Table 2-3. TCH Requirements

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	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-300, 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.

2.7 GROUND POINT OF INTERCEPT (GPI).

Calculate GPI distance using the following formula:

$$GPI = \frac{TCH}{\tan(GPA)}$$

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

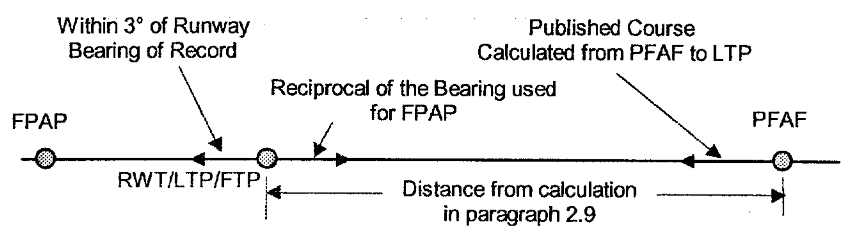
(OPTIMUM course is the runway bearing) as a forward azimuth value, and an appropriate distance. If an ILS or MLS serves the runway, the appropriate distance in feet is the distance from the LTP to the localizer antenna minus 1,000 feet, or the distance from the LTP to the DER, whichever is greater. Apply table 2-4 to determine the appropriate distance for runways not served by an ILS or MLS.

Table 2-4. Runways not served by an ILS or MLS

Runway Length	FPAP Distance from LTP	Splay	± Width
≤ 9,023'	9,023'	2.0°	350'
> 9,023' and ≤ 12,366'	to DER	$\text{ArcTan}\left(\frac{350}{\text{RWY length}+1000}\right)$	350'
> 12,366 and ≤ 16,185'	to DER	1.5°	$\tan(1.5)(\text{RWY length}+1{,}000))$
> 16,185' (AFS or Appropriate Military Agency Approval)	to DER or as specified by approving agency	1.5°	$\tan(1.5)(\text{RWY length}+1{,}000))$

2.9 DETERMINING PFAF/FAF COORDINATES. See figure 2-4.

Figure 2-4. Determining PFAF Location



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 2 formula includes earth curvature}

Step 1: Formula: $z = A - F$

Example: $2{,}100 - 562.30 = 1{,}537.70$

Step 2: Formula: $D = 364{,}609\left(90 - \theta - \sin^{-1}\left(\frac{20{,}890{,}537\sin(90+\theta)}{z + 20{,}890{,}537}\right)\right)$

Example:

$$D = 364{,}609\left(90 - 3 - \sin^{-1}\left(\frac{20{,}892{,}537\sin(90+3)}{1{,}537.7 + 20{,}890{,}537}\right)\right)$$

$$D = 28{,}956.03$$

Where: A = FAF Altitude in feet (example 2,100)
F = LTP elevation in feet (example 562.30)
θ = Glidepath angle (example 3.00°)

2.9.1 Distance Measuring Equipment (DME).

When installed with ILS, DME may be used in lieu of the outer marker. When a unique requirement exists, DME information derived from a separate facility, as specified in Volume 1, paragraph 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).

Airports division is responsible for maintaining obstruction requirements in AC 150/5300-13, Airport Design. Appropriate military directives apply at military installations. For the purpose of this order, 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 (USAF NA):

- For GPA ≤ 4.2°: 250-¾
- For GPA > 4.2°: 350-1

NOTE: Application of Volume 1, paragraph 251 may require a higher minimum visibility value.

2.12 GLIDEPATH QUALIFICATION SURFACE (GQS)

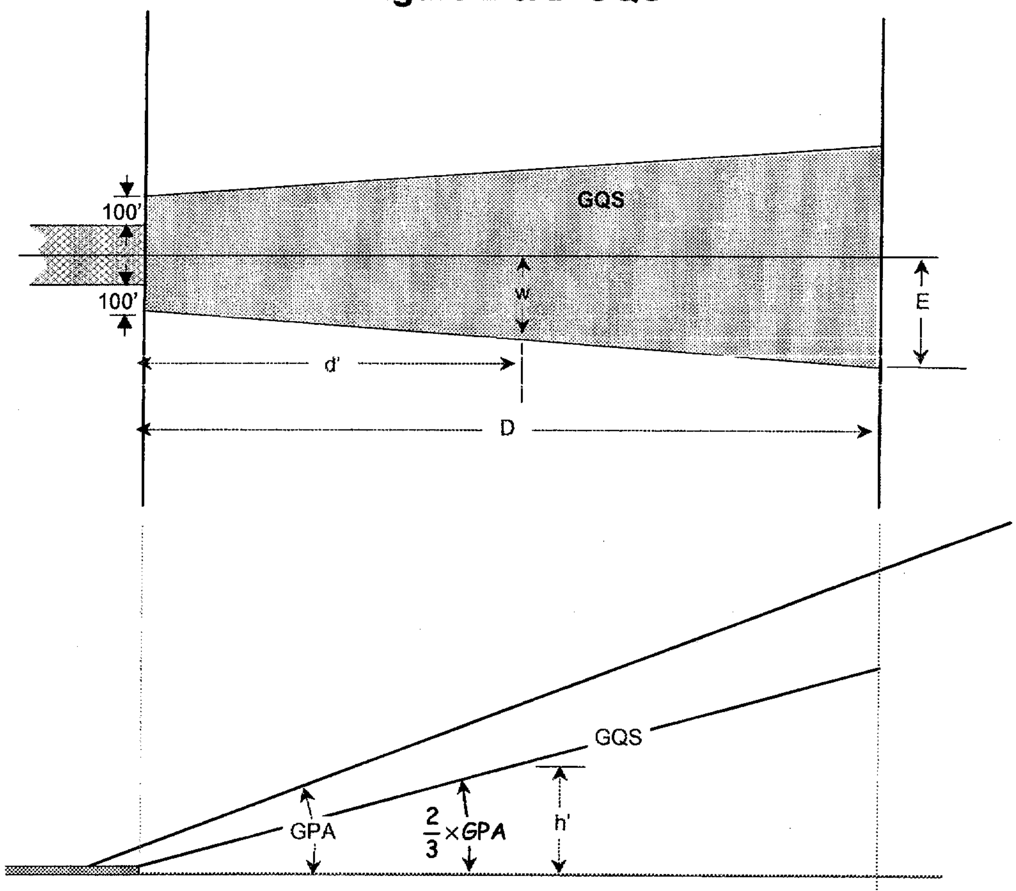
The GQS extends from the runway threshold along the runway centerline extended to the DA point. It limits the height of obstructions between DA and RWT. When obstructions exceed the height of the GQS, an approach procedure with positive vertical guidance (ILS, MLS, TLS, GLS, VNAV, etc.) is not authorized (see figures 2-5A and 2-5B).

2.12.1 Area.

2.12.1 a. **Length**. The GQS extends from the runway threshold to the DA point.

2.12.1 b. **Width**. The GQS originates 100 feet from the runway edge at RWT.

Figure 2-5A. GQS



Calculate the half-width of the GQS (E) from the runway centerline 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

2.12.1 c. **If the course is offset** from the runway centerline 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 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."

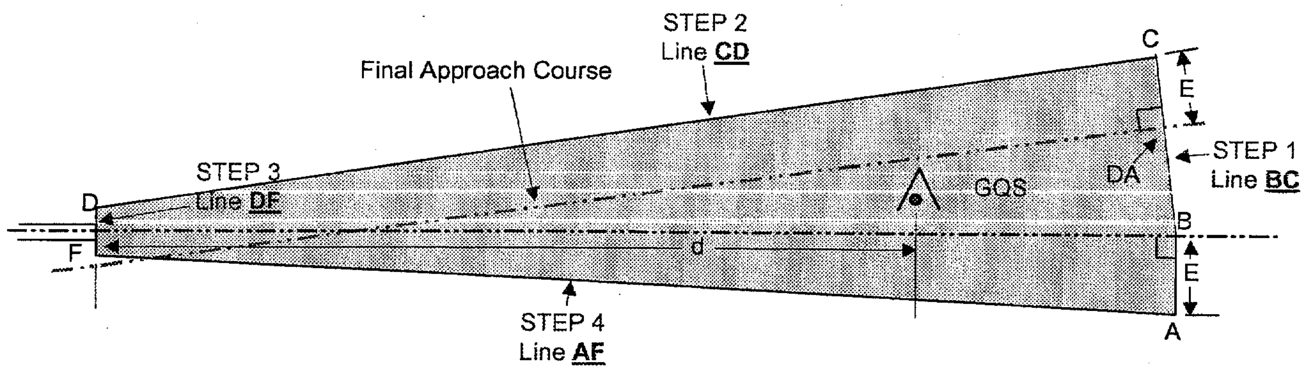
STEP 2. Construct line CD. Locate point "D" 100 feet from the edge of the runway perpendicular to the LTP. Draw a line connecting point "C" to point "D."

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 centerline extended. Connect point "A" to point "F."

STEP 5. Construct line AB. Connect point "A" to point "B."

Figure 2.5B. Final Approach Course Offset >3°



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

$$k = \frac{\text{RWT width}}{2} + 100$$

2.12.1 **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:

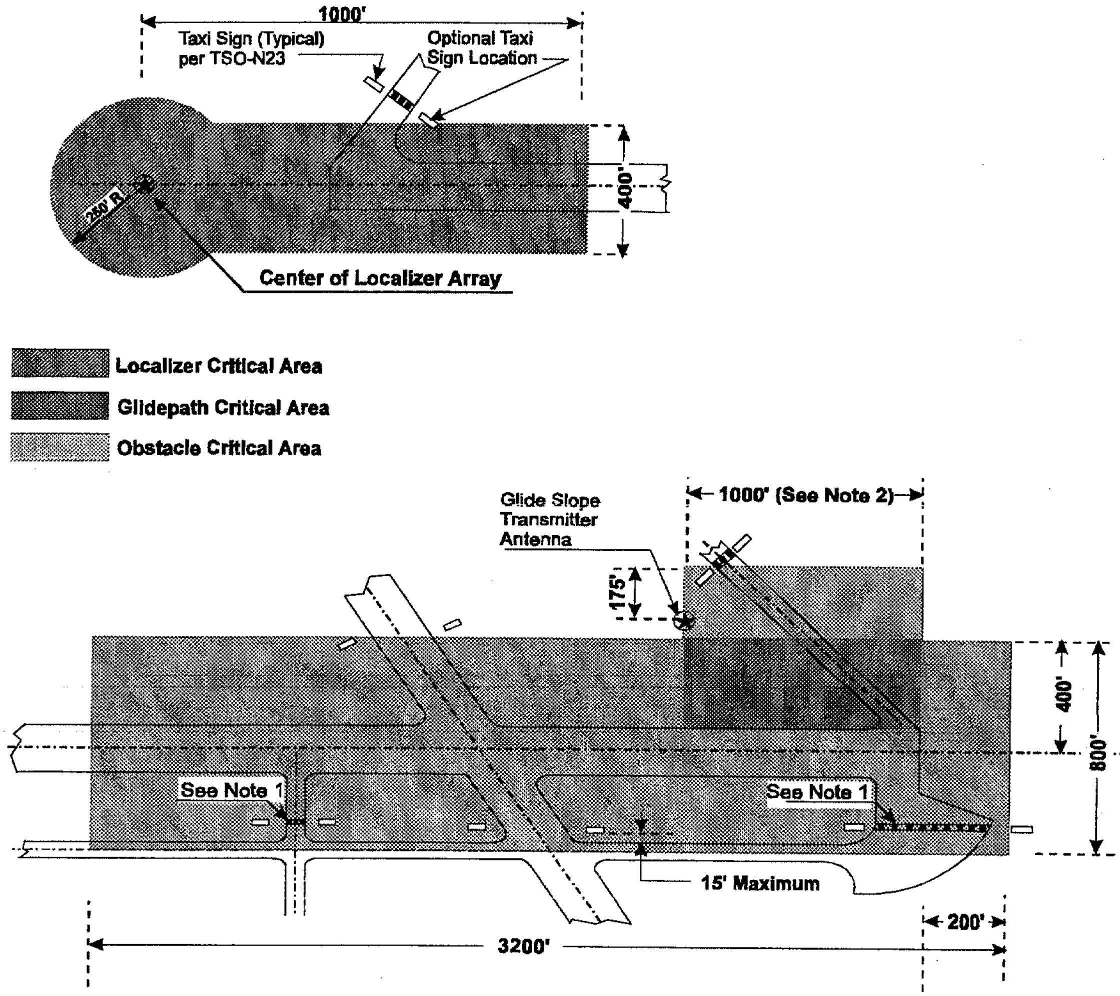
$$h = \tan\left(\frac{2\theta}{3}\right) d$$

Where d = distance from RWT (ft)
θ = glidepath angle

2.13 ILS/MLS Critical Areas.

Figure 2-6 identifies the critical area that must be clear during IFR ILS/MLS approach operations.

Figure 2-6. Category II Critical Areas

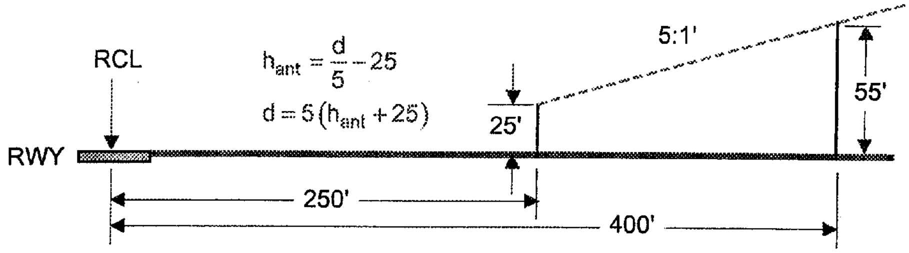


NOTES: 1. Location of hold lines when operations are permitted on a 400-foot parallel taxiway.
2. Or to the end of the runway, whichever is greater.

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 centerline 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 the following formula:

Figure 2-7. ILS Antenna Mast Limitations



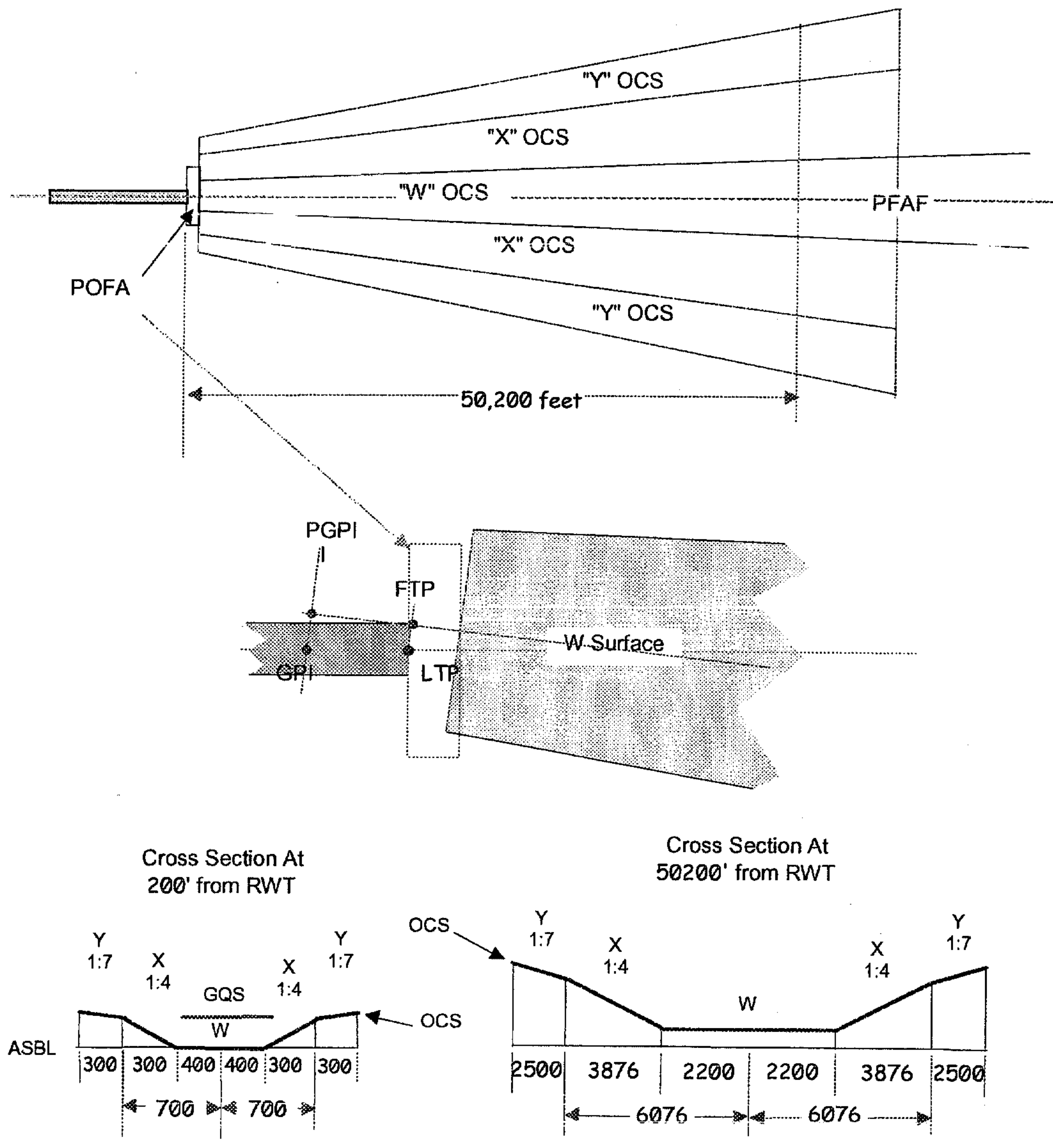
Where h_{ant} = MAXIMUM height of mast above RCL abeam mast
d = perpendicular distance from RCL (250' MINIMUM)

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.

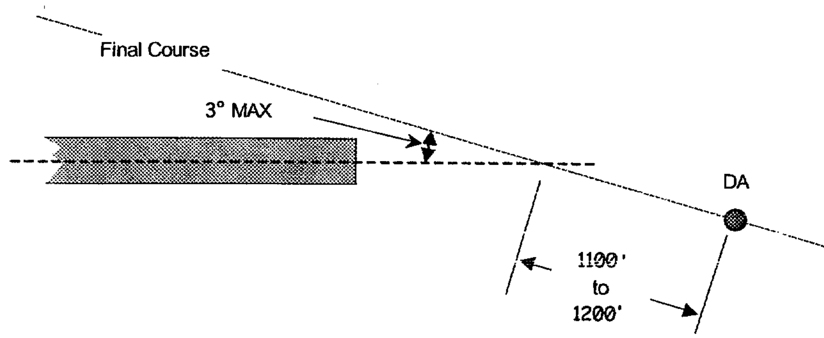
Figure 3-1. Precision Obstacle Clearance Areas



3.1 ALIGNMENT.

The final course is normally aligned with the runway centerline 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 2,400 feet. Additionally, the course must intersect the runway centerline 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



3.2 OCS SLOPE(S).

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:

$$S = \frac{102}{GPA} \qquad \text{example: } \frac{102}{3} = 34$$

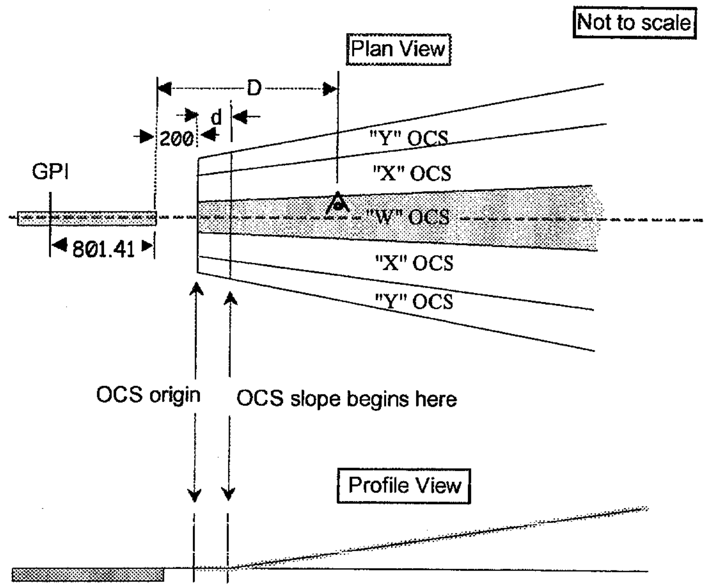
3.2.1 Origin.

The OCS begins at 200 feet from LTP or FTP, measured along course centerline 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':

$$d = 954 - GPI \qquad \text{Example: } 954 - 801.41 = 152.59$$

Where GPI = 801.41

Figure 3-3. OCS Slope Origin When GPI <954'



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:

$$\frac{102\left[\frac{D-(200+d)}{s}+p\right]}{D-(200+d)} = \text{Revised Angle} \qquad \text{Example: } \frac{102\left[\frac{2200-(200+0)}{34}+2.18\right]}{2200-(200+0)} = 3.12°*$$

Where D = distance (ft) from RWT
d = d from paragraph 3.2.1 for GPI < 954', 0 for GPI 954' or greater
s = "W" surface slope
p = penetration in feet

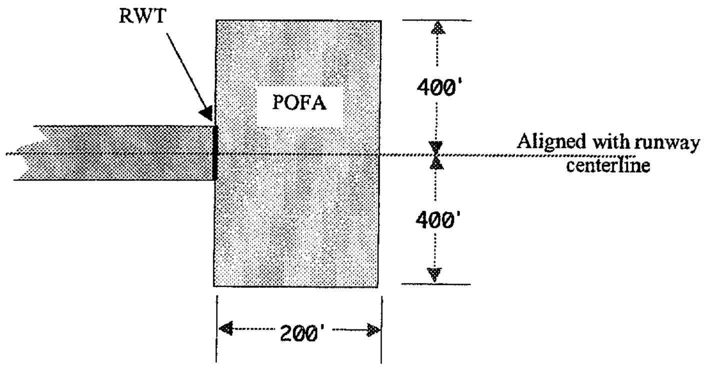
Where D = 2200
d = 0
s = 34
p = 2.18

*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 centered on the runway centerline extended, beginning at the RWT, 200 feet long, and ± 400 feet wide. The airport sponsor is responsible for maintaining POFA obstruction requirements in AC 150/5300-13 (see figure 3-4). If the POFA is not clear, the minimum HAT/visibility is 250 feet/ 3/4 SM.

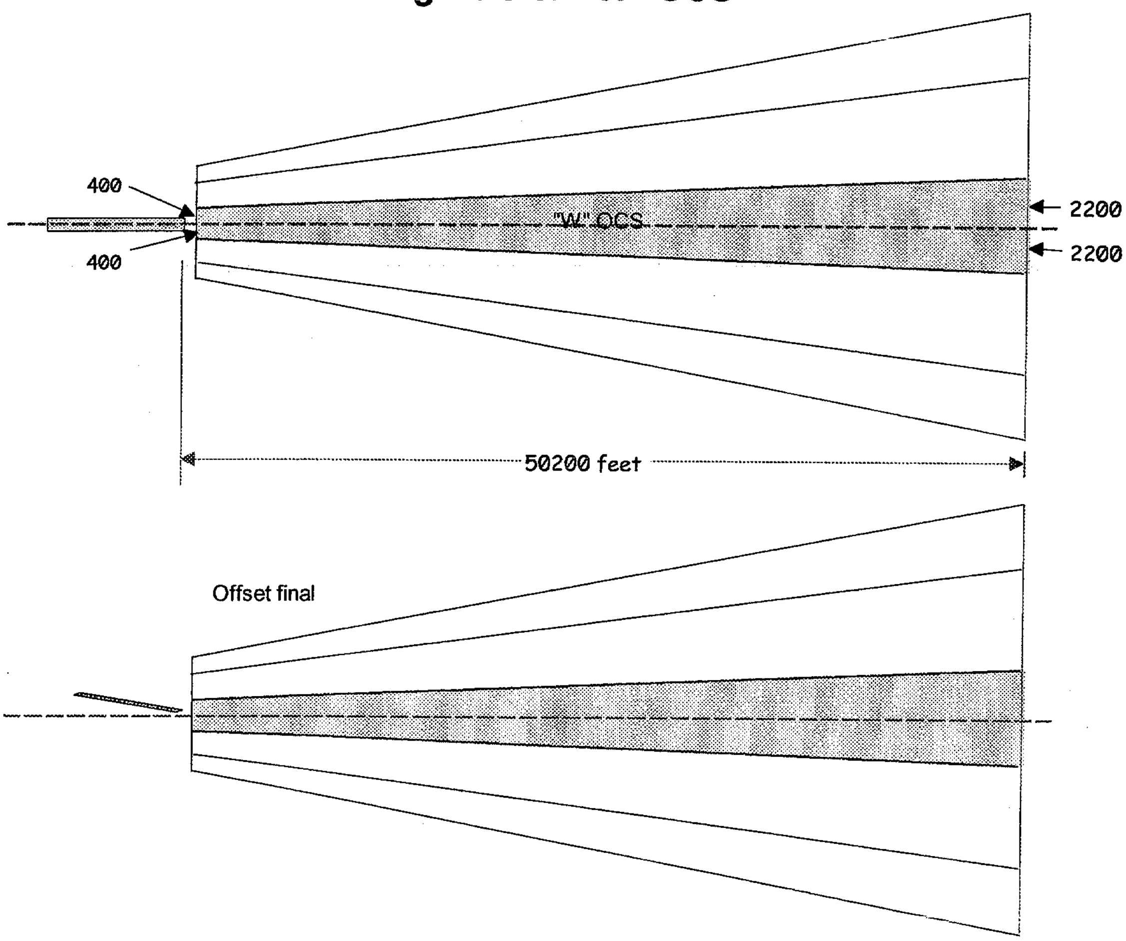
Figure 3-4. POFA



Scale exaggerated for emphasis

3.4 **"W" OCS.** See figure 3-5.

Figure 3-5. "W" OCS



3.4.1 **Width.** The width is 400 feet either side of course at the beginning, 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.

3.4.2 **Height.** The height (Z_W) of the "W" OCS above ASBL is defined by the formula:

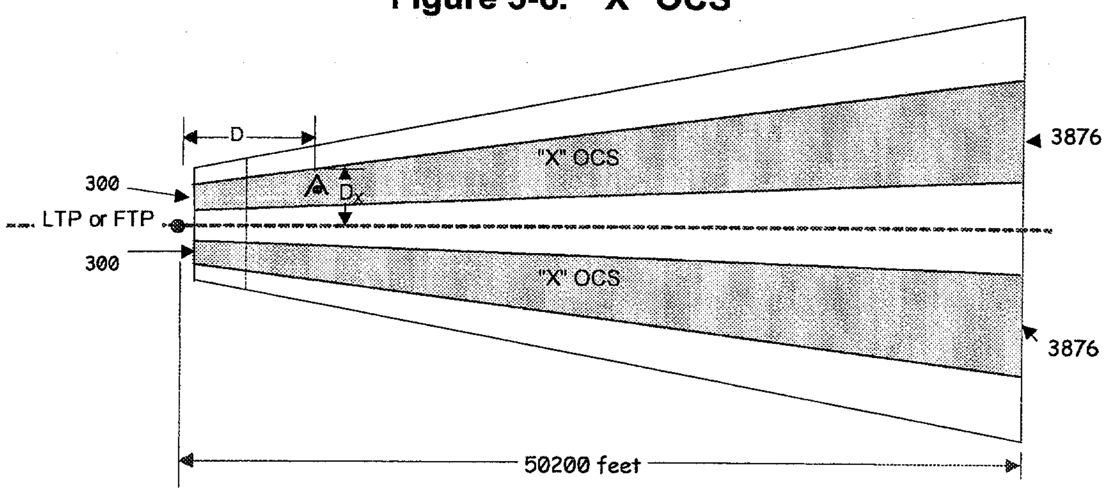
$$Z_W = \frac{D-(200+d)}{S}$$

Where D = the distance in feet from RWT
d = d from paragraph 3.2.1 for GPI < 954', 0 for GPI 954' or greater
S = "W" surface slope

3.4.3 **"W" OCS Penetrations.** Lowest minimums are achieved when the "W" surface is clear. If the surface is penetrated by an existing obstacle, adjust obstruction height, raise the GPA (see paragraph 3.2.2), or displace the RWT to eliminate the penetration. If the penetration cannot be eliminated, adjust the DA (see paragraph 3.8).

3.5 **"X" OCS.** See figure 3-6.

Figure 3-6. "X" OCS



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:

$$Z_X = \underbrace{\frac{D-(200+d)}{S}}_{\text{Height of "W" Sfc}} + \underbrace{\frac{D_O - D_W}{4}}_{\text{Rise of "X" Sfc}}$$

Where D = the distance in feet from LTP or FTP,

d = d from paragraph 3.2.1 for GPI < 954', 0 for GPI 954' or greater

D_O = the perpendicular distance in feet between course centerline and a specific point in the "X" surface

D_W = the perpendicular distance between course centerline and the "W" surface boundary.

S = Slope associated with GPA $\left[\frac{102}{GPA}\right]$

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.

3.5.3 a. **Remove or adjust** the obstruction location and/or height.

