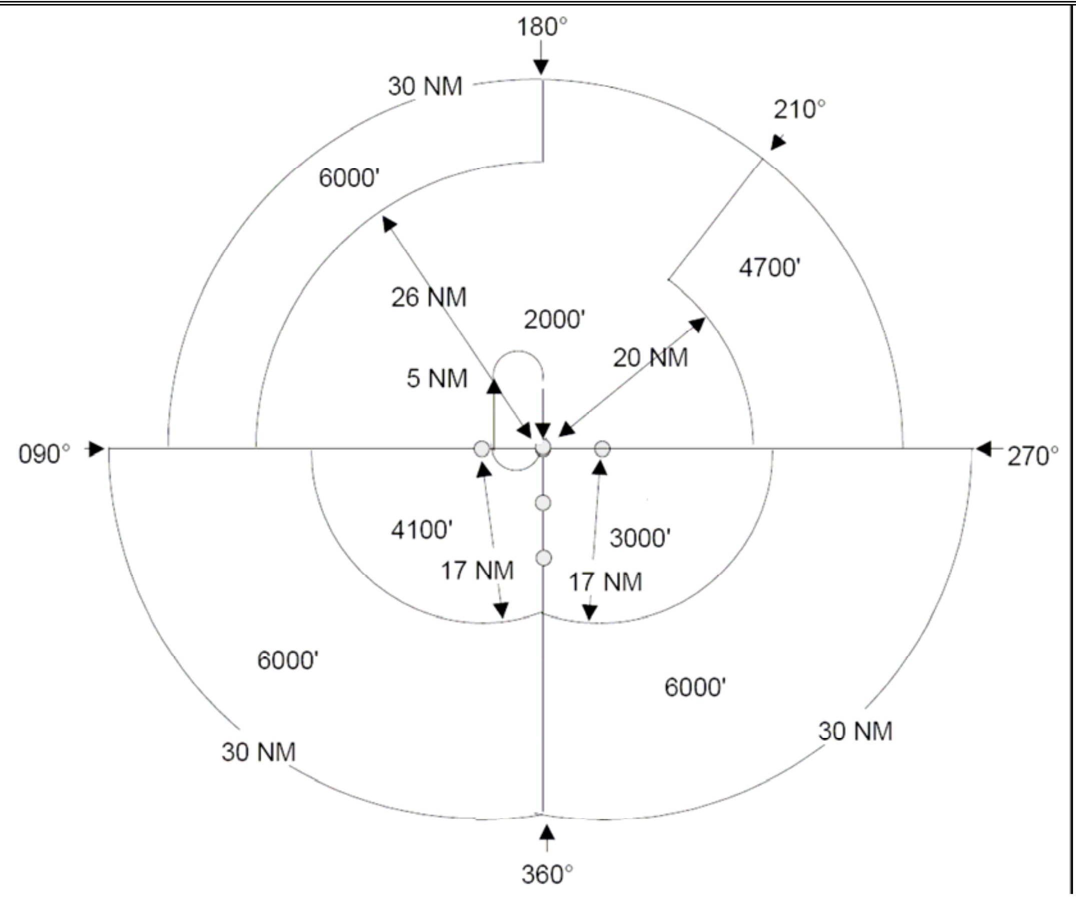


Figure 4A: A Sectorized TAA with Stepdown Arcs

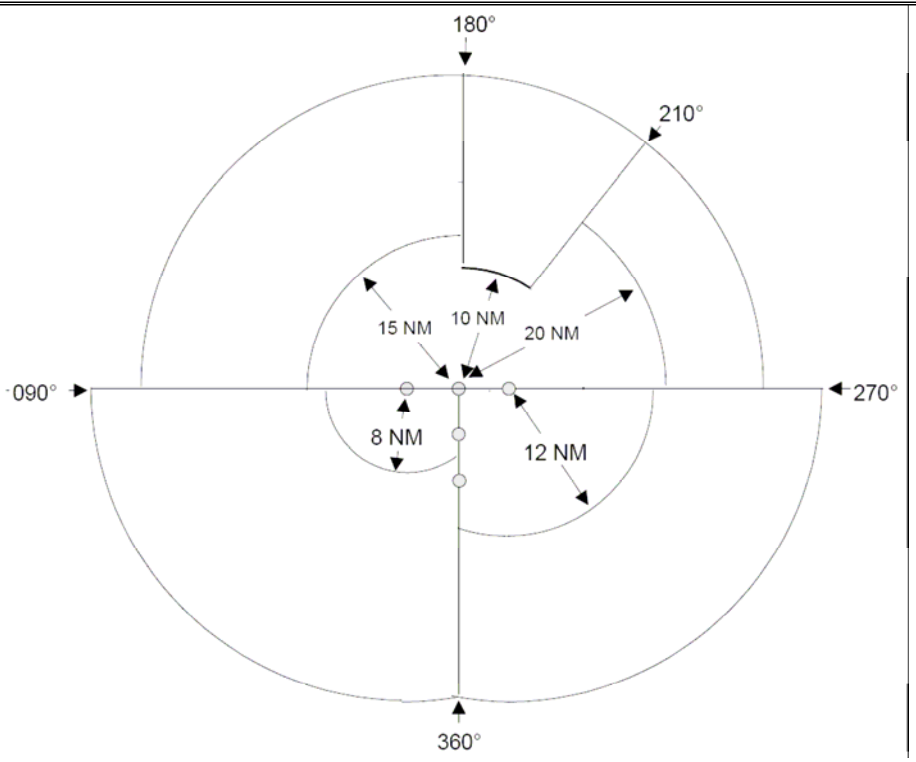


Figure 4B: TAA Maximum Sectorization with Maximum Stepdown Arcs

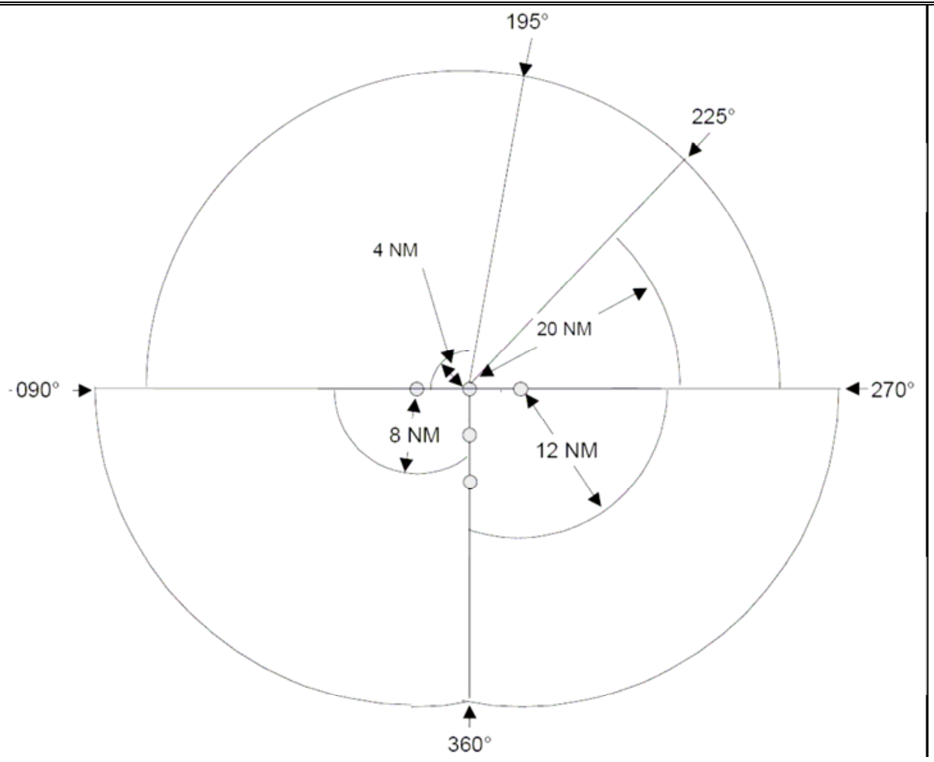


Figure 4C: TAA Maximum Sectorization with Maximum Stepdown Arcs

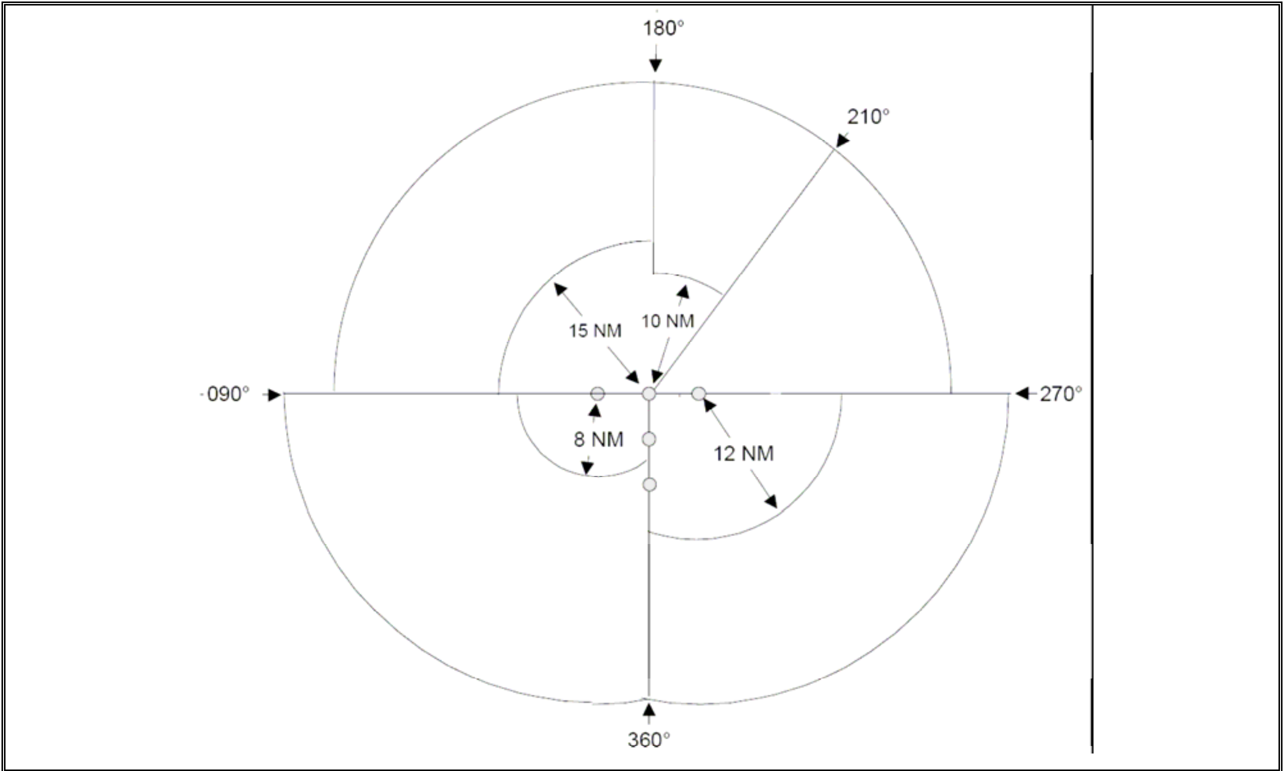


Figure 4D: TAA Maximum Sectorization with Maximum Stepdown Arcs

8.3.2 Altitude Sectors.

Sectors must provide appropriate required obstacle clearance within the sector boundaries and over all obstacles within a 4-NM buffer area (measured perpendicular to the radial boundary line) and within a 2-NM buffer from the outer boundary and any stepdown arcs. See figure 4E for a method to calculate the distance from a straight-in boundary line.

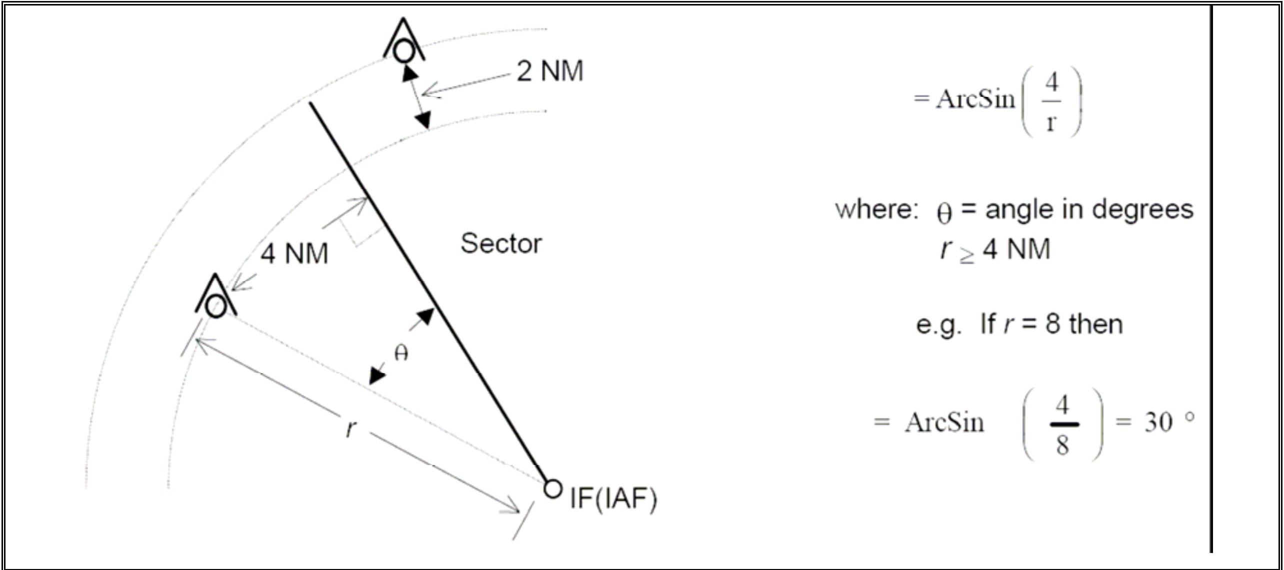


Figure 4E: Calculating Radial Sector Boundaries

8.4 TAA AREA MODIFICATIONS

Modifications to the standard TAA design may be necessary to accommodate operational requirements. Variations may eliminate one or both base areas, and/or limit or modify the angular size of the straight-in area. If the left or right base area is eliminated, modify the straight-in area by extending its 30-mile radius to join the remaining base area boundary. If the left and right base areas are eliminated, extend the straight-in 30-mile radius to complete 360° of arc. Construct a sector that requires a course reversal in the extended straight-in area to accommodate entry at the IF(IAF) at angles greater than 120°. When the NoPT turn at the IF(IAF) is between 90° and 120°, apply TERPS table 3 to determine the minimum intermediate segment length. This sector does not count toward the sectorization limitation stated in paragraph 8.3.1a (see figures 5A through 5E).

8.5 CONNECTION TO EN ROUTE STRUCTURE

Normally, a portion of the TAA will overlie an airway. If this is not the case, construct at least one feeder route from an airway fix or NAVAID to the TAA boundary aligned along a direct course from the en route fix/NAVAID to the appropriate IF(IAF) and/or T IAF(s) (see figure 5F). Multiple feeder routes may be established if the procedure specialist deems necessary.

8.6 AIRSPACE REQUIREMENTS

The TAA should (USAF ‘shall’) be wholly contained within controlled airspace insofar as possible. The TAA will normally overlie Class “E” airspace (1,200' floor) in the eastern 33 states, minus the upper Peninsula of Michigan and a portion of southwest Texas. The remaining states will require close study to ensure controlled airspace containment for the TAA.

8.6.1 If the TAA overlies Class B airspace, in whole or in part, the Air Traffic Control (ATC) facility exercising control responsibility for the airspace may recommend minimum TAA sector altitudes. It is the responsibility of the ATC facility providing approach control service for the airport to resolve TAA altitude and overlapping airspace issues with adjoining ATC facilities. Modify the TAA to accommodate controlled/restricted/warning areas as appropriate.

8.6.2 When notified that an RNAV approach and a standard TAA are being initiated for an airport not underlying controlled airspace, the regional Air Traffic division(s) shall initiate rule-making action to establish a 1,200 feet above ground level Class E airspace area with an appropriate radius of the airport reference point (ARP) to accommodate the TAA. If a modified TAA is proposed, the airspace will be sized to contain the TAA. The TAA will not be charted or implemented until controlled airspace actions are completed.

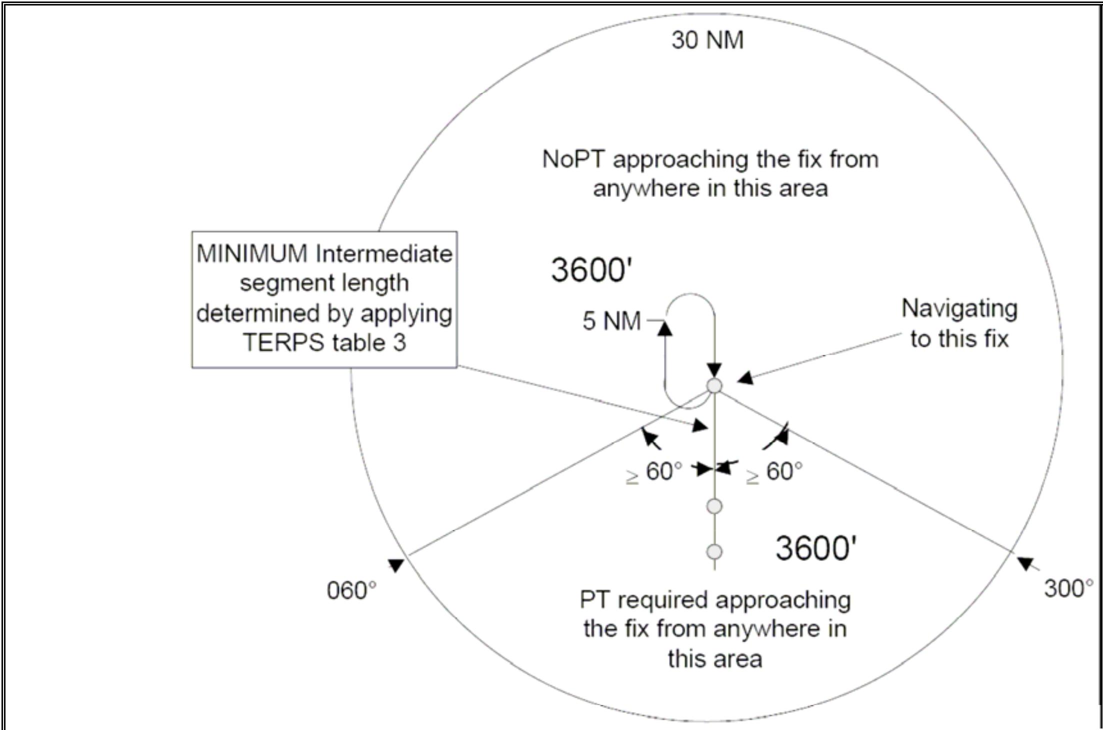


Figure 5A: TAA with Left and Right Base Areas Eliminated

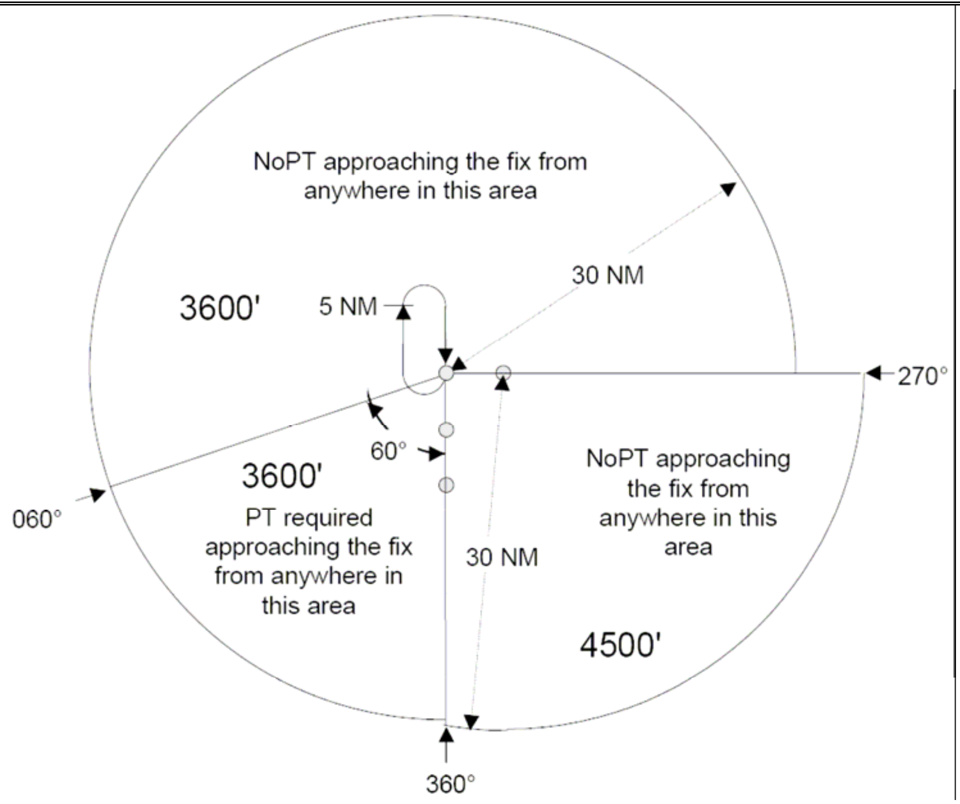


Figure 5B: TAA with Right Base Eliminated

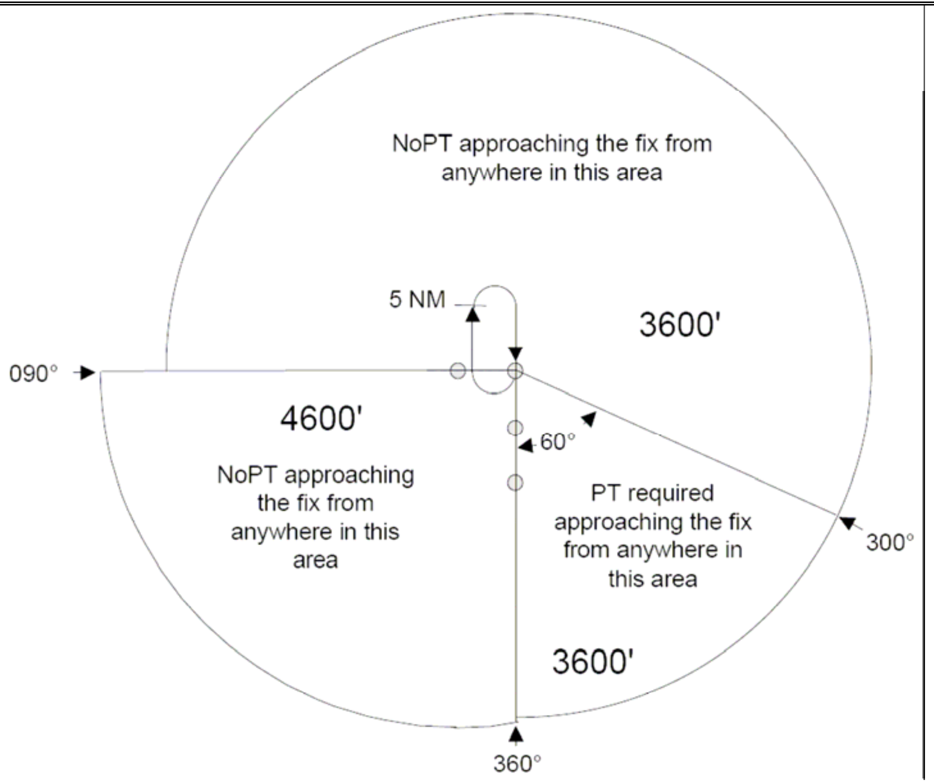


Figure 5C: TAA with Left Base Eliminated

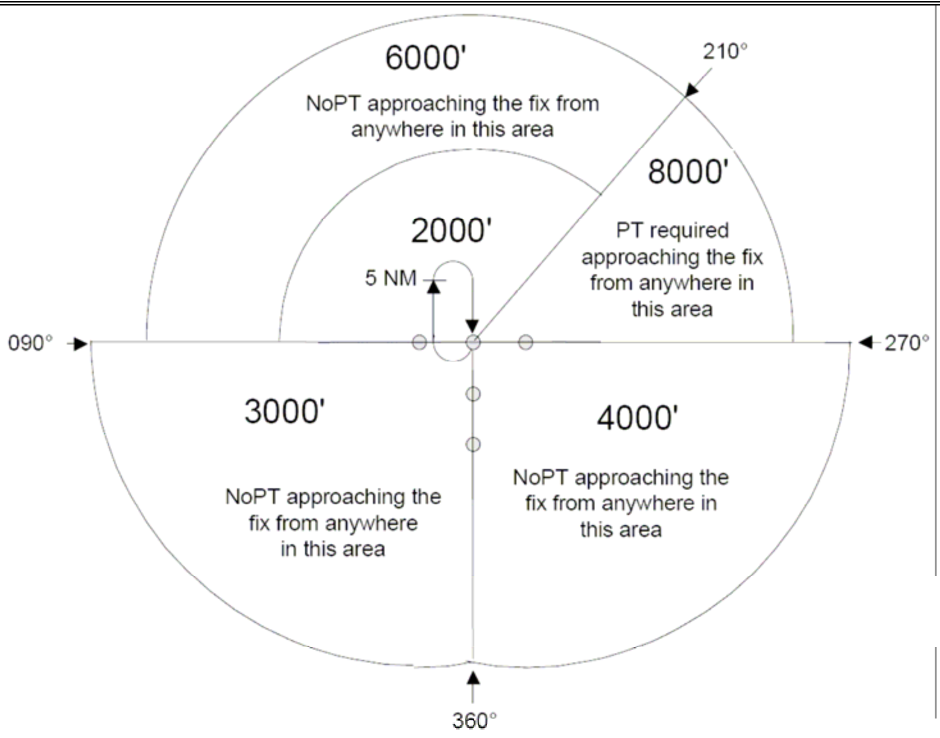


Figure 5D: TAA with Part of Straight-In Area Eliminated

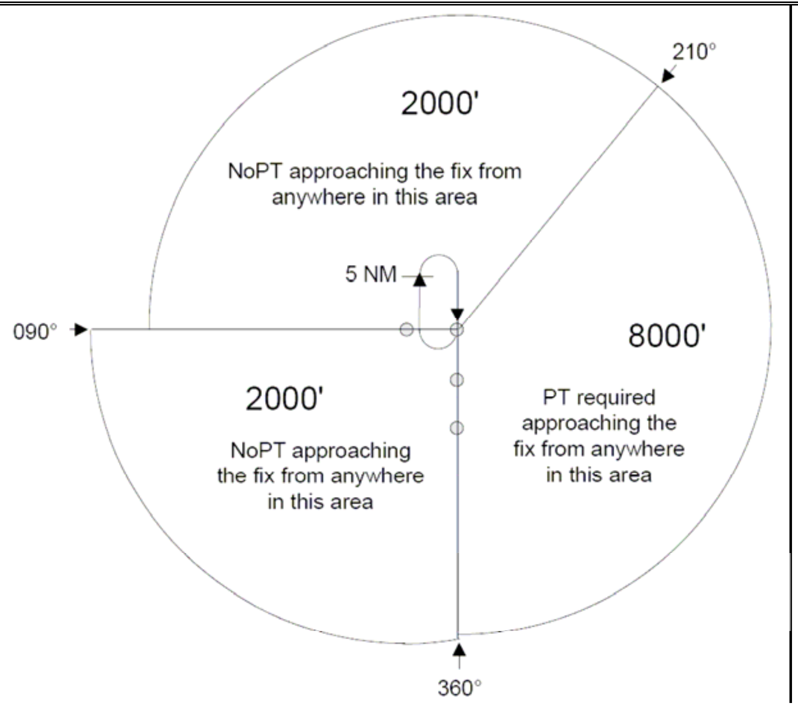
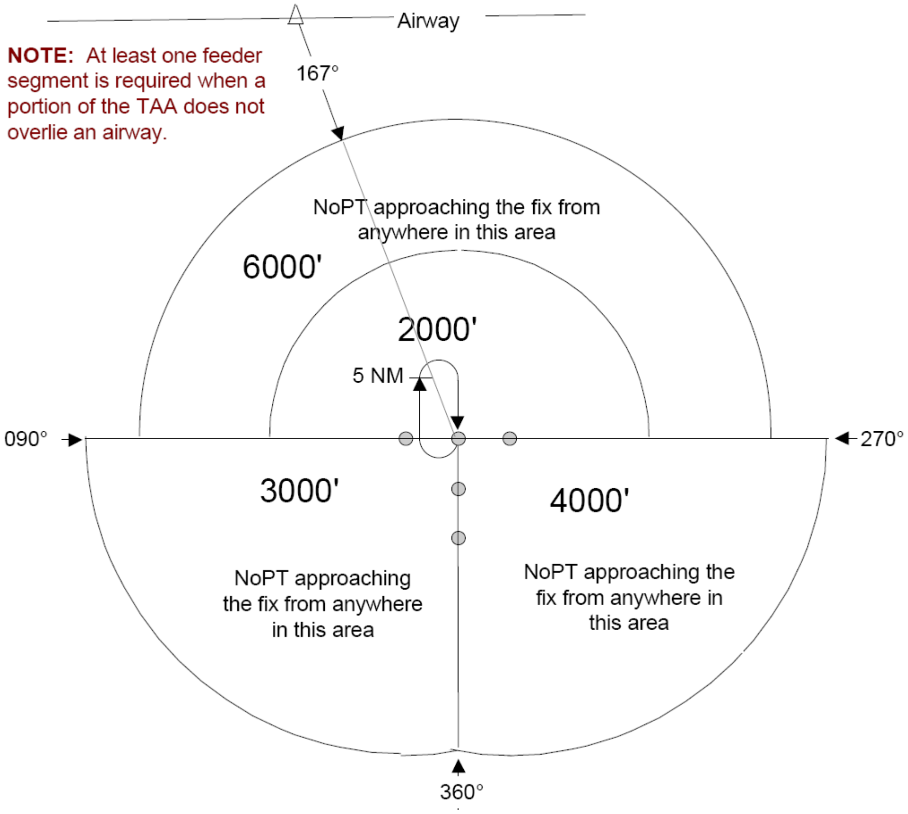


Figure 5E: TAA Examples with Left Base and Part of Straight-In Area Eliminated



NOTE: At least one feeder segment is required when a portion of the TAA does not overlie an airway.

Figure 5F: Examples of a TAA with Feeders from an Airway

Figure 6. RESERVED

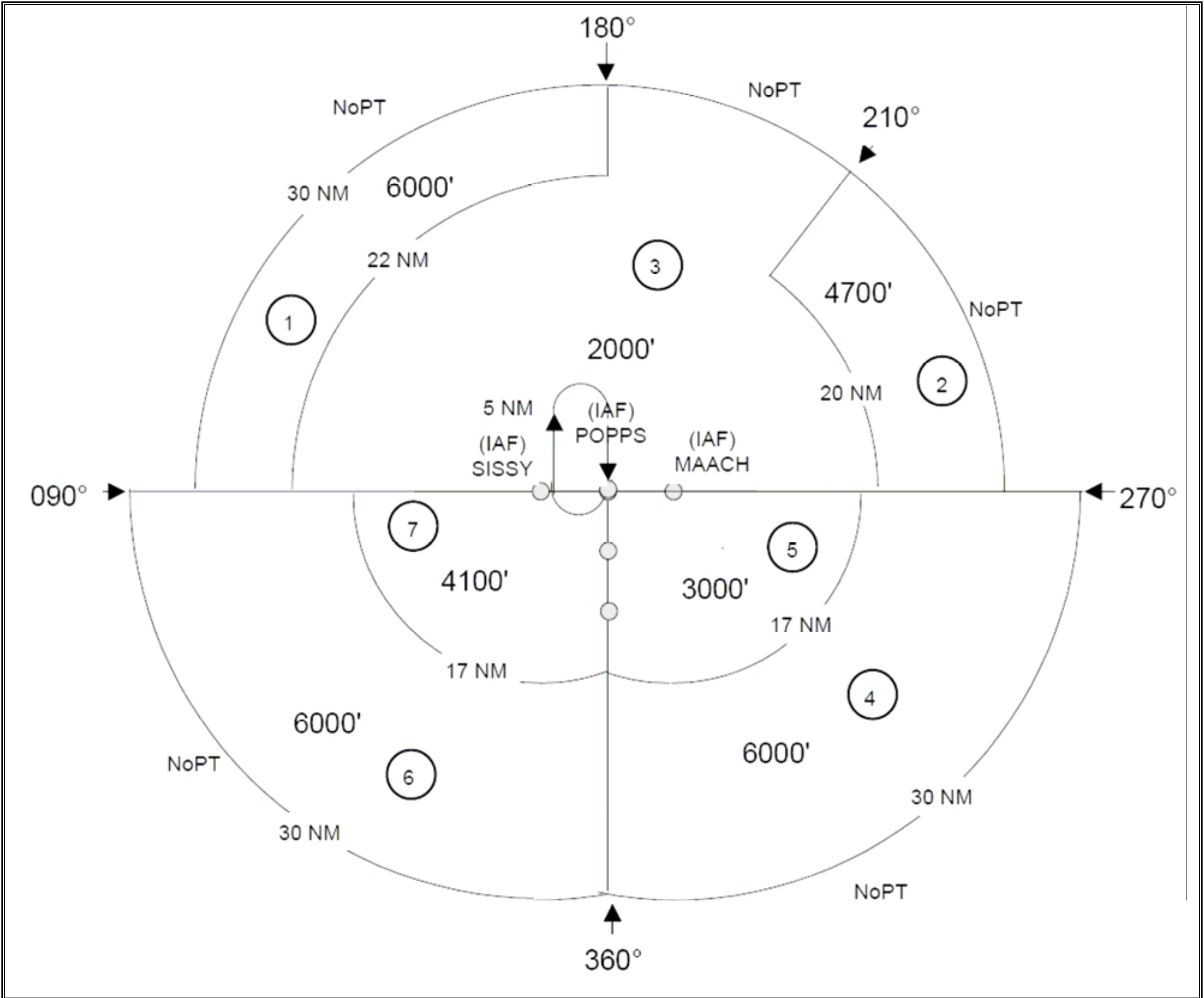


Figure 7A. Example 1

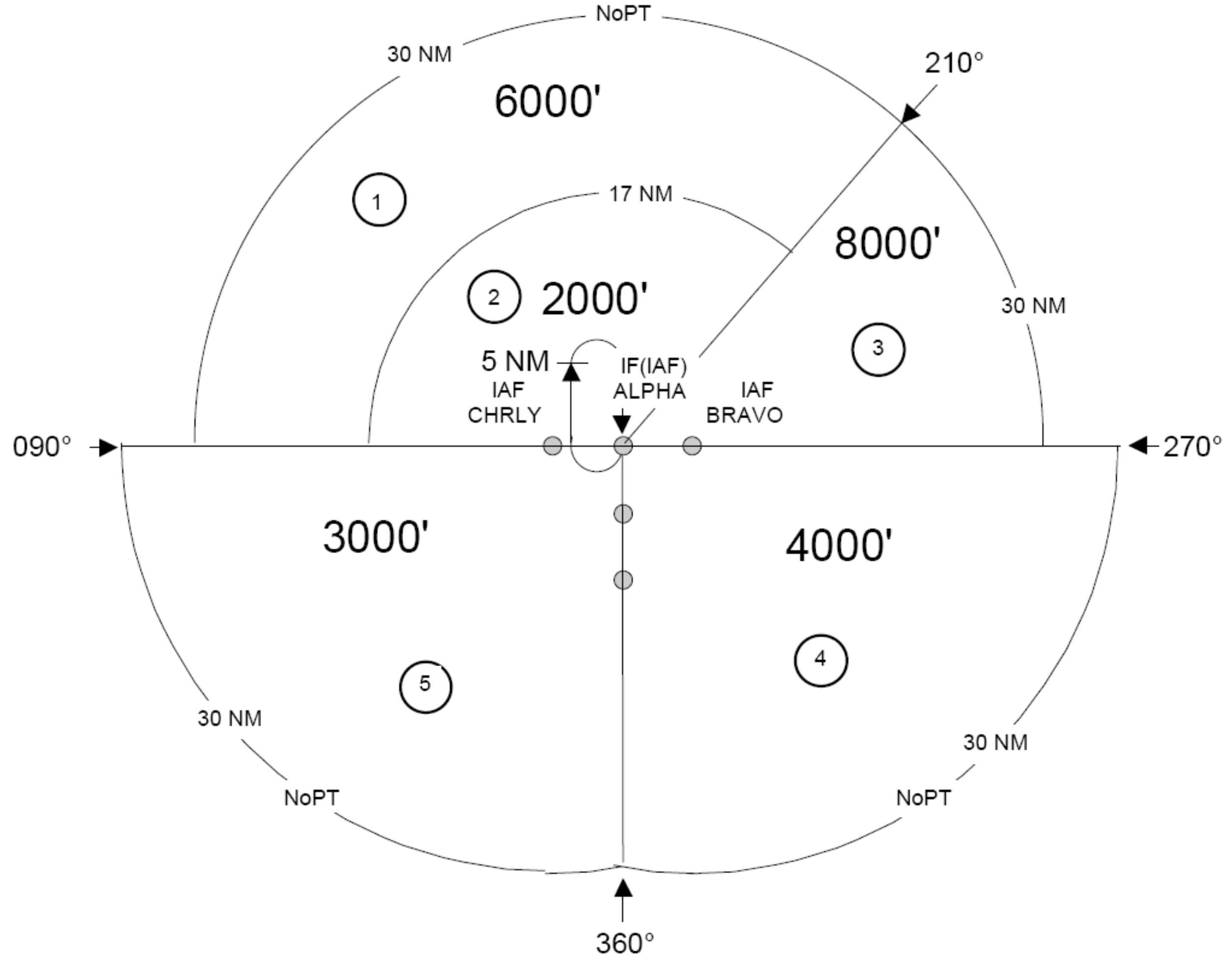


Figure 7B. Example 2

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CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

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PRECISION APPROACH OBSTACLE ASSESSMENT AND CATEGORY II/III REQUIREMENTS

(CAT II/IIII)

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CHAPTER 1. GENERAL

1.0 PURPOSE.

This notice provides guidance for airport obstacle clearance criteria for precision Category (CAT) I/II/III obstacle free zones (OFZ) and the relationship to glide slope antenna placement and taxiing/parked aircraft. Appendix 1 contains the current criteria and guidance for CAT I/II/III OFZ. Appendix 2 contains the Runway/Parallel Taxiway Separation.

2.0 DISTRIBUTION.

RESERVED

3.0 BACKGROUND.

This document is a safety initiative to publish current guidance for airport obstacle clearance criteria.

4.0 DISPOSITION.

The criteria and standards provided in appendixes 1 and 2 will eventually migrate into the applicable Volume (1-5) of TP308/GPH209.

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APPENDIX 1. PRECISION APPROACH OBSTACLE ASSESSMENT AND CATEGORY II/III REQUIREMENTS

1.0 GENERAL

General precision obstacle clearance criteria are contained in Volume 3. Airport and facility requirements to support approval of Category (CAT) I, II, and III precision operations are contained in the latest editions of the following United States (US) Federal Aviation Administration (FAA) directives:

- AC 120-29, Criteria for Approval of Category I and Category II Weather Minima for Approach.
- AC 120-28, Criteria for Approval of Category III Weather Minima for Takeoff, Landing, and Rollout.
- Order 6750.24, Instrument Landing System (ILS) and Ancillary Electronic Component Configuration and Performance Requirements.
- Order 8400.8 , Procedures For The Approval Of Facilities For Far Part 121 And Part 135 Cat IIII Operations
- Order 8400.13, Procedures for the Approval of Special Authorization Category II and Lowest Standard Category I Operations.

2.0 ACCEPTABLE OBSTACLES.

Some equipment essential to flight operations is permitted in the OFZ and/or specified TP308/GPH209 surfaces. An obstacle may be considered acceptable when its type is permitted to be excluded in the specific area/surface where it is physically located, and it meets the prerequisites for exclusion described in the following paragraphs and in table 1. Surface penetrations by acceptable obstructions require no adjustment of minima, and the procedure may be considered “unrestricted”. Any object “fixed by function” on a runway crossing or adjacent to a CAT II or III runway must also conform to the specified conditions.

2.1 ALL VISUAL AIDS ON FRANGIBLE MOUNTS.

Visual aids (to include visual glide slope indicator (VGSI), taxiway signage, runway distance remaining markers, etc.) installed in accordance with (IAW) the latest editions of FAA Order 6850.2, Visual Guidance Lighting Systems, and US Advisory Circular 150/5340-18, Standards for Airport Sign Systems, are acceptable obstacles excluded from TERPS consideration.

2.2 NAVIGATIONAL AID (NAVAID) AND AUTOMATED SURFACE OBSERVING SYSTEM (ASOS) COMPONENTS.

The minimum siting distance for glide slope shelter, precision approach radar (PAR), runway visual range (RVR), and ASOS components (except wind sensor towers) is specified in US AC 150/5300-13, Airport Design and Order 6560.10, Runway Visual Range. In order for one of these components to be considered acceptable for TP308/GPH209, it must be located at least 400 ft from runway centerline and must not exceed a height of 15 ft above the elevation of the point on the runway centerline abeam them. ASOS wind sensors exceeding 15 ft above the runway centerline elevation but sited in accordance with the Federal Standard for Siting Meteorological Equipment at Airports are also considered acceptable obstacles. Obstacles more than 15 ft above the runway centerline elevation may be permitted if the minimum distance from the runway centerline is increased 10 ft for each foot the structure exceeds 15 ft. Frangible PAR reflectors are not considered obstacles.

Obstacle type	Location	Prerequisite for Exclusion
Visual Navigation Aids * • VGSI (PAPI, PVASI, VASI, etc.) • Approach light Systems • REILS • Airport Beacon • Visual Landing Aids (Wind Cone, etc.) • Airport Signage	○ Final W, X ○ Inner Approach OFZ ○ Missed Section 1 A,B,C,D A1	* only when installed IAW applicable siting standard (i.e., Order 6850.2, AC 150/5340-30, or military equivalent, etc.)
Electronic NAVAIDs/Components # • ILS Glideslope Shelter • PAR components • Radar reflectors on frangible mounts Glideslope Antenna † Localizer Antenna serving opposite runway £	○ o Final W, X ○ o Inner Approach OFZ ○ o Missed Section 1 A,B,C,D, A1	# only when installed IAW applicable siting standards, AC 150/5300-13 or military equivalent † only when meets par 2.2.1 £ only when meets par 4.0
Meteorological Equipment % • Cloud height sensors • Visibility sensors • Wind sensors • Temperature/dew point sensors • Lightning Detection sensor • Precipitation sensors • Pressure sensors • AWOS/ASOS components • Runway Visual Range components	○ o Final W, X ○ o Inner Approach OFZ ○ o Missed Section 1 A,B,C,D, A1	% only when installed IAW Federal Standard for Siting Meteorological Equipment at Airports, other applicable FAA standards or military equivalents
Taxiing/ holding/ Parked Aircraft/ Ground Vehicles $	○ Precision Final OCS (W,X,Y) ○ POFZ ○ CAT II/III Missed section 1, B, C, D, A1	$ only when meets paragraph 2.3

Table 1. Acceptable Obstructions.

2.2.1 Glide Slope Antennas.

Glide slope antennas for CAT I procedures are not excluded from TERPS evaluation, and must remain clear of OFZs in accordance with AC 150/5300-13. For CAT II/III evaluations, glide slope antennas meeting the following standards are considered acceptable obstacles. Antenna location is referenced by meas-urement from the runway threshold along runway centerline (X), perpendicular distance from runway centerline (Y), and height above the runway centerline elevation abeam the antenna (Z). The minimum “Y” value (Ymin) is 250 ft for antenna masts with a “Z” value of 45 ft. For antenna masts with a “Z” value > 45 ft, the Ymin distance from runway centerline is increased 10 ft laterally for each foot the antenna height exceeds 45 ft. Calculate Ymin using the formula below.

$$Y_{MIN} = 10(Z) - 200$$

Simplified from

$$Y_{MIN} = 250 + 10(Z - 45)$$

Antennas that penetrate a 10:1 rising surface originating 250 ft from runway centerline at a “Z” value of 45 ft require a frangible mast and Flight Technologies and Procedures Division (AFS-400) approval (see figure 1).

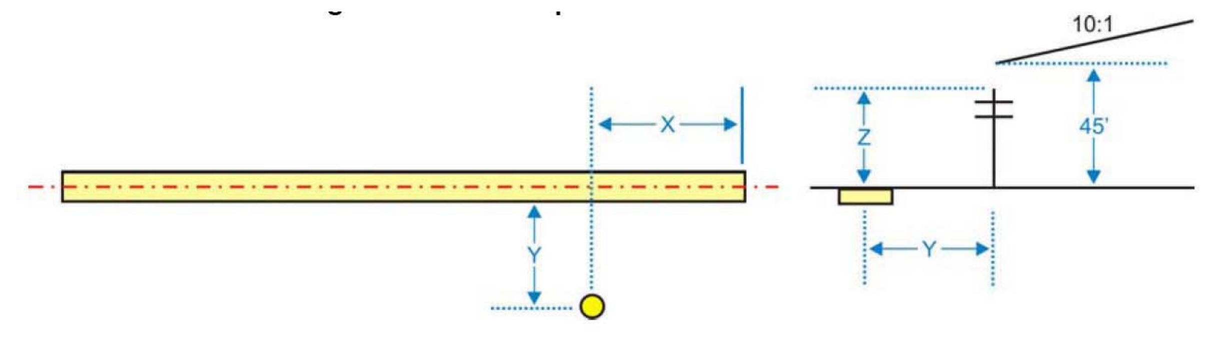


Figure 1: Glide Slope Antenna Placement.

2.3 AIRCRAFT/GROUND VEHICLE CONSIDERATION AS OBSTACLES.

Taxiing, holding, parked aircraft and ground vehicles are considered obstacles for instrument procedure obstacle clearance. When evaluating aircraft as obstacles, consider the location of the taxiway/ramp and consider the highest aircraft surface that falls within the area (see table 2 for design group tail heights). For ground vehicles consider the road/taxiway/ramp with routine vehicle traffic and apply the appropriate height from Volume 1, Chapter 2, Paragraph 216. In order to achieve the lowest landing minimums, aircraft/vehicles must not penetrate the obstacle free zone (OFZ), final, or missed approach obstacle clearance surfaces (OCS), visual segment OCS, or the precision obstacle free zone (POFZ), except as permitted below:

Table 2 lists the aircraft design group standards applicable to this document.

GROUP #	TAIL HEIGHT (FT)	WINGSPAN (FT)
I	< 20	< 49
II	20 - < 30	49 - < 79
III	30 - < 45	79 - < 118
IV	45 - < 57	118 - < 171
V	57 - < 66	171 - < 214
VI	66 - < 80	214 - < 262

Table 2. Aircraft Design Groups (ADG)

2.3.1 Precision Final Segment Obstacle Clearance Surfaces.

Taxiing, holding, and parked aircraft/ground vehicles are considered obstacles in the final segment W, X, and Y OCS surfaces (see figure 2) unless positive controls have been established to keep the surfaces clear when aircraft on approach to the same runway are within 2 nautical miles (NM) of the landing threshold when the reported weather is less than 800 ft ceiling and/or the prevailing visibility is less than 2 statute miles (SM). Positive controls include proper placement of hold markings/signage as specified by FAA Airports Engineering Division and/or establishment of Air Traffic Control (ATC) operating procedures. Private/airport access roads that traverse one or more final segment OCS are considered acceptable when positive controls are established to either keep the surface clear when the reported weather is less than 800 - 2, or controls are in place to restrict access to vehicles necessary for the maintenance of the airport/navigation facilities of less than 10 ft in height. Controls must also prevent vehicles that penetrate the OCS from parking in the surface without being in direct contact with ATC.

2.3.2 CAT II/III Missed Approach Section 1.

Aircraft/ground vehicles that penetrate the CAT II/III missed approach surface may be eliminated from TERPS consideration when compliant with the minimum runway/parallel taxiway standards from AC 150/5300-13 and as described below.

a. **Design Groups I-IV.** Minimum runway/taxiway separation is 400 ft at sea level.

b. **Design Group V.** Minimum runway/taxiway separation is 500 ft at sea level.

c. **Design Group VI.** Minimum runway/taxiway separation is 550 ft at sea level.

d. **Adjust the minimum taxiway separation** described above for airports above sea level as follows:

Determine the values of the following variables:

$Y = 440 + (1.08S) - (0.024E)$
$B = 53 - 0.13S$
$C = B - (0.0022E)$
$X = C + (Y - R/5)$ or 150, whichever is lower
$Z_{SEA} = B + ((D - R)/5)$

Where E = Threshold MSL elevation
R = Runway OFZ half-width
D = Minimum runway/taxiway separation for Design Group
S = Wingspan of most restrictive aircraft (NOT SEMI-SPAN)
A = Adjusted minimum taxiway separation (round to nearest foot)

If ZSEA ≤ X
$A = D + 0.011E$

If ZSEA > X
$A = Y + 6(ZSEA – X)$

Example 1:
Threshold elevation: 841 MSL
Aircraft Design Group: V (D = 500 IAW 2.3.2b)
Wingspan of most restrictive aircraft: 214
Runway OFZ = 400

Step 1. Determine values of variables.	**Step 2. Determine formula to apply.**
$Y = 440 + (1.08S) - (0.024E)$ $Y = 440 + (1.08 * 214) - (0.024 * 841)$ $Y = 440 + 231.12 - 20.184$ $Y = 650.936$ $B = 53 - 0.13S$ $B = 53 - 0.13 * 214$ $B = 25.18$ $C = B - (0.0022E)$ $C = 25.18 - (0.0022 * 841)$ $C = 23.3298$ $X = C + ((Y – R)/5)$ or 150, whichever is lower $X = 23.3298 + ((650.936 - 200)/5)$ $X = 23.3298 + (90.188)$ $X = 113.5178$ $Z_{SEA} = B + ((D - R)/5)$ $Z_{SEA} = 25.18 + ((500 - 200)/5)$ $Z_{SEA} = 25.18 + (60)$ $Z_{SEA} = 85.18$	Z_{SEA} (85.18) ≤ X (113.5178) $A = D + 0.011E$ $A = 500 + 0.011 * 841$ $A = 509.25$ (round up to 510)

Example 2:

Threshold elevation: 5883 MSL
Aircraft Design Group: II (D = 400 IAW 2.3.2a)
Wingspan of most restrictive aircraft: 78

Step 1. Determine values of variables.	Step 2. Determine formula to apply.
Y = 440 + (1.08S) - (0.024E) Y = 440 + (1.08 * 78) - (0.024 * 5883) Y = 440 + 84.24 - 141.192 Y = 383.048 B = 53 - 0.13S B = 53 - (0.13 * 78) B = 53 - 10.14 B = 42.86 C = B - (0.0022E) C = 42.86 - (0.0022 * 5883) C = 42.86 - 12.9426 C = 29.9174 X = C + ((Y – R)/5) or 150, whichever is lower X = 29.9174 + ((383.048 - 200)/5) X = 29.9174 + (36.6096) X = 66.527 Z_{SEA} = B + ((D - R)/5) Z_{SEA} = 42.86 + ((400-200/5) Z_{SEA} = 42.86 + (40) Z_{SEA} = 82.86	Z_{SEA} (82.86) > X (66.527) A = Y + 6(ZSEA – X) A = 383.05 + 6(82.86 - 66.527) A = 383.05 + 6(16.333) A = 383.05 + 97.998 A = 481.048 (round to 482)

2.3.3 Precision Obstacle Free Zone (POFZ). Applicable to any runway served by a vertically-guided approach with landing minimums less than 250 ft height above touchdown (HAT) and/or prevailing visibility less than 3/4 SM or RVR 4000. Taxiing, holding, and parked aircraft/ground vehicles are considered obstacles in the POFZ (see figure 2), unless positive controls have been established to keep the surface clear when aircraft on approach are within 2 NM of the landing threshold when the reported weather is less than 300 ft ceiling and/or the prevailing visibility is less than 3/4 SM/RVR 4000. The area is considered clear when the tail and/or fuselage of a taxiing aircraft does not penetrate the POFZ. Additionally, the wing of aircraft holding on a perpendicular taxiway, waiting for runway clearance, may penetrate the POFZ, however, the fuselage or tail must not infringe the area. Positive controls include proper placement of hold markings/signage as specified by FAA Airports Engineering Division and/or establishment of Air Traffic Control operating procedures. Private/airport access roads, that traverse the POFZ, are considered acceptable when positive controls are established to either keep the surface clear when the reported weather is less than 300 - 3/4, or restrict access to vehicles necessary for the maintenance of the airport/navigation facilities of less than 10 ft in height. Controls must also prevent vehicles from parking in the POFZ without being in direct contact with ATC.

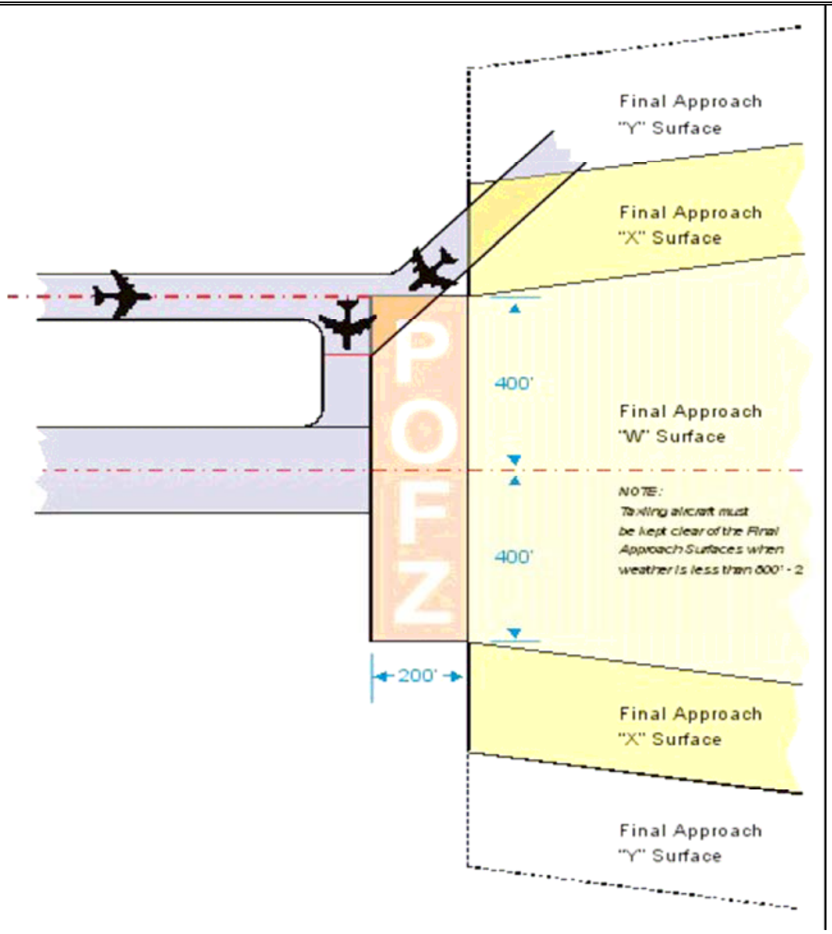


Figure 2: POFZ/Final Segment Obstacle Clearance Surfaces.

2.4 FAILURE TO MEET STANDARDS AS AN ACCEPTABLE OBSTACLE.

Where the above standards cannot be met, consider the following actions to eliminate, limit, or mitigate a breach of the standards under paragraph 2.3.

2.4.1 Remove the obstacle.

2.4.2 Increase the HAT/visibility.

2.4.3 Modify aircraft taxi routes, limit access to private roads, or establish positive controls to keep the applicable surfaces clear.

2.4.4 Increase the Hold Line distance.

3.0 INSTRUMENT LANDING SYSTEM/MICROWAVE LANDING SYSTEM (ILS/MLS) CRITICAL AREA.

Precision approach system critical areas are described in Orders 6750.16, Siting Criteria for Instrument Landing Systems, and 6830.5, Criteria for Siting Microwave Landing Systems. CAT II/III ILS glide slope, localizer, and obstacle critical areas will be marked and lighted to ensure that ground traffic does not violate these areas during CAT II or III operations (except as allowed in Order 7110.65, Air Traffic Control).

4.0 APPROACH LIGHT AREA.

Airports operators are responsible for maintaining obstruction requirements associated with airport visual aids. Obstructions must not penetrate the approach light plane (see figure 3) or the inner-approach OFZ in accordance with AC 150/5300-13 and other applicable directives (Order 6850.2, AC 150/5340-30). For approach light plane clearance purposes, consider all roads, highways, vehicle parking areas, and railroads as vertical solid objects. Make the clearance required above interstate highways 17 feet, for railroads 23 feet, and for all other roads, highways, and vehicle parking areas 15 feet. Measure the clearance for roads and highways from the crown and edges of the road and make measurements for railroads from the top of rails. Make measurements for vehicle parking areas' clearances from the grade in the vicinity of the highest point. Airport service roads, where vehicular traffic is controlled in any manner that would preclude blocking the view of the approach lights by landing aircraft, are not considered as obstructions in determining the approach light plane.

Note: *The OFZ clearing standard precludes taxiing and parked airplanes and object penetrations, except for frangible visual NAVAIDs that need to be located in the OFZ because of their function. A localizer antenna serving the opposite runway end may penetrate the approach light plane if it does not obscure the approach lights or penetrate the inner-approach OFZ.

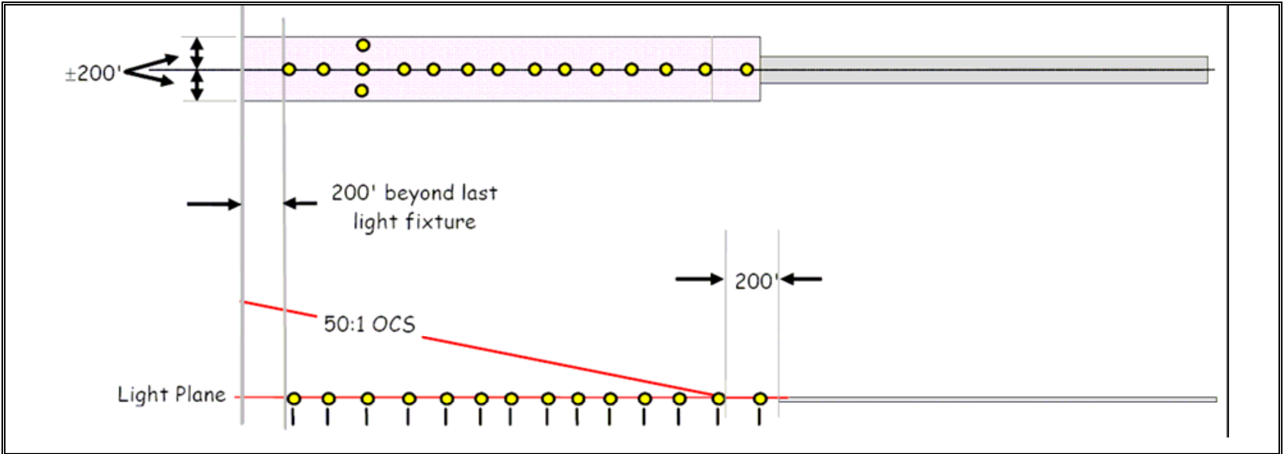


Figure 3: Inner Approach OFZ and Approach Light Area Plane.

5.0 REQUIREMENTS FOR CAT I PRECISION OPERATIONS.

5.1 OBSTACLE FREE ZONE (OFZ) REQUIREMENTS.

The OFZ requirements contained in AC 150/5300-13 appropriate for precision runways must be met to enable CAT I landing operations.

5.2 LIGHTING REQUIREMENTS.

See Volume 3.

5.3 MINIMUMS.

See Volume 3, table 2-2B.

5.4 FINAL AND MISSED APPROACH EVALUATIONS.

See Volume 3, chapters 1-3.

6.0 REQUIREMENTS FOR CAT II PRECISION OPERATIONS.

The CAT I requirements of paragraph 5 apply. In addition, the following criteria apply.

6.1 OFZ REQUIREMENTS.

Apply the OFZ standards described in AC 150/5300-13.

6.2 LIGHTING REQUIREMENTS

(DND: apply appropriate military directives).

CAT II required lighting includes the following:

6.2.1 Standard ALSF-1 or ALSF-2 approach lights;

6.2.2 Standard touchdown zone lights;

6.2.3 Standard runway centerline lights; and

6.2.4 Standard high intensity runway lights.

> **Note:** Exceptions to lighting criteria may be authorized only if an equivalent level of safety can be demonstrated by an alternate means. Examples of exceptions are: substitution for required approach lighting components due to an approved specific aircraft system providing equivalent information or performance (such as an autoland system, head up display (HUD) with inertial augmented flight path vector display), or availability of redundant, high integrity, computed or sensor based runway information (e.g., high resolution radar or approved enhanced flight vision systems (EFVS)), suitably displayed to a pilot.

6.3 SURFACE MOVEMENT GUIDANCE AND CONTROL SYSTEM (SMGCS).

Approved SMGCS operation per AC 120-57, Surface Movement Guidance and Control System, as required.

6.4 MARKING AND SIGNS.

Develop CAT II procedures only when the airport/runway meets applicable standards for taxiway markings and airport surface signs for CAT II precision operations (or ICAO equivalent at Non-United States airports). CAT II hold lines should be marked in accordance with 14 CFR Part 139.311 and AC 150/5340-1, Standards for Airport Markings. Runway markings must meet applicable standards to allow CAT II precision operations unless approved by AFS-400. Other guidance, such as Order 6750.24, Instrument Landing System and Ancillary Electronic Component Configuration and Performance Requirements, OpSpecs, and an approved SMGCS plan, may permit operational contingencies or exceptions. Examples of these actions are: snow removal, rubber deposit removal on runway touchdown zone markings or centerline markings, critical area hold line or runway centerline marking repainting, runway hold line sign snow removal, etc.

6.5 AN UNRESTRICTED CAT I PROCEDURE.

The CAT I final approach segment obstacle evaluation applies to the CAT II approach authorization. The CAT I procedure must support a 200-ft HAT and lowest possible visibility (no restrictions incurred by lack of infrastructure or obstacle surface penetrations).

Note: The final course alignment must be coincident with the runway centerline.

6.6 OPERATIONAL AIR TRAFFIC CONTROL TOWER (ATCT).

An operating on-airport ATCT must support CAT II ground and flight operations. If the ATCT does not provide continuous service, publish a note on the chart indicating the procedure is not authorized when the tower is closed.

6.7 APPROACH MINIMUMS.

CAT II procedures require special authorization from the FAA. AC 120-29 contains equipment and flight crew qualifications. Operators desiring lower than CAT I minimums require OpSpecs authorization for air carrier operations or a Letter of Authorization (LOA) for Part 91 operations. Table 3 lists lowest authorized minimums allowed by Order 8260.3. Higher minimums may be necessary based on environmental factors in the vicinity of the airport or other Flight Standards requirements. Class II/T/2 is the minimum class of performance authorized for CAT II operations. For public Part 97 procedures, the lowest CAT II HAT/RVR values in feet are 100/1200. Table 2 lists RVR values for HAT values greater than 100.

HAT (ft)	RVR (ft)
101-140 (01 - 40 adjustment)	1200
141-180 (41 - 80 adjustment)	1600
181-199 (81 - 99 adjustment)	1800

Note: *Chart only one set of minimums indicating the lowest authorized CAT II HAT.

Table 3. Lowest Public CAT II Minimums*

6.7.1 Calculation of Radio Altimeter (RA) Height.

To determine RA height, determine the distance (d) from landing threshold point (LTP) to the point decision altitude (DA) occurs. Obtain the terrain elevation on final approach course at distance (d) feet from LTP. Subtract the terrain elevation from the DA to calculate the RA (see figure 4).

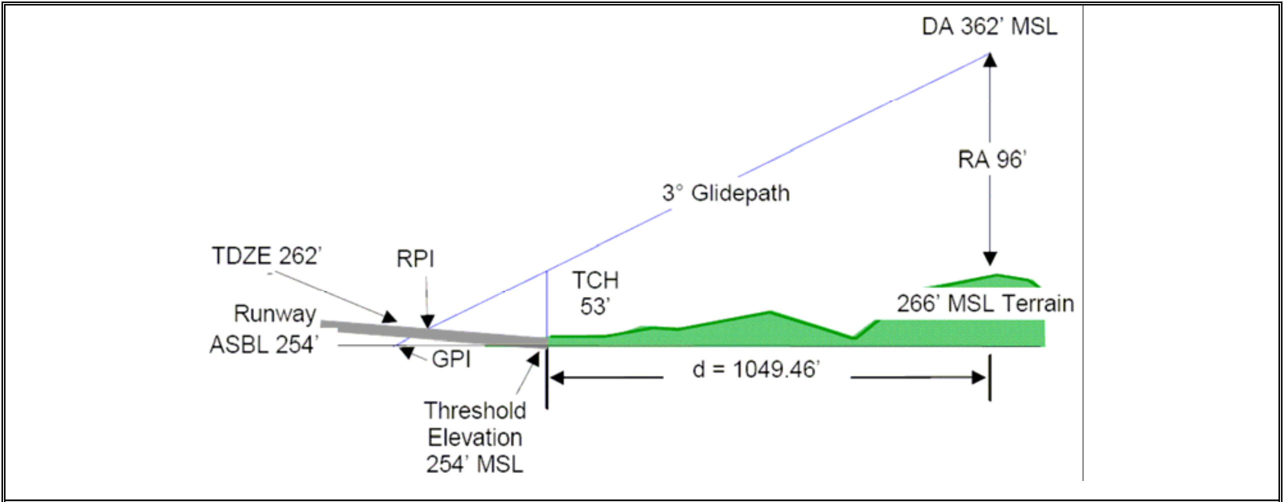


Figure 4: Calculating RA.

$$d = \frac{DA - (Threshold\_Elev + TCH)}{\tan(GPA)} = \frac{362 - (254 + 53)}{\tan(3)} = 1049.46 \text{ from LTP}$$

$$RA = DA - terrain\_elevation = 362 - 266 = 96 \text{ ft}$$

6.8 ADJUSTMENT OF CAT II MINIMUMS.

The HAT is measured in feet from the highest elevation of the runway in the touchdown area (first 3,000 ft of runway), and visibility in RVR reported in feet. The lowest attainable values are a HAT of 100 ft and RVR of 1,200 ft. Applica-tion of CAT II obstacle clearance criteria may identify objects that exceed the allowable height in surface “A” (see paragraph 6.9.1) or penetrate the approach light surface (except allowable localizer antenna, see paragraph 4.0 Note). In such cases, adjustment to the HAT must be made as follows:

NOTE: If the adjusted HAT is greater than or equal to 200, revert to CAT I criteria.

6.8.1 Penetrations of the Final Approach Surface.

6.8.2 Penetrations of the primary (W, X) surfaces are not authorized.

Taxiing, holding, and parked aircraft are obstacles in the final segment analysis. Apply Order 8260.3, Volume 3, paragraph 3.6.3 to obstacle penetrations in the “Y” surface, except paragraph 3.6.3c is not applicable (see paragraph 6.5 Note).

6.8.3 Inner-Approach OFZ and Missed Approach Surface "A, B, C, or D."

For penetrations of the inner-approach OFZ or missed approach surface A, when an obstacle is not considered acceptable, adjust the HAT upward one foot for each foot of surface penetration and adjust the RVR, as specified in table 3. For obstacle penetrations of the missed approach surface B, C, or D, increase the RVR, as specified in table 3, as if the HAT was adjusted, but do not raise the HAT.

6.9 MISSED APPROACH SEGMENT.

6.9.1 Section 1.

The area begins at the end of the final OCS trapezoid and is aligned with a continuation of the final approach course, continuing in the direction of landing for a distance of 9,200 excluding extensions. It is comprised of 5 surfaces: surface A, surface B, surface C, surface D, and surface A1 (see figure 5). Surface A, B, C, or D must not be penetrated unless the obstacle is either deemed acceptable IAW paragraph 2.0 or the minima is adjusted (see paragraph 6.8). Surface A1 or A1 extended must not be penetrated, unless the obstacle is either deemed acceptable IAW paragraph 2.0 or the procedure is published as a Special and mitigated with a non-standard climb gradient (see paragraph 6.9.2c). Use the following formulas to calculate the MSL height of the OCS at any given distance (X) from threshold and (Y) from runway centerline:

h = MSL height of OCS

X = distance (ft) from runway threshold measured parallel to runway centerline

Y = perpendicular distance (ft) from runway centerline

e = MSL elevation of the runway centerline at distance X

f = MSL elevation of the runway centerline 3,000 ft from threshold

k = increase in surface width due to altitude:

If airport elevation ≤1000 MSL then 0=k or

if airport elevation >1000 MSL then)1000(01.0−=vairportelek

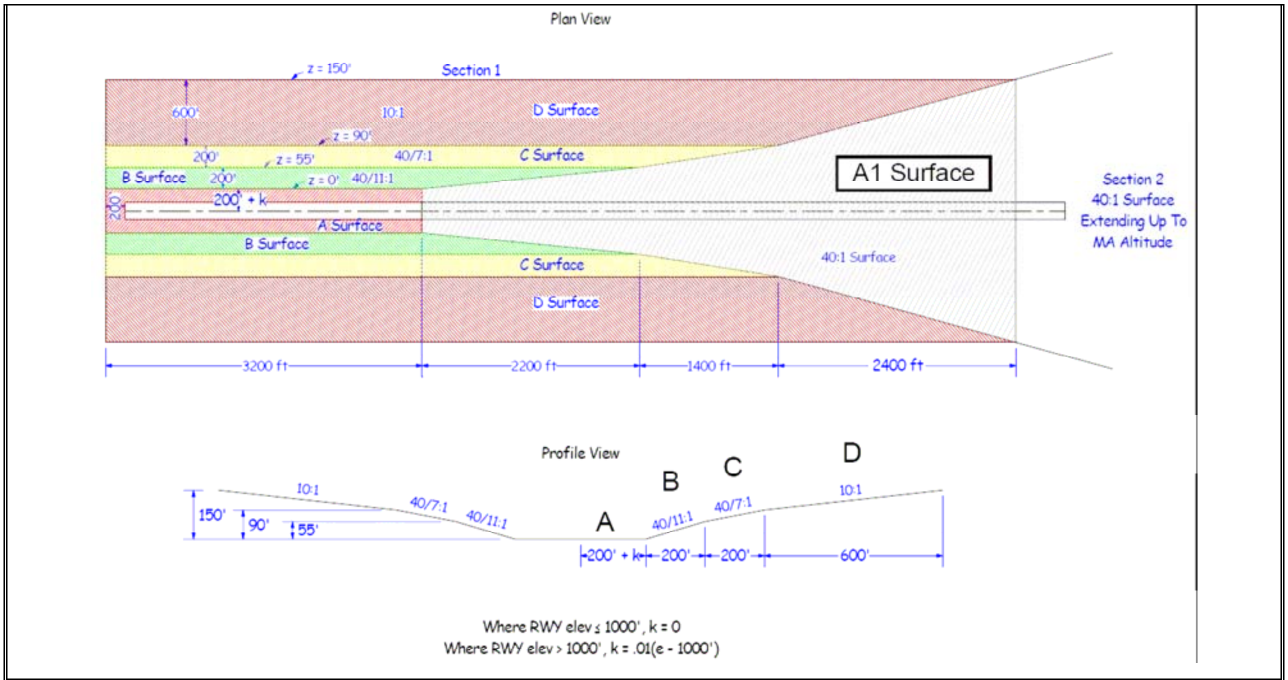
<u>CASE 1. Where X ≤ 3000’ and:</u>

Y < (200+k):	$h = e$	A Surface
Y ≥ (200+k):	$h = \frac{11(Y-(200+k))}{40} + e$	B Surface
Y > (400+k):	$h = \frac{7(Y-(400+k))}{40} + 55 + e$	C Surface
Y > (600+k):	$h = \frac{(Y-(600+k))}{10} + 90 + e$	D Surface

CASE 2. Where X > 3000’ and:

(Calculate h using the following formulas, select highest value of the 2 results)

Y > (200+k):	$h = \frac{11(Y-(200+k))}{40} + e$	(B surface)
	$h = \frac{X-3{,}000}{40} + f$	(A1 Surface)
Y > (400+k):	$h = \frac{7(Y-(400+k))}{40} + 55 + e$	(C surface)
	$h = \frac{X-3{,}000}{40} + f$	(A1 Surface)
Y > (600+k):	$h = \frac{(Y-(600+k))}{40} + 90 + e$	(D surface)
	$h = \frac{X-3{,}000}{10} + f$	(A1 Surface)



Where RWY elev ≤ 1000', k = 0
Where RWY elev > 1000', k = .01(e - 1000')

Figure 5: CAT II/III Missed Approach Section 1.

6.9.2 Section 2.

See figure 6.

a. **Straight-Ahead Missed Approach Area (applies to turns 15 degrees or less).** This area starts at the end of the A1 surface and is centered on the specified missed approach course. The width increases uniformly from +/- (1200 + k) feet at the beginning to en route width at a point 15 miles from the runway threshold. When positive course guidance is provided for the missed approach procedure, secondary reduction areas that are zero miles wide at the point of beginning and increase uniformly to initial secondary width may be added to section 2 (see figure 6).

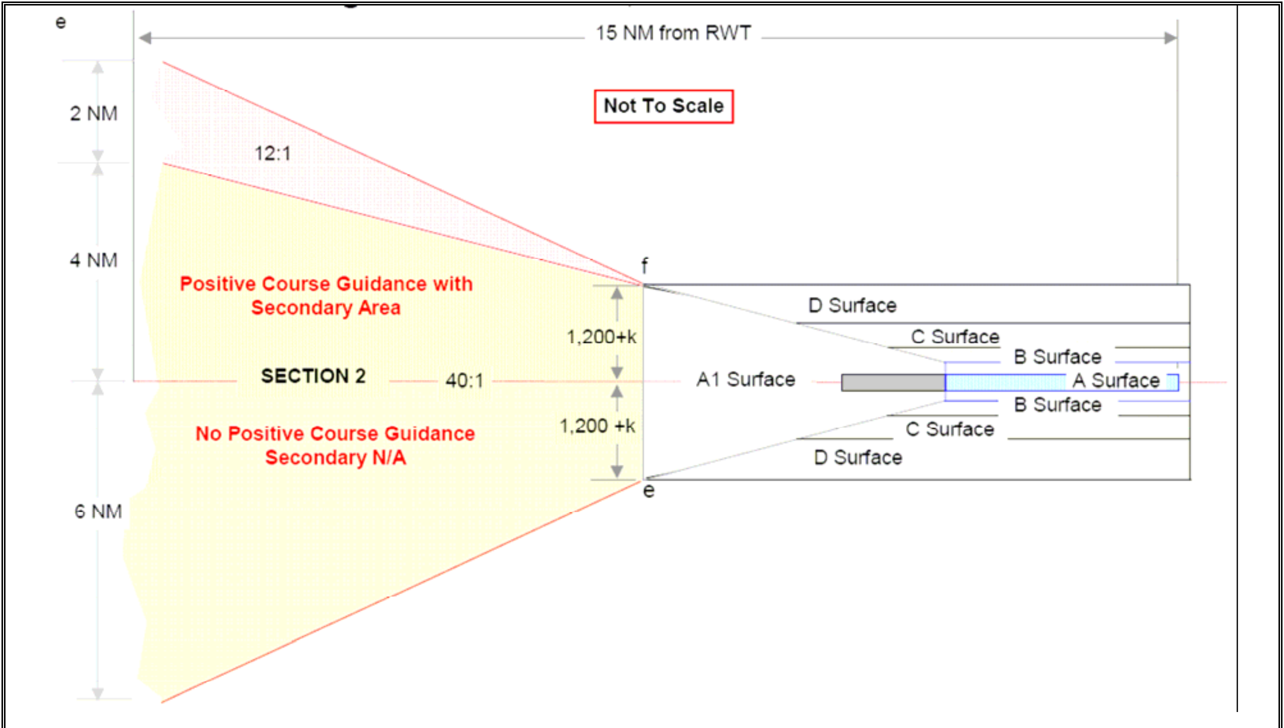


Figure 6: Section 2, Non-RNAVDTA.

b. **Turning Missed Approach Area.** (Applies to turns of more than 15°). See figures 7, 8, and 9. Missed approach section 1 obstacle clearance surface is based on the assumption that aircraft will be 200 ft above the runway elevation at the end of the A surface at the nominal end of the A1 surface. However, the design of the turning missed approach area must consider that aircraft executing a missed approach will climb straight ahead until reaching a height of at least 400 ft above the TDZE. The A1 surface area must be extended longitudinally using the following formula:

d = $(T_{MSL} - (A_{MSL} + 200))$ * Slope
d = A1 surface extension distance in feet
A_{MSL} = Runway elevation at end of A surface
T_{MSL}= Turn height (as a minimum, TDZE + 400)
Slope = 6076.11548/CG.

Note: For special procedures requiring a climb gradient A1 surface extended may be shortened (see figure 10).

The A1 surface extended OCS will continue to slope at 40:1 and the area will splay at 15 degrees from the nominal end of A1 surface width until reaching the turn altitude/point. Apply the applicable turning flight track/outer boundary radius (see Order 8260.3 Volume 1, chapter 2, table 5) both originating on the line marking the end of A1 surface extended. Unless a fix/facility identifies the turn point, the inner boundary line must commence at the inside turn edge of the D surface opposite the end of the touchdown area (A surface). When the turn point is marked by a fix/facility, the inside tieback may be constructed relative to the end of the A1 surface extended (see Order 8260.3 Volume 1, paragraph 277). When the point on the inside turn side of section 2 area abeam the clearance limit is past an imaginary line extended perpendicular to the edge of section 1 abeam the end of the touchdown zone on inside turn side, the inner boundary line commences on the outside turn edge of the D surface opposite the end of the touchdown area (A surface). See figure 9. The outer and inner boundary lines extend to points each side at flight track at the clearance limit at a rate that achieves initial segment width 15 miles from the runway threshold. Where secondary areas are required, they must commence after completion of the turn at the point where PCG is achieved.

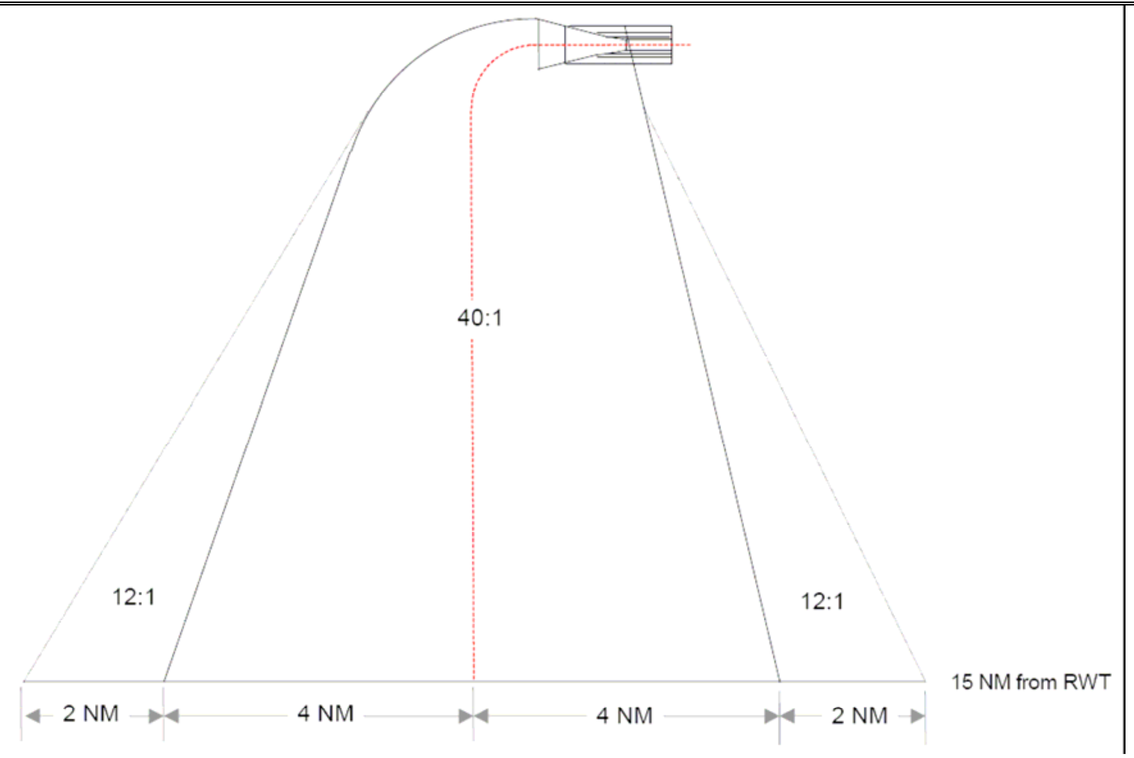
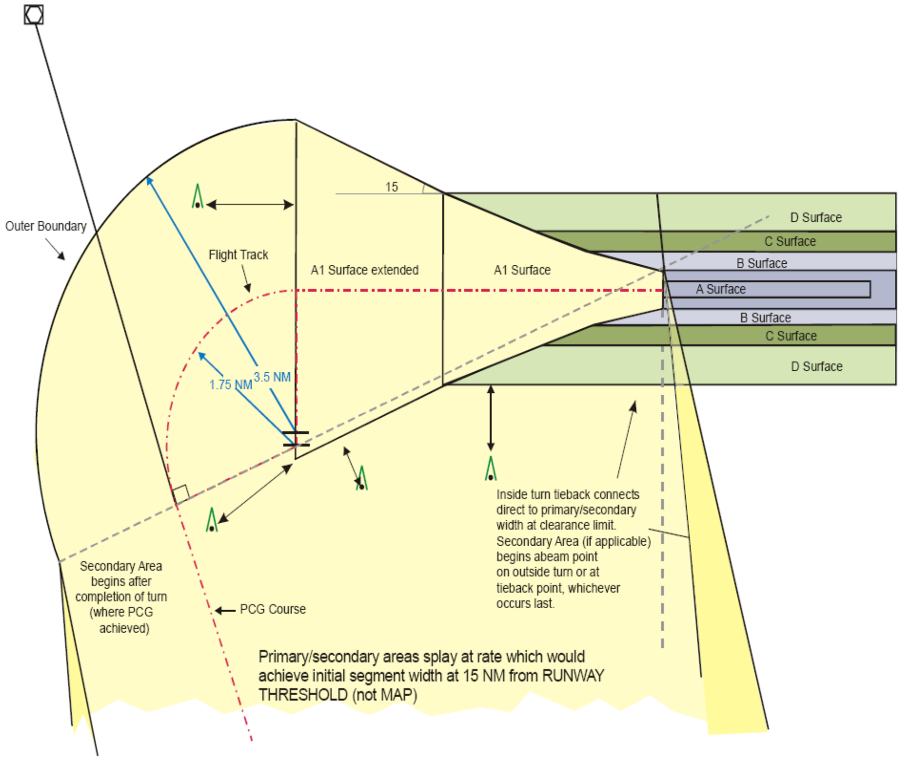


Figure 7: Turning Missed Approach Detail.



Inside turn tieback connects direct to primary/secondary width at clearance limit. Secondary Area (if applicable) begins abeam point on outside turn or at tieback point, whichever occurs last.

Secondary Area begins after completion of turn (where PCG achieved)

Primary/secondary areas splay at rate which would achieve initial segment width at 15 NM from RUNWAY THRESHOLD (not MAP)

Figure 8: Turning Missed Approach (Section 1 Extended).

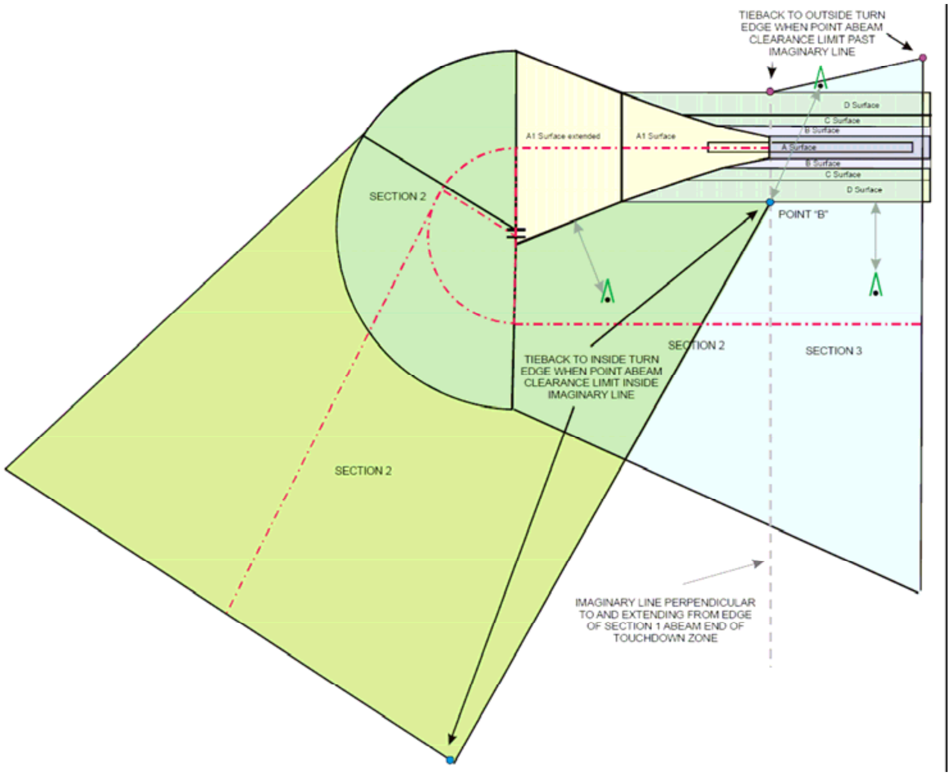


Figure 9: Turning Missed Approach Detail – Continued.

c. **Section 2, Obstacle Clearance.** Section 2 OCS is a 40:1 inclined plane originating at the end of section 1. Beginning height is equivalent to the end of the A1 surface height on centerline. When the A1 surface is extended for turning missed approach, section 2 originates at the end of the A1 surface extended and the beginning height is equivalent to the A1 extended surface height on centerline. Obstacles in section 2 are measured to the nearest edge of section 1 (or to the A1 surface extended). Section 3 is necessary for turns more than 90° as described in Order 8260.3 Volume 1, paragraph 276b, except point "B" is defined as the point of the inside of turn edge of section 1 abeam the end of the A surface regardless of the location of the inside tieback point (see paragraph 6.9.2b). When an object penetrates the 40:1 surface in the A1 surface extended or section 2, a public procedure is not authorized. A special procedure (see Order 8260.19 chapter 4, section 4) with a missed approach climb gradient > 200 ft/NM may be constructed consistent with Order 8260.3 Volume 3, paragraph 3.9.3. The missed approach procedure will contain a note specifying the minimum rate of climb required to clear the obstruction by the number of feet determined by the following formula:

$$c = \frac{h-e}{0.76d} \qquad \text{Example } c = \frac{619-112}{0.76x2} = 333.55\, {}^{ft}\!/_{NM} \text{ round to 334 } {}^{ft}\!/_{NM}$$

Where: c = climb gradient (ft/NM)

h = obstruction MSL elevation - elevation of runway at end of A surface

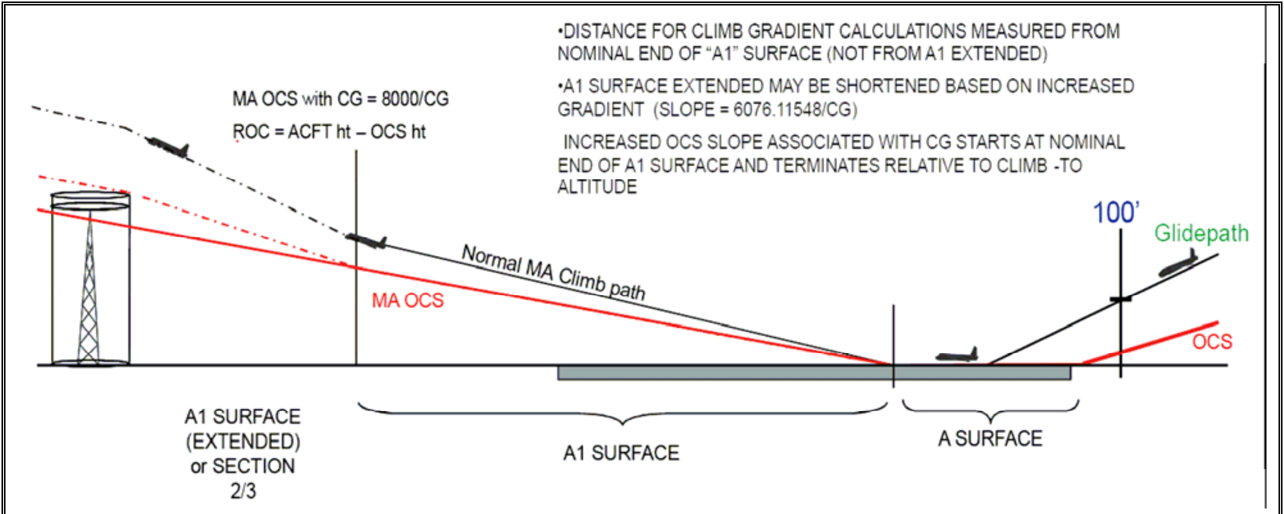
e = centerline height at nominal end of A1 surface

d = in A1 surface extended, shortest distance in NM to line marking nominal end of A1 surface. In section 2/3, distance in NM from nominal end of A1 surface to A1 surface extended + distance to nearest edge of section 1 (to include A1 surface extended).

The climb gradient is effective until reaching the hundred-foot (3100; 1600; etc.) altitude equal to the height of the obstacle + ROC. Do not publish climb gradients less than 200 ft per NM.

Example:

Chart plan view note: "Missed approach obstructions require a minimum climb gradient of (number) ft/NM to (altitude)."



•DISTANCE FOR CLIMB GRADIENT CALCULATIONS MEASURED FROM NOMINAL END OF "A1" SURFACE (NOT FROM A1 EXTENDED)

•A1 SURFACE EXTENDED MAY BE SHORTENED BASED ON INCREASED GRADIENT (SLOPE = 6076.11548/CG)

INCREASED OCS SLOPE ASSOCIATED WITH CG STARTS AT NOMINAL END OF A1 SURFACE AND TERMINATES RELATIVE TO CLIMB -TO ALTITUDE

Figure 10: Missed Approach Climb Gradient (Special Procedures).

7.0 REQUIREMENTS FOR CAT III PRECISION.

AC 120-28 refers to use of ICAO Annex 10 criteria, Order 6750.24, and the applicable NAVAID classification for CAT III operations. NAVAID use is predicated on applicable ILS, MLS, or GLS performance classifications; e.g., ILS III/E/3, GLS II/D/3, or equivalent classification at non-U.S. facilities. For GLS, an appropriate equivalent performance classification to ILS, as specified by FAA or the ICAO, may also be used; e.g., Performance Level/Coverage/Integrity as in "II/T/2." Threshold crossing height (TCH) requirements contained in Order 8260.3, Volume 3, paragraph 2.6 applies. Except as noted below, the above criteria for CAT II precision applies.

7.1 REQUIREMENTS FOR LOWER THAN CAT II (RVR 1200) OPERATIONS.

7.1.1 Lighting Requirements.

Lead on/off lights are required to approve operations below RVR 600.

7.1.2 Surface Movement Guidance and Control System (SMGCS).

Approved SMGCS operation per AC 120-57, as required.

CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 5.3

VOLUME 6

DOC 7

AREA NAVIGATION (RNAV)

TRANSPORT CANADA
NATIONAL DEFENCE

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CHAPTER 1. GENERAL

1.0 Purpose

This document specifies criteria for obstacle clearance evaluation of area navigation (**RNAV**) approach procedures; e.g., Localizer Performance with Vertical Guidance (**LPV**), Lateral Navigation (**LNAV**), Lateral Navigation/Vertical Navigation (**LNAV/VNAV**), and Localizer Performance (**LP**). Apply feeder segment criteria (paragraph 2.7) to satisfy RNAV Standard Terminal Arrival Route (**STAR**) and Tango (**T**) Air Traffic Service (**ATS**) route obstacle clearance requirements.

Note: These criteria do not support very high frequency (**VHF**) omnidirectional range/distance measuring equipment (**VOR/DME**) RNAV, inertial navigation system (**INS**), or inertial reference unit (**IRU**) RNAV operations, or DME/DME RNAV final or missed approach operations.

1.1 – 1.6 Reserved

1.7 Definitions

1.7.1 Along-Track Distance (ATD).

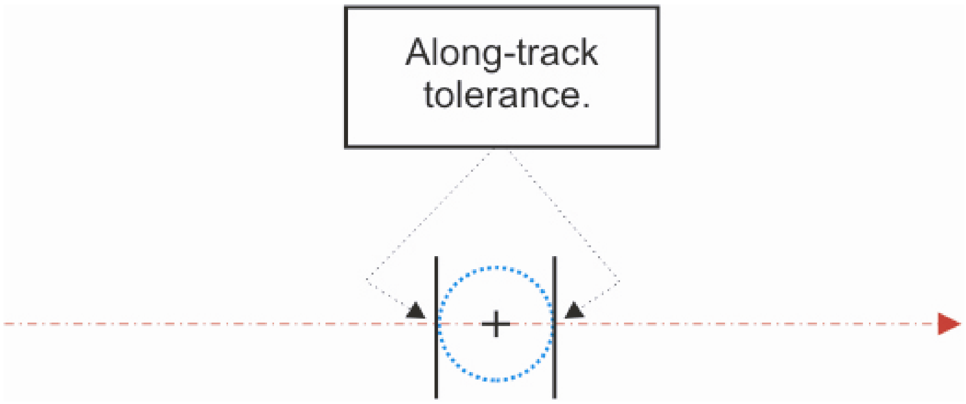
A distance specified in nautical miles (NM) along a defined track to an RNAV fix.

1.7.2 Along-Track (ATRK) Tolerance (ATT).

The amount of possible longitudinal fix positioning error on a specified track expressed as a ± value (see figure 1-1).

1.7.3 Barometric Altitude.

A barometric altitude measured above mean sea level (**MSL**) based on atmospheric pressure measured by an aneroid barometer. This is the most common method of determining aircraft altitude.



Note: The acronym **ATRK FDT** (along-track fix displacement tolerance) has been used in lieu of **ATT** in the past. The change to **ATT** is a step toward harmonization of terms with **ICAO** Pans-Ops.

Figure 1-1: ATT

1.7.4 Cross-Track (XTT) Tolerance.

The amount of possible lateral positioning error expressed as a ± value (see figure 1-2).

1.7.5 Decision Altitude (DA).

The **DA** is a specified barometric altitude at which a missed approach must be initiated if the required visual references to continue the approach have not been acquired. **DA** is referenced to **MSL**. It is applicable to vertically guided approach procedures.

1.7.6 Departure End of Runway (DER).

The **DER** is the end of the runway that is opposite the landing threshold. It is sometimes referred to as the stop end of runway.

1.7.7 Distance of Turn Anticipation (DTA).

DTA represents the maximum distance from (prior to) a fly-by-fix that an aircraft is expected to start a turn to intercept the course of the next segment. The **ATT** value associated with a fix is added to the **DTA** value when **DTA** is applied (see figure 1-3).

1.7.8 Fictitious Threshold Point (FTP).

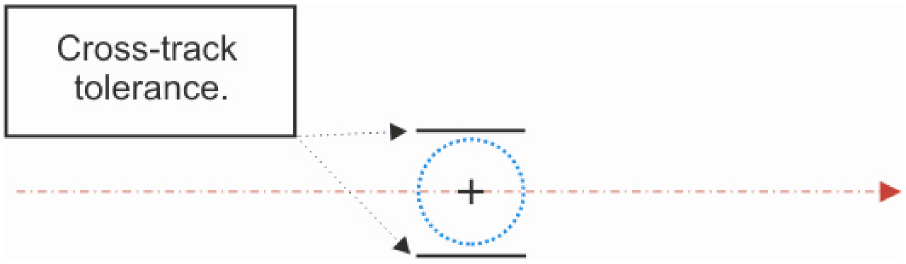
The **FTP** is the equivalent of the landing threshold point (**LTP**) when the final approach course is offset from the runway centerline and is not aligned through the **LTP**. It is the intersection of the final course and a line perpendicular to the final course that passes through the **LTP**. **FTP** elevation is the same as the **LTP** (see figure 1-4). For the purposes of this criteria, where **LTP** is used, **FTP** may apply as appropriate.

1.7.9 Fix Displacement Tolerance (FDT).

FDT is a legacy term providing 2-dimensional (2D) quantification of positioning error. It is now defined as a circular area with a radius of **ATT** centered on an RNAV fix (see figure 1-3). The acronym **ATT** is now used in lieu of **FDT**.

1.7.10 Flight Path Alignment Point (FPAP).

The **FPAP** is a 3-dimensional (3D) point defined by World Geodetic System of 1984/ North American Datum of 1983 (WGS-84/NAD-83) latitude, longitude, **MSL** elevation, and WGS-84 Geoid height. The **FPAP** is used in conjunction with the **LTP** and the geometric center of the WGS-84 ellipsoid to define the final approach azimuth (**LPV** glidepath's vertical plane) associated with an **LP** or **LPV** final course.



Note: The acronym **XTRK FDT** (cross-track fix displacement tolerance) has been used instead of **XTT** in the past. The change to **XTT** is a step toward harmonization of terms with ICAO Pans-Ops.

Figure 1-2: XTT

1.7.11 Geoid Height (GH).

The **GH** is the height of the Geoid relative to the WGS-84 ellipsoid. It is a positive value when the Geoid is above the WGS-84 ellipsoid and negative when it is below. The value is used to convert an **MSL** elevation to an ellipsoidal or geodetic height - the height above ellipsoid (**HAE**).

Note: The Geoid is an imaginary surface within or around the earth that is everywhere normal to the direction of gravity and coincides with mean sea level (**MSL**) in the oceans. It is the reference surface for **MSL** heights.

1.7.12 Glidepath Angle (GPA).

The **GPA** is the angle of the specified final approach descent path relative to a horizontal line tangent to the surface of the earth at the runway threshold (see figure 1-5). In this criteria, the glidepath angle is represented in formulas and figures as the Greek symbol theta (**θ**).

1.7.13 Glidepath Qualification Surface (GQS).

The **GQS** is a narrow inclined plane centered on the runway centerline that limits the height of obstructions between the **DA** and **LTP**. A clear **GQS** is required for authorization of vertically-guided approach procedure development.

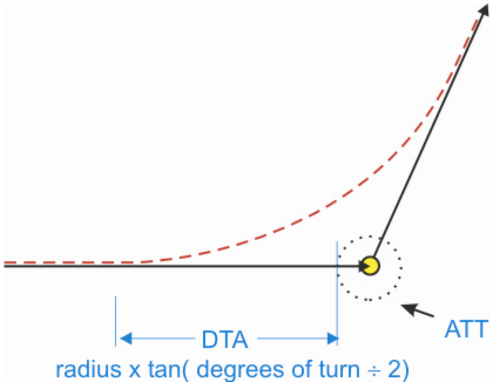


Figure 1-3: DTA

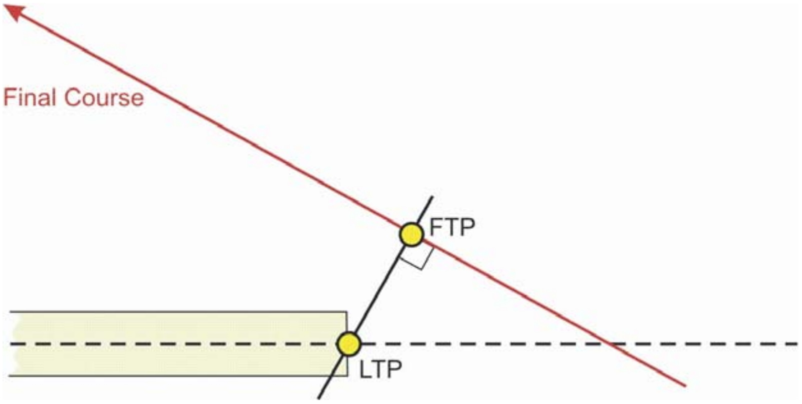


Figure 1-4: FTP

1.7.14 Height Above Ellipsoid (HAE).

The elevation of the glidepath origin (threshold crossing height [**TCH**] point) for an **LPV** approach procedure is referenced to the **LTP**. RNAV avionics calculate heights relative to the WGS-84 ellipsoid. Therefore, it is important to specify the **HAE** value for the **LTP**. This value differs from a height expressed in feet above the geoid (essentially **MSL**) because the reference surfaces (WGS-84 ellipsoid and the geoid) do not coincide. Ascertain the height of the orthometric geoid (**MSL** surface) relative to the WGS-84 ellipsoid at the **LTP**. This value is considered the **GH**. For Oxford House, MB (CYOH) the GH is –38.854 m (-127.474 feet) see NRCan website*. This means the geoid is 127.474 ft below the WGS-84 ellipsoid at the latitude and longitude of the runway 23 threshold. To convert an MSL height to an HAE height, algebraically add the geoid height value to the MSL value. HAE elevations are not used for instrument procedure construction, but are documented for inclusion in airborne receiver databases.

Note: * Use the following NRCan website to calculate **GH**: http://www.geod.nrcan.gc.ca/apps/gpsh/gpsh_e.php

1.7.15 Height Above Threshold (HATh).

The **HATh** is the height of the **DA** above **LTP** elevation.

1.7.16 Inner-Approach Obstacle Free Zone (OFZ).

The inner-approach **OFZ** is the airspace above a surface centered on the extended runway centerline. It applies to runways with an approach lighting system of any authorized type.

1.7.17 Inner-Transitional OFZ.

The inner-transitional **OFZ** is the airspace above the surfaces located on the outer edges of the runway **OFZ** and the inner-approach **OFZ**. It applies to runways with approach visibility minimums less than ¾ statute miles (SM).

1.7.18 Landing Threshold Point (LTP).

The **LTP** is a 3D point at the intersection of the runway centerline and the runway threshold (**RWT**). WGS-84/ NAD-83 latitude, longitude, **MSL** elevation, and geoid height define it. It is used in conjunction with the **FPAP** and the geometric center of the WGS-84 ellipsoid to define the vertical plane of an RNAV final approach course (see figure 1-5).

Note: Where an **FTP** is used, apply **LTP** elevation (**$\mathbf{LTP_E}$**).

1.7.19 Lateral Navigation (LNAV).

LNAV is RNAV lateral navigation. This type of navigation is associated with non precision approach procedures (**NPA**) because vertical path deviation information is not provided. **LNAV** criteria are the basis of the **LNAV** minima line on RNAV (GNSS) approach procedures.

1.7.20 Lateral Navigation/Vertical Navigation (LNAV/VNAV).

An approach with vertical guidance (**APV**) evaluated using the **Baro VNAV** obstacle clearance surfaces conforming to the lateral dimensions of the **LNAV** obstruction evaluation area (**OEA**). The final descent is flown using **Baro VNAV** to a Decision Altitude.

1.7.21 Localizer Performance (LP).

An **LP** approach is an RNAV **NPA** procedure evaluated using the lateral obstacle evaluation area dimensions of the precision localizer trapezoid, with adjustments specific to the **WAAS**. See chapter 3. These procedures are published on RNAV (**GNSS**) approach charts as the **LP** minima line.

1.7.22 Localizer Performance with Vertical Guidance (LPV).

An approach with vertical guidance (**APV**) evaluated using the **OCS** dimensions (horizontal and vertical) of the precision approach trapezoid, with adjustments specific to the **WAAS**. See chapter 5. These procedures are published on RNAV (GNSS) approach charts as the **LPV** minima line.

1.7.23 Obstacle Evaluation Area (OEA).

An area within defined limits that is subjected to obstacle evaluation through application of required obstacle clearance (**ROC**) or an obstacle clearance surface (**OCS**).

