Table 10.2.1 Inspection Sheet for the Line of Sight of KTM VOR/DME from SE through NW Direction (Con't.)

Line	Distance from KTM VOR/DME (m/nm)	Height above MSL (ft)	Height above KTM VOR/DME site (ft/m)	Direction from KTM VOR/DME (degrees true)	Slope from KTM VOR/DME (%)
GG	8500/4.6	5000	700/213	258	2.506
	11500/6.2	8000	3700/1128		9.809
	32000/17.3	8520	4220/1286		4.019
HH	8500/4.6	5000	700/213	261	2.506
	12000/6.5	7000	2700/823		6.858
	30500/16.5	8000	3700/1128		3.698
II	10000/5.4	5000	700/213	268	2.13
	13000/7.0	7500	3200/975		7.5
JJ	11000/5.9	5000	700/213	272	1.936
	15000/8.1	7500	3200/975		6.5
	21000/11.3	7835	3535/1077		5.129
KK	12000/6.5	5000	700/213	276	1.775
	15000/8.1	6500	2200/671		4.473
	35000/18.9	7208	2908/886		2.531
LL	14000/7.6	5000	700/213	279	1.521
	24500/13.2	6382	2082/635		2.592
MM	9000/4.9	5000	700/213	292	2.367
	12500/6.7	6198	1898/579		4.632
NN	9500/5.1	5000	700/213	306	2.242
	25500/13.8	6803	2503/763		2.992
OO	9500/5.1	5000	700/213	315	2.242
	11000/5.9	6975	2675/1120		10.182
	21000/11.3	7000	2700/823		3.919

Table 10.2.2 The Altitude of the Line of Sight at Points between 15 nm and 25 nm on Each Check Line from KTM VOR/DME

Obstacles						Altitude of line sight at the following point							
Line	Distance from KTM VOR/DME (m/nm)	Height above MSL (ft)	Height above KTM VOR/DME site (ft/m)	Direction from KTM VOR/DME (degrees true)	Slope from KTM VOR/DME (%)	15 NM (ft)	18 NM (ft)	20 NM (ft)	22 NM (ft)	23 NM (ft)	24 NM (ft)	25 NM (ft)	Remarks
A	16,500/8.9	6,036	1,736/529	111	3.206	7,421	8,093	8,550	9,015	9,249	9,485	9,724	
B	8,300/4.5	5,000	700/213	113	2.566	6,838	7,393	7,772	8,159	8,355	8,552	8,752	
C	11,000/5.9	6,500	2,200/671	118	6.100	10,059	11,259	12,067	12,883	13,294	13,705	14,120	
D	11,000/5.9	6,587	2,287/697	120	6.336	10,274	11,517	12,354	13,199	13,624	14,050	14,479	
E	11,000/5.9	6,500	2,200/671	126	6.100	10,059	10,147	12,067	12,883	13,294	13,705	14,120	
F	10,500/5.7	6,500	2,200/671	128	6.390	10,323	11,576	12,419	13,271	13,699	14,128	14,561	
G	11,500/6.2	6,500	2,200/671	132	5.385	9,817	10,969	11,745	12,529	12,923	13,319	13,718	
H	14,500/7.8	7,000	2,700/823	137	5.676	9,672	10,795	11,552	12,316	12,701	13,087	13,476	
I	10,000/5.4	6,500	2,200/671	139	6.710	10,615	11,926	12,808	13,699	14,146	14,595	15,047	
J	10,000/5.4	7,000	2,700/823	143	8.230	12,000	13,588	14,655	15,730	16,270	16,812	17,355	
K	10,000/5.4	7,000	2,700/823	146	8.230	12,000	13,588	14,655	15,730	16,270	16,812	17,355	
L	17,500/9.4	9,500	5,200/1,585	149	9.057	12,754	14,493	15,660	16,836	17,426	18,018	18,612	
M	13,000/7.0	9,050	4,750/1,448	153	11.138	14,650	16,769	18,189	19,618	20,334	21,052	21,773	
N	13,500/7.3	8,500	4,200/1,280	160	9.481	13,140	14,956	16,176	17,403	18,019	18,636	19,256	
O	10,500/5.7	7,500	3,200/975	166	9.286	12,962	14,743	15,939	17,142	17,746	18,351	18,960	
P	22,500/12.1	8,274	3,974/1,211	172	5.382	9,404	10,473	11,194	11,923	12,290	12,658	13,029	
Q	13,000/7.0	6,000	1,700/518	180	3.985	8,131	8,945	9,497	10,056	10,338	10,621	10,907	
R	15,000/8.1	7,000	2,700/823	188	5.487	9,500	10,588	11,322	12,064	12,437	12,812	13,189	
S	14,500/7.8	7,500	3,200/975	196	6.724	10,627	11,941	12,825	13,717	14,166	14,615	15,068	
T	15,500/8.4	7,500	3,200/975	200	6.290	10,232	11,466	12,298	13,137	13,559	13,983	14,409	
U	15,000/8.1	7,000	2,700/823	204	5.487	9,500	10,588	11,322	12,064	12,437	12,812	13,189	
V	12,500/6.7	5,000	700/213	211	1.704	6,052	6,451	6,725	7,007	7,150	7,295	7,442	
W	27,500/14.8	7,392	3,092/942	219	3.425	7,621	8,333	8,816	9,307	9,555	9,805	10,057	
X	24,500/13.2	7,500	3,200/975	221	3.980	8,126	8,940	9,491	10,049	10,331	10,614	10,900	
Y	25,500/13.8	8,297	3,997/1,218	226	4.776	8,852	9,811	10,458	11,113	11,443	11,775	12,109	
Z	13,500/7.3	6,500	2,200/671	229	4.970	9,029	10,023	10,694	11,373	12,017	12,058	12,404	
AA	13,500/7.3	6,000	1,700/518	233	3.837	7,996	8,784	9,317	9,858	10,131	10,405	10,682	
BB	12,500/6.7	7,000	2,700/823	238	6.584	10,500	11,788	12,655	13,530	13,970	14,411	14,855	
CC	13,000/7.0	7,000	2,700/823	243	6.331	10,269	11,511	12,348	13,192	13,617	14,042	14,471	
DD	12,500/6.7	8,000	3,700/1,128	248	9.024	12,724	14,457	15,620	16,792	17,380	17,969	18,562	
EE	12,000/6.5	8,000	3,700/1,128	251	9.400	13,066	14,868	16,077	17,294	17,906	18,518	19,133	
FF	11,250/6.1	8,289	3,989/1,216	256	10.809	14,351	16,409	17,789	19,178	19,875	20,572	21,273	
GG	11,500/6.2	8,000	3,700/1,128	258	9.809	13,439	15,315	16,574	17,841	18,477	19,114	19,754	
HH	12,000/6.5	7,000	2,700/823	261	6.858	10,750	12,088	12,988	13,896	14,353	14,811	15,272	
II	13,000/7.0	7,500	3,200/975	268	7.500	11,335	12,790	13,768	14,755	15,250	15,747	16,247	
JJ	15,000/8.1	7,500	3,200/975	272	6.500	10,423	11,696	12,553	13,418	13,853	14,289	14,728	
KK	15,000/8.1	6,500	2,200/671	276	4.473	8,576	9,479	10,090	10,708	11,020	11,333	11,649	
LL	24,500/13.2	6,382	2,082/635	279	2.592	6,861	7,422	7,804	8,194	8,391	8,590	8,791	
MM	12,500/6.7	6,198	1,898/579	292	4.632	8,721	9,653	10,283	10,921	11,242	11,565	11,890	
NN	25,500/13.8	6,803	2,503/763	306	2.992	7,226	7,859	8,290	8,729	8,950	9,173	9,399	
OO	11,000/5.9	6,975	2,675/1,120	315	10.182	13,779	15,723	17,027	18,340	18,998	19,658	20,321	