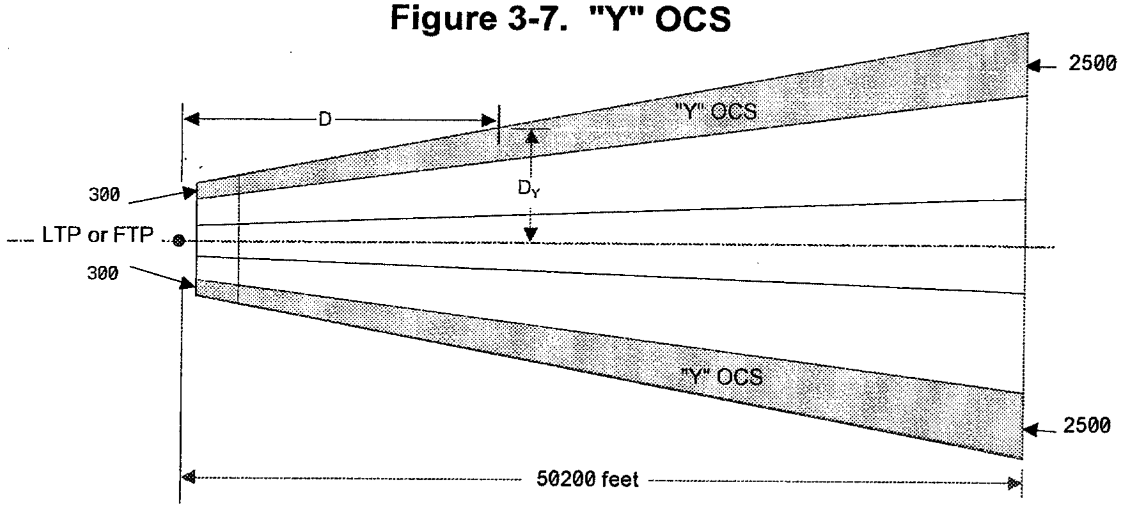
3.5.3 b. **Displace the RWT.**

3.5.3 c **Raise the GPA** (see paragraph 3.2.2) within the limits of table 2-2A.

3.5.3 d. **Adjust DA** (for existing obstacles only). (See paragraph 3.8).

3.6 **"Y" OCS.** See figure 3-7.

Figure 3-7. "Y" OCS



3.6.1 **Width.** The perpendicular distance (D_Y) from the runway centerline 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:

$$D_Y = \underbrace{\frac{D-(200+d)}{S}}_{\text{Height of "W" Sfc}} + \underbrace{\frac{D_X - D_W}{4}}_{\text{Rise of "X" Sfc}} + \underbrace{\frac{D_O - D_X}{7}}_{\text{Rise of "Y" Sfc}}$$

Where D = the distance in feet from the LTP or FTP,
d = d from paragraph 3.2.1 for GPI < 954′, 0 for GPI 954′ or greater
D_x = the perpendicular distance in feet between course centerline and "X" surface outer boundary,
D_0 = perpendicular distance in feet between course centerline 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. (**USAF**: Adjustment mandatory if obstruction cannot be removed, height adjust, or options in paragraphs 3.6.3 b-d cannot be accomplished.) If an adjustment is required, take the appropriate actions from the following list:

3.6.3 a. **Adjust DA** for existing obstacles (see paragraph 3.8).

3.6.3 b. **Displace threshold**.

3.6.3 c. **Offset final course**.

3.6.3 d. **Raise GPA** (see paragraph 3.2.2).

3.6.3 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.

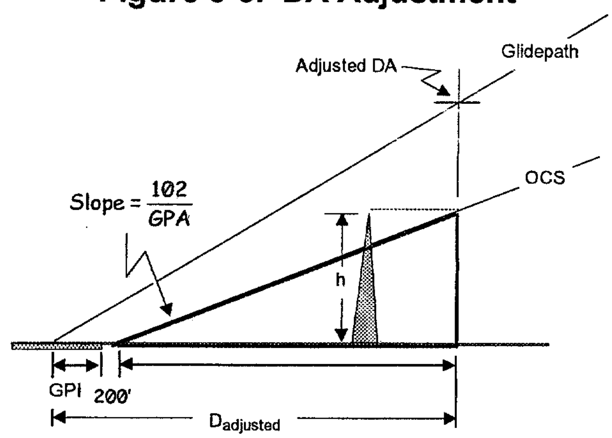
3.8.1 **GPI Distance.** Determine the distance from LTP to the adjusted DA point using the formula:

$$D_{adjusted}=\frac{102h}{GPA}+(200+d)$$

Where $D_{adjusted}$ =adjusted distance (ft) from LTP to DA
D=d from paragraph 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



3.8.2 **Calculate the adjusted DA and HAT:**

$$DA=\tan\left(\left[\frac{102h}{GPA}+(200+d)\right]+\frac{TCH}{\tan(GPA)}\right)+LTP_{elevation}$$

$$HAT=DA-TDZE$$

3.8.3 **Calculate the revised minimum HAT/maximum ROC** using the formula:

$$Min\ Hat\ and\ Max\ ROC=\frac{GPA}{3}250$$

3.8.4 **Compare HAT and Minimum HAT.** Publish the higher of the two values.

3.8.5 **Mark and Light**. Initiate action to mark and light obstruction(s) that would require DA adjustment when they are located between the DA and the LTP/FTP.

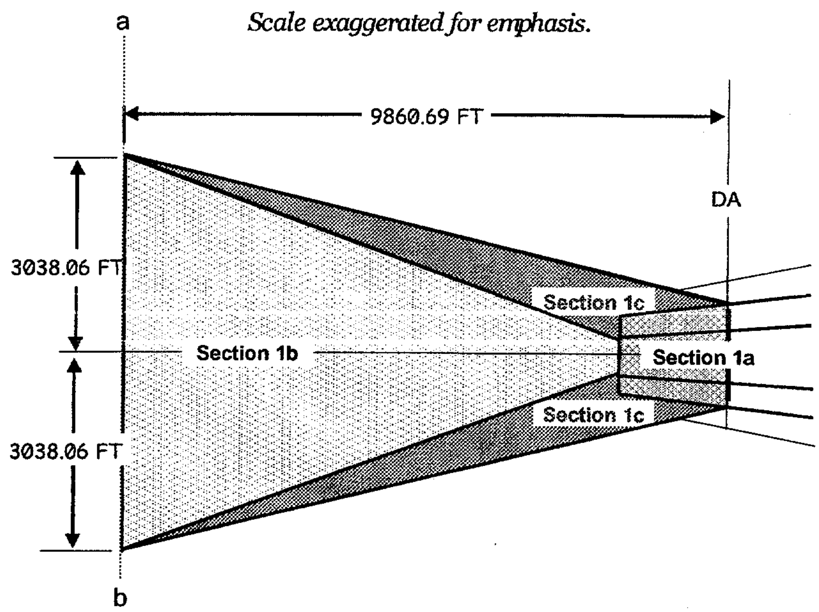
3.9 **MISSED APPROACH.**

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 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 centerline. The MA procedure is limited to two turn fixes (see figure 3-9A).

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.

Figure 3-9A. Missed Approach Sections 1a,b,c



3.9.1 **a. Section 1a.**

3.9.1 a. **(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).

3.9.1 **a. (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.

Figure 3-9B . Section 1a

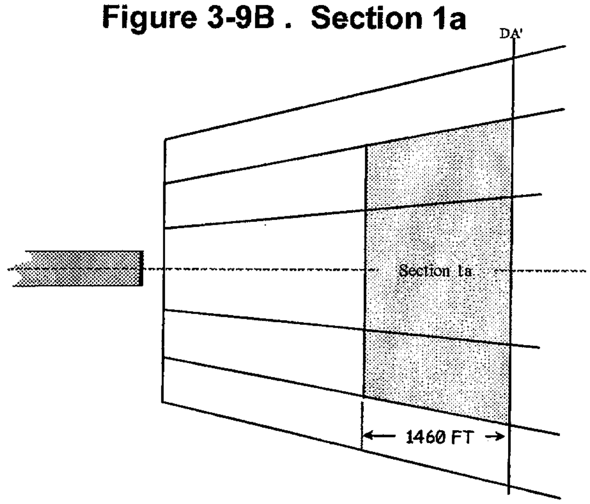
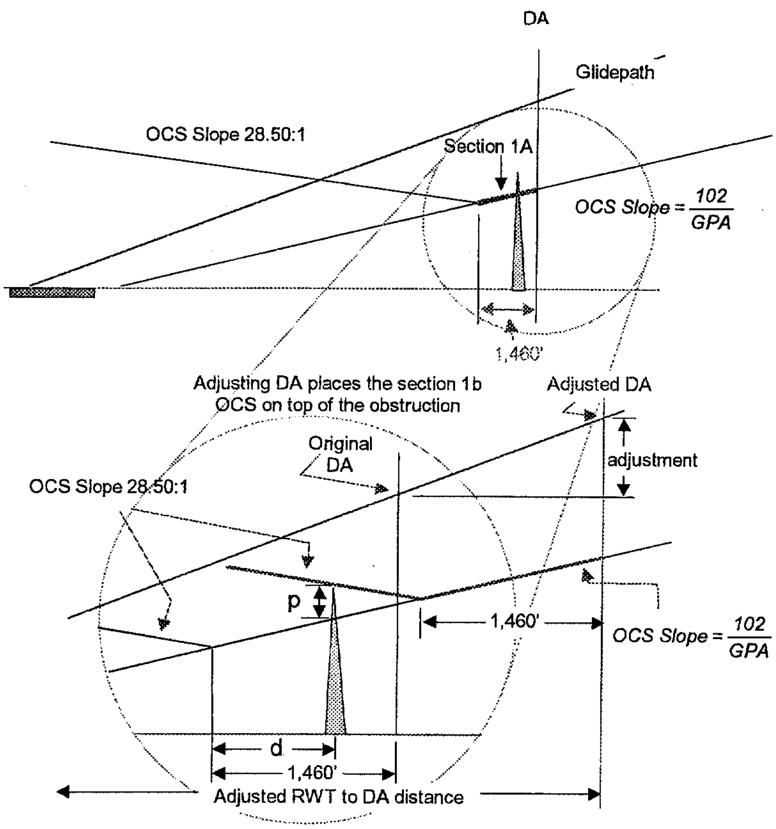


Figure 3-9C. Penetration of Section 1a OCS



$$d = x_O - (\text{RWT to DA Distance} - 1{,}460)$$

$$\text{adjustment} = \tan(\text{GPA}) \times \left[\left(\frac{p}{\frac{1}{28.50} + \frac{\text{GPA}}{102}} \right) + d \right]$$

$$\text{adjusted DA (MSL)} = \text{original DA} + \text{adjustment}$$

$$\text{adjusted RWT to DA Distance} = \frac{\text{Adjusted DA (MSL)} - (\text{RWT MSL Elevation} + \text{TCH})}{\tan(\text{GPA})}$$

where p = penetration (ft)
GPA = glidepath angle
x_O = distance from RWT to obstruction
d = distance (ft) from obstruction to point where the 28.50 : 1 OCS originates

3.9.1 b. Section 1b.

3.9.1 **b. (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).

3.9.1 **b. (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.

Figure 3-9D. Section 1b

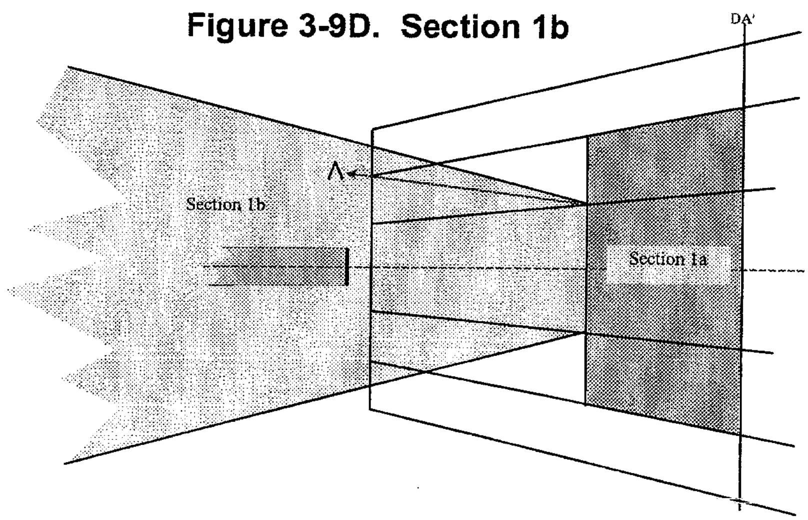
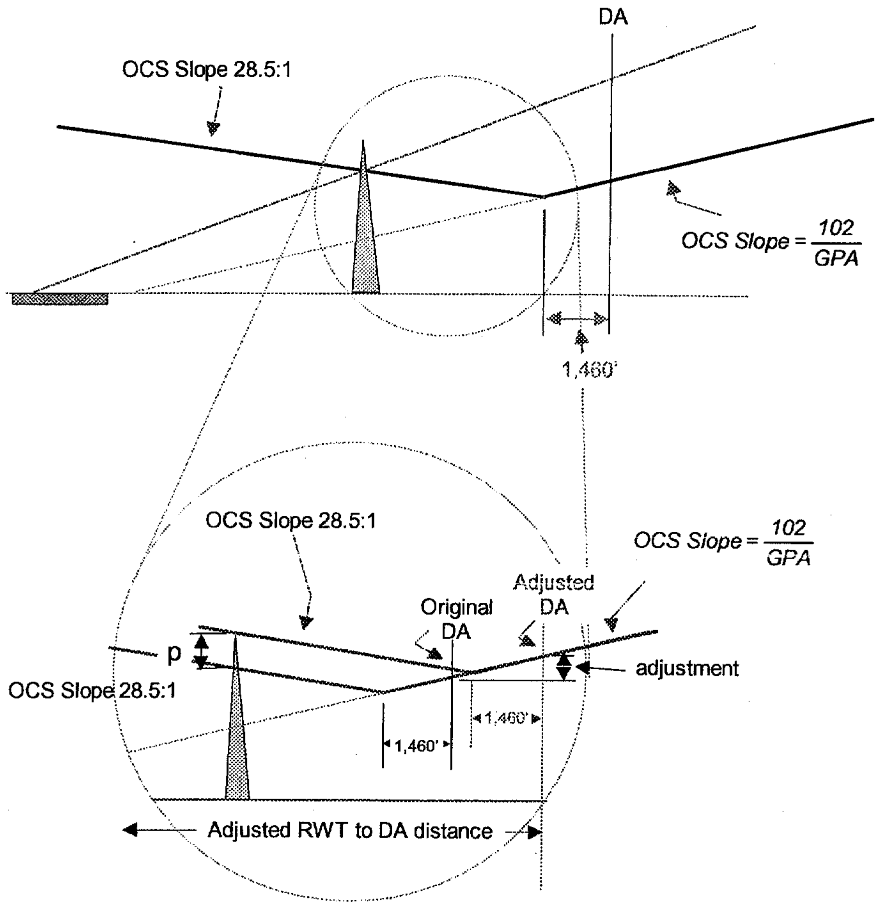


Figure 3-9E. Penetration of Section 1b OCS



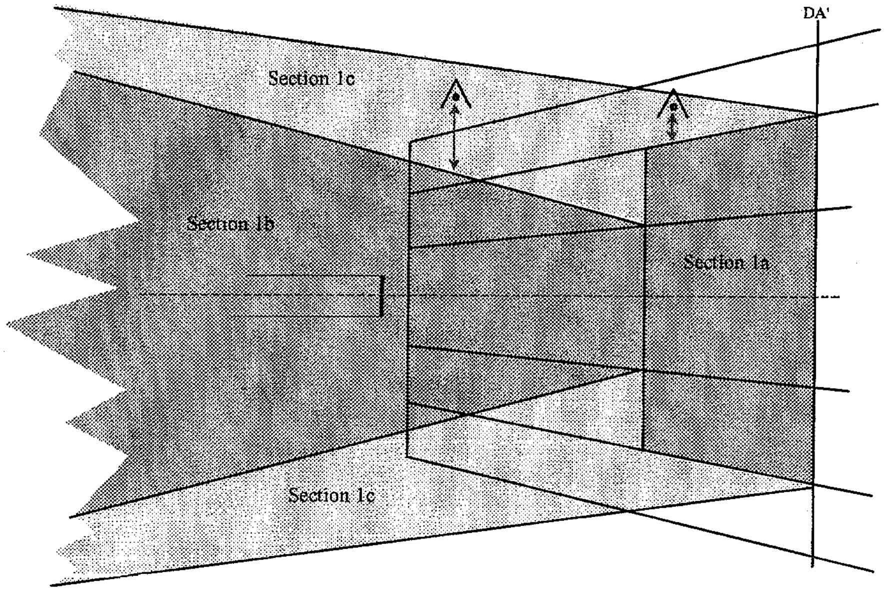
$$\text{adjustment} = \tan(\text{GPA}) \times \left(\frac{p}{\frac{1}{28.5} + \frac{\text{GPA}}{102}} \right)$$

$$\text{adjusted DA (MSL)} = \text{original DA} + \text{adjustment}$$

$$\text{adjusted RWT to DA Distance} = \frac{\text{adjusted DA (MSL)} - (\text{RWT MSL Elevation} + \text{TCH})}{\tan(\text{GPA})}$$

where p = penetration (ft)
GPA = glide path angle

Figure 3-9F. Section 1c



3.9.1 **c. Section 1c** (see figure 3-9F).

3.9.1 **c. (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.

3.9.1 **c. (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.

3.9.1 **d. Section 2. [RNAV Only]** Apply 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 centerline, 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 Order 8260.44, table 2. Establish the outer boundary radius of a turning procedure based on the highest category aircraft authorized to use the approach.

Table 3-1

Category	*MA Altitude < 10,000' MSL*	*MA Altitude ≥ 10,000' MSL*
A, B	200 KIAS	200 KIAS
C, D, E	250 KIAS	310 KIAS

Figure 3-10A. Turning Missed Approach with Turning Fix at the Minimum Required Distance

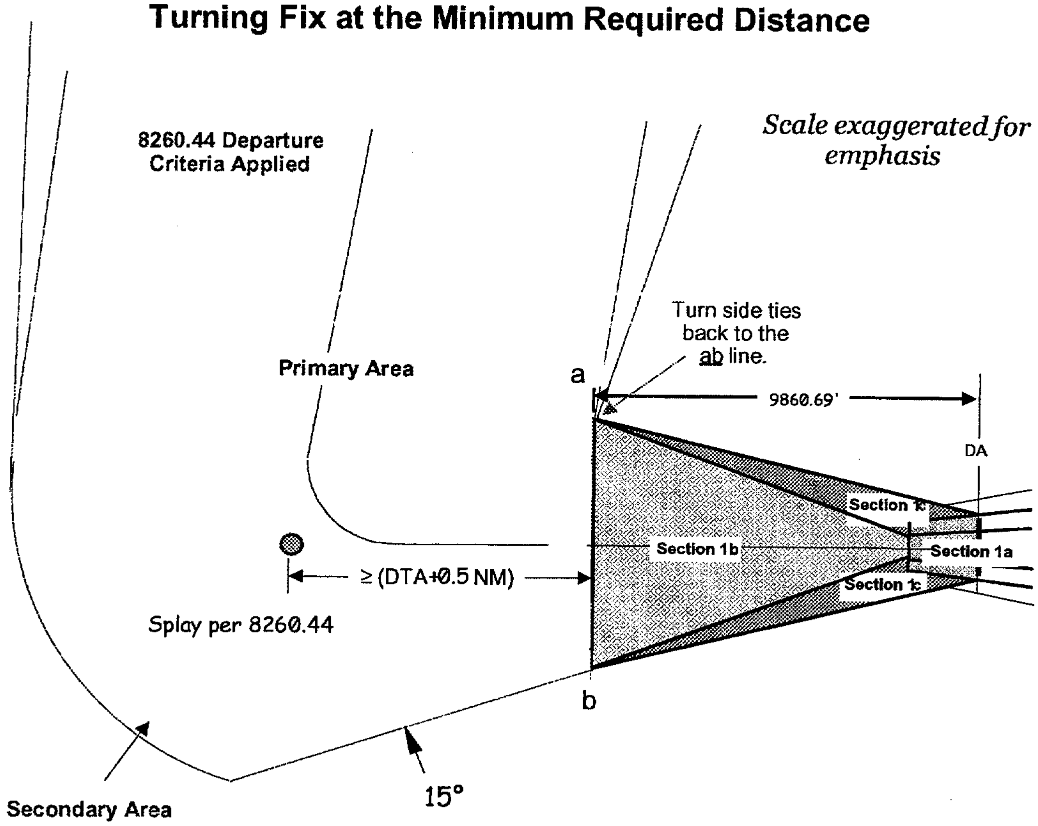
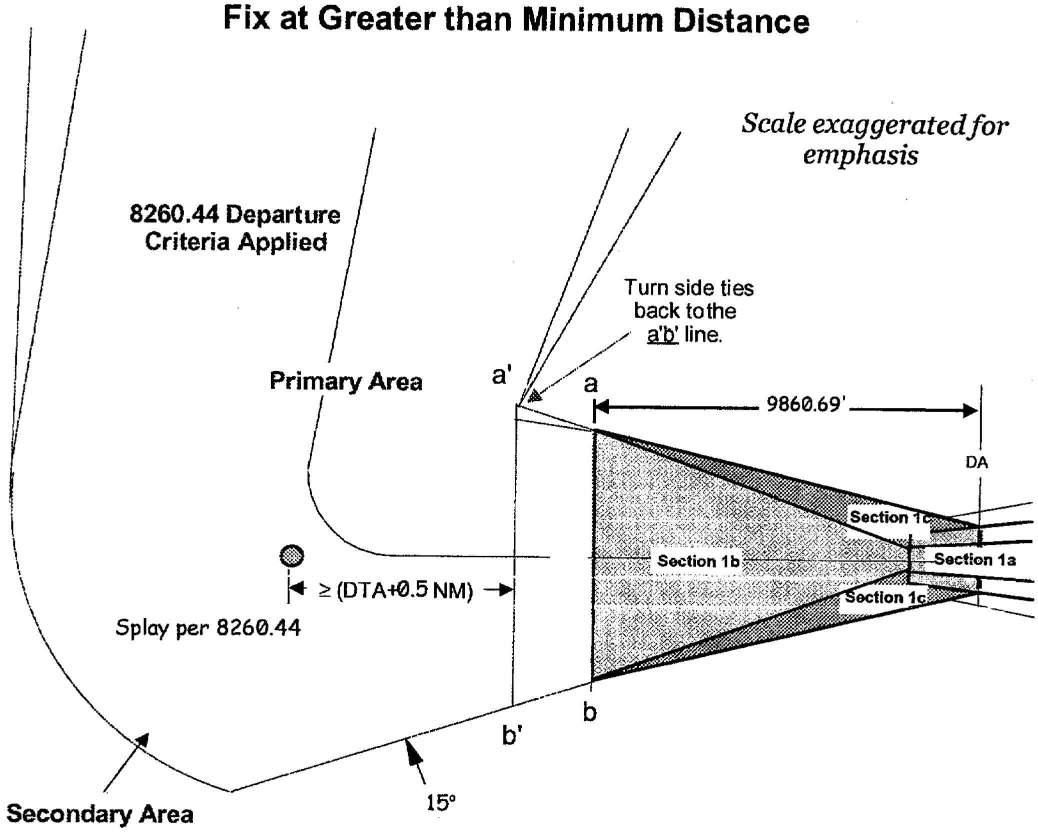


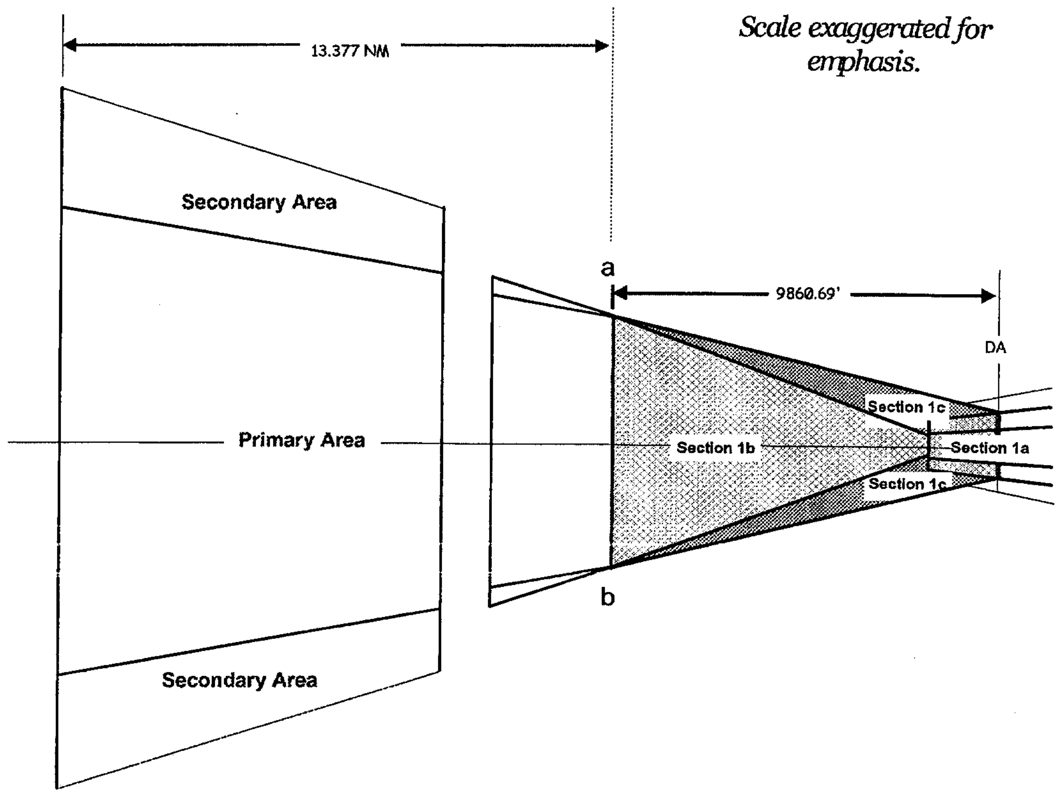
Figure 3-10B. Turning Missed Approach with Turn Fix at Greater than Minimum Distance



3.9.1 **e. Section 2. [Non-RNAV]**

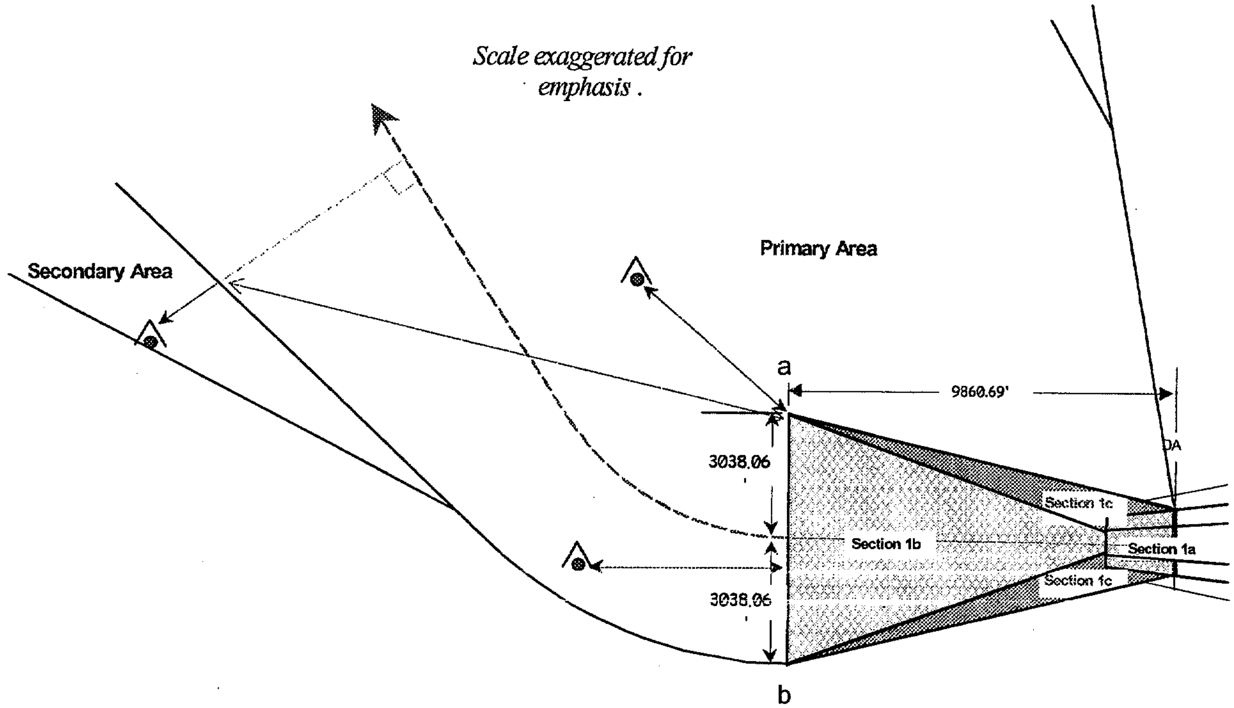
3.9.1 **e. (1) Straight-Ahead** (15° or less of final course heading). Section 2 is a 40:1 OCS that starts at the end of section 1 and is centered on the missed approach course. The width increases uniformly from 1 mile at the beginning to 12 miles at a point 13.377 miles from the beginning. A secondary area for reduction of obstacle clearance is identified within section 2. The secondary area begins at zero miles wide and increases uniformly to 2 miles wide at the end of section 2. PCG is required to reduce obstacle clearance in the secondary areas (see figure 3-11A). Use TERPS Volume 1, paragraph 277e, to determine if a climb-in-holding evaluation is required.