1.7.24 Obstacle Clearance Surface (OCS).

An **OCS** is an upward or downward sloping surface used for obstacle evaluation where the flight path is climbing or descending. The separation between this surface and the vertical path angle defines the MINIMUM required obstruction clearance at any given point.

1.7.25 Obstacle Positions (OBS_X, OBS_Y, OBS_Z).

OBS_X, OBS_Y, & **OBS_Z** are the along track distance to an obstacle from the **LTP**, the perpendicular distance from the centerline extended, and the **MSL** elevation, respectively, of the obstacle clearance surfaces.

1.7.26 Precise Final Approach Fix (PFAF).

The **PFAF** is a calculated WGS-84 geographic position located on the final approach course where the designed vertical path (**NPA** procedures) or glidepath (**APV** and **PA** procedures) intercepts the intermediate segment altitude (glidepath intercept altitude). The **PFAF** marks the beginning of the final approach segment (see figure 1-6). The calculation of the distance from **LTP** to **PFAF** includes the earth curvature.

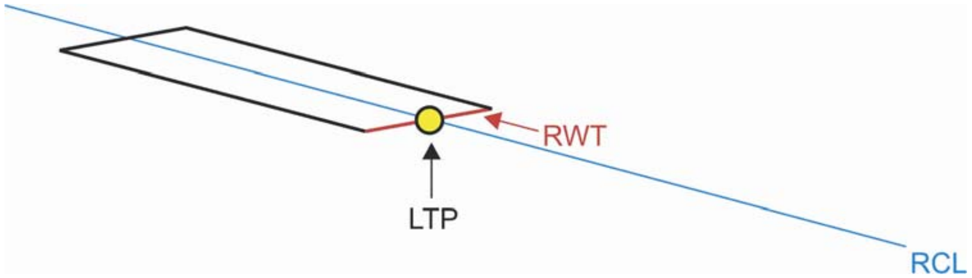


Figure 1-5: LTP

1.7.27 Reference Datum Point (RDP).

The **RDP** is a 3D point defined by the **LTP** or **FTP** latitude/longitude position, **MSL** elevation, and a threshold crossing height (**TCH**) value. The **RDP** is in the vertical plane associated with the final approach course and is used to relate the glidepath angle of the final approach track to the landing runway. It is also referred to as the **TCH** point or flight path control point (**FPCP**) (see figure 1-7).

1.7.28 Runway Threshold (RWT).

The **RWT** marks the beginning of the part of the runway that is usable for landing (see figure 1-5). It includes the entire width of the runway.

1.7.29 Start of Climb (SOC).

The **SOC** is the point located at a calculated along-track distance from the decision altitude/missed approach point (**DA/MAP**) where the 40:1 missed approach surface originates.

1.7.30 Threshold Crossing Height (TCH).

The height of the glidepath above the threshold of the runway measured in feet (see figure 1-7). The **LPV** glidepath originates at the **TCH** value above the **LTP**.

1.7.31 Visual Glide Slope Indicator (VGSI).

The **VGSI** is an airport lighting aid that provides the pilot a visual indication of the aircraft position relative to a specified glidepath to a touchdown point on the runway.

1.7.32 Wide Area Augmentation System (WAAS).

The **WAAS** is a navigation system based on the GNSS. Ground correction stations transmit position corrections that enhance system accuracy and add satellite based **VNAV** features.

1.7.33 Approach Surface Baseline (ASBL)

The **ASBL** is a line aligned to the runway centerline (**RCL**) that lies in a plane parallel to a tangent to the WGS-Ellipsoid at the landing threshold point. It is used as a baseline reference for vertical measurement of the height of glidepath and **OCS**.

1.8 – 1.9 Reserved

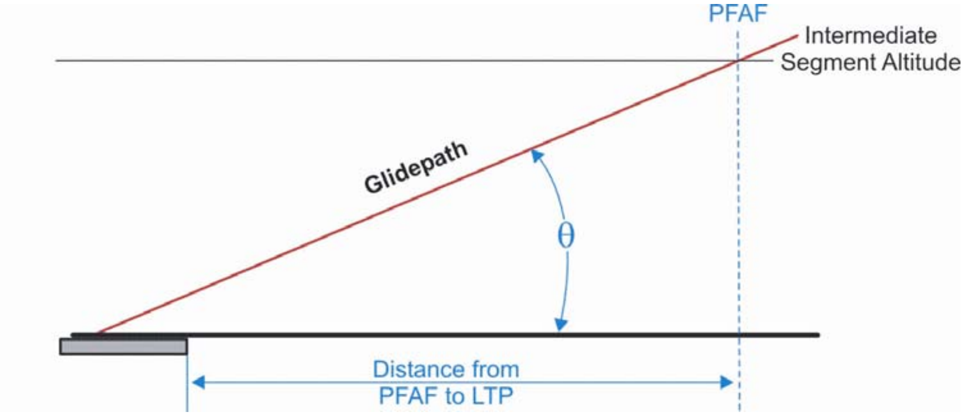


Figure 1-6: PFAF

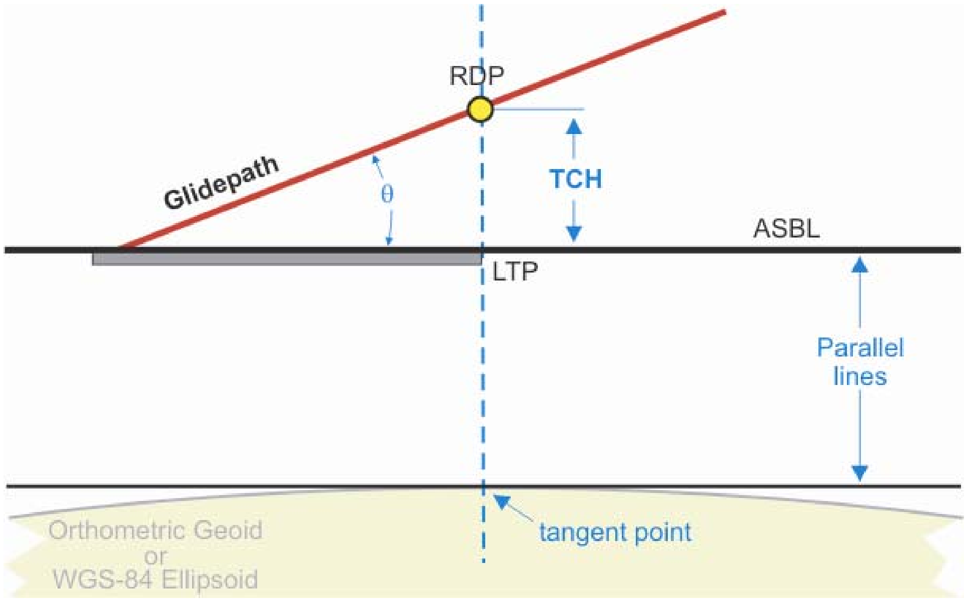


Figure 1-7: RDP, TCH, GPA (θ)

Formula 1-1. HAE Example.

Standard Text	HAE = Z + GH
Math Notation	Z+GH

Given values:

HAE = Height above Ellipsoid
Z = MSL Elevation
GH = Geoid Height

Example

HAE = Z + GH
= 1117.000 + (-87.146)
= 1029.854

Formula 1-2. HATh Example.

Standard Text	HATh = DA − LTP_{elev}
Math Notation	DA-LTPelev

Given values:

HATh = Height above Threshold
DA = Decision Altitude
LTP_{elev} = LTP Elevation

Example

HATh = DA − LTPelev
= 262 - 208
= 54

Turn Height Above Airport	**Standard Tailwind Component (Knots)**	
500	**25**	
1,000-2,500	**Standard**	**TC or DND Approval (as appropriate)**
1,000	**37.5**	**30**
1,500	**50**	**35**
2,000	**50**	**40**
2,500	**50**	**45**
3,000	**50**	
3,500	**55**	
4,000	**60**	
4,500	**65**	
5,000	**70**	
5,500	**75**	
6,000	**80**	
6,500	**85**	
7,000	**90**	
7,500	**95**	
8,000	**100**	
8,500	**105**	
9,000	**110**	
9,500	**115**	
10,000	**120**	
10,500	**125**	
≥11,000	**130**	

Table 1-3. Tailwind Component (V_{KTW}) for Turn Calculations

CHAPTER 2. GENERAL CRITERIA

SECTION 1. BASIC CRITERIA INFORMATION

2.0 Criteria

Volume 1, Chapter 18 remains applicable for Holding Criteria.

The feeder, initial, intermediate, final, and missed approach criteria described in this criteria supersede the other criteria contained in TP308/GPH209. See Volume 1, chapter 3 to determine visibility minima. The feeder criteria in paragraph 2.7 may be used to support RNAV Standard Terminal Arrival Route (**STAR**) and Tango (**T**) Air Traffic Service (**ATS**) route construction.

Formulas are numbered by chapter and depicted in standard mathematical notation and in standard text to aid in computer programming.

2.1 Data Resolution

Perform calculations using an accuracy of **at least 15 significant digits**; i.e., floating point numbers must be stored using at least 64 bits. Do not round intermediate results. Round only the final result of calculations for documentation purposes. Required accuracy tolerance is 1 centimeter for distance and 0.002 arc-second for angles. The following list specifies the minimum accuracy standard for documenting data expressed numerically. This standard applies to the documentation of final results only; e.g., a calculated adjusted glidepath angle of 3.04178 degrees is documented as 3.05 degrees. The standard does not apply to the use of variable values during calculation. Use the most accurate data available for variable values.

2.1.1 Documentation Accuracy:

- **a.** WGS-84 latitudes and longitudes to the nearest one hundredth (0.01) arc second; [nearest five ten thousandth (0.0005) arc second for Final Approach Segment (**FAS**) data block entries].
- **b.** **LTP** mean sea level (**MSL**) elevation to the nearest foot;
- **c.** **LTP** height above ellipsoid (**HAE**) to the nearest tenth (0.1) meter;
- **d.** Glidepath angle (**GPA**) to the next higher one hundredth (0.01) degree;
- **e.** Courses to the nearest one hundredth (0.01) degree; and
- **f.** Course width at threshold to the nearest quarter (0.25) meter;
- **g.** Distances to the nearest hundredth (0.01) unit [except for “length of offset” entry in **FAS** data block which is to the nearest 8 meter value].

2.1.2 Mathematics Convention.

Formulas in this document as depicted are written for radian calculation.

Note: The value for 1 NM was previously defined as 6,076.11548 ft. For the purposes of RNAV criteria, 1 NM is defined as the result of the following calculation: $1NM = \frac{1852}{0.3048}$

a. Conversions:

(1) Degree measure to radian measure:............................. $Radians = Degrees \times \frac{\pi}{180}$

(2) Radian measure to degree measure:............................ $Degrees = Radians \times \frac{180}{\pi}$

(3) Feet to meters .... $meters = feet \times 0.3048$

(4) Meters to feet .... $feet = \frac{meters}{0.3048}$

(5) Feet to Nautical Miles (NM)... $NM = feet \times \frac{0.3048}{1852}$

(6) NM to feet.. $feet = NM \times \frac{1852}{0.3048}$

(7) NM to meters.. $meters = NM \times 1852$

(8) Meters to NM.. $NM = \frac{meters}{1852}$

(9) Temperature Celsius to Fahrenheit:............................. $T_{Fahrenheit} = 1.8 \times T_{Celcius} + 32$

(10) Temperature Fahrenheit to Celsius..................................... $T_{Celcius} = \frac{T_{Fahrenheit} - 32}{1.8}$

b. Definition of Mathematical Functions.

a + b	indicates addition
a − b	indicates subtraction
a × b or ab	indicates multiplication
$\frac{a}{b}$ or a/b or a ÷ b	indicates division
(a − b)	indicates the result of the process within the parenthesis
$\lvert a - b \rvert$	indicates absolute value
≈	indicates approximate equality
$\sqrt{a}$ or $a^{0.5}$ or a^0.5	indicates the square root of quantity "a"
a^2 or a^2	indicates a × a
ln(a) or log(a)	indicates the natural logarithm of “a”
tan(a)	indicates the tangent of "a" degrees
$\tan^{-1}(a)$ or atan(a)	indicates the arc tangent of "a"
sin(a)	indicates the sine of "a" degrees
$\sin^{-1}(a)$ or asin(a)	indicates the arc sine of "a"
cos(a)	indicates the cosine of "a" degrees
$\cos^{-1}(a)$ or acos(a)	indicates the arc cosine of "a"

e The constant **e** is the base of the natural logarithm and is sometimes known as Napier’s constant, although its symbol (**e**) honours Euler. With the possible exception of π, e is the most important constant in mathematics since it appears in myriad mathematical contexts involving limits and derivatives. Its value is approximately 2.718281728459045235360287471352662497757 …

r The TP308/GPH209 constant for the mean radius of the earth for spherical calculations in feet. **r** = 20890537

c. Operation Precedence (Order of Operations).

First:	Grouping Symbols: parentheses, brackets, braces, fraction bars, etc.
Second:	Functions: Tangent, sine, cosine, arcsine and other defined functions
Third:	Exponentiations: Powers and roots
Fourth:	Multiplication and Division: Products and quotients
Fifth:	Addition and subtraction: Sums and differences

e.g,

$5 - 3 \times 2 = -1$	because multiplication takes precedence over subtraction
$(5 - 3)\times 2 = 4$	because parentheses take precedence over multiplication
$\frac{6^2}{3} = 12$	because exponentiation takes precedence over division
$\sqrt{9+16} = 5$	because the square root sign is a grouping symbol
$\sqrt{9} + \sqrt{16} = 7$	because roots take precedence over addition
$\frac{\sin(30^\circ)}{0.5} = 1$	because functions take precedence over division
$\sin\left(30^\circ/0.5\right) = 0.8660254$	because parentheses take precedence over functions

<u>Notes on calculator usage:</u>

1. Most calculators are programmed with these rules of precedence.
2. When possible, let the calculator maintain all of the available digits of a number in memory rather than re-entering a rounded number. For highest accuracy from a calculator, any rounding that is necessary should be done at the latest opportunity.

2.1.3 Geospatial Standards

a. The following standards apply to the evaluation of obstacle and terrain horizontal position and elevation data relative to RNAV OEAs and OCSs.

(1) **Terrain and obstacle data** are reported in NAD-83 (latitude, longitude) in Canada (note: NAD 27 charts still exists in Canada) and NAD 83 in the US.

(2) **Elevation data** are reported relative to mean sea level (MSL) in both countries.

(3) **Vertical Datum** in Canada is the Canadian Geodetic Vertical Datum of 1928 (CGVD 28) while in the US the vertical datum is either the National Geodetic Vertical Datum of 1929 (NGVD 29) or North American Vertical Datum of 1988 (NAVD 88).

(4) **Obstacle and terrain horizontal evaluation** should use NAD 83 and for elevation use CGVD 28 (in Canada) and NGVD 29 or NAVD 88 (in the US).

(5) **Procedure course centerline and all associated waypoints** as well as the OEA boundaries should be referenced to the WGS 84 and OCS elevations as appropriate.

b. WGS 84 for Position and Course Construction.

(1) The **World Geodetic Reference System** 1984 (WGS 84) is used by the FAA and the U.S. Department of Defense (DoD). It is defined by the National Geospatial-Intelligence Agency (NGA), formerly the National Imagery and Mapping Agency (NIMA), which is formerly the Defense Mapping Agency (DMA).

(2) In 1986, the Geodetic Survey Division of Natural Resources Canada (NRCan) and the U.S. National Geodetic Survey (NGS), redefined and readjusted the **North American Datum** of 1927 (NAD 27), creating the North American Datum of 1983 (NAD 83). In contrast, the WGS 84 was defined by the Defense Mapping Agency (DMA). Both NAD 83 and WGS 84 were originally defined (in words) to be geocentric and oriented as the Bureau International d l'Heure (BIH) Terrestrial System.

(3) In principle, the three-dimensional (3D) coordinates of a single physical point should therefore be the same in both **NAD 83** and **WGS 84** systems; in practice however, small differences are sometimes found. The original intent was that both systems would use the Geodetic Reference System of 1980 (GRS 80) as a reference ellipsoid. As it happened, the WGS 84 ellipsoid differs very slightly from GRS 80. The difference is 0.0001 meters in the semi-minor axis.

(4) In January 2, 1994, the WGS 84 reference system was realigned to be compatible with the International Terrestrial Reference Frame of 1992 (ITRF92) and renamed WGS 84 (G730). In doing so, the origin of WGS 84 (G730) was shifted about 2 m from the original WGS 84 (and NAD 83), resulting in horizontal shifts of about 1.5 m at the surface of the Earth. The reference system underwent subsequent improvements in 1996, referenced as WGS 84 (G873) closely aligned with ITRF94, to the current realization adopted by the NGA in 2001, referenced as WGS 84 (1150) and considered equivalent to ITRF2000.

c. CGVD 28 for elevation values.

(1) CGVD 28 is the Canadian vertical control datum established in 1928 and officially adopted in 1935. CGVD 28 is an adjustment of the Canadian leveling network that is constrained to three tide gauges on the East Coast (Pointe-au-Père, Halifax and Yarmouth) and two tide gauges on the West Coast (Vancouver and Prince Rupert).

(2) Since the original adjustment in 1928, all new leveling observations have been included by regional piecemeal adjustments. Because the CGVD 28 tide gauge constraints are not on the same equipotential surface and the observations are corrected for normal gravity (approximate values), CGVD 28 has a one-meter range distortion nationally with respect to an equipotential surface.

Note: Canada is moving towards a new height system by 2013. The new datum will be defined by an equipotential surface representing the average coastal mean sea level for North America. The new datum will be realized by a geoid model allowing compatibility with GNSS (e.g., GPS, GLONASS) positioning.

d. OEA Construction and Obstacle Evaluation Methodology.

(1) **Courses, fixes, boundaries** (lateral dimension). Construct straight-line courses as a WGS-84 ellipsoid geodesic path. If the course outbound from a fix differs from the course inbound to the fix (courses measured at the fix), then a turn is indicated. Construct parallel and trapezoidal boundary lines as a locus of points measured perpendicular to the geodesic path. (The resulting primary and/or secondary boundary lines do not display a “middle bulge” due to curvature of the ellipsoids surface since they are not geodesic paths.). **NAD 83 latitude/longitude positions are acceptable for obstacle, terrain, and airport data evaluation**. Determine obstacle lateral positions relative to course center-line/OEA boundaries using ellipsoidal calculations.

(2) **Elevations** (vertical dimension). Evaluate obstacles, terrain, and airport data using their elevation relative to their orthometric height above the geoid (for our purposes, MSL) referenced to the CGVD 28 vertical datum in Canada and NAVD 88 in the US. The elevations of OCSs are determined spherically relative to their origin MSL elevation (CGVD28 or NAVD 88).

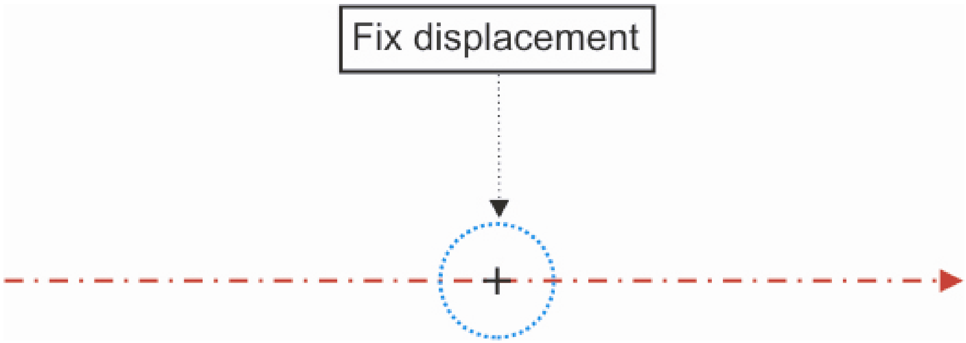
2.1.4 Terrain and Obstacle Data (TOD).

Volume 1, Chapter 2, paragraph 216. Controlling Obstacle(s) applies

Apply the vertical and horizontal accuracy standards in Annex J – Terrain and Obstacle Data (TOD)

2.1.5 ATT Values.

ATT is the value used (for segment construction purposes) to quantify position uncertainty of an RNAV fix. The application of **ATT** can; therefore, be considered "circular;" i.e., the **ATT** value assigned describes a radius around the plotted position of the RNAV fix (see figure 2-1 and table 2-1).



Note: Cross-track tolerance (XTT) values were considered in determining minimum segment widths, and are not considered further in segment construction.

Figure 2-1: ATT

2.2 Procedure Identification

Title RNAV procedures based on GNSS or WAAS: "RNAV (GNSS) RWY XX." Where more than one RNAV titled approach is developed to the same runway, identify each with an alphabetical suffix beginning at the end of the alphabet. Procedures with the lowest minimums should normally be titled with a "Z" suffix.

Examples

RNAV (GNSS) Z RWY 13	(Lowest **HATh**: example 200 ft)
RNAV (RNP) Y RWY 13	(2nd lowest **HATh**: example 278 ft)
RNAV (GNSS) X RWY 13	(3rd lowest **HATh**: example 360 ft)

Note: Operational requirements may occasionally require a different suffix grouping.

2.3 Segment Width (General)

Table 2-2 lists primary and secondary width values for all segments of an RNAV approach procedure. Where segments cross* a point 30 NM from airport reference point (**ARP**), segment primary area width increases (expansion) or decreases (taper) at a rate of 30 degrees relative to course to the appropriate width (see figure 2-3).

Secondary area expansion/taper is a straight-line connection from the point the primary area begins expansion/taper to the point the primary area expansion/taper ends (see figure 2-2). Reference to route width values is often specified as NM values measured from secondary area edge across the primary area to the secondary edge at the other side. For example, route width for segments more than 30 NM from **ARP** is "2-4-4-2." For distances ≤ 30 NM, the width is "1-2-2-1." See table 2-2 and figures 2-2 and 2-3.

Note: * **STARs** and Feeder segment width is 2-4-4-2 at all distances greater than 30 NM from **ARP**. A segment designed to cross within 30 NM of the **ARP** more than once does not taper in width until the 30 NM limit is crossed for approach and landing; i.e., crosses the limit for the last time before landing. A missed approach segment designed to cross a point 30 NM of the **ARP** more than once expands when it crosses the boundary the first time and remains expanded.

2.3.1 Width Changes at 30 NM from ARP (non-RF).

Receiver sensitivity changes at 30 NM from **ARP**. From the point the designed course crosses 30 NM from **ARP**, the primary **OEA** can taper inward at a rate of 30 degrees relative to course from ± 4 NM to ± 2 NM. The secondary area tapers from a 2 NM width when the 30 NM point is crossed to a 1 NM width abeam the point the primary area reaches the ± 2 NM width. The total along-track distance required to complete the taper is approximately 3.46 NM (21,048.28 ft).

Segment width tapers regardless of fix location within the tapering section unless a turn is associated with the fix. Delay **OEA** taper until the turn is complete and normal **OEA** turn construction is possible.

EXCEPTION: The taper may occur in an **RF** turn segment if the taper begins at least 3.46 NM (along-track distance) from the **RF** leg termination fix; i.e., if it is fully contained in the **RF** leg.

2.3.2 Width Changes at 30 NM from ARP (RF).

When the approach segment crosses the point 30 NM from airport reference point in an **RF** leg, construct the leg beginning at a width of 2-4-4-2 prior to the 30 NM point and taper to 1-2-2-1 width after the 30 NM point. Calculate the perpendicular distance ($B_{PRIMARY}$, $B_{SECONDARY}$) from the **RF** segment track centerline to primary and secondary boundaries at any along-track distance (specified as degrees of **RF** arc "α") from the point the track crosses the 30 NM point using formula 2-1 (see figure 2-3b).

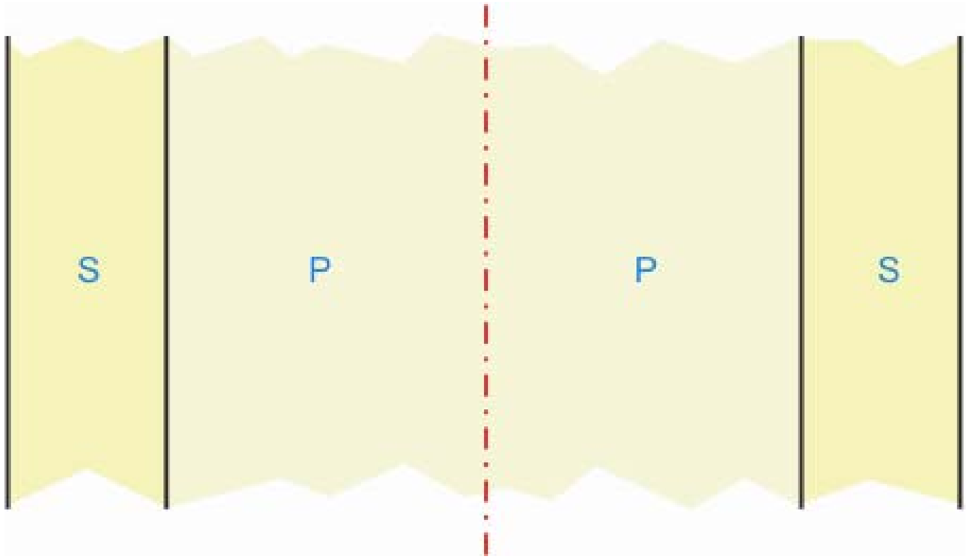


Figure 2-2: Segment Width Variables

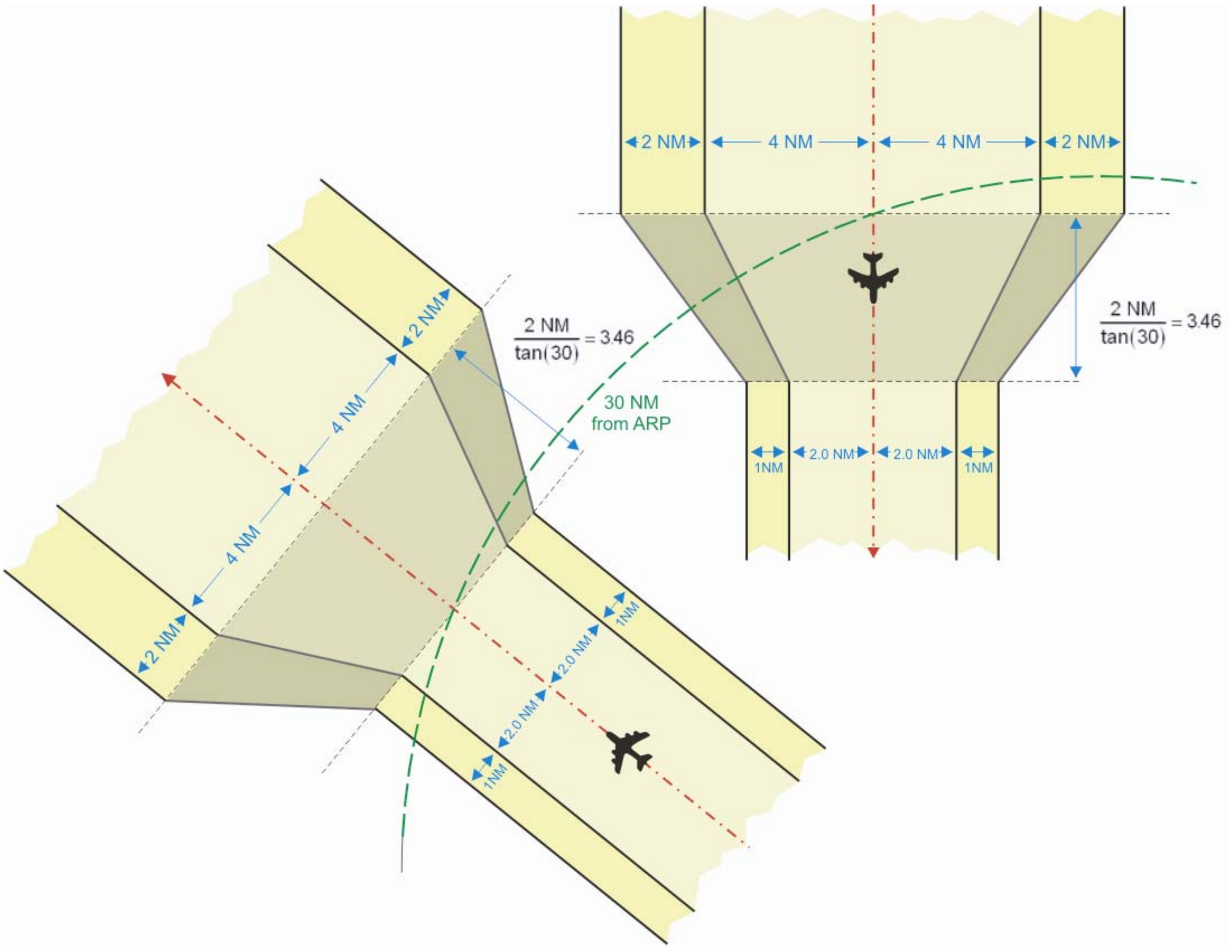


Figure 2-3a: Segment Width Changes at 30 NM

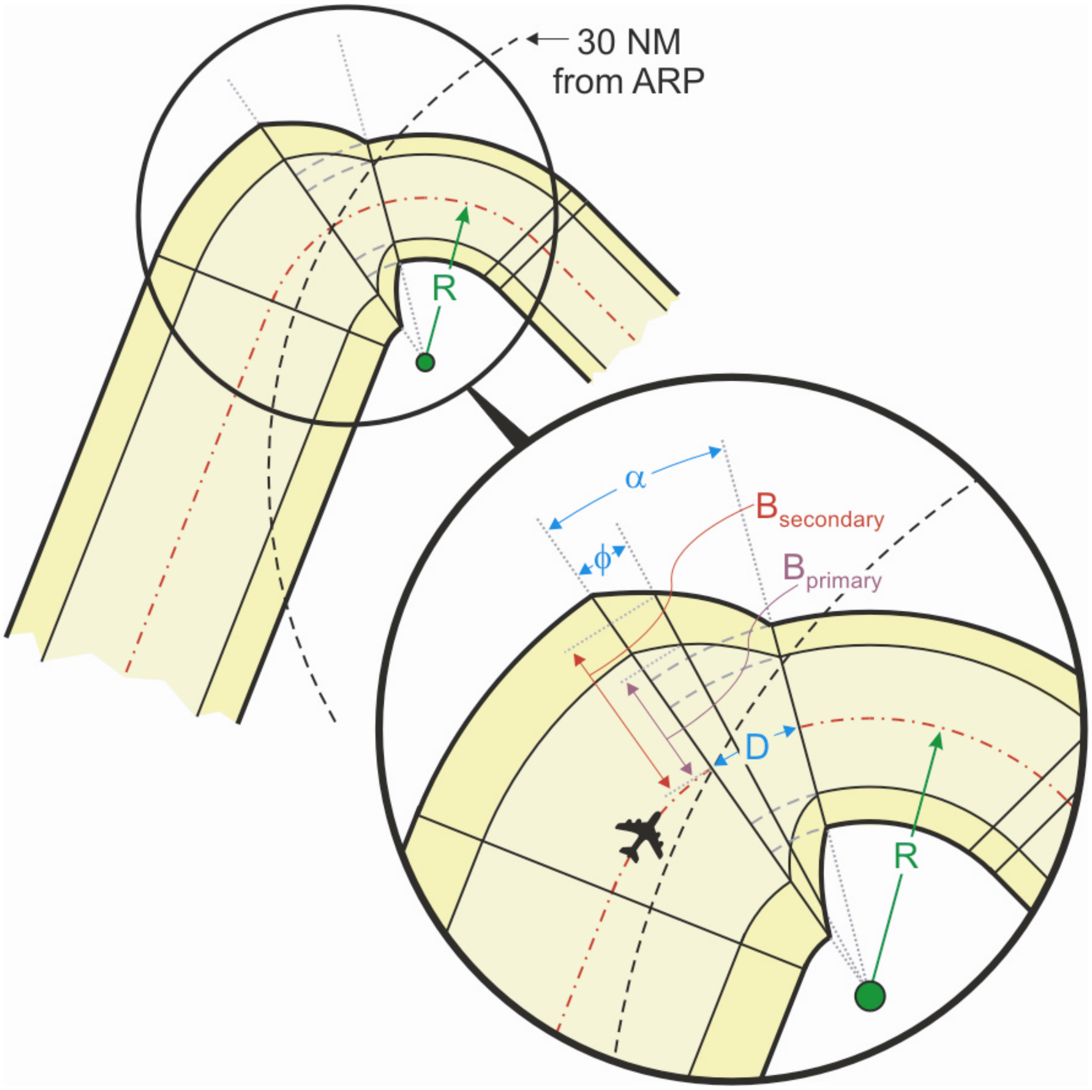


Figure 2-3b: Segment Width Changes in RF Leg (advanced avionics required)

2.4 Calculating the Turn Radius (R)

The design turn radius value is based on four variables:

- indicated airspeed, assumed tailwind, altitude, and bank angle.

Apply the indicated airspeed from table 2-3 for the highest speed aircraft category that will be published on the approach procedure. Apply the highest expected turn altitude value. The design bank angle is assumed to be 18 degrees.

Note: Determine the highest altitude within a turn by:

For approach – calculate the vertical path altitude (**VP_{ALT}**) by projecting a 3-degree vertical path from the **PFAF** along the designed nominal flight track to the turn fix (see formula 2-2).

For missed approach – project a vertical path along the nominal flight track from the **SOC** point and altitude to the turn fix, that rises at a rate of 250 ft/NM (Cat A/B), 500 ft/NM (Cat C/D) or a higher rate if a steeper climb gradient is specified.
For turn at altitude construction, determine the altitude to calculate **V_{KTAS}** based on the climb-to altitude plus an additive based on a continuous climb of 250 (Cat A/B) or 500 (Cat C/D) ft per 12 degrees of turn [ϕ*250/12 or ϕ*500/12] (not to exceed the missed approach altitude). Cat D example: 1,125 ft would be added for a turn of 27 degrees, 958 ft would be added for 23 degrees, 417 ft for 10 degrees of turn.

Compare the vertical path altitude at the fix to minimum published fix altitude. The altitude to use is the higher of the two. For missed approach, the turn altitude must not be higher than the published missed approach altitude.

STEP 1: Determine the true airspeed (**KTAS**) for the turn using formula 2-3a. Locate and use the appropriate knots indicated airspeed (**KIAS**) from table 2-3. Use the highest altitude within the turn.

STEP2: Calculate the appropriate tailwind component (**V_{KTW}**) using formula 2-3b for the highest altitude within the turn. EXCEPTION: If the MSL altitude is 2,000 ft or less above airport elevation, use 30 knots.

STEP 3: Calculate **R** using formula 2-3c.

Notes: 1. (formula 2-3c) For fly-by turns where the highest altitude in the turn is between 10,000 ft and flight level 195, where the sum of "**V_{KTAS}+V_{KTW}**" is greater than 500 knots, use 500 knots.

Notes: 2. (formula 2-3c) For fly-by turns, where the highest altitude in the turn is greater than flight level 195, use 750 knots as the value for "**V_{KTAS}+V_{KTW}**" and 5 degrees of bank rather than 18 degrees. If the resulting **DTA** is greater than 20 NM, then

$$R = \frac{20}{Tan\left(\frac{\phi}{2} \bullet \frac{\pi}{180}\right)}$$

where ϕ is the amount of turn (heading change). Use formula 2-8 to verify the required bank angle does not exceed 18 degrees.

2.5 Turn Construction

If the course outbound from a fix differs from the course inbound to the fix (courses measured at the fix), a turn is indicated.

2.5.1 Turns at Fly-Over Fixes (see figures 2-4 and 2-5).

a. Extension for Turn Delay.

Turn construction incorporates a delay in start of turn to account for pilot reaction time and roll-in time (**rr**). Calculate the extension distance in feet using formula 2-4.

STEP 1: Determine **R**. See formula 2-3c.

STEP 2: Determine **rr**. See formula 2-4.

STEP 3: Establish the baseline for construction of the turn expansion area as the line perpendicular to the inbound track at a distance past the turn fix equal to (**ATT + rr**).

STEP 4: On the baseline, locate the center points for the primary and secondary turn boundaries. The first is located at a distance R from the non-turning side primary boundary. The second is located at a distance R from the turning side secondary boundary (see figures 2-4 and 2-5).

STEP 5: From these center points construct arcs for the primary boundary of radius **R**. Complete the secondary boundary by constructing additional arcs of radius ($\mathbf{R+W_S}$) from the same center points. ($\mathbf{W_S}$=width of the secondary). This is shown in figures 2-4 and 2-5.

STEP 6: The arcs constructed in step 5 are tangent to the outer boundary lines of the inbound segment. Construct lines tangent to the arcs based on the first turn point tapering inward at an angle of 30 degrees relative to the outbound track that joins the arc primary and secondary boundaries with the outbound segment primary and secondary boundaries. If the arcs from the second turn point are inside the tapering lines as shown in figure 2-4, then they are disregarded and the expanded area construction is completed. If not, proceed to step 7.

STEP 7: If both the inner and outer arcs lie outside the tapering lines constructed in step 6, connect the respective inner and outer arcs with tangent lines and then construct the tapering lines from the arcs centered on the second center point as shown in figure 2-5.

STEP 8: The inside turn boundaries are the simple intersection of the preceding and succeeding segment primary and secondary boundaries.

The inbound **OEA** end (± **ATT**) is evaluated for both inbound and outbound segments.

b. Minimum length of TF leg following a fly-over turn.

The leg length of a **TF** leg following a fly-over turn must be sufficient to allow the aircraft to return to course centerline. Determine the minimum leg length (**L**) using formulas 2-5 and 2-6.

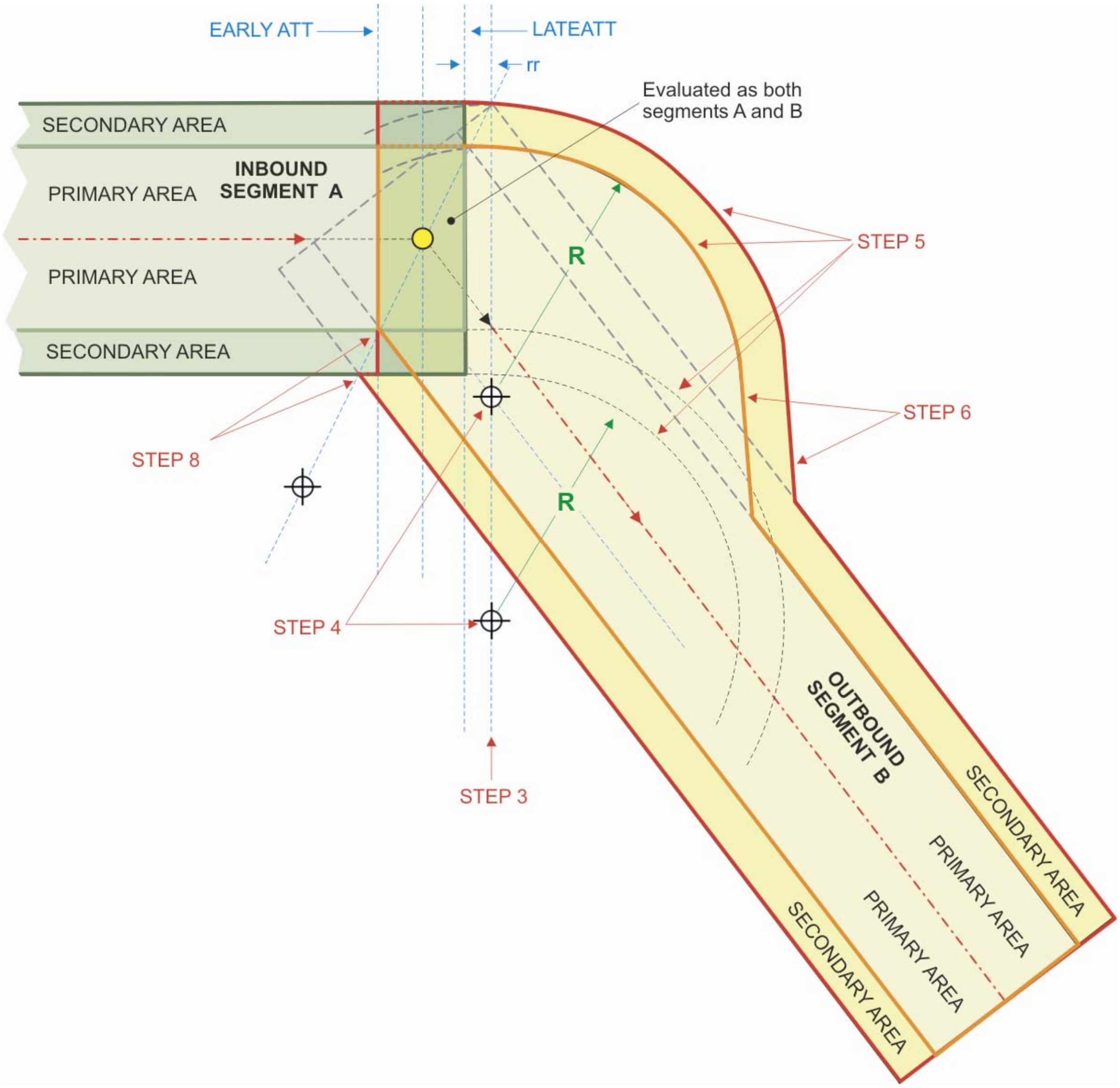


Figure 2-4: Fly-Over with No Second Arc Expansion

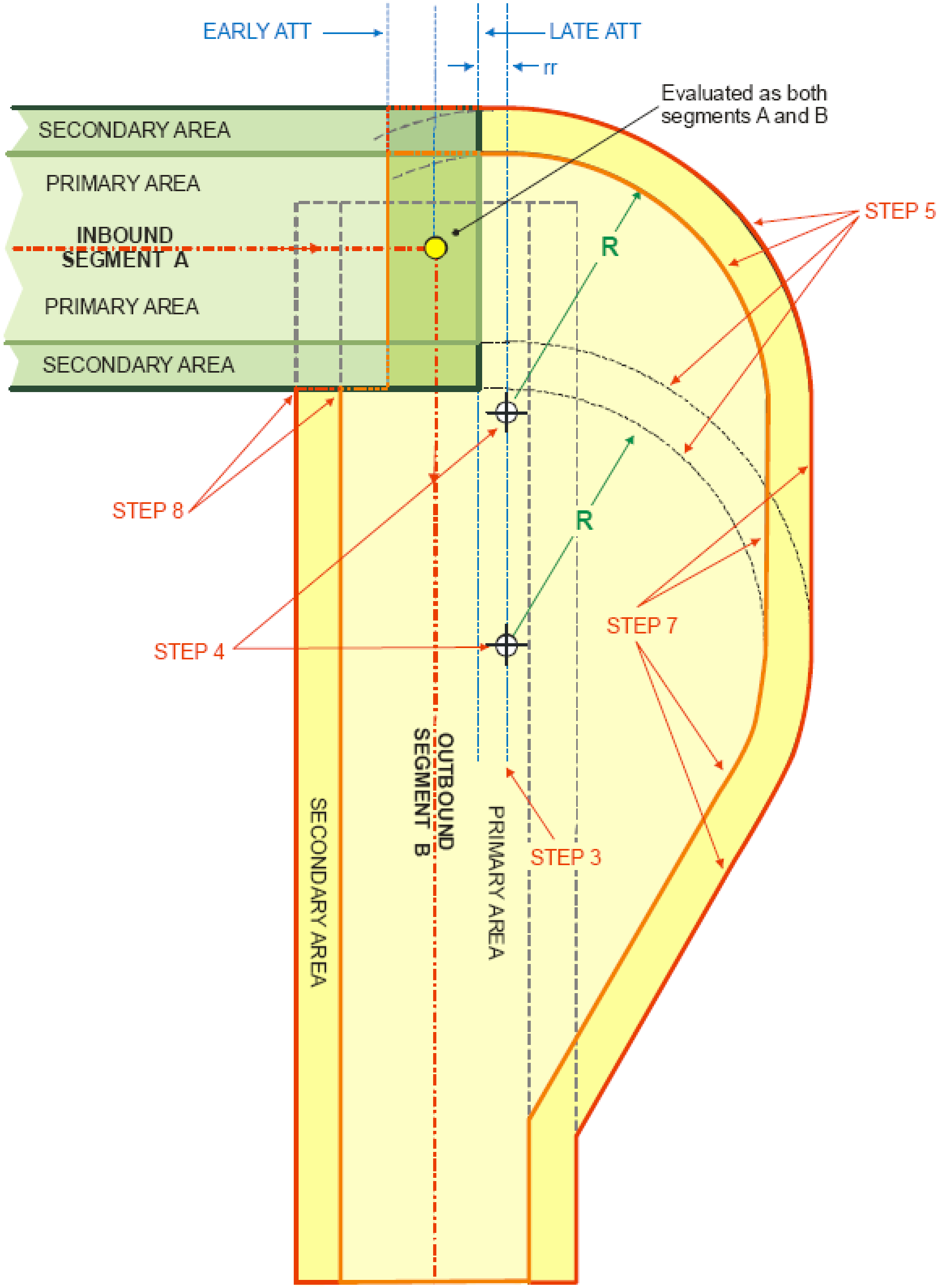


Figure 2-5: Fly-Over with Second Arc Expansion

2.5.2 Fly-By Turn. See figure 2-6.

STEP 1: Establish a line through the turn fix that bisects the turn angle. Determine Turn Radius (**R**). See formula 2-3c. Scribe an arc (with origin on bisector line) of radius **R** tangent to inbound and outbound courses. This is the designed turning flight path.

STEP 2: Scribe an arc (with origin on bisector line) that is tangent to the inner primary boundaries of the two segment legs with a radius equal to

$$\frac{Primary\_Area\_Half\_Width}{2}$$

(example: ½ width of 2 NM, the radius would be R+1.0 NM).

STEP 3: Scribe an arc that is tangent to the inner secondary boundaries of the two segment legs using the origin and radius from step 2 minus the secondary width.

STEP 4: Scribe the primary area outer turning boundary with an arc with a radius equal to the segment half width centered on the turn fix.

STEP 5: Scribe the secondary area outer turning boundary with the arc radius from step 4 plus the secondary area width centered on the turn fix.

a. Minimum length of track-to-fix (TF) leg following a fly-by turn.

Calculate the minimum length for a **TF** leg following a fly-by turn using formula 2-7.

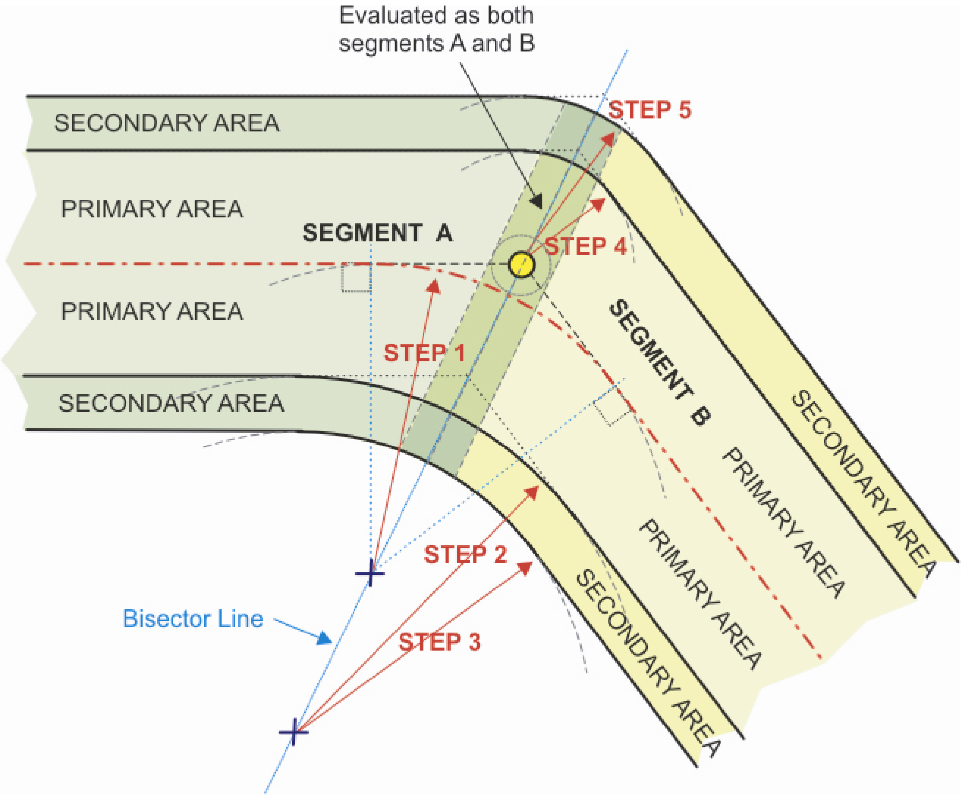


Figure 2-6: Fly-By Turn Construction

2.5.3 Radius-to-Fix (RF) Turn.

Incorporation of an **RF** segment may limit the number of aircraft served by the procedure.

RF legs are used to control the ground track of a turn where obstructions prevent the design of a fly-by or fly-over turn, or to accommodate other operational requirements*. The curved leg begins tangent to the previous segment course at its terminating fix and ends tangent to the next segment course at its beginning fix (see figure 2-7). **OEA** construction limits turn radius to a minimum value equal-to or greater-than the **OEA** (primary and secondary) half-width. The **RF** segment **OEA** boundaries are parallel arcs.

Note: * **RF** legs segments are not applicable to the final segment or section 1 of the missed approach segment. **RF** legs in the intermediate segment must terminate at least 2 NM prior to the PFAF. Where **RF** legs are used, annotate the procedure (or segment as appropriate) “**RF Required**.” Use Table 1-3 for $\mathbf{V_{KTW}}$ values for radius calculations for **RF** legs.

STEP 1: Determine the segment turn radius (**R**) that is required to fit the geometry of the terrain/airspace. Enter the required radius value into formula 2-8 to verify the resultant bank angle is ≤ 20 degrees (maximum allowable bank angle). Where a bank angle other than 18 degrees is used, annotate the value on the Instrument Procedure Design Submission Form.

STEP 2: Turn Center. Locate the turn center at a perpendicular distance **R** from the preceding and following segments.

STEP 3: Flight path. Construct an arc of radius **R** from the tangent point on the preceding course to the tangent point on the following course.

STEP 4: Primary area outer boundary. Construct an arc of radius **R+Primary** area half-width from the tangent point on the preceding segment primary area outer boundary to the tangent point on the following course primary area outer boundary.

STEP 5: Secondary area outer boundary. Construct an arc of radius **R+Primary** area half-width+secondary area width from the tangent point on the preceding segment secondary area outer boundary to the tangent point on the following course secondary area outer boundary.

STEP 6: Primary area inner boundary. Construct an arc of radius **R-(Primary area half-width)** from the tangent point on the preceding segment inner primary area boundary to the tangent point on the following course inner primary area boundary.

STEP 7: Secondary area inner boundary. Construct an arc of radius **R-(Primary area half-width+secondary area width)** from the tangent point on the preceding segment inner secondary area boundary to the tangent point on the following course inner secondary area boundary.

2.6 Descent Gradient

a. Feeder and Initial segment Descent Gradient (**DG**)

(1) Optimum............. 250 ft/NM (4.11%, 2.356°)

(2) Maximum............ 500 ft/NM (8.23%, 4.70°)

For high altitude penetrations

(3) Optimum............. 800 ft/NM (13.17%, 7.5°);

(4) Maximum............ 1,000 ft/NM (16.46%, 9.35°).

b. Intermediate Segment Descent Gradient (**DG**)

(1) Optimum............. 150 ft/NM (2.47%, 1.41°)

(2) Maximum............ 318 ft/NM (5.23%, 3.0°)

2.6.1 Calculating Descent Gradient (DG).

Determine total altitude lost between the plotted positions of the fixes. Determine the distance (**D**) in NM. Divide the total altitude lost by **D** to determine the segment descent gradient (see figure 2-8 and formula 2-10).

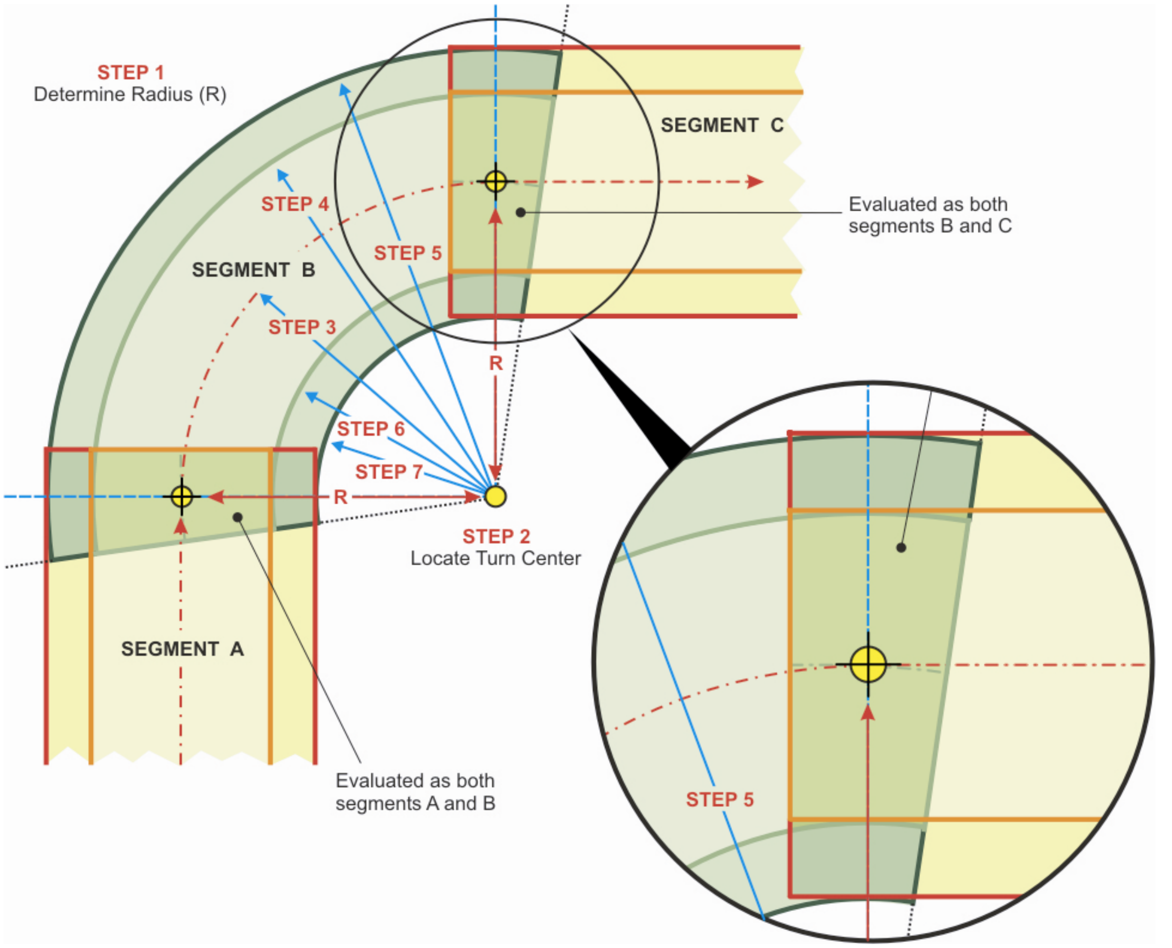


Figure 2-7: RF Turn Construction.

2.7 Feeder Segment

When the initial approach fix (**IAF**) is not part of the en route structure, it may be necessary to designate feeder routes from the en route structure to the **IAF**. The feeder segment may contain a sequence of **TF** segments (and/or **RF** segments). The maximum course change between **TF** segments is 70 degrees above FL190, and 90 degrees (70 degrees preferred) below FL190. Formula 2-3c Notes 1 and 2 apply. Paragraph 2.5 turn construction applies. The feeder segment terminates at the **IAF** (see figures 2-9a and 2-9b).

2.7.1 Length.

The minimum length of a sub-segment is determined under paragraph 2.5.1b or 2.5.2a as appropriate. The maximum length of a sub-segment is 500 miles. The total length of the feeder segment should be as short as operationally possible.

2.7.2 Width.

Primary area width is ± 4.0 NM from course centerline; secondary area width is 2.0 NM (2-4-4-2). These widths apply from the feeder segment initial fix to the approach **IAF**/termination fix. Where the initial fix is on an airway, chapter 2 construction applies.

Note: These criteria also support **STARs**. **STARs** beginning ≤ 30 NM from **ARP** width is ± 2.0 NM from course centerline; secondary area width is 1.0 NM (1-2-2-1).

2.7.3 Obstacle Clearance.

The minimum **ROC** over areas not designated as mountainous is 1,000 ft. The **ROC** values within designated Mountainous Areas are 1000, 1500, and 2000 feet as specified in Vol 1, Chap 17, Para 1720. The published minimum feeder route altitude must provide at least the minimum **ROC** value and must not be less than the altitude established at the **IAF**.

2.7.4 Descent Gradient. (feeder, initial, intermediate segments)

See paragraph 2.6 Descent Gradient

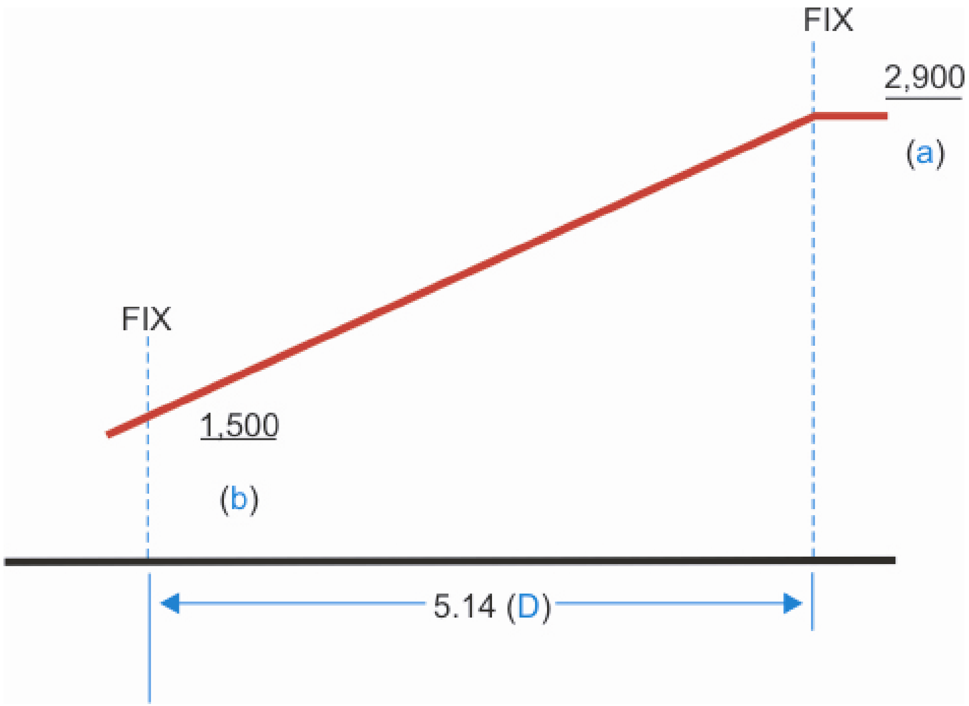


Figure 2-8: Fly-Over with No Second Arc Expansion

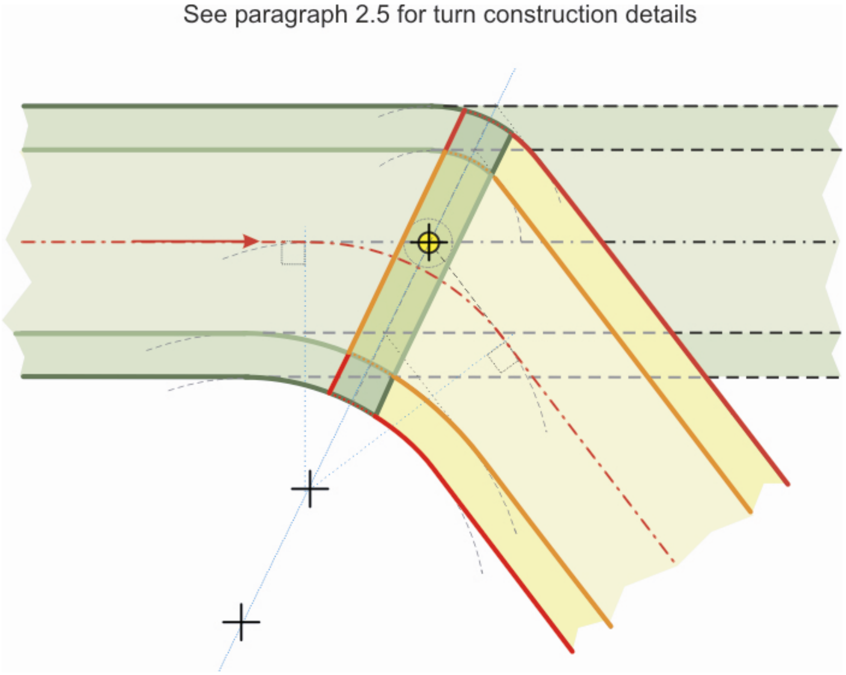


Figure 2-9a: Feeder route (fly-by protection)

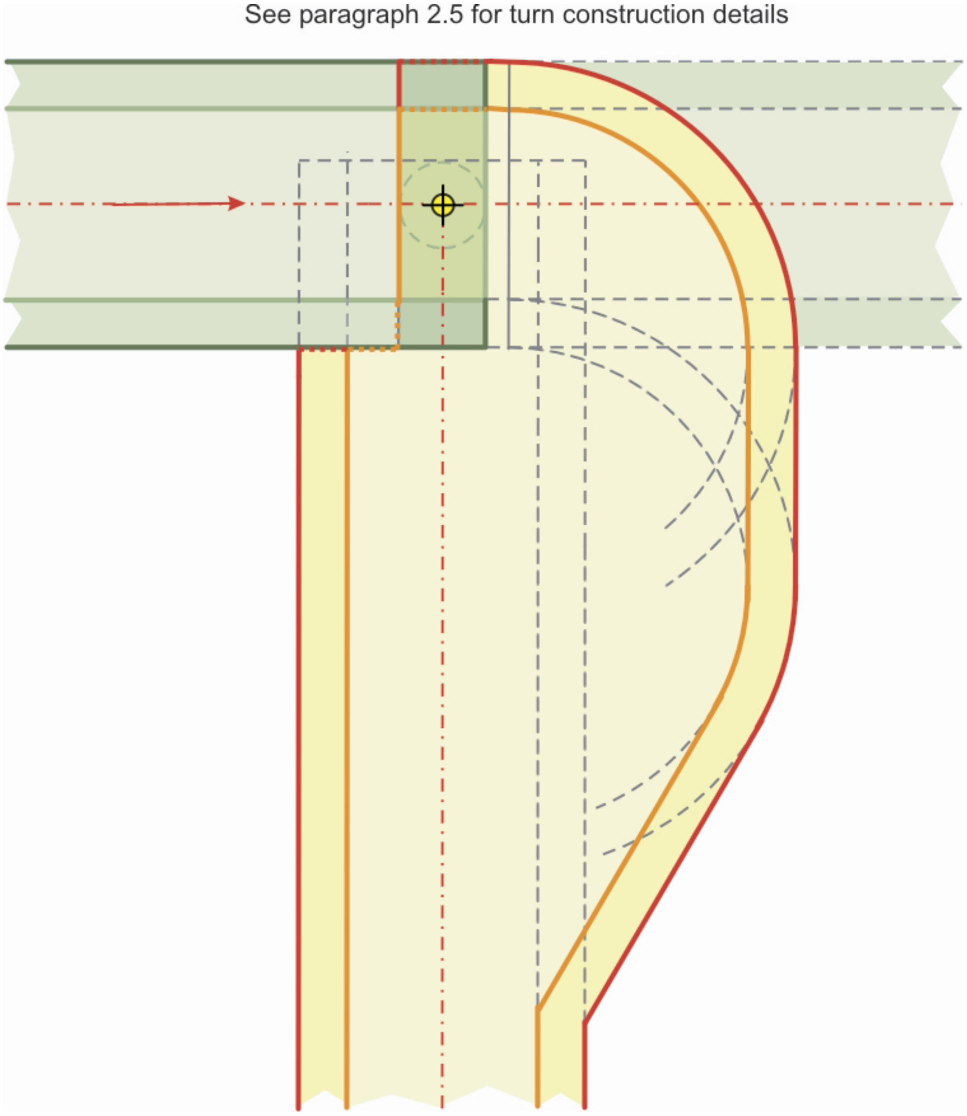


Figure 2-9b: Feeder Route (Fly-over Protection)

SECTION 2. TERMINAL SEGMENTS

2.8 Initial Segment

The initial segment begins at the **IAF** and ends at the intermediate fix (**IF**). The initial segment may contain sequences of straight sub segments (see figure 2-10). Paragraphs 2.8.2, 2.8.3, 2.8.4, and 2.8.5 apply to all sub segments individually. The total length of all sub segments must not exceed 50 NM. For descent gradient limits, see paragraph 2.7.4.

2.8.1 Course Reversal.

The optimum design incorporates the basic Y or T configuration. This design eliminates the need for a specific course reversal pattern. Where the optimum design cannot be used and a course reversal is required, establish a holding pattern at the initial or intermediate approach fix. See paragraph 2.8.6b. The maximum course change at the fix (**IAF/IF**) is to 90 degrees (70 degrees above FL 190).

2.8.2 Alignment.

Design initial/initial and initial/intermediate **TF** segment intersections with the smallest amount of course change that is necessary for the procedure. No course change is optimum. Where a course change is necessary, it should normally be limited to 70 degrees or less; 30 degrees or less is preferred.

The **maximum** allowable course change between **TF** segments is 90 degrees.

2.8.3 Area – Length.

The maximum segment length (total of sub segments) is 50 NM. Minimum length of sub segments is determined as described in paragraphs 2.5.1b and 2.5.2a.

2.8.4 Area – Width (see table 2-2).

2.8.5 Obstacle Clearance.

Apply 1,000 ft of **ROC** over the highest obstacle in the primary **OEA**. The **ROC** in the secondary area is 500 ft at the primary boundary tapering uniformly to zero at the outer edge (see figure 2-11).

Calculate the secondary **ROC** values using formula 2-11a.

2.8.6 Holding Pattern Initial Segment.

A holding pattern may be incorporated into the initial segment procedure design where an operational benefit can be derived; e.g., arrival holding at an **IAF**, course reversal pattern at the IF, etc. See Volume 1, Chapter 18 for RNAV holding pattern construction guidance.

a. Arrival Holding. Ideally, the holding pattern inbound course should be aligned with the subsequent **TF** leg segment (tangent to course at the initial fix of the subsequent **RF** segment). See figure 2-12a. If the pattern is offset from the subsequent **TF** segment course, the subsequent segment length must accommodate the resulting **DTA** requirement. Maximum offset is 90 degrees (70 degrees above FL190). Establish the minimum holding altitude at or above the **IAF/IF** (as appropriate) minimum altitude. **MEA** minimum altitude may be lower than the minimum holding altitude.

b. Course Reversal. Ideally, establish the minimum holding altitude as the minimum **IF** fix altitude (see figure 2-12b). In any case, the published holding altitude must result in a suitable descent gradient in the intermediate segment:

- **optimum** is 150 ft/NM (2.47%, 1.41°);
- **maximum** is 318 ft/NM (5.23%, 3.0°).

If the pattern is offset from the subsequent **TF** segment course, the subsequent segment length must accommodate the resulting **DTA** requirement. **Maximum** offset is 90 degrees.

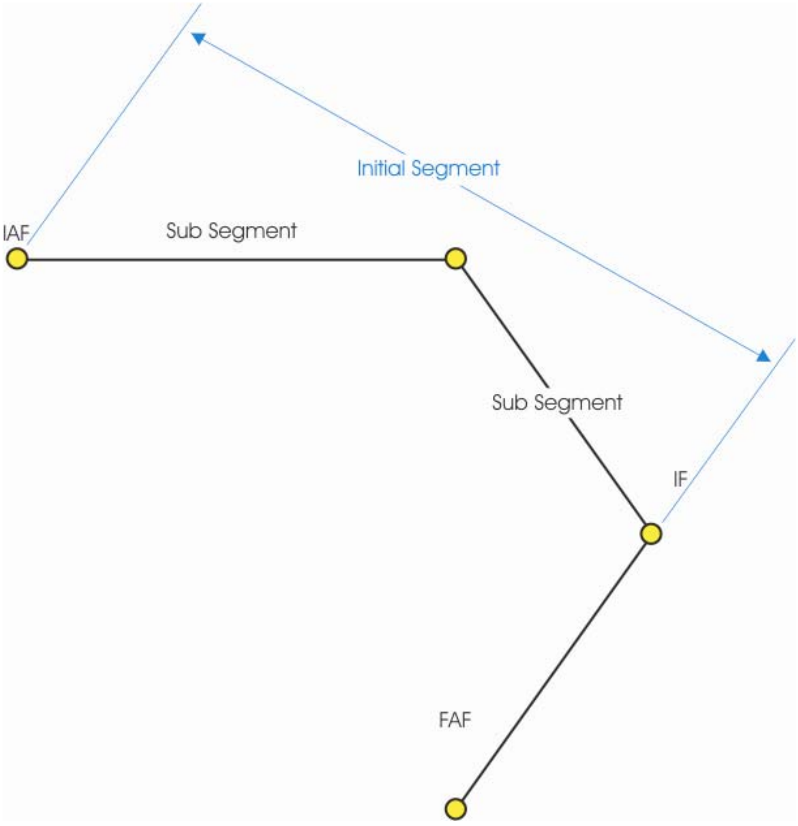


Figure 2-10: Initial Sub Segments.

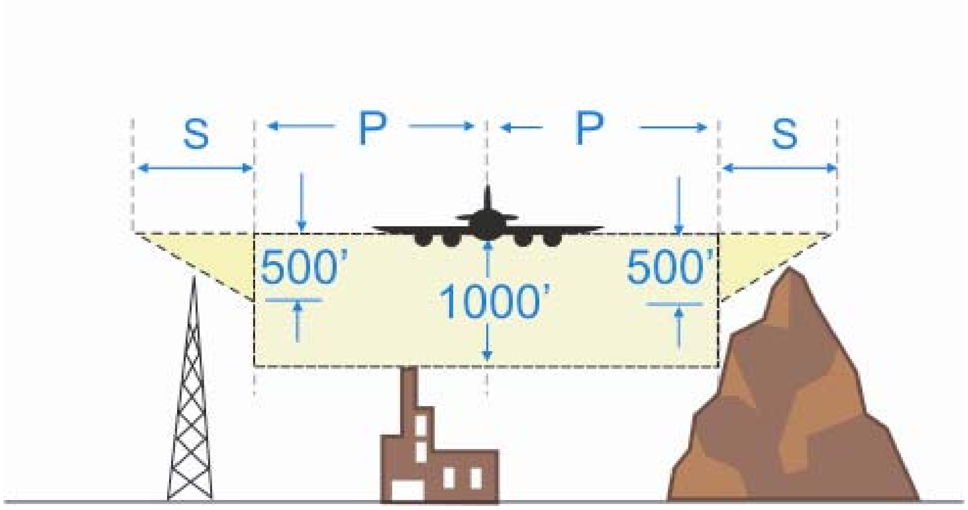


Figure 2-11: Initial Segment ROC.

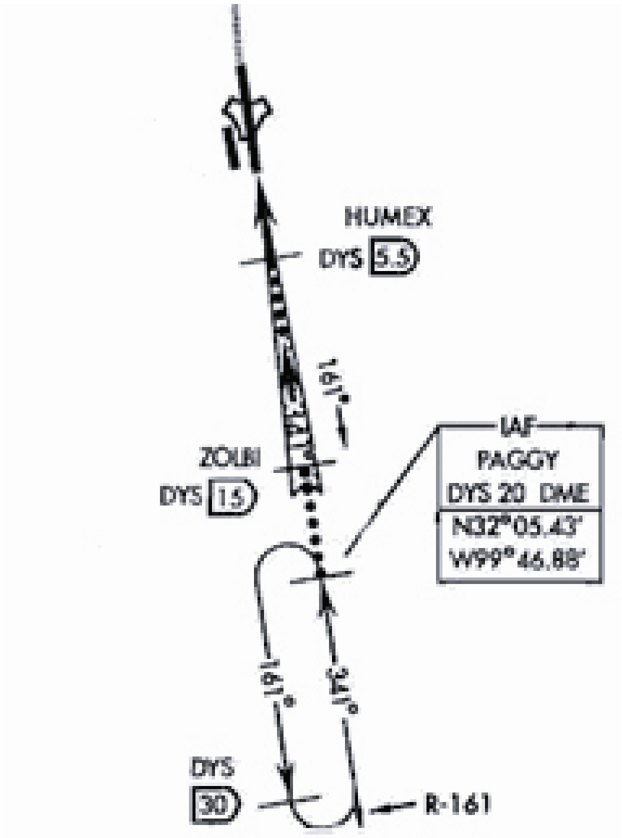


Figure 2-12a: Arrival Holding Example.

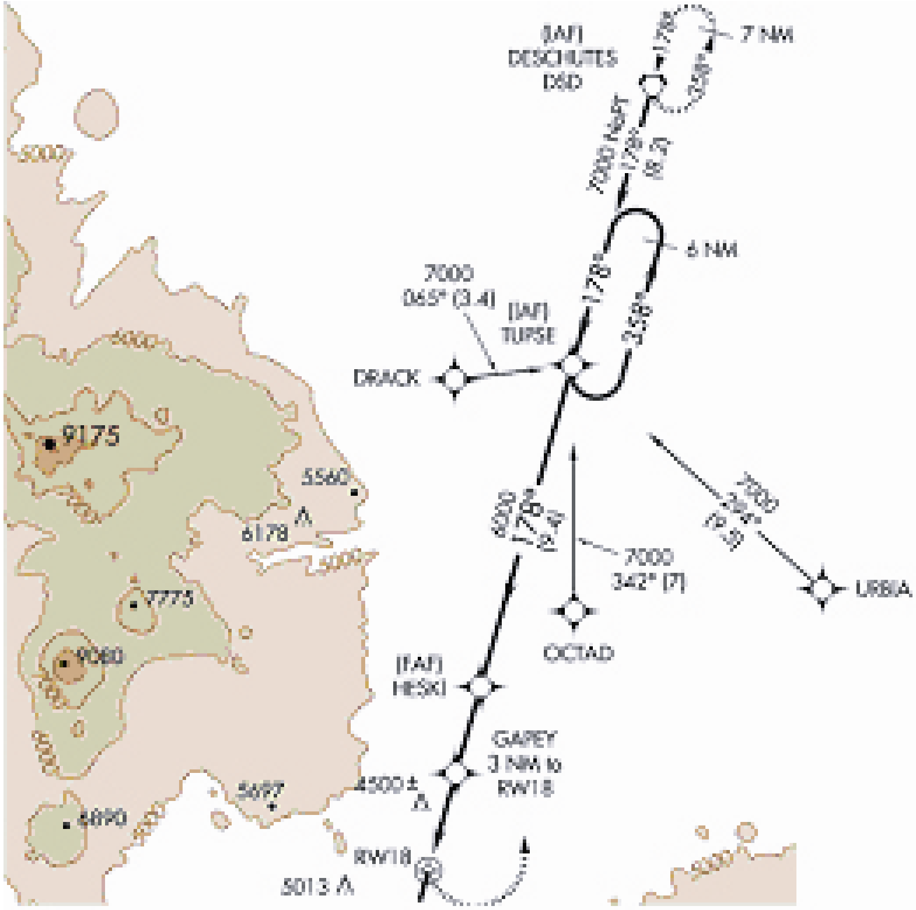


Figure 2-12b: Course Reversal Example.

2.9 Intermediate Segment

The intermediate segment primary and secondary boundary lines connect abeam the plotted position of the PFAF at the appropriate primary and secondary final segment beginning widths.

2.9.1 Alignment (Maximum Course Change at the PFAF).

- **LPV & LNAV/VNAV**. Align the intermediate course within 15 degrees of the final approach course (15 degrees maximum course change).
- **LNAV & LP**. Align the intermediate course within 30 degrees of the final approach course (30 degrees maximum course change).

Note: For RNAV transition to **ILS** final, no course change is allowed at the **PFAF**.

2.9.2 Length (Fix to Fix).

The minimum category (CAT) A/B segment length is 3 NM; the optimum is 3 NM. The minimum CAT C/D segment length is 4 NM; the optimum is 5 NM, where turns over 45 degrees are required, the minimum is 6 NM. The minimum CAT E segment length is 6 NM. Where turns to and from the intermediate segment are necessary, determine minimum segment length using formula 2-6 or 2-7 as appropriate.

2.9.3 Width.

The intermediate segment primary area tapers uniformly from ± 2 NM at a point 2 NM prior to the **PFAF** to the outer boundary of the **X OCS** abeam the **PFAF** (1 NM past the **PFAF** for **LNAV** and **LNAV/VNAV**). The secondary boundary tapers uniformly from 1 NM at a point 2 NM prior to the **PFAF** to the outer boundary of the Y **OCS** abeam the **PFAF** (1 NM past the PFAF for **LNAV** and **LNAV/VNAV**). See figures 2-13a and 2-13b.

If a turn is designed at the **IF**, it is possible for the inside turn construction to generate boundaries outside the normal segment width at the taper beginning point 2 miles prior to the **PFAF**. Where these cases occur, the inside (turn side) boundaries are a simple straight line connection from the point 1 NM past the **PFAF** on the final segment, to the tangent point on the turning boundary arc as illustrated in figures 2-13c and 2-13d.

a. **LNAV/VNAV, LNAV Offset Construction.** Where **LNAV** intermediate course is not an extension of the final course, use the following construction (see figure 2-13e).

STEP 1: Construct line **A** perpendicular to the intermediate course 2 NM prior the **PFAF**.

STEP 2: Construct line **B** perpendicular to the intermediate course extended 1 NM past the **PFAF**.

STEP 3: Construct the inside turn boundaries by connecting the points of intersection of line **A** with the turn side intermediate segment boundaries with the intersection of line **B** with the turn side final segment boundaries.

STEP 4: Construct arcs centered on the **PFAF** of 1 NM and 1.3 NM radius on the non-turn side of the fix.

<u>STEP 5:</u> Connect lines from the point of intersection of line **A** and the outside primary and secondary intermediate segment boundaries to tangent points on the arcs constructed in step 4.

<u>STEP 6:</u> Connect lines tangent to the arcs created in step 4 that taper inward at 30 degrees relative to the **FAC** to intersect the primary and secondary final segment boundaries as appropriate.

The final segment evaluation extends to a point **ATT** prior to the angle bisector. The intermediate segment evaluation extends **ATT** past the angle bisector. Therefore, the area within **ATT** of the angle bisector is evaluated for both the final and intermediate segments.

b. LPV, LP Offset Construction. Where **LP** intermediate course is not an extension of the final course, use the following construction (see figure 2-13f).

<u>STEP 1:</u> Construct line **A** perpendicular to the intermediate course 2 NM prior the **PFAF**.

<u>STEP 2:</u> Construct line **B** perpendicular to the intermediate course extended 1 NM past the **PFAF**.

<u>STEP 3:</u> Construct the inside turn boundaries by connecting the points of intersection of line **A** with the turn side intermediate segment boundaries with the intersection of line **B** with the turn side final segment boundaries.

<u>STEP 4:</u> Connect lines from the point of intersection of line **A** and the outside primary and secondary intermediate segment boundaries to the final segment primary and secondary final segment lines at a point perpendicular to the final course at the **PFAF**.

The final segment evaluation extends to a point **ATT** prior to the angle bisector. The intermediate segment evaluation extends **ATT** past the angle bisector. Therefore, the area within **ATT** of the angle bisector is evaluated for both the final and intermediate segments.

c. RF intermediate segments. Locate the intermediate leg's **RF** segment's terminating fix at least 2 NM outside the **PFAF**.

2.9.4 Obstacle Clearance.

Apply 500 ft of **ROC** over the highest obstacle in the primary **OEA**. The **ROC** in the secondary area is 500 ft at the primary boundary tapering uniformly to zero at the outer edge (see figure 2-14). Calculate the secondary **ROC** values using formula 2-11b.

2.9.5 Minimum IF to LTP Distance.

(Applicable for **LPV** and **LP** procedures with no turn at **PFAF**)

Locate the ***IF*** <u>at least</u> $\mathbf{D_{IF}}$ (NM) from the **LTP** (see formula 2-12).

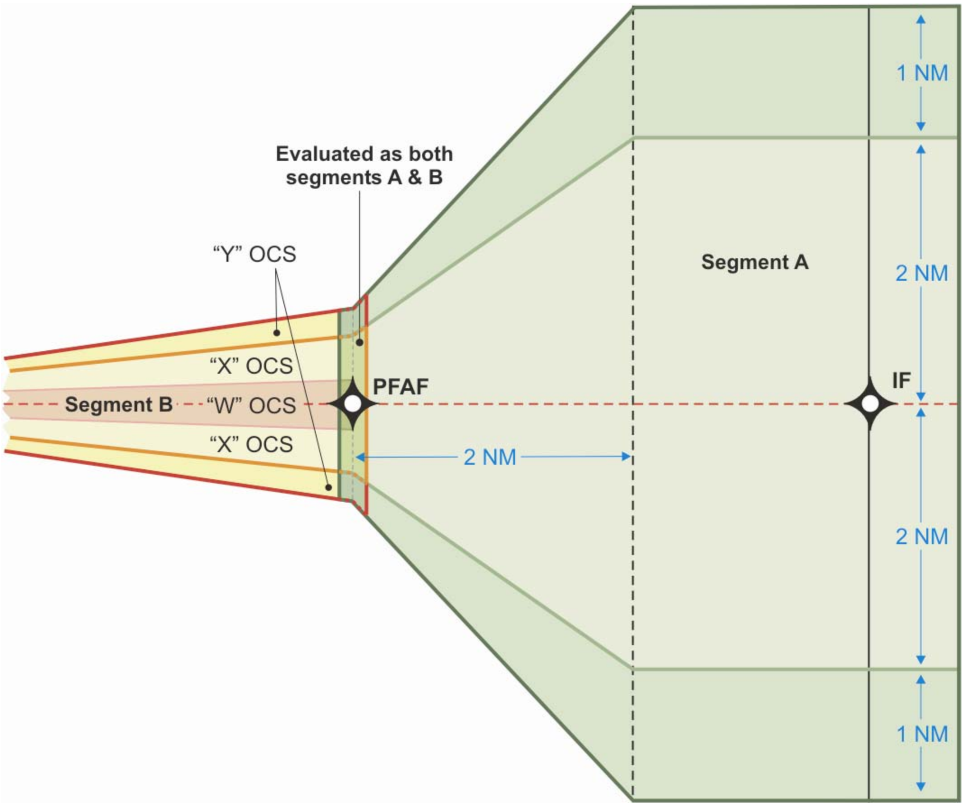


Figure 2-13a: RNAV Intermediate Segment (LPV, ILS, LP).

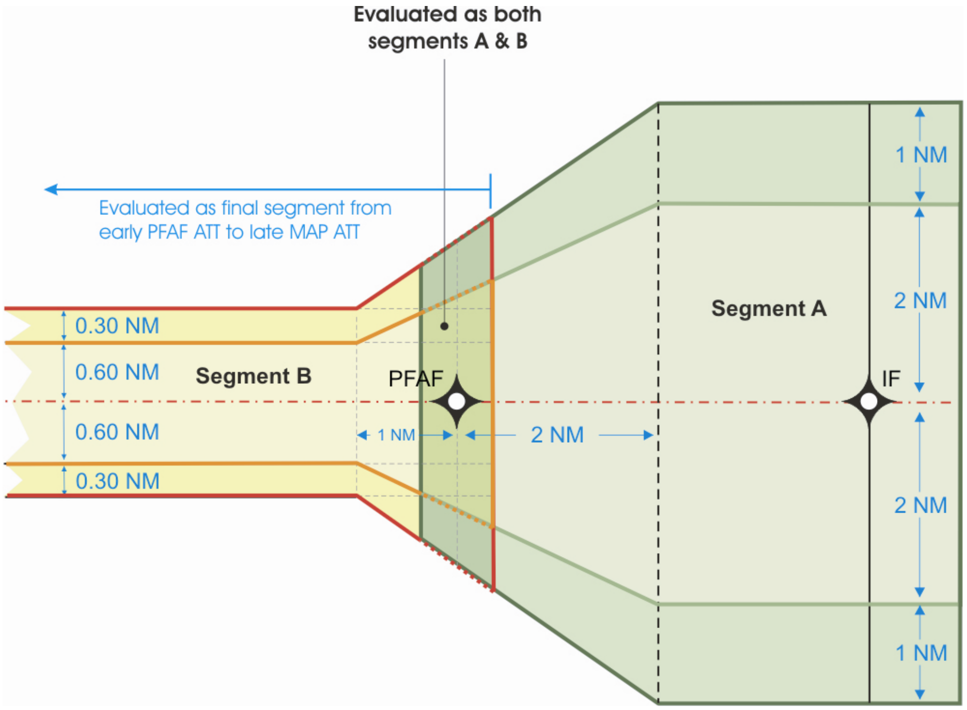
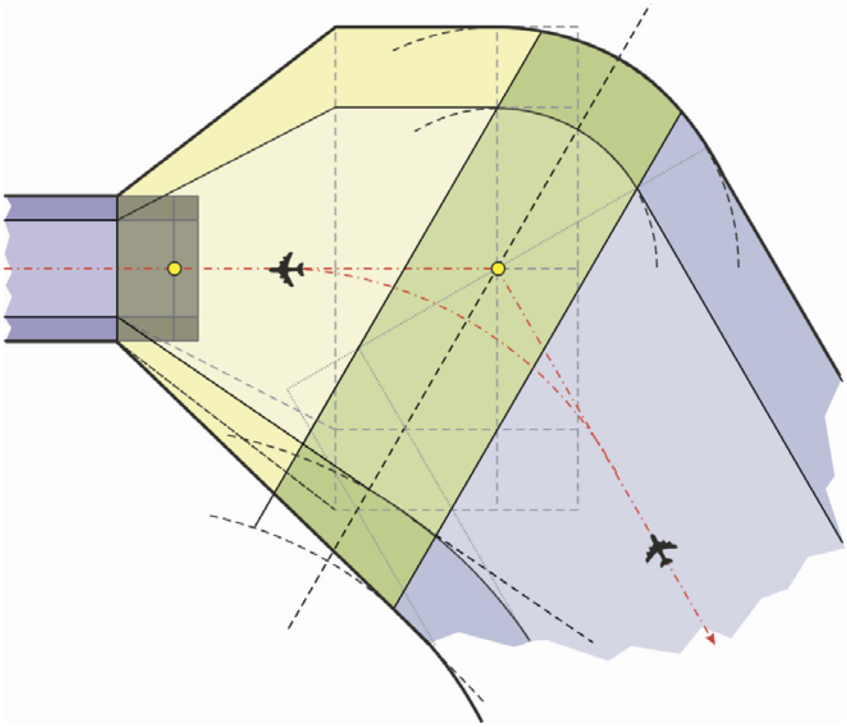
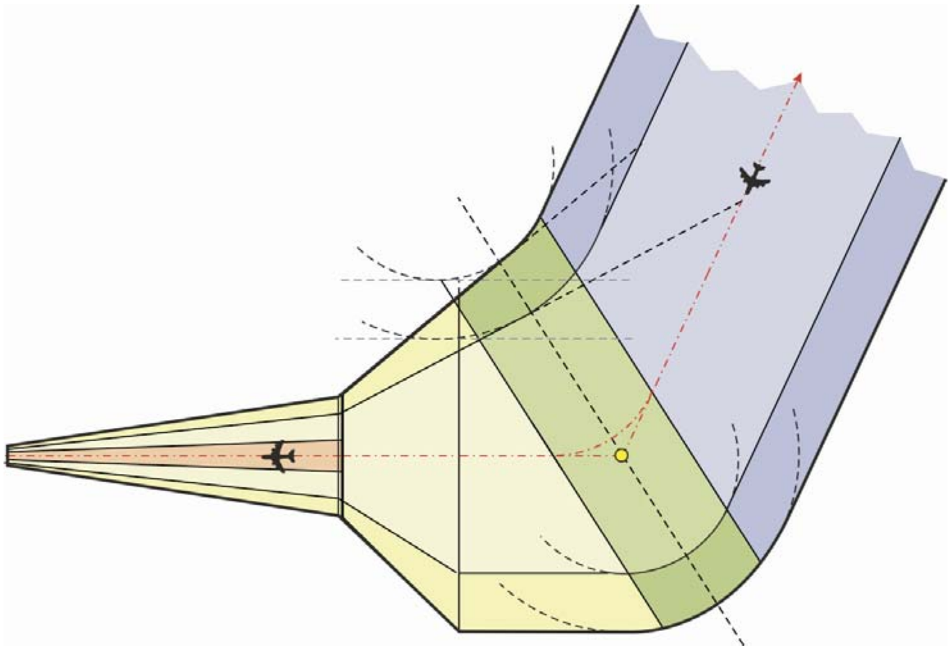


Figure 2-13b: RNAV Intermediate Segment (LNAV and LNAV/VNAV).



See paragraph 2.5.2, Fly-By Turn

Figure 2-13c: LNAV, LNAV/VNAV Example.



See paragraph 2.5.2, Fly-By Turn

Figure 2-13d: LP, LPV Example.

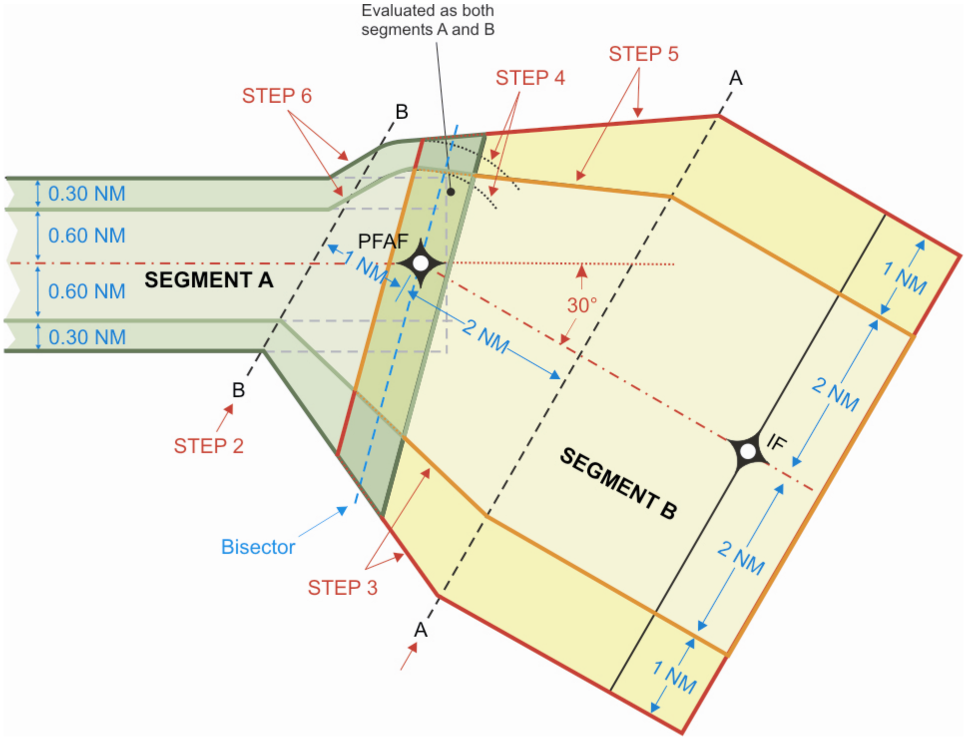


Figure 2-13e: Offset LNAV Construction.

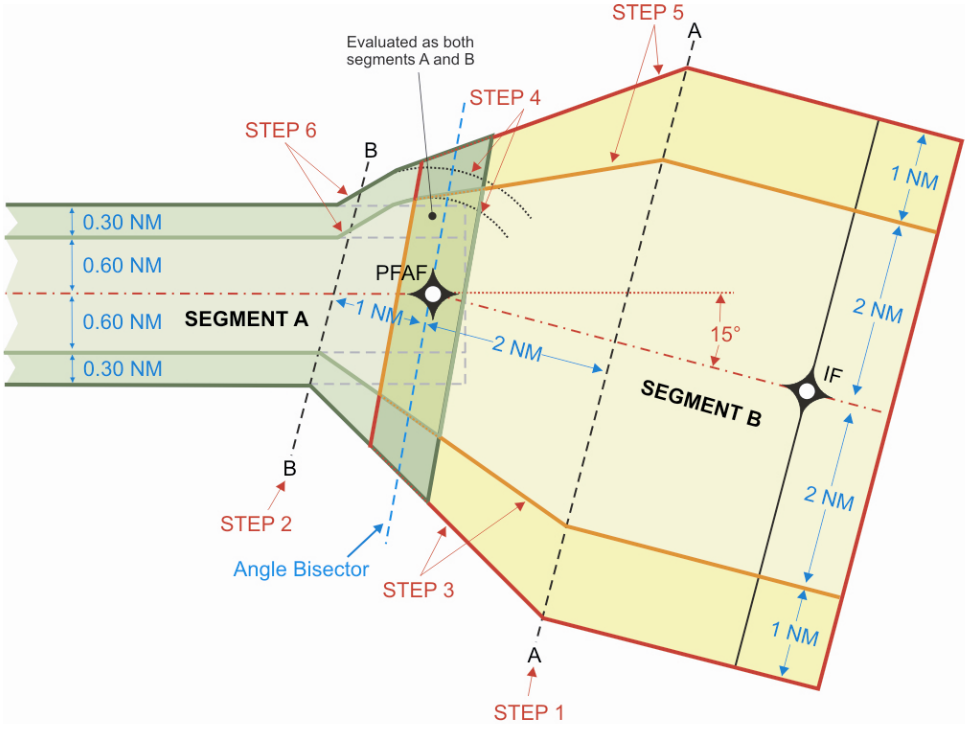


Figure 2-13e: Offset LNAV/VNAV Construction.

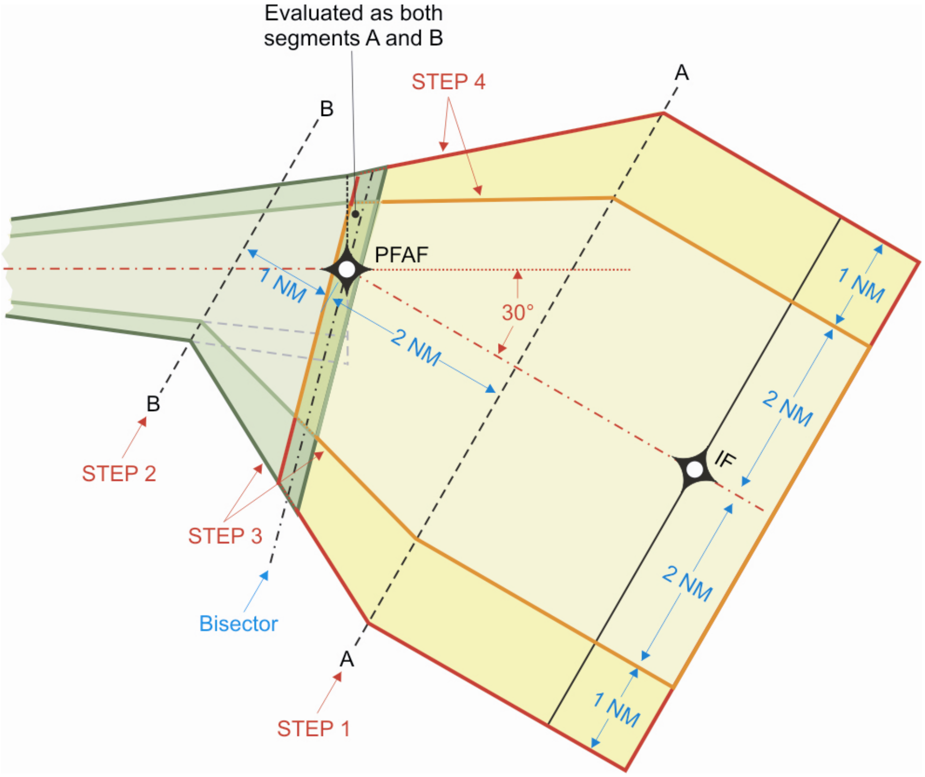


Figure 2-13f: Offset LP Construction.

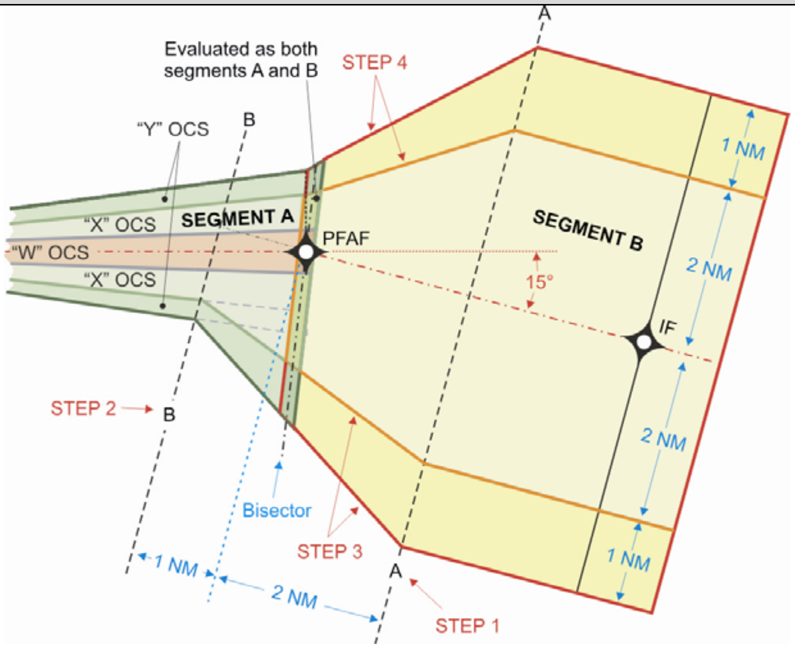


Figure 2-13f. Offset LPV Construction.

SECTION 3. BASIC VERTICALLY GUIDED FINAL SEGMENT GENERAL CRITERIA

2.10 Authorized Glidepath Angle (GPA)

The **optimum** (design standard) glidepath angle is 3 degrees.

GPAs greater than 3 degrees that conform to table 2-4 are authorized with TC or DND approval (as appropriate) only when obstacles prevent use of 3 degrees. TC or DND approval is required for angles less than 3 degrees or for angles greater than the minimum angle required for obstacle clearance.

2.11 Threshold Crossing Height (TCH)

Select the appropriate **TCH** from table 2-5. Publish a note indicating **VGSI** not coincident with the procedures designed descent angle (**VDA** or **GPA**, as appropriate) when the **VGSI** angle differs by more than 0.2 degrees or when the **VGSI TCH** is more than 3 ft from the designed **TCH**.

Note: If an **ILS** is published to the same runway as the RNAV procedure, it's **TCH** and glidepath angle values should be used in the RNAV procedure design. The **VGSI TCH**/angle should be used (if within table 2-5 tolerances) where a vertically guided procedure does not serve the runway.

2.12 Determining FPAP Coordinates (LPV and LP only)

The positional relationship between the **LTP** and the **FPAP** determines the final approach ground track. Geodetically calculate the latitude and longitude of the **FPAP** using the **LTP** as a starting point, the desired final approach course (optimum course is the runway bearing) as a forward true azimuth value, and an appropriate distance (see formulas 2-13, 2-14, and 2-15). Apply table 2-6 to determine the appropriate distance from **LTP** to **FPAP**, signal splay, and course width at **LTP**.

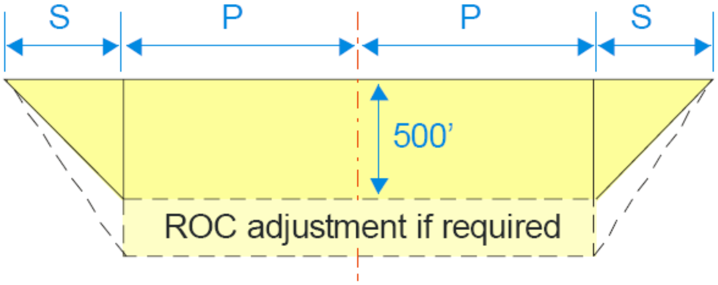


Figure 2-14: Intermediate Segment ROC.

2.13 Determining Precise Final Approach Fix/Final Approach Fix (PFAF/FAF) Coordinates

See Figure 2-15. Geodetically calculate the latitude and longitude of the **PFAF** using the true bearing from the landing threshold point (**LTP**) to the **PFAF** and the horizontal distance (**D_{PFAF}**) from the **LTP** to the point the glidepath intercepts the intermediate segment altitude. The **ILS/LPV** glidepath is assumed to be a straight line in space. The **LNAV/VNAV** (**BaroVNAV**) glidepath is a curved line (logarithmic spiral) in space. The calculation of **PFAF** distance from the **LTP** for a straight line is different than the calculation for a curved line. Therefore, two formulas are provided for determining this distance. Formula 2-16a calculates the glide slope intercept point (**GPIP**, **ILS** nomenclature; **PFAF**, **LPV** nomenclature) distance from **LTP**; i.e., the point that the straight line glide slope intersects the minimum intermediate segment altitude.) Formula 2-16b calculates the **LNAV/VNAV PFAF** distance from **LTP**; i.e., the point that the curved line **BaroVNAV** based glidepath intersects the minimum intermediate segment altitude. If **LNAV/VNAV** minimums are published on the chart, use formula 2-16b. If no **LNAV/VNAV** line of minima is published on the approach chart, use formula 2-16a, (**D_{GPIP} = D_{PFAF}**).

Note: Where an RNAV **LNAV/VNAV** procedure is published to an **ILS** runway, and the **ILS PFAF** must be used, publish the actual **LNAV/VNAV** glidepath angle (**θ_{BVNAV}**) calculated using formula 2-16c.

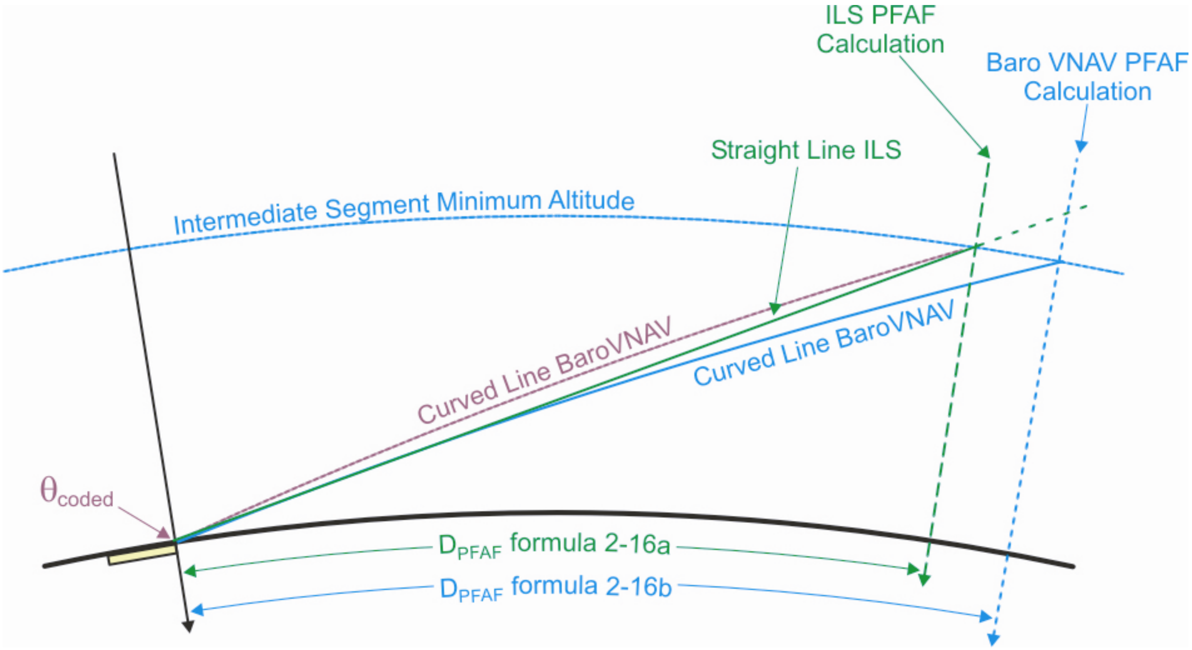


Figure 2-15: Determining PFAF Distance to LTP

2.14 Determining Glidepath Altitude At A Fix

Calculate the altitude ($\mathbf{Z_{glidepath}}$) of the glidepath at any distance ($\mathbf{D_Z}$) from the **LTP** using formula 2-17a for **ILS** and **LPV**, and formula 2-17b for **LNAV/VNAV**.