(2) The Study for the Establishment of New ATS Routes

1) The Outline of the New ATS Routes

New ATS routes as shown in Figures 10.2.2 and 3 were studied for the establishment of arrival routes for Tribhuvan International Airport as follows.

a) The route between Kathmandu VOR/DME and Nepalgunj VOR/DME
b) Pokhara and Bharatpur NDB
c) Bharatpur NDB and Simara NDB
d) The route segment between Simara NDB and a point at 265320N/863644E (KTM R-126/D82)

2) The Assumptions for the Revision of the Airspace Configuration

The new ATS routes mentioned above were planned taking into account the establishment of the arrival routes for TIA. It is considered that they will contribute for the improvement of the safe and expeditious flow of air traffic in the vicinity of TIA when the revision of the ATS route system from one-way routes to two-way routes in the vicinity of TIA is made.

Also to finalize the new airspace system, it should be done with close cooperation and understanding with the neighboring countries and airlines operating at TIA.

MEAs on each route segment were obtained by the adding of 2,000 feet and 1,000 feet of obstacle clearance above the highest obstacle within the each segment in the mountainous and plane areas respectively. However, these MEAs should be flight-checked including MRA (Minimum Reception Altitude) for the safety of aircraft operations.

3) Recommendations

Simara and Bharatpur NDBs occupy the important positions for the configuration of the new ATS routes to the west of TIA. Therefore, it is recommended that VOR/DME, which is not influenced by static (lightning), should be installed at the same site or nearby to the NDBs sites to ensure the safety of aircraft operations.

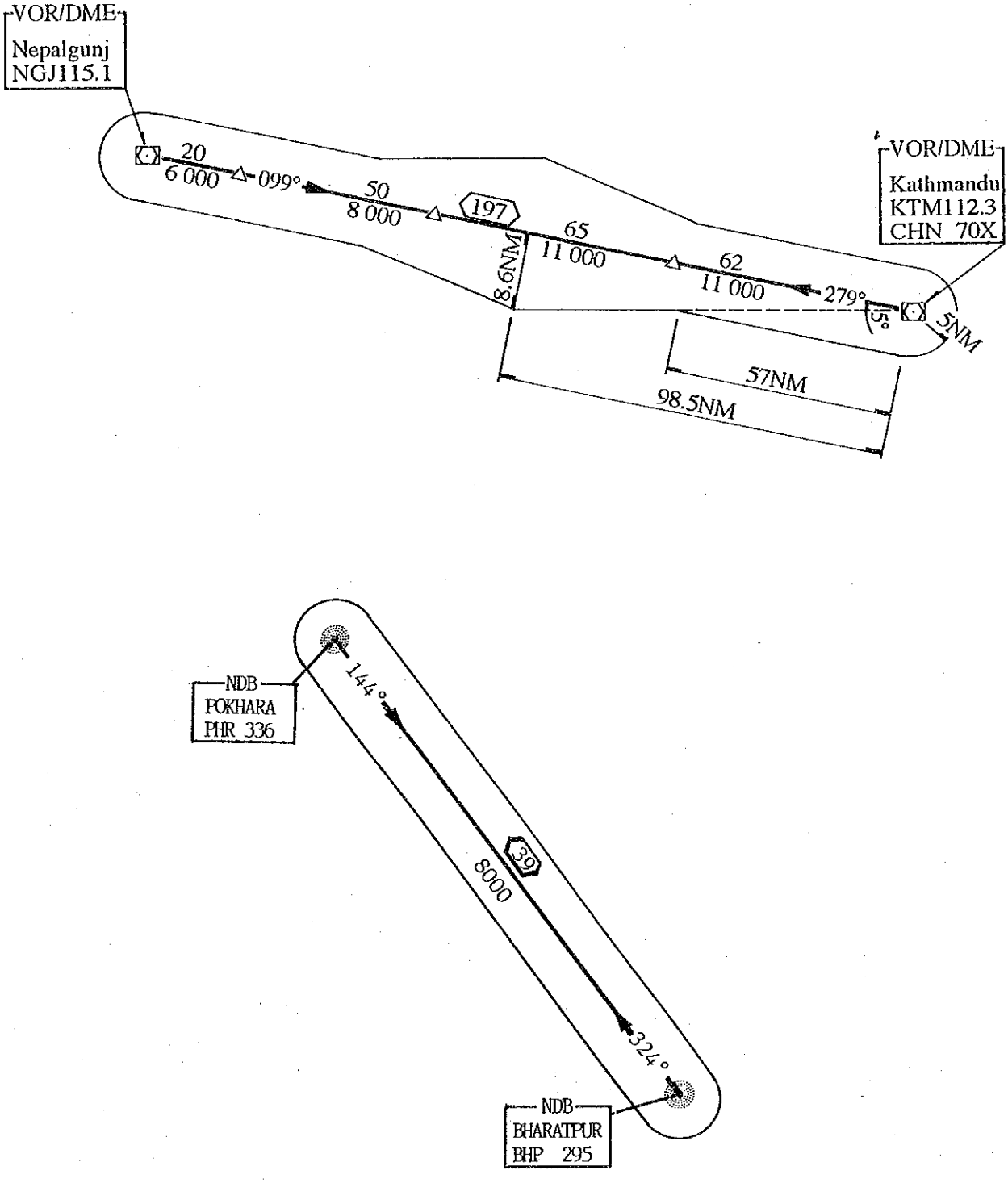
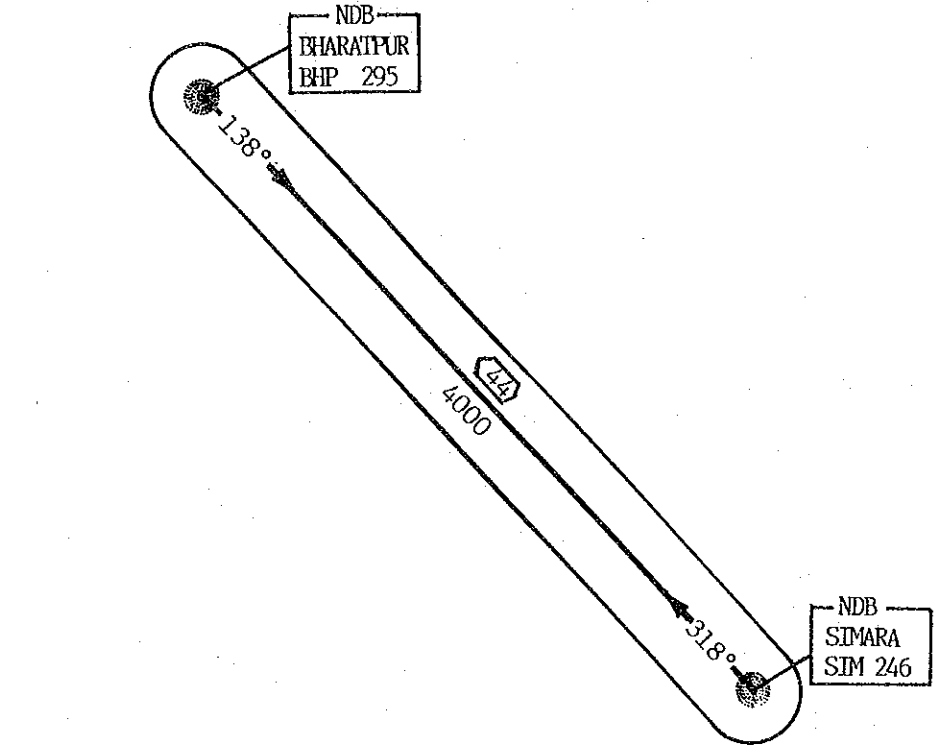