Figure 3-11A. Straight Missed Approach



3.9.1 **e. (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 175 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. Specify the "climb to" altitude in the published missed approach procedure. The flight track and outer boundary radii used shall be as specified in TERPS Volume 1, table 5, paragraph 275. 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 miles 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 miles wide and increase uniformly to 2 miles wide at the end of section 2. PCG is required to reduce obstacle clearance in the secondary area.

Figure 3-11B. Turning Missed Approach



3.9.1 **e. (3) Combination Straight-Turning Missed Approach Procedures.** Use TERPS Volume 1, paragraphs 277d and f to establish the charted missed approach altitude. Use TERPS Volume 1, paragraph 277e to determine if a climb-in-holding evaluation is required.

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.

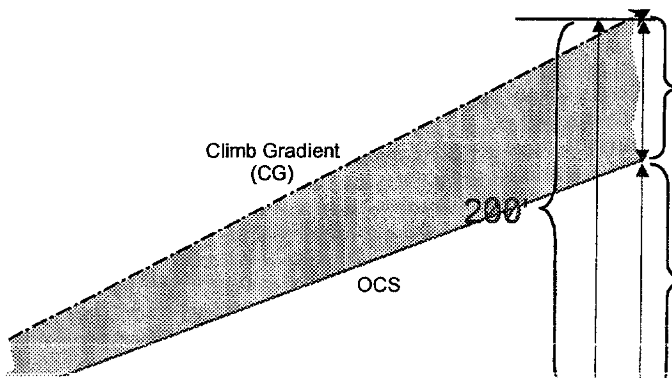
$$\frac{o-(DA-\tan(\theta)(1460)+276.52)}{0.76d}=CG \quad \text{Example: } \frac{1849-(613-\tan(3)(1460)+276.52)}{(0.76)(5.26)}=259.15\approx 260$$

Where o = MSL height of obstruction
d = shortest distance (NM) from end of section 1B to obstacle
θ = glidepath angle

3.9.3 Missed Approach ROC Rationale.

The obstacle clearance concept applied to the departure and missed approach climb maneuver 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 maneuver 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% $\left(\frac{19}{25}\right)$ of the altitude gained defines the OCS slope; 24% $\left(\frac{6}{25}\right)$ of the altitude gained defines the ROC value.

Figure 3-12. ROC and OCS Slope Values



$$0.24 \times AG = ROC \text{ or } \frac{6}{25} \times AG = ROC$$

$$0.24 \times 200 = 48 \text{ ft/NM or } \frac{6 \times 200}{25} = 48 \text{ ft/NM}$$

$$0.76 \times AG = OCS \text{ or } \frac{19}{25} \times AG = OCS$$

$$0.76 \times 200 = 152 \text{ ft/NM or } \frac{19 \times 200}{25} = 152 \text{ ft/NM}$$

$$\frac{152}{6076.11548} \approx 1:40$$

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 ($0.24 \times [Y > 200] = [Z > 48]$). The ROC expressed in ft/NM can be calculated using the formula: $\frac{0.24h}{0.76d}$ or $\frac{6h}{19d}$ 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.

CHAPTER 4.
BAROMETRIC VERTICAL NAVIGATION (BARO VNAV)

4.0 GENERAL.

Design LNAV/VNAV approach procedures under these criteria. Baro VNAV operations are not authorized where remote altimeter is used, or in areas of precipitous terrain. The allowable range of glidepath angles is:

MINIMUM glidepath angle is 2.75°;
OPTIMUM glidepath angle is 3.00°,
MAXIMUM glidepath angle is 3.5°.

4.1 PUBLISHING ON RNAV CHARTS.

When published on an RNAV approach chart that depicts multiple lines of minima (LNAV/VNAV, LNAV, etc.), the TCH, GPA, course alignment, PFAF/FAF, and missed approach route and altitudes shall be identical for all depicted procedures. When minimums are based on remote altimeter and/or temperature settings, or the final segment overlies precipitous terrain, annotate the chart with a note to indicate Baro VNAV is not authorized. Where Baro VNAV is authorized, publish the minimum temperature for which the procedure was designed.

4.2 GROUND INFRASTRUCTURE.

If the airport obstacle free zones or the POFA are penetrated, LOWEST minimums are 300-foot ceiling and 3/4 mile visibility.

4.3 GLIDEPATH QUALIFICATION SURFACE (GQS).

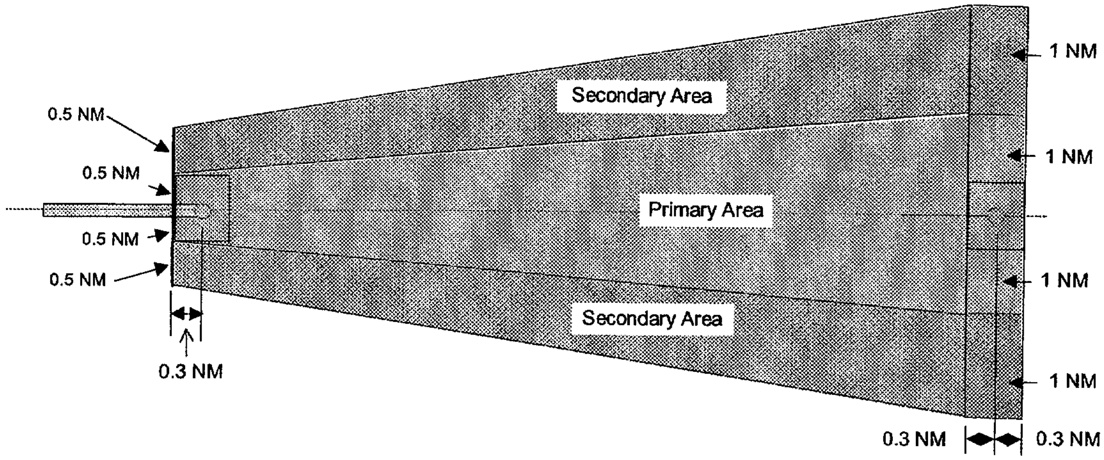
Penetrations of the GQS are not authorized. Apply paragraph 2.12.

4.4 FINAL APPROACH SEGMENT.

LNAV/VNAV procedures are based on the LNAV trapezoid. The Baro VNAV vertical surfaces conform to the LNAV trapezoid.

4.4.1 Area. See figure 4-1A.

Figure 4-1A. LNAV-VNAV Primary and Secondary Areas



4.4.2 **Alignment.**

The default final course aiming point is the LTP/FTP. OPTIMUM alignment is with the runway centerline (RCL) extended. The MAXIMUM offset from RCL is 15°. Approaches serving category A and B aircraft only may be designed with the offset course passing through the LTP/FTP regardless of degree of offset (see figure 4-1B). Where larger aircraft categories (CAT C, D, and E) are accommodated, the offset course must cross the RCL extended at least a MINIMUM distance from the RWT determined by the degree of offset, except as noted below:

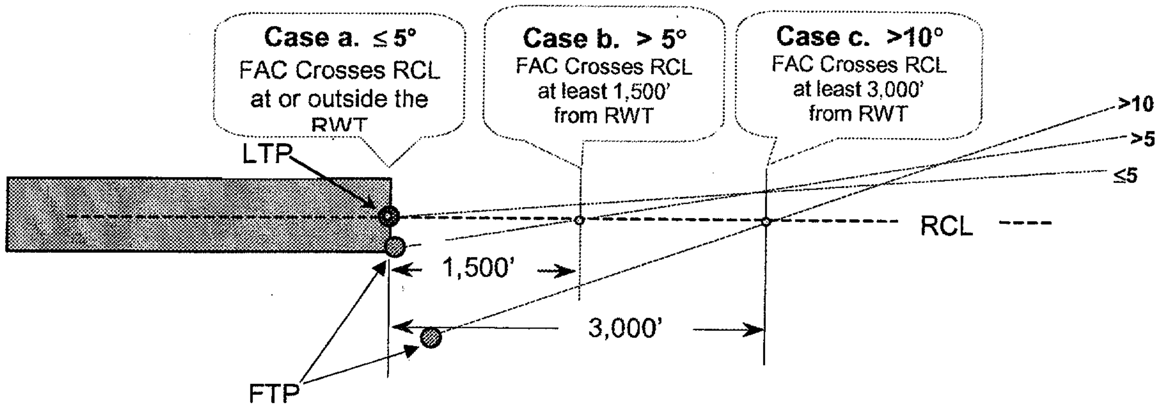
4.4.2 a. **Where the FAC is ≤5°** from the RCL alignment, the FAC shall cross the RCL at or outside the RWT.

4.4.2 b. **When the FAC is >5°** from RCL alignment, the FAC shall cross the RCL at least 1,500 feet from the RWT.

4.4.2 c. **When the FAC is >10°** from RCL alignment, the FAC shall cross the RCL at least 3,000 feet from the RWT.

NOTE: A FAC that intersects the RCL inside RWT, does not intersect the RCL extended or intersects at a distance greater than 3,000 feet from RWT may be established provided that the course lies laterally within 500 feet of the extended RCL at a point 3,000 feet outward from the RWT.

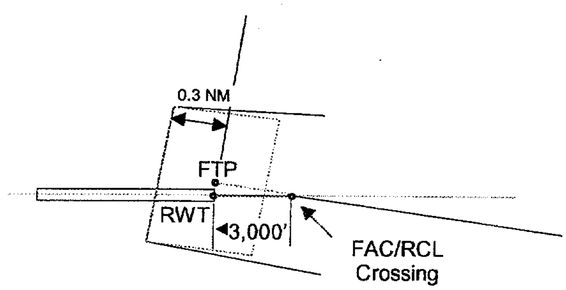
Figure 4-1B. Offset Final Course and RCL Extended Crossing Points



4.4.3 Length.

The primary OCS begins at the earliest point the FAF can be received and extends 0.3 NM past the RWT or FTP (see figures 4-1A, 4-1B, and 4-2).

Figure 4-2. End of Final Trapezoid, 15° Offset



4.4.4 Width.

4.4.4 a. Primary Area.

Calculate the perpendicular distance (D_Y) from the course extended to the outer boundary of the primary area for any distance (D) from RWT or FTP using the following formula:

$$D_Y = \frac{0.5\,NM}{L} \times (D + 1822.83) + 3038.06$$

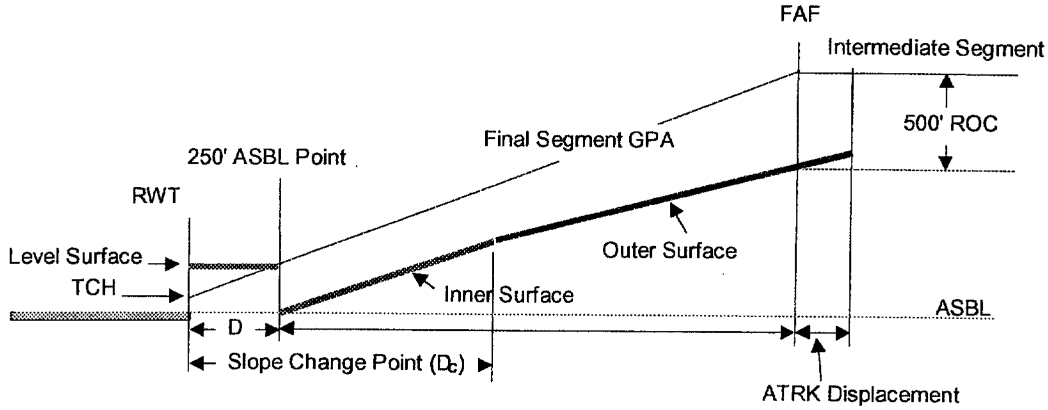
Where D = the distance in feet from RWT or FTP along course centerline
L = the final length in NM from plotted position of FAF to plotted position of RWT or FTP

4.4.4 b. Secondary Area.

The width of the secondary area is equal to the ½ width of the primary at any distance "D" from RWT or FTP (see paragraph 4.4.4a).

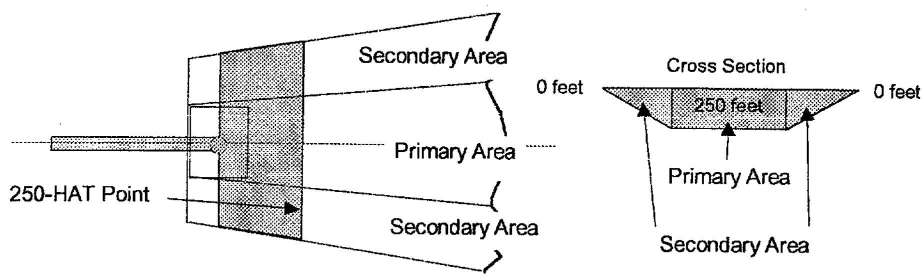
4.4.5 **Obstacle Clearance Between RWT and 250' ASBL Point** (see figure 4-3).

Figure 4-3. Baro VNAV OCS's



The area between the RWT or FTP and the 250 feet above ASBL point consists of primary and secondary ROC areas. Apply ROC in the appropriate shaded area below to arrive at a preliminary DA (pDA) (see figure 4-4).

Figure 4-4. Obstacle Clearance Inside the 250 Feet Above ASBL Point



In the primary area, apply 250 feet ROC to the highest obstruction (see figure 4-4). Calculate secondary area ROC using the following formulae:

$$D_P = \frac{3{,}038.06}{L} \times (D_X + 1{,}822.83) + 3038.06$$

Example: $\frac{3{,}038.06}{28{,}557.74} \times (3{,}000 + 1{,}822.83) + 3{,}038.06 = 3{,}551.13$

$D_S = D_P$

$$ROC_S = \frac{250}{D_S} \times ([2 \times D_s] - D_y)$$

Example: $\frac{250}{3{,}551.15} \times ([2 \times 3{,}551.13] - 4{,}200) = 204.32$

Where
L = final length in feet (plotted position of FAF to plotted position of RWT or FTP).
DP=the distance in feet from course centerline to the primary area outer boundary.
D_S =the width of the secondary area at distance D_X.
D_X = the distance in feet from RWT or FTP to the obstacle measured along course centerline.
D_Y=the perpendicular distance in feet from course centerline to the obstacle.

Determine the pDA by adding the appropriate ROC value to the controlling obstruction height and round up to the next higher 20-foot increment.

4.4.6 Inner Surface.

The inner surface originates at the point on the ASBL corresponding distance from RWT that the glidepath reaches 250 feet above ASBL (see figure 4-3). Calculate the distance (D_{250}) from RWT or FTP to the OCS origin using the following formula:

$$D250 = \frac{250 - TCH}{\tan(\theta)} \qquad \text{Example: } \frac{250\text{-}53}{\tan(3)} = 3758.98$$

Where θ = glidepath angle

Determine the slope of the inner surface (S_V) as follows:

STEP 1: Obtain the mean low temperature of the coldest month of the year for the last five years of data. If the data is given in Fahrenheit (°f), convert the temperature to Celsius (°c) and enter table 4-1. Use the following formulae to convert between Celsius and Fahrenheit temperatures:

$$°c = \frac{°f - 32}{1.8} \qquad \text{Example}: \frac{76-32}{1.8} = 24.44°c$$

$$°f = (1.8 \times °c) + 32 \qquad \text{Example}: (1.8 \times 24.44) + 32 = 75.99°f$$

STEP 2: Convert the mean temperature into a deviation from ISA using the following formula:

$$\text{deviation} = °c - \left[15°c - \left(\frac{\text{Airport Elevation}}{500}\right)\right] \qquad \text{Example}: -28 - \left[15°c - \left(\frac{1{,}528}{500}\right)\right] = -39.9°$$

Round deviation to the next lower 5°c increment. Use this rounded deviation or -15°c, whichever is lower, and the GPA to find the surface slope from table 4-1.

Table 4-1. S_V Considering GPA and International Standard Atmosphere (ISA) Temperature Deviation

ISA (C) DEV	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	20.4	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 glidepath angle falls between table values, use the higher value.

4.4.7 Outer Surface.

Calculate the slope of the outer surface (S_W) appropriate for the glidepath angle (θ) using the following formula: $S_W = \frac{102}{\theta}$ The outer surface begins at point "c" and ends at the earliest point the FAF can be received (see figure 4-3). Calculate the distance (D_C) from RWT or FTP to point C using the following formula

$$D_C = \frac{(a \times S_W) - (200 \times S_V)}{(S_W - S_V)}$$

Where a=distance from RWT or FTP to OCS origin (D_{250})

4.4.8 Height of the OCS.

4.4.8 **a. Calculate the height** (I_Z) above ASBL of the inner surface using the following formula:

$$I_Z = \frac{D_O - D_{250}}{S_V}$$

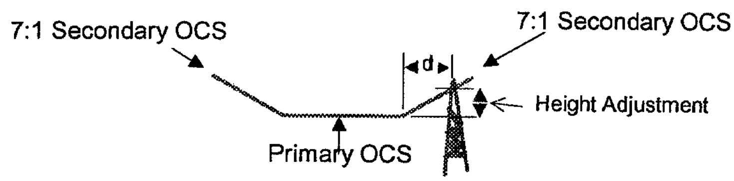
Where D_O = the distance in feet from the RWT or FTP to the obstacle
D_{250} = the distance from the RWT or FTP origin to the inner surface origin

4.4.8 **b. Calculate the height** (O_Z) above ASBL of the outer OCS using the following formula:

$$O_Z = \frac{(D_O - 200) \times GPA}{102}$$

4.4.8 **c. The secondary OCS** has a slope of 7:1 measured perpendicular to the segment centerline. To evaluate the height of a secondary OCS obstruction, reduce the obstruction height by the amount of secondary surface rise from the edge of the primary OCS (see figure 4-5). Then evaluate the revised height of the obstruction against the height of the primary OCS abeam the obstruction.

Figure 4-5. Secondary OCS Evaluation



Cross Section

$$\textit{Height Adjustment} = \frac{d}{7}$$

Where d = distance in feet from edge of primary OCS measured perpendicular to the segment centerline.

4.4.9 **OCS Penetrations.**

Obstructions should not penetrate the OCS. If the OCS is clear, publish the pDA value. If the OCS is penetrated, take one of the following actions. These actions are listed in order of preference.

ACTION 1: Remove or adjust the obstruction location and/or height.

ACTION 2: Raise glidepath angle.

ACTION 3: Adjust DA.

4.4.9 **a. Adjustment of DA for Penetration of INNER SURFACE.**

CASE 1: If elevation (revised elevation if paragraph 4.4.8c applied) of the obstacle is less than the elevation of point C ($C_{elevation}$):

$$C_{elevation}=E+\frac{D_C-D_{250}}{S_V}$$

$$DA_{adjusted}=E+\tan(\theta)\left(\left(D_O+\frac{TCH}{\tan(\theta)}\right)+(p\times S_V)\right)$$

Where θ = glidepath angle
D_O = distance (ft) to obstacle from LTP measured parallel to FAC
p = amount of penetration (ft)
S_V = slope of inner surface
E = LTP elevation (ft)

CASE 2: If the elevation (revised elevation if paragraph 4.4.8c applied) of the obstacle is equal to or greater than the elevation of point C:

$$DA_{adjusted}=E+\tan(\theta)\left[([h-c]S_W)+D_C+\frac{TCH}{\tan(\theta)}\right]$$

Where h = obstacle MSL elevation (revised elevation if para 4.4.8c applied)
c = elevation (MSL) of point C

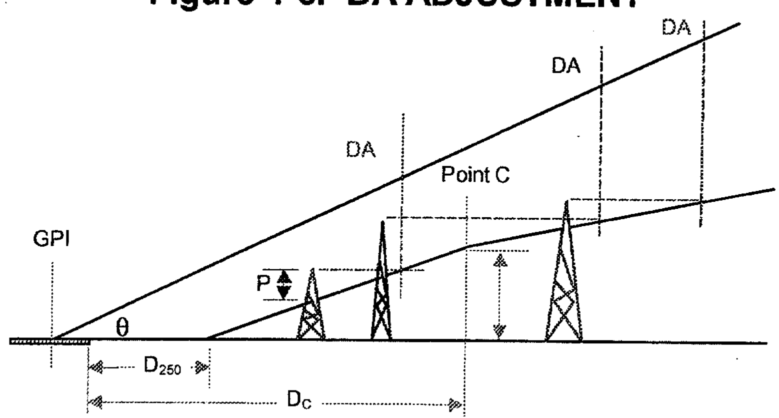
4.4.9 **b. Adjustment of DA for penetration of OUTER SURFACE** (see figure 4-6):

$$DA_{adjusted}=E+\tan(\theta)\left[(pS_W)+D_O+\frac{TCH}{\tan(\theta)}\right]$$

$$\text{Distance LTP to } DA_{adjusted}=\frac{DA_{adjusted}-E}{\tan(\theta)}-\frac{TCH}{\tan(\theta)}$$

Where $DA_{adjusted}$=Adjusted DA (MSL)

Figure 4-6. DA ADJUSTMENT



4.5 VISIBILITY MINIMUMS.

To determine visibility minimums, refer to TERPS Volume 1, chapter 3 for localizer procedures.

4.6 MISSED APPROACH SEGMENT.

Height loss is assumed after DA. The missed approach area begins at the cd line prior to the DA point. Apply RNAV departure criteria (Order 8260.44) from the segment origin to the missed approach holding fix. Locate the first fix encountered after DA at least 9,114 feet from the ab line and a maximum of 5 NM. If a turn is associated with a fly-by fix, the minimum distance is 9,114+DTA (see figures 4-7 and 4-8A and 4-8B).

Figure 4-7. Straight Missed Approach Surfaces

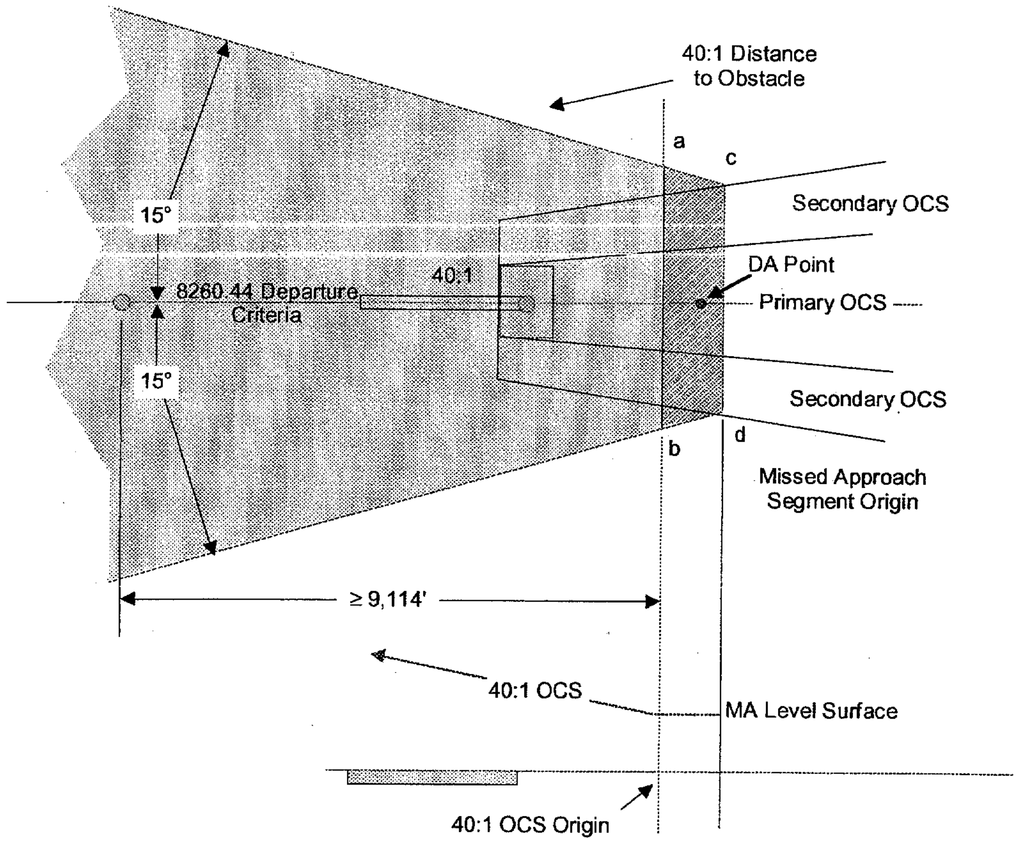


Figure 4-8A. Turning Approach Surfaces Minimum Distance from DA to Turn Fix

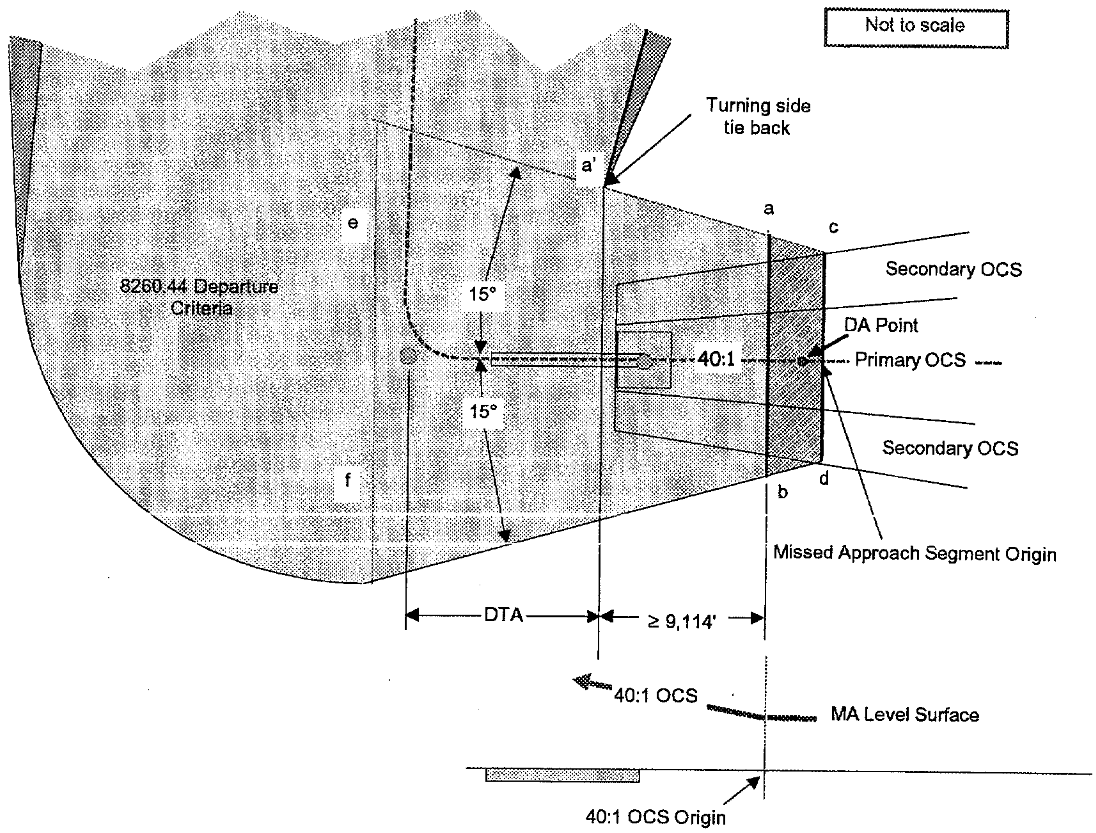
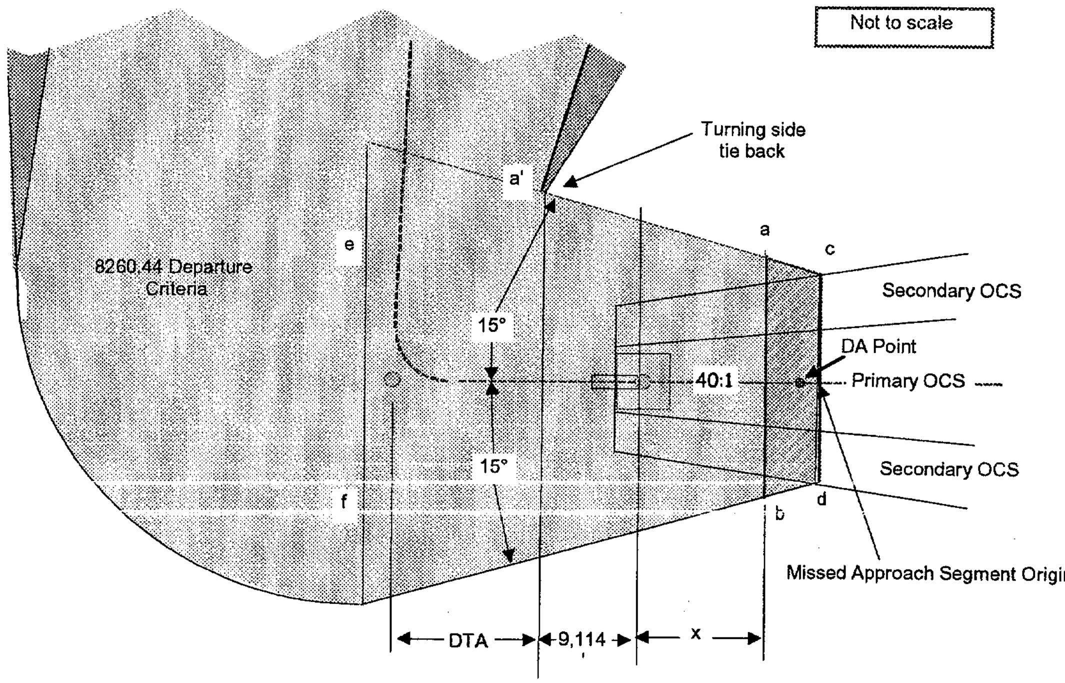


Figure 4-8B. Turning Approach Surfaces Greater than Minimum Distance from DA to Turn Fix



4.6.1 **Area.**

4.6.1 **a. Level Surface.** See figure 4-9.