2.15 Common Fixes

Design all procedures published on the same chart to use the same sequence of charted fixes.

2.16 Clear Areas And Obstacle Free Zones (OFZ)

Transport Canada, Aerodrome Standards is responsible for maintaining obstruction requirements in TP312. For the purpose of this criteria, there are two **OFZs** that apply: the runway **OFZ** and the inner approach **OFZ**. The runway **OFZ** parallels the length of the runway and extends 200 ft beyond the runway threshold. The inner **OFZ** overlies the approach light system from a point 200 ft from the threshold to a point 200 ft beyond the last approach light. If approach lights are not installed or not planned, the inner **OFZ** does not apply. When obstacles penetrate either the runway or inner **OFZ**, visibility credit for lights is not authorized, and the lowest ceiling and visibility values are:

- For GPA ≤ 4.2°: 300-¾ (RVR 4000)
- For GPA > 4.2°: 400-1 (RVR 5000)

2.17 Glidepath Qualification Surface (GQS).

The **GQS** extends from the runway threshold along the runway centerline extended to the **DA** point. It limits the height of obstructions between **DA** and runway threshold (**RWT**). When obstructions exceed the height of the **GQS**, an approach procedure with positive vertical guidance (**ILS**, **LPV**, **Baro-VNAV**, etc.) is not authorized.*

Note: *Where obstructions penetrate the **GQS**, vertically guided approach operations may be possible with aircraft groups restricted by wheel height. Contact Transport Canada or DND (as appropriate) for approval.

2.17.1 Area.

a. Origin and Length. The **GQS** extends from the origin to the **DA**. The **OCS** origin is dependent on the **TCH** value (see figures 2-16a, b, and c).

- If the **TCH** > 50, the **GQS** originates at z feet above **LTP** elevation (see formula 2-18a).
- If the **TCH** ≥ 40 and ≤ 50, the **GQS** originates at **RWT** at **LTP** elevation.
- If the **TCH** < 40, the **GQS** originates x feet from (toward **PFAF**) **RWT** at **LTP** elevation. See formula 2-18b.

Where $\mathbf{X_{offset}}$ > 200 ft, the area between the end of the **POFZ** (see paragraph 2.18) and the **GQS** origin is ± $\frac{RWYWidth}{2}+100$ feet wide, centered on the runway centerline extended.

Obstacles higher than the clearway plane (see paragraph 2.17.1e) that are not fixed by function for instrument landing operations are not allowed in this area.

b. **Width**. The **GQS** originates 100 ft from the runway edge at RWT.

Calculate the **GQS** half-width **E** at the **DA** point measured along the runway centerline extended using formula 2-18c

Calculate the half-width of the **GQS** at any distance **d** from **RWT** using the formula 2-19:

c. **If the course is offset** from the runway centerline, expand the **GQS** area on the side of the offset as follows referring to figures 2-17 and 2-18:

STEP 1: Construct line **BC**. Locate point **B** on the runway centerline extended perpendicular to course at the **DA** point. Calculate the half-width (**E**) of the **GQS** for the distance from point **B** to the **RWT**. Locate point **C** perpendicular to the course distance **E** from the course line. Connect points **B** and **C**.

STEP 2: Construct line **CD**. Locate point **D** 100 ft from the edge of the runway perpendicular to the **LTP**. Draw a line connecting point **C** to point **D**.

STEP 3: Construct line **DF**. Locate point **F** 100 ft from the edge of the runway perpendicular to the **LTP**. Draw a line connecting point **D** to point **F**.

STEP 4: Construct line **AF**. Locate point **A** distance **E** from point **B** perpendicular to the runway centerline extended. Connect point **A** to point **F**.

STEP 5: Construct line **AB**. Connect point **A** to point **B**.

Calculate the half-width of the offset side of the **GQS** trapezoid using formula 2-20.

d. **OCS.** The **GQS** vertical characteristics reflect the glidepath characteristics of the procedure; i.e., the **ILS/LPV** based glidepath is a straight line in space, and the Baro-VNAV based glidepath (**LNAV/VNAV**, **RNP**) is a curved line in space. Obstructions must not penetrate the **GQS**. Calculate the **MSL** height of the **GQS** at any distance “**d**” measured from runway threshold (**RWT**) along runway centerline (**RCL**) extended to a point abeam the obstruction using the applicable version of formula 2-21.

e. **Terrain under the clearway plane** (1^{st} 1,000 ft off the approach end of the runway) is allowed to rise at a slope of 80:1 (grade of 1.25%) or appropriate military equivalent (see figure 2-19). Terrain and obstacles under the 80:1 slope (grade of 1.25 percent) are not considered obstructions; i.e., for the first 1,000 ft of the **GQS**, only obstacles that penetrate the clearway plane are evaluated.

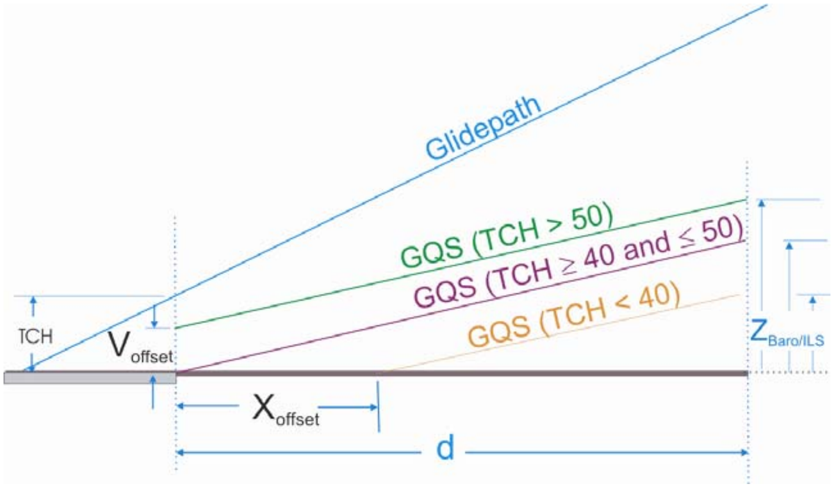


Figure 2-16a: GQS Origin

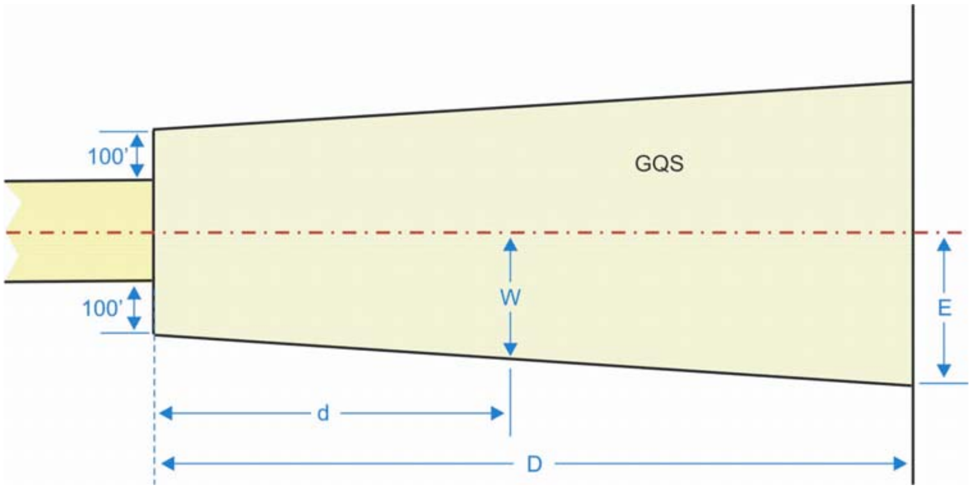


Figure 2-16b: GQS (TCH ≥ 40).

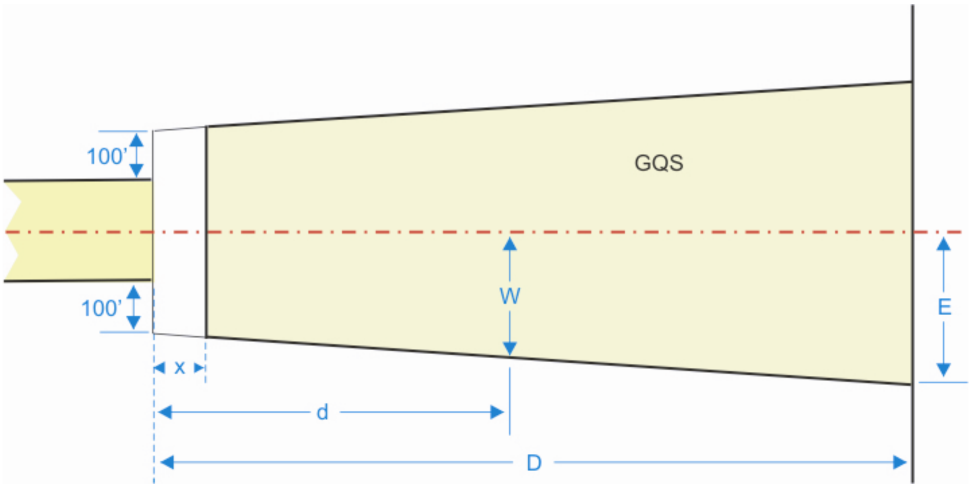


Figure 2-16c: GQS (TCH < 40).

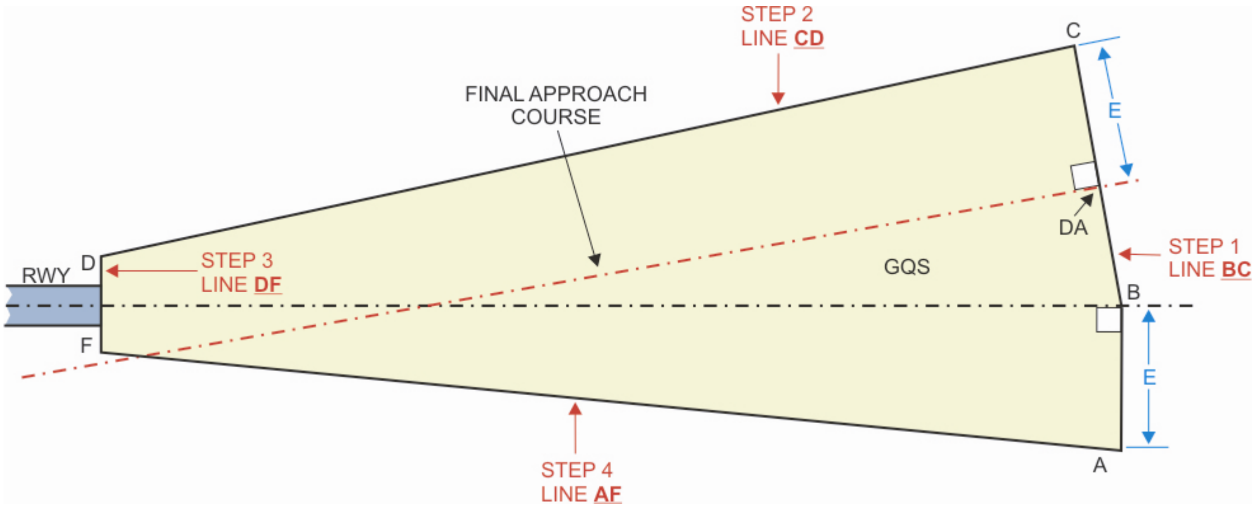


Figure 2-17: Example: TCH ≥ 40 ft.

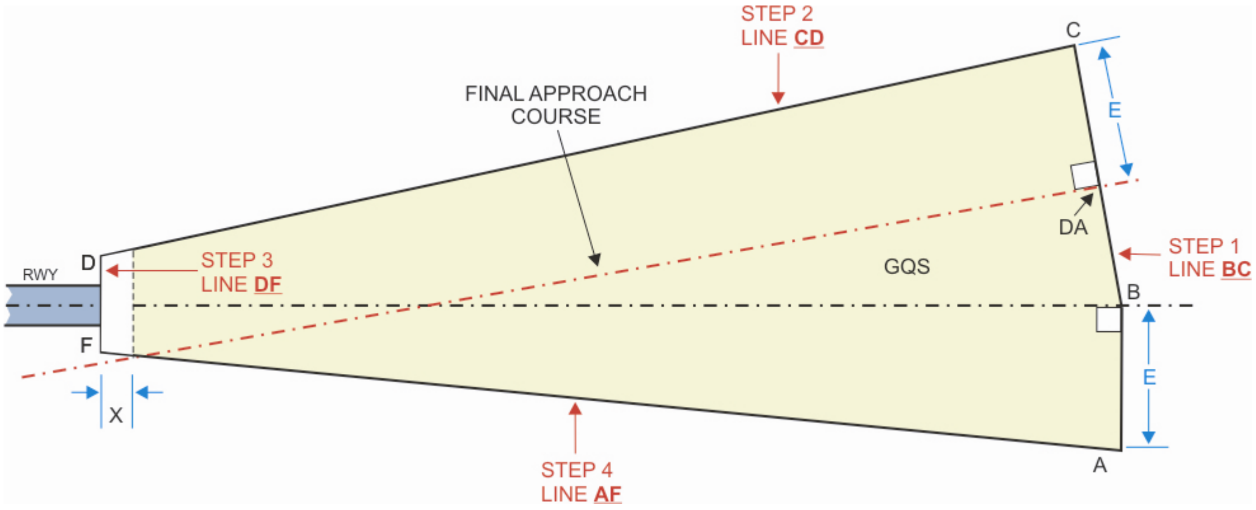


Figure 2-18: Example: TCH < 40 ft.

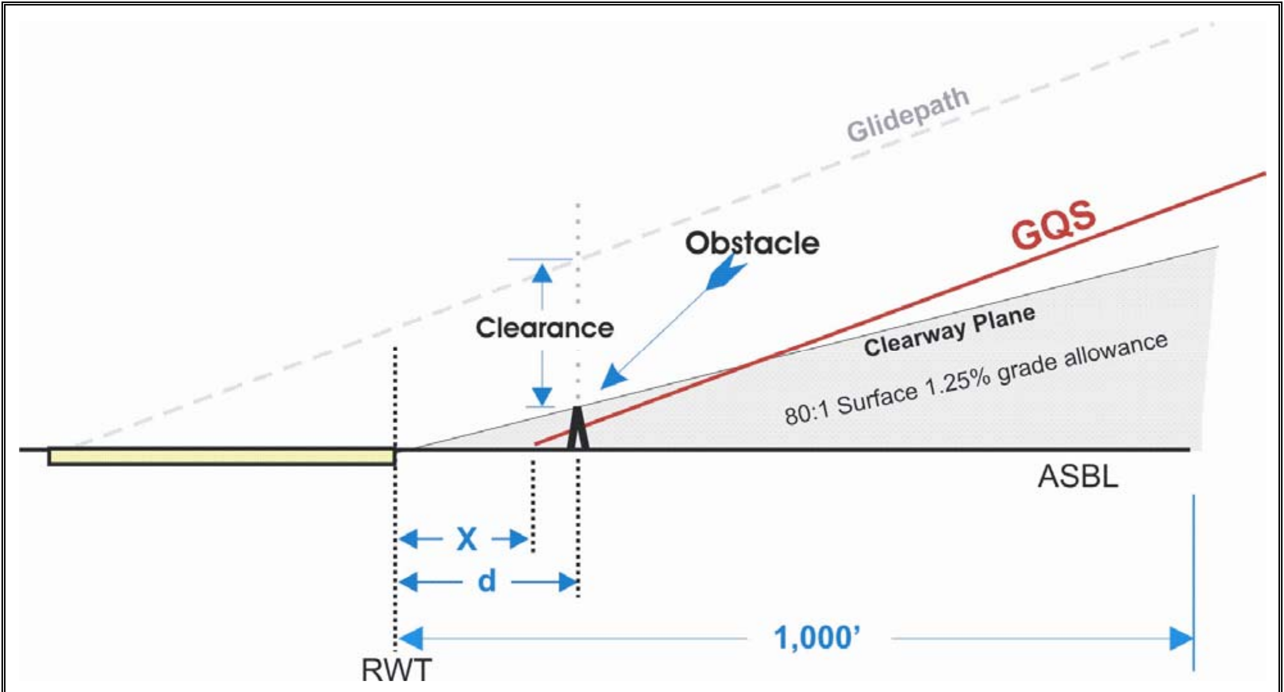


Figure 2-19: Allowable GQS Penetrations.

2.18 Precision Obstacle Free Zone (POFZ)

(Effective when reported ceiling is less than 300 ft and/or visibility less than ¾ statute miles (**SM**) while an aircraft on a vertically guided approach is within 2 NM of the threshold.)

The tail and/or fuselage of a taxiing aircraft must not penetrate the **POFZ** when an aircraft flying a vertically guided approach (**ILS**, **LPV**, **RNP**, **LNAV/ VNAV**, **PAR**) reaches 2 NM from threshold. The wing of aircraft holding on a perpendicular taxiway waiting for runway clearance may penetrate the **POFZ**; however, the fuselage or tail must not infringe the area. The minimum authorized **HATh** and visibility for the approach is 250 ft and ¾ SM where the **POFZ** is not clear (see figure 2-20).

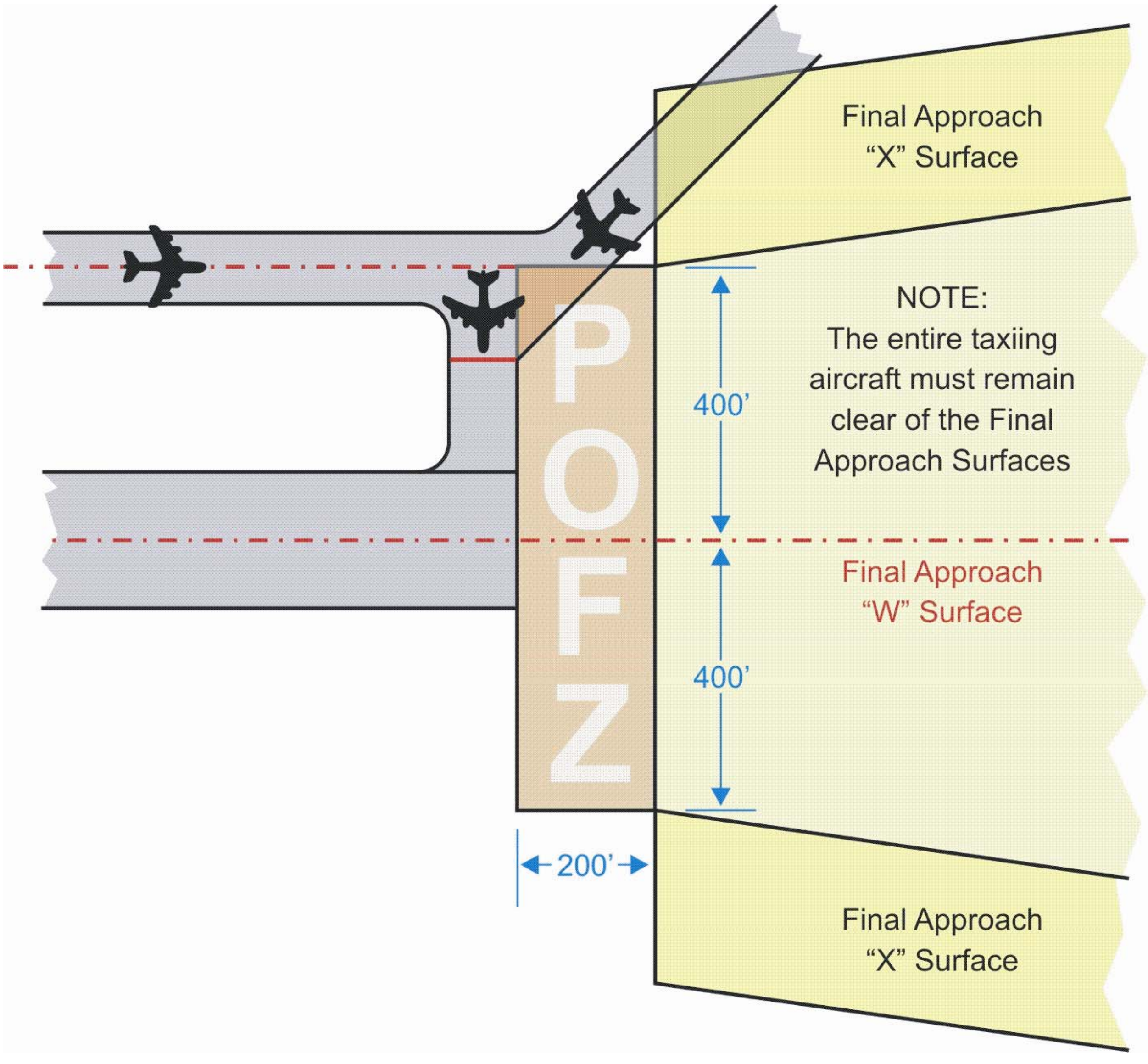


Figure 2-20: POFZ.

SECTION 4. MISSED APPROACH GENERAL INFORMATION

2.19 Missed Approach Segment (MAS) Conventions

Figure 2-21 defines the **MAP** point **OEA** construction line terminology and convention for section 1.

The missed approach obstacle clearance standard is based on a minimum aircraft climb gradient of 200 ft/NM, protected by a **ROC** surface that rises at 152 ft/NM. The **MA ROC** value is based on a requirement for a 48 ft/NM (200-152 = 48) increase in **ROC** value from the start-of-climb (**SOC**) point located at the **JK** line (**AB** line for **LPV**). The actual slope of the **MA** surface is (1 NM in feet)/152 ≈ 39.974. In manual application of instrument procedure design criteria, the rounded value of 40:1 has traditionally been applied, the full value (to 15 significant digits) is used in calculations. The nominal **OCS** slope ($\mathbf{MA_{OCSslope}}$) associated with any given missed approach climb gradient is calculated using formula 2-22.

Maximum Missed Approach Segment (**MAS**) Climb Gradient (**CG**) is 200'/NM unless approved by TC or DND (as appropriate). See paragraph 6.5.

2.19.1 Charted Missed Approach Altitude.

Apply Volume 1, paragraphs 277d and 277f to establish the preliminary and charted missed approach altitudes.

2.19.2 Climb-In-Holding.

Apply Volume 1, paragraph 277e for climb-in-holding guidance.

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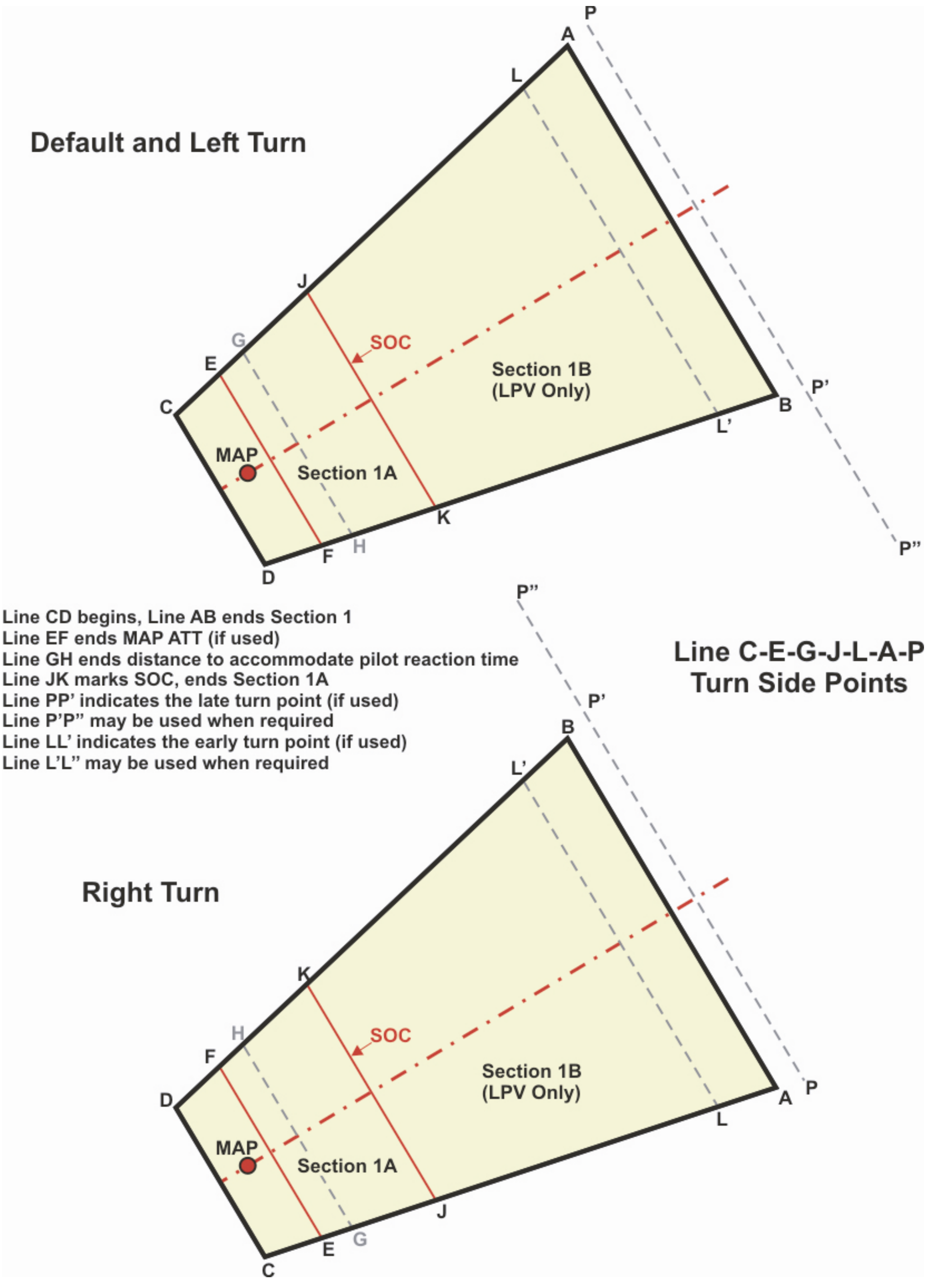


Default and Left Turn

Line CD begins, Line AB ends Section 1
Line EF ends MAP ATT (if used)
Line GH ends distance to accommodate pilot reaction time
Line JK marks SOC, ends Section 1A
Line PP’ indicates the late turn point (if used)
Line P’P” may be used when required
Line LL’ indicates the early turn point (if used)
Line L’L” may be used when required

Line C-E-G-J-L-A-P
Turn Side Points

Right Turn

Figure 2-21: MAS Point/Line Identification.

	Phase	Segment	ATT Value
GNSS	**EnRoute**	STARs, SIDs, Feeder, Initial, Intermediate, Missed Approach > 30 NM	**2.0 NM**
	Terminal	STARs, SIDs, Feeder, Initial, Intermediate, Missed Approach ≤ 30 NM	**1.0 NM**
	Approach	Final	**0.3 NM**
WAAS* (LPV & LP)	**Approach**	Final	**40 meters**

Note: *Applies to final segment only. Apply GNSS values to all other segments of the approach procedure.

Table 2-1. ATT Values

Segment		Primary Area Half-Width (p)	Secondary Area (s)
STARs, Feeder, Initial & Missed Approach	**> 30 NM from ARP**	± 4.00	2.00
		2-4-4-2	
STARs, Feeder, Initial , Missed Approach	**≤ 30 NM from ARP**	± 2.00	1.00
		1-2-2-1	
Intermediate		Continues initial segment width until 2 NM prior to PFAF. Then tapers uniformly to final segment width	Continues initial segment width until 2 NM prior to PFAF. Then it tapers to final segment width

Table 2-2. RNAV Linear Segment Width (NM) Values

Segment		**Indicated Airspeed by Aircraft Category (CAT)**				
		CAT A	**CAT B**	**CAT C**	**CAT D**	**CAT E**
Feeder, Initial, Intermediate, Missed Approach	**Above 10,000 ft**	180	250	300	300	350
Feeder, Initial, Intermediate	**At/Below 10,000 ft**	150		250		
Final		90	120	140	165	165 or as specified*
Missed Approach (MA)		110	150	240	265	265 or as specified*

Note: * Record Cat E final or MA indicated airspeed in procedure documentation if different than listed.

Interpretation – If a non standard airspeed is used; the indicated airspeed limitation would be annotated on the procedure forms to indicate the nonstandard value used in turn radius calculations.

Table 2-3. Indicated Airspeeds (knots)

Category	**θ**
A**	5.7
B	4.2
C	3.6
D&E	3.1

Notes:

* LPV: Where HATh < 250, Cat A-C Max 3.5 degrees, Cat D/E Max 3.1°.

** Cat A 6.4 degrees if **V_{KIAS}** limited to 80 knots maximum. Apply Volume 1, chapter 3 minimum **HATh** values based on glidepath angle where they are higher than the values in this criteria.

Table 2-4. Maximum Allowable GPAs*.

Representative Aircraft Type	Approximate Glidepath-to-Wheel Height	Recommended TCH ± 5 Ft	Remarks
HEIGHT GROUP 1 General Aviation, Small Commuters, Corporate turbojets: T-37, T-38, C-12, C-20, C-21, T-1, T-3, T-6, UC-35, Fighter Jets	10 ft or less	40 ft	Many runways less than 6,000 ft long with reduced widths and/or restricted weight bearing which would normally prohibit landings by larger aircraft.
HEIGHT GROUP 2 F-28, CV-340, CV-440, CV-580, B-737, C-9, DC-9, C-130, T-43, B-2, S-3	15 ft	45 ft	Regional airport with limited air carrier service.
HEIGHT GROUP 3 B-727, B-707, B-720, B-757, B-52, C-17, C-32, C-135, C-141, E-3, P-3, E-8	20 ft	50 ft	Primary runways not normally used by aircraft with ILS glidepath-to-wheel heights exceeding 20 ft.
HEIGHT GROUP 4 B-747, B-767, B-777, L-1011, DC-10, A-300, B-1, KC-10, E-4, C-5, VC-25	25 ft	55 ft	Most primary runways at major airports.

Notes:

1. To determine the minimum allowable TCH, add 20 ft to the glidepath-to-wheel height.
2. To determine the maximum allowable TCH, add 50 ft to the glidepath-to-wheel height.
3. Maximum LPV TCH is 60 ft.

Table 2-5. TCH Requirements.

1		2	3	4	5
ILS Serves Runway		**ILS Does Not Serve Runway**	**±Splay**	**± Width**	**Offset Length**
LTP Dist to LOC	**FPAP Dist from LTP**	**FPAP Dist from LTP**			
> 9,023' and ≤ 10,023'	**9023**	**9023**	**2.0° ****	**350 ft (106.75 m) * & ****	**Formula 2-15 ****
> 10,023' and ≤ 13,366'	**To DER**		**Formula 2-13* & ****		**0 ****
> 13,366 and ≤ 17,185'			**1.5° ****	**Formula 2-14 * & ****	
> 17,185' (TC or DND Approval as appropriate)	**To DER or as specified (contact TC or DND)**				

Notes:

- * Round result to the nearest 0.25 meter.
- ** Use the ILS database values if applying column 1.

Table 2-6. FPAP Location.

Formula 2-1. RF Segment Taper Width.

Math Notation	$D = \frac{4-2}{\tan\left(30 \bullet \frac{\pi}{180}\right)}$ and $\phi = \frac{180 \bullet \mathrm{D}}{\pi \bullet \mathrm{R}}$ Calculates degrees of arc (Φ) to complete taper $B_{PRIMARY} = 4 - 2 \bullet \frac{\phi \bullet \pi \bullet R}{180 \bullet D}$ and $B_{SECONDARY} = 6 - 3 \bullet \frac{\phi \bullet \pi \bullet R}{180 \bullet D}$
Standard Text	D = (4-2)/tan(30-π/180) Φ = (180*D)/(π*R) **B$_{\mathbf{PRIMARY}}$** = 4-2*(Φ*π*R)/(180*D) **B$_{\mathbf{SECONDARY}}$** = 6-3*(Φ*π*R)/(180*D)
Given values:	R = RF Leg Radius Φ = Degrees of arc (RF track) Note: "D" will be in the same units as "R"

Formula 2-2. Vertical Path Altitude.

Math Notation	$VP_{ALT} = e^{\frac{D_Z \bullet Tan\left(\theta \frac{\pi}{180}\right)}{r}} \bullet \left(r + PFAF_{ALT}\right) - r$
Standard Text	e^((DZ*tan(θ*π/180))/r)*(r+PFAFalt)-r
Given values:	VP$_{\text{ALT}}$ = Vertical Path Altitude PFAF$_{\text{ALT}}$ = Designed PFAF MSL altitude θ = Glidepath Angle D$_{\text{Z}}$ = Distance (ft) from PFAF to fix r = 20890537 Note: If **D$_{\mathbf{Z}}$** is a NM value, convert to feet by multiplying NM by 1852/0.3048

Formula 2-3a. True Airspeed.

Math Notation	$V_{KTAS} = \frac{V_{KIAS} \bullet 171233 \bullet \sqrt{(288+15) - 0.00198 \bullet alt}}{(288 - 0.00198 \bullet alt)^{2.628}}$
Standard Text	(VKIAS*171233*((288+15)-0.00198*alt)^0.5)/(288-0.00198*alt)^2.628
Given values:	V$_{\text{KTAS}}$ = Knots true airspeed alt = Aircraft MSL elevation V$_{\text{KIAS}}$ = Knots indicated airspeed

Formula 2-3b. Tailwind.

Math Notation	$V_{KTW} = 0.00198 \bullet alt + 47$
Standard Text	0.00198*alt+47
Given values:	V_{KTW} = Knots tailwind component alt = Highest turn altitude *Note: If "alt" is 2000 or less above airport elevation, then $V_{KTW} = 30$*

Formula 2-3c. Turn Radius.

Math Notation	$R = \dfrac{(V_{KTAS} + V_{KTW})^2}{Tan\left(BANK_{ANGLE} \bullet \dfrac{\pi}{180}\right) \bullet 68625.4}$
Standard Text	(VKTAS+VKTW)^2/(tan(bankangle*π/180)*68625.4)
Given values:	R = Turn Radius $BANK_{ANGLE}$ = Assumed bank angle (normally 14° for CAT A, 18° for CATs B-D V_{KTW} = Calculated tailwind (Formula 2-3b) V_{KTAS} = Calculated True airspeed (Formula 2-3a)

Formula 2-4. Reaction & Roll Distance.

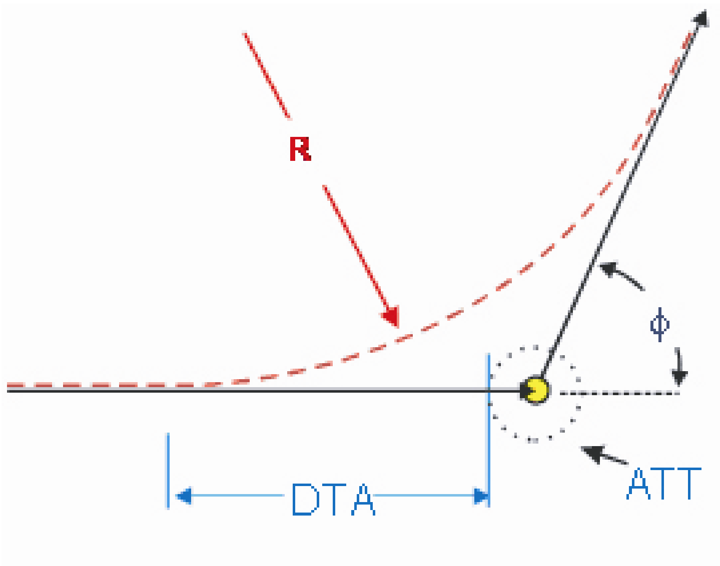
Math Notation	$rr = 6 \bullet \dfrac{\dfrac{1852}{0.3048}}{3600} \bullet V_{KTAS}$
Standard Text	6*(1852/0.3048/3600)*VKTAS
Given values:	rr = Reaction & Roll Distance V_{KTAS} = Knots True Airspeed

Formula 2-5. Distance of Turn Anticipation.

Math Notation	$DTA = R \bullet Tan\left(\frac{\phi}{2} \bullet \frac{\pi}{180}\right)$
Standard Text	R*tan(Φ /2*π/180)

Given values:

DTA = Distance of Turn Anticipation
R = Turn Radius from Formula 2-3c
Φ = Degrees of heading change



Formula 2-6. TF Leg Minimum Length Following Fly-Over Turn.

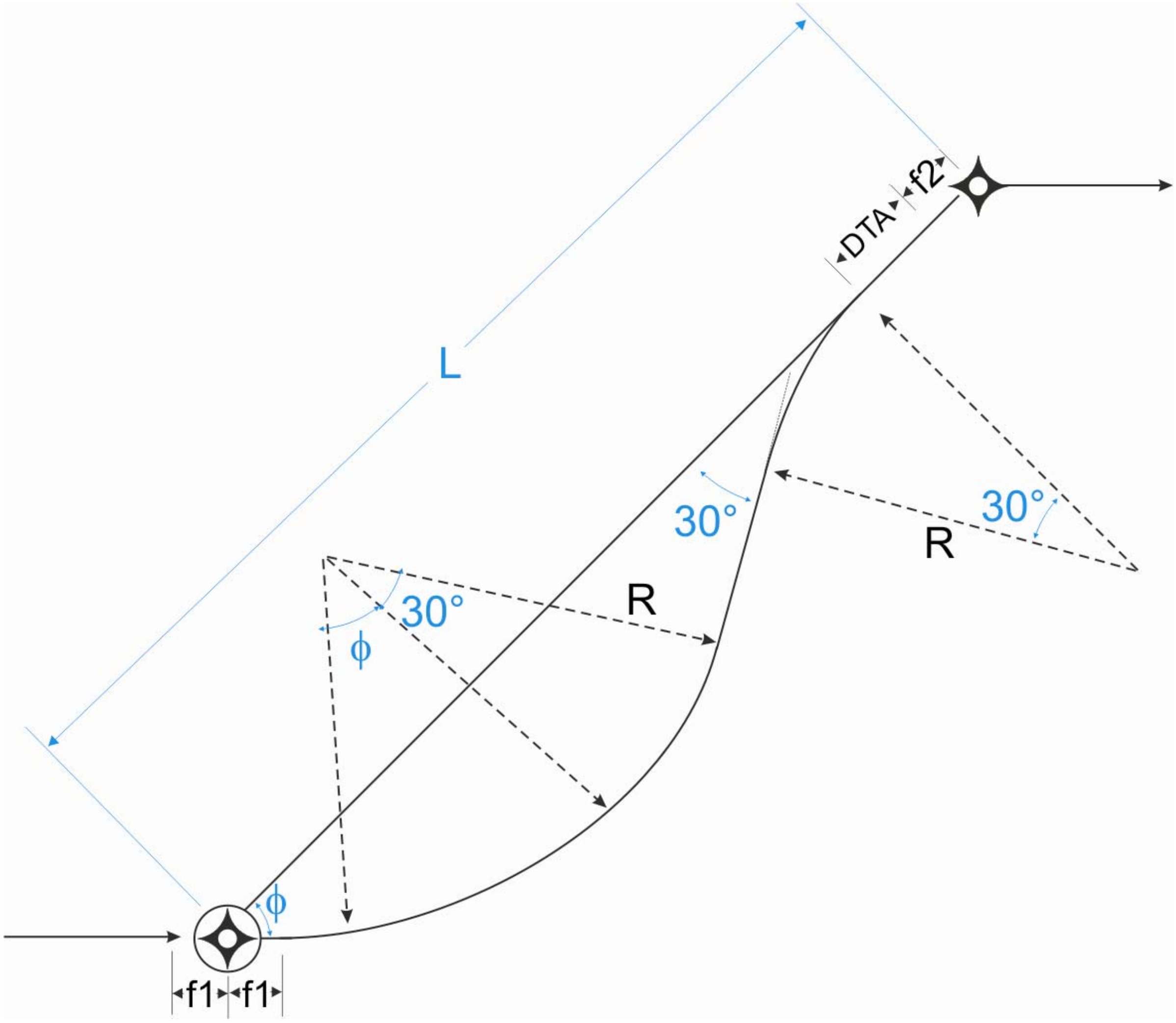
Math Notation

$$L = f1 \bullet \left(\cos\left(\phi \bullet \frac{\pi}{180} \right) + \sqrt{3} \bullet \sin\left(\phi \bullet \frac{\pi}{180} \right) \right) + R \bullet \left(\sin\left(\phi \bullet \frac{\pi}{180} \right) + 4 - \sqrt{3} - \sqrt{3} \bullet \cos\left(\phi \bullet \frac{\pi}{180} \right) \right) + DTA + f2$$

Standard Text	f1*(cos(Φ *π/180)+3^0.5*sin(Φ*π/180))+R*(sin(Φ *π/180) +4-3^0.5-3^0.5*cos(Φ *π/180))+DTA+f2

Given values:

R = Turn Radius (NM) from Formula 2-3c
Φ = Degrees of track change at fix
f1 = ATT (NM) of fly-over fix (segment initial fix)
f2 = ATT (NM) of segment termination fix
DTA = Value from formula 2-5 (applicable only if the fix is “fly-by”)

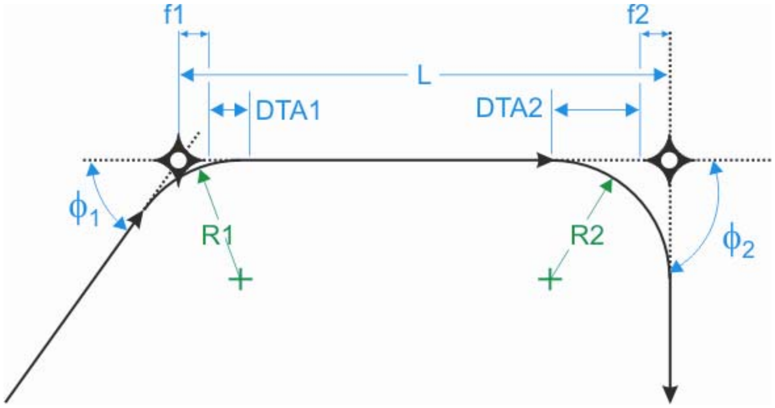


Formula 2-7. TF Leg Minimum Length Following Fly-By Turn.

Math Notation	$DTA1 = R1 \bullet \tan\left(\frac{\phi_1}{2} \bullet \frac{\pi}{180}\right)$ $DTA2 = R2 \bullet \tan\left(\frac{\phi_2}{2} \bullet \frac{\pi}{180}\right)$ L = f1+DTA1+DTA2+f2
Standard Text	DTA1 = R1*tan((Φ1/2)*(π/180)) DTA2 = R2*tan((Φ2/2)*(π/180)) L =f1+DTA1+DTA2+f2

Given values:

L = TF Leg Minimum Length following Fly-By Turn
f1 = ATT of initial fix
f2 = ATT of termination fix
R1 = Turn radius for first fix from formula 2-3c
R2 = Turn radius for subsequent fix from formula 2-3c Note: zero when Φ2 is fly-over
Φ_1 = Degrees of heading change at initial fix
Φ_2 = Degrees of heading change at termination fix Note: zero when Φ_2 is fly-over



Formula 2-8. RF Bank Angle

Math Notation	$bank_{angle} = a\tan\left(\frac{(V_{KTAS} + V_{KTW})^2}{R \bullet 68625.4}\right) \bullet \frac{180}{\pi}$
Standard Text	atan((VKTAS+VKTW)^2/(R*68625.4))*180/π

Given values:

$Bank_{Angle}$ = RF Bank Angle
V_{KTAS} = value from formula 2-3a
V_{KTW} = value from Table 1-3
R = required radius

Formula 2-9. RF Segment Length.

Math Notation	$Segmentlength = \frac{\pi \bullet R \bullet \phi}{180}$
Standard Text	π*R*Φ/180

Given values:

$Segment_{Length}$ = RF Segment Length
R = RF segment radius (answer will be in the units entered
Φ = # of degrees of ARC (heading change)

Formula 2-10. Descent Gradient.

Math Notation	$DG = \frac{r \bullet \ln\left(\frac{r+a}{r+b}\right)}{D}$
Standard Text	(r*ln((r+a)/(r+b)))/D

Given values:

DG = Descent gradient
a = Beginning altitude
b = Ending altitude
D = Distance (NM) between fixes
r = 20890537

Formula 2-11a. Secondary ROC.

Math Notation	$ROC_{SECONDARY} = 500 \bullet \left(1 - \frac{d}{D}\right)$
Standard Text	500*(1-d/D)

Given values:

ROC_{SEC} = Secondary ROC Value
D = Width (ft) of secondary
d = Distance (ft) from edge of primary area measured perpendicular to boundary

Formula 2-11b. Secondary ROC.

Math Notation	$ROC_{secondary} = (500 + adj) \bullet \left(1 - \frac{d_{primary}}{W_S}\right)$
Standard Text	(500+adj)*(1-dprimary/WS)

Given values:

$d_{primary}$ = Perpendicular distance (ft) from edge of primary area

W_s = Width of the secondary area

adj = Volume 1, Chapter 3 adjustments

Formula 2-12. Min IF Distance.

Math Notation	$d_{IF} = 0.3 \bullet \frac{d}{a} - d \bullet \frac{0.3048}{1852}$
Standard Text	0.3*d/a-d*0.3048/1852

Given values:

d_{IF} = Minimum IF Distance

d = Distance (ft) from FPAP to LTP/FTP

a = Width (ft) of azimuth signal at LTP (table 2-6, column 4 value)

Formula 2-13. Signal Splay.

Math Notation	$Splay = a\tan\left(\frac{350}{RWY_{length} + 1000}\right) \bullet \frac{180}{\pi}$
Standard Text	atan(350/(RWYlength+1000))*180/π

Formula 2-14. Width at LTP..

Math Notation	$Width = \tan\left(1.5 \bullet \frac{\pi}{180}\right) \bullet (RWY_{length} + 1000) \bullet 0.3048$ Round results to the nearest 0.25 meters
Standard Text	tan(1.5*π/180)*(RWYlength+1000)*0.3048

Formula 2-15. Offset Length.

Math Notation	$Offset_{length} = FPAP_{Dist} - RWY_{length}$
Standard Text	FPAPDist-RWYlength

Formula 2-16a. ILS GPIP/LPV PFAF.

Math Notation	$*d_{GPIP} = r \bullet \left(\frac{\pi}{2} - \theta \bullet \frac{\pi}{180} - a\sin\left(\frac{\cos\left(\theta \bullet \frac{\pi}{180}\right) \bullet \left(r + LTP_{elev} + TCH\right)}{r + alt}\right)\right)$ * This formula is for use to determine both D_{GPIP} and D_{PFAF} values.
Standard Text	r*(π/2-θ*π/180-asin((cos(θ*π/180)*(r+LTPelev+TCH))/(r+alt)))

Given values:

alt = Minimum intermediate segment altitude

LTP_{elev} = LTP MSL elevation

TCH = TCH Value

r = 20890537

θ = Glidepath angle

Formula 2-16b. LNAV/VNAV PFAF.

Math Notation	$DPFAF = \frac{\ln\left(\frac{r + alt}{r + LTP_{elev} + TCH}\right) \bullet r}{\tan\left(\theta \bullet \frac{\pi}{180}\right)}$
Standard Text	(ln((r+alt)/(r+LTPelev+TCH))*r)/tan(θ*π/180)

Given values:

Same as those found in formula 2-16a

Formula 2-16c. LNAV/VNAV Angle.

Math Notation	$\theta_{BVNAV} = a\tan\left(\ln\left(\frac{r + PFAF_{ALT}}{r + LTP_{elev} + TCH}\right) \bullet \frac{r}{D_{PFAF}}\right) \bullet \frac{180}{\pi}$
Standard Text	atan(ln((r+PFAFalt)/(r+LTPelev+TCH))*r/DPFAF)*180/π

Given values:

LTP_{elev} = LTP MSL elevation

$PFAF_{alt}$ = Minimum MSL altitude at PFAF

D_{PFAF} = Value from formula 2-16a or distance of existing PFAF

TCH = TCH value

r = 20890537

Formula 2-17a. ILS/LPV.

Math Notation	$Z_{glidepath} = \dfrac{(r + LTP_{elev} + TCH) \bullet \cos\left(\theta \bullet \dfrac{\pi}{180}\right)}{\cos\left(\dfrac{D_Z}{r} + \theta \bullet \dfrac{\pi}{180}\right)} - r$
Standard Text	((r+LTPelev+TCH)*cos(θ*π/180)) /cos(DZ/r+θ*π/180)-r

Given values:

LTP_{elev} = LTP MSL elevation

TCH = TCH Value

r = 20890537

θ = Glidepath angle

D_Z = Distance (ft) from LTP to fix.

Formula 2-17b. LNAV/VNAV.

Math Notation	$Z_{glidepath} = e^{\frac{D_Z \bullet \tan\left(\theta \frac{\pi}{180}\right)}{r}} \bullet (r + LTP_{elev} + TCH) - r$
Standard Text	e^((DZ*tan(θ*π/180))/r)*(r+LTPelev+TCH)-r

Given values:

LTP_{elev} = LTP MSL elevation

TCH = TCH Value

r = 20890537

θ = Glidepath angle

D_Z = Distance (ft) from LTP to fix.

Formula 2-18a. OCS Origin height adjustment.	
Math Notation	$V_{offset} = TCH - 50$
Standard Text	TCH-50

Formula 2-18b. OCS Origin along-track adjustment.	
Math Notation	$X_{offset} = \dfrac{40 - TCH}{\tan\left(\theta \bullet \dfrac{\pi}{180}\right)}$
Standard Text	(40-TCH)/tan(θ *π/180)
Given values:	θ = Glidepath angle TCH = TCH Value

Formula 2-18c. Half Width.	
Math Notation	$E = 0.036 \bullet D + 392.8$
Standard Text	0.036*D+392.8
Given values:	D = Distance (ft) measured along RCL Extended from LTP to DA Point.

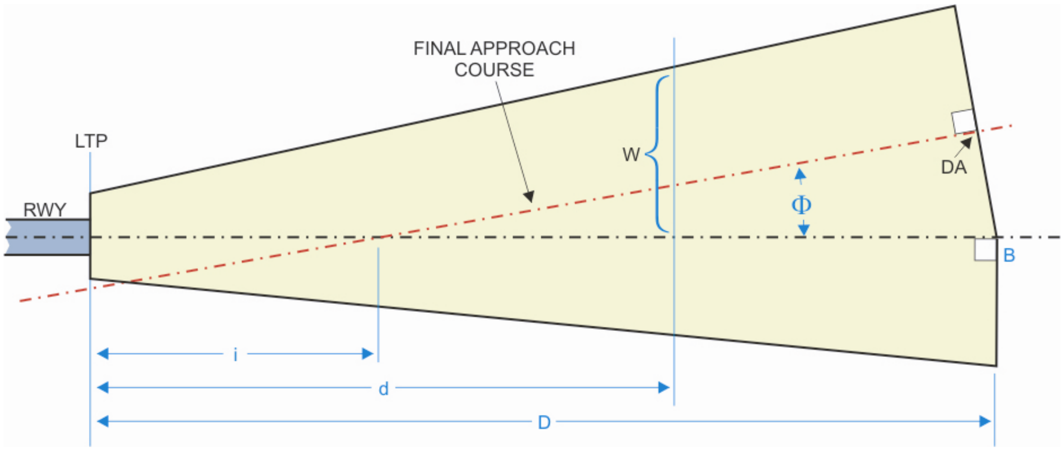
Formula 2-19. GQS Half-Width.	
Math Notation	$w = \dfrac{E - k}{D} \bullet d + k$
Standard Text	d*(E-k)/D+k
Given values:	D = Distance (ft) measured along RCL Extended from LTP to DA Point. E = Result of formula 2-18c d = Desired distance (ft) from LTP w = GQS half-width at distance "d" k = $\dfrac{RWY_{width}}{2} + 100$

Formula 2-20. Offset Side Half-Width.

Math Notation	$W_{offset} = d \bullet \left(\frac{\cos\left(\phi \bullet \frac{\pi}{180}\right) \bullet \left(\sin\left(\phi \bullet \frac{\pi}{180}\right) \bullet (D-i) + E\right) - k}{D - \sin\left(\phi \bullet \frac{\pi}{180}\right) \bullet \left(\sin\left(\phi \bullet \frac{\pi}{180}\right) \bullet (D-i) + E\right)} \right) + k$
Standard Text	d*((cos(Φ*π/180)*(sin(Φ*π/180)*(D-i)+E)-k) /(D-sin(Φ*π/180)*(sin(Φ*π/180)*(D-i)+E)))+k

Given values:

d = Distance (ft) from LTP to point in question
D = Distance (ft) along RCL from LTP to point B
i = Distance (ft) from LTP to RWY centerline intersection
Φ = Degrees of offset
E = 0.036D+392.8
k = $\frac{RWY_{width}}{2} + 100$



Formula 2-21. GQS Elevation.

Math Notation	$Z_{GQS} = \dfrac{(r + LTP_{elev} + V_{offset})\cos\left(\dfrac{2\theta}{3} \bullet \dfrac{\pi}{180}\right)}{\cos\left(\dfrac{d - X_{offset}}{r} + \dfrac{2\theta}{3} \bullet \dfrac{\pi}{180}\right)} - r$
Standard Text	(r+LTPelev+Voffset)*cos((2*θ /3)*π/180) /cos((d-Xoffset)/r+(2*θ /3)*π/180)-r
Given values:	d = Obstacle along RCL distance (ft) from RWT LTP_{elev} = LTP MSL elevation θ = Glidepath angle V_{offset} = See formula 2-18a X_{offset} = See formula 2-18b
Math Notation	$Z_{BARO} = e^{\frac{(d - Xoffset)\bullet\tan\left(\frac{2\theta}{3}\bullet\frac{\pi}{180}\right)}{r}} \bullet (r + LTP_{elev} + V_{offset}) - r$
Standard Text	e^((d-Xoffset)*tan((2*θ /3)*π/180)/r) *(r+LTPelev+Voffset)-r
Given values:	d = Obstacle along RCL distance (ft) from RWT LTP_{elev} = LTP MSL elevation θ = Glidepath angle V_{offset} = See formula 2-18a X_{offset} = See formula 2-18b.

Formula 2-22. Missed Approach OCS Slope.

Math Notation	$MA_{OCSSLOPE} = \dfrac{1852}{0.3048 \bullet (CG - 48)}$
Standard Text	1852/(0.3048*(CG-48))
Given values:	CG = Climb Gradient (nominally 200 ft/NM)

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CHAPTER 3. NON-VERTICALLY GUIDED PROCEDURES

3.0 General

This chapter contains obstacle evaluation criteria for Lateral Navigation (**LNAV**), and Localizer Performance (**LP**) non-vertically guided approach procedures. When constructing a “stand-alone” non-vertically guided procedure, locate the **PFAF** using formula 2-16b, nominally based on a 3-degree vertical path angle. The **PFAF** location for circling procedures that do not meet straight-in alignment are based on the position of the MAP instead of the **LTP** (substitute Airport elevation + 50 for **LTP** elevation + **TCH**).

3.1 Alignment

Optimum non-vertically guided procedure final segment alignment is with the runway centerline extended through the **LTP**. When published in conjunction with a vertically guided procedure, alignment must be identical with the vertically guided final segment.

3.1.1 When the final course must be offset, it may be offset up to 30 degrees (published separately) when the following conditions are met:

a. For offset ≤ 5 degrees, align the course through **LTP**.

b. For offset > 5 degrees and ≤ 10 degrees, the course must cross the runway centerline extended at least 1,500 ft prior to **LTP** (5,200 ft maximum).

c. For offset > 10 degrees and ≤ 20 degrees, the course must cross the runway centerline extended at least 3,000 ft prior to **LTP** (5,200 ft maximum). (Offsets >15 degrees, Category C/D minimum published visibility 1 SM, minimum HATh of 300)

d. For offset > 20 to 30 degrees (Cat A/B only), the course must cross the runway centerline extended at least 4,500 ft prior to the **LTP** (5,200 ft maximum).

Note: Where conditions a. - d. above cannot be attained or the final course does not intersect the runway centerline or intersects the centerline more than 5,200 ft from **LTP**, and an operational advantage can be achieved, the final may be aligned to lie laterally within 500 ft of the extended runway centerline at a point 3,000 ft outward from **LTP**. This option requires TC or DND approval (as appropriate).

3.1.2 Circling.

The **OPTIMUM** final course alignment is to the center of the landing area, but may be to any portion of the usable landing surface. The latest point the **MAP** can be located is abeam the nearest usable landing surface.

3.2 Area - LNAV Final Segment

The intermediate segment primary and secondary areas taper from initial segment **OEA** width (1-2-2-1) to the width of the final segment **OEA**. The taper begins at a point 2 NM prior to the **PFAF** and ends 1.0 NM past the **PFAF**. The final segment **OEA** primary and secondary areas follow the tapering boundaries of the intermediate segment from **ATT** prior to the **PFAF** to the point 1 NM past the **PFAF**, and then are a constant width to 0.3 NM past the **MAP**. See figure 3-1.

3.2.1 Length.

The **OEA** begins 0.3 NM prior to the **PFAF** and ends 0.3 NM past the **LTP**. Segment length is the distance from the **PFAF** location to the **LTP**/**FTP** location. Determine the **PFAF** location per paragraph 2.13. The maximum length is 10 NM.

3.2.2 Width.

The final segment **OEA** primary and secondary boundaries are coincident with the intermediate segment boundaries (see paragraph 2.9) from a point 0.3 NM prior to the **PFAF** to a point 1 NM past the **PFAF**. See formula 3-1. From this point, the Primary **OEA** boundary is ± 0.6 NM (≈ 3,646 ft) from course centerline. A 0.3 NM (≈ 1,823 ft) secondary area is located on each side of the primary area. Where the intermediate segment is not aligned with the final segment, the segment boundaries are constructed under chapter 2, paragraph 2.9.3a.

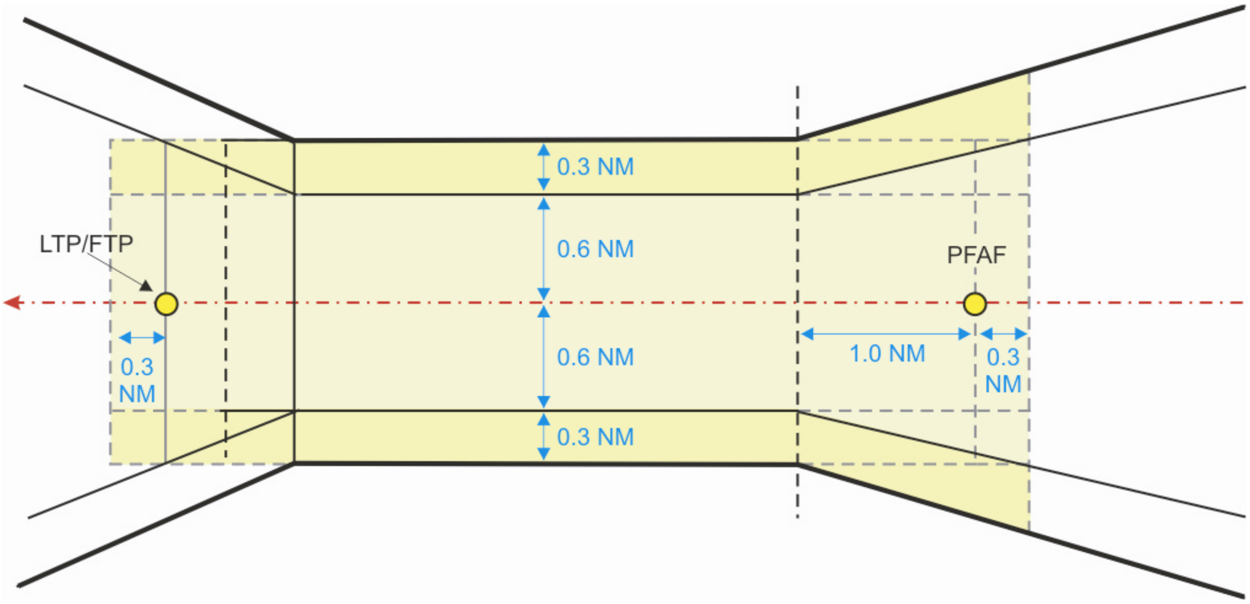


Figure 3-1: LNAV Final Segment OEA.

3.3 Area – LP Final Segment

The intermediate segment primary and secondary areas taper from initial segment **OEA** width (1-2-2-1) to the width of the final segment **OEA**. The taper begins at a point 2 NM prior to the **PFAF** and ends abeam the **PFAF**. The final segment **OEA** primary and secondary areas are linear (constant width) at distances greater than 50,200 ft from **LTP**. Inside this point, they taper uniformly until reaching a distance of 200 ft from **LTP**. From this point the area is linear to the **OEA** end 131.23 ft (40 m) past the **LTP**. See figure 3-2.

3.3.1 Length.

The **OEA** begins 131.23 ft (40 m) prior to the **PFAF** and ends 131.23 ft (40 m) past the **LTP**. Segment length is the distance from the **PFAF** location to the **LTP**/**FTP** location. Determine the **PFAF** location per paragraph 2.13. The **maximum** length is 10 NM.

3.3.2 Width. (See figure 3-2)

The perpendicular distance (**Wp**) from the course centerline to the outer boundary of the primary area is a constant 700 ft from a point 131.23 ft (40 m) past (inside) the **LTP** to a point 200 prior to (outside) the **LTP**. It expands from this point in a direction toward the PFAF. Calculate **Wp** from the 200 ft point to a point 50,200 from **LTP** using formula 3-2. The value of **Wp** beyond the 50,200-ft point is 6,076 ft.

The perpendicular distance (**Ws**) from the course centerline to the outer boundary of the secondary area is a constant 1,000 ft from a point 40 meters past (inside) the **LTP** to a point 200 prior to (outside) the **LTP**. It expands from this point in a direction toward the **PFAF**. Calculate **Ws** from the 200 ft point to a point 50,200 from **LTP** using formula 3-3. The value of **Ws** beyond the 50,200-ft point is 8,576 ft.

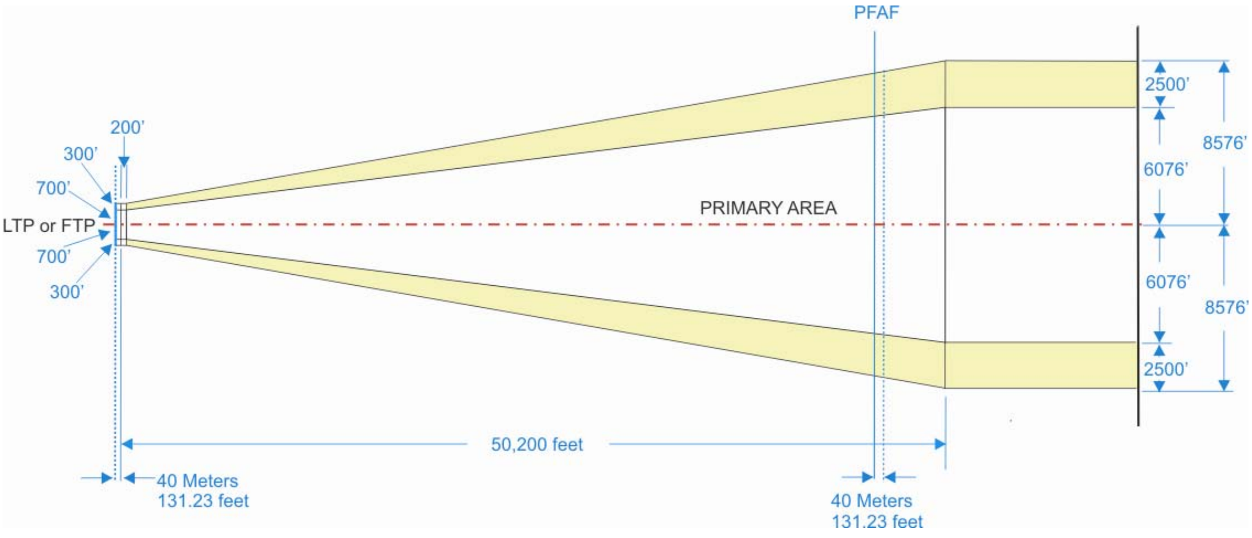


Figure 3-2: LP Final Area.

3.4 Obstacle Clearance

3.4.1 Primary Area.

Apply 250 ft of **ROC** to the highest obstacle in the primary area. Volume 1, chapter 3 precipitous terrain, remote altimeter, and excessive length of final adjustments apply.

3.4.2 Secondary Area.

Secondary **ROC** tapers uniformly from 250 ft (plus adjustments) at the primary area boundary to zero at the outer edge. See figure 3-3.

Calculate the secondary **ROC** value using formula 3-4.

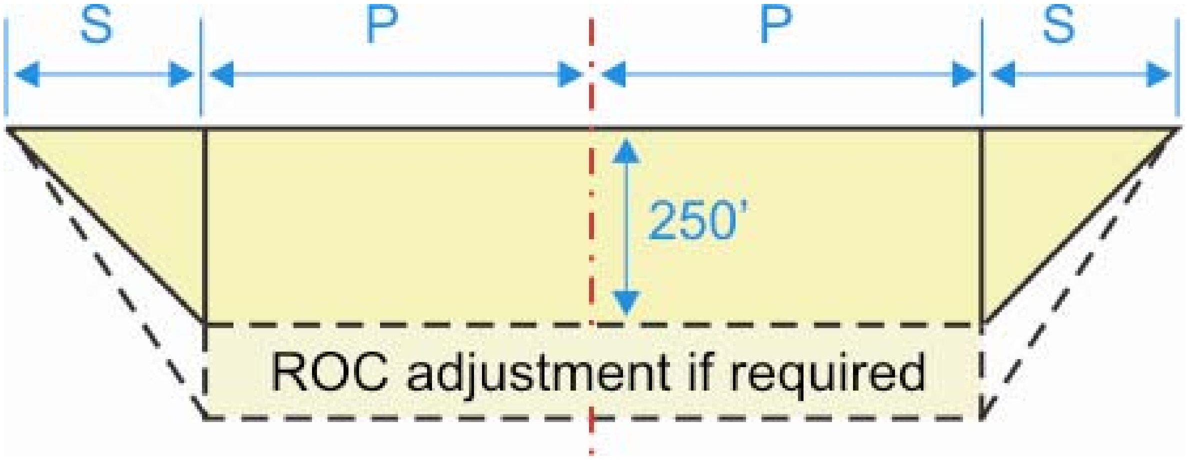


Figure 3-3: Primary/Secondary ROC.

3.5 Final Segment Stepdown Fixes (SDF)

Where the **MDA** can be lowered at least 60 ft or a reduction in visibility can be achieved, **SDFs** may be established in the final approach segment.

3.5.1 Volume 1, paragraph 289 applies, with the following:

a. Establish step-down fix locations in 0.10 NM increments from the **LTP**/**FTP**.

b. The minimum distance between stepdown fixes is 1 NM.

c. For step-down fixes published in conjunction with vertically-guided minimums, the published altitude at the fix must be equal to or less than the computed glidepath altitude at the fix.

Note: Glidepath altitude is calculated using the formula associated with the basis of the **PFAF** calculation.

d. The altitude at any stepdown fix may be established in 20 ft increments and shall be rounded to the next **HIGHER** 20-ft increment. For example, 2104 becomes 2120.

e. Where a **RASS** adjustment is in use, the published stepdown fix altitude must be established no lower than the altitude required for the greatest amount of adjustment (i.e., the published minimum altitude must incorporate the greatest amount of **RASS** adjustment required).

f. Volume 1, paragraph 252 applies to **LNAV** and **LP** descent gradient.

Note: Where turns are designed at the **PFAF**, the 7:1 **OIS** starts **ATT** prior to the angle bisector, and extends 1 NM parallel to the final approach centerline. See figure 2-13e (**LNAV**) and figure 2-13f (**LP**).

g. Obstacles eliminated from consideration under this paragraph must be noted in the procedure documentation.

h. Use the following formulas to determine **OIS** elevation ($\mathbf{OIS_Z}$) at an obstacle and minimum fix altitude ($\mathbf{MF_a}$) based on an obstacle height.

3.6 Minimum Descent Altitude (MDA)

The **MDA** value is the sum of the controlling obstacle elevation **MSL** (including vertical error value when necessary) and the **ROC + adjustments**. Round the sum to the next higher 20-ft increment; e.g., 623 rounds to 640. The minimum **HATh** value is 250 ft.

3.7 Missed Approach Section 1. (MAS-1)

Section 1 begins **ATT** prior to the **MAP** and extends to the start-of-climb (**SOC**) or the point where the aircraft is projected to cross 400 ft above airport elevation, whichever is the greatest distance from **MAP**. See figure 3-4.

3.7.1 Length.

a. Flat Surface Length (FSL).

(1) **LNAV**. Section 1 flat surface begins at the **cd** line (0.3 NM prior to the **MAP**) and extends (distance **FSL** feet) to the **jk** line.

(2) **LP**. Section 1 flat surface begins at the **cd** line (40 meters prior to the **MAP**) and extends (distance **FSL** feet) to the **jk** line.

Calculate the value of **FSL** using formula 3-6.

b. Location of end of section 1 (ab line).

(1) **MDA** ≥ 400 ft above airport elevation. The **ab** line is coincident with the **jk** line.

(2) **MDA** < 400. The **ab** line is located $\frac{1852}{(0.3048 \bullet CG)}$ feet beyond the **jk** line for each foot of altitude needed to reach 400 ft above airport elevation. The surface between the **jk** and **ab** lines is a rising surface with a slope commensurate with the rate of climb (nominally 40:1).

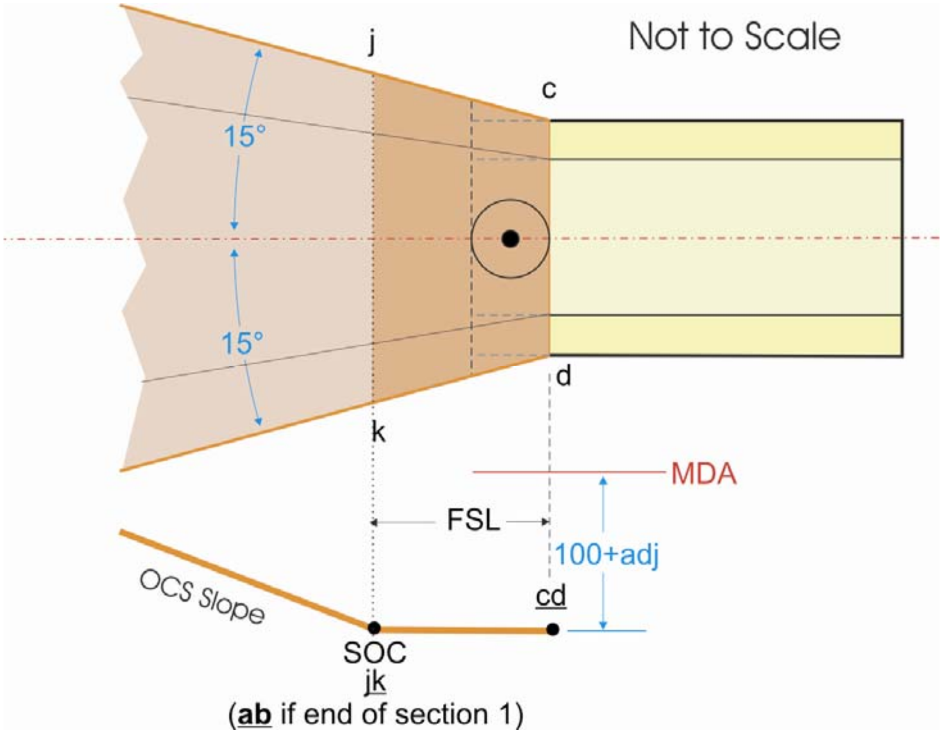
3.7.2 Width. LNAV and LP.

a. LNAV. The primary area boundary splays uniformly outward from the edge of the primary area at the **cd** line until it reaches a point 2 NM from course centerline. The secondary area outer boundary lines splay outward 15 degrees relative to the missed approach course from the outer edge of the secondary areas at the **cd** line (0.3 NM prior to **MAP**) until it reaches a point 3 NM from course centerline. Calculate the distance from course centerline to the primary and outer secondary boundary of the **MAS-1 OEA** at any distance from the **cd** line using formula 3-7a.

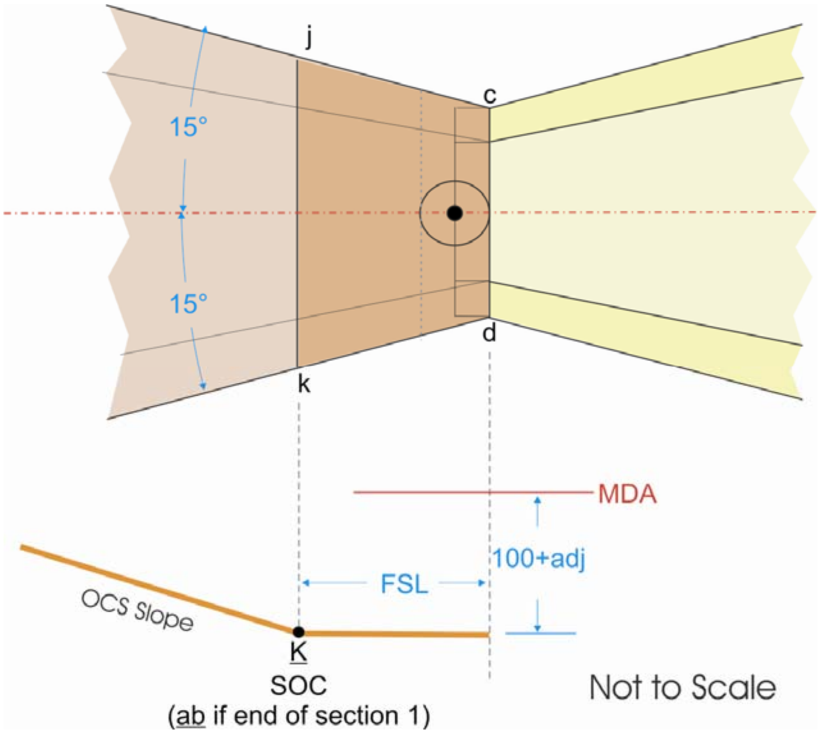
b. LP. The primary area boundary splays uniformly outward from the edge of the primary area at the **cd** line until it reaches a point 2 NM from course centerline. The secondary area outer boundary lines splay outward 15 degrees relative to the missed approach course from the outer edge of the secondary areas at the **cd** line (40 meters prior to **MAP**) until it reaches a point 3 NM from course centerline. Calculate the distance from course centerline to the primary and outer secondary boundary of the **MAS-1 OEA** at any distance from the **cd** line using formula 3-7b.

3.7.3 Obstacle Clearance. LNAV and LP.

The **MAS**-1 **OCS** is a flat surface. The **MSL** height of the surface (**HMAS**) is equal to the MDA minus 100 ft plus precipitous terrain, remote altimeter (only if full time), and excessive length of final (volume 1, chapter 3) adjustments. See formula 3-8.



LNAV – Lateral Navigation



LP – Localizer Performance

Figure 3-4: Missed Approach Section 1

Formula 3-1. Tapering Segment Width.

Math Notation	$\frac{1}{2}Wp = \frac{1.4d}{3} + 0.6$ and $Ws = \frac{0.7\text{d}}{3} + 0.3$
Standard Text	½W_p = 1.4*d/3+0.6 W_s = 0.7*d/3+0.3

Given values:

d = along track distance from line “B” (See figure 2-13e)

Formula 3-2. Primary Area Width.

Math Notation	$Wp = 0.10752 \bullet D + 678.496$
Standard Text	0.10752*D+678.496

Given values:

D = Along track distance (> 200 ≤ 50,200) from LTP/FTP

Formula 3-3. Secondary Area Width.

Math Notation	$Wp = 0.15152 \bullet D + 969.696$
Standard Text	0.15152*D+969.696

Given values:

D = Along track distance (> 200 ≤ 50,200) from LTP/FTP

Formula 3-4. Secondary Area ROC.

Math Notation	$ROC_{SECONDARY} = (250 + adj) \bullet \left(1 - \frac{d_{PRIMARY}}{W_s}\right)$
Standard Text	(250+adj)*(1-dprimary/W_S)

Given values:

$d_{primary}$ = Perpendicular (relative to course centerline Distance (ft) from edge of primary area.

W_S = Width of the secondary area(s)

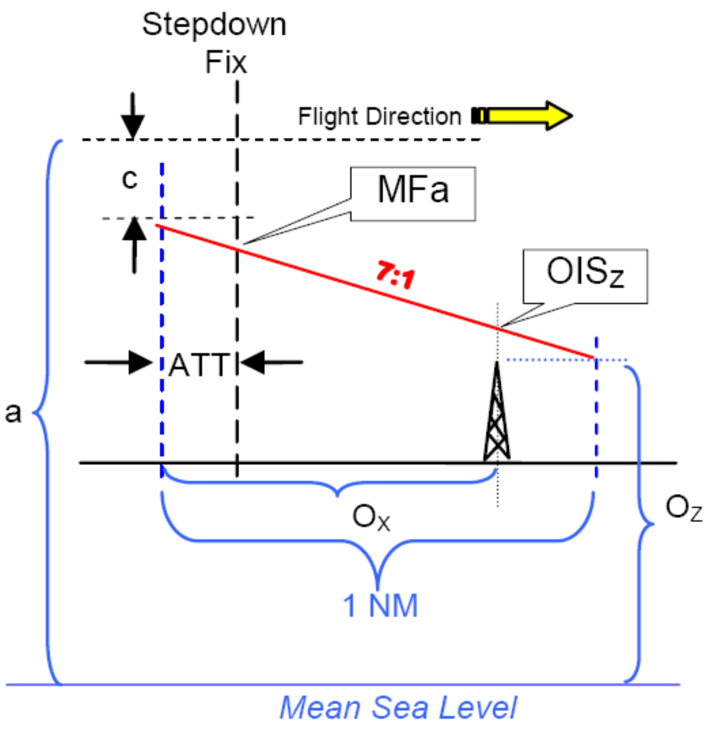
adj = Vol. 1, Chap 3 adjustments

Formula 3-5. OIS elevation & Minimum Fix Altitude.

Math Notation	$OIS_Z = a - c - \frac{O_X}{7}$ and $MFa = O_Z + c + \frac{O_X}{7}$
Standard Text	OISZ=a-c-OX/7 and MFa=OZ+c+OX/7

Given values:

c = ROC plus adjustments (Vol 1, Chap 3)
a = MSL fix altitude
O_X = Obstacle along-track distance (ft) from ATT prior to fix (1 NM max)
O_Z = MSL obstacle elevation



Formula 3-6. Flat Surface Length.

Math Notation	

$$FSL = 20.2537 \bullet \left(\left(V_{KIAS} \bullet \frac{171233 \bullet \sqrt{(288+15) - 0.00198 \bullet MDA}}{(288 - 0.00198 \bullet MDA)^{2.628}} \right) + 10 \right) + 2 \bullet ATT$$

Standard Text	20.2537*((VKIAS*(171233*((288+15)-0.00198*MDA)^0.5)/(288-0.00198*MDA)^2.628)+10)+2*ATT

Given values:

V_{KIAS} = Indicated Airspeed (knots)
ATT = Along Track Tolerance (Feet)
MDA = Minimum Descent Altitude

Formula 3-7a. LNAV Primary & Secondary Width.

Math Notation

$$MAS_{YPRIMARY} = d \bullet \frac{\tan\left(15 \bullet \frac{\pi}{180}\right) \bullet 1.4 \bullet NM}{2.1 \bullet NM} + 0.6 \bullet NM$$

$$MAS_{YSECONDARY} = d \bullet \tan\left(15 \bullet \frac{\pi}{180}\right) + 0.9 \bullet NM$$

Standard Text	MASYprimary=d*((tan(15*π/180)*1.4 *1852/0.3048))/(2.1*1852/0.3048) +0.6*1852/0.3048 MASYsecondary=d*tan(15*π/180)+0.9 *1852/0.3048

Given values:

d = Along track distance (ft) from the cd line ≤ 47620.380

NM = 1852 / 0.3048

Formula 3-7b. LP Primary & Secondary Width.

Math Notation

$$MAS_{YPRIMARY} = d \bullet \frac{\tan\left(15 \bullet \frac{\pi}{180}\right) \bullet (2 \bullet NM - W_P)}{3 \bullet NM - W_S} + W_P$$

$$MAS_{YSECONDARY} = d \bullet \tan\left(15 \bullet \frac{\pi}{180}\right) + W_S$$

Standard Text	MASYprimary= d*((tan(15*π/180)*(2*1852 /0.3048-W_P))/(3*1852/0.3048-WS))+W_P MASYsecondary= d*tan(15*π/180)+W_S

Given values:

d = Along track distance (ft) from the **cd** line ≤ 64297.064

NM = 1852 / 0.3048

Formula 3-8. HMAS.

Math Notation	$HMAS = MDA - (100 + adj)$
Standard Text	MDA-(100+adj)

Given values:

adj = Precipitous terrain, remote altimeter (only if full time), and excessive length of final adjustments

CHAPTER 4. LATERAL NAVIGATION WITH VERTICAL GUIDANCE (LNAV/VNAV)

4.0 General

An **LNAV/VNAV** approach is a vertically-guided approach procedure using **Baro VNAV** or **WAAS VNAV** for the vertical guidance. Obstacle evaluation is based on the **LNAV OEA** dimensions and **Baro-VNAV OCS**. The actual vertical path provided by **Baro VNAV** is influenced by temperature variations; i.e., during periods of cold temperature, the effective glidepath may be lower than published. Because of this phenomenon, minimum (for aircraft that are not equipped with temperature compensating systems) are published on the approach chart. Additionally, **LNAV/VNAV** approach procedures at airports where remote altimeter is in use or where the final segment overlies precipitous terrain must be annotated to indicate the approach is not authorized for **Baro VNAV** systems. ROC adjustments for excessive length of final (Volume 1, Chapter 3) do not apply to **LNAV/VNAV** procedures. **LNAV/VNAV** minimum **HATh** value is 250 ft.

4.1 Final Approach Course Alignment

Optimum final segment alignment is with the runway centerline (± 0.03°) extended through the **LTP**.

4.1.1 Where lowest minimums can only be achieved by offsetting the final course, it may be offset up to 15 degrees when the following conditions are met:

a. For offset ≤ 5 degrees, align the course through **LTP**.

b. For offset > 5 degrees and ≤ 10 degrees, the course must cross the runway centerline extended at least 1,500 ft (5200 ft maximum) prior to **LTP**. (**d1**=1,500) Determine the minimum **HATh** value using formula 4-1.

c. For offset > 10 degrees and ≤ 15 degrees, the course must cross the runway centerline extended at least 3,000 ft (5,200 ft maximum) prior to **LTP** (**d1**=3,000). Determine the minimum **HATh** value (**MINHATh**) using formula 4-1.

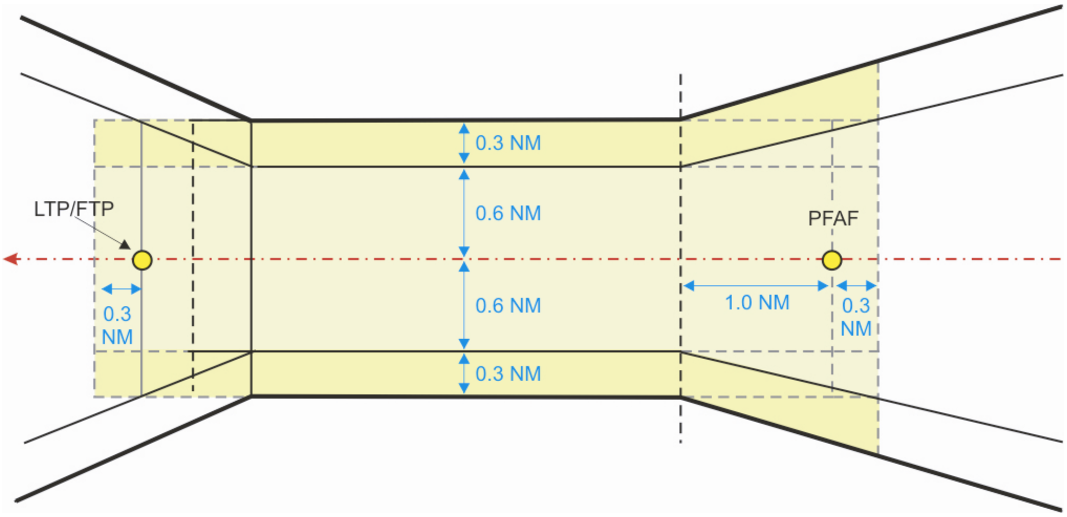


Figure 4-1: LNAV/VNAV Final Segment OEA.

4.2 Area

The intermediate segment primary and secondary areas taper from initial segment **OEA** width (1-2-2-1) to the width of the final segment **OEA** width (0.3-0.6-0.6-0.3) The taper begins at a point 2 NM prior to the **PFAF** and ends 1.0 NM following (past) the **PFAF**. The final segment **OEA** primary and secondary areas follow the tapering boundaries of the intermediate segment from **ATT** prior to the **PFAF** to the point 1 NM past the **PFAF**, and then are a constant width to 0.3 NM past the **MAP**. See figure 4-1.

4.2.1 Length.

The **OEA** begins 0.3 NM prior to the **PFAF** and ends 0.3 NM past the **LTP**. Segment length is determined by **PFAF** location. Determine the **PFAF** location per paragraph 2.13. The maximum length is 10 NM.

4.2.2 Width.

The final segment primary and secondary boundaries are coincident with the intermediate segment boundaries (see paragraph 2.9) from a point 0.3 NM prior to the **PFAF** to a point 1 NM past the **PFAF**. From this point, the Primary **OEA** boundary is ± 0.6 NM (≈ 3,646 ft) from course centerline. A 0.3 NM (≈ 1,823 ft) secondary area is located on each side of the primary area. Where the intermediate segment is not aligned with the final segment, the segment boundaries are constructed under chapter 2, paragraph 2.9.3a.

4.3 Obstacle Clearance Surface (OCS)

Obstacle clearance is provided by application of the **Baro VNAV OCS**. The **OCS** originates at **LTP** elevation at distance $\mathbf{D_{origin}}$ from **LTP** as calculated by formula 4-2.

The **OCS** is a sloping plane in the primary area, rising along the course centerline from its origin toward the **PFAF**. The **OCS** slope ratio calculated under paragraph 4.3.3. In the primary area, the elevation of the **OCS** at any point is the elevation of the **OCS** at the course centerline abeam it. The **OCS** in the secondary areas is a 7:1 surface sloping upward from the edge of the primary area **OCS** perpendicular to the flight track. See figure 4-2.

The primary area **OCS** slope varies with the designed glidepath angle. The effective glidepath angle (actual angle flown) depends on the deviation from International Standard Atmosphere (**ISA**) temperature associated with airport elevation. Calculate the **ISA** temperature for the airport using formula 4-3.

4.3.1 Low Temperature Limitation.

a. **BARO VNAV** criteria does not accommodate for the effect of temperature on the vertical path. Temperatures below ISA (15°C at MSL) will result in a lesser actual glide path angle (than that published) and hence a reduced obstacle clearance.

b. Published low temperature limitation:

   (1) for **non temperature compensating** avionic systems, the instrument procedure shall not be flown when aerodrome temperature is below $\mathbf{T_{LIMC}}$

   (2) for **temperature compensating** avionic systems, the low temperature limitation does not apply and can be ignored.

   (3) A note annotating the $\mathbf{T_{LIMC}}$ must be published on all **BARO VNAV** instrument procedures. Example: “For uncompensated **BARO VNAV** systems, LNAV/VNAV not authorized below -35°C.”

c. Calculation method to determine Low Temperature Limitation ($\mathbf{T_{LIMC}}$)

   (1) Use **Formula 4-4a** to determine the temperature which provides an Actual Glide Path Angle ($\mathbf{GPA_A}$) of 2.5°,

   (2) Use **Formula 4-4b** to determine the temperature deviation ($\mathbf{T_{DEV}}$) from ISA (°C),

   (3) Determine the inner surface ($\mathbf{S_V}$) slope (**Table 4-1**). If the inner slope is penetrated, choose a slope that clears the obstacle. This will result in a higher **GPA**, a smaller $\mathbf{T_{DEV}}$, or a warmer $\mathbf{T_{LIMC}}$. If the outer surface is penetrated, the **GPA** must be raised. In some situations the only alternative will be to raise the **DA**.

   (4) Use **Formula 4-4c** to determine the $\mathbf{T_{LIMC}}$ for the procedure:

   (5) Use **Formula 4-4d** to determine the actual vertical path angle ($\mathbf{GPA_A}$) for a specific temperature. The purpose of this formula is to confirm the $\mathbf{GPA_A}$ is 2.5° or greater.

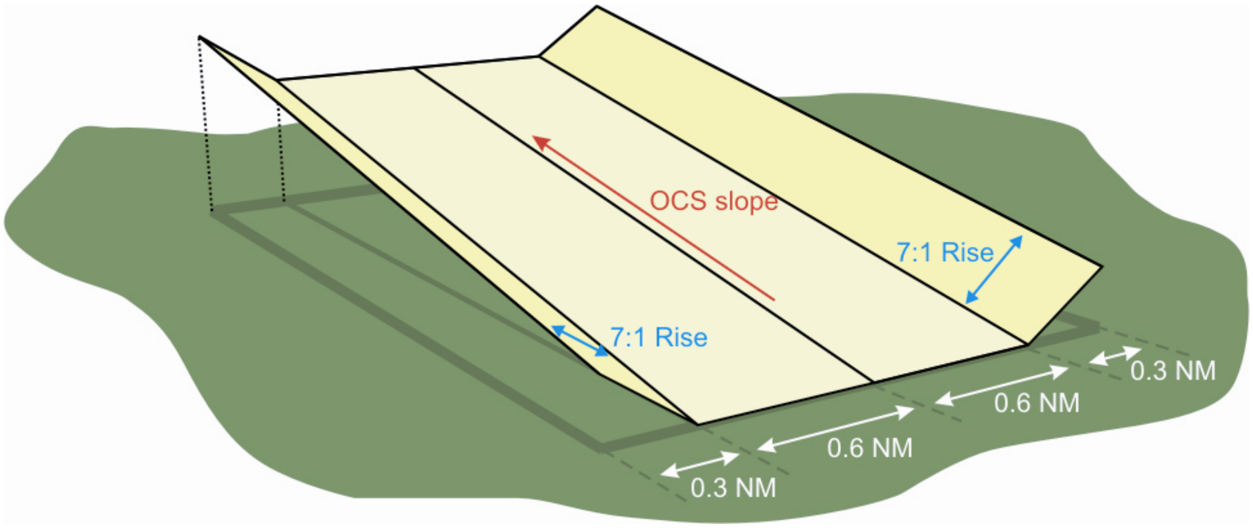


Figure 4-2: Final Segment OCS.

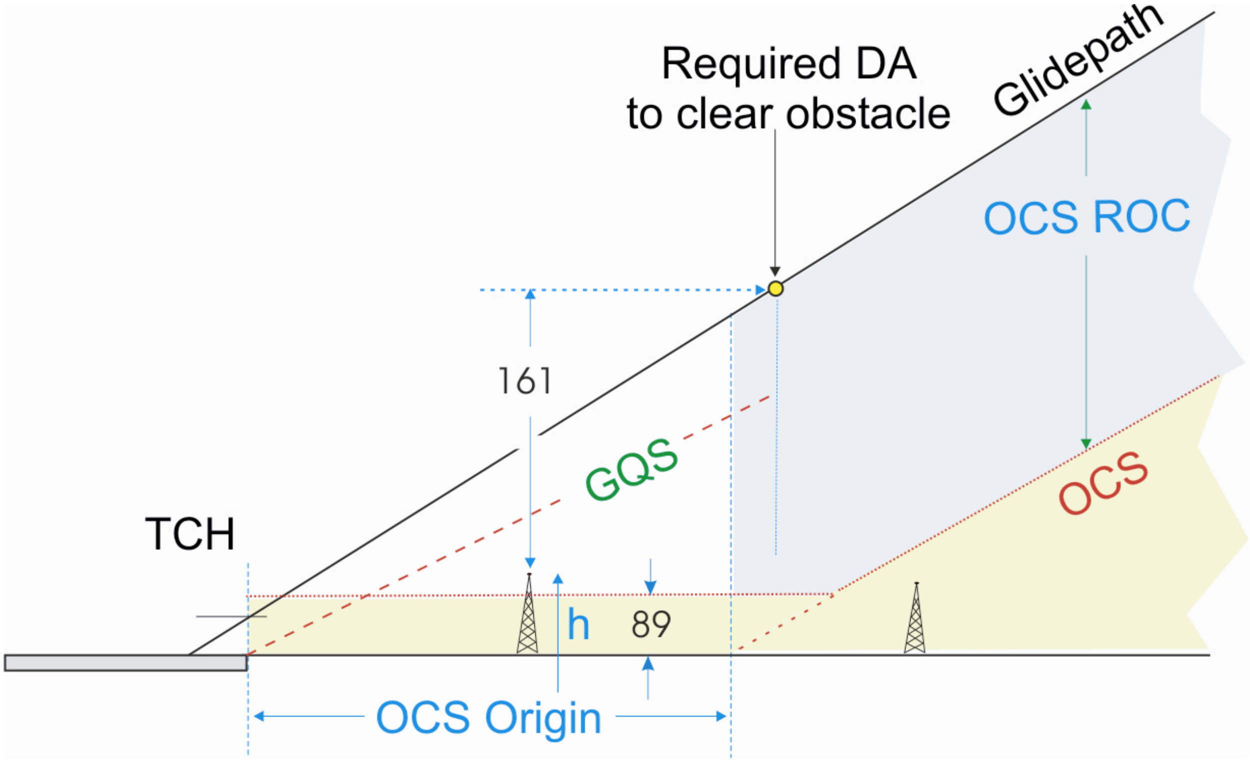


Figure 4-3. Obstacle Evaluation.

4.3.2 Reserved.

4.3.3 OCS Slope.

The **OCS** slope is dependent upon the published glidepath angle (**θ**), airport **ISA**, and the **ACT** temperatures. Determine the **OCS** slope value using formula 4-9.

4.3.4 Final Segment Obstacle Evaluation.

The final segment **OEA** is evaluated by application of an **ROC** and an **OCS**. **ROC** is applied from the **LTP** to the point the **OCS** reaches 89 ft above LTP elevation. The **OCS** is applied from this point to a point 0.3 NM outside the **PFAF**. See figure 4-3.

If an obstacle is in the secondary area (transitional surface), adjust the height of the obstacle using formula 4-10, then evaluate it at the adjusted height as if it is in the primary area.

a. **ROC** application. Apply the appropriate value from Table 4-2 to the higher of the following:

- height of the obstacle exclusion area or
- highest obstacle above the exclusion area.

Calculate the **DA** based on **ROC** application ($\mathbf{DA_{ROC}}$) using formula 4-11. Round the result to the next higher foot value.

b. **OCS** Evaluation.

The **OCS** begins $\mathbf{D_{ORIGIN}}$ from **LTP** at **LTP** elevation ($\mathbf{LTP_E}$). Application of the **OCS** begins at the point the **OCS** reaches 89 ft above **LTP** elevation. Determine the distance from **LTP** that the **OCS** reaches 89 ft above **LTP** using formula 4-12a. The **MSL** elevation of the **OCS** ($\mathbf{OCS_{elev}}$) at any distance ($\mathbf{OBS_X}$) from **LTP** ($\mathbf{OBS_X > D_{origin}}$) is determined using formula 4-12b.

Where obstacles penetrate the **OCS**, determine the minimum **DA** value ($\mathbf{DA_{OCS}}$) based on the **OCS** evaluation by applying formula 4-13 using the penetrating obstacle with the highest **MSL** value (see figure 4-4).

c. Final Segment **DA**. The published **DA** is the higher of $\mathbf{DA_{ROC}}$ or $\mathbf{DA_{OCS}}$.

d. Calculating **DA** to **LTP** distance. Calculate the distance from **LTP** to **DA** using formula 4-14.

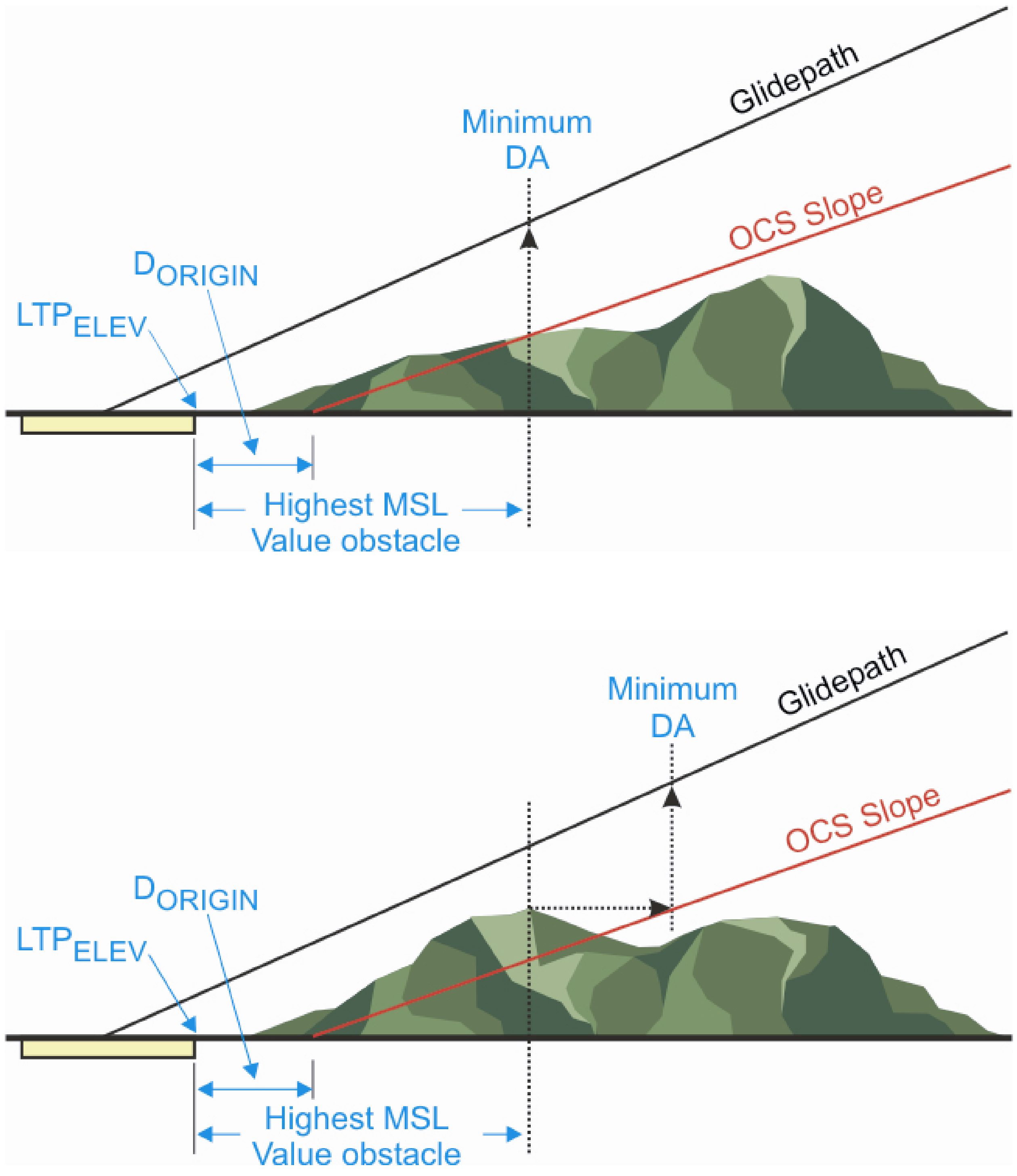


Figure 4-4: OCS Penetrations.

4.4 Missed Approach Section 1

Section 1 extends from **DA** along a continuation of the final course to the start-of climb (**SOC**) point or the point where the aircraft reaches 400 ft above airport elevation, whichever is farther. Turns are not allowed in section 1. See figure 4-6.

4.4.1 Area.

Section 1 provides obstacle protection allowing the aircraft to arrest descent, and configure the aircraft to climb. It begins at a line (**CD** line) perpendicular to the final approach track at **DA** (**D_{DA}** prior to threshold) and extends along the missed approach track to the **AB** line (the **SOC** point or the point the aircraft reaches 400 ft above airport elevation, whichever is farther from the **DA** point). The **OEA** contains a flat **ROC** surface, and a rising **OCS** (40:1 standard) if climb to 400 ft above airport elevation is necessary. See figure 4-5 and 4-6.

a. Length.

The area from the **DA** point to **SOC** is termed the "Flat Surface." Calculate the Flat Surface Length (**FSL**) using formula 4-15a.

The end of the flat surface is **SOC** marked by the **JK** construction line. If the published **DA** is lower than 400 ft above airport, a 40:1 rising surface extension is added to section 1. Calculate the length (in feet) **s1extension** of the extension using formula 4-15b.

b. Width.

The **OEA** splays at an angle of 15 degrees relative to the **FAC** from the outer edge of the final segment secondary area (perpendicular to the final approach course 5,468.5 ft from **FAC**) at the **DA** point. The splay ends when it reaches a point 3 NM from the missed approach course centerline (47,620.38 ft [7.8 NM] from DA point).

c. OCS.

The height of the missed approach surface (**HMAS**) below the **DA** point is determined by formula 4-16 using the **ROC** value (**hl**) from table 4-2. Select the **hl** value for the fastest aircraft category for which minimums are published.

(1) **The missed approach surface remains level (flat)** from the **DA** (**CD** line) point to the **SOC** point (**JK** line). Obstacles must not penetrate the flat surface. Where obstacles penetrate the flat surface, raise the **DA** by the amount of penetration and re-evaluate the missed approach segment. See figure 4-6.

(2) **At SOC the surface begins to rise** along the missed approach course centerline at a slope ratio (40:1 standard) commensurate with the minimum required rate of climb (200 ft/NM standard); therefore, the **OCS** surface rise at any obstacle position is equal to the along-track distance from **SOC** (**JK** line) to a point abeam the obstacle. Obstacles must not penetrate the 40:1 surface. Where obstacles penetrate the 40:1 **OCS**, adjust **DA** by the amount (**ΔDA**) calculated by formula 4-17 and reevaluate the missed approach segment.

