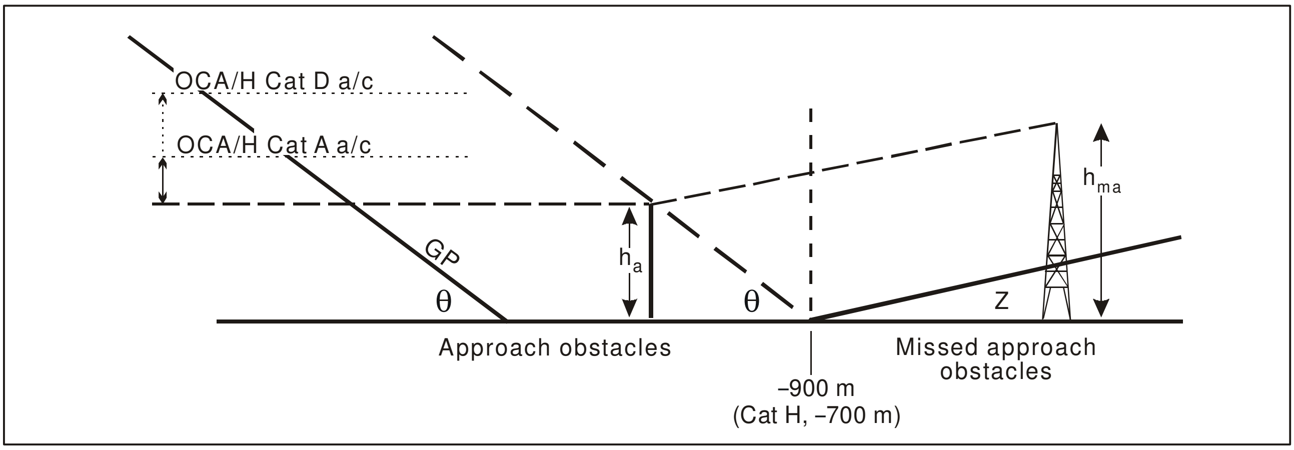


Figure II-1-1-13. Missed approach obstacle after range –900 m

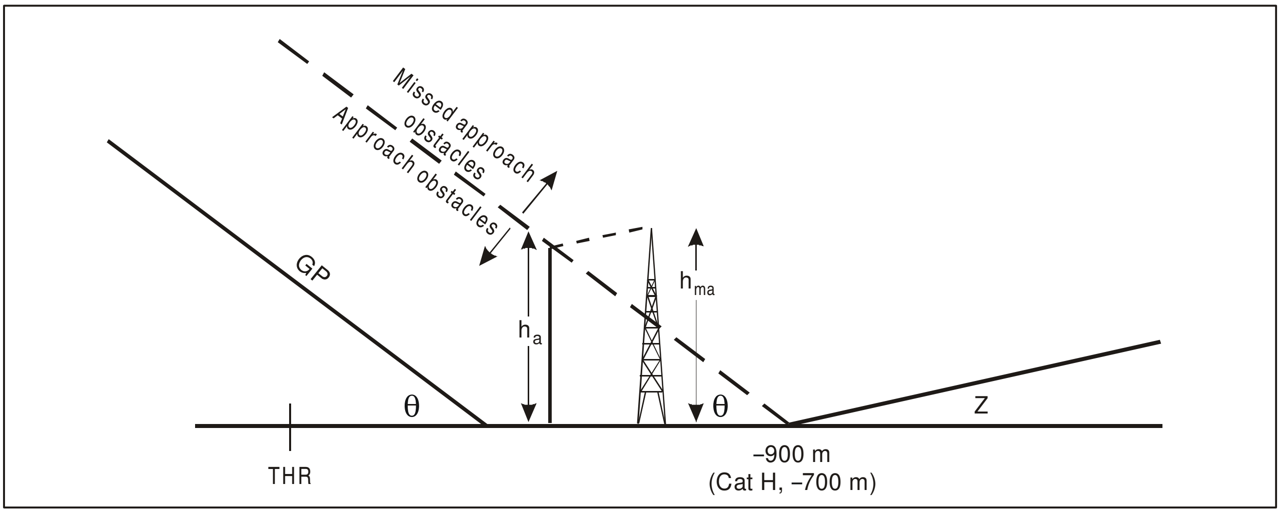


Figure II-1-1-14 Missed approach obstacle before range –900 m

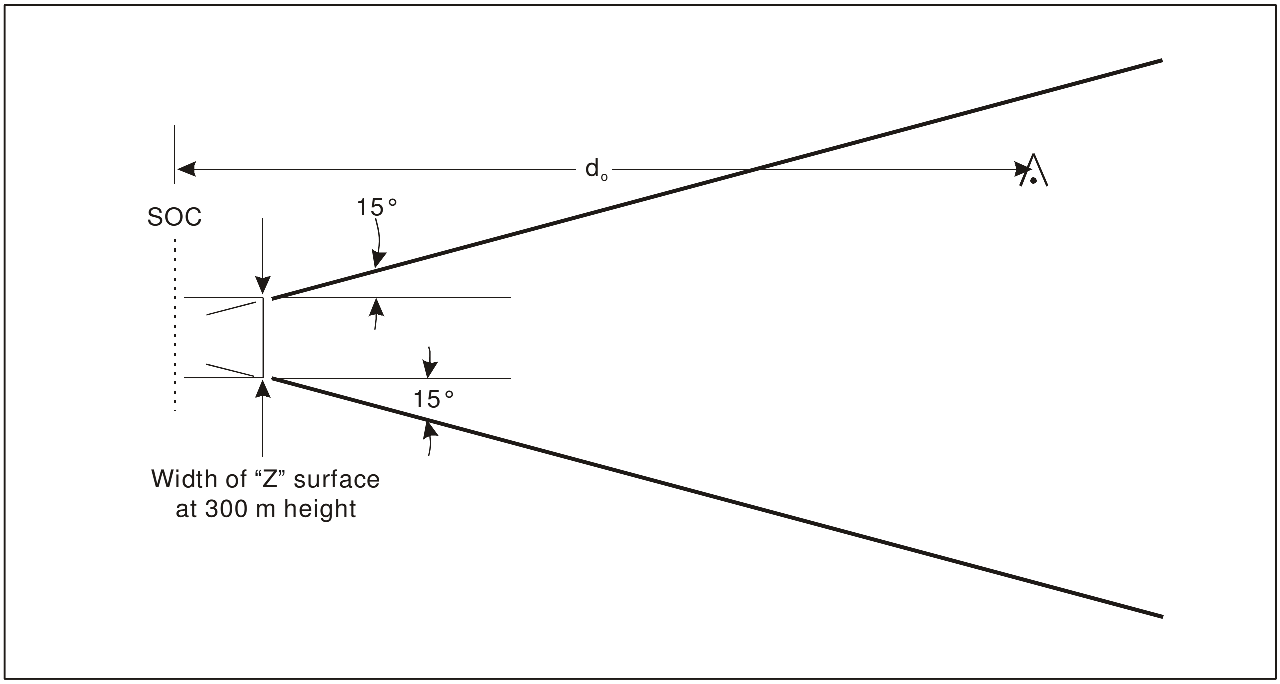


Figure II-1-1-15. Final segment of straight missed approach

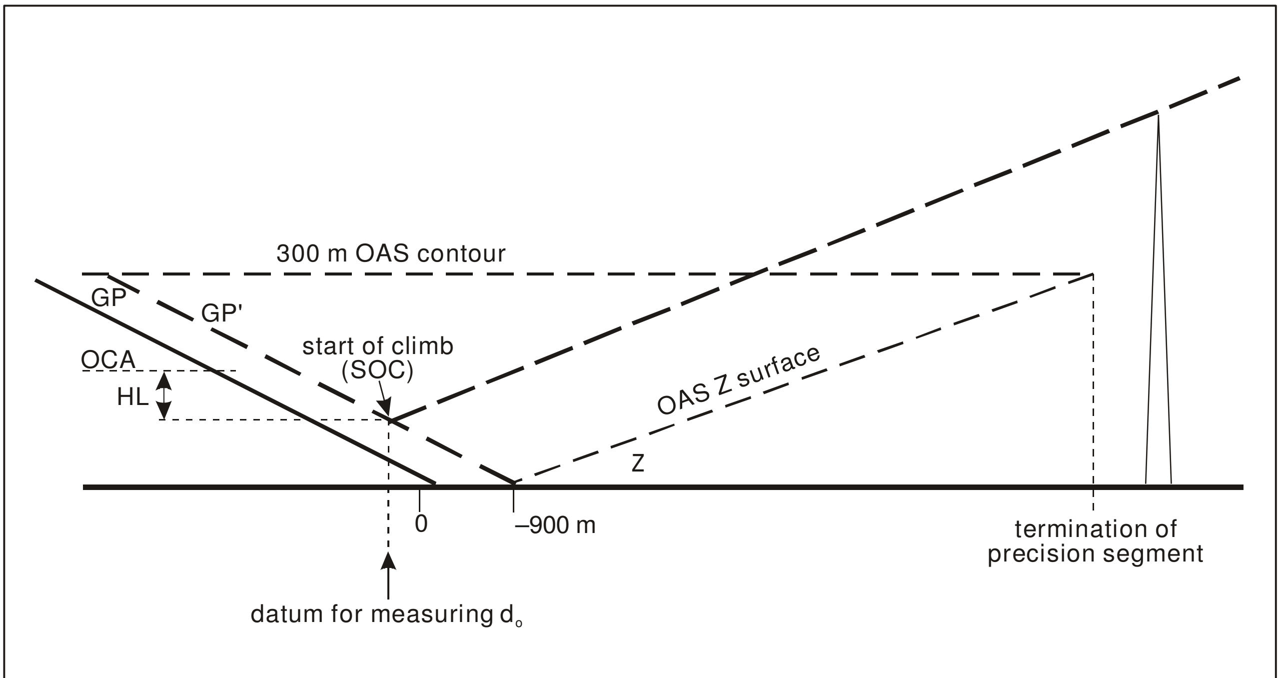


Figure II-1-1-16. Straight missed approach obstacle clearance

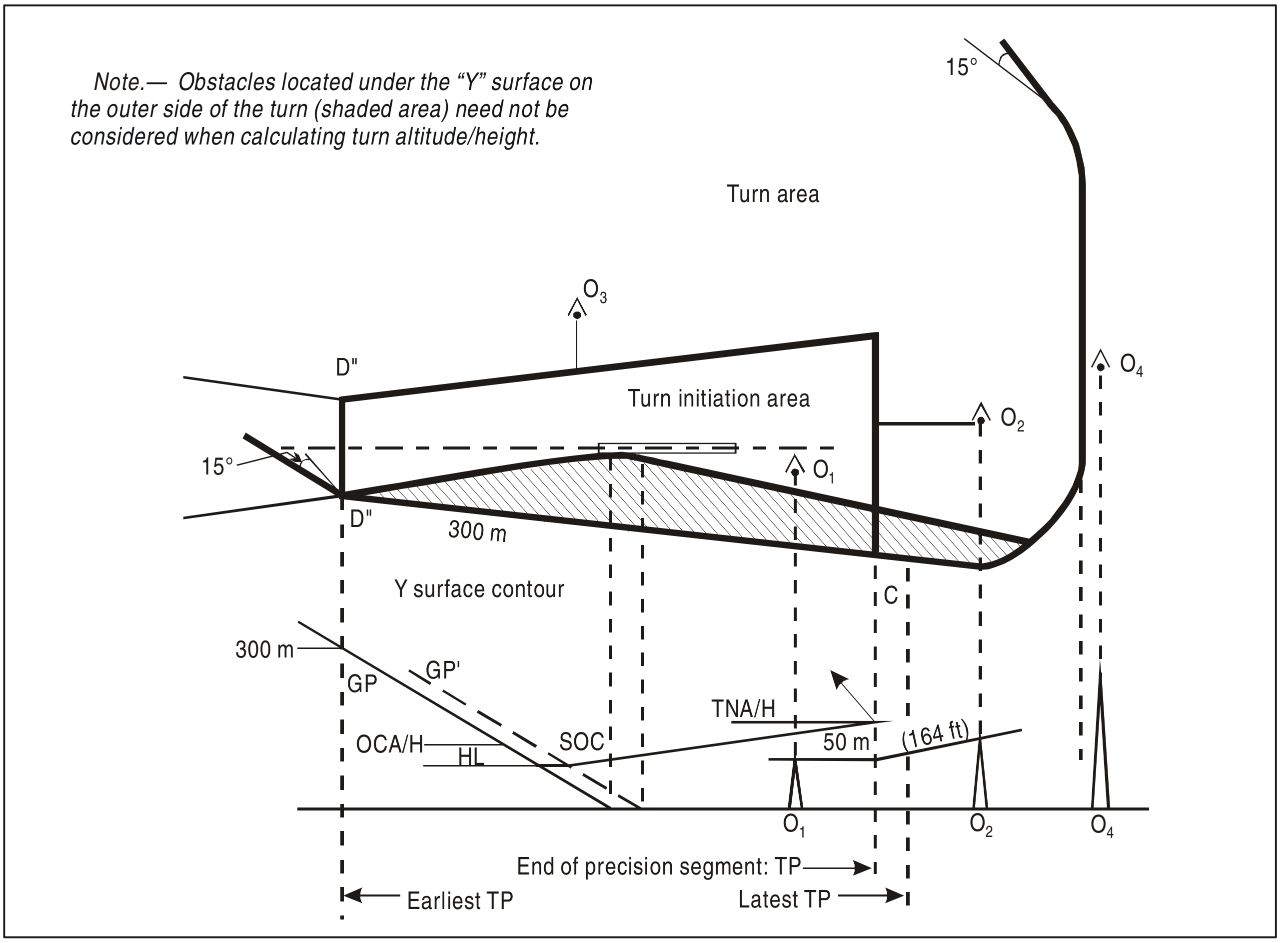
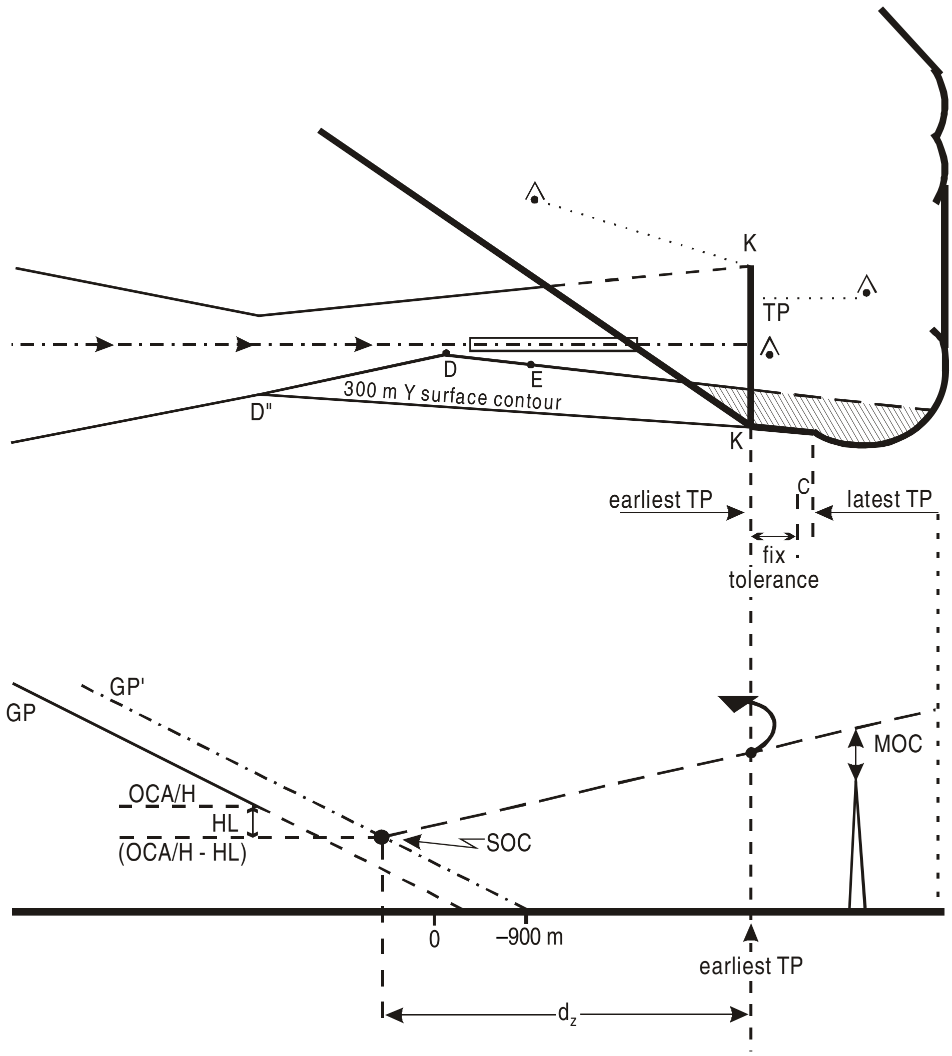


Figure II-1-1-17. Turn at a designated altitude



Note 1.— $d_o = d_z$ + shortest distance from obstacle to line K-K.

Note 2.— Obstacles located under the "Y" surface (shaded area) need not be considered.

Figure II-1-1-18. Turn at designated TP (with TP fix)

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Appendix A to Chapter 1

ILS: TURNING MISSED APPROACH ASSOCIATED WITH A PRECISION APPROACH

(see Chapter 1, 1.5.3, "Turning missed approach")

1. INTRODUCTION

1.1 This appendix contains some guidance material about the way to adjust the turn altitude or the TP location in the case of turning missed approach associated with a precision approach, and it gives some simple formulae to use when the OCA/H has to be increased.

1.2 This appendix also describes a method of treating a turn at an altitude from within the precision segment which reduces the penalty some obstacles cause when the more general techniques of Chapter 1, 1.5.3, "Turning missed approach" are used.

2. TURN ALTITUDE/TP LOCATION ADJUSTMENTS

2.1 Turn at an altitude

2.1.1 Assume that a turn at an altitude has been designed to avoid obstacle 01.

2.1.2 *Obstacle straight ahead in the turn area* (see Figure II-1-1-App A-1). If an obstacle in the turn area, located at 02, cannot be overflown with the adequate margin, the options to solve the problem are:

a) lower the turn altitude in order to exclude 02 from the turn area. In this case obstacles in the turn initiation area (like 03) might become a problem. This means that it might not be possible to lower the turn altitude as much as needed (since turn altitude must be at least the elevation of obstacle 03 + MOC applicable to turns);

b) restrict the final missed approach speed. Then the radius of turn will be reduced and the turn area might exclude 02. (Of course, if speed restriction is applied, the published speed shall be kept above the intermediate missed approach speed); and

c) increase OCA/H. This will raise the turn altitude without moving the latest TP. New OCA/H can be found by using the method described in paragraph 3.

2.1.3 *Obstacle in the turn initiation area.* If an obstacle in the turn initiation area (like 03) is higher than the turn altitude less the margin applicable to turns, then the turn altitude has to be increased. The options are:

a) increase the turn altitude by moving the latest TP further from the SOC. This is acceptable to the extent that 01 still remains outside the turn area;

b) if this does not appear to be possible, the final missed approach speed might be restricted, to reduce the radius of turn and keep 01 outside the turn area; and

c) increase OCA/H without moving the latest TP. New OCA/H can be found by using the formula in paragraph 3.

2.1.4 *Obstacle in the turn area abeam the straight ahead missed approach track.* If an obstacle in the turn area, like 04, cannot be overflown with the appropriate margin, the options a) or b) presented in 2.1.3, "Obstacle in the turn initiation area" above, will be used.

2.2 Turn at a designated TP

2.2.1 *Obstacle straight ahead in the turn area.* If an obstacle straight ahead in the turn area cannot be overflown with the appropriate margin (like 02 in Figure II-1-1-App A-2), the options are:

a) move the TP closer to the SOC in order to exclude 02 from the turn area. The difficulty in this case is that it might then be difficult to get the vertical margin applicable to turns at the earliest TP (which will occur at a lower point of the nominal flight path);

b) if this cannot be solved, the final missed approach speed might be restricted in order to decrease the radius of turn and exclude 02 from the area; and

c) increase OCA/H by using the method shown in paragraph 3.

2.2.2 *Obstacle abeam the straight ahead missed approach track (and before the earliest TP range).* If an obstacle like 04 (see Figure II-1-1-App A-2) cannot be overflown with the appropriate margin, the options to solve the problem are:

a) move the TP further from the SOC. This will increase the nominal altitude over the obstacle and could even exclude 04 from the turn area. Of course this is acceptable to the extent obstacle 01 (see Figure II-1-1-App A-2) can be kept outside the area;

b) if this is not possible, then the final missed approach speed might be restricted; and

c) increase OCA/H by using the method shown in paragraph 3.

3. CALCULATION OF OCA/H

3.1 Calculation of OCH from obstacle data (h_o, d_o)

Whenever there are obstacles in the turn area it is possible to find the OCH compatible with these obstacles by using the formula:

$$OCH = \frac{(h_o + MOC) \cot Z - d}{\cot Z + \cot \theta} + 900 + HL$$

where: h_o is the height (in meters) of the obstacle above threshold

θ is the glide path angle

MOC is the margin applicable to turns (in metres) and

d (in metres) = distance (threshold to TP) + d_o

In the case of a turn at an altitude:

d_o is the shortest distance from obstacle to the turn initiation area boundary and

d = distance (threshold to earliest TP) + d_o

In the case of turn at a designated TP:

d_o is the shortest distance from the obstacle to the earliest TP (line K-K).

3.2 Calculation of OCH from an amount of altitude missing above an obstacle

This method is applicable whenever it has been established that one obstacle is a problem. This means that the nominal altitude above the obstacle will not be adequate for an airplane climbing at the SOC from the previously calculated OCH. If we express the difference in altitude as dif (alt), the necessary increase of OCH (dif (OCH)) will be obtained by the formula:

$$\text{dif (OCH)} = \frac{\text{dif (alt)} \cot Z}{\cot Z + \cot \theta}$$

This method may also be applied for turns at altitude, when an obstacle in the turn initiation area is higher than (turn altitude – MOC). Then the necessary increase of OCH (see 2.1.3, "Obstacle in the turn initiation area", item b)) will be obtained by the formula above where:

dif (alt) = obstacle elevation + MOC – previous turn altitude.

4. TECHNIQUE FOR REDUCTION OF THE TURN AREA FOR A TURN AT AN ALTITUDE FROM INSIDE THE PRECISION SEGMENT

4.1 Turn initiation area

The turn initiation area can be more precisely defined by plotting an area which consists of two parts. The first part is the area enclosed by the turn altitude OAS contour truncated at the turn point as described in Chapter 1, 1.5.3.2.1. The second part of the area is bounded by:

a) the 300 m OAS contour truncated by the line joining the D" points; and

b) two lines D_{TL} defined as follows:

D_T = (HL – RDH) cot θ + 900 m SI units

where D_T is the distance from a missed approach point on GP to the corresponding SOC on GP'.

The distance D_T is then plotted from each D" point in the direction of E" to points Y and V. Lines D_{TL} are then constructed through points Y and V from the 300 m OAS contour to the turn altitude OAS contour so that they are parallel to the lines DD". The area enclosed by the two parts of the construction is the turn initiation area (see Figure II-1-1-App A-3).

4.2 Turn area

The turn area outer boundary may now be constructed from the turn initiation area described above using the principles and techniques detailed in Part I, Section 2, Chapter 3, "Turn area construction" and applying them to points D", V, W and X. However, when the outer boundary (line B — see Figure II-1-1-App A-4) becomes parallel to line D_{TL} and for turns through all greater angles, a turn spiral from point Y must also be considered.

4.3 Obstacle clearance for turns less than 75°

4.3.1 *Turn areas for turns less than 75°.* The turn area is divided into four areas for application of obstacle clearance. Area 1 is contained within the turn height OAS contour truncated by the turn point line. The other areas are defined by the turn area boundaries — and lines 1 and 2 in Figure II-1-1-App A-5 which are drawn parallel to the early turn boundary and from the most penalistic point of the turn height OAS contour and the turn point line respectively. The areas are numbered from 1 to 4 as shown in Figure II-1-1-App A-5.

4.3.2 *Area 1.* In area 1, the obstacle elevation/height shall be less than:

Turn altitude/height – MOC

MOC = 50 m (164 ft) for turns over 15° and

MOC = 30 m (98 ft) for turns of 15° or less.

4.3.3 *Area 2.* In area 2, the obstacle elevation/height shall be less than:

Turn altitude/height + d_o tan Z – MOC

where: d_o = shortest distance from the obstacle to the turn point line (see Figure II-1-1-App A-6)

Z = angle of missed approach surface

MOC = 50 m (164 ft) for turns over 15° and 30 m (98 ft) for turns of 15° or less.

4.3.4 *Area 3.* In area 3, the obstacle elevation/height shall be less than:

Turn altitude/height + d_o tan Z – MOC

where: d_o = distance from the obstacle to the turn altitude OAS contour measured along a line parallel to the early turn boundary (see Figure II-1-1-App A-6)

Z = angle of the missed approach surface

MOC = 50 m (164 ft) for turns over 15° and 30 m (98 ft) for turns of 15° or less.

4.3.5 *Area 4.* In area 4, the obstacle height shall be less than:

$$A_w X_M + C_w + d_o \tan Z - MOC$$

where: Aw = W surface OAS coefficient A

X_M = OAS X coordinate for point M

Cw = W surface OAS coefficient C

d_o = distance from the obstacle to the W OAS surface measured along a line parallel to the early turn boundary (see Figure II-1-1-App A-6)

Z = angle of the missed approach surface

MOC = 50 m (164 ft) for turns over 15° and 30 m (98 ft) for turns of 15° or less.

4.3.6 *Obstacles not considered.* Obstacles in the shaded area of Figure II-1-1-App A-6 do not require consideration as missed approach obstacles because the precision segment has considered their missed approach significance and because the missed approach turns the aircraft away from them. The inner boundaries of this area are the turn point line extended, the turn altitude OAS contour and the W OAS surface.

4.4 Obstacle clearance for turns greater than 75°

4.4.1 *Turn areas for turns greater than 75°.* The turn area is divided into two areas for application of obstacle clearance. The first area is that contained within the turn altitude OAS contour truncated by the turn point line as described in 4.3.1, "Turn areas for turns less than 75°" above. In this area the obstacle elevation/height shall be less than:

$$\text{Turn altitude/height} - 50 \text{ m}$$

In the remainder of the area , the obstacle elevation/height shall be less than:

$$\text{Turn altitude/height} + d_o \gamma - 50 \text{ m}$$

where: d_o = shortest distance from the obstacle to the turn altitude OAS contour or the turn point line (see Figure II-1-1-App A-7)

γ = either the climb gradient of the missed approach surface or the OAS W surface coefficient A, whichever is the lesser.

4.4.2 *Obstacles not considered.* Obstacles beneath the portion of the outer Y surface which is bounded by:

a) the 300 m contour;

b) the turn altitude OAS contour;

c) the turn point line extended; and

d) the DD" line;

need not be considered as missed approach obstacles (see the shaded portion of Figure II-1-1-App A-7).

4.5 OCH greater than 140 m

The constructions described in 4.3.1, “Turn areas for turns less than 75°” and 4.4.1, “Turn areas for turns greater than 75°” above will not be possible when the OCH is greater than approximately 140 m. Figures II-1-1-App A-6 and II-1-1-App A-7 are then modified as shown in Figures II-1-1-App A-8 and II-1-1-App A-9 respectively.

5. PROMULGATION

If, for a turn at altitude, the final missed approach speed is restricted in order to reduce the radius of turn and exclude an obstacle, then the published speed shall be kept above the intermediate missed approach speed.

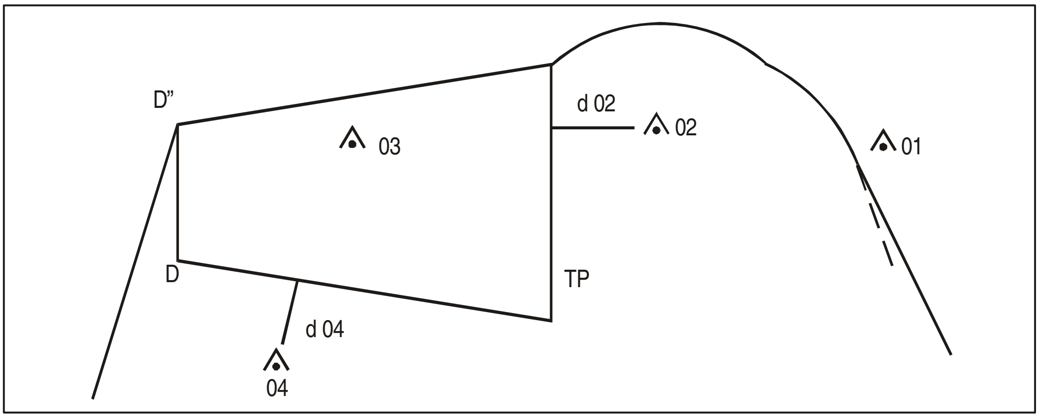

Figure II-1-1-App A-1. Turn at an altitude

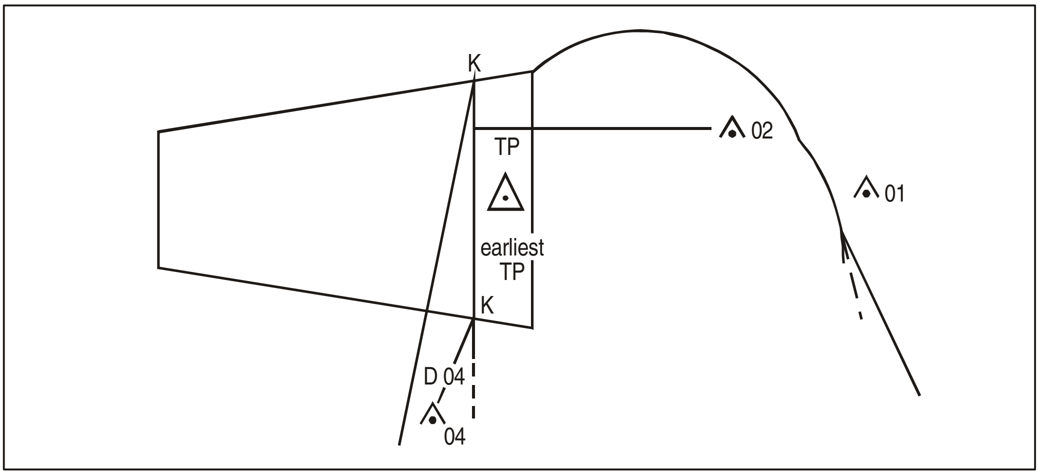

Figure II-1-1-App A-2. Turn at a designated turning point

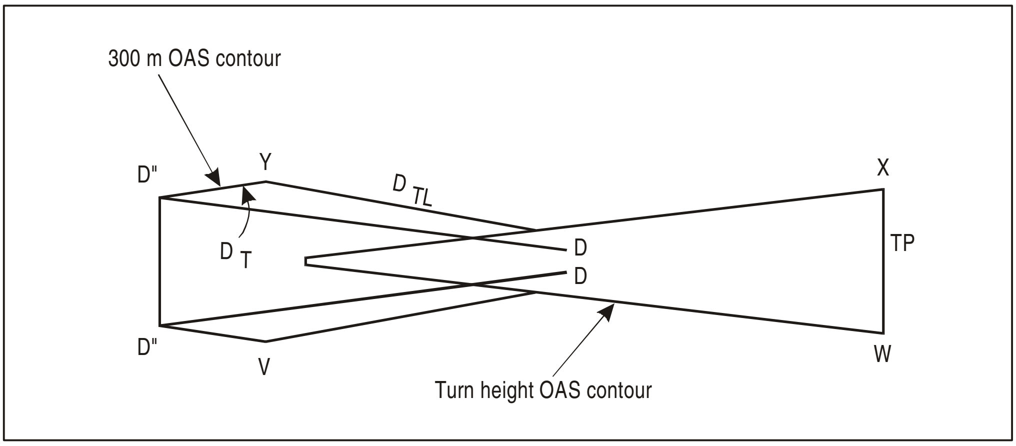

Figure II-1-1-App A-3. Turn initiation area (turn height 90 m)

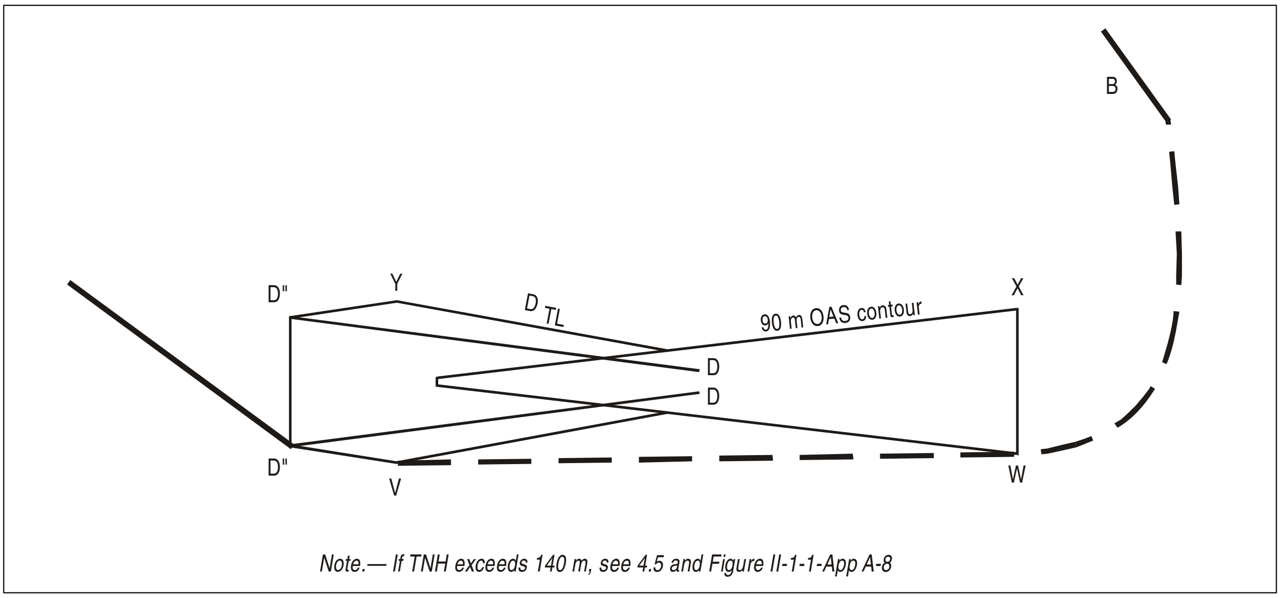

Figure II-1-1-App A-4. Turn area (TNH = 90 m)

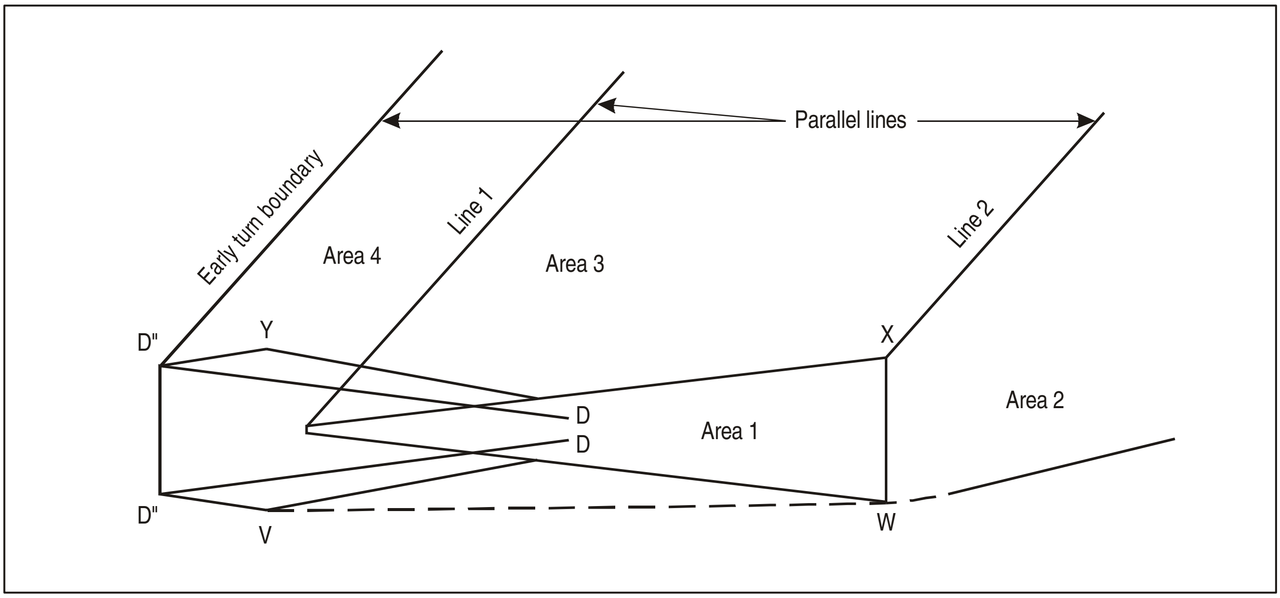

Figure II-1-1-App A-5. Areas for the application of obstacle clearance (TNH = 90 m)

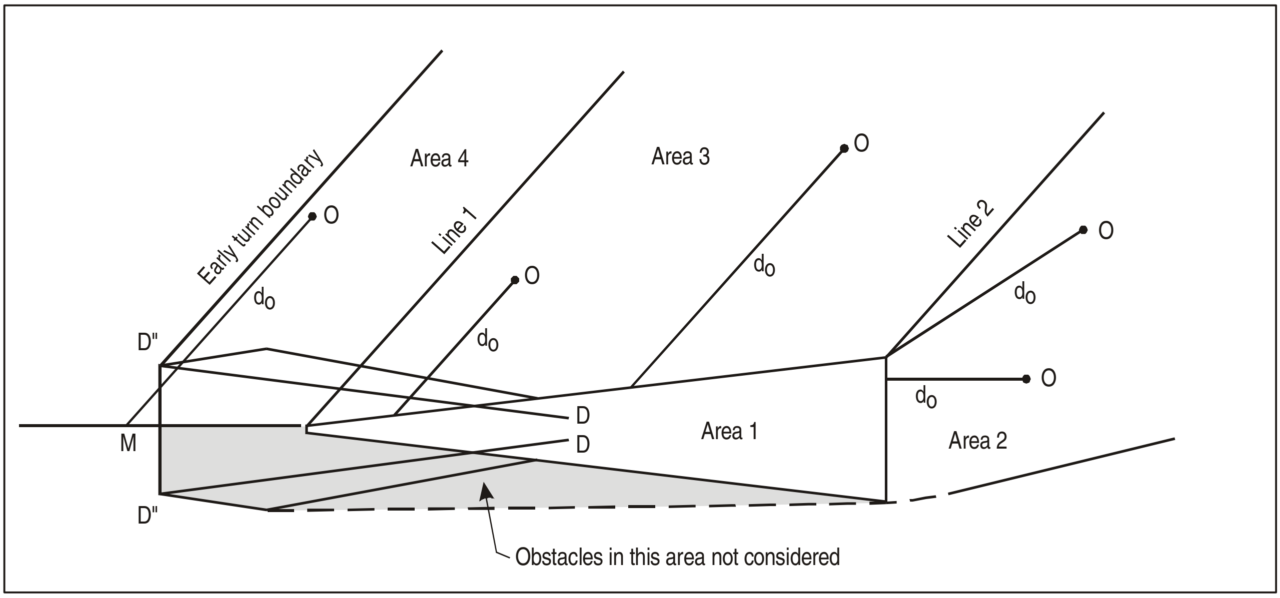

Figure II-1-1-App A-6. Measurement of distances d_o to obstacles (turn less than 75°)

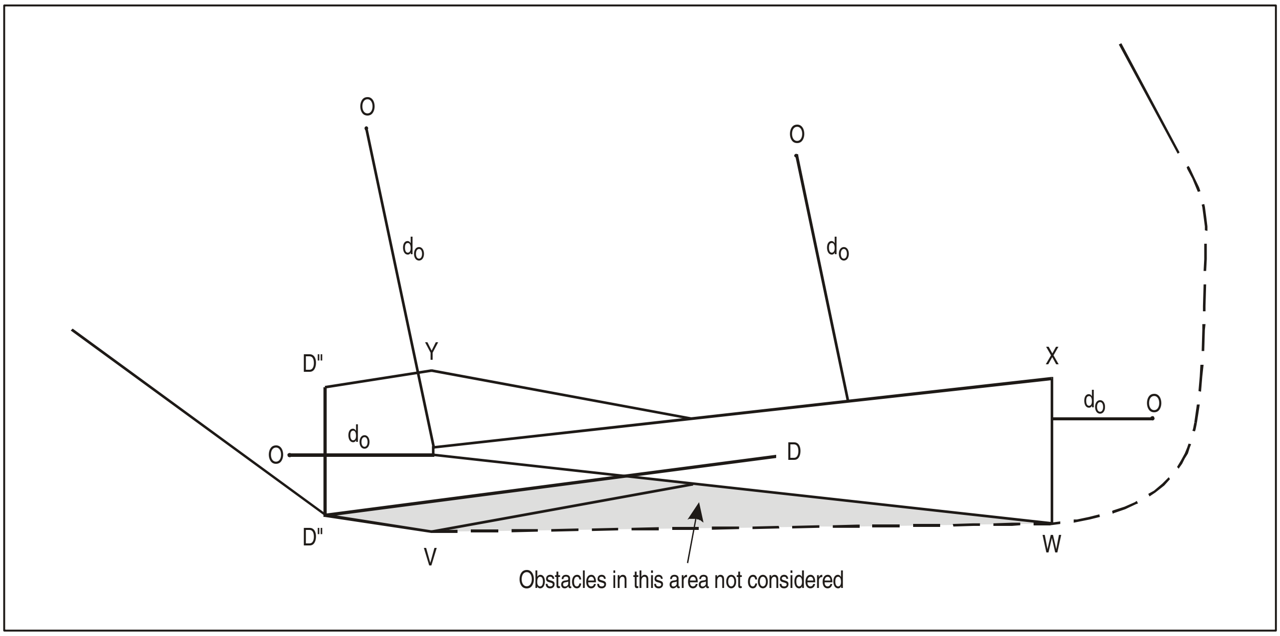

Figure II-1-1-App A-7. Measurement of distances d_o to obstacles (turn more than 75°)

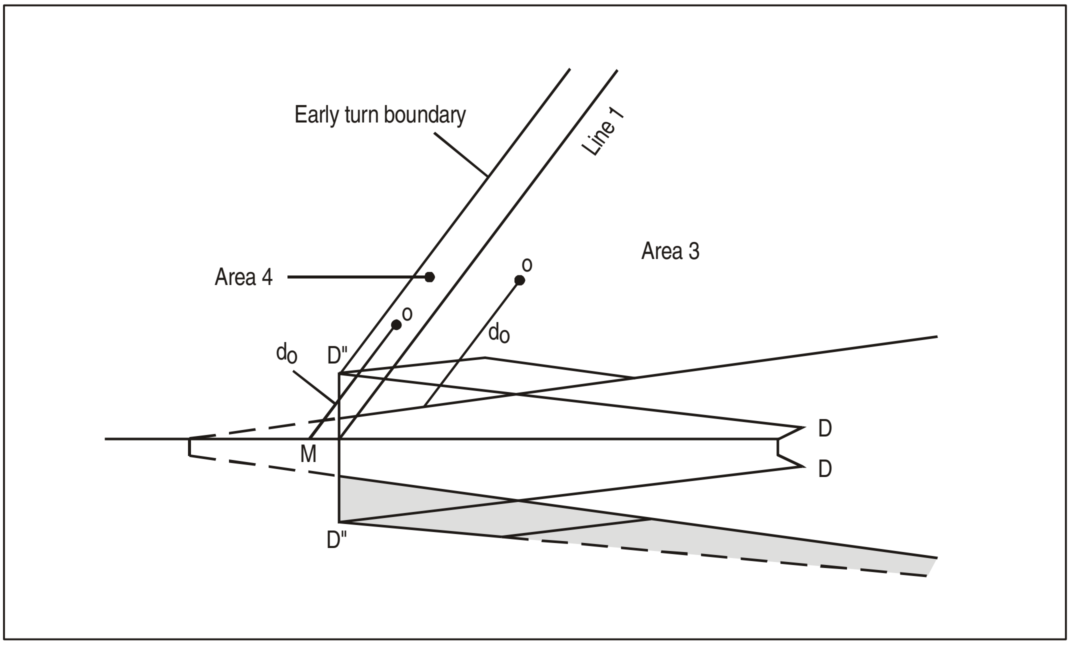

Figure II-1-1-App A-8. Case when TNH is above 140 m approximately (turn less than 75°)

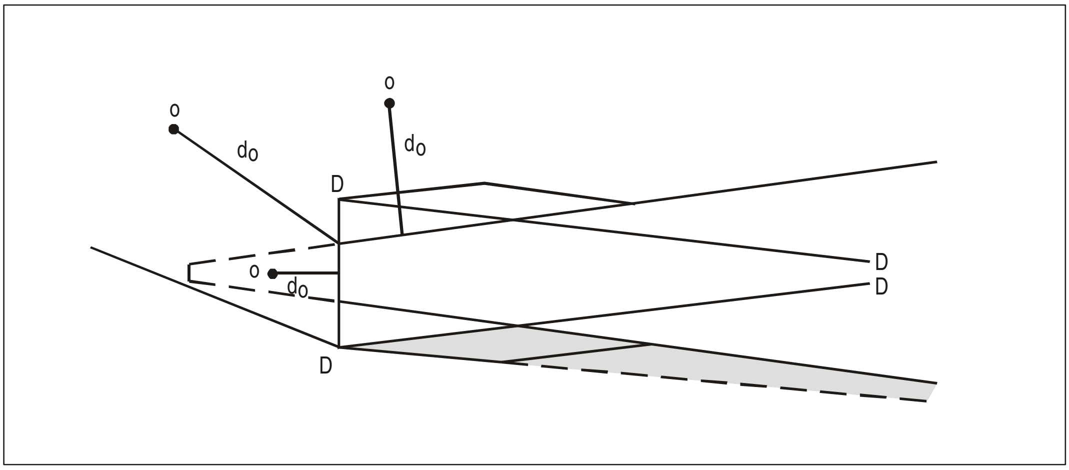

Figure II-1-1-App A-9. Case when TNH is above 140 m approximately (turn more than 75°)

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Appendix B to Chapter 1

STEEP GLIDE PATH ANGLE APPROACHES

1. GENERAL

Glide path angles above 3.5° should be used in approach procedure design only for obstacle clearance purposes and must not be used as a means to introduce noise abatement procedures. Such procedures are non-standard and require a special approval.