The level surface accounts for possible along track errors inherent with barometric altimetry and allows an aircraft to lose (dip down) 50 feet prior to commencing climb.

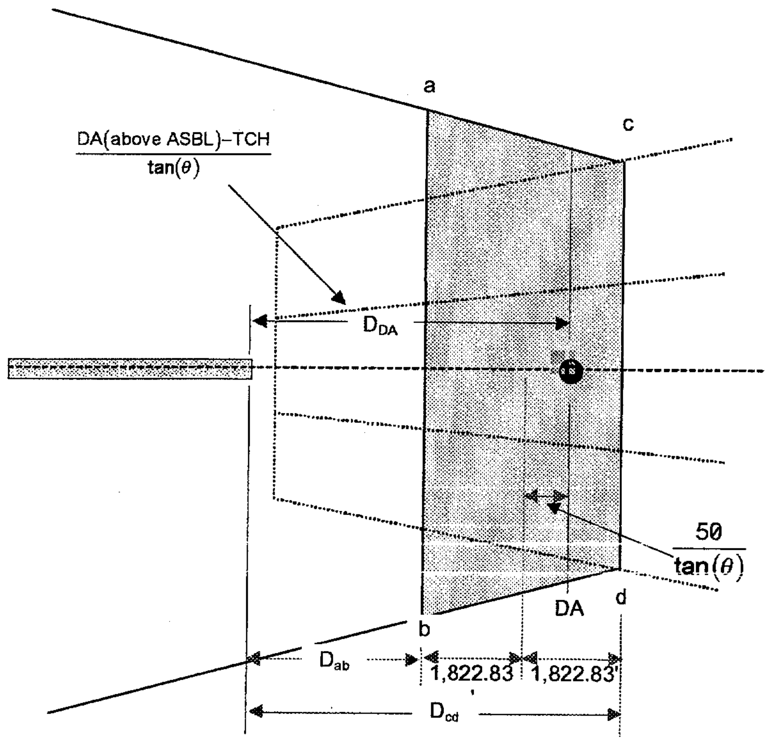
4.6.1 **a. (1) Length.** Calculate the distance (D_{cd}) from RWT to the **origin** of the MA segment (<u>cd</u> line), and the distance (D_{ab}) from RWT to the end of the level surface (<u>ab</u> line), using the following formulae:

$$D_{cd} = \frac{DA - (E + TCH)}{\tan(\theta)} - \frac{50}{\tan(\theta)} + 1822.83$$

$$D_{ab} = D_{cd} - 3645.66$$

Where E = RWT elevation
θ = GPA

Figure 4-9. Level Surface



4.6.1 **a. (2) Width.** The area splays at 15° relative to the MA course beginning at the secondary outer boundary at the cd line (see figure 4-9).

4.6.1 **a. (3) OCS.** A level surface overlies the primary area. Where obstructions penetrate the OCS, increase the DA by the value of the penetration. The height of the MA LEVEL OCS (MSL) is determined by the formula:

$$hmas = DA - ROC$$

4.6.1 **b. 40:1 Surface.** Apply Order 8260.44 criteria.

4.6.1 **b. (1) Length.** The 40:1 surface begins at the ab and extends along the MA course until the clearance limit.

4.6.1 **b. (2) Width.** The primary area splays as specified in Order 8260.44 relative to the MA course beginning at the final primary outer boundary at the cd line (see figure 4-9).

4.6.1 **b. (3) OCS.** Where obstructions penetrate the OCS, increase the DA by the value ($DA_{adjustment}$) calculated by the following formula:

$$DA_{adjustment} = \frac{\theta(40p)}{102}$$

Where p = amount of penetration in feet

4.6.1 **c. Missed Approach Altitude.**

4.6.1 **c. (1) Straight Missed Approach Procedures.** Use TERPS paragraphs 274b and d to establish the charted missed approach altitude. Use TERPS paragraph 274c to determine if a climb-in-holding evaluation is required.

4.6.1 **c. (2) Combination Straight Turning Missed Approach Procedures.** Use TERPS paragraphs 277d and f to establish the charted missed approach altitude. Use TERPS paragraph 277e to determine if a climb-in-holding evaluation is required.

APPENDIX 1. CATEGORY (CAT) II AND III PRECISION MINIMUMS REQUIREMENTS

RESERVED

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 paragraph 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 Volume 1, chapter 2, paragraph 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.

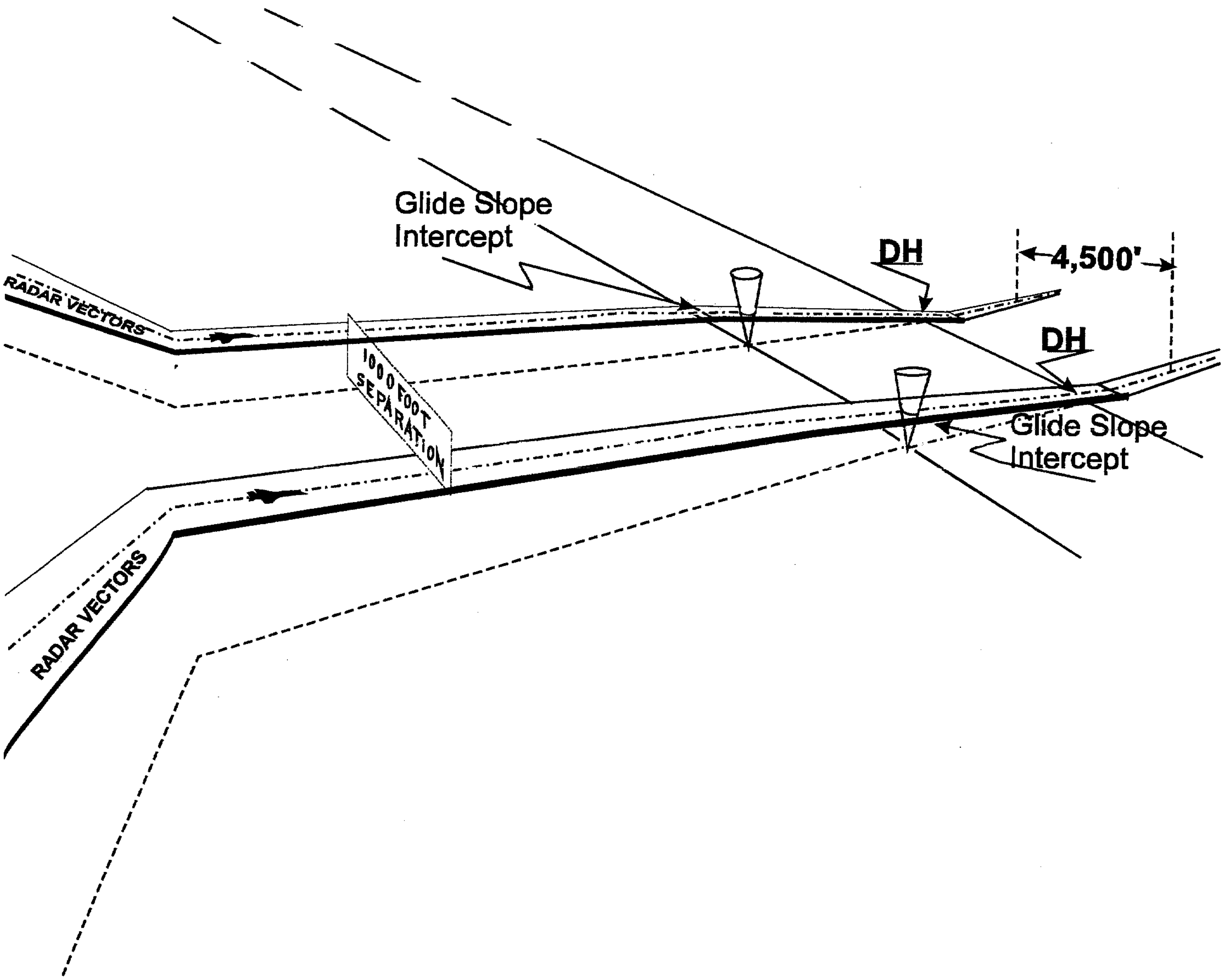
4.1 ALTITUDE SELECTION.

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).

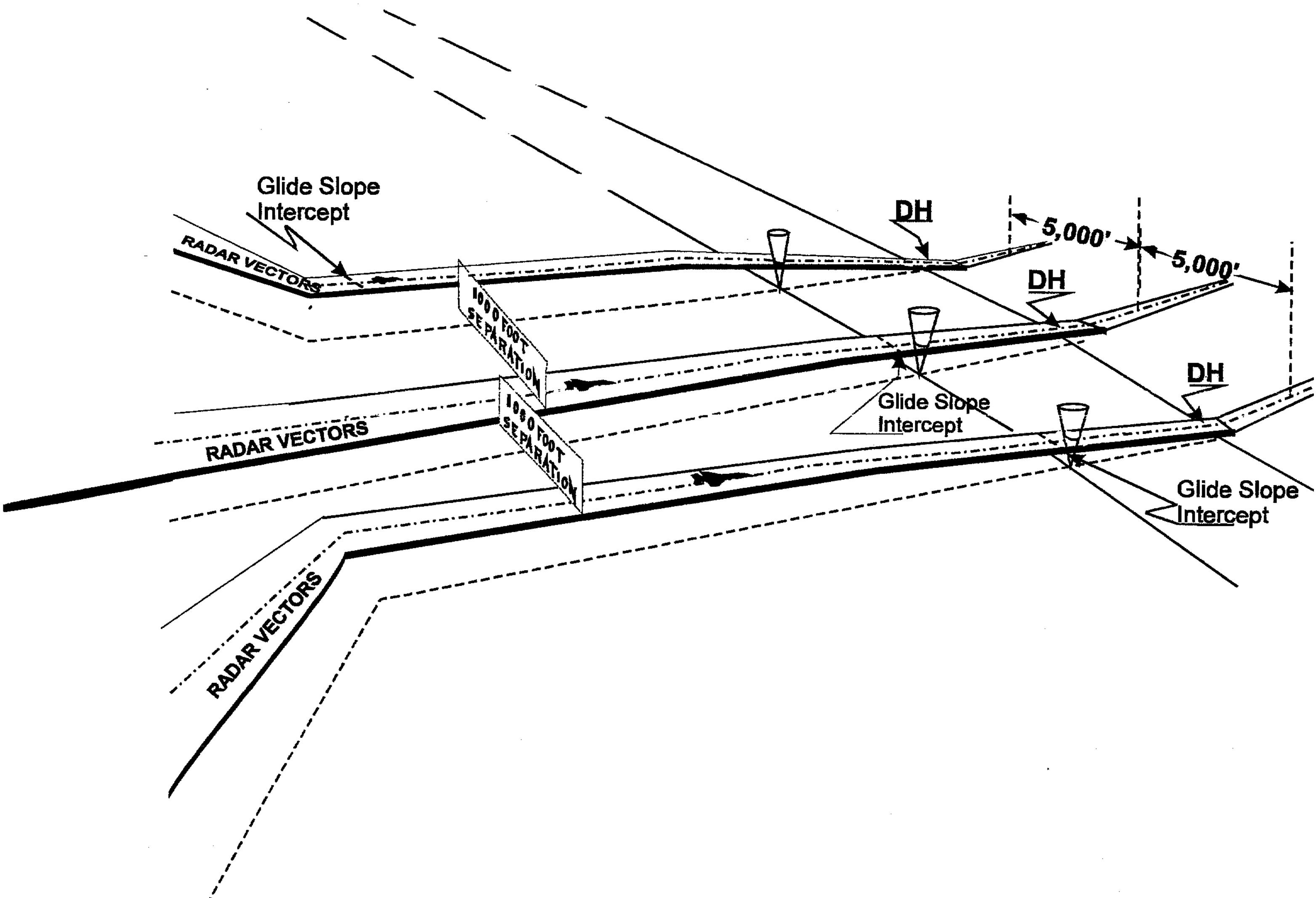
Figure A2-1. Initial Approach Segment, Simultaneous ILS



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).

Figure A2-2. Initial Approach Segment for Triple Simultaneous ILS



4.2 LOCALIZER INTERCEPT POINT.

The localizer intercept point shall be established UNDER chapter 2, paragraph 2.3 of this Volume. Intercept angles may not exceed 30°; 20° is optimum.

5.0 INTERMEDIATE APPROACH SEGMENT.

Criteria for the intermediate segment are contained in Volume 1, paragraphs 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, paragraph 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 FAC's for simultaneous ILS approaches require the following:

7.1 DUAL APPROACHES.

The MINIMUM distance between parallel FAC's is 4,300 feet.

7.2 TRIPLE APPROACHES.

The MINIMUM distance between parallel FAC's 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.

7.3 NO TRANSGRESSION ZONE (NTZ).

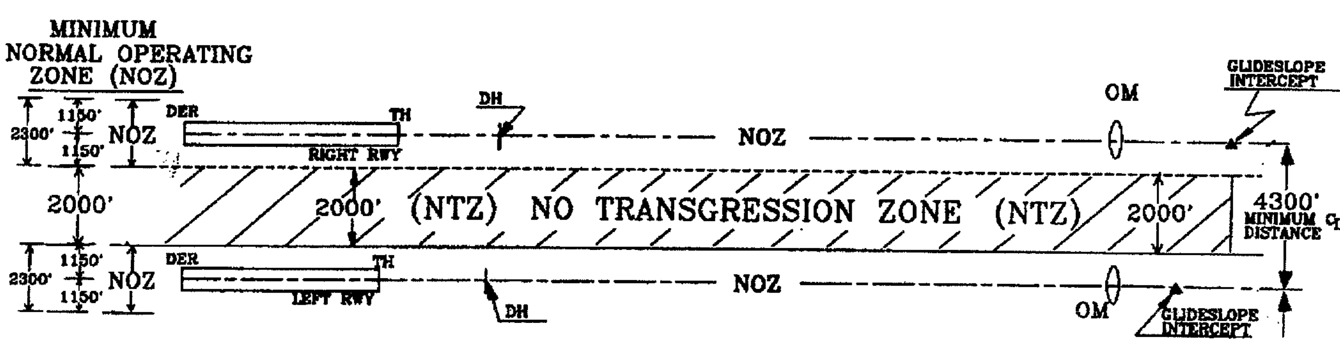
The NTZ shall be 2,000 feet wide equidistant between FAC's.

7.4 NORMAL OPERATING ZONE (NOZ).

The area between the FAC and the NTZ is half of the NOZ.

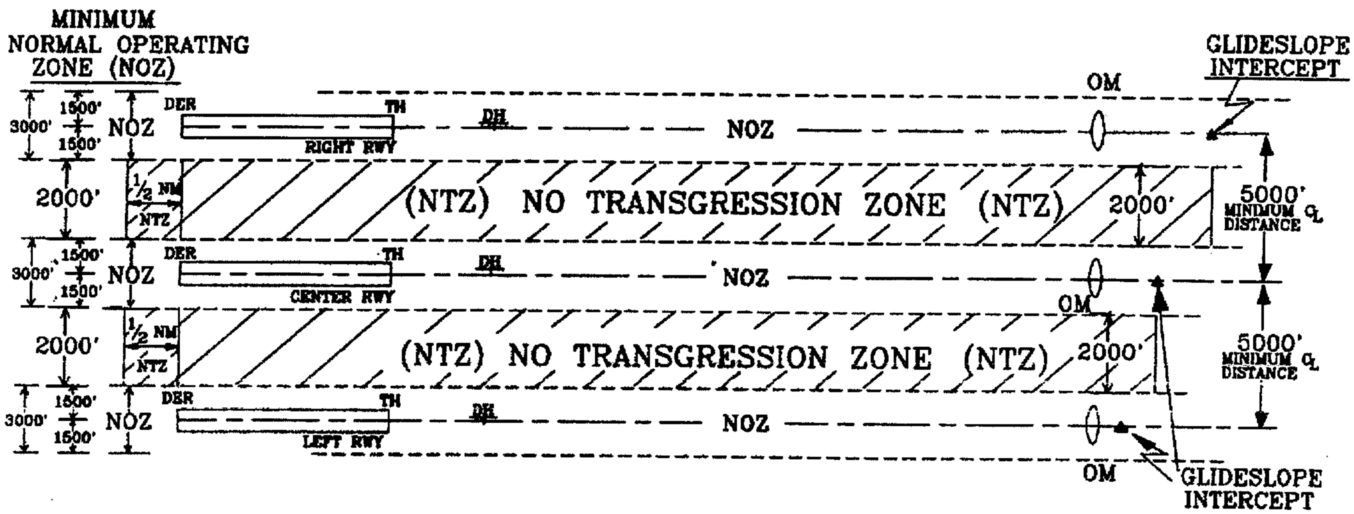
7.4.1 **The NOZ for dual simultaneous ILS approaches** shall not be less than 1,150 feet in width each side of the FAC (see figure A2-3).

Figure A2-3. Dual Simultaneous ILS "No Transgression And Normal Operating Zones"



7.4.2 **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).

Figure A2-4. Triple Simultaneous ILS "No Transgression Zone and Normal Operating Zones"



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 center runway should continue straight ahead. A minimum of 45° 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.

2.1 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. Paragraph 3.1.2 defines the precision runway monitor (PRM) systems alerts.

2.2 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.

2.3 CLOSE PARALLELS.

Two parallel runways whose extended centerlines 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°.

2.4 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.

2.5 LOCALIZER/AZIMUTH OFFSET.

An angular offset of the localizer/azimuth from the runway extended centerline in a direction away from the no transgression zone (NTZ) that increases the normal operating zone (NOZ) width.

2.6 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.

2.7 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).

2.8 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.)

2.9 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 color 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 centerlines 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 inter-changeably 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 paragraph 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 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.** A full ILS or MLS on each runway.

3.1.2 **PRM.** A PRM system includes the following:

3.1.2 **a. Radar**. Phased array electronically scanned (E-Scan) antenna; update intervals of 1.0 second.

3.1.2 **b. Final Monitor Aid (FMA).** Large (not less than 20" x 20"), high resolution (100 pixels/inch minimum), color monitors with associated visual and audible alerts.

3.1.2 **b. (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).

3.1.2 **b. (2) Warning Alert.** A warning alert when the aircraft has penetrated the NTZ (e.g., the target symbol and data block change to red).

3.1.2 **b. (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, paragraph 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.

Volume 3, chapter 2, paragraph 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°.

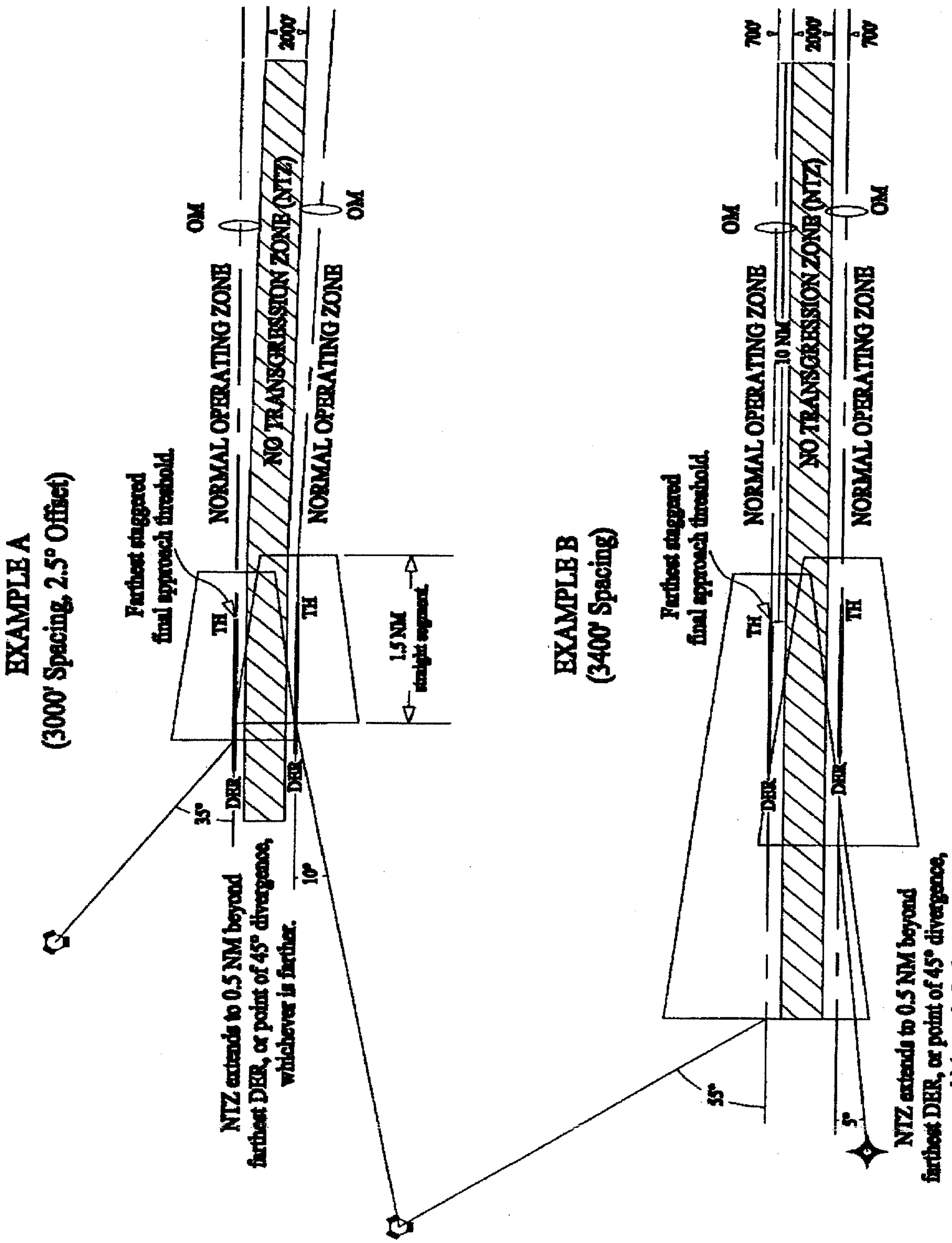
4.3 NTZ.

An NTZ is established and depicted on the FMA as a protected zone 2,000 feet wide, equidistant between parallel runway centerlines, 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 centerline, and the half-width is defined by the distance from the nearest edge of the NTZ to the final approach course centerline. 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′



5.0 INTERMEDIATE APPROACH SEGMENT.

Chapter 2, paragraph 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 chapter 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 paragraph 3.1.2.

6.3 NTZ.

An appropriate NTZ shall be established between close parallel final approach courses as described in paragraph 4.3 (see figure A3-1).

6.4 NOZ.

Appropriate NOZ's shall be established for each parallel final approach segment as described in paragraph 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 centerline 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:

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 centerline.

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 paragraph 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 paragraph 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.

2.1 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 centerline 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:

$$W = \text{ArcTan}\left(\frac{350}{D}\right) \quad \text{Total Course Width at RWT} = 2 \times W$$

Where: W = Half Width (in degrees) at RWT

D = Distance from localizer antenna to RWT (in feet)

2.2 PARALLEL APPROACH OBSTRUCTION ASSESSMENT (PAOA).

An examination of obstruction identification surfaces, in addition to the ILS TERPS surfaces, in the direction away from the NTZ and adjacent parallel ILS runway, into which an aircraft on an early ILS breakout could fly.

2.3 PARALLEL APPROACH OBSTRUCTION ASSESSMENT SURFACES (PAOAS).

PAOA assessment surfaces for identifying obstacles that may impact simultaneous precision operations.

2.4 PARALLEL APPROACH OBSTRUCTION ASSESSMENT SURFACE PENETRATION.

One or more obstructions that penetrate the PAOAS.

2.5 PARALLEL APPROACH OBSTRUCTION ASSESSMENT CONTROLLING OBSTRUCTION (PAOACO).

The obstruction within the boundaries of the PAOAS which constitutes the maximum penetration of that surface.

2.6 NO TRANSGRESSION ZONE (NTZ).

See Volume 3, appendix 3, paragraph 4.3.

2.7 NORMAL OPERATIONAL ZONE (NOZ).

See Volume 3, appendix 3, paragraph 4.4.

3.0 GENERAL.

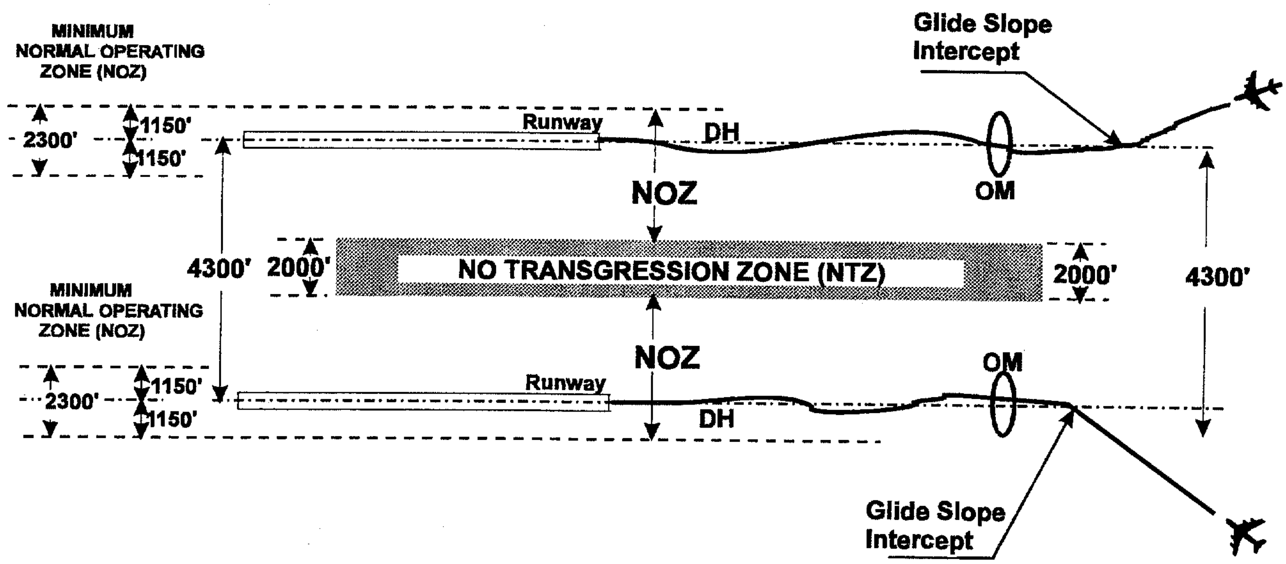
This order characterizes criteria used during the interim test phase of evaluating close parallel operations where early turnout obstacle assessments were accomplished by contractual means using terrestrial photometric techniques combined with survey methods of surface evaluation. This assessment technique 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 nautical miles (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.

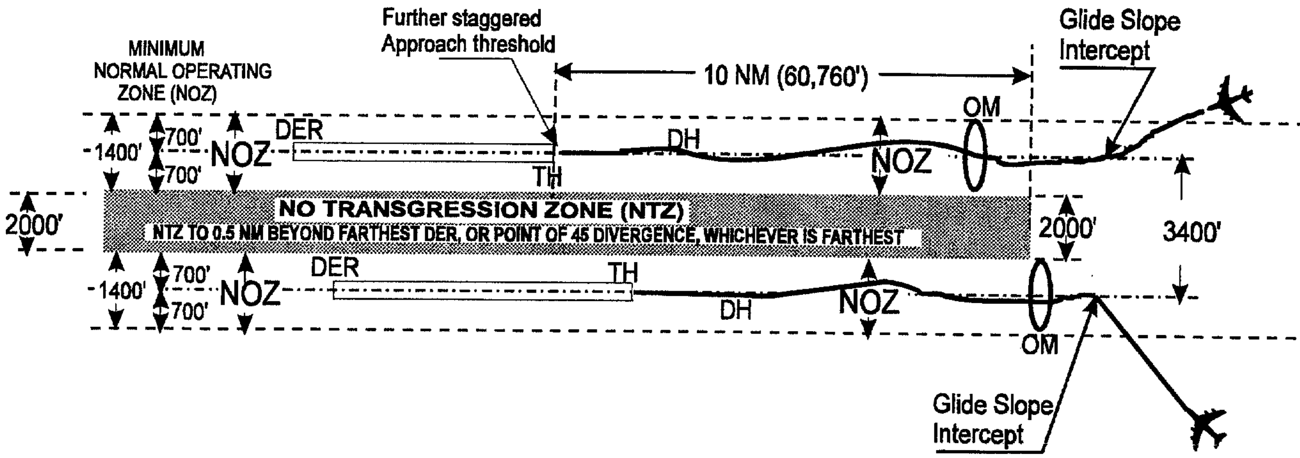
3.1.1 **When lateral radar separation is less than the 3 NM** and the 1,000-foot altitude buffer is lost, the aircraft must be monitored on radar. The controllers, on separate and discrete frequencies, will observe the parallel approaches, and if an aircraft blunders from the NOZ into a 2,000-foot NTZ, the monitor controller can intervene so that threatened aircraft on the adjacent approach are turned away in time to prevent a possible encounter. This maneuver, 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 centerline while the other directs the breakout (see figure A4-1).