Figure 10.2.2 Newly Required ATS Routes for the Establishment of the Arrival Routes for TIA



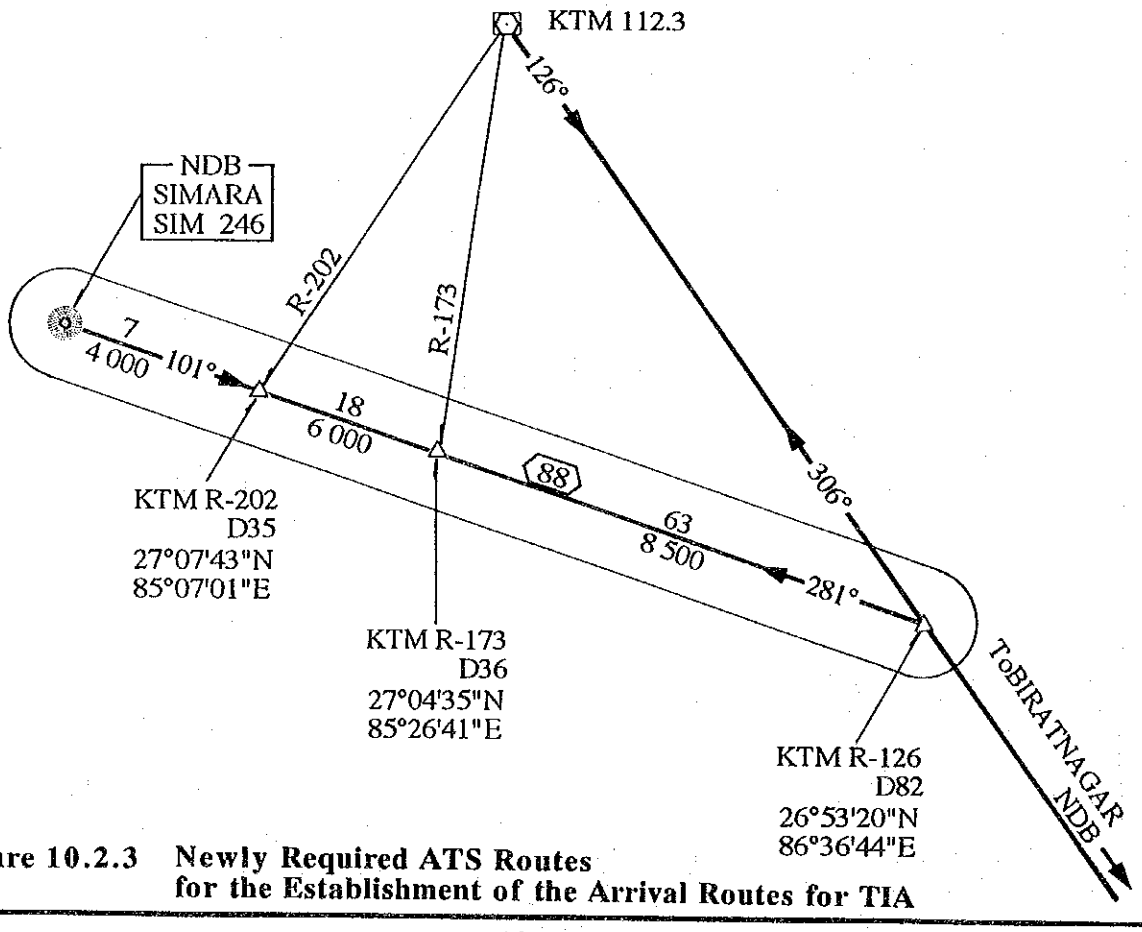


Figure 10.2.3 Newly Required ATS Routes for the Establishment of the Arrival Routes for TIA

(3) The Study of the Arrival Routes for Tribhuvan International Airport

Figures 10.2.4 and 5 show the arrival routes for TIA.

1) The Outline of the Arrival Routes

Four arrival routes were studied as follows:

a) Arrival Routes from the Southwest of TIA

i) From over KTM R-126/D82, descend via KTM R-126 to KTM D25, then turn left and proceed via KTM 20 DME arc, turn right to intercept and proceed via KTM R-202 to Sierra. Cross Sierra at 9,500'.

Maintain 18,000' until KTM R-160, 15,000' until KTM R-170 and 13,000' until KTM R-191 during arc approach.

ii) From over KTM R-126/D82, descend on 281° to Simara NDB, then turn right to intercept and proceed via KTM R-202 to Sierra. Cross Sierra at 9,500'.

Maintain 12,000' until crossing KTM R-194.

b) Arrival Routes from the West of TIA

i) From over Bharatpur NDB, descend via KTM R-272 to KTM D25, then turn right proceed via KTM 20 DME arc, left turn to intercept and proceed via KTM R-202 to Sierra. Cross Sierra at 9,500'.

Maintain 18,000' until crossing KTM R-225 and 11,000' until crossing KTM R-212 during arc approach.

ii) From over Bharatpur NDB, descend on 138° to Sierra NDB, turn left after crossing KTM R-210 to intercept and proceed via KTM R-202 to Sierra. Cross Sierra at 9,500'. Maintain 12,000' until crossing KTM R-210.

The MEAs (Minimum En Route IFR Altitude) on each route segment were studied taking into account the obstacle clearance requirements and the acceptable altitude of the KTM VOR/DME signal along the each route segment with reference to the data recorded in Table 10.2.2.

2) The Conditions for the Application of Arrival Routes

As a minimum requirement, the following subjects should be examined.