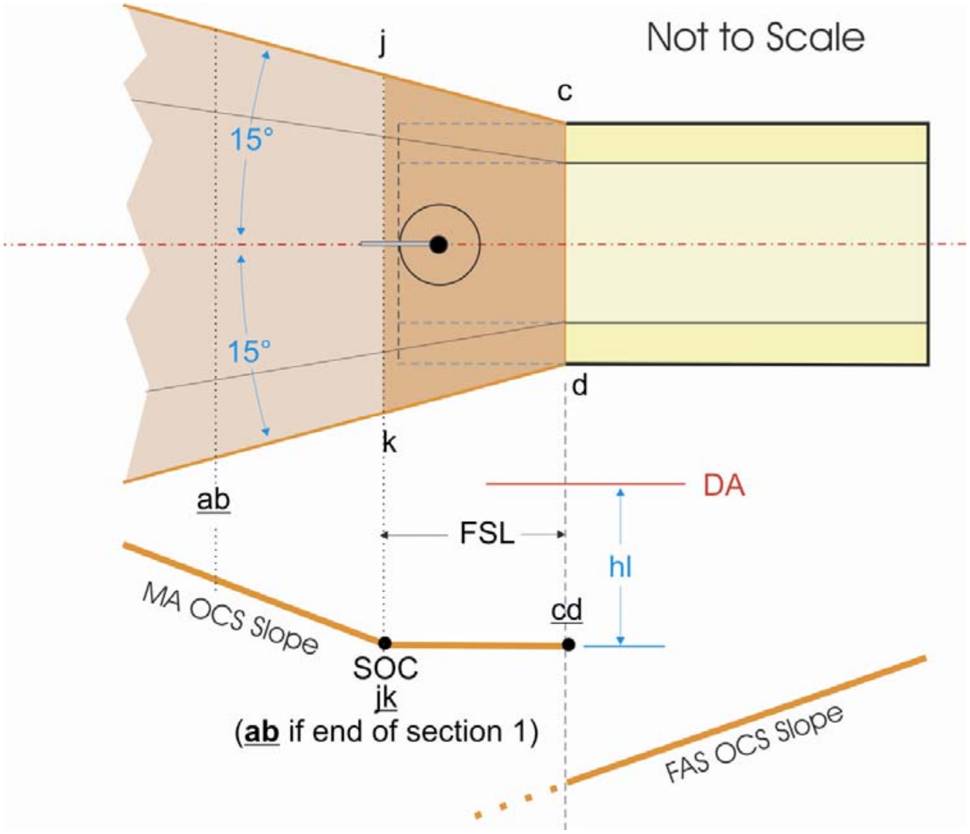


Figure 4-5: Section 1 Area.

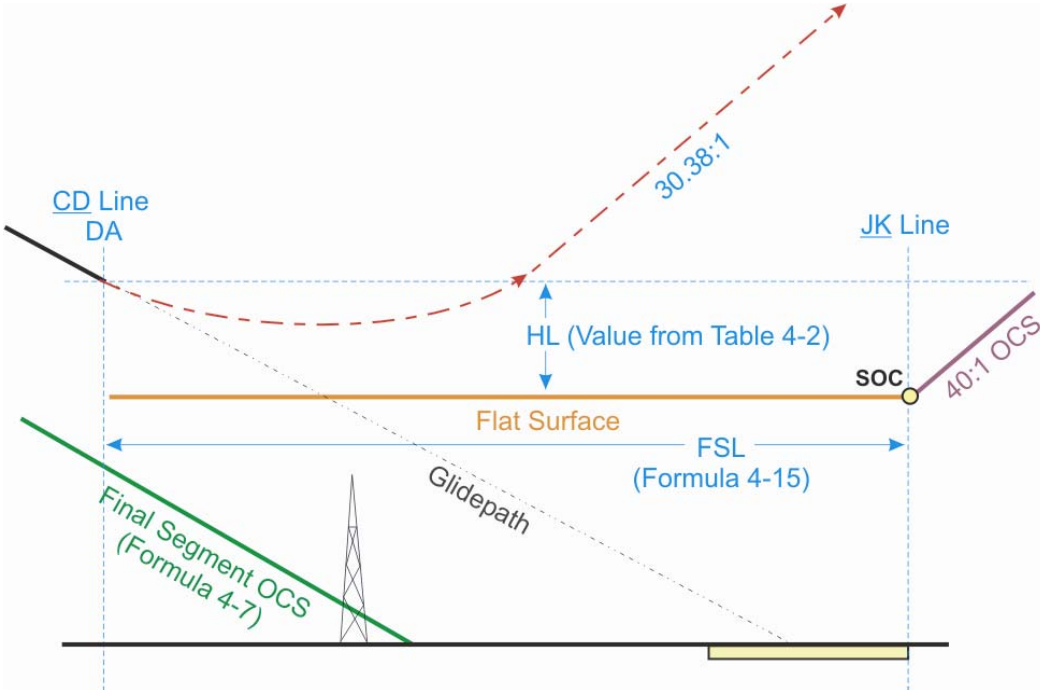


Figure 4-6: Missed Approach Flat Surface.

ISA (C) DEV	Glide Path Angle (GPA)											
	2.7	**2.8**	**2.9**	**3.0**	**3.1**	**3.2**	**3.3**	**3.4**	**3.5**	**3.6**	**3.7**	**3.8**
- 10	23.2	22.4	21.7	21.0	20.4	19.8	19.3	18.8	18.3	17.8	17.4	17.0
- 15	23.8	23.0	22.2	21.6	20.9	20.3	19.8	19.3	18.8	18.3	17.9	17.5
- 20	24.4	23.6	22.9	22.2	21.5	20.9	20.3	19.8	19.3	18.8	18.4	18.0
- 25	25.1	24.3	23.5	22.8	22.1	21.5	20.9	20.3	19.9	19.4	18.9	18.5
- 30	25.8	25.0	24.2	23.4	22.8	22.1	21.5	21.0	20.5	20.0	19.5	19.1
- 35	26.6	25.7	24.9	24.1	23.4	22.8	22.2	21.6	21.1	20.6	20.1	19.6
- 40	27.4	26.5	25.7	24.9	24.2	23.5	22.9	22.3	21.7	21.2	20.7	20.3
- 45	28.2	27.3	26.5	25.7	24.9	24.2	23.6	23.0	22.4	21.9	21.4	20.9
- 50	29.1	28.2	27.3	26.5	25.8	25.0	24.4	23.8	23.2	22.6	22.1	21.6

Note: If the glide path angle falls between table values, use the higher value.

Table 4-1: S_V Considering GPA and ISA Temperature Deviation. Para 4.4.6

Aircraft Category	hl (ft)
A	131
B	142
C	150
D/E	161

Table 4-2. Level Surface ROC Values (hl)

Formula 4-1. Offset Alignment Minimum DA	
Math Notation	$d2 = \frac{V_{KTAS}^{2} \bullet \tan\left(\frac{\alpha}{2} \bullet \frac{\pi}{180}\right)}{68625.4 \bullet \tan\left(18 \bullet \frac{\pi}{180}\right)} \bullet \frac{1852}{0.3048}$ $Min_{HATh} = e^{\frac{(d1+d2)\tan\left(\theta \bullet \frac{\pi}{180}\right)}{r}} \bullet (r + LTP_{elev} + TCH) - (r + LTP_{elev})$
Standard Text	d2=(VKIAS^2*tan(α/2*π/180))/(68625.4*tan(18*π/180))*1852/0.3048 MinHATh=e^(((d1+d2)*tan(θ*π/180))/r)*(r+LTPelev+TCH)-(r+LTPelev)
Given values: α = Degree of offset θ = Glidepath angle r = 20890537 feet LTP_{elev} = LTP MSL elevation d1 = Value from paragraph 4.1.1.b/c as appropriate	

Formula 4-2. Distance OCS Origin

Math Notation	$D_{ORIGIN} = \dfrac{250 - TCH}{\tan\left(\theta \bullet \dfrac{\pi}{180}\right)}$
Standard Text	(250-TCH)/tan(θ*π/180)

Given values:

θ = Glidepath Angle

Formula 4-3. Airport ISA

Math Notation	$ISA_{AIRPORTC} = 15 - 0.00198 \bullet AirportElevation$ $ISA_{AIRPORTF} = 1.8 \bullet ISA_{AIRPORTC} + 32$
Standard Text	ISAairportC=15-0.00198*Airport Elevation ISAairportF=(1.8*ISA airportC)+32

Formula 4-4. Convert ACT from °F to °C.

Math Notation	$ACT°C = \dfrac{ACT°F - 32}{1.8}$
Standard Text	(ACT°F-32)/1.8

Formula 4-4a. Temperature for GPA_A of 2.5°

Math Notation	$T_{2.5} = \dfrac{2.5(288 - (0.00198xh))}{GPA} - 273$
Standard Text	2.5*(288-(0.00198*h))/GPA-273

Given values:

GPA = Published Glide Path Angle
h = Aerodrome Elevation
$T_{2.5}$ = Temperature which gives a glide path angle of 2.5°

Example:

h = 3000 feet
GPA = 3.0°

$$T_{2.5} = \frac{2.5(288 - (0.00198x3000))}{3.0} - 273 = -37.95$$

This value provides an estimate of T_{LIMC}.

Formula 4-4b. Temperature Deviation from ISA

Math Notation	$T_{DEV} = T_{2.5} - [15 - (h/500)]$
Standard Text	T2.5 – [15 – (h/500)]

Given values:

T_{DEV} = Temperature deviation for ISA (°C)
h = Aerodrome Elevation
$T_{2.5}$ = Temperature which gives a glide path angle of 2.5°

Example:

$T_{2.5}$ = -37.95°C (Formula 4-4a)
h = 3000 feet
$T_{DEV} = -37.95 - [15 - (3000/500)] = -46.95$
T_{DEV} = -45°C (rounded warmer 5°C)

Formula 4-4c. Low temperature limitation (T_{LIMC})

Math Notation	$T_{LIMC} = T_{DEV} + [15 - (h/500)]$
Standard Text	TDEV + [15 – (h/500)]

Given values:

T_{LIMC} = Low Temperature Limitation (°C)
T_{DEV} = Temperature deviation for ISA (°C)
h = Aerodrome Elevation

Example:

h = 3000 feet
T_{DEV} = -45°C (Formula 4-4b)
$T_{LIMC} = -45°C + [15°C - (3000/500)] = -36°C$
Round the result to the warmest whole degree.

Formula 4-4d. Actual Vertical Path Angle for Temperature

Math Notation	$GPA_A = \frac{GPA(273 + T_{LIMC})}{288 - (0.00198 * h)}$
Standard Text	GPA*(273+TLIMC)/(288-(0.00198*h))

Given values:

GPA = Published Glide Path Angle
GPA_A = Actual GPA at selected temperature
h = Aerodrome Elevation
T_{LIMC} = Low Temperature Limitation (Formula 4-4c)

Example:

T_{LIMC} = -36°C
h = 3000 feet
GPA = 3.0°

$$GPA_A = \frac{3(273 + (-36))}{288 - (0.00198 * 3000)} = 2.52°$$

Formula 4-5. Maximum Descent Rate Angle

Math Notation	$V_{KTAS} = V_{KIAS} \bullet \frac{171233 \bullet \sqrt{288 - 0.00198 \bullet \left(LTP_{elev}\right) + 250}}{\left(288 - 0.00198 \bullet \left(LTP_{elev} + 250\right)\right)^{2.628}}$ $MDR_{angle} = \frac{180}{\pi} \bullet a\sin\left(\frac{60 \bullet 1000}{\left(V_{KTAS} + 10\right) \bullet \frac{1852}{0.3048}}\right)$
Standard Text	VKTAS = VKIAS*(171233*(288-0.00198*(LTPelev+250))^0.5)/(288-0.00198*(LTPelev+250))^2.628 MDRangle = 180/π*asin(60000/((VKTAS+10)*1852/0.3048))
Given values: V_{KIAS} = Indicated airspeed LTP_{elev} = LTP MSL elevation	

Formula 4-6. High Temp PFA Alt

Math Notation	$c = e^{\frac{D_{PFAF} \bullet \tan\left(MDR_{angle} \bullet \frac{\pi}{180}\right)}{r}} \bullet \left(r + LTP_{elev} + TCH\right) - r$
Standard Text	e^((DPFAF*tan(MDRangle*π/180))/r)*(r+LTPelev+TCH)-r
Given values: D_{PFAF} = Value from paragraph 2.13 LTP_{elev} = LTP MSL elevation TCH = Threshold crossing height MDR_{angle} = Result of formula 4-5 LTP_{elev} = LTP MSL elevation	

Formula 4-7. ΔISA$_{high}$ Calculation.

Math Notation	$\Delta ISA_{high} = \frac{c - PFAF_{alt} + 0.032 \bullet \left(PFAF_{alt} - \left(LTP_{elev} + 250\right)\right) - 4.9}{0.19 + 0.0038 \bullet \left(PFAF_{alt} - \left(LTP_{elev} + 250\right)\right)}$
Standard Text	(c-PFAFalt+0.032*(PFAFalt-(LTPelev+250))-4.9)/(0.19+0.0038*(PFAFalt-(LTPelev+250)))

Formula 4-8. Maximum Descent Rate Angle

Math Notation	$NA_{above}\left(C^\circ\right) = Airport_{ISA} + \Delta ISA_{high}$ $NA_{above}\left(F^\circ\right) = NA_{above}\left(C^\circ\right) \bullet 1.8 + 32$
Standard Text	NA$_{above}$(C°)=AirportISA+ΔISA$_{high}$ NA$_{above}$(F°)=NA$_{above}$(C°)*1.8+32 For ΔISA$_{high}$ see Formula 4-7

Formula 4-9. OCS Slope.

Math Notation	$OCS_{slope} = \dfrac{1}{\tan\left(\theta \bullet \dfrac{\pi}{180}\right) \bullet \left(0.928 + 0.0038 \bullet \left(ACT°C - ISA°C\right)\right)}$
Standard Text	1/(tan(θ*π/180)*(0.928+0.0038*(ACT°C- ISA°C)))

Given values:

θ = Glidepath angle

ISA°C = Airport ISA from formula 4-3

ACT°C = Value from paragraph 4.3.1

Formula 4-10. Secondary Area Adjusted Obstacle Height.

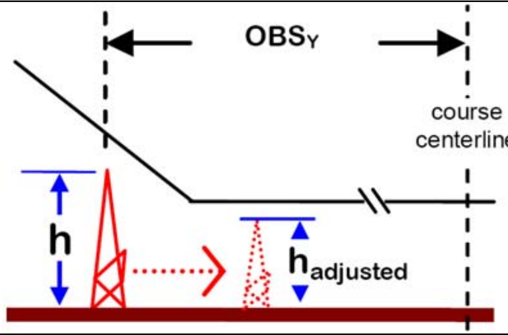
Math Notation	$h_{adjusted} = h - \dfrac{OBS_Y - Width_{primary}}{7}$
Standard Text	h-(OBSY-Widthprimary)/7

Given values:

h = Obstacle MSL elevation

$Width_{primary}$ = Perpendicular distance (ft) of primary boundary from course centerline

OBS_Y = Obstacle perpendicular distance (ft) from course centreline



Formula 4-11. DA Based on ROC Application

Math Notation	$DA_{ROC} = h + hl$
Standard Text	h+hl

Given values:

h = Higher of:
Obstacle MSL elevation ($h_{adjusted}$ if in secondary, or
Height of Obstacle exclusion surface (89 ft above LTP elev)
hl = Level surface ROC value (Table 4-2)

Formula 4-12a. Distance from LTP that OCS application begins

Math Notation	$D_{OCS} = D_{origin} + r \bullet OCS_{slope} \bullet \ln\left(\frac{LTP_{elev} + 89 + r}{r + LTP_{elev}}\right)$
Standard Text	D_{origin}+r*OCS_{slope}*ln((LTP_{elev}+89+r)/(r+LTP_{elev}))

Given values:

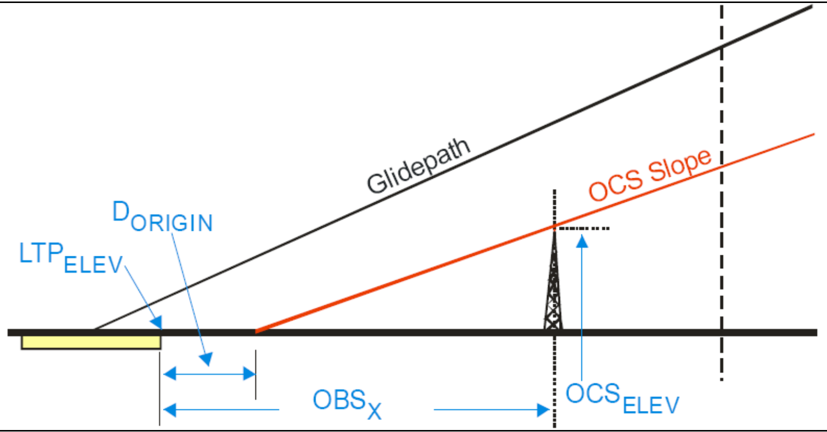
LTP_{elev} = LTP MSL elevation
D_{origin} = Distance from formula 4-2
OCS_{slope} = Slope from formula 4-9
r = 20890537
e = 2.17182818284

Formula 4-12b. OCS Elevation.

Math Notation	$OCS_{elev} = (r + LTP_{elev}) \bullet e^{\frac{OBS_X - D_{origin}}{r \bullet OCS_{slope}}} - r$
Standard Text	(r+LTPelev)*e^((OBSX-Dorigin)/(r*OCSslope))-r

Given values:

LTP_{elev} = LTP MSL elevation
D_{origin} = Distance (ft) from LTP to OCS origin
OCS_{slope} = OCS slope ratio (run/rise; e.g., 34)
OBS_X= Distance (ft) measured along course from LTP
r = 20890537
e = 2.17182818284



Formula 4-13. DA Based on OCS	
Math Notation	$d = \left(r + LTP_{elev}\right) \bullet OCS_{slope} \bullet \ln\left(\frac{r + O_{MSL}}{r + LTP_{elev}}\right) + D_{origin}$ $DA_{OCS} = e^{\frac{d \bullet \tan\left(\theta \bullet \frac{\pi}{180}\right)}{r}} \bullet \left(r + LTP_{elev} + TCH\right) - r$
Standard Text	d = (r+LTPelev)*OCSslope*LN((r+OMSL)/(r+LTPelev))+Dorigin DAOCS = e^((d*tan(θ*π/180))/r)*(r+LTPelev+TCH)-r

Given values:

θ = Glidepath angle
O_{MSL} = Obstacle MSL elevation
D_{origin} = Value from formula 4-2
LTP_{elev} = LTP MSL elevation
OCS_{slope} = Value from formula 4-9
TCH = Threshold crossing height
r = 20890537
e = 2.17182818284

Formula 4-14. Distance to DA	
Math Notation	$D_{DA} = \frac{\ln\left(\frac{r + DA}{r + LTP_{elev} + TCH}\right) \bullet \left(r + LTP_{elev}\right)}{\tan\left(\theta \bullet \frac{\pi}{180}\right)}$
Standard Text	(ln((r+DA)/(r+LTPelev+TCH))*(r+LTPelev))/tan(θ*π/180)

Given values:

LTP_{elev} = LTP MSL elevation
TCH = Threshold crossing height in feet
r = 20890537
θ = Glidepath angle

Formula 4-15a. Flat Surface Length	
Math Notation	$FSL = 25.317\left(\left(V_{KIAS} \bullet \frac{171233 \bullet \sqrt{(288+15) - 0.00198 \bullet DA}}{(288 - 0.00198 \bullet DA)^{2.628}}\right) + 10\right)$
Standard Text	25.317*((VKIAS*(171233*((288+15)-0.00198*DA)^0.5)/(288-0.00198*DA)^2.628)+10)

Given values:

V_{KIAS} = Knots indicated airspeed
DA = Decision altitude

Formula 4-15b. Calculation of extension for climb to 400 ft.	
Math Notation	$D_{DA} = \dfrac{\ln\left(\dfrac{r+DA}{r+LTP_{elev}+TCH}\right)\bullet\left(r+LTP_{elev}\right)}{\tan\left(\theta\bullet\dfrac{\pi}{180}\right)}$
Standard Text	(ln((r+DA)/(r+LTPelev+TCH))*(r+LTPelev))/tan(θ*π/180)

Given values:

Z = Number of feet to climb to reach 400’ above airport

CG = Climb gradient (standard 200)

Formula 4-16. HMAS Elevation.	
Math Notation	$HMAS = DA - hl$
Standard Text	DA-hl

Given values:

hl = Level surface ROC from table 4-2

Formula 4-17. DA Adjustment Value.	
Math Notation	$\Delta DA = e^{\frac{p\bullet\frac{MAslope\bullet\tan\left(\theta\bullet\frac{\pi}{180}\right)}{1+MAslope\bullet\tan\left(\theta\bullet\frac{\pi}{180}\right)}}{r}}\bullet r - r$
Standard Text	e^((p*(MAslope*tan(θ*π/180))/(1+MAslope*tan(θ*π/180))/r))*r-r

Given values:

p = Number of feet to climb to reach 400’ above airport

θ = Glidepath angle

MA_{slope} = MA OCS slope (nominally 40:1)

r = 20890537

CHAPTER 5. LPV FINAL APPROACH SEGMENT (FAS) EVALUATION

5.0 General

The obstruction evaluation area (**OEA**) and associated obstacle clearance surfaces (**OCSs**) are applicable to **LPV** final approach segments. These criteria may also be applied to construction of an RNAV transition to an **ILS** final segment where the glidepath intercept point (**GPIP**) is located within 50,200 ft of the **LTP**. For RNAV transition to **ILS** final, use **LPV** criteria to evaluate the final and missed approach section 1.

5.1 Final Segment Obstruction Evaluation Area (OEA)

The **OEA** originates 200 ft from **LTP** or **FTP** as appropriate, and extends to a point ≈131 ft (40 meters **ATT**) beyond the **GPIP** (**GPIP** is determined using formula 2-16a). It is centered on the final approach course and expands uniformly from its origin to a point 50,000 ft from the origin where the outer boundary of the **X** surface is 6,076 ft perpendicular to the course centerline. Where the **GPIP** must be located more than 50,200 ft from **LTP**, the **OEA** continues linearly (boundaries parallel to course centerline) to the **GPIP** (see figure 5-1)*. The primary area **OCS** consists of the **W** and **X** surfaces. The **Y** surface is an early missed approach transitional surface. The **W** surface slopes longitudinally along the final approach track, and is level perpendicular to track. The **X** and **Y** surfaces slope upward from the edge of the **W** surface perpendicular to the final approach track. Obstacles located in the **X** and **Y** surfaces are adjusted in height to account for perpendicular surface rise and evaluated under the **W** surface.

Note: * **ILS** continues the splay, only **LPV** is linear outside 50,200 ft.

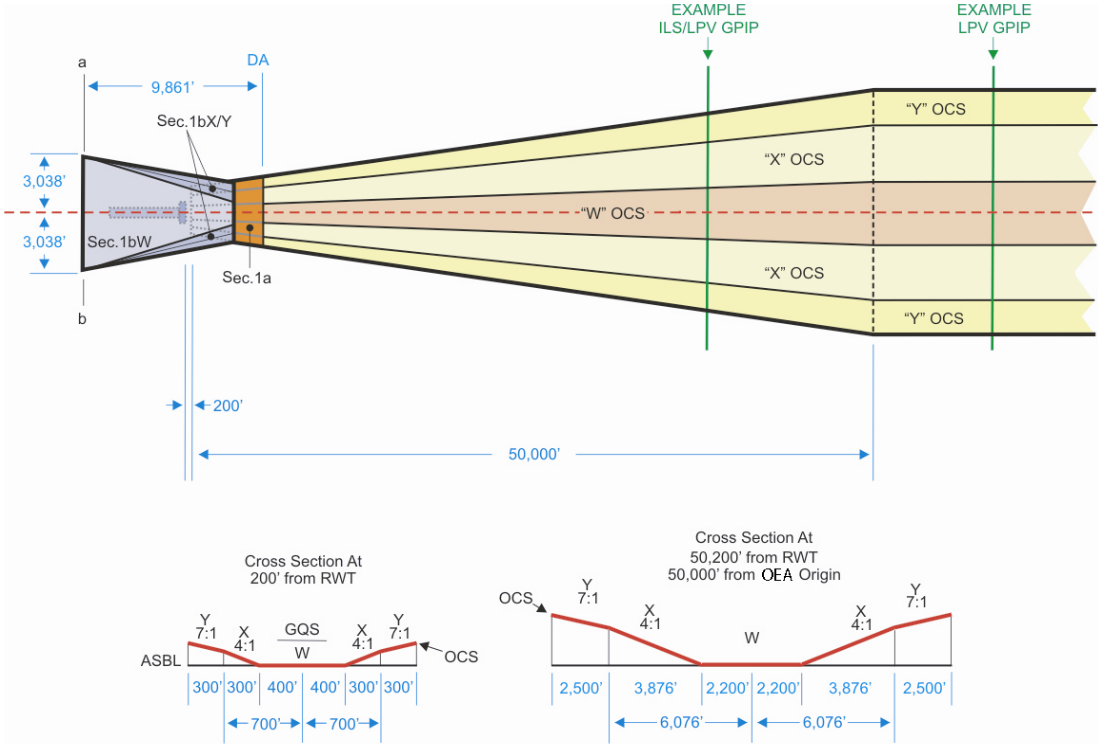


Figure 5-1: LPV/ILS Final/Missed Section 1 OCSs.

5.1.1 OEA Alignment.

The final course is normally aligned with the runway centerline (**RCL**) extended (± 0.03°) through the **LTP** (± 5 ft). Where a unique operational requirement indicates a need to offset the course from **RCL**, the offset must not exceed 3 degrees measured geodetically* at the point of intersection. If the course is offset, it must intersect the **RCL** at a point 1,100 to 1,200 ft inside the decision altitude (**DA**) point (see figure 5-2). Where the course is not aligned with **RCL**, the minimum **HATh** value is 250.

Note: * Geodetic measurements account for the convergence of lines of longitude. Plane geometry calculations are not compatible with geodetic measurements.

5.1.2 OCS Slope(s) (see figure 5-3).

In this document, slopes are expressed as run over rise; e.g., 34:1. Determine the **OCS** slope (**S**) associated with a specific glidepath angle (**θ**) using formula 5-1.

5.1.3 OCS Origin.

The **OEA** (all **OCS** surfaces) originates from **LTP** elevation at a point 200 ft from **LTP** (see figure 5-3) measured along course centerline and extends approximately 131 feet (40m) beyond the **GPIP**. The longitudinal (along-track) rising W surface slope begins at a point 200+d feet from **OEA** origin. The value of **d** is dependent on the **TCH**/glidepath angle relationship.

Where $\dfrac{TCH}{\tan\left(\theta \bullet \dfrac{\pi}{180}\right)} \geq 954$, d equals zero (0),

Where $\dfrac{TCH}{\tan\left(\theta \bullet \dfrac{\pi}{180}\right)} < 954$, calculate the value of d using formula 5-2.

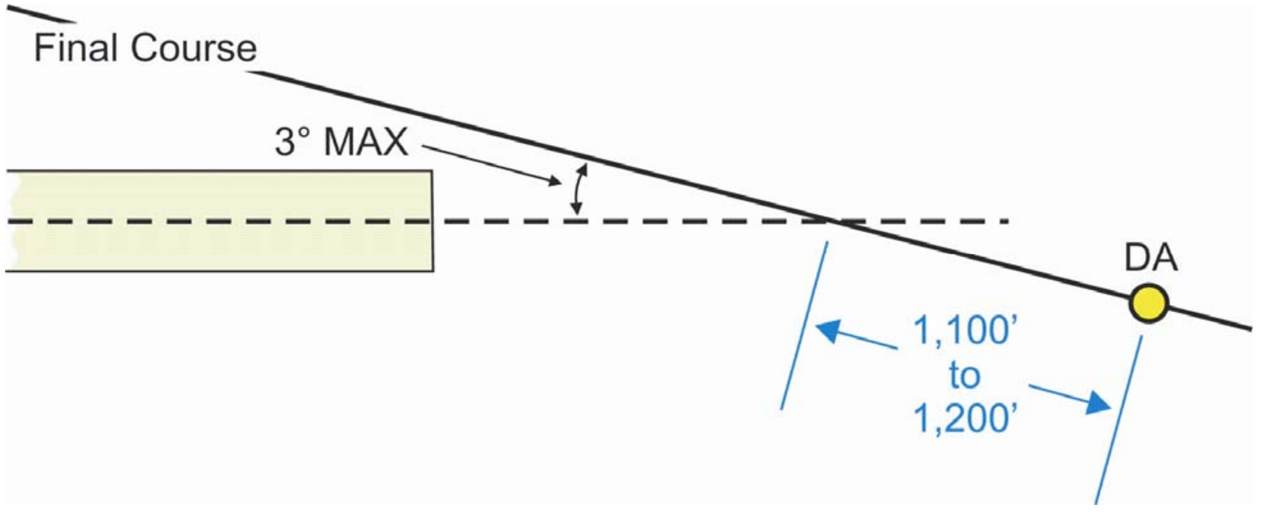


Figure 5-2: Offset Final Course.

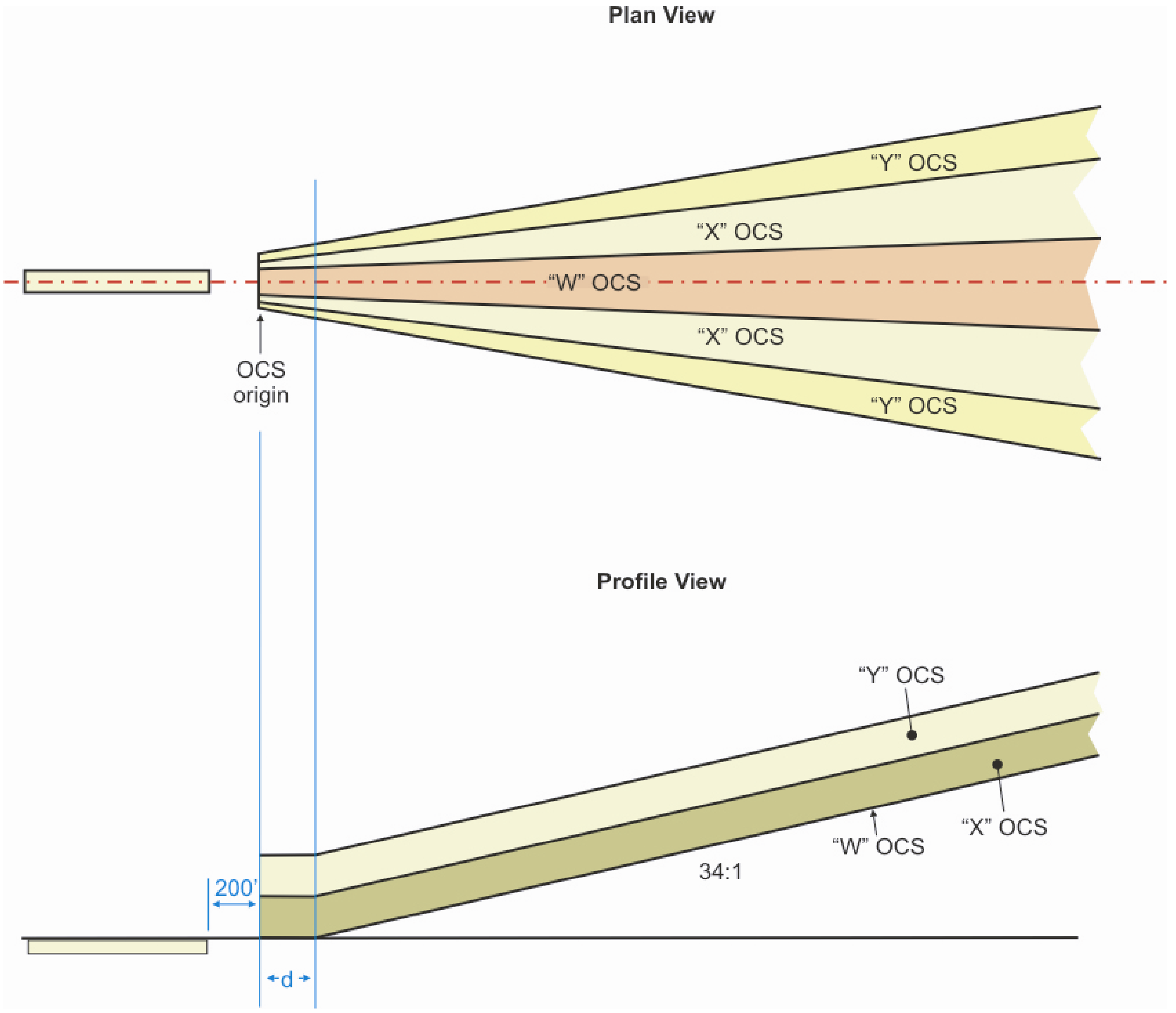


Figure 5-3: OCS Slope Origin.

5.2 **W OCS** (See Figure 5-4)

All final segment **OCS** (**W, X, and Y**) obstacles are evaluated relative to the height of the **W** surface based on their along-track distance (**OBS_X**) from the **LTP**, perpendicular distance (**OBS_Y**) from the course centerline, and **MSL** elevation (**OBS_{MSL}**) adjusted for earth curvature and **X/Y** surface rise if appropriate. This adjusted elevation is termed obstacle evaluation elevation (**OEE**) and is covered in paragraph 5.2.2.

5.2.1 Width. (Perpendicular distance from course centerline to surface boundary)

The perpendicular distance (**$W_{boundary}$**) from course centerline to the boundary is 400 ft at the origin, and expands uniformly to 2,200 ft at a point 50,200 ft from **LTP**/**FTP**.

Calculate **$W_{boundary}$** for any distance from **LTP** using formula 5-3. For obstacle evaluation purposes, the distance from **LTP** is termed **OBS_X**.

5.2.2 Height.

Calculate the **MSL** height (ft) of the **W OCS** (**W_{MSL}**) at any distance **OBS_X** from **LTP** using formula 5-4.

The **LPV** (and **ILS**) glidepath is considered to be a straight line in space extending from **TCH**. The **OCS** is; therefore, a flat plane (does not follow earth curvature) to protect the straight-line glidepath. The elevation of the **OCS** at any point is the elevation of the **OCS** at the course centerline abeam it. Since the earth's surface curves away from these surfaces as distance from **LTP** increases, the **MSL** elevation (**OBS_{MSL}**) of an obstacle is reduced to account for earth curvature. This reduced value is termed the obstacle effective **MSL** elevation (**OEE**). Calculate **OEE** using formula 5-5.

5.2.3 W OCS Evaluation.

Compare the obstacle **OEE** to **W_{MSL}** at the obstacle location. Lowest minimums are achieved when the W surface is clear. To eliminate or avoid a penetration, take one or more of the following actions listed in the order of preference.

a. Remove or adjust the obstruction location and/or height.

b. Displace the **RWT**.

c. Raise the **GPA** (see paragraph 5.6) within the limits of table 2-4.

d. Adjust **DA** (for existing obstacles only) see paragraph 5.5.2.

e. Raise **TCH** (see paragraph 5.7).

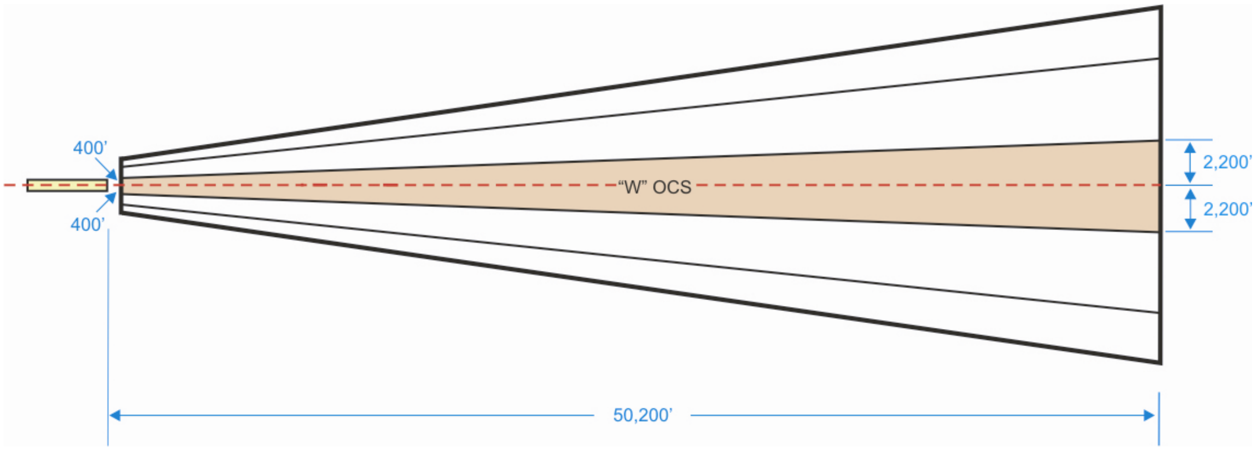


Figure 5-4: W OCS.

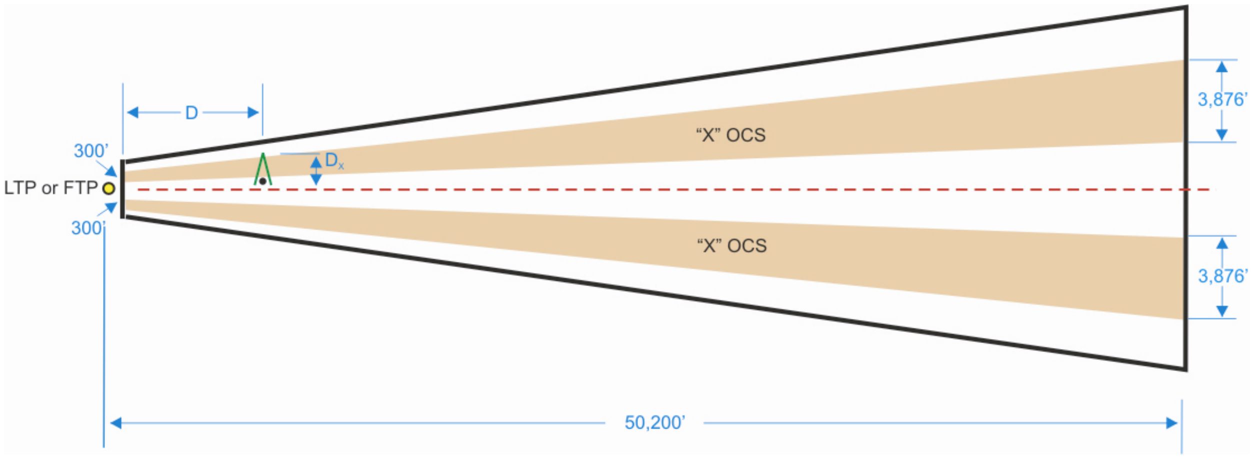


Figure 5-5: X OCS.

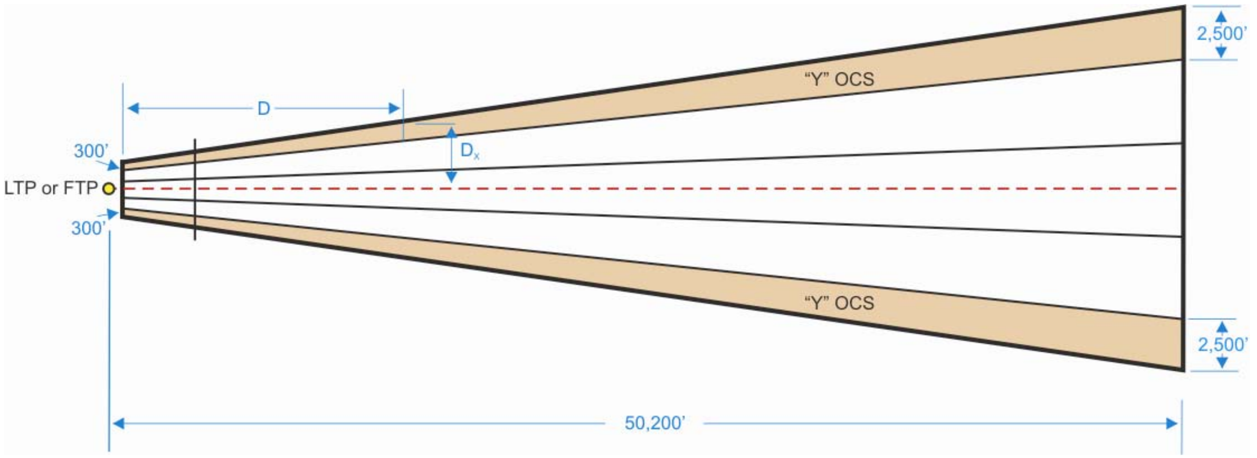


Figure 5-6: Y OCS.

5.3 X OCS (See Figure 5-5)

5.3.1 Width.

The perpendicular distance from the course centerline to the outer boundary of the **X OCS** is 700 ft at the origin and expands uniformly to 6,076 ft at a point 50,200 ft from **LTP/FTP**. Calculate the perpendicular distance ($\mathbf{X_{boundary}}$) from the course centerline to the **X** surface boundary using formula 5-6.

Note: Where the intermediate segment is NOT aligned with the **FAC**, take into account the expansion of the final based on the intermediate segment taper.

5.3.2 X Surface Obstacle Elevation Adjustment (Q).

The **X OCS** begins at the height of the **W** surface and rises at a slope of 4:1 in a direction perpendicular to the final approach course. The **MSL** elevation of an obstacle in the **X** surface is adjusted (reduced) by the amount of surface rise. Use formula 5-7 to determine the obstacle height adjustment (**Q**) for use in formula 5-5.

Evaluate the obstacle under paragraphs 5.2.2 and 5.2.3.

5.4 Y OCS (See Figure 5-6)

5.4.1 Width.

The perpendicular distance from the course centerline to the outer boundary of the **Y OCS** is 1,000 ft at the origin and expands uniformly to 8,576 ft at a point 50,200 ft from **LTP/FTP**. Calculate the perpendicular distance ($Y_{boundary}$) from the course centerline to the **Y** surface boundary using formula 5-8.

Note: Take into account the expansion of the final based on the intermediate segment taper.

5.4.2 Y Surface Obstacle Elevation Adjustment (Q).

The **Y OCS** begins at the height of the **X** surface and rises at a slope of 7:1 in a direction perpendicular to the final approach course. The **MSL** elevation of an obstacle in the **Y** surface is adjusted (reduced) by the amount of **X** and **Y** surface rise. Use formula 5-9 to determine the obstacle height adjustment (**Q**) for use in formula 5-5. Evaluate the obstacle under paragraphs 5.2.2 and 5.2.3.

5.5 HATh and DA

The **DA** value may be derived from the **HATh**. Where the **OCS** is clear, the minimum **HATh** for **LPV** operations is the greater of 200 ft or the limitations noted on table 2-4. If the **OCS** is penetrated, minimum **HATh** is 250. Round the **DA** result to the next higher whole foot.

5.5.1 DA Calculation (Clear OCS).

Calculate the **DA** using formula 5-10.

Calculate the **along-course distance** in feet from **DA to LTP/FTP (X_{DA})** using formula 5-11.

5.5.2 DA Calculation (OCS Penetration). (See figure 5-7)

Calculate the adjusted **DA** for an obstacle penetration of the **OCS** using formula 5-12.

5.6 Revising Glidepath Angle (GPA) for OCS Penetrations

Raising the **GPA** may eliminate **OCS** penetrations. To determine the revised minimum **GPA**, use formula 5-13.

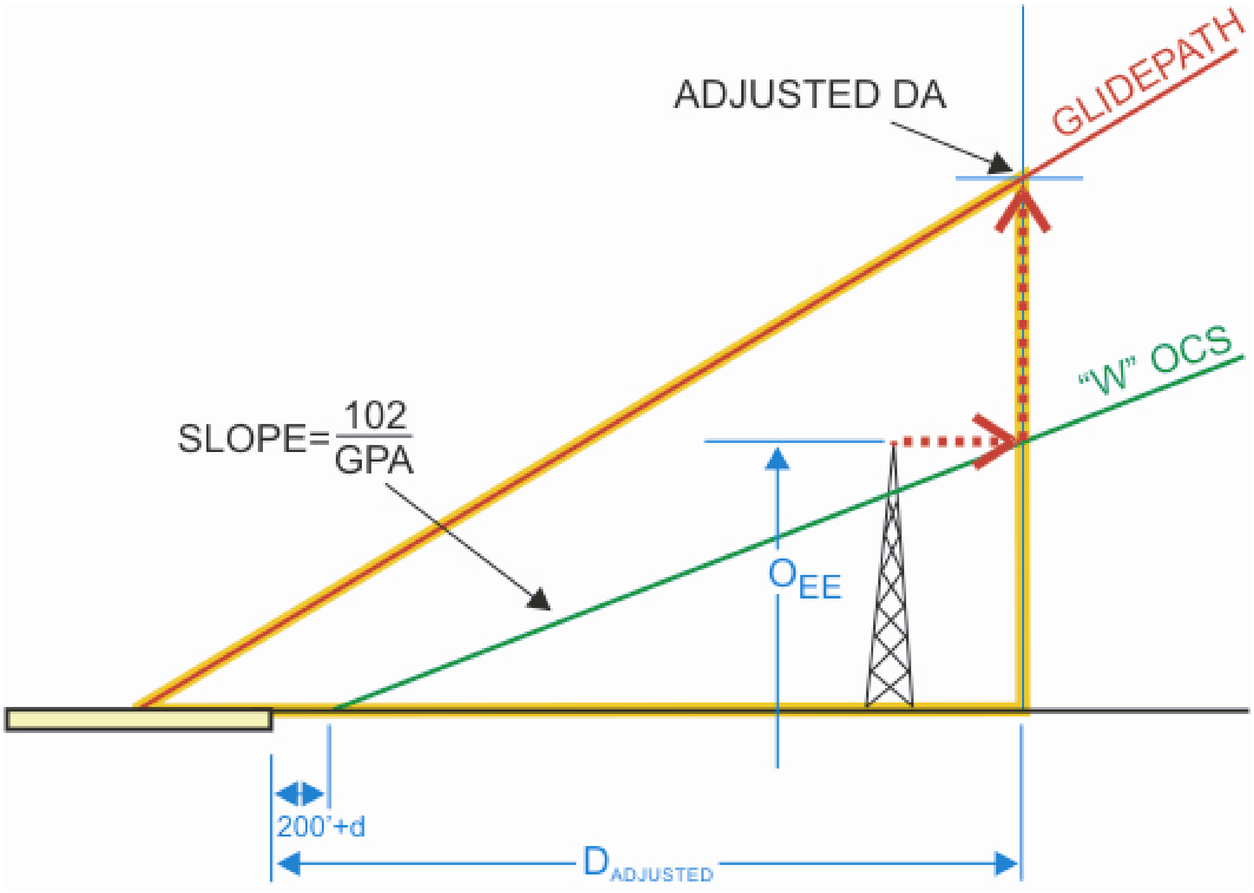


Figure 5-7: DA Adjustment.

5.7 Adjusting TCH To Reduce/Eliminate OCS Penetrations

This paragraph is applicable ONLY where **d** from paragraph 5.1.3, formula 5-2, is greater than zero. Adjusting **TCH** is the equivalent to relocating the glide slope antenna in **ILS** criteria. The goal is to move the **OCS** origin toward the **LTP/FTP** (no closer than 200 ft) sufficiently to raise the **OCS** at the obstacle location. To determine the maximum **W** surface vertical relief (**Z**) that can be achieved by adjusting **TCH**, apply formula 5-14. If the value of **Z** is greater than the penetration (**p**), you may determine the amount to increase **TCH** by applying formula 5-15. If this option is selected, re-evaluate the final segment using the revised **TCH** value.

5.8 Missed Approach Section 1 (Height Loss and Initial Climb)

Section 1 begins at **DA** (**CD** line) and ends at the **AB** line. It accommodates height loss and establishment of missed approach climb gradient. Obstacle protection is based on an assumed minimum climb gradient of 200 ft/NM (≈30.38:1 slope). Section 1 is centered on a continuation of the final approach track and is subdivided into sections 1a and 1b (see figures 5-8a and 5-8b).

5.8.1 Section 1a.

Section 1a is a 1,460 ft continuation of the **FAS OCS** beginning at the **DA** point to accommodate height loss. The portion consisting of the continuation of the **W** surface is identified as section **1aW**. The portions consisting of the continuation of the **X** surfaces are identified as section **1aX**. The portions consisting of the continuation of the **Y** surfaces are identified as section **1aY**. Calculate the width and elevation of the section **1aW**, **1aX**, and **1aY** surfaces at any distance from **LTP** using the final segment formulas.

5.8.2 Section 1b.

The section 1b surface extends from the **JK** line at the end of section 1a as an upsloping surface for a distance of 8,401 ft to the **AB** line. Section 1b is subdivided into sections **1bW**, **1bX**, and **1bY** (see figure 5-8b).

a. **Section 1bW.** Section **1bW** extends from the end of section **1aW** for a distance of 8,401 ft. Its lateral boundaries splay from the width of the end of the **1aW** surface to a width of ± 3,038 ft either side of the missed approach course at the 8,401 ft point.

Calculate the width of the **1bW** surface ($\mathbf{width_{1bW}}$) at any distance $\mathbf{d_{1aEnd}}$ from the end of section 1a using formula 5-16.

Calculate the elevation of the end of the **1aW** surface ($\mathbf{elev_{1aEnd}}$) using formula 5-17.

The surface rises from the elevation of the **1aW** surface at the end of section 1a at a slope ratio of 28.5:1. Calculate the elevation of the surface ($\mathbf{elev_{1bW}}$) using formula 5-18.

b. **Section 1bX.** Section **1bX** extends from the end of section **1aX** for a distance of 8,401 ft. Its inner boundary is the outer boundary of the **1bW** surface. Its outer boundary splays from the end of the **1aX** surface to a width of ± 3,038 ft either side of the missed approach course at the 8,401 ft point. Calculate the distance from the missed approach course centerline to the surface outer boundary ($\mathbf{width_{1bX}}$) using formula 5-19.

The surface rises at a slope ratio of 4:1 perpendicular to the missed approach course from the edge of the **1bW** surface. Calculate the elevation of the **1bX** missed approach surface ($\mathbf{elev_{1bX}}$) using formula 5-20.

c. **Section 1bY.** Section **1bY** extends from the end of section **1aY** for a distance of 8,401 ft. Its inner boundary is the outer boundary of the **1bX** surface. Its outer boundary splays from the outer edge of the 1aY at the surface at the end of section 1a to a width of ± 3,038 ft either side of the missed approach course at the 8,401 ft point.

Calculate the distance from the missed approach course centerline to the surface outer boundary ($\mathbf{width_{1bY}}$) using formula 5-21.

The surface rises at a slope ratio of 7:1 perpendicular to the missed approach course from the edge of the **1bX** surface. Calculate the elevation of the **1bY** missed approach surface ($\mathbf{elev_{1bY}}$) using formula 5-22.

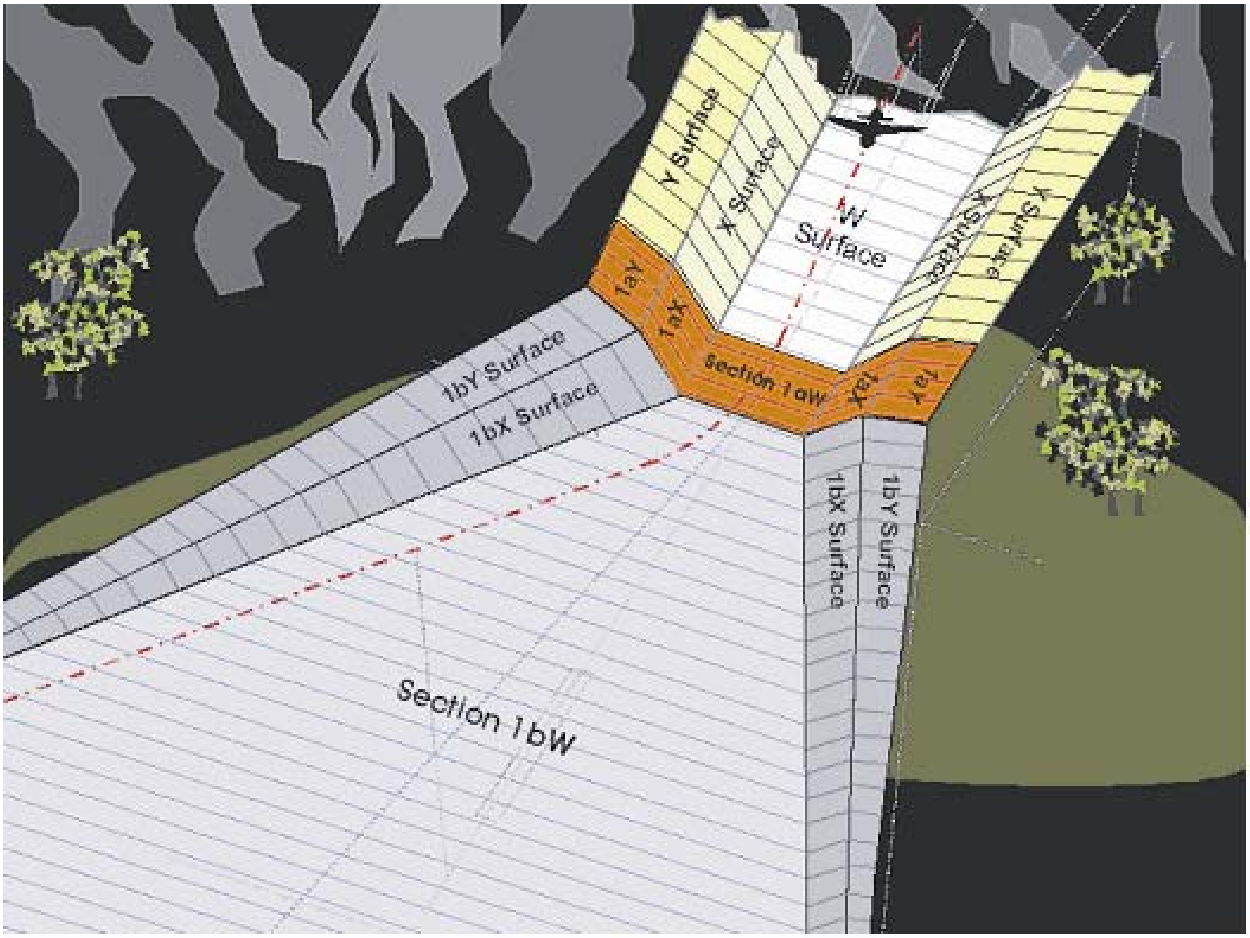


Figure 5-8a: Section 1 3D Perspective.

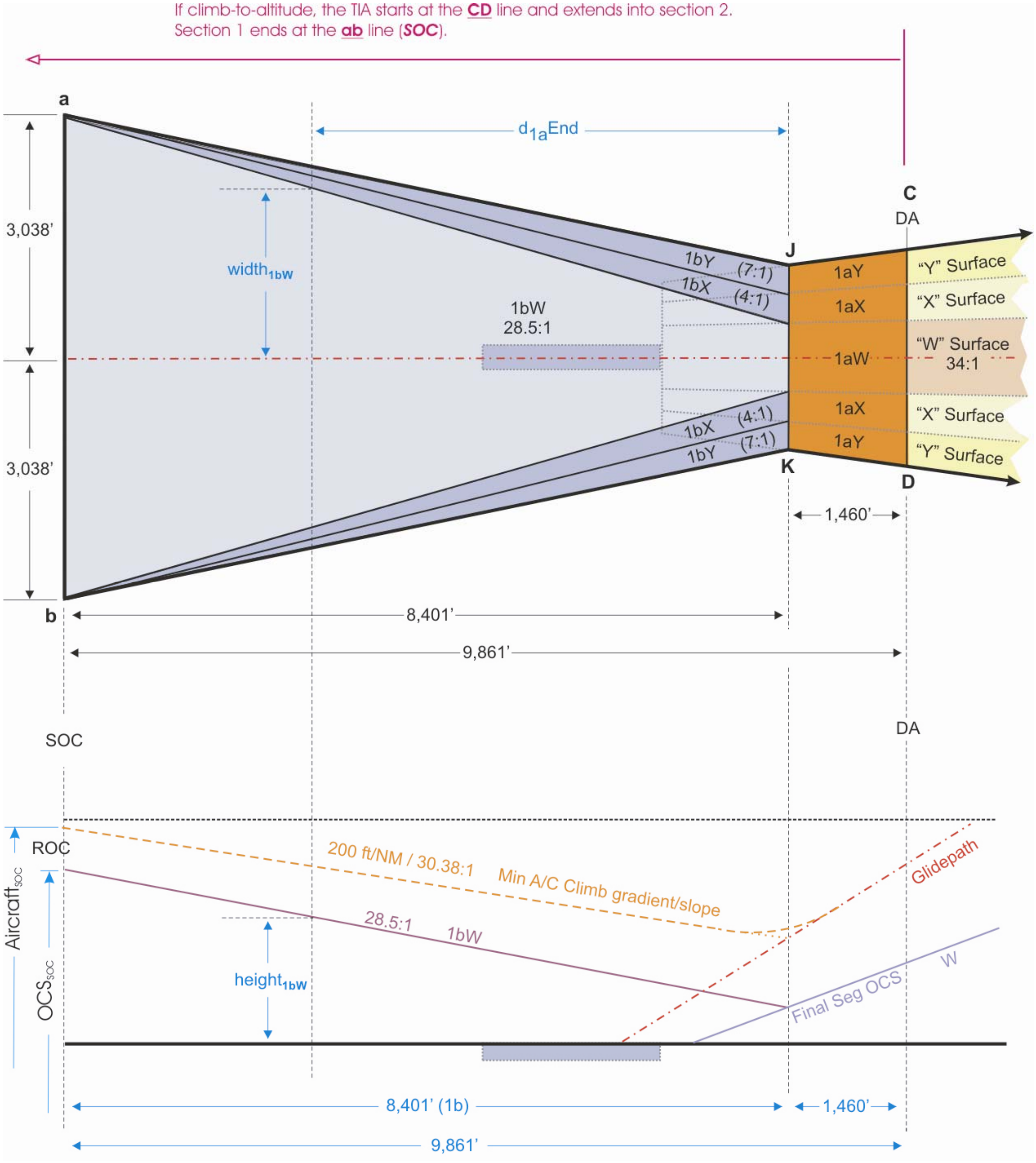


Figure 5-8b: Section 1 (a/b) 2D Perspective.

5.9 Surface Height Evaluation

5.9.1 Section 1a.

Obstacles that penetrate these surfaces are mitigated during the final segment OCS evaluation. However in the missed approach segment, penetrations are not allowed; therefore, penetrations must be mitigated by:

- Raising **TCH** (if **GPI** is less than 954 ft).
- Removing or reducing obstruction height.
- Raising glidepath angle.
- Adjusting **DA** (for existing obstacles).

5.9.2 DA Adjustment for a Penetration of Section 1b Surface.

The **DA** is adjusted (raised and consequently moved further away from **LTP**) by the amount necessary to raise the 1b surface above the penetration. For a 1b surface penetration of **p** ft, the **DA** point must move ΔX_{DA} feet farther from the **LTP** as determined by formula 5-23.

This increase in the **DA** to **LTP** distance raises the **DA** (and **HATh**). Calculate the adjusted **DA** ($DA_{adjusted}$) using formula 5-24. Round up the result to the next 1-ft increment.

5.9.3 End of Section 1 Values.

Calculate the assumed **MSL** altitude of an aircraft on missed approach, the **OCS** MSL elevation, and the **ROC** at the end of section 1 (**ab** line) using formula 5-25. The end of section 1 (**ab** line) is considered **SOC**.

Formula 5-1. OCS Slope

Math Notation	$S = \frac{102}{\theta}$
Standard Text	S = 102/θ
Given values: S = OCS Slope	

Formula 5-2. Slope Origin 1

Math Notation	$d = 954 - \frac{TCH}{\tan\left(\theta \bullet \frac{\pi}{180}\right)}$
Standard Text	954-TCH/tan(θ*π/180)
Given values: d = Distance to Slope origin (from POFZ)	

Formula 5-3. W OCS ½ Width

Math Notation	$W_{boundary} = 0.036 \bullet OBS_X + 392.8$ where OBS_X = along-track distance (ft) from LTP to obstacle
Standard Text	0.036*OBSX+392.8

Formula 5-4. W OCS MSL Elevation

Math Notation	$W_{MSL} = \frac{(r + LTP_{elev}) \bullet \cos\left(a\tan\left(\frac{\theta}{102}\right)\right)}{\cos\left(\frac{OBS_X - (200 + d)}{r} + a\tan\left(\frac{\theta}{102}\right)\right)} - r$
Standard Text	((r+LTPelev)*cos(atan(θ/102))/cos((OBSX-(200+d))/r+atan(θ/102))-r
Given values: OBS_X = Obstacle along-track distance (ft) from LTP/FTP LTP_{elev} = LTP MSL elevation θ = Glidepath angle d = Value from paragraph 5.1.3 r = 20890537	

Formula 5-5. EC Adjusted Obstacle MSL Elevation

Math Notation	$O_{EE} = OBS_{MSL} - \left(\left(r + LTP_{elev} \right) \bullet \left(\frac{1}{\cos\left(\frac{OBS_Y}{r} \right)} - 1 \right) + Q \right)$
Standard Text	OBS$_{MSL}$-((r+LTP$_{elev}$)*(1/cos(OBS$_{Y}$/r)-1)+Q)

Given values:

OBS_{MSL} = Obstacle MSL elevation
OBS_Y = Perpendicular distance (ft) from course centerline to obstacle.
LTP_{elev} = LTP MSL elevation
r = 20890537
Q = Adjustment for “X” or “Y” surface rise (0 if in W Surface). See formula 5-7 and/or 5-9

Formula 5-6. Perpendicular Dist to X Boundary

Math Notation	$X_{boundary} = 0.10752 \bullet OBS_X + 678.496$
Standard Text	0.10752*OBSX+678.496

Given values:

OBS_X = Obstacle along-track distance (ft) from LTP/FTP

Formula 5-7. X OCS Obstacle Height Adjustment (Q)

Math Notation	$Q = \frac{OBS_Y - W_{boundary}}{4}$
Standard Text	(OBSY-Wboundary)/4

Given values:

OBS_Y = Perpendicular distance (ft) from course centerline to obstacle
$W_{boundary}$ = Half-width of W surface abeam obstacle (formula 5-3)

Formula 5-8. Perpendicular Distance to Y Boundary

Math Notation	$Y_{boundary} = 0.15152 \bullet OBS_X + 969.696$
Standard Text	0.15152*OBSX+969.696

Given values:

OBS_X = Obstacle along-track distance (ft) from LTP/FTP.

Formula 5-9. Y OCS Obstacle Height Adjustment (Q)	
Math Notation	$Q = \frac{X_{boundary} - W_{boundary}}{4} + \frac{OBS_Y - X_{boundary}}{7}$
Standard Text	(Xboundary-Wboundary)/4+(OBSY-Xboundary)/7
Given values:	$W_{boundary}$ = Perpendicular distance (ft) from course centerline to the W surface boundary $X_{boundary}$ = Perpendicular distance (ft) from course centerline to the X surface outer boundary OBS_Y = Perpendicular distance (ft) from course centerline to the obstacle in the Y surface.

Formula 5-10. DA Calculation	
Math Notation	$DA = HATh + LTP_{elev}$
Standard Text	HATh+LTPelev
Given values:	HATh = Height above threshold LTP_{elev} = LTP MSL elevation

Formula 5-11. Distance LTP to DA	
Math Notation	$X_{DA} = r \bullet \left(\frac{\pi}{2} - \theta \bullet \frac{\pi}{180} - a\sin\left(\frac{\cos\left(\theta \bullet \frac{\pi}{180}\right) \bullet \left(r + LTP_{elev} + TCH\right)}{r + DA} \right) \right)$
Standard Text	r*(π/2-θ*π/180-asin((cos(θ*π/180)*(r+LTPelev+TCH))/(r+DA)))

Formula 5-12. Adjusted DA

Math Notation	$D_{adjusted} = r \bullet \left(\frac{\pi}{2} - a\tan\left(\frac{\theta}{102}\right) - a\sin\left(\frac{\cos\left(a\tan\left(\frac{\theta}{102}\right)\right)\left(r + LTP_{elev} - \frac{\theta \bullet (200+d)}{102}\right)}{r + O_{EE}} \right) \right)$ $DA_{adjusted} = \frac{(r + LTPelev + TCH) \bullet \cos\left(\theta \bullet \frac{\pi}{180}\right)}{\cos\left(\frac{D_{adjusted}}{r} + \theta \bullet \frac{\pi}{180}\right)} - r$
Standard Text	D$_{adjusted}$=r*(π/2-atan(θ/102)-asin((cos(atan(θ/102))*((r+LTPelev)-(θ*(200+d))/102))/(r+OEE))) DA$_{adjusted}$=((r+LTPelev+TCH)*cos(θ*π/180))/cos(Dadjusted/r+θ*π/180)-r
Given values:	r = 20890537 d = Value from paragraph 5.1.3 θ = Glidepath angle O_{EE} = From formula 5-5

Formula 5-13. Glidepath Angle Adjustment.

Math Notation	$SRD = \sqrt{(r + O_{EE})^2 + (r + LTP_{elev})^2 - 2 \bullet (r + O_{EE}) \bullet (r + LTP_{elev}) \bullet \cos\left(\frac{OBS_X - (200+d)}{r}\right)}$ $RS = \frac{1}{\tan\left(a\cos\left(\frac{SRD^2 + (r + LTP_{elev})^2 - (r + O_{EE})^2}{2 \bullet SRD \bullet (r + LTP_{elev})}\right) - \frac{\pi}{2}\right)}$ $\theta_{required} = \frac{102}{RS}$
Standard Text	SRD=((r+OEE)^2+(r+LTPelev)^2-2*(r+OEE)*(r+LTPelev)*cos((OBSX-(200+d))/r))^0.5 RS=1/tan(acos((SRD^2+(r+LTPelev)^2-(r+OEE)^2)/(2*SRD*(r+LTPelev)))-π/2) θ$_{required}$=102/RS
Given values:	r = 20890537 O_{EE} = From formula 5-5 OBS_X = Along-track distance (ft) from LTP to penetrating obstacle d = Value from paragraph 5.1.3 SRD = Slope Required Distance RS = Required Slope

Formula 5-14. Vertical Relief.	
Math Notation	$Z = \frac{d \bullet \theta}{102}$
Standard Text	(d*θ)/102
Given values:	d = “d” from paragraph 5.1.3, formula 5-2 θ = Glidepath angle

Formula 5-15. TCH Adjustment.	
Math Notation	$TCH_{adjustment} = \tan\left(\theta \bullet \frac{\pi}{180}\right) \bullet \frac{102 \bullet p}{\theta}$
Standard Text	tan(θ*π/180)*(102*p)/θ
Given values:	P = Penetration (ft) [p ≤ z] θ = Glidepath angle

Formula 5-16. Section 1bW Boundary Perpendicular Distance.	
Math Notation	$width_{1bW} = \frac{d_{1bW} \bullet (3038 - C_W)}{8401} + C_W$
Standard Text	D1aEnd*(3038-CW)/8401+CW
Given values:	D_{1aEnd} = Along-track distance (ft) from end of section 1a C_W = Half-width of 1aW surface at section 1a end

Formula 5-17. W OCS End Elevation.	
Math Notation	$elev_{1aEnd} = \frac{(r + LTP_{elev}) \bullet \cos\left(a\tan\left(\frac{\theta}{102}\right)\right)}{\cos\left(\frac{X_{DA} - d - 1660}{r} + a\tan\left(\frac{\theta}{102}\right)\right)} - r$
Standard Text	(r+LTPelev)*cos(atan(θ/102))/cos((XDA-d-1660)/r+atan(θ/102))-r
Given values:	X_{DA} = Along-track distance (ft) from LTP to DA d = Value from paragraph 5.1.3

Formula 5-18. Section 1bW OCS Elevation.	
Math Notation	$elev_{1bW} = \left(r + elev_{1aEnd}\right) \bullet e^{\left(\frac{d1aEnd}{28.5 \bullet r}\right)} - r$
Standard Text	(r+elev1aEnd)*e^(d1aEnd/(28.5*r))-r
Given values:	$Elev_{1aEnd}$ = W OCS End Elevation (formula 5-17) D_{1aEnd} = Along-track distance (ft) from end of section 1a.

Formula 5-19. Section 1bX Boundary Perpendicular Distance.	
Math Notation	$elev_{1bX} = \frac{d_{1aEnd} \bullet \left(3038 - C_X\right)}{8401} + C_X$
Standard Text	d1aEnd*(3038-CX)/8401+CX
Given values:	D_{1aEnd} = Along-track distance (ft) from end of section 1a C_X = Perpendicular distance (ft) from course centerline to 1aX outer edge at section 1a end

Formula 5-20. Section 1bX OCS Elevation.	
Math Notation	$elev_{1bX} = elev_{1bW} + \frac{a - width_{1bW}}{4}$
Standard Text	elev1bW+(a-width1bW)/4
Given values:	a = Perpendicular distance (ft) from the MA course

Formula 5-21. Section 1bY Boundary Perpendicular Distance.	
Math Notation	$width_{1bY} = \frac{d1aEnd \bullet \left(3038 - C_Y\right)}{8401} + C_Y$
Standard Text	d1aEnd*(3038-CY)/8401+CY
Given values:	d_{1aEnd} = Along track distance (ft) from end of section 1a C_Y = Perpendicular distance (ft) from course centerline to 1aY outer edge at section 1a end

Formula 5-22. Section 1bY OCS Elevation.

Math Notation	$elev_{1bY} = elev_{1bX} + \frac{a - width_{1bX}}{7}$
Standard Text	elev1bX+(a-width1bX)/7

Given values:
a = Perpendicular distance (ft) from the MA course

Formula 5-23. Section 1bY Boundary Perpendicular Distance.

Math Notation	$DA_{adjusted} = \tan\left(\theta \bullet \frac{\pi}{180}\right) \bullet \left(X_{DA} + \Delta X_{DA}\right) + LTP_{elev} + TCH$
Standard Text	tan(θ*π/180)*(XDA+ΔXDA)+LTPelev+TCH

Given values:
θ = glidepath angle
ΔX_{DA} = From formula 5-23
X_{DA} = Fom formula 5-11

Formula 5-24. Adjusted DA.

Math Notation	$Aircraft_{SOC} = DA - \tan\left(\theta \bullet \frac{\pi}{180}\right) \bullet 1460 + 276.525$ $OC_{SOC} = \left(r + elev_{1Aend}\right) \bullet e^{\left(\frac{8401}{28.5 \bullet r}\right)} - r$ $ROC_{SOC} = Aircraft_{SOC} - OCS_{SOC}$
Standard Text	$Aircraft_{SOC}$ = DA-tan(θ*π/180)*1460+276.525 OCS_{SOC} = (r+elev1aEnd)*e^(8401/(28.5*r))-r ROC_{SOC} = AircraftSOC-OCSSOC

Given values:
r = 20890537
θ = Glidepath angle
DA = Published decision altitude (MSL)
$Elev_{1Aend}$ = Value from formula 5-17
d = Value from paragraph 5.1.3

CHAPTER 6. MISSED APPROACH SECTION 2

6.0 General

a. Word Usage.

- **Nominal** refers to the designed/standard value, whether course/track or altitude, etc.
- **Altitude** refers to elevation (**MSL**).
- **Height** refers to the vertical distance from a specified reference (geoid, ellipsoid, runway threshold, etc.).

b. These criteria cover two basic **missed approach (MA) constructions:**

- Straight missed approach
- Turning missed approach

Note: These two construction methods accommodate traditional combination straight and turning missed approaches.

Refer to individual final chapters for **MA** section1 information. The section 2 **OEA** begins at the end of section 1 (**AB** line), and splays at 15 degrees relative to the nominal track to reach full width (1-2-2-1 within 30 NM) (see figure 6-1). See chapter 2, paragraph 2.3 for segment width and expansion guidance. The section 2 standard **OCS** slope begins at the **AB** line. (See paragraph 2.19 and formula 2-22 for information and to calculate precise **OCS** values).

Note: All references to 'standard **OCS** slope' and use of '40:1' or the '40:1 ratio' refer to the output of formula 2-22 with an input **CG** of 200ft/NM.

Where a higher climb gradient (**CG**) than the standard **OCS** slope is required, apply the **CG** and its associated **OCS** from **SOC** (See **LPV** chapter for the section 1 **OCS** exception). Apply secondary areas as specified in this chapter. Measure the 12:1 secondary **OCS** perpendicular to the nominal track. In expansion areas, the slope rises in a direction perpendicular from the primary boundary (arc, diagonal corner-cutter, etc.), except where obstacles cannot be measured perpendicularly to a boundary, measure to the closest primary boundary. See figures 6-1 through 6-14c at the end of this chapter. Higher-than-standard **CGs** (200'/NM) require approval from TC or DND (as appropriate).

6.1 Straight Missed Approach

The straight missed approach course is a continuation of the final approach course (**FAC**). The straight MA section 2 **OEA** begins at the end of section 1, (the **AB** line) and splays at 15 degrees relative to the nominal track until reaching full primary and secondary width (1-2-2-1 within 30 NM).

Apply the section 2 standard **OCS**, (or the **OCS** associated with a higher **CG**) beginning at the **AB** line from the section 1 end **OCS** elevation. Revert to the standard **OCS** when the increased **CG** is no longer required. **OCS** values for the default 200 ft/NM climb gradient and others shall be derived using formula 2-22 (no rounding, 15 significant digits required).

To determine primary **OCS** elevation at an obstacle, measure the along-track distance from the **AB** line to a point at/abeam the obstacle. Where the obstacle is located in the secondary area, apply the primary **OCS** slope to a point abeam the obstacle, then apply the 12:1 secondary slope (perpendicular to the track), from the primary boundary to the obstacle. See figure 6-1.

6.2 Turning Missed Approach (First Turn)

Apply turning criteria when requiring a turn at or beyond **SOC**. Where secondary areas exist in section 1, they continue, (splaying if necessary to reach full width) into section 2, including non-turn side secondary areas into the first-turn wind spiral and outside arc construction (see figures 6-2, and 6-4 to 6-13). Terminate turn-at-fix turn-side secondary areas not later than the early turn point. Do not apply turn-side secondary areas for turn-at-altitude construction. There are two types of turn construction for the first missed approach turn:

- Turn at an altitude (see paragraph 6.2.1)
    - Always followed by a **DF** leg ending with a **DF/TF** connection.
- Turn at a fix (see paragraph 6.2.2)
    - Always followed by a **TF** leg ending with a **TF/TF** connection, (or **TF/RF**, which requires advanced avionics) when the initial straight leg is less than full width.
    - May be followed by an **RF** leg (which requires advanced avionics) when the initial straight leg has reached full width, ending with an **RF/TF** or **RF/RF** connection.

Following a turn, the minimum segment length (except **DF** legs) must be the greater of:

- The minimum length calculated using the chapter 2 formulas (2-6 and 2-7); or,
- The distance from previous fix to the intersection of the 30 degrees converging outer boundary line extension and the nominal track, (plus segment end fix **DTA** and **ATT**).

Minimum **DF** leg length must accommodate 6 seconds (minimum) of flight time based on the fastest aircraft category (**KTAS**) expected to use the procedure, applied between the **WS**/direct-to-fix-line tangent point, and the earliest maneuvering point (early turn point) for the **DF/TF** fix. Convert to **TAS** using the **TIA** turn altitude plus the altitude gained at 250 ft/NM (Cat A/B), or 500 ft/NM (Cat C/D) from the **TIA** end center point to the **DF** fix.

6.2.1 Turn At An Altitude.

Apply turn-at-an-altitude construction unless the first missed approach turn is at a fix. Since pilots may commence a missed approach at altitudes higher than the **DA/MDA** and aircraft climb rates differ, turn-at-an-altitude construction protects the large area where turn initiation is expected. This construction also provides protection for 'turn as soon as practicable' and combination straight and tuning operations.

When a required aircraft turning altitude exceeds the minimum turning altitude (typically 400 ft above the airport), specify the turning altitude.

a. Turn Initiation Area (TIA).

Construct the **TIA** as a straight missed approach to the climb-to altitude, beginning from the earliest **MA** turn point (**CD** line) and ending where the specified minimum turning altitude (STEP 1) is reached (**AB** or **LL'** line, as appropriate). Base the **TIA** length on the climb distance required to reach the turning altitude (see appropriate STEP 2 below). The **TIA** minimum length must place the aircraft at an altitude from which obstacle clearance is provided in section 2 outside of the **TIA**. The **TIA** boundary varies with length, the shortest **B-A-C-D,** where **AB** overlies **JK**. Where the **TIA** is contained within section 1, **B-A-J-C-D-K** defines the boundary. Where the required turn altitude exceeds that supported by section 1, the **TIA** extends into section 2, (see figure 6-2) and points **L'-L-A-J-C-D-K-B** define its boundary. In this case, **L-L'** is the early turn point based on the aircraft climbing at the prescribed **CG**. Calculate **TIA** length using the appropriate formula, 6-2a, 6-2b, or 6-2c.

Note: Points E and F may not be used or may be overridden by the **JK** line.

STEP 1: **Turn altitude**. The turn altitude is either operationally specified (must be at or above altitude required by obstacles) or determined by obstacle evaluation. Evaluate the nominal standard **OCS** slope (40:1). If the **OCS** is penetrated, mitigate the penetration with one or a combination of the following:

a. Raise **DA/MDA**

b. Establish a **climb gradient** that clears the obstacle

c. Move **MAP**

d. If penetration is outside **TIA**, consider raising the climb-to altitude

(1) Determine the aircraft required minimum turning altitude based on obstacle evaluation:

- Identify the most significant obstacle in section 2 (straight **MA**)
    - For straight **OCS**/**CG**/length options
- Identify the most significant/controlling obstacle outside the **TIA**, (typically turn-side).
- Find the shortest distance from the **TIA** lateral boundary to the obstacle
- Apply this distance and the standard **OCS** slope, (or higher **CG** associated slope) to find the **TIA**-to-obstacle **OCS** rise.
- The minimum **TIA OCS** boundary elevation, (and **OCS** end elevation) equals the obstacle elevation minus **OCS** rise.
- The minimum turn altitude is the sum of **TIA OCS** boundary elevation and:
    - 100 ft for non-vertically guided procedures, or
    - The table 4-2 ROC value for vertically guided procedures, rounded to the next higher 100-ft increment.

Notes:

1. **TIA** lateral boundary is the straight segment (portion) lateral boundary until the required minimum turn altitude and **TIA** length are established.
2. Repeat step 1 until acceptable results are obtained.

The specified turn altitude must equal or exceed the section 1 end aircraft altitude. Apply formula 5-25 to find **LPV** section 1 end altitude ($\mathbf{Aircraft_{SOC}}$), and section 1 **OCS** end elevation ($\mathbf{OCS_{SOC}}$). Find non-**LPV** section 1 end altitude using formula 6-1.

The section 2 standard **OCS** slope, (or the higher slope associated with the prescribed climb (**CG**)) begins at the **AB** line **OCS** elevation. See figures 6-2 through 6-7. See appropriate final chapters for the variable values associated with each final type.

STEP 2 (LPV):

Calculate **LPV TIA** length using formula 6-2a1/6-2a2 (see paragraph 5.8 for further section 1 details). Apply **TIA** calculated lengths from the **CD** line.

Where an increased **CG** terminates prior to the **TIA** turn altitude, apply formula 6-2a1, otherwise apply formula 6-2a2.

STEP 2 (LNAV/LP):

Calculate **LNAV** and **LP TIA** length using formula 6-2b and the appropriate **FSL** value (see paragraph 3.7 for further section 1 details).

Where an increased **CG** terminates prior to the **TIA** turn altitude, apply formula 6-2b1, otherwise apply formula 6-2b2.

STEP 2 (LNAV/VNAV):

Calculate **LNAV/VNAV TIA** length using formula 6-2c (see paragraph 4.4 for further section 1 details).

Where an increased **CG** terminates prior to the **TIA** turn altitude, apply formula 6-2c1, otherwise apply formula 6-2c2.

STEP 3: Locate the **TIA** end at a distance **TIA** length beyond **CD** (from STEP 2) (**LL'**). See figure 6-2.

The **OEA** includes areas to protect the earliest and latest direct tracks from the **TIA** to the fix. Construct the obstacle areas about each of the tracks as described below. See figures 6-2 through 6-9 for various turn geometry construction illustrations.

b. OEA Construction after TIA.

(1) Early Turn Track and OEA Construction.

Where the early track from the **FAC/CD** intersection defines a turn less than or equal to 75 degrees relative to the **FAC**, the tie-back point is point C (see figure 6-3); if the early track defines a turn greater than 75 degrees relative to the **FAC**, the tie-back point is point D (see figure 6-4). Where the early track represents a turn greater than 165 degrees~, begin the early turn track and the 15 degrees splay from the non-turn side **TIA end + rr** (formula 2-4) (**PP'**) (see figure 6-5).

STEP 1: Construct a line (representing the earliest-turn flight track) from the tie back point, to the fix. See figure 6-2.

STEP 2: Construct the outer primary and secondary **OEA** boundary lines parallel to this line (1-2-2-1 segment width). See figure 6-2.

STEP 3: From the tie-back point, construct a line splaying at 15 degrees to intersect the parallel boundary lines or segment end, whichever occurs earlier (see figure 6-2 and 6-3).

Apply secondary areas only after the 15 degrees splay line intersects the primary boundary line.

(2) Late Turn Track and OEA Construction.

Apply wind spirals for late-turn outer boundary construction using the following calculations, construction techniques, and 15-degree bank angles. Calculate **WS** construction parameters for the appropriate aircraft category.

<u>STEP 1:</u> Find the no-wind turn radius (**R**) using formula 6-3.

Note: Apply the category's indicated airspeed from table 2-3 and the minimum assigned turn altitude when converting to true airspeed for this application.

<u>STEP 2:</u> Calculate the Turn Rate (**TR**) using formula 6-3a. Maximum **TR** is 3 degrees per second. Apply the lower of 3 degrees per second or formula 6-3a output.

<u>STEP 2a:</u> Calculate the Turn Magnitude (**TMAG**) using the appropriate no-wind turn radius and the arc distance (in degrees) from start of turn (at **<u>PP'</u>**) to the point of tangency with a line direct to the fix.

<u>STEP 2b:</u> Calculate the highest altitude in the turn using formula 2-2 (see Missed Approach note following the formula). Determine altitude at subsequent fixes using fix-to-fix direct measurement and 500 ft per NM climb rate.

<u>STEP 3:</u> Find the omni-directional wind component ($\mathbf{V_{KTW}}$) for the highest altitude in the turn using formula 2-3b.

<u>STEP 4:</u> Apply this common wind value (Step 3) to all first-turn wind spirals.

Note: Apply 30 knots for turn altitudes ≤ 2,000 ft above airport elevation.

<u>STEP 5:</u> Calculate the wind spiral radius increase (**ΔR**) (relative R), for a given turn magnitude (**Φ**) using formula 6-4.

Note: See **ΔR** examples in figures 6-2 to 6-5.

<u>STEP 6:</u> Wind Spiral Construction (see paragraph 6.4).

6.2.2 Turn-At-A-Fix.

The first **MA** turn-at-a-fix may be a fly-by or fly-over fix. Use fly-by unless a flyover is required for obstacle avoidance or where mandated by specific operational requirements. The turn fix early-turn-point must be at or beyond section 1 end.

a. Early/Late Turn Points.

The fly-by fix early-turn-point is located at (**FIX**-**ATT**-**DTA**) prior to the fix.

The fly-by fix late-turn-point is located at a distance (**FIX** + **ATT** – **DTA** + **rr**) from the fix.

The fly-over early-turn-point is located at a distance (**FIX** - **ATT**) prior to the fix.

The fly-over late-turn-point is located at a distance (**FIX** + **ATT** + **rr**) beyond the fix.

Fly-by fixes (see figure 6-10).

- Early_{TP}=Fix – ATT – DTA Late_{TP} = Fix + ATT – DTA + rr

Fly-over fixes (see figure 6-10).

- Early_{TP} = Fix – ATT Late_{TP} = Fix + ATT +rr

b. Turn-at-a-Fix (First MA turn) Construction.

The recommended maximum turn is 70 degrees; the absolute maximum is 90 degrees. The first turn fix must be located on the final approach track extended.

STEP 1: Calculate aircraft altitude at the **AB** line using formula 6-1.

STEP 2: Calculate fix distance based on minimum fix altitude. Where the first fix must be located at the point the aircraft reaches or exceeds a specific altitude, apply formula 6-5 (using the assigned/applied **CG**), to calculate fix distance ($\mathbf{D_{fix}}$) (NM) from the **AB** line.

STEP 3: Calculate the altitude an aircraft climbing at the assigned **CG** would achieve over an established fix using formula 6-6.

c. Fly-By Turn Calculations and Construction.

(Consider direction-of-flight-distance positive, opposite-flight-direction distance negative).

(1) Fly-By Turn Calculations.

STEP 1: Calculate the fix to early-turn distance (**EarlyTP**) using formula 6-7.

(2) Early Turn Area Construction.

(3) Inside turn (Fly-By) Construction is predicated on the location of the **LL'** and primary/secondary boundary intersections (early turn connections), relative the outbound segment, see table 6-1. See figures 6-11a, 6-11b, 6-11c, and 6-12.

See similar construction figure 6-6.

Where no inside turn secondary area exists in section 1, apply secondary areas only after the turn expansion lines intersect the outbound segment boundaries. Apply the same technique to primary and secondary area connections when both inbound segment connection points fall either outside the outbound segment, or inside the outbound segment primary area. When both inbound connection points are within the outbound segment secondary area, or its extension, table 6-1 displays a connection method for each point.

Note: Where half-turn-angle construction is indicated, apply a line splaying at the larger of, half-turn-angle, or 15 degrees relative the outbound track. Where a small angle turn exists and standard construction is suitable for one, but not both splays; connect the uncommon splay, normally primary, to the outbound primary boundary at the same along-track distance as the secondary connection. Maintain or increase primary area as required.

STEP 1: Construct a baseline (**LL'**) perpendicular to the inbound track at distance **DearlyTP** (formula 6-7) prior to the fix.

- **CASE 1:** The outbound segment boundary, or its extension, is beyond the baseline (early-turn connection points are prior to the outbound segment boundary).

  STEP 1: Construct the inside turn expansion area with a line, drawn at one-half the turn angle from the inbound segment primary early turn connection point, to intercept the outbound segment primary boundary (see figures 6-11a, 6-6).

  STEP 2: **(if required):** Construct the inside turn expansion area with a line, drawn at one-half the turn angle, from the inbound segment secondary early turn connection point, to intercept the outbound segment secondary boundary (see figure 6-11a).

- **CASE 2:** The outbound segment secondary boundary or its extension is prior to the **LL’** baseline and outbound segment primary boundary or its extension is beyond the **LL’** baseline, (early-turn connection points are both within the outbound segment secondary area or its extension).

  STEP 1: Construct the inside-turn expansion area with a line splaying at 15 degrees, (relative the outbound track) from the inbound segment secondary early turn connection point to intersect the outbound segment boundary.

  STEP 1 Alt: Begin the splay from **L’** when the turn angle exceeds 75 degrees.

  STEP 2: Construct the primary boundary with a line, drawn at one-half the turn angle, from the inbound segment primary early turn connection point to intercept the outbound segment primary boundary (see figure 6-11b).

- **CASE 3:** The outbound segment secondary and primary boundaries, or their extensions, are prior to the **LL’** baseline (early-turn connection points are inside the outbound segment primary area).

  STEP 1: Construct the inside turn expansion area with a line, splaying at 15 degrees (relative the outbound track) from the more conservative point, (**L’**) or (the intersection of **LL’** and the inbound segment inner primary boundary), to intersect the outbound segment boundaries.

  STEP 1 Alt: Begin the splay from **L’** when the turn angle exceeds 75 degrees.

  In this case, the inside turn secondary area is terminated at the outbound segment primary boundary, as it falls before the early turn points, **LL’** (see figure 6-11c for **L’** connection).

(4) Outside Turn (Fly-By) Construction.

STEP 1: Construct the outer primary boundary using a radius of one-half primary width (2 NM), centered on the plotted fix position, drawn from the inbound segment extended primary boundary until tangent to the outbound segment primary boundary (see figures 6-11a through 6-11c). See figure 6-7.

STEP 2: Construct the secondary boundary using a radius of one-half segment width (3 NM), centered on the plotted fix position, drawn from the inbound segment extended outer boundary until tangent to the outbound segment outer boundary (see figures 6-11a through 6-11c). See figure 6-7.

d. Fly-Over Turn Construction.

(1) Inside Turn (Fly-Over) Construction.

STEP 1: Construct the early-turn baseline (**LL'**) at distance **ATT** prior to the fix, perpendicular to the inbound nominal track.

STEP 2: Refer to paragraph 6.2.2.c(3), (skip STEP 1).

(2) Outside Turn (Fly-Over) Construction.

STEP 1: Construct the late-turn baseline (**PP'**) at distance (**ATT** + **rr**) beyond the fix, perpendicular to the inbound nominal track. Calculate late turn distance using formula 6-8.

STEP 2: Apply wind spiral outer boundary construction for the first **MA** fly-over turn. See paragraph 6.2.1b.(2) for necessary data, using the higher of formula 6-6 output, or the assigned fix crossing altitude for **TAS** and turn radius calculations.

Apply paragraph 6.4 for wind spiral construction. A non-turn side secondary area may extend into the **WS1** area.

(3) Obstacle Evaluations. See paragraph 6.2.3.

6.2.3 Section 2 Obstacle Evaluations.

a. Turn at an Altitude Section 2.

Apply the standard **OCS** slope, (or the assigned **CG** associated slope) slope to section 2 obstacles (during and after the turn) based on the shortest primary area distance (**d_O**) from the TIA boundary to the obstacle. Shortest primary area distance is the length of the shortest line kept within primary segments that passes through the early turn baseline of all preceding segments.

STEP 1: Measure and apply the **OCS** along the shortest primary area distance (**d_O**) from the **TIA** boundary to the obstacle (single and multiple segments). See figures 6-2 through 6-13, (skip 6-10) for various obstacle measurement examples.

STEP 2: For obstacles located in secondary areas, measure and apply the **OCS** along the shortest primary area distance (**d_o**) from the **TIA** boundary to the primary boundary abeam the obstacle, then the 12:1 slope along the shortest distance to the obstacle, (taken perpendicular to the nominal track or in expansion areas, to the primary arc, the primary corner-cutter, corner apex, or other appropriate primary boundary). Where an obstacle requires multiple measurements (an obstacle is equidistant from multiple primary boundary points, or lies along perpendiculars from multiple primary boundary points, etc.), apply the more adverse result from each of the combined primary/secondary measurements. See figures 6-1 and 6-2 through 6-11c.

b. Turn at Fix Section 2.

Apply the standard **OCS** slope, (or the assigned **CG** associated slope) beginning at the **AB** line at the inbound-segment end **OCS** height.

STEP 1: Measure and apply the **OCS** along the shortest distance (**d_O**) from the **AB** line (parallel to track) to **LL'**, the shortest primary distance to the obstacle (single and multiple segments). See figures 6-2 through 6-13, (skip 6-10) for various obstacle measurement examples.

STEP 2: For obstacles located in secondary areas, measure and apply the **OCS** along the shortest primary area distance (**d_O**) from the **TIA** boundary to the primary boundary abeam the obstacle, then the 12:1 slope along the shortest distance to the obstacle, (taken perpendicular to the nominal track or in expansion areas, to the primary arc, the primary corner-cutter, corner apex, or other appropriate primary boundary). Where an obstacle requires multiple measurements (where an obstacle is equidistant from multiple primary boundary points, or lies along perpendiculars from multiple primary boundary points, etc.), apply the more adverse result from each of the combined primary/secondary measurements (see figures 6-6 through 6-8). Additional obstacle measurements examples appear in figures 6-1 through 6-11c.

6.3 Turning Missed Approach (Second Turn)

6.3.1 DF/TF Turn (Second Turn, following turn-at-altitude).

Turns at the **DF** path terminator fix will be fly-by or fly-over to a **TF** leg. In either case, the outer boundary provides fly-over protection, and the inner boundary provides fly-by protection. Maximum turn angle is 90 degrees (applicable to both tracks within the **DF** segment). This application provides that construction under chapter 2, or this chapter will apply, including cases where the inside and outside turn construction differs.

a. DF/TF (Fly-By) Turn.

(1) Inside DF/TF (Fly-By) construction.

- <u>**CASE 1:**</u> Full width inside secondary exists at the early turn point (<u>**LL'**</u>).

  <u>**STEP 1:**</u> Construct a baseline (<u>**LL'**</u>) perpendicular to the inbound track nearer the turn side boundary at distance $\mathbf{D_{earlyTP}}$ (formula 6-7) prior to the fix.

  <u>**STEP 2:**</u> Apply chapter 2, paragraph 2.5.2 criteria.

- <u>**CASE 2:**</u> Less than full width inside secondary exists at (<u>**LL'**</u>).

  <u>**STEP 1:**</u> Apply paragraph 6.2.2.c(3) criteria.

(2) Outside DF/TF (Fly-By) construction.

- <u>**CASE 1:**</u> Full width outside secondary exists at the early turn point (<u>**L'L''**</u>).

  <u>**STEP 1:**</u> Construct a baseline (<u>**L'L''**</u>) perpendicular to the inbound track nearer the non-turn side boundary at distance $\mathbf{D_{earlyTP}}$ (formula 6-7) prior to the fix.

  <u>**STEP 2:**</u> Apply chapter 2, paragraph 2.5.2 criteria. See figures 6-6 through 6-8.

- <u>**CASE 2:**</u> Less than full width outside secondary exists at (<u>**L'L''**</u>).

  <u>**STEP 1:**</u> Apply paragraph 6.2.2.c(4) criteria.

b. DF/TF (Fly-Over) Turn.

(1) Inside DF/TF (Fly-Over) Turn Construction.

STEP 1: Construct a baseline (**LL'**) perpendicular to the inbound track nearer the turn side boundary at distance ATT prior to the fix (see figure 6-9).

Note: Where half-turn-angle construction is specified, apply a line splaying at the larger of half-turn-angle or 15 degrees relative the outbound track.

- **CASE 1:** No inside secondary area exists at **LL'**.

STEP 1: Create the **OEA** early-turn protection by constructing a line, splaying at the larger of one-half (1/2) the turn angle, or 15 degrees relative the outbound track, from the intersection of **LL'** and the inbound segment inner primary boundary to connect with the outbound **TF** segment boundaries.

The **TF** secondary area begins at the intersection of this diagonal line and the outbound segment boundary.

- **CASE 2:** Partial width inside secondary area exists at **LL'**.

STEP 1: Create the **OEA** early-turn primary area protection by constructing a line, splaying at the larger of one-half (1/2) the turn angle, or 15 degrees relative the outbound track, from the intersection of **LL'** and the inbound segment inner primary boundary to connect with the **TF** segment primary boundary.

STEP 2: Create the **OEA** early-turn secondary protection by constructing a line, splaying at the larger of one-half (1/2) the turn angle, or 15 degrees relative the outbound track, from the intersection of **LL'** and the inbound segment inner boundary to connect with the **TF** segment boundary.

- **CASE 3**: Full width inside secondary area exists at **LL'**.

STEP 1: Apply chapter 2 criteria. See figure 6-9.

(2) Outside DF/TF (Fly-Over) Turn Construction.

STEP 1: Construct the late-turn baseline for each inbound track, (**PP'**) for the track nearer the inside turn boundary, and (**P'P''**) for the outer track at distance (**ATT** + **rr**) beyond the fix, perpendicular to the appropriate inbound track. See figure 6-9.

Note: A **DF/TF** Fly-Over turn is limited to 90 degrees (both inbound tracks) and should require no more than one **WS** per baseline. Construct the outside track **WS** (**WS1**) on base line **P'P''**), then construct **WS2** on baseline **PP'**.

STEP 2: Apply wind spiral construction, see paragraph 6.2.1.b(2) for necessary data, and paragraph 6.4 for wind spiral construction See figure 6-9.

6.3.2 TF/TF Turn (Second Turn, following turn-at-fix).

Turns at the **TF** path terminator fix will be fly-by or fly-over to a **TF** leg. In either case, the outer boundary provides fly-over protection, and the inner boundary provides fly-by protection. Maximum turn angle is 90 degrees. This application provides that construction under chapter 2, or this chapter will apply, including cases where the inside and outside turn construction differs.

a. TF/TF (Fly-By) Turn.

(1) Inside TF/TF (Fly-By) construction.

STEP 1: Apply chapter 2, paragraph 2.5.2 criteria.

(2) Outside TF/TF (Fly-By) construction.

STEP 1: Apply chapter 2, paragraph 2.5.2 criteria.

b. TF/TF (Fly-Over) Turn.

(1) Inside **TF/TF** (Fly-Over) Turn Construction.

STEP 1: Apply chapter 2, paragraph 2.5.1 criteria.

(2) Outside **TF/TF** (Fly-Over) Turn Construction.

STEP 1: Apply chapter 2, paragraph 2.5.1 criteria.

6.4 Wind Spiral Cases

Wind Spiral (**WS**) construction applies to turn-at-an-altitude, turn-at-a-fix (Fly-Over) for the first MA turn, and **DF/TF** (Fly-Over) for the second turn. The late turn line **P'** designator is typically placed where the baselines cross. Where baseline extension is required, mark each baseline inner end with **P'**.

Each **WS** has several connection options along its boundary. The chosen connection/s must provide the more reasonably conservative, (larger area) track and protection areas (see figures 6-14a, 6-14b, and 6-14c for examples).

- A 15-degree, (or greater*) splay line to join outbound segment outer boundaries, from:
  - **WS**/direct-to-fix tangent point
  - **WS** to **WS** tangent line origin
  - **WS** to **WS** tangent line end
  - **WS**/outbound segment parallel point (**DF** segment **NA**)
- A tangent line to join the next **WS**
- A tangent line direct to the next fix (**DF** segment)
- A tangent line, converging at 30 degrees to the segment track (**TF** segment)

Note: * See paragraph 6.4.1.a and b for alternate connection details.

Outbound segment type and turn magnitude are primary factors in **WS** application. Refer to table 6-2 for basic application differences. Calculate **rr** using formula 2-4.

a. Turn-at-Fix (FO) and Turn-at-Altitude WS Comparison.

Three cases for outer-boundary wind spirals commonly exist:

- (Case 1), Small angle turns use one wind spiral (**WS1**);
- (Case 2), Turns near/exceeding 90° ~ use a second wind spiral (**WS2**); and
- (Case 3), turns near/exceeding 180° ~ use a third wind spiral (**WS3**).

(1) Turn-at-Altitude WS application concludes with a line tangent to the final **WS** direct to the next fix.

(2) Turn-at-Fix (FO) WS application concludes with a line tangent to the final **WS** converging at a 30-degree angle to the outbound segment nominal track. The intersection of this line with the nominal track establishes the earliest maneuvering point for the next fix. The minimum segment length is the greater of:

- The minimum length calculated using the chapter 2 formulas (2-6 and 2-7); or,
- The distance from previous fix to the intersection of the 30-degree converging outer boundary line extension and the nominal track, (plus **DTA** and **ATT**). See paragraph 6.2.2.c.3.

(3) Second MA Turn DF/TF Turn-at-Fix (FO) WS application concludes with a line tangent to the final **WS** converging at a 30-degree angle to the outbound segment nominal track This construction requires two **WS** baselines, one for each inbound track. Each late turn baseline is located (**ATT** + **rr**) beyond the fix, oriented perpendicular to the specific track. The baseline for the inbound track nearer the inside turn boundary is designated **PP’**, the baseline associated with the outside turn track is designated **P’P’’**. For convenience P’ is often placed at the intersection of the two baselines, but a copy properly goes with each baseline inner end where baseline extensions are required.

6.4.1 First MA Turn WS Construction.

Find late turn point distance (**DlateTP**) using formula 6-8.

a. **CASE 1:** Small angle turn using 1 **WS**.

STEP 1: Construct the **WS1** baseline, (**PP'**) perpendicular to the straight missed approach track at the late-turn-point (see table 6-2 for line **PP'** location). See figures 6-3, 6-12.

STEP 2: Locate the wind spiral center on **PP'** at distance **R** (no-wind turn radius, using formula 6-3; see figure 6-2) from the intersection of **PP'** and the inbound-segment outer-boundary extension. See figures 6-4, 6-12.

STEP 3: Construct **WS1** from this outer boundary point in the direction of turn until tangent to the **WS**/Segment connecting line from table 6-2. See figure 6-4, 6-12.

CASE 1-1: Turn-altitude (**WS1** ends when tangent to a line direct to fix)

STEP 1: Construct the **OEA** outer primary and secondary boundary lines parallel to this track (1-2-2-1 segment width). See figure 6-3.

STEP 2: Construct a line from the **WS1** tangent point, splaying at 15 degrees from the **WS1**-to- fix track until it intersects the parallel boundary lines or reaches the segment end (see figures 6-2 through 6-6).

Note: Consider 'full-width protection at the fix' to exist where the splay line is tangent to a full-width- radius- circle about the fix.

STEP 2alt-1: Where Step 2 construction provides less than full-width protection at the **DF** fix, construct the **OEA** outer boundary with a line splaying from the **WS1**/direct-to-fix tangent point at 15 degrees relative the direct-to-fix line, (or greater where required to provide full-width protection at the **DF** fix), until it intersects the parallel boundary lines (not later than tangent/tangent extension to the full-width-arc about the fix), and provides full-width protection at or before the **DF** fix. **DF** secondary areas begin/exist only where full width primary exists. See figures 14a, and 14b.

Note: Where excessive splay (dependent upon various conditions but generally in the 35-40 degree range), consider lengthening the segment, restricting the speed, category, etc. to avoid protection and/or construction difficulties.

CASE 1-2: Turn-at-Fix (**FO**) (**WS1** ends when tangent to a 30-degree line converging to nominal track).

STEP 1: Construct the **OEA** outer boundary line using **WS1** and the tangent 30- degree converging line until it crosses the outbound segment boundaries (see figure 6-12).

STEP 1a: Where **WS1** lies within the outbound segment primary boundary, construct the **OEA** boundary using **WS1** and a line (from the point **WS1** is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary lines.

STEP 1b: Where **WS1** lies within the outbound segment secondary boundary, construct the e **OEA** boundary using WS1 and a line (from the point WS1 is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary line. Continue **WS1** and the tangent 30-degree converging line to establish the inner primary/secondary boundary.

b. **CASE 2: Larger turn using more than 1 WS.** For turns nearing or greater than 90 degrees, **WS2** may be necessary. See figures 6-4, 6-13.

STEP 1: To determine **WS2** necessity, locate its center on baseline **PP'**, at distance **R** from the inbound-segment inner-boundary extension.

STEP 2: Construct **WS2** from this inner boundary point in the direction of turn until tangent to the **WS**/Segment connecting line from table 6-2. See figure 6-13.

STEP 3: Where **WS2** intersects **WS1** construction, (including the connecting and expansion lines where appropriate), include **WS2** in the **OEA** construction. Otherwise revert to the single **WS** construction.

STEP 3a: Connect **WS1** and **WS2** with a line tangent to both (see figures 6-4, 6-13).

Note: The **WS1**/ **WS2** tangent line should parallel a line between the **WS** center points.

CASE 2-1: Turn-at-Altitude: (WS2 ends when tangent to a line direct to fix)

STEP 1: Construct the **OEA** outer primary and secondary boundary lines parallel to this track (1-2-2-1 segment width).

STEP 2: Construct a line from the **WS2** tangent point, splaying at 15 degrees from the **WS2**-to-fix track until it intersects the parallel boundary lines or reaches the segment end (see figure 6-4).

Note: Consider 'full-width protection at the fix' exists where the splay line is tangent to a full-width- radius- circle about the fix.

STEP 2alt-1: Where Step 2 construction provides less than full-width protection at the **DF** fix, construct the **OEA** outer boundary with a line splaying from the **WS2**/direct-to-fix tangent point at 15 degrees relative the direct-to-fix line, (or greater where required to provide full-width protection at the **DF** fix), until it intersects the parallel boundary lines (not later than tangent/tangent extension to the full-width-arc about the fix), and provides full-width protection at or before the **DF** fix. Where the turn angle is ≤ 105 degrees, or the divergence angle between the **WS**/**WS** tangent line and the direct-to-fix line is ≤ 15 degrees, apply the splay line form the **WS1/WS2** tangent line origin. **DF** secondary areas begin/exist only where full width primary exists (see figures 6- 14a and 6-14c).

Note: Where excessive splay (dependent upon various conditions but generally in the 35-40 degree range), consider using an earlier splay origin point, lengthening the segment, restricting the speed, category, etc. to avoid protection or construction difficulties (see paragraph 6.4 for origin points).

CASE 2-2: Turn-at-Fix (FO): (WS2 ends when tangent to a 30-degree line converging to nominal track).

STEP 1: Construct the **OEA** outer boundary line using **WS2** and the 30-degree converging line until it crosses the outbound segment boundaries (see figure 6-13).