Figure A4-1. Simultaneous precision parallel Runway Approach Zones



3.1.2 **The 2,000-foot NTZ**, flanked by two equal NOZ's, provides strong guidance to the monitor controller and maneuvering 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 A4-2. Simultaneous ILS No Transgression Zone and Normal Operating Zone



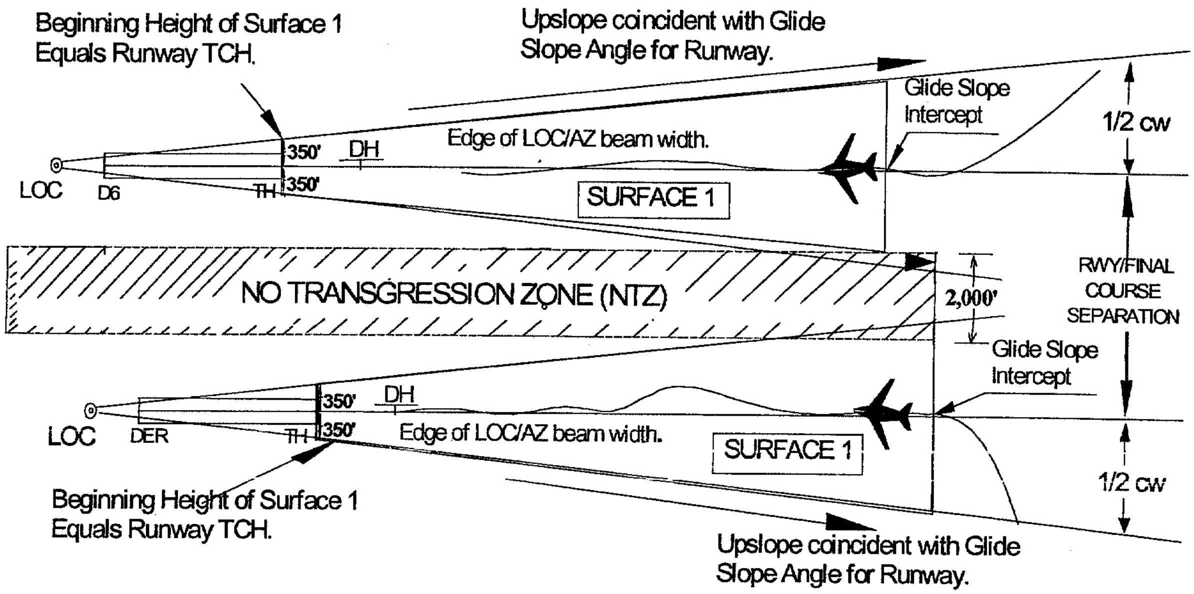
4.0 **PAOA EVALUATION.**

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 centerline 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).

Figure A4-3. Final Approach Descent Surface 1



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 $\frac{\text{(LOC/AZ Beam Angle).}}{2}$

Suface 1 Height – Distance from TH in feet along C_L X TAN of the GS/GP angle + TCH.

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 = Width of Surface 1

A = Distance from RWT measured parallel to course

B = Course Width Beam Angle

OR

$$\frac{1}{2}W = L \times Tan\left(\frac{B}{2}\right)$$

Where W = Width of Surface 1

L = Distance from Azimuth antenna (in feet)

B = Course Width Beam Angle

4.1.3 **Surface 1 Height.** Surface height at any given centerline distance (d), may be determined in respect to threshold elevation, by adding the TCH to the product of centerline distance in feet from threshold times the tangent of the GS/GP angle.

$$h1 = [d \times Tan(GPA)] + TCH$$

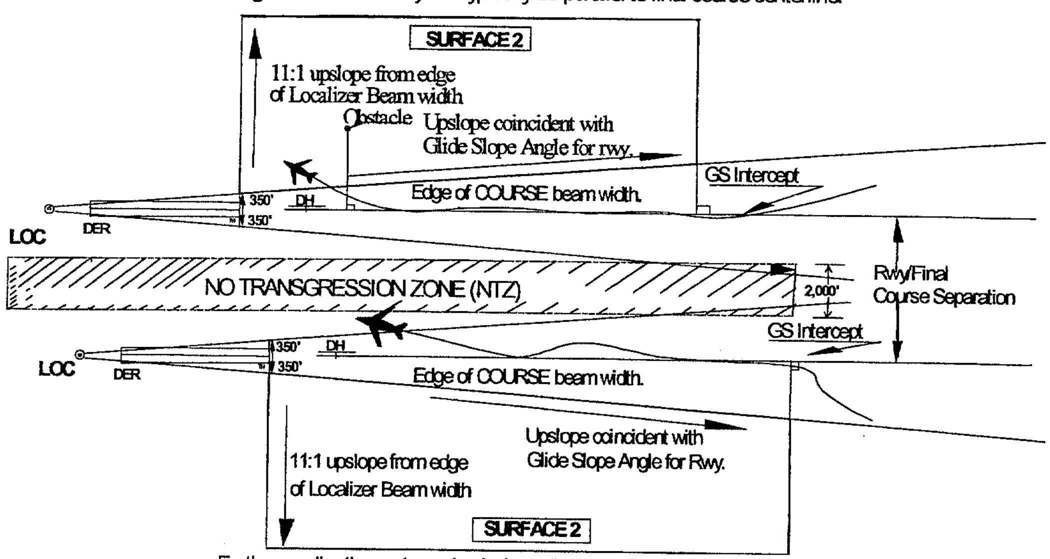
Where: h1 = surface 1 height above ASBL

4.2 **SURFACE 2.**

4.2.1 **Length.** Same as paragraph 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 centerline. 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



4.3 **SURFACE 3 (CATEGORY I).**

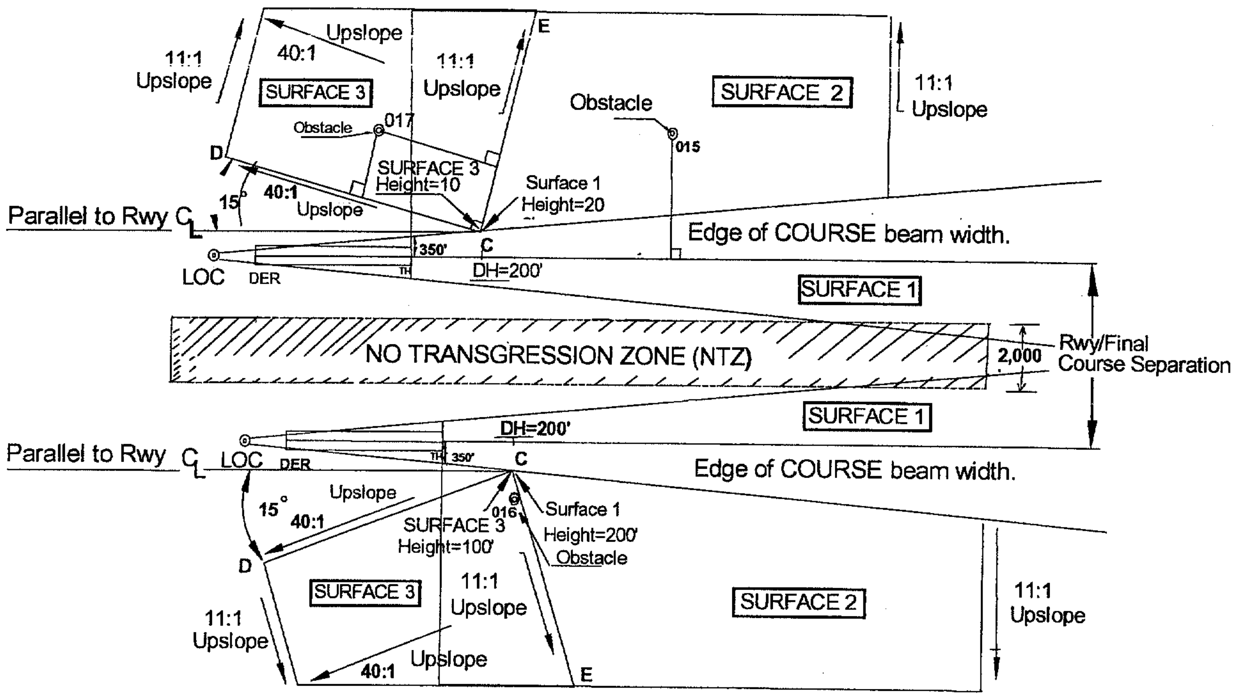
4.3.1 **Length.** For category I operations, surface 3 begins at the point where surface 1 reaches a height of 200 feet above the TDZE and extends to the point the 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest.

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 centerline.

4.3.3 **Surface 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).

Figure A4-5. CAT I Missed Approach Early Breakout Parallel Approach Obstacle Assessment Surface 3.

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. Obs.) perpendicular to Line CD + Height of 40:1 Slope measured (fr. Obs.) perpendicular to Line CE + 100 feet.

4.4 **SURFACE 4 (CATEGORY II).**

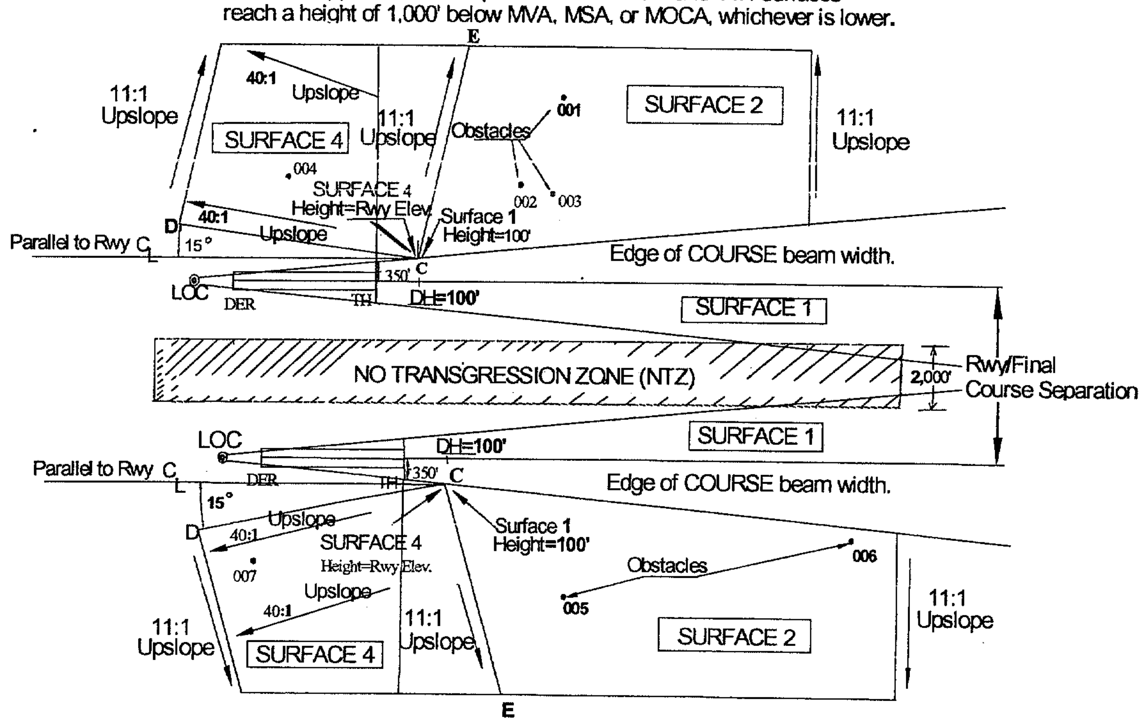
4.4.1 **Length.** Surface 4 begins at the point where surface 1 reaches a height of 100 feet above the runway TDZE and extends to the point 40:1 and 11:1 slopes reach a height of 1,000 feet below the MVA, MSA, or MOCA, whichever is lowest.

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 centerline.

4.4.3 **Surface 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).

Figure A4-6. CAT II Missed Approach Early Breakout Parallel Approach Obstacle Assessment Surface 4

The outer edges of Surface 2 or 4 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 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.

4.5 **ESTABLISH A LATITUDE-LONGITUDE LIST** for all obstacles penetrating 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.

APPENDIX 5.

THRESHOLD CROSSING HEIGHT

GROUND POINT OF INTERCEPT

RUNWAY POINT OF INTERCEPT

TCH/GPI/RPI CALCULATION

The following spreadsheets are a part of this appendix and can be found on the internet "http:\\terps.faa.gov"

Figure A5-1. Non-Radar Precision TCH/GPI/RPI

Figure A5-2. Precision Approach Radar (PAR) (Scanning Radar)

Figure A5-3. Precision Radar TCH/GPI/RPI

Version 1.0

Figure A5-1. Non-Radar Precision TCH/GPI/RPI

1,016.00	A=Distance (ft) from GS antenna to RWT
100.00	a=RWT elevation (MSL)
98.00	c=Elevation (MSL) of runway crown at RPI/TDP
90.00	h=ILS antenna base elevation (MSL)
107.20	p=Phase center (MSL) of elevation antenna
3.00	e=Glidepath angle

STEP 1: CALCULATE OR SPECIFIY TCH

51.25	**ILS** (smooth terrain)	$\tan(e) \times A - (a - c)$
43.25	**ILS** (rapidly dropping terrain)	$\tan(e) \times A - (a - h)$
60.45	**MLS**	$\tan(e) \times A + (p - a)$
50.00	**LAAS/WAAS**	Specify TCH

STEP 2: CALCULATE GPI

977.84 ILS (smooth terrain)

825.19 ILS (rapidly dropping terrain)

1,153.38 MLS

954.06 LAAS/WAAS

$$\frac{TCH}{\tan(e)}$$

STEP 3: CALCULATE RPI

1,016.00 ILS (smooth terrain)

863.35 ILS (rapidly dropping terrain)

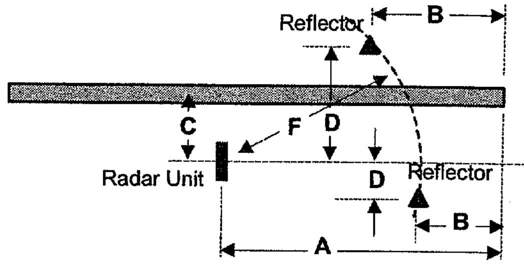
1,191.55 MLS

992.22 LAAS/WAAS

$$\frac{TCH + (a - c)}{\tan(e)}$$

Figure A5-2.
Precision Approach Radar (PAR)
(Scanning Radar)

Version 1.0

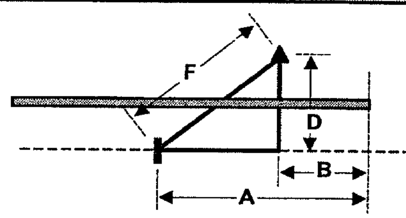


ELEVATIONS (MSL):		DISTANCES (FT):	
Threshold [a]:	100	AZ antenna to threshold [A]:	4500
Touchdown Reflector [b]:	105	TD reflector to threshold [B]:	750
RWY Crown in TDZE [c]:	100.7	AZ antenna to centerline [C]:	450
RPI (if known) [d]:	100.5	TD reflector to CLA line [D]:	475
Glidepath Angle [e]:	3	RWY gradient (if required) [E]:	0.00023333

STEP 1: Determine distance from AZ antenna to TD reflector [F].

3,779.96

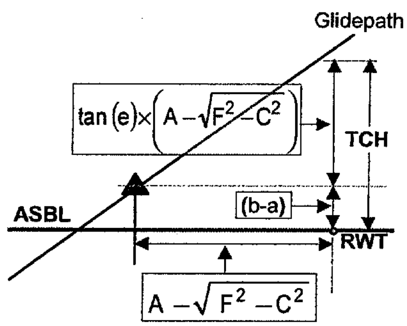
$$F=\sqrt{(A-B)^2+D^2}$$

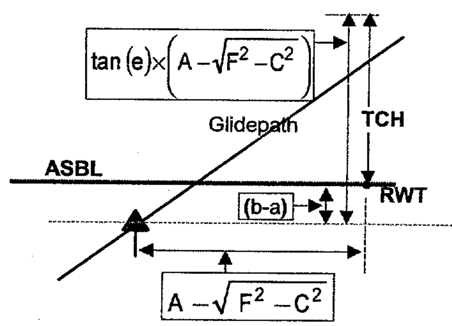


STEP 2: Determine threshold crossing height [TCH].

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

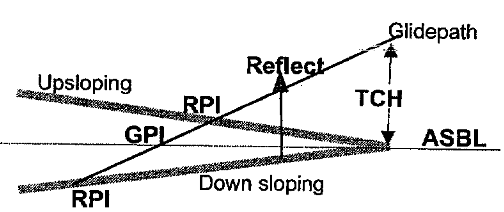
838.59

$$RPI=\frac{TCH}{\tan(e)+E}$$ for up sloping runway

[d] unknown

846.09

$$RPI=\frac{TCH}{\tan(e)-E}$$ for down sloping runway



Version 1.0

Figure A5-3. Precision Radar TCH/GPI/RPI

(Tracking Radar)

100.00	a=RWT elevation (MSL)
98.00	c=Elevation (MSL) of runway crown at RPI/TDP
3.00	e=Glidepath angle

STEP 1: **SPECIFIY TCH**

50.00 <== TCH

STEP 2: **CALCULATE GPI**

954.06 <== GPI $\frac{TCH}{\tan(e)}$

STEP 3: **CALCULATE RPI**

992.22 <== RPI $\frac{TCH + (a - c)}{\tan(e)}$

FAA ORDER **8260.3B**

Army
Navy
Coast Guard
Air Force

TM 95-226
OPNAV Inst. 3722.16C
CG 318
AFMAN 11-226(I)

UNITED STATES STANDARD
FOR
TERMINAL
INSTRUMENT
PROCEDURES
(TERPS)

<u>VOLUME 4</u>

DEPARTURE PROCEDURE CONSTRUCTION

U. S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

VOLUME 4. TABLE OF CONTENTS

DEPARTURE PROCEDURE CONSTRUCTION

Page

CHAPTER 1. GENERAL CRITERIA

VOLUME 4. TABLE OF CONTENTS (Continued)

VOLUME 4. TABLE OF CONTENTS (Continued)

CHAPTER 1. GENERAL CRITERIA

1.0 GENERAL.

IFR departure procedures may be designed and published for all runways authorized by the approving authority. For civil procedures, runway/taxiway separations, and airport obstacle free zones (OFZ) must meet the standards in Advisory Circular (AC) 150/5300-13, Airport Design, or appropriate military directives for military procedures for specified departure visibility minimums. Criteria for RNAV-equipped aircraft are provided in Orders 8260.44, Civil Utilization of Area Navigation (RNAV) Departure Procedures, and 8260.40, Flight Management System (FMS) Instrument Procedures Development.

1.1 TERMINOLOGY, ABBREVIATIONS, AND DEFINITIONS.

1.1.1 Climb Gradient (CG).

A climb requirement expressed in ft/NM (gradient greater than 200 ft/NM).

1.1.2 Course.

A specified track measured in degrees from magnetic north.

1.1.3 Dead Reckoning (DR).

The navigation of an airplane solely by means of computations based on airspeed, course, heading, wind direction, speed, ground speed, and elapsed time.

1.1.4 Departure End of Runway (DER).

The end of the runway opposite the landing threshold. It is sometimes referred to as the stop end of runway (SER).

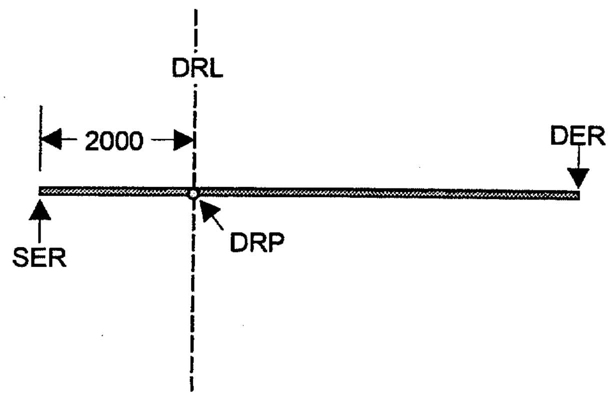
1.1.5 Departure Reference Line (DRL).

An imaginary line of indefinite length perpendicular to runway centerline at the DRP.

1.1.6 Departure Reference Point (DRP).

A point on the runway centerline 2,000 feet from the SER (see figure 1-1).

Figure 1-1. Runway Terms



1.1.7 Departure Route.

A specified course and altitude along a track defined by positive course guidance (PCG) to a clearance limit, fix, or altitude.

1.1.8 Departure Sector.

Airspace defined by a heading or a range of headings for aircraft departure operations.

1.1.9 Diverse Vector Area (DVA).

An area in which a prescribed departure route is not required. Radar vectors may be issued below the minimum vectoring or minimum IFR altitude. It can be established for diverse departure, departure sectors, and/or video map radar areas portraying obstacles and terrain.

1.1.10 Diverse Departure.

A departure without restrictions to the route of flight.

1.1.11 Diverse Departure Evaluation to Establish Sector(s) for Prescribed Departure Routes.

An evaluation of a diverse area to establish an unrestricted area or sector for purposes of publishing departure routes, including multi-turns and legs.

1.1.12 Initial Climb Area (ICA).

An area beginning at the DER to provide unrestricted climb to at least 400 feet above DER elevation.

1.1.13 **ICA Baseline (ICAB).**

A line at DER, perpendicular to runway centerline, denoting the beginning of the ICA.

1.1.14 **ICA End-Line (ICAE).** A line at end of ICA perpendicular to the departure course.

1.1.15 **Instrument Flight Rules (IFR).**

Rules governing the conduct of flight under instrument meteorological conditions.

1.1.16 **Instrument Meteorological Conditions (IMC).**

Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling less than the minima specified for visual meteorological conditions.

1.1.17 **Obstacle.**

Synonymous with natural or man-made obstacles, obstructions, or obstructing terrain.

1.1.18 **Obstacle Clearance Surface (OCS).**

An inclined surface associated with a defined area for obstacle evaluation.

1.1.19 **Obstruction Evaluation Area (OEA).**

Areas requiring obstacle evaluation.

1.1.20 **Positive Course Guidance (PCG).**

A continuous display of navigational data, which enables an aircraft to be flown along a specific course, e.g., radar vector, RNAV, ground-based NAVAID's.

1.1.21 **Required Obstacle Clearance (ROC).**

Required vertical clearance expressed in feet between an aircraft and an obstruction.

1.1.22 **Standard Climb Gradient (SCG).**

Departure and missed approach obstacle clearance is based on the assumption that an aircraft will climb at a gradient of at least 200 feet per NM. This is the standard climb gradient.

1.1.23 Start End of Runway (SER).

The beginning of the takeoff runway available.

1.1.24 Takeoff Runway Available (TORA).

The length of runway declared available and suitable for satisfactory takeoff run requirements.

1.1.25 Visual Flight Rules (VFR).

Rules that govern the procedures for conducting flight under visual conditions.

1.1.26 Visual Meteorological Conditions (VMC).

Meteorological conditions expressed in terms of visibility, distance from clouds, and ceiling equal to or better than specified minima.

1.1.27 Visual Climb Area (VCA).

Areas around the airport reference point (ARP) to develop a VCOA procedure.

1.1.28 Visual Climb over Airport (VCOA).

Option to allow an aircraft to climb over the airport with visual reference to obstacles to attain a suitable altitude from which to proceed with an IFR departure.

1.2 DEPARTURE CRITERIA APPLICATION.

Evaluate runways for IFR departure operations by applying criteria in the sequence listed below (paragraphs 1.2.1 through 1.2.3).

1.2.1 **Perform a diverse departure evaluation** to each runway authorized for IFR takeoff. Diverse departure is authorized if the appropriate OCS is clear. If the OCS is penetrated, consider development of departure sectors and/or climb gradients.

1.2.2 **Develop departure routes** where obstacles prevent diverse departure operations.

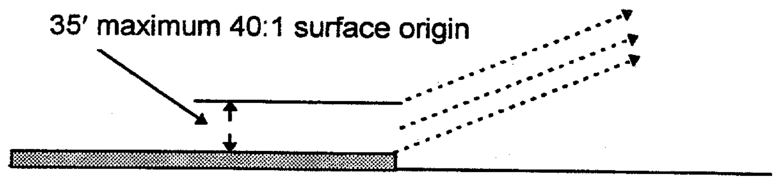
1.2.3 **Develop a VCOA procedure** where obstacles more than 3 statute miles from DER require climb gradients greater than 200 ft/NM (see chapter 4).

1.2.4 **At locations served by terminal radar**, air traffic control may request development of diverse vector areas to aid in radar vectoring departure traffic (see chapter 2, paragraph 2.3).

1.3 **DEPARTURE OCS APPLICATION.**

The OCS begins at the DER at DER elevation. EXCEPTION: Adjust the origin height up to 35 feet above DER as necessary to clear existing obstacles (see figure 1-2). Evaluate proposed obstacles assuming the OCS origin is at DER elevation.

Figure 1-2. OCS Starting Elevation



1.3.1 **Low, Close-In OCS Penetrations.**

Do not publish a CG to a height of 200 feet or less above the DER elevation. Annotate the location and height of any obstacles that cause such climb gradients.

1.3.2 **Calculating OCS Height.**

The OCS height is based on the distance measured from the OCS origin along the shortest distance to an obstacle within the segment.

1.3.2 a. **Primary Area.** The OCS slope is 40:1. Use the following formula to calculate the OCS height:

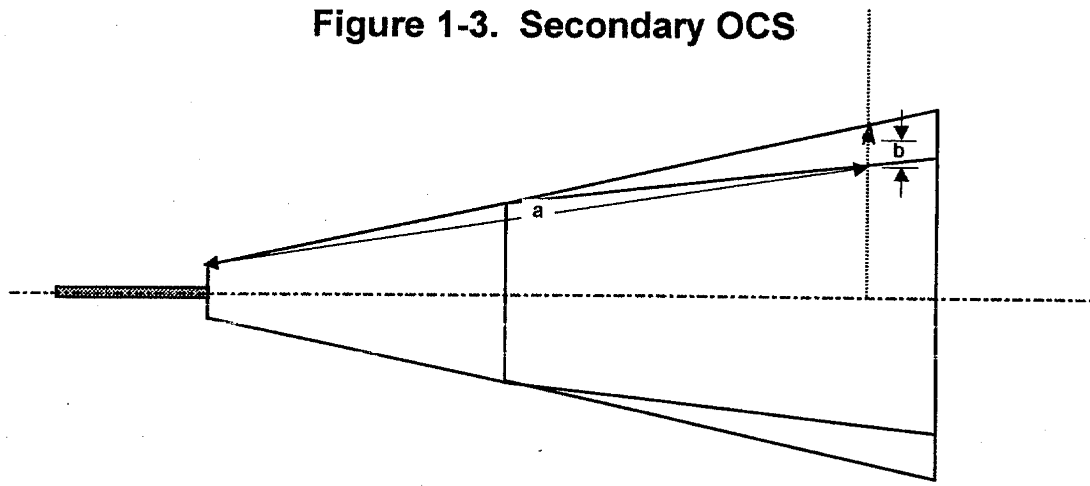
$$h_{OCS} = \frac{d}{40} + e$$

where d=shortest distance (ft) from the OCS origin to the obstacle
e=OCS origin elevation

$$\text{Example: } \frac{8923}{40} + 1221 = 1444.08 \text{ ft}$$

1.3.2 **b. Secondary Area.** (Applicable only when PCG is identified.) The OCS slope is 12:1. The secondary OCS elevation is the sum of the 40:1 OCS rise (a) in the primary area to a point the obstacle is perpendicular to the departure course, and the secondary OCS rise (b) from the edge of the primary OCS to the obstacle (see figure 1-3).

Figure 1-3. Secondary OCS



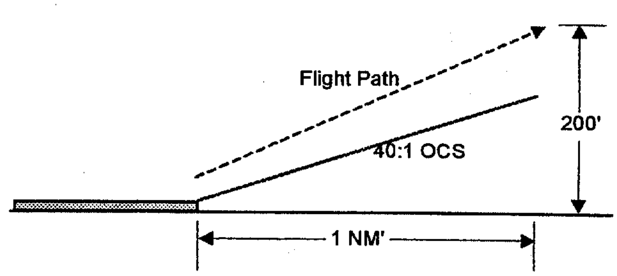
$$h_{SECONDARY} = \frac{a}{40} + \frac{b}{12}$$

Example: $$\frac{21191}{40} + \frac{318}{12} = 556.28$$

1.4 CLIMB GRADIENTS.

Departure procedure obstacle clearance is based on a minimum climb gradient performance of 200 ft/NM (see figure 1-4).

Figure 1-4. Standard Climb Gradient



1.4.1 Calculating Climb Gradients to Clear Obstacles.

Climb gradients in excess of 500 ft/NM require approval of the Flight Standards Service or the appropriate military authority. Calculate climb gradients using the following formula::

Standard Formula

$$CG = \frac{O - E}{0.76\ D}$$

DoD Option*

$$CG = \frac{(48D + O) - E}{D}$$

where O = obstacle MSL elevation
E = climb gradient starting MSL elevation
D = distance (NM) from DER to the obstacle

Examples:

$$\frac{2049\text{-}1221}{0.76 \times 3.1} = 351.44$$

Round to 352 ft/NM

$$\frac{(48 \times 3.1 + 2049) - 1221}{3.1} = 315.10$$

Round to 316 ft/NM

* For use by military aircraft only. Not for civil use.