2. PROCEDURE DESIGN

2.1 Obstacle clearance criteria

The following obstacle clearance criteria should be adjusted for specific glide path angle:

a) the W surface of the OAS;

b) origin of the Z surface of the OAS; and

c) height loss/altimeter margin (see paragraph 3).

2.2 Determination of the OAS coefficients

W surface: Coefficient A_W is determined by the formula

$$A_W = 0.0239 + 0.0092\ (\theta - 2.5)$$

where θ is the glide path angle in degrees.

Coefficient $C_W = -6.45$

X and Y surfaces: The X and Y surface coefficients for 3.5° glide path at the appropriate localizer/threshold distance are used for all glide path angles greater than 3.5°.

Z surface: The coefficient C_z for the Z surface is determined by the formula

$$C_Z = -A_Z\ X_{ZO}$$

where A_Z is the A coefficient for the selected missed approach gradient; and X_{zo} is the new co-ordinate of the Z surface origin:

$$X_{ZO} = -900 - 50\ (\theta - 3.5°)/0.1°$$

2.3 Determination of the height of equivalent approach obstacle

Use the formula:

$$h_a = [h_{ma} \cot Z + (x - X_{zo})]/(\cot Z + \cot \theta)$$

where:
- h_a = height of equivalent approach obstacle
- h_{ma} = height of missed approach obstacle
- θ = glide path angle
- Z = angle of missed approach surface
- X_{zo} = new co-ordinate of Z surface origin
- x = range of obstacle relative to threshold (negative after threshold).

Note.— In using criteria specified in the text and drawings of paragraphs 1.5 and Chapter 3, 3.5, "Missed approach segment" *use the newly calculated co-ordinate of "Z" surface origin (X_{zo}) instead of the value of –900 m.*

2.4 Re-survey of obstacles

As the configuration of the OAS is changed, a re-survey of obstacles may be required.

2.5 Promulgation

A special note shall be included on the instrument approach chart stating that appropriate aircraft and crew qualifications are required to use such a procedure (see Annex 4, 11.10.8.6).

3. HEIGHT LOSS MARGIN AND OTHER CONSIDERATIONS

3.1 Height loss margins for glide paths greater than 3.5° or less than 3.5°

The height loss margin can be obtained by extrapolation from the formulas in 1.4.8.8.3.1 and Chapter 3, 3.4.8.8.3.1, both entitled "Height loss (HL)/altimeter margins". However, this extrapolation may not be valid for glide paths greater than 3.5° or less than 3.5° when the nominal rate of descent (V_{at} for the aircraft type × the sine of the glide path angle) exceeds 5 m/sec (1 000 ft/min), unless certification on flight trials has verified the effects of:

a) minimum drag configuration;

b) effect of wind shear;

c) control laws;

d) handling characteristics;

e) minimum power for anti-icing;

f) GPWS modification;

g) use of flight director/autopilot;

h) engine spin-up time; and

i) V_{at} increase for handling considerations.

3.2 Additional operational considerations for height loss margin

In addition, the height loss margin may be inadequate unless operational consideration is given to configuration, engine-out operation, maximum tail wind — minimum head wind limits, GPWS, weather minima, visual aids and crew qualifications, etc.

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Appendix C to Chapter 1

DETERMINING ILS GLIDE PATH DESCENT/MLS ELEVATION HEIGHTS AND DISTANCES

1. ILS/MLS glide path heights (H) and horizontal distances (D) from the threshold are calculated by solving a right-angle triangle:

SI units

$$H = h + 1\,000\ D \tan\theta \quad \text{and} \quad D = 0.001(H - h)\cot\theta$$

where: H = height in metres

h = reference datum height in metres

D = distance from the threshold in kilometres

θ = glide path angle in degrees

Non-SI units

$$H = h + 6\,076\ D \tan\theta \quad \text{and} \quad D = 0.0001646(H - h)\cot\theta$$

where: H = height in feet

h = reference datum height in feet

D = distance from the threshold in nautical miles

θ = glide path angle in degrees

2. The influence of the curvature of the earth's surface should be considered in order to check that the heights and distances to the threshold determined in this manner meet the Annex 10 and PANS-OPS requirements. To perform such a check, Tables II-1-1-App C-1 and II-1-1-App C-2 may be used. For intermediate distances, heights and glide path angles, the linear interpolation method is used.

For reference datum heights (h) other than 15 m (49 ft):

a) the values obtained from Table II-1-1-App C-1 should be corrected by adding ΔH where:

SI units: $\Delta H = h - 15$ (Table II-1-1-App C-1a))

and

Non-SI units: $\Delta H = h - 49$ (Table II-1-1-App C-1b))

b) the values obtained from Table II-1-1-App C-2 should be corrected by adding ΔD where:

SI units: $\Delta D = 0.00092(15 - h) \cot \theta$ (Table II-1-1-App C-2a))

and

Non-SI units: $\Delta D = 0.0001514(49 - h) \cot \theta$ (Table II-1-1-App C-2b))

The following formulae may be used for intermediate distances, heights and glide path angles as well as for values which are greater than the maximum values indicated in Tables II-1-1-App C-1 and II-1-1-App C-2:

SI units: $H = h + 1\,000\ D \tan \theta + 0.0785\ D^2$

and

Non-SI units: H = h + 6 076 D tan θ + 0.8833 D2

3. Heights are rounded up to the nearest multiple of 5 m (10 ft), and distances are rounded to the nearest tenth of a kilometre (nautical mile).

Note 1.— When heights are rounded up to the nearest multiple of 5 m (10 ft), the check referred to in paragraph 2 will not result in significant differences from the conventional geometric right-angle triangle calculation for threshold distances of less than 8 km or 4 NM. This also applies when distances are rounded to the nearest tenth of a kilometre (NM) for heights less than 500 m or 2 100 ft.

Note 2.— To determine glide path heights at the outer marker fix or other fix, unrounded height values are used.

Table II-1-1-App C-1a). Fix height over threshold in metres taking account of the curvature of the earth (reference datum height of 15 m) — SI units

Glide path angle	Fix distance from threshold (km)																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2.5°	59	103	147	191	235	280	324	369	414	459	505	550	596	642	688	734	780	826	873	920
2.6°	60	106	152	198	244	290	337	383	430	477	524	571	618	666	714	762	810	858	906	955
2.7°	62	110	157	205	253	301	349	397	446	494	543	592	641	691	740	790	839	889	939	990
2.8°	64	113	162	212	262	311	361	411	462	512	562	613	664	715	766	818	869	921	972	1 024
2.9°	66	117	168	219	270	322	373	425	477	529	582	634	687	740	792	846	899	952	1 006	1 060
3.0°	67	120	173	226	279	332	386	439	493	547	601	655	710	764	819	874	929	984	1 039	1 094
3.1°	69	124	178	233	288	343	398	453	509	564	620	676	732	788	845	902	958	1 015	1 072	1 130
3.2°	71	127	183	240	296	353	410	467	524	582	639	697	755	813	871	930	988	1 047	1 106	1 164
3.3°	73	131	189	247	305	364	422	481	540	599	659	718	778	838	898	958	1 018	1 078	1 139	1 200
3.4°	74	134	194	254	315	374	435	495	556	617	678	739	801	862	924	986	1 048	1 110	1 172	1 235
3.5°	76	138	199	261	323	385	447	509	572	634	697	760	823	887	950	1 014	1 077	1 141	1 205	1 270

Glide path angle	Fix distance from threshold (km)																			
	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
2.5°	966	1 014	1 061	1 108	1 156	1 203	1 251	1 299	1 347	1 395	1 444	1 492	1 541	1 590	1 639	1 688	1 738	1 787	1 837	1 887
2.6°	1 003	1 052	1 101	1 150	1 199	1 249	1 298	1 348	1 398	1 448	1 498	1 548	1 599	1 650	1 700	1 751	1 803	1 854	1 905	1 957
2.7°	1 040	1 090	1 141	1 192	1 243	1 294	1 346	1 397	1 449	1 500	1 552	1 604	1 657	1 709	1 762	1 814	1 867	1 920	1 974	2 027
2.8°	1 077	1 129	1 181	1 234	1 287	1 340	1 393	1 446	1 499	1 553	1 606	1 660	1 714	1 769	1 823	1 877	1 932	1 987	2 042	2 097
2.9°	1 113	1 167	1 222	1 276	1 330	1 385	1 440	1 495	1 550	1 605	1 661	1 716	1 772	1 828	1 884	1 940	1 997	2 053	2 110	2 167
3.0°	1 150	1 206	1 262	1 318	1 374	1 431	1 487	1 544	1 601	1 657	1 715	1 772	1 830	1 888	1 945	2 003	2 062	2 120	2 178	2 237
3.1°	1 187	1 244	1 302	1 360	1 418	1 476	1 534	1 593	1 652	1 710	1 769	1 828	1 888	1 947	2 007	2 066	2 126	2 186	2 246	2 307
3.2°	1 224	1 283	1 342	1 402	1 462	1 522	1 582	1 642	1 702	1 763	1 824	1 884	1 945	2 007	2 068	2 129	2 191	2 253	2 315	2 377
3.3°	1 260	1 322	1 383	1 444	1 506	1 567	1 629	1 691	1 753	1 815	1 878	1 940	2 003	2 066	2 129	2 192	2 256	2 319	2 383	2 447
3.4°	1 297	1 360	1 423	1 486	1 549	1 613	1 676	1 740	1 804	1 868	1 932	1 996	2 061	2 126	2 190	2 256	2 321	2 386	2 451	2 517
3.5°	1 334	1 398	1 463	1 528	1 593	1 658	1 724	1 789	1 854	1 920	1 986	2 052	2 119	2 185	2 252	2 318	2 385	2 452	2 520	2 587

Table II-1-1-App C-1b). Fix height over threshold in feet taking account of the curvature of the earth (reference datum height of 49 ft) — Non-SI units

Glide path angle	Fix distance from threshold (NM)																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
2.5°	315	583	853	1 124	1 398	1 672	1 949	2 228	2 508	2 790	3 074	3 360	3 647	3 936	4 227	4 520	4 814	5 110	5 408	5 708
2.6°	326	604	885	1 167	1 451	1 736	2 024	2 313	2 604	2 896	3 191	3 487	3 785	4 085	4 386	4 690	4 994	5 302	5 610	5 920
2.7°	336	626	916	1 209	1 504	1 800	2 098	2 398	2 699	3 003	3 308	3 615	3 923	4 234	4 546	4 860	5 175	5 493	5 812	6 133
2.8°	347	647	948	1 252	1 557	1 864	2 172	2 483	2 795	3 109	3 425	3 742	4 061	4 382	4 705	5 030	5 356	5 684	6 014	6 346
2.9°	357	668	980	1 294	1 610	1 928	2 247	2 568	2 891	3 215	3 542	3 870	4 200	4 531	4 865	5 200	5 537	5 876	6 216	6 558
3.0°	368	689	1 012	1 336	1 663	1 991	2 321	2 653	2 986	3 322	3 659	3 997	4 338	4 680	5 024	5 370	5 718	6 067	6 418	6 771
3.1°	379	711	1 044	1 379	1 716	2 055	2 396	2 738	3 082	3 428	3 776	4 125	4 476	4 829	5 183	5 540	5 898	6 258	6 620	6 984
3.2°	390	732	1 076	1 422	1 770	2 119	2 470	2 823	3 178	3 534	3 892	4 253	4 614	4 978	5 343	5 710	6 079	6 450	6 822	7 196
3.3°	400	753	1 108	1 464	1 823	2 183	2 545	2 908	3 274	3 640	4 010	4 380	4 753	5 127	5 502	5 880	6 260	6 641	7 024	7 409
3.4°	411	774	1 140	1 507	1 876	2 247	2 619	2 993	3 369	3 747	4 127	4 508	4 891	5 276	5 662	6 051	6 441	6 833	7 226	7 622
3.5°	422	796	1 172	1 550	1 929	2 310	2 694	3 078	3 465	3 854	4 244	4 636	5 029	5 425	5 822	6 221	6 622	7 024	7 428	7 835

Table II-1-1-App C-2a). Distance of final approach point/descent fix before threshold in kilometres taking account of the curvature of the earth (reference datum height of 15 m) — SI units

Glide path angle	Final approach point/descent fix height over threshold (m)														
	100	200	300	400	500	600	700	800	900	1 000	1 100	1 200	1 300	1 400	1 500
2.5°	1 941	4 207	6 455	8 686	10 899	13 096	15 276	17 440	19 588	21 721	23 839	25 942	28 031	30 105	32 166
2.6°	1 866	4 047	6 212	8 361	10 494	12 613	14 717	16 806	18 881	20 942	22 990	25 024	27 045	29 053	31 049
2.7°	1 798	3 899	5 986	8 059	10 118	12 164	14 196	16 215	18 221	20 215	22 197	24 166	26 124	28 069	30 004
2.8°	1 734	3 761	5 776	7 778	9 768	11 745	13 710	15 663	17 605	19 536	21 455	23 363	25 260	27 147	29 023
2.9°	1 674	3 633	5 580	7 516	9 440	11 353	13 255	15 147	17 028	18 899	20 759	22 610	24 450	26 281	28 102
3.0°	1 619	3 513	5 397	7 270	9 133	10 986	12 829	14 663	16 487	18 301	20 106	21 901	23 689	25 467	27 236
3.1°	1 566	3 400	5 225	7 040	8 846	10 642	12 430	14 208	15 978	17 739	19 492	21 236	22 972	24 700	26 419
3.2°	1 518	3 295	5 064	6 824	8 575	10 318	12 053	13 780	15 499	17 209	18 912	20 608	22 295	23 976	25 648
3.3°	1 472	3 196	4 912	6 620	8 321	10 013	11 699	13 376	15 047	16 710	18 366	20 015	21 657	23 292	24 920
3.4°	1 429	3 102	4 769	6 428	8 081	9 726	11 344	12 995	14 620	16 238	17 849	19 454	21 052	22 644	24 230
3.5°	1 388	3 014	4 634	6 247	7 854	9 454	11 048	12 635	14 216	15 791	17 360	18 923	20 480	22 031	23 576

Glide path angle	Final approach point/descent fix height over threshold (m)														
	1 600	1 700	1 800	1 900	2 000	2 100	2 200	2 300	2 400	2 500	2 600	2 700	2 800	2 900	3 000
2.5°	34 212	36 246	38 267	40 274	42 270	44 252	46 223	48 182	50 129	52 064	53 989	55 902	57 804	59 696	61 577
2.6°	33 032	35 003	36 963	38 910	40 846	42 771	44 685	46 588	48 480	50 361	52 232	54 093	55 944	57 785	59 616
2.7°	31 927	33 839	35 740	37 630	39 510	41 380	43 239	45 088	46 928	48 758	50 578	52 389	54 191	55 983	57 767
2.8°	30 889	32 745	34 591	36 427	38 254	40 071	41 878	43 677	45 466	47 247	49 018	50 781	52 536	54 282	56 020
2.9°	29 914	31 717	33 510	35 295	37 071	38 838	40 596	42 346	44 087	45 821	47 546	49 263	48 092	52 674	54 368
3.0°	28 996	30 749	32 492	34 228	35 955	37 674	39 386	41 089	42 785	44 473	46 154	47 827	49 493	51 152	52 803
3.1°	28 131	29 835	31 531	33 220	34 901	36 575	38 241	39 901	41 553	43 198	44 836	46 467	40 092	49 710	51 321
3.2°	27 314	28 972	30 623	32 268	33 904	35 535	37 159	38 776	40 386	41 990	43 581	45 178	46 763	48 341	49 914
3.3°	26 541	28 156	29 764	31 366	32 961	34 550	36 133	37 709	39 280	40 844	42 402	43 955	45 501	47 042	48 577
3.4°	25 809	27 383	28 950	30 511	32 066	33 616	35 159	36 697	38 229	39 756	41 277	42 792	44 302	45 807	47 306
3.5°	25 116	26 649	28 177	29 700	31 217	32 728	34 235	35 736	37 231	38 722	40 207	41 687	43 162	44 632	46 097

Table II-1-1-App C-2b). Distance of final approach point/descent fix before threshold in nautical miles taking account of the curvature of the earth (reference datum height of 49 ft) — Non-SI units

Glide path angle	Final approach point/descent fix height over threshold (ft)														
	300	600	900	1 200	1 500	1 800	2 100	2 400	2 700	3 000	3 300	3 600	3 900	4 200	4 500
2.5°	943	2 063	3 175	4 278	5 374	6 462	7 543	8 616	9 682	10 741	11 793	12 838	13 877	14 909	15 934
2.6°	907	1 985	3 055	4 118	5 174	6 223	7 265	8 301	9 330	10 353	11 370	12 380	13 385	14 384	15 376
2.7°	874	1 912	2 944	3 969	4 988	6 000	7 007	8 008	9 003	9 992	10 976	11 953	12 926	13 893	14 855
2.8°	843	1 844	2 840	3 830	4 814	5 793	6 766	7 734	8 697	9 654	10 606	11 554	12 496	13 433	14 366
2.9°	814	1 781	2 743	3 700	4 652	5 599	6 541	7 478	8 410	9 338	10 261	11 179	12 093	13 002	13 907
3.0°	786	1 722	2 653	3 579	4 501	5 418	6 330	7 238	8 142	9 041	9 936	10 827	11 714	12 597	13 475
3.1°	761	1 667	2 569	3 466	4 359	5 248	6 132	7 063	7 890	8 762	9 631	10 496	11 358	12 215	13 069
3.2°	738	1 615	2 489	3 359	4 225	5 088	5 946	6 801	7 652	8 500	9 344	10 184	11 022	11 855	12 685
3.3°	715	1 567	2 414	3 259	4 100	4 937	5 771	6 601	7 428	8 252	9 073	9 890	11 704	11 515	12 323
3.4°	694	1 521	2 344	3 164	3 981	4 795	5 605	6 413	7 217	8 018	8 818	9 612	10 404	11 194	11 980
3.5°	674	1 477	2 278	3 075	3 869	4 660	5 449	6 234	7 017	7 797	8 574	9 349	10 120	10 889	11 655

Glide path angle	Final approach point/descent fix height over threshold (ft)														
	4 800	5 100	5 400	5 700	6 000	6 300	6 600	6 900	7 200	7 500	7 800	8 100	8 400	8 700	9 000
2.5°	16 954	17 967	18 974	19 975	20 970	21 960	22 994	23 922	24 895	25 862	26 824	27 781	28 733	29 680	30 622
2.6°	16 364	17 345	18 321	19 292	20 257	21 217	22 172	23 121	24 066	25 006	25 941	26 871	27 796	28 717	29 633
2.7°	15 812	16 764	17 710	18 651	19 588	20 520	21 447	22 369	23 287	24 200	25 109	26 014	26 914	27 810	28 702
2.8°	15 294	16 217	17 136	18 050	18 959	19 864	20 765	21 662	22 554	23 442	24 326	25 206	26 082	26 454	27 823
2.9°	14 808	15 704	16 596	17 484	18 368	19 247	20 123	20 995	21 863	22 727	23 588	24 444	25 297	26 147	26 992
3.0°	14 350	15 221	16 088	16 951	17 810	18 666	19 518	20 366	21 211	22 052	22 890	23 724	24 555	25 383	26 207
3.1°	13 919	14 766	15 609	16 448	17 284	18 117	18 946	19 772	20 595	21 414	22 230	23 043	23 853	24 660	25 463
3.2°	13 512	14 336	15 156	15 973	16 787	17 598	18 405	19 210	20 011	20 810	21 605	22 398	23 187	23 974	24 758
3.3°	13 128	13 930	14 728	15 524	16 317	17 106	17 893	18 677	19 458	20 237	21 013	21 786	22 556	23 324	24 089
3.4°	12 764	13 545	14 323	15 098	15 871	16 641	17 408	18 172	18 934	19 694	20 450	21 205	21 957	22 706	23 453
3.5°	12 419	13 180	13 938	14 694	15 448	16 198	16 947	17 693	18 436	19 177	19 916	20 652	21 386	22 118	22 848

Appendix D to Chapter 1

INDEPENDENT PARALLEL APPROACHES TO CLOSELY SPACED PARALLEL RUNWAYS

1. INTRODUCTION

1.1 Independent parallel approaches to closely spaced parallel runways are allowed when the distance between runways is not less than 1 035 m. To guarantee the safety of such operations, an obstacle assessment has to be carried out to protect a lateral break-out manoeuvre, which may need to be executed to avoid collision with a potential blundering aircraft. This will provide obstacle clearance from obstacles in the areas adjacent to the final approach segments.

1.2 The following method provides an example for the assessment of these obstacles and was derived from an existing procedure used by one State. This section includes the considerations made in developing the basis for the assessment.

1.3 It was considered that a difference exists between the current precision approach procedures described in Chapter 1, "Instrument landing system (ILS)" and Chapter 3, "MLS", and the break-out procedures. For the approach procedures, an extensive data collection could be performed from which statistical probabilities of aircraft distributions could be obtained. In establishing a target level of safety (TLS) of 10^{-7}, obstacle assessment surfaces (OAS) and the collision risk model (CRM) are derived. For the assessment surfaces of the break-out manoeuvre, this type of method was not considered feasible due to the low probability of occurrence of a break-out manoeuvre. From one State's report, it was learned that the occurrence of a break-out during simultaneous approaches was initially assumed to be in the order of 10^{-4} and 10^{-5} per approach and may even be lower.

1.4 In order to find obstacle clearance criteria for break-out manoeuvres, other methods were considered. One way was to use the existing missed approach criteria. However, these criteria are based on an occurrence of 10^{-2} which may be unduly restrictive at some aerodromes, and missed approaches are not primarily designed for break-out manoeuvres.

2. PARALLEL APPROACH OBSTACLE ASSESSMENT SURFACES (PAOAS)

2.1 The proposed method for the obstacle assessment for simultaneous parallel approaches was based on existing criteria provided by one State (FAA Order 8260.41). An evaluation was carried out by the Obstacle Clearance Panel (OCP). This evaluation was made by means of certification and operational criteria contained in the FAR/JAR 23/25 minimum climb requirements with all engines operating, together with the operational assumptions made by the ICAO Study Group on Simultaneous Operations on Parallel or Near-parallel Instrument Runways (SOIR), which established the minimum runway separation for use with simultaneous independent precision approaches (Cir 207). The evaluation considered that the initial part of the break-out manoeuvre would be executed in the landing configuration, followed by a climb gradient of 8.3 per cent within a height of 120 m (400 ft) above the break-out altitude/height. This evaluation indicated, in general, that the following restrictions to the break-out manoeuvres were necessary:

a) no break-out manoeuvres below 120 m (400 ft); and

b) maximum 45° break-out angle.

2.2 Due to the nature of the surfaces, these two parameters are interdependent. During the evaluation, it was found that the lower the break-out was considered, the earlier the assessment surfaces would be penetrated, causing the break-out angle to be reduced, e.g. a minimum break-out height of 60 m (200 ft) would result in a break-out angle of 20°, and a minimum break-out height of 300 m (1 000 ft) would result in a break-out angle of 65°.

2.3 It was considered necessary to restrict the minimum break-out altitude/height. One reason was that break-out manoeuvres at too low heights could be considered unsafe. Moreover, considering the maximum assumed blunder angle of 30° and approach speed of 150 kt, it could be assumed that below a certain height the blundering aircraft could not reach the threatened aircraft before it landed. and therefore it would be of no use to protect for these low heights.

2.4 Information available in respect of flight and simulator tests conducted by one State for these manoeuvres showed that phraseology used by the air traffic services (ATS) was similar to that contained in the PANS-ATM, Chapter 12, on independent parallel approaches. Following the instructions from air traffic services, the pilot actually first arrested the descent and then established climb, crossing the glide path (if below) before turning. This information supported the assumptions used to validate the proposed obstacle assessment criteria.

2.5 The evaluation report further indicated that it was not considered convenient to provide additional obstacle assessment surface (OAS) constant tables in PANS-OPS for these cases for each localizer-threshold distance combination. The proposed surfaces are based on operational rather than statistical considerations. Therefore, it was proposed to use one set of surfaces for all combinations of localizer-threshold distances. These surfaces would guarantee protection for aircraft following the assumed operational scenario.

2.6 A mathematical match was made from the surfaces for an average runway length/localizer distance contained in the Federal Aviation Administration (FAA) Order (8260.41). This approach was considered acceptable for the assessment of rare events for which statistical analysis was not feasible.

3. APPLICATION OF PARALLEL APPROACH OBSTACLE ASSESSMENT SURFACE (PAOAS) CRITERIA

3.1 General

In addition to the application of OAS criteria specified in Chapter 1, 1.4.8, "Obstacle clearance of the precision segment using (OAS) criteria," parallel approach obstacle assessment surfaces (PAOAS) are defined to safeguard the execution of an immediate climb and turn manoeuvre to the assigned heading and altitude/height. PAOAS criteria are used to demonstrate obstacle clearance, accommodating turns up to 45° from the approach path and a lowest break-out manoeuvre initiation of 120 m (400 ft) above threshold elevation. PAOAS criteria are valid for all categories of instrument landing system/microwave landing system (ILS/MLS) approaches.

3.2 Definition of surfaces.

3.2.1 The PAOAS consists mainly of two sloping plane surfaces (denoted P1 and P2) positioned on the side of the runway opposite to the adjacent runway. The geometry of the sloping surfaces is defined, similar to the OAS surfaces (see Chapter 1, 1.4.8.4, "Definition of obstacle assessment surfaces (OAS)") by a linear equation of the form $z = Ax + By + C$. The constants are related to the glide path angle only. They are independent of the category of ILS/MLS operations and localizer-threshold distance. The constants are given in Table II-1-1-App D-1.

3.2.2 Where the OAS surfaces are below P1 or P2, they become the PAOAS. Where the Z surface is above the PAOAS, it becomes the PAOAS. A typical example of the layout of combined OAS and PAOAS surfaces is depicted in Figure II-1-1-App D-1. The surfaces terminate at a height of 300 m (1 000 ft) below minimum altitude/height associated with tactical radar vectoring.

3.3 Calculation of PAOAS height

To calculate the height z of P1 or P2 surfaces at a location x', y', the appropriate constants should be obtained from Table II-1-1-App D-1 and substituted in the equation z = Ax' + By' + C. Similarly, the height of the OAS surfaces should be calculated according to Chapter 1, 1.4.8. The height of the PAOAS is then determined as specified in 3.2, "Definition of surfaces," above.

3.4 Obstacle assessment

3.4.1 The obstacle elevation/height in the area to be considered shall be less than the PAOAS height as specified in 3.2, "Definition of surfaces," above. Obstacles below the Z surface, or its extension, need not be considered. PAOAS penetrations shall be identified and considered for electronic mapping on controller displays.

3.4.2 If possible, obstacles should be removed. Where obstacle removal is not feasible, air traffic operational rules shall be established to avoid obstacles, and a risk assessment shall be required to provide guidance on whether independent simultaneous ILS/MLS operations to parallel runways should be approved.

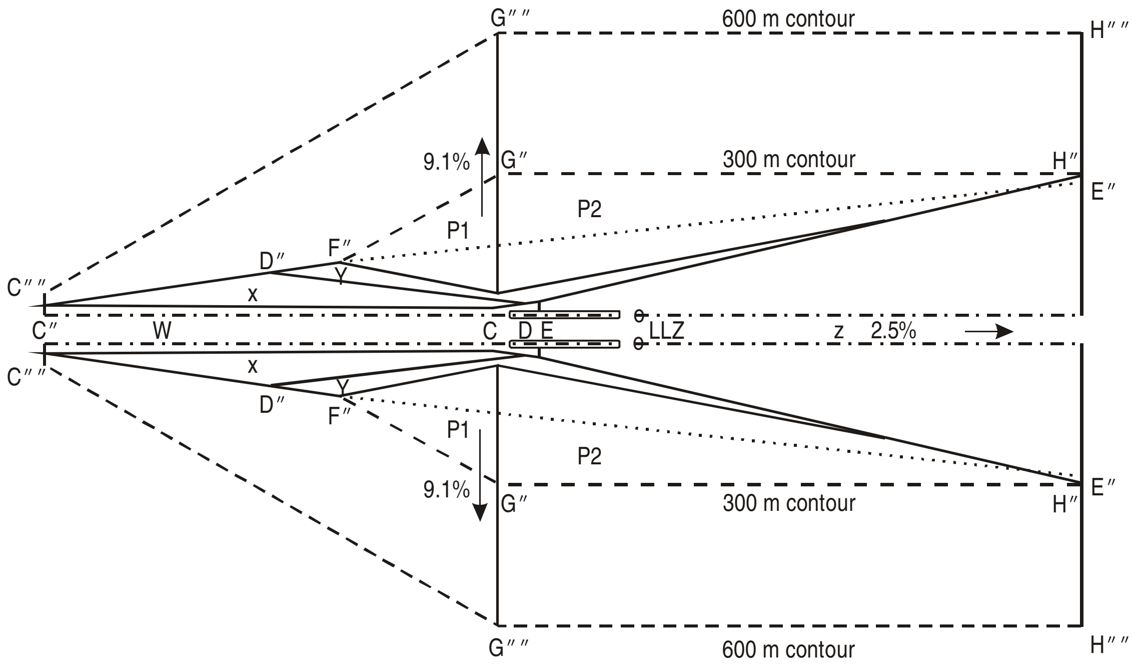
Table II-1-1-App D-1. Constants for calculation of PAOAS

PAOAS	A	B	C
P1	tan θ	0.091	5
P2	0	0.091	15

θ = ILS glide path angle or MLS elevation angle

PAOAS coordinates in metres

Category I/GP angle 3°/LLZ-THR 3 000 m/missed approach gradient 2.5 percent



Equations of the obstacle assessment surfaces:
OAS:
W l z = .0285x – 8.01
X l z = .027681x + .1825y – 16.72
Y l z = .023984x + .210054y – 21.51
Z l z = – .025x – 22.50
PAOAS:
Pllz = .05241x + .091y + 5
P2l z = .091y + 15

Coordinates of points C, D, E, C″, D″, E″, F″, G″, H″ (m):

	C	D	E	C″	D″	E″	F″	G″	H″
x	281	–286	–900	10 807	5 438	–12 900	3 707	191	–12 900
y	49	135	205	96	910	3 001	1 108	3 135	3 135
z	0	0	0	300	300	300	300	300	300

Coordinates of points C″″, F″″, H″″ (m):

	C″″	G″″	H″″
x	10 807	2 099	–12 900
y	315	6 424	6 424
z	600	600	600

Note.— OAS contours between parallel runways not drawn.

Figure II-1-1-App D-1. Example of typical PAOAS and OAS contours for standard size aircraft

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Appendix E to Chapter 1

CALCULATION OF OBSTACLE ASSESSMENT SURFACE HEIGHT

Editorial Note.— The table previously contained in Attachment I has been replaced by the PANS-OPS OAS CD-ROM which is enclosed in this document.

The PANS-OPS OAS CD-ROM provides the calculation of the Obstacle Assessment Surfaces (OAS) parameters for specific ILS/MLS/GLS geometry, aircraft dimensions and missed approach climb gradient, and calculates the height of the OAS surface (Z) above a specific location (X, Y) for the selected system and aircraft parameters. The programme prints the parameters and results for any specific set of conditions and also all or any individual pages of the table previously contained in Attachment I to Part III (Doc 8168, Volume II, Amdt. 11).

Chapter 2

OFFSET ILS

2.1 USE OF ILS CAT I WITH OFFSET LOCALIZER ALIGNMENT

2.1.1 In certain cases it may not be physically practicable to align the localizer with the runway centre line because of siting problems, or because airfield construction work demands a temporary offset location. An offset course shall not be established as a noise abatement measure.

2.1.2 The localizer course line shall intersect the runway extended centre line:

a) at an angle not exceeding 5°; and

b) at a point where the nominal glide path reaches a height of at least 55 m (180 ft) above threshold. This is called intercept height.

2.1.3 The procedure shall be annotated: "localizer offset ... degrees" (tenth of degrees). The general arrangement is shown in Figure II-1-2-1.

2.2 OBSTACLE CLEARANCE CRITERIA

The provisions contained in Chapter 1 apply except that:

a) all the obstacle clearance surfaces and calculations are based on a fictitious runway aligned with the localizer course. This fictitious runway has the same length, the same threshold elevation, and the same distance threshold to intercept point as the real one. The localizer course width and the ILS reference datum height are based on the threshold of the fictitious runway; and

b) the OCA/H for this procedure shall be at least: intercept altitude/height + 20 m (66 ft).

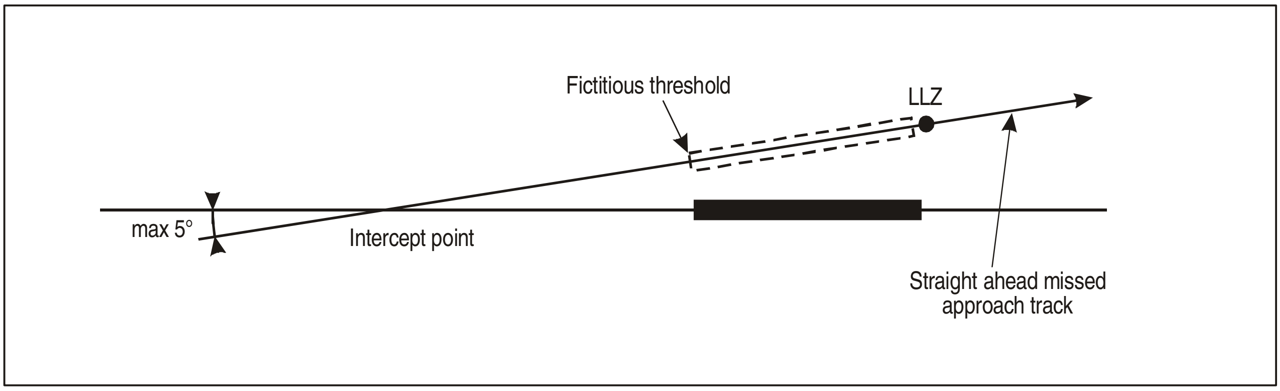


Figure II-1-2-1. Offset localizer

Chapter 3

MLS

3.1 INTRODUCTION

3.1.1 Application

The MLS criteria in this part are based on ILS criteria and are related to the ground and airborne equipment performance and integrity required to meet the Standards and Recommended Practices described in Annex 10. The following criteria apply to MLS Category I, II and III procedures based on the zero-degree azimuth and a glide path (elevation angle) of the MLS ground equipment and are intended for application pending the introduction of specific MLS criteria to be developed on the basis of further operational experience.

3.1.2 Procedure construction

The procedure from en-route to the precision segment of the MLS approach conforms to the general criteria in as Part I, Sections 1, 2 and 4. The differences are found in the MLS precision segment which contains the final approach segment and the initial/intermediate phases of the missed approach segment. The final approach track for the MLS procedure is always specified and promulgated in degrees magnetic. Figure II-1-3-l (for MLS Category I, II and III) shows a typical layout where the final approach track is defined by the MLS zero-degree azimuth and is aligned with the runway extended centre line.

3.1.3 Standard conditions

The following list contains the standard assumptions on which procedures are developed. Provisions are made for adjustments where appropriate. Adjustments are mandatory when conditions differ adversely from standard conditions (see 3.4.8.7, "Adjustment of OAS constants").

a) Maximum aircraft dimensions are assumed to be the following:

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

Note 1.— OCA/H for D_L aircraft is published when necessary.

Note 2.— The dimensions shown are those which encompass current aircraft types. They are chosen to facilitate OCA/H calculations and promulgation of aircraft category related minima. It is assumed that these dimensions are not intended to be used for other purposes than the OCA/H calculations in other ICAO documents. The use of OAS surfaces to calculate OCA/H may result in significant differences between aircraft categories because of small differences in size. For this reason, it is always preferable to use the Collision Risk Model (3.4.9) which will allow for more realistic assessment for both height and position of obstacles.

Note 3.— Current Category E aircraft are not normally civil transport aircraft and their dimensions are not necessarily related to Vat at maximum landing mass. For this reason, they should be treated separately on an individual basis.

b) Category II/III is flown autocoupled (for Category II flown with flight director, see 3.4.8.7.6).

c) Missed approach climb gradient 2.5 per cent.

d) The approach azimuth deviation information is displayed using sensitivity characteristics in accordance with the following table (Annex 10, Volume I, Attachment G to Part I, 7.4.1.1).

Approach azimuth antenna to threshold distance (ATT)	*Nominal course width*
0 – 400 m	± 3.6 degrees
500 – 1 900 m	± 3.0 degrees
2 000 – 4 100 m	$\pm \arctan \frac{(105)}{ATT}$ degrees
4 200 – 6 300 m	± 1.5 degrees

Note.— The displacement sensitivity characteristics given above for the ATT distances from 2 000 m to 4 100 m are based upon a nominal course width of 210 m at the MLS approach reference datum.

e) Glide path (elevation angle):

1) minimum: 2.5°;

2) optimum: 3.0°; and

3) maximum: 3.5° (3° for Cat II/III operations).

Note.— The glide path angle of the procedure must be greater than or equal to the minimum glide path (see Annex 10, Part I, 3.11.1 — Definitions).

f) MLS approach reference datum height 15 m (50 ft).

g) All obstacle heights are referenced to threshold elevation.

h) For Cat II and Cat III operations the Annex 14 inner approach, inner transitional and balked landing surfaces have not been penetrated. Where the Cat II OCA/H is higher than the level of the inner horizontal surface, but below 60 m, the inner approach and balked landing surfaces should be extended to the Cat II OCA/H level to accommodate Cat III operations.

When azimuth antenna to threshold distance is less than 2 000 m, the obstacle assessment surface (OAS) tables for a 2 000 m localizer to threshold are to be used. When using the ILS CRM or the OAS table, the ATT distances and displacement sensitivity characteristics shown in 3.1.3 d) above are to be used.

3.1.4 Obstacle clearance altitude/height (OCA/H)

3.1.4.1 The MLS criteria enable an OCA/H to be calculated for each category of aircraft. See Part I, Section 4, Chapter 1, 1.8, "Categories of aircraft". Where statistical calculations were involved, the OCA/H values were designed against an overall safety target of 1×10^{-7} (1 in 10 million) per approach for risk of collision with obstacles.

3.1.4.2 The OCA/H ensures clearance of obstacles from the start of the final approach to the end of the intermediate missed approach segment.

Note.— This OCA/H is only one *of the factors to be taken into account in determining decision height as defined in Annex 6.*

3.1.4.3 Additional material is included to allow operational benefit to be calculated for the improved missed approach climb performance in Cat I, II and III.

3.1.4.4 Benefit may also be calculated for aircraft with dimensions smaller than the standard size assumed in the basic calculations and adjustments must be made for larger aircraft. An OCA/H is not associated with Cat III operations. These are supported by the obstacle limitation surfaces defined in Annex 14, in association with overlapping protection from the Cat II criteria.

3.1.5 Methods of calculating OCA/H

3.1.5.1 *General.* Three methods of calculating OCA/H are presented, which involve progressive increases in the degree of sophistication in the treatment of obstacles. Standard conditions (as specified in 3.1.3) are assumed to exist unless adjustments for non-standard conditions have been made.

3.1.5.2 *First method.* The first method involves a set of surfaces derived from the Annex 14 precision approach obstacle limitation surfaces and a missed approach surface described in 3.4.7.2, "Definition of basic ILS surfaces". From this point forward, these are termed "basic ILS surfaces". Where the standard conditions exist as specified in 3.1.3 and where the basic ILS surfaces are free of penetrations (see 3.4.7.1), the OCA/H for Cat I and Cat II is defined by aircraft category margins, and there are no restrictions on Cat III operations. If the basic ILS surfaces are penetrated, then the OCA/H is calculated as described in 3.4.7.3, "Determination of OCA/H with basic ILS surfaces".

3.1.5.3 *Second method.* The second method involves a set of obstacle assessment surfaces (OAS) above the basic ILS surfaces (see 3.4.8.3, "Definition of basic ILS surfaces".If the OAS are not penetrated, — and provided the obstacle density below the OAS is operationally acceptable (see 3.4.8.9, "Effect of obstacle density on OCA/H") — the OCA/H for Cat I and Cat II is still defined by the aircraft category margins, and Cat III operations remain unrestricted. However, if the OAS are penetrated, then an aircraft category-related margin is added to the height of the highest approach obstacle, or to the adjusted height of the largest missed approach penetration, whichever is greater. This value becomes the OCA/H.

3.1.5.4 *Third method.* The third method, using the ILS collision risk model (CRM), is employed either as an alternative to the use of the OAS criteria (second method) or when the obstacle density below the OAS is considered to be excessive. The ILS CRM accepts all objects as an input and assesses, for any specific OCA/H value, both the risk due to individual obstacles and the accumulated risk due to all the obstacles. In this way it assists operational judgement in the choice of an OCA/H value which will ensure that the hazard due to obstacles, both individually and collectively, can be contained within the overall safety target.