- To study the expansion of the terminal control area to meet the airport radar service area for TIA taking into account the introduction of a terminal radar service and the application to arrival routes in the future

- To examine the establishment of additional reporting points along the routes for the confirmation of the position of arriving aircraft continuously when terminal radar service is not provided

- To examine the installation of VOR/DME at Bharatpur and Simara airports

3) Recommendations

The application of these arrival routes for TIA will bring the following advantages.

- The dispersion of arriving aircraft
- The establishment of sufficient separation between arriving aircraft
- The prevention of the convergence of arriving aircraft over Simara NDB

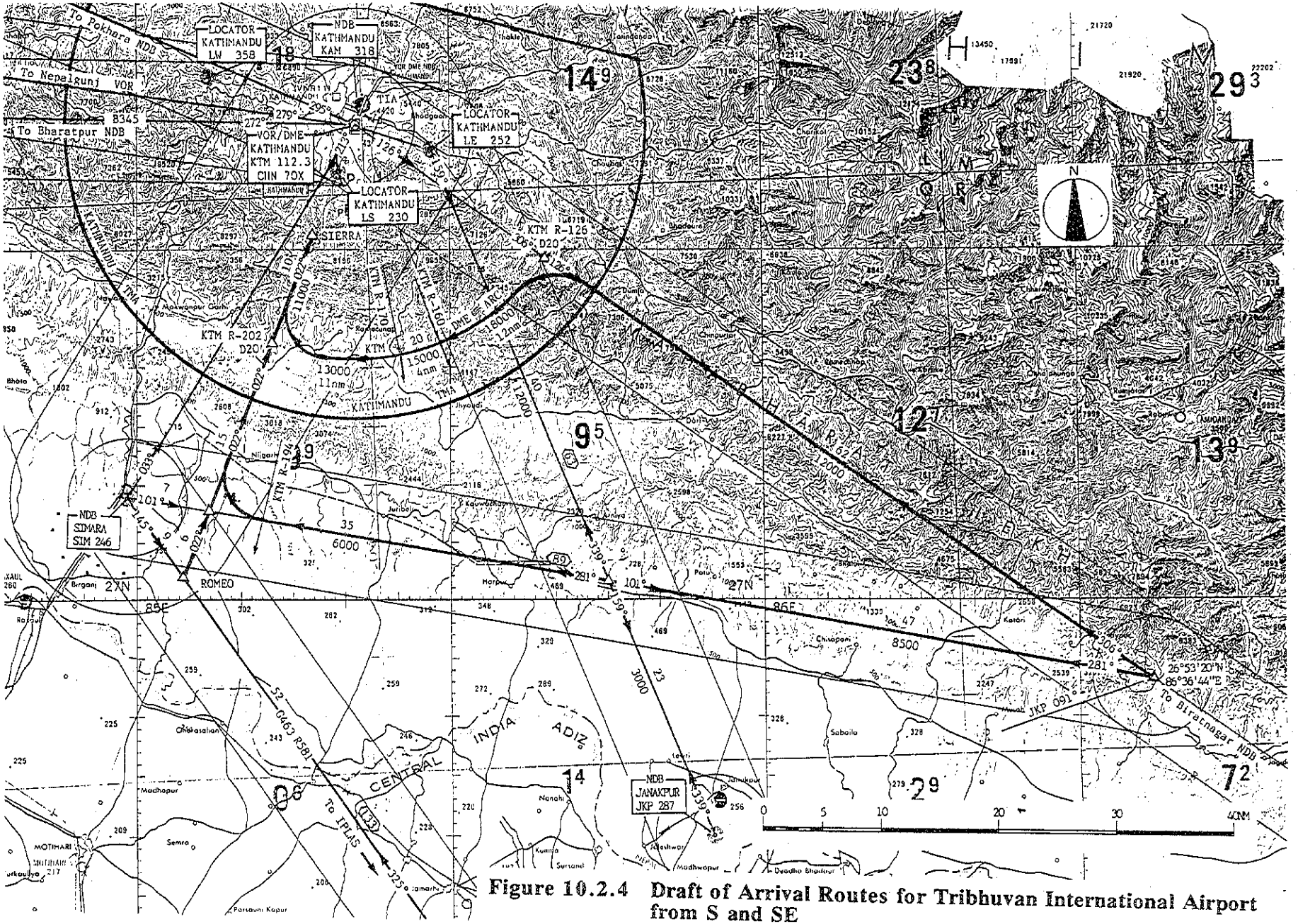


Figure 10.2.4 Draft of Arrival Routes for Tribhuvan International Airport from S and SE

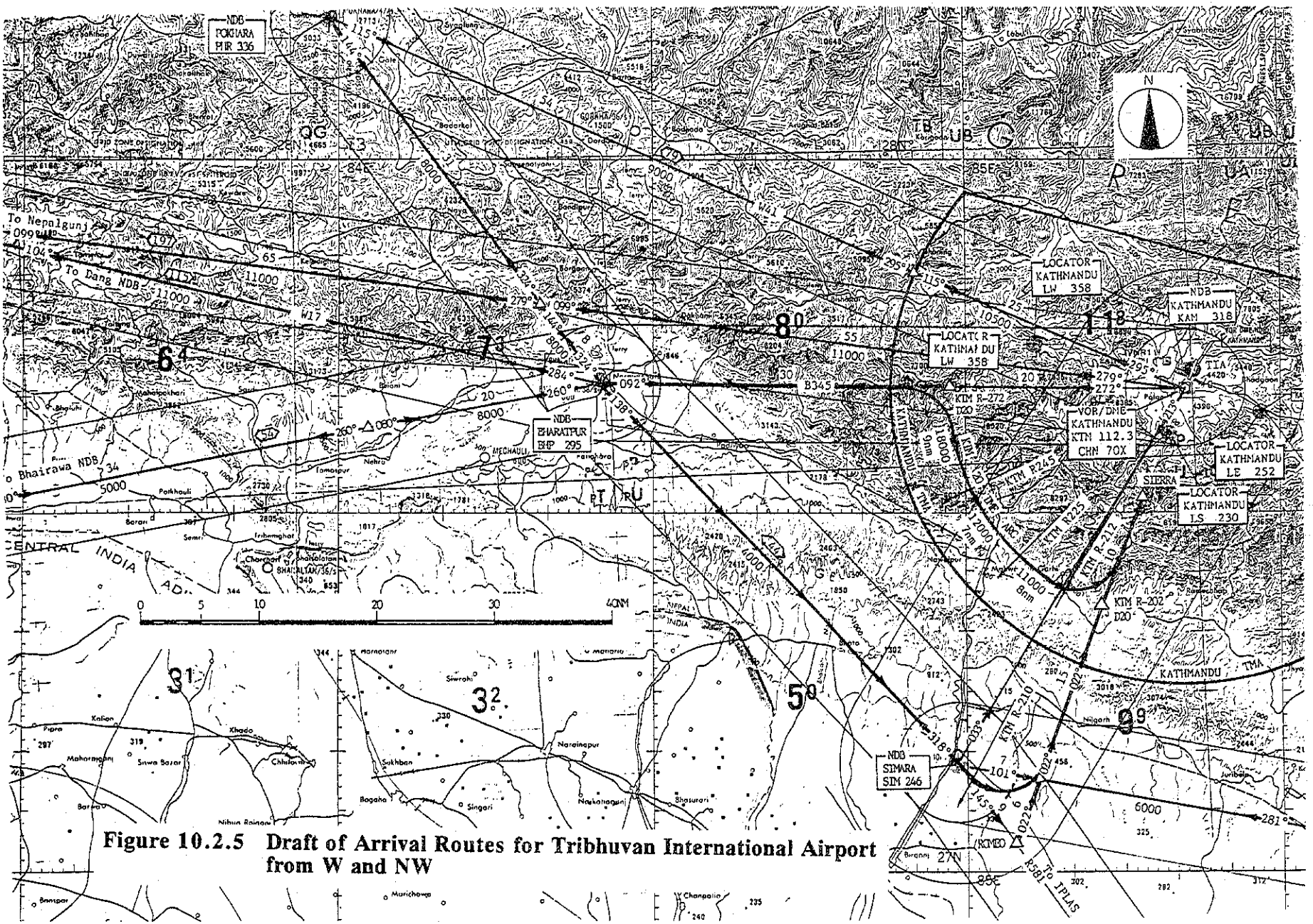
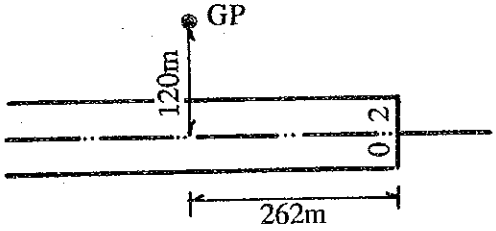