1.4.2 Calculating the CG Termination Altitude.

When the aircraft achieves an altitude that provides the required obstacle clearance, the CG restriction may be lifted. This altitude is called the "climb to" altitude (A). Calculate the climb-to altitude using the following formula:

$$A = E + (CG \times D)$$

Example: $1221 + (352 \times 3.1) = 2312.20$ Round to 2400

1.4.3 Climb Gradients to Altitudes for Other than Obstacles, i.e., ATC.

Calculate the climb gradient to the stated "climb to" altitude using the following formula where (D) is the distance from the beginning of the climb to the point where the altitude is required:

$$CG = \frac{A\text{-}E}{D}$$

Example: $\frac{3000\text{-}1221}{5} = 355.8$ round to 356 ft/NM

NOTE: The climb gradient must be equal to or greater than the gradient required for obstacles along the route of flight.

1.4.4 Multiple Climb Gradients Application.

Do not publish a number of different gradients for a series of segments. Consider only one climb gradient, which is the most efficient gradient to represent the entire length of the climb gradient distance that encompasses all of the climb gradients required.

1.4.5 **Limiting TORA to Reduce Climb Gradient.**

Limiting the available length of the departure runway during takeoff is an option that can be used to reduce departure climb gradients. Use of this option requires approval of FAA Flight Standards or the appropriate military authority. Use the following formula to determine the TORA for a given desired climb gradient (DCG):

$$TORA = L - \left(\frac{A}{DCG} - \frac{A}{CG}\right) 6076.11548$$

Where A=Altitude above DER elevation where CG ends
CG=Required climb gradient before adjustments
DCG=Desired climb gradient
L=Full length of runway available for departure before adjustments

$$\text{Example:} \quad 10000 - \left(\frac{1000}{250} - \frac{1000}{300}\right) 6076.11548 = 5949.26'$$

1.4.6 **Effect of DER-To-Obstacle Distance.**

1.4.6 **a. Where obstacles 3 statute miles or less** from the DER penetrate the OCS:

1.4.6 **a. (1) Publish** a note identifying the obstacle(s) type, location relative to DER, AGL height, and MSL elevation, and

1.4.6 **a. (2) Publish** standard takeoff minimums with a required CG to a specified altitude, and

1.4.6 **a. (3) Publish** a ceiling and visibility to see and avoid the obstacle(s), and/or

1.4.6 **a. (4) Develop** a specific textual or graphic route to avoid the obstacle(s).

NOTE: Where low, close-in obstacles result in a climb gradient to an altitude 200 feet or less above DER elevation, only paragraph 1.4.6a(1) applies.

1.4.6 **b. Where obstacles more than 3 statute miles** from the DER penetrate the OCS:

1.4.6 **b. (1) Publish** standard takeoff minimums with a required CG to a specified altitude, and

1.4.6 **b. (2) Develop** a VCOA procedure to an altitude that will provide obstacle clearance without a CG, and/or

1.4.6 **b. (3) Develop** a specific textual or graphic departure route to avoid the obstacle(s).

1.5 CEILING AND VISIBILITY.

1.5.1 Ceiling.

Specify a ceiling value equal to the height of the obstruction above the airport elevation rounded to the next higher 100-foot increment.

1.5.2 Visibility.

Specify a visibility value equal to the distance measured directly from the DER to the obstruction rounded to the next higher reportable value. Limit the visibility to a distance of 3 statute miles.

1.6 INITIAL CLIMB AREA (ICA).

The ICA is an area centered on the runway centerline extended used to evaluate obstacle clearance during the climb to 400 feet above DER (minimum climb gradient 200 ft/NM).

1.6.1 ICA Terms.

1.6.1 **a. ICA baseline (ICAB).** The ICAB is a line extending perpendicular to the runway centerline ± 500 at DER. It is the origin of the ICA (see figure 1-5).

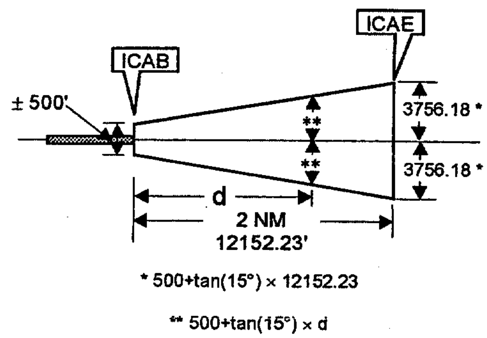
1.6.1 **b. ICA end-line (ICAE).** The ICAE is a line at the end of the ICA perpendicular to the runway centerline extended. The splay of 15° and length of the ICA determine its width (see figure 1-5).

1.6.2 Area.

1.6.2 **a. Length.** The ICA length is normally 2 NM, measured from the ICAB to the ICAE along runway centerline extended. It may be less than 2 NM in length for early turns by publishing a climb gradient, or a combination of climb gradient and reduction in TORA. The ICA may be extended beyond 2 NM to maximum length of 10 NM. A specified altitude (typically 400' above DER) or the interception of PCG route must identify the ICAE.

1.6.2 **b. Width.** The ICA origin is 1,000 feet (± 500 perpendicular to runway centerline) wide at the DER. The area splays outward at a rate of 15° relative to the departure course (normally runway centerline).

Figure 1-5. ICA



1.6.2 **c. OCS.** The OCS originates at the ICAB, normally at DER elevation (see paragraph 1.3). Apply the OCS by measuring the shortest distance from the ICAB to the obstacle and evaluate per paragraph 1.3. The MSL elevation of the ICAE is calculated using the following formula:

MSL ICAE elevation=a+b+303.81

where a=DER elevation
b=OCS origin height above DER elevation (nominally 0)

Example: ICAE elevation=987.24+0+303.81=1291.05

CHAPTER 2. DIVERSE DEPARTURE

2.0 GENERAL.

Evaluate diverse "A" and "B" areas to a distance of 25 NM for nonmountainous areas (see figure 2-1) and 46 NM for mountainous areas. If obstacles do not penetrate the OCS, unrestricted diverse departure may be authorized; publish standard takeoff minimums.

2.1 AREA.

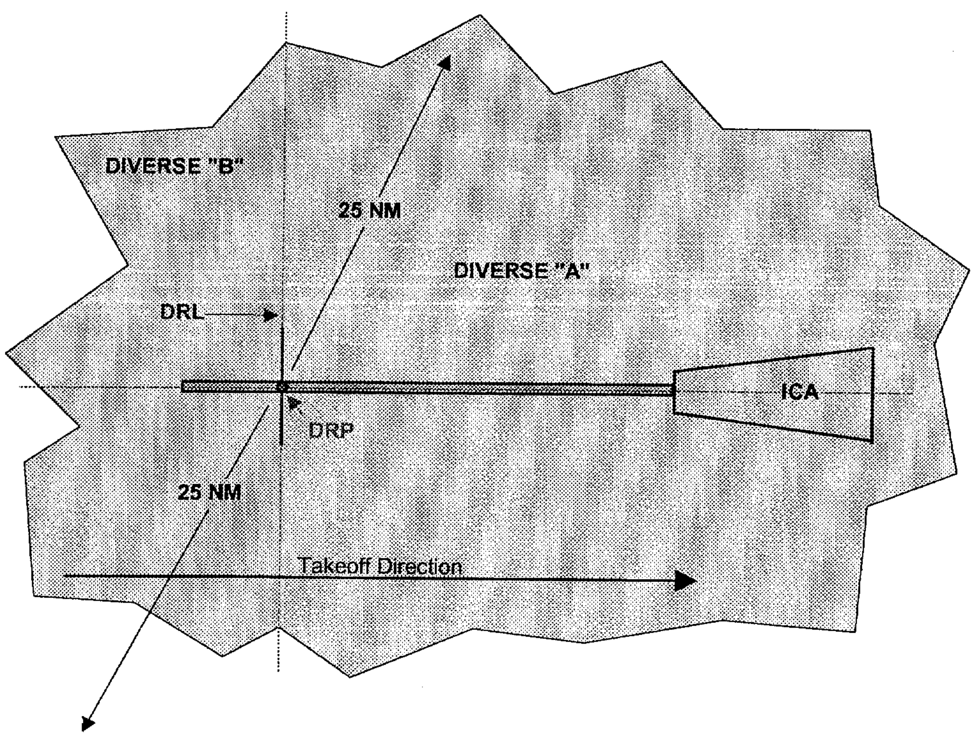
The diverse departure evaluation covers three areas:

Initial Climb Area. See chapter 1, paragraph 1.6.

Diverse A. All areas on the DER side of the DRL.

Diverse B. All areas on the SER side of the DRL.

Figure 2-1. Diverse "A" and "B" Areas



2.1.1 Initial Climb Area (ICA).

Evaluate the ICA under paragraph 1.6.

2.1.2 Diverse "A" Area.

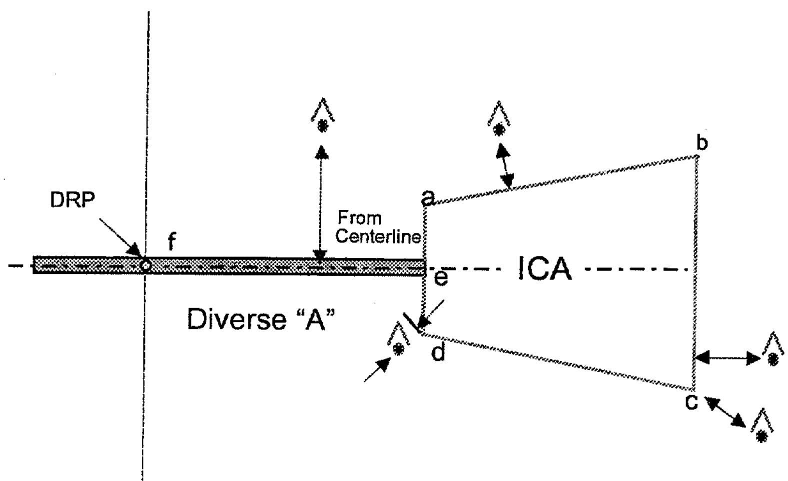
Calculate the height of the OCS at any given location in the diverse "A" area by measuring the distance from the obstacle to the closest point on the centerline of the runway between the DRP and DER, or the closest point on ICA boundary lines as appropriate (see figure 2-2). The beginning OCS elevation is equal to the MSL elevation of the ICAE.

$$h = a + \frac{d}{40}$$

where h=OCS MSL elevation at obstacle
d=distance (ft) from obstacle to closest point
a=ICAE MSL elevation

Example: $h = 1309.77 + \frac{18002.33}{40} = 1759.83$

Figure 2-2. Diverse "A" Area Evaluation



2.1.3 Diverse "B" Area.

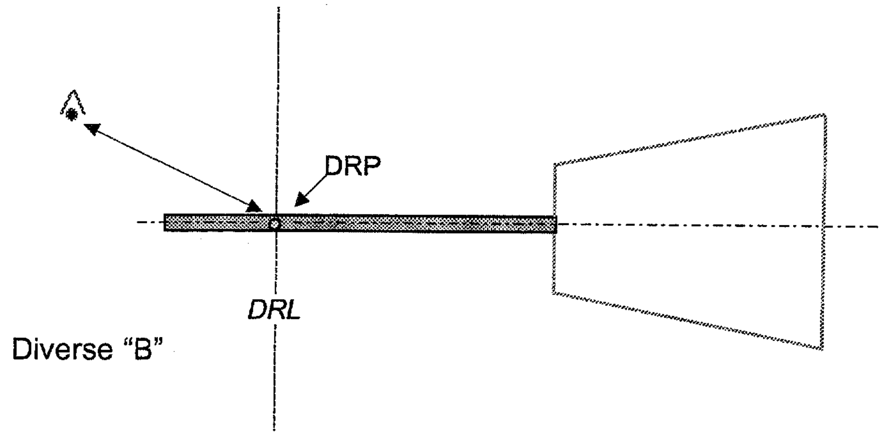
Evaluate obstacles in the Diverse "B" area by measuring the distance in feet from the obstacle to the DRP (see figure 2-3). Calculate the OCS MSL elevation at the obstacle using the following formula:

$$h = \frac{d}{40} + (b + 400)$$

where h=OCS MSL elevation at obstacle
d=distance (ft) from obstacle to DRP
b=Airport MSL elevation

Example: $h = \frac{8500}{40} + (1283.22 + 400) = 1895.72$

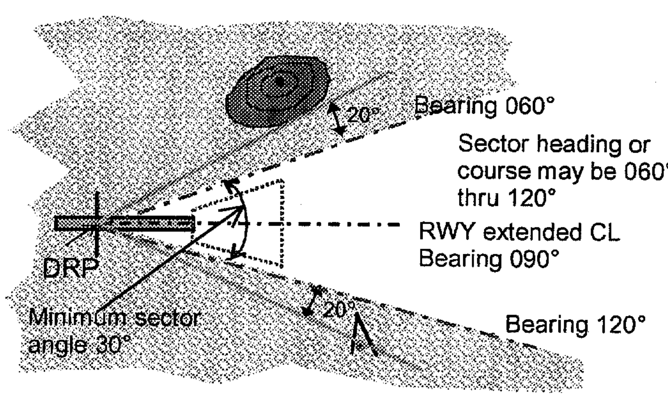
Figure 2-3. Diverse "B" Area



2.2 DEPARTURE SECTORS.

Where OCS penetrations prevent unrestricted diverse departure, consider constructing sectors within the diverse areas where departure flight is prohibited. Departure instructions must assure the aircraft will maneuver clear of the prohibited sector boundaries. Separate sector boundaries from obstacles via a buffer established by the 20° splay from the DRP. The minimum angle between sector boundaries is 30°. The ICA must be protected at all times (see figure 2-4).

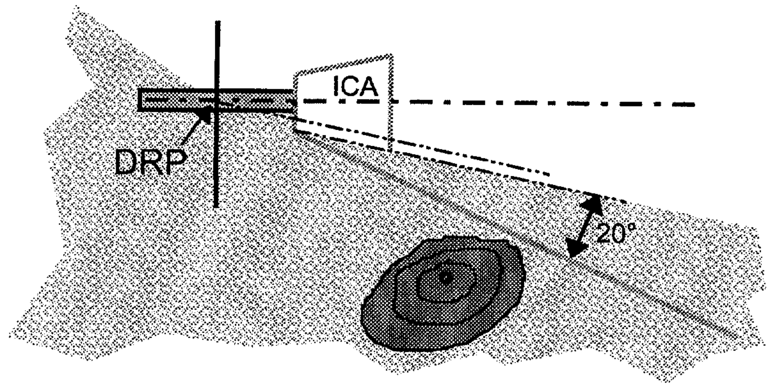
Figure 2-4. Minimum Sector Area



2.2.1 Boundary Based on the ICA.

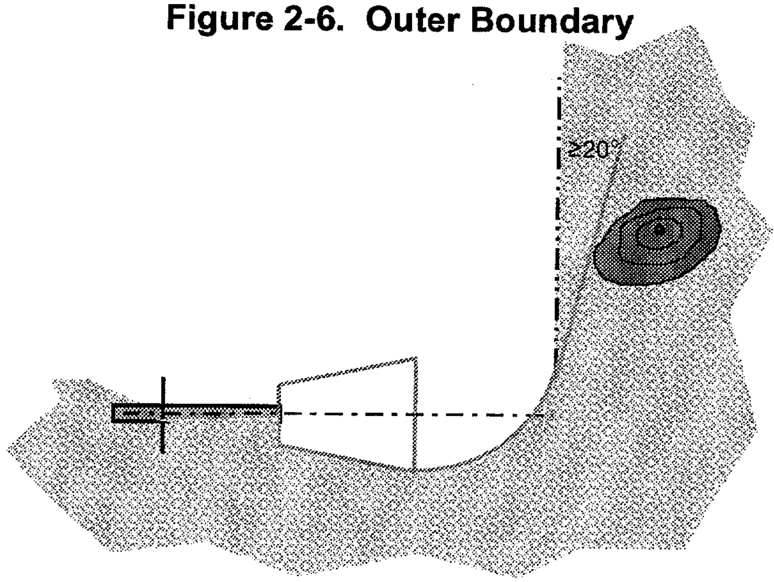
When the 20° splay from the DRP cuts across the ICA, construct a line 20° relative to the side of the ICA. To protect the ICA, no obstacle may lie inside this line (see figure 2-5).

Figure 2-5. Boundary Based on ICA



2.2.1 **a. Outer Boundary involving a Turn.** Locate the turn point on runway centerline (extended) and establish the ICAE. Construct the outer boundary from the ICAE, using table 1-1 for selection of the outer boundary radius. Construct a line from the obstacle tangent to the outer boundary radius. Establish the outer boundary buffer 20° from this line on the maneuvering side. Begin the 20° buffer at the tangent point where the obstacle line intercepts the arc (see figure 2-6).

Figure 2-6. Outer Boundary



2.2.2 **Defining Sector Boundaries.**

Construct boundaries to define each sector. Sector boundaries originate at the DRP, or are defined tangentially from the outer boundary radius (see figure 2-7A). Define and publish sector boundaries by reference to aircraft magnetic headings. Sector "headings" shall be equivalent to the magnetic bearing of the sector boundaries from their origins.

2.2.3 **Sector Limitations.**

2.2.3 a. **The maximum turn** from the takeoff runway in any one direction is 180° relative to takeoff runway heading.

Figure 2-7A. Sector Limitations

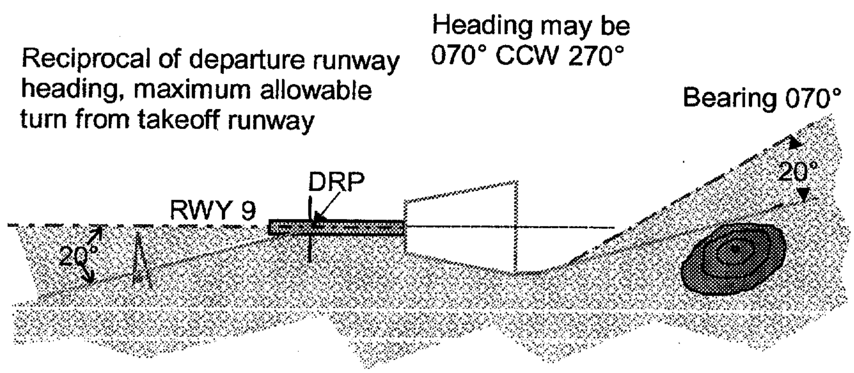
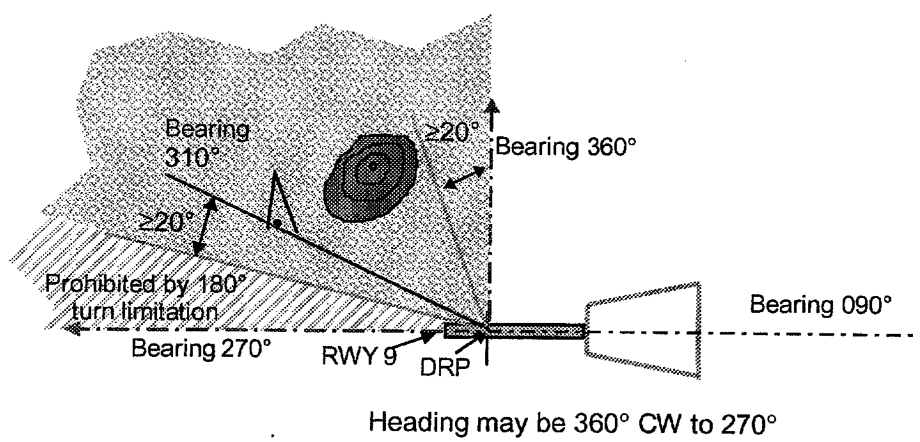


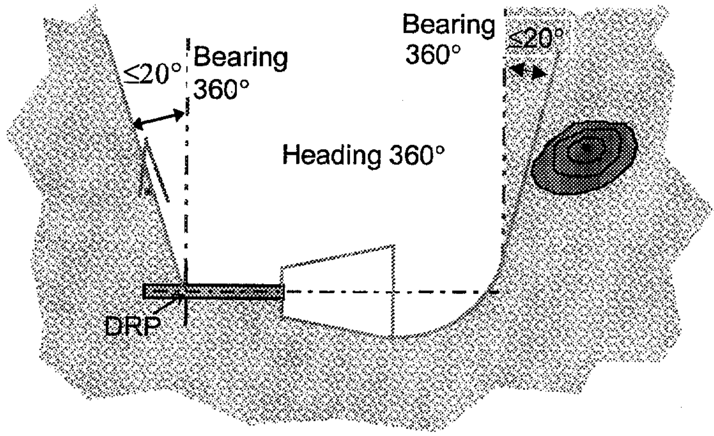
Figure 2-7B shows a sector of 360° clockwise, 270° could be assigned; however, the maximum turn to the right is a heading not in excess of the reciprocal of the takeoff runway heading.

Figure 2-7B. Maximum Heading Limitation



2.2.3 b. **Assign a single heading for a sector** which has parallel boundaries. The heading must parallel the boundaries. Figure 2-8 shows heading 360° as the only heading allowable.

Figure 2-8. Parallel Boundaries



2.2.3 c. **Do not establish a sector** if the boundaries converge. Example: In figure 2-8, if the bearing from the DRP had been 001° or greater or the outer bearing 359° or less, the sector could not be established.

2.3 DVA EVALUATION (ASR Required).

A DVA area based on diverse departure criteria may be established at the request of the AT manager and developed for any airport within the radar facility's area of jurisdiction and radar coverage. When established, reduced separation from obstacles is provided by application of the 40:1 OCS which will be used to radar vector departing IFR aircraft below the MVA/MIA. DVA's should not be developed that require climb gradients greater than 200 ft/NM unless there is no other suitable means to avoid obstacles except in situations where high volumes of high performance aircraft routinely make accelerated climbs.

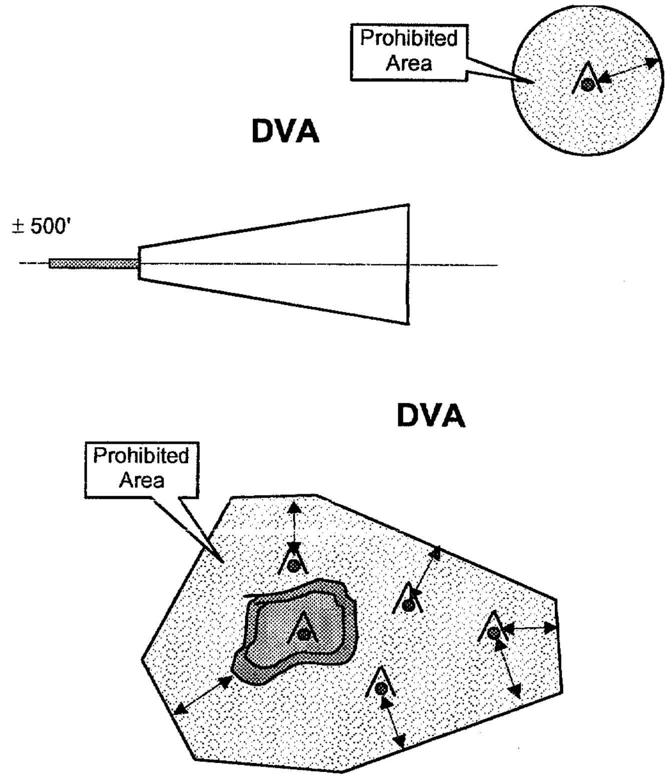
2.3.1 ICA.

See chapter 1, paragraph 1.6.

2.3.2 DVA "A" and "B" Areas.

Where obstacles penetrate the 40:1 OCS, construct a prohibited sector containing the obstruction(s) so it may be avoided by appropriate radar separation standards. Identify prohibited sectors with boundary lines 3/5 NM, as appropriate, from the penetrating obstacle(s). See figure 2-9.

Figure 2-9. Typical DVA Areas

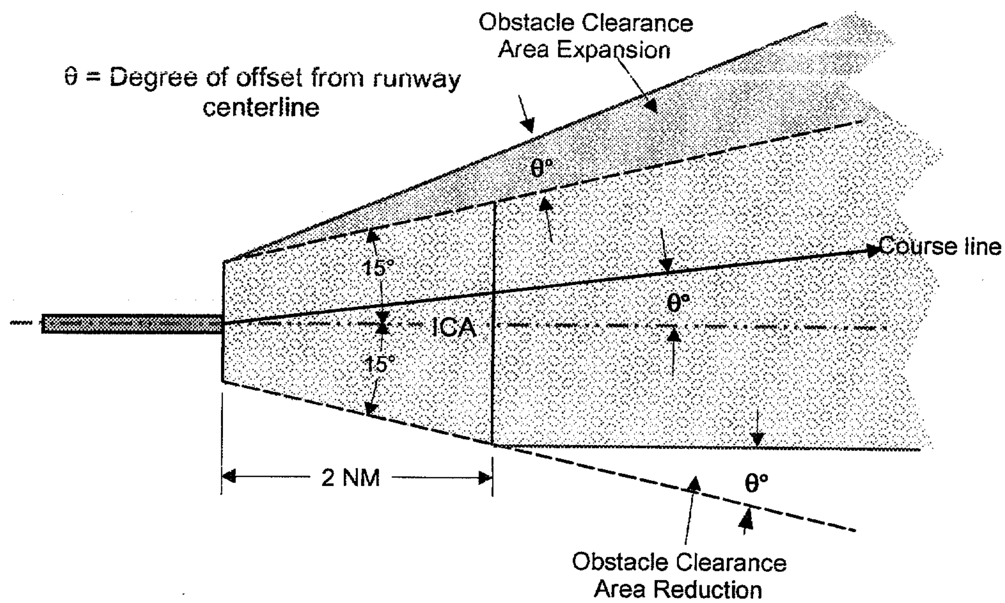


CHAPTER 3. DEPARTURE ROUTES

3.0 STRAIGHT ROUTE DEPARTURE SEGMENTS.

Straight departures are aligned within 15° of the runway centerline. The initial climb area (ICA) is aligned along the runway centerline for at least 2 NM (see paragraph 1.6). If a turn at the departure end of runway (DER) is desired, expand the obstacle clearance area in the direction of the turn an amount equal to the departure course degree of offset from runway centerline (see figure 3-1). Reduce the obstacle clearance area following the ICA on the side opposite the turn an amount equal to the expansion on the opposite side.

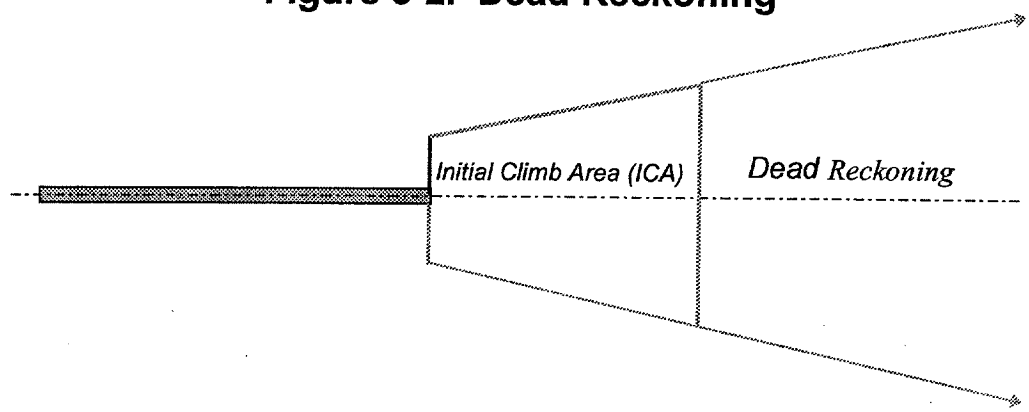
Figure 3-1. Turn ≤15° at DER



3.1 DEAD RECKONING (DR) DEPARTURE.

The boundary lines of the departure obstacle clearance surface (OCS) splay outward 15° relative to the departure course from the end of the ICA (see figures 3-1 and 3-2). Limit the DR segment to a maximum distance of 10 NM from DER.