3.1.6 References

The following appendices relate to and amplify the material contained in this chapter:

a) background information relating to the derivation of the OAS material (Attachment to Part II, paragraph 1) and to airborne and ground equipment performance assumed in the derivation of the OAS (Attachment to Part II, paragraph 2);

b) turning missed approach after precision approach (Appendix A to Chapter 1);

c) independent parallel approaches to closely spaced parallel runways (Appendix D to Chapter 1);

d) determining ILS glide path descents/MLS elevation heights and distances (Appendix C to Chapter 1); and

e) PANS-OPS OAS CD-ROM.

Examples of OCA/H calculation for ILS can be found in *Instrument Flight Procedures Construction Manual* (Doc 9368).

3.1.7 MLS with glide path inoperative

The MLS with glide path inoperative is a non-precision approach procedure. The principles of Section 2, Chapter 2, “Offset MLS”, apply.

3.2 INITIAL APPROACH SEGMENT

3.2.1 General

The initial approach segment for MLS must ensure that the aircraft is positioned within the operational service volume of the azimuth on a track that will facilitate azimuth interception. Consequently, the general criteria applicable to the initial segment (see Part I, Section 4, Chapter 3) are modified in accordance with 3.2.2, “Initial approach segment alignment” and 3.2.3, “Initial approach segment area”, below. For RNAV initial approach segments, the criteria in the applicable RNAV chapters apply.

3.2.2 Initial approach segment alignment

The angle of interception between the initial approach track and the intermediate track should not exceed 90°. In order to permit the autopilot to couple on to the azimuth, an interception angle not exceeding 30° is desirable. When the angle exceeds 70°, a radial, bearing, radar vector, or DME or RNAV information providing at least 4 km (2 NM) of lead shall be identified to assist the turn onto the intermediate track. When the angle exceeds 90°, the use of a reversal, racetrack, or dead reckoning (DR) track procedure should be considered (see Part I, Section 4, Chapter 4, “Initial approach segment” and Part I, Section 4, Appendix A to Chapter 3, “Initial approach using dead reckoning track procedure”).

3.2.3 Initial approach segment area

The area is as described in the general criteria (see Part I, Section 4, Chapter 3, 3.3.3, “Area”). The difference is that the intermediate approach fix (IF) must be located within the service volume of the MLS azimuth signal, and normally at a distance not exceeding 41.7 km (22.5 NM) from the azimuth antenna. When radar is used to provide track guidance to the IF, the area shall be in accordance with 6.2, “Initial approach segment” (Section 2, Chapter 6, “SRE”).

3.3 INTERMEDIATE APPROACH SEGMENT

3.3.1 General

3.3.1.1 The intermediate approach segment for MLS differs from the general criteria in that:

a) the alignment coincides with the MLS azimuth specified for final approach track;

b) the length may be reduced; and

c) in certain cases the secondary areas may be eliminated.

3.3.1.2 The primary and secondary areas at the FAP are defined in terms of the ILS surfaces. Consequently, the general criteria in Part I, Section 4, Chapter 4, “Intermediate approach segment” are applied except as modified or amplified in the paragraphs below with regards to alignment, area length and width, and for obstacle clearance. For RNAV initial approach segments, the criteria in the applicable RNAV chapters apply.

3.3.2 Intermediate approach segment alignment

The intermediate approach segment of an MLS procedure shall be aligned with the MLS azimuth specified for the final approach track.

3.3.3 Intermediate approach segment length

3.3.3.1 The optimum length of the intermediate approach segment is 9 km (5 NM). This segment shall allow interception with the final approach track and with the glide path (MLS elevation angle).

3.3.3.2 Segment length should be sufficient to permit the aircraft to stabilize and establish its course on the final approach track prior to intercepting the glide path (MLS elevation angle), taking into consideration the angle of interception of the final approach track.

3.3.3.3 Minimum values for distance between interception of final approach track and interception of glide path are specified in Table II-1-3-1; however, these minimum values should only be used if usable airspace is restricted. The maximum length of the segment is governed by the requirement that it be located wholly within the operational coverage region of the approach azimuth, and normally at a distance not exceeding 37 km (20 NM) from the runway threshold.

3.3.4 Intermediate approach segment area width

3.3.4.1 The total width at the beginning of the intermediate approach segment is defined by the final total width of the initial approach segment. It tapers uniformly to match the horizontal distance between the OAS X surfaces at the FAP (see 3.4.8.3, “Definition of obstacle assessment surfaces (OAS)”).

3.3.4.2 For obstacle clearance purposes the intermediate approach segment is usually divided into a primary area bounded on each side by a secondary area. However, when a DR track is used in the initial approach segment, the primary area of the intermediate approach segment extends across its full width and secondary areas are not applied.

3.3.4.3 The primary area is determined by joining the primary initial approach area with the final approach surfaces (at the FAP). At the interface with the initial approach segment the width of each secondary area equals half the width of the primary area. The secondary area width decreases to zero at the interface with the final approach surfaces. See Figures II-1-3-2, II-1-3-3 and II-1-3-4.

3.3.4.4 Where a racetrack or reversal manoeuvre is specified prior to intercepting the final approach track, the provisions in 5.7.4, "Turn not at the facility" apply, the facility being the MLS azimuth itself and the FAF being replaced by the FAP (see Figure II-1-3-5).

3.3.5 Intermediate approach segment obstacle clearance

The obstacle clearance is the same as defined in Part I, Section 4, Chapter 4, "Intermediate approach segment" except where the procedure permits a straight-in approach in which the aircraft is stabilized on the final approach track prior to crossing the IF. In this case, obstacles in the secondary areas need not be considered for the purpose of obstacle clearance.

3.4 PRECISION SEGMENT

3.4.1 General

The precision segment for MLS is aligned with the specified MLS azimuth and contains the final descent for landing as well as the initial and intermediate phases of the missed approach segment. Criteria are generally the same as for ILS, except as amended below. See Figure II-1-3-6.

3.4.2 Origin

The precision segment starts at the final approach point (FAP), that is, the intersection of the glide path (elevation angle) and the minimum altitude specified for the preceding segment. The FAP should not normally be located more than 18.5 km (10.0 NM) before threshold. This distance may be extended for operational requirements provided that:

a) adequate guidance is available; and

b) obstacle clearance requirements are not compromised (extension of the W and X surfaces of the OAS).

3.4.3 Descent fix

3.4.3.1 A descent fix may be located at the FAP to overcome certain obstacles located before the FAP as an alternative to increasing the glide path (GP) angle. When so located, it becomes the final approach fix, linking the MOC in the preceding segment smoothly with the precision surfaces. The descent fix should not normally be located more than 18.5 km (10.0 NM) before threshold, unless adequate glide path guidance beyond the minimum specified in Annex 10 is provided. The maximum fix tolerance is ± 0.9 km (± 0.5 NM). The range shall be stated in tenths of kilometres (nautical miles).

Note.— Guidance material for determining the distance to the descent fix from the threshold is contained in Chapter 1, Appendix C.

3.4.3.2 *Obstacle clearance at the descent fix.* When a descent fix is provided , the precision approach surfaces start at the earliest point of the FAF tolerance area (see Figure II-1-3-3). The provisions of Part I, Section 2, Chapter 2, 2.7.4, "Obstacle close to a final approach fix or stepdown fix" which allow obstacles close to the fix to be ignored, apply in the area below the 15 per cent gradient within the precision surfaces (Cat H, 15 per cent gradient or the nominal gradient multiplied by 2.5, whichever is greater). Where a descent fix is not provided at the FAP, no curtailment of the precision surfaces is permitted (see Figure II-1-3-4). If the precision surfaces are extended into the preceding segment, they shall not be extended beyond the intermediate approach segment.

3.4.4 Glide path verification check

A DME fix is necessary so as to permit comparison between the indicated glide path (elevation angle) and the aircraft altimeter information. The fix shall not have a fix tolerance exceeding ± 0.9 km (± 0.5 NM). The range shall be stated in tenths of kilometres (nautical miles).

Note.— Guidance material for determining the height crossing the DME fix is contained in Chapter 1, Appendix C.

3.4.5 Missed approach

The missed approach point is defined by the intersection of the nominal glide path and the decision altitude/height (DA/H). The DA/H is set at or above the OCA/H, which is determined as specified in 3.4.7 to 3.4.9 and 3.5.

3.4.6 Termination

The precision segment normally terminates at the point where the final phase of the missed approach commences (see Part I, Section 4, Chapter 6, 6.1.2, "Phases of missed approach segment") or where the missed approach climb surface Z (starting 900 m past threshold) reaches a height of 300 m (984 ft) above threshold, whichever is lower.

3.4.7 Obstacle clearance in the precision segment application of basic ILS surfaces

3.4.7.1 *General.* The area required for the precision segment is bounded overall by the basic ILS surfaces defined in 3.4.7.2, below. In standard conditions there is no restriction on objects beneath these surfaces (see 3.1.3, "Standard conditions"). Objects or portions of objects that extend above these surfaces must be either:

a) minimum mass and frangible; or

b) taken into account in the calculation of the OCA/H.

3.4.7.2 *Definition of basic ILS surfaces.* The surfaces to be considered correspond to a subset of Annex 14 obstacle limitation surfaces as specified for precision approach runway code numbers 3 or 4 (see Figure II-1-3-7). These are:

a) the approach surface, continuing to the final approach point (FAP) (first section 2 per cent gradient, second section 2.5 per cent as described in Annex 14);

b) the runway strip assumed to be horizontal at the elevation of the threshold;

c) the missed approach surface. This is a sloping surface which:

   1) starts at a point 900 m past threshold at threshold elevation;

   2) rises at a 2.5 per cent gradient; and

   3) splays so as to extend between the transitional surfaces.

   It extends with constant splay to the level of the inner horizontal surface. Thereafter, it continues at the same gradient but with a 25 per cent splay until the termination of the precision segment; and

d) the extended transitional surfaces, which continue longitudinally along the sides of the approach and missed approach surfaces and up to a height of 300 m above threshold elevation.

3.4.7.3 *Determination of OCA/H with basic ILS surfaces*

3.4.7.3.1 Where the basic ILS surfaces specified in 3.4.7.2 are not penetrated, the OCA/H for Category I and Category II is defined by the margins specified in Table II-1-3-2, and Category III operations are not restricted. Obstacles may be excluded when they are below the transitional surface defined by Annex 14 for runways with code numbers 3 and 4, regardless of the actual runway code number (i.e., the surfaces for code numbers 3 and 4 are used for the obstacle assessment on runways with code numbers 1 and 2).

3.4.7.3.2 If the basic ILS surfaces listed above are penetrated by objects other than those listed in Table II-1-3-3 the OCA/H may be calculated directly by applying height loss/altimeter margins to obstacles (see 3.4.8.8.2, "Calculation of OCA/H values with OAS").

3.4.7.3.3 The obstacles in Table II-1-3-3 may only be exempted if the following two criteria are met:

a) the nominal course has the standard width of 210 m (see 3.1.3, "Standard conditions"); and

b) the MLS Category I decision height is not less than 60 m (200 ft) or the MLS Category II decision height is not less than 30 m (100 ft).

3.4.7.3.4 An object which penetrates any of the basic ILS surfaces and becomes the controlling obstacle, but which must be maintained because of its function with regards to air navigation requirements, may be ignored under certain circumstances in calculating the OCA/H with the following provision. It must be established by the appropriate authority that the portion which penetrates the surface is of minimum mass and frangibly mounted and would not adversely affect the safety of aircraft operations.

3.4.8 Obstacle clearance in the precision segment using obstacle assessment surface (OAS) criteria

3.4.8.1 *General*

3.4.8.1.1 This section describes the OAS surfaces, the constants which are used to define these surfaces, and the conditions under which adjustments may or must be made. The OAS dimensions are related to:

a) the MLS geometry (azimuth antenna-threshold distance, MLS RDH, azimuth antenna sector width), glide path (elevation angle);

b) the category of MLS operation; and

c) other factors, including aircraft geometry, missed approach climb gradient.

Thus, a table of OCA/H values for each aircraft category may be calculated for Cat I and II MLS operations at the particular airfield.

3.4.8.1.2 Additional material is included to enable appropriate authorities to assess realistic benefits for claims of improved performance and associated conditions. See 3.4.8.7, "Adjustment of OAS constants".

3.4.8.1.3 Note that the OAS are not intended to replace Annex 14 surfaces as planning surfaces for unrestricted obstacle growth. The obstacle density between the basic ILS surfaces and the OAS must be accounted for (see 3.4.8.9, "Effect of obstacle density on OCA/H").

3.4.8.2 *Frame of reference*

Positions of obstacles are related to a conventional x, y, z coordinate system with its origin at threshold. See Figure II-1-3-11. The x axis is parallel to the precision segment track: positive x is distance before threshold and negative x is distance after threshold. The y axis is at right angles to the x axis. Although shown conventionally in Figure II-1-3-11, *in all calculations associated with OAS geometry, the y coordinate is always counted as positive.* The z axis is vertical, heights above threshold being positive. All dimensions connected with the OAS are specified in metres only. The dimensions should include any adjustments necessary to cater for tolerances in survey data (see Part I, Section 2, Chapter 1, 1.8, "Charting accuracy").

3.4.8.3 *Definition of obstacle assessment surfaces (OAS)*

3.4.8.3.1 The OAS consist of six sloping plane surfaces (denoted by letters W, X, Y and Z) arranged symmetrically about the precision segment track, together with the horizontal plane which contains the threshold (see Figures II-1-3-9 and II-1-3-10). The geometry of the sloping surfaces is defined by four linear equations of the form $z = Ax + By + C$. In these equations x and y are position coordinates and z is the height of the surface at that position (see Figure II-1-3-8).

3.4.8.3.2 For each surface a set of constants (A, B and C) are obtained from the PANS-OPS OAS CD-ROM for operational range of localizer threshold distances and glide path angles. Separate sets of constants are provided for Category I and II. These constants may be modified by the programme as specified (see 3.4.8.7, "Adjustment of OAS constants"

3.4.8.3.3 The Category I OAS are limited by the length of the precision segment and, except for the W and X surfaces, by a maximum height of 300 m. The Category II OAS are limited by a maximum height of 150 m.

3.4.8.3.4 Where the Annex 14 approach and transitional obstacle limitation surfaces for code number 3 and 4 precision approach runways penetrate the OAS, the Annex 14 surfaces become the OAS (i.e. the surfaces for code numbers 3 and 4 are used for obstacle assessment on runways with code numbers 1 and 2).

3.4.8.3.5 The Annex 14 inner approach, inner transitional and balked landing obstacle limitation surfaces protect Category III operations, provided the Category II OCA/H is at or below the top of those surfaces, which may be extended up to 60 m if necessary (see Figure II-1-3-7).

3.4.8.4 *OAS constants — specification*

For Category I and II operations the constants A, B and C for each sloping surface are obtained from the PANS-OPS OAS CD-ROM with the constraint that the Category II flight director constants shall be used for MLS Category II autocoupled operations. The PANS-OPS OAS CD-ROM gives coefficients for glidepath angles between 2.5° and 3.5° in 0.1° steps, and for any azimuth-threshold distance between 2 000 m and 4 500 m. Extrapolation outside these limits is not permitted. If an azimuth-threshold distance outside this range is entered, the PANS-OPS OAS CD-ROM gives the coefficients for 2 000 m or 4 500 m as appropriate, which must be used. For an example of the PANS-OPS OAS CD-ROM results, see Figure II-1-3-13.

3.4.8.5 *Calculation of OAS heights*

To calculate the height z of any of the sloping surfaces at a location x', y', the appropriate constants should be first obtained from the PANS-OPS OAS CD-ROM. These values are then substituted in the equation z = Ax' + By' + C. If it is not clear which of the OAS surfaces is above the obstacle location, this should be repeated for the other sloping surfaces. The OAS height is the highest of the plane heights (zero if all the plane heights are negative).

Note.— The PANS-OPS OAS CD-ROM also contains an OCH calculator that will show the height of the OAS surface z above any x, y location. It includes all the adjustments specified for MLS geometry, aircraft dimensions, missed approach climb gradient and MLS approach reference datum height.

3.4.8.6 *OAS template construction*

Templates, or plan views of the OAS contours to map scale, are sometimes used to help identify obstacles for detail survey (see Figure II-1-3-12). The OAS data in the PANS-OPS CD-ROM includes the coordinates of the points of intersection:

a) of the sloping surfaces at threshold level. The intersection coordinates are labeled as C, D and E (Figure II-1-3-12);

b) at 300 m above threshold level for Cat I; and

c) at 150 m for Cat II.

3.4.8.7 *Adjustment of OAS constants*

3.4.8.7.1 *General.* The following paragraphs describe the adjustments that the PANS-OPS OAS CD-ROM makes to the OAS constants. These adjustments are mandatory when the standard conditions are not met (see 3.1.3, "Standard conditions"). Optional adjustments may be made when so specified. For examples of calculations see the *Instrument Flight Procedures Construction Manual* (Doc 9368).

3.4.8.7.2 *Reasons for adjusting constants.* The constants may be modified to account for the following:

a) dimensions of specific aircraft (see 3.4.8.7.3, below);

b) the height of the MLS approach reference datum above the nominal value (see 3.4.8.7.4, below);

c) Category I azimuths having a sector width greater than 210 m at threshold (see 3.4.8.7.5, below);

d) use of flight director (manually flown) in Cat II (see 3.4.8.7.6, below); and

e) missed approach climb gradient (see 3.4.8.7.7, below).

3.4.8.7.3 *Specific aircraft dimensions.* An adjustment is mandatory where aircraft dimensions exceed those specified in 3.1.3, “Standard Conditions” and is optional for aircraft with smaller dimensions. The PANS-OPS OAS CD-ROM adjust the OAS coefficients and template coordinates for the standard dimensions of Category A, B, C, D and D_L aircraft automatically. It will do the same for specific aircraft dimensions in any category. It uses the following correction formula to adjust the coefficient C for the W, X and Y surfaces:

W surface: $C_w corr = C_w - (t - 6)$

X surface: $C_x corr = C_x - B_x \, . \, P$

Y surface: $C_y corr = C_y - B_y \, . \, P$

where:

$$P = \left[\frac{t}{B_x} \text{ or } S + \frac{t-3}{B_x} \text{, whichever is the maximum} \right] - \left[\frac{6}{B_x} \text{ or } 30 + \frac{3}{B_x} \text{, whichever is the maximum} \right]$$

and: s = semi-span

t = vertical distance between paths of the GP antenna and the lowest part of the wheels.

3.4.8.7.4 *Height of the MLS approach reference datum.* The constants are based on an MLS approach reference datum height (RDH) of 15 m. An adjustment to the OAS constants is mandatory for an RDH less than 15 m, and is optional for an RDH greater than 15 m. The PANS-OPS OAS CD-ROM adjusts the OAS coefficients and template coordinates by correcting the tabulated values of the coefficient C for the W, X and Y surfaces as follows:

$$C_{corr} = C + (RDH - 15)$$

where: C_{corr} = corrected value of coefficient C for the appropriate surface

C = tabulated value.

3.4.8.7.5 *Modification for Cat I azimuths with nominal course width greater than 210 m at threshold.* Where the MLS azimuth sector width at threshold is greater than the nominal value of 210 m, the ILS collision risk model (CRM) method described in 3.4.9 shall be used. Adjustments for sector widths less than 210 m shall not be made and are inhibited in the PANS-OPS OAS CD-ROM.

3.4.8.7.6 *Use of flight director (manually flown) in Cat II.* The Cat I OAS shall be used.

3.4.8.7.7 *Missed approach gradient.* If equipment is capable of missed approach climb gradients better than the nominal 2.5 per cent, the Y and Z surfaces may be adjusted. This adjustment is achieved by selecting the desired missed approach climb gradient in the PANS-OPS OAS CD-ROM. The programme then adjusts the Y and Z surface coefficients.

3.4.8.8 *Determination of OCA/H with OAS or basic ILS surfaces*

3.4.8.8.1 *General.* The OCA/H is determined by accounting for all obstacles which penetrate the basic ILS surfaces defined in 3.4.7.2 and the OAS surfaces applicable to the ILS category of operation being considered. The exemptions listed in 3.4.7.3, “Determination of OCA/H with basic ILS surfaces” for obstacles penetrating the basic ILS surfaces may be applied to obstacles penetrating the OAS, providing the criteria listed in that paragraph are met. The surfaces which apply to each MLS category of operations are:

a) *MLS Cat I:* ILS Cat I OAS;

b) *MLS Cat II flight director:* ILS Cat I OAS;

c) *MLS Cat II autocoupled:* ILS Cat II OAS, using flight director and those portions of ILS Cat I which lie above the limits of ILS Cat II; and

d) *MLS Cat III autocoupled:* Same as MLS Cat II autocoupled.

3.4.8.8.2 *Calculation of OCA/H values with OAS.* Accountable obstacles, as determined below in 3.4.8.8.2.1, "OCA/H calculation steps" are divided into approach and missed approach obstacles. The standard method of categorization is as follows: Approach obstacles are those between the FAP and 900 m after threshold. Missed approach obstacles are those in the remainder of the precision segment (see Figure II-1-3-14). However, in some cases this categorization of obstacles may produce an excessive penalty for certain missed approach obstacles (see Attachment to Part II, 1.9). Where desired by the appropriate authority, missed approach obstacles may be defined as those above a plane surface parallel to the plane of the glide path (elevation angle) and with origin at –900 m (see Figure II-1-3-15), i.e. obstacle height greater than $[(900 + x) \tan \theta]$.

3.4.8.8.2.1 *OCA/H calculation steps*

a) Determine the height of the highest approach obstacle.

b) Convert the heights of all missed approach obstacles (h_{ma}) to the heights of equivalent approach obstacles (h_a) by the formula given below, and determine the highest equivalent approach obstacle.

c) Determine which of the obstacles identified in steps a) and b) is the highest. This is the controlling obstacle.

d) Add the appropriate aircraft category related margin (Table II-1-3-2) to the height of the controlling obstacle.

$$h_a = \frac{h_{ma} \cot Z + (x_z + x)}{\cot Z + \cot \theta}$$

where:

where:	h_a	=	height of equivalent approach obstacle
	h_{ma}	=	height of missed approach obstacle
	θ	=	angle of glide path (elevation angle)
	Z	=	angle of missed approach surface
	x	=	range of obstacle relative to threshold (negative after threshold)
	x_z	=	distance from threshold to origin of Z surface (900 m (700 m Cat H))

3.4.8.8.3 *Adjustment for high airfield elevations and steep glide path angles*

3.4.8.8.3.1 *Height loss (HL)/altimeter margins.* The margins in Table II-1-3-2 shall be adjusted as follows:

a) for airfield elevation higher than 900 m (2 953 ft), the tabulated allowances shall be increased by 2 per cent of the radio altimeter margin per 300 m (984 ft) airfield elevation; and

b) for glide path (elevation angles) greater than 3.2° in exceptional cases, the allowances shall be increased by 5 per cent of the radio altimeter margin per 0.1° increase in glide path (elevation angle) between 3.2° and 3.5°.

3.4.8.8.3.1.1 Procedures involving glide paths greater than 3.5° or any angle when the nominal rate of descent (V_{at} for the aircraft type × the sine of the glide path angle) exceeds 5 m/sec (1 000 ft/min), are non-standard. They require the following:

a) increase of height loss margin (which may be aircraft type specific);

b) adjustment of the origin of the missed approach surface;

c) adjustment of the slope of the W surface;

d) re-survey of obstacles; and

e) the application of related operational constraints.

Such procedures are normally restricted to specifically approved operators and aircraft, and are associated with appropriate aircraft and crew restrictions. They are not to be used as a means to introduce noise abatement procedures.

3.4.8.8.3.1.2 Appendix B to Chapter 1 shows the procedure design changes required and the related operational/certification considerations.

Example: Aircraft Category C — Aerodrome elevation: 1 650 m above MSL; glide path angle 3.5°.

Tabulated allowances: radio altimeter 22 m

(Table II-1-3-2) pressure altimeter 46 m

Correction for aerodrome elevation:

$$22 \times \frac{2}{100} \times \frac{1\,650}{300} = 2.42 \text{ m}$$

Correction for glide path angle:

$$22 \times \frac{5}{100} \times \frac{3.5 - 3.2}{0.1} = 3.30 \text{ m}$$

Total correction 5.72 m rounded up to 6 m.

Corrected radio altimeter margin 22 + 6 = 28 m.

Corrected pressure altimeter margin 46 + 6 = 52 m.

3.4.8.8.3.2 *Exceptions and adjustments to values in Table II-1-3-2.* Values in Table II-1-3-2 are calculated to account for a aircraft using normal manual overshoot procedures from OCA/H on the nominal approach path. The values in Table II-1-3-2 do not apply to Cat III operations. The values do not consider the lateral displacement of an obstacle nor the probability of an aircraft being so displaced. If consideration of these joint probabilities is required, then the ILS CRM discussed in 3.4.9 shall be used. Values in Table II-1-3-2 may be adjusted for specific aircraft types where adequate flight and theoretical evidence is available, i.e. the height loss value corresponding to a probability of 1×10^{-5} (based on a missed approach rate of 10^{-2}).

3.4.8.8.3.3 *Radio altimeter verification.* If the radio altimeter OCA/H is promulgated, operational checks shall have confirmed the repeatability of radio altimeter information.

3.4.8.8.3.4 *Height loss (HL)/altimeter margins for a specific speed at threshold.* If a height loss/altimeter margin is required for a specific V_{at}, the following formulae apply (see also Table II-1-3-4):

Use of radio altimeter:

Margin = $(0.096\ V_{at} - 3.2)$ metres where V_{at} in km/h

Margin = $(0.177\ V_{at} - 3.2)$ metres where V_{at} in kt

Use of pressure altimeter:

Margin = $(0.068\ V_{at} + 28.3)$ metres where V_{at} in km/h

Margin = $(0.125\ V_{at} + 28.3)$ metres where V_{at} in kt

where V_{at} is the speed at threshold based on 1.3 times stall speed in the landing configuration at maximum certificated landing mass.

Note.— The equations assume the aerodynamic and dynamic characteristics of the aircraft are directly related to the speed category. Thus, the calculated height loss/altimeter margins may not realistically represent small aircraft with V_{at} at maximum landing mass exceeding 165 kt.

3.4.8.9 *Effect of obstacle density on OCA/H.* To assess the acceptability of obstacle density below the OAS, the ILS CRM described in 3.4.9 may be used. This can provide assistance by comparing aerodrome environments and by assessing risk levels associated with given OCA/H values. It is emphasized that it is not a substitute for operational judgement.

3.4.9 Obstacle clearance in the precision segment — application of the ILS collision risk model (CRM) to MLS operations

3.4.9.1 *General.* The ILS CRM is a computer program that establishes the numerical risk which can be compared to the target level of safety for aircraft operating to a specified OCA/H height. A description of the programme and instructions on its use, including the precise format of both the data required as input and the output results, are given in the *Manual on the Use of the Collision Risk Model (CRM) for ILS Operations* (Doc 9274).

3.4.9.2 *Input.* When applied to MLS operations, the ILS CRM requires the following data as input:

a) *aerodrome details*: name, runway threshold position and runway orientation in map grid coordinates (optional), threshold elevation above MSL;

b) *MLS parameters*: category (the appropriate ILS category as defined in 3.4.8.8.1), glide path (elevation angle), azimuth-threshold distance, azimuth nominal course width, height of MLS reference datum above threshold;

c) *missed approach parameters*: decision height (obstacle clearance height) and missed approach turn point;

d) *aircraft parameters*: type, wheel height (antenna to bottom of wheel), and wing semi-span, aircraft category (A, B, C, D or D_L) missed approach climb gradient; and

Note.— The CRM does not consider Category E aircraft.

e) *obstacle data*: obstacle boundaries (either as x and y coordinates relative to the runway threshold or as map grid coordinates) and obstacle height (either above threshold elevation or above MSL). For density assessment, all obstacles penetrating the basic ILS surfaces described in 3.4.7.2 must be included.

3.4.9.3 *Output and application.* The output of the programme is:

a) the overall (total) risk of collision with obstacles for aircraft operating to a specified OCA/H; and

b) the minimum OCA/H which will provide the target level of safety.

These options are detailed in Doc 9274, *Manual on the Use of the Collision Risk Model (CRM) for ILS Operations.* The user, by rerunning the ILS CRM with the appropriate parameters, can assess the effect on the safety of operations of any alteration in the parameters, typically varying the glide path, elevation angle or remaining obstacles.

3.5 MISSED APPROACH SEGMENT

3.5.1 General

3.5.1.1 The criteria for the final missed approach are based on those for the general criteria (see Part I, Section 4, Chapter 6). Certain modifications have been made to allow for the different areas and surfaces associated with the MLS precision segment and for the possible variation in OCA/H for that segment with aircraft category. Area construction is according to the navigation system specified for the missed approach.

3.5.1.2 The datum used for calculation of distances and gradients in obstacle clearance calculations is termed "start of climb" (SOC). It is defined by the height and range at which the plane GP' — a plane parallel with the glide path (elevation angle) and with origin at –900 m at threshold level — reaches an altitude OCA/H – HL (OCA/H and HL must both relate to the same category of aircraft).

3.5.1.3 Where obstacles identified in the final missed approach segment result in an increase in any of the OCA/H calculated for the precision segment, a higher gradient of the missed approach surface (Z) may be specified in addition if this will provide clearance over those obstacles at a specified lower OCA/H (see Part I, Section 4, Chapter 6, 6.2.2.1, "Climb gradient in the intermediate phase").

3.5.2 Straight missed approach

3.5.2.1 *General.* The precision segment terminates at the point where the Z surface reaches a height 300 m above threshold. The width of the Z surface at that distance defines the initial width of the final missed approach area which splays at an angle of 15 degrees from that point, as shown in Figure II-1-3-16. There are no secondary areas.

3.5.2.2 *Straight missed approach obstacle clearance.* (See Figure II-1-3-17.) Obstacle elevation/height in this final missed approach area shall be less than

$$(OCA/H_{ps} - HL) + d_o \tan Z$$

where:

a) OCA/H of the precision segment (OCA/H_{ps}) and HL (Table II-1-3-2 value) both relate to the same aircraft category;

b) d_o is measured from SOC parallel to the straight missed approach track; and

c) Z is the angle of the missed approach surface with the horizontal plane.

If this requirement cannot be met, a turn shall be prescribed to avoid the obstacle in question. If a turn is not practical, the OCA/H shall be raised.

3.5.3 Turning missed approach

3.5.3.1 *General.* Turns may be prescribed at a designated turning point (TP), at a designated altitude/height, or "as soon as practicable". The criteria used depend on the location of the turn relative to the normal termination of the precision segment (see 3.4.6, "Termination") and are as follows:

a) *turn after normal termination of the precision segment*. If a turn is prescribed after normal termination of the precision segment, the general criteria of Part I, Section 4, Chapter 6, 6.4.5, "Turn initiated at a designated altitude/height" and Part I, Section 4, Chapter 6, 6.4.6, "Turn initiated at a designated turning point (TP)" apply with the following exceptions:

   1) OCA/H is replaced by (OCA/H – HL) as in 3.5.2.2, "Straight missed approach obstacle clearance"; and

   2) because SOC is related to OCA/H, it is not possible to obtain obstacle clearance by the means used in non-precision approaches (that is, by independent adjustment of OCA/H or MAPt); and

b) *turn before normal termination of the precision segment*. If a turn is prescribed at a designated altitude/height which is less than 300 m above threshold, or at a designated TP such that the earliest TP is within the normal termination range, the criteria specified in 3.5.3.2 and 3.5.3.3 below shall be applied.

Note.— Adjustments to designated TP location or to the designated turn altitude may involve redrawing the associated areas and recalculating the clearances. This can exclude some obstacles or introduce new ones. Thus, when it is necessary to obtain the minimum value of OCA/H – particularly when constraints due to obstacles are very high — it may be necessary to adjust the designated TP or turn altitude by trial and error. (See Section 1, Appendix A to Chapter 1).

3.5.3.2 *Turn at a designated altitude/height less than 300 m above threshold*

3.5.3.2.1 The general criteria apply (see Part I, Section 4, Chapter 6, 6.4.5, "Turn initiated at a designated altitude/height") as amplified and modified by the contents of this section. Construction of the turn initiation area and the subsequent turn are illustrated in Figure II-1-3-18.

3.5.3.2.2 *Turn altitude/height.* The general criteria apply, modified as follows. The precision segment terminates (and the final missed approach segment begins) at the TP. This allows the calculation of OCA/H_{ps} and (OCA/H_{ps} – HL). SOC is then determined, and turn altitude/height (TNA/H) is computed from the following relationship:

$$TNA/H = OCA/H_{ps} - HL + d_z \tan Z$$

where: d_z is the horizontal distance from SOC to the TP; and

OCA/H_{ps} = OCA/H calculated for the precision segment.

If the TP is located at the SOC, the chart shall be annotated "turn as soon as practicable to ... (heading or facility)" and shall include sufficient information to identify the position and height of the obstacles dictating the turn requirement.

3.5.3.2.3 *Areas*

3.5.3.2.3.1 *Turn initiation area* (See Figure II-1-3-18). The turn initiation area is bounded by the 300 m Category I Y surface contour, and terminates at the TP.

Note.— The earliest TP is considered to be at the beginning of the 300 m Category I Y surface contour (point D") unless a fix is specified to limit early turns (see 3.5.3.2.4.2), "Safeguarding of early turns"*).*

3.5.3.2.3.2 *Turn boundary construction.* Turn boundaries are constructed as specified in Part I, Section 2, Chapter 3, "Turn area construction"

3.5.3.2.4 *Obstacle clearance*

a) *Obstacle clearance in the turn initiation area.* Obstacle elevation/height in the turn initiation area shall be less than:

   1) turn altitude/height – 50 m (164 ft) for turns more than 15°; and

   2) turn altitude/height – 30 m (98 ft) for turns 15° or less,

   except that obstacles located under the Y surface on the outer side of the turn need not be considered when calculating turn altitude/height.

b) *Obstacle clearance in the turn area.* Obstacle elevation/height in the turn area and subsequently shall be less than:

   turn altitude/height + d_o tan Z – MOC

   where d_o is measured from the obstacle to the nearest point on the turn initiation area boundary and MOC is:

   1) 50 m (164 ft) for turns more than 15°; and

   2) 30 m (98 ft) for turns 15° or less,

   reducing linearly to zero at the outer edge of the secondary areas, if any.

3.5.3.2.4.1 *Turn altitude/height adjustments.* If the criteria specified in 3.5.3.2.4, "Obstacle clearance", above cannot be met, the turn altitude/height shall be adjusted. This can be done in two ways:

a) *adjust turn altitude/height without changing OCA/H:* this means that the TP will be moved and the areas redrawn accordingly; and

b) *raise turn altitude/height by increasing OCA/H:* this results in a higher turn altitude over the same TP. The turn areas remain unchanged.

3.5.3.2.4.2 *Safeguarding of early turns.* Where the published procedure does not specify a fix to limit turns for aircraft executing a missed approach from above the designated turn altitude/height, an additional check of obstacles shall be made The general criteria of Part I, Section 4, Chapter 6, 6.4.5.6, "Safeguarding of early turns" and general principles of Part I, Section 4, Chapter 6, Figure I-4-6-14 apply with the following modifications:

a) the limit of the final approach area is replaced by the line DD" of the OAS surfaces and its extension;

b) the FAF is replaced by the FAP;

c) the earliest MAPt is replaced by the line D”D” (earliest limit of the turn initiation area); and

d) if the criterion cannot be met, then the procedure must prohibit turns before a point equivalent to the MAPt and a note must be added on the profile view of the approach chart.

3.5.3.3 *Turn at a designated TP with earliest TP before normal termination of precision segment*

3.5.3.3.1 Where a turn is specified at a designated TP, and the earliest TP is before the normal termination range of the precision segment, the precision segment terminates at the earliest TP. This allows the calculation of OCA/H_{ps} and (OCA/H_{ps} – HL); SOC is then determined.

3.5.3.3.2 *Turn area.* The turn area is constructed as specified in Part I, Section 4, Chapter 6, 6.4.6.3, “Construction of the turn area” except that it is based on the width of the 300 m OAS Y surface contours at the earliest and latest TP (see Figure II-1-3-19).

3.5.3.3.3 *Obstacle clearance.* Obstacle elevation/height shall be less than:

$$(OCA/H_{ps} - HL) + d_o \tan Z - MOC$$

where:

d_o = d_z + shortest distance from obstacle to line K-K,

d_z = horizontal distance from SOC to the earliest TP,

and MOC is:

50 m (164 ft) for turns more than 15° and

30 m (98 ft) for turns 15° or less.

If the obstacle elevation/height exceeds this value, the OCA/H must be increased, or the TP moved to obtain the required clearance (see Appendix A to Chapter 1).

3.6 SIMULTANEOUS PRECISION APPROACHES TO PARALLEL OR NEAR-PARALLEL INSTRUMENT RUNWAYS

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

3.6.1 General

When it is intended to use precision approach procedures to parallel runways simultaneously, the following additional criteria shall be applied in the design of both procedures:

a) the maximum intercept angle with the final approach course is 30°. The point of intercepting final approach course should be located at least 3.7 km (2.0 NM) prior to the point of intercepting the glide path;

b) the minimum altitudes of the intermediate approach segments of the two procedures differ by at least 300 m (1 000 ft); and

c) the nominal tracks of the two missed approach procedures diverge by at least 30°. Associated missed approach turns shall be specified as "as soon as practicable".

3.6.2 Obstacle clearance

The obstacle clearance criteria for precision approaches, as specified in the designated chapters apply for each of the parallel precision procedures. In addition to these criteria, a check of obstacles shall be made in the area on the far side of the parallel runway in order to safeguard early turns required to avoid potential intruding aircraft from the adjacent runway. This check can be made using a set of separately defined parallel approach obstacle assessment surfaces (PAOAS). An example of a method to assess obstacles for these procedures is included in Appendix D to Chapter 1.

3.7 PROMULGATION

3.7.1 General

3.7.1.1 The general criteria in Part I, Section 2, Chapter 1, 1.9, "Promulgation" apply. The instrument approach chart for an MLS approach procedure shall be identified by the title MLS Rwy XX. If Category II and/or III minima are included on the chart, the title shall read MLS Rwy XX CAT II or MLS Rwy XX CAT II & III, as appropriate. If more than one MLS approach is published for the same runway, the Duplicate Procedure Title convention shall be applied, with the approach having the lowest minima being identified as MLS Z Rwy XX.

3.7.1.2 If more than one MLS approach is published for the same runway and some segments of the two approaches are not equal, the Duplicate Procedure Title convention shall be applied. As an example, when considering two MLS approaches to the same runway that have different missed approach procedures, the Duplicate Procedure Title convention shall be applied. When two different approaches to the same runway are published, the approach having the lowest minima should be identified as MLS Z Rwy XX.

3.7.1.3 When a final approach fix is identified at the FAP, a warning shall be appended to the procedure stating that descent on the glidepath below the FAF altitude is not permitted until passing the FAF.

3.7.2 Promulgation of OCA/H values

3.7.2.1 *Promulgation of OCA/H for MLS Cat I and II approach procedures*

3.7.2.1.1 The OCA or OCH values, as appropriate, shall be promulgated for those categories of aircraft for which the procedure is designed. The values shall be based on the following standard conditions:

a) Cat I flown with pressure altimeter;

b) Cat II flown autocoupled with radio altimeter;

c) Cat II flown with radio altimeter and flight director;

d) standard aircraft dimensions (see 3.1.3, "Standard conditions"); and

e) 2.5 per cent missed approach climb gradient.

3.7.2.1.2 Additional values of OCA/H may be agreed upon between operators and the appropriate authority and promulgated, on the basis of evidence supporting the modifications defined in 3.4.8.7, "Adjustment of OAS constants".

3.7.2.1.3 Use of OCA/H values for MLS Category I approach procedures based on radio altimeter height loss margins may be agreed upon between operators and the appropriate authority, and the values promulgated, if the requirement of 3.4.8.8.3.3, "Radio altimeter verification" is met.

3.7.2.2 *Promulgation of MLS Category III approach procedures*

Category III operations may be permitted subject to the appropriate Category II OCA/H being below the height of the Annex 14 inner horizontal surface. Category III operations may also be permitted with a Category II OCA/H between the height of the inner horizontal surface and 60 m provided the Annex 14 Category II inner approach, inner transitional and balked landing surfaces are extended to protect that OCA/H.

3.7.3 Degrees magnetic

The final approach track for the MLS procedure is always specified and promulgated in degrees magnetic.

3.7.4 Turn at a designated altitude/height (missed approach)

If the TP is located at the SOC, the chart shall be annotated "turn as soon as practicable to ... (heading or facility)" and shall include sufficient information to identify the position and height of the obstacles dictating the turn requirement.

3.7.5 Turn at a designated TP (missed approach)

Where the procedure requires that a turn be executed at a designated TP, the following information must be published with the procedure:

a) the TP, when it is designated by a fix; or

b) the intersecting VOR radial, NDB bearing, or DME distance where there is no track guidance (see Part I, Section 2, Chapter 2, 2.6.5, "Missed approach fixes").

3.7.6 Procedures involving non-standard glide path angles

Procedures involving glide paths greater than 3.5° or any angle when the nominal rate of descent exceeds 5 m/sec (1 000 ft/min), are non-standard and subject to restrictions (see 3.4.8.8.3.1, "Height loss (HL)/altimeter margins". They are normally restricted to specifically approved operators and aircraft, and are promulgated with appropriate aircraft and crew restrictions annotated on the approach chart.

3.7.7 Additional gradient for the final missed approach segment

If obstacles identified in the final missed approach segment result in an increase in any of the OCA/H calculated for the precision segment, an additional steeper gradient may also be specified for the gradient of the missed approach surface (Z) for the purposes of lowering the OCA/H (see Part I, Section 4, Chapter 6, 6.2.3.1, "Climb gradient in the final phase").