Figure 10.2.5 Draft of Arrival Routes for Tribhuvan International Airport from W and NW

10.2.2 Study of ILS and LLZ Approach Procedures to RWY 02

The possibility of the establishment of an ILS approach procedure, category I, for Runway 02 at TIA was examined in accordance with the PANS-OPS (Procedures for Air Navigation Services, Aircraft Operations, DOC 8168-OPS/611 Third Edition-1986 ICAO) with the following assumptions.

(1) Assumptions
a) Elevation of Runway 02 threshold : 4313 feet
b) Orientation of Runway : 22°24'58"/202°24'58"
c) Magnetic Variation : 1 degree west
d) Type of Operation : Category I
e) Distance between THR-LLZ : 3200 m
f) Glide path angle : 3.0 degrees
g) The Height of TCH: 17 m/55 feet
h) GP antenna site : As shown below.



i) Location of IAF, IF and FAF :
(i) IAF : Over Simara NDB
(ii) IF : 10 nm south of FAF on the final approach area
(iii) FAF : 10 nm south of GP antenna site on the final approach area

Note : a) Runway Orientation

Runway Orientation is one of the important factors for study of instrument approach procedures. Since suitable data for Runway orientation are not received yet, the location of Runway was drawn on the 1/50,000 scale geographical map with reference to an aerial photo as shown in Figure 10.2.6. Runway orientation was calculated as follows:

$$\text{Angle Alpha} = \frac{4{,}125}{10{,}000} = 0.4125$$

Arc tan 0,4125 = 22°24'58"

b) Distance between THR-GP

The assumed distance between THR and GP antenna site and it's elevation are calculated as shown in Figure 10.2.7.

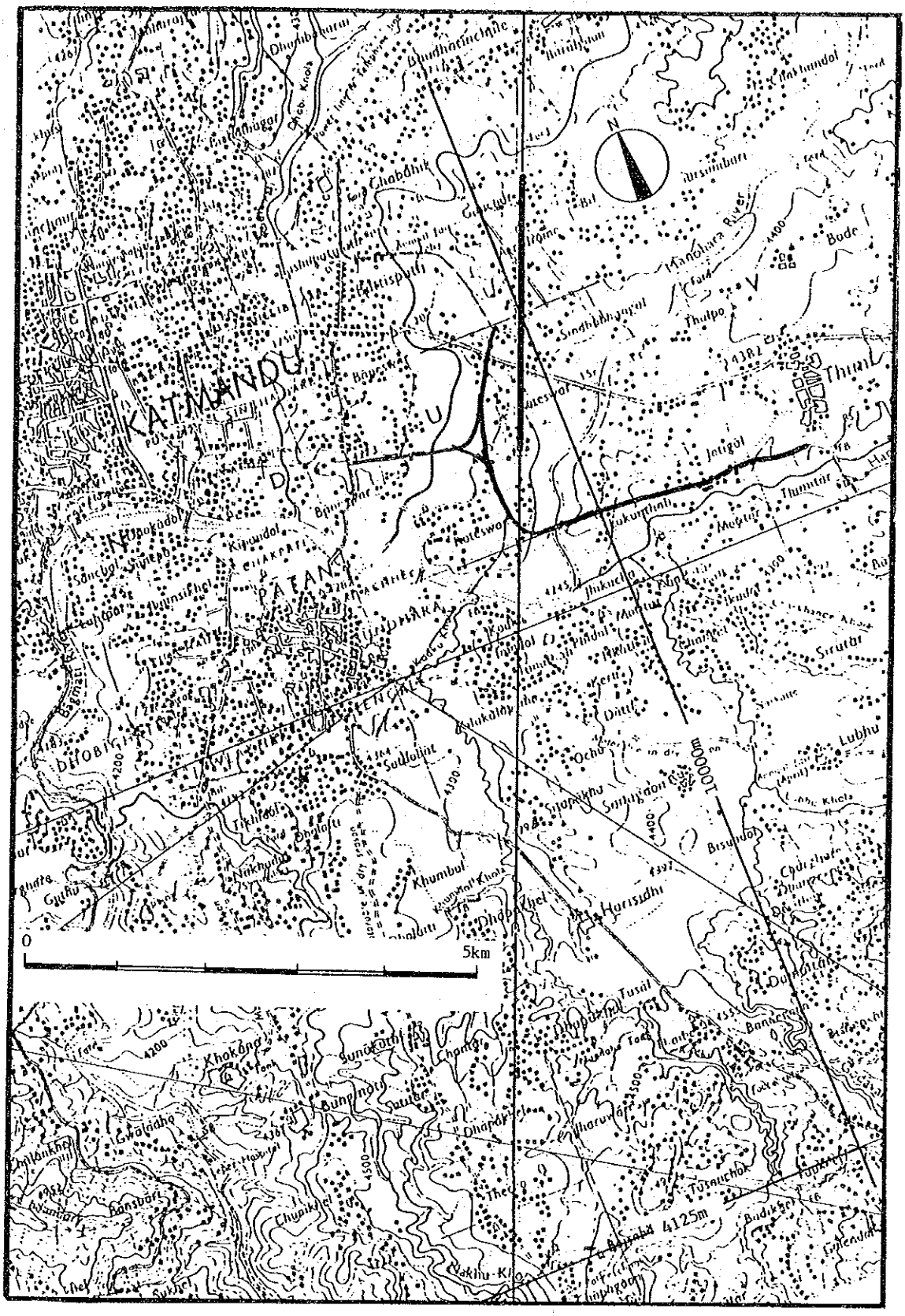
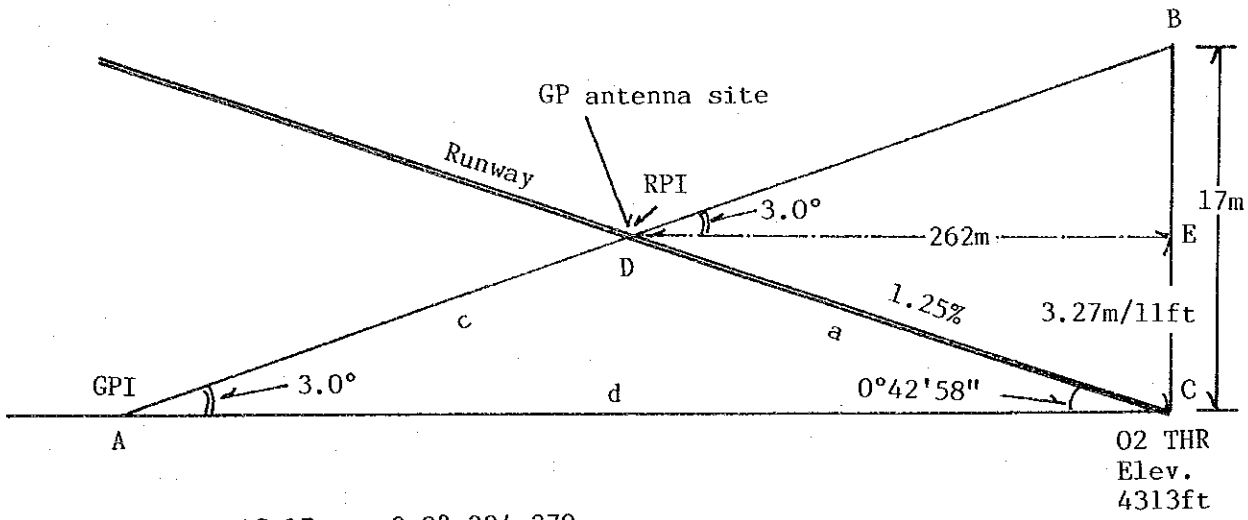