STEP 1a: Where **WS2** lies within the outbound segment primary boundary, construct the **OEA** boundary using **WS1**, **WS2** and a line (from the point **WS1** or **WS2** is parallel to the outbound segment nominal track, the more conservative), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary lines.

STEP 1b: Where **WS2** lies within the outbound segment secondary boundary, construct the **OEA** boundary using **WS1**, **WS2** and a line (from the point **WS2** is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary line. Continue **WS2** and the tangent 30-degree converging line to establish the inner primary/secondary boundary.

c. CASE 3: Larger turn using more than 2 WSs. (Not applicable to Turn-at- Fix due to 90° turn limit). For turns nearing or greater than 180 degrees ~ (such as a missed approach to a holding fix at the **IF**),

STEP 1: Construct the **WS3** baseline perpendicular to the straight missed approach track along the **CD** line-extended toward the turn side. See figure 6-5.

STEP 2: To determine **WS3** necessity, locate its center on the WS3 baseline at distance **R** from point C. See figure 6-5.

STEP 3: Construct **WS3** from point C in the direction of turn until tangent to the **WS**/Segment connecting line from table 6-2. See figure 6-5.

STEP 4: Where **WS3** intersects **WS2** construction, include **WS3** in the **OEA** construction. Otherwise revert to the dual **WS** construction. See figure 6-5.

STEP 5: Connect **WS2** and **WS3** with a line tangent to both (see figure 6-4, 6-5).

Note: The **WS2** & **WS3** tangent line should parallel a line between the **WS** center points.

CASE 3-1: Turn-at-Altitude: (WS3 ends when tangent to a line direct to fix)

STEP 1: Construct the **OEA** outer primary and secondary boundary lines parallel to this track (1-2-2-1 segment width). See figure 6-5.

STEP 2: Construct a line from the **WS3** tangent point, splaying at 15 degrees from the **WS3**-to- fix track until it intersects the parallel boundary lines or reaches the segment end. See figure 6-5.

d. Outside Turn Secondary Area. Outbound segment secondary areas following wind spirals begin where either the 30-degree converging line crosses the secondary and primary boundaries from outside the segment, or the 15-degree splay line crosses the primary boundary from inside the segment.

6.4.2 Second MA Turn WS Construction (DF/TF FO).

To accommodate the two inbound tracks in the **DF** leg, the second **MA** turn **DF/TF** (fly-over) construction uses two **WS** baselines, **<u>PP'</u>** and **<u>P'P''</u>**.

Note: Apply table 6-2 **<u>PP'</u>** location information for each baseline (formula is identical).

a. CASE 1: Small angle turn using 1 WS for each inbound DF track.

<u>STEP 1:</u> Construct the **WS1** baseline, (**<u>P'P''</u>**) perpendicular to the **DF** track nearer the outside of the **DF/TF** turn, at the late-turn-point (see table 6-2 for line **<u>PP'</u>** location).

<u>STEP 1a:</u> Construct the **WS2** baseline, (**<u>PP'</u>**) perpendicular to the **DF** track nearer the inside of the **DF/TF** turn, at the late-turn-point (see table 6-2 for line **<u>PP'</u>** location).

<u>STEP 2:</u> Locate the **WS1** center on **<u>P'P''</u>** at distance **R** (no-wind turn radius, using formula 6-3; see figure 6-2) from the intersection of **<u>P'P''</u>** and the inbound-segment outer-boundary extension.

<u>STEP 2a:</u> Locate the **WS2** center on **<u>PP'</u>** at distance **R** (no-wind turn radius, using formula 6-3; see figure 6-9) from the intersection of **<u>PP'</u>** and the inbound-segment inner-boundary extension.

<u>STEP 3:</u> Construct **WS1** from this outer boundary point in the direction of turn until tangent to the **WS**/Segment connecting line from table 6-2.

<u>STEP 3a:</u> Construct **WS2** from this inner boundary point in the direction of turn until tangent to the **WS**/Segment connecting line from table 6-2.

<u>STEP 4:</u> Where **WS2** intersects **WS1** construction, include **WS2** in the **OEA** construction, and connect **WS1** to **WS2** with a tangent line. Otherwise revert to the single **WS** construction.

CASE 1-1: WS1 and/or WS2 lie outside the outbound segment boundary.

<u>STEP 1:</u> Construct the **OEA** outer boundary using **WS1** and/or **WS2** and the tangent 30-degree converging line until it crosses the outbound segment boundaries (see figure 6-9).

CASE 1-2: WS1 and WS2 lie inside the outbound segment boundary.

<u>STEP 1:</u> Where **WS1** and/or **WS2** lie inside the outbound segment primary boundary, construct the **OEA** outer boundary using **WS1** and/or **WS2** and a line (from the point **WS1** or **WS2** is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary lines.

<u>STEP 1a:</u> Where **WS1** and/or **WS2** lie inside the outbound segment secondary boundary, construct the **OEA** outer boundary using **WS1** and/or **WS2** and a line (from the point **WS1** or **WS2** is parallel to the outbound segment nominal track), splaying at 15 degrees relative the outbound segment nominal track until it intersects the outbound segment boundary line. Continue the final **WS** and 30-degree converging line to establish the primary/secondary boundary.

6.5 Missed Approach Climb Gradient

Where the standard **OCS** slope is penetrated and the lowest **HATh** (final segment evaluation) is required, specify a missed approach **CG** to clear the penetrating obstruction. MA starting ROC is 100 ft for Non-Vertically-Guided-Procedures (**NVGP**), formula 5-25 output for **LPV**, or table 4-2 values for other Vertically-Guided-Procedures, plus appropriate Volume 1, chapter 3 **ROC** adjustments. **ROC** increases at 48 ft per NM, measured parallel to the missed approach track to **TIA** end (Turn-at-Altitude), or early-turn point (Turn-at-Fix), then shortest primary distance to the next fix. Apply fix-to-fix distance for subsequent segments. Where a part-time altimeter is in use, consider the aircraft **SOC** altitude to be the **MDA** associated with the local altimeter (ensures adequate **CG** is applied).

STEP 1: Calculate the **ROC**, the altitude at which the **ROC** for the obstacle is achieved, and the required **CG** (ft/NM) using formula 6-9. See formula 2-22 for **MA** Slope calculations.

STEP 2: Apply the **CG** to:

- The altitude which provides appropriate **ROC**, or
- The point/altitude where the subsequent standard **OCS** slope clears all obstacles.

STEP 2a: Where a **RASS** adjustment is applicable for climb-to-altitude operations (prior to turn, terminate **CG**, etc.), apply the **CG** associated with the lower **MDA**/**DA** (formula 6-9). To establish the **RASS**-based climb-to-altitude, add the difference between the Local altimeter-based **MDA** and the **RASS**-based **MDA** to the climb-to-altitude and round to the next higher 100-ft increment (see Volume 1, chapter 3 for further details).

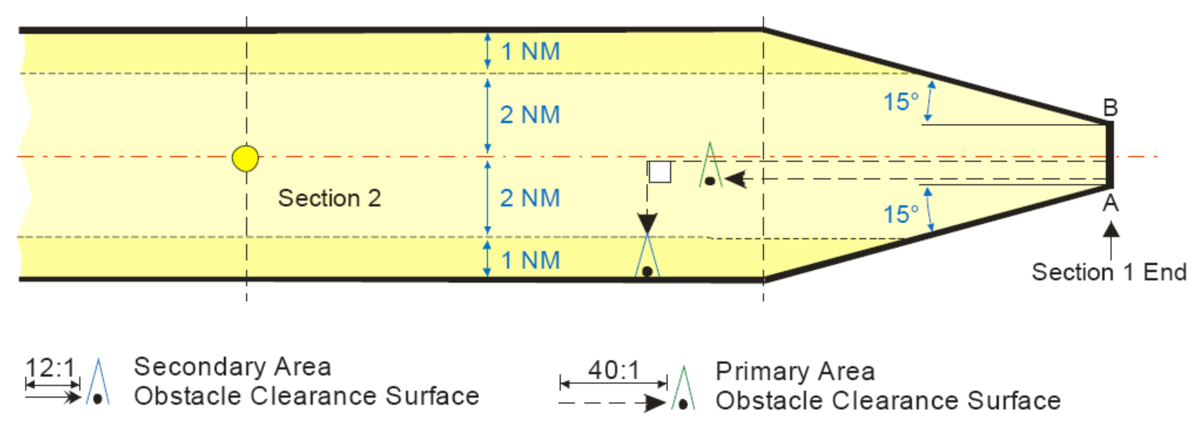


Figure 6-1: Straight Missed Approach (Legs with Specified Tracks)

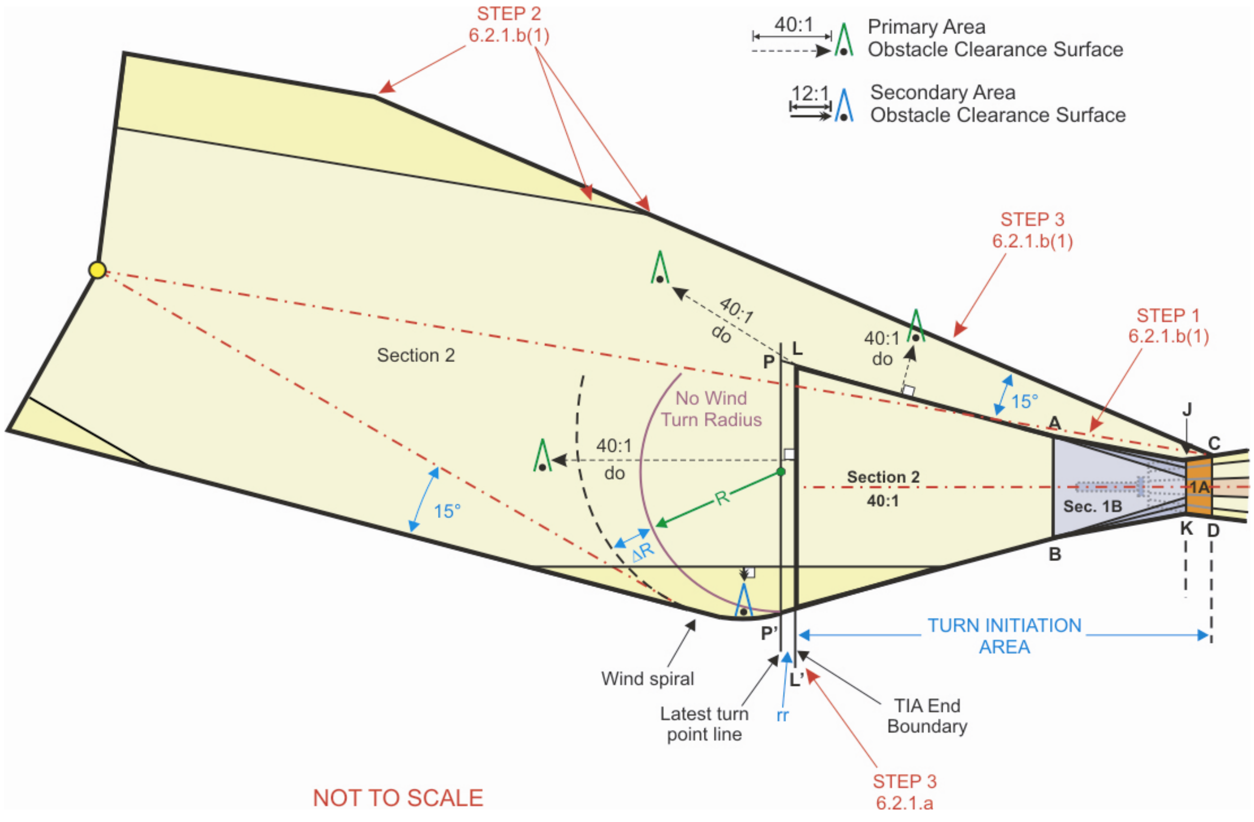


Figure 6-2: Turn at Altitude – Direct to Waypoint Small Angle Turn

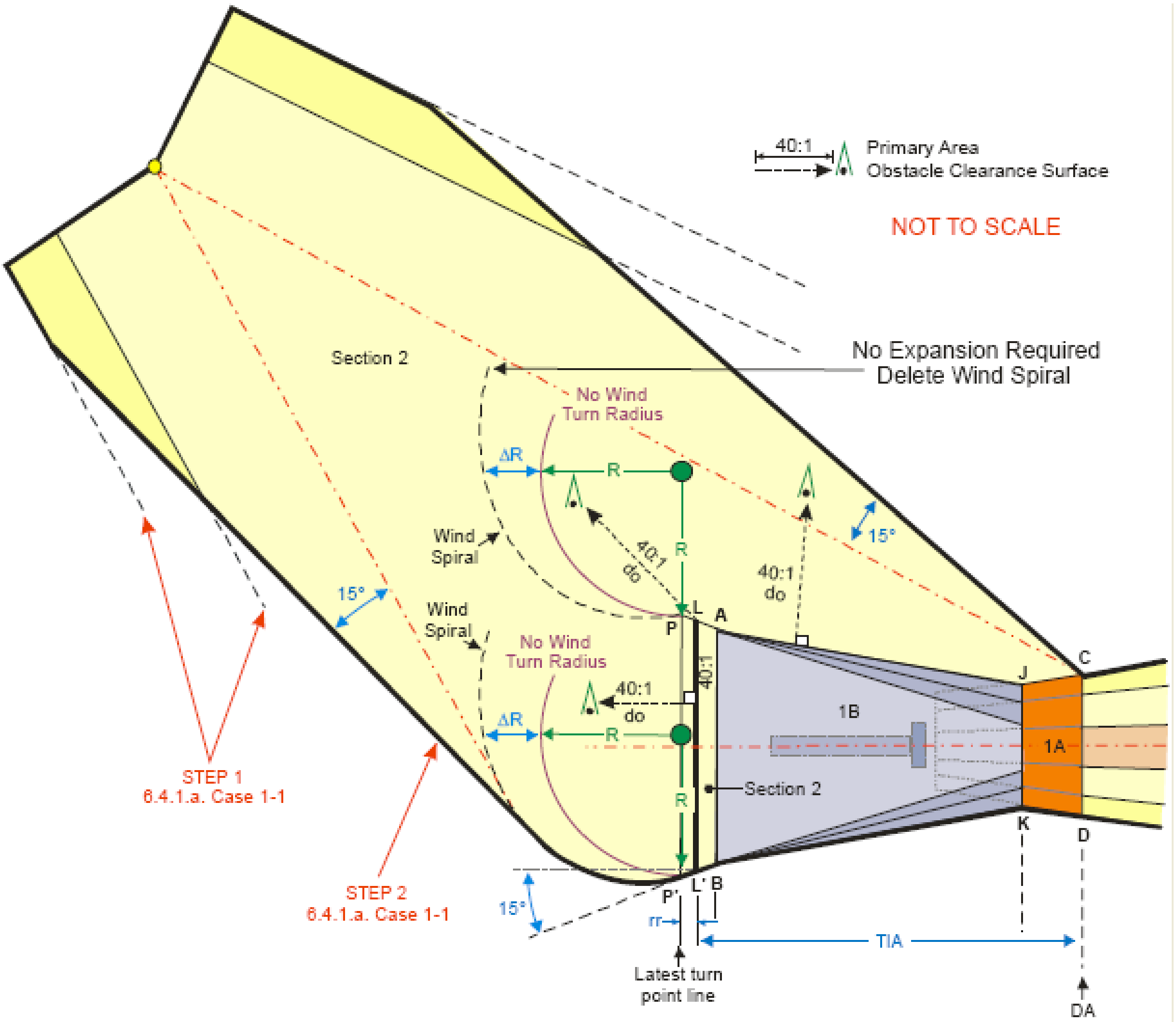


Figure 6-3: Turn at Altitude. TIA must Extend to the End of Section 1B.

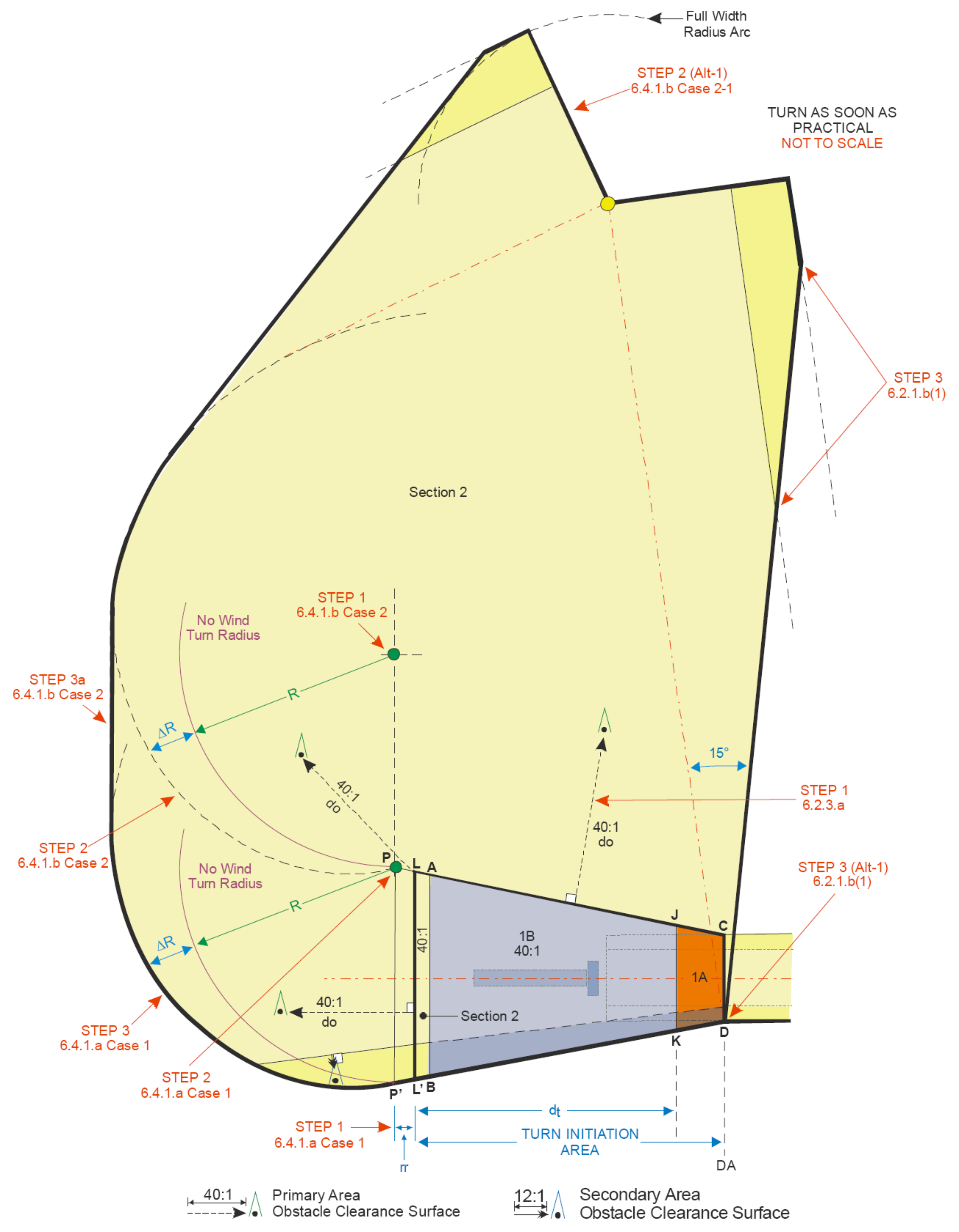


Figure 6-4: Turn at Altitude (Minimum Straight Segment).

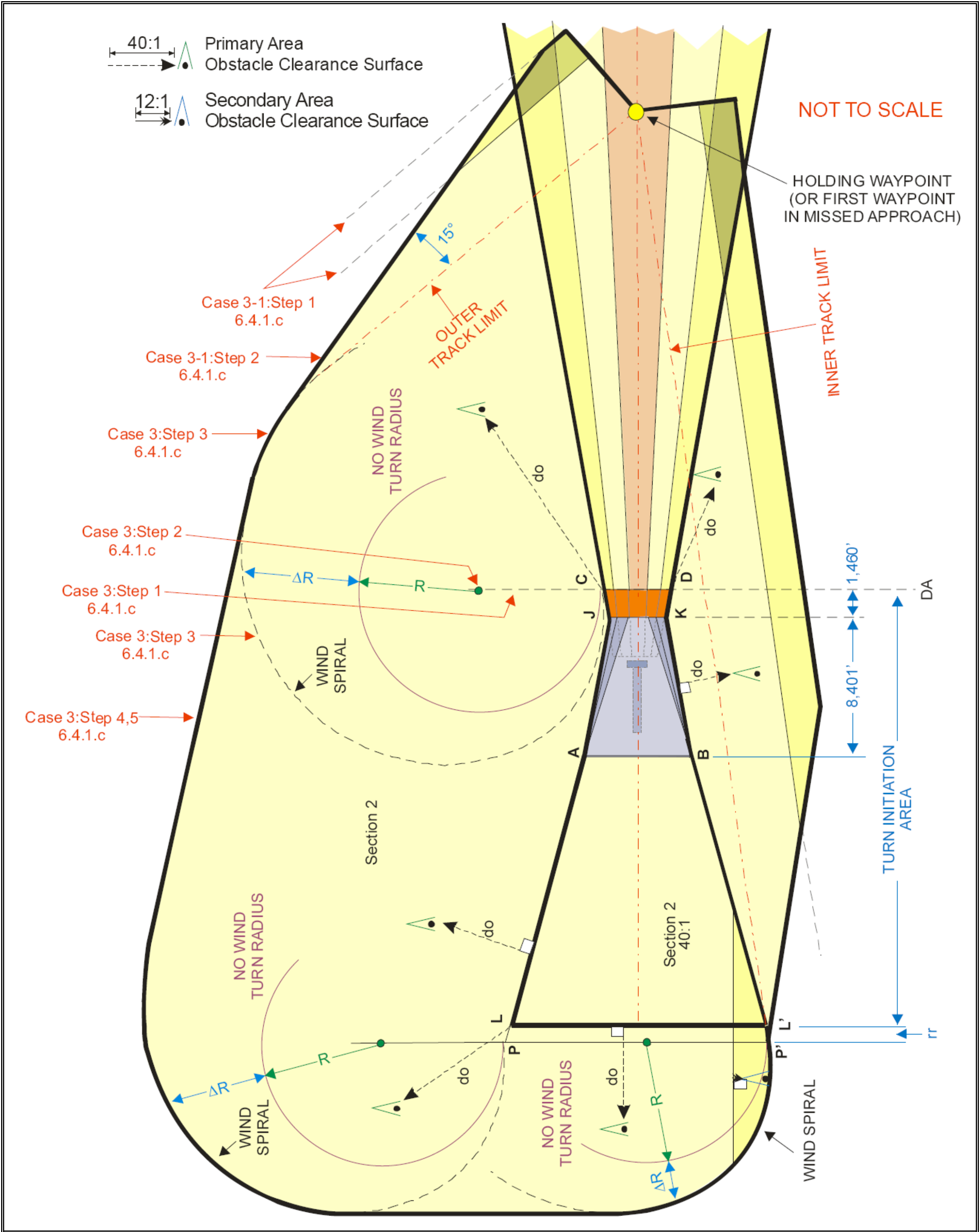


Figure 6-5: Turn at Altitude ≥ 180°.

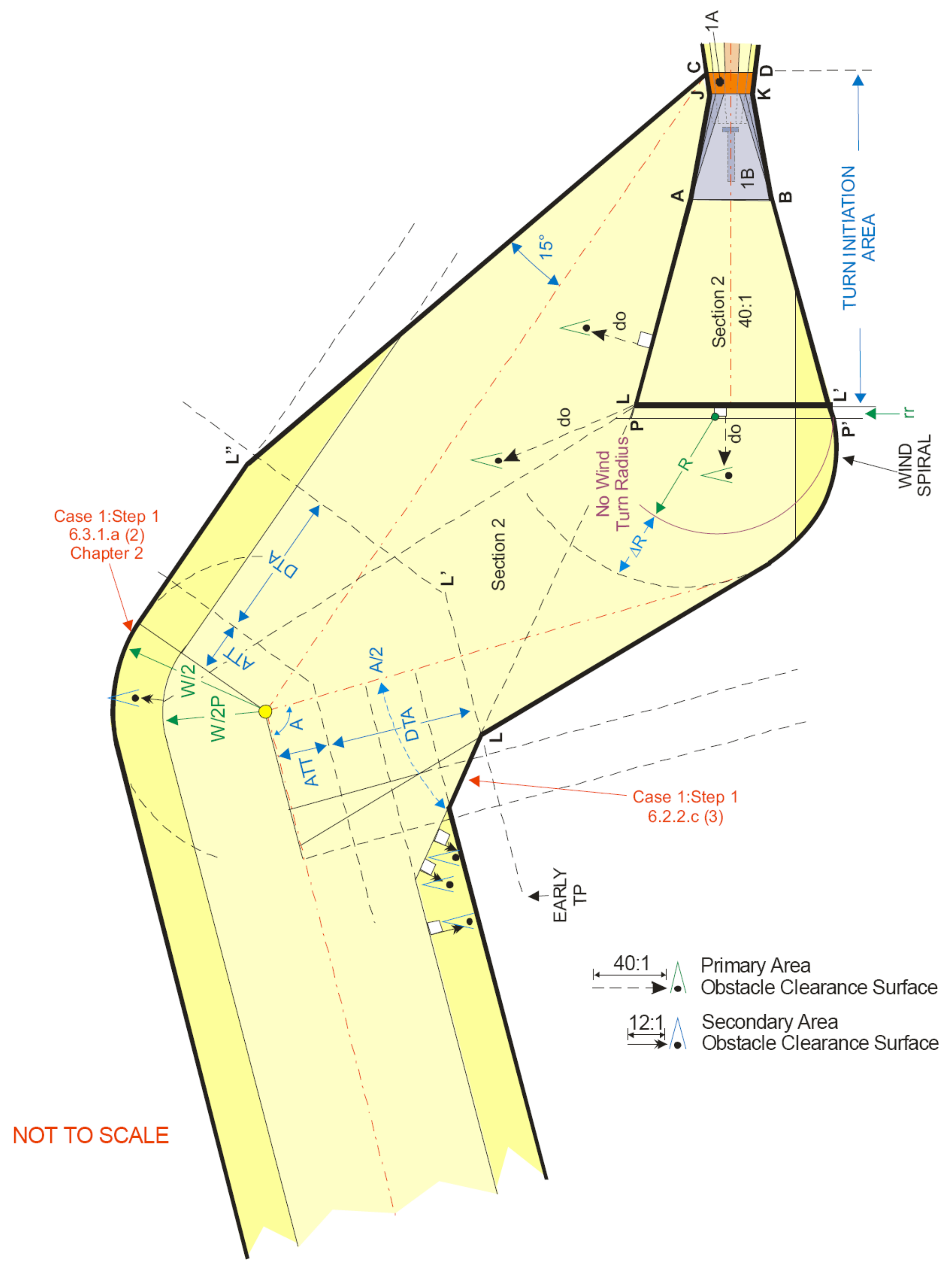
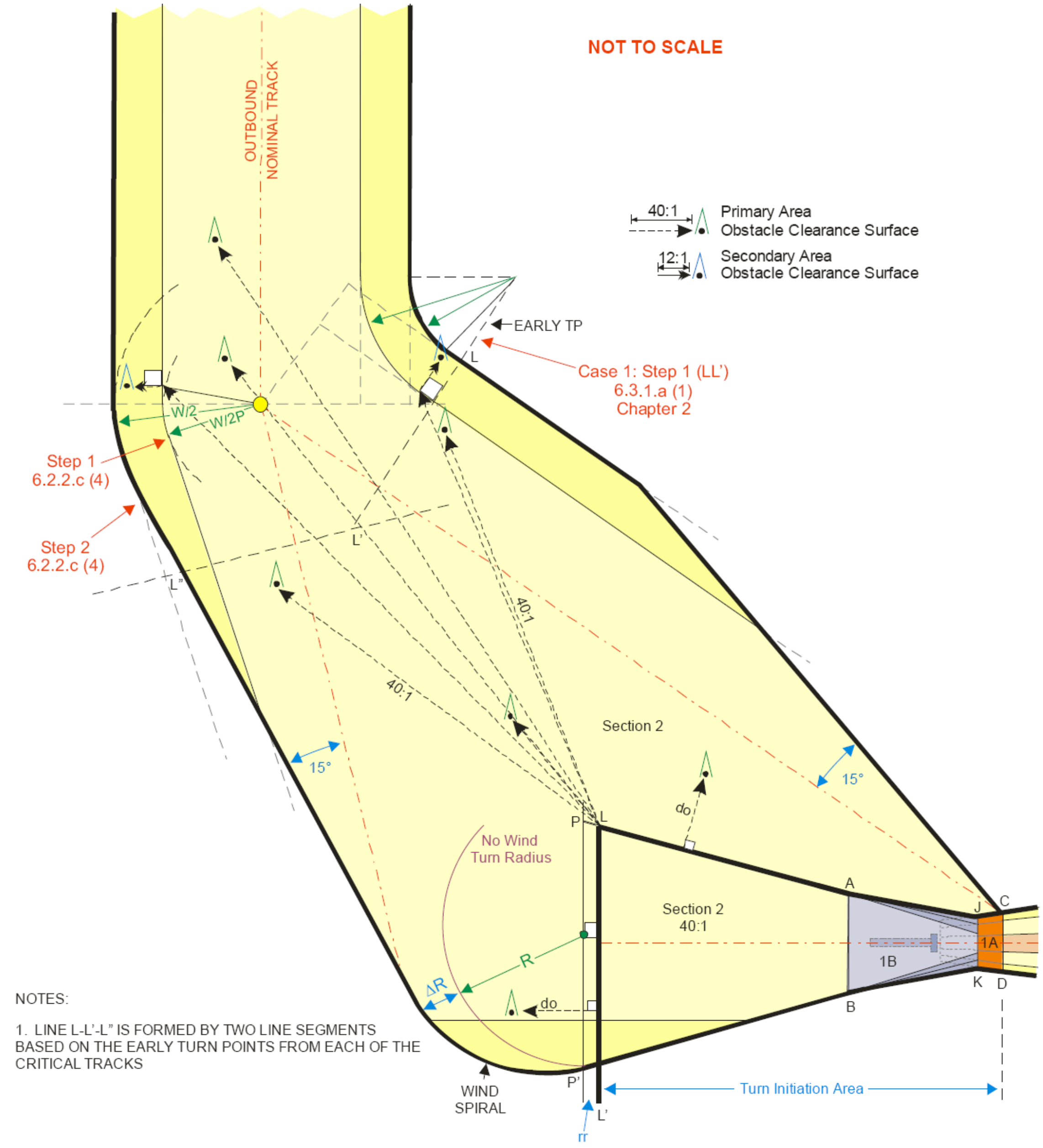


Figure 6-6: Fly-By DF/TF Turn Following Turn at Altitude.



NOTES:

1. LINE L-L'-L" IS FORMED BY TWO LINE SEGMENTS BASED ON THE EARLY TURN POINTS FROM EACH OF THE CRITICAL TRACKS

Figure 6-7: Turn at Altitude to Fly-By Waypoint.

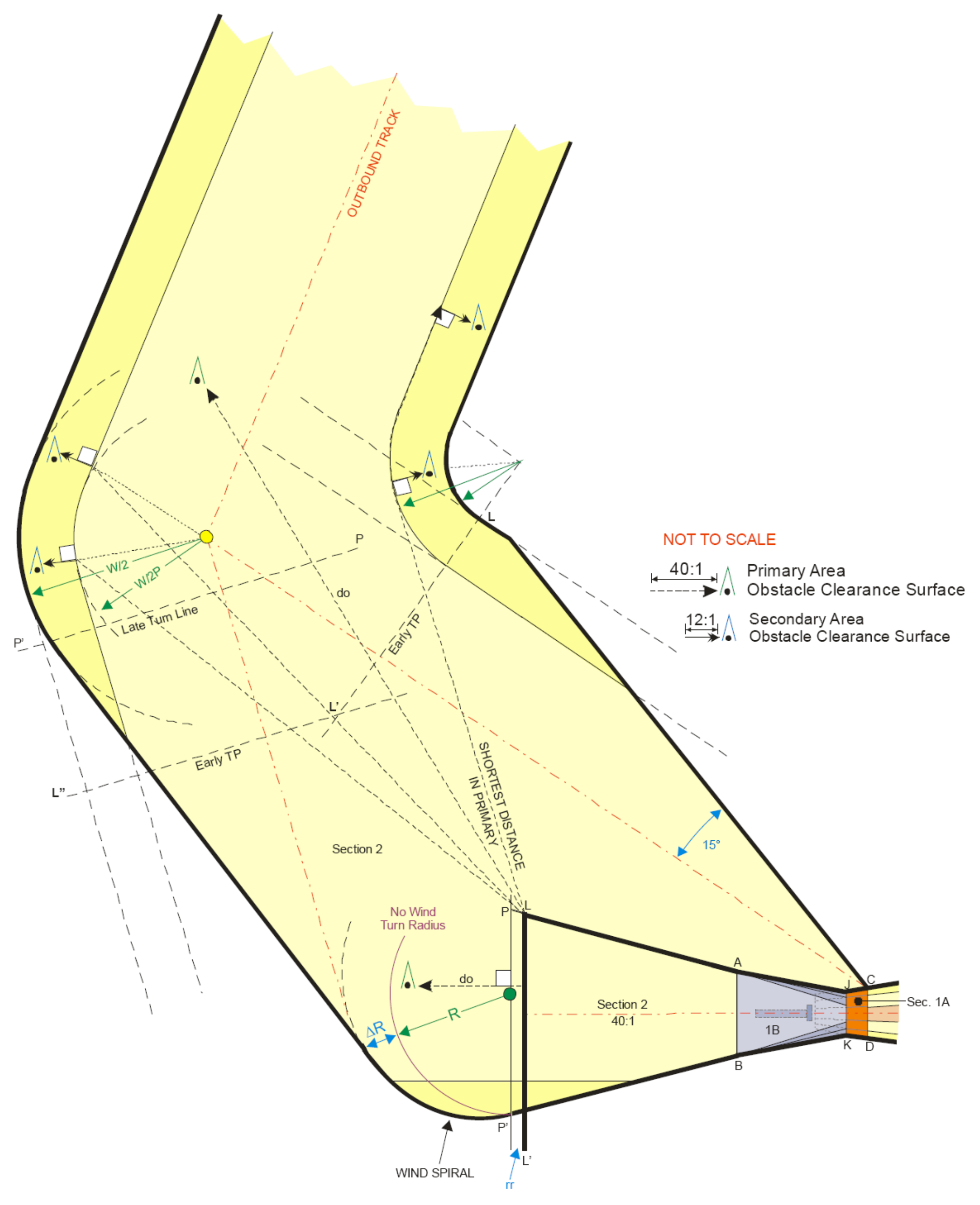


Figure 6-8: Maximum Turn (Fly-By) Following Turn at Altitude.

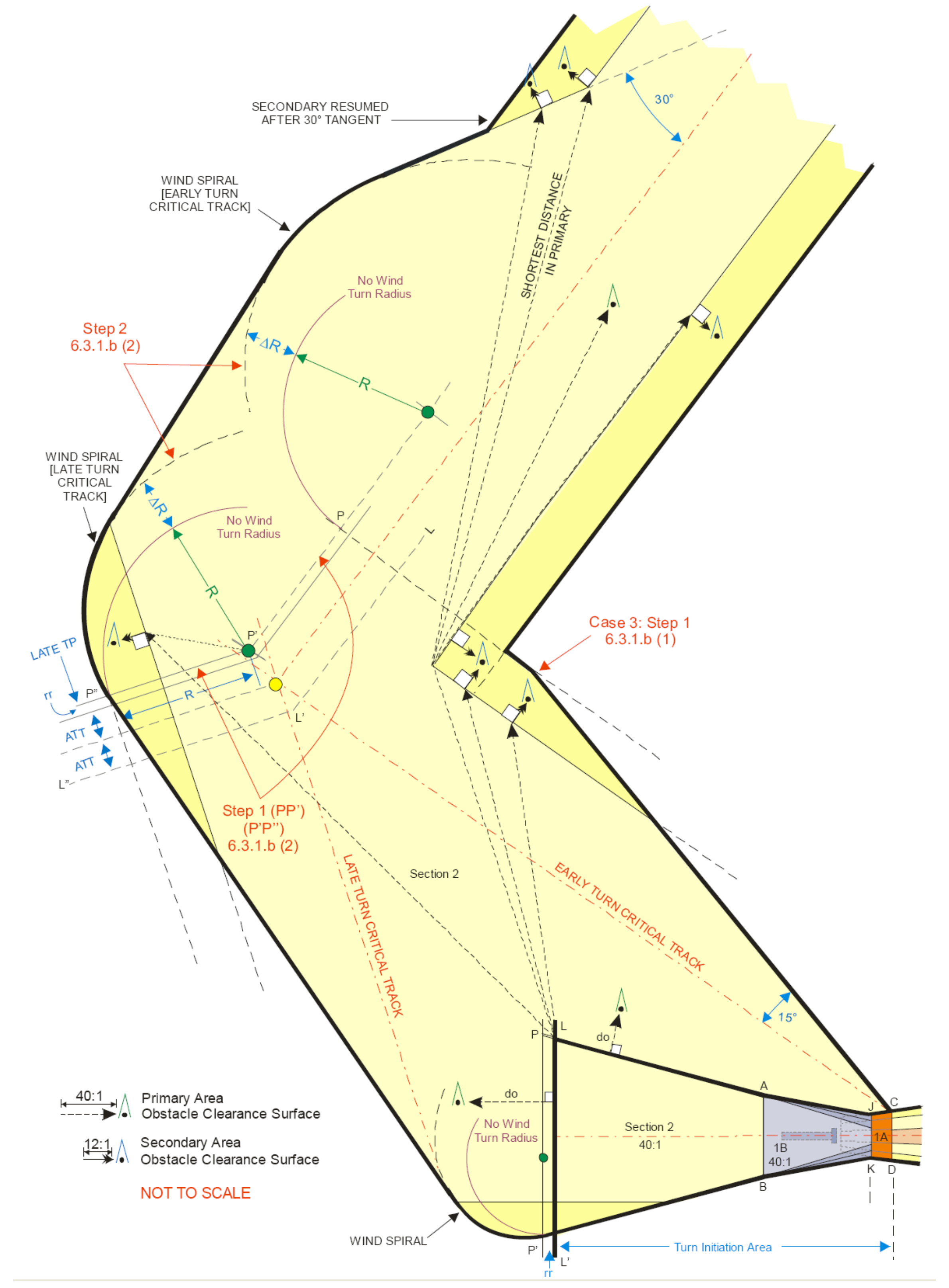


Figure 6-9: Turn at Altitude to a Fly-Over Waypoint.

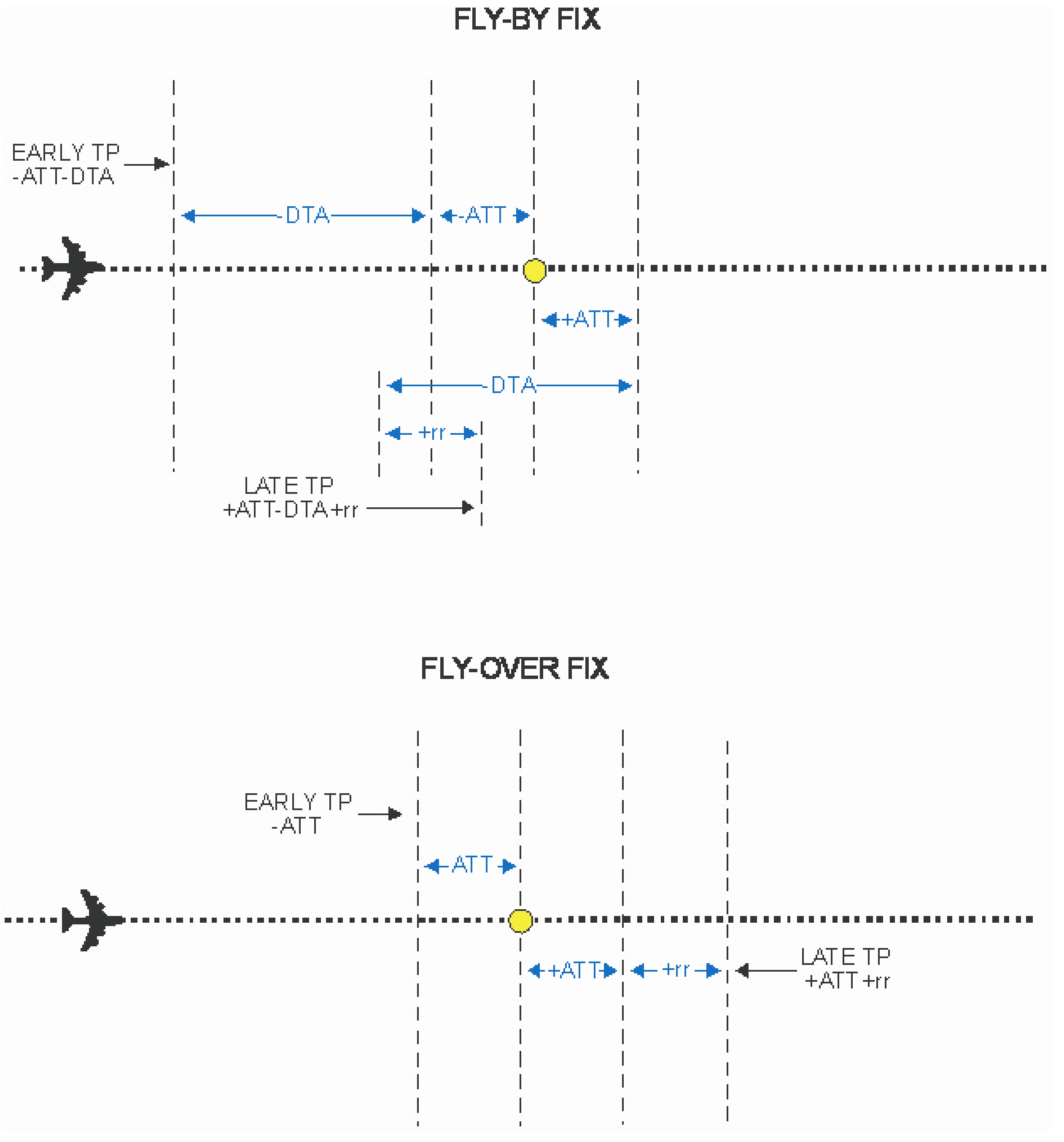


Figure 6-10: Fly-Over/ Fly-By Fix Diagrams.

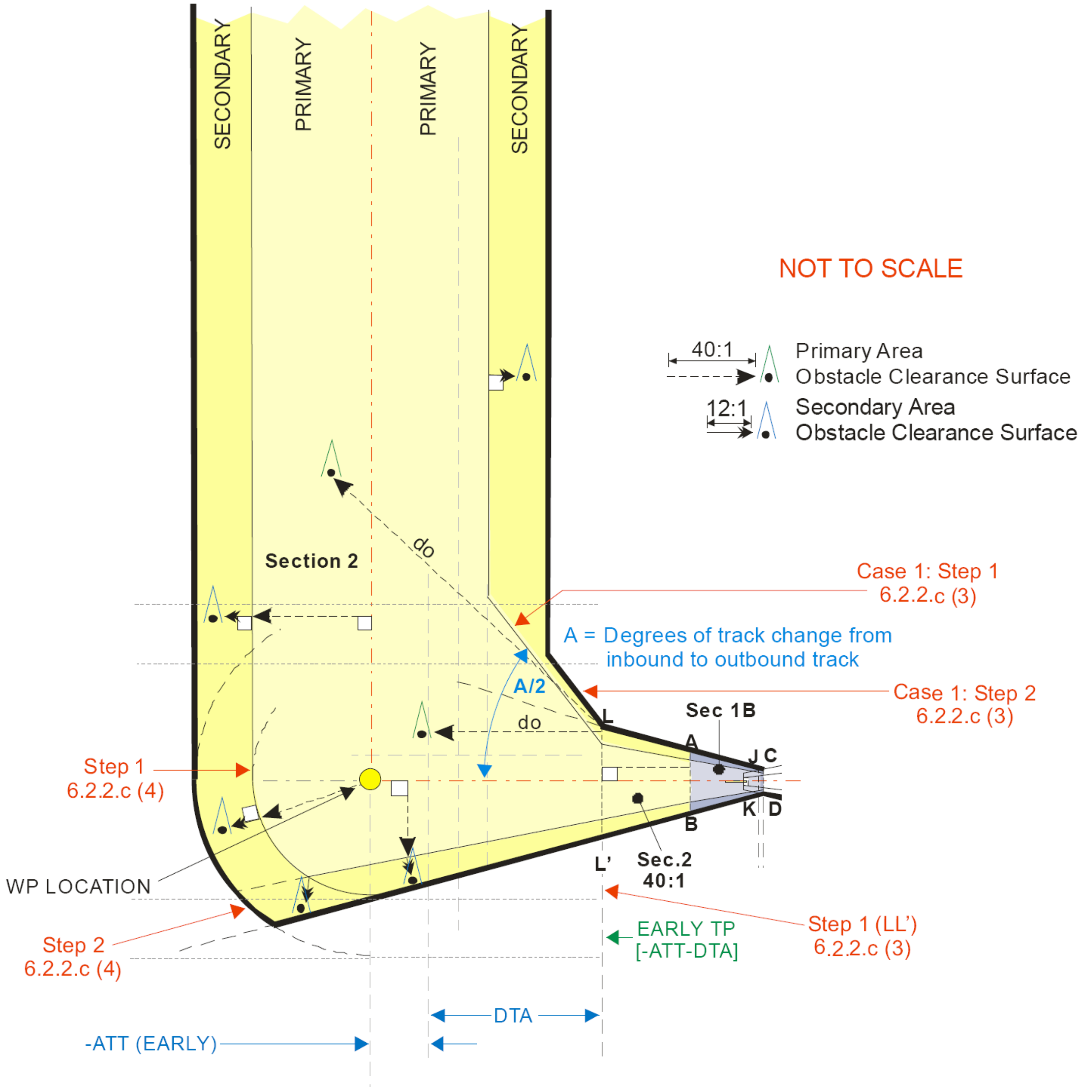


Figure 6-11a: Turn at Waypoint (Fly-By).

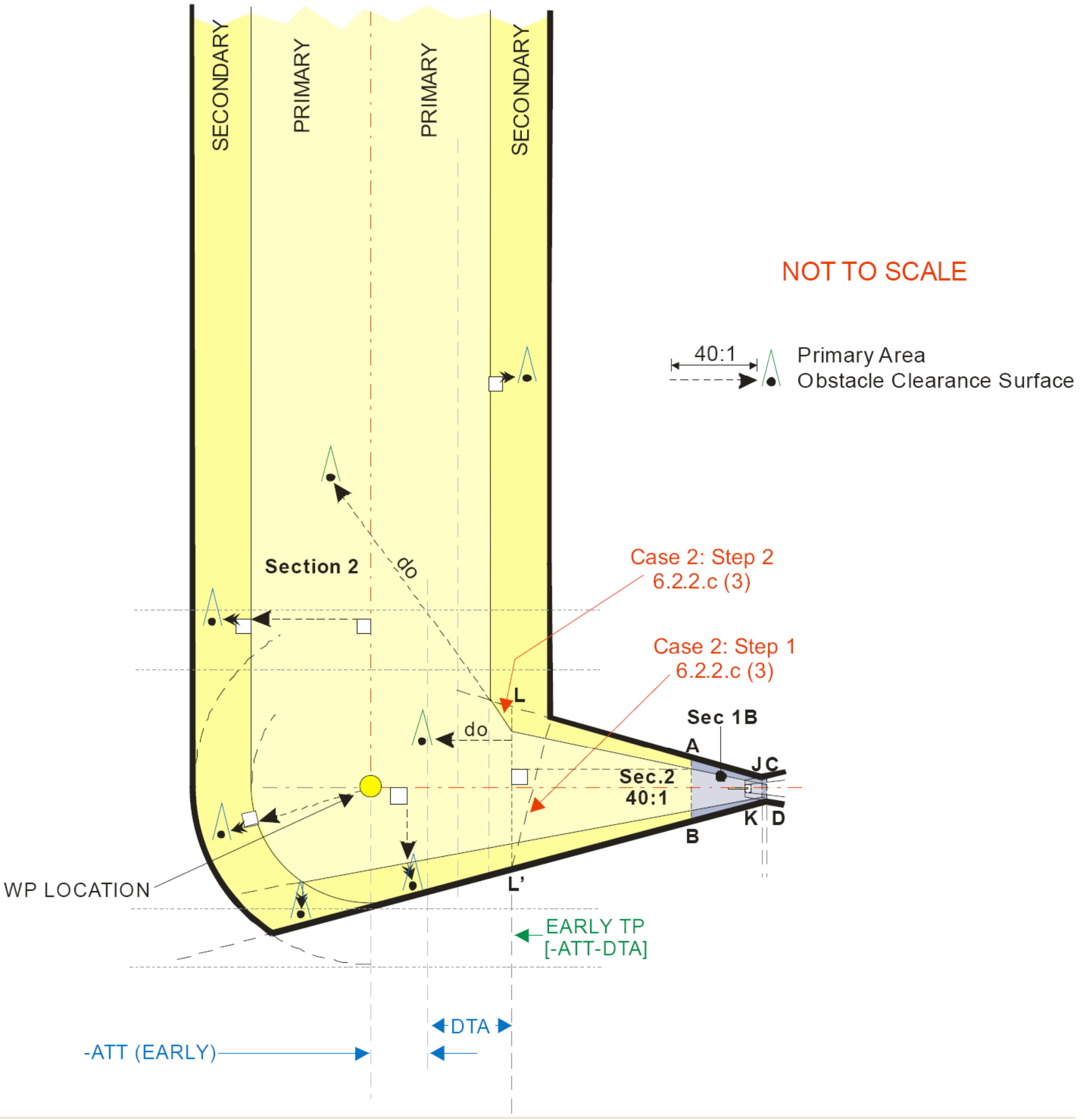


Figure 6-11b: Turn at Waypoint (Fly-By).

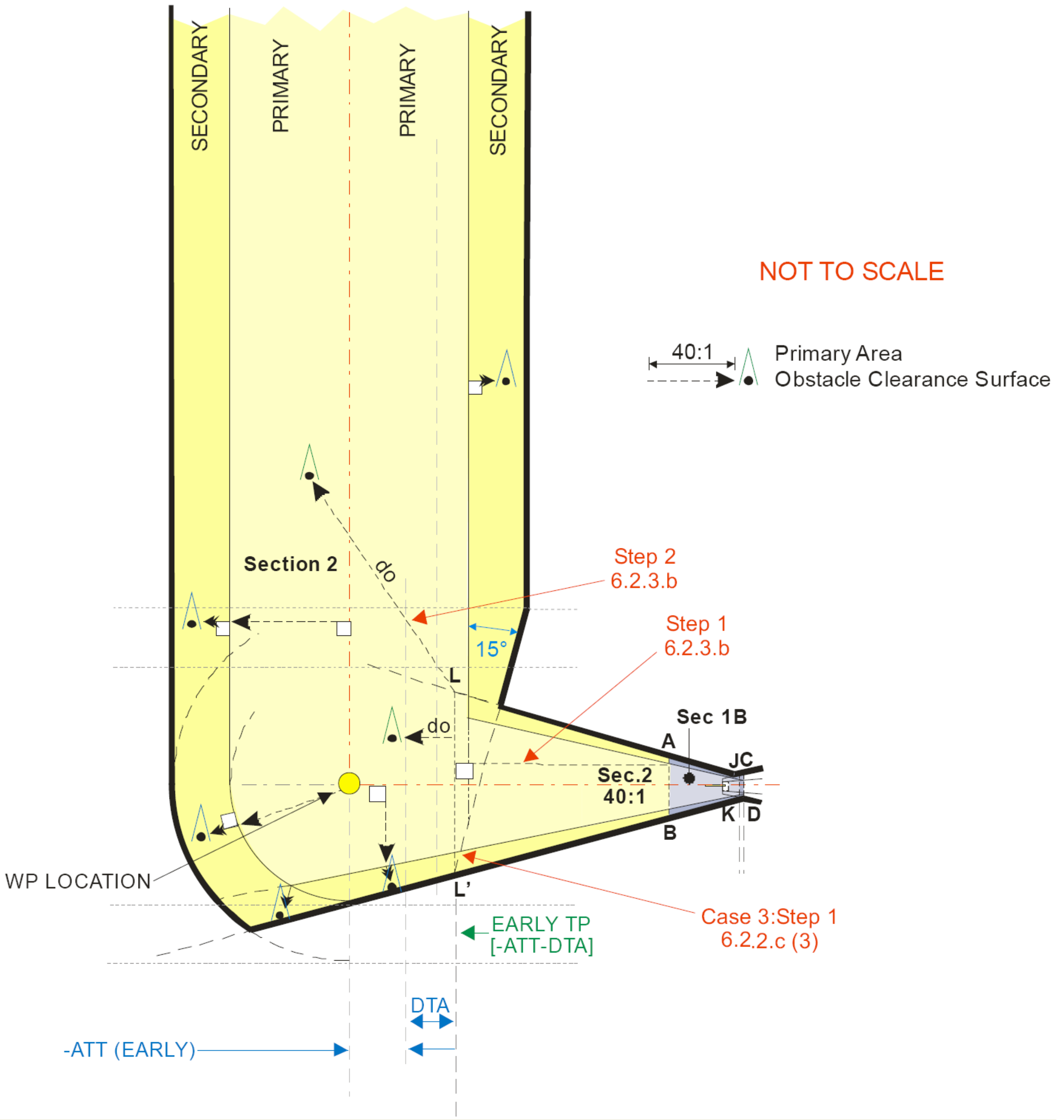


Figure 6-11c: Turn at Waypoint (Fly-By).

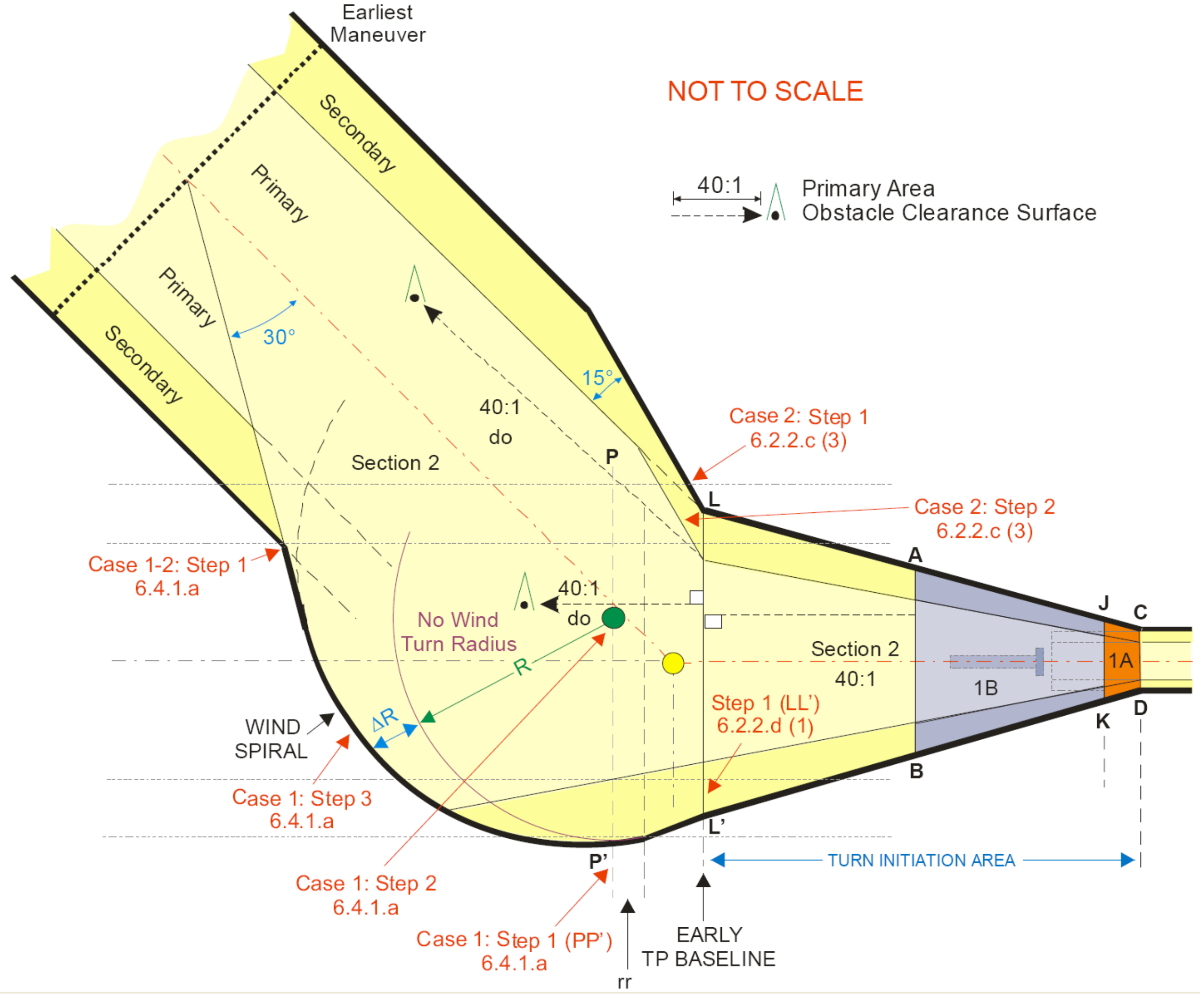


Figure 6-12: Turn at Waypoint (Fly-Over), < 75°.

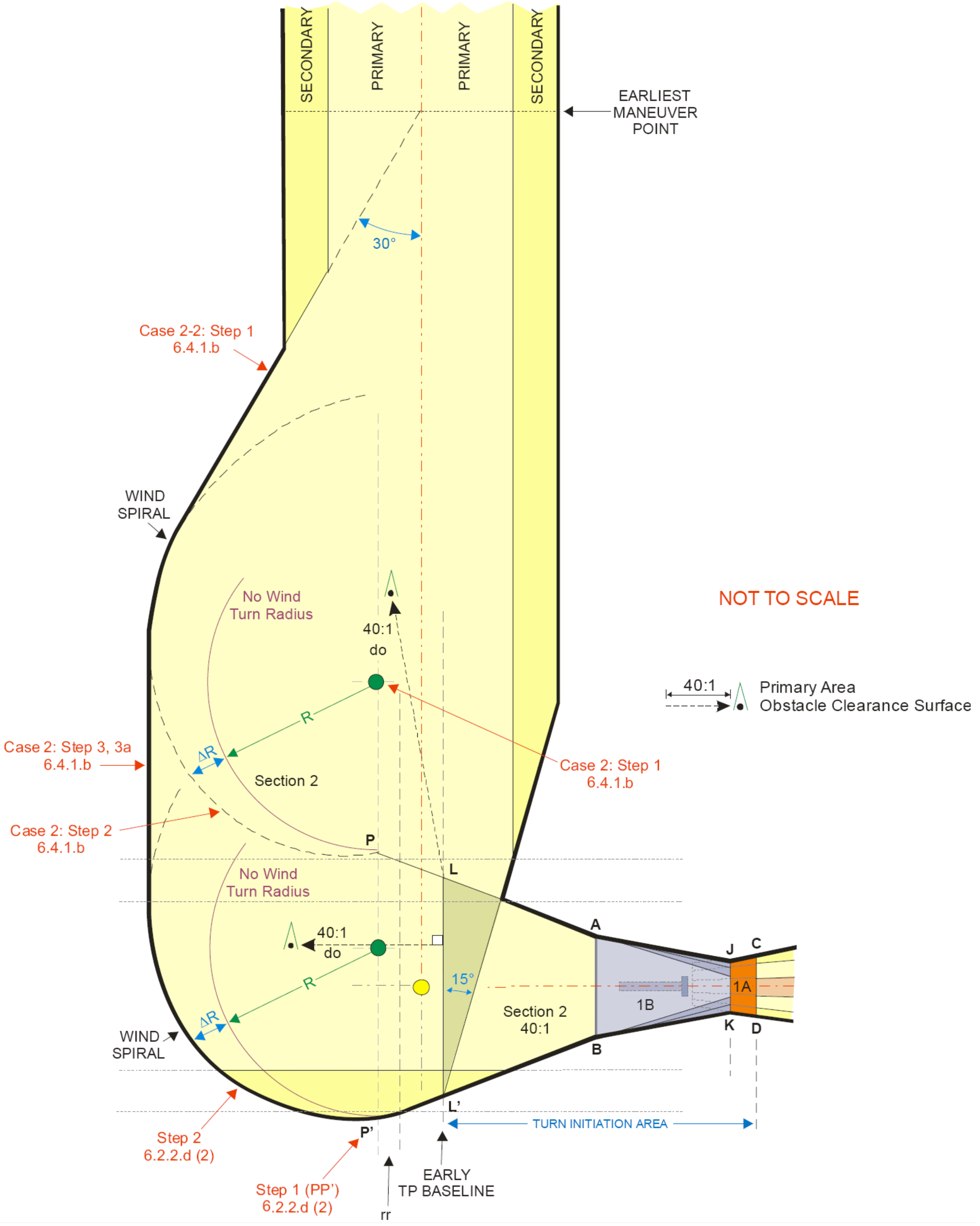
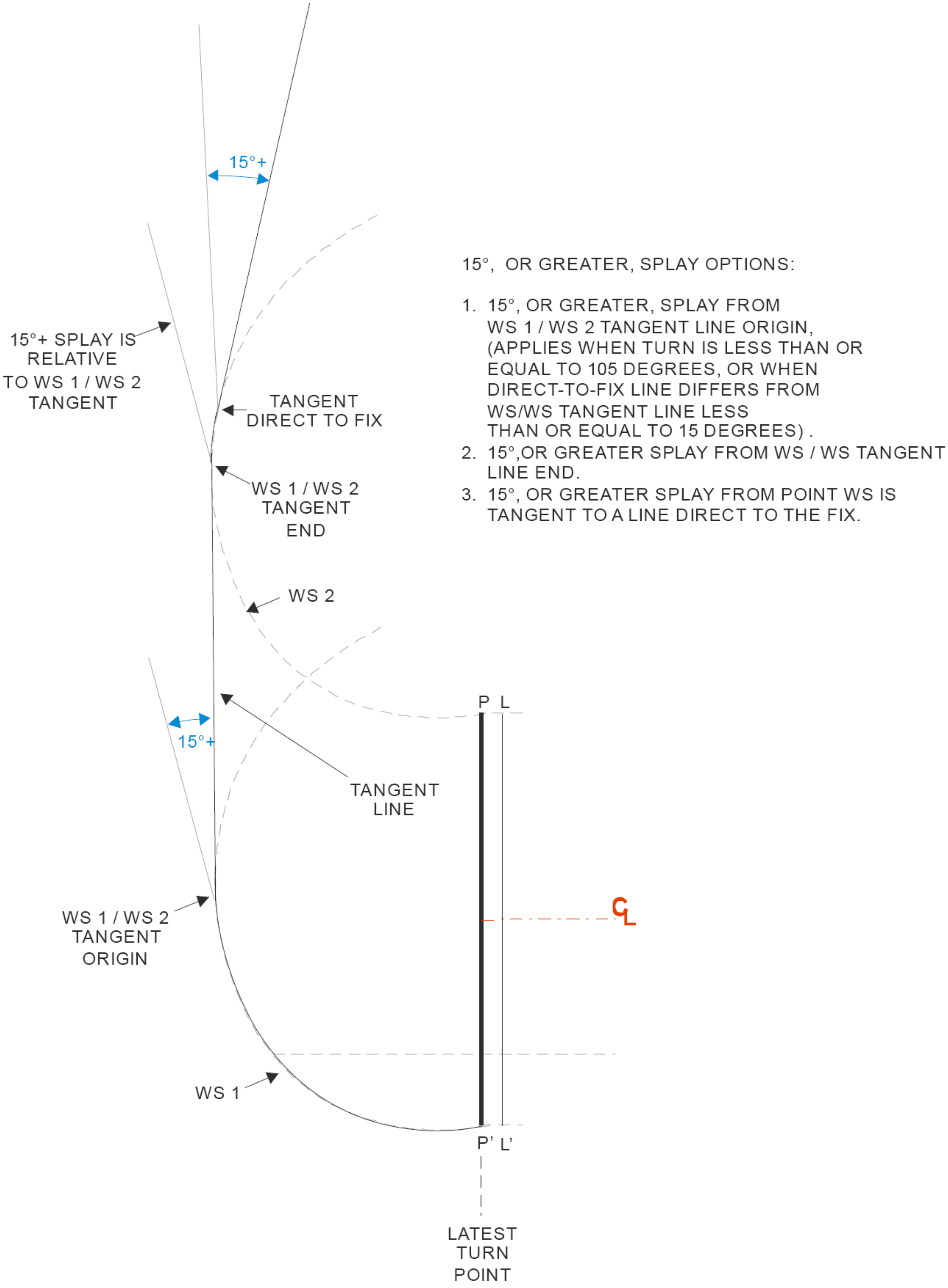


Figure 6-13: Turn at Waypoint (Fly-Over), 90°.



15°, OR GREATER, SPLAY OPTIONS:

1. 15°, OR GREATER, SPLAY FROM WS 1 / WS 2 TANGENT LINE ORIGIN, (APPLIES WHEN TURN IS LESS THAN OR EQUAL TO 105 DEGREES, OR WHEN DIRECT-TO-FIX LINE DIFFERS FROM WS/WS TANGENT LINE LESS THAN OR EQUAL TO 15 DEGREES) .
2. 15°,OR GREATER SPLAY FROM WS / WS TANGENT LINE END.
3. 15°, OR GREATER SPLAY FROM POINT WS IS TANGENT TO A LINE DIRECT TO THE FIX.

Figure 6-14a: WS Outer Boundary Connections.

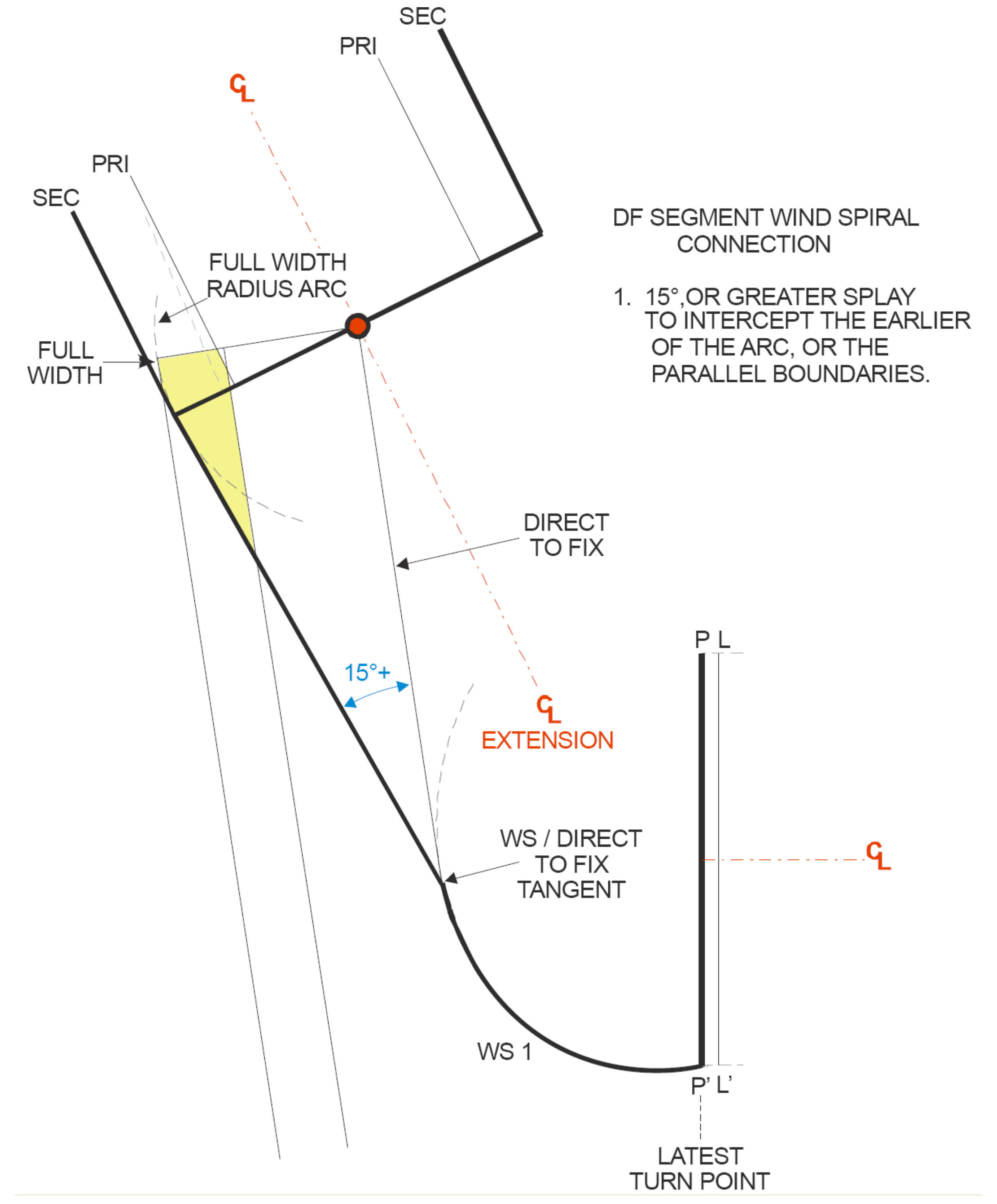
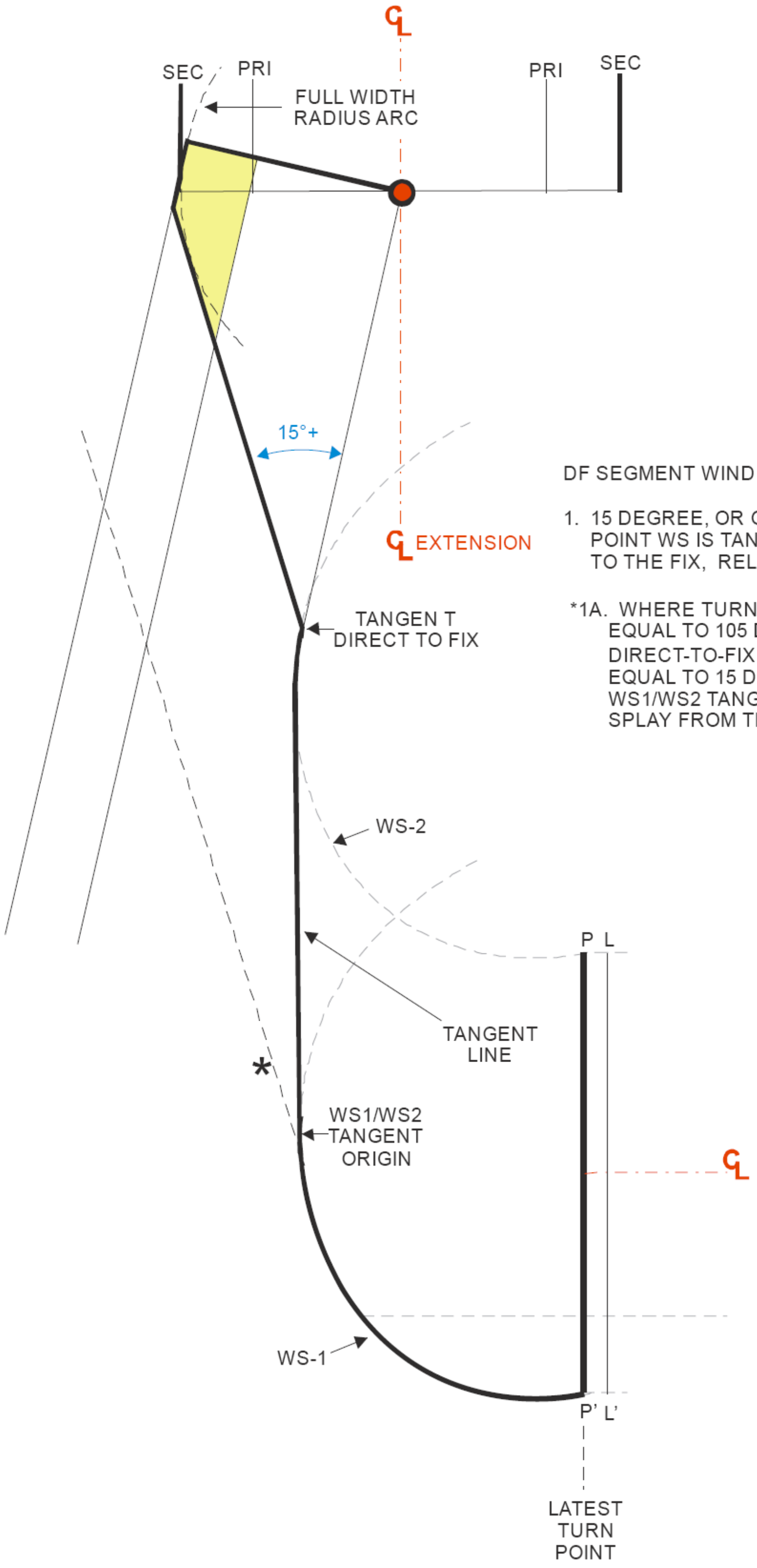


Figure 6-14b: WS1 Outer Boundary Connection.



DF SEGMENT WIND SPIRAL CONNECTION

1. 15 DEGREE, OR GREATER SPLAY FROM POINT WS IS TANGENT TO A LINE DIRECT TO THE FIX, RELATIVE THE DIRECT TO FIX LINE.

*1A. WHERE TURN ANGLE IS LESS THAN OR EQUAL TO 105 DEGREES, OR WHERE THE DIRECT-TO-FIX LINE DIFFERS LESS THAN OR EQUAL TO 15 DEGREES FROM THE WS1/WS2 TANGENT LINE , APPLY THE SPLAY FROM THE WS1/WS2 TANGENT ORIGIN.

Figure 6-14c: Turn at Waypoint (Fly-Over, 90°.

OB Segment Boundary Relative ETP Connections	**Expansion Line Required**
Secondary & Primary Prior ETP	15° Line
Secondary Prior ETP	15° Line
Primary Beyond ETP	A/2
Secondary & Primary beyond ETP	A/2

Note: ETP = **<u>LL’</u>** early turn point connection, 15-degree line relative OB segment, A/2 = half turn-angle

Table 6-1. Inside Turn Expansion Guide.

	Turn at Fix (FO)	**Turn at Altitude**
WS1 Baseline (PP’)	Fix + ATT + rr	TIA + rr
WS2 Baseline (PP’)	Fix + ATT + rr	TIA + rr
WS Number	1 or 2	1, 2 or 3*
Final WS Connection (Tangent Line)	30 degrees to outbound track	Direct to Fix

Note: * Where a required turn exceeds that served by three wind spirals, consider adding fixes to avoid prohibitively large protection areas resulting from further wind spiral application.

Table 6-2. MA First Turn Wind Spiral Application Comparison.

Formula 6-1. Section 1 End Aircraft Altitude (Non-LPV)

Math Notation	$Aircraft_{SOC} = \left(r + MDAorDA\right) \bullet e^{\left(\frac{AB_{NM} \bullet CG}{r}\right)} - r$
Standard Text	(r+(MDA or DA))*e^((ABNM*CG)/r)-r

Given values:

AB_{NM} = SOC to AB distance (NM)
r = Earth Radius (20890537 ft)
CG = Applied climb gradient (ft/NM)

Formula 6-2a1. TIA Length Multi-CG (LPV)

Math Notation	$TIA_{length} = 9861 + \frac{r}{CG1} \bullet \frac{1852}{0.3048} \bullet \ln\left(\frac{r + CG1_{termalt}}{r + Aircraft_{SOC}}\right) + \frac{r}{CG2} \bullet \frac{1852}{0.3048} \bullet \ln\left(\frac{r + turn_{alt}}{r + CG1_{termalt}}\right)$
Standard Text	9861+r/CG1*1852/0.3048*ln((r+CG1termalt)/(r+AircraftSOC))+ r/CG2*1852/0.3048*ln((r+turnalt)/(r+ CG1termalt))

Given values:

$CG1_{termalt}$ = Initial CG termination altitude
r = Earth Radius (20890537 ft)
$turn_{alt}$ = required turn altitude
$Aircraft_{SOC}$ = SOC Aircraft Altitude (formula 5-25)
CG1 = Initial Climb Gradient (≥ Standard 200)
CG2 = Second Climb Gradient (Standard 200)

Formula 6-2a2. TIA Length Single-CG (LPV)

Math Notation	$TIA_{length} = 9861 + \frac{r}{CG} \bullet \frac{1852}{0.3048} \bullet \ln\left(\frac{r + turn_{alt}}{r + Aircraft_{SOC}}\right)$
Standard Text	9861+r/CG*1852/0.3048*ln((r+turnalt)/(r+AircraftSOC))

Given values:

$Turn_{alt}$ = Required turn altitude
r = Earth Radius (20890537 ft)
$Aircraft_{SOC}$ = SOC Aircraft Altitude (formula 5-25)
CG = Climb gradient (Standard 200)

Formula 6-2b1. TIA Length Multi-CG (LNAV/LP)

Math Notation	$TIA_{length} = FSL + \frac{r}{(r+MDA)} + \frac{r}{CG1} \bullet \frac{1852}{0.3048} \bullet \ln\left(\frac{r+CG1_{termalt}}{r+MDA}\right) + \frac{r}{CG2} \bullet \frac{1852}{0.3048} \bullet \ln\left(\frac{r+turn_{alt}}{r+CG1_{termalt}}\right)$
Standard Text	FSL*r/(r+MDA)+r/CG1*1852/0.3048*ln((r+CG1termalt)/(r+MDA))+ r/CG2*1852/0.3048*ln((r+turnalt)/(r+CG1termalt))

Given values:

$CG1_{termalt}$ = Initial CG termination altitude
r = Earth Radius (20890537 ft)
MDA = Aircraft Final MDA
CG1 = Initial Climb Gradient (≥ Standard 200)
CG2 = Second Climb Gradient (Standard 200)

Formula 6-2b2. TIA Length Single-CG (LNAV/LP)

Math Notation	$TIA_{length} = FSL \bullet \frac{r}{(r+MDA)} + \frac{r}{CG} \bullet \frac{1852}{0.3048} \bullet \ln\left(\frac{r+turn_{alt}}{r+MDA}\right)$
Standard Text	FSL*(r/(r+MDA))+r/CG*1852/0.3048*ln((r+turnalt)/(r+MDA))

Given values:

$Turn_{alt}$ = Required turn altitude
r = Earth Radius (20890537 ft)
DA = Final DA
CG = Climb gradient (Standard 200)

Formula 6-2c1. TIA Length Multi-CG (LNAV/VNAV)

Math Notation	$TIA_{length} = FSL + \frac{r}{(r+DA)} + \frac{r}{CG1} \bullet \frac{1852}{0.3048} \bullet \ln\left(\frac{r+CG1_{termalt}}{r+DA}\right) + \frac{r}{CG2} \bullet \frac{1852}{0.3048} \bullet \ln\left(\frac{r+turn_{alt}}{r+CG1_{termalt}}\right)$
Standard Text	FSL*r/(r+DA)+r/CG1*1852/0.3048*ln((r+CG1termalt)/(r+DA))+ r/CG2*1852/0.3048*ln((r+turnalt)/(r+CG1termalt))

Given values:

$CG1_{termalt}$ = Initial CG termination altitude
r = Earth Radius (20890537 ft)
DA = Aircraft Final DA
CG1 = Initial Climb Gradient (≥ Standard 200)
CG2 = Second Climb Gradient (Standard 200)

Formula 6-2c2. TIA Length Single-CG (LNAV/VNAV)

Math Notation	$TIA_{length} = FSL \bullet \frac{r}{(r+DA)} + \frac{r}{CG} \bullet \frac{1852}{0.3048} \bullet \ln\left(\frac{r+turn_{alt}}{r+DA}\right)$
Standard Text	FSL*r/(r+DA)+r/CG*1852/0.3048*ln((r+turnalt)/(r+DA))

Given values:

$Turn_{alt}$ = Required turn altitude
r = Earth Radius (20890537 ft)
DA = Final DA
CG = Climb gradient (Standard 200)

Formula 6-3. No Wind Turn Radius (R)

Math Notation	$R = \frac{(V_{KTAS})^2}{\tan\left(15 \bullet \frac{\pi}{180}\right) \bullet 68625.4}$
Standard Text	(VKTAS)^2/(tan(15*π/180)*68625.4)

Formula 6-3a. TR

Math Notation	$TR = \frac{3431 \bullet \tan\left(15 \bullet \frac{\pi}{180}\right)}{\pi \bullet V_{KTAS}}$
Standard Text	(3431*tan(15*π/180))/(π*VKTAS)

Formula 6-4. WS ΔR

Math Notation	$\Delta R = \frac{V_{KTW} \bullet \phi}{3600 \bullet TR}$
Standard Text	(Φ*VKTW)/(3600*TR)

Given values:

Φ = Degrees of turn
TR = Formula 6-3a (Max 3 degrees/second)
V_{KTW} = Formula 2-3b Wind Speed

Formula 6-5. Fix Distance (D_{fix}).

Math Notation	$D_{fix} = \ln\left(\frac{Alt_{fix} + r}{Aircraft_{SOC} + r}\right) \bullet \frac{r}{CG}$
Standard Text	ln((Altfix+r)/(Aircraftsoc+r))*r/CG
Given values:	Alt_{fix} = Degrees of turn $Aircraft_{SOC}$ = Aircraft **AB** line (SOC) altitude CG = Climb Gradient (Standards 200 ft/NM)

Formula 6-6. Altitude Achieved at Fix.

Math Notation	$Altfix = (r + Aircraft_{SOC}) \bullet e^{\left(\frac{CG \bullet D_{fix}}{r}\right)} - r$
Standard Text	(r+AircraftSOC) *e^(CG*Dfix/r)-r
Given values:	D_{fix} = Distance (NM) from **AB** line to fix $Aircraft_{SOC}$ = Aircraft **AB** line (SOC) altitude CG = Climb Gradient (Standards 200 ft/NM)

Formula 6-7. Early Turn Distance.

Math Notation	$Dearly_{TP} = ATT + DTA$
Standard Text	ATT + DTA
Given values:	ATT = Along-track tolerance DTA = Distance of turn anticipation

Formula 6-8. Late Turn Point Distance.

Math Notation	$D_{lateTP} = ATT + rr$
Standard Text	ATT + rr
Given values:	ATT = Along-track tolerance (feet) rr = Delay/roll-in (formula 2-4)

<table>
<tr><th colspan="2">Formula 6-9. ROC/CG Minimum Altitude/OCS..</th></tr>
<tr><td colspan="2">STEP 1</td></tr>
<tr><td>Math Notation</td><td>$ROC_{obs} = ROC_{start} + 48 \bullet d$</td></tr>
<tr><td>Standard Text</td><td>ROC_{start}+48*d</td></tr>
<tr><td colspan="2">Given values:
ROC_{start} = SOC ROC (Table 4-2 value) or (100 ft for NVGP) (Include Vol 1, Chap 3 ROC adjustments). For LPV ROC_{start} value see Formula 5-25.
d = Distance (NM) CG origin (SOC) to obstacle</td></tr>
<tr><td colspan="2">STEP 2</td></tr>
<tr><td>Math Notation</td><td>$Alt_{\min} = O_{elev} + ROC_{obs}$</td></tr>
<tr><td>Standard Text</td><td>Oelev+ROCobs</td></tr>
<tr><td colspan="2">Given values:
ROC_{obs} = Step 1 result
O_{elev} = Obstacle elevation (MSL)</td></tr>
<tr><td colspan="2">STEP 3</td></tr>
<tr><td>Math Notation</td><td>$CG = \frac{r}{d} \bullet \ln\left(\frac{(r + Alt_{\min})}{(r + Aircraft_{SOC})}\right)$</td></tr>
<tr><td>Standard Text</td><td>r/d*ln((r+ALTmin)/(r+AircraftSOC))</td></tr>
<tr><td colspan="2">Given values:
Alt_{min} = Step 2 result
$Aircraft_{SOC}$ = Aircraft altitude (MSL) at CG origin
d = Distance (NM), CGorigin (SOC) to obstacle</td></tr>
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CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

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CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

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ANNEX A

GLOSSARY

TRANSPORT CANADA
NATIONAL DEFENSE

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ACRONYMS AND ABBREVIATIONS

AAF	Airway Facilities Service
AARN	Air Navigation Services and Airspace
ABM	abeam
AC	Advisory Circular
ADF	automatic direction finder
AGL	above ground level
AIM	Aeronautical Information Manual
AIS	Aeronautical Information Services
ALSF-1	approach lighting system with sequenced flashing lights (CAT I Configuration)
ALSF-2	approach lighting system with sequenced flashing lights (CAT II Configuration)
APT	Airport
APV	approach with vertical guidance (ICAO)
ARA	airborne radar approach
ARC	Airport Reference Code
ARDH	achieved reference datum height
ARP	aerodrome reference point
ARSR	air route surveillance radar
ASBL	approach surface baseline
ASL	above sea level
ASOS	automated surface observing system
ASR	airport surveillance radar
AT	Air Traffic
ATC	Air Traffic Control
ATS	Air Traffic Service
ATD	along track distance
ATRK	along track
ATS	Air Traffic Service
AVN	Aviation System Standards
AWO	all weather operations
AWOS	automated weather observation system
AWS	Aviation Weather System
BaroVNAV	Barometric vertical navigation
BAZ	back azimuth
BC	back course
BPOC	before proceeding on course
CAT	Category
CF	course to fix
CFIT	controlled flight into terrain
CG	climb gradient

CGL	circling guidance light
CIH	climb-in-hold
COP	changeover point
CP	critical point
CRM	collision risk model
CW	course width
DA	decision altitude
dB	decibel
DCG	desired climb gradient
DER	departure end of runway
DF	direct to fix
DF	direction finder
DG	descent gradient
DH	decision height
DME	distance measuring equipment
DND	Department of National Defense
DP	departure procedure
DR	dead reckoning
DRL	departure reference line
DRP	departure reference point
DTA	distance of turn anticipation
DVA	diverse vector area
EARTS	en route automated radar-tracking system
EDA	elevation differential area
ELEV	elevation
EOR	end of runway
ESA	emergency safe altitudes
ESV	expanded service volume
FAC	final approach course
FAF	final approach fix
FAP	final approach point
FAS	final approach segment
FATO	final approach and takeoff area
FAWP	final approach waypoint
FDC	Flight Data Control
FDR	Flight Data Record
FDT	fix displacement tolerance
FEP	final end point
FIFO	Flight Inspection Field Office
FMP	first maneuver point
FMPD	first maneuver point distance
FMS	flight management system

FMWP	first maneuver waypoint
FPAP	flight path alignment point
FPCP	flight path control point
FSC	final straight course
FSS	Flight Service Station
FTE	flight technical error
FTIP	foreign terminal instrument procedure
FTP	fictitious threshold point
FWP	feeder waypoint
GA	General Aviation
GCA	ground controlled approach
GH	Geoid Height
GLONASS	Global Orbiting Navigation Satellite System
GLS	GNSS Landing System
GNSS	Global Navigation Satellite System
GP	glidepath
GPA	glidepath angle
GPI	ground point of intercept
GPS	Global Positioning System
GRI	group repetition interval
GS	glide slope
HAA	height above airport
HAE	height above ellipsoid
HAH	height above heliport
HAI	Helicopter Association International
HAL	height above landing area elevation
HAS	height above surface
HAT	height above touchdown
HAT	height above threshold
HCH	heliport crossing height
HF	high frequency
HIRL	high intensity runway lights
HRP	heliport reference point
HUD	heads-up display
IAC	initial approach course
IAF	initial approach fix
IAP	instrument approach procedure
IAPA	instrument approach procedure automation
IAWP	initial approach waypoint
IC	intermediate course
ICA	initial climb area
ICAB	ICA baseline

ICAE	ICA end-line
ICAO	International Civil Aviation Organization
ICPS	Instrument Check Pilot School
ICWP	initial course waypoint
IDF	initial departure fix
IF	intermediate fix
IF	initial fix
IF/IAF	intermediate/initial approach fix
IFR	instrument flight rules
ILS	instrument landing system
IMC	instrument meteorological conditions
INS	inertial navigation system
IPV	instrument procedure with vertical guidance
IRU	inertial reference unit
ISA	International Standard Atmosphere
IWP	intermediate waypoint
kHz	kilohertz
KIAS	knots indicated airspeed
LAAS	Local Area Augmentation System
LAB	landing area boundary
LAHSO	land and hold short operations
LDA	localizer type directional aid
LDIN	lead-in lighting system
LF/mf	low frequency/medium frequency
LIRL	low intensity runway lights
LNAV	lateral navigation
LPV	Lateral Precision Performance with Vertical Guidance
LOA	Letter of Agreement
LOB	lines of business
LOC	localizer
LORAN	long-range navigation system
LTP	landing threshold point
MAHWP	missed approach holding waypoint
MALS	minimum intensity approach lighting system
MALSF	minimum intensity approach lighting system with sequenced flashing
MALSR	minimum intensity approach lighting system with runway alignment indicator lights
MAP	missed approach point
MAWP	missed approach waypoint
MCA	minimum crossing altitude
MDA	minimum descent altitude
MEA	minimum en route altitude

MHA	minimum holding altitude
MHz	megahertz
MIA	minimum IFR altitudes
MIRL	medium intensity runway lights
MLS	Microwave Landing System
MOA	Memorandum of Agreement
MOA	military operations area
MOC	minimum obstacle clearance
MOCA	minimum obstruction clearance altitude
MOU	Memorandum of Understanding
MRA	minimum reception altitude
MSA	minimum safe/sector altitude
MSL	mean sea level
MTA	minimum turn altitude
MVAC	minimum vectoring altitude chart
NAD	North American Datum
NAVAID	navigational aid
NDB	nondirectional radio beacon
NCFIO	NAVCANADA Flight Inspection Office
NM	nautical mile
NOTAM	Notice to Airmen
NOZ	normal operating zone
NPA	nonprecision approach
NTZ	no transgression zone
OC	obstruction chart
OCA	obstacle clearance altitude
OCH	obstacle clearance height
OCL	obstacle clearance limit
OCS	obstacle clearance surface
ODALS	omnidirectional approach lighting system
OEA	obstruction evaluation area
OE/AAA	Obstruction Evaluation/Airport Airspace Analysis
OFA	object free area
OIS	obstacle identification surface
ORE	obstacle rich environment
OSAP	off-shore approach procedure
PA	precision approach
PAPI	precision approach path indicator
PAR	precision approach radar
PCG	positive course guidance
PDA	preliminary decision altitude
PFAF	precision final approach fix

PGPI	pseudo ground point of intercept
PinS	point-in-space
PLS	precision landing system
POC	point of contact
PRM	precision runway monitor
PT	procedure turn
PVG	positive vertical guidance
PVGSI	pseudo visual glide slope indicator
RA	radio altimeter
RAIL	runway alignment indicator lights
RAPCON	radar approach control
RASS	remote altimeter setting source
RCL	runway centerline
RDP	reference datum point
REIL	runway end identifier lights
RF	radio frequency
RF	radius to fix
RNAV	area navigation
RNP	required navigation performance
ROC	required obstacle clearance
RPI	runway point of intercept
RRP	runway reference point
RVR	runway visual range
RWP	runway threshold waypoint
RWT	runway threshold
RWTE	runway threshold evaluation
RWY	runway
SALS	short approach lighting system
SATNAV	satellite navigation
SCG	standard climb gradient
SDF	simplified directional facility
SDF	step-down fix
SER	start end of runway
SIAP	standard instrument approach procedure
SID	standard instrument departure
SM	statute mile
SSALF	short simplified approach lighting system with sequenced flashers
SSALR	short simplified approach lighting system with runway alignment indicator lights
STAR	standard terminal arrival route
STOL	short takeoff and landing
TAA	terminal arrival area

TACAN	tactical air navigational aid
TC	Transport Canada
TCH	threshold crossing height
TD	time difference
TDP	touchdown point
TDZ	touchdown zone
TDZE	touchdown zone elevation
TDZL	touchdown zone lights (system)
TERPS	terminal instrument procedures
TF	track to fix
THLD	threshold
TLOF	touchdown and life-off area
TLS	transponder landing system
TORA	takeoff runway available
TP	tangent point
TPD	tangent point distance
TRACON	terminal radar approach control facility
TWP	turn waypoint
UHF	ultra high frequency
VA	heading to altitude
VASI	visual approach slope indicator
VCA	visual climb area
VCOA	visual climb over airport
VDA	vertical descent area
VDP	visual descent point
VFR	visual flight rules
VGA	vertically guided approach
VGSI	visual glide slope indicator
VHF	very high frequency
VLF	very low frequency
VMC	visual meteorological conditions
VNAV	vertical navigation
VOR	very high frequency omnidirectional radio range
VOR/DME	very high frequency omnidirectional radio range collocated with distance measuring equipment
VORTAC	very high frequency omnidirectional radio range collocated with tactical air navigation
VPA	vertical path angle
VSDA	visual segment descent angle
VTOL	vertical take-off and landing
WAAS	Wide Area Augmentation System
WATCO	Wing Air Traffic Control Officer
WCH	wheel crossing height

WP	waypoint
XTRK	crosstrack

GLOSSARY OF TERMS

Aerodrome	any area of land, water (including the frozen surface thereof) or other supporting surface used or designated, prepared, equipped or set apart for the use either in whole or in part for the arrival or departure, movement of servicing of aircraft and includes any buildings, installations and equipment in connection therewith.
Aerodrome elevation	the elevation of the highest point of the landing area measured to the nearest foot above or below mean sea level.
Aerodrome authorization for part VII operations	Where an aerodrome does not meet the full requirements for certification, an aerodrome authorization may be issued to accommodate Part VII operations. An Aerodrome Authorization is required by the aerodrome operator for each air operator applying to use the aerodrome. The requirements for issuing an Aerodrome Authorization are available from Transport Canada Aerodrome Safety in the document entitled *"Aerodrome Authorization for Part VII Operations"*.
Aerodrome operator attestation	When the aerodrome is not certified and/or does not have an Aerodrome Authorization, an Aerodrome Operator Attestation is required in order to support instrument approach procedures below 500 feet HAT. The Aerodrome Operator Attestation identifies the aerodrome physical characteristics and the obstacle environment required to support the instrument operational limits for the critical aeroplane wing span, used by operators at a specific aerodrome.
Aerodrome reference point (ARP)	The designated geographical location of an aerodrome given to the nearest second of latitude and longitude. The ARP is located as near as practicable to the geometric centre of the landing area taking into account possible future development (see Annex C, Para 13).
Altitude	The vertical distance of a level, a point or an object considered as a point, measured from mean sea level.
Angle of divergence (minimum)	The smaller of the angles formed by the intersection of two courses, radials, bearings, or combinations thereof.
Approach procedure with vertical guidance (APV)	An instrument approach procedure that utilizes lateral and vertical guidance that do not meet the requirements established for a precision approach. Minima shall be expressed as DA(H).
Approach surface baseline (ASBL)	An imaginary horizontal line at threshold elevation.
Bearing	The horizontal angle at a given point, measured clockwise from a specific reference datum, to a second point. Bearings are expressed as True, Magnetic, Relative, Astronomic, Grid, etc. according to the reference datum used.
Change over point (COP)	A point defined between navigation facilities along airway/route segments, which indicate the pilot should change over his navigation equipment to receive course guidance from the facility ahead of the aircraft instead of the one behind.

Circling approach	The visual maneuvering required, after completing an instrument approach, to bring an aircraft into position for landing on a runway that is not suitably indicated for straight-in landing.
Controlling obstacle	The highest obstacle relative to a prescribed plane (obstacle clearance surface) within a specified area.
Dead reckoning	The estimating or determining of position by advancing an earlier known position by the application of direction and speed data. For example, flight based on a heading from one VORTAC azimuth and distance fix to another is dead reckoning.
Decision altitude (DA)	The DA is the barometric altitude, specified in feet above MSL, at which a missed approach shall be initiated if the required visual reference has not been established. The DA applies to approach procedures where the pilot is provided with glidepath deviation information; e.g., ILS, MLS, TLS, GLS, LNAV/VNAV, Baro VNAV, or PAR.
Decision height (DH)	The DH is the value of the DA expressed in feet above the highest runway elevation in the touchdown zone. This value is also referred to as HAT.
Diverse vector	An instruction issued by a radar controller to fly a specific course, which is not a part of a predetermined radar pattern. Also referred to as a “random vector.”
DME arc	A track, indicated as a constant DME distance, around a navigation facility that provides distance information.
DME distance	The line of sight distance (slant range) from the source of the DME signal to the receiving antenna.
Elevation (Elev)	The vertical distance of a point or a level, on or affixed to the surface of the earth measured from mean sea level.
Final approach	That part of an instrument approach procedure from the time the aircraft has a. completed the last procedure turn or base turn, where one is specified; or b. crossed the final approach fix or point; or c. intercepted the last track specified for the procedure; until it reaches the missed approach point. It is in this portion of the procedure that alignment and descent for landing are accomplished.
Final approach fix (FAF)	A fix that indicates the commencement of the final approach segment of a non-precision instrument approach procedure.
Fix	A geographical location determined by means of radio aids or other navigation devices
Geographic centre of the aerodrome	The centre of the runway pattern; see Annex C for a method of determining the geometric centre of an aerodrome.
Glidepath (GP)/ glide slope (GS)	A descent profile that is electronically determined for vertical guidance during a final approach.
Glide path/ glide slope angle	The angle of the glide path/glide slope measured above the horizontal plane.

Ground point of intercept	A point in the vertical plane on the runway centerline at which it is assumed that the straight line extension of the glide slope intercepts the runway approach surface baseline.
Gradient	A slope expressed in feet per mile, or as a ratio of the horizontal to the vertical distance. For example, 40:1 means 40 feet horizontally to 1 foot vertically.
Heading	The direction in which longitudinal axis of the aircraft is pointed expressed in degrees from north (true, magnetic, compass or grid).
Height	The vertical distance of a level, a point or an object considered as a point, measured from a specified datum.
Height above aerodrome (HAA)	The height in feet of the MDA above the published aerodrome elevation. HAA will be published for all circling minima.
Height above touchdown zone (HAT)	The height in feet of the DH or MDA above the touch down zone elevation.
Holding procedure	A predetermined manoeuvre which keeps an aircraft within a specified airspace while awaiting further clearance.
Initial approach	That part of an instrument approach procedure in which the aircraft has departed an initial approach fix and is maneuvering to enter the intermediate segment of the approach.
Initial approach fix (IAF)	A fix at which an aircraft leaves the en route phase of operations in order to commence the approach.
Instrument approach procedure (IAP)	A series of predetermined maneuvers for the orderly transfer of an aircraft under instrument flight conditions from the beginning of the initial approach to a point from which a landing may be made visually.

Instrument runway	One of the following types of runways intended for the operation of aircraft using instrument approach procedures: a. Non-precision approach runway. An instrument runway served by visual aids and a non-visual navigation aid providing at least directional guidance adequate for a straight-in approach to a minimum descent height less than 500 ft above the runway threshold but not less than 250 ft above the runway threshold. b. Precision approach runway, Category I. An instrument runway served by visual and non-visual navigation aids where operations are conducted down to a decision height lower than 250 ft but not lower than 200 ft and a visibility not less than 2600 ft. c. Precision approach runway, Category II. An instrument runway served by visual and non-visual navigation aids where operations are conducted down to 100 ft decision height and a RVR not less than 1200 ft. d. Precision approach runway, Category III. An instrument runway served by non-visual guidance systems to and along the surface of the runway and: (1) CAT IIIa where operations are conducted or intended to be conducted down to an RVR not less than 600 ft (no decision height being applicable); (2) CAT IIIb where operations are conducted or intended to be conducted down to an RVR not less than 300 ft (no decision height being applicable); (3) CAT IIIc where operations are conducted or intended to be conducted with no decision height and no runway visual range limitations.
Intermediate approach	That part of an instrument approach procedure in which aircraft configuration, speed and positioning adjustments are made for entry into the final approach.
Intermediate fix (IF)	The fix at which the aircraft enters the intermediate approach segment of an instrument approach.
Landing area	That part of the movement area intended for the landing or take-off run of aircraft.
Localizer	The component of an ILS which provides lateral guidance with respect to the runway centerline.
Localizer type directional aid	A facility of comparable utility and accuracy to a LOC, but which is not part of a full ILS and may not be aligned with the runway.
Minimum descent altitude (MDA)	A specified altitude referenced to sea level for a non-precision approach below which descent must not be made until the required visual reference to continue the approach to land has been established.

Minimum sector altitude (MSA)	The lowest which will provide a minimum clearance of 1,000 feet, under conditions of standard temperature and pressure, above all obstacles located in an area contained within a defined sector of a circle of 25 nautical miles radius centred on an identified navigational facility or waypoint.
Missed approach point (MAP)	That point on the final approach track which signifies the termination of the final approach and the commencement of the missed approach. It may be: a. the intersection of an electronic glide path with a Decision Height; b. a navigational facility located on the aerodrome; c. a suitable fix (e.g., DME); d. specified distance past the facility or final approach fix, not to exceed the distance from that facility or fix to the nearest boundary of the aerodrome.
Missed approach procedure	The procedure to be followed, if for any reason, after an instrument approach, a landing is not affected.
Non-precision approach (NPA)	An instrument approach procedure which does not utilize vertical guidance. Minima shall be expressed as MDA(H).
Obstacle	An existing object, object of natural growth, or terrain at a fixed geographical location or that may be expected at a fixed location within a prescribed area, with reference to which vertical clearance is or must be provided for flight operations.
Obstacle clearance limit (OCL)	The lowest altitude that will satisfy the obstacle clearance requirement for the particular segment of an instrument approach procedure that is under consideration.
Obstacle clearance surface (OCS)	A surface above which obstacles may not penetrate if the required obstacle clearance is to be maintained.

Obstacle limitation surface (OLS).	A surface that establishes the limit to which objects may project into the airspace associated with an aerodrome so that aircraft operations at the aerodrome may be conducted safely. Obstacle limitation surfaces consist of the following: 1. Take-off/Approach surface. An incline plane beyond the end of the runway and preceding the threshold of a runway. The origin of the plane comprise: (a) An inner edge of specified length (strip width), perpendicular to and evenly divided on each side of the extended centre line of the runway, and beginning at the end of the runway strip; (b) Two sides originating at the ends of the inner edge, diverging uniformly at a specified rate in the direction of take-off; (c) The elevation of the inner edge is equal to the elevation of the threshold. 2. Transitional surface. A complex surface sloping up at a specified rate from the side of the runway strip and from part of the take-off/approach surface. The elevation of any point on the lower edge of the surface is: (a) Along the side of the take-off/approach surface, equal to the elevation of the take-off/approach surface at that point; and, (b) Along the runway strip, equal to the elevation of the centre line of the runway, perpendicular to that point.
Obstacle rich environment (ORE)	An environment is obstacle rich when it is not possible to construct an unguided discontinued approach using procedural means. Approach operations in an ORE require supplementary guidance to proceed along the published course to the missed approach point and achieve a climb to the minimum vectoring altitude or minimum IFR altitude.
Omnidirectional facility	A facility capable of receiving or transmitting in all directions. Omnidirectional facilities include VOR, TACAN, VORTAC, NDB and DME.
Operational advantage	An improvement that benefits the users of an instrument procedure without compromise to safety
Penetration turn	That part of the initial approach segment, which permits a high performance aircraft to reverse direction and to lose altitude while remaining within a limited area.
Precipitous terrain	Terrain characterized by steep or abrupt slopes.