Table II-1-3-1. Minimum length of intermediate segment

Intercept angle with the final Approach track (degree)	*Minimum distance between the interception of the final approach track and the interception of the glide path*	
	Cat A/B	*Cat C/D/E*
0 – 15	2.8 km (1.5 NM)	2.8 km (1.5 NM)
16 – 30	3.7 km (2.0 NM)	3.7 km (2.0 NM)
31 – 60	3.7 km (2.0 NM)	4.6 km (2.5 NM)
61 – 90 or within a racetrack or reversal procedure	3.7 km (2.0 NM)	5.6 km (3.0 NM)

Table II-1-3-2. Height loss/altimeter margin

Aircraft category (Vat)	*Margin using radio altimeter*		*Margin using pressure altimeter*	
	Metres	*Feet*	*Metres*	*Feet*
A — 169 km/h (90 kt)	13	42	40	130
B — 223 km/h (120 kt)	18	59	43	142
C — 260 km/h (140 kt)	22	71	46	150
D — 306 km/h (165 kt)	26	85	49	161

Table II-1-3-3. Objects which may be ignored in OCA/H calculations

	Maximum height above threshold	*Minimum lateral distance from runway centre line*
EL antenna	17 m (55 ft)	120 m
Aircraft taxiing	22 m (72 ft)	150 m
A/C in holding bay or in taxi holding position at a range between threshold and -250 m	22 m (72 ft)	120 m
A/C in holding bay or in taxi holding position at a range between threshold and -250 m (Cat I only)	15 m	75 m

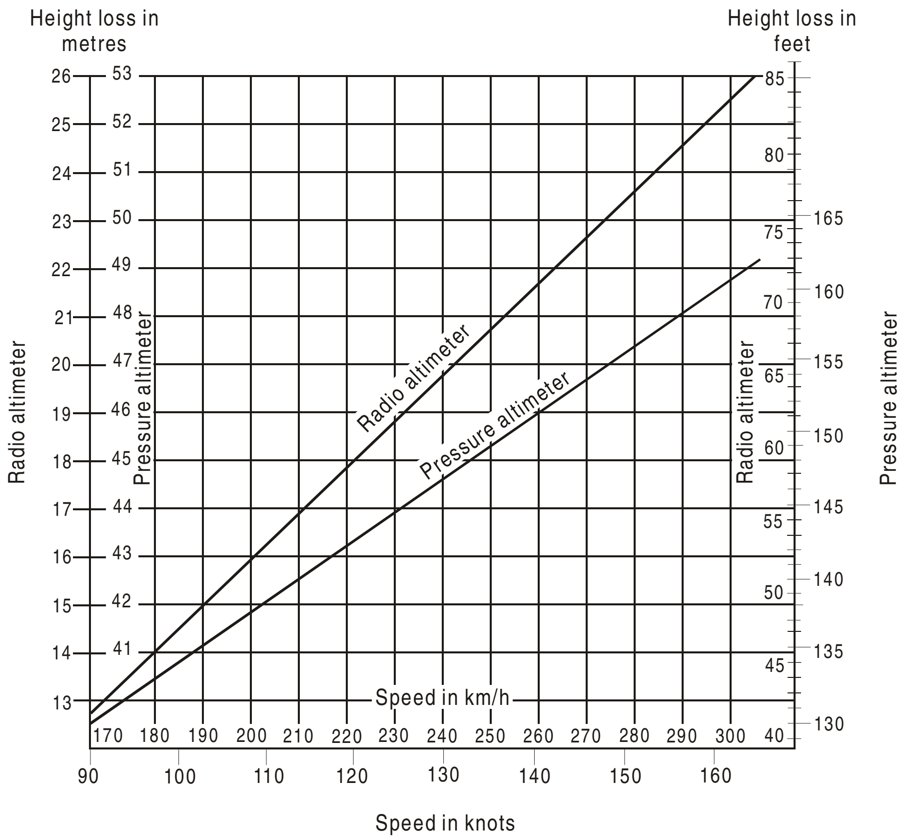


Table II-1-3-4. Height loss altimeter setting vs. speed

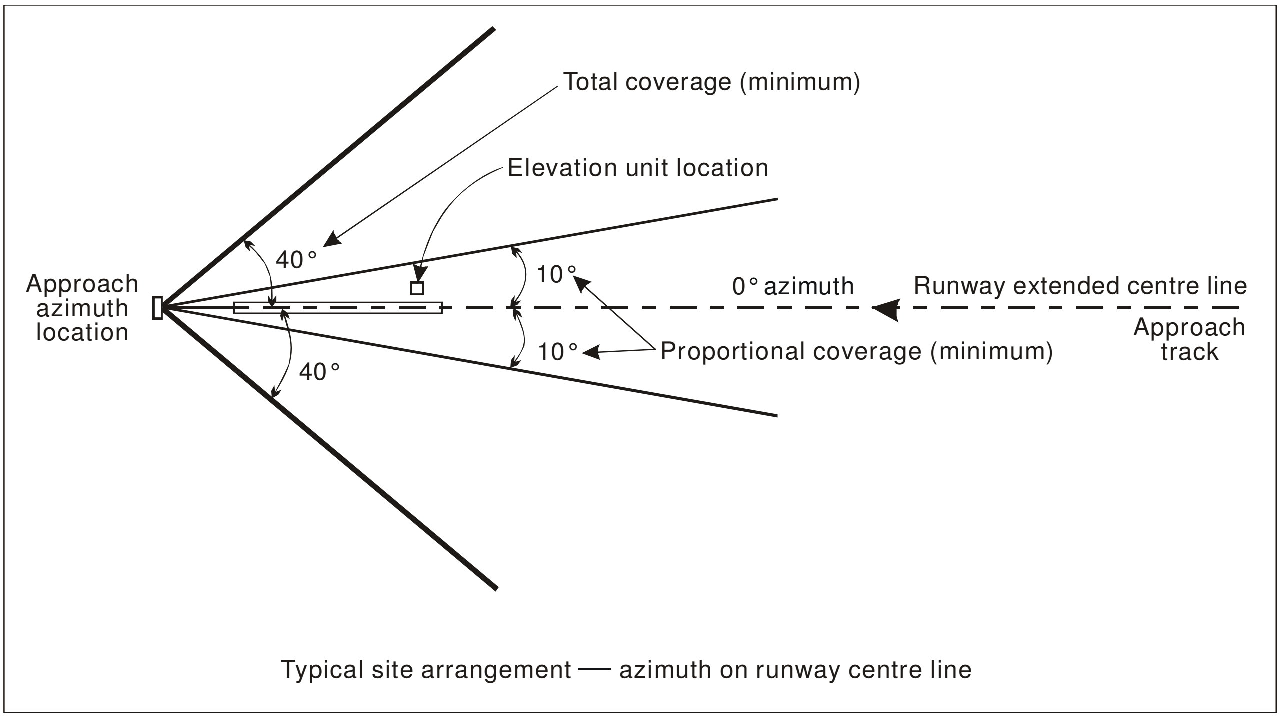


Figure II-1-3-1. Site arrangements suitable for MLS criteria application

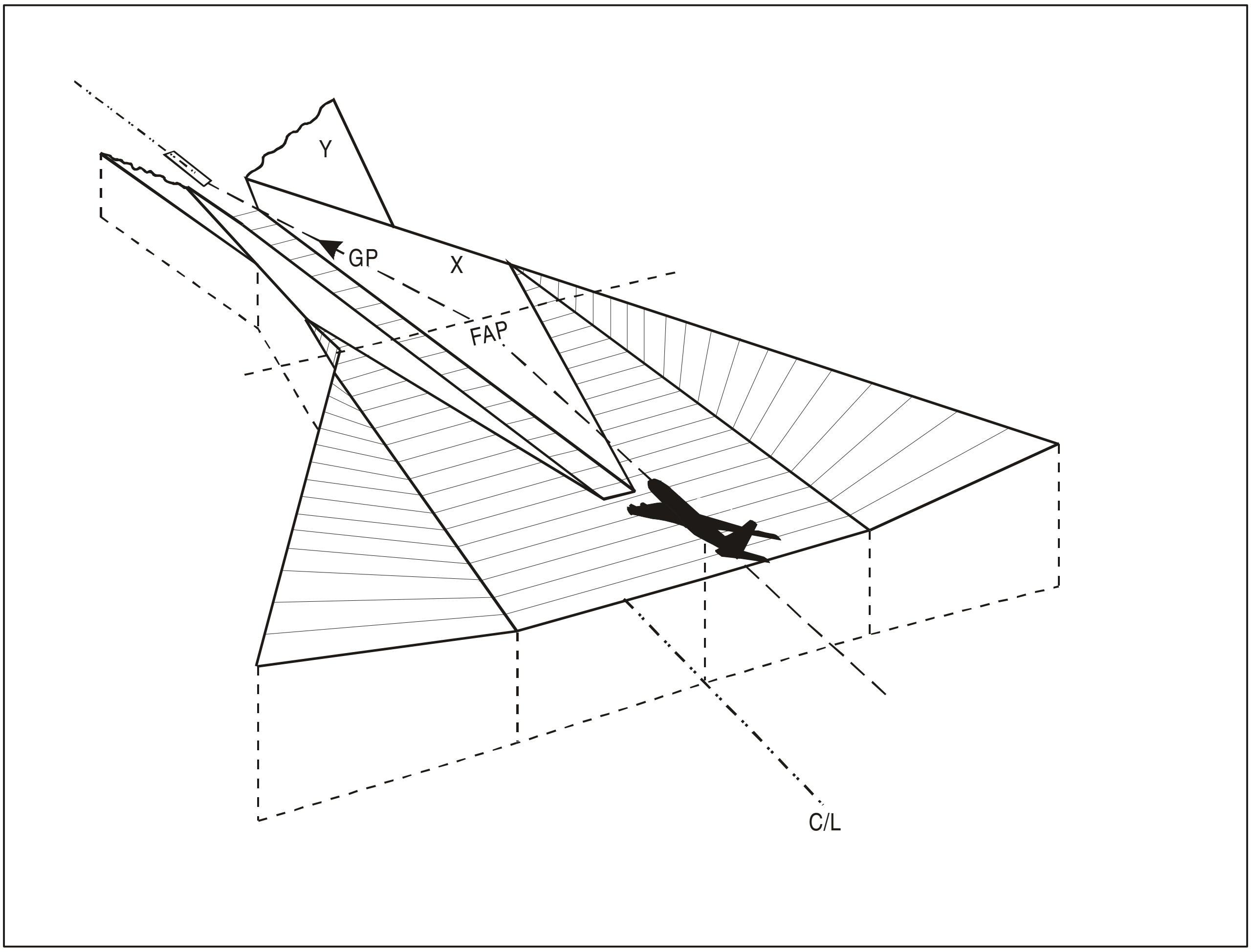


Figure II-1-3-2. Interface — final approach/preceding segment perspective view

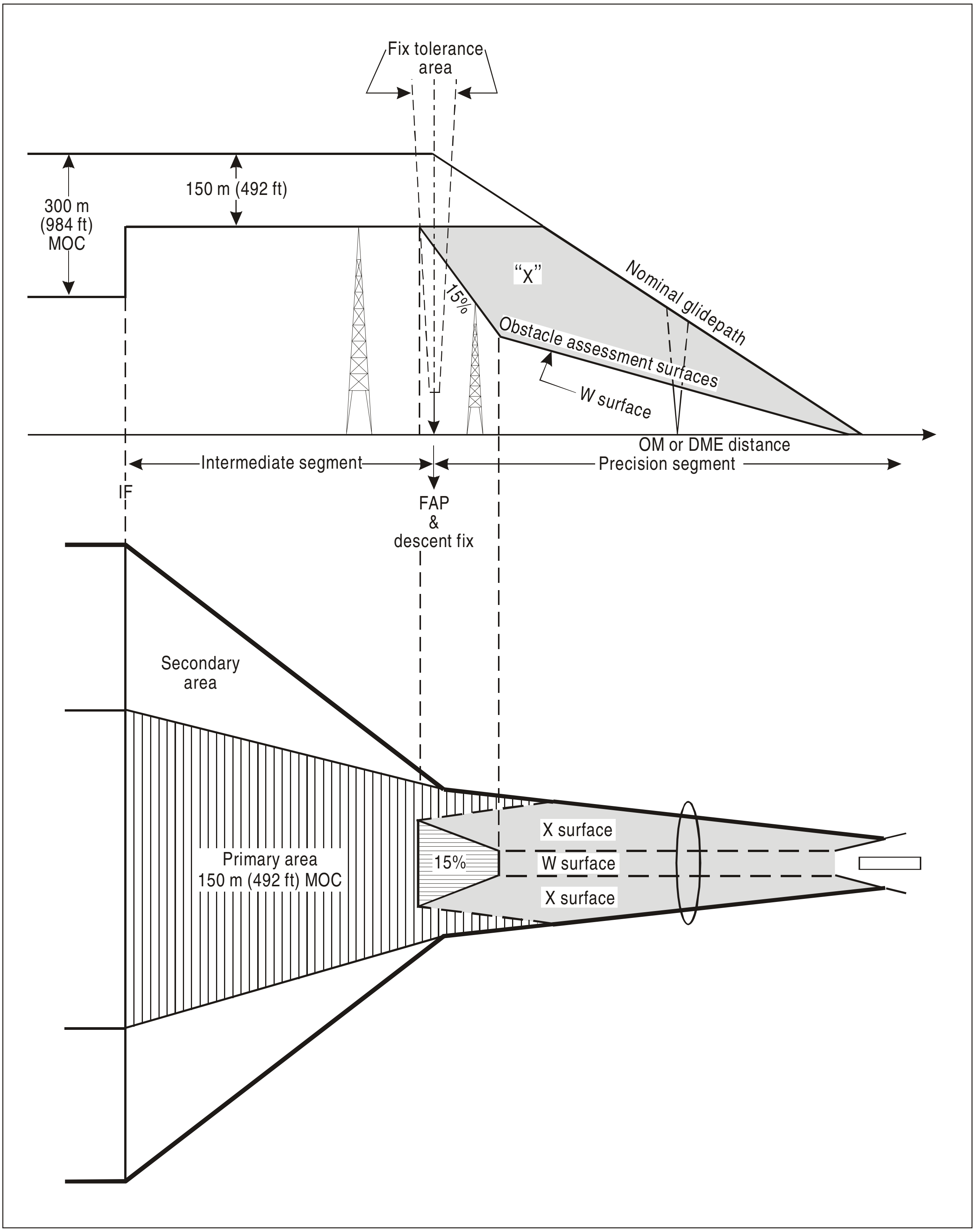


Figure II-1-3-3. Final approach fix defined by descent fix located at final approach point

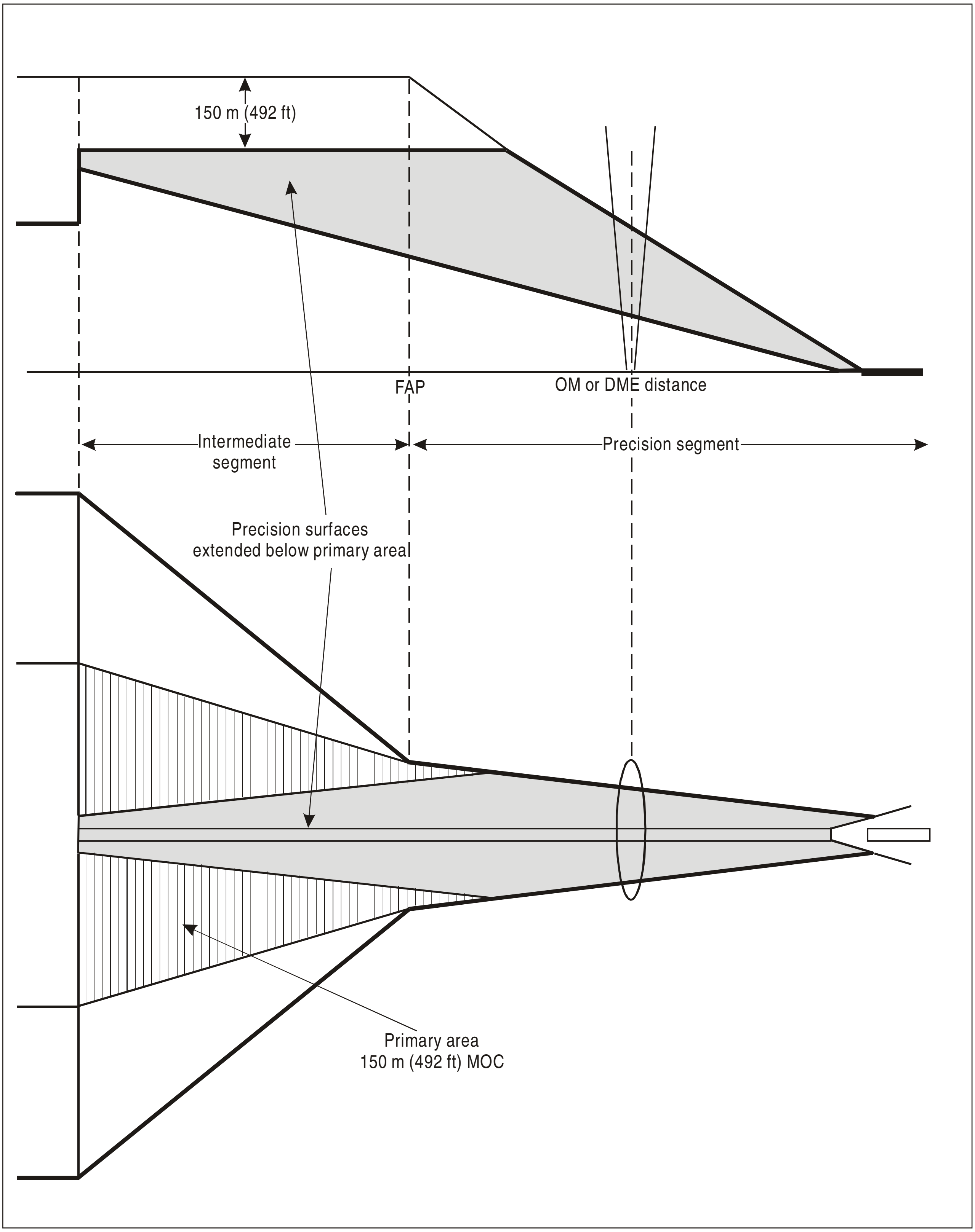


Figure II-1-3-4. Precision segment with no final approach fix

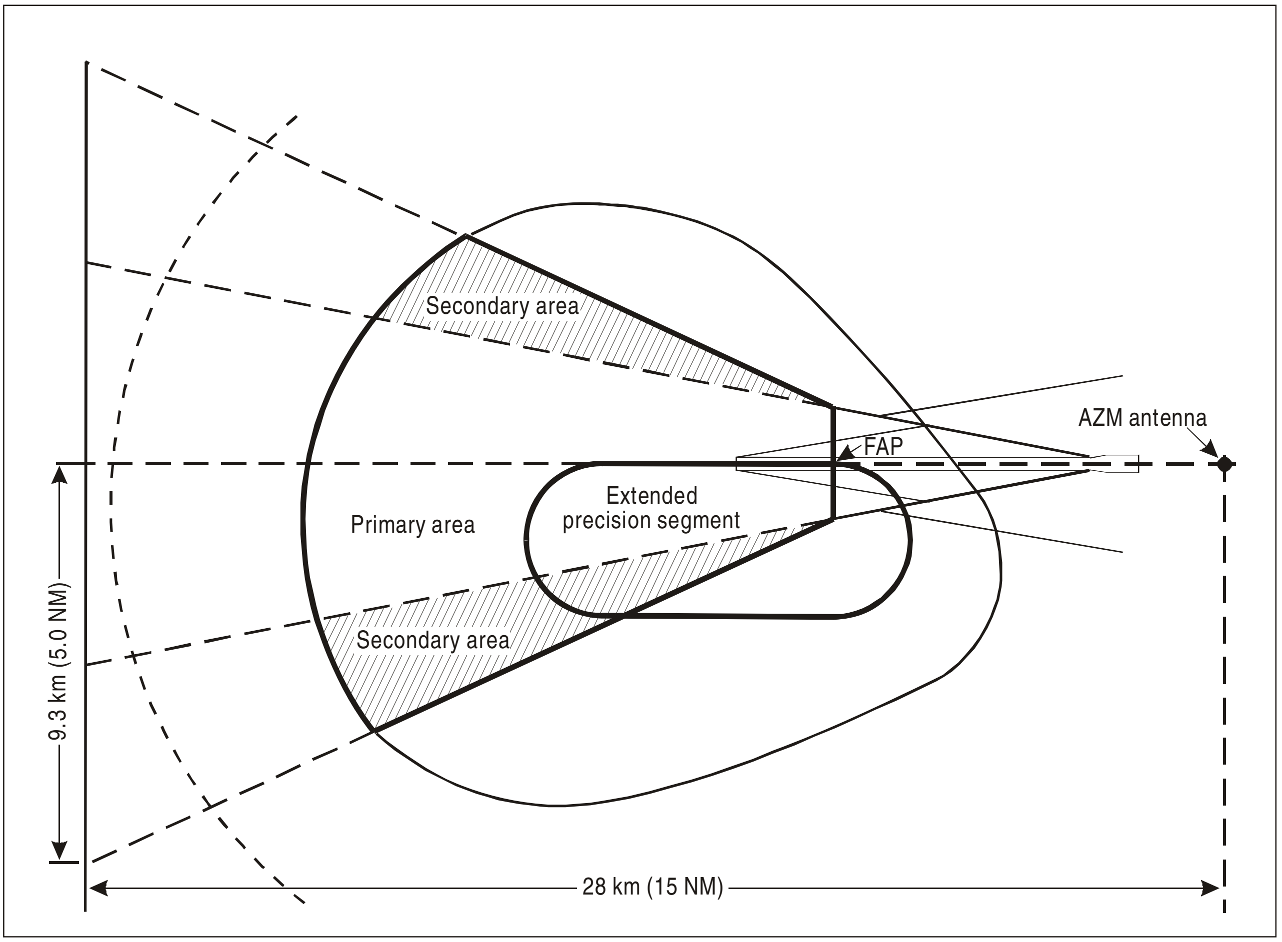


Figure II-1-3-5. Intermediate approach area. MLS approach using reversal or racetrack procedure

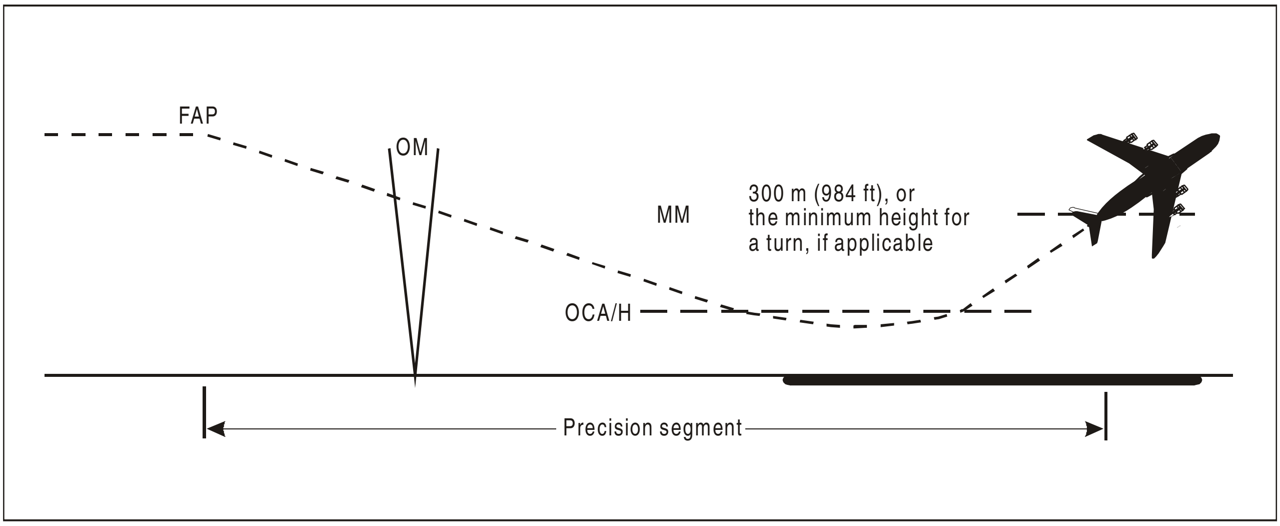


Figure II-1-3-6. Precision segment

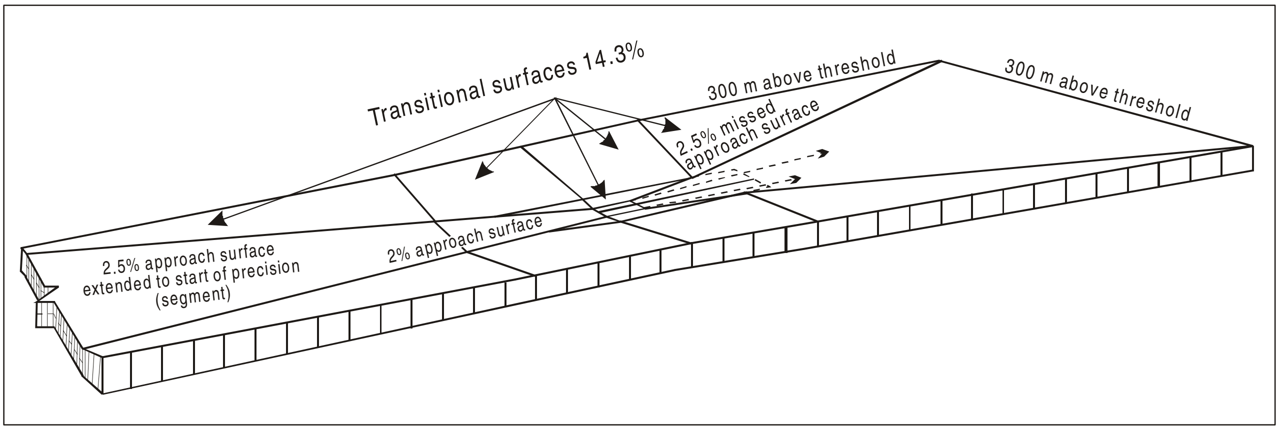
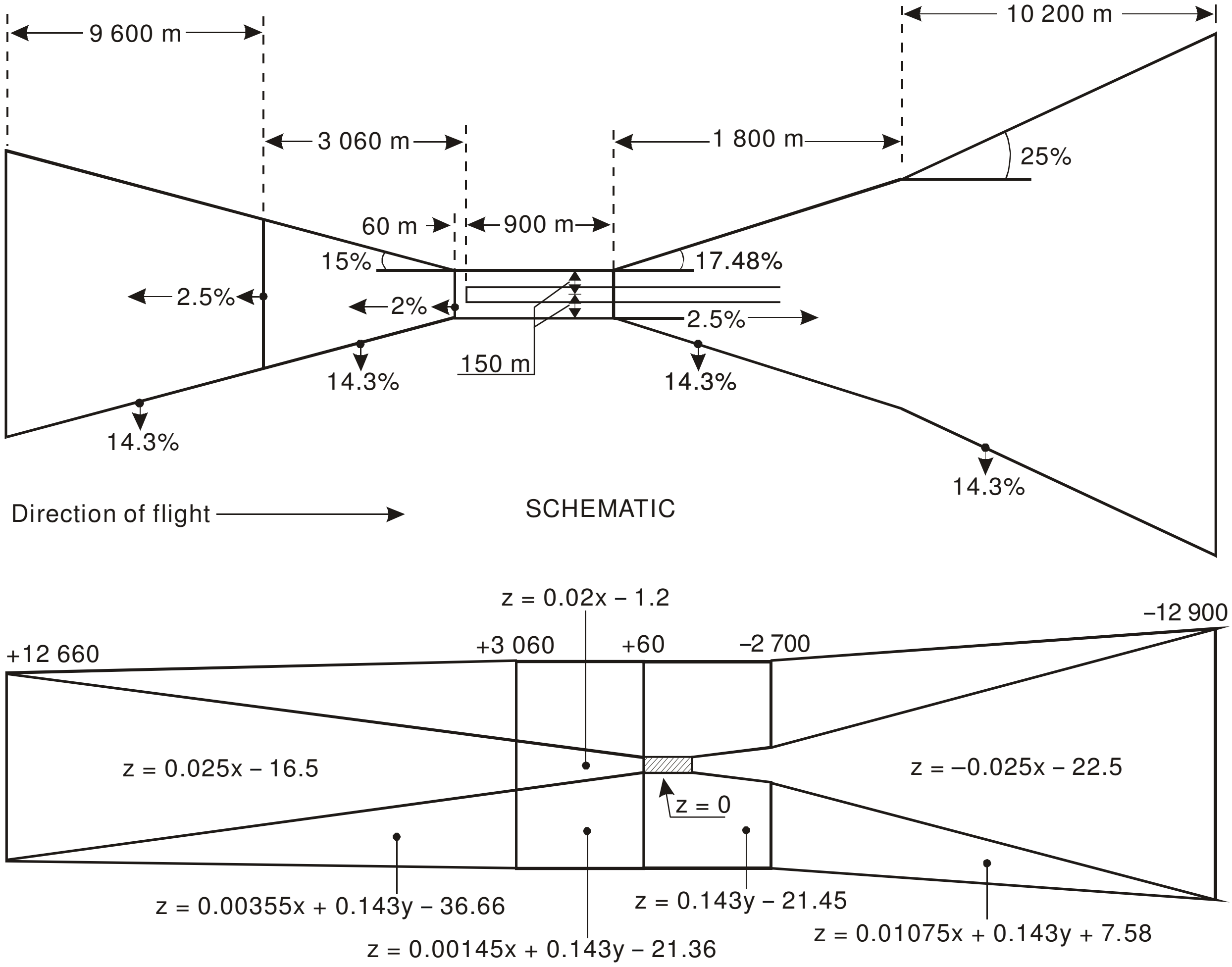


Figure II-1-3-7. Illustration of basic ILS surfaces as described in 3.4.7.2



Note.— The surface equations shown use the same frame of reference and notation as the OAS. See 3.4.8.2, 3.4.8.3 and 3.4.8.5. The equations assume the runway is horizontal. (All values are in metres.)

Figure II-1-3-8. Surface equations — basic ILS surfaces

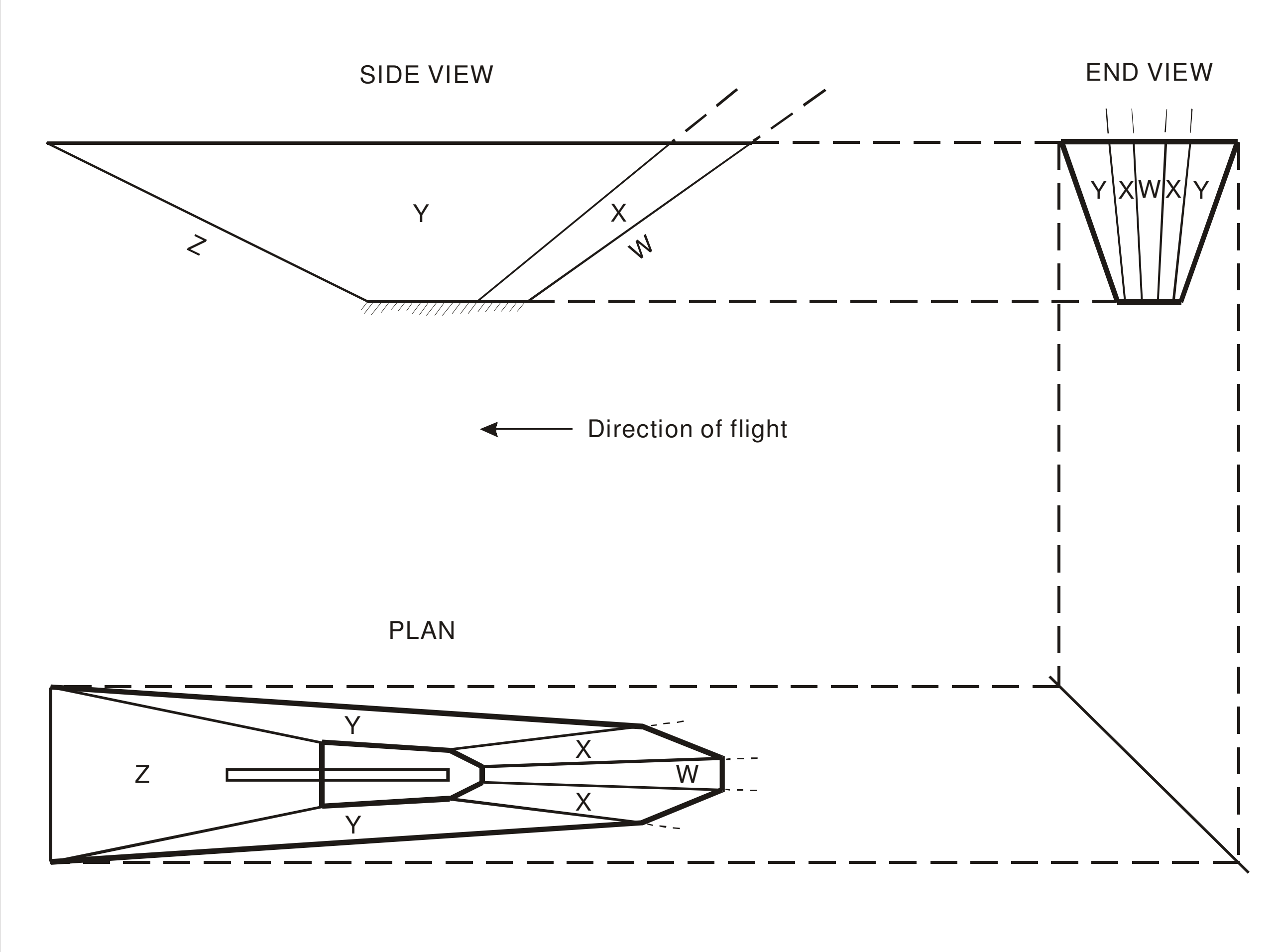


Figure II-1-3-9. Illustrations of ILS obstacle assessment surfaces

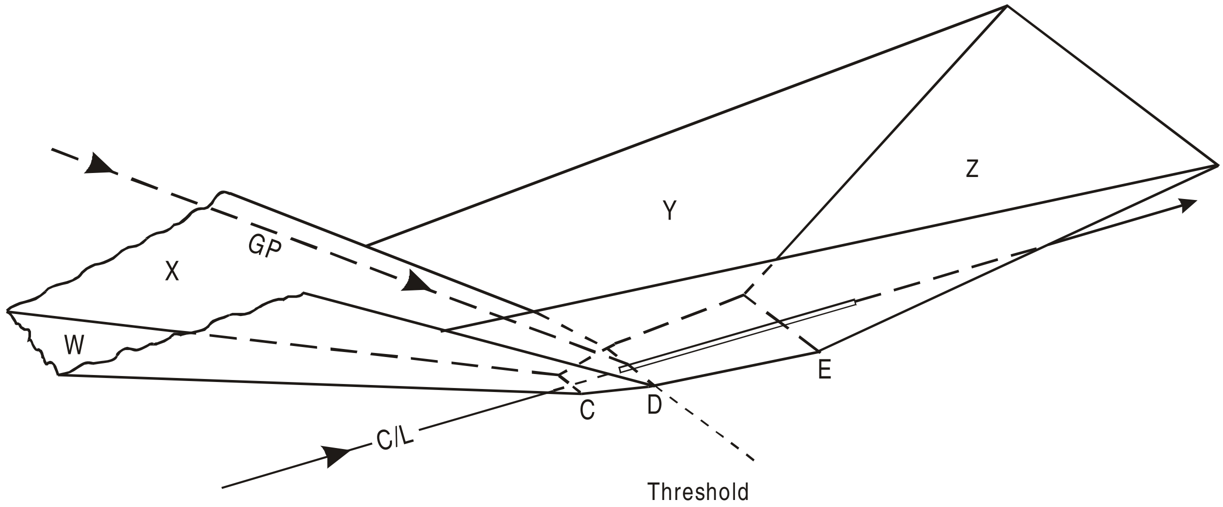


Figure II-1-3-10. Illustrations of ILS obstacle assessment surfaces — perspective view

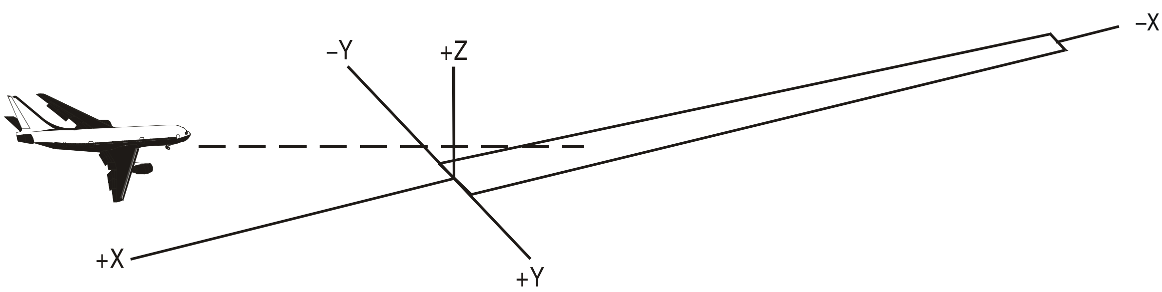
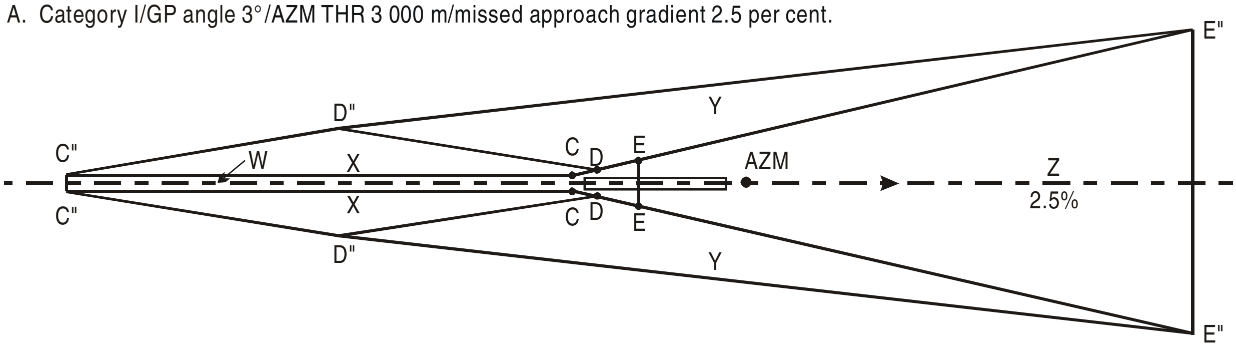


Figure II-1-3-11. System of coordinates

A. Category I/GP angle 3°/AZM THR 3 000 m/missed approach gradient 2.5 per cent.



Equations of the obstacle assessment surfaces:

$W\ I\ z = 0.0285x - 8.01$

$X\ I\ z = 0.027681x + 0.1825y - 16.72$

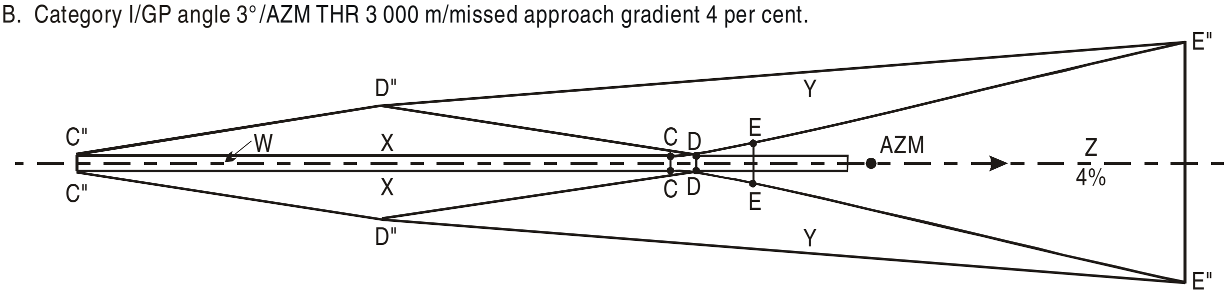
$Y\ I\ z = 0.023948x + 0.210054y - 21.51$

$Z\ I\ z = -0.025x - 22.50$

Coordinates of points C, D, E, C", D", E" (m):

	C	D	E	C"	D"	E"
x	281	–286	–900	10 807	5 438	–12 900
y	49	135	205	96	910	3 001
z	0	0	0	300	300	300

B. Category I/GP angle 3°/AZM THR 3 000 m/missed approach gradient 4 per cent.



Equations of the obstacle assessment surfaces:

$W\ I\ z = 0.0285x - 8.01$

$X\ I\ z = 0.027681x + 0.1825y - 16.72$

$Y\ I\ z = 0.020158x + 0.238021y - 26.37$

$Z\ I\ z = -0.04x - 36.00$

Coordinates of points C, D, E, C", D", E" (m):

	C	D	E	C"	D"	E"
x	281	–286	–900	10 807	5 438	–8 400
y	49	135	187	96	910	2 082
z	0	0	0	300	300	300