Figure 10.2.6 Runway Orientation at TIA Drawn on a Geographical Map with Reference to Aerial Photography



$AC = 17m \cdot \cot 3.0° = 324.379m$

$$a = \frac{d \sin \angle A}{\sin \angle D} = 261.934m$$

$EC = a \cdot \sin 0°42'58" = 3.27m/10.7ft \fallingdotseq 11ft$

$BE = BC - EC = 13.37m$

$DE = BE \cdot \cot 3.0° = 261.98m \fallingdotseq 262m$

Elevation at Point D=02THR elev.+EC=4324ft

Figure 10.2.7 Calculation of the Distance between THR 02 and GP Antenna Site and Elevation of GP Antenna Site

(2) ILS Approach Procedures to Runway 02 at TIA

Figure 10.2.8 shows the plane view of the ILS approach procedure to Runway 02 at TIA commencing over Simara NDB.

(a) Initial Approach Segment

Initial approach segment between Simara NDB (IAF) and IF has no significant obstacle against safe aircraft operations.

(b) Intermediate Approach Segment

A 7,500 feet AMSL mountain, located approximately 9 nm south of the assumed GP antenna site will be the highest obstacle in this segment.

Accordingly, the MEA for this segment will be 8100 feet (7,500' + 500' + 50') based on the PANS-OPS criteria. However, more clearance should be added to this MEA taking into consideration that there are so many high mountains in and around this segment.

(c) Final Approach Segment

Figures 10.2.9 and 10 show the plane and profile view of the final approach segment.
The shaded portions to drawn around FAF in Figure 10.2.8 indicate the mountainous area of 7,000 feet AMSL or above. The peak of the mountain, 7,500 feet AMSL, located 9.0 nm south of GP antenna site will be considered as the most influence obstacle for safe aircraft operations.
Figure 10.2.10 shows the relationship between the mountains in this segment and the slope of glide path of 3 degrees and W surface.

From this Figure, it can be understood that the 7,500 feet AMSL mountains located at 9.0 nm and 9.4 nm south of the GP antenna site in this segment preclude above the slope of path of 3 degrees and its OCS, and the 7,500 feet mountain, located 9.0 nm south of GP antenna site will be considered as the most influence obstacle to the slope of glide path of 3 degrees.

The corrected GP angle for Runway 02 which corresponds to the W surface to clear the obstacle mentioned above is calculated as follows.

Figure 10.2.11 shows the angle from the beginning point of the W surface to the top of the mountain, 7,500 feet AMSL, located 9.0 nm south of the GP antenna site.

From this diagram, the angle of the W surface is calculated as 3°26'46" (971/16,125 = 0.060217054, arc tan = 3°26'46")