Precision and non precision	These terms are used to differentiate between navigational facilities that provide a combined azimuth and glide slope guidance to a runway (Precision) and those that do not. The term nonprecision refers to facilities without a glide slope, and does not imply an unacceptable quality of course guidance.
Precision approach (PA)	An instrument approach procedure utilizing precision lateral and vertical guidance with minima as determined by the category of operation.
Precision approach radar (par)	Primary radar equipment used to determine the position of an aircraft during final approach, in terms of lateral and vertical deviations relating to a predetermined approach path, and in range relative to a predetermined touchdown point.
Procedure turn (PT)	A manoeuvre in which a turn is made away from a designated track, followed by a turn in the opposite direction, both turns being executed so as to permit the aircraft to intercept and proceed along the reciprocal of the designated track. **Note:** Procedure turns are designated left or right according to the direction of the initial turn.
Positive course (Track) guidance	A continuous display of navigational data which enables an aircraft to be flown along a specific course (track). **Note:** Radar vectors are considered meeting the requirements of positive course (track) guidance.
Primary area	The area within a segment in which full obstacle clearance is applied.
Radial	A bearing extending from a VOR, or TACAN facility.
Runway	A defined rectangular area, on a land aerodrome, prepared for the landing and take-off of aircraft along its length.
Runway environment	The runway threshold, lighting aids, markers or markings identifiable with the runway.
Runway visual range (RVR)	The maximum distance in the direction of take-off or landing at which the runway or specified lights or markers delineating it can be seen from a position above a specified point on its centreline at a height corresponding to the average eye-level of pilots at touchdown. **Note:** A height of 16 feet is regarded as corresponding to average eye-level of pilots at touchdown. RVR is determined from information provided by a transmissometer located near the touchdown point on a runway and where CAT II ILS is installed a second transmissometer is located near the midpoint of the runway length.

Safe altitude 100 nm	The lowest altitude that may be used that will provide a minimum clearance of 1,000 feet, under conditions of standard temperature and pressure, above all obstacles located in an area contained within a circle of 100 nautical miles radius of the geographic centre of the aerodrome.
Service volume	That volume of airspace surrounding a navigational facility within which a signal of usable strength exists and where the signal is not operationally limited by co-channel interference.
Segment	The basic functional division of an instrument approach procedure. The segment is oriented with respect to the course to be flown. Specific values for determining course alignment, obstacle clearance areas, descent gradients, and obstacle clearance requirements are associated with each segment according to its functional purpose.
Straight-in approach	An instrument approach where final approach is begun without first having executed a procedure turn. Straight-in approaches are not necessarily completed with a straight-in landing or made to straight-in landing minimums.
Straight-in landing minima	Approach minima published in association with an instrument approach procedure that conforms with specified final approach alignment and descent gradient criteria.
Strip	An area of specified dimensions enclosing a runway, intended to reduce the risk of damage to aircraft running off a runway, and to protect aircraft flying over it during take-off and landing operations.
Threshold	The beginning of that portion of the runway usable for landing.
Threshold crossing height	The height of the straight-line extension of the glide slope above the runway at the threshold.
Touchdown zone (TDZ)	The first 3,000 feet of runway, or the first one-third which ever is less, measured from the threshold in the direction of landing.
Touchdown zone elevation (TDZE)	The highest runway centreline elevation in the touchdown zone.
Track	The projection on the earth's surface of the path of an aircraft, the direction of which path at any point is usually expressed in degrees from North (true, magnetic, or grid).
Visibility	The ability, as determined by atmospheric conditions and expressed in units of distance, to see and identify prominent unlighted objects by day and prominent lighted objects by night.

CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 4

ANNEX B

MINIMUM VECTORING ALTITUDE

TRANSPORT CANADA
NATIONAL DEFENSE

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MINIMUM VECTORING ALTITUDE CHARTS

1. Chart Preparation

Radar vectoring charts are developed for areas where there are numerous minimum vectoring altitudes due to variable terrain features or man-made obstacles. The responsible ATC facility shall determine whether their radar systems require vectoring charts. Procedure design specialists or WICPs shall establish the minimum altitudes by ensuring all MVA charts meet the obstacle requirements outlined within this Annex. Completed charts will be reviewed and approved in accordance with the coordination signature blocks identified on form 26-0445.

2. Areas Of Consideration

The area considered for obstacle clearance shall be based upon the maximum range of the applicable radar. This area may be subdivided into sectors to gain relief from obstacles that are clear of the area in which flight is to be conducted. There is no limit on the size, shape or orientation of the sectors; however, they must be designed with consideration to aircraft maneuvering ability, obstacle clearance requirements and air traffic flow requirements.

To avoid excessively high MVAs within a sector, radars meeting the specifications of RAMP RADAR may isolate prominent obstacles by enclosing the obstacle within a buffer area whose boundaries are at least 3 NM from the obstacle up to and including 60 NM from the radar antenna and 5 NM from obstacle beyond 60 NM from the radar antenna. Radars not meeting RAMP RADAR specifications may isolate obstacles by 5 NM in all cases.

Rapidly rising terrain, although possibly not a factor in identifying prominent obstacles, may trigger activation of ground proximity warning devices onboard aircraft due to an aircraft descending to a MVA in these areas. Procedure designers should consider this when establishing sectors and MVAs with a view to eliminating this possibility during the development of MVA charts.

All MVAs shall be contained within controlled airspace.

3. Obstacle Clearance

Obstacle clearance shall be provided over all obstacles with all the designated vectoring areas or sectors irrespective of the minimum altitude radar coverage determined by a flight check. Selected altitudes shall provide clearance over all obstacles outside of the sector within 3 NM of the sector boundaries (5 miles beyond 60 NM from the radar antenna). In areas of overlapping radar coverage, where data from an antenna more that 60 NM away may be used, only 5 NM clearance shall be applied. Normally, 1000 feet of obstacle clearance is provided in non-mountainous areas and 1500 feet or 2000 feet, as appropriate, in areas designated as mountainous in the Designated Airspace Handbook. Chosen MVAs may be rounded off to the nearest 100 foot increment provided the required obstacle clearance within the appropriate sector is not violated.

4. Obstacle Clearance Reductions

Where lower MVAs are required in designated mountainous areas to achieve compatibility with terminal routes or to permit vectoring to an instrument approach procedure, obstacle clearances may be reduced to not less than 1000 feet when precipitous terrain is not a factor.

5. Radar Data Processing (RDP)

Radar information presented to the controller may be provided from multiple antennas. MVA charts for these facilities shall provide obstacle clearance determined by using the antenna location that is the greatest distance from the obstacle.

6. Construction

a. MVAC's should initially be drawn on an appropriately scaled aeronautical chart as per Figure B–1, Terminal Surveillance Radar (TSR), or Figure B–2, Independent Secondary Surveillance Radar (ISSR).

b. The centre of the chart should represent the radar antenna site, however, operations requirements may dictate otherwise. The chart may be divided into sectors as required by different obstacle clearance altitudes. The configuration of each sector, and the features to be displayed, depends upon the local terrain and operational considerations. The following guidelines should be to used when developing MVA charts:

   (1) Depict each sector in relation to its magnetic bearing from the antenna site, radials from NAVAIDS, radar display range marks, or controller airspace boundaries. To facilitate a correlation between the chart and radar displays, make the sector boundaries coincide with map overlay or video map data, if possible.

   (2) Make each sector large enough to permit the vectoring of aircraft within the sector. Establish the boundary of each sector at least 3 NM from the obstacle determining the minimum altitude (5 NM, if more than 60 NM from the antenna site).

   (3) If there is a large sector with an excessively high altitude, due to an isolated prominent obstacle, the buffer area must have boundaries that are at least 3 NM from the obstacle (5 NM, if more than 60 NM from the antenna site).

   (4) Determine and depict the minimum altitude in each sector that will provide the required obstacle clearance.

c. Complete the Minimum Vectoring Altitude Computations form, TC form 26-0445, to determine selected sector altitudes. See Figure B–3. The temperature difference, Section C.5 on the form, is calculated by finding the mean minimum temperature for each month. This temperature may be found in Environment Canada publication, "Principal Station Data," Table 1, line two, "Minimum". The lowest mean minimum temperature is then subtracted from the ICAO Standard Atmosphere (ISA) temperature for the elevation of the airport/altimeter setting source. This is the number used in Section C.5.

d. Transfer all data to the Minimum Vectoring Altitude Chart, TC form 26-0446. See Figure B–4. Complete the obstacle data for the controlling obstacle for each sector. Obtain the required signatures and retain on unit files.

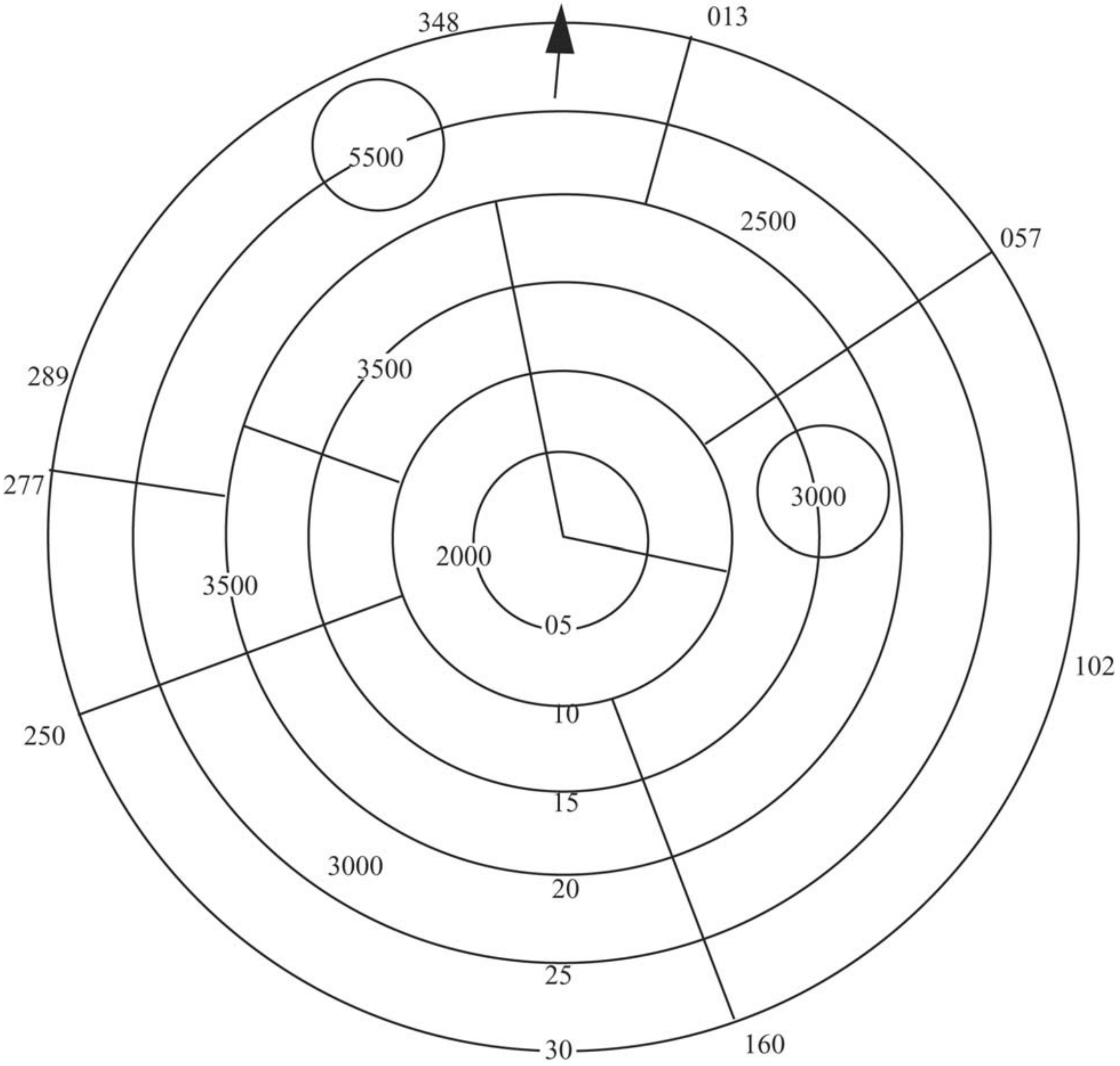

Figure B-1: Terminal Surveillance Radar (TSR)

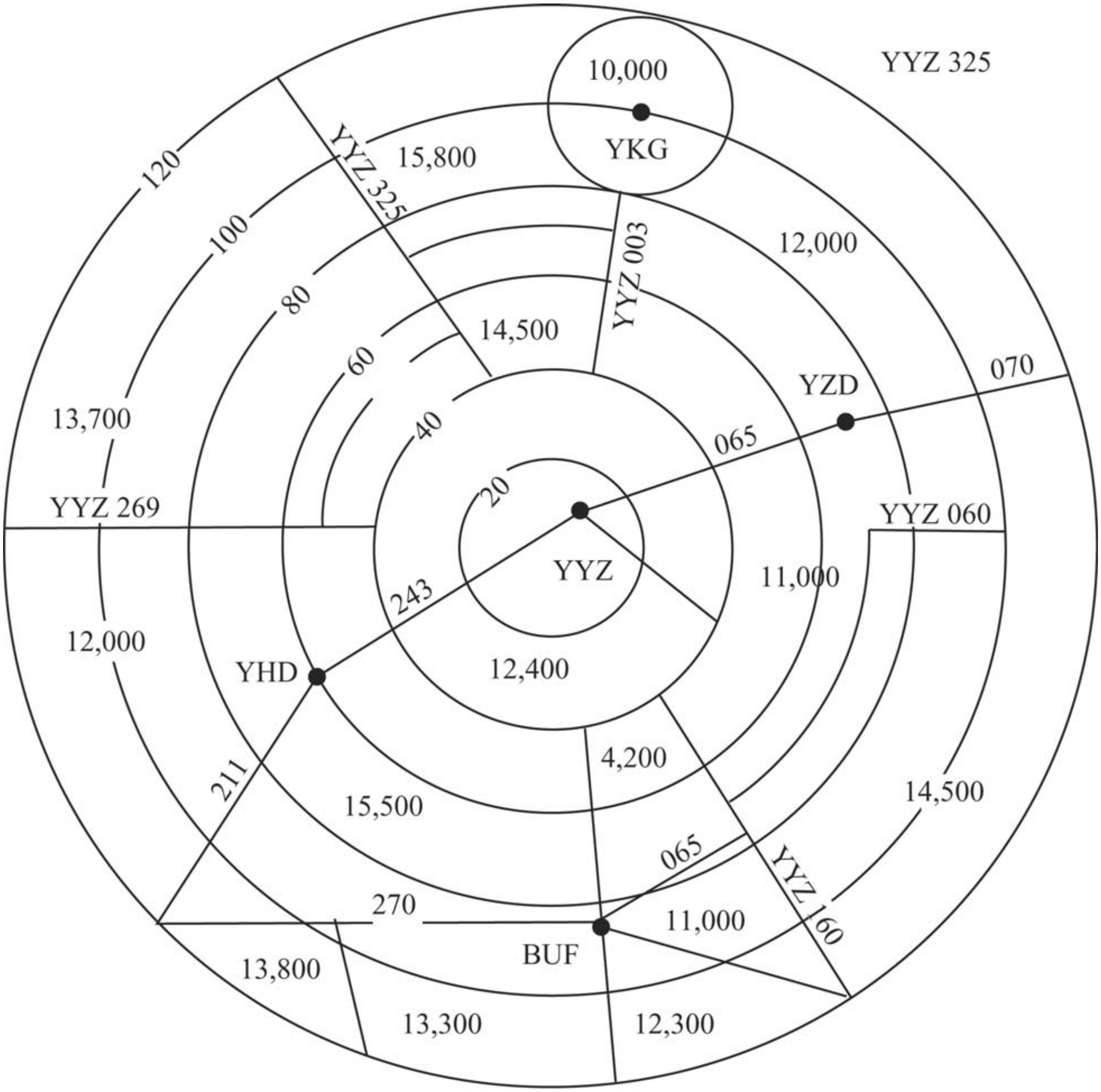

Figure B-2: Independent Secondary Surveillance Radar (ISSR)

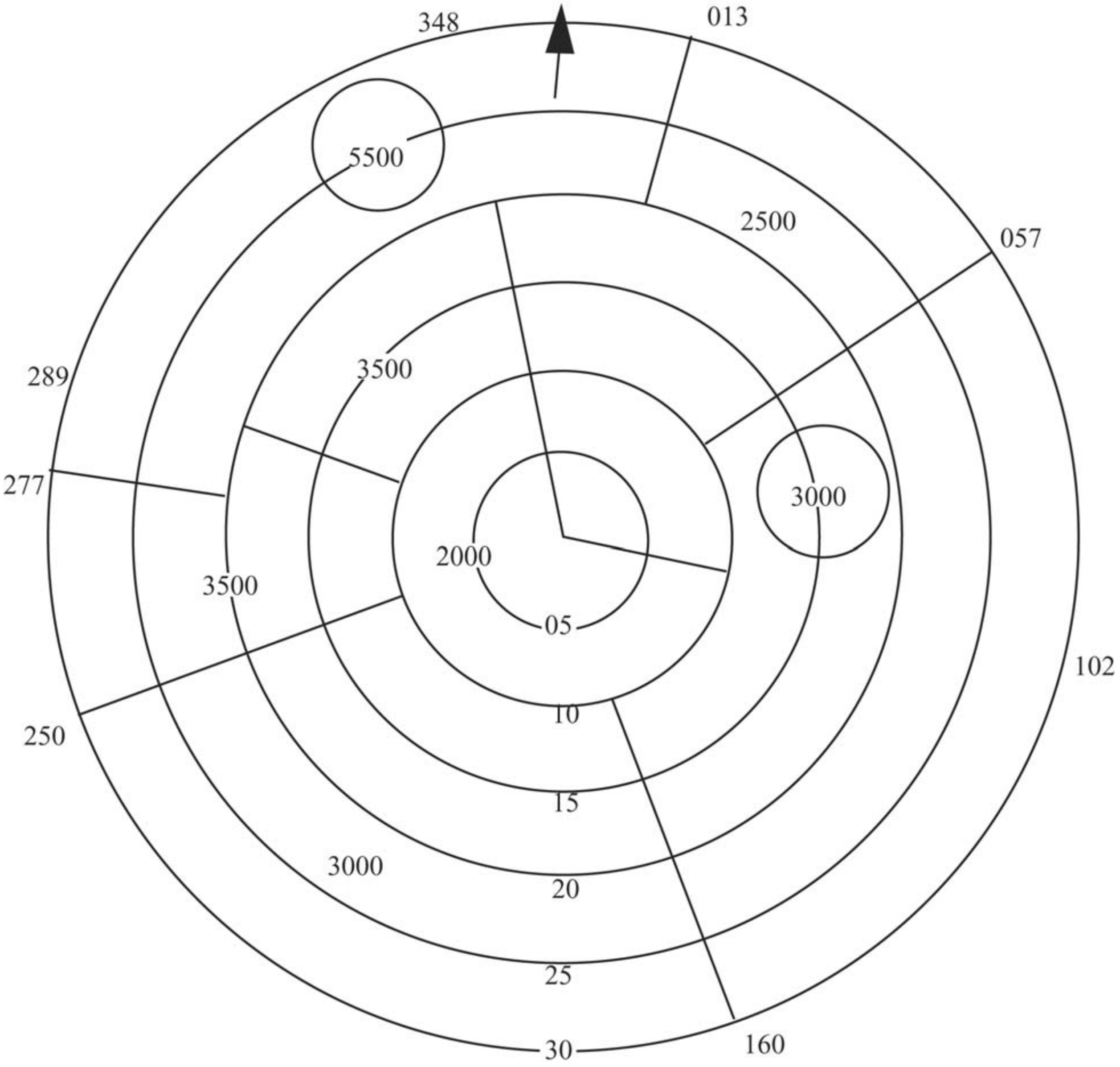

Figure B-4: Minimum Vectoring Altitude Chart.

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MINIMUM VECTORING ALTITUDE COMPUTATIONS

For completion instructions, see TP 308/GPH 209, Annex B.

Name of Facility	**>**	**Sector** _____
Name of Airport	**>**	**of** _____

SECTOR *(Enter Description)*

A. MVA Required for Terrain Obstacle Clearance	**Buffer Area**	**Sector**
1. Controlling obstacle *(Enter Description)*		
2. Controlling Obstacle Height (MSL)		
3. Required Obstacle Clearance *(Normally 1000 (1500 or 2000 mountainous Area)*	+	+
4. ROC Adjustment (Precipitous terrain – Para 323)		
5. Required Altitude based on Obstacle Clearance	=	=
B. MVA Required for Airspace		
1. Floor of Controlled Airspace *(AGL)(if MSL, Skip 1&2)*		
2. Highest Terrain in Sector		+
3. Required Altitude Based on Airspace Floor		=
C. MVA Required for Temperature Correction		
1. Required Altitude based on Obstacle Clearance (A.5)		
2. Airport/ Altimeter Setting Source Elevation		-
3. Elevation Differential		=
4. Elevation Factor (C.3/1000)		
5. Temperature Difference (Standard ____°C Winter _____°C)		
6. Temperature Correction (C.4 x C.5 x 4)		
7. Required Altitude based on Obstacle Clearance (A.5)		
8. Required Altitude Based on Temperature Correction		=
D. Selected Sector Altitude		
1. For months when mean temperature is > 0°C *(Highest of A.5 or B.3 rounded as per Para 1041.a.(3))*		
2. For months when mean temperature is ≤ 0°C *(Highest of B.3 or C.8 rounded as per Para 1041.a.(3))*		
Remarks:		

26-0445 (JAN 08)

Figure B-3: Minimum Vectoring Altitude Computations Forms.

TSR/ISSR Magnetic Variation:

Obstacle Data

Sector	Controlling Obstacle No.	Elevation MSL	LAT / LONG

Remarks

26-0445 (JAN 08)

Figure B-4: Minimum Vectoring Altitude Chart (continued).

CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 4

ANNEX C

SAMPLE PROBLEMS

TRANSPORT CANADA
NATIONAL DEFENSE

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SAMPLE PROBLEMS

1. Secondary Areas

The graphs contained in this Annex and the sample problems, which illustrate their use, are provided to assist in computing secondary area widths and required obstacle clearance (ROC) at the location of an obstacle.

2. Secondary Area Obstacle Problems

Figure C–1 illustrates the location of problem obstacles in the various approach segment secondary areas. It also identifies the appropriate figures in this annex that apply to each particular problem obstacle.

3. Initial Secondary Area Obstacle Clearance

The graph in Figure C–3 is used to determine the required obstacle clearance in the initial approach secondary area.

Problem 1.

a. The obstacle in the secondary area .3 mile from the inner edge. Find the ROC.

b. Solution.

   (1) Enter the graph in Figure C–3 on the bottom scale at the distance the obstacle is from the inner edge.

   (2) Proceed vertically to intersect with the 2 mile slant line.

   (3) Move left horizontally and read the ROC, 425 feet.

4. Width Of Intermediate Approach Secondary Area

The graph in Figure C–2 is used to determine the width of the intermediate approach secondary area at the location of a problem obstacle.

Problem 2.

a. The FAF is 10 miles from the facility. An obstacle is 2.8 miles from the FAF and .48 mile from the inner edge of the secondary area. Find the width of the secondary area at the FAF and at the location of the obstacle.

b. Solution.

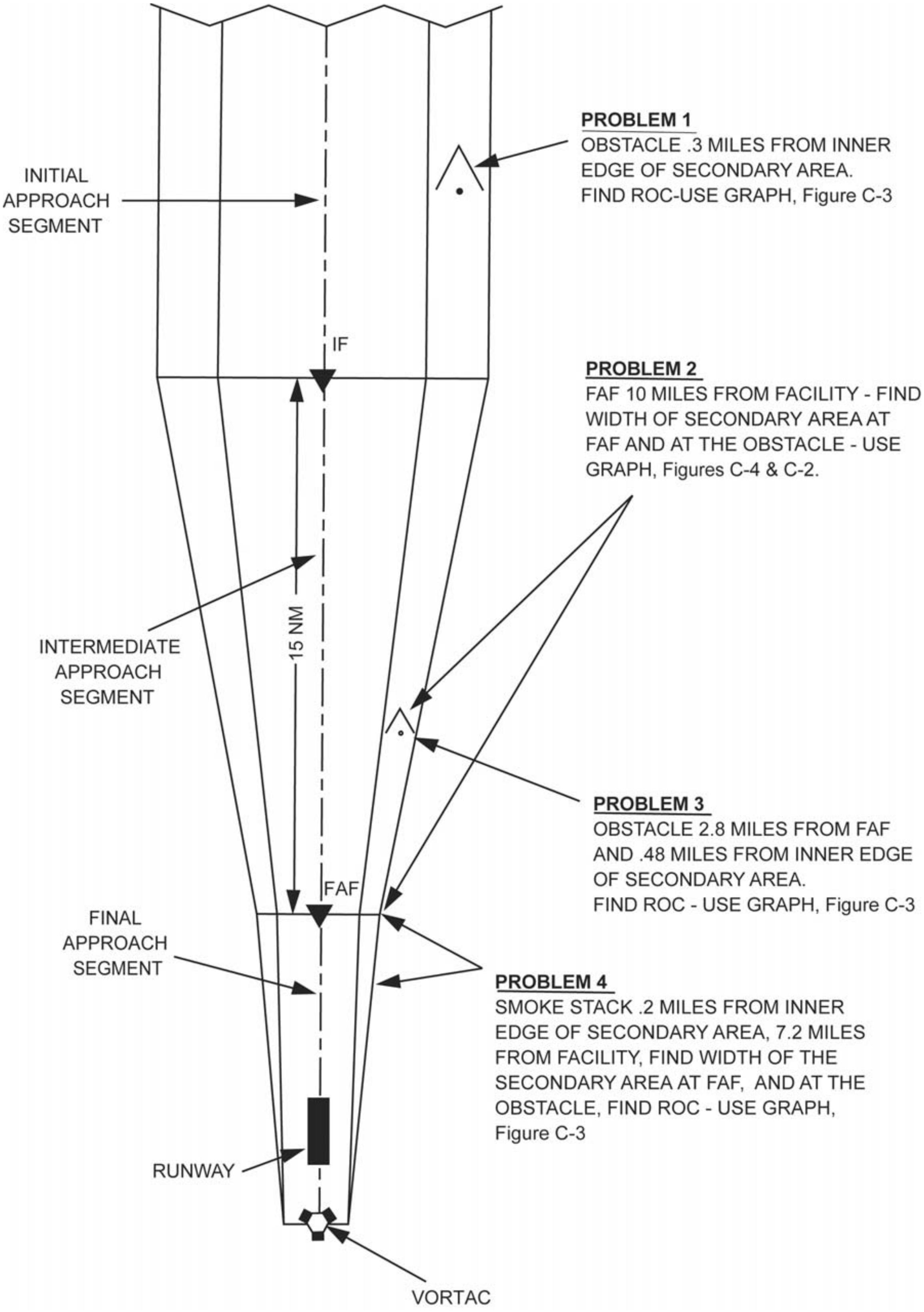
   (1) Determine the width of the secondary area at the FAF (.33) mile) by using Figure C-4.

   (2) Place a straight edge on Figure C–2 between .33 mile on the secondary area width scale and 15 miles* on the length of segment scale.

   (3) Locate 2.8 miles on the length of segment scale, and proceed horizontally to intersect with the straight edge.

   (4) Drop vertically from the intersection point to read .64 mile on the secondary area width scale. This is the width of the secondary area at the location of the obstruction.

Note: Use the actual length of the intermediate segment. It may be between 5 and 15 miles long.



PROBLEM 1

OBSTACLE .3 MILES FROM INNER EDGE OF SECONDARY AREA. FIND ROC-USE GRAPH, Figure C-3

PROBLEM 2

FAF 10 MILES FROM FACILITY - FIND WIDTH OF SECONDARY AREA AT FAF AND AT THE OBSTACLE - USE GRAPH, Figures C-4 & C-2.

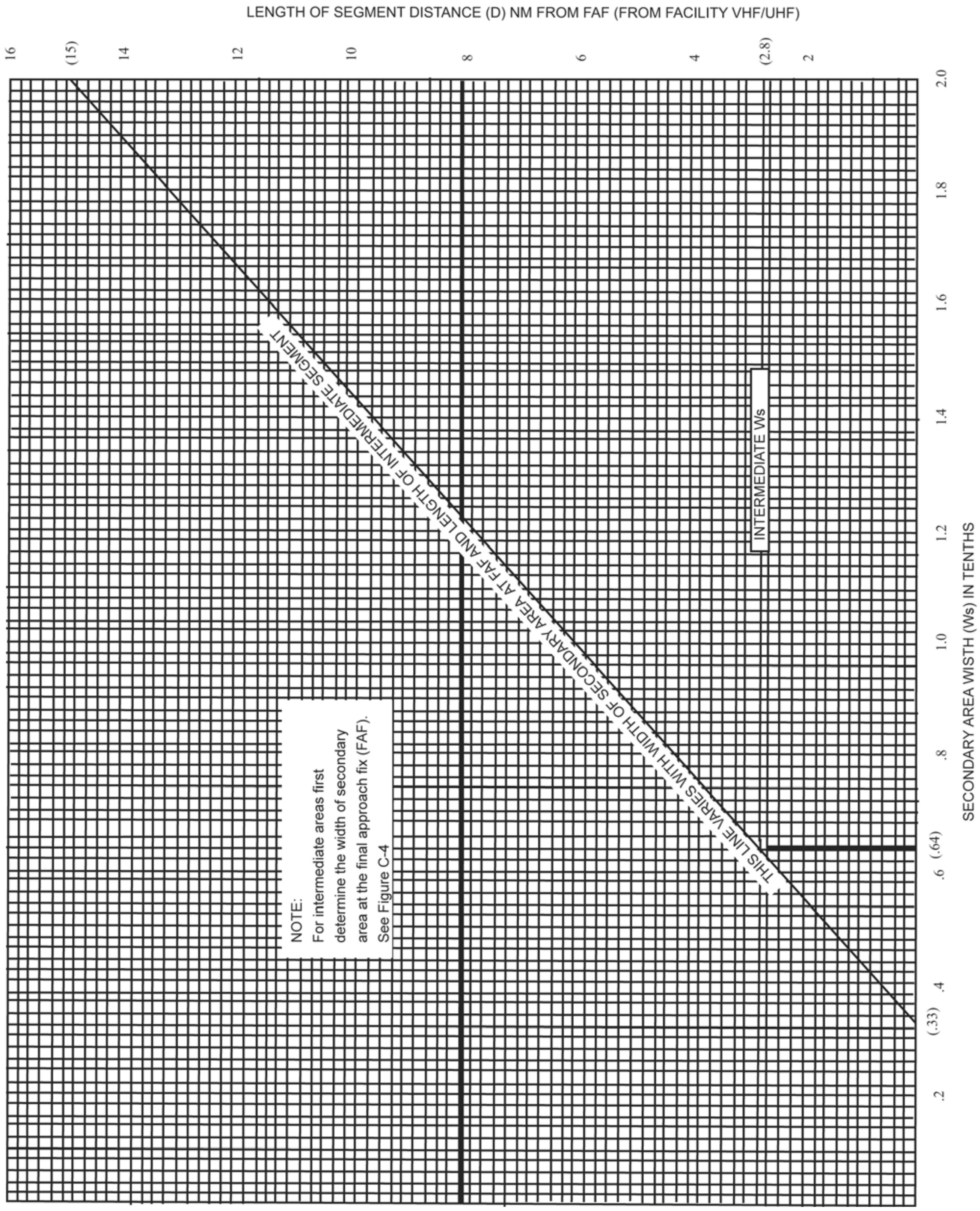
PROBLEM 3

OBSTACLE 2.8 MILES FROM FAF AND .48 MILES FROM INNER EDGE OF SECONDARY AREA. FIND ROC - USE GRAPH, Figure C-3

PROBLEM 4

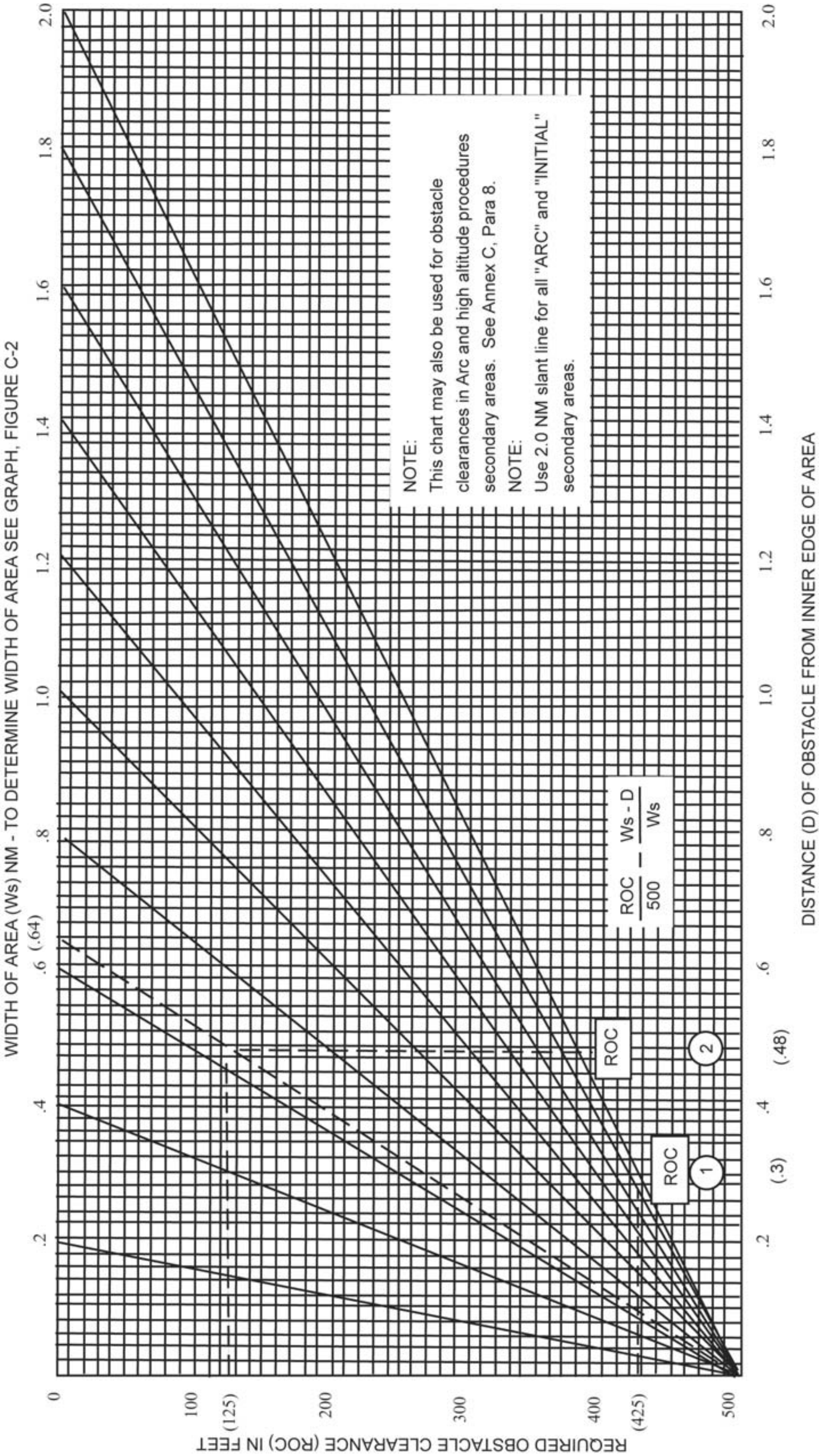
SMOKE STACK .2 MILES FROM INNER EDGE OF SECONDARY AREA, 7.2 MILES FROM FACILITY, FIND WIDTH OF THE SECONDARY AREA AT FAF, AND AT THE OBSTACLE, FIND ROC - USE GRAPH, Figure C-3

Figure C-1: Secondary Area Obstacle Problems. Para 2.



NOTE:
For intermediate areas first determine the width of secondary area at the final approach fix (FAF). See Figure C-4

Figure C-2: Width Of Intermediate Approach Secondary Area. Para 3.



$$\frac{ROC}{500} = \frac{Ws - D}{Ws}$$

NOTE:
This chart may also be used for obstacle clearances in Arc and high altitude procedures secondary areas. See Annex C, Para 8.

NOTE:
Use 2.0 NM slant line for all "ARC" and "INITIAL" secondary areas.

Figure C-3: Initial And Intermediate Secondary Area Obstacle Clearance. Para 3 & 5.

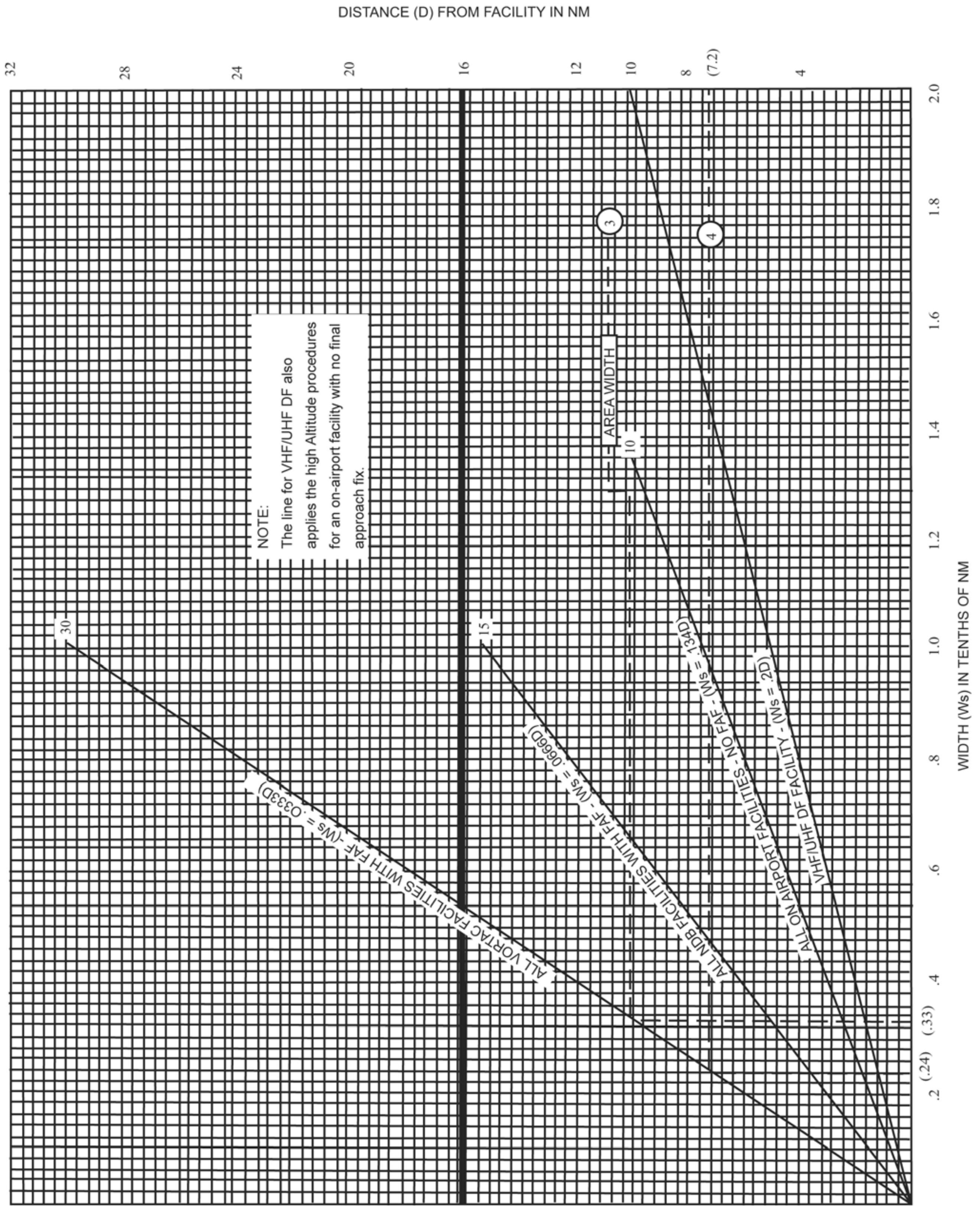


Figure C-4: Width Of Final Approach Secondary Area. Para 4 & 6.

5. Intermediate Secondary Area Obstacle Clearance

The graph in Figure C–3 is used to determine the required obstacle clearance (ROC) in the intermediate secondary area.

Problem 3.

a. The obstacle is in the secondary area 2.8 miles from the FAF and .48 mile from the inner edge of the secondary area. Find the ROC.

b. Solution. From Figure C–2, we have determined the width of the secondary area at the location of the obstacle. It is.64 mile.

   (1) Enter the graph in Figure C–3 on the bottom scale at the distance the obstacle is from the inner edge (.48 mile).

   (2) Proceed vertically to intersect with the appropriate area width slanted line (.64 NM).

   (3) Move horizontally to the left and read ROC 125 feet.

6. Width Of Final Approach Secondary Area

The graph in Figure C–4 is used to determine the width of the final approach secondary area at any given distance from the navigation facility.

Problem 4.

a. In a procedure based on a VOR-TAC, the FAF is 10 miles from the facility. Find the width of the secondary area at the FAF.

b. Solution.

   (1) Enter the graph in Figure C–4 at 10 on the distance from facility scale.

   (2) Proceed horizontally to a point of intersection with the slant line for VORTAC with FAF.

   (3) Drop vertically from the intersection point to read the width of the seconday area at the FAF (.33 mile).

Problem 5.

a. In a procedure based on a VOR with FAF, an obstacle is 7.2 miles from the facility. Find the width of the secondary area at the obstacle location.

b. Solution.

   (1) Enter the graph in Figure C–4 at 7.2 on the distance from facility scale.

   (2) Proceed horizontally to a point of intersection with the slant line for VORTAC with FAF.

   (3) Drop vertically from the intersection point to read the width of the secondary area (.24 mile).

   Note: Figure C–4 can be used to find the width of the final approach secondary area for the several conditions and facilities which are included in the figure.

7. Final Approach Secondary Area Obstacle Clearance

The graph in Figure C–5 is used to determine the required obstacle clearance in the final approach secondary area. Figure C–5 applies only to procedures that require primary area obstacle clearance of 250 feet. Subsequent Figures C–6 and C–7 apply to procedures in which the primary area obstacle clearance is 300 and 350 feet respectively.

Problem 6.

a. In a procedure based on a VOR with FAF, an obstacle is in the secondary .2-mile from the inner edge and 7.2 miles from the facility. Find the ROC.

b. Solution. From Figure C–4, we have determined the width of the secondary area at the obstacle location (.24 mile).

   (1) Enter the graph in Figure C–5 on the bottom scale at the distance the obstacle is from the inner edge (.2 mile).

   (2) Proceed vertically to intersect with the appropriate area width slant line (.24 mile).

   (3) Move left horizontally and read the ROC (42 feet).

8. VHF/UHF DF And High Altitude Penetration (No FAF)

The required obstacle clearance in the final approach areas can be determined by the method prescribed in Para 6 and 7. However, the graph in Figure C–3 must be used in lieu of the graph in Figure C–7.

9. Computing Glide Slope Threshold Height

a. Definitions.

   (1) Straight Line Extension of Glide Slope. The assumed path which the glide slope would follow if it were a straight line in space from a point over the outer marker position to a point of interception with the approach surface baseline.

   (2) Threshold Crossing Height (TCH). The height of the straight-line extension of the glide slope above the runway at the threshold.

   (3) Established Glide Slope Angle. The angle of the glide slope as determined by currently effective commissioning flight check. Flight inspection will provide information concerning the height of the glide slope at the outer marker position or other point known distance from the runway threshold on the final approach.

   (4) Runway Point of Intercept (RPI). The point where the extended glide slope intercepts the runway centreline on the runway surface.

b. Computation Method. The glide slope threshold crossing height is computed as follows: (See Figure C–8):

   (1) Multiply "D_1" (distance in feet from the GPI to a point abeam the runway threshold "T") by the tangent of the established glide slope angle. The result is the TCH.

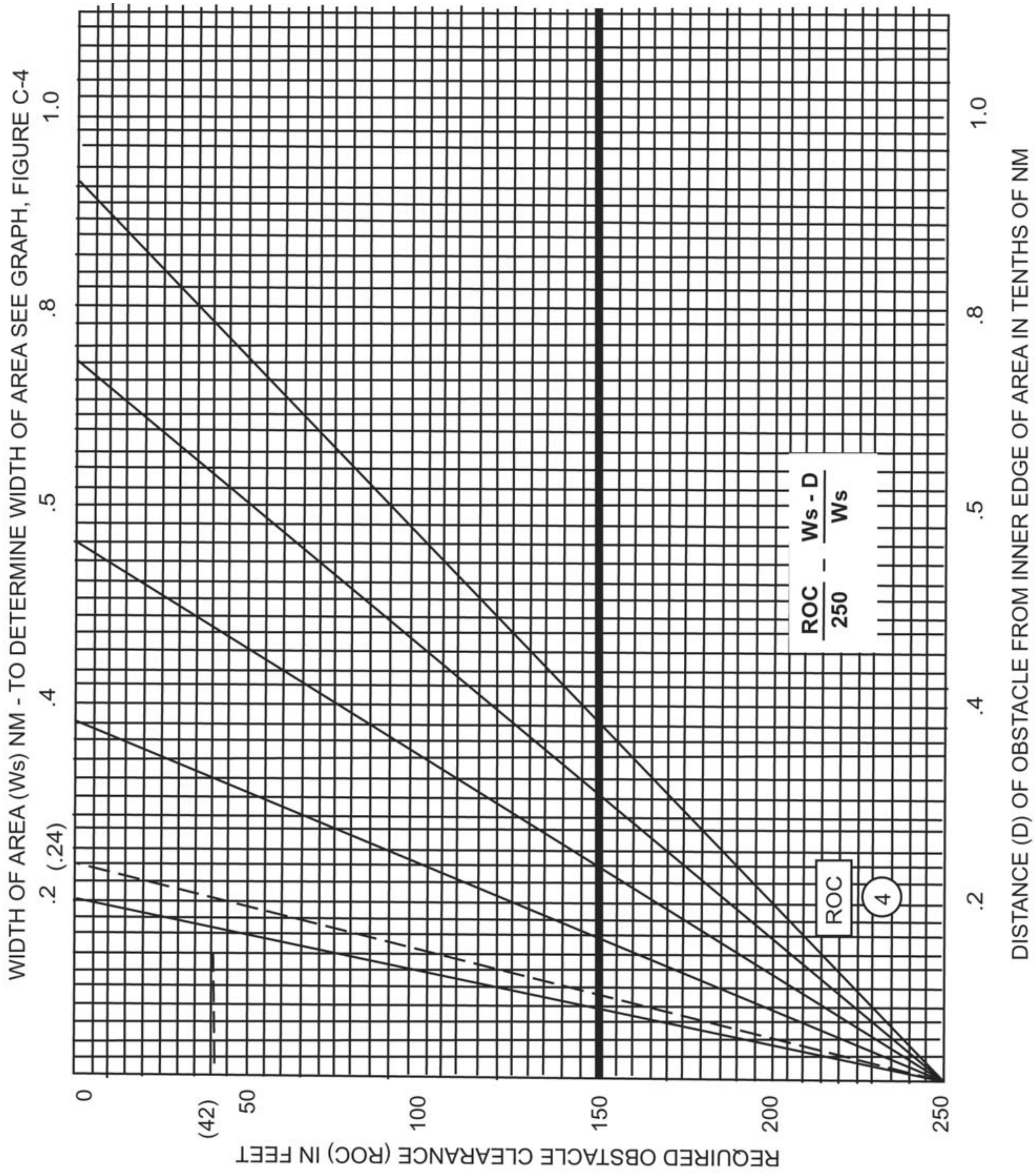


Figure C-5: Final Approach Secondary Area Obstacle Clearance VOR/DME or TACAN with FAF. Para 7.

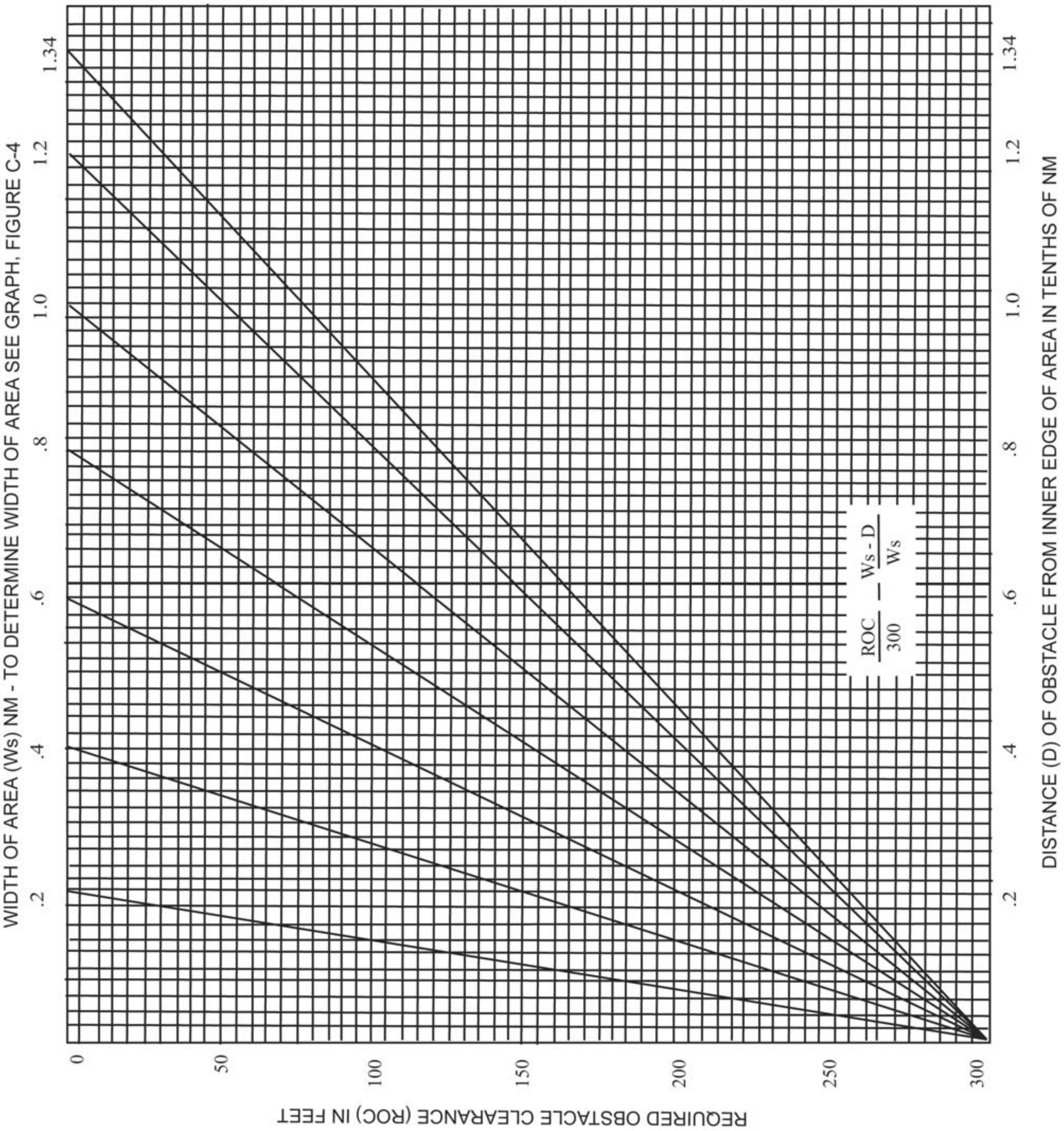


Figure C-6: Final Approach Secondary Area Obstacle Clearance. VOR without FAF and NDB with FAF. Para 7.

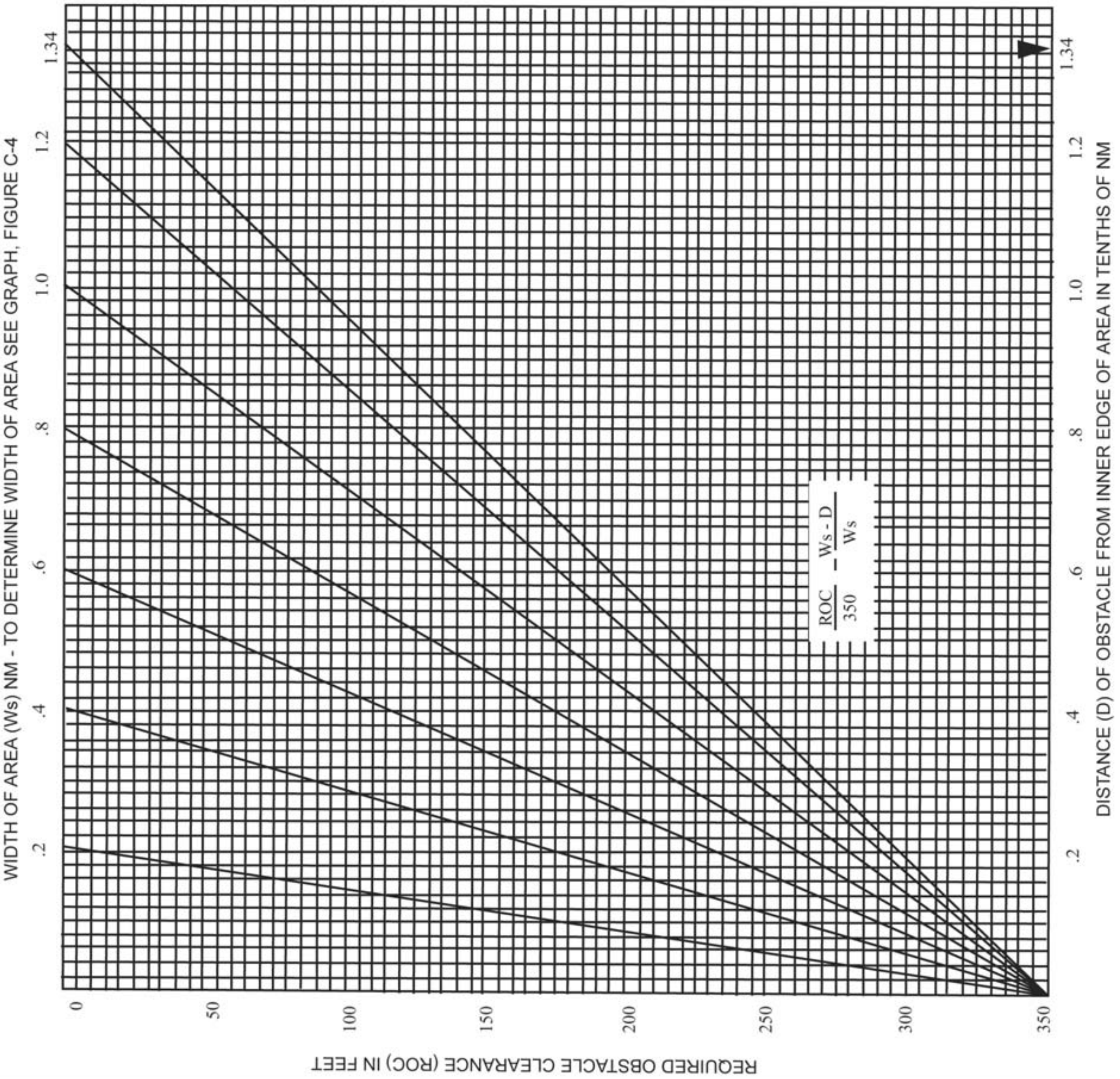


Figure C-7: Final Approach Secondary Area Obstacle Clearance. NDB without FAF. Para 7.

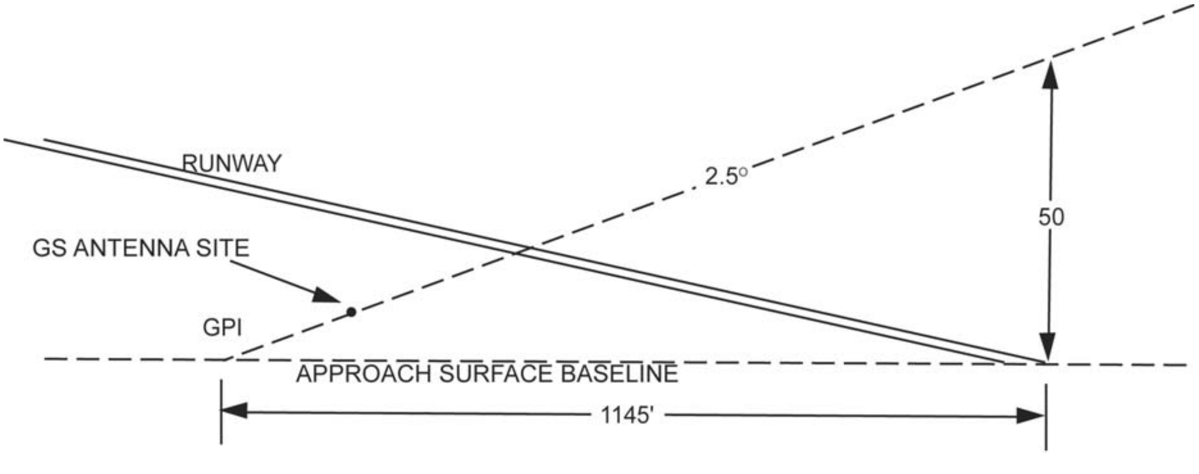
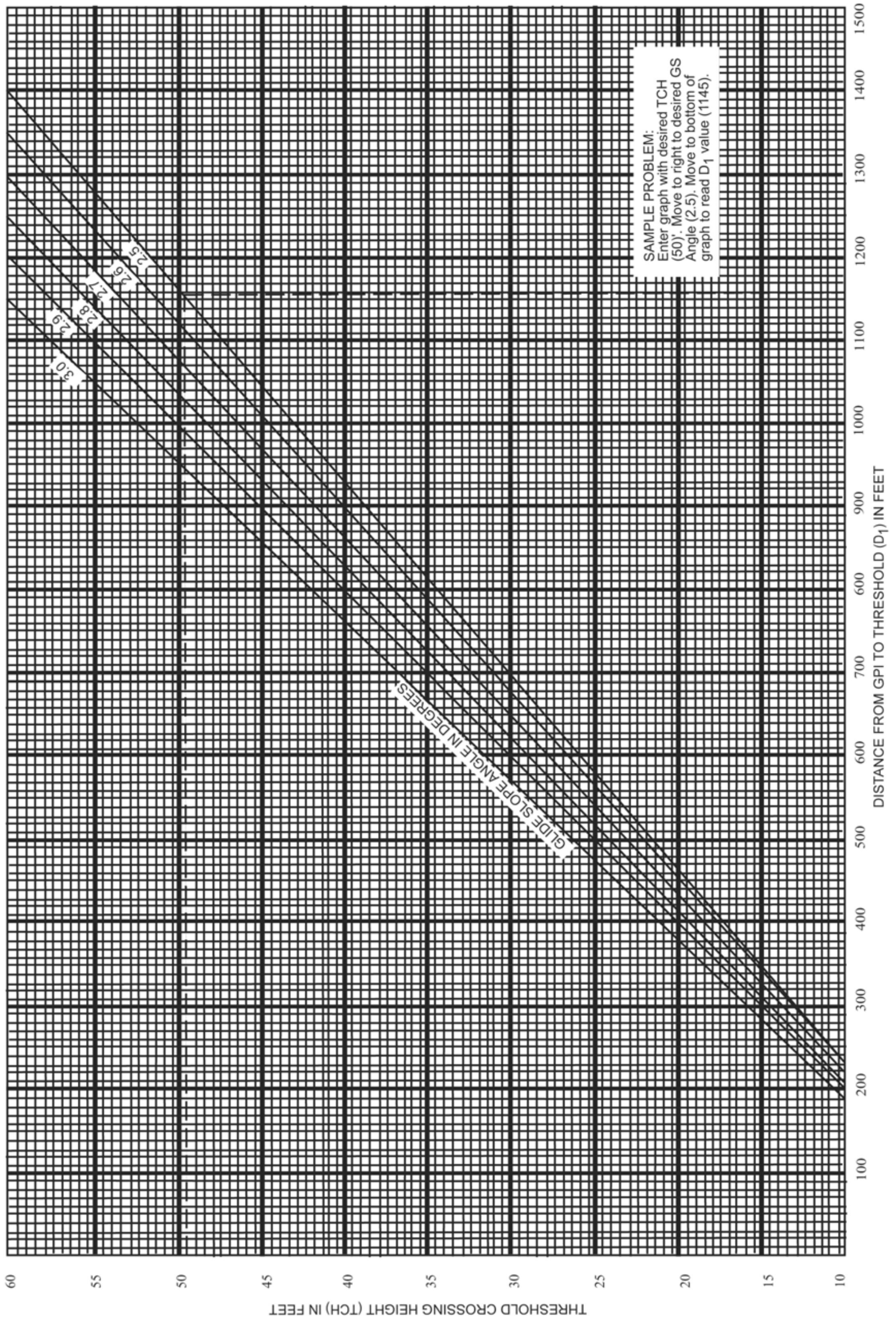


Figure C-8: Computing Threshold Crossing Height. Para 9.



SAMPLE PROBLEM:
Enter graph with desired TCH (50)'. Move to right to desired GS Angle (2.5). Move to bottom of graph to read D_1 value (1145).

Figure C-9: Relationship Of GS Angle, TCH and Distance From GPI. Para 9.

(2) Problem: Find the TCH if:

GS angle is 2 ½ degrees. (Tan is 0.04366)
Distance D_1 is 1,145 feet.

TCH = D_1 x Tan GS angle
= 1,145 x 0.04366
= 50 feet.

c. Glide Slope Antenna Location. The glide slope antenna will be sited in accordance with appropriate civil or military installation standards to provide the desired TCH and GPI.

d. Quick Reference of Relationships. Figure C–9 provides a graphic presentation of the relationship between GS angle, TCH, and D_1. The third value may be found of two are known.

(1) Example. With GS angle 2.6 degrees and TCH 48 feet, D, is 1,057 feet.

(2) Example. With the same TCH, but a GS angle of 2.7 degrees, D, is 101 7 feet.

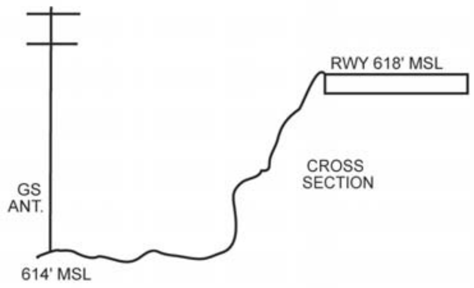
(3) Example. D, is 1 000 feet. For the optimum 50 foot TCH, the GS angle is 2.86 degrees.

(4) Example. GS angle is 2.7 degrees and D, is 1050 feet. TCH is 49.5 feet.

10. Computation Of GPI When TCH Is Known

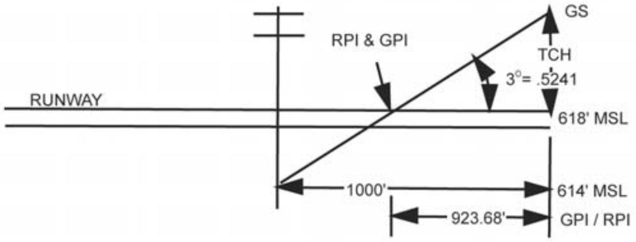
The GPI will be located abeam the glide slope antenna only when the terrain in the vicinity of the runway is perfectly flat. When the terrain slopes significantly between the runway threshold and the GS antenna location, the GPI will not be located abeam the GS antenna. This is because the GPI is the point at which the straight line extension of the glide slope intersects the approach surface base line (ASB). The ASB has the same elevation as the runway threshold. Therefore, the GPI will always be the same distance from the threshold when TCH and GS angle are the same. See Figure C–10A, C–10B and C–10C.

RPI / GPI /TCH COMPUTATIONS FOR ILS WITH RAPIDILY DROPPING TERRAIN.



ILS ANTENNA ELEVATION IS MEASURED AT THE ANTENNA PAD (PROPOSED OR ESTABLISHED) WHEN TERRAIN DROPS OFF RAPIDLY FROM RUNWAY TO ANTENNA.

RUNWAYS WITH ZERO SLOPE



TCH = (TAN GS)(DIST ANT TO TH) - (TH ELEV-ANT ELEV)

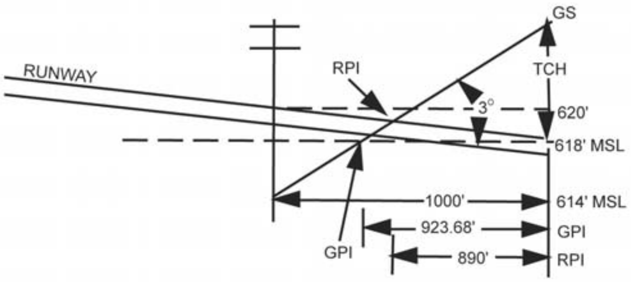
TCH = (.05241)(1000) - (618-614) = 48.41'

GPI = TCH / TAN GS

GPI = 48.41 / .05241 = 923.68'

RPI = GPI

POSITIVE SLOPING RUNWAYS



TCH = (TAN GS)(DIST ANT TO TH) - (TH ELEV-ANT ELEV)

TCH = (.05241)(1000) - (618-614) = 48.41'

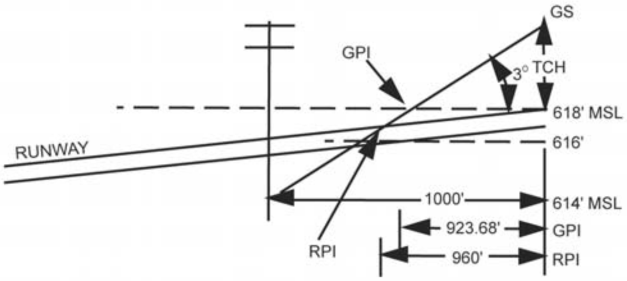
GPI = TCH / TAN GS

GPI = 48.41 / .05241 = 923.68'

$$\text{RPI} = \frac{\text{(TCH)(DIST ANT TO TH)}}{\text{TCH + (RWY CROWN ELEV ABEAM ANT - ANT ELEV)}}$$

$$\text{RPI} = \frac{(48.41)(1000)}{48.41 + (616-614)} = 890'$$

NEGATIVE SLOPING RUNWAYS



TCH = (TAN GS)(DIST ANT TO TH) - (TH ELEV-ANT ELEV)

TCH = (.05241)(1000) - (618-614) = 48.41'

GPI = TCH / TAN GS

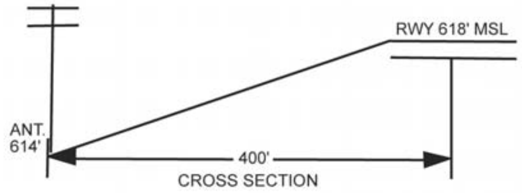
GPI = 48.41 / .05241 = 923.68'

$$\text{RPI} = \frac{\text{(TCH)(DIST ANT TO TH)}}{\text{TCH + (RWY CROWN ELEV ABEAM ANT - ANT ELEV)}}$$

$$\text{RPI} = \frac{(48.41)(1000)}{48.41 + (616-614)} = 960'$$

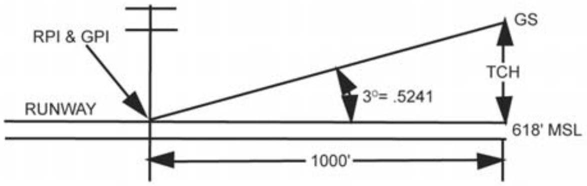
Figure C-10A: RPI/GPI/TCH Computations For ILS With Rapidly Dropping Terrain. Para 10.

RPI / GPI /TCH COMPUTATIONS FOR ILS WITH RELATIVELY SMOOTH TERRAIN.



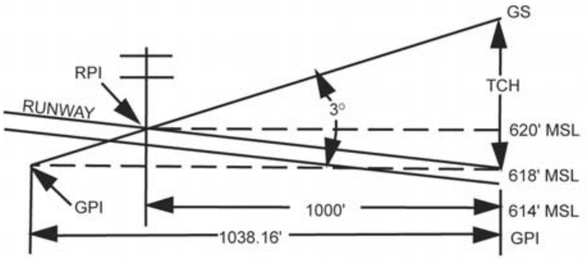
THE ILS ANTENNA IS ASSUMED TO BE AT RUNWAY CROWN ELEVATION WHEN TERRAIN FROM RUNWAY TO ANTENNA SITE (PROPOSED OR ESTABLISHED) HAS A RELATIVELY SMOOTH AND UNIFORM GRADIENT.

RUNWAYS WITH ZERO SLOPE



TCH = (TAN GS) (DIST ANT FROM TH)
TCH = (.05241)(1000) = 52.41'
GPI = TCH / TAN GS
GPI = 52.41 / .05241 = 1000'
RPI = GPI

POSITIVE SLOPING RUNWAYS

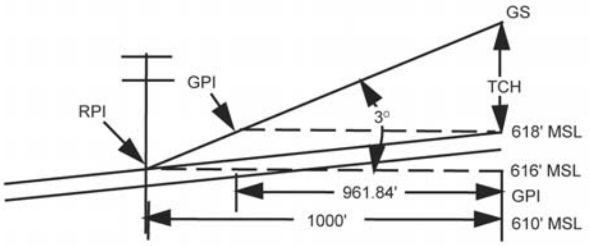


TCH = (TAN GS) (DIST ANT FROM TH) - (TH ELEV- RWY CROWN ELEV ABEAM ANT)
TCH = (.05241)(1000) - (618-620) = 54.41'
GPI = TCH / TAN GS
GPI = 54.41 / .05241 = 1038.16'

$$\text{RPI} = \frac{\text{(TCH) + (TH ELEV- RWY CROWN ELEV ABEAM ANT)}}{\text{TAN GS}}$$

$$\text{RPI} = \frac{50.41 + (618 - 620)}{.05241} = 1000'$$

NEGATIVE SLOPING RUNWAYS



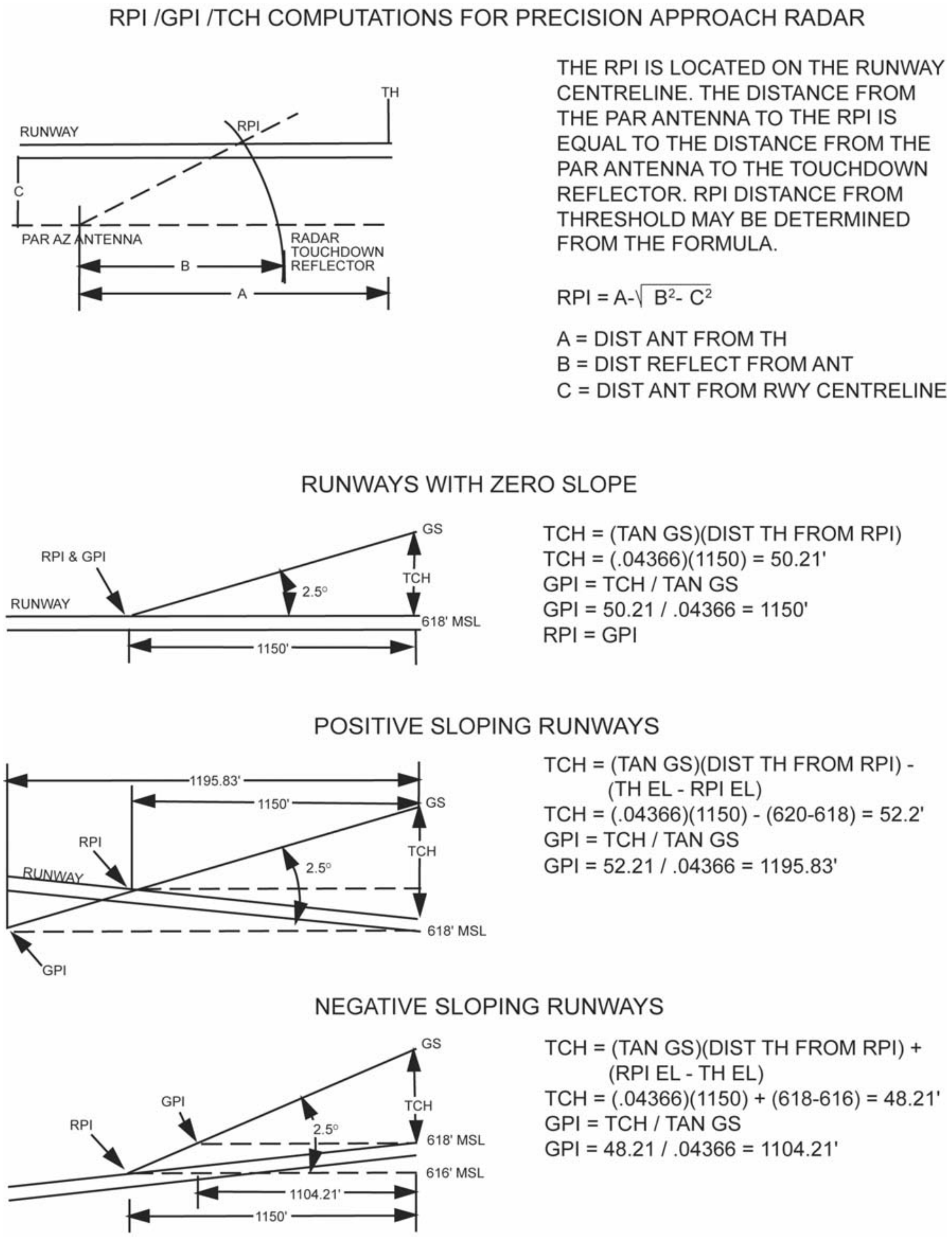
TCH = (TAN GS) (DIST ANT FROM TH) - (TH ELEV- RWY CROWN ELEV ABEAM ANT)
TCH = (.05241)(1000) - (618-616) = 50.41'
GPI = TCH / TAN GS
GPI = 50.41 / .05241 = 961.84'

$$\text{RPI} = \frac{\text{(TCH) + (TH ELEV- RWY CROWN ELEV ABEAM ANT)}}{\text{TAN GS}}$$

$$\text{RPI} = \frac{50.41 + (618 - 616)}{.05241} = 1000'$$

Note: GPI has the same elevation as end of runway.
RPI is the point where the extended glide path intercepts the runway centreline.

Figure C-10B: RPI/FPI/TCH Computations For ILS With Relatively Smooth Terrain. Para 10.



RPI /GPI /TCH COMPUTATIONS FOR PRECISION APPROACH RADAR

THE RPI IS LOCATED ON THE RUNWAY CENTRELINE. THE DISTANCE FROM THE PAR ANTENNA TO THE RPI IS EQUAL TO THE DISTANCE FROM THE PAR ANTENNA TO THE TOUCHDOWN REFLECTOR. RPI DISTANCE FROM THRESHOLD MAY BE DETERMINED FROM THE FORMULA.

$RPI = A-\sqrt{B^2-C^2}$

A = DIST ANT FROM TH
B = DIST REFLECT FROM ANT
C = DIST ANT FROM RWY CENTRELINE

RUNWAYS WITH ZERO SLOPE

TCH = (TAN GS)(DIST TH FROM RPI)
TCH = (.04366)(1150) = 50.21'
GPI = TCH / TAN GS
GPI = 50.21 / .04366 = 1150'
RPI = GPI

POSITIVE SLOPING RUNWAYS

TCH = (TAN GS)(DIST TH FROM RPI) - (TH EL - RPI EL)
TCH = (.04366)(1150) - (620-618) = 52.2'
GPI = TCH / TAN GS
GPI = 52.21 / .04366 = 1195.83'

NEGATIVE SLOPING RUNWAYS

TCH = (TAN GS)(DIST TH FROM RPI) + (RPI EL - TH EL)
TCH = (.04366)(1150) + (618-616) = 48.21'
GPI = TCH / TAN GS
GPI = 48.21 / .04366 = 1104.21'

Figure C-10C: RPI/GPI/TCH Computations For Precision Approach Radar. Para 10.

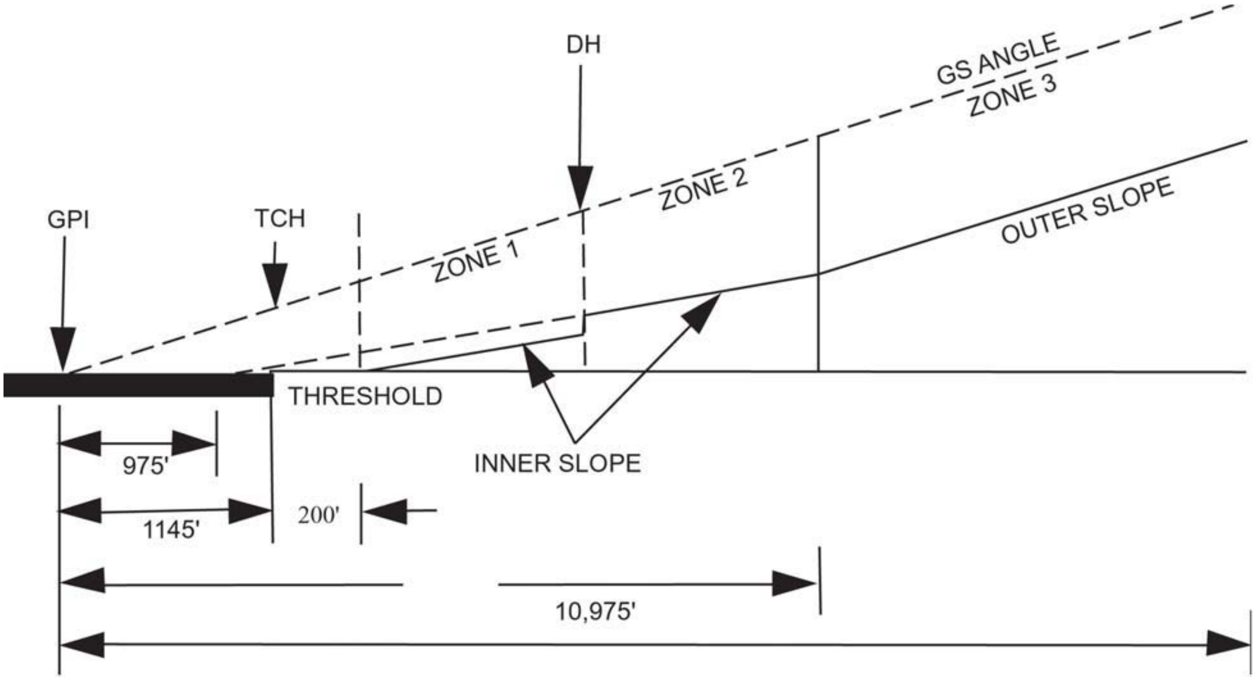


Figure C-11: Final Approach Area Segments. Para 11.

11. Application Of ILS/PAR Obstacle Clearance Criteria

The Required Obstacle Clearance (ROC) may be defined as the minimum vertical separation between the glide slope and the final approach obstacle clearance surface. Since obstacle clearance requirements change in the final approach area, it has been segmented (Para b. below) for ease of application into Zones 1, 2, and 3 for determining the appropriate obstacle clearance requirements. See Figure C–11.

a. Definition and Symbols.

(1) Ground Point of Intercept (GPI). A point in the vertical plane of the runway centreline at which it is assumed that the straight line extension of the glide slope intercepts the approach surface baseline.

(2) Approach Surface Baseline (ASB). An imaginary horizontal line at the threshold elevation.

(3) Final Approach Obstacle Clearance Surface. An inclined plane which originates at the runway landing threshold elevation, and;

(a) In Zone 1, 200 feet out from the landing threshold.

(b) In Zones 2 and 3, 975 feet outward from the GPI.

(4) d = distance from the GS antenna to the threshold.

(5) D = distance from the GPI to an obstacle.

(6) Dj = distance from the GPI to the threshold.

(7) D(t) = distance from the threshold to an obstacle minus 200 feet.

(8) S(i) = slope of inner section approach surface.

b. Final Approach Critical Zones. See Figure C–11.

(1) Zone 1. This zone starts at a point 200 feet outward from the landing threshold at the threshold elevation, and extends up to but not including the decision height (DH) point. (See Para 935). The following formula may be used to compute the ROC in this zone:

ROC = (D x Tan GS angle) - (D(t) / S(i))

Note: The Formula is equal to the separation of the glide slope and the associated slope of the approach surface inner section. See Para 931 and Figure C–12.

(2) Zone 2. This zone starts at the DH and extends up to but not including a point 10,975 feet from the GPI. (See Para 934). The following formula may be used to compute the ROC in this zone:

ROC = 0.02366D + 20 feet

Note: The Zone 2 ROC formula is approximately equal to the separation of the glide slope and the associated slope of the approach surface inner section. See Para 931 and Table 9–2.

(3) Zone 3. This zone starts at a point 10,975 feet outward from the GP [and extends outward to a maximum distance of 15 miles or to a point where the glide slope interception occurs, whichever is the lesser. See Para 934 and Figure 9–2. The following formula may be used to compute the ROC in this zone:

ROC = 0.01866D + 75 feet

Note: The Zone 3 ROC formula is approximately equal to the separation of the glide slope and the associated slope of the approach surface outer section. See Para 931 and Table 9–2.

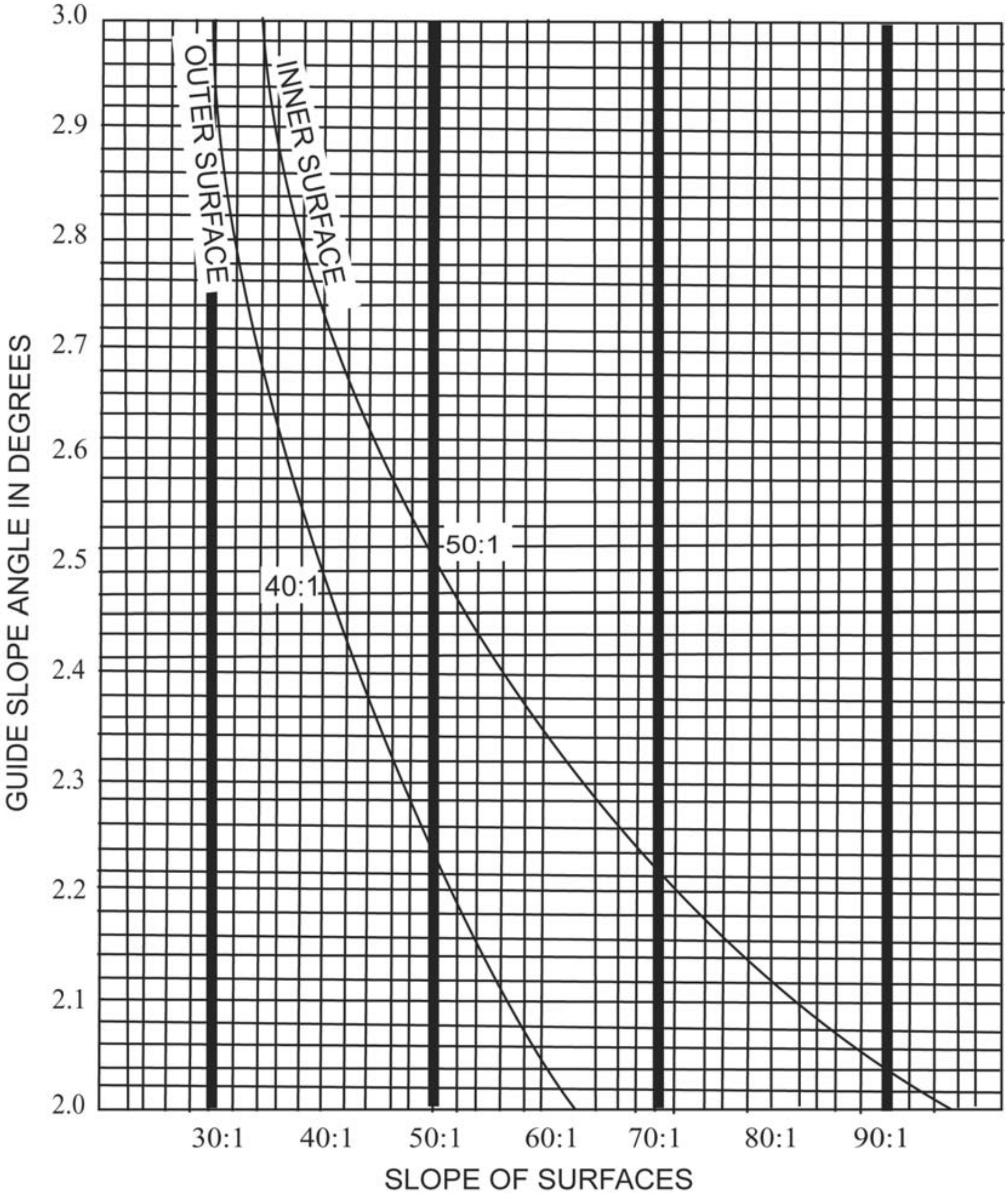


Figure C-12: GS Angle vs Slope Of Surfaces. Para 931 & 1021.

12. Analysis Of Obstacle Clearance

a. Problem. Runway threshold elevation is 342 feet MSL. Obstacles in the approach area are:

Zone 1: 22 feet above threshold and 1,200 feet from threshold.
Zone 2: 228 feet above threshold and 8,000 feet from threshold.
Zone 3: 450 feet above threshold and 20,000 feet from threshold.

b. Tentative GPI Location and Operating Parameters.

(1) Desired GS angle = 2.5 degrees.

(2) Desired TCH = 50 feet.

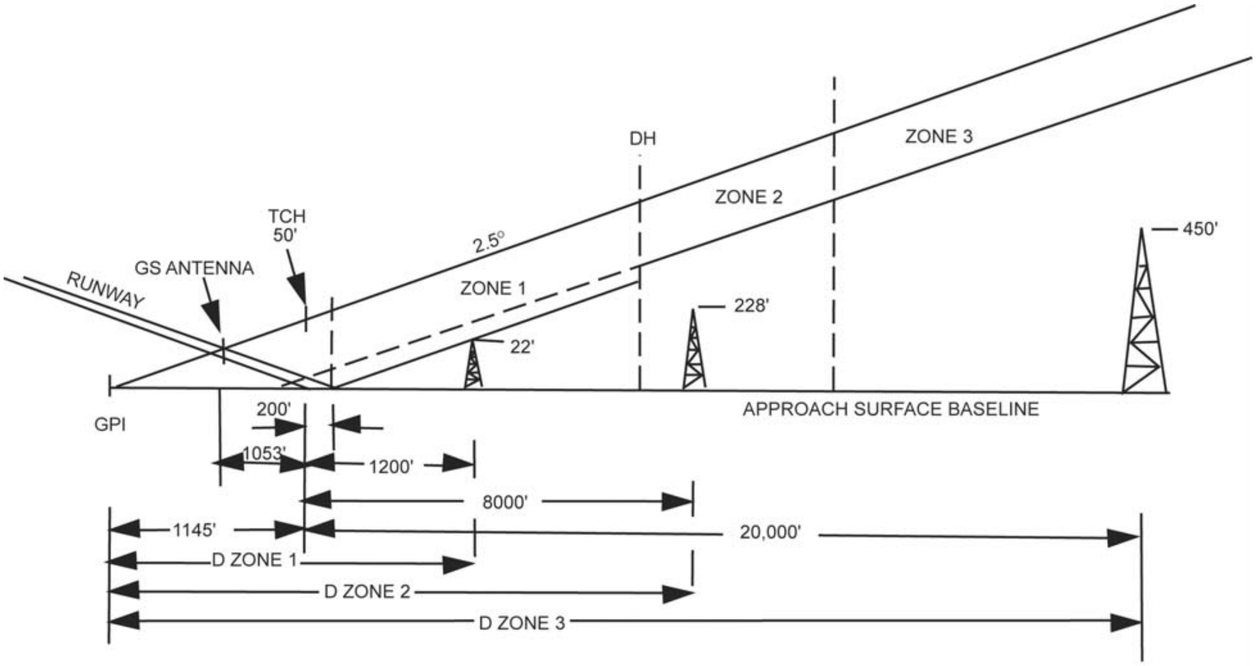


Figure C-13: Application Of Obstacle Clearance Criteria. Para 12.

c. Obstacle Clearance Criteria Application. See Figure C–13.

(1) Distance"D_1" from threshold to GPI

$$D_1 = \frac{\text{TCH}}{\text{Tan GS angle}}$$

$$= \frac{50}{0.04366}$$

= 1,145 feet (Figures C–10A and C–10B)

(2) Zone 1 ROC.

D = 1,145 + 1,200 = 2 345 feet
D(t) = 1,200 – 200 = 1,000 feet
S(i) = 50 (See Figure C–12. 50:1 = 50, 40:1 = 40)

ROC = (D x Tan GS angle) – (D(t)/S(i))
= (2,345 x 0.04366) – (1 000 / 50)
= 102 – 20
= 82 feet

Actual Clearance
C = (D x Tan GS angle) – Obstacle Height
= (2,345 x 0.04366) – 22
= 102 – 22
= 80 feet (Note Violation)

(3) Zone 2 ROC.

D = 1,145 + 8,000 = 9145 feet
ROC = 0.2366D + 20
= (0.02366 x 9,145) + 20
= 216 + 20
= 236 feet

Actual Clearance
C = (D x Tan GS angle) – Obstacle Height
= (9,145 x 0.04366) – 228
= 399 – 228
= 171 feet (Note Violation)

(4) Zone 3 ROC.

D = 1,145 + 20,000 = 21,145 feet
ROC = 0.01866D + 75
= (0.01866 x 21,145) + 75
= 395 + 75
= 470 feet

Actual Clearance
C = (D x Tan GS angle) – Obstacle Height
= (21,145 x 0.04366) – 450
= 923 – 450
= 473 pieds

d. Analysis. It is noted that violation to ROC criteria exist in Zones 1 and 2.

(1) Zone 1. Violation could be corrected by:

(a) Raising the GS angle.

$$
\begin{aligned}
S(i) &= \frac{D(t)}{\text{Obstacle Height}} \\
&= \frac{1{,}000}{22} \\
&= 45.5 \text{ (or } 45.5{:}1)
\end{aligned}
$$

Minimum Angle from Figure C–12 = 2.62 degrees

(2) Or; by retaining the 2.5 degree GS angle and displacing the threshold.

$$
\begin{aligned}
\text{Minimum } D(t) &= S(i)\,\big((D \times \text{Tan GS angle}) - \text{Actual Clearance}\big) \\
&= 50 \times \big((2{,}345 \times 0.04366) - 80\big) \\
&= 50 \times (102 - 80) \\
&= 50 \times 22 \\
&= 1{,}100 \text{ feet. Requires displacement of threshold 100 feet}
\end{aligned}
$$

(3) Zone 2. Violation could be corrected by:

(a) Raising the GS angle.

$$
\begin{aligned}
\text{Minimum GS angle (arc tan)} &= \frac{\text{ROC} + \text{Obstacle Height}}{D} \\
&= \frac{236 + 228}{9{,}145} \\
&= \frac{464}{9{,}145} \\
&= 0.05074 \text{ (arc Tan)}
\end{aligned}
$$

Table of tangents shows the angle for 0.05074 to be 2.91 degrees

(b) Or by retaining the 2.5 degree GS angle and increasing the distance D_1 between the GPI and the runway threshold. To do this, we must first determine the correct D based upon obstacle height and the ROC at the new D:

$$
\begin{aligned}
D \text{ (in Zone 2)} &= \frac{\text{Obstacle Height} + 20}{0.02} \\
&= \frac{228 + 20}{0.02} \\
&= \frac{248}{0.02} \\
&= 12{,}400 \text{ feet}
\end{aligned}
$$

Since the new D_1 is greater than 10,975 feet, this movement of the GS would cause the obstacle to fall in Zone 3. Therefore, further analysis would require Zone 3 treatment.

$$\begin{aligned} D \text{ (in Zone 3)} &= \frac{\text{Obstacle Height} + 75}{0.025} \\ &= \frac{228 + 75}{0.025} \\ &= \frac{303}{0.025} \\ &= 12{,}120 \text{ feet} \end{aligned}$$

$$\begin{aligned} \text{Minimum } D_1 &= D - 8{,}000 \\ &= 12{,}120 - 8{,}000 \\ &= 4{,}120 \text{ feet} \end{aligned}$$

It should be noted that once the GPI is changed a recalculation of all ROC's must be performed and a new sketch made. However, for the purpose of this analysis the new ROC for this obstacle will be computed and checked.

$$\begin{aligned} \text{ROC} &= 0.01866D + 75 \\ &= (0.01866 \times 12{,}120) + 75 \\ &= 226 + 75 \\ &= 301 \text{ feet} \end{aligned}$$

Actual Clearance

$$\begin{aligned} C &= (D \times \text{Tan GS angle}) - \text{Obstacle Height} \\ &= (12{,}120 \times 0.04366) - 228 \\ &= 529 - 228 \\ &= 301 \text{ feet} \end{aligned}$$

e. Conclusions. The above analysis shows that one of the following must be done to satisfy the Zone 1 and 2 ROC criteria, while limiting the glide slope angle to a maximum of 3 degrees and the TCH to a maximum of 60 feet:

   (1) Increase the GS angle to 2.91 degrees without changing the position of the GPI. This will also increase the TCH to 58.2 feet:

   $$\begin{aligned} \text{TCH} &= D_1 (\tan \text{GS angle}) \\ &= 1{,}145 \times 0.05084 \\ &= 58.2 \text{ feet} \end{aligned}$$

   (2) Change the GS angle and reselect the GPI as follows: See Para 11.d.(2)(b).

      (a) When the GS angle is 3 degrees, the minimum DI to clear obstacles in Zones 1 and 2 would be 853 feet. However, this would provide a TCH of only 44.7 feet, which is below that desired.

      (b) When the GS angle is 3 degrees and DI is 954 feet, a TCH of 50 feet is obtained. A recalculation of the ROC in Zone 3 will be required if this solution is chosen since D was decreased from the original.

      (c) When the GS angle is 2.95 degrees and the minimum DI is 1004 feet, a TCH of 51.7 feet is obtained. A recalculation of the Zone 3 ROC will also be required if this solution is chosen.

      (d) When the GS angle is 2.9 degrees and the minimum DI is 1 1 59 feet, a TCH of 58.7 is obtained. It will also satisfy ROC requirements in Zone 3.

f. Recommendation. By analysis of the various solutions, it can be concluded that the GS angle of 2.95, DI of 1004 feet, and TCH of 51.7 feet found in Para 12.e.(2)(c) above would provide the best solution since it satisfies the TCH requirement and all obstacle clearance requirements as well. Therefore, it is offered as the best recommendation.

13. Geographic Centre Of The Aerodrome

Several methods have been used from time to time to determine the geometric centre of an aerodrome. The following method has been found to give consistently good results and is to be used for all normal determinations of aerodrome centres that are involved in the publication of geographic coordinates. The method gives the centre of the runway pattern.

The geometric centre is at the intersection of two lines determined as follows:

a. A N-S line, which is midway between N-S lines passing through the runway thresholds, which are the furthest east and furthest west points of the runway pattern; and

b. An E-W line, which is midway between E-W lines passing through the runway thresholds, which are the furthest north and furthest south points of the runway pattern.

From a practical viewpoint the convergence of meridians (True North) and the curvature of parallels of latitude can be disregard. See Figure C–14.

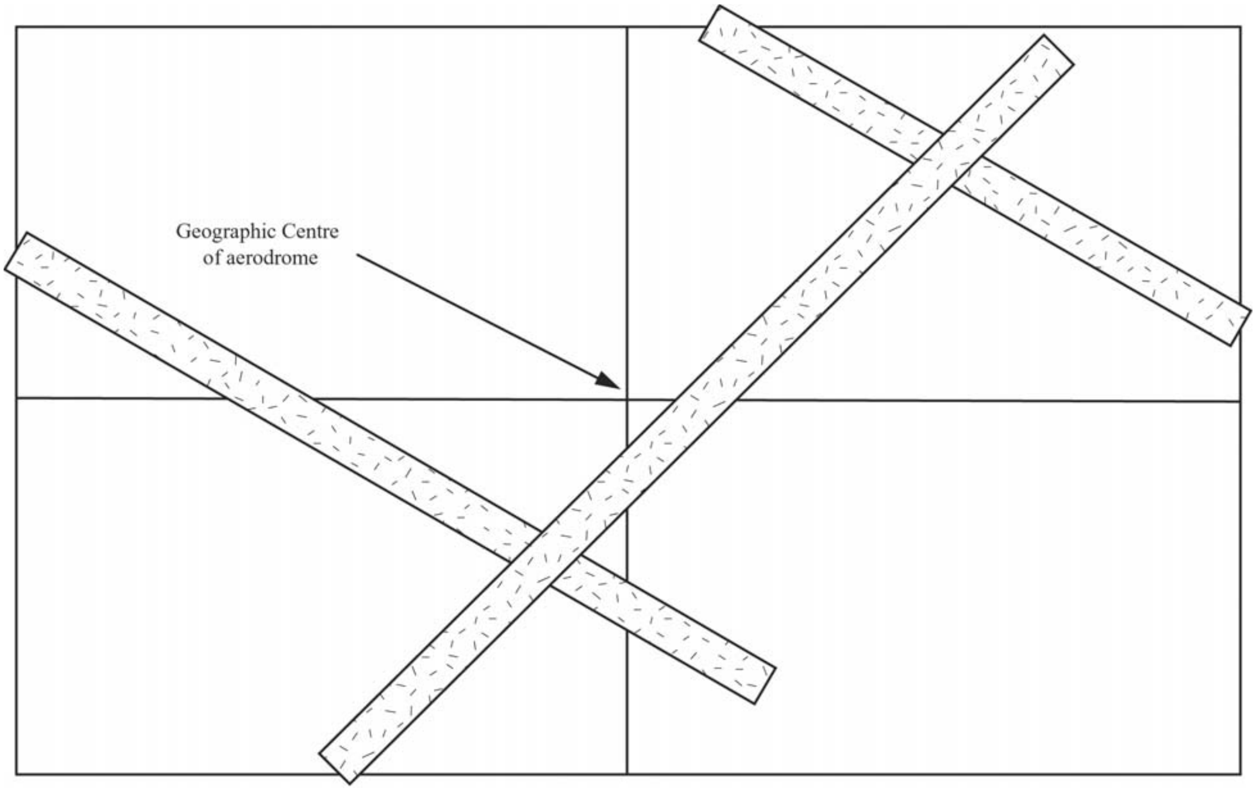


Figure C-14: Geographic Centre Of The Aerodrome. Para 13.

CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 4

ANNEX D

TANGENTS

TRANSPORT CANADA
NATIONAL DEFENSE

INTENTIONALLY
LEFT
BLANK

TABLE OF TANGENTS

Degree	Tangent
0.00 =	0.00000
0.01 =	0.00017
0.02 =	0.00035
0.03 =	0.00052
0.04 =	0.00070
0.05 =	0.00087
0.06 =	0.00105
0.07 =	0.00122
0.08 =	0.00140
0.09 =	0.00157
0.10 =	0.00175
0.11 =	0.00192
0.12 =	0.00209
0.13 =	0.00227
0.14 =	0.00244
0.15 =	0.00262
0.16 =	0.00279
0.17 =	0.00297
0.18 =	0.00314
0.19 =	0.00332
0.20 =	0.00349
0.21 =	0.00367
0.22 =	0.00384
0.23 =	0.00401
0.24 =	0.00419
0.25 =	0.00436
0.26 =	0.00454
0.27 =	0.00471
0.28 =	0.00489
0.29 =	0.00506
0.30 =	0.00524
0.31 =	0.00541
0.32 =	0.00559
0.33 =	0.00576
0.34 =	0.00593
0.35 =	0.00611
0.36 =	0.00628
0.37 =	0.00646
0.38 =	0.00663
0.39 =	0.00681
0.40 =	0.00698
0.41 =	0.00716
0.42 =	0.00733
0.43 =	0.00751
0.44 =	0.00768
0.45 =	0.00785
0.46 =	0.00803
0.47 =	0.00820
0.48 =	0.00838
0.49 =	0.00855
0.50 =	0.00873
0.51 =	0.00890
0.52 =	0.00908
0.53 =	0.00925
0.54 =	0.00943
0.55 =	0.00960
0.56 =	0.00977
0.57 =	0.00995
0.58 =	0.01012
0.59 =	0.01030
0.60 =	0.01047
0.61 =	0.01065
0.62 =	0.01082
0.63 =	0.01100
0.64 =	0.01117
0.65 =	0.01135
0.66 =	0.01152
0.67 =	0.01169
0.68 =	0.01187
0.69 =	0.01204
0.70 =	0.01222
0.71 =	0.01239
0.72 =	0.01257
0.73 =	0.01274
0.74 =	0.01292
0.75 =	0.01309
0.76 =	0.01327
0.77 =	0.01344
0.78 =	0.01361
0.79 =	0.01379
0.80 =	0.01396
0.81 =	0.01414
0.82 =	0.01431
0.83 =	0.01449
0.84 =	0.01466
0.85 =	0.01484
0.86 =	0.01501
0.87 =	0.01519
0.88 =	0.01536
0.89 =	0.01553
0.90 =	0.01571
0.91 =	0.01588
0.92 =	0.01606
0.93 =	0.01623
0.94 =	0.01641
0.95 =	0.01658
0.96 =	0.01676
0.97 =	0.01693
0.98 =	0.01711
0.99 =	0.01728
1.00 =	0.01746
1.01 =	0.01763
1.02 =	0.01780
1.03 =	0.01798
1.04 =	0.01815
1.05 =	0.01833
1.06 =	0.01850
1.07 =	0.01868
1.08 =	0.01885
1.09 =	0.01903
1.10 =	0.01920
1.11 =	0.01938
1.12 =	0.01955
1.13 =	0.01972
1.14 =	0.01990
1.15 =	0.02007
1.16 =	0.02025
1.17 =	0.02042
1.18 =	0.02060
1.19 =	0.02077
1.20 =	0.02095
1.21 =	0.02112
1.22 =	0.02130
1.23 =	0.02147
1.24 =	0.02165
1.25 =	0.02182
1.26 =	0.02199
1.27 =	0.02217
1.28 =	0.02234
1.29 =	0.02252
1.30 =	0.02269
1.31 =	0.02287
1.32 =	0.02304
1.33 =	0.02322
1.34 =	0.02339
1.35 =	0.02357
1.36 =	0.02374
1.37 =	0.02392
1.38 =	0.02409
1.39 =	0.02426
1.40 =	0.02444
1.41 =	0.02461
1.42 =	0.02479
1.43 =	0.02496
1.44 =	0.02514
1.45 =	0.02531
1.46 =	0.02549
1.47 =	0.02566
1.48 =	0.02584
1.49 =	0.02601
1.50 =	0.02619
1.51 =	0.02636
1.52 =	0.02654
1.53 =	0.02671
1.54 =	0.02688
1.55 =	0.02706
1.56 =	0.02723
1.57 =	0.02741
1.58 =	0.02758
1.59 =	0.02776

Degree	Tangent
1.60 =	0.02793
1.61 =	0.02811
1.62 =	0.02828
1.63 =	0.02846
1.64 =	0.02863
1.65 =	0.02881
1.66 =	0.02898
1.67 =	0.02916
1.68 =	0.02933
1.69 =	0.02950
1.70 =	0.02968
1.71 =	0.02985
1.72 =	0.03003
1.73 =	0.03020
1.74 =	0.03038
1.75 =	0.03055
1.76 =	0.03073
1.77 =	0.03090
1.78 =	0.03108
1.79 =	0.03125
1.80 =	0.03143
1.81 =	0.03160
1.82 =	0.03178
1.83 =	0.03195
1.84 =	0.03213
1.85 =	0.03230
1.86 =	0.03247
1.87 =	0.03265
1.88 =	0.03282
1.89 =	0.03300
1.90 =	0.03317
1.91 =	0.03335
1.92 =	0.03352
1.93 =	0.03370
1.94 =	0.03387
1.95 =	0.03405
1.96 =	0.03422
1.97 =	0.03440
1.98 =	0.03457
1.99 =	0.03475
2.00 =	0.03492
2.01 =	0.03510
2.02 =	0.03527
2.03 =	0.03545
2.04 =	0.03562
2.05 =	0.03579
2.06 =	0.03597
2.07 =	0.03614
2.08 =	0.03632
2.09 =	0.03649
2.10 =	0.03667
2.11 =	0.03684
2.12 =	0.03702
2.13 =	0.03719
2.14 =	0.03737
2.15 =	0.03754
2.16 =	0.03772
2.17 =	0.03789
2.18 =	0.03807
2.19 =	0.03824
2.20 =	0.03842
2.21 =	0.03859
2.22 =	0.03877
2.23 =	0.03894
2.24 =	0.03912
2.25 =	0.03929
2.26 =	0.03946
2.27 =	0.03964
2.28 =	0.03981
2.29 =	0.03999
2.30 =	0.04016
2.31 =	0.04034
2.32 =	0.04051
2.33 =	0.04069
2.34 =	0.04086
2.35 =	0.04104
2.36 =	0.04121
2.37 =	0.04139
2.38 =	0.04156
2.39 =	0.04174
2.40 =	0.04191
2.41 =	0.04209
2.42 =	0.04226
2.43 =	0.04244
2.44 =	0.04261
2.45 =	0.04279
2.46 =	0.04296
2.47 =	0.04314
2.48 =	0.04331
2.49 =	0.04349
2.50 =	0.04366
2.51 =	0.04384
2.52 =	0.04401
2.53 =	0.04419
2.54 =	0.04436
2.55 =	0.04454
2.56 =	0.04471
2.57 =	0.04489
2.58 =	0.04506
2.59 =	0.04523
2.60 =	0.04541
2.61 =	0.04558
2.62 =	0.04576
2.63 =	0.04593
2.64 =	0.04611
2.65 =	0.04628
2.66 =	0.04646
2.67 =	0.04663
2.68 =	0.04681
2.69 =	0.04698
2.70 =	0.04716
2.71 =	0.04733
2.72 =	0.04751
2.73 =	0.04768
2.74 =	0.04786
2.75 =	0.04803
2.76 =	0.04821
2.77 =	0.04838
2.78 =	0.04856
2.79 =	0.04873
2.80 =	0.04891
2.81 =	0.04908
2.82 =	0.04926
2.83 =	0.04943
2.84 =	0.04961
2.85 =	0.04978
2.86 =	0.04996
2.87 =	0.05013
2.88 =	0.05031
2.89 =	0.05048
2.90 =	0.05066
2.91 =	0.05083
2.92 =	0.05101
2.93 =	0.05118
2.94 =	0.05136
2.95 =	0.05153
2.96 =	0.05171
2.97 =	0.05188
2.98 =	0.05206
2.99 =	0.05223
3.00 =	0.05241
3.01 =	0.05258
3.02 =	0.05276
3.03 =	0.05293
3.04 =	0.05311
3.05 =	0.05328
3.06 =	0.05346
3.07 =	0.05363
3.08 =	0.05381
3.09 =	0.05398
3.10 =	0.05416
3.11 =	0.05433
3.12 =	0.05451
3.13 =	0.05468
3.14 =	0.05486
3.15 =	0.05503
3.16 =	0.05521
3.17 =	0.05538
3.18 =	0.05556
3.19 =	0.05573

Degree	Tangent
3.20 =	0.05591
3.21 =	0.05608
3.22 =	0.05626
3.23 =	0.05643
3.24 =	0.05661
3.25 =	0.05678
3.26 =	0.05696
3.27 =	0.05713
3.28 =	0.05731
3.29 =	0.05748
3.30 =	0.05766
3.31 =	0.05783
3.32 =	0.05801
3.33 =	0.05818
3.34 =	0.05836
3.35 =	0.05854
3.36 =	0.05871
3.37 =	0.05889
3.38 =	0.05906
3.39 =	0.05924
3.40 =	0.05941
3.41 =	0.05959
3.42 =	0.05976
3.43 =	0.05994
3.44 =	0.06011
3.45 =	0.06029
3.46 =	0.06046
3.47 =	0.06064
3.48 =	0.06081
3.49 =	0.06099
3.50 =	0.06116
3.51 =	0.06134
3.52 =	0.06151
3.53 =	0.06169
3.54 =	0.06186
3.55 =	0.06204
3.56 =	0.06221
3.57 =	0.06239
3.58 =	0.06256
3.59 =	0.06274
3.60 =	0.06291
3.61 =	0.06309
3.62 =	0.06327
3.63 =	0.06344
3.64 =	0.06362
3.65 =	0.06379
3.66 =	0.06397
3.67 =	0.06414
3.68 =	0.06432
3.69 =	0.06449
3.70 =	0.06467
3.71 =	0.06484
3.72 =	0.06502
3.73 =	0.06519
3.74 =	0.06537
3.75 =	0.06554
3.76 =	0.06572
3.77 =	0.06589
3.78 =	0.06607
3.79 =	0.06624
3.80 =	0.06642
3.81 =	0.06660
3.82 =	0.06677
3.83 =	0.06695
3.84 =	0.06712
3.85 =	0.06730
3.86 =	0.06747
3.87 =	0.06765
3.88 =	0.06782
3.89 =	0.06800
3.90 =	0.06817
3.91 =	0.06835
3.92 =	0.06852
3.93 =	0.06870
3.94 =	0.06887
3.95 =	0.06905
3.96 =	0.06923
3.97 =	0.06940
3.98 =	0.06958
3.99 =	0.06975
4.00 =	0.06993
4.01 =	0.07010
4.02 =	0.07028
4.03 =	0.07045
4.04 =	0.07063
4.05 =	0.07080
4.06 =	0.07098
4.07 =	0.07115
4.08 =	0.07133
4.09 =	0.07151
4.10 =	0.07168
4.11 =	0.07186
4.12 =	0.07203
4.13 =	0.07221
4.14 =	0.07238
4.15 =	0.07256
4.16 =	0.07273
4.17 =	0.07291
4.18 =	0.07308
4.19 =	0.07326
4.20 =	0.07344
4.21 =	0.07361
4.22 =	0.07379
4.23 =	0.07396
4.24 =	0.07414
4.25 =	0.07431
4.26 =	0.07449
4.27 =	0.07466
4.28 =	0.07484
4.29 =	0.07501
4.30 =	0.07519
4.31 =	0.07537
4.32 =	0.07554
4.33 =	0.07572
4.34 =	0.07589
4.35 =	0.07607
4.36 =	0.07624
4.37 =	0.07642
4.38 =	0.07659
4.39 =	0.07677
4.40 =	0.07695
4.41 =	0.07712
4.42 =	0.07730
4.43 =	0.07747
4.44 =	0.07765
4.45 =	0.07782
4.46 =	0.07800
4.47 =	0.07817
4.48 =	0.07835
4.49 =	0.07853
4.50 =	0.07870
4.51 =	0.07888
4.52 =	0.07905
4.53 =	0.07923
4.54 =	0.07940
4.55 =	0.07958
4.56 =	0.07976
4.57 =	0.07993
4.58 =	0.08011
4.59 =	0.08028
4.60 =	0.08046
4.61 =	0.08063
4.62 =	0.08081
4.63 =	0.08099
4.64 =	0.08116
4.65 =	0.08134
4.66 =	0.08151
4.67 =	0.08169
4.68 =	0.08186
4.69 =	0.08204
4.70 =	0.08221
4.71 =	0.08239
4.72 =	0.08257
4.73 =	0.08274
4.74 =	0.08292
4.75 =	0.08309
4.76 =	0.08327
4.77 =	0.08345
4.78 =	0.08362
4.79 =	0.08380

Degree	Tangent
4.80 =	0.08397
4.81 =	0.08415
4.82 =	0.08432
4.83 =	0.08450
4.84 =	0.08468
4.85 =	0.08485
4.86 =	0.08503
4.87 =	0.08520
4.88 =	0.08538
4.89 =	0.08555
4.90 =	0.08573
4.91 =	0.08591
4.92 =	0.08608
4.93 =	0.08626
4.94 =	0.08643
4.95 =	0.08661
4.96 =	0.08679
4.97 =	0.08696
4.98 =	0.08714
4.99 =	0.08731
5.00 =	0.08749
5.01 =	0.08766
5.02 =	0.08784
5.03 =	0.08802
5.04 =	0.08819
5.05 =	0.08837
5.06 =	0.08854
5.07 =	0.08872
5.08 =	0.08890
5.09 =	0.08907
5.10 =	0.08925
5.11 =	0.08942
5.12 =	0.08960
5.13 =	0.08978
5.14 =	0.08995
5.15 =	0.09013
5.16 =	0.09030
5.17 =	0.09048
5.18 =	0.09066
5.19 =	0.09083

Degree	Tangent
5.20 =	0.09101
5.21 =	0.09118
5.22 =	0.09136
5.23 =	0.09154
5.24 =	0.09171
5.25 =	0.09189
5.26 =	0.09206
5.27 =	0.09224
5.28 =	0.09242
5.29 =	0.09259
5.30 =	0.09277
5.31 =	0.09294
5.32 =	0.09312
5.33 =	0.09330
5.34 =	0.09347
5.35 =	0.09365
5.36 =	0.09382
5.37 =	0.09400
5.38 =	0.09418
5.39 =	0.09435
5.40 =	0.09453
5.41 =	0.09470
5.42 =	0.09488
5.43 =	0.09506
5.44 =	0.09523
5.45 =	0.09541
5.46 =	0.09558
5.47 =	0.09576
5.48 =	0.09594
5.49 =	0.09611
5.50 =	0.09629
5.51 =	0.09647
5.52 =	0.09664
5.53 =	0.09682
5.54 =	0.09699
5.55 =	0.09717
5.56 =	0.09735
5.57 =	0.09752
5.58 =	0.09770
5.59 =	0.09787

Degree	Tangent
5.60 =	0.09805
5.61 =	0.09823
5.62 =	0.09840
5.63 =	0.09858
5.64 =	0.09876
5.65 =	0.09893
5.66 =	0.09911
5.67 =	0.09928
5.68 =	0.09946
5.69 =	0.09964
5.70 =	0.09981
5.71 =	0.09999
5.72 =	0.10017
5.73 =	0.10034
5.74 =	0.10052
5.75 =	0.10069
5.76 =	0.10087
5.77 =	0.10105
5.78 =	0.10122
5.79 =	0.10140
5.80 =	0.10158
5.81 =	0.10175
5.82 =	0.10193
5.83 =	0.10211
5.84 =	0.10228
5.85 =	0.10246
5.86 =	0.10263
5.87 =	0.10281
5.88 =	0.10299
5.89 =	0.10316
5.90 =	0.10334
5.91 =	0.10352
5.92 =	0.10369
5.93 =	0.10387
5.94 =	0.10405
5.95 =	0.10422
5.96 =	0.10440
5.97 =	0.10457
5.98 =	0.10475
5.99 =	0.10493

Degree	Tangent
6.00 =	0.10510
6.01 =	0.10528
6.02 =	0.10546
6.03 =	0.10563
6.04 =	0.10581
6.05 =	0.10599
6.06 =	0.10616
6.07 =	0.10634
6.08 =	0.10652
6.09 =	0.10669
6.10 =	0.10687
6.11 =	0.10705
6.12 =	0.10722
6.13 =	0.10740
6.14 =	0.10758
6.15 =	0.10775
6.16 =	0.10793
6.17 =	0.10811
6.18 =	0.10828
6.19 =	0.10846
6.20 =	0.10863
6.21 =	0.10881
6.22 =	0.10899
6.23 =	0.10916
6.24 =	0.10934
6.25 =	0.10952
6.26 =	0.10969
6.27 =	0.10987
6.28 =	0.11005
6.29 =	0.11022
6.30 =	0.11040
6.31 =	0.11058
6.32 =	0.11075
6.33 =	0.11093
6.34 =	0.11111
6.35 =	0.11128
6.36 =	0.11146
6.37 =	0.11164
6.38 =	0.11181
6.39 =	0.11199

Degree	Tangent
6.40 =	0.11217
6.41 =	0.11234
6.42 =	0.11252
6.43 =	0.11270
6.44 =	0.11287
6.45 =	0.11305
6.46 =	0.11323
6.47 =	0.11341
6.48 =	0.11358
6.49 =	0.11376
6.50 =	0.11394
6.51 =	0.11411
6.52 =	0.11429
6.53 =	0.11447
6.54 =	0.11464
6.55 =	0.11482
6.56 =	0.11500
6.57 =	0.11517
6.58 =	0.11535
6.59 =	0.11553
6.60 =	0.11570
6.61 =	0.11588
6.62 =	0.11606
6.63 =	0.11623
6.64 =	0.11641
6.65 =	0.11659
6.66 =	0.11677
6.67 =	0.11694
6.68 =	0.11712
6.69 =	0.11730
6.70 =	0.11747
6.71 =	0.11765
6.72 =	0.11783
6.73 =	0.11800
6.74 =	0.11818
6.75 =	0.11836
6.76 =	0.11853
6.77 =	0.11871
6.78 =	0.11889
6.79 =	0.11907

Degree	Tangent
6.80 =	0.11924
6.81 =	0.11942
6.82 =	0.11960
6.83 =	0.11977
6.84 =	0.11995
6.85 =	0.12013
6.86 =	0.12031
6.87 =	0.12048
6.88 =	0.12066
6.89 =	0.12084
6.90 =	0.12101
6.91 =	0.12119
6.92 =	0.12137
6.93 =	0.12154
6.94 =	0.12172
6.95 =	0.12190
6.96 =	0.12208
6.97 =	0.12225
6.98 =	0.12243
6.99 =	0.12261
7.00 =	0.12278
7.01 =	0.12296
7.02 =	0.12314
7.03 =	0.12332
7.04 =	0.12349
7.05 =	0.12367
7.06 =	0.12385
7.07 =	0.12402
7.08 =	0.12420
7.09 =	0.12438
7.10 =	0.12456
7.11 =	0.12473
7.12 =	0.12491
7.13 =	0.12509
7.14 =	0.12527
7.15 =	0.12544
7.16 =	0.12562
7.17 =	0.12580
7.18 =	0.12597
7.19 =	0.12615

Degree	Tangent
7.20 =	0.12633
7.21 =	0.12651
7.22 =	0.12668
7.23 =	0.12686
7.24 =	0.12704
7.25 =	0.12722
7.26 =	0.12739
7.27 =	0.12757
7.28 =	0.12775
7.29 =	0.12793
7.30 =	0.12810
7.31 =	0.12828
7.32 =	0.12846
7.33 =	0.12864
7.34 =	0.12881
7.35 =	0.12899
7.36 =	0.12917
7.37 =	0.12934
7.38 =	0.12952
7.39 =	0.12970
7.40 =	0.12988
7.41 =	0.13005
7.42 =	0.13023
7.43 =	0.13041
7.44 =	0.13059
7.45 =	0.13076
7.46 =	0.13094
7.47 =	0.13112
7.48 =	0.13130
7.49 =	0.13147
7.50 =	0.13165
7.51 =	0.13183
7.52 =	0.13201
7.53 =	0.13219
7.54 =	0.13236
7.55 =	0.13254
7.56 =	0.13272
7.57 =	0.13290
7.58 =	0.13307
7.59 =	0.13325

Degree	Tangent
7.60 =	0.13343
7.61 =	0.13361
7.62 =	0.13378
7.63 =	0.13396
7.64 =	0.13414
7.65 =	0.13432
7.66 =	0.13449
7.67 =	0.13467
7.68 =	0.13485
7.69 =	0.13503
7.70 =	0.13521
7.71 =	0.13538
7.72 =	0.13556
7.73 =	0.13574
7.74 =	0.13592
7.75 =	0.13609
7.76 =	0.13627
7.77 =	0.13645
7.78 =	0.13663
7.79 =	0.13681
7.80 =	0.13698
7.81 =	0.13716
7.82 =	0.13734
7.83 =	0.13752
7.84 =	0.13769
7.85 =	0.13787
7.86 =	0.13805
7.87 =	0.13823
7.88 =	0.13841
7.89 =	0.13858
7.90 =	0.13876
7.91 =	0.13894
7.92 =	0.13912
7.93 =	0.13930
7.94 =	0.13947
7.95 =	0.13965
7.96 =	0.13983
7.97 =	0.14001
7.98 =	0.14018
7.99 =	0.14036

Degree	Tangent
8.00 =	0.14054
8.01 =	0.14072
8.02 =	0.14090
8.03 =	0.14107
8.04 =	0.14125
8.05 =	0.14143
8.06 =	0.14161
8.07 =	0.14179
8.08 =	0.14196
8.09 =	0.14214
8.10 =	0.14232
8.11 =	0.14250
8.12 =	0.14268
8.13 =	0.14286
8.14 =	0.14303
8.15 =	0.14321
8.16 =	0.14339
8.17 =	0.14357
8.18 =	0.14375
8.19 =	0.14392
8.20 =	0.14410
8.21 =	0.14428
8.22 =	0.14446
8.23 =	0.14464
8.24 =	0.14481
8.25 =	0.14499
8.26 =	0.14517
8.27 =	0.14535
8.28 =	0.14553
8.29 =	0.14571
8.30 =	0.14588
8.31 =	0.14606
8.32 =	0.14624
8.33 =	0.14642
8.34 =	0.14660
8.35 =	0.14678
8.36 =	0.14695
8.37 =	0.14713
8.38 =	0.14731
8.39 =	0.14749

Degree	Tangent
8.40 =	0.14767
8.41 =	0.14785
8.42 =	0.14802
8.43 =	0.14820
8.44 =	0.14838
8.45 =	0.14856
8.46 =	0.14874
8.47 =	0.14892
8.48 =	0.14909
8.49 =	0.14927
8.50 =	0.14945
8.51 =	0.14963
8.52 =	0.14981
8.53 =	0.14999
8.54 =	0.15016
8.55 =	0.15034
8.56 =	0.15052
8.57 =	0.15070
8.58 =	0.15088
8.59 =	0.15106
8.60 =	0.15124
8.61 =	0.15141
8.62 =	0.15159
8.63 =	0.15177
8.64 =	0.15195
8.65 =	0.15213
8.66 =	0.15231
8.67 =	0.15249
8.68 =	0.15266
8.69 =	0.15284
8.70 =	0.15302
8.71 =	0.15320
8.72 =	0.15338
8.73 =	0.15356
8.74 =	0.15374
8.75 =	0.15391
8.76 =	0.15409
8.77 =	0.15427
8.78 =	0.15445
8.79 =	0.15463

Degree	Tangent
8.80 =	0.15481
8.81 =	0.15499
8.82 =	0.15517
8.83 =	0.15534
8.84 =	0.15552
8.85 =	0.15570
8.86 =	0.15588
8.87 =	0.15606
8.88 =	0.15624
8.89 =	0.15642
8.90 =	0.15660
8.91 =	0.15677
8.92 =	0.15695
8.93 =	0.15713
8.94 =	0.15731
8.95 =	0.15749
8.96 =	0.15767
8.97 =	0.15785
8.98 =	0.15803
8.99 =	0.15821
9.00 =	0.15838
9.01 =	0.15856
9.02 =	0.15874
9.03 =	0.15892
9.04 =	0.15910
9.05 =	0.15928
9.06 =	0.15946
9.07 =	0.15964
9.08 =	0.15982
9.09 =	0.16000
9.10 =	0.16017
9.11 =	0.16035
9.12 =	0.16053
9.13 =	0.16071
9.14 =	0.16089
9.15 =	0.16107
9.16 =	0.16125
9.17 =	0.16143
9.18 =	0.16161
9.19 =	0.16179

Degree	Tangent
9.20 =	0.16196
9.21 =	0.16214
9.22 =	0.16232
9.23 =	0.16250
9.24 =	0.16268
9.25 =	0.16286
9.26 =	0.16304
9.27 =	0.16322
9.28 =	0.16340
9.29 =	0.16358
9.30 =	0.16376
9.31 =	0.16394
9.32 =	0.16411
9.33 =	0.16429
9.34 =	0.16447
9.35 =	0.16465
9.36 =	0.16483
9.37 =	0.16501
9.38 =	0.16519
9.39 =	0.16537
9.40 =	0.16555
9.41 =	0.16573
9.42 =	0.16591
9.43 =	0.16609
9.44 =	0.16627
9.45 =	0.16645
9.46 =	0.16663
9.47 =	0.16680
9.48 =	0.16698
9.49 =	0.16716
9.50 =	0.16734
9.51 =	0.16752
9.52 =	0.16770
9.53 =	0.16788
9.54 =	0.16806
9.55 =	0.16824
9.56 =	0.16842
9.57 =	0.16860
9.58 =	0.16878
9.59 =	0.16896

CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 4

ANNEX E

FORMS

TRANSPORT CANADA
NATIONAL DEFENSE

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APPROACH PROCEDURE SUBMISSION AND CALCULATION FORMS

1. Approach Procedure Forms

These forms document the elements and calculation processes that establish the MDA/DH, HAT/HAA and visibility. Notes on how the data gathered were applied to the procedures should be a part of, or attached to, the forms.

The information on these forms will be transferred to forms that will be used by the chart producer; consequently, the accuracy of the information is of utmost importance. Examples of remarks to be included are: the point at which the final approach course crosses the runway centerline extended, climb gradient in feet/NM required for the missed approach, restrictions on circling, caution notes, etc.

2. Aircraft/ Mission Requirements

In designing an instrument approach, simplicity and flyability are the objectives of a good procedure. Keep in mind throughout the process that many aircraft may have only the pilot aboard and complicated procedures could be a hazard. Remembering that transient and tenant aircraft will be using the procedure, as well as primary mission aircraft, may influence the procedure design to some extent.

3. Human Factors

Throughout the world, unnecessarily complicated instrument procedures have been attributed to causing aircraft accidents. Procedure designers must consider the final procedure design from the viewpoint of the cockpit crew and human factors flight safety.

4. Drawings On Charts/ Tracings

There will probably be several drawings comprising the submission package. In compiling the package, it may be beneficial to complete all drawings using tracing paper rather than drawing on the map itself. These could include drawings depicting the:

a. Complete Procedure (showing all segments joined, excluding circling areas and holding patterns). Specific items to include are:

   (1) Controlling Obstacles in Each Segment. When obstacles or NAVAIDS are not shown on the chart, they should be plotted in their proper location and their source noted. Verify the location of obstacles when given by coordinates to ensure that the particular map/chart has current information concerning the location of obstacle/coordinates. The exact information on height and Location of such obstacles/NAVAIDS should be included in the supporting documents. When giving DME and azimuth, plot as accurately as possible. Use survey results, whenever available.

   (2) True and Magnetic Courses. During periodic reviews, ensure that the published courses have not changed because of change in magnetic variation.

b. Individual Segment Drawings. In some cases, it may be necessary to draw the final approach, missed approach, or other segment on separate charts or maps that provide greater detail to clearly determine obstacle information. When this has been done, identify obstacles as in a.(1), above, and transpose them to the composite drawing of the complete procedure. The final and missed approach segments should be drawn on the largest scale map available (that is, 1:50,000, 1:25,000).

c. Circling Areas. Include a drawing depicting the circling area for each category required and the controlling obstacle(s) for that area. Areas excluded from circling minima should be indicated on the charts. One chart may be used for all circling procedures with care taken to ensure that all requirements affecting circling approaches have been considered.

d. Holding Pattern. Most available templates are made for 1:500,000 scale. It may be useful to depict holding patterns on this scale chart using templates in lieu of manually constructing the holding patterns. When applicable, fix errors should be indicated for the minimum holding altitude. Obstacles in the primary and secondary areas should be identified for each holding pattern airspace area.

e. Minimum Sector Altitude, Safe Altitude 100 NM, and Minimum Vectoring Altitude Chart. Non-radar approaches normally have minimum safe altitudes published. Sectors shall be not less than 90° to avoid clutter and it may be necessary to depict these on a separate chart. Minimum sector altitudes are developed for a 25-mile radius of a navigation facility. Safe Altitudes 100 NM are established within a 100-mile radius of the geographic centre of the aerodrome, but are not subdivided into sectors. Minimum vectoring altitude charts are developed by terminal radar facilities and cover the area of maximum radar coverage, or the control area of jurisdiction, whichever is greater.

f. Combining of Instrument Approach Procedures. If at all possible, instrument approach procedures should be combined, provided the combining does not result in pilot confusion and chart clutter. The following criteria apply when approaches are combined. No more that two procedures may be combined. An ILS and LOC procedure is considered a single approach:

   (1) The non-precision final approach fixes must be collocated.

   (2) The final approach courses shall be within 4° with only one track depicted. Example: ILS 150°/TAC 154°.

   (3) Step-down fixes in the final approach segment must be applicable to all non-precision procedures.

   (4) Missed approach procedures (excluding the precision missed approach points) must be identical.

   (5) Common circling minima may be provided when the circling minima for combined procedures are within 300 feet of each other. Separate minima for circling must be applied when differences are greater than 300 feet.

5. Completing Instrument Approach Procedures Submission Form

Note: The computation forms must be attached to the procedure submission forms when submitted. The following numbers correspond to the numbers on the Instrument Procedure Design – Submission Form. All coordinates shall be provided in NAD 83 / WGS 84 in compliance with ICAO Annex 4 & 15.

Item 1. CAP/GPH 200 or RCAP Procedure:
- Canada Air Pilot/GPH 200 (mil) or Restricted Canada Air Pilot.
- Select where the procedure will be published.

Item 2. New/Revised
- Indicate whether the procedure is first time published "New", or has been reviewed and revised "Revised".

Item 3. Effective Date
- The date the procedure will become effective

item 4. Procedure Identification
- The name of the procedure following criteria/ depiction standards.

Item 5. Aerodrome Name
- Provide the official name of the aerodrome as indicated on the operating certificate.

Item 6. Community Name
- Provide the name of the community where the aerodrome is located.

Item 7. Field elevation
- The aerodrome elevation is the highest point on the usable landing surface, expressed in feet Above Sea level (ASL).

Item 8. TDZE Rwy
- Touchdown Zone Elevation
- Enter the runway designator and highest elevation at runway centerline in the first 3000 feet or the first one third of the runway; whichever is less, in the direction of landing.

Item 9. Aerodrome Geographical Coordinates
- Aerodrome Geographical Centre Coordinates
- Provide the latitude and longitude coordinates to the nearest 1/100 second. The coordinates shall be based on NAD 83/ WGS 84.

Item 10. Communications Block
- Enter the communication agencies and primary frequencies as required. Enter limited hours and/or operation symbol, MF/NM data, etc., as required.

Item 11. Notes
- Enter notes, which are to appear on the plan view.

Item 12. Plan view
- Non PAR or PAR:
  - Non PAR. Use the depiction format employed in the CAP General (CAP GEN).
  - PAR. Enter radar arrival routes and patterns to include distance and altitude and minimum vector altitude by sector and distance. Information in the inner ring should be to scale. The outer ring is used to reflect facilities and fixes which are used as radar hand-off points to the facility performing terminal control. Information outside the inner ring need not be to scale.

- High or Low Altitude Procedure:

- High Altitude.
    - Outer ring (en route facilities). Show facilities or fixes that are a part of the en route high altitude airway structure as published on the Enroute High Altitude chart, with bearing, distance and MEA to the initial approach facility or fix, or feeder facility. If the facility is used to form a fix or is used in the missed approach include the name, frequency or channel number and identification.
    - Inner ring. The inner ring has a radius of 20 NM. The plan view is drawn to scale with the approach facility located at the centre of the circle. In cases where it is not practical to locate the approach facility at the centre of the circle, the circle may be centered on the FAF. Depict all outbound or inbound courses, turn direction, fixes, FAF, missed approach track and facilities required for the approach.
- Low Altitude.
    - Outer ring (en route facilities). Show facilities or fixes that are a part of the en route low altitude airway structure as published on the Enroute Low Altitude chart, with bearing, distance and MEA to the initial approach facility or fix, or feeder facility. If the facility is used to form a fix or is used in the missed approach include the name, frequency or channel number and identification.
    - Inner ring. The inner ring has a radius of 10 NM. The plan view is drawn to scale with the approach facility located at the centre of the circle. In cases where it is not practical to locate the approach facility at the centre of the circle, the circle may be centered on the FAF. Depict all outbound or inbound courses, turn direction, fixes, FAF, missed approach track and facilities required for the approach.
- Additional Information.
    - Facilities and Fixes. Enter the name, type, frequency or channel number and identification for each facility used in the procedure. Intersection and DME fixes should show the name and how formed. Show bearings and distances to facilities or fixes to the nearest degree and mile.
    - Obstructions. Enter the highest obstruction within 10 NM (low altitude) or 20 NM (high altitude).

Item 13. Location Identifier

- The ICAO identifier for the aerodrome shall be provided.

Item 14. MSA circle

- Draw the NAVAID upon which MSA is based. Enter sectors and altitudes from "Minimum Sector Altitudes".

Item 15. Circling

- Depict any maneuvering limitations within this circle to circling approach procedures using the runway sketch for orientation. If circling is restricted to only certain aircraft categories, identify these categories on the outer upper part of the circle.

Item 16. Safe Altitude 100 NM

- Enter the Safe Altitude 100 NM.

Item 17. Profile Sketch:

- Non PAR or PAR.
    - Non PAR. Use the depiction format employed in CAP GEN/GPH 200.
    - PAR. Depict the PAR profile including glide slope intercept altitude, MAP and distances. Depict the ASR profile including FAF, MAP, distances and minimum altitudes.
        - High and Low Altitude Procedures. The profile shall be drawn using the same depiction format contained in Canada Air Pilot/GPH 200. The runway and distance to the FAF should be drawn to scale. Enter the altitude (FL for high procedures) at which the procedure begins. Depict all outbound, inbound tracks and courses, step down fixes and FAF (DME as required), FAF crossing altitude and MAP. Minimum altitudes for initial and intermediate segments are shown as required. Missed approach and procedure turn instructions are detailed at items 18 and 20.
    - ILS. Provide the height of the glide slope at the OM/FAF. Show the OM/FAF distance from the end of the runway (Displaced threshold, if applicable). Provide the glide slope angle to the nearest 10th of a degree.

Item 18. Aerodrome sketch notes

- Enter notes, which are to appear on the aerodrome sketch, e.g., right hand circuits, ARCAL, etc.

Item 19. Missed Approach

- Enter the missed approach instructions as you wish them published. Include all relevant information such as, missed approach track, altitude, shuttle, etc.

Item 20. Missed Approach climb gradient and vertical velocity

- Military/RCAP only
- Enter the missed approach climb gradient and the resulting vertical velocities, if required.

Item 21. Procedure Turn

- Enter the procedure turn instructions as you wish them to be published.

Item 22. Variation

- Enter the slaved variation for navigation aids and magnetic variation for the aerodrome.
- Indicate whether the variation is an epoch value or an actual value (indicate date) for RNAV procedures.
- The magnetic variation and the variation used to slave the NAVAID may be different.
- Military only: If the aerodrome is north of 67 degrees North, give the grid variation to the nearest degree.

Item 23. TCH
- Provide the applicable Threshold Crossing Height for the procedure (if applicable)

Item 24. GP Angle
- Provide the Glide Path Angle for the approach

Item 25. Landing Minima
- The landing minima for each approach type and category of aircraft are separated into three groups: minima ASL, minima AGL, and visibility.
- Enter the applicable Minima ASL value, Decision Height (DH), Decision Altitude (DA) or Minimum Descent altitude (MDA)
- Enter the applicable Minima AGL value, Height Above Threshold (HAT), or Height Above Aerodrome (HAA)
- Enter the applicable visibility value and include Runway Visual Range (RVR) if applicable
- Categories may be combined when none of the minima elements differ.
- Enter "Not Auth." where minima are not authorized.

Item 26. Time and Distance
- Enter the facility or fix (from) and the description of the missed approach point, i.e., airport, threshold, etc. (to).
- Enter the distance from the final approach fix to the missed approach point. If the missed approach point is based on time and distance, enter the FAF to MAP times.
- Do not enter the FAF to MAP times if the missed approach is based on DME.

Item 27. Take off minima
- Enter the Take Off instructions as you wish them to be published.

Item 28. Visual Aids
- Enter the type and length of approach lights. Enter the type and spacing of runway lights. Other lights include touchdown zone, centerline, runway end, sequenced flashing strobes, etc.
- Enter the type of visual approach aid and setting of glide slope.

Item 29. Coordinates
- Enter the coordinates for the runway thresholds, NAVAID(S) used for the approach, navigation fixes (intermediate and final approach fixes), waypoints and any other reference points used.
- Provide the type of each reference point, the identification, and frequency (if applicable).
- Coordinates shall be resolved to the nearest 1/100 of a second (0.01 arc second).
- All coordinates are to be entered in latitude and longitude.

Item 30. Controlling Obstacles

- Identify the segment (i.e., initial, final, missed, etc.) and the controlling obstacle for the segment (i.e., tree, tower, terrain, etc.).
- Enter the coordinates. Coordinates are to be entered in lat/long to the nearest 1/10 second.
- Circle or otherwise identify the controlling obstacle for each segment on the accompanying charts.

Item 31. Holding/Shuttle

- State the minimum holding altitude (FT ASL, or FL, as applicable)
- Identify each holding fix, the holding template used and the hold direction (to or from the NAVAID). Enter the controlling obstacle location by coordinates (lat/long). Enter the controlling obstacle MSL elevation, ROC of 1,000' unless the controlling obstacle is in the secondary area, the maximum holding altitude and the maximum holding airspeed.
- Shuttle information should be clearly laid out.

Item 32. Minimum Sector Altitude

- Minimum Sector Altitude (MSA)
- Define the sectors. Identify the controlling obstacle in each sector. Enter the controlling obstacle location by coordinates (lat/long). Enter the controlling obstacle MSL elevation. Enter the Minimum Sector Altitude.
- Sector altitudes may be raised and combined with adjacent higher sectors where a height difference does not exceed 300 feet.

Item 33. Safe Altitude 100 NM

- The safe altitude 100 NM is centered on the geographic centre of the aerodrome. Enter the controlling obstacle information. Coordinates are to be entered in lat/long to the nearest 1/10 second.

Item 34. Feeder Routes

- Provide the start and end point of the feeder route, governing obstacle information (coordinates to the nearest 1/10 second, and elevation MSL), ROC applied, and the minimum altitude.

Item 35. Exemption From Criteria

- The purpose of this section is to clearly identify that there is a requirement for a Exemption from Criteria. If applicable, check the box indicating the Exemption from Criteria, and provide the reason for the Exemption.
- No signature is required on the submission form, but the letter from transport Canada authorizing the Exemption to Criteria shall be attached to the IP Submission Form.

Item 36. Flight Check

- A flight check shall be conducted to verify the controlling obstacle of each segment and the flyability of the approach. A qualified person shall conduct the flight check.
- For military procedures, the CICP, GICP or a delegated WICP shall conduct the flight check.
- Provide date of the flight check, aircraft type used for the flight check and the name and signature of the flight check pilot.

Item 37. Coordination

- The people/organization(s) involved in the submission of the instrument procedure must be clearly indicated, and provide contact information.
- In order to be compliant with TP 308, the submission forms must include 4 signature blocks. They include the Designer, the Independent Reviewer, the Flight Check, and the ATS coordination.
- Designer — Must be signed by the designer of the procedure. The individual must be qualified in accordance with CAR 803.02 for the criteria being used. The designer must ensure that the procedure meets the regulations, standards and criteria.
- Independent review — Must be signed by the designer who conducted the review. This individual must be qualified in accordance with CAR 803.02 for the criteria being used. Individual conducting this review should not participate in the design of the procedure. This is an independent review of the procedure. The review must ensure that all aspect of the procedure design meet regulations, standards and criteria. If discrepancies are identified during the review they must be corrected, documented and reviewed prior to final signature.
- Flight Check — Must be signed by the individual that has conducted the flight check.
- ATS co ordination — Must be signed by appropriate ATS unit. Shall ensure that the impact of the procedure on surrounding airspace has been analyzed.
- The above are the minimum signatures required. Additional signatures may be required by the Service Provider or DND.
- All required coordination blocks shall be signed. Copies of coordination letters or messages shall be included in the submission of the procedure.

Item 38. Remarks: As required.

Instrument Procedure Design – Submission Form

1. ☐Canada Air Pilot/GPH200
☐Restricted Canada Air Pilot

2. ☐ New
☐ Revised

3. Effective Date -

4. Procedure - Identification	5. Aerodrome Name	7. Field Elevation -
	6. Community Name	8. TDZE Runway -

9. Aerodrome Geographical Coordinates ► **NAD 83 / WGS 84**

10. Communications Block

ATIS	Clearance Del	Ground	Tower	Arrival	Departure	RADIO	MF	ATF	UNICOM	RADAR

11. Notes

12. Plan View

13. Location Identifier

15. Categories

14. MSA 25 NM

16. Safe Altitude 100 NM ►

17. Profile Sketch

18. Aerodrome Sketch Notes

19. Missed Approach

18. Aerodrome Sketch Notes					
/NM					
GS	**60**	**120**	**180**	**240**	**300**
FPM					

21. Procedure Turn

22. Variation / Grivation
NAVAID ► ☐ Epoch
ARPT ► ☐ Actual, Date _______________

23. TCH
►

24. GP Angle
►

25. Landing minima

CAT **APP**	**DH / DA or MDA HAT / HAA VIS / RVR**				
	A	B	C	D	E

26. Time and Distance

From	**To**	**Distance**	**Kts**	**70**	**90**	**110**	**130**	**150**
			Min : Sec					

27. Take Off

TAKE OFF MINIMA

28. Visual Aids

Approach Lights	**Runway Lights**	**Other Lights**	**VASI / PAPI`**

29. Coordinates

	Type	**IDENT**	**Frequency**	**Latitude / Longitude**
THLD				
THLD				

30. Controlling Obstacles

Segment	Controlling Obstacle	Elev MSL	Lat / Long

31. Holding / Shuttle

Minimum Holding Altitude ▶	

Holding Fix	Template / Direction	Obstacle	Lat / Long	Elevation MSL	ROC	Max Hold Altitude	Max A/S

32. Minimum Sector Altitude

Navigation Aid: **Type:** **IDENT:**

Sector	Obstacle	Lat / Long	Elevation MSL	ROC	MSA
NW					
NE					
SE					
SW					

33. Safe Altitude 100 NM

Obstacle	Lat / Long	Elevation MSL	ROC	Altitude

34. Feeder Routes

From / To	Obstacle	Lat / Long	Elevation MSL	ROC	Altitude

35. Exemption from Criteria

☐ Exemption Required	Reason	(Attach memorandum)

36. Flight Check

Date	Aircraft Type	Aircraft Registration	Weather Information at time of Flight Check
Flight Check Pilot Remarks			

37. Coordination

Sponsor	Name	Company	Address	Telephone
	Signature	Date	Email Address	
Designer	Name	Company	Address	Telephone
	Signature	Date	Email Address	
Independent Reviewer	Name	Company	Address	Telephone
	Signature	Date	Email Address	
Flight Check Pilot	Name	Company	Address	Telephone
	Signature	Date	Email Address	
ATS	Name	Company	Address	Telephone
	Signature	Date	Email Address	
Other	Name	Company	Address	Telephone
	Signature	Date	Email Address	

38. Remarks

6. COMPUTATION & SUBMISSION FORMS – Reserved

- Precision Computation Form – Revoked with supporting materials
- Non-Precision Computation Form – Revoked with supporting materials
- Helicopter Non-Precision Computation Form – Revoked with supporting materials
- Application Of Departure Criteria Form – Revoked with supporting materials

7. Completing Airways Designation Form

This form is used to document the requirements to determine an airway. The form shows samples for three rent airway segments (VOR, LF and LF/VOR).

1. Designator. This is the Alpha-numeric designator for the airway segment.
2. Between. This section details information about the navigation aids or significant points that define the ends of the airway segment. The navigation aids or significant points are listed from West to East or from South to North, "A" being the westerly or southerly NAVAID/significant point for the airway segment and "B" the easterly or northerly NAVAID. This information shall include the location of the navigation aid, the type of navigation aid, significant point identification, the geodetic coordinates in NAD 83, and the NAVAID local variation.

   Note: When a significant point is established on a straight segment, its geodetic coordinates shall be at a point on the true course of the two NAVAID.
3. VOR Airways. Flight track information is provided for the route segment from position "A" to "B" and reciprocal information from "B" to "A".
   a. True Track. Enter the true outbound track to the nearest degree.
   b. Variation. Enter the NAVAID variation.
   c. Radial. Calculate the radial by applying the NAVAID variation to the true track.
4. LF Airways. Flight track information is provided for the route segment from position "A" to "B".
   a. True Track. Enter the true outbound track to the nearest degree.
   b. ¼ Point Variation. Enter the local variation for the first quarter distance of the track ¼ point.
   c. Magnetic Track. Calculate the outbound magnetic track by applying the magnetic variation to the true track.

5. VOR and LF Airways. Obstacle clearance, minimum altitude and distance information is provided for the route segments.

   a. Highest Ground Elevation. Enter the highest ground elevation plus any vegetation within the defined boundaries of the airway segment.

   b. Highest Obstacle. Enter the elevation of the controlling obstacle for the airway segment.

   c. ROC. Enter the required ROC for the designated region.

   d. Minimum Obstacle Clearance Altitude (MOCA). Calculate the MOCA by applying the ROC to the controlling obstacle elevation and rounding to the next higher 100-foot increment.

   e. Base of Controlled Airspace. Normally, the height of the base of controlled airspace is 2,200 feet above ground level (AGL).

   f. Minimum En Route Altitude (MEA). Determine the MEA by selecting the highest or the following:

      (1) the MOCA, or

      (2) the highest ground elevation plus the base of controlled airspace (AGL) rounded to the nearest 100 foot increment, provided the ROC is not violated.

   g. Distance. Enter the distance in NM of the airway segment.

6. Remarks. Enter any remarks that are pertinent to the airway segment or will be required in order to facilitate the approval process.

7. Revocations. Enter the airway route designator, the portion of the airway segment from which significant point to which significant point and the reason for the revocation.

8. Coordination. All coordination blocks shall be signed.

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AIRWAYS DESIGNATORS

DESIGNATOR	BETWEEN List from West to East or South to North		VOR AIRWAYS A → B			VOR AIRWAYS A → B			LF AIRWAYS			VOR & LF AIRWAYS							REMARKS
	A	B	TrueTrack	VAR Applied	Radial (OBS Setting)	TrueTrack	VAR Applied	Radial (OBS Setting)	TrueTrack	1/4 point Variation	Mag Track	Highest Ground Elevation	Highest Obstacle	ROC	MOCA	Base of Controlled Airspace	MEA	Distance	
R21	REGINA NDB N 50 22 11 W 102 32 23 14° E	BROADVIEW VORTAC N 50 21 47 W 102 32 23 12° E				271	12°E	259	090	13°E	077	2430	2550	1000	3600	2200 AGL	4600	78 NM	NDB To VORTAC airway to replace old airway when DR NDB is decomissioned. Lower old MEA from 5000'
V303	SASKATOON VORTAC N 52 10 52 W 106 43 09 16° E	PRINCE ALBERT VOR/DME N 53 12 59 W 105 39 58 15° E	031	16°E	015	212	15°E	197				1780	2334	1000	3400	2200 AGL	4000	73 NM	Lower MEA. Flight checked 20 Sep 90.
R6	NORTH BATTLEFORD NDB N 52 48 14 W 108 20 04 17° E	SASKATOON NDB N 52 11 23 W 106 48 48 16° E							123	16°E	107	2030	2152	1000	3200	2200 AGL	4300	67 NM	Lower MEA. Flight checked 20 Sep 90.
	SASKATOON NDB	NORTH BATTLEFORD NDB							303	16°E	287								

REVOCATIONS				COORDINATION
DESIGNATOR	FROM	TO	REASON FOR REVOCATION	
				DATE Designer
				DATE Flight Inspection Pilot
				APPROVED BY
				DATE ATS
				DATE RMNR
				DATE AANDH

Aerodrome Operator Attestation

I attest that the most critical aircraft, based on wing span, to be used by operators at the aerodrome is:	*(Type of aircraft)*
I attest that the information, as specified below, on Aerodrome Physical Characteristics provided for the specified aerodrome is accurate.	*(Name of Aerodrome)*

and I further agree to maintain the physical characteristics of the aerodrome in the same, or improve, condition as they were on the date of the signing of this document. Failing this, I agree to immediately inform NAV CANADA of any change or modification of the aerodrome characteristics in order that an assessment of the continuing validity of these procedures be made.

Organization	
Name of contact, Title	
Telephone Number	
Signature of Aerodrome operator	*Signature* *Date*

1. Aerodrome Physical Characteristics

RWY ID	**Threshold Elevation (feet)**	**RWY Orientation (degrees)**	**Threshold Coordinates (1/100 sec)**

Characteristics	**Type of Runway**	
	Non-instrument Runway	**Non-Precision Runway**
Aircraft Size (Enter Aircraft wing span)		
Strip Specifications:		
Strip Width (each side of center line)	__________m (ft)	__________m (ft)
Strip Length (Prior to threshold and beyond departure end)	__________m (ft)	__________m (ft)
Approach/Take-off Slopes and Dimensions:		
Length of inner edge	__________m (ft)	__________m (ft)
Distance from threshold	__________m (ft)	__________m (ft)
Divergence (min each side)	________%	________%
Length (minimum)	__________m (ft)	__________m (ft)
Slope (maximum)	_______% (1:_______)	_______% (1:_______)
Transition Surfaces (Slope)	_______% (1:_______)	_______% (1:_______)

Notes:

1. Aircraft with wing spans greater than 52 m (171 ft) shall be evaluated individually.
2. A form is required for each runway served by an instrument approach procedure.

AERODROME PHYSICAL CHARACTERISTICS

Minimum Requirements

	TYPE of RUNWAY							
	Non-Instrument Runway				**Non-Precision Runway**			
AIRCRAFT SIZE (Based on wing span)	Up to but not including 15m (49 ft)	15 m up to but not including 24m (79 ft)	24 m up to but not including 36m (118 ft)	36 m up to but not including 52m (171 ft) *	Up to but not including 15m (49 ft)	15 m up to but not including 24m (79 ft)	24 m up to but not including 36m (118 ft)	36 m up to but not including 52m (171 ft) *
CHARACTERISTICS								
Strip Specifications:								
Strip width (each side of center line)	**30 m** (98.5 ft)	**30 m** (98.5 ft)	**45 m** (148 ft)	**75 m** (246 ft)	**45 m** (148 ft)	**45 m** (148 ft)	**75 m** (246 ft)	**150 m** (492 ft)
Strip length (Prior to threshold and beyond departure end)	**30 m** (98.5 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)
Approach/Take-off Slopes and Dimensions:								
Length of the inner edge	**60 m** (197 ft)	**60 m** (197 ft)	**90 m** (295 ft)	**150 m** (492 ft)	**90 m** (295 ft)	**90 m** (295 ft)	**150 m** (492 ft)	**300 m** (984 ft)
Distance from threshold	**30 m** (98.5 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)	**60 m** (197 ft)
Divergence (minimum each side)	10%	10%	10%	10%	10%	10%	15%	15%
Length (minimum)	**2500 m** (8202 ft)	**2500 m** (8202 ft)	**2500 m** (8202 ft)	**2500 m** (8202 ft)	**2500 m** (8202 ft)	**2500 m** (8202 ft)	**3000 m** (9843 ft)	**3000 m** (9843 ft)
Slope (maximum)	5% (1:20)	4% (1:25)	2.50% (1:40)	2.50% (1:40)	3.33% (1:30)	3.33% (1:30)	2.50% (1:40)	2.50% (1:40)
Transition Surfaces (Slope)	20.00% (1:5)	20.00% (1:5)	14.30% (1:7)	14.30% (1:7)	14.30% (1:7)	14.30% (1:7)	14.30% (1:7)	14.30% (1:7)

NOTE * : aircraft 52 m (171 ft) and wider will be evaluated individually.

**INTENTIONALLY
LEFT
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Aerodrome
Procedure Identification

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TDZE	ELEV$_{A/D}$	MSA	TCH	ELEV$_{thld}$

STEP 1. FINAL APPROACH SEGMENT ALTITUDE (MDA & STEP DOWN FIXES)

Part I - Obstacle in primary area

1	Obstacle #					
2	**(ALT$_{obs}$)** Obstacle Altitude	**ALT$_{obs}$** =				
3	**(ROC$_P$)** Determine primary ROC. (as applicable per TP308, vol 1)	**ROC$_P$** =				
4	**(ALT$_{adj}$)** Adjustments (para 323 a, b* & c). ***Note**: If RASS not used full time, then "b" is for chart depiction only.	**ALT$_{adj}$** =				
5	**(MDA$_{unc}$)** Uncorrected MDA: MDA$_{unc}$ = ALT$_{obs}$ + ROC$_P$ + ALT$_{adj}$	**MDA$_{unc}$** =				
6	**(MDA$_{FAS}$)** MDA final approach segment MDA$_{FAS}$ = MDA$_{unc}$ rounded to upper 20ft	**MDA$_{FAS}$** =				

NOTE: With exception of the last step down fix (upper 20 ft), round other step down fixes to upper 100 ft.

Part II - obstacle in secondary area

7	Obstacle #					
8	**(ALT$_{obs}$)** Obstacle altitude	**ALT$_{obs}$** =				
9	**(W$_S$)** Width of secondary	**W$_S$** =				
10	**(d$_S$)** Distance of obstacle in secondary	**d$_S$** =				
11	Secondary ROC (as applicable per TP308, vol 1) **ROC$_S$** = ROC$_P$ x ((W$_S$ - d) / W$_S$)	**ROC$_S$** =				
12	**(ALT$_{adj}$)** Adjustments (para 323 a, b* & c). ***Note**: If RASS not used full time, then "b" is for chart depiction only.	**ALT$_{adj}$** =				
13	**(MDA$_{unc}$)** Uncorrected MDA: MDA$_{unc}$ = ALT$_{obs}$ + ROC$_S$ + ALT$_{adj}$	**MDA$_{unc}$** =				
14	**(MDA$_{FAS}$)** MDA final approach segment MDA$_{FAS}$ = MDA$_{unc}$ rounded to upper 20ft	**MDA$_{FAS}$** =				

NOTE: With exception of the last step down fix (upper 20 ft), round other step down fixes to upper 100 ft.

Part III - Select highest MDA based on Final Approach Segment (MDA$_{FAS}$)

15	**(MDA$_{FAS}$)** Select highest MDA (Compare MDA$_{FAS}$ from Part I & Part II)	**MDA$_{FAS}$** =	

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Procedure Identification

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TDZE	ELEV$_{A/D}$	MSA	TCH	ELEV$_{thld}$

STEP 2. MDA BASED ON MISSED APPROACH SEGMENT

Part I - Check for penetration of MA OCS

1	**MDA$_{FAS}$** (Highest from Step 1):	**MDA$_{FAS}$** =				
2	**(ROC$_P$)** primary ROC from final segment	**ROC$_P$** =				
3	**(ALT$_{adj}$)** Adjustments from Step 1.	**ALT$_{adj}$** =				
4	**(HMAS)** Height of missed approach surface HMAS = MDA$_{FAS}$ - (ROC$_P$ + ALT$_{adj}$)	**HMAS** =				
5	**Obstacle #**					
6	**(ALT$_{obs}$)** Obstacle altitude	**ALT$_{obs}$ =**				
7	**(d$_P$)** Distance of obstacle in primary	**d$_P$ =**				
8	**(d$_S$)** Distance of obstacle in secondary	**d$_S$ =**				
9	**(R$_P$)** Rise of primary OCS: **R$_P$** = d$_P$/40	**R$_P$ =**				
10	**(R$_S$)** Rise of secondary OCS: **R$_S$** = d$_S$/12	**R$_S$ =**				
11	**(R$_{OCS}$)** Rise of OCS at obstacle: **R$_{ocs}$** = R$_P$ + R$_S$	**R$_{ocs}$ =**				
12	**(ALT$_{OCS}$)** Altitude of OCS at obstacle: **ALT$_{ocs}$** = HMAS + R$_{ocs}$	**ALT$_{ocs}$ =**				
13	**(p)** Check for penetration: p = ALT$_{ocs}$ - ALT$_{obs}$	**p =**				
	Penetration? Yes/No If **p** is negative, there is penetration.	**Yes/No**				

Note: If penetration exists go to Part II otherwise skip to Step 3.

Aerodrome
Procedure Identification

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TDZE	$ELEV_{A/D}$	MSA	TCH	$ELEV_{thld}$

STEP 2. MDA BASED ON MISSED APPROACH SEGMENT (cont'd)

Part II - Penetration in the Missed Approach Segment

Note: Other options may include redrawing the MA path, removing the obstacle or altering the MAP.

Part II a) - Raise MDA

15	Obstacle #					
16	**(p)** Select greatest penetration value from Step 2, Part I (absolute value)	**p** =				
17	**MDA_{FAS}** (Highest from Step 1):	**MDA_{FAS}** =				
18	**(MDA_{unc})** uncorrected MDA: $MDA_{unc} = MDA_{FAS} + p$	**MDA_{unc}** =				
19	**(MDA_{MAS})** MDA missed approach segment: $MDA_{MAS} = MDA_{unc}$ rounded to upper 20ft	**MDA_{MAS}** =				

Part II b) - Missed Approach Climb Gradient *

* **Note:** Part II b) is available only for Military or Restricted procedures.

20	Obstacle #					
21	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
22	**(d_P)** Distance of obstacle in primary	**d_P** =				
24	Required OCS Climb Gradient: **CG_{ocs}** = $(ALT_{obs} - R_S - HMAS) / (d_P / 6076.11548)$	**CG_{ocs}** =				
25	**(CG_{unc})** required aircraft CG (uncorrected) $CG_{unc} = CG_{ocs} / 0.76$	**CG_{unc}** =				
26	**(CG_{PUB})** Published CG: $CG_{PUB} = CG_{unc}$ rounded to upper 10 ft	**CG_{PUB}** =				

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Procedure Identification

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TDZE	ELEV$_{A/D}$	MSA	TCH	ELEV$_{thld}$

STEP 3. MINIMUM DESCENT ALTITUDE SELECTION*

* **Note:** DG to be verified (see Step 14)

		CAT A	CAT B	CAT C	CAT D	CAT E
1	**Selected MDA (highest of Section A or B)**					
2	**TDZE**					
3	**HAT (Selected MDA - TDZE)**					

STEP 4. ADVISORY VISIBILITY

		CAT A	CAT B	CAT C	CAT D	CAT E
1	Distance from MAP to threshold (in SM)					
2	Visibility determined by HAT (Table 3-2)					
3	No light visibility (highest of Step 4.1 or Step 4.2)					
4	Approach light credit (in SM) (Table 3-2 note)					
5	Visibility required (Step 4.3 - Step 4.4)					
6	Minimum visibility allowed (Table 3-1)	**1.5**	**1.5**	**2.0**	**2.0**	**2.0**
7	Published visibility (highest of Step 4.5 or Step 4.6): (include associated RVR, if applicable)					

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TDZE	$ELEV_{A/D}$	MSA	TCH	$ELEV_{thld}$

STEP 5. CIRCLING MINIMUM DESCENT ALTITUDE (CMDA)

Part I - Initial CMDA calculations

		CAT A	CAT B	CAT C	CAT D	CAT E
1	Obstacle #					
2	**(ALT_{obs})** Obstacle altitude					
3	**ROC**	**300**	**300**	**300**	**300**	**300**
4	**(ALT_{adj})** Adjustments (para 323 a, b* & c). * **Note**: If RASS is not used full time, then "323 b" is calculated for chart depiction only.					
5	**($CMDA_{unc}$)** Uncorrected CMDA: $CMDA_{unc} = ALT_{obs} + ROC + ALT_{adj}$					
6	**(CMDA)** Corrected CMDA CMDA = $CMDA_{unc}$ rounded to upper 20 ft					

Part II - Secondary CMDA calculations

		CAT A	CAT B	CAT C	CAT D	CAT E
7	**(HAA_{min})** Minimum HAA required (Table 3-1)	**500**	**500**	**500**	**600**	**600**
8	**$ELEV_{A/D}$**					
9	**($CMDA_{unc}$)** Uncorrected CMDA $CMDA_{unc} = HAA_{min} + ELEV_{A/D}$					
10	**(CMDA)** Corrected CMDA CMDA = $CMDA_{unc}$ rounded to upper 20 ft					

Part III - MDA based on Final or MA segments

		CAT A	CAT B	CAT C	CAT D	CAT E
11	Selected MDA (results from Step 3)					

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Procedure Identification

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TDZE	ELEV$_{A/D}$	MSA	TCH	ELEV$_{thld}$

STEP 6. CIRCLING MINIMUM DESCENT ALTITUDE SELECTION *

	* **Note:** DG to be verified (see Step 14)	CAT A	CAT B	CAT C	CAT D	CAT E
1	**Selected CMDA** (Select highest from Step 5, Parts I, II or III)					
2	**ELEV$_{A/D}$**					
3	**(HAA)** Height Above A/D: HAA = Selected CMDA - ELEV$_{A/D}$					

STEP 7. CIRCLING ADVISORY VISIBILITY

		CAT A	CAT B	CAT C	CAT D	CAT E
1	Distance from MAP to nearest landing surface (in SM)					
2	HAA (Step 6.3)					
3	Visibility determined by HAA (Table 3-2)					
4	Mimimum visibility allowed (Table 3-1)	**1.5**	**1.5**	**2.0**	**2.0**	**2.0**
5	No light straight-in visibility (from Step 4.3)					
6	Published visibility (highest above)					

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Procedure Identification

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TDZE	$ELEV_{A/D}$	MSA	TCH	$ELEV_{thld}$

STEP 8. INITIAL APPROACH — CENTRE *

* **Note:** May be used for Holds / Procedure Turns.

Part I - Obstacle in primary area

1	**Obstacle #**					
2	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
3	**(ROC_P)** Determine primary ROC. (as applicable per TP308, vol 1)	**ROC_P** =				
4	**(ALT_{adj})** Adjustments (para 323 a, b* & c). ***Note**: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj}** =				
5	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc}** =				
6	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =				

Part II - Obstacle in secondary area

7	**Obstacle #**					
8	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
9	**(W_S)** Width of secondary	**W_S** =				
10	**(d_S)** Distance of obstacle in secondary	**d_S** =				
11	Secondary ROC (as applicable per TP308, vol 1) **ROC_S** $= 500 \times ((W_S - d_S) / W_S)$	**ROC_S** =				
12	**(ALT_{adj})** Adjustments (para 323 a, b* & c). ***Note**: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj}** =				
13	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_S + ALT_{adj}$	**SMA_{unc}** =				
14	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =				

Part III - Select highest Procedure Turn Altitude

15	Segment minimum altitude - centre: (Select highest **SMA_{IA}** from Parts I & II)	

Note: The difference between the PT altitude and the FAF crossing altitude shall not be greater than those shown in Table 2-1B. (See para 234d.)

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TDZE	$ELEV_{A/D}$	MSA	TCH	$ELEV_{thld}$

STEP 9. INITIAL APPROACH — LEFT

Part I - Obstacle in primary area

1	**Obstacle #**					
2	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
3	**(ROC_P)** Determine primary ROC. (as applicable per TP308, vol 1)	**ROC_P** =				
4	**(ALT_{adj})** Adjustments (para 323 a).	**ALT_{adj}** =				
5	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc}** =				
6	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =				

Part II - Obstacle in secondary area

7	**Obstacle #**					
8	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
9	**(W_S)** Width of secondary	**W_S** =				
10	**(d_S)** Distance of obstacle in secondary	**d_S** =				
11	Secondary ROC (as applicable per TP308, vol 1) **ROC_S** $= 500 \times ((W_S - d_S) / W_S)$	**ROC_S** =				
12	**(ALT_{adj})** Adjustments (para 323 a).	**ALT_{adj}** =				
13	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_S + ALT_{adj}$	**SMA_{unc}** =				
14	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =				

Part III - Select highest Initial Segment Altitude - LEFT

15	Segment minimum altitude - left: (Select highest **SMA_{IA}** from Parts I & II)	

Note: Segment Minimum Altitude shall not be below the PT altitude. (Para 231)

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Procedure Identification	

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TDZE	ELEV$_{A/D}$	MSA	TCH	ELEV$_{thld}$

STEP 10. INITIAL APPROACH — RIGHT

Part I - Obstacle in primary area

1	**Obstacle #**					
2	**(ALT$_{obs}$)** Obstacle altitude	**ALT$_{obs}$** =				
3	**(ROC$_P$)** Determine primary ROC. (as applicable per TP308, vol 1)	**ROC$_P$** =				
4	**(ALT$_{adj}$)** Adjustments (para 323 a).	**ALT$_{adj}$** =				
5	**(SMA$_{unc}$)** Segment Minimum Alt (Uncorrected): SMA$_{unc}$ = ALT$_{obs}$ + ROC$_P$ + ALT$_{adj}$	**SMA$_{unc}$** =				
6	**(SMA$_{IA}$)** Seg Min Alt Initial Approach (corrected) SMA$_{IA}$ = SMA$_{unc}$ rounded to upper 100 ft	**SMA$_{IA}$** =				

Part II - Obstacle in secondary area

7	**Obstacle #**					
8	**(ALT$_{obs}$)** Obstacle altitude	**ALT$_{obs}$** =				
9	**(W$_S$)** Width of secondary	**W$_S$** =				
10	**(d$_S$)** Distance of obstacle in secondary	**d$_S$** =				
11	Secondary ROC (as applicable per TP308, vol 1) **ROC$_S$** = 500 x ((W$_S$ - d$_S$) / W$_S$)	**ROC$_S$** =				
12	**(ALT$_{adj}$)** Adjustments (para 323 a).	**ALT$_{adj}$** =				
13	**(SMA$_{unc}$)** Segment Minimum Alt (Uncorrected): SMA$_{unc}$ = ALT$_{obs}$ + ROC$_S$ + ALT$_{adj}$	**SMA$_{unc}$** =				
14	**(SMA$_{IA}$)** Seg Min Alt Initial Approach (corrected) SMA$_{IA}$ = SMA$_{unc}$ rounded to upper 100 ft	**SMA$_{IA}$** =				

Part III - Select highest Initial Segment Altitude - LEFT

15	Segment minimum altitude - left: (Select highest **SMA$_{IA}$** from Parts I & II)	

Note: Segment Minimum Altitude shall not be below the PT altitude. (Para 231)

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TDZE	$ELEV_{A/D}$	MSA	TCH	$ELEV_{thld}$

STEP 11. INTERMEDIATE APPROACH SEGMENT

Part I - Obstacle in primary area

1	**Obstacle #**					
2	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
3	**(ROC_P)** Determine primary ROC. (as applicable per TP308, vol 1)	**ROC_P** =				
4	**(ALT_{adj})** Adjustments (para 323 a & b*). * **Note**: If RASS is part-time, then "323 b" is calculated for the plan view note.	**ALT_{adj}** =				
5	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc}** =				
6	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) SMA_{IA} = SMA_{unc} rounded to upper 100 ft	**SMA_{IA}** =				

Part II - Obstacle in secondary area

7	**Obstacle #**					
8	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
9	**(W_S)** Width of secondary	**W_S** =				
10	**(d_S)** Distance of obstacle in secondary	**d_S** =				
11	Secondary ROC (as applicable per TP308, vol 1) **ROC_S** $= 500 \times ((W_S - d_S) / W_S)$	**ROC_S** =				
12	**(ALT_{adj})** Adjustments (para 323 a & b*). * **Note**: If RASS is part-time, then "323 b" is calculated for the plan view note.	**ALT_{adj}** =				
13	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc}** =				
14	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) SMA_{IA} = SMA_{unc} rounded to upper 100 ft	**SMA_{IA}** =				

Part III - Select highest Intermediate Segment Altitude

15	Select highest **SMA_{int}** (Segment Minimum Altitude) for intermediate (compare corrected altitudes from Part I & Part II).	

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NPA Calc Form

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Aerodrome

Procedure Identification

- All references are from Vol. 5 unless otherwise stated.
- Acronyms used may not reflect those in TP308.

TDZE	$ELEV_{A/D}$	MSA	TCH	$ELEV_{thld}$

STEP 12. DESCENT GRADIENT INITIAL APPROACH SEGMENTS (DG_{IA})

			LEFT	RIGHT	CENTRE
1	**(ALT_{MSA})** MSA or feeder altitude	**ALT_{MSA}** =			
2	**(SMA_{IA})** Segment Min Alt for Initial Approaches	**SMA_{IA}** =			
3	**Amount of descent** = (ALT_{MSA} - SMA_{IA})				
4	**(SL_{IA})** Initial Approach segment lengths (in NM)	**SL_{IA}** =			
5	**(DG_{IA})** Initial Descent Gradient (ft/NM) **DG_{IA}** = (Amount of Descent / SL_{IA})	**DG_{IA} =**			

Note: OPTIMUM DG is 250 ft/NM, MAX is 500 ft/NM

STEP 13. DESCENT GRADIENT INTERMEDIATE SEGMENT (DG_{int})

1	**(SMA_{IA})** Segment Minimum Altitude Initial Approach **(select highest)**	**SMA_{IA}** =	
2	**(SMA_{int})** Seg Min Alt for Intermediate	**SMA_{int}** =	
3	**Amount of descent** = (SMA_{IA} - SMA_{int})		
4	**(SL_{int})** Length of intermediate approach segment (in NM)	**SL_{int}** =	
5	**(DG_{int})** Descent Gradient Intermediate (ft/NM) **DG_{int}** = (M3 / SL_{int})	**DG_{int}** =	

Note: OPTIMUM DG is 150 ft/NM, MAX is 318 ft/NM

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Procedure Identification

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- Acronyms used may not reflect those in TP308.

TDZE	$ELEV_{A/D}$	MSA	TCH	$ELEV_{thld}$

STEP 14. DESCENT GRADIENT FINAL SEGMENT (DG_{fin})

Part I - Straight-in approach (fix to threshold)

1	**(SMA_{int})** Seg Min Alt for Intermediate	**SMA_{int}** =	
2	**($ELEV_{thld}$)** Threshold Elevation	**$ELEV_{thld}$** =	
3	**(TCH)** Threshold crossing height	**TCH** =	
4	**Amount of descent =** SMA_{int} - (TCH + $ELEV_{thld}$)		
5	**(SL_{fin})** Length of final approach segment (in NM)	**SL_{fin}** =	
6	**(DG_{fin})** Descent Gradient Final (ft/NM): DG_{fin} = Amount of descent / SL_{fin}	**DG_{fin}** =	

Note: OPTIMUM DG is 318 ft/NM, MAX is 400 ft/NM

Part II - Circling Approach (fix to first useable portion of landing surface)

		CAT A	CAT B	CAT C	CAT D	CAT E
7	**(SMA_{int})** Seg Min Alt for Intermediate					
8	**Selected CMDA** (Step 6.1)					
9	**Amount of descent =** SMA_{int} - Selected CMDA					
10	**(SL_{fin})** Length of final approach segment (in NM)					
11	**(DG_{fin})** Descent Gradient Final (ft/NM): DG_{fin} = Amount of descent / SL_{fin}					

Note: OPTIMUM DG is 318 ft/NM, MAX is 400 ft/NM

Aerodrome

Procedure Identification

- All references are from Vol. 5 unless otherwise stated.
- Acronyms used may not reflect those in TP308.

TDZE	$ELEV_{A/D}$	MSA	TCH	$ELEV_{thld}$

STEP 14. DESCENT GRADIENT FINAL SEGMENT (DG_{fin}) (cont'd)

Part III - Straight-in (fix to fix)

		CAT A	CAT B	CAT C	CAT D	CAT E
12	**(ALT_1)** altitude of first fix (higher)					
13	**(ALT_2)** altitude of second fix (lower)					
14	**Amount of descent =** ALT_1 - ALT_2					
15	**(SL_{fix})** Length of segment between fixes (in NM)					
16	**(DG_{fix})** Fix to Fix Descent Gradient (ft/NM): DG_{fix} = Amount of descent / SL_{fix}					

Note: OPTIMUM DG is 318 ft/NM, MAX is 400 ft/NM

Part IV - Select most critical final DG

17	Select steepest DG from Part I, Part II or Part III	

Aerodrome

Procedure Identification

- All references are from Vol. 5 unless otherwise stated.
- Acronyms used may not reflect those in TP308.

TDZE	$ELEV_{A/D}$	MSA	TCH	$ELEV_{thld}$

INTENTIONALLY
LEFT
BLANK

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Procedure Identification

- All references are from Vol. 5 unless otherwise stated.
- Acronyms used may not reflect those in TP308.

ROC_P	ROC_S	TDZE	TCH	$ELEV_{thld}$

STEP 1. FINAL APPROACH SEGMENT ALTITUDE (MDA & STEP DOWN)

Part I - Obstacle in Primary Area

1	Obstacle #					
2	**(ALT_{obs})** Obstacle Altitude	**ALT_{obs}** =				
3	**(ROC_P)** Determine primary ROC. (as applicable per TP308, vol 1)	**ROC_P =**				
4	**(ALT_{adj})** Adjustments (para 323 a, b* & c). ***Note**: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj}** =				
5	**(MDA_{unc})** Uncorrected MDA: $MDA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**MDA_{unc}** =				
6	**(MDA_{FAS})** MDA final approach segment $MDA_{FAS} = MDA_{unc}$ rounded to upper 20ft	**MDA_{FAS}** =				

NOTE: With exception of the last step down fix (upper 20 ft), round other step down fixes to upper 100 ft.

Part II - obstacle in secondary area

7	Obstacle #					
8	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
9	**(W_S)** Width of secondary	**W_S** =				
10	**(d_S)** Distance of obstacle in secondary	**d_S** =				
11	Secondary ROC (as applicable per TP308, vol 1) **ROC_S** $= ROC_P \times ((W_S - d) / W_S)$	**ROC_S** =				
12	**(ALT_{adj})** Adjustments (para 323 a, b* & c). ***Note**: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj}** =				
13	**(MDA_{unc})** Uncorrected MDA: $MDA_{unc} = ALT_{obs} + ROC_S + ALT_{adj}$	**MDA_{unc}** =				
14	**(MDA_{FAS})** MDA final approach segment $MDA_{FAS} = MDA_{unc}$ rounded to upper 20ft	**MDA_{FAS}** =				

Note: For step down altitudes round to upper 100 ft.

Part III - Select highest MDA based on Final Approach Segment

15	**(MDA_{FAS})** Select highest MDA (Compare MDA_{FAS} from Part I & Part II)	**MDA_{FAS}** =	

Aerodrome
Procedure Identification

- All references are from Vol. 5 unless otherwise stated.
- Acronyms used may not reflect those in TP308.

ROC_P	ROC_S	TDZE	TCH	$ELEV_{thld}$

STEP 2. MDA BASED ON MISSED APPROACH SEGMENT

Part I - Check for penetration of MA OCS

1	**MDA_{FAS}** (Highest from Step 1):	**MDA_{FAS}** =				
2	**(ROC_P)** primary ROC from final segment	**ROC_P** =				
3	**(ALT_{adj})** Adjustments from Step 1.	**ALT_{adj}** =				
4	**(HMAS)** Height of missed approach surface $HMAS = MDA_{FAS} - (ROC_P + ALT_{adj})$	**HMAS** =				
5	**Obstacle #**					
6	**(ALT_{obs})** Obstacle altitude	**ALT_{obs} =**				
7	**(d_P)** Distance of obstacle in primary	**d_P =**				
8	**(d_S)** Distance of obstacle in secondary	**d_S =**				
9	**(R_P)** Rise of primary OCS: $R_P = d_P/20$	**R_P =**				
10	**(R_S)** Rise of secondary OCS: $R_S = d_S/4$	**R_S =**				
11	**(R_{OCS})** Rise of OCS at obstacle: $R_{ocs} = R_P + R_S$	**R_{ocs} =**				
12	**(ALT_{OCS})** Altitude of OCS at obstacle: $ALT_{ocs} = HMAS + R_{ocs}$	**ALT_{ocs} =**				
13	**(p)** Check for penetration: $p = ALT_{ocs} - ALT_{obs}$	**p =**				
14	**Penetration?** Yes/No If **p** is negative, there is penetration.	**Yes/No**				

Note: If penetration exists go to Part II otherwise skip to Step 3.

Aerodrome
Procedure Identification

- All references are from Vol. 5 unless otherwise stated.
- Acronyms used may not reflect those in TP308.

ROC_P	ROC_S	TDZE	TCH	$ELEV_{thld}$

STEP 2. MDA BASED ON MISSED APPROACH SEGMENT (cont'd)

Part II - Penetration in the Missed Approach Segment

Note: Other options may include redrawing the MA path, removing the obstacle or altering the MAP.

Part II a) - Raise MDA

15	Obstacle #					
16	**(p)** Select greatest penetration value from Step 2 - Part I (absolute value)	**p** =				
17	**MDA_{FAS}** (Highest from Step 1):	**MDA_{FAS}** =				
18	**(MDA_{unc})** uncorrected MDA: $MDA_{unc} = MDA_{FAS} + p$	**MDA_{unc}** =				
19	**(MDA_{MAS})** MDA missed approach segment: $MDA_{MAS} = MDA_{unc}$ rounded to upper 20ft	**MDA_{MAS}** =				

Part II b) - Missed Approach Climb Gradient *

* **Note:** Part II b) is only available for Military or Restricted procedures.

20	Obstacle #					
21	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
22	**(d_P)** Distance of obstacle in primary	**d_P** =				
24	Required OCS Climb Gradient: **CG_{ocs}** $= (ALT_{obs} - R_S - HMAS) / (d_P / 6076.11548)$	**CG_{ocs}** =				
25	**(CG_{unc})** required aircraft CG (uncorrected) $CG_{unc} = CG_{ocs} / 0.76$	**CG_{unc}** =				
26	**(CG)** Published CG: $CG_{PUB} = CG_{unc}$ rounded to upper 10 ft	**CG** =				

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- Acronyms used may not reflect those in TP308.

ROC$_P$	ROC$_S$	TDZE	TCH	ELEV$_{thld}$

STEP 3. MINIMUM DESCENT ALTITUDE SELECTION

		CAT A	CAT B	CAT C	CAT D	CAT E
1	**Selected MDA** **(highest of Section A or B)**					
2	**TDZE**					
3	**HAT (Selected MDA - TDZE)**					

STEP 4. VISIBILITY

Part I - Straight-in approach

		CAT A	CAT B	CAT C	CAT D	CAT E
1	**Distance** from MAP to centre of landing area. (MAX 1/2 SM (2600 feet) for straight-in minima)					
2	Approach **light** credit (in SM) (Vol. 5, para 128)					
3	**Visibility** required (D1 - D2)					
4	**Minimum** Visibility determined by HAL or HAT? (SM) (Vol. 5, Table 1-25)					
5	**Published** visibility (highest of D3 or D4)					

Part II - Point-in-Space approach

6	If **HAL** > 800 ft then min vis = 1 SM If **HAL** ≤ 800 ft then min vis = 3/4 SM					
7	Approach light **credit** (in SM) (Vol. 5, para 128)					
8	**Published** visibility (D6 - D7)					

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Procedure Identification

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ROC_P	ROC_S	TDZE	TCH	$ELEV_{thld}$

STEP 5. INITIAL APPROACH SEGMENT - CENTRE (Holding / Procedure Turn*)

Part I - Obstacle in primary area

1	**Obstacle #**					
2	**(ALT_{obs})** Obstacle altitude	**ALT_{obs} =**				
3	**(ROC_P)** Determine primary ROC. (as applicable per TP308, vol 1)	**ROC_P =**				
4	**(ALT_{adj})** Adjustments (para 323 a, b* & c). ***Note**: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj} =**				
5	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc} =**				
6	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA} =**				

Part II - Obstacle in secondary area

7	**Obstacle #**					
8	**(ALT_{obs})** Obstacle altitude	**ALT_{obs} =**				
9	**(W_S)** Width of secondary	**W_S =**				
10	**(d_S)** Distance of obstacle in secondary	**d_S =**				
11	Secondary ROC (as applicable per TP308, vol 1) **ROC_S** $= 500 \times ((W_S - d_S) / W_S)$	**ROC_S =**				
12	**(ALT_{adj})** Adjustments (para 323 a, b* & c). ***Note**: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj} =**				
13	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_S + ALT_{adj}$	**SMA_{unc} =**				
14	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA} =**				

Part III - Select highest Altitude

15	Selected minimum PT Altitude (Compare **SMA_{IA}** from Part I & Part II, select highest)				

NOTE 1): The difference between the holding altitude and the FAF crossing altitude shall not be greater than 600 ft. (See Vol. 5, para 112)

NOTE 2): The difference between the PT altitude and the FAF crossing altitude shall not be greater than those shown in Table 1-23 (See Vol. 5, para 112).

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Procedure Identification

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ROC_P	ROC_S	TDZE	TCH	$ELEV_{thld}$

STEP 6. INITIAL APPROACH SEGMENT - LEFT

Part I - Obstacle in primary area

1	**Obstacle #**						
2	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =					
3	**(ROC_P)** Determine primary ROC. (as applicable per TP308, vol 5)	**ROC_P** =					
4	**(ALT_{adj})** Adjustments (para 323 a, b* & c). *__Note__: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj}** =					
5	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc}** =					
6	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =					

Part II - Obstacle in secondary area

7	**Obstacle #**						
8	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =					
9	**(W_S)** Width of secondary	**W_S** =					
10	**(d_S)** Distance of obstacle in secondary	**d_S** =					
11	Secondary ROC (as applicable per TP308, Vol 5) **ROC_S** = 500 x ((W_S - d_S) / W_S)	**ROC_S** =					
12	**(ALT_{adj})** Adjustments (para 323 a, b* & c). *__Note__: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj}** =					
13	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_S + ALT_{adj}$	**SMA_{unc}** =					
14	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =					

Part III - Select highest Initial Segment Altitude - LEFT

15	Select highest **SMA_{IA}** from Part I & Part II	**SMA_{IA}** =					

NOTE: Initial segment altitude shall not be below the PT altitude. (Vol. 5, Para 231)

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ROC_P	ROC_S	TDZE	TCH	$ELEV_{thld}$

STEP 7. INITIAL APPROACH SEGMENT - RIGHT

Part I - Obstacle in primary area

1	**Obstacle #**					
2	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
3	**(ROC_P)** Determine primary ROC. (as applicable per TP308, vol 5)	**ROC_P** =				
4	**(ALT_{adj})** Adjustments (para 323 a, b* & c). *__Note__: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj}** =				
5	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc}** =				
6	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =				

Part II - Obstacle in secondary area

7	**Obstacle #**					
8	**(ALT_{obs})** Obstacle altitude	**ALT_{obs}** =				
9	**(W_S)** Width of secondary	**W_S** =				
10	**(d_S)** Distance of obstacle in secondary	**d_S** =				
11	Secondary ROC (as applicable per TP308, Vol 5) **ROC_S** $= 500 \times ((W_S - d_S) / W_S)$	**ROC_S** =				
12	**(ALT_{adj})** Adjustments (para 323 a, b* & c). *__Note__: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj}** =				
13	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_S + ALT_{adj}$	**SMA_{unc}** =				
14	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =				

Part III - Select highest Initial Segment Altitude - RIGHT

15	Select highest **SMA_{IA}** from Part I & Part II	**SMA_{IA}** =				

NOTE: Initial segment altitude shall not be below the PT altitude. (Vol. 5, Para 231)

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Procedure Identification

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ROC_P	ROC_S	TDZE	TCH	$ELEV_{thld}$

STEP 8. INTERMEDIATE APPROACH SEGMENT

Part I - Obstacle in primary area

1	**Obstacle #**						
2	**(ALT_{obs})** Obstacle altitude	**ALT_{obs} =**					
3	**(ROC_P)** Determine primary ROC. (as applicable per TP308, vol 5)	**ROC_P =**					
4	**(ALT_{adj})** Adjustments (para 323 a, b* & c). *__Note__: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj} =**					
5	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc} =**					
6	**(SMA_{INT})** Seg Min Alt Intermediate Approach (corr) $SMA_{INT} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{INT} =**					

Part II - Obstacle in secondary area

7	**Obstacle #**						
8	**(ALT_{obs})** Obstacle altitude	**ALT_{obs} =**					
9	**(W_S)** Width of secondary	**W_S =**					
10	**(d_S)** Distance of obstacle in secondary	**d_S =**					
11	Secondary ROC (as applicable per TP308, Vol 5) **ROC_S** $= 500 \times ((W_S - d_S) / W_S)$	**ROC_S =**					
12	**(ALT_{adj})** Adjustments (para 323 a, b* & c). *__Note__: If RASS not used full time, then "b" is for chart depiction only.	**ALT_{adj} =**					
13	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_S + ALT_{adj}$	**SMA_{unc} =**					
14	**(SMA_{INT})** Seg Min Alt Intermediate Approach (corr) $SMA_{INT} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{INT} =**					

Part III - Select highest Intermediate Segment Altitude

15	Select highest **SMA_{INT}** (Segment Minimum Altitude) for intermediate (Part I & Part II).	**SMA_{INT} =**					

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- Acronyms used may not reflect those in TP308.

ROC_P	ROC_S	TDZE	TCH	$ELEV_{thld}$

STEP 9. DESCENT GRADIENT INITIAL APPROACH SEGMENTS (DG_{IA})

Note: For Proc Turns / Holds see Vol 5, para 112.

			LEFT	RIGHT	CENTRE
1	**(ALT_{MSA})** MSA or feeder altitude	**ALT_{MSA}** =			
2	**(SMA_{IA})** Segment Min Alt for Initial Approaches	**SMA_{IA}** =			
3	**Amount of descent** = (ALT_{MSA} - SMA_{IA})				
4	**(SL_{IA})** Initial Approach segment lengths (in NM)	**SL_{IA}** =			
5	Initial Descent Gradient (ft/NM) **DG_{IA}** = (Amount of Descent / SL_{IA})	**DG_{IA} =**			

NOTE 1): OPTIMUM DG is 400 ft/NM, MAX is 600 ft/NM (may use up to 800 ft/NM if depicted on chart)

STEP 10. DESCENT GRADIENT INTERMEDIATE SEGMENT (DG_{INT})

1	**(SMA_{IA})** Segment Minimum Altitude Initial Approach **(select highest)**	**SMA_{IA}** =	
2	**(SMA_{INT})** Seg Min Alt for Intermediate	**SMA_{INT}** =	
3	**Amount of descent** = (SMA_{IA} - SMA_{int})		
4	**(SL_{int})** Length of intermediate approach segment (in NM)	**SL_{INT}** =	
5	Descent Gradient Intermediate (ft/NM) **DG_{INT}** = (Amount of Descent / SL_{int})	DG_{INT} =	

NOTE: OPTIMUM DG is 400 ft/NM, MAX is 600 ft/NM (may use up to 800 ft/NM if depicted on chart)

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Procedure Identification

- All references are from Vol. 5 unless otherwise stated.
- Acronyms used may not reflect those in TP308.

ROC_P	ROC_S	TDZE	TCH	$ELEV_{thld}$

STEP 11. DESCENT GRADIENT FINAL SEGMENT (DG_{FIN})

Part I - Straight-in approach (fix to threshold)

1	**(SMA_{int})** Seg Min Alt for Intermediate	**SMA_{INT}** =	
2	**($ELEV_{thld}$)** Threshold Elevation	**$ELEV_{thld}$** =	
3	**(TCH)** Threshold crossing height	**TCH** =	
4	**Amount of descent =** SMA_{int} - (TCH + $ELEV_{thld}$)		
5	**(SL_{fin})** Length of final approach segment (in NM)	**SL_{FIN} =**	
6	Descent Gradient Final (ft/NM): **DG_{fin}** = Amount of descent / SL_{fin}	**DG_{fin} =**	

NOTE: OPTIMUM DG is 400 ft/NM, MAX is 600 ft/NM (may use up to 800 ft/NM if depicted on chart)

Part II - Circling Approach (fix to first useable portion of landing surface)

7	**(SMA_{INT})** Seg Min Alt for Intermediate	**SMA_{INT}** =	
8	**CMDA**	**CMDA =**	
9	**Amount of descent =** SMA_{int} - CMDA		
10	**(SL_{fin})** Length of final approach segment (in NM)	**SL_{FIN}** =	
11	Descent Gradient Final (ft/NM): DG_{fin} = Amount of descent / SL_{fin}	**DG_{FIN} =**	

NOTE: Not sure of max DG for circling (para 252)

Part III - Straight-in (fix to fix)

12	**(ALT_1)** altitude of first fix (higher)	**ALT_1** =	
13	**(ALT_2)** altitude of second fix (lower)	**ALT_2** =	
14	**Amount of descent =** ALT_1 - ALT_2		
15	**(SL_{fix})** Length of segment between fixes (in NM)	**SL_{fix}** =	
16	**(DG_{fix})** Fix to Fix Descent Gradient (ft/NM): DG_{fix} = Amount of descent / SL_{fix}	**DG_{fix} =**	

NOTE: OPTIMUM DG is 400 ft/NM, MAX is 600 ft/NM (may use up to 800 ft/NM if depicted on chart)

Part IV - Select most critical DG

17	Select steepest DG from Part I, Part II or Part III	

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ILS CAT I Calc Form

TP 308 - Volume 3

Aerodrome	Procedure Identification

Unless otherwise stated:

- Acronyms used may not reflect those in TP308.
- Distances and RVR in feet, Altitudes in feet ASL.
- Heights referenced to Landing Threshold Point Elev ($ELEV_{LTP}$).
- Visibilities in Statute Miles (SM).

	TCH	$ELEV_{thld\ or\ ASBL\ or\ LTP}$	GPI	GPA	DA	HAT	TDZE
Initial							
* Adjusted							

* record calculations/reasons for adjustments

STEP 1. INITIAL VALUES

Part I - Determine minimum HAT and Visibility

1	**(TDZE)** Thouchdown Zone Elevation **TDZE** =	
2	**(Θ)** Glidepath Angle (GPA) **Θ** =	
3	Approach lighting configuration: (circle one) 1) No lights, 2) MALSR, SSALR, ALFS 3) MALSR, SSALR, ALFS plus TDZ/CL lights	
4	Minimum HAT / VIS (from Table 2-2B) **HAT / VIS =**	

Part II - Initial adjustments

5	If POFA is not clear, minimum HAT / visibility is **250** - **3/4**. (Para 3.3)	
6	If OFZ is penetrated, visibility credit for lights is **not** authorized and the minimum HAT / visibility is **250 - 3/4** (for GPA ≤ 4.2°) or **350 - 1** (for GPA > 4.2°). (Para 2.11)	
7	If inbound course is not lined up with RCL, minimum HAT and RVR are **250** and **2600 ft** respectively. (Para 3.1)	

Part III - Selection

8	**Initial** min **HAT / VIS** (select highest value from Parts I & II)	
9	**(DA)** Decision Altitude: (use HAT from Step 1.8): DA = HAT + TDZE **Initial DA** =	

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STEP 2. DISTANCE (D_{DA}) OF DECISION ALTITUDE (DA) FROM RWT

1	**(DA) Initial Decision Altitude** (from Step 1-Part III)	**HAT** =	
2	**($ELEV_{LTP}$)** LTP elevation	**$ELEV_{LTP}$** =	
3	**(TCH)** Threshold crossing height	**TCH** =	
4	**(h)** height of DA above TCH: $h = DA - (ELEV_{LTP} + TCH)$	**h** =	
5	**(Θ)** Glidepath Angle (GPA)	**Θ** =	
6	**(D_{DA})** distance from RWT to DA: $D_{DA} = (HAT - TCH) / \tan \Theta$	**D_{DA}** =	

STEP 3. GLIDEPATH QUALIFICATION SURFACE (GQS) VERIFICATION (Para 2.12)

1	Obstruction #.						
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =					
3	**($ELEV_{LTP}$)** LTP elevation	**$ELEV_{LTP}$** =					
4	**(d)** Distance of obstacle from LTP. (measured along runway centre line)	**d** =					
5	**(Θ)** Glidepath Angle	**Θ** =					
6	**(h)** Height of GQS at obstacle location. $h = (\tan[2 \times \Theta / 3] \times d) + ELEV_{LTP}$	**h** =					
7	**(p)** Penetration: $p = h - ALT_{obs}$	**p** =					

Note: If p is negative, there is penetration. Approach procedure with vertical guidance not approved.

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STEP 4. INTERMEDIATE SEGMENT ASSESSMENT FOR PRELIMINARY PFAF/FAF ALT

Part I - Obstacle in primary area			PFAF	FAF
1	Obstruction #			
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =		
3	**(ROC_P)** Determine primary ROC. (as applicable per TP308, vol 1)	**ROC_P** =		
4	**(ALT_{adj})** Adjustments (para 323 a & b*). * **Note**: If RASS is part-time, then "323 b" is calculated for the plan view note.	**ALT_{adj}** =		
5	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc}** =		
6	**(SMA_{int})** Seg Min Alt (Corrected): $SMA_{int} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{int}** =		

Part II - Obstacle in secondary area			PFAF	FAF
7	Obstruction #			
8	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =		
9	**(W_S)** Width of secondary	**W_S** =		
10	**(d_S)** Distance of obstacle in secondary	**d_S** =		
11	**(ROC_S)** Secondary ROC (as per TP308, vol 1): $ROC_S = 500 \times ([W_S - d_S] / W_S)$	**ROC_S** =		
12	**(ALT_{adj})** Adjustments (para 323 a & b*). * **Note**: If RASS is part-time, then "323 b" is calculated for the plan view note.	**ALT_{adj}** =		
13	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_S + ALT_{adj}$	**SMA_{unc}** =		
14	**(SMA_{int})** Seg Min Alt (Corrected): $SMA_{int} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{int}** =		

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STEP 4. INTERMEDIATE SEGMENT ASSESSMENT (cont'd)

Part III - PFAF/FAF crossing ALT based on GPA and Dist

			PFAF	FAF
15	**(D_{PFAF})** Distance from PFAF (or FAF) to LTP..	**D_{PFAF} =**		
16	**($ELEV_{LTP}$)** LTP elevation	**$ELEV_{LTP}$** =		
17	**(TCH)** Threshold crossing height	**TCH** =		
18	**(Θ)** Glidepath Angle	**Θ** =		
19	**(ALT_{GPA})** Altitude of GPA at the PFAF/FAF: $ALT_{GPA} = (D_{PFAF} \times \tan \Theta) + ELEV_{LTP} + TCH$	**ALT_{GPA}** =		
20	**(ALT_{PFAF})** Altitude crossing PFAF (or FAF): $ALT_{PFAF} = ALT_{GPA}$ rounded to **lower** 100 ft.	**ALT_{PFAF}** =		

Part IV - Select Altitudes

		PFAF	FAF
21	Select highest of **ALT_{PFAF}** or **SMA_{int}** for intermediate segment. (Compare corrected altitudes from Part I, Part II or Part III).		

STEP 5. PFAF (or FAF) DISTANCE FROM LTP (Para 2.9)

1	**(ALT_{PFAF})** Selected PFAF (or FAF) altitude. (from Step 4 - Part IV)	**ALT_{PFAF}** =	
2	**($ELEV_{LTP}$)** LTP elevation	**$ELEV_{LTP}$** =	
3	**(H_{PFAF})** Height of PFAF (or FAF): $H_{PFAF} = ALT_{PFAF} - ELEV_{LTP}$	**H_{PFAF}** =	
4	**(Θ)** Glidepath Angle	**Θ** =	
5	Find **V**, $V = \arcsin((20890537 \times \sin[90 - \Theta]) / (ELEV_{FAF} + 20890537))$		
6	**(D)** Distance of PFAF (or FAF) to GPI: $D = 364609 \times (90 - \Theta - V)$	**D** =	
7	**(GPI)** Ground Point of Intercept	**GPI =**	
8	**(D_{PFAF})** Distance of PFAF (or FAF) from LTP $D_{PFAF} = D - GPI$	**D_{PFAF} =**	

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STEP 6. FAF GLIDE PATH CHECK ALTITUDE

1	**(D)** Distance of FAF to GPI.	**D** =	
2	**($ELEV_{LTP}$)** LTP elevation	**$ELEV_{LTP}$** =	
3	**(Θ)** Glidepath Angle	**Θ** =	
4	**(H_{FAF})** Height of FAF: $H_{FAF} = D \times \tan \Theta$	**H_{FAF}** =	
5	**(ALT_{GPunc})** Altitude of glidepath check (uncorr): $ALT_{GPunc} = H_{FAF} + ELEV_{LTP}$	**ALT_{GPunc}**=	
6	**(E)** Curve of the Earth correction: $E = (D_{GPI}^{2} \times 0.8833)$	**E** =	
7	**(ALT_{GP})** Altitude of glidepath check: $ALT_{GP} = (ALT_{GPunc} + E)$	**ALT_{GP}** =	
8	Published ALT_{GP} (round to nearest 10 ft).		

STEP 7. FINAL APPROACH SURFACE VERIFICATION

7a. Z_W SURFACE (Para 3.4)

1	Obstruction #					
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =				
3	**(H_{obs})** Obstruction height above ASBL: $H_{obs} = ALT_{obs} - ELEV_{ASBL}$	**H_{obs}** =				
4	**(d)** Obstacle distance from LTP (along course centreline)	**d** =				
5	**(D_{OCS})** OCS origin alteration: $D_{OCS} = 954 - GPI$ (if $GPI \geq 954$ ft, then $D_{OCS} = 0$)	**D_{OCS}** =				
6	**(Θ)** Glidepath Angle	**Θ** =				
7	**(S_w)** W surface slope: $S_w = 102 / \Theta$	**S_w** =				
8	**(Z_w)** Height of W surface at d: $Z_w = (d - [200 + D_{OCS}]) / S_w$	**Z_w** =				
9	**(p)** Penetration: $p = Z_w - H_{obs}$	**p** =				

Note: If p is negative, there is penetration. Go to Step 14a.

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STEP 7. FINAL APPROACH SURFACE VERIFICATION (cont'd)

7b. Z_X SURFACE (Para 3.5)

1	Obstruction #						
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =					
3	**(H_{obs})** Obstruction height above ASBL: $H_{obs} = ALT_{obs} - ELEV_{ASBL}$	**H_{obs}** =					
4	**(d)** Obstruction distance from LTP (along course centreline)	**d** =					
5	**(D_{OCS})** OCS origin alteration: $D_{OCS} = 954 - GPI$ (if GPI ≥ 954 ft, then $D_{OCS} = 0$)	**D_{OCS}** =					
6	**(Θ)** Glidepath Angle	**Θ** =					
7	**(S_w)** W Surface slope: $S_w = 102 / \Theta$	**S_w** =					
8	**(D_w)** Dist of W outer boundary from centreline at d: $D_w = 0.036 (d - 200) + 400$	**D_w** =					
9	**d_x** = Distance from course centreline to a point in the X surface.	**d_x** =					
10	**(Zx)** Height of the X surface at d: $Z_x = (d - [200 + D_{OCS}]) / S_w + (d_x - D_w) / 4$	**Zx** =					
11	**(p)** Penetration: $p = Z_x - H_{obs}$	**p** =					

Note: If p is negative, there is penetration. Go to Step 14b.

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STEP 7. FINAL APPROACH SURFACE VERIFICATION (cont'd)

7c. Z_Y SURFACE (Para 3.6)

1	Obstruction #					
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =				
3	**(H_{obs})** Obstruction height: $H_{obs} = ALT_{obs} - ELEV_{ASBL}$	**H_{obs}** =				
4	**(d)** Obstruction distance from LTP (along course centreline)	**d** =				
5	**(D_{OCS})** OCS origin alteration: D_{OCS} = 954 - GPI (if GPI ≥ 954 ft, then D_{OCS} = 0)	**D_{OCS}** =				
6	**(Θ)** Glidepath Angle	**Θ** =				
7	**(S_w)** W Surface slope: $S_w = 102 / \Theta$	**S_w** =				
8	**(D_w)** Dist of W outer boundary from C/L at d: $D_w = 0.036 (d - 200) + 400$	**D_w** =				
9	**(D_x)** Dist of X outer boundary from centreline at d: $D_x = 0.10752 (d - 200) + 700$	**d_x** =				
10	**d_Y** = Distance from course centreline to a point in the Y surface.	**d_Y** =				
11	**(Z_Y)** Height of the Y surface at d: $Z_y = (d - [200 + D_{OCS}]) / S_w + (D_x - D_w) / 4 + (d_Y - D_x) / 7$	**Z_Y** =				
12	**(p)** Penetration: $p = Z_Y - H_{obs}$	**p** =				

Note: If p is negative, there is penetration. Go to Step 14c.

STEP 8. ADJUSTED VALUE and DA DISTANCE

		Altitude	Dist from LTP
1	If DA value was adjusted due to final approach segment penetration(s), insert adjusted DA **value** (DA_{adj}) here, otherwise go to next Step.		
2	If DA value was adjusted due to final approach segment penetration(s), insert adjusted DA **distance** (adjust D_{DA}) here, otherwise go to next Step.		

Aerodrome	Procedure Identification

STEP 9. MISSED APPROACH OCS VERIFICATION

Current DA (the value used for the following MA OCS verifications):	

9a. SECTION 1a VERIFICATION (Para 3.9.1)

Part I - Overlying the "W" surface

1	Obstruction #					
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =				
3	**(H_{obs})** Obstruction height: $H_{obs} = ALT_{obs} - ELEV_{LTP}$	**H_{obs}** =				
4	**(d)** Obstruction distance from LTP (along course centreline)	**d** =				
5	**(D_{OCS})** OCS origin alteration: D_{OCS} = 954 - GPI (if GPI ≥ 954 ft, then $D_{OCS} = 0$)	**D_{OCS}** =				
6	**(Θ)** Glidepath Angle	**Θ** =				
7	**(S_w)** W surface slope: $S_w = 102 / \Theta$	**S_w** =				
8	**(Z_w)** Height of W surface at d: $Z_w = (d - [200 + D_{OCS}]) / S_w$	**Z_w** =				
9	**(p)** Penetration: $p = Z_w - H_{obs}$	**p** =				

Note: If p is negative, there is penetration. Go to Step 15a.

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STEP 9. MISSED APPROACH OCS VERIFICATION (cont'd)

Part II - Overlying the "X" surface

10	Obstruction #					
11	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =				
12	**(H_{obs})** Obstruction height: $H_{obs} = ALT_{obs} - ELEV_{LTP}$	**H_{obs}** =				
13	**(d)** Obstruction distance from LTP (along course centreline)	**d** =				
14	**(D_{OCS})** OCS origin alteration: $D_{OCS} = 954 - GPI$ (if $GPI \geq 954$ ft, then $D_{OCS} = 0$)	**D_{OCS}** =				
15	**(Θ)** Glidepath Angle	**Θ** =				
16	**(S_w)** W surface slope: $S_w = 102 / \Theta$	**S_w** =				
17	**(D_w)** Dist of W outer boundary from centreline at d: $D_w = 0.036 (d - 200) + 400$	**D_w** =				
18	**(D_x)** Dist of X outer boundary from centreline at d: $D_x = 0.10752 (d - 200) + 700$	**D_x** =				
19	**(Z_x)** Height of the X surface at d: $Z_x = (d - [200 + D_{OCS}]) / S_w + (D_X - D_w) / 4$	**Z_x** =				
20	**(p)** Penetration: $p = Z_x - H_{obs}$	**p** =				

Note: If p is negative, there is penetration. Go to Step 15a.

Aerodrome	Procedure Identification

STEP 9. MISSED APPROACH OCS VERIFICATION (cont'd)

9b. SECTION 1b VERIFICATION (Para 3.9.1)

Part I: Height of OCS at beginning of Section 1b (B_{1b})

1	**(D_{DA})** distance from LTP to DA (or DA_{adj})	**D_{DA}** =	
2	**(D_{1b})** Start of section 1b: $D_{1b} = (D_{DA} - 1460)$	**D_{1b}** =	
3	**(Θ)** Glidepath Angle	**Θ** =	
4	**(S_w)** W surface slope: $S_w = 102 / \Theta$	**S_w** =	
5	**(D_{OCS})** OCS origin alteration: $D_{OCS} = 954 - GPI$ (if GPI ≥ 954 ft, then $D_{OCS} = 0$)	**D_{OCS}** =	
6	**(B_{1b})** Height of OCS at beginning of Section 1b: $B_{1b} = (D_{1b} - [200 + D_{OCS}]) / S_w$	**B_{1b}** =	

Part II: Missed Approach OCS (SECTION 1b)

7	Obstruction #					
8	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =				
9	**(H_{obs})** Obstruction height: $H_{obs} = ALT_{obs} - ELEV_{LTP}$	**H_{obs}** =				
10	**(d_{1b})** Shortest distance from end of section 1a to obstacle.	**d_{1b}** =				
11	**(R_{1b})** Rise of section 1b OCS at obstruction: $R_{1b} = d_{1b} / 28.5$	**R_{1b}** =				
12	**(H_{1B})** Height of section 1b OCS at obstruction: $H_{1b} = B_{1b} + R_{1b}$	**H_{1B}** =				
13	**(p)** Penetration: $p = H_{1b} - H_{obs}$	**p** =				

Note: If p is negative, there is penetration. Go to Step 15b.

Aerodrome	Procedure Identification

STEP 9. MISSED APPROACH OCS VERIFICATION (cont'd)

9c. SECTION 1c VERIFICATION (Para 3.9.1)

Part I - adjacent to Section 1a

1	Obstruction #					
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =				
3	**(H_{obs})** Obstruction height: $H_{obs} = ALT_{obs} - ELEV_{LTP}$	**H_{obs}** =				
4	**(d)** Obstruction distance from LTP (along course centreline)	**d** =				
5	**(D_{OCS})** OCS origin alteration: $D_{OCS} = 954 - GPI$ (if $GPI \geq 954$ ft, then $D_{OCS} = 0$)	**D_{OCS}** =				
6	**(Θ)** Glidepath Angle	**Θ** =				
7	**(S_w)** W surface slope: $S_w = 102 / \Theta$	**S_w** =				
8	**(D_w)** Dist of W outer boundary from centreline at d: $D_w = 0.036\ (d - 200) + 400$	**D_w** =				
9	**(D_x)** Dist of X outer boundary from centreline at d: $D_x = 0.10752\ (d - 200) + 700$	**D_x** =				
10	**(d_{1c})** Distance from course centreline to obstruction.	**d_{1c}** =				
11	**(R_{1c})** Rise of section 1c OCS at d_{1c}: $R_{1c} = (d_{1c} - D_x) / 7$	**R_{1c}** =				
12	**(H_{1c})** Height of section 1c OCS at obstruction: $H_{1c} = (d - [200 + D_{OCS}]) / S_w + (D_x - D_w) / 4 + R_{1c}$	**H_{1c}** =				
13	**(p)** Penetration: $p = H_{1c} - H_{obs}$	**p** =				

Note: If p is negative, there is penetration. Go to Step 15c - Part I.

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STEP 9. MISSED APPROACH OCS VERIFICATION (cont'd)

Part II - adjacent to Section 1b

Subpart I: Height of OCS at beginning of Section 1b (B_{1b})

14	**(D_{DA})** distance from LTP to DA (or DA_{adj})	**D_{DA}** =	
15	**(D_{1b})** Start of section 1b: $D_{1b} = (D_{DA} - 1460)$	**D_{1b}** =	
16	**(Θ)** Glidepath Angle	**Θ** =	
17	**(S_w)** W surface slope: $S_w = 102 / \Theta$	**S_w** =	
18	**(D_{OCS})** OCS origin alteration: $D_{OCS} = 954 - GPI$ (if GPI ≥ 954 ft, then $D_{OCS} = 0$)	**D_{OCS}** =	
19	**(B_{1b})** Height of OCS at beginning of Section 1b: $B_{1b} = (D_{1b} - (200 + D_{OCS})) / S_w$	**B_{1b}** =	

Subpart II: Rise of Sections 1b and 1c

20	Obstruction #					
21	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =				
22	**(H_{obs})** Obstruction height: $H_{obs} = ALT_{obs} - ELEV_{LTP}$	**H_{obs}** =				
23	**(d_{1b})** Shortest distance from start of section 1b to obstruction.	**d_{1b}** =				
24	**(R_{1b})** Rise of section 1b OCS at obstruction: $R_{1b} = d_{1b} / 28.5$	**R_{1b}** =				
25	**(d_{1c})** Obstruction distance from edge of Section 1b (measured perpendicular to course centreline)	**d_{1c}** =				
26	**(R_{1c})** Rise of section 1c OCS at obstruction: $R_{1c} = d_{1c} / 7$	**R_{1c}** =				
27	**(H_{1c})** Height of section 1c OCS at obstruction: $H_{1c} = S_{1b} + S_{1c} + B_{1b}$	**H_{1c}** =				
28	**(p)** Penetration: $p = H_{1c} - H_{obs}$	**p** =				

Note: If p is negative, there is penetration. Go to Step 15c - Part II.