Figure II-1-3-12. Typical OAS contours for standard size aircraft

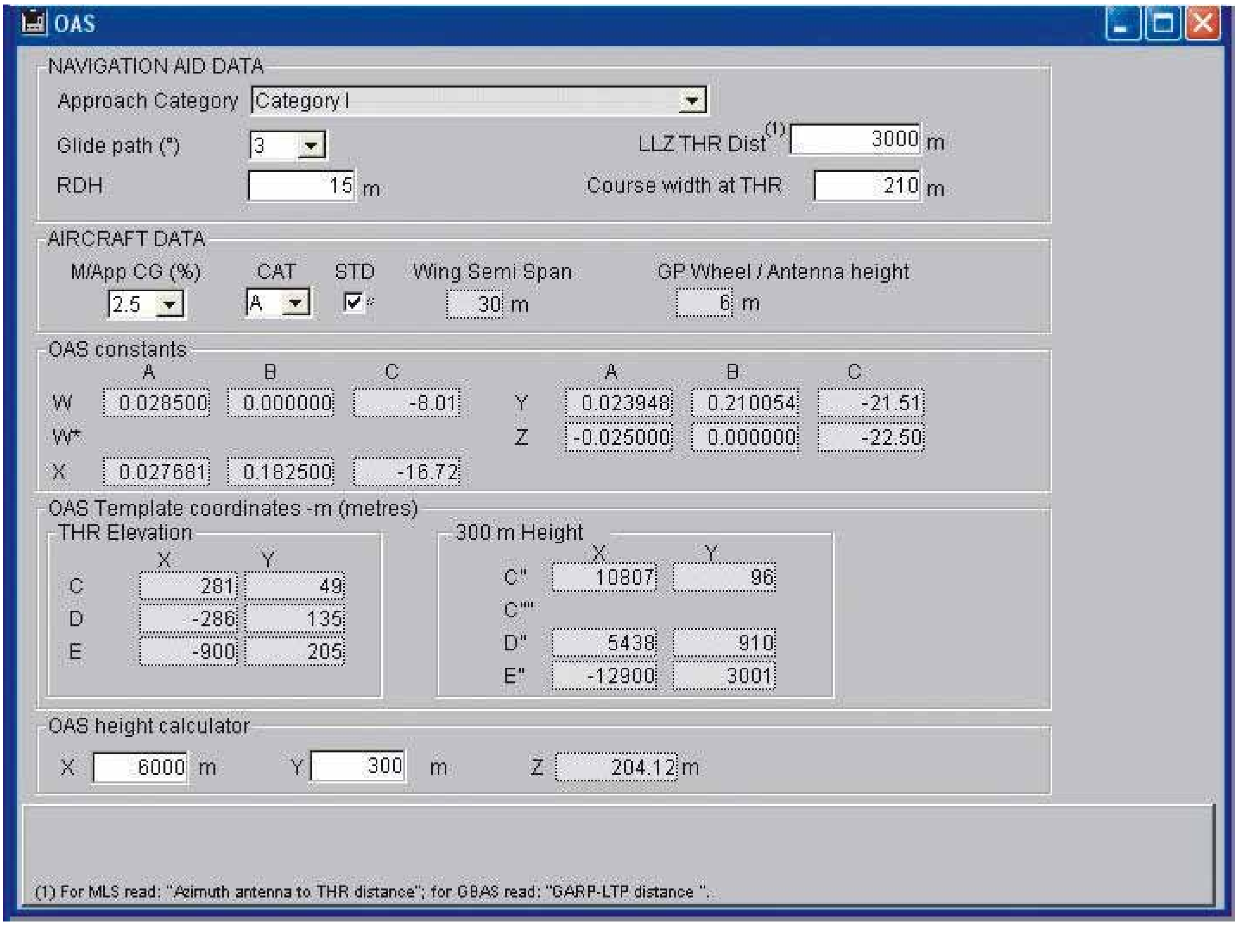


Figure II-1-3-13. OAS output data generated by the PANS-OPS OAS CD-ROM

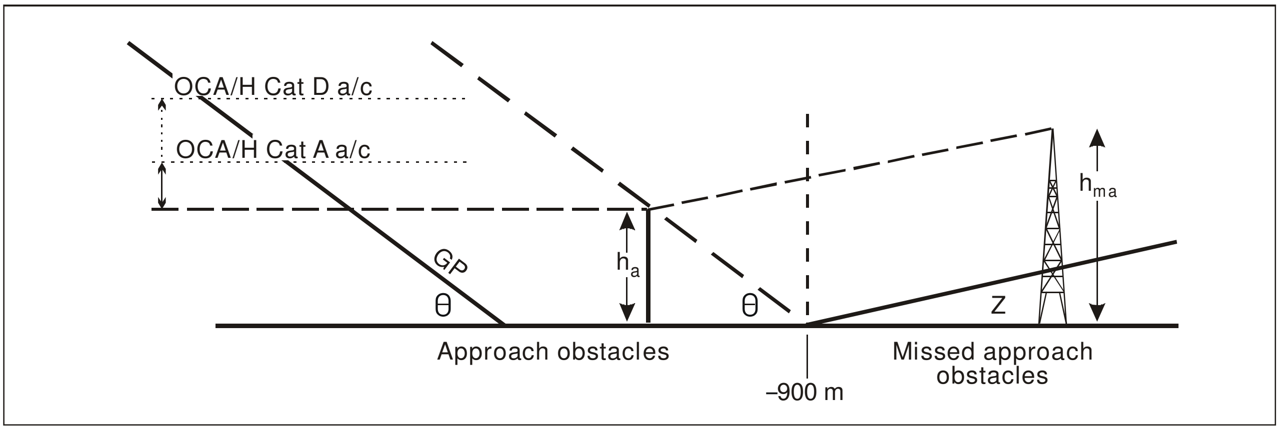


Figure II-1-3-14. Missed approach obstacle after range -900 m

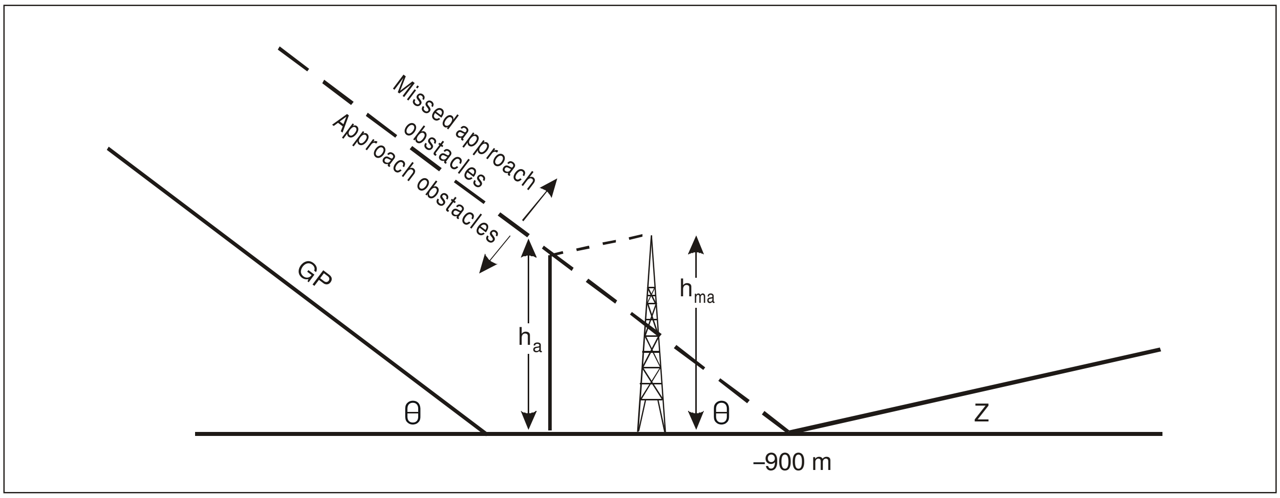


Figure II-1-3-15. Missed approach obstacle before range -900 m

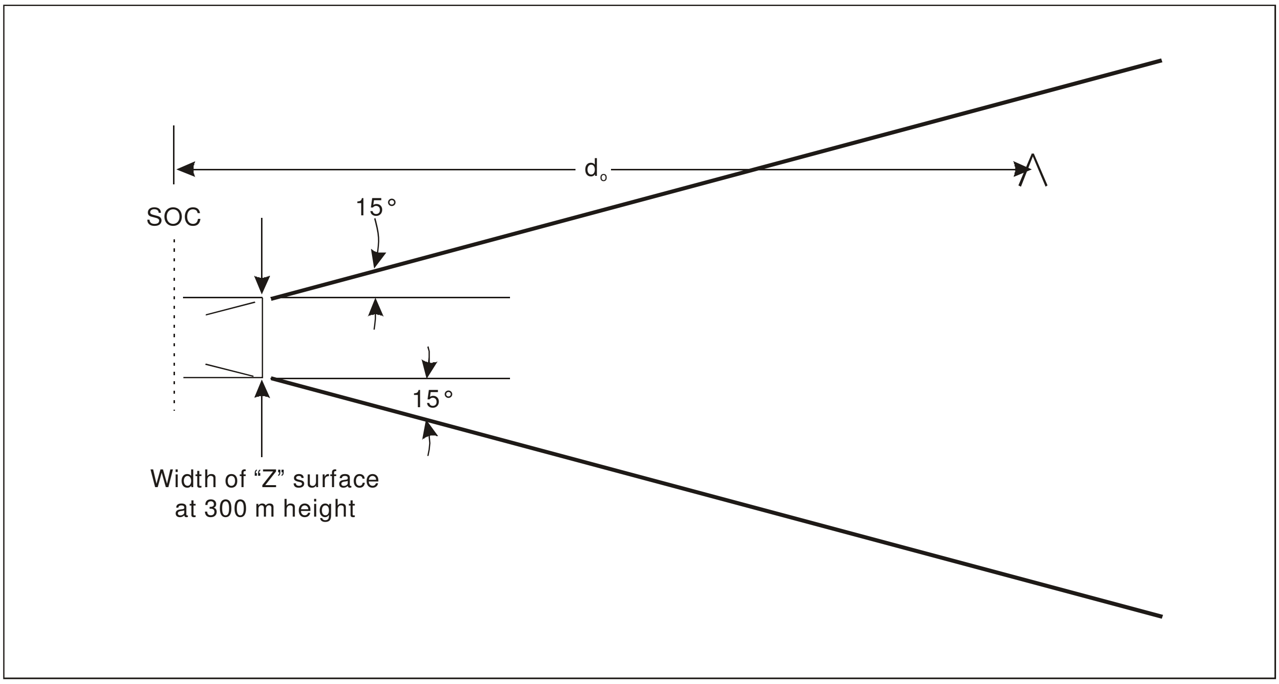


Figure II-1-3-16. Final segment of straight missed approach

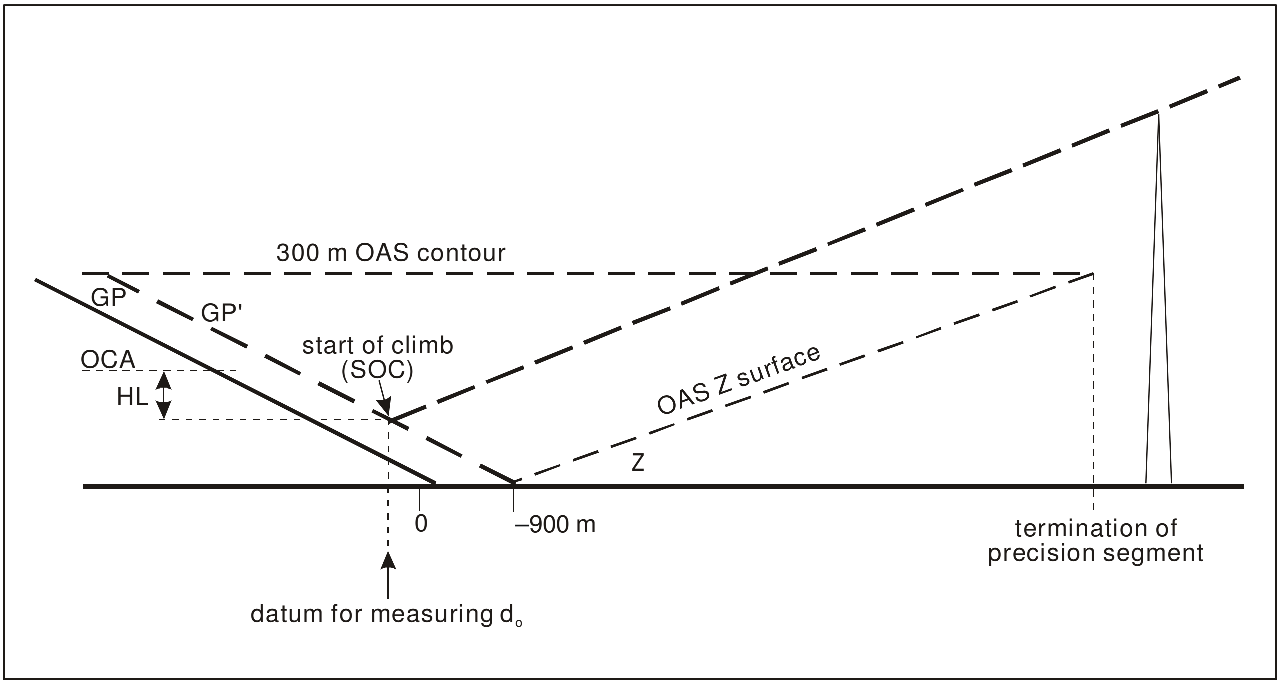


Figure II-1-3-17. Straight missed approach obstacle clearance

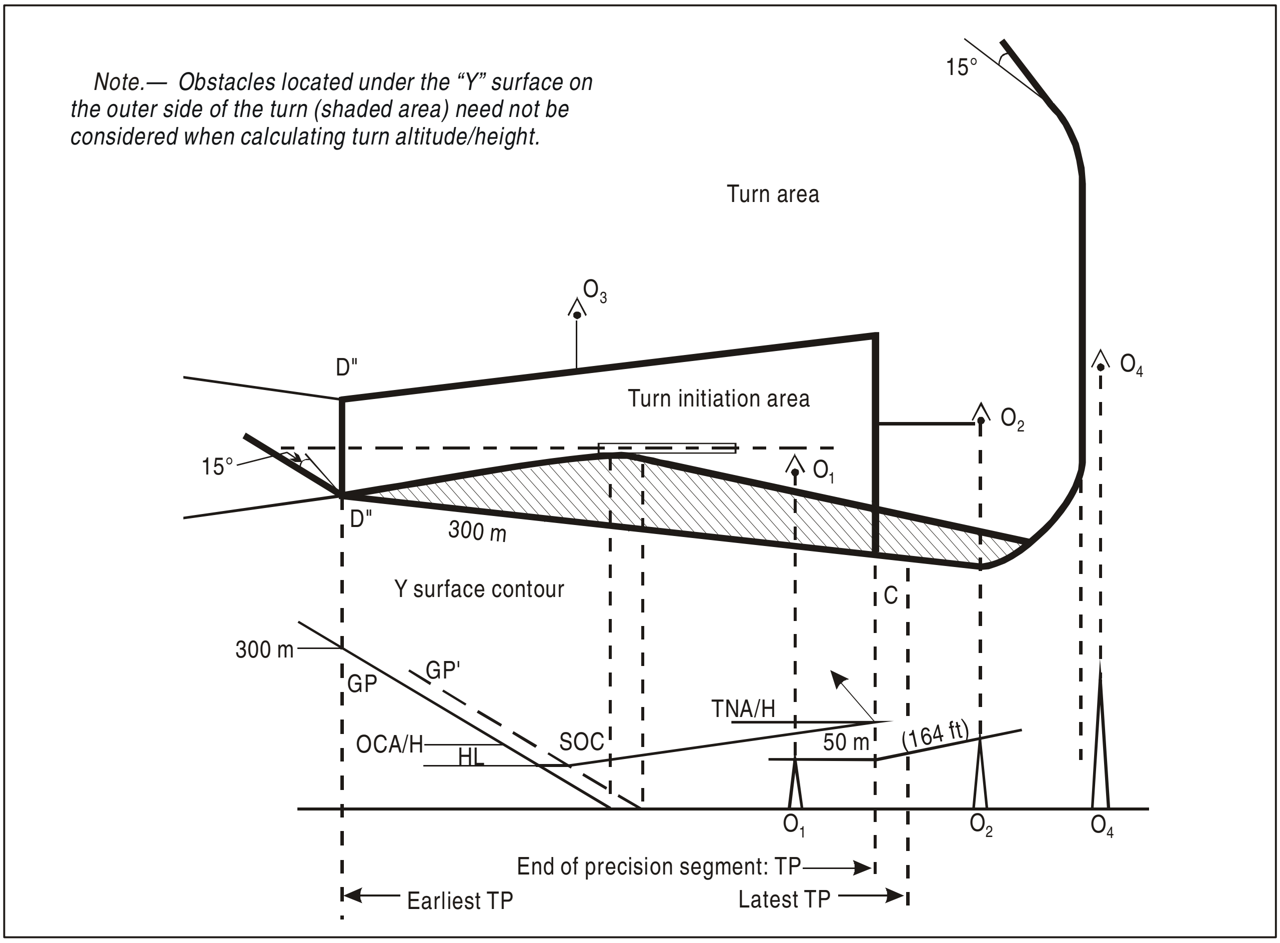
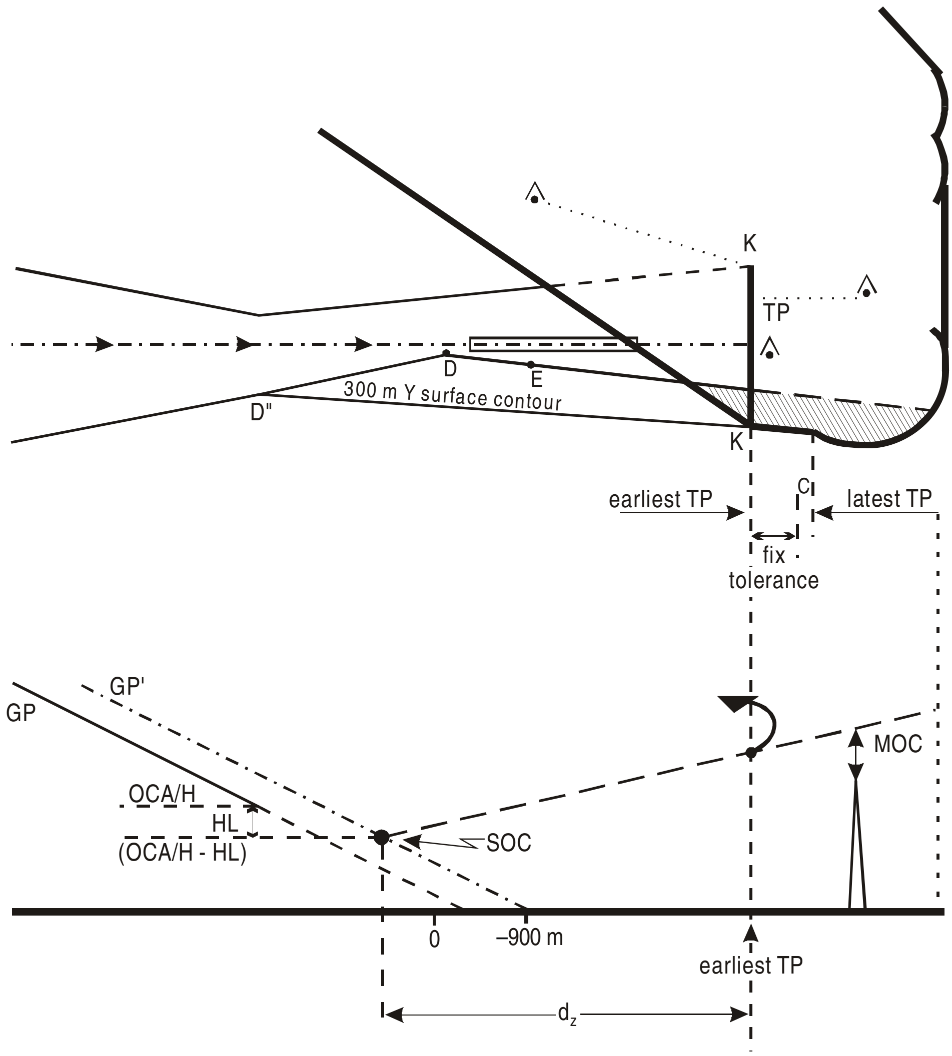


Figure II-1-3-18. Turn at a designated altitude



Note 1: d_o = d_z + shortest distance from obstacle to line K-K.

Note 2: Obstacles located under the "Y" surface (shaded area) need not be considered.

Figure II-1-3-19. Turn at designated TP (with TP fix)

Chapter 4

OFFSET MLS

4.1 USE OF MLS CAT I WITH OFFSET AZIMUTH ALIGNMENT

4.1.1 In certain cases it may not be physically practicable to align the azimuth with the runway centre line because of siting problems, or because airfield construction work demands a temporary offset location. An offset azimuth shall not be established as a noise abatement measure.

4.1.2 The zero-degree azimuth shall intersect the runway extended centre line:

a) at an angle not exceeding 5°; and

b) at a point where the nominal glide path (elevation angle) reaches a height of at least 55 m (180 ft) above threshold. This is called intercept height.

4.1.3 The procedure shall be annotated: “azimuth offset ... degrees” (tenth of degrees). The general arrangement is shown in Figure II-1-4-1.

4.2 OBSTACLE CLEARANCE CRITERIA

The provisions contained in Chapter 3 apply except that:

a) all the obstacle clearance surfaces and calculations are based on a fictitious runway aligned with the azimuth specified for the final approach track. This fictitious runway has the same length, the same threshold elevation, and the same distance threshold to intercept point as the real one. The azimuth sector width and the MLS approach reference datum height are based on the threshold of the fictitious runway; and

b) the OCA/H for this procedure shall be at least: intercept altitude/height + 20 m (66 ft).

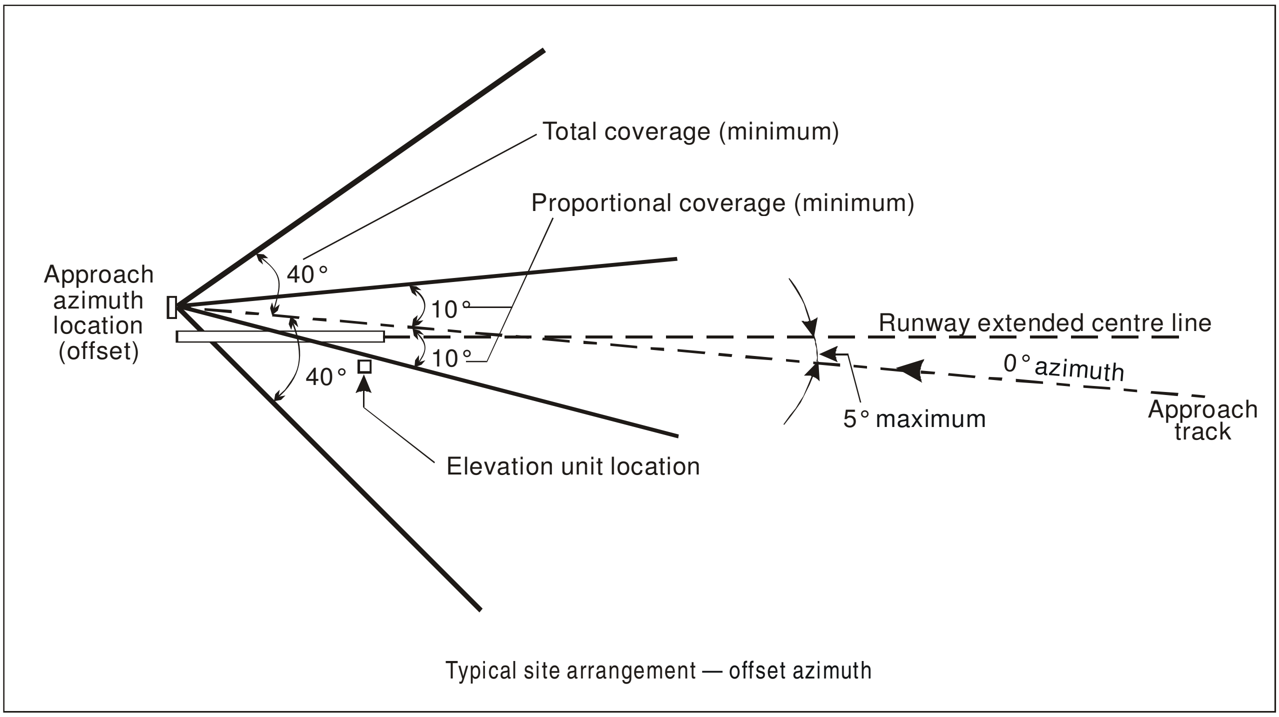


Figure II-1-4-1. Site arrangements suitable for MLS criteria application

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Chapter 5

PAR

Note.— Only PAR approaches down to OCA/H of the order of 60 m (200 ft) have been considered.

5.1 ARRIVAL PHASE OPERATIONS

The arrival phase operations through initial and intermediate approach to the extended centre line of the runway will normally be made from an associated en-route navigation facility or within a radar vectoring area. This approach will be made on pre-determined tracks between such fixes or as directed by radar controllers within the radar vectoring area following radar identification. The time of flight from the last known fix should be sufficient to ensure that the radar identification procedure may be completed. In the event of radar contact not being established, or of the pilot becoming uncertain of his or her position, a return to the last fix should be prescribed.

5.2 INTERMEDIATE APPROACH

5.2.1 General

The interception with the descent path should be established at least 4 km (2 NM) inside the coverage of the radar.

5.2.2 Intermediate approach utilizing a suitable navigation facility or fix on or offset from the extended centre line of the runway

Routes shall be specified from the navigation facility, fix, predetermined tracks, or as directed by the radar controller, to intercept the extended centre line such that the aircraft, when aligned on the inbound track, is in a position from which the final approach can be started. The distance between the point of interception with the extended centre line and the interception with the descent path should be sufficient to permit the aircraft to stabilize (speed and configuration) and establish on the extended centre line prior to intercepting the descent path.

5.2.3 Length

The optimum length of the intermediate segment is 9 km (5 NM) (Cat H, 3.7 km (2 NM)). The minimum length depends upon the angle at which it is intercepted by the initial approach track and is specified in Table II-1-5-1. However, these minimum values should be used *only* if usable airspace is restricted.

5.2.4 Intermediate approach utilizing a suitable navigation facility or fix on the extended centre line of the runway

If a straight-in approach using such a facility on the extended centre line of the runway is possible, no special intermediate approach procedure is required other than radar identification.

5.2.5 Intermediate approach with no fix

Where no suitable navigation facility or fix is available for the procedures in 5.2.2 and 5.2.4 the procedure shall:

a) ensure a track is available from the last positive fix at a suitable level above the MDA/H for the segments in question; and

b) allow for identification turns in accordance with ATC instructions.

5.3 FINAL APPROACH

The procedure shall ensure that an aircraft on the inbound track of the extended runway centre line intercepts the glide path (minimum 2.5°, optimum 3.0°, maximum 3.5°) following radar control instructions at the altitude/height specified for the procedure which shall be at least 150 m (500 ft) above the horizontal part of the obstacle clearance surface (OCS). (See Figure II-1-5-1.) When instructed by radar of interception of descent path, descent is made in accordance with the radar controllers' instructions to the OCA/H.

Note.— The term obstacle clearance surface (OCS) is used only in precision approach radar procedures on the final approach.

5.4 MISSED APPROACH

The missed approach should normally be a track which is as near as possible a continuation of the final approach track after due consideration of obstructions, terrain and other factors influencing the safety of the operation (see 5.7).

5.5 ARRIVAL AND INITIAL APPROACH AREAS AND OBSTACLE CLEARANCES

5.5.1 Arrival and initial approach areas

The arrival and initial approach areas shall be at least 19 km (10 NM) wide (9.3 km (5.0 NM) either side of the predetermined track). Where navigation facilities are available which provide a very accurate track on initial approach, the distance of 9.3 km (5.0 NM) specified above may be reduced to a minimum of 5.6 km (3.0 NM). See Section 2, Chapter 6, 6.2.2, "Procedures based on predetermined tracks".

5.5.2 Arrival and initial approach obstacle clearances

The arrival and initial approaches shall not be made below an altitude which provides a clearance of 300 m (1 000 ft) above all obstacles within the area defined in Section 2, Chapter 6, 6.2.2, “Procedures based on predetermined tracks”. However, this altitude should not be lower than the altitude at which the glide path will be intercepted, and if a procedure turn is required not lower than the procedure turn altitude.

5.6 INTERMEDIATE AND FINAL APPROACH AREA AND OBSTACLE CLEARANCES

5.6.1 Combined intermediate and final approach area

5.6.1.1 This is an area symmetrical about the extended centre line extending from a point situated at a distance of D calculated as in 5.6.2.1 b) from the threshold to the point at which the final approach is commenced. The intermediate approach shall normally be commenced at a distance not exceeding 28 km (15 NM) from the threshold. The intermediate approach transforms into the final approach at the point where the aircraft intercepts the descent path.

5.6.1.2 The area has a constant width of 600 m from its origin at the distance D from the threshold as in 5.6.2.1 b), to a point 1 060 m before the threshold. From this point the area widens with a splay of 15 per cent on either side to a total width of 7.4 km (4.0 NM) at a distance of 24 km (13 NM) from the threshold, thence maintaining a constant width to the outer boundary of the joint intermediate/final approach area, normally not more than 28 km (15 NM) from the threshold (see Figures II-1-5-2, II-1-5-3 and II-1-5-4). Where the Annex 14 approach surface penetrates the approach surfaces and the initial missed approach surface shown in Figure II-1-5-2, the Annex 14 surface is used as the obstacle clearance surface.

Note 1.— In the event of D becoming greater than 1 060 m the figure of 1 060 m will be used.

Note 2.— The combined intermediate/final approach area corresponds to the extended area for instrument runways specified in Annex 14.

Note 3.— The length of the final approach area is limited by the convergence of the radar.

5.6.2 Intermediate and final approach obstacle clearances

5.6.2.1 The minimum obstacle clearance above obstacles within the limits of the intermediate and final approach area shall be as specified herein:

a) from the beginning of intermediate approach, the obstacle clearance surface shall be the horizontal plane whose height is equal to that of the highest obstacle in the intermediate approach area, to the point where this surface intersects the plane described under b) hereafter; the obstacle clearance above this plane shall not be less than 150 metres (500 feet) up to a point where the obstacle clearance intersects the plane described under b); and

b) thereafter, within the final approach area, the obstacle clearance surface is contained in a plane inclined at an angle not greater than 0.6 θ. This plane intersects the horizontal plane through the threshold in a line at right angles to the runway centre line, at a distance D before the threshold, where:

$$D = \frac{30}{\tan 0.6\,\theta} - \frac{H}{\tan \theta} \text{ (D and H in metres)}$$

or

$$D = \frac{98}{\tan 0.6\,\theta} - \frac{H}{\tan \theta} \quad \text{(D and H in feet)}$$

where: θ = nominal glide path angle;

$0.6\,\theta$ = worst assumed descent path angle; and

H = height of the nominal descent path over the threshold.

5.6.2.2 The final approach OCA/H is obtained by adding the values for pressure altimeter from Section 1, Chapter 1, Table II-1-1-2 to the highest obstruction penetrating the plane defined in 5.6.2.1 b), or to the highest obstruction in the initial missed approach area, whichever is higher. (See Figure II-1-5-5.) It must also assure missed approach obstacle clearance is provided (see 5.7.2.2).

5.7 MISSED APPROACH AREA AND OBSTACLE CLEARANCE

5.7.1 Missed approach area

The initial phase of the missed approach area starts at the MAPt which is at the end of the final approach area (i.e. at a distance D before the threshold). The initial phase continues from there with a constant width of 600 m, there being 300 m on either side of the runway centre line, to a distance of not less than 900 m nor normally, more than 1 800 m beyond the threshold. At this point, the intermediate phase of the missed approach area commences. This intermediate phase is an area symmetrical about the missed approach track extending a sufficient distance to ensure that an aircraft climbing at a gradient of 2.5 per cent has reached an altitude at which a major turn can be initiated, acceleration may commence or obstacle clearances (such as for en route or holding) become effective. (See Part I, Section 4, Chapter 6, 6.2.2, “Intermediate phase”). The width of the intermediate phase of the missed approach area is 600 m until it reaches 1 800 m beyond the threshold or reaches the runway end, whichever is the least, then widening with a splay of 15° on either side. The final phase shall be in accordance with criteria contained in Part I, Section 4, Chapter 6. Where positive radar guidance is provided throughout the missed approach procedure, the splay may be reduced to a minimum of 10°. Criteria for additional track guidance is contained in Part I, Section 4, Chapter 6, 6.3.2.3, “Additional track guidance”.

Note.— In determining the missed approach area for a particular runway, the following considerations are pertinent:

a) the maximum distance from the threshold of 1 800 m for the commencement of the assumed gradient of 2.5 per cent may be unduly restrictive for certain aircraft operations and where this is so, this point may be varied to suit the conditions existing, but in any case the commencing point should not be less than 900 m from the threshold; and

b) the angular deviations of 10° and 15° allow for pilot ability to maintain track during missed approach with or without radar guidance.

5.7.2 Missed approach obstacle clearance

5.7.2.1 The minimum vertical clearance above all obstacles in the missed approach area shall be 30 m (98 ft).

5.7.2.2 The OCA/H for the intermediate phase of the missed approach area is determined by assuming a missed approach climb gradient that clears all obstacles in the intermediate phase of the missed approach area by at least 30 m (98 ft). This OCA/H for missed approach shall be the height at which a 2.5 per cent plane, passing at least 30 m (98 ft) above any object in the intermediate phase of the missed approach area intersects in a horizontal line a vertical plane at right angles to the runway centre line and situated at the beginning of the intermediate phase of the missed approach area. The OCA/H shall also assure that MOC in the final phase of the missed approach is provided. See Part I, Section 4, Chapter 6.

5.7.3 Obstacle clearance altitude/height

The OCA/H published for the procedure shall be the higher of the values calculated in 5.6.3.1 and 5.7.2.1, but it shall not be less than 60 m (200 ft). See Figures II-1-5-1 and II-1-5-5.

Table II-1-5-1. Minimum length of intermediate segment

Intercept angle with localizer (degrees)	*Minimum distance between localizer and glide path interceptions*	
	Cat A to E	Cat H
0 – 15	2.8 km (1.5 NM)	2.8 km (1.5 NM)
16 – 30	3.7 km (2.0 NM)	3.7 km (2.0 NM)
31 – 60	4.6 km (2.5 NM)	3.7 km (2.0 NM)
61 – 90	5.6 km (3.0 NM)	3.7 km (2.0 NM)

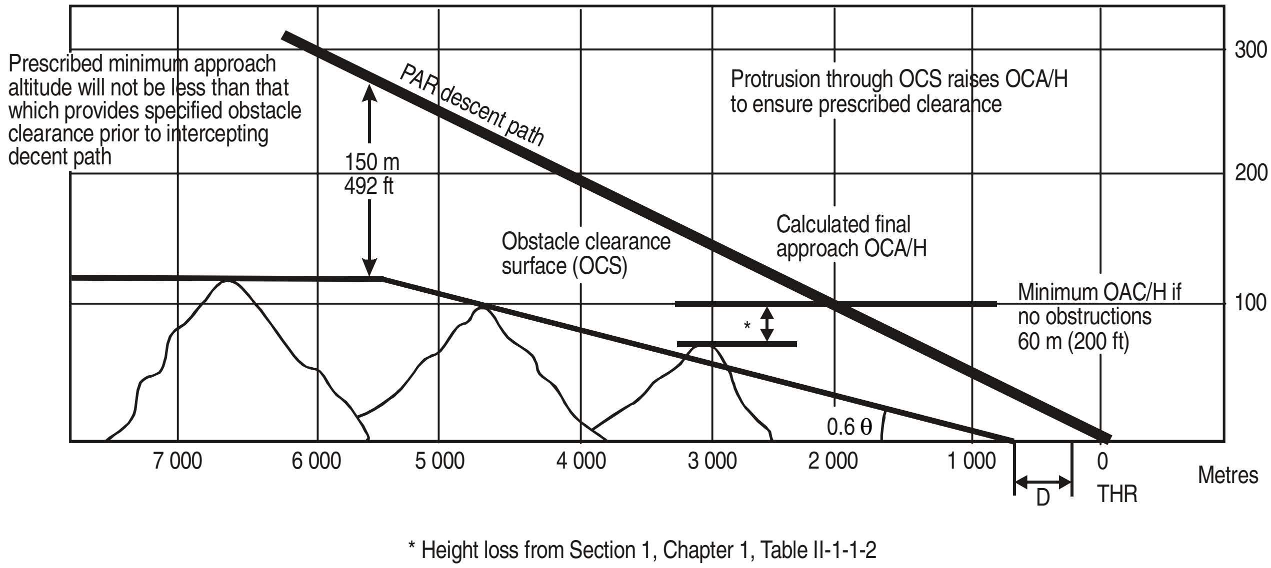


Figure II-1-5-1. Determination of final approach OCA/H for PAR

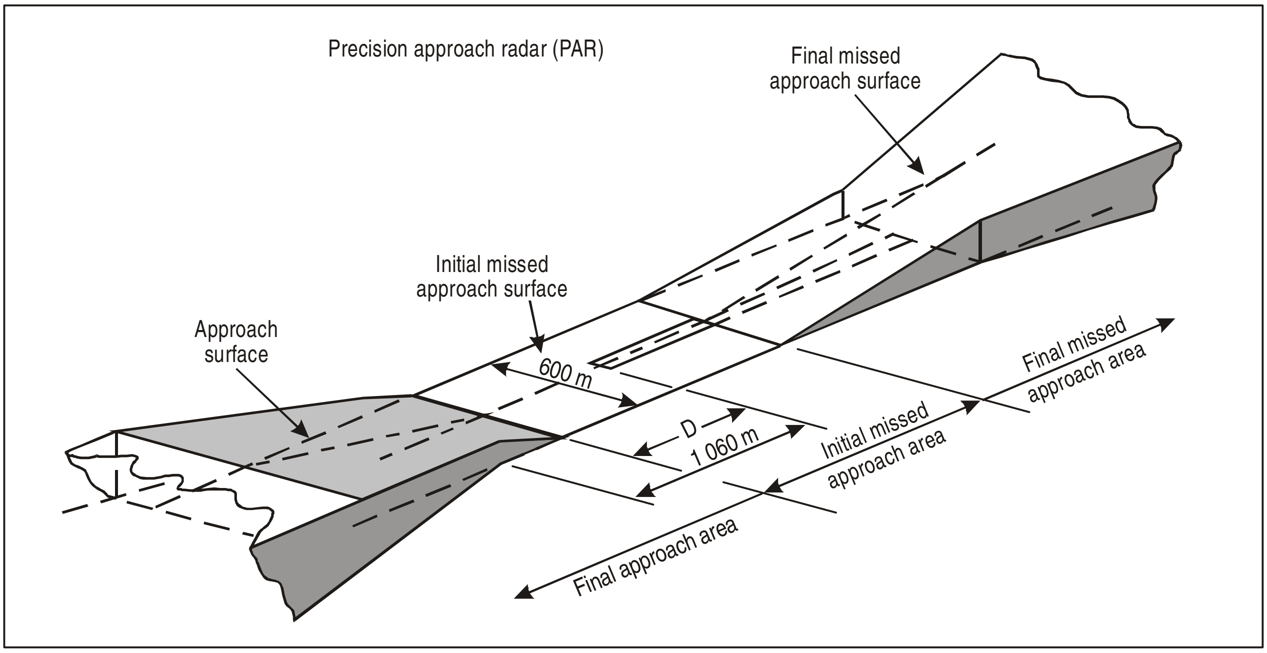


Figure II-1-5-2. Final approach and missed approach areas and surfaces

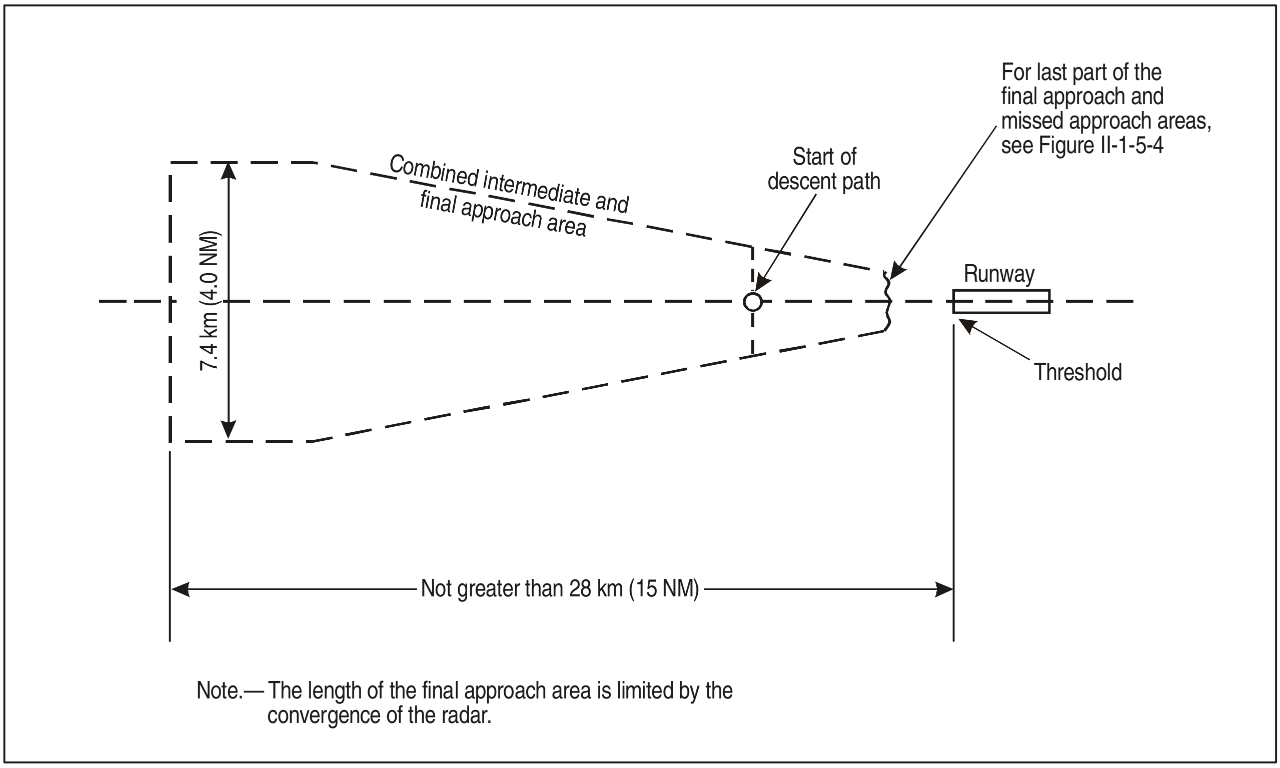


Figure II-1-5-3. Intermediate approach area precision approach radar

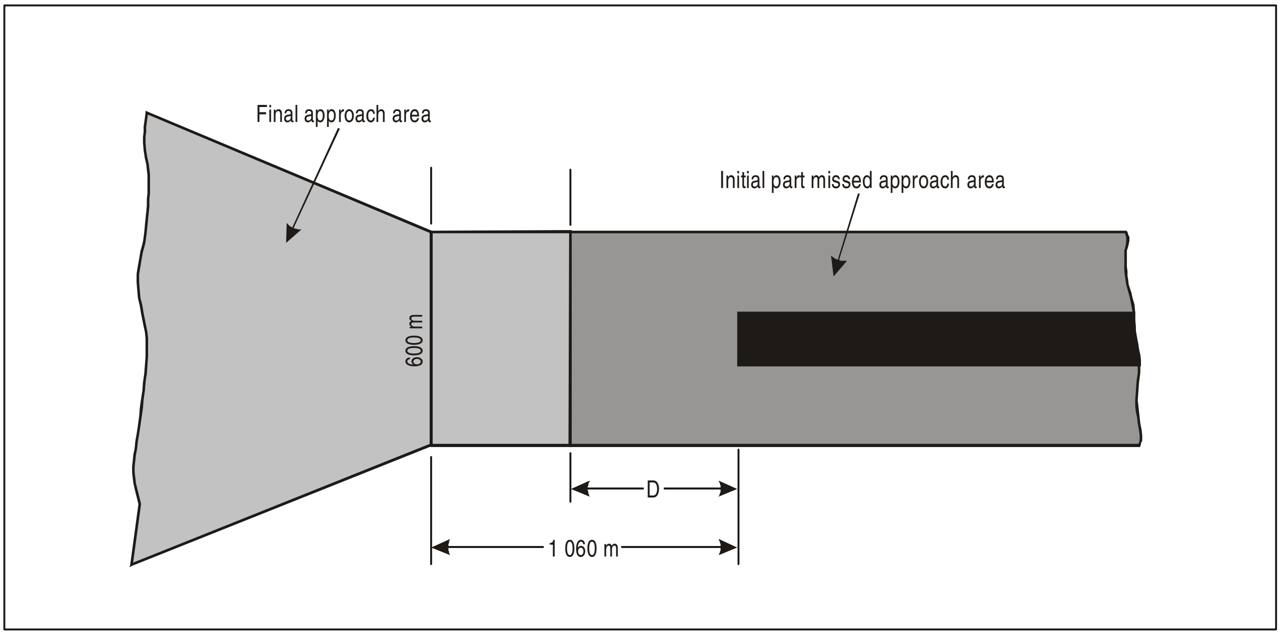


Figure II-1-5-4. Final and initial missed approach areas precision approach radar

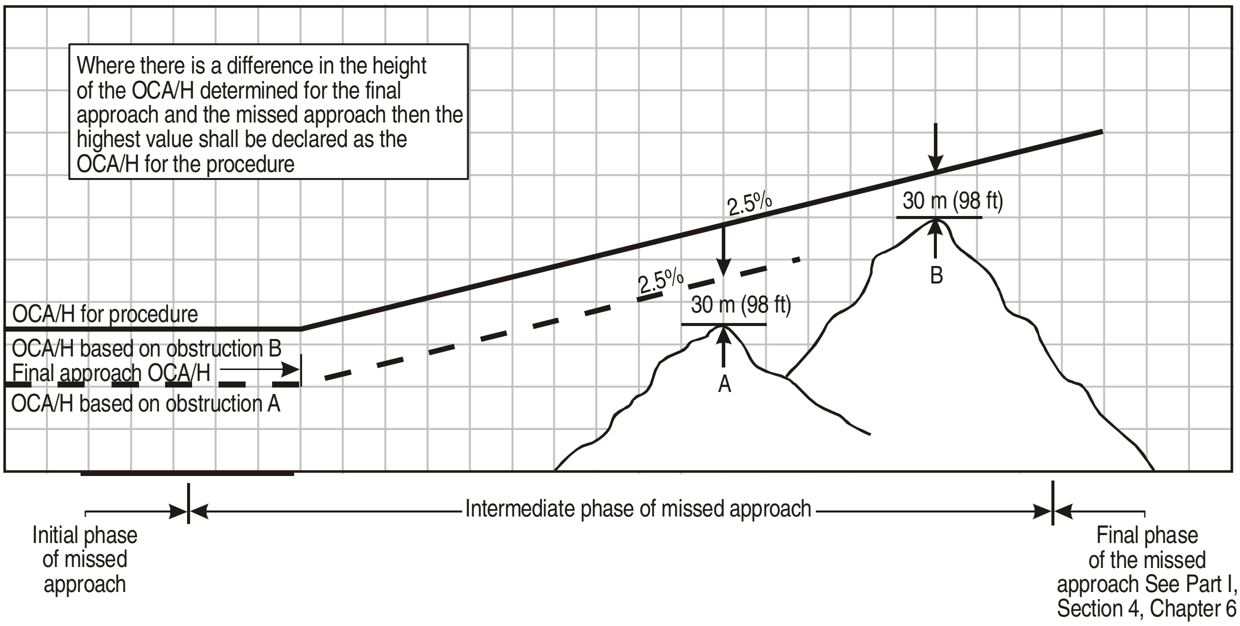


Figure II-1-5-5. Determination of missed approach OCA/H for PAR

Section 2

NON-PRECISION APPROACHES

Chapter 1

LLZ only

1.1 GENERAL

The localizer only procedure is a non-precision approach procedure. The general criteria apply with the following exceptions.

1.2 INTERMEDIATE APPROACH

The intermediate approach segment shall terminate at the FAF (outer marker or any fix meeting the FAF requirements). The width of the primary and secondary areas shall meet the criteria specified in Section 1, Chapter 1, 1.3.3, "Intermediate approach segment area width", the FAP being replaced by the FAF.

1.3 FINAL APPROACH SEGMENT

1.3.1 Beginning and end

The final approach segment shall start at the FAF. It shall terminate at the MAPt, which shall not be beyond the threshold.