Figure 3-2. Dead Reckoning



3.2 **POSITIVE COURSE GUIDANCE (PCG) DEPARTURE, 15° OR LESS.**

Calculating Obstruction Area Half Widths. Apply the values from table 3-1 to the following formulae to calculate the obstruction primary area half-width (1/2 W_P), and the width of the secondary area (W_S).

$$\tfrac{1}{2}W_p = k \times D + A$$
$$W_S = f_S \times D + A$$

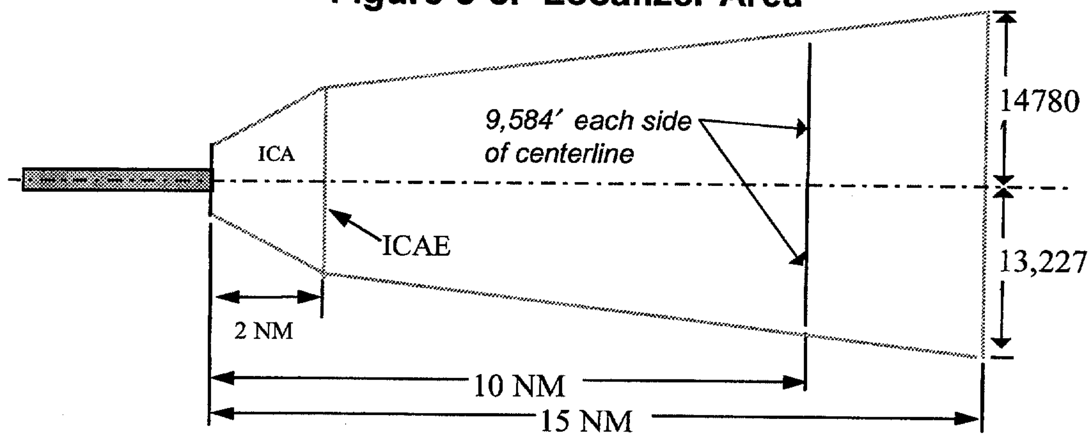
Table 3-1

½ Width	k	f_s	D	A
Dep DR	0.267949	none	Distance (ft) from DER	500′
Localizer	0.139562	none	Distance (ft) from ICAE	3756.18′
NDB	0.0333	0.0666	Distance (NM) from facility	1.25 NM
VOR / TACAN	0.059	0.099	Distance (NM) from facility	1 NM

3.3 **LOCALIZER GUIDANCE.**

The obstruction evaluation area (OEA) begins at the initial climb area end-line (ICAE). The maximum length of the segment is 15 NM from DER. Evaluate for standard climb gradient (SCG) in accordance with paragraph 1.4.1. If necessary, calculate the required minimum climb gradient using the formula in paragraph 1.4.2 where D is the shortest distance to the initial climb area baseline (ICAB) (see figure 3-3).

Figure 3-3. Localizer Area



3.3.1 **NDB Guidance.** Evaluate for SCG in accordance with paragraph 1.4.1. If necessary, calculate the required minimum climb gradient using the formula in paragraph 1.4.2. Figures 3-5, 3-6, and 3-7 illustrate possible facility area configurations.

3.3.2 **VOR/TACAN Guidance.** Evaluate for SCG in accordance with paragraph 1.4.1. If necessary, calculate the required minimum climb gradient using the formula in paragraph 1.4.2. Figures 3-4, 3-5, and 3-6 illustrate possible facility area configurations.

Figure 3-4. Facility Area and DR Area Relationship

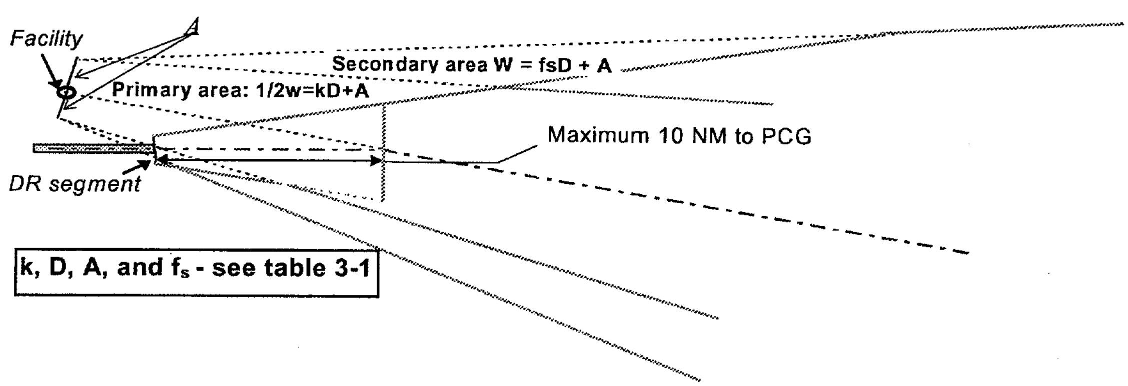
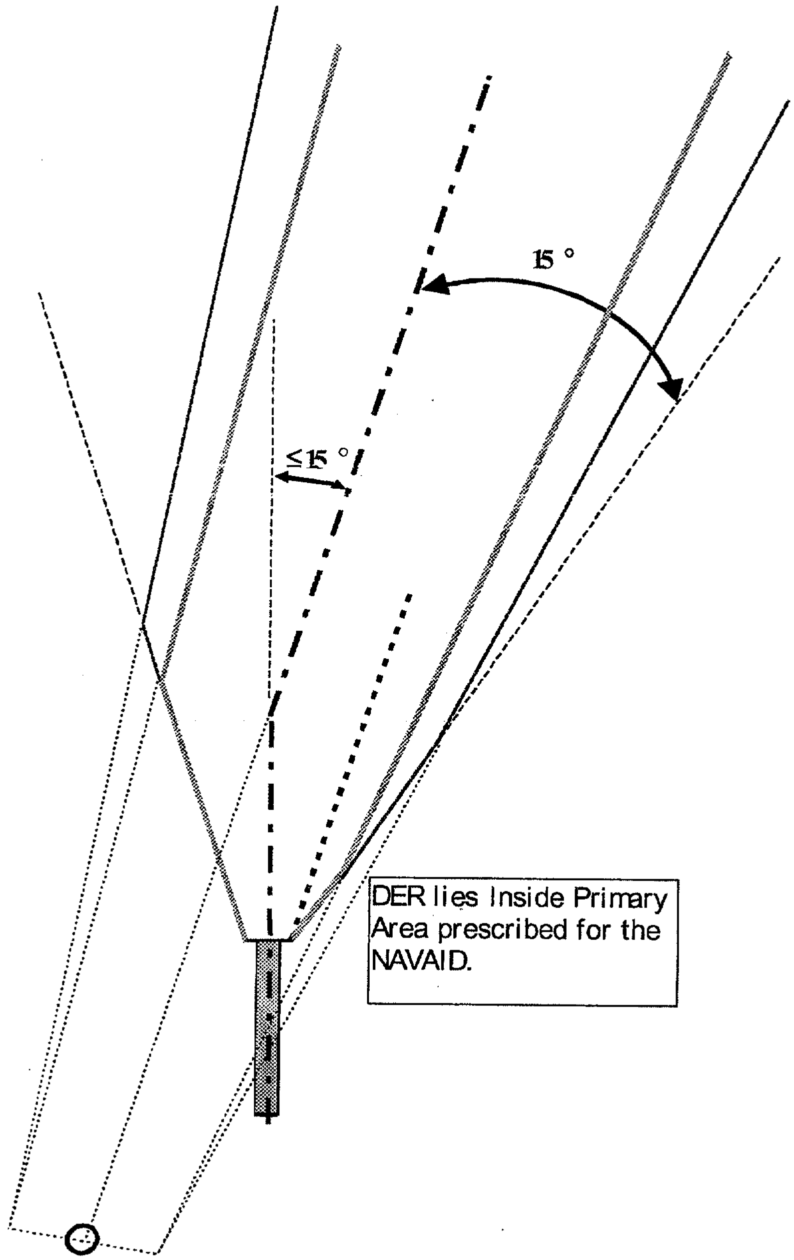


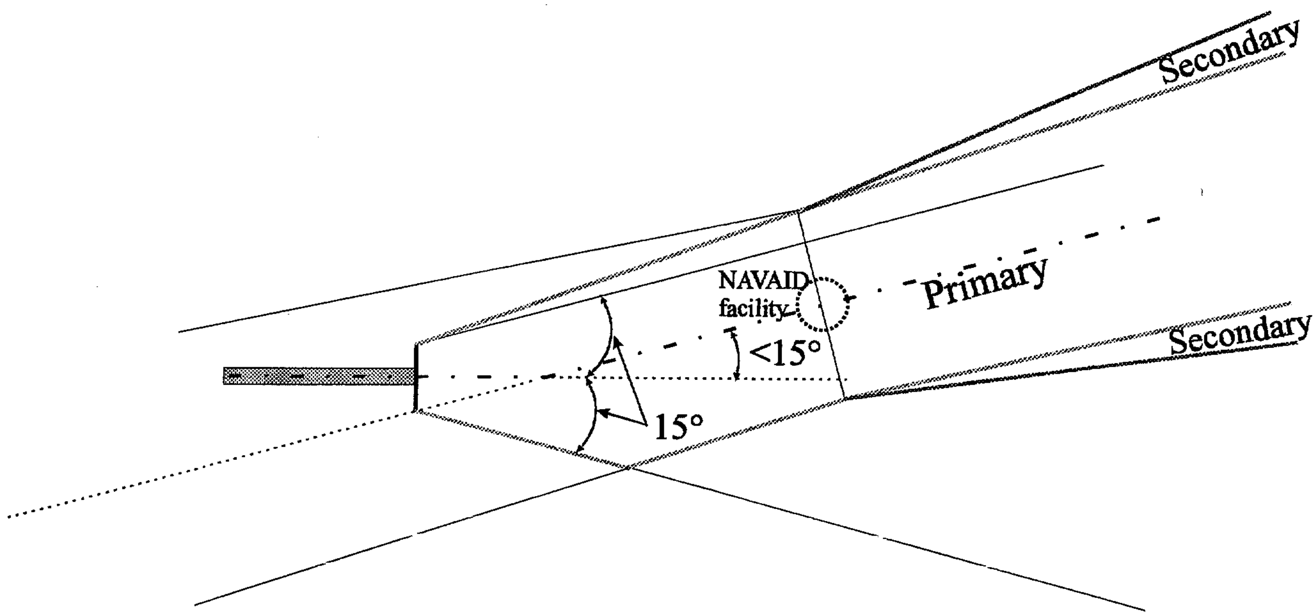
Figure 3-5. DER within Primary Area Facility



3.3.3 **Secondary Area Obstructions.** Secondary areas may be constructed and employed where PCG is provided.

3.4 **RESERVED.**

Figure 3-6. Facility Area Relationship



3.5 **TURNING SEGMENT CONSTRUCTION.**

3.5.1 **General.** Construct turning segments when the course change is more than 15°. Establish an ICA. For outer boundary radius use table 3-2 and apply paragraphs 3.5.1a through 3.5.1d, as appropriate. Use next higher airspeed in table 3-2 if specific speed is not given.

3.5.1 a. **For turns below 10,000 feet** mean sea level (MSL), use 250 KIAS unless a speed restriction other than 250 KIAS is noted on the procedure for that turn. Use 200 KIAS for a minimum speed for Category C and 230 KIAS for Category D aircraft.

3.5.1 b. **For turns at 10,000 feet and above,** use 310 KIAS unless a speed restriction not less than 250 KIAS above 10,000 through 15,000 feet is noted on the procedure for that turn. Above 15,000 feet, speed reduction below 310 KIAS is not permitted.

3.5.1 c. **When speeds greater than** 250 KIAS are authorized below 10,000 feet MSL, and speeds greater than 310 KIAS are authorized at or above 10,000 feet MSL, use the appropriate speed in table 3-2.

3.5.1 d. **Use the following standard** Note to publish a speed restriction: "Do NOT exceed (speed) until CHUCK (fix)."

Table 3-2

	Primary Area Outer Boundary radius (R1)			
Aircraft Speeds	**90**	**120**	**150**	**175**
Turn radii:				
Below 10,000′ MSL	0.9	1.4	1.9	2.4
10,000′ MSL and above	1.4	2.0	2.7	3.3
Aircraft Speeds	**180**	**210**	**240**	**250**
Turn radii:				
Below 10,000′ MSL	2.5	3.2	3.9	4.2
10,000′ MSL and above	3.4	4.3	5.2	5.5
Aircraft speeds	**270**	**300**	**310**	**350**
Turn radii:				
Below 10,000′ MSL	4.7	5.6	6.0	7.3
10,000′ MSL and above	6.2	7.3	7.7	9.3

(Speeds include 60-knot omni winds below 10,000′ MSL; 90-knot omni winds at 10,000′ and above; bank angle 23°.)

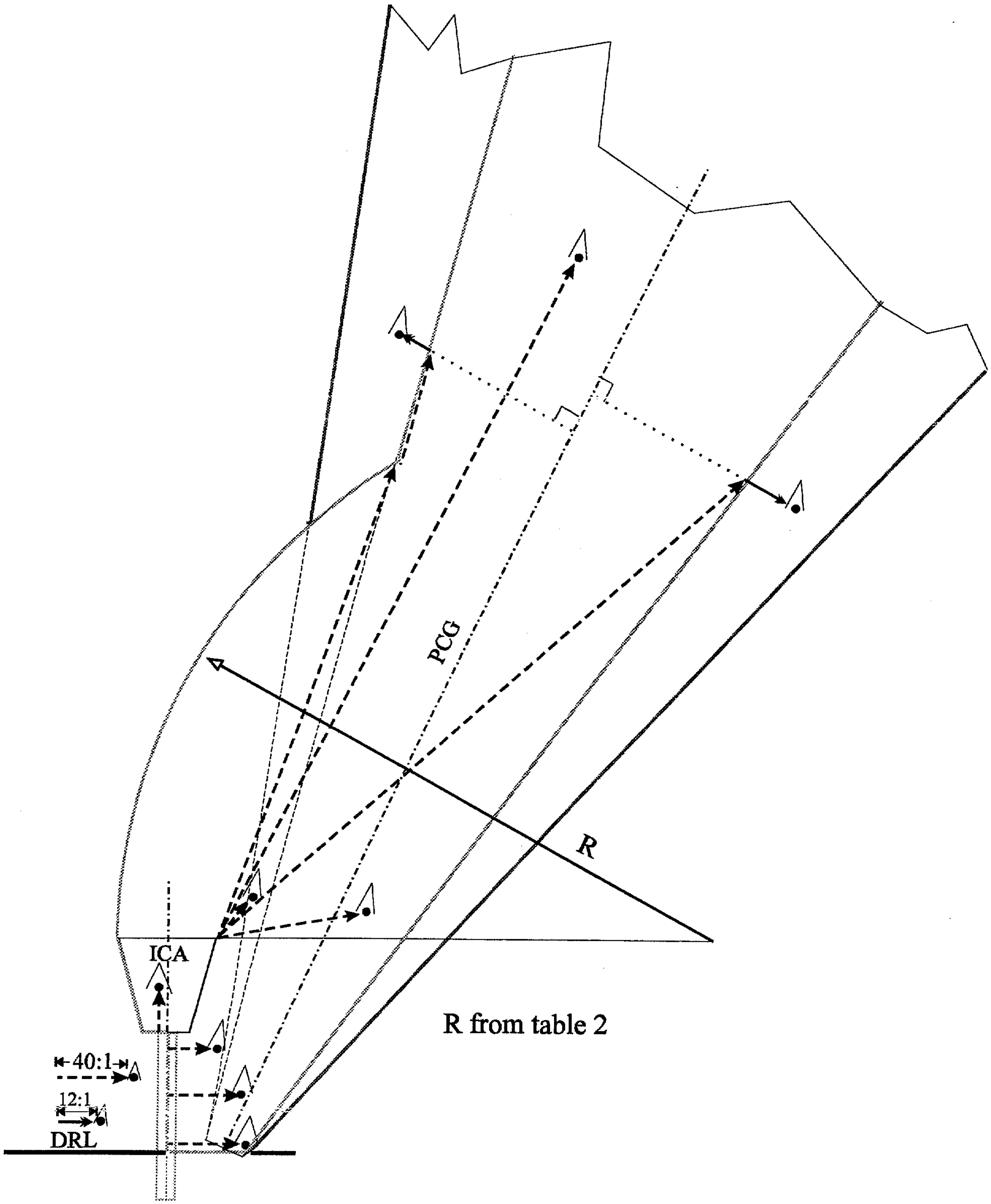
3.6 RESERVED.

3.7 TURN TO PCG.

3.7.1 **Extend the ICA boundaries** as necessary to intersect the boundaries appropriate to the PCG provided. Where the ICA outer boundary will not intersect the PCG boundary, construct an outer boundary radius from the outer edge of the ICA to intersect the PCG boundary. For the radius length, use table 3-2 or the width of the end of ICA, whichever is longer (see figure 3-7).

3.7.2 **Specify a course, not aligned with the runway centerline,** to intersect a PCG course. The amount of turn is not restricted.

Figure 3-7. ICA Joining PCG Area



3.8 MULTIPLE TURNS.

Use table 3-1 to establish dimensions of basic trapezoids.

3.8.1 **Climb to Altitude and Turn; Turns less than 90°.** See figure 3-8. Construct a line from departure reference point (DRP) to edge of obstacle area at the fix denoting the second turn point. Extend splay of ICA to line A,B, (perpendicular to runway centerline extended), where altitude is reached for the turn. Measure out runway centerline extended using SCG.

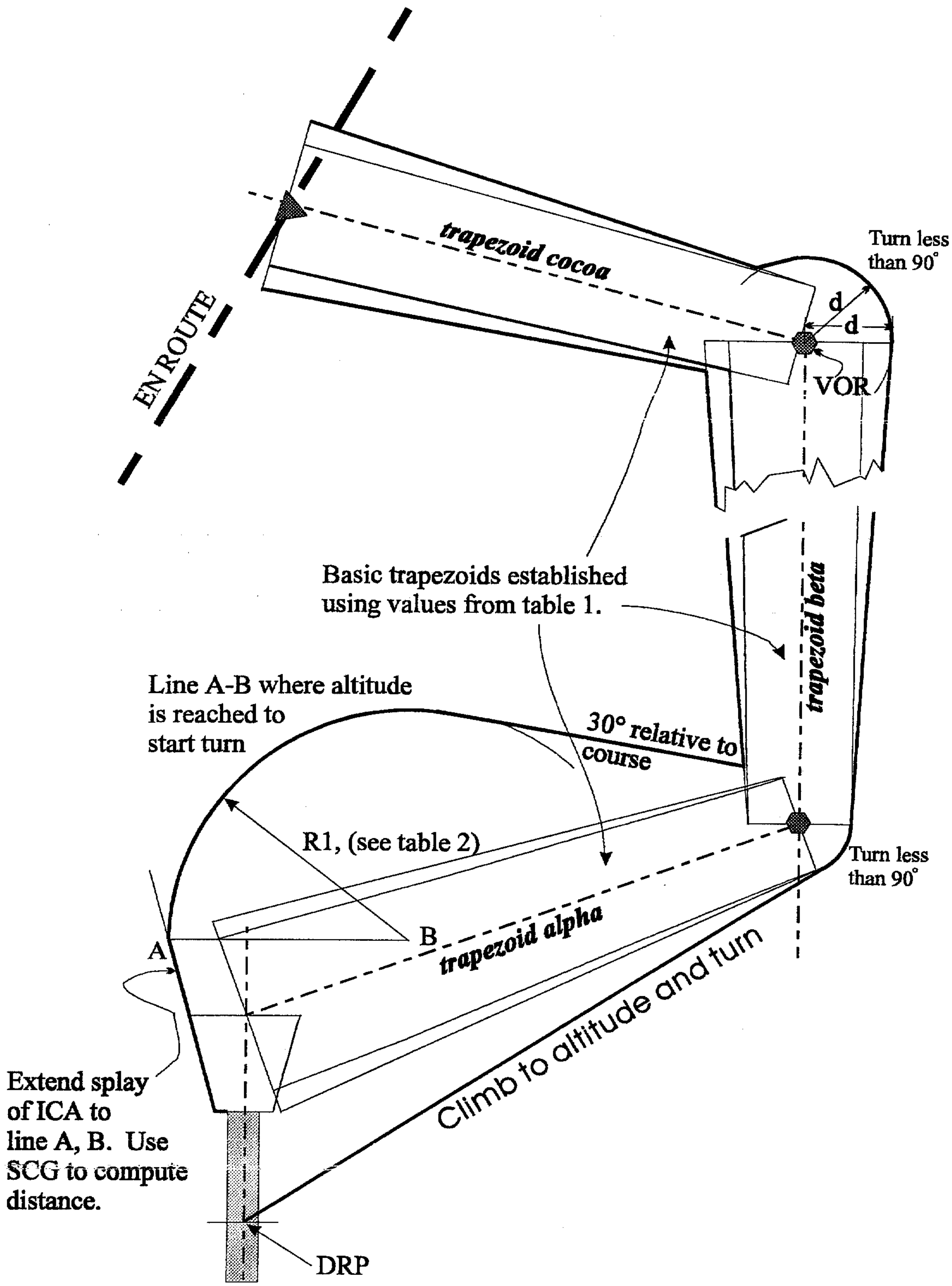
3.8.1 a. **Align the centerline** of trapezoid alpha, through point C (end of ICA on runway centerline extended).

3.8.1 b. **Construct an arc from point A** using radius R1 (table 3-2) centered on point B. Construct a tangent from the arc to the boundary of the secondary area of the next segment, (trapezoid beta), 30° relative to trapezoid alpha centerline.

3.8.1 c. **Construct trapezoid beta.** Extend the outer boundary area, radius "d", to join trapezoid cocoa. Inside boundaries join at the primary and secondary intersections.

3.8.1 d. **Construct trapezoid cocoa** and its associated segment, if necessary, to join en route structure.

Figure 3-8. Climb to an Altitude and Turn Direct to Fix with Multiple Turns.



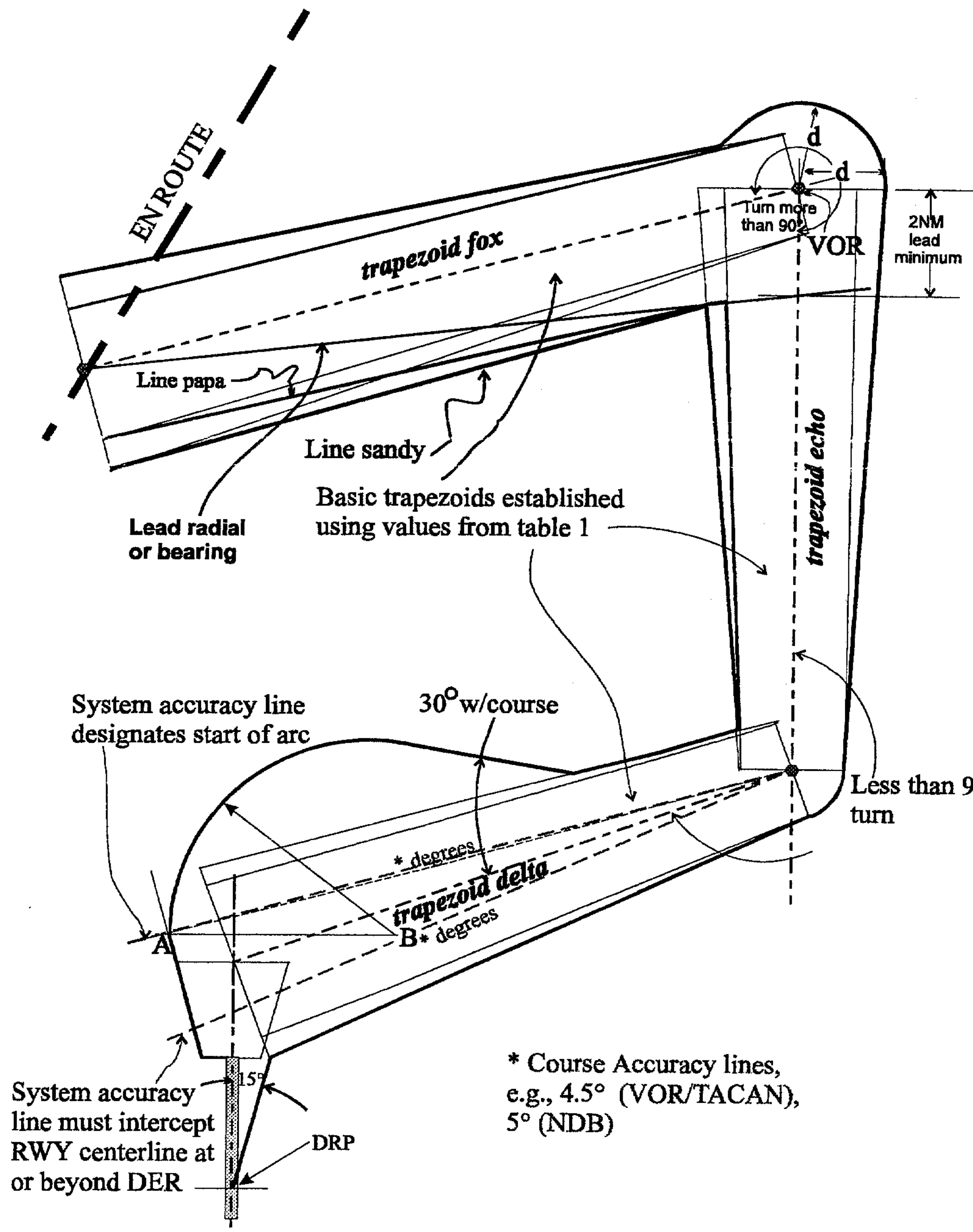
3.8.2 **Climb to Intercept a Course.** See figure 3-9. Construct a 15° splay relative to runway centerline from the departure reference point (DRP) to the secondary boundary of trapezoid delta (inside of turn) area. System accuracy line of delta must intercept runway centerline at or beyond DER.

3.8.2 a. **Extend the splay of ICA to line A, B.** System accuracy line of trapezoid delta (outside of turn) intercepts the ICA splay at point A.

3.8.2 b. **Construct an arc from point A** using radius R1 (table 3-2) centered on point B. Construct a tangent from the arc to the boundary of next segment (trapezoid echo) 30° relative to trapezoid delta centerline.

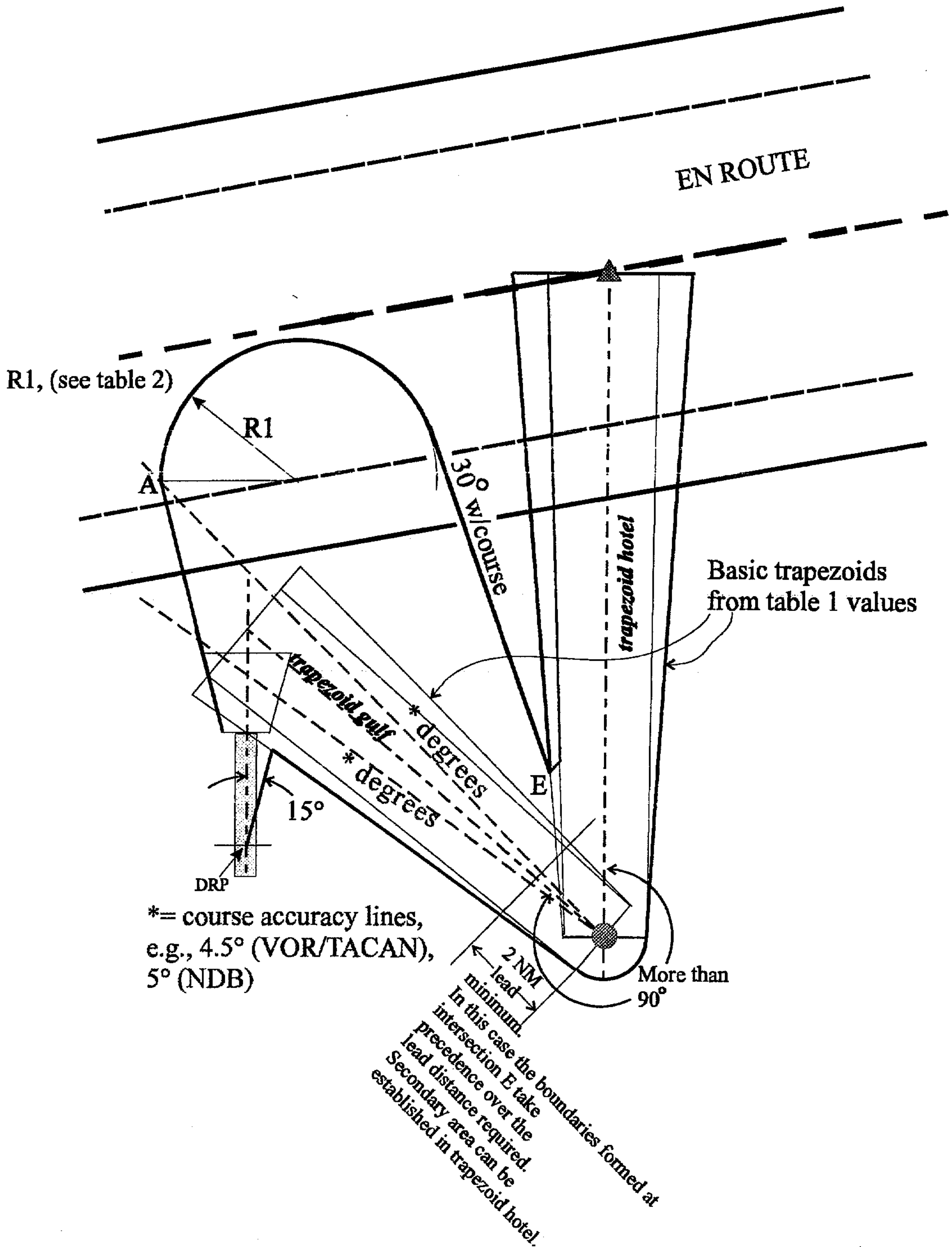
3.8.2 c. **Construct trapezoids echo and fox** as necessary. Provide a 2-NM lead area when turns are more than 90°, prior to the "VOR" turning into trapezoid fox. Specify a 2-mile lead when possible with a radial, bearing, or DME. When unable to identify the lead point, construct and provide a 2-mile lead area for evaluation of obstacles. Outside protection arc must be as large as the end of the trapezoid, i.e., "d" at fix jiffy. In the segment containing trapezoid fox, note primary "line papa" and secondary "line sandy" originate from the 2-mile lead of trapezoid echo.