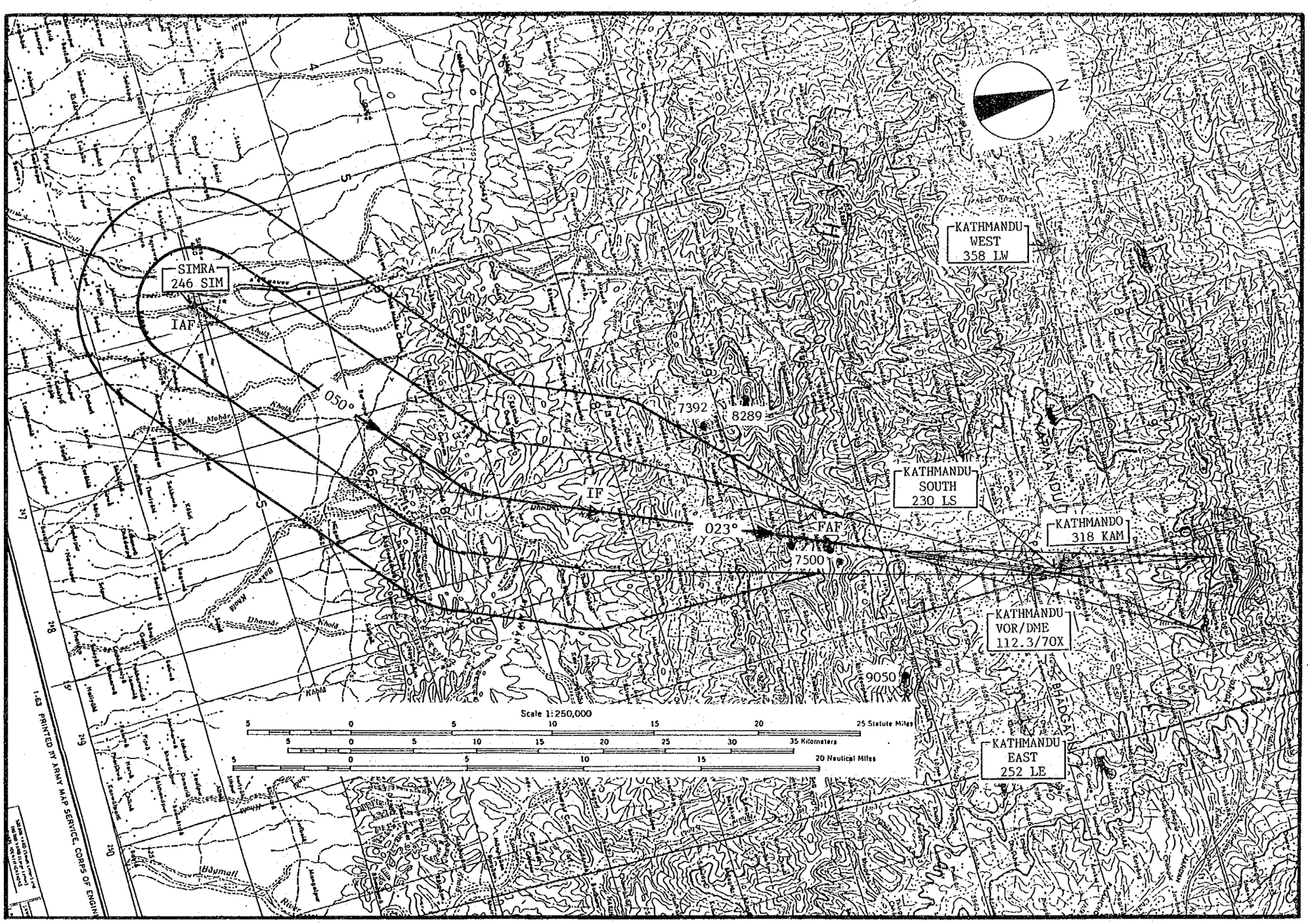


Figure 10.2.8 Plane View of the ILS Approach for Runway 02 at TIA Commencing over the Simara NDB

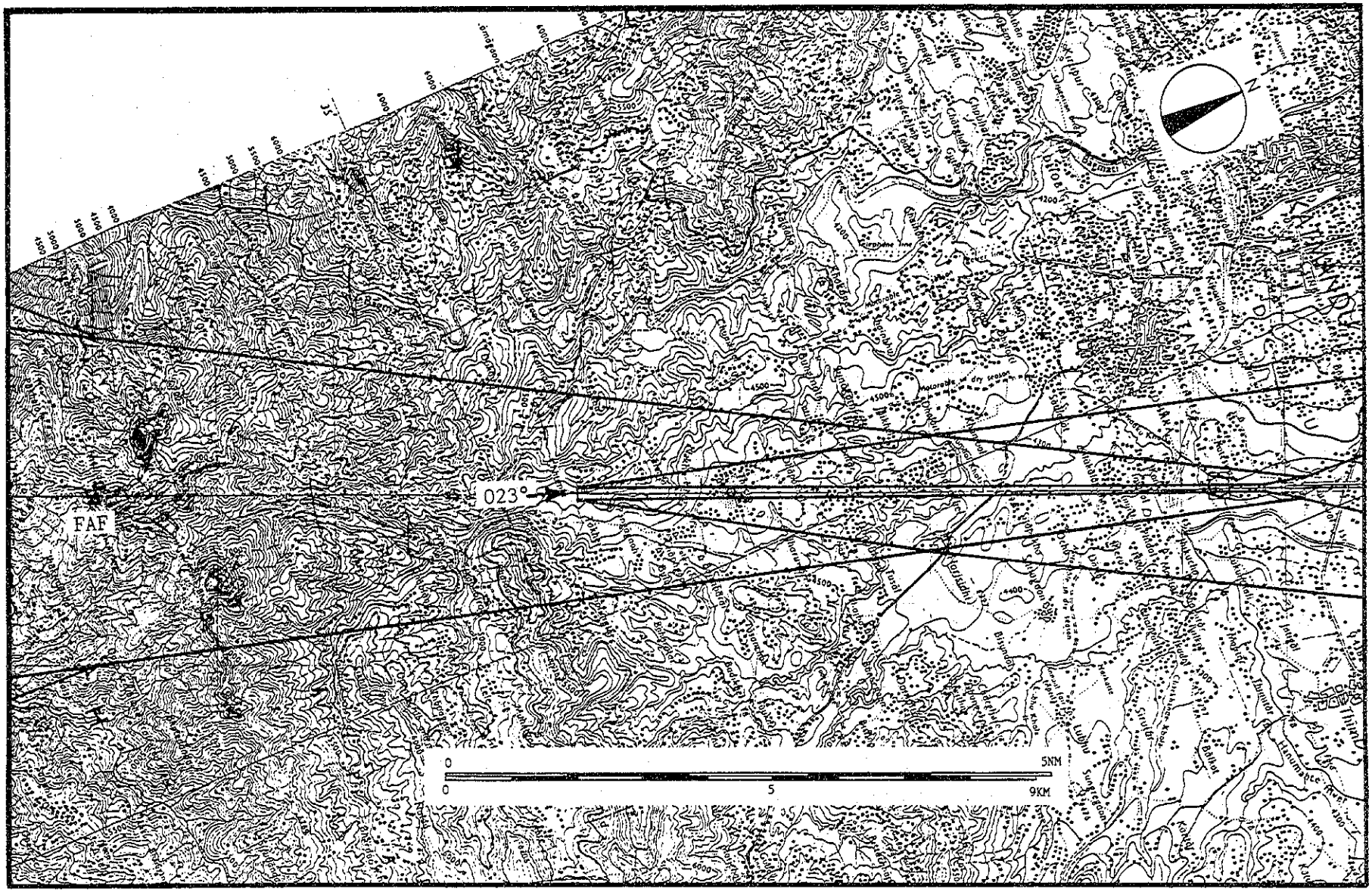


Figure 10.2.9 Plane View of the Final Approach Segment of the ILS Approach Procedure to Runway 02 at TIA