1.3.2 Alignment

In general, the localizer antenna is sited on the runway centre line; nevertheless, in some cases this is not possible. In this case, the alignment of the final approach track with the runway centre line determines whether a straight-in or circling approach may be established. (See general criteria of Part I, Section 4, Chapter 5, 5.2, "Alignment".)

1.3.3 Areas

1.3.3.1 The final approach/initial missed approach area is defined by the outer edges of the OAS X surfaces appropriate to the ILS Category I procedure between the FAF and the distance where those edges reach a height 300 m (984 ft) above threshold level. After that point, the area shall be equal in width to the 300 m (984 ft) Y surface contour (see Figure II-2-1-1).

1.3.3.2 Where there is no glide path a 3° glide path angle shall be used when determining the 300 m (984 ft) OAS contour.

1.3.3.3 The X and Y surfaces mentioned above may be replaced by the approach and extended transitional surfaces defined in items a) and c) of Section 1, Chapter 1, 1.4.7.2, "Definition of basic ILS surfaces".

1.3.3.4 In the final approach and missed approach areas, those areas bounded by the lines joining points D, D”, E” and E are treated as secondary areas.

1.3.3.5 The final approach/initial missed approach areas terminate at the end of the transitional tolerance area as determined in the general criteria (see Part I, Section 4, Chapter 6; see also Part I, Section 2, Chapter 2, 2.6.4.2, “Use of 75 MHz marker beacon” and Part I, Section 4, Chapter 6, 6.1.6.2, “Determining SOC with an MAPt defined by a navigation facility or fix” for use of markers as missed approach points).

1.3.3.6 For turning missed approaches the general criteria in Part I, Section 4, Chapter 6, 6.4, “Turning missed approach” may be applied from the end of the transitional tolerance area.

1.3.3.7 The straight missed approach area is defined by the width of the 300 m (984 ft) Y surface contour to point E” (see Figure II-2-1-1) after which the splay increases to 15 degrees.

1.3.4 Obstacle clearance

The MOC is 75 m (246 ft) in the primary area, reducing to zero at the outer edges of the secondary areas. The general criteria apply except that obstacles in the secondary areas underlying the OAS Y surfaces are only considered if they penetrate those surfaces, in which case the required obstacle clearance is determined as in Part I, Section 2, Chapter 1, Figure I-2-1-3, and Figure II-2-1-2. See item b) in Part I, Section 4, Chapter 5, 5.4.5, “MOC and OCA/H adjustments” for increased MOC due to excessive length of final segment and Part I, Section 2, Chapter 1, 1.5, “Increased altitudes/heights for mountainous areas” regarding increased altitudes/heights for mountainous areas.

1.3.5 Descent gradient for an ILS procedure with glide path inoperative

This type of procedure is associated with glide path failure. Therefore it is recommended, when possible, to specify the same descent gradient for both the ILS procedure with glide path inoperative and the corresponding ILS procedure (see Annex 4, 11.10.8.5).

1.3.6 Promulgation

1.3.6.1 The general criteria in Part I, Section 2, Chapter 1, 1.10, “Promulgation” apply. The instrument approach chart for a localizer-only approach procedure shall be identified by the title LLZ RWY XX. If the localizer-only approach is published on the same chart as the ILS approach, the chart shall be entitled ILS or LLZ RWY XX. If a DME is required it shall be indicated in a note on the chart.

1.3.6.2 For promulgation of procedure altitudes/heights and the descent gradient/angle for an ILS procedure with glide path inoperative, see Part I, Section 4, Chapter 5, 5.5, “Promulgation”.

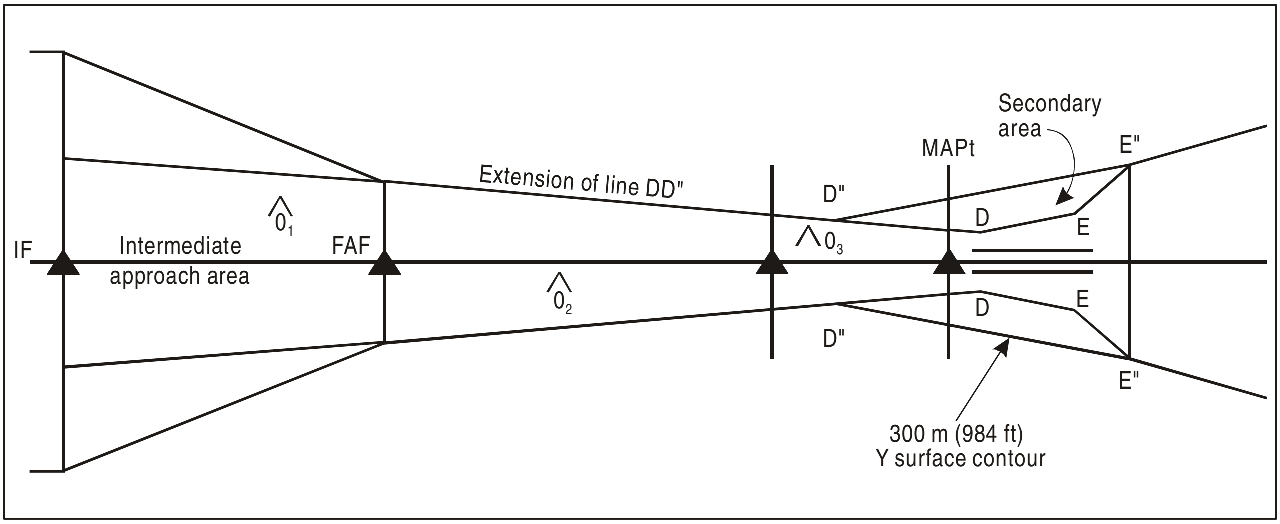


Figure II-2-1-1. Localizer-only procedure — areas

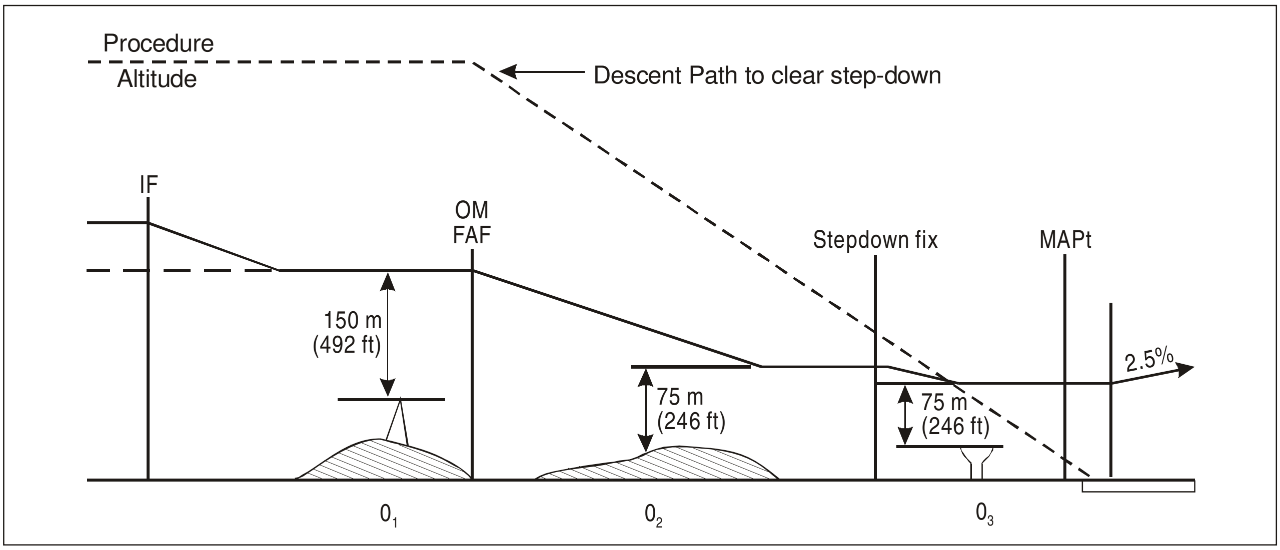


Figure II-2-1-2. Localizer-only procedure — obstacle clearance and procedure altitude

Chapter 2

MLS AZIMUTH ONLY

2.1 GENERAL

The azimuth-only procedure is a non-precision approach procedure. The general criteria apply with the following exceptions.

2.2 INTERMEDIATE APPROACH

The intermediate approach segment shall terminate at the FAF (outer marker or any fix meeting the FAF requirements). The width of the primary and secondary areas shall meet the criteria specified in Section 1, Chapter 3, 3.3.4, "Intermediate approach segment area width", the FAP being replaced by the FAF.

2.3 FINAL APPROACH SEGMENT

2.3.1

The final approach segment shall start at the FAF. It shall terminate at the MAPt, which shall not be beyond the threshold.

2.3.2 Alignment

In general, the azimuth antenna is sited on the runway centre line; nevertheless, in some cases this is not possible. In this case, the alignment of the final approach track with the runway centre line determines whether a straight-in or circling approach may be established (see general criteria of Part I, Section 4, Chapter 5, 5.2, "Alignment").

2.3.3 Areas

2.3.3.1 The final approach/initial missed approach area is defined by the outer edges of the ILS OAS X surfaces appropriate to the MLS Category I procedure from the FAF to the range where those edges reach a height 300 m (984 ft) above threshold level. After that range the area shall be equal in width to the 300 m (984 ft) Y surface contour (see Figure II-2-2-1).

2.3.3.2 Where there is no glide path a 3° glide path angle shall be used when determining the 300 m (984 ft) OAS contour.

2.3.3.3 The X and Y surfaces may be replaced by the approach and extended transitional surfaces defined in items a) and c) of Section 1, Chapter 3, 3.4.7.2, "Definition of basic ILS surfaces".

2.3.3.4 In the final approach and missed approach areas, those areas bounded by the lines joining points D, D”, E” and E are treated as secondary areas.

2.3.3.5 The final approach/initial missed approach areas terminate at the end of the transitional tolerance area as determined in the general criteria (see Part I, Section 4, Chapter 6; see also Part I, Section 2, Chapter 2, 2.6.4.2, “Use of 75 MHz marker beacon” and Part I, Section 4, Chapter 6, 6.1.6.2, “Determining SOC with an MAPt defined by a navigational facility or fix” for use of markers as missed approach points).

2.3.3.6 For turning missed approaches the general criteria in Part I, Section 4, Chapter 6, 6.4, “Turning Missed Approach” may be applied from the end of the transitional tolerance area.

2.3.3.7 The straight missed approach area is defined by the width of the 300 m (984 ft) Y surface contour to point E” (see Figure II-2-2-1) after which the splay increases to 15 degrees.

2.3.4 Obstacle clearance

The MOC is 75 m (246 ft) in the primary area, reducing to zero at the outer edges of the secondary areas. The general criteria apply except that obstacles in the secondary areas underlying the OAS Y surfaces are only considered if they penetrate those surfaces, in which case the required obstacle clearance is determined as in Part I, Section 2, Chapter 1, Figure I-2-1-3, and Figure II-2-2-2. See item b) in Part I, Section 4, Chapter 5, 5.4.6, “MOC and OCA/H adjustments” for increased MOC due to excessive length of final segment and Part I, Section 2, Chapter 1, 1.5, “Increased altitudes/heights for mountainous areas” regarding increased altitudes/heights for mountainous areas.

2.3.5 Descent gradient for an MLS procedure with glide path inoperative

This type of procedure is associated with glide path failure. Therefore it is recommended, when possible, to specify the same descent gradient for both the MLS procedure with glide path unserviceable and the corresponding MLS procedure (see Annex 4, 11.10.8.5).

2.4 PROMULGATION

2.4.1 The general criteria in Part I, Section 2, Chapter 1, 1.10, “Promulgation” apply. The instrument approach chart for an azimuth-only approach procedure shall be identified by the title LLZ Rwy XX. If the azimuth-only approach is published on the same chart as the MLS approach, the chart shall be entitled MLS or LLZ Rwy XX. If a DME is required it shall be indicated in a note on the chart.

2.4.2 For promulgation of procedure altitudes/heights and the descent gradient/angle for an MLS procedure with azimuth-only, see Part I, Section 4, Chapter 5, 5.5, “Promulgation”.

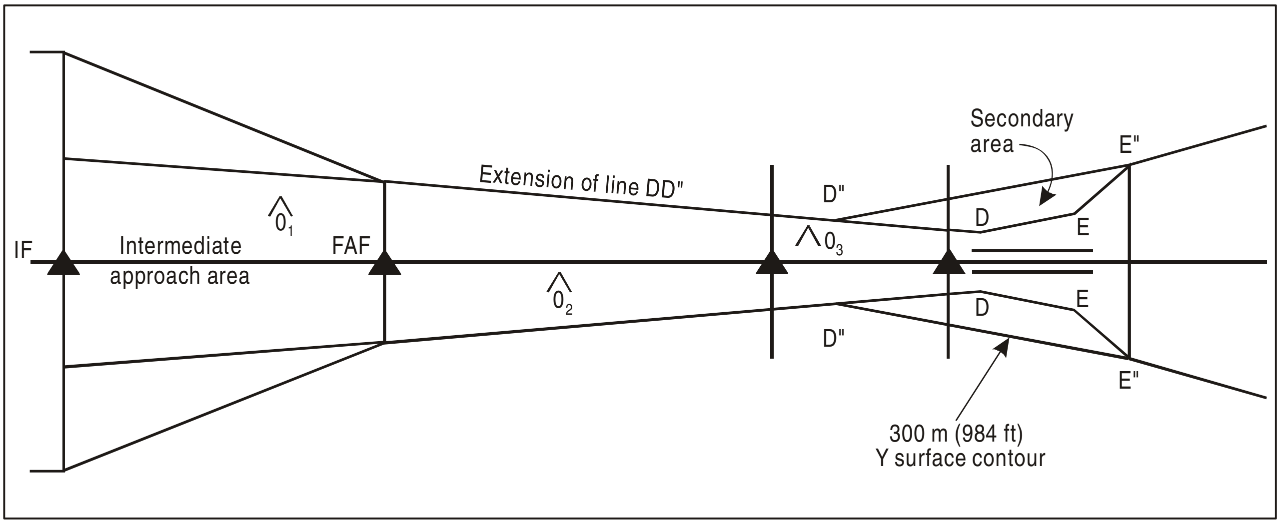


Figure II-2-2-1. Azimuth-only procedure — areas

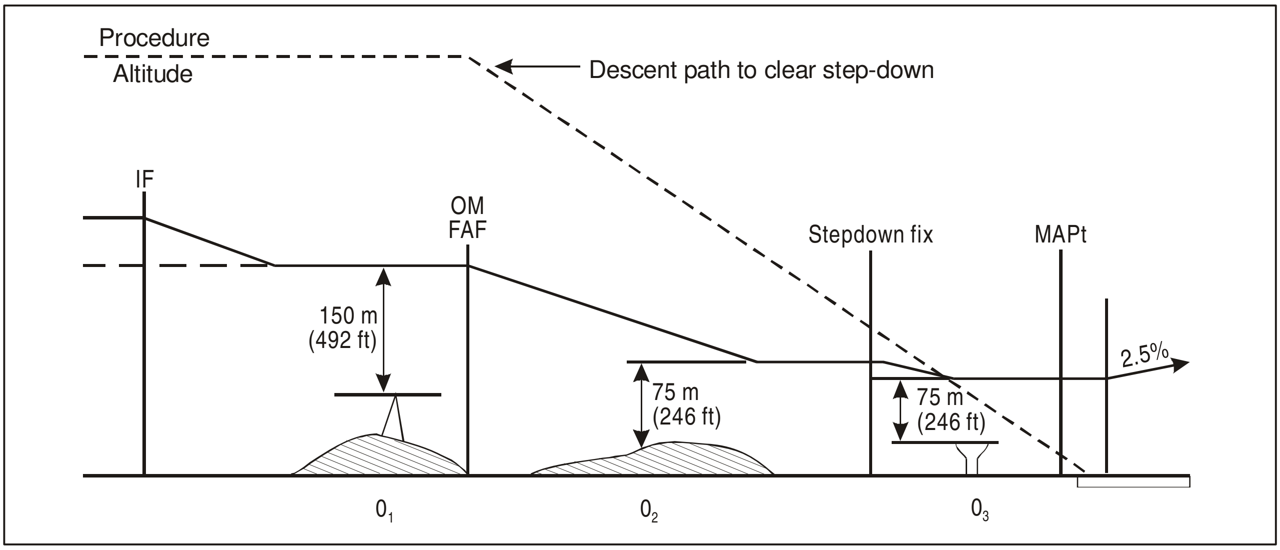


Figure II-2-2-2. Azimuth-only procedure — obstacle clearance and procedure altitude

Chapter 3

VOR OR NDB WITH NO FAF

Note.— A no-FAF instrument approach procedure does not easily support a stable final approach descent profile and therefore may contribute to unstabilized flight profiles. Therefore, the development of approach procedures in this chapter are not encouraged, and shall only be considered when a specific need to accommodate non-RNAV equipped aircraft exists.

3.1 GENERAL

This chapter deals with the specific criteria of procedures based on a VOR or NDB facility located on an aerodrome in which no FAF is established. An on-aerodrome facility is one which is located within 1.9 km (1.0 NM) of the nearest portion of the usable landing surface. These procedures must incorporate a reversal or racetrack procedure. The general criteria in Part I, Sections 1, 2 and 4 apply as amplified or modified herein.

3.2 INITIAL APPROACH SEGMENT

The initial approach fix (IAF) is defined by overheading the navigation facility. The initial approach is a reversal or racetrack procedure.

3.3 INTERMEDIATE SEGMENT

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

3.4 FINAL APPROACH SEGMENT

3.4.1 General

The final approach begins where the reversal or racetrack procedure intersects the final approach track inbound.

3.4.2 Alignment

The alignment of the final approach track with the runway centre line determines whether a straight-in or circling approach may be established (see Part I, Section 4, Chapter 5, 5.2, “Alignment”).

3.4.3 Area

3.4.3.1 Figure II-2-3-1 illustrates the final approach primary and secondary areas. The area is longitudinally centred on the final approach track. For VOR or NDB on-aerodrome procedures where there is no FAF a reversal or racetrack procedure must be executed before the final approach and the final approach area shall extend to the far boundary of the area for reversal or racetrack procedure.

3.4.3.2 *VOR Area*

The final approach area is 3.7 km (2.0 NM) wide at the facility and splays at an angle of 7.8° on either side. A secondary area, comprising 25 per cent of the total width, lies on each side of the primary area, which comprises 50 per cent of the total (see Part I, Section 2, Chapter 1, 1.2, “Areas”).

3.4.3.3 *NDB Area*

The area is 4.6 km (2.5 NM) wide at the facility and splays at an angle of 10.3° on either side. A secondary area, comprising 25 per cent of the total width lies on each side of the primary area, which comprises 50 per cent of the total (see Part I, Section 2, Chapter 1, 1.2, “Areas”).

3.4.4 Obstacle clearance

3.4.4.1 *Straight-in approach*

The minimum obstacle clearance in the primary area is 90 m (295 ft). In the secondary area 90 m (295 ft) of obstacle clearance shall be provided at the inner edge, reducing uniformly to zero at the outer edge.

3.4.4.2 *Circling approach*

3.4.4.2.1 Obstacle clearance in the visual manoeuvring (circling) area shall be as prescribed in Part I, Section 4, Chapter 7, Table I-4-7-3 (see also Part I, Section 4, Chapter 5, 5.4.4, “OCA/H for visual manoeuvring (circling)” for OCA/H calculation).

3.4.4.2.2 A circling approach is not prescribed for helicopters. When the final approach track alignment does not meet the criteria for a straight-in landing, the helicopter must manoeuvre visually to join the FATO axis. The track alignment should ideally be made to the centre of the FATO. In exceptional cases it may be aligned to a point in space.

3.5 DESCENT GRADIENT

The descent gradient relates to the length of time specified for the reversal or racetrack procedure. Criteria in Part I, Section 4, Chapter 3, 3.7.1, “General” apply to the initial segment. Rates of descent in the final approach phase are given in Part I, Section 4, Chapter 5, 5.3, “Descent gradient”.

3.6 USE OF STEPDOWN FIX

3.6.1 The use of a stepdown fix (Part I, Section 2, Chapter 2, 2.7.3) is permitted. Where a stepdown fix is provided then the obstacle clearance may be reduced to 75 m (246 ft) between the stepdown fix and the MAPt so long as the distance from the fix to the threshold does not exceed 11 km (6 NM). See Figure II-2-3-2.

3.6.2 If the distance from the fix to the threshold exceeds 11 km (6 NM), obstacle clearance penalties will be incurred (see Part I, Section 4, Chapter 5, 5.4.5.2 b), "Excessive length of final approach").

3.7 MISSED APPROACH POINT (MAPt)

The MAPt is located at the facility or defined by an adequate fix. The missed approach area shall commence at the MAPt.

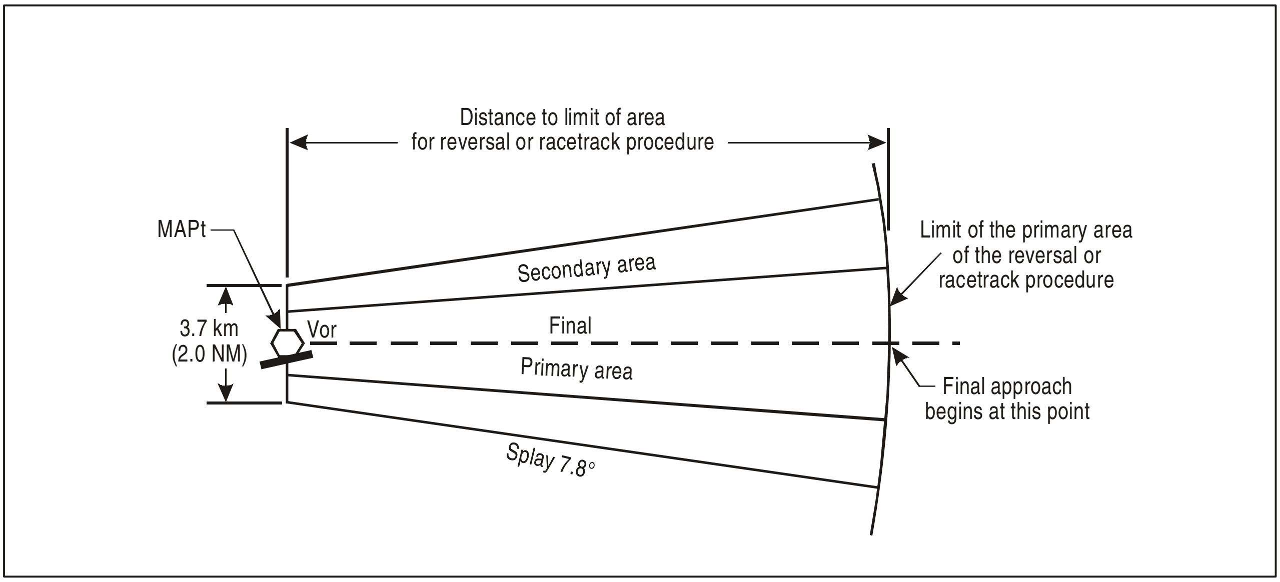


Figure II-2-3-1. Final approach area (VOR)

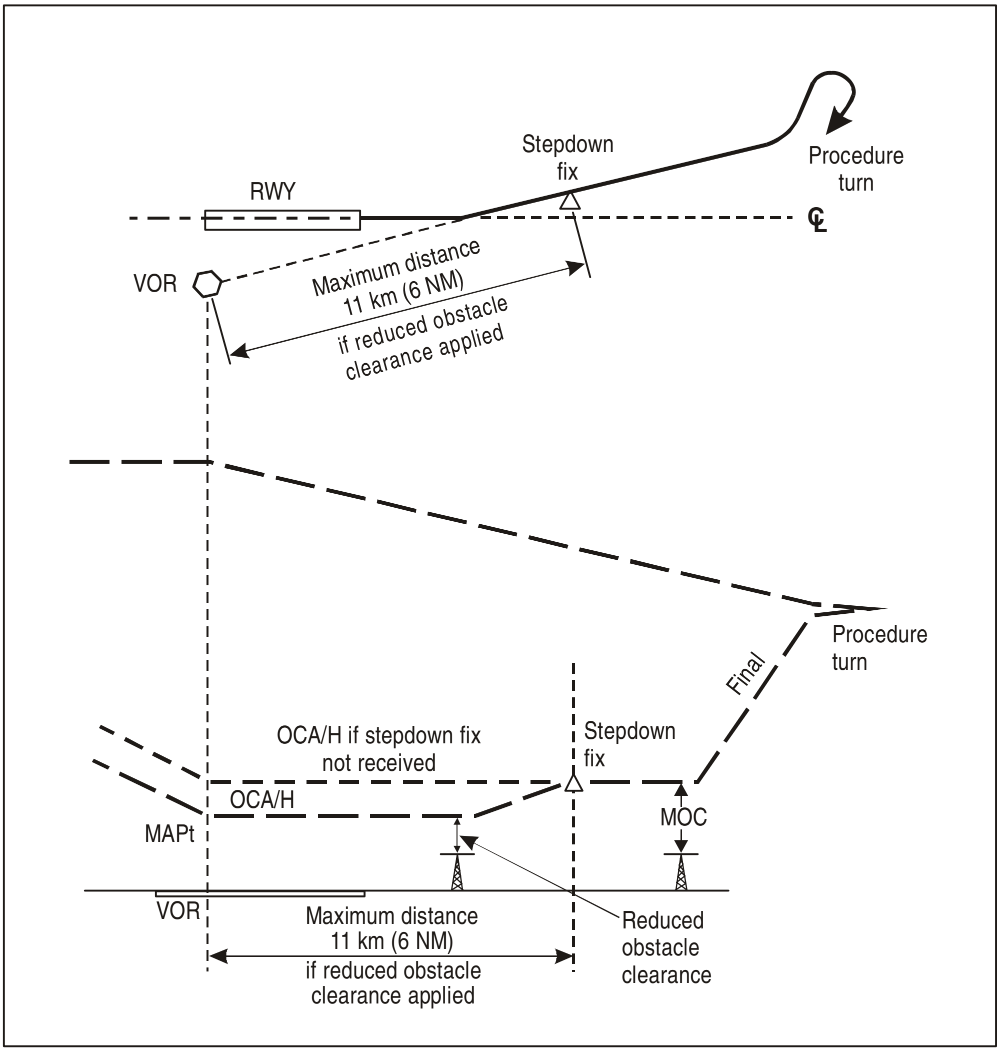


Figure II-2-3-2. Stepdown fix with dual OCA/H

Chapter 4

VOR or NDB with FAF

4.1 GENERAL

This chapter deals with the specific criteria of procedures based on a VOR or an NDB facility in which a FAF is incorporated. The general criteria in Part I, Sections 1, 2 and 4 apply, as amplified or modified herein.

4.2 INITIAL APPROACH SEGMENT

The general criteria in Part I, Section 4, Chapter 3 apply.

4.3 INTERMEDIATE APPROACH SEGMENT

The general criteria in Part I, Section 4, Chapter 4 apply.

4.4 FINAL APPROACH SEGMENT

4.4.1 The final approach may be made either "from" or "toward" the VOR. The final approach segment begins at the FAF and ends at the MAPt. See Figures II-2-4-1, II-2-4-2 and II-2-4-3 for typical approach segments.

4.4.2 Alignment

The alignment of the final approach track with the runway centre line determines whether a straight-in or circling only approach may be established. (See Part I, Section 4, Chapter 5, 5.2, "Alignment")

4.4.3 Descent gradient

4.4.3.1 The descent gradient criteria of Part I, Section 4, Chapter 5, 5.3, "Descent gradient" apply.

4.4.3.2 *Profile descent with DME.* Where a DME is suitably located, it may be used to define the distance/height relationship for the descent path angle required. This information may be published on the appropriate approach chart, preferably in increments of 2 km (1 NM).

4.4.4 Area

4.4.4.1 The area considered for obstacle clearance in the final approach segment starts at the FAF and ends at the MAPt. It is a portion of a 37 km (20 NM) (NDB: 28 km (15 NM)) long trapezoid which is made up of primary and secondary areas. The area is centred longitudinally on the final approach track. It is 3.7 km (2.0 NM) wide at the facility and splays uniformly at an angle of 7.8° either side of the area to 37 km (20 NM) from the VOR (28 km (15 NM) from the NDB). The inner 50 per cent of the area is the primary area, while the outer 25 per cent on each side of the primary area is the secondary area.

4.4.4.2 Final approach may be made to aerodromes which are a maximum of 37 km (20 NM) from the VOR (28 km (15 NM) from the NDB). However, only that portion of the 37 km (20 NM) (NDB: 28 km (15 NM)) trapezoid which falls between the FAF and the MAPt shall be considered as the final approach segment for obstacle clearance purposes. See Figure II-2-4-4.

4.4.4.3 The optimum length of the final approach segment is 9 km (5 NM) (Cat H, 3.7 km (2 NM)). The maximum length should not normally be greater than 19 km (10 NM) (see Part I, Section 4, Chapter 5, 5.4.5.2 b), "Excessive length of final approach" for excessive length consideration). The minimum length shall provide adequate distance for an aircraft to make the required descent, and to regain track alignment when a turn is required over the FAF. Table II-2-4-1 shall be used to determine the minimum length needed to regain the track after a turn over the FAF.

4.4.4.4 If the turn at the FAF is greater than 10° the final approach area should be widened on the outer side of the turn as specified in Part I, Section 4, Chapter 6, 6.4.6.3.2, "TP marked by a facility (NDB or VOR)".

4.4.5 Station providing track guidance

When more than one facility is on the final approach track, the facility to be used for track guidance for final approach shall be clearly identified.

4.4.6 Obstacle clearance

4.4.6.1 *Straight-in approach.* The minimum obstacle clearance in the primary area is 75 m (246 ft). In the secondary area 75 m (246 ft) of clearance shall be provided over all obstacles at the inner edge, tapering uniformly to zero at the outer edge. See Part I, Section 4, Chapter 5, 5.4.5.2 b), "Excessive length of final approach" for increased MOC due to excessive length of final segment and Part I, Section 2, Chapter 1, 1.7, "Increased altitudes/heights for mountainous areas".

4.4.6.2 *Circling approach.* Obstacle clearance in the visual manoeuvring area shall be as described in Part I, Section 4, Chapter 7, "Visual manoeuvring (circling) area".

4.5 MISSED APPROACH POINT (MAPt)

4.5.1 Off-aerodrome facility — Straight-in approach

The MAPt is located at a point on the final approach track which is not farther from the FAF than the threshold. See Figure II-2-4-4.

4.5.2 Off-aerodrome facility — Circling approach

The MAPt is located at a point on the final approach track which is not farther from the FAF than the first usable portion of the landing surface.

4.5.3 On-aerodrome facility

The MAPt is located at a point on the final approach track which is not farther from the FAF than the facility.

4.6 PROMULGATION

The general criteria in Part I, Section 2, Chapter 1, 1.10, "Promulgation" apply. The instrument approach chart for a VOR approach procedure shall be identified by the title VOR RWY XX. If a DME is required it shall be indicated in a note on the chart. When a DME has been used to obtain lower minima, no additional note is required as this shall be shown in the minimum boxes. If a DME is used to define the distance/height relationship for a profile descent, the information shall be published on the chart, preferably in increments of 2 km (1 NM). If separate approach charts are published for different aircraft categories, the Duplicate Procedure Title convention shall be applied, with the approach having the lowest minima being identified as ILS RWY XX, LLZ RWY XX, VOR Z RWY XX, NDB Y RWY XX, etc. A note shall be included on the chart detailing the applicable aircraft categories.

Table II-2-4-1. Minimum length of final approach segment after a turn over the FAF

Aircraft category	*Magnitude of turn over FAF*			
	10°	*20°*	*30°*	*60°*
A	1.9 km (1.0 NM)	2.8 km (1.5 NM)	3.7 km (2.0 NM)	—
B	2.8 km (1.5 NM)	3.7 km (2.0 NM)	4.6 km (2.5 NM)	—
C	3.7 km (2.0 NM)	4.6 km (2.5 NM)	5.6 km (3.0 NM)	—
D	4.6 km (2.5 NM)	5.6 km (3.0 NM)	6.5 km (3.5 NM)	—
E	5.6 km (3.0 NM)	6.5 km (3.5 NM)	7.4 km (4.0 NM)	—
H	1.9 km (1.0 NM)	2.8 km (1.5 NM)	3.7 km (2.0 NM)	5.6 km (3.0 NM)

This table may be interpolated. If turns of more than 30° (Cat H, 60°) are required, or if the minimum lengths specified in the table are not available for the procedure, straight-in minimums are not authorized.

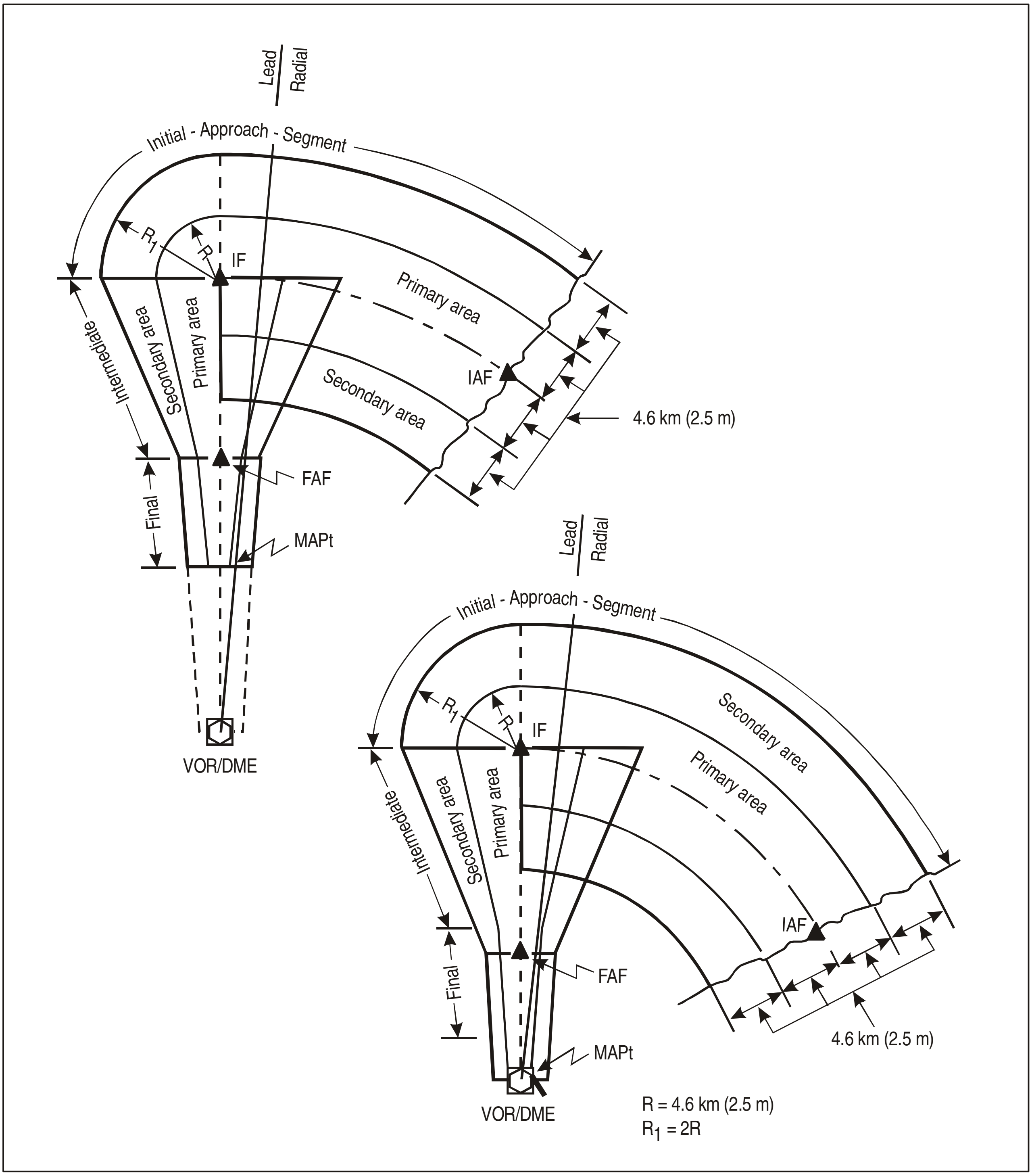


Figure II-2-4-1. Typical approach segments (with DME arcs)

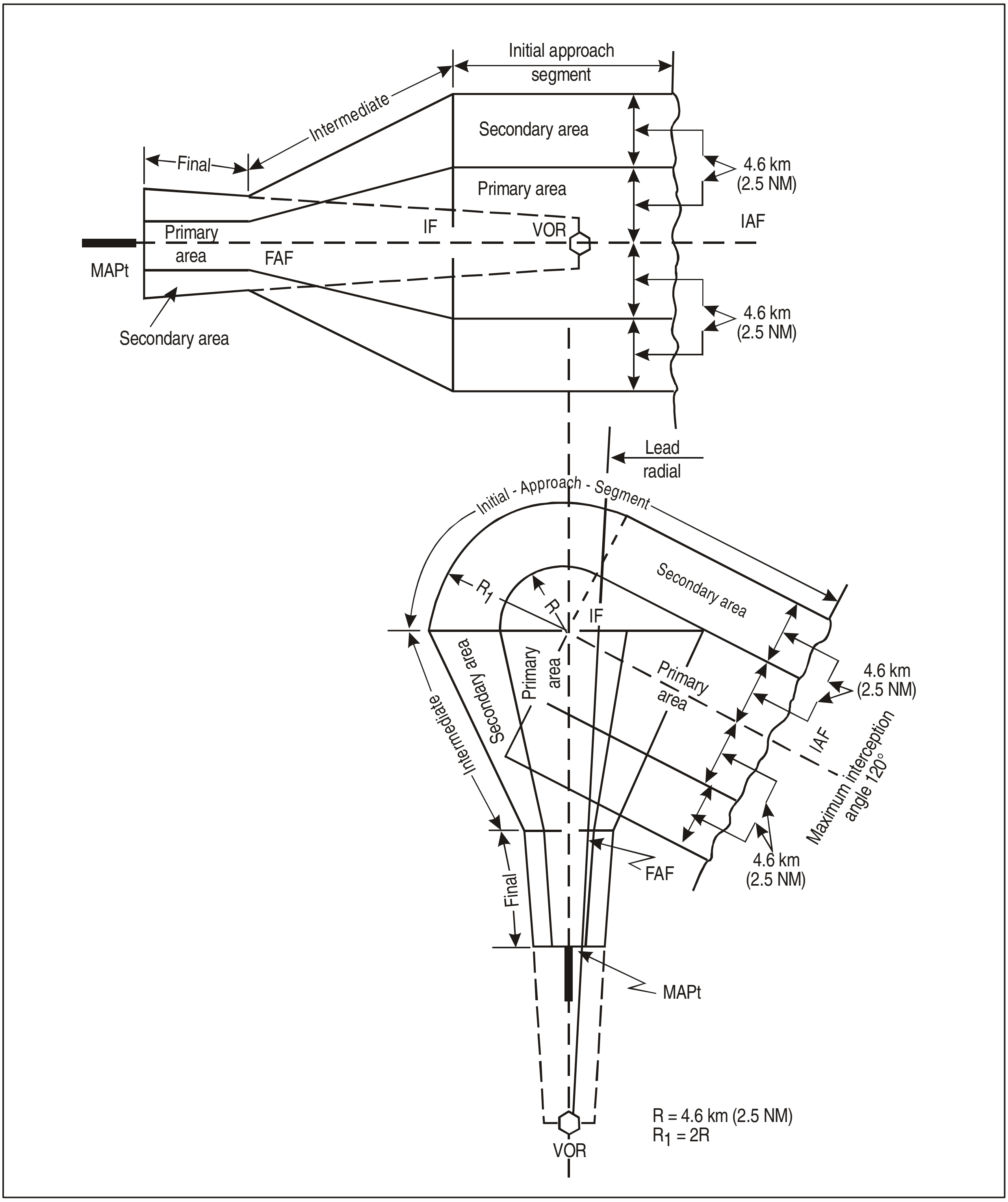


Figure II-2-4-2. Typical approach segments (straight and >90° turn)

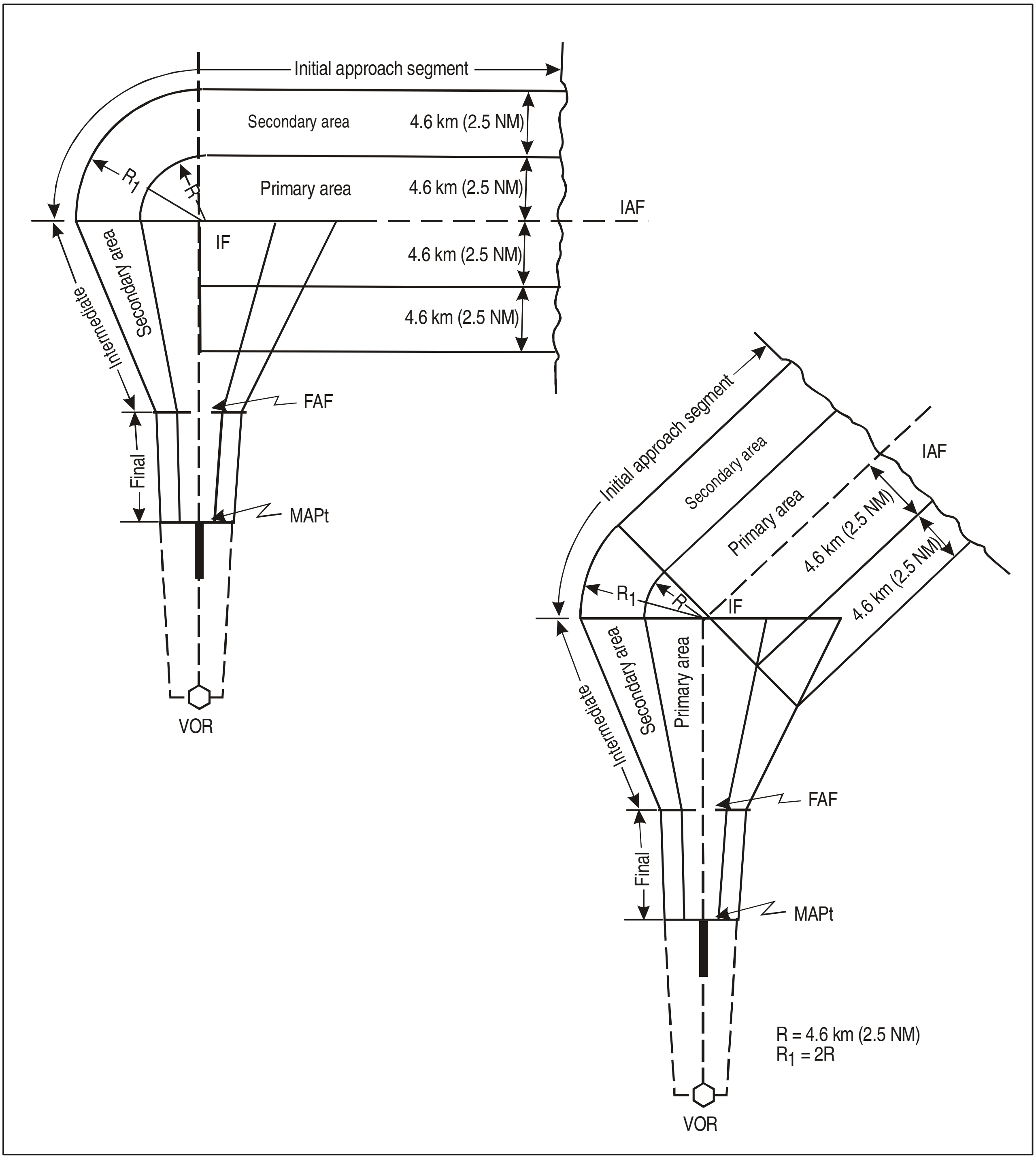


Figure II-2-4-3. Typical approach segment (45° and 90° turns)

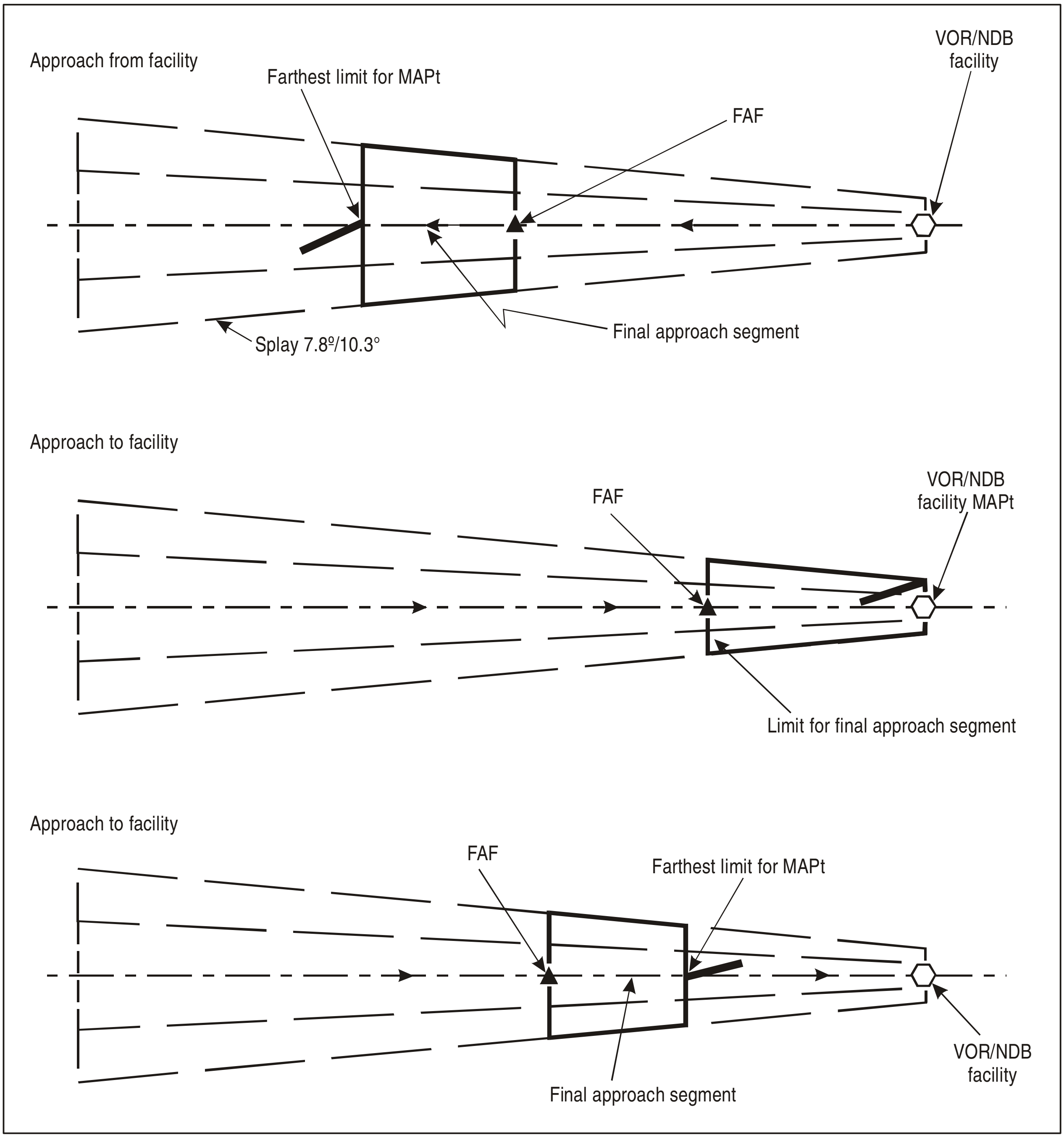


Figure II-2-4-4. Final approach segment (VOR/NDB)

Chapter 5

DF

5.1 GENERAL

This chapter deals with the specifics of procedures based on a very high frequency direction-finding (VDF) station located on or close to an aerodrome, that is, within 2 km (1 NM) of the nearest portion of the usable landing surface. These procedures must incorporate a base turn (see Part I, Section 4, Chapter 3, 3.5.4, “Types of reversal procedures”). The general criteria in Part I, Sections 1, 2 and 4 apply, as amplified or modified herein.