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STEP 9. MISSED APPROACH OCS VERIFICATION (cont'd)

9d. SECTION 2 (Para 3.9.1) VERIFICATION

Part I - Height of OCS surface at beginning of Section 2

1	**(D_{DA})** distance from LTP to DA (or DA_{adj})	**D_{DA}** =	
2	**(D_{1b})** Start of section 1b: $D_{1b} = (D_{DA} - 1460)$	**D_{1b}** =	
3	**(Θ)** Glidepath Angle	**Θ** =	
4	**(S_w)** W surface slope: $S_w = 102 / \Theta$	**S_w** =	
5	**(D_{OCS})** OCS origin alteration: D_{OCS} = 954 - GPI (if GPI ≥ 954 ft, then D_{OCS} = 0)	**D_{OCS}** =	
6	**(B_{1b})** Height of OCS at beginning of Section 1b: $B_{1b} = (D_{1b} - (200 + D_{OCS})) / S_w$	**B_{1b}** =	
7	**(R_{1b})** Rise of section 1b: R_{1b} = (9860.69 ft - 1460 ft) / 28.5	**R_{1b}** =	**294.7610526**
8	**(H_{2b})** Height at beginning of Section 2 OCS: $H_{2b} = R_{1b} + B_{1b}$		

Note: If obstruction in primary area, go to **Part II;** if obstacle in secondary area, go to **Part III**.

Part II - Primary area verification

9	Obstruction #					
10	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =				
11	**($ELEV_{LTP}$)**	**$ELEV_{LTP}$** =				
12	**(H_{obs})** Obstruction height: $H_{obs} = ALT_{obs} - ELEV_{LTP}$	**H_{obs}** =				
13	**(d_p)** Shortest distance from end of section 1b (or along section 1c boundary) to obstacle:	**d_p** =				
14	**(R_{2P})** Rise of Section 2 primary OCS at obstruction: $R_{2p} = d_p / 40$	**R_{2P}** =				
15	**(H_2)** Height of Section 2 OCS at obstruction: $H_2 = R_{2p} + H_{2b}$	**H_2** =				
16	**(p)** Penetration: $p = H_2 - H_{obs}$	**p** =				

Note: If p is negative, there is penetration. Move or shorten the obstruction and / or adjust DA height (see Step 15d).

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STEP 9. MISSED APPROACH OCS VERIFICATION (cont'd)

Part III - Secondary area verification

17	Obstruction #						
18	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =					
19	**($ELEV_{LTP}$)**	**$ELEV_{LTP}$** =					
20	**(H_{obs})** Obstruction height: $H_{obs} = ALT_{obs} - ELEV_{LTP}$	**H_{obs}** =					
21	**(d_p)** Shortest distance from end of Section 1b (or along section 1c boundary) to the edge of the primary area (perpendicular to the obstacle).	**d_p** =					
22	**(d_s)** Distance (perpendicular to course centerline) from obstruction to edge of primary area.	**d_s** =					
23	**(R_{2P})** Rise of Section 2 primary OCS at obstruction: $R_{2p} = d_p / 40$	**R_{2P}** =					
24	**(R_{2S})** Rise of Section 2 secondary OCS at obstruction: $R_{2S} = d_S / 12$	**R_{2S}** =					
25	**(H_2)** Height of Section 2 OCS at obstruction: $H_2 = R_{2S} + R_{2P} + H_{2b}$	**H_2** =					
26	**(p)** Penetration: $p = H_2 - H_{obs}$	**p** =					

Note: If p is negative, there is penetration. Move or shorten the obstruction, alter MA heading and/or adjust DA height (see Step 15d).

STEP 10. ADJUSTED DA VALUE and DA DISTANCE

		Altitude	Dist from LTP
1	If DA value was adjusted due to MA penetration(s), insert adjusted DA **value** (DA_{adj}) here, otherwise go to next Step.		
2	If DA value was adjusted due to MA penetration(s), insert adjusted DA **distance** (adjust D_{DA}) here, otherwise go to next Step.		

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STEP 11. INITIAL APPROACH SEGMENT VERIFICATION - LEFT/RIGHT & CENTRE*

* **Note:** May be used for Holds / Procedure Turns.

Part I - Obstacle in primary area

			LEFT	RIGHT	CENTRE
1	Obstruction #				
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =			
3	**(ROC_P)** Determine Required Obstacle Clearance primary. (as applicable per TP308, vol 1)	**ROC_P** =			
4	**(ALT_{adj})** Adjustments (para 323 a).	**ALT_{adj}** =			
5	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_P + ALT_{adj}$	**SMA_{unc}** =			
6	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =			

Part II - Obstacle in secondary area

			LEFT	RIGHT	CENTRE
7	Obstruction #				
8	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =			
9	**(W_S)** Width of secondary	**W_S** =			
10	**(d_S)** Distance of obstacle in secondary	**d_S** =			
11	**(ROC_S)** Secondary ROC: $ROC_S = 500 \times ([W_S - d_S] / W_S)$	**ROC_S** =			
12	**(ALT_{adj})** Adjustments (para 323 a).	**ALT_{adj}** =			
13	**(SMA_{unc})** Segment Minimum Alt (Uncorrected): $SMA_{unc} = ALT_{obs} + ROC_S + ALT_{adj}$	**SMA_{unc}** =			
14	**(SMA_{IA})** Seg Min Alt Initial Approach (corrected) $SMA_{IA} = SMA_{unc}$ rounded to upper 100 ft	**SMA_{IA}** =			

Part III - Select highest Initial Segment Altitude

		LEFT	RIGHT	CENTRE
15	Segment Minimum Altitudes: (Select highest **SMA_{IA}** from Parts I & II)			

Note: - Segment Minimum Altitudes shall not be below the PT altitude. (Para 231)

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STEP 12. DESCENT GRADIENT CALCULATIONS

		LEFT	RIGHT	CENTRE
1	Insure descent gradients (DG) are not exceeded between all segments. (TP308 Volume 1)			

STEP 13. MINIMA FOR CAT I ILS APPROACH

		DA	VIS
1	Insert selected DA & VIS from Step 1.		
2	Insert selected DA from Step 8 and (if adjusted).		
3	Insert selected DA from Step 10 (if adjusted).		

		CAT A	CAT B	CAT C	CAT D	CAT E
4	Selected **DA** (highest from above)					
5	TDZE					
6	**HAT** = DA - TDZE					
7	VIS (highest from Step 13.1 or Vol. 1 Tables 3-3, 3-1)					
8	RVR (from Vol. 1 Table 3-4)					

Aerodrome	Procedure Identification

ADJUSTMENT CALCULATIONS

STEP 14. FINAL APPROACH SEGMENT ADJUSTMENTS

14a. POSSIBLE OPTIONS for W OCS PENETRATIONS

Choose one (or a combination) of the options below.

	1	2	3	4	other
Option(s) chosen					

Option I : Remove or adjust height of obstruction.

1	**YES** or **NO**	

Note: If "yes" make note of obstacle to be adjusted and continue with "Surface Verifications".

Option II : Revise GPA (Para 3.2.2)

2	Obstruction #		
3	**(d)** Obstruction distance from RWT (along course centreline)	**d** =	
4	**(D_{OCS})** OCS origin alteration: D_{OCS} = 954 - GPI (if GPI ≥ 954 ft, then D_{OCS} = 0)	**D_{OCS}** =	
5	**(Θ)** Glidepath Angle	**Θ** =	
6	**(S_w)** W surface slope: $S_w = 102 / \Theta$	**S_w** =	
7	**(p)** Penetration (from Step 7a):	**p** =	
8	**(Θ_{adj})** Adjusted glidepath angle: $\Theta_{adj} = (102 [(d - (200 + D_{OCS})) / S_w + p]) / (d - (200 + D_{OCS}))$	**Θ_{adj}** =	

Notes:

1) Round to the next higher hundredth (0.01°) degree and verify with Para. 2.5.

2) The "ILS Calculation Form" should be redone with adjusted GPA value. Record adjustment calculations for traceability.

3) Verify with Table 2-2C to insure that adjusted TCH within limits.

Aerodrome	Procedure Identification

STEP 14. FINAL APPROACH SEGMENT ADJUSTMENTS (cont'd)

Option III : Displace RWT *

* **Note:** This calculation valid for penetrations in the **W** surface only.

9	Obstruction #		
10	**(p)** Penetration (from Step 7a):	**p** =	
11	**(Θ)** Glidepath Angle	**Θ** =	
12	**(S_w)** W surface slope: $S_w = 102 / \Theta$	**S_w** =	
13	**(D_{thld})** Threshold Displacement: $D_{thld} = p \times S_w$	**D_{thld}** =	

Note: The "ILS Calculation Form" should be redone with new value. Record adjustment calculations for

Option IV : Raise DA (DA_{adj}) (Para 3.8)

14	Obstruction #		
15	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =	
16	**($ELEV_{ASBL}$)** Elevation of ASBL	**$ELEV_{ASBL}$** =	
17	**(H_{obs})** Height of obstruction above ASBL : $H_{obs} = ALT_{obs} - ELEV_{ASBL}$	**H_{obs}** =	
18	**(D_{OCS})** OCS origin alteration: $D_{OCS} = 954 - GPI$ (if $GPI \geq 954$ ft, then $D_{OCS} = 0$)	**D_{OCS}** =	
19	**(Θ)** Glidepath Angle	**Θ** =	
20	**(adjust D_{DA})** Adjusted distance from DA_{adj} to LTP: adjust $D_{DA} = (102 \times H_{obs} / \Theta) + (200 + D_{OCS})$	**D_{DA}** =	
21	**(TCH)** Threshold crossing height	**TCH** =	
22	**(Θ)** Glidepath Angle	**Θ** =	
23	**(GPI)** Glidepath intercept: $GPI = TCH / \tan \Theta$	**GPI** =	
24	**(DA_{adj})** Adjusted DA: $DA_{adj} = \tan \Theta$ (adjust D_{DA} + GPI) + TCH	**DA_{adj}** =	

Note: Verify all penetrations in final approach segment. Choose highest adjusted DA, then redraw missed approach before going to Step 8.

Aerodrome	Procedure Identification

STEP 14. FINAL APPROACH SEGMENT ADJUSTMENTS (cont'd)

Option V : Other

- Record details of alternate option.

14b. POSSIBLE OPTIONS for X OCS PENETRATIONS

Choose one (or a combination) of the options below.

	1	2	3	4	other
Option(s) chosen					

Option I : Remove or adjust height of obstruction.

See Step 14a. option I. (Use penetrations from Step 7b.).

Option II : Revise GPA (Para 3.2.2)

See Step 14a. option II. (Use penetrations from Step 7b.)

Option III : Displace RWT *

- * Form to be developped.

Option IV : Raise DA (DA_{adj}) (Para 3.8)

1	Obstruction #		
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =	
3	**($ELEV_{ASBL}$)** Elevation of ASBL	**$ELEV_{ASBL}$** =	
4	**(H_{obs})** Height of obstruction above ASBL : $H_{obs} = ALT_{obs} - ELEV_{ASBL}$	**H_{obs}** =	
5	**(Θ)** Glidepath Angle	**Θ** =	
6	**(D_{OCS})** OCS origin alteration: D_{OCS} = 954 - GPI (if GPI ≥ 954 ft, then D_{OCS} = 0)	**D_{OCS}** =	
7	**(d)** Obstruction distance from LTP (along course centreline)	**d** =	
8	**(D_w)** Dist of W outer boundary from centreline at d: $D_w = 0.036 (d - 200) + 400$	**D_w** =	
9	**d_X** = Distance from course centreline to a point in the X surface.	**d_X** =	
10	**(R_X)** Rise of X surface: $R_X = (d_X - D_W) / 4$	**R_X** =	
11	**(adjust D_{DA})** Adjusted distance from DA_{adj} to LTP: adjust $D_{DA} = (102 \times (H_{obs} - R_X) / \Theta) + (200 + D_{OCS})$	**D_{DA}** =	
12	**(TCH)** Threshold crossing height	**TCH** =	
13	**(Θ)** Glidepath Angle	**Θ** =	
14	**(GPI)** Glidepath intercept: GPI = TCH / tan Θ	**GPI** =	
15	**(DA_{adj})** Adjusted DA: $DA_{adj} = \tan \Theta$ (adjust D_{DA} + GPI) + TCH	**DA_{adj}** =	

Note: Verify all penetrations in final approach segment. Choose highest adjusted DA, then redraw missed approach before going to Step 8.

Aerodrome	Procedure Identification

STEP 14. FINAL APPROACH SEGMENT ADJUSTMENTS (cont'd)

Option V : Other

- Record details of alternate option.

14c. POSSIBLE OPTIONS for Y OCS PENETRATIONS

Choose one (or a combination) of the options below.

	1	2	3	4	other
Option(s) chosen					

Option I : Remove or adjust height of obstruction.

See Step 14a. option I. (Use penetrations from Step 7c.)

Option II : Revise GPA (Para 3.2.2)

See Step 14a. option II. (Use penetrations from Step 7c.)

Option III : Displace RWT *

- * Form to be developed.

Option IV : Raise DA (DA_{adj}) (Para 3.8)

1	Obstruction #		
2	**(ALT_{obs})** Obstruction altitude	**ALT_{obs}** =	
3	**($ELEV_{ASBL}$)** Elevation of ASBL	$ELEV_{ASBL}$ =	
4	**(H_{obs})** Height of obstruction above ASBL : $H_{obs} = ALT_{obs} - ELEV_{ASBL}$	**H_{obs}** =	
5	**(Θ)** Glidepath Angle	**Θ** =	
6	**(D_{OCS})** OCS origin alteration: D_{OCS} = 954 - GPI (if GPI ≥ 954 ft, then D_{OCS} = 0)	**D_{OCS}** =	
7	**(d)** Obstruction distance from RWT (along course centreline)	**d** =	
8	**(D_w)** Dist of W outer boundary from centreline at d: $D_w = 0.036 (d - 200) + 400$	**D_w** =	
9	**(D_X)** Dist of X outer boundary from centreline at d: $D_X = 0.10752 (d - 200) + 700$	**D_X** =	

Aerodrome	Procedure Identification

STEP 14. FINAL APPROACH SEGMENT ADJUSTMENTS (cont'd)

10	**(R_X)** Rise of X surface: $R_X = (D_X - D_W) / 4$	**R_X** =	
11	**d_Y** = Distance from course centreline to a point in the Y surface.	**d_Y** =	
12	**(R_Y)** Rise of Y surface: $R_Y = (dY - D_X) / 7$	**R_Y** =	
13	**(adjust D_{DA})** Adjusted distance from DA_{adj} to LTP: adjust $D_{DA} = (102 \times (H_{obs} - R_X - R_Y) / \Theta) + (200 + D_{OCS})$	**D_{DA}** =	
14	**(TCH)** Threshold crossing height	**TCH** =	
15	**(Θ)** Glidepath Angle	**Θ** =	
16	**(GPI)** Glidepath intercept: $GPI = TCH / \tan \Theta$	**GPI** =	
17	**(DA_{adj})** Adjusted DA: $DA_{adj} = \tan \Theta\ (\text{adjust } D_{DA} + GPI) + TCH$	**DA_{adj}** =	

Note: Verify all penetrations in final approach segment. Choose highest adjusted DA, then redraw missed approach before going to Step 8.

Option V : Offset final approach course
- Redraw and reassess procedure.

Option VI : Other
- Record details of alternate option.

ILS CAT I Calc Form

Aerodrome	Procedure Identification

STEP 15. DA ADJUSTMENTS FOR MA OCS PENETRATIONS

Current DA (from Step 9) ☐

15a. SECTION 1a ADJUSTMENT (Fig 3-9C)

1	Obstruction #		
2	**(p)** Penetration (from Step 9a):	**p** =	
3	**(Θ)** Glidepath Angle	**Θ** =	
4	**(d)** Obstruction distance from LTP (along course centreline)	**d** =	
5	**(D_{DA})** distance from LTP to DA (or DA_{adj})	**D_{DA}** =	
6	**(D_{1b})** Start of section 1b: $D_{1b} = D_{DA} - 1460$ ft	**D_{1b}** =	
7	**(d_{1b})** Distance from obstruction to start of Section 1b: $d_{1b} = d - D_{1b}$	**d_{1b}** =	
8	Adjustment: **Adjust** = $\tan \Theta \times ([p / (1/28.5 + \Theta/102)] + d_{1b})$		
9	**(DA_{adj})** Adjusted DA (uncorrected): DA_{adj} = current DA + Adjust	**DA_{adj}** =	
10	DA_{adj} value rounded to the next higher foot		

Notes:
1) If DA is adjusted, redraw missed approach.
2) To find DA_{adj} distance from LTP, goto Step 16.

15b. SECTION 1b ADJUSTMENT (Fig 3-9E)

1	Obstruction #		
2	**(p)** Penetration (from Step 9b):	**p** =	
3	**(Θ)** Glidepath Angle	**Θ** =	
4	Adjustment: **Adjust** = $\tan \Theta \times (p / [1/28.5 + \Theta/102])$		
5	**(DA_{adj})** Adjusted DA (uncorrected): DA_{adj} = current DA + Adjust	**DA_{adj}** =	
6	DA_{adj} value rounded to the next higher foot		

Notes:
1) If DA is adjusted, redraw missed approach.
2) To find DA_{adj} distance from LTP, go to Step 16.

Aerodrome	Procedure Identification

STEP 15. DA ADJUSTMENTS FOR MA OCS PENETRATIONS

15c. SECTION 1c ADJUSTMENT (Para 3.9.1c)

Part I - adjacent to Section 1a

1	Obstruction #		
2	**(p)** Penetration (from Step 9c - Part I)	**p** =	
3	**(Θ)** Glidepath Angle	**Θ** =	
4	**(d)** Obstruction distance from LTP (along course centreline)	**d** =	
5	**(D_{DA})** distance from LTP to DA (or DA_{adj})	**D_{DA}** =	
6	**(D_{1b})** Start of section 1b: $D_{1b} = D_{DA}$ - 1460 ft	**D_{1b}** =	
7	**(d_{1b})** Dist from obstruction to start of Section 1b: $d_{1b} = d - D_{1b}$	**d_{1b}** =	
8	Adjustment: **Adjust** = tan Θ x ([p / (1/28.5 + Θ/102)] + d_{1b})		
9	**(DA_{adj})** Adjusted DA (uncorrected): DA_{adj} = current DA + Adjust	**DA_{adj}** =	
10	DA_{adj} value rounded to the next higher foot		

Notes:

1) If DA is adjusted, redraw missed approach.
2) To find DA_{adj} distance from LTP, go to Step 16.

Part II - adjacent to Section 1b

11	Obstruction #		
12	**(p)** Penetration (from Step 9c - Part II)	**p** =	
13	**(Θ)** Glidepath Angle	**Θ** =	
14	Adjustment: **Adjust** = tan Θ x (p / [1/28.5 + Θ/102])		
15	**(DA_{adj})** Adjusted DA (uncorrected): DA_{adj} = current DA + Adjust	**DA_{adj}** =	
16	DA_{adj} value rounded to the next higher foot		

Notes:

1) If DA is adjusted, redraw missed approach.
2) To find DA_{adj} distance from RWT, go to Step 16.

Aerodrome	Procedure Identification

STEP 15. DA ADJUSTMENTS FOR MA OCS PENETRATIONS

15d. SECTION 2 ADJUSTMENT (Para. 3.9.1e)

1	Obstruction #		
2	**(p)** Penetration (from Step 9d)	**p** =	
3	**(Θ)** Glidepath Angle	**Θ** =	
4	DA adjustment: **Adjust** = (p / [1/40 + Θ/102]) x tan Θ		
5	**(DA_{adj})** Adjusted DA (uncorrected): DA_{adj} = current DA + Adjust	**DA_{adj}** =	
6	DA_{adj} value rounded to the next higher foot		

Notes:

1) If DA is adjusted, redraw missed approach.
2) To find DA_{adj} distance from RWT, go to Step 16.

STEP 16. ADJUSTED DA to RWT DISTANCE (DA_{adj}) (Fig 3-9C)

1	**DA_{adj}** (adjusted Decision Altitude)	**DA_{adj}** =	
2	$ELEV_{LTP}$	$ELEV_{LTP}$ =	
3	TCH	**TCH =**	
4	**(Θ)** Glidepath Angle	**Θ** =	
5	**(H_{DA})** Height of DA_{adj} above TCH: $H_{DA} = DA_{adj} - (ELEV_{LTP} + TCH)$	**H_{DA}** =	
6	**(Adjust D_{DA})** Adjusted distance of DA_{adj} to RWT: Adjust $D_{DA} = H_{DA}$ / tan Θ	**Adjust D_{DA}** =	

Note: Redraw missed approach using adjusted distance.

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Departure Procedures

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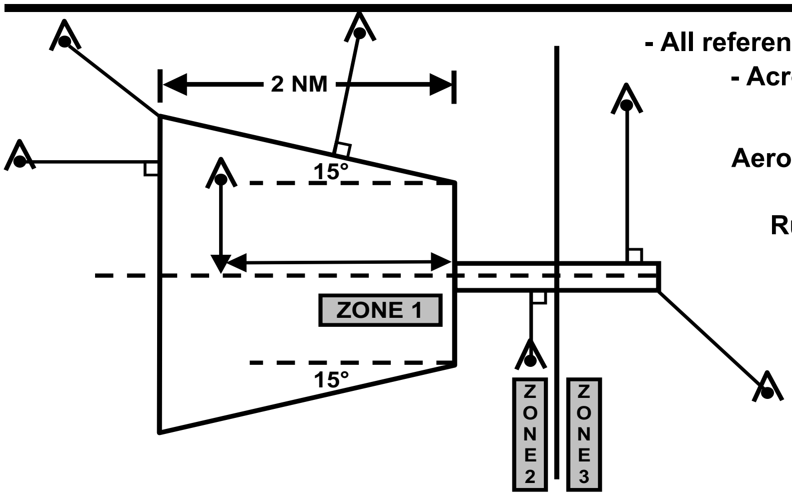


- All references are from Vol. 1 unless otherwise stated.
- Acronyms used may not reflect those in TP308.

Aerodrome: ____________________

Runway: ____________________

Date: ____________________

$ELEV_{DER}$	$ELEV_{A/D}$

STEP 1. ZONE 1

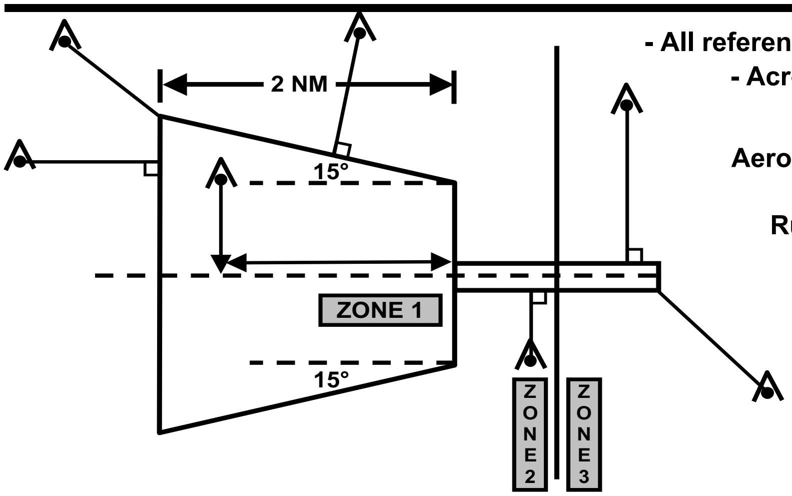
Part I - Obstacle Verification

1	Obstacle #						
2	**(ALT_{obs})** Obstacle Altitude	**ALT_{obs}** =					
3	**($ELEV_{DER}$)** Altitude of Departure End	**$ELEV_{DER}$** =					
4	**(d_{Z1})** Distance of obstacle from DER in zone 1	**d_{Z1}** =					
5	Rise of Zone 1 OIS (at obstacle) **R_{Z1}** $= d_{Z1} / 40$	**R_{Z1}** =					
6	Altitude of OIS at obstacle **ALT_{OIS}** $= ELEV_{DER} + R_{Z1}$	**ALT_{OIS}** =					
7	**(p)** Check for penetration $p = ALT_{OIS} - ALT_{obs}$	**p** =					
8	If **p** is negative, there is penetration.						

Part II - Increasing Climb Gradient

Note: The highest penetrating obstacle is not necessarily the most critical.

9	OIS climb gradient required **CG_{OIS}** $= (6076.11548 \times [ALT_{obs} - ELEV_{DER}]) / d_{Z1}$	**CG_{OIS}** =					
10	**(CG_{unc})** Uncorrected climb gradient $CG = CG_{OIS} / 0.76$	**CG_{unc}** =					
11	**(CG)** Corrected Climb Gradient (round to upper 10 ft) Select highest.	**CG** =					



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Aerodrome: ______________________

Runway: ______________________

Date: ______________________

$ELEV_{DER}$	$ELEV_{A/D}$

STEP 2. ZONE 2

Part I - Obstacle Verification

1	Obstacle #					
2	(**ALT_{obs}**) Obstacle Altitude	**ALT_{obs}** =				
3	(**ALT_{DER}**) Altitude of Departure End	**ALT_{DER}** =				
4	Rise of Zone 1 OIS (2 NM / 40) **R_{Z1}** = 303.81 ft	**R_{Z1}** =	303.81	303.81	303.81	303.81
5	Altitude of OIS at end of Zone 1 **ALT_{Z1}** = R_{Z1} + ALT_{DER}	**ALT_{Z1}** =				
6	(**d_{Z2}**) Distance of obstacle from Runway Edge or Zone 1	**d_{Z2}** =				
7	Rise of Zone 2 OIS at obstacle **R_{Z2}** = d_{Z2} / 40	**R_{Z2}** =				
8	Altitude of OIS at obstacle **ALT_{OIS}** = ALT_{Z1} + R_{Z2}	**ALT_{OIS}** =				
9	(**p**) Check for penetration **p** = ALT_{OIS} - ALT_{obs}	**p** =				
10	If **p** is negative, there is penetration.					

Part II - Increasing Climb Gradient

Note: The highest penetrating obstacle is not necessarily the most critical.

11	OIS climb gradient required **CG_{OIS}** = (6076.11548 x [ALT_{obs} - ALT_{Z1}]) / d_{Z2}	**CG_{OIS}** =				
12	(**CG_{unc}**) Uncorrected climb gradient CG = CG_{OIS} / 0.76	**CG_{unc}** =				
13	(**CG**) Corrected Climb Gradient (round to upper 10 ft) Select highest.	**CG** =				

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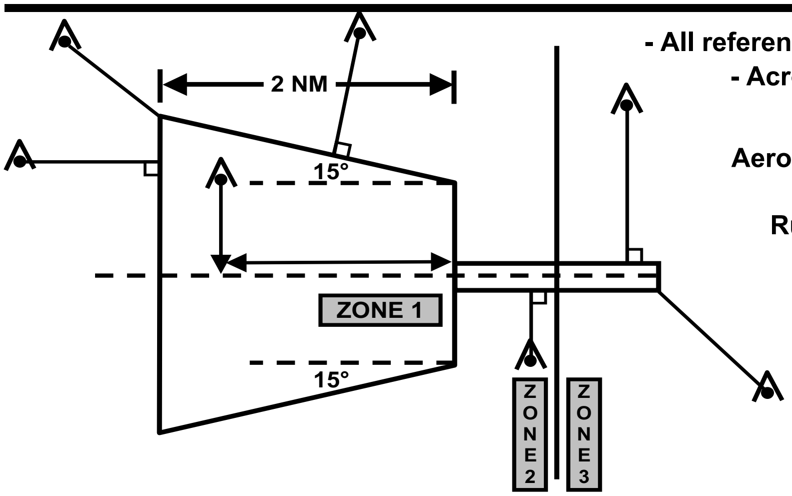

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Aerodrome: ______________________

Runway: ______________________

Date: ______________________

$ELEV_{DER}$	$ELEV_{A/D}$

STEP 3. ZONE 3

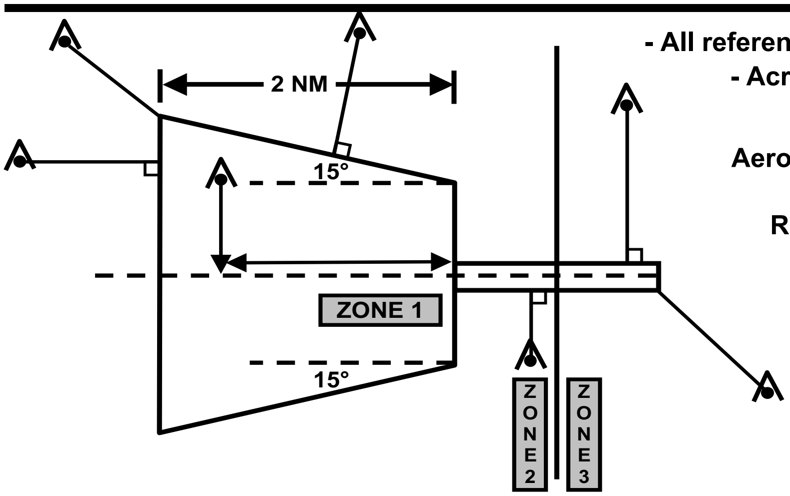
Part I - Obstacle Verification

1	Obstacle #					
2	**(ALT_{obs})** Obstacle Altitude	**ALT_{obs}** =				
3	**($ELEV_{A/D}$)** Aerodrome Elevation	**$ELEV_{A/D}$** =				
4	Rise of Zone 1 OIS (2 NM / 40) **R_{Z1}** = 303.81 ft	**R_{Z1}** =	303.81	303.81	303.81	303.81
5	Altitude of OIS at beginning of Zone 3 **ALT_{Z3}** = $ELEV_{A/D}$ + 400 ft	**ALT_{Z3}** =				
6	**(d_{Z3})** Distance of obstacle from Runway Edge	**d_{Z3}** =				
7	Rise of Zone 3 OIS at obstacle **R_{Z3}** = d_{Z3} / 40	**R_{Z3}** =				
8	Altitude of OIS at obstacle **ALT_{OIS}** = ALT_{Z3} + R_{Z3}	**ALT_{OIS}** =				
9	**(p)** Check for penetration **p** = ALT_{OIS} - ALT_{obs}	**p** =				
10	If **p** is negative, there is penetration.					

Part II - Increasing Climb Gradient

Note: The highest penetrating obstacle is not necessarily the most critical.

11	OIS climb gradient required **CG_{OIS}** = (6076.11548 x [ALT_{obs} - ALT_{Z3}]) / d_{Z3}	**CG_{OIS}** =				
12	**(CG_{unc})** Uncorrected climb gradient CG = CG_{OIS} / 0.76	**CG_{unc}** =				
13	**(CG)** Corrected Climb Gradient (round to upper 10 ft) Select highest.	**CG** =				



- All references are from Vol. 1 unless otherwise stated.
- Acronyms used may not reflect those in TP308.

Aerodrome: ______________________

Runway: ______________________

Date: ______________________

$ELEV_{DER}$	$ELEV_{A/D}$

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CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 4

ANNEX F

OLS VS OCS

TRANSPORT CANADA
NATIONAL DEFENSE

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NOTE ON THE DISTINCTION BETWEEN OBSTACLE LIMITATION SURFACES AND OBSTACLE CLEARANCE SURFACES

Care should be taken to distinguish between Obstacle Limitation Surfaces (OLS) dealt with in TP 312/CETO C-98-001-003/MS-022, and Obstacle Clearance Surfaces (OCS) dealt with in TP308/GPH209, as their purpose is different.

a. Obstacle Limitation Surface (Take-off/Approach, Transitional, and Outer Surface) define the volume of airspace that should ideally be kept free from obstacles in order to minimize the dangers presented by obstacles to an aircraft, either during an entirely visual approach or during the visual segment of an instrument approach (see Figure F-1). The Obstacle Limitation Surfaces are intended to be of a permanent nature Values are fixed in relation to the proposed airport use and therefore they form the basis for an enactment of Zoning Regulations.[1]

b. Obstacle Clearance Surfaces are intended to be used by instrument procedure specialists for the construction of instrument flight procedures and for specifying minimum safe altitudes for each segment of the procedure. Obstacle Clearance Surfaces are designed to meet the needs of a particular runway environment based on the location and height of existing obstacles, aeroplane speed, the navigational aid being used and in some cases the equipment fitted to the aeroplane. Rarely would two sets of OCSs be the same for the same type on instrument approach at different runways.

The standards for Obstacle Limitation Surface described in TP 312/CETO C-98-001-003/MS-022 determine whether an aerodrome can be certified and whether a runway can be authorized as an instrument runway or non-instrument runway. Once Obstacle Limitation Surfaces are in place, it is possible to exercise some discretion on what to do when they are penetrated. TP 312/CETO C-98-001-003/MS-022 Para 4.1.2 states, "New objects or extensions of existing objects shall not be permitted...except when in the opinion of the certifying authority, the new object or extension would be shielded by an existing immoveable object."

In the case of Obstacle Clearance Surfaces, the Minimum Vertical Clearance is always based on existing obstacles. If a new obstacle appears, the entire instrument approach procedure must be reviewed.

In summary, TP 308/GPH 209 (OCS) specifies the size and dimensions of the obstacle-free airspace needed for an instrument approach, a missed approach initiated at or above the Obstacle Clearance Altitude and for the visual maneuvering (circling) procedure. Aeroplanes continuing their descent below the specified Obstacle Clearance Altitude, and therefore having visual confirmation that they are properly aligned, are protected by TP 312/CETO C-98-001-003/MS-022 (OLS) and related obstacle limitations and marking/lighting requirements.

---

[1] "Registered Zoning Regulations" is defined as the enactment of Registered Zoning Regulations pursuant to the *Aeronautics Act*, Part 1, Sections 5.4 to 5.8, for the protection of approach and departure paths surrounding an aerodrome. In normal Canadian practice a Registered Zoning Regulation forbids penetration of runway Take-off/Approach, Transitional, and Outer Surfaces as described in TP312/CETO C-98-001-003/MS-022.

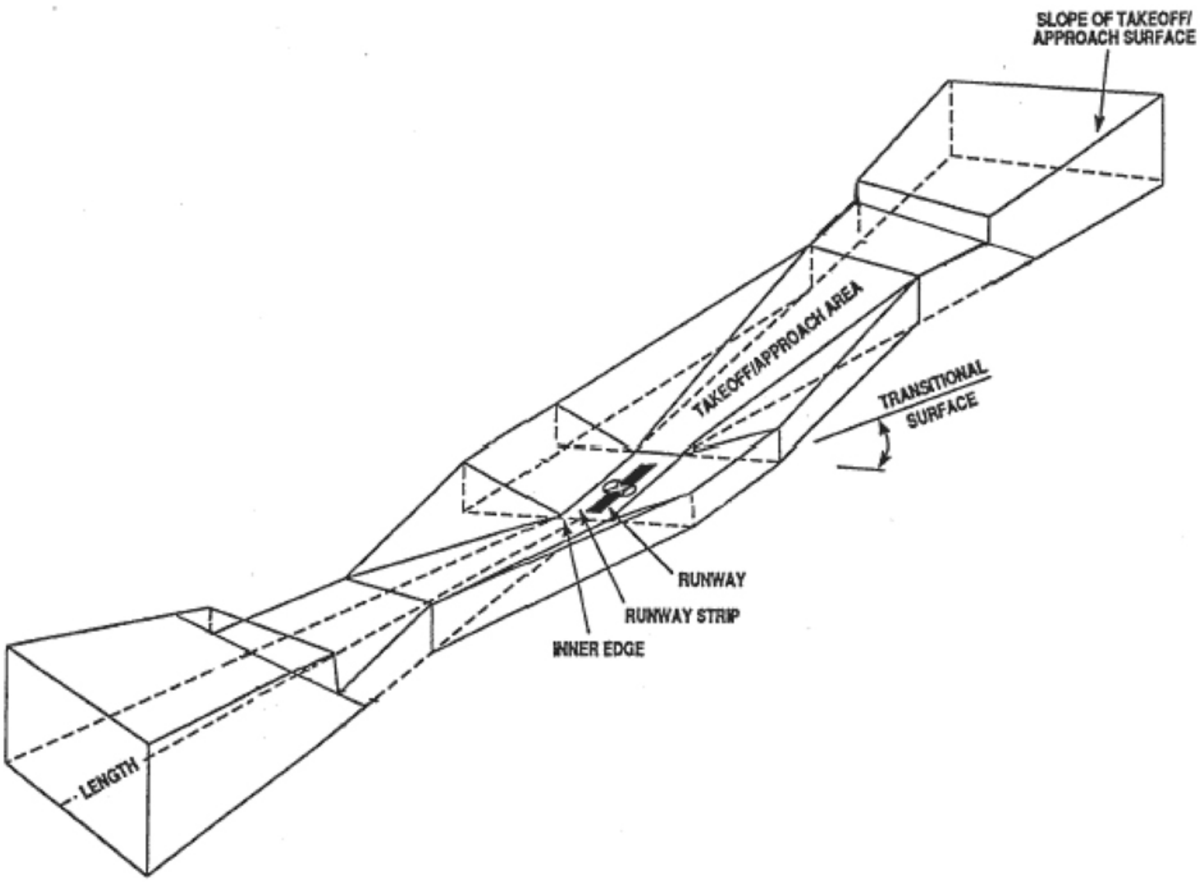

Figure F-1: Obstacle Limitation Surface

An example may serve to further clarify the above distinction. If a new object were to penetrate the Take-off/Approach Surface of an unzoned, precision approach runway, remedial options to be considered could include the following:

(1) Removal of the object,

(2) Displacing the threshold to retain a 2% gradient,

(3) Downgrading the level of operations to non-precision or non-instrument, or

(4) Marking the obstacle with a suitable hazard beacon.

(Although raising the glide path angle is another possibility, the size of the acceptable change - from the normal 3° to a maximum of 3.2° - is almost invariably too small to make this a practical option). If an Instrument Procedures Specialist determined that the obstruction would not affect landing minima, the certifying authority could chose to implement any of the above options. For example, if the object were a long way from threshold, and penetration were minimal, merely marking or lighting the obstruction could satisfy safety requirements. However, if the application of the Minimum Vertical Clearance to the penetration results in unacceptably higher minima, the certifying authority would have only the option of arranging removal of the obstruction or downgrading the level of operations. Of these, the one that least disrupted safety and regularity would be chosen.

Note: A Registered Zoning Regulation relates to lands "adjacent to or in the vicinity of airports", therefore it has no force with regard to lands inside the airport boundary. However, any penetration of an OLS inside the boundary would be sanctioned only if the object had to be so located for navigation or guidance purposes.

Note: Obstacles existing at the time a Registered Zoning Regulation comes into force are not affected by such Regulation. Removal of such an obstacle by legal means can only be done by acquiring the property under the Expropriation Act or payment of compensation.

Definitions:

Obstacle Limitation Surface (OLS). A surface that establishes the limit to which objects may project into the airspace associated with an aerodrome so that aircraft operations at the aerodrome may be conducted safely. Obstacle limitation surfaces consist of the following:

(1) Take-off/Approach surface. An incline plane beyond the end of the runway and preceding the threshold of a runway. The origin of the plane comprise:

  (a) An inner edge of specified length (strip width), perpendicular to and evenly divided on each side of the extended centre line of the runway, and beginning at the end of the runway strip;

  (b) Two sides originating at the ends of the inner edge, diverging uniformly at a specified rate in the direction of take-off;

  (c) The elevation of the inner edge is equal to the elevation of the threshold.

(2) Transitional surface. A complex surface sloping up at a specified rate from the side of the runway strip and from part of the take-off/approach surface. The elevation of any point on the lower edge of the surface is:

  (a) Along the side of the take-off/approach surface, equal to the elevation of the take-off/approach surface at that point; and,

  (b) Along the runway strip, equal to the elevation of the center line of the runway, perpendicular to that point.

Strip: An area of specified dimensions enclosing a runway, intended to reduce the risk of damage to aircraft running off a runway, and to protect aircraft flying over it during take-off and landing operations.

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ANNEX G

FORMULAS

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FORMULAS

1. Area Widths

FINAL APPROACH - VOR with FAF

½ $W_p = 0.05D + 1$
$W_s = 0.0333D$
W_p (NM) is the width of the primary area.
W_s (NM) is the width of the secondary area.
D (NM) is the distance from the VOR.

FINAL APPROACH - NDB with FAF

½ $W_p = 0.08333D + 1.25$
$W_s = 0.0666D$
W_p (NM) is the width of the primary area.
W_s (NM) is the width of the secondary area.
D (NM) is the distance from the NDB.

FINAL APPROACH - On-Airport VOR no FAF

½ $W_p = 0.02D + 1$
$W_s = 0.134D$
W_p (NM) is the width of the primary area.
W_s (NM) is the width of the secondary area.
D (NM) is the distance from the VOR.

FINAL APPROACH - On-Airport NDB no FAF

½ $W_p = 0.175D + 1.25$
$W_s = 0.134D$
W_p (NM) is the width of the primary area.
W_s (NM) is the width of the secondary area.
D (NM) is the distance from the NDB.

FINAL APPROACH – ILS

½ $W = 0.015D + 500$
W (feet) is the width of the primary area.
D (feet) is the distance from the threshold minus 200 feet.

FINAL APPROACH – ASR

$\frac{1}{2}\ W_p = .1D + 1$
W_p (NM) is the width of the primary area.
D (NM) is the distance from the radar antenna.

FINAL APPROACH – MLS

$\frac{1}{2}\ W_w = 0.036\ (D – 200) + 400$
$\frac{1}{2}\ W_x = 0.1075223\ (D – 200) + 700$
$\frac{1}{2}\ W_y = 0.1515223\ (D – 200) + 1{,}000$
W_w (feet) is the width of the "W" surface.
W_x (feet) is the width of the "X" surface.
W_y (feet) is the width of the "Y" surface.
D (feet) is the along track distance from the threshold.

FINAL APPROACH - MLS AZIMUTH-ONLY APPROACH

$\frac{1}{2}\ W_p = .1075223\ (D – 200) + 700$
$\frac{1}{2}\ W_s = .1515223\ (D – 200) + 1{,}000$
W_p (feet) is the width of the primary area.
W_s (feet) is the width of the secondary area.
D (feet) is the along track distance from the threshold.

2. Curve Of The Earth

Curve = D^2 (NM) x 0.8833
Curve = D^2 (SM) x 0.66679
Curve = D^2 (KM) x 0.25745
Curve is the curve of the earth in feet.
D is the distance (NM/SM/KM) from the ILS GPI or MLS Reference Datum.

3. Distance Flown Along An Arc

$$\text{Distance flown along an arc} = \frac{\text{Radius of arc (NM) X Angle}}{57.3}$$

Angle is the number of degrees of arc flown.

4. Required Obstacle Clearance

Secondary Areas

ROC INITIAL AND INTERMEDIATE SECONDARY AREA - See Graph C–3.

$$\mathrm{ROC} = \frac{500\,(W_s - D)}{W_s}$$

W_s (tenths of NM) is the width of the secondary area.

D (tenths of NM) is the distance of the obstacle from the inner edge of the secondary area.

ROC FINAL APPROACH SECONDARY AREA - VOR/DME, VOR with FAF or TACAN - i.e., where ROC in Final Primary Area is 250' - See Graph C–5.

$$\mathrm{ROC} = \frac{250\,(W_s - D)}{W_s}$$

W_s (tenths of NM) is the width of the secondary area.

D (tenths of NM) is the distance of the obstacle from the inner edge of the secondary area.

ROC FINAL APPROACH SECONDARY AREA - VOR without FAF or NDB with FAF - i.e., where ROC in Final Primary Area is 300' - See Graph C–6.

$$\mathrm{ROC} = \frac{300\,(W_s - D)}{W_s}$$

W_s (tenths of NM) is the width of the secondary area.

D (tenths of NM) is the distance of the obstacle from the inner edge of the secondary area.

ROC FINAL APPROACH SECONDARY AREA - NDB without FAF – i.e., where ROC in Final Primary Area is 350' - See Graph C–7.

$$\mathrm{ROC} = \frac{350\,(W_s - D)}{W_s}$$

W_s (tenths of NM) is the width of the secondary area.

D (tenths of NM) is the distance of the obstacle from the inner edge of the secondary area.

ROC SECONDARY AREA - VHF AIRWAY - See Figure 17–19.

$$ROC = \frac{500 \times D^2}{D^1}$$

D^1 (feet) is the total width of the secondary area.

Note: D^1 has a total width of 2 NM or 12,152 feet out to a distance of 51 NM from the en route facility, and then increases at a rate of 236 feet for each additional NM.

D^2 is the distance from the obstacle to the outer edge of the secondary area.

Note: Add an extra 1,000 feet in mountainous regions where 2,000 feet of obstacle clearance is provided and 500 feet in the regions where 1,500 feet of obstacle clearance is provided.

ILS Final Approach Zones

ROC ILS FINAL APPROACH - ZONE 1 - See Figure C–11.

$$ROC = (D \times \text{Tan GS angle}) - \frac{D(t)}{S(i)}$$

D (feet) is the distance from the GPI to the obstacle.

D(t) (feet) is the distance from the threshold to the obstacle minus 200 feet.

S(i) is the slope of the inner section approach surface.

ROC ILS FINAL APPROACH - ZONE 2 - See Figure C–11.

$$ROC = 0.02366D + 20 \text{ feet}$$

D (feet) is the distance from the GPI to the obstacle. D must be less than 10,975 feet.

ROC ILS FINAL APPROACH - ZONE 3 - See Figure C–11.

$$ROC = 0.01866D + 75 \text{ feet}$$

D (feet) is the distance from the GPI to the obstacle. D must be 10,975 feet or greater.

5. Helicopter Procedures

PAR FINAL APPROACH OBSTACLE CLEARANCE SURFACE

$$\text{Tan Angle} = \frac{\text{Obstacle Height}}{\text{D} - 775}$$

Obstacle Height is the height of the controlling obstacle above GPI.

D (feet) is the distance from the GPI to the obstacle.

6. TCH/GPI/RPI computations

ILS

RPI FOR RUNWAYS WITH ZERO SLOPE

TCH = (TAN GS) (DIST ANT TO TH) – (TH ELEV – ANT ELEV)
GPI = TCH / TAN GS
RPI = GPI

TCH (feet) is the height of the glide path above the runway threshold.

DIST ANT TO TH (feet) is the distance of the glide slope antenna to the runway threshold

GPI (feet) is the distance from the runway threshold where the glideslope intersects the approach surface baseline.

RPI (feet) is the distance from the runway threshold where the glideslope intersects the runway.

RPI COMPUTATIONS WITH SLOPING RUNWAYS

$$\text{RPI} = \frac{\text{TCH} = \text{(TCH) (DIST ANT FROM TH)}}{\text{TCH} + \text{(RWY CROWN ELEV ABEAM ANT - ANT ELEV)}}$$

TCH (feet) is the height of the glide path above the runway threshold.

DIST ANT TO TH (feet) is the distance of the glide slope antenna to the runway threshold

RPI (feet) is the distance from the runway threshold where the glideslope intersects the runway.

RWY CROWN ELEV ABEAM ANT is the elevation (MSL) of the crown of the runway centreline abeam the glideslope antenna.

ANT ELEV is the elevation (MSL) of the base of the glideslope antenna.

PAR

GPI/TCH FOR RUNWAYS WITH ZERO SLOPE

$$\text{RPI} = \text{A} - \sqrt{\text{B2 - C2}}$$

$$\text{GPI} = \text{RPI}$$

$$\text{GPI} = \text{TCH /TAN GS}$$

RPI (feet) is the distance from the runway threshold where the glideslope intersects the runway.

A (feet) is the distance from the PAR azimuth antenna to the threshold.

B (feet) is the distance from the radar reflector to the PAR azimuth antenna.

C (feet) is the distance from the PAR azimuth antenna to the runway centreline.

GPI (feet) is the distance from the runway threshold where the glideslope intersects the approach surface baseline.

TCH (feet) is the height of the glideslope above the runway threshold.

TCH COMPUTATIONS WITH POSITIVE SLOPING RUNWAYS

TCH = (TAN GS) (DIST TH FROM RPI) – (TH EL – RPI EL)

TCH (feet) is the height of the glide path above the runway threshold.

DIST TH FROM RPI (feet) is the distance of the runway point of intercept to the to the runway threshold.

TH EL is the elevation (MSL) of the runway threshold.

RPI EL is the elevation (MSL) of the RPI.

TCH COMPUTATIONS WITH NEGATIVE SLOPING RUNWAYS

TCH = (TAN GS) (DIST TH FROM RPI) + (TH EL – RPI EL)

TCH (feet) is the height of the glide path above the runway threshold.

DIST TH FROM RPI (feet) is the distance of the runway point of intercept to the to the runway threshold.

TH EL is the elevation (MSL) of the runway threshold.

RPI EL is the elevation (MSL) of the RPI.

7. Miscellaneous Formulas

FIX DISPLACEMENT ERROR

$$E = \frac{6067.115 \text{ x } D \text{ x } \sin B}{\sin (A + B)}$$

$$F = \frac{6067.115 \text{ X } D \text{ X } \sin B}{\sin (A - B)}$$

E/F (feet) are the along track fix displacement tolerance for a crossing radial/bearing.

D (NM) is the distance from the crossing radial/bearing facility to the plotted position of the fix.

A is the acute angle formed by the flight track and crossing radial/bearing.

B is the fix tolerance angle of the crossing fix facility.

REMOTE ALTIMETER SETTING SOURCE

$$\text{RASS Adjustment} = 2.3\ d_R + 0.14e \text{ (or E)}$$

RASS Adjustment (feet) is the increase to the ROC when a remote altimeter source is utilized.

d_R (NM) is the distance from the remote altimeter source to the ARP.

e (feet) is the elevation differential between the elevation of the RASS and the elevation of the airport/heliport/vertiport.

E (feet) is the terrain differential between the lowest and highest elevation points contained within the elevation differential area.

ILS

ACTUAL CLEARANCE OF OBSTACLE FROM ILS GLIDEPATH

$$C = (D \text{ x } \tan \text{GS angle}) - \text{Obstacle height}$$

C (feet) is the vertical clearance of the obstacle from the glidepath.

GS angle is the angle of the glidepath.

Obstacle height (feet) is the height of the obstacle above the approach surface baseline.

OBSTACLE PENETRATION VIOLATION CORRECTION - ZONE 1

S(i) = D(t) / obstacle height

S(i) is the required slope of the glidepath.

D(t) (feet) is the distance from the obstacle to the threshold minus 200 feet.

Obstacle height (feet) is the height of the obstacle above the approach surface baseline.

OBSTACLE PENETRATION VIOLATION CORRECTION - ZONE 2/3 (MINIMUM GLIDEPATH)

Tan (Minimum Glidepath) = (ROC + Obstacle height) / D

ROC (feet) is the required obstacle clearance for the obstacle located in Zone 2.

Obstacle height (feet) is the height of the obstacle above the approach surface baseline.

D (feet) is the distance from the GPI to the obstacle.

RNAV

FORMULA FOR THE 4 NM ZONE CURVE

$$\frac{X^2}{(25.5)^2} + \frac{Y^2}{(53)^2} = 1$$

X (NM) is the along track distance from the tangent point.

Y (NM) is the tangent point distance.

FORMULA FOR THE 8 NM ZONE CURVE

$$\frac{X^2}{(51)^2} + \frac{Y^2}{(102)^2} = 1$$

X (NM) is the along track distance from the tangent point.

Y (NM) is the tangent point distance.

DISTANCE OF TURN ANTICIPATION

DTA = 2 x Tan (turn angle / 2)

DTA is the distance of turn anticipation prior to the earliest point can be received.

Turn Angle is the magnitude of turn over the waypoint.

MLS

ALONG TRACK DISPLACEMENT TOLERANCE AT THE TRANSITION WAYPOINT - Tracking towards the DME facility.

$$E_{AT} = d - \big((d - 0.25) / 1.0125\big)$$

E_{AT} is the along track displacement tolerance at the TWP.

D is the direct distance from the earliest point the transition way point can be received to the DME facility.

ALONG TRACK DISPLACEMENT TOLERANCE AT THE TRANSITION WAYPOINT - Tracking away from the DME facility.

$$E_{AT} = d + \big((d + 0.25) / 0.09875\big)$$

E_{AT} is the along track displacement tolerance at the TWP.

D is the direct distance from the earliest point the transition way point can be received to the DME facility.

EFFECTIVE OBSTACLE HEIGHT

$$\text{EOH} \quad = H + (954 - \text{GPI}) / S$$

EOH is the effective obstacle height adjustment for GPIs less than 954 feet.

H is the altitude (MSL) of the obstacle.

GPI is the distance of the GPI from the threshold.

S is the "W" surface slope for the glidepath angle.

MINIMUM GLIDEPATH DETERMINATION AND ROC ADJUSTMENTS FOR GLIDEPATH ANGLES GREATER THAN 3°.

$$\text{"W" surface slope} = d / \big((H - O) + W\big)$$

H is the height of the obstacle above the approach surface baseline.

O is the height of the OCS above the approach surface baseline.

W is the height of the "W" surface OCS abeam the obstacle.

d is the ATD abeam the obstacle to the start of the "W" surface.

SPIRAL RADIUS PITCH FACTOR.

$$P = S(2\pi r)$$

P is the pitch factor for a 360° turn.

S is the splay factor for the surface boundary (W = 0.036, X= 0.1075233, Y=0.1515133).

r is the flight track radius of turn (NM)

$\pi = 3.1415927$

SPIRAL RADIUS FOR EACH OUTSIDE SURFACE BOUNDARY.

$$R_o \quad r + W_p + (P / 360)\,t$$

R_o (NM) is the spiral radius for the outside boundary.

R (NM) is the flight track radius of turn.

W_p (NM) is ½ of the surface width at the ROWP.

P is the pitch factor for a 360° turn.

t is the amount of turn in 15° segments.

SPIRAL RADIUS FOR EACH INSIDE SURFACE BOUNDARY.

$$R_j \quad = r - W_p + (P / 360)\,t$$

R_j (NM) is the spiral radius for the inside boundary.

R (NM) is the flight track radius of turn.

W_p (NM) is ½ of the surface width at the ROWP.

P is the pitch factor for a 360° turn.

t is the amount of turn in 15° segments.

OBSTACLE RICH ENVIRONMENT - GLIDEPATH ALTITUDE AT BEAM THE CRITICAL POINT

$$\text{GP Altitude} = \big((\text{ATD} + \text{GPI}) \times \text{Tan GP}\big) + \text{ASB}$$

GP Altitude is the altitude (MSL) abeam the critical point.

ATD (feet) is the along track distance abeam the critical point to the threshold.

GPI (feet) is the distance from the threshold to the GPI.

Tan GP is the tangent of the glide path angle.

ASB is the altitude (MSL) of the approach surface baseline.

OBSTACLE RICH ENVIRONMENT ASSESSMENT - FINAL APPROACH SEGMENT

ORE Surface $= ((D - 200) / S] + ((D_x - D_w) / 4) + ((D_y - D_x) / 7) + (D_c / 40)$

ORE Surface (feet) is the height of the ORE surface above the approach surface baseline.

D (feet) is the along track distance from the threshold to abeam the critical point.

S is the slope of the "W" surface for the glidepath angle.

D_x (feet) is the width of the "X" surface boundary abeam the critical point.

D_w (feet) is the width of the "W" surface boundary abeam the critical point.

D_y (feet) is the width of the "Y" surface boundary at the critical point.

D_c (feet) is the distance along the 15° splay from the critical point to the obstacle.

OBSTACLE RICH ENVIRONMENT ASSESSMENT - INTERMEDIATE APPROACH SEGMENT

ORE Surface = MDA + $(D_c / 40)$

ORE Surface (feet) is the height of the ORE surface above the approach surface baseline.

MDA is the Minimum Descent Altitude (MSL) for the intermediate segment

D_c (feet) is the distance along the 15° splay from the critical point to the obstacle.

8. Trigonometric Formulas

Tangent of an angle = O / A

O is the length of the side opposite to the angle.

A is the length of the side adjacent to the angle.

Sine of an angle = O / H

O is the length of the side opposite to the angle.

H is the length of the hypotenuse the triangle.

Cosine of an angle = A / H

A is the length of the side adjacent to the angle.

H is the length of the hypotenuse the triangle.

$H^2 = O^2 + A^2$

H is the length of the hypotenuse of the triangle.

O is the length of the side opposite to the angle.

A is the length of the side adjacent to the angle.

CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

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ANNEX H

WAYPOINT CALCULATIONS

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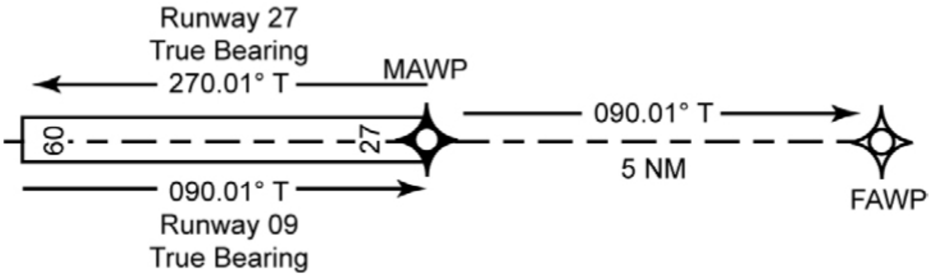
CALCULATION OF WAYPOINT CO-ORDINATES

1. Waypoint Co-Ordinates

For the calculation of all approach waypoints from the IAWP to and including the MAWP that lie on the runway centreline extended, the reciprocal of the true bearing of the landing runway is used. It is applied outward from the landing threshold. To establish approach waypoint co-ordinates on the extended runway centreline of Runway 27, apply 090.07ºT (the reciprocal of the runway 27 true bearing) from the MAWP which is the landing threshold in the figure below. For departure procedures, use the actual true bearing of the departure runway applied from the start end of the runway.

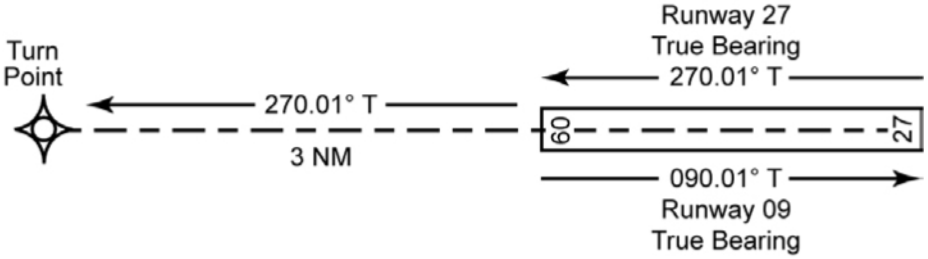


Example : To calculate the co-ordinates of the FAWP for RWY 27:

Given:

RWY 27 Threshold Co-ordinates:	N45 25 34.99435W075 34 16.84551
Distance, Threshold to FAWP:	5NM
RWY 27 True Bearing:	270.01°T
Reciprocal (270.01 – 180):	090.01°T
True Bearing Applied:	090.01°T
Calculated FAWP Co-ordinates:	N45 25 34.72137W075 27 10.88036

To establish departure waypoint co-ordinates for a departure from RWY 27, apply the departure runway true bearing and the distance from the threshold to the waypoint.



Example : Calculate the co-ordinates of a departure turn point:

Given:

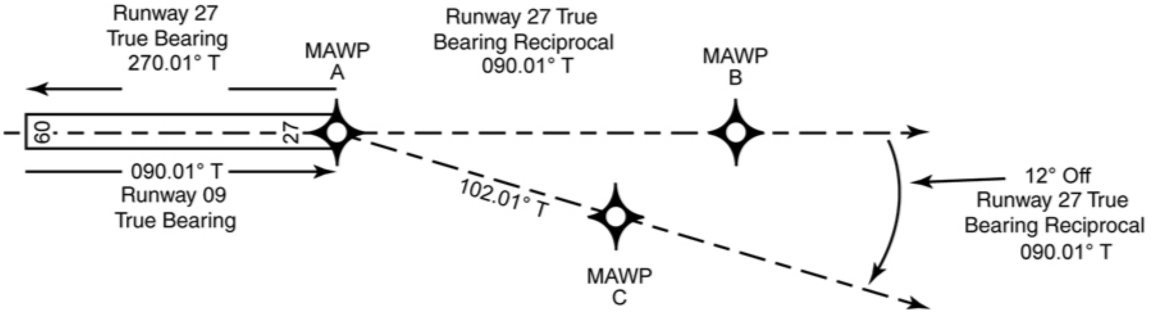
RWY 27 Threshold Co-ordinates:	N45 25 34.99435W075 34 16.84551
Distance, Threshold to Turn Point:	3.8 NM (including runway length)
RWY 27 True Bearing:	270.01°T
Calculated Turn Point Co-ordinates:	N45 25 34.94634W075 38 32.42482

2. Missed Approach Waypoint Co-Ordinates

MAWP A—Where the MAWP is located at the runway threshold, use the co-ordinates of the designated centre of the landing threshold as the MAWP co-ordinates.

MAWP B—Where the MAWP is located on the runway centreline extended, use the reciprocal of the landing runway true bearing, threshold co-ordinates and intended distance from the threshold to the MAWP for calculating the co-ordinates.

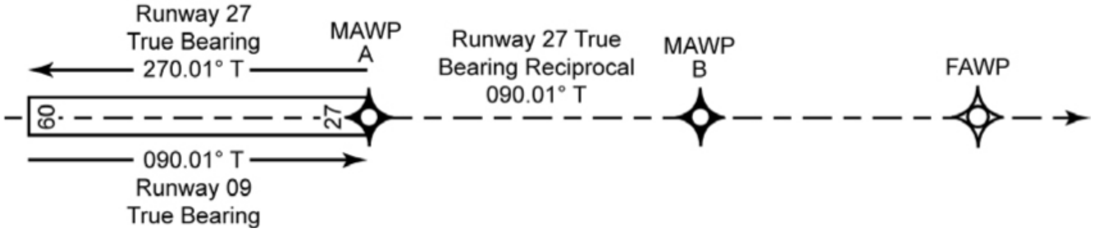
MAWP C—Where the final approach course is offset from the runway centreline extended and the MAWP is located prior to the runway threshold, use the threshold co-ordinates, and the true bearing and the intended distance from the threshold to the MAWP for calculating the co-ordinates.



3. Final Approach Fix (FAWP) Co-Ordinates

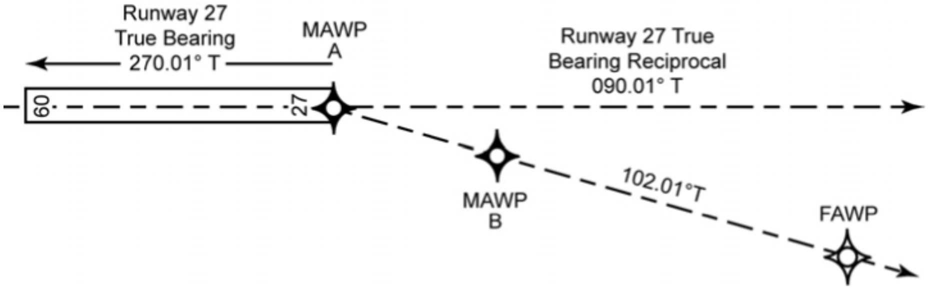
Example 1: Where the FAWP is on the runway centreline extended, use the reciprocal of the landing runway true bearing, threshold co-ordinates, and the intended distance from the threshold to the FAWP for calculating the co-ordinates.

Note: The MAWP may or may not be located at the threshold.



Example 2: Where a continuous great circle course includes the FAWP, the MAWP and the threshold but does not lie on the runway centreline extended, calculate the FAWP co-ordinates using the threshold co-ordinates and the true bearing and distance from the threshold.

Note: Use the same true bearing to create both the MAWP and FAWP co-ordinates. The MAWP may or may not be located at the threshold.

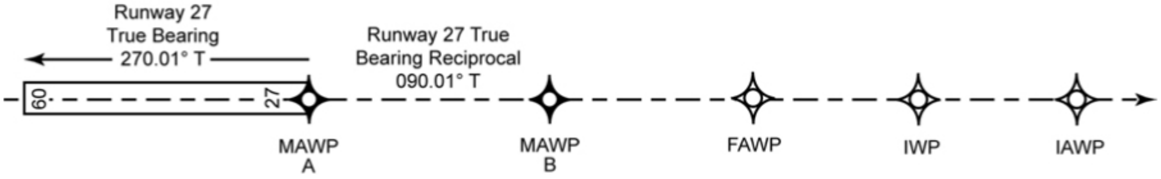


Example 3: Where a continuous great circle course includes the FAWP and the MAWP but does not pass through the threshold, calculate the FAWP co-ordinates using the MAWP co-ordinates and the true bearing and intended from the MAWP to the FAWP.

4. Intermediate Waypoint (IWP) And Initial Approach Waypoint (IAWP) Co-Ordinates

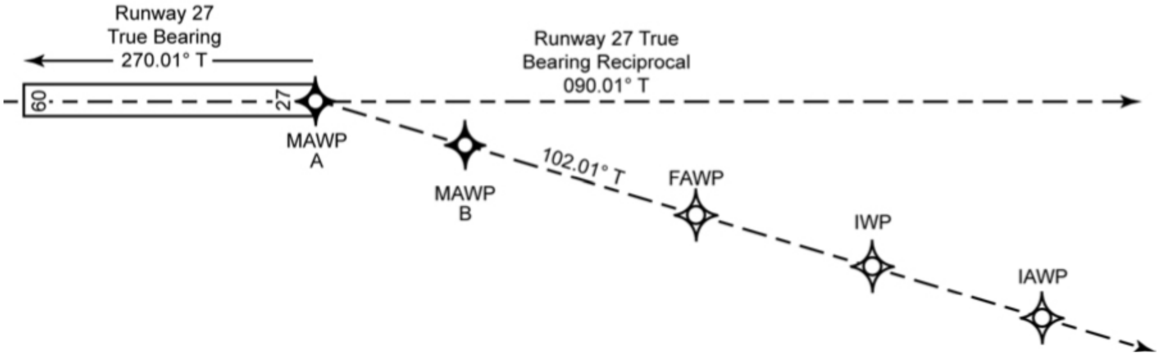
Example 1: Where the IAWP, IWP, FAWP and MAWP are located on the runway centreline extended, use the threshold co-ordinates, the reciprocal of the landing runway true bearing and the distance from the threshold to the IAWP and IWP for calculating the co-ordinates.

Note: The MAWP may or may not be located at the threshold.

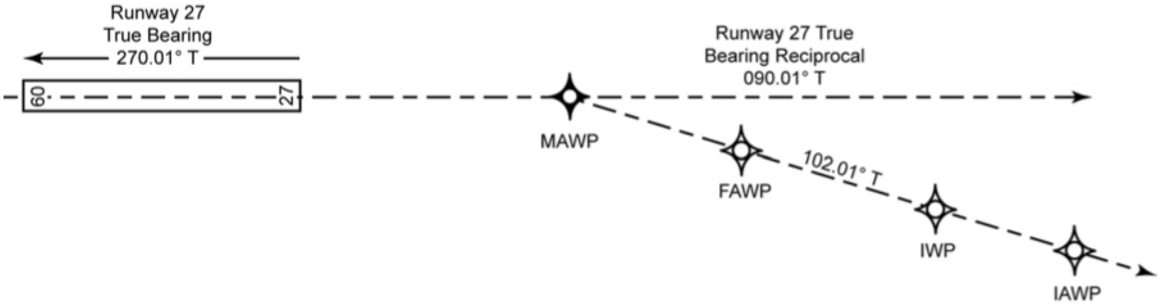


Example 2: Where a continuous great circle course includes the IAWP, IWP, FAWP, MAWP and the threshold but does not lie on the runway centreline extended, calculate the IWP co-ordinates using the threshold co-ordinates and the true bearing and distance from the threshold to the IAWP and IWP.

Note: The MAWP may or may not be located at the threshold.

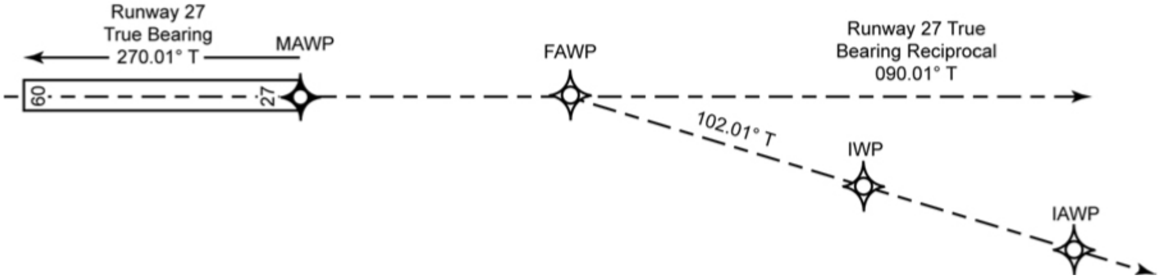


Example 3: Where a continuous great circle course includes the IAWP, IWP, FAWP and the MAWP but not pass through the threshold, calculate the IWP co-ordinates using the MAWP co-ordinates and true bearing and distance from the MAWP to the IAWP and IWP.

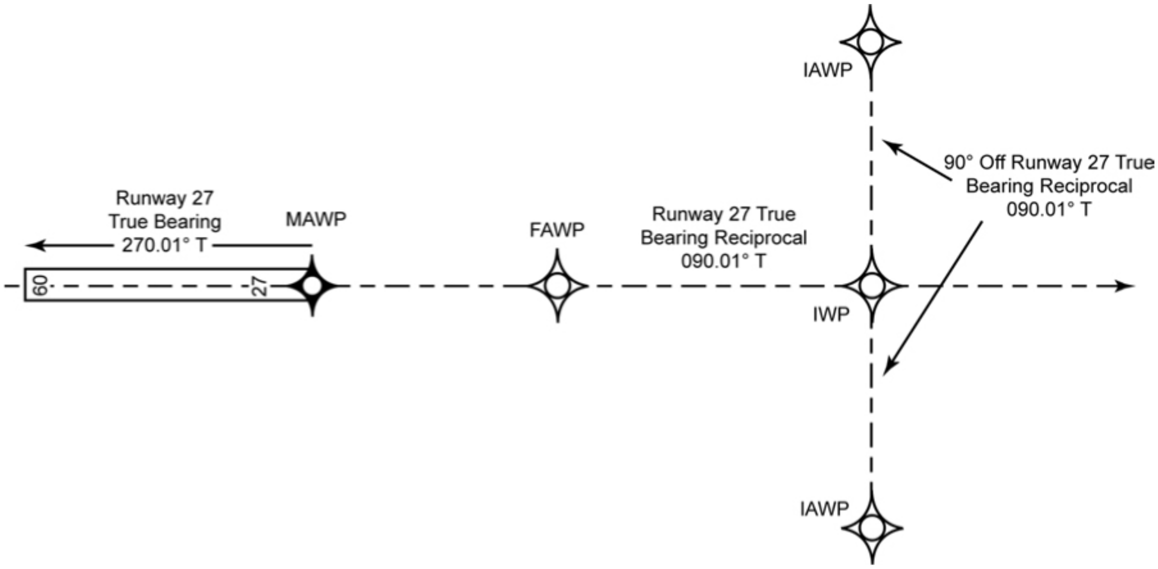


Example 4: Where the IAWP and IWP is not on a continuous great circle course that includes both the FAWP and the MAWP, use the FAWP co-ordinates and the true bearing

and distance from the FAWP to IAWP/IWP for calculating the IAWP/IWP co-ordinates.



Example 5: To calculate the co-ordinates of waypoints on a typical "T" procedure, use the reciprocal bearing of the landing runway as the reference.



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CRITERIA FOR THE DEVELOPMENT OF INSTRUMENT PROCEDURES

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ANNEX I

FLIGHT CHECK PROCEDURES

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PROCEDURES FOR CONDUCTING FLIGHT CHECKS

This Annex provides direction to aircrews conducting instrument procedure (IP) flight checks. These procedures are in addition to and do not supercede regulations such as Canadian Aviation Regulations (CARs), authorized Aircraft Flight Manuals, appropriate Operations Certificates and Specifications, and approved Flight Operations Manuals and Checklists that currently apply to the aircraft used.

1. Flight Safety

The flight procedures described in this Annex are designed to accomplish the objectives of the flight check in a safe and efficient manner. They are not intended to be limiting nor may they cover all possible circumstances or contingencies. Since it is impossible to foresee and accommodate every operational environment, and there will undoubtedly be occasions when deviations from these procedures will be necessary, pilots must exercise good judgment and airmanship. Any change from the planned mission or deviation from SOP's must be clearly communicated to the crew and understood prior to execution. When safety of flight is in jeopardy, the flight check shall be discontinued until the condition is resolved.

If the aircraft is certified for single pilot operation, the flight check shall not be undertaken without a safety pilot.

2. Definitions And Abbreviations

a. Flight Check (FC) – A flight assessment of an instrument procedure or airway, for the purpose of evaluating and verifying that the procedure is operationally acceptable for safety, flyability and design accuracy.

b. Flight Inspection (FI) - The operation of an aircraft for the purpose of calibrating air NAVAIDs or monitoring/evaluating the performance of air NAVAIDs. It is the responsibility of the NAVCANADA Flight Inspection Office (NCFIO) to conduct FI flights.

3. Purpose Of The Flight Check

A flight check must be conducted on each instrument procedure to confirm the following minimum requirements:

a. Obstacle Evaluation:

   (1) Verification of controlling obstacles in accordance with Para 6.a; and

   (2) Verification of other relevant obstacles that may need to be identified and noted on the IAP chart for safety purposes;

b. Verification of Draft IP Data:

   (1) The classification of airspace associated with the procedure, including noise and environmental considerations, is appropriate;

   (2) The availability of communication and surveillance services is as expected throughout each segment;

   (3) The approach chart (or equivalent) contains comprehensive information necessary to fly the approach safely, and is unambiguous;

   (4) The aerodrome facilities (runway markings, lighting, wind direction indicators) are consistent with the draft procedure calculations (visibility limits) and depictions;

  - (5) The accurate position of all fixes and waypoints, by comparing NAVAID information, FMS/GPS co-ordinates, and visual confirmation of positions plotted on topographical maps;
  - (6) All navigational information, including the bearings and distances, are accurate within the tolerances specified in this document;
  - (7) Confirm track accuracy (heading and alignment) with reference to topographical maps;
  - (8) Any other aspect that may affect the safety or effectiveness of the procedure.

c. Flyability Assessment:

  - (1) A verification of the flyability of the procedure in accordance with Para 4.c;

4. Crew Responsibilities

a. Pilot-in-Command (PIC). The PIC shall be responsible for the safe and effective operation of the aircraft in accordance with applicable policies and procedures. The PIC shall ensure that all standard preparations, authorizations, operations, and reports are completed and submitted, as regards to the aircraft.

b. The First Officer, or Second-in-Command pilot, shall perform standard procedures as directed.

c. Pilot Flying (PF). The PF is primarily responsible for the safe and effective handling of the aircraft, however, during the flight check, the PF shall also be responsible for the assessment of procedure flyability (see Para 3.c and 4.c).

d. Pilot Not Flying (PNF). In addition to normal flight duties, the PNF or safety pilot shall be responsible for the flight check verifications detailed in Para 3.a & b., and all other associated flight check requirements in accordance with this document.

e. Flight Check Pilot (FCP). The PNF or safety pilot shall be designated as the FCP and be responsible for the safe and efficient completion of the Flight Check as detailed in this Annex. If the FCP is not the procedure designer, the FCP must be very thoroughly briefed, by the procedure designer, on the specific details of the draft procedure and the flight check requirements, as detailed in this Annex.

5. Pre-Flight Preparations

a. Procedure Package. The procedure designer shall provide a flight check package that at a minimum shall include:

  - (1) Topographical map coverage of the procedure area;
  - (2) CAP Chart, or front page of the IP submission form; and
  - (3) Copy of submission form and worksheets giving the following;
  - (4) List of relevant obstacles:
  - (5) Identification of controlling obstacles:
  - (6) Waypoint and fix calculations and co-ordinates;
  - (7) Procedure tracks, distances and altitude calculations
  - (8) Any other documentation that may support the Flight Check.
  - (9) Flight Check Report Form;

The FCP should normally be the procedure designer. If not, then the FCP must ensure he/she is thoroughly conversant with all aspects of the draft procedure prior to flight. In all cases the FCP must ensure that the flight check crew is familiar with the procedure, the flight check requirements, profile and altitudes to be flown.

b. Waypoint Entry. Flight checks often require the entry of fixes or waypoints in an FMS or other aircraft navigation systems, to assist with navigation or to confirm the accuracy of topographical positions plotted on maps. It is recommended that all programming be done on the ground, however, unforeseen requirements may require this to occur during the flight.

Prior to use, a second party shall confirm the accuracy of the co-ordinates for all fixes and waypoints entered. This may be achieved through observation by another person, done while each waypoint is entered or, preferably, by confirming all parameters after the procedure is completely programmed. (i.e.. PNF or safety pilot would make all the necessary entries in the FMS or GPS system and then the PF verifies those entries).

c. Waypoint or Fix Accuracies. All waypoint positions that have been computed, based on a distance and bearing from another waypoint, fix or NAVAID must be verified for accuracy after entry in the FMS or GPS, and verified during the flight as follows:

(1) Waypoints shall be transferred to the avionics with a precision of 0.01 minutes for all waypoint co-ordinates.

(2) Distances within 0.1 NM of those intended in the procedure design;

(3) Track bearings shall agree within ±1º (see Para 3.g below) ; and

(4) Waypoint position shall be within 600 feet of the plotted position.

d. Tracking Accuracy. FMS and GPS systems do calculations and in-flight tracking using "True". Variation is only added for display purposes. The variation applied is local variation, applied in real-time, and based on the aircrafts current positional co-ordinates. Due to the difference between the applied local variation and the average variation used in calculations (i.e.. 1/4 or mid point variation on airways/air routes), there may be a display difference of +/- 1º or more. If a difference is noted, double check track accuracies by selecting True track on the FMS/GPS display and compare the True values. The values should then agree within ± 1º.

6. In-Flight Procedures

Crews should use an appropriate checklist (see samples - Attachment I-1) to ensure all flight check items are completed and to record acceptability and flyability of the IP.

a. Obstacle Assessment:

A primary purpose of the flight check is to verify all obstacles that affect the procedure. Controlling obstacles dictate procedural altitudes such as MOCA's and MDA's. They must be confirmed for accuracy of positional co-ordinates and estimated height. Crews must also verify all segments to detect and report unexpected obstacles that may bear some significance, and also make note of and report those obstructions that may be in the NAV CANADA Aeronautical Information Database System (NAIDS) but are incorrect or no longer present.

A recommended technique is to search each segment or area in a pre-planned manner at a low enough altitude that may promote observation of obstacles against the horizon. A height of 500' AGL is recommended. The PNF or safety pilot is responsible for visually searching for and verifying obstructions. Although the PF may assist in searching to a limited degree, he shall be primarily concerned with maneuvering the aircraft such that the pilot not flying (PNF) has an optimum view of the area or position in question. Smaller areas may be adequately covered by flight near the centerline, whereas larger areas may require a flight around the perimeter. The controlling obstacle as identified by the designer should be investigated first, then others that are significant. Programming positions in the FMS or GPS and using the "Hold Position" feature may be useful. The height of trees and vegetation atop any significant terrain spot heights should also be confirmed. Finally, the search must be thorough enough to ascertain that no other obstruction or terrain feature is higher than the expected controlling obstacle.

Crews should be prudent when approaching obstructions, to confirm position and height ASL and AGL. Determination of obstacle height shall not be attempted by flying over it. If flight conditions permit, and the maneuver can be accomplished safely, obstacle height may be estimated by flying adjacent to the obstacle with a lateral separation of at least 500 feet. Obstacle heights that are in question shall be reported to the appropriate NAV CANADA Field Office, for further investigation. The flight check shall not be signed off until the issue is resolved satisfactorily.

When vertical guidance aspects such as ILS glideslope or VNAV final, are assessed for obstacles, the Obstacle Clearance Surface should be flown using FMS VNAV, with temperature correction applied. Similarly, the missed approach Obstacle Identification Surface should be flown at a climb gradient of 148 feet per NM, commencing at the MAP, from a recommended height of 100 feet below the MDA, to the published altitude.

b. Verification of Data.

(1) Defining a New Waypoint In Flight: Occasionally, programming an additional fix, position, or waypoint may be required after the flight check has commenced. During flight in a two-crew situation, the PF will have to perform the verification of coordinates. For safety, the particular inspection sequence must be discontinued and the aircraft should be established in level flight at least 1000 feet above local terrain and obstacles. (i.e.. The PNF shall enter all of the required co-ordinates. The PF shall then transfer control (monitor for safe flight if on autopilot) to the PNF, prior to confirming the entries.)

(2) Altitudes: Procedural altitudes, such as the Glide Path check altitude at the FAF, etc., must be confirmed.

(3) Altimeter Setting Source: Availability of the Altimeter source must be confirmed.

(4) NAVAID Monitoring: Prior to inspecting any aeronautical product, the identification of all conventional radio navigational systems must be confirmed for clarity of signal and accuracy of identifier. As well, it is recommended that one pilot monitor the outbound NAVAID while the other monitors the inbound during an airway inspection. At distant ranges, navigational information may appear useable, but is not valid without reception of the identifier. If any doubt exists regarding adequate coverage, NCFIO shall be requested to do an FI to establish coverage level (i.e.. MEA for airways).

(5) Communication: Air-to-ground radio communications must be confirmed available where intended for the procedure. In controlled airspace, communications with an appropriate ATS facility must be available for an IAP at the initial approach fix minimum altitude and missed approach clearance limit altitude, and along an airway at the MEA. In uncontrolled airspace, in addition to the appropriate MF or other

specified aerodrome frequencies, 126.7 MHz should be monitored when practical. As flight check maneuvering requirements may be unusual to local traffic, crews are encouraged to broadcast frequent advisories of intended maneuvers.

(6) Confirming Fix or Waypoint Positions:

(a) RNAV fixes: All fixes and waypoints in any procedure must be verified to correspond to the position intended by the procedure designer, as plotted on topographical charts. Normally, each should be programmed in an FMS or GPS, using the designer’s calculated co-ordinates, and designated “fly-over” to avoid turn-anticipation. Close-in navigation should be in stable flight with a minimum of flight technical error, at a recommended low altitude of 500-1000 AGL. The position should be verified visually with reference to the topographical chart to be within a lateral tolerance of ±0.1 NM or 600’.

(b) Conventional fixes: Should the fix have reference to conventional navaid’s, such as radial/DME or NDB cross bearing, the navigational performance should be noted upon crossing the plotted fix. It must be within the acceptable fix error tolerances, which should have calculated values available in the procedure package and be depicted on the procedure maps. Should any fix appear outside the displacement limits, it should be over flown a second time for confirmation, and the result reported to the designer for resolution. Common displacement values as per articles 285 and 286 of TP308 are:

(i) Along Track

- VOR/TACAN radials: ± 4.5°
- Localizer course: ± 1°
- LF bearings: ± 5°

(ii) Cross Track

- VOR/TACAN radials: ± 3.6°
- Localizer course: ± 0.5°
- LF bearings: ± 5°

(iii) Radar: Greater of ± 500’ or 3 percent of distance to the antenna.

(iv) DME: ± .25 NM plus .0125 of distance to transmitter.

(c) Tracking: The accuracy of any published track, which is the line or route between two fixes or waypoints, or the bearing or radial that is out from or inbound to a navigational aid, must be confirmed. These tracks are normally plotted on topographical maps, from which obstacle clearance minima are determined. The navigation equipment should be tuned to the primary NAVAIDs, such as VOR’s for a VHF low-level airway, but the track should also be programmed in the FMS/GPS for reference. This check becomes the subjective comparison of three aspects: the conventional navaid performance, the FMS performance, and visual reference to the track as drawn on a topographical map.

The recommended technique is to display FMS information on the PF instruments, and conventional navaid information on the PNF instruments. The planned centreline of the primary navaid should be flown, and displacement from the plotted track on the topographical chart should be estimated and noted. Alternatively, the aircraft may be flown over the plotted track by visual reference to the map, and the performance of the navigational instruments should be observed for accuracy. A number of factors will affect accuracy, such as atmospheric conditions, aircraft antenna position, instrument errors, and flight technical error. Normally, tracking between fixes in close proximity such as in an IAP should be within 0.1 NM laterally, whereas tracks between distant fixes such as on an airway should be within 0.5 NM lateral. A.I.P Canada states navigation aid course accuracy parameters as follows:

(i) VOR/TACAN Radial - within 3°

(ii) NDB - within 5° for approach, 10° for enroute

(iii) DME – within 0.5 NM or 3% of distance

(iv) GPS – within 100m, 95% of the time

Gross errors exceeding these parameters shall be reported to the procedure designer for resolution, and once resolved another flight check should normally be performed before commissioning the procedure.

c. Flyability Assessment

(1) The PF shall assess the procedure for flyability. He/she is not required to be the original designer of the approach, but must be trained or thoroughly briefed on the assessment criteria, and shall complete any documentation related to that portion of the inspection.

(2) The flyability assessment shall be flown at speeds and aircraft configurations consistent with normal IFR operations and to meet the design intent.

(3) The procedure must be flown with sole reference to the navigational aids specified. Each segment of the approach, including the complete missed approach, shall be flown at least once during the flyability assessment, at the altitudes specified for publication. Should more than one initial segment or transition be specified, all must be flown. The cross-track error shall be continuously monitored and maintained within normal tolerances by the PF.

(4) Since the aircraft and equipment capability of the anticipated user population should be considered, the PF shall ascertain that all aircraft manoeuvring required during the approach is consistent with safe operating practices for those aircraft and pilots commonly expected to use the procedure.

Note: Particular attention shall be paid to any turning areas. These areas shall be flown at both the minimum and maximum Category speeds that could be used to ensure obstacles have been satisfactorily assessed inside and outside the turn area.

(5) Items for flyability assessment shall include:

(a) Turn anticipation;

(b) Approach speeds;

(c) Descent gradients;

(d) Required bank angles, especially at the IWP turn;

(e) Distance to runway at minima;

(f) Rate of descent from minima to conduct a safe landing;

(g) Acceptability of leg lengths, considering maximum category speeds and the greater of 25° bank or 3°/sec turns; and

(h) Pilot workload

(6) Should the crew discover any aspect of the approach that has the potential to compromise safety, such as excessive descent rates or bank angles, or excessive cockpit workload, then the flyability assessment shall be considered failed. In this case, the issue shall be referred to the appropriate procedure designer for resolution, and a subsequent successful flight check shall be completed before commissioning the procedure.

d. GPS Procedures

GPS NPA procedures normally consist of a sequence of four or more waypoints that define the approach, organized into segments as follows:

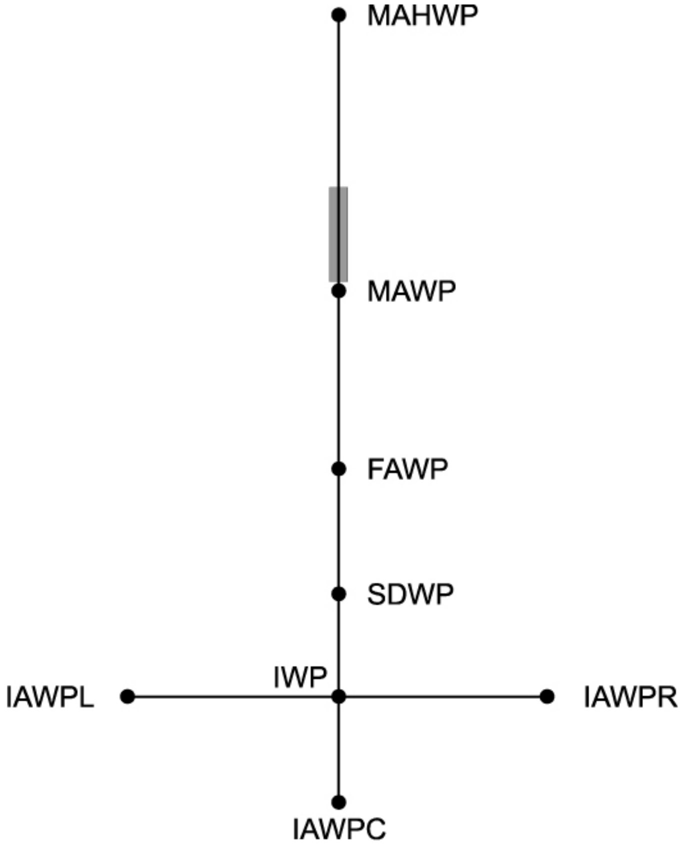
(1) Initial Segment: IAWP (L, R, or C) to IWP

(2) Intermediate Segment: IWP to FAWP

(3) Final Segment: FAWP to MAWP

(4) Missed Approach Segment: MAWP to MAHWP

The figure below shows a typical approach procedure:



Note that any segment may contain one or more stepdown waypoint to reduce the effect of critical obstacles.

Missed approach turning waypoints may also be included in the missed approach segment to facilitate navigation to the MAHWP.

(1) GPS Preflight: To ensure that a sufficient number of satellites and adequate geometry are available during the inspection, it is recommended that the crew obtain GPS status and forecast information and perform a RAIM prediction as part of the flight planning. An aircraft should not be dispatched unless there is a reasonable certainty that RAIM will be available throughout the inspection. Furthermore, HDOP and the number of satellites expected to be in view during the inspection should be noted. To minimize GPS position errors, it is recommended that inspections be conducted only when the predicted HDOP is 1.5 or less.

Flight management systems using TSO C129A approach-certified GPS sensors will meet the equipment requirements, when provided with a suitable means of logging data. Panel mount GPS receivers, if properly certified, may also meet the requirements.

The GPS approach to be inspected should be programmed into the FMS or GPS avionics. All positional co-ordinates should be confirmed, and each leg of the approach should be verified to agree with the approach design, within the required tolerances of ±0.1 NM distance and ±1 degree track. Any waypoint name that is duplicated in the database should be replaced by a temporary one, and reported to the designer.

(2) GPS In-flight: Prior to conducting the GPS flight check, a RAIM check must be performed, and all non-GPS navigation sensors must be deselected.

(a) MAWP Verification: The MAWP verification of accuracy is critical and must be conducted first, since it confirms the threshold co-ordinates that anchor the entire approach. It provides a check for gross errors previously undetected, and confirms that an aircraft flying the approach will be guided to the MAWP, usually the threshold.

The recommended practice is to fly the final approach segment in approach mode, with auto-pilot coupled. The PF should ensure that the centreline is tracked with minimal technical flight error, and he should count down the distance to the MAWP in tenths of a NM. Upon call-out of MAWP passage, the PNF should visually estimate the along-track and across-track errors relative to the MAWP, and record the co-ordinates by activating the “Hold Position” function of the avionics. If either the cross or along-track error exceeds the allowable tolerance of ±300 ft, then the inspection should be terminated and the anomaly referred to the designer for investigation.

If the MAWP is not the runway threshold, then other means of visually identifying the waypoint should be used, such as reference to terrain features on the topographical map.

The track errors and MAWP co-ordinates should be recorded. The number of satellites and the HDOP value should also be noted immediately prior or after the MAWP verification.

(b) Waypoint Verification: All waypoints in the procedure must be verified to correspond to the position intended by the procedure designer, as plotted on topographical charts. Each waypoint shall be over flown at low altitude, 500 - 1000 AGL, and verified visually with reference to the topographic chart to within a lateral tolerance of ±0.1 NM or 600’.

A recommended method is to program a route, with the waypoints in the appropriate sequence. Certain waypoints may be designated as “fly-over” to prevent turn anticipation. As with the MAWP verification technique, the PF should maneuver the aircraft as accurately as possible and count down until the “on-top”. The PNF should confirm the accuracy of each position visually, and check it off the list.

(c) Obstacle Verification: Controlling and other significant obstacles must be identified in all segments, in any order, at the discretion of the Inspector. As well, obstacles that govern the circling areas and 25 NM minimum sector altitudes should be verified if not already confirmed recently during an FI of another IAP at the same site.

(d) Operational Acceptability and Flyability: A standard assessment of operational acceptability shall be conducted, with particular attention made to turn anticipation, and to length and alignment of final, which are special characteristics of GPS procedures.

During the flyability check, the CDI sensitivity for each segment should correspond to a full-scale deflection at ±0.3 NM during the final approach. The full-scale CDI deflection for all other segments, including the missed approach, shall be no greater than ±1.0 NM. The cross-track error shall be continuously monitored and maintained within these tolerances by the PF.

Each segment of the approach, including the missed approach, shall be flown at least once during the flyability assessment. Should there be more than one IAWP defined, all initial segments shall be flown until the intermediate track is captured.

7. Post-Flight Procedures

a. After the flight is complete, all normal after-flight duties as related to the aircraft should be completed in accordance with applicable SOP's and flight operations manuals. Particular attention should be made to closing all flight plans. The flight checklist items should be completed and any additional observations and comments recorded.

b. If an item of significant nature was discovered that could affect safety of flight or operational effectiveness of an aeronautical product in current use, the NAV CANADA Field office concerned shall be immediately notified and directed to issue a suitable NOTAM. The appropriate NAV CANADA Field Office shall also be advised of the observation so that it may be investigated and resolved.

c. Anomalies with obstacles, such as erroneous coordinates or towers that are missing, shall be reported to the appropriate NAV CANADA Field Office (procedure designer) for resolution and the NAIDS and other obstacle databases updated.

d. The FCP shall sign the appropriate flight check forms used, as well as the IP submission form (annex E), indicating that the procedure has been flight checked successfully. The complete Instrument Procedure Package and supporting documentation shall then be returned to the appropriate NAV CANADA Field Office or procedure designer, for analysis, correction and/or final administrative processing. It is advisable for the FCP to retain a complete copy of all documentation as a backup, and for his/her own records.

e. Retention of Reports: Reports, topographic maps, and all IP design documents shall be retained by NAV CANADA, until the procedure is removed from publication.

IINSTRUMENT PROCEDURE
PLANNING & PREFLIGHT CHECKLIST

Aerodrome: ________________ Procedure: ________________

Date: ______________________

FCP: ______________________ PF: ______________________

PLANNING

Documentation

Inspection Checklist….. ……………………..☐
Flight Check Form…. …………………… ☐
IAP Submission Package. ……………… ☐

Anticipated Flight Check
Date/Time______________________

Validation & Familiarization Review

IAP Submission Form. …………………… ☐
Approach Plate……………………………. ☐
Topographical Maps…………………..……☐
Obstacle List…….………………………….☐
Controlling Obstacles. …………………… ☐

GPS

Data Collection System/DTU………….. ☐
Blank Disks………………………………… ☐
RAIM Prediction for FC Date…………… ☐

PRE-FLIGHT

Co-ordination

ATC………………………………………………..☐
Airport Authority……………………………..….☐

Flight Planning

Wx ____________________________

____

NOTAMs...………………………………………. ☐
Flight plan filed ………………………………..☐

Crew Briefing

- Sequence………………………………… ☐
- Altitudes……………………………… ….☐
- Significant/Controlling Obstacles……… ..☐
- PF - Flyability Check requirements…… ..☐

FMS/GPS

RAIM(HIL) _____________
Number of Sats __________ HDOP _______

Program FMS/GPS. ……………………… …☐
Fix Co-ords Verification…………………… ..☐

REMARKS:

CONVENTIONAL IAP
INFLIGHT CHECKLIST

Aerodrome: ____________________ Procedure: ____________________

Date: ________________________

FCP: _________________________ PF: ___________________________

Confirm:

Altimeter Setting Source……….. ☐
RAIM Check ……………………. ☐
Pre-Inspection Airborne Check... ☐

Communication Check…………. ☐
NAVAIDs Identified……………… ☐
Post-Inspection Airborne Check ☐

Segment	**Obstacles**	**Tracking**
Initial …………… ……	☐……………	☐
Procedure Turn………	☐	
Arc Left………………	☐……………	☐
Arc Right………………	☐……………	☐
Intermediate………….	☐……………	☐
Final……………………	☐……………	☐
Missed …………………	☐……………	☐
Circling ………………….	☐	
25 NM MSA ……………	☐	
Departure ……………..	☐	

Fix/Waypoint Positions:

Initial Approach Fix……………….☐
Arc Start Fix Left ……………….. ☐
Arc Start Fix Right……………….. ☐
Intermediate Fix………………… ☐
FACF……………………………….☐
FAF………………………………..☐
Step-Down………………………..☐
MAP………………………………. ☐
Missed Holding Point…………….☐
Other________________…………☐
Other________________…………☐

Comments:

____
FCP

AIRWAY/ROUTE
INFLIGHT CHECKLIST

Airway/Route Designator: ______Segment:____________ /_______

Date: ______________________

FCP:_______________________PF:_________________________

NAVAIDS/INTERSECTIONS: / IDENTIFIED……☐

RADIALS/BEARINGS IN/OUT: / TRACKING ……☐

MEA/MOCA:_________**ft**______________**to**______________

_________**ft**______________**to**______________

_________**ft**______________**to**______________

_________**ft**______________**to**______________

COMM CHECKS:

Agency	**Freq**	**Location/Altitude**
___________	_______________	__________________________
___________	_______________	__________________________
___________	_______________	__________________________

SIGNIFICANT ITEMS:

COMMENTS:

FCP

MVA
INFLIGHT CHECKLIST

Location: ______________ FCP: ______________________

Date: _________________ PF: ________________________

Radar: ________________ ATC Agency: ________________

Sector #	**Altitude**	**Obstacles**	**Radar**	**Comms**
______________	☐	☐	☐	☐
______________	☐	☐	☐	☐
______________	☐	☐	☐	☐
______________	☐	☐	☐	☐
______________	☐	☐	☐	☐
______________	☐	☐	☐	☐
______________	☐	☐	☐	☐

SIGNIFICANT ITEMS:

COMMENTS:

____
FCP

GPS IAP
CHECKLIST – INFLIGHT

Aerodrome: ______________________ Procedure: ______________________

Date: ___________________________

FCP: ____________________________ PF: ____________________________

Altimeter Setting Source……………… ☐
Waypoint Entry Verification…………. ☐
Leg Lengths/Tracks……………..……. ☐
Duplicate Waypoints…………………. ☐
Pre-Inspection Airborne Checklist …. ☐

RAIM Check…………………………. ☐
Deselect Non-GPS Sensors……….. ☐
Communication Check………………..☐
Data Recording……………………… ☐
Post-Inspection Airborne Checklist….☐

Confirm MAWP Position:

N ______________________________ XTE __________________________
W ______________________________ ATE __________________________
Num Sats _________________________ HDOP_________________________

Obstacle Verification:

Initial L …………………………… ☐
Initial R …………………………… ☐
Initial C ………………..………… ☐
Intermediate ……..……………… ☐
Final ……………………………… ☐
Missed …………………………… ☐
Circling …………………………… ☐
25 NM MSA ……………………… ☐
Departure ………………………… ☐

Confirm Waypoint Positions:

IAWL ……………..……………… ☐
IAWPR …………………………… ☐
IAWPC …………………………… ☐
IWP ……………….……………… ☐
SDWP……………………………… ☐
FAWP……………………………… ☐
SDWP……………………………… ☐
MAWP…………………………… ☐
MATWP …………………………… ☐
MAHWP…………………………… ☐

Comments:

____
FCP

OPERATIONAL FLIGHT CHECK FORM

Aerodrome: ______________________ Procedure: ________________________

Date: ____________________________ A/C Type: _________________________

FCP: ______________________________ PF: _______________________________

Intended User A/C: GA, Helo, Commuter, B/Jet, Heavy, Military, Other_______
(Circle all applicable)

Intended Use:

Airspace …………………………… ☐
Noise ……………………………… ☐
Environmental …………………… ☐
Communications ………………… ☐
Surveillance……………………… ☐
Approach Plate …………………… ☐
Aerodrome Facilities……………… ☐

Flyability:

Suitable for Critical A/C …………… ☐
Descent Gradient …………………… ☐
Segment Length …………………… ☐
Alignment on Final ………………… ☐
Gradient/Alignment Combo ……… ☐

Workload Rating ……………… ___________
(1-7 acceptable, 8-10 excessive)

____
(PF Signature)

Comments:

OVERALL
ASSESSMENT

Pass ☐ **Fail** ☐

____
(FCP Signature)

CRITERIA FOR THE
DEVELOPMENT OF
INSTRUMENT PROCEDURES

TP 308 / GPH 209 – CHANGE 5.3

ANNEX J

TERRAIN AND
OBSTACLE DATA (TOD)

TRANSPORT CANADA
NATIONAL DEFENSE

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TERRAIN AND OBSTACLE DATA (TOD)

1.0. General

The primary purpose of obstacle evaluation is to determine how an obstacle will affect instrument flight procedures. The evaluations provide accurate, consistent, and meaningful results only if procedure specialists apply the same rules, criteria, and processes during development, revision, and cyclical review. This annex establishes the minimum accuracy standards for obstacle data and its application in the development, revision, and cyclical review of instrument procedures. The minimum standards, regardless of the data source, are to be applied by instrument procedure specialists in all instrument procedure obstacle evaluations.

1.1 Reserved

1.2. Obstacle Data Accuracy Standards

This paragraph identifies the MINIMUM requirement for accuracy of obstacle data used in the development of minimum vectoring altitudes (MVA) and instrument procedures; providing the minimum accuracy standards for each.

a. Concept. Obstacle data accuracy is not absolute, and the accuracy depends on the data source. The magnitude of the inaccuracy does not preclude its use, provided it is identified, accounted for and documented. In some cases, upgrading obstacle accuracy can provide relief from operational restrictions in an instrument procedure. This will allow expenditure of funds for obstacle surveys in areas where benefit to the aviation community would result. In no case, will the application of obstacle data accuracy preempt the requirement for the flight check of an instrument procedure for discrepancies.

b. Standards. The minimum accuracy standards in this annex are for use in the development, revision, and cyclical review of instrument procedures. They must be applied to all new procedures and to existing procedures at the next revision or cyclical review, whichever occurs first. The minimum accuracy standards are listed below. ADJUST the location/elevation data of the segment-controlling obstacle by the actual horizontal and vertical accuracy values ONLY, if the specified accuracy value does not meet or exceed the following standards.

(1) +20 ft horizontal and +3 ft vertical accuracy: Precision and APV final and missed approach segments.

(2) +50 ft horizontal and +20 ft vertical accuracy: Non precision final segments; missed approach 40:1 surface evaluation; circling areas; and the Obstruction Evaluation Area (OEA) for a climb to 400 ft above DER on all departure procedures.

(3) +250 ft horizontal and +50 ft vertical accuracy: Intermediate segment. All areas outside of OEA for a climb to 400 ft above DER.

(4) +500 ft horizontal and +125 ft vertical accuracy: (1,000 ft ROC) Initial segments, feeder segments, en route areas, missed approach holding/level surface evaluation; MSA, Safe Altitude 100 NM and the level route portion for SIDs.

(5) +1,000 ft horizontal and +250 ft vertical accuracy: (1,500/ 2,000 ft ROC) Feeder segments, en route areas, Safe Altitude 100 NM, MVA and the level route portion for SIDs.

1.3. Accuracy Standards Application

Determine the segment-controlling obstacle using raw obstacle data only (i.e., accuracy adjustments not applied) then, if required under paragraph 1.2.b., add the actual horizontal and/or vertical accuracy adjustments to the raw values to determine the obstacle's most adverse location and elevation. Accuracy adjustments are not applied to obstacles evaluated relative to TP 308, volume 1, paragraph 289.

Examples:

1) **Non Precision Final Approach Segment** (50 ft H, 20 ft V Required Accuracy)
Controlling Obstacle: 175 ft with 55 ft Horizontal and 20 ft Vertical accuracy
Conclusion(s): Horizontal standard NOT met, Vertical standard met.
Action(s): Adjust obstacle location data by 55 feet horizontally

2) **Precision Final Approach Segment** (20 ft H, 3 ft V Required Accuracy)
Controlling Obstacle: 112 ft with 20 ft Horizontal and 2 ft Vertical accuracy
Conclusion(s): Both Horizontal and Vertical standards are met.
Action(s): Nil (no adjustment required)