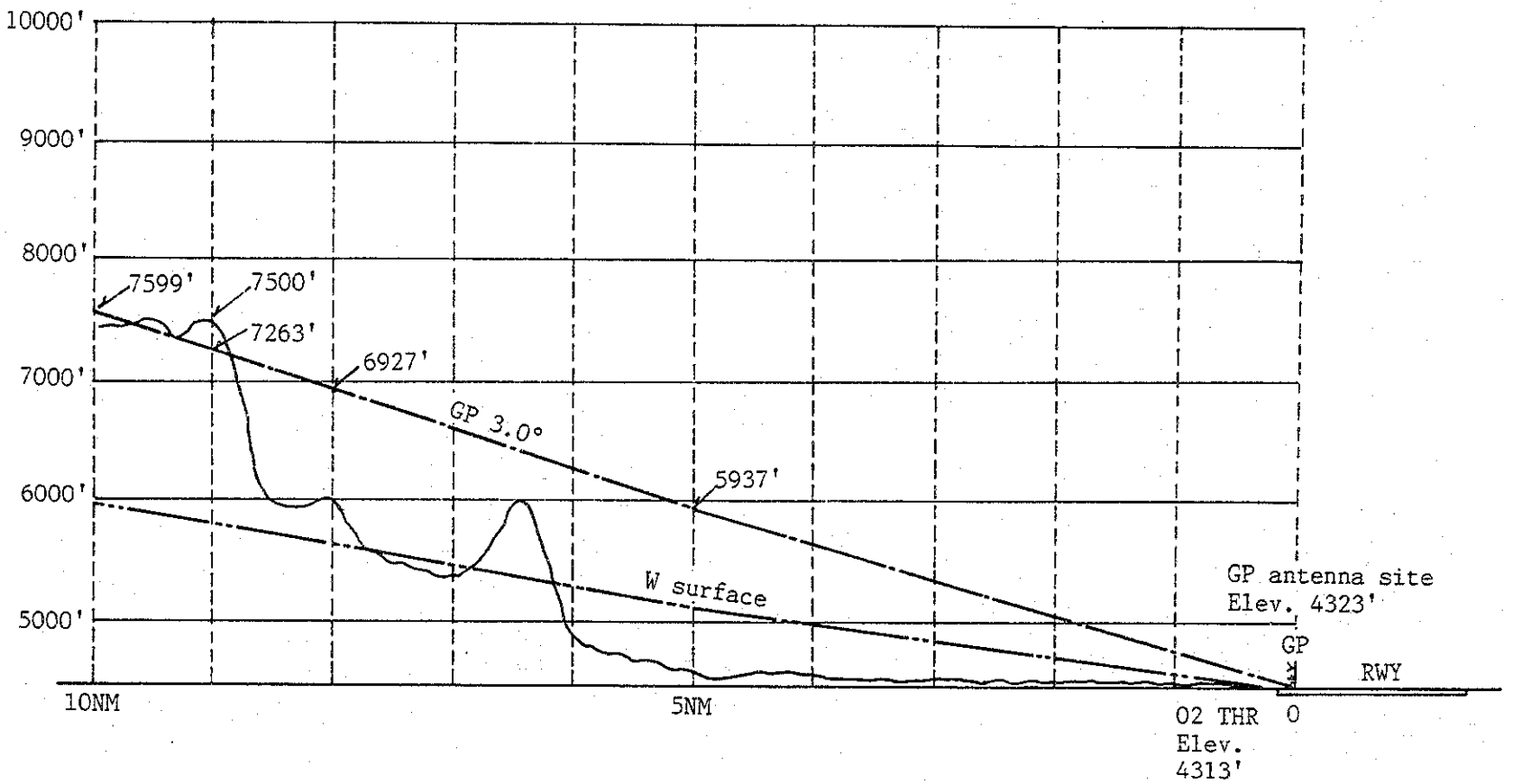


Figure 10.2.10 **Profile View of the Final Approach Segment of the ILS Approach Procedure to Runway 02 at TIA**

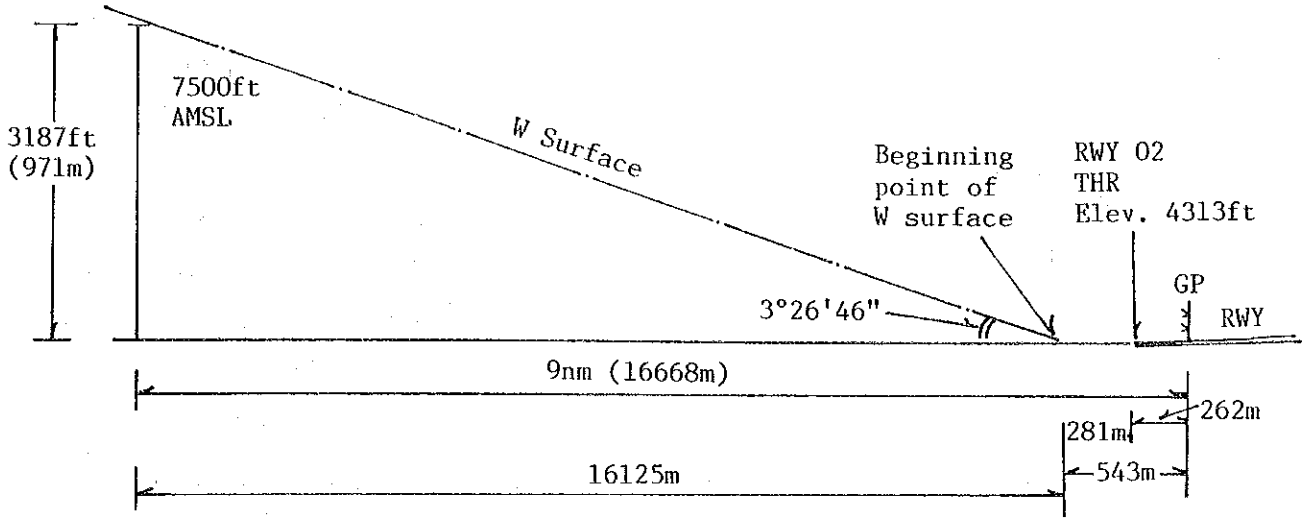


Figure 10.2.11 Diagram for Explanation for the Angle of the W Surface from the Beginning Point of the W Surface to the Top of the Mountain, 7,500 feet AMSL, Located 9.0 nm South of the GP Antenna Site

PANS-OPS prescribes the relationship between the GP and W surface angles as shown in Table 10.2.3.

Table 10.2.3 Relationship between GP angle and W surface angle prescribed in PANS-OPS

Angle of GP (1)	Angle of W surface (2)	Comparison (1) and (2) (3)
2.5	0.023900 / 1°22'09"	0.5474
2.6	0.024820 / 1°25'18"	0.5466
2.7	0.025740 / 1°28'28"	0.5458
2.8	0.026660 / 1°31'38"	0.5451
2.9	0.027580 / 1°34'47"	0.5444
3.0	0.028500 / 1°37'57"	0.5438
3.1	0.029420 / 1°41'07"	0.5432
3.2	0.030340 / 1°44'16"	0.5427
3.3	0.031260 / 1°47'26"	0.5421
3.4	0.032180 / 1°50'35"	0.5417
3.5	0.033100 / 1°53'45"	0.5412

Table 10.2.3 shows that angle of the W surface is 0.54 times that the GP angle on average.

Accordingly, the GP angle corresponding to the W surface with 3°26'46" is calculated as 6°22'54" (3°26'46" / 0.54).

This calculated GP angle of 6°22'54" is too steep and not practicable for safe aircraft operations. Thus, it is considered that the installation of ILS for Runway 02 is not suitable for safe aircraft operations.

An ILS approach with offset for Runway 02 was also studied. However, 7,500 feet AMSL class mountains still remain in the intermediate and final approach segments.
This means that the MEA for the intermediate approach segment will be more than 8,000 feet and would be very difficult to intercept and maintain the glide path.

Therefore, it is considered that for Runway 02 it is not possible to use an ILS approach procedure.

(3) LLZ Approach Procedures

The construction of the ILS approach procedure for Runway 02 at TIA was studied in the preceding paragraph and difficulties in utilizing the ILS approach procedure for Runway 02 were estimated.