5.2 DESCENT GRADIENT

The rates of descent in the initial and final approach segments shall be as specified in Part I, Section 4, Chapter 3, Table I-4-3-1.

5.3 INITIAL APPROACH SEGMENT

5.3.1 General

5.3.1.1 The initial approach fix (IAF) is received by overheading the navigation facility. The initial approach is a base turn.

5.3.1.2 *Time of flight outbound.* The time of flight outbound should be limited to the period sufficient to ensure that the base turn is completed at a distance which permits descent from the base turn altitude/height to the MDA/H specified.

Note.— The angle between the outbound and inbound tracks is determined by the formula 36/t for Category A and B and 54/t for Category C, D, and E aircraft, where t is the outbound specified time expressed in minutes. The outbound track should be sufficient to ensure that at least 2 minutes are allowed inbound to permit proper establishment of track.

5.3.2 Area

The area is a sector of a circle centred on the navigation facility, symmetrical about the bisector of the inbound and outbound tracks, with an angle of:

a) 20° + 36/t for Category A and B; and

b) 20° + 54/t for Category C, D and E aircraft,

having a radius D for all aircraft.

D is described by the following equation:

$$D = (\frac{V}{60} + 1.9)t + 2.8 \text{ km}$$

$$[D = (\frac{V}{60} + 1.0)t + 1.5 \text{ NM}]$$

where: D = the radius in km [NM]

V = true aircraft speed in km/h [kt]

t = outbound time in minutes.

This sector shall be extended in all directions by a margin of 3.7 km (2.0 NM). (See Figure II-2-5-1.)

5.3.3 Obstacle clearance in the initial approach

The obstacle clearance in the initial approach area shall be 300 m (984 ft).

5.4 INTERMEDIATE SEGMENT

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

5.5 FINAL APPROACH SEGMENT

5.5.1 General

The final approach begins where the base turn intersects the final approach track inbound.

5.5.2 Alignment

5.5.2.1 The alignment of the final approach track with respect to:

a) the facility;

b) the runway centre line; and

c) the runway threshold,

will determine whether a straight-in or circling approach may be established. (See Part I, Section 4, Chapter 5, 5.2, "Alignment".)

5.5.2.2 *Alignment — Helicopter procedures.* When the final approach track alignment of a helicopter procedure does not meet the criteria for a straight-in landing, the helicopter must be manoeuvred visually to join the FATO axis. Track alignment should ideally be made to the centre of the FATO. In exceptional cases it may be aligned to a point in space.

5.5.3 Area

Figure II-2-5-2 illustrates the final approach area. There are no secondary areas. The area is symmetrical about the final approach track. It is 5.6 km (3.0 NM) wide at the facility and expands at an angle of 10° either side. It extends to the far boundary of the base turn area.

5.5.4 Obstacle clearance in the final approach

5.5.4.1 *Straight-in.* The minimum obstacle clearance in the final approach area is 90 m (295 ft). See Part I, Section 4, Chapter 5, 5.4.5.2 b), "Excessive length of final approach" for increased MOC due to excessive length of final segment and Part I, Section 2, Chapter 1, 1.7, "Increased altitudes/heights for mountainous areas".

5.5.4.2 *Visual manoeuvring (circling).* In addition to the minimum requirement specified in 5.5.4.1 above, obstacle clearance in the visual manoeuvring (circling) area shall be as prescribed in Part I, Section 4, Chapter 7, "Visual manoeuvring (circling) area".

5.6 MISSED APPROACH SEGMENT

The MAPt is located at the facility. The missed approach area shall commence at the MAPt. The longitudinal tolerance of the MAPt area shall be calculated as in Part I, Section 4, Chapter 6, "Missed approach segment" and for the purpose of this calculation, the FAF tolerance error shall be ± 1.9 km (1.0 NM).

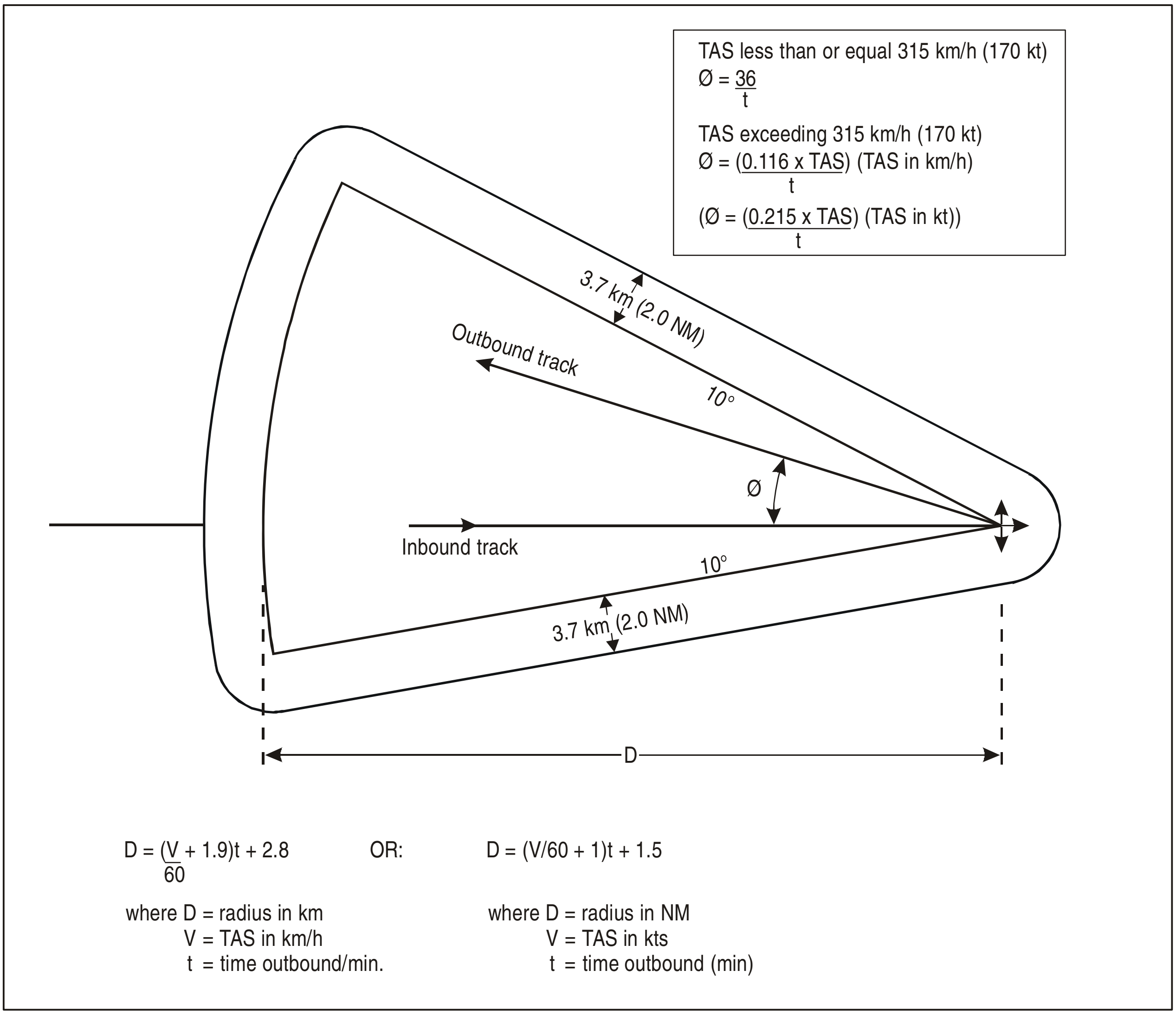


Figure II-2-5-1. D/F facility (on or close to an aerodrome)

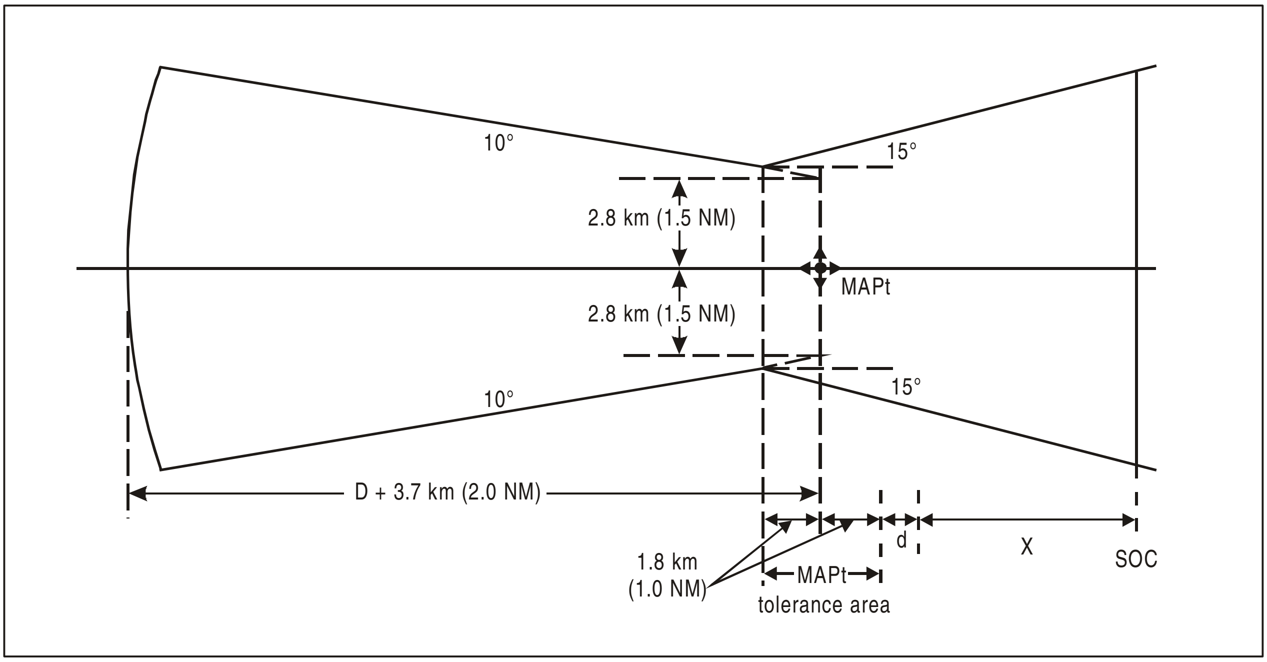


Figure II-2-5-2. Final approach area

Chapter 6

SRE

6.1 GENERAL

Surveillance radar may be used to provide primary navigation guidance within the operational coverage of the radar. Straight-in and circling approaches may be authorized to aerodromes where the quality of radar coverage and target resolution are adequate to support the procedure (see Figure II-2-6-1).

Note.— Detailed procedures regarding the use of primary radar in the approach control service are set forth in the PANS-ATM, Doc 4444, Procedures for Air Navigation Services — Air Traffic Management.

6.2 INITIAL APPROACH SEGMENT

6.2.1 General

The initial segment begins at the initial approach fix (IAF), which is defined as the position at which radar contact with the aircraft for the purpose of executing an approach has been established. It ends at the IF. In this segment, radar vectoring may be provided along predetermined tracks (6.2.2) or on a tactical basis (6.2.3).

Note.— See the PANS-ATM, Chapter 12, for identification procedures.

6.2.2 Procedures based on predetermined tracks

The establishment of radar procedure patterns requires the following:

a) *Area.* The area width on each side of the predetermined radar track is 9.3 km (5.0 NM). The area has no specific maximum or minimum length; however, it should be long enough to permit the altitude loss required by the procedure at the authorized descent gradient.

   Note.— The width of the area may be reduced to 5.6 km (3.0 NM) on each side of the track within 37 km (20 NM) of the radar antenna depending upon the accuracy of the radar equipment, as determined by the appropriate authority. See the PANS-ATM, Chapter 12.

b) *Obstacle clearance.* A minimum of 300 m (984 ft) of clearance shall be provided over all obstacles in the initial approach area. Clearance over a prominent obstacle, if displayed as a permanent echo on the radar scope may be discontinued after the aircraft has been observed to pass the obstacle.

6.2.3 Procedures based on tactical vectoring

The following restrictions apply:

a) *Area.* The area considered for obstacle clearance shall be the entire area within the operational coverage of the radar. This area may be subdivided to gain relief from obstacles which are clear of the area in which flight is to be conducted. There is no prescribed limit on the size, shape or orientation of these subdivisions; however, in all cases the boundary of the subdivision must be located at a distance not less than 5.6 km (3 NM) from an obstacle which is to be avoided or from another area over which flights are prohibited. The subdivision boundaries are depicted on video map and designed to emphasize simplicity and safety in radar ATC application. (See note under 6.1.)

b) *Obstacle clearance.* A minimum of 300 m (984 ft) of clearance shall be provided over all obstacles within the area or approximate subdivision where subdivisions have been established. Levels established for use shall also provide 300 m (984 ft) of clearance over all obstacles within 5.6 km (3.0 NM) of the area boundary when up to 37 km (20 NM) from the radar antenna, or within 9.3 km (5.0 NM) of the boundary at distances greater than 37 km (20 NM) from the antenna.

c) *Minimum vectoring altitudes.* Minimum vectoring altitudes shall be corrected for cold temperature. The cold temperature shall be based on seasonal or annual minimum temperature records. See PANS-OPS, Volume I, Part III, Section 1, Chapter 4, Tables III-1-4-1 a) and b).

6.2.4 Descent gradients

The optimum descent gradient in the initial approach is 4.0 per cent (Cat H, 6.5 per cent). Where a higher descent rate is necessary, the maximum permissible gradient is 8.0 per cent (Cat H, 10 per cent).

6.3 INTERMEDIATE APPROACH SEGMENT

6.3.1 General

The intermediate segment begins at the radar fix where the initial approach track intersects the intermediate approach track. The point of intersection is the IF. The intermediate segment extends along the intermediate track inbound to the point where it intersects the final approach track. This point is the FAF.

6.3.2 Alignment

The intermediate track shall not differ from the final approach track by more than 30°.

6.3.3 Area

The width of the intermediate area is determined by the width of the initial area at the IF, tapering to the width of the final area at the FAF. The length of the intermediate segment shall not exceed 28 km (15 NM) (Cat H, 9.3 km (5 NM)). The optimum length of the intermediate segment is 9 km (5 NM) (Cat H, 3.7 km (2 NM)). The minimum length depends upon the angle at which it is intercepted by the initial approach track and is specified in Table II-2-6-1. However, these minimum values should be used *only* if usable airspace is restricted. The maximum angle of interception shall be 90°.

6.3.4 Obstacle clearance

A minimum of 150 m (500 ft) of clearance shall be provided over all obstacles in the intermediate area.

6.3.5 Descent gradient

Because the intermediate segment is used to prepare the aircraft speed and configuration for entry into the final approach segment, the gradient should be flat (Cat H, 6.5 per cent). Where a higher gradient is necessary the maximum permissible gradient is 5.0 per cent (Cat H, 10 per cent).

6.4 FINAL APPROACH SEGMENT

6.4.1 General

The final approach segment begins at the FAF, which is a radar fix on the final approach track.

6.4.2 Alignment

For straight-in approaches, the final approach track shall coincide with the extended runway centre line. For circling approaches, the final approach track shall be aligned to cross the aerodrome manoeuvring area or to intercept the downwind leg of the visual manoeuvring (circling) pattern.

6.4.3 Area

The area to be considered for obstacle clearance begins at the FAF and ends at the MAPt or the runway threshold whichever occurs last and is centred on the final approach track (see Figure II-2-6-2). The minimum length of the final approach area shall be 6 km (3 NM) (Cat H, 1.9 km (1 NM)). The length shall be established by taking account of the permissible descent gradient. See 6.4.5. The maximum length should not exceed 11 km (6 NM). Where a turn is required over the FAF, Table II-2-4-1 of Chapter 4 applies. The width of the area is proportional to the distance from the radar antenna, according to the following formula:

$$W/2 = (1.9 + 0.1\ D)\ \text{km}$$

$$[W/2 = (1.0 + 0.1\ D)\ \text{NM}]$$

where: W = width in km [NM]

D = distance from antenna to track in km [NM]

Maximum value for D is 37 km (20 NM) subject to the accuracy of the radar equipment as determined by the appropriate authority.

6.4.4 Obstacle clearance

The minimum obstacle clearance is 75 m (246 ft).

6.4.5 Descent gradient

The general criteria of Part III, Chapter 6, 6.3 apply.

6.4.6 Computation of altitudes/heights

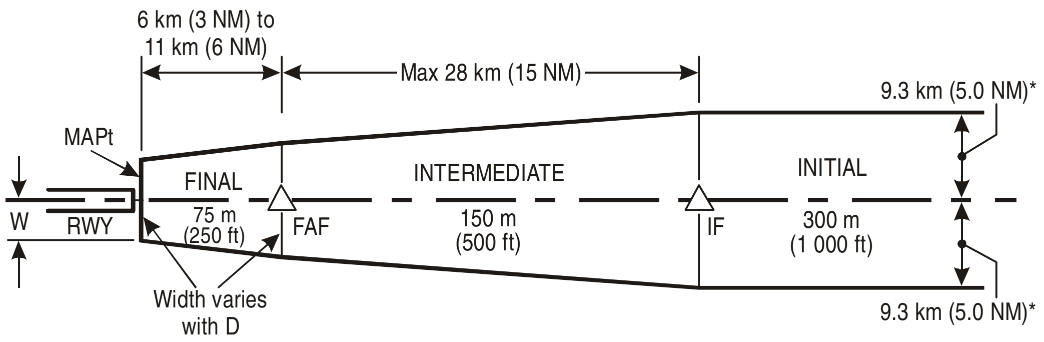
Altitudes/heights through which the aircraft should pass to maintain the required descent path should be computed for each 2 or 1 km (1 or 1/2 NM) from touchdown assuming a 15 m (50 ft) height at the runway threshold. The resultant altitudes/heights should be rounded out to whole 10 m or 100 ft increments, except for distances less than 4 km (2 NM) from touchdown, where they should be rounded up to the next whole 10 m or 10 ft increment as appropriate. Precomputed altitudes/heights should be available to the radar controller and published in aeronautical information publications.

6.5 MISSED APPROACH SEGMENT

A surveillance radar approach shall be terminated 4 km (2 NM) before the threshold, except that when approved by the appropriate authority, it may be continued to a point not later than the runway threshold when the accuracy of the radar permits. The missed approach point (MAPt) is located at the point where the radar approach terminates. See Figure II-2-6-3 and Part I, Section 4, Chapter 6 for missed approach criteria.

Table II-2-6-1. Minimum length of intermediate segment

Intercept angle with localizer (degrees)	*Minimum distance between localizer and glide path interceptions*	
	Cat A to E	Cat H
0 – 15	2.8 km (1.5 NM)	2.8 km (1.5 NM)
16 – 30	3.7 km (2.0 NM)	3.7 km (2.0 NM)
31 – 60	4.6 km (2.5 NM)	3.7 km (2.0 NM)
61 – 90	5.6 km (3.0 NM)	3.7 km (2.0 NM)



**Note.— The width of the area may be reduced to 5.6 km (3.0 NM) on each side of the track within 37 km (20 NM) of the radar antenna, depending upon the accuracy of the radar equipment, as determined by the appropriate authority. See PANS-ATM, Chapter 12.*

Figure II-2-6-1. Surveillance radar approach segments

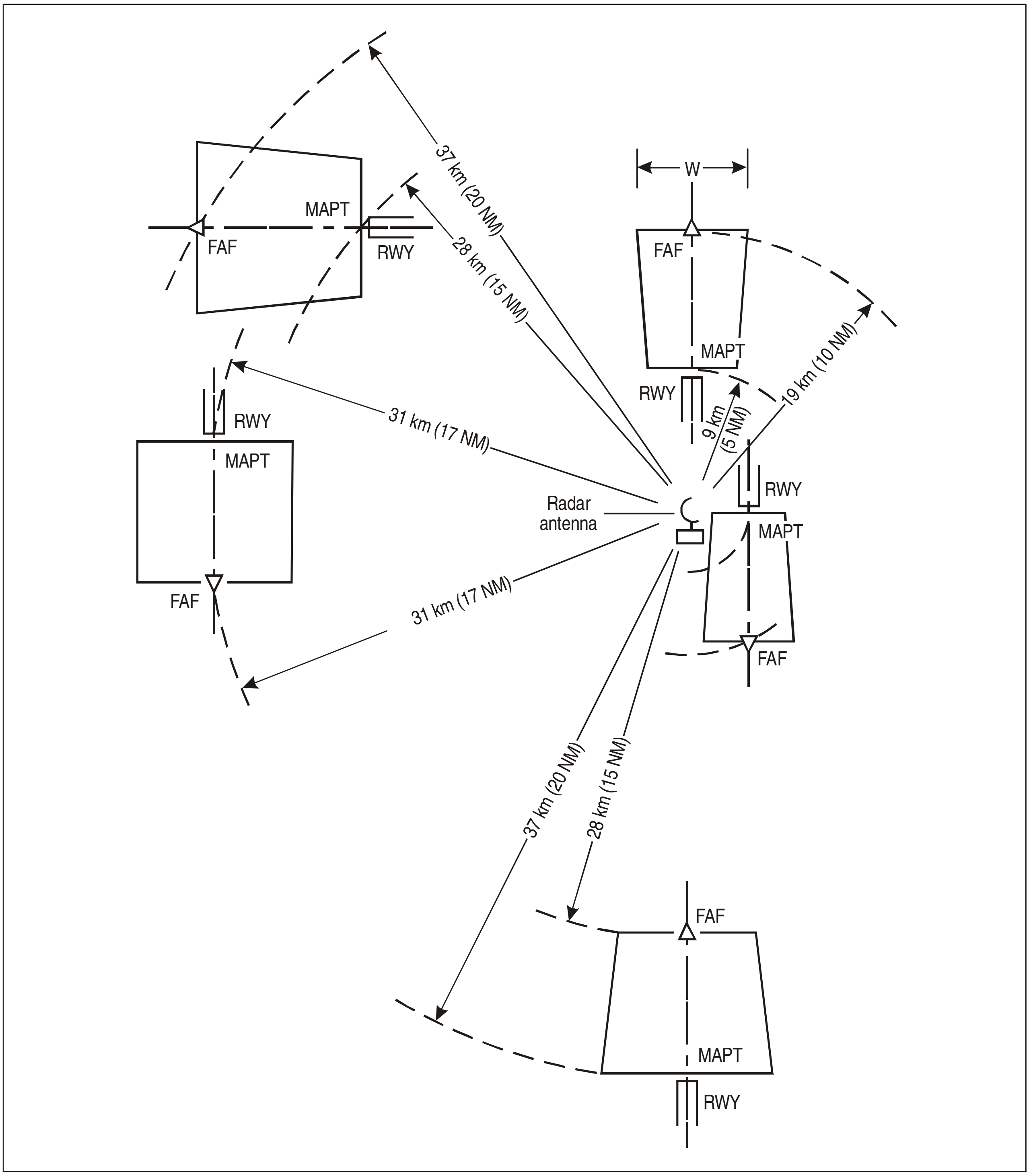


Figure II-2-6-2. Examples of surveillance radar final approach

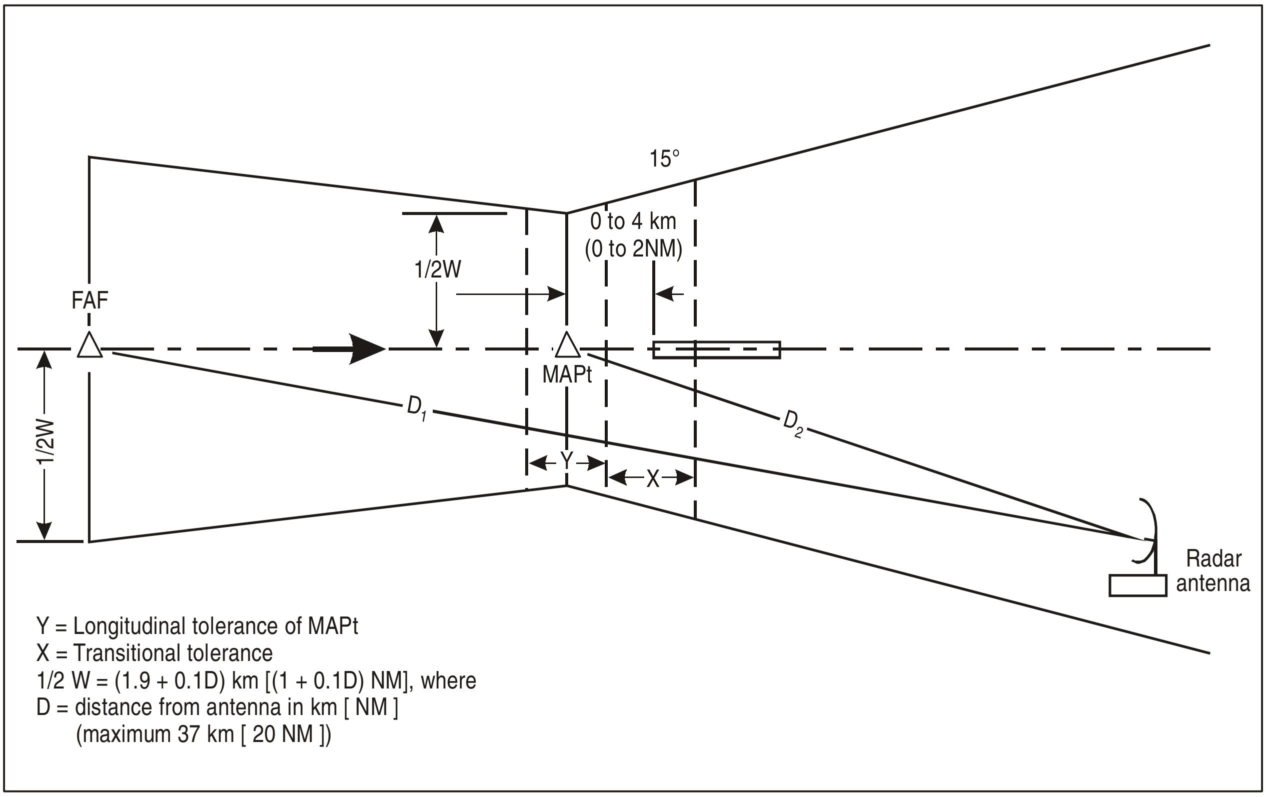


Figure II-2-6-3. Surveillance radar approach

Section 3

EN-ROUTE CRITERIA

Chapter 1

VOR AND NDB ROUTES

1.1 GENERAL

1.1.1 Scope

The areas associated with en-route criteria extend over very large surfaces; in some regions, the number of obstacles to consider is very high. Moreover, at crossing points, it may happen that several possibilities are offered to continue the flight, which can raise difficulties for the protection of all possible turns. For these reasons, two methods have been developed:

a) a simplified method, presented in this chapter and retained as the standard method; and

b) a refined method, described in Appendix A, which can be used when the simplified method is too constraining.

1.1.2 Segments

A route is generally composed of several segments. Each segment begins and ends at a designated fix.

1.2 OBSTACLE CLEARANCE AREAS

1.2.1 General

This section contains the description of the areas used for en-route obstacle clearance purposes.

1.2.2 Straight segment

The obstacle clearance areas consist of a primary area and a buffer area. The width of the primary and buffer areas is constant from their width abeam the facility until a specified distance from the system giving track. From this point, the areas splay as a function of the angular tolerance lines of the applicable facility, as described below in 1.4.2.3, "Angular limits". (See also Figure II-3-1-2 and Figure II-3-1-3.)

1.2.3 Area without track guidance

When track guidance is not provided, for example outside the coverage of navigation facilities along the route, the primary area splays each side at an angle of 15° from its width at the last point where track guidance was available. The width of the buffer area is progressively reduced to zero, ending in an area without track guidance where the full MOC is applied (see Figure II-3-1-8).

1.2.4 Maximum area width

There is no maximum area width for routes within the coverage of the facilities defining the route. Outside coverage of the facilities defining the route, the area splays each side at 15°, as specified above in 1.2.3, "Area without track guidance".

1.2.5 Turn area

The obstacle clearance areas consist of a primary area; no buffer areas are applied. Turn area construction is described in 1.4, "Construction of areas for VOR and NDB routes".

1.3 OBSTACLE CLEARANCE

1.3.1 Minimum obstacle clearance (MOC)

1.3.1.1 The minimum obstacle clearance value to be applied in the primary area for the en-route phase of an IFR flight is 300 m (984 ft). In the buffer area, the minimum obstacle clearance is equal to half the value of the primary area MOC (see Figure II-3-1-1).

1.3.1.2 A minimum altitude is determined and published for each segment of the route. Charting accuracies must be taken into account when establishing minimum altitudes by adding both a vertical and a horizontal tolerance to the depicted objects on the chart, as specified in Part I, Section 2, Chapter 1, 1.7, "Increased altitude/heights for mountainous areas".

1.3.2 MOC in mountainous areas

1.3.2.1 In mountainous areas, the MOC shall be increased, depending on variation in terrain elevation as shown in the table below. The MOC in the buffer area is half the value of the primary area MOC (see Figure II-3-1-1).

Elevation	*MOC*
Between 900 m (3 000 ft) and 1 500 m (5 000 ft)	450 m (1 476 ft)
Greater than 1 500 m (5 000 ft)	600 m (1 969 ft)

1.3.2.2 Mountainous areas shall be identified by the State and promulgated in the State Aeronautical Information Publication (AIP), section GEN 3.3.5, "The criteria used to determine minimum flight altitudes".

1.3.3 MOC for turns

The full MOC applies over the total width of the turning area as shown in Figure II-3-1-5. There is no buffer area.

1.3.4 MOC when no track guidance provided

When track guidance is not provided, for example outside the coverage of navigation facilities along the route, the primary area splays each side at an angle of 15° from its width at the last point where track guidance was available. The width of the buffer area is progressively reduced to zero, ending in an area without track guidance where the full MOC is applied (see Figure II-3-1-8).

1.4 CONSTRUCTION OF AREAS FOR VOR AND NDB ROUTES

1.4.1 General

This section contains methods for calculating the areas used for en-route obstacle clearance purposes. The statistical derivation of these calculations, which are based on a root sum square method of the navigation system use accuracy, appears in Appendix B.

1.4.2 Straight areas

1.4.2.1 *Area descriptions.* The obstacle clearance areas consist of a primary area and two lateral buffer areas on each side.

1.4.2.2 *Width abeam the facility.* Abeam the facility, the total area has a constant width of 18.5 km (10.0 NM), which is comprised of the primary area and a buffer area. The primary area maintains a constant width of 9.3 km (5.0 NM) on either side of the nominal track. The buffer area also maintains a constant width of 9.3 km (5.0 NM) on either side of the primary area.

1.4.2.3 *Angular limits.* When the distance from the facility is greater than:

a) 92.3 km (49.8 NM) for VOR; and

b) 60 km (32 NM) for NDB,

the areas diverge, following the angular tolerance lines of their respective facilities (See Table II-3-1-1).

1.4.2.4 *Width after the point of divergence.* After the limiting distance stated in 1.4.2.3, “Angular limits”, the width of the primary area is increased by the angle of splay. The buffer area is determined by the angle of splay plus an additional fixed width on the outside of the buffer area, parallel to its edge (see Figures II-3-1-2 and II-3-1-3). This width is:

a) 3.7 km (2.0 NM) for VOR; and

b) 4.6 km (2.5 NM) for NDB.

1.4.2.5 *Longitudinal limits*. The longitudinal limits of the area associated with a straight segment are determined as follows:

a) the earliest limit of the area is a half circle, centred on the first fix and tangent to the lateral limits of the total area; and

b) the latest limit of the area is a half circle, centred on the second fix and tangent to the lateral limits of the total area.

1.4.2.6 *Combination of VOR and NDB criteria.* In case of a straight segment based on a VOR at one end and an NDB at the other end, the area is designed as shown in Figure II-3-1-4.

1.4.2.7 *Offset change-over point (COP).* If the change-over point between two facilities is offset due to facility performance problems the system accuracy limits must be drawn from the farthest facility to a point abeam the COP and then joined by lines drawn directly from the nearer facility, which in this case have no specific angles (see Figure II-3-1-7). The COP will be published.

1.4.3 Protection areas associated with turns

1.4.3.1 Turns can be executed overhead a facility or at a fix.

1.4.3.2 *Fix or facility tolerances.*

a) 4.5° (7.9 %) for VOR angular intersecting tolerance.

b) 6.2° (10.9 %) for NDB angular intersecting tolerance.

c) If available, DME can be used as a turning point fix. For DME accuracy values, see Part I, Section 2, Chapter 2, 2.4.4, "DME".

d) Facility tolerances — See Part I, Section 2, Chapter 2, 2.5, "Fix tolerance overheading a station".

1.4.3.3 *Turn parameters.* The following turn parameters are applied:

a) altitude — an altitude at or above which the area is designed;

b) temperature — ISA for the specified altitude plus 15° C;

c) indicated airspeed — 585 km/h (315 kt);

d) wind — omnidirectional for the altitude h, w = (12 h + 87) km/h, where h is in kilometres, [w = (2 h + 47) kt, where h is in thousands of feet];

e) average achieved bank angle: 15°;

f) maximum pilot reaction time: 10 s;

g) bank establishment time: 5 s; and

h) turn anticipation distance: r*tan (α/2), where α is the angle of the course change.

1.4.3.4 *Turn area construction*. Turn area construction (see Figure II 3-1-5) is comprised of the following four steps:

a) *Start of turn area.* The turn area starts at line K-K. Line K-K is perpendicular to the nominal track and is located at a distance of:

 1) r*tan (α/2), plus

 2) the fix tolerance before the nominal fix or facility

 where: α = angle of course change

 r = radius of turn

b) *Outer edge of the turn.* The outer edge of the turn area is composed of:

1) a straight extension of the outer edge of the segment before the turn;

2) the arc of a circle having a radius of T, which is centred on the turning point (nominal fix or facility); and

3) the tangent of the arc of this circle which makes an angle of 30° with the following segment.

The value of T is described by the following equation:

$$T = SA + 2*r + E_{165°}$$

where: r = radius of turn

$E_{165°}$ = wind effect to account for 120° course change plus 30° convergence angle plus 15° drift

SA = area semi-width

This method is based on the assumption that the size of the tolerance associated with the turn point is included in the area corresponding to a straight segment.

Note 1.— Use the highest minimum altitude of all the segments intersecting at the turning point.

Note 2.— Maximum turn angle is 120°.

Note 3.— A constant wind effect ($E_{165°}$) needs to be applied for all turn angles.

Example calculation for an altitude of 4 500 m. Given the turn parameters as stated in 1.4.3.3, "Turn parameters" and area semi-width of 18.5 km, it follows that:

the radius of turn (r) = 16.77

wind effect ($E_{165°}$) = 9.00

T = 18.5 + 33.54 + 9.00 = 61.04 km

c) *Inner edge of the turn.* From point K of the turn, draw a line making an angle of $\alpha/2$ with the nominal track in segment 2 (the segment following the turn). This line ends where it intersects the edge of segment 2.

d) *End of turn area.* The arc as described under (2) also denotes the end of the turn area.

1.4.3.5 *Bidirectional routes.* The method of construction of the turn area assumes a direction of flight. When the route is to be flown in both directions, it is necessary to construct both turn areas to account for both directions of flight and to apply the minimum obstacle clearance over the whole combined turn area (see Figure II-3-1-6).

1.5 MINIMUM ALTITUDES FOR SIGNAL RECEPTION

The minimum altitude en route based on VOR or NDB navigation, providing a minimum obstacle clearance, shall allow a proper reception of the relevant facilities. The following formula can be used for planning purposes.

D = 4.1√H where distance (D) is in km and the minimum height (H) is in metres

D= 1.2√H where D is in NM and H is in feet

Note.— The formulae given may be optimistic where high terrain exists in the area of the facility or en route.

1.6 PROMULGATION

1.6.1 Minimum altitude

A minimum altitude is determined and published for each segment of the route.

1.6.2 Mountainous areas

Mountainous areas shall be identified by the State and promulgated in the State Aeronautical Information Publication (AIP), section GEN 3.3.5, "The criteria used to determine minimum flight altitudes".

1.6.3 Offset change-over point (COP)

If the change-over point between two facilities is offset due to facility performance problems the system accuracy limits must be drawn from the farthest facility to a point abeam the COP and then joined by lines drawn directly from the nearer facility, which in this case have no specific angles (see Figure II-3-1-7). The COP will be published.