Figure 3-9. Climb RWY Heading to Intercept a Course With Multiple Turns.



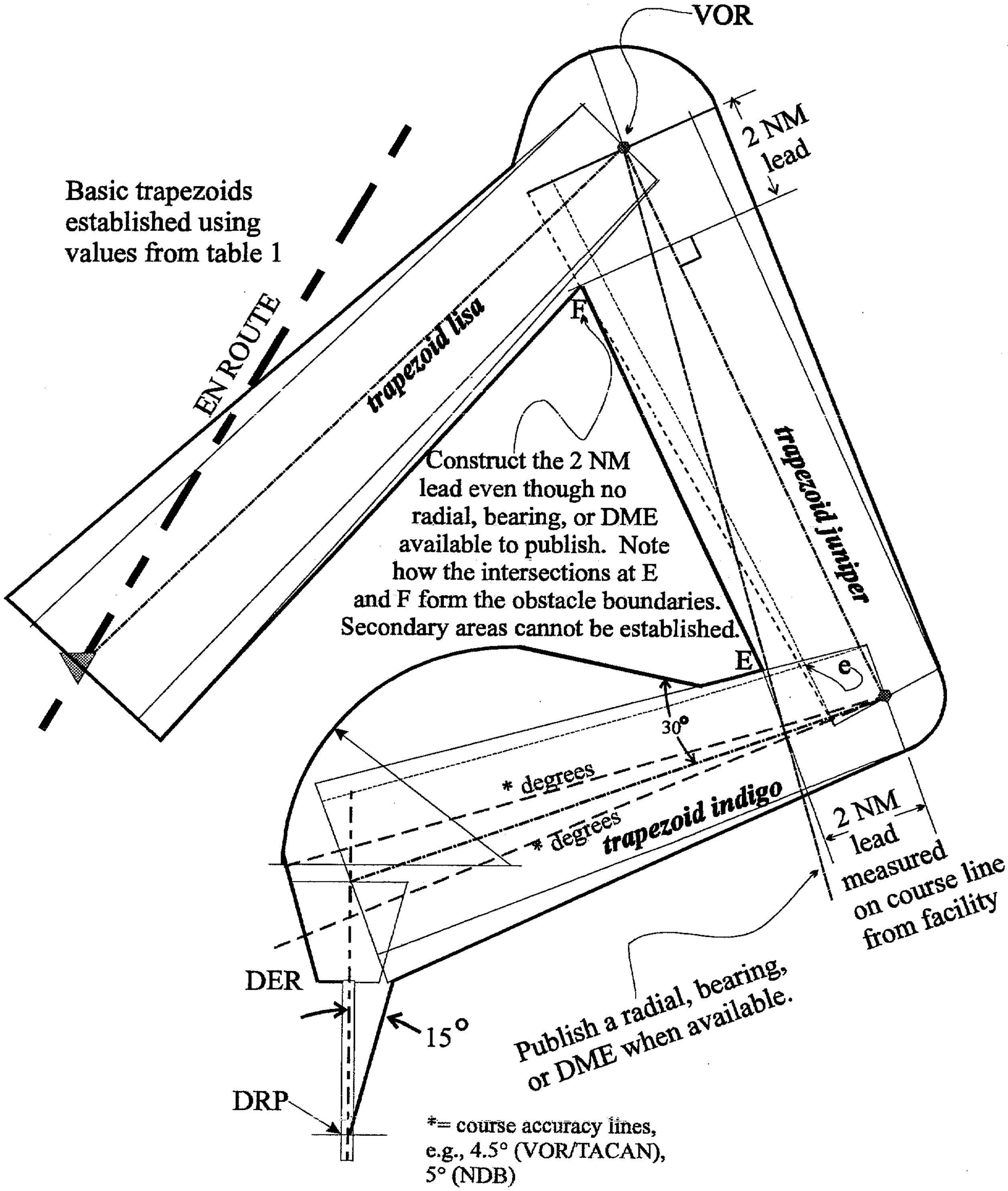
3.8.3 **Figure 3-10 illustrates multiple turns more than 90°.** Initial course intercepts positive course of trapezoid gulf after takeoff from DER. The obstacle area radius is constructed from point A with a tangent 30° relative to the course in trapezoid gulf. The area formed around the intersection of E with trapezoid hotel takes precedence over the 2-NM lead requirement. Primary and secondary areas can be established on the inside of the turn in trapezoid hotel because the 2-mile lead does not cut off any of the primary area.

Figure 3-10. Climb to Intercept Course.



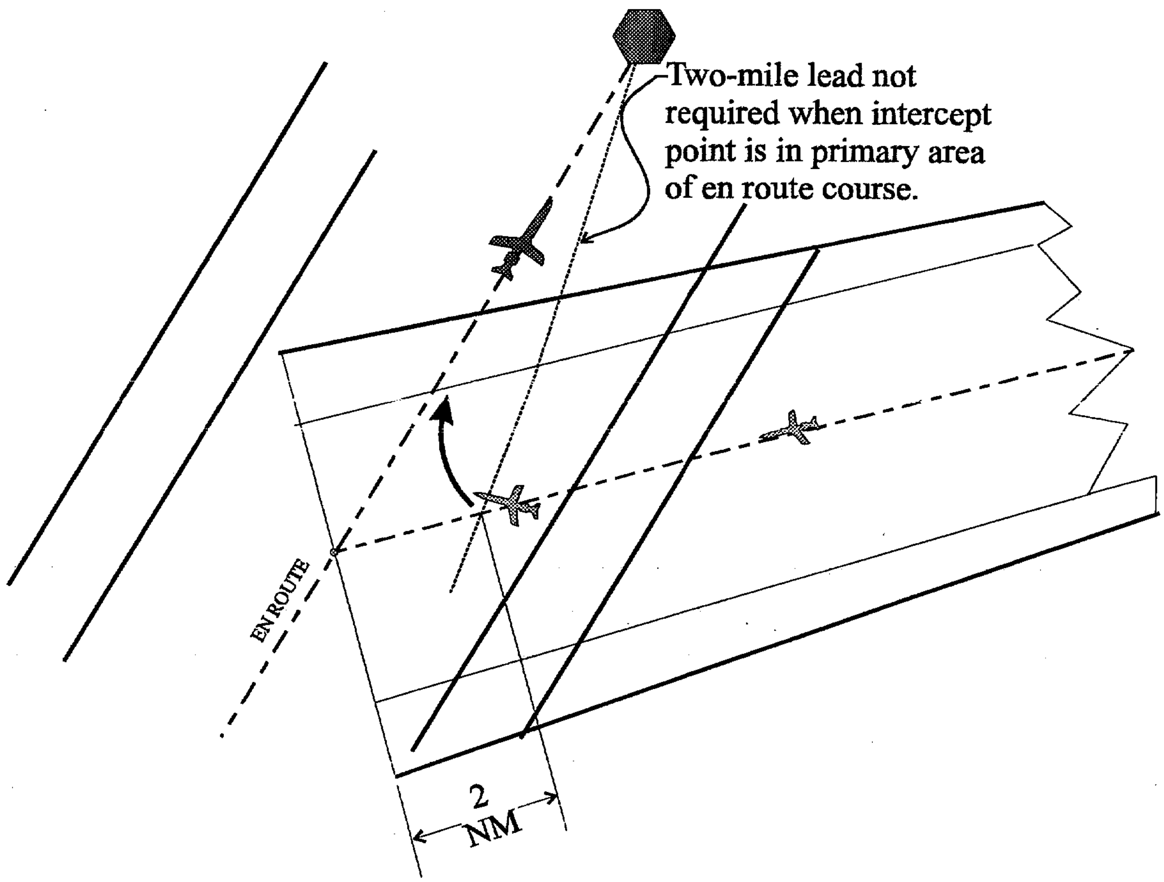
3.8.4 **Figure 3-11 illustrates multiple turns more than 90°.** Publish either a radial, bearing, or a DME when available. Construct a 2-NM lead even though no radial, bearing, nor DME is available. This provides a lead area for the pilot's early turn. Note how the intersections at E and F form the boundaries of obstacle clearance areas. Point E is established abeam the 2-mile lead. The dark lines around point E form a primary area boundary. A secondary area cannot be established on the inside area of trapezoid juniper because the 2-mile lead forms the area that takes precedence over the normal primary and secondary areas at "e".

Figure 3-11. Multiple turns.



3.8.5 **Figure 3-12 illustrates the 2-mile lead** not required when lead point is within primary area of en route course.

Figure 3-12. Turn on to En Route Course.



3.8.6 **Evaluation of Multiple Turn Areas.** See figures 3-13 and 3-14.

3.8.6 a. **Measure 40:1 straight-line distance** from lines d-c-b of the ICA directly to the obstacles outside of the ICA associated with trapezoid alpha in figure 3-13 and trapezoid gulf in figure 3-14. Measure 40:1 from runway centerline to obstacles abeam the runway between the DRP and the DER. Points b and c are at the end of the ICA, a and d at corners of the ICA abeam the DER. In figure 3-13, no secondary areas exist in trapezoid alpha's segment, and in figure 3-14, no secondary evaluation is allowed for the far turn from DER because the beginning of PCG cannot be determined. However, on the inside turn area a secondary area evaluation could be allowed for trapezoid gulf's segment.

3.8.6 b. **Measure 40:1 to point E for obstacles** in trapezoids beta, figure 3-13, and hotel, figure 3-14, segments, respectively. Measure 12:1 into secondary area from edge of primary area perpendicular to the segment's course. Convert the secondary area obstacles to primary equivalent at edges of primary area. Measure 40:1 to the conversion points to assess appropriate obstacle clearance.

3.8.6 c. **Measure 40:1 to E, then 40:1 down the edge** of the primary area of trapezoid beta from E to F to obstacles in trapezoid cocoa's segment. From F measure 40:1 to obstacles in primary area of trapezoid cocoa, figure 3-13. Measure along edge of primary area to a point abeam the obstacles in secondary area. Measure 12:1 from edge of primary area to the obstacle in secondary area perpendicular to applicable course line. Perform secondary area obstacle evaluation.

3.8.6 d. **Climbing in a Holding Pattern.** When a climb in a holding pattern is used, no obstacle shall penetrate the holding pattern obstacle clearance surface. This surface begins at the end of the segment, F-G, figure 3-14, leading to the holding fix. Its elevation is that of the departure OEA at the holding fix. It rises 40:1 from the nearest point of the F-G line to the obstacle in the primary area. It also rises 40:1 to the edge of the primary area of the holding pattern abeam an obstacle in the secondary area of the holding pattern. In the secondary area, the surface rises 12:1 to the obstacle measuring the shortest distance between the obstacle and the edge of the primary area (see figure 3-14). The holding pattern altitude must have a level surface evaluation of 1,000 feet.

Figure 3-13. Climb to an Altitude and Turn Direct to Facility with Multiple Turns.

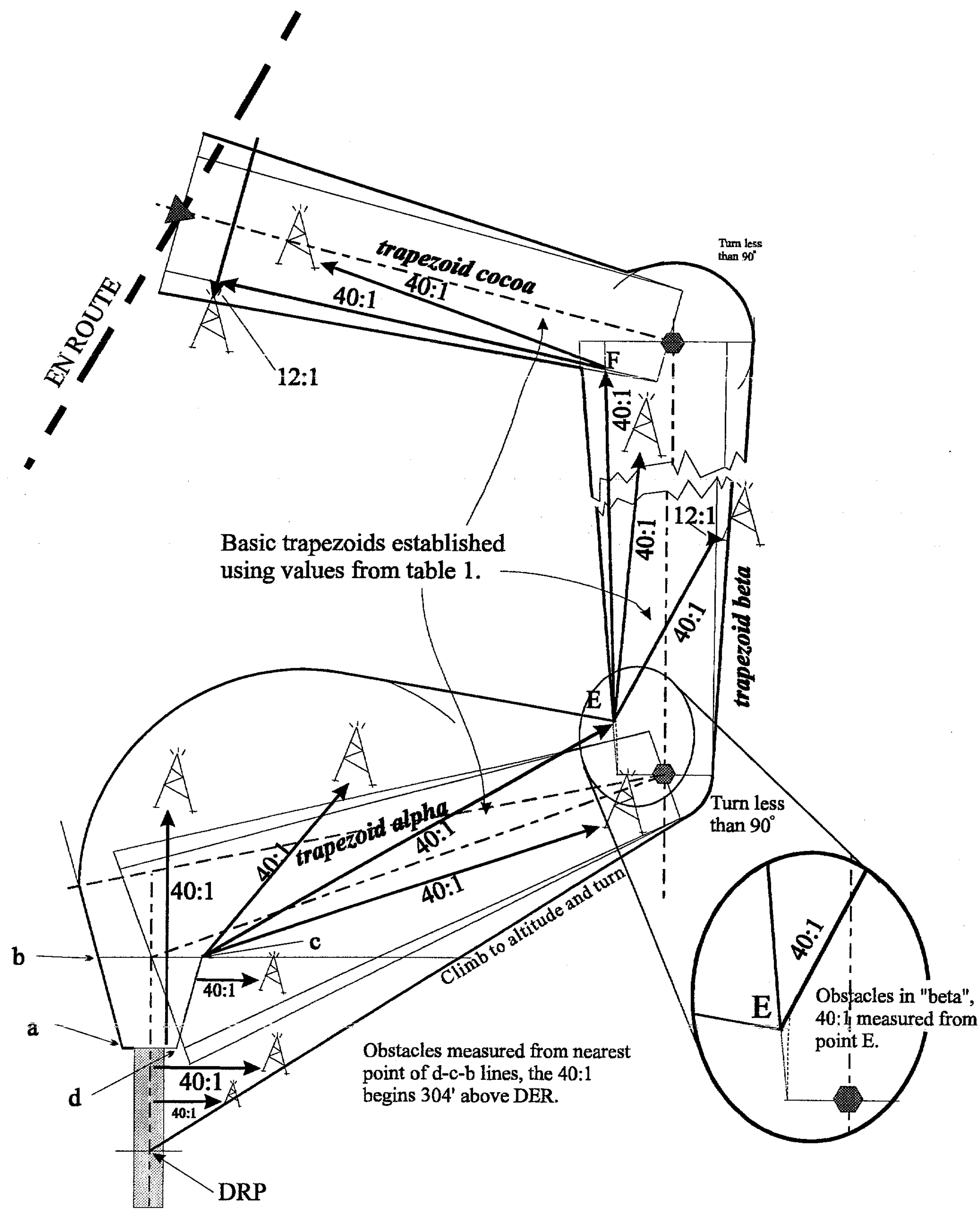
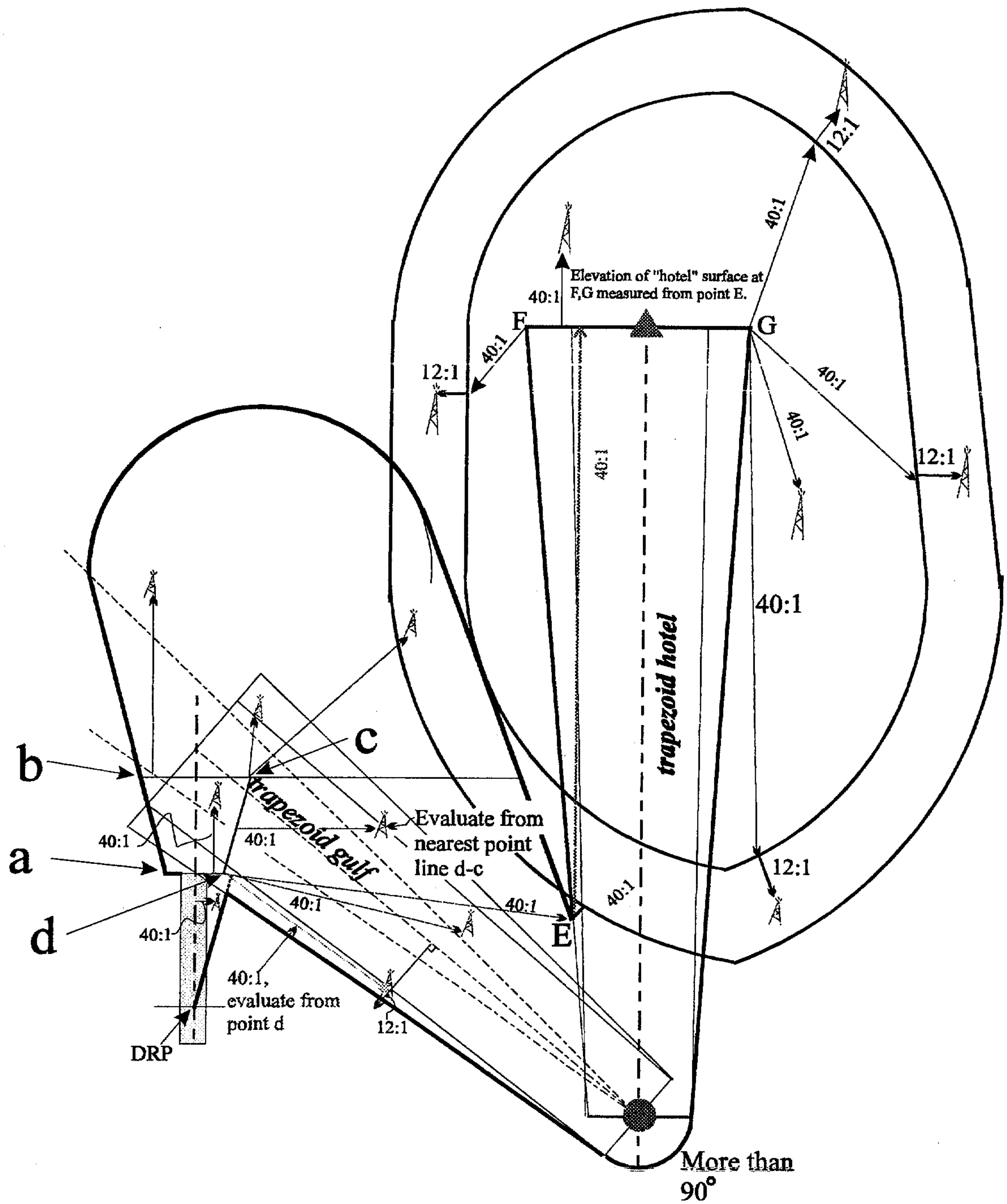


Figure 3-14. Climb in a Holding Pattern, Turns More Than 90 Degrees Evaluation.



CHAPTER 4. VISUAL CLIMB OVER AIRPORT (VCOA)

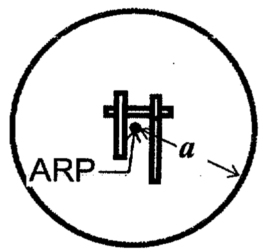
4.0 GENERAL.

VCOA is an alternative method for pilots to depart the airport where aircraft performance does not meet the specified climb gradient. Development of a VCOA is mandatory when obstacles more than 3 statute miles from the departure end of runway (DER) require a greater than 200 ft/NM climb gradient.

4.1 BASIC AREA.

Construct a visual climb area over the airport using the airport reference point (ARP) as the center of a circle (see figure 4-1). Use R1 in table 4-1 plus the distance ARP to the most distant runway end as the radius for the circle.

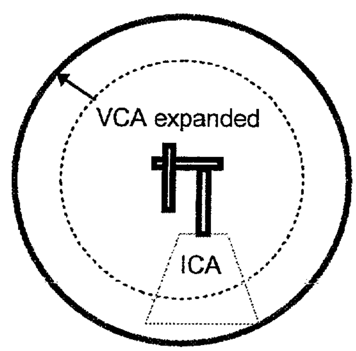
Figure 4-1. VCA



a=R1 (table 1-3) plus the Distance from ARP to most distant DER

Select 250 KIAS as the standard airspeed and apply the appropriate MSL altitude to determine the R1 value. Use other airspeeds in table 4-1, if specified on the procedure, using the appropriate radius for the selected airspeed. Altitude must equal or exceed field elevation. The VCA must encompass the area of the ICA from the departure runway(s). Expand the VCA radius if necessary to include the ICA (see figure 4-2).

Figure 4-2. VCA Expanded



The VCA must completely encompass the ICA.

Table 4-1. Radius Values

Altitudes MSL	2,000'	5,000'	10,000'
Speed KIAS			
90	2.0	2.0	2.0
120	2.0	2.0	2.0
180	2.0	2.0	2.5
210	2.1	2.5	3.2
250	2.8	3.4	4.2
310	4.2	4.9	6.0
350	5.2	6.0	7.3

(Table 4-1 speeds include 30-knot tail winds up to 2,000' MSL, 45-knot tail winds up to 5,000' MSL, and 60-knot tail winds at 10,000′ MSL; bank angle: 23°.)

4.2 VCOA EVALUATION.

4.2.1 Diverse VCOA.

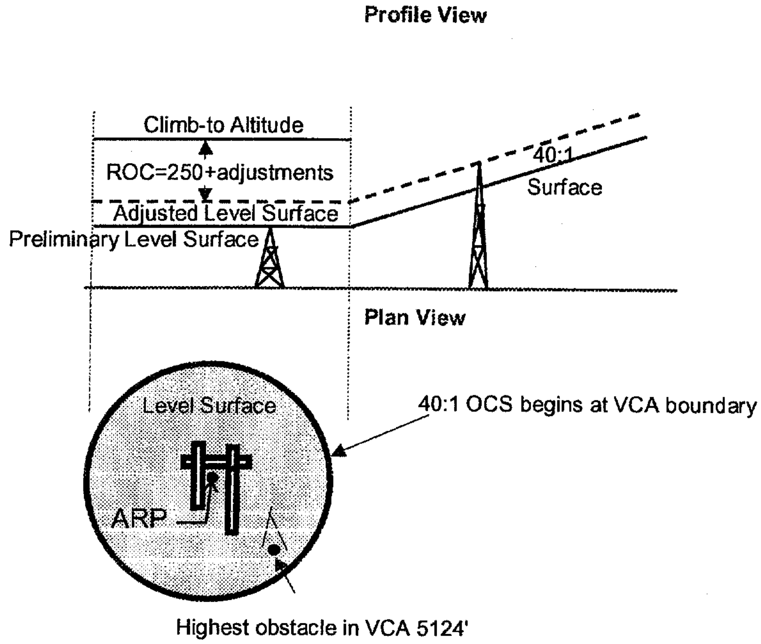
Identify the highest obstruction within the visual climb area (VCA). This is the preliminary height of the VCA level surface. Evaluate a 40:1 surface from the edge of the level surface. If the 40:1 surface is penetrated, raise the VCA level surface height by the amount of the greatest penetration (see figure 4-3). Determine the VCOA "climb-to" altitude using the following formula:

$$\text{climb to altitude} = \text{level surface MSL height} + 250' \text{ ROC} + \text{adjustments (vol. 1, para 323a)}$$

$$\text{Example: } 5124 + 250 + 0 = 5374 \text{ rounds to } 5400'$$

$$\text{Where OCS height} = 5124$$
$$\text{adjustments} = 0$$

Figure 4-3. Diverse VCOA Evaluation



4.2.2 **Departure Routes.**

Where VCOA Diverse Departure is not feasible, construct a VCOA departure route.

4.2.2 a. **Construct** the VCA per paragraph 4.1.

4.2.2 b. **Determine** the preliminary level surface height as in paragraph 4.2.1.

4.2.2 c. **Locate**, within the VCA, the beginning point of the route.

4.2.2 d. **Construct** the departure route using criteria for the navigation system desired. The 40:1 surface rise begins along a line perpendicular to the route course and tangent to the VCA boundary (see figure 4-4).

4.2.2 e. **OCS Evaluation.** Where obstacles penetrate the route 40:1 OCS:

4.2.2 e. **(1)** Raise the VCA level surface the amount of penetration. Determine the climb-to altitude using the formula below, **or…**

$$\text{climb to altitude} = \text{level surface MSL height} + 250' \text{ ROC} + \text{adjustments (vol. 1, para 323a)}$$

$$\text{Example: } 5124 + 250 + 0 = 5374 \text{ rounds to } 5400'$$

$$\text{Where OCS height} = 5124$$
$$\text{adjustment} = 0$$

4.2.2 **e.** **(2)** Determine a climb gradient that will clear the obstacle using the formula:

$$CG = \frac{a - b}{0.76 \times d}$$

where a = obstacle MSL altitude
b = VCA climb - to altitude
d = distance (NM) from 40 : 1 origin to obstacle

$$\text{Example: } CG = \frac{3379 - 2100}{0.76 \times 5.34} = 315.15 \text{ ft/NM}$$

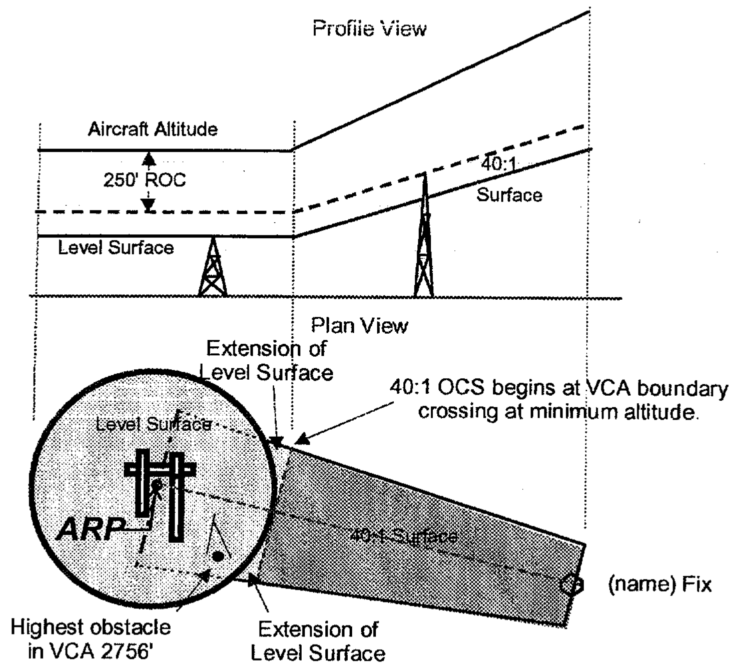
Calculate altitude (alt) that the CG may be discontinued:

$$alt = b + (d \times CG)$$

Example:

$$alt = 2100 + (5.34 \times 316) = 3787.44 \text{ round up to } 3800'$$

Figure 4-4. Route Out of VCA

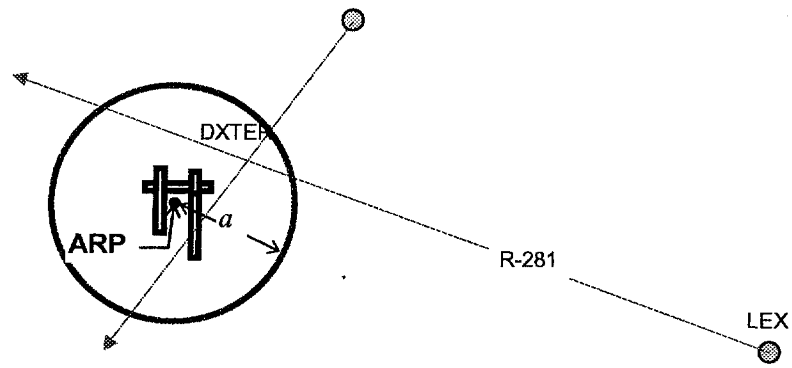


Climb to altitude	2800'
	+100
	2900
Airport	-2315'
Raw ceiling value	585'
Minimum Ceiling	600'

4.2.3 **Published Annotations.**

The procedure must include instructions specifying an altitude to cross a fix/location over the airport, followed by routing and altitude instructions to the en route system. Example: "Climb in visual conditions to cross Wiley Post airport westbound at or above 6,000′, then climb to FL180 via AMA R-098 to AMA VORTAC", "Climb in visual conditions to cross DXTER eastbound at 5,000′, then via LEX R-281 to LEX." (see figure 4-5).

Figure 4-5. VCOA Departure Route



4.3 CEILING AND VISIBILITY.

Publish a ceiling that is the 100-foot increment above the "climb-to" altitude over the VCA. Obstacles inside the VCA are subject to see and avoid maneuvers. Obstacles outside the VCA may be avoided by publishing a ceiling above an altitude that must be attained inside the VCA over a specified fix or identifiable point. From this altitude, a 40:1 OCS from the VCA boundary clears all obstacles outside the VCA omni-directionally, or along a route of flight (see figures 4-3, 4-4). Determine the published visibility from table 4-2.

Table 4-2. Visibility

Altitudes MSL	2,000'	5,000'	10,000'
Speed KIAS			
90	1	1	1
120	1	1	1 1/4
180	1 1/2	2	2 1/2
210	2	2 1/2	2 3/4
250	2 1/2	3	3
310	3	3	3
350	3	3	3

FAA ORDER **8260.3B**

Army
Navy
Coast Guard
Air Force

TM 95-226
OPNAV Inst. 3722.16C
CG 318
AFMAN 11-226(I)

UNITED STATES STANDARD
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<u>VOLUME 5</u>

HELICOPTER AND POWERED LIFT INSTRUMENT PROCEDURE CONSTRUCTION

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