Table II-3-1-1. Primary and Buffer area splay

	Primary area splay	*Buffer area splay*
VOR	5.7° (10%)	9.1° (15.86%)
NDB	7.95° (14%)	13.0° (23%)

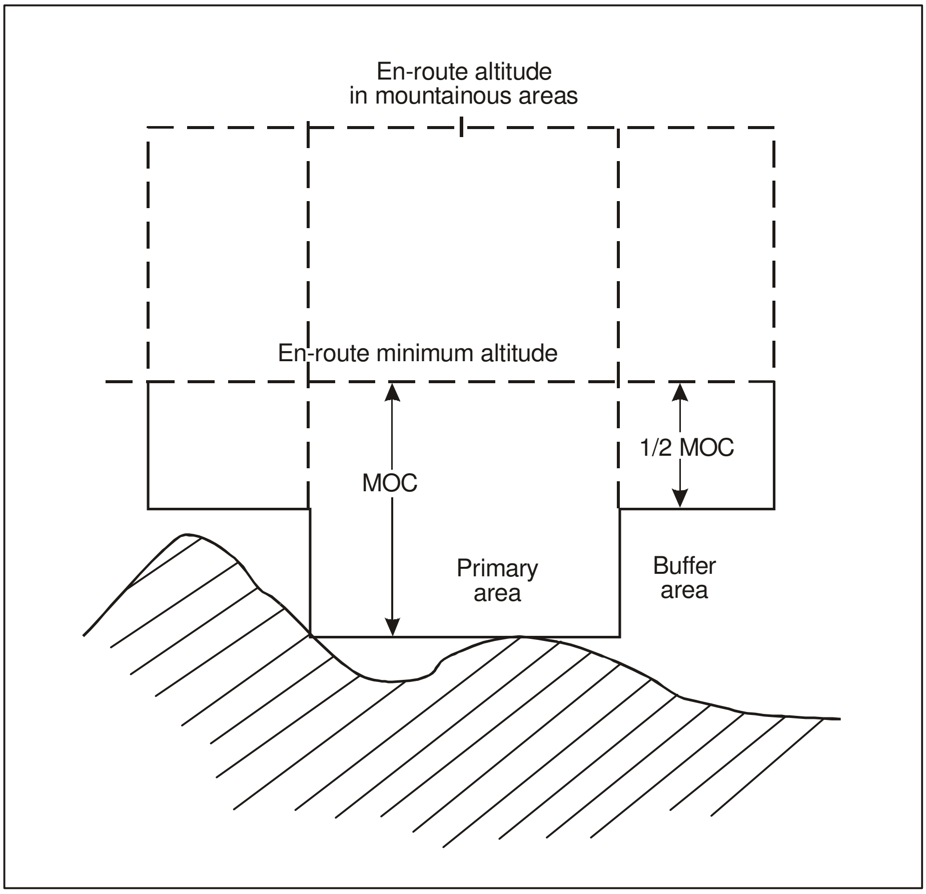


Figure II-3-1-1. En-route MOC — Primary and buffer areas

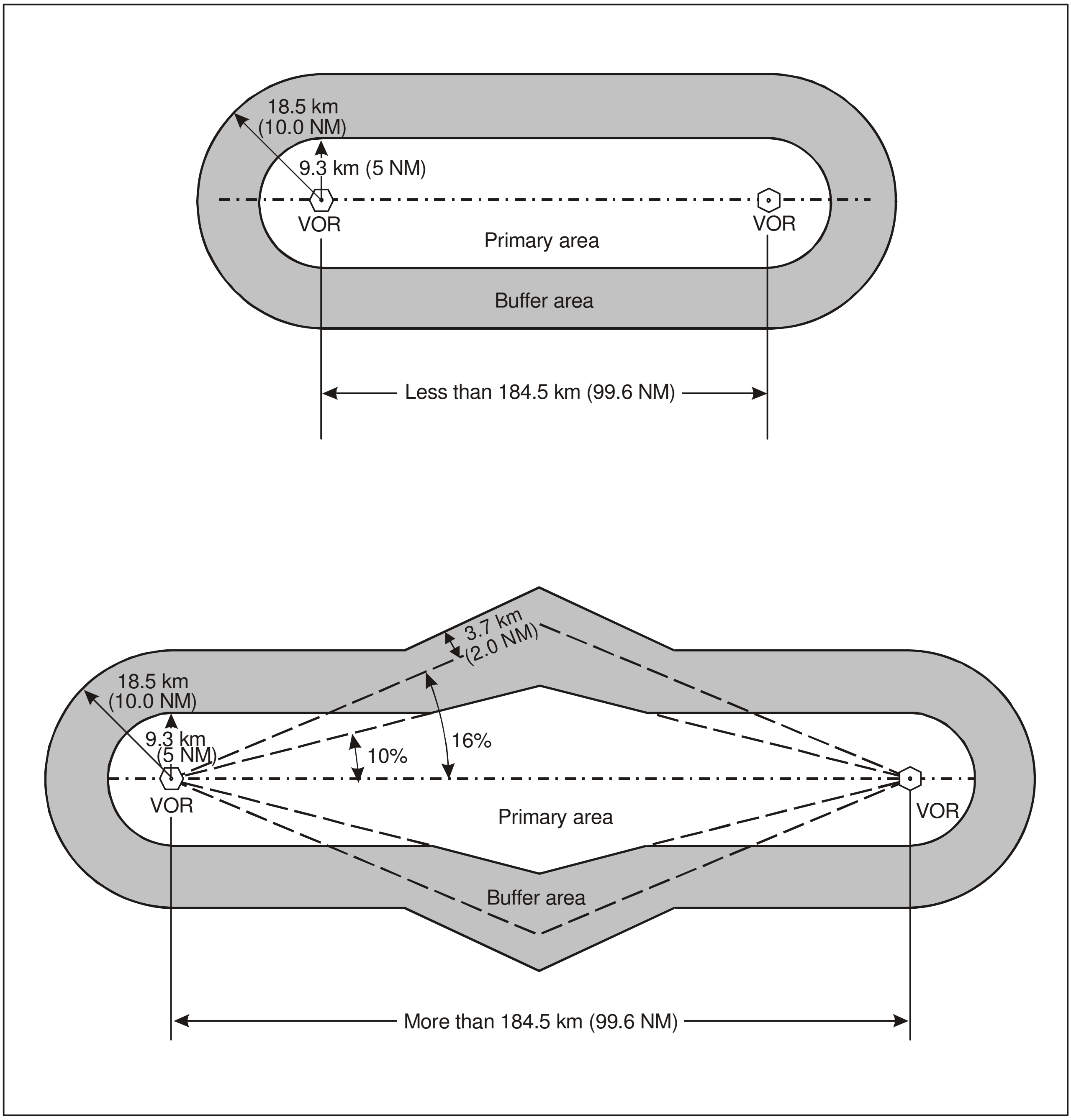


Figure II-3-1-2. Obstacle clearance areas for VOR en-route navigation. Straight segment

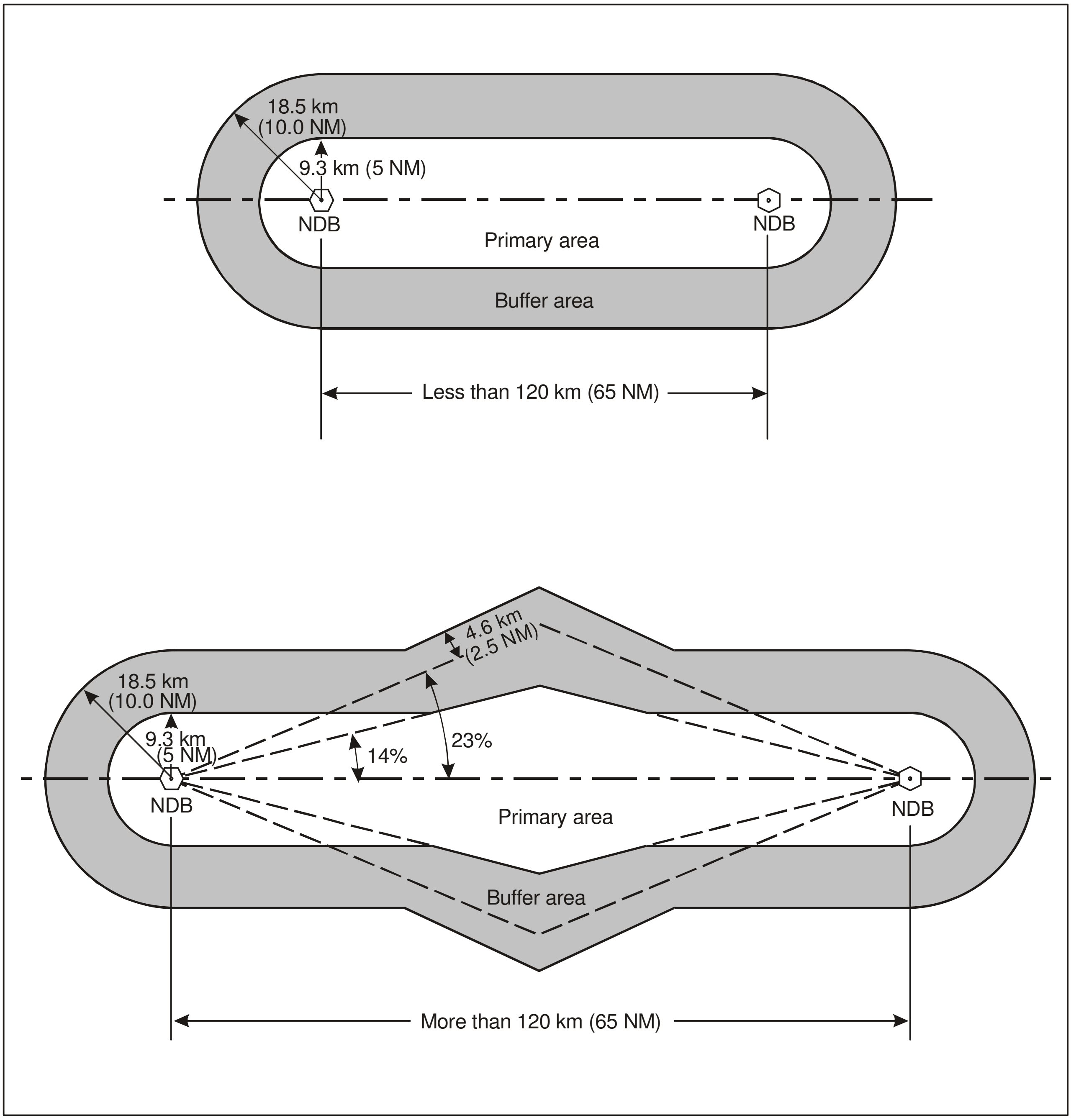


Figure II-3-1-3. Obstacle clearance areas for NDB en-route navigation. Straight segment

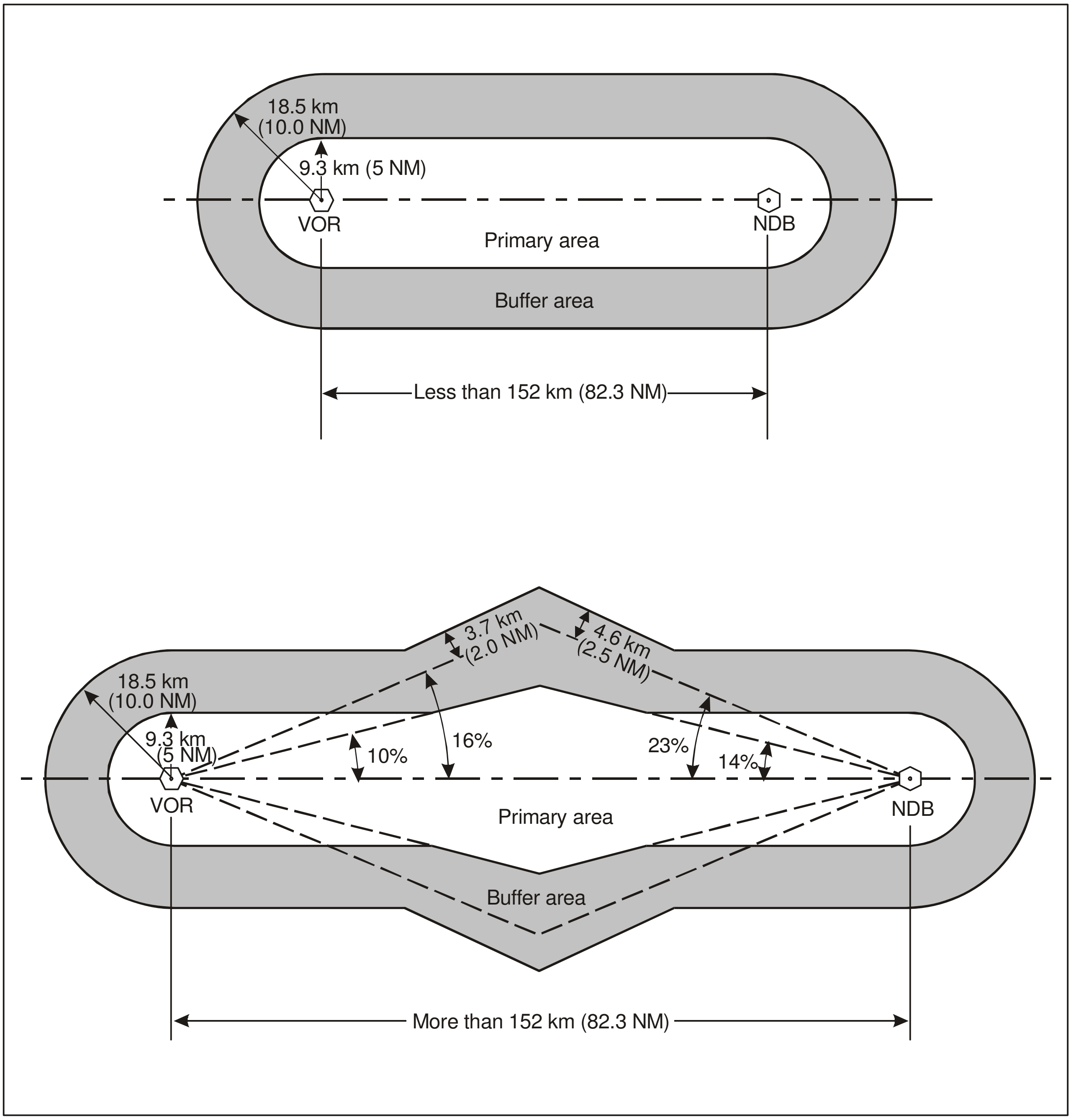


Figure II-3-1-4. Combination of VOR and NDB criteria

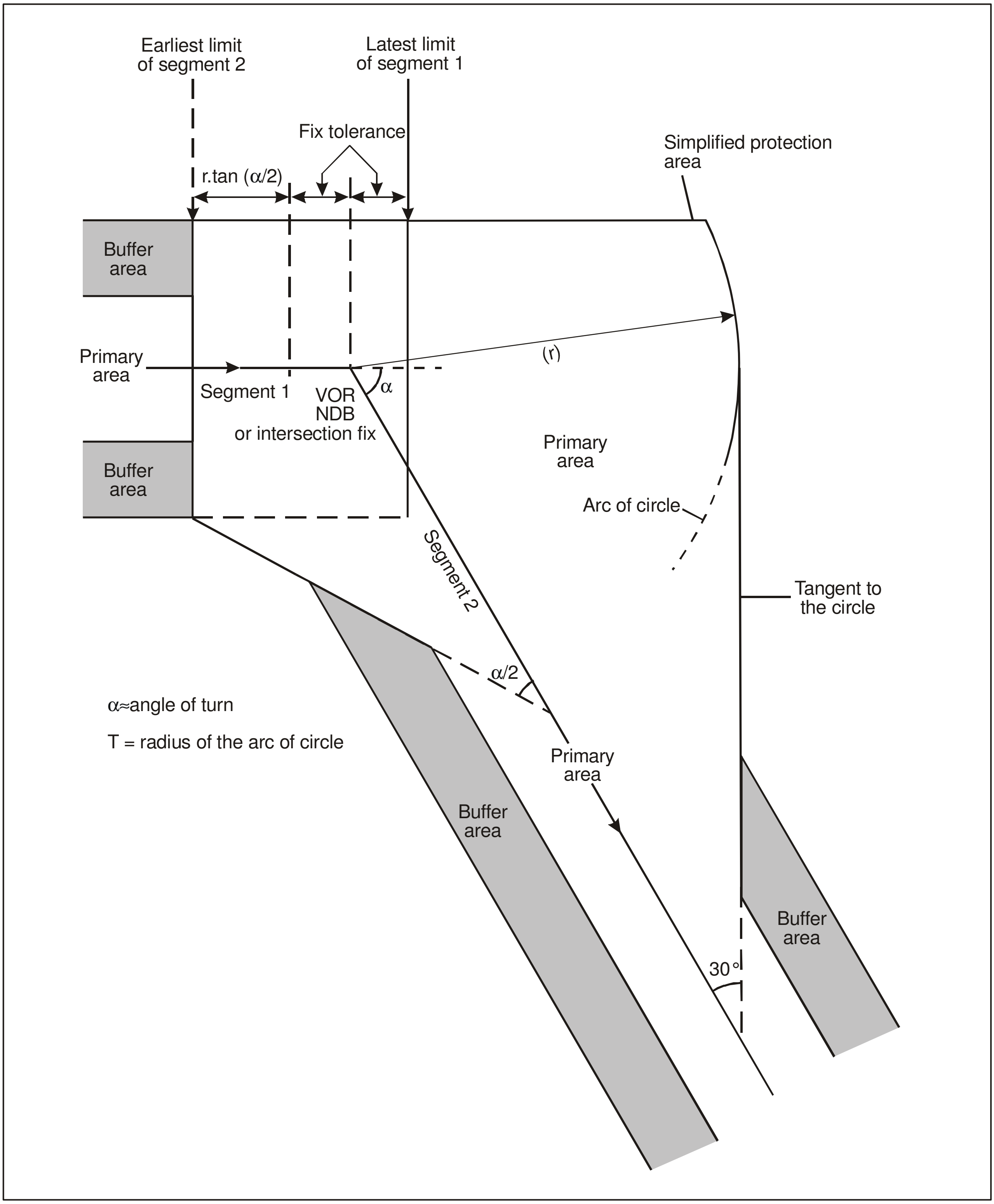


Figure II-3-1-5. Turn overhead a facility or at an intersection fix

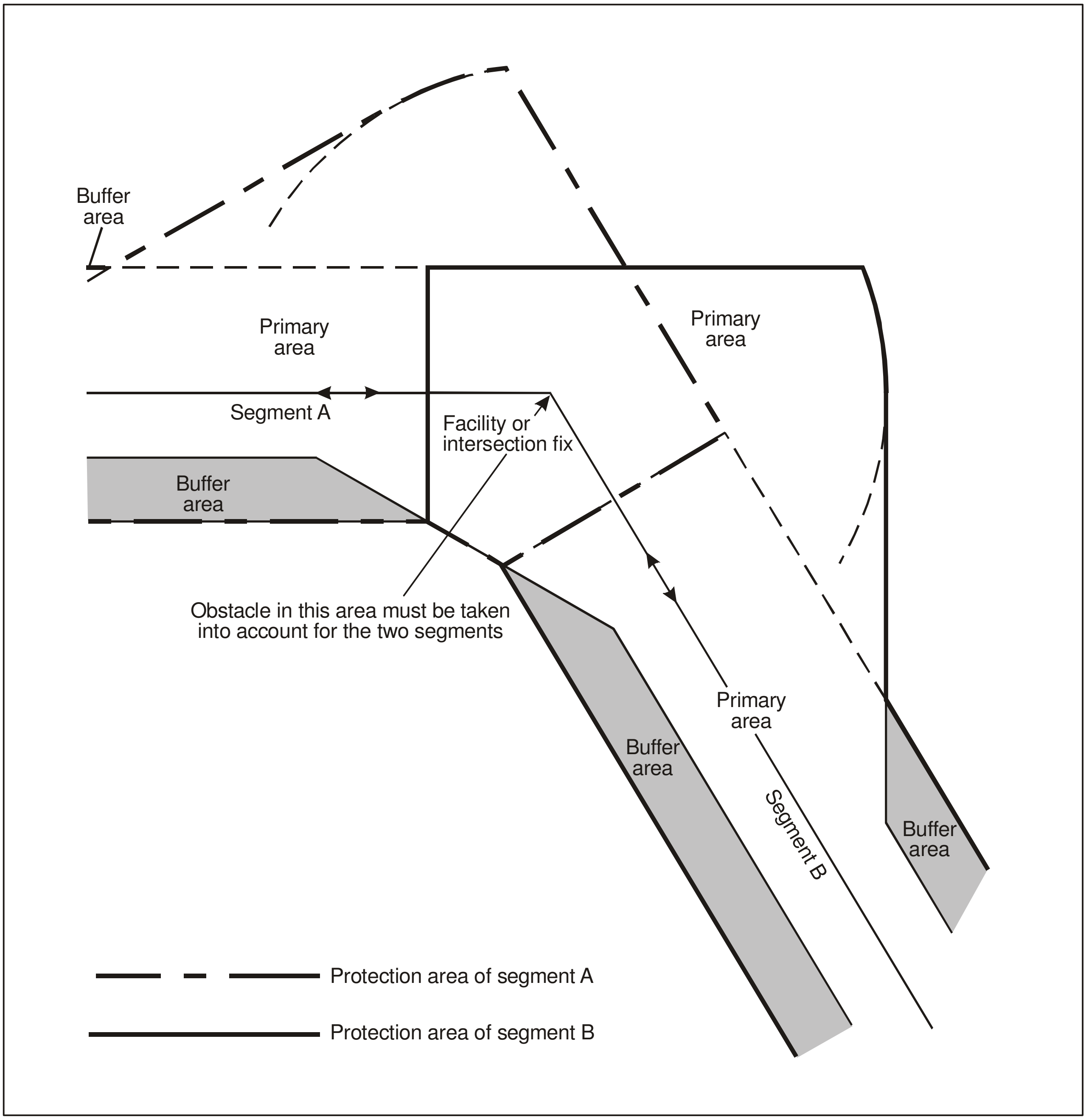


Figure II-3-1-6. Combination of turn areas for both directions of flight

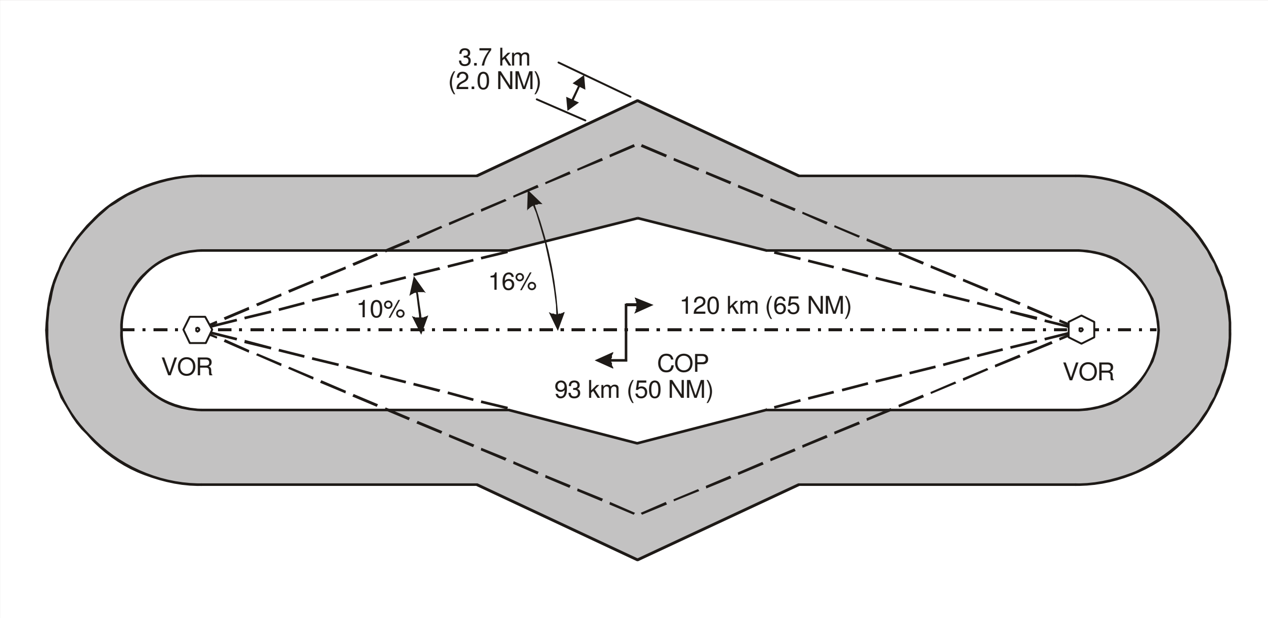


Figure II-3-1-7. Offset changeover point. Example with two VORs

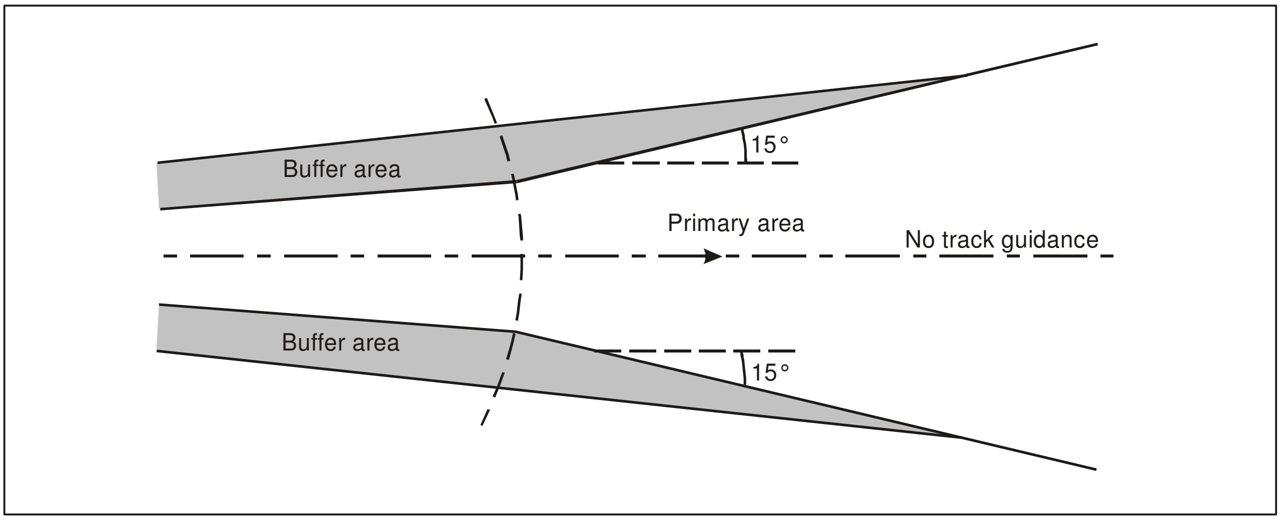


Figure II-3-1-8. Area without track guidance

Appendix A to Chapter 1

VOR AND NDB ROUTES — REFINED METHOD FOR THE CONSTRUCTION OF OBSTACLE CLEARANCE AREAS

1. GENERAL

1.1 Scope

The "refined method" presented in this appendix, related to obstacle clearance criteria for the en-route phase of an IFR flight, can be used when the criteria contained in Chapter 1 are not sufficient to address particular obstacle constraints. The criteria presented in this appendix amplify and/or modify the criteria as presented in Chapter 1.

2. OBSTACLE CLEARANCE AREAS

2.1 Primary and secondary areas

The obstacle clearance area is divided into a central primary area and two lateral secondary areas which replace the buffer areas in the standard method as described in Chapter 1.

2.2 Reductions to secondary area widths

Secondary areas for en-route operations may be reduced when justified by factors such as:

a) when there is relevant information on flight operational experience;

b) regular flight inspection of facilities to ensure better than standard signals; and/or

c) radar surveillance.

3. OBSTACLE CLEARANCE

The criteria as contained in Chapter 1 apply. The MOC of the secondary area tapers from the full MOC of the primary area to zero at the outer edge.

4. CONSTRUCTION OF AREAS FOR VOR AND NDB ROUTES

4.1 VOR

4.1.1 *Constant width starting abeam the facility.* In Annex 11, Attachment A, values are indicated for the width of ATS routes navigated by VOR. Abeam the facility, values of ± 7.4 km (4 NM) and ± 11.1 km (6 NM) correspond respectively to 95 per cent and 99.7 per cent of probability of containment. The first value is specified for the limits of the primary area; the second value plus an additional value of 3.7 km (2.0 NM) is applied for the limits of the secondary area.

4.1.2 *Angular limits.* For distances greater than 70 km (38 NM) from the facility, the angular tolerances will cause the area width to increase. (See Figure II-3-1-App A-1.)

4.2 NDB

4.2.1 *Constant width starting abeam the facility.* To determine the width of the areas abeam the NDB, a factor of 1.25 is applied to the values specified in the VOR case, as in Part II, Section 2, Chapters 2 and 3. The resulting values are ± 9.3 km (5.0 NM) and ± 18.5 km (10.0 NM). (See Figure II-3-1-App A-2.)

4.2.2 *Angular limits.* For distances greater than 60 km (32 NM) from the facility, the angular tolerances will cause the area width to increase. (See Figure II-3-1-App A-2.)

4.3 Protection areas associated with turns

4.3.1 Turns can be executed overhead a facility or at a fix.

4.3.2 *Turn parameters*. The turn is constructed based on the parameters specified in Chapter 1, 1.4.3.3, “Turn parameters” and the following additional parameters:

a) maximum pilot reaction time: 10 s; and

b) bank establishment time: 5 s.

4.3.3 The turn area is constructed as follows (see Figures II-3-1-App A-3 and II-3-1-App A-4):

a) on the outer edge of the turn, a wind spiral is constructed at the limit of the primary area and starting at a distance after the nominal turn point corresponding to the fix tolerance plus 15 seconds of flight at the nominal TAS plus a maximum tail wind. (See Part I, Section 2, Chapter 3 for the construction of the wind spiral); the convergence angle after the turn is 30°; the secondary area width is constant throughout the turn; and

b) on the inner edge of the turn, the primary area splays from a point located at a distance equal to $r*\tan(\alpha/2)$ prior to the fix tolerance of the nominal turn point, at an angle of half the angle of turn. The secondary area width is constant during the turn.

   If on one edge of the turn, the convergence angle cannot be used because the area of the segment being entered is already too wide, a splay angle of 15° is applied instead, measured from the nominal track of the segment being entered (see Figure II-3-1-App A-4).

5. PROMULGATION

5.1 Minimum altitude

A minimum altitude is determined and published for each segment of the route.

5.2 Navigation system use accuracy

Smaller accuracy values may be used provided they are based on sufficient statistical data. Where different values are used they should be promulgated.

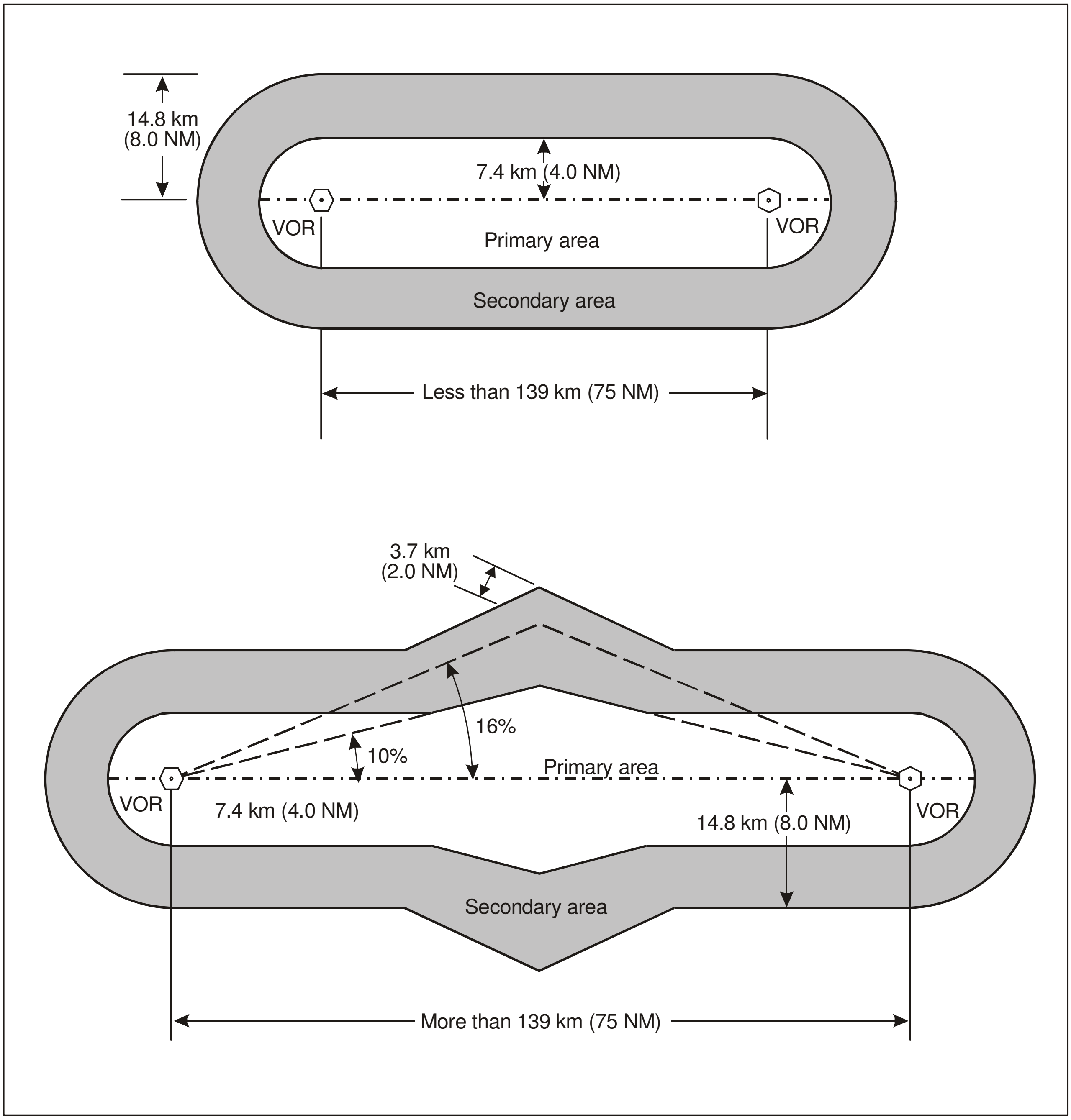


Figure II-3-1-App A-1. Obstacle clearance areas for VOR en-route navigation

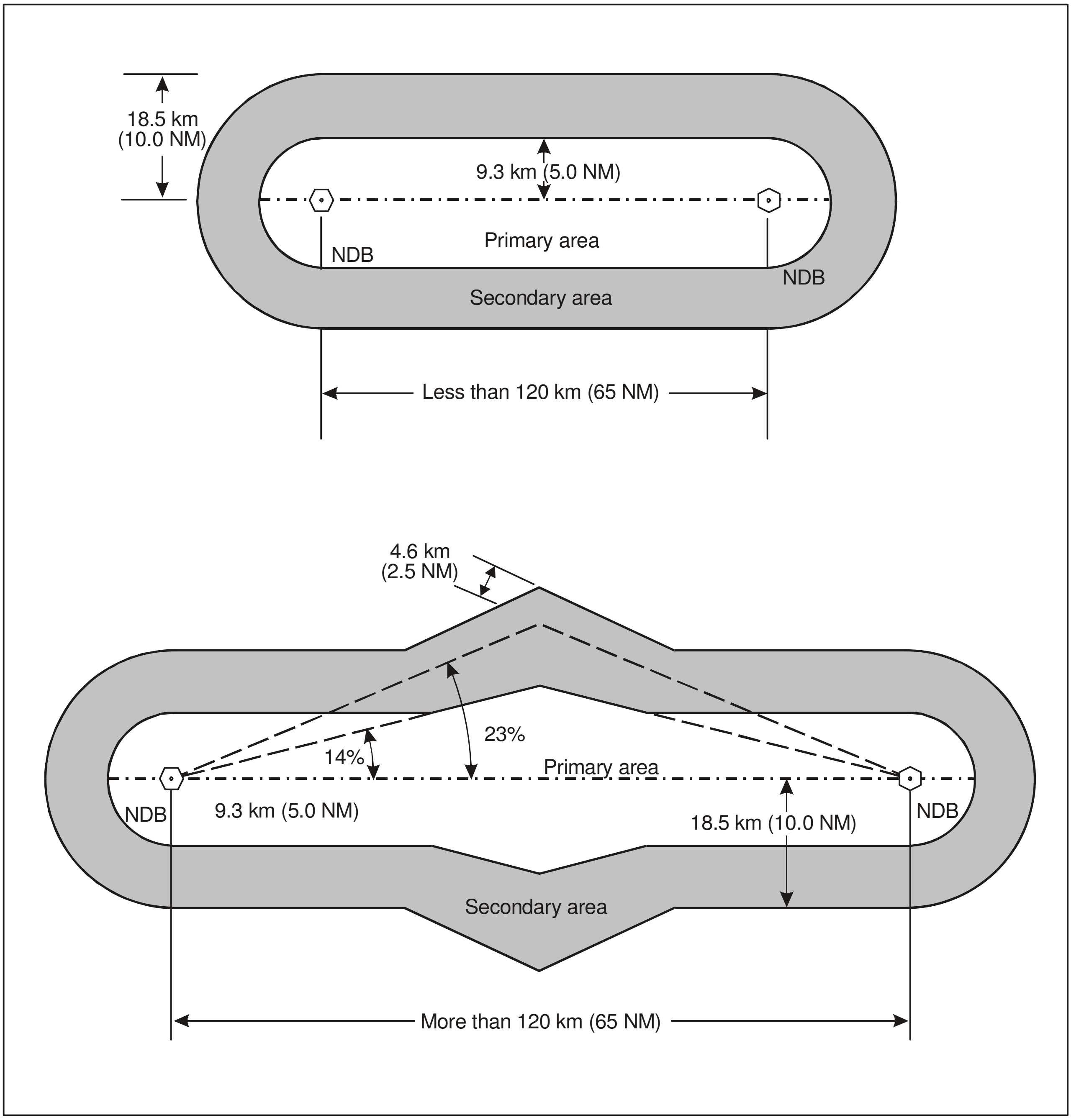


Figure II-3-1-App A-2. Obstacle clearance areas for NDB en-route navigation

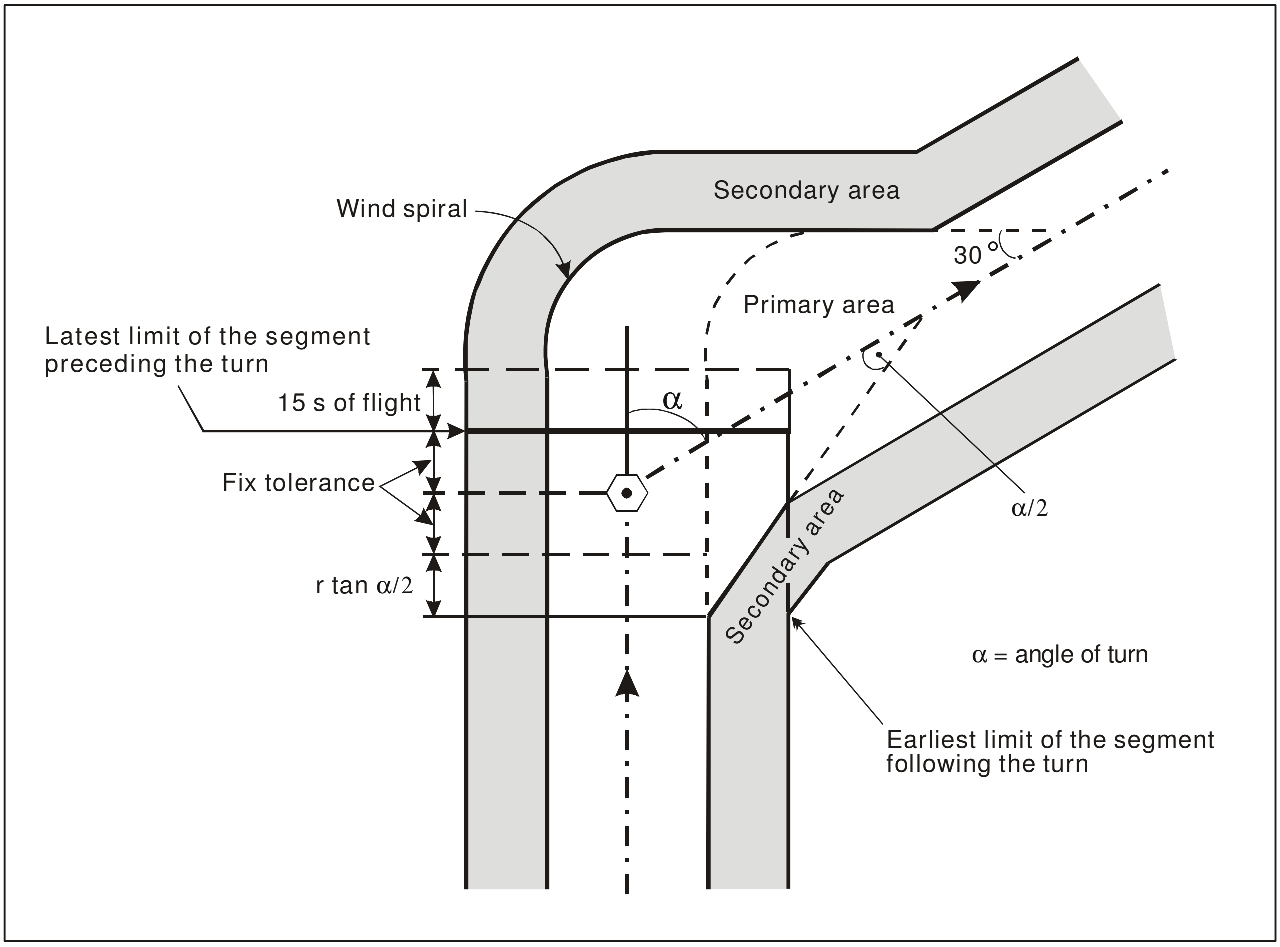


Figure II-3-1-App A-3. Turn overhead a facility

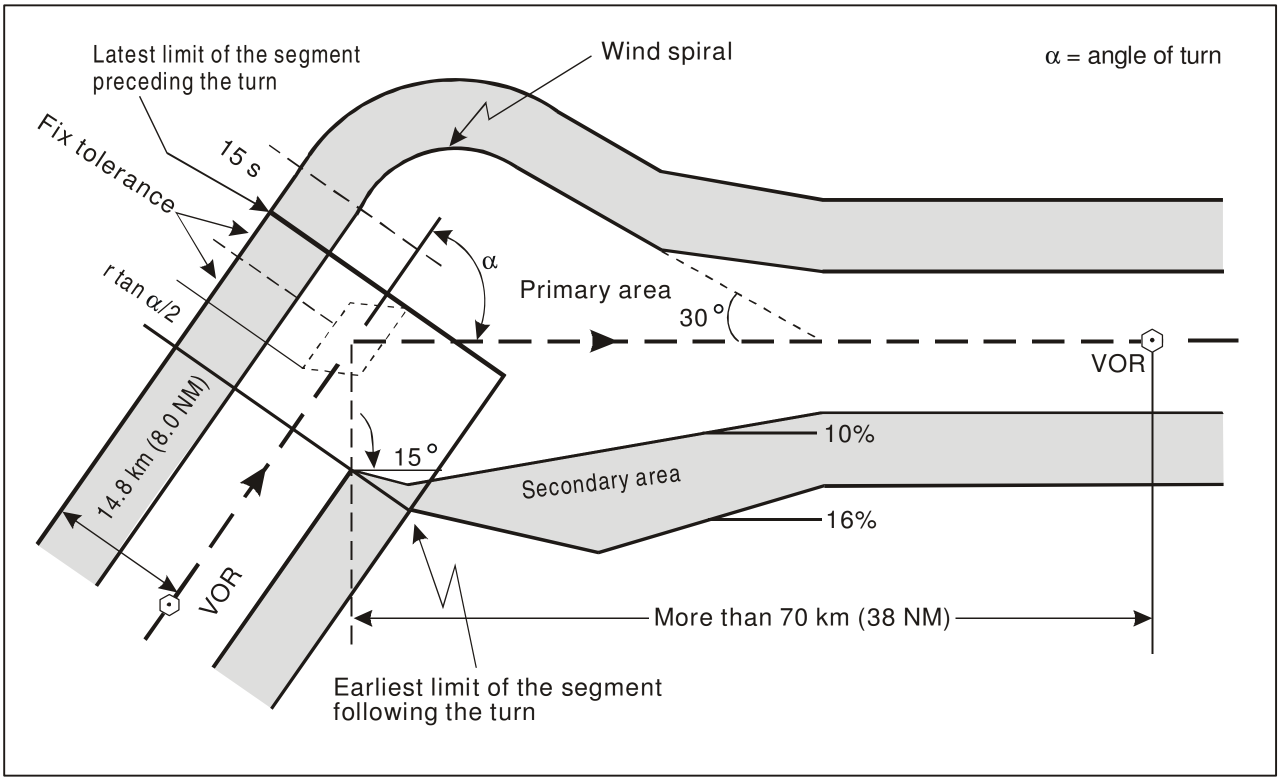


Figure II-3-1-App A-4. Turn at an intersection fix

Appendix B to Chapter 1

STATISTICAL CALCULATIONS FOR PRIMARY AND SECONDARY AREAS AND THEIR ANGLES OF SPLAY

1. GENERAL

The obstacle clearance area is divided into a central primary area and two buffer areas on either side. The primary area represents 95 per cent probability of containment (2 SD), as calculated on a root sum square basis from the system use accuracy. The buffer/secondary area represents 99.7 per cent probability of containment (3 SD), calculated in the same fashion.

2. NAVIGATION SYSTEM USE ACCURACY

2.1 The system accuracies used in the development of obstacle clearance criteria are based on minimum system performance factors. The various accuracy values, when considered as statistically independent, are combined on a root sum square (RSS) basis to produce limits corresponding to approximately 95 per cent probability of containment (2 SD) and limits corresponding to approximately 99.7 per cent probability of containment (3 SD).

2.2 The following system use accuracy values apply to VOR:

a) ± 3.5° ground system tolerance;

b) ± 2.7° receiver tolerance;

c) ± 3.5° flight technical tolerance; and

d) ± 1.0° monitoring tolerance.

2.3 The following system use accuracy values apply to NDB:

a) ± 3° ground equipment;

b) ± 5.4° airborne equipment; and

c) ± 5° flight technical tolerance.

2.4 *Fix or facility tolerances*

2.4.1 *VOR intersecting tolerance.* The VOR angular intersecting tolerance, calculated without the flight technical tolerance, results in 7.9 per cent (4.5°).

2.4.2 *NDB intersecting tolerance.* The NDB angular intersecting tolerance, calculated without the flight technical tolerance, results in 10.9 per cent (6.2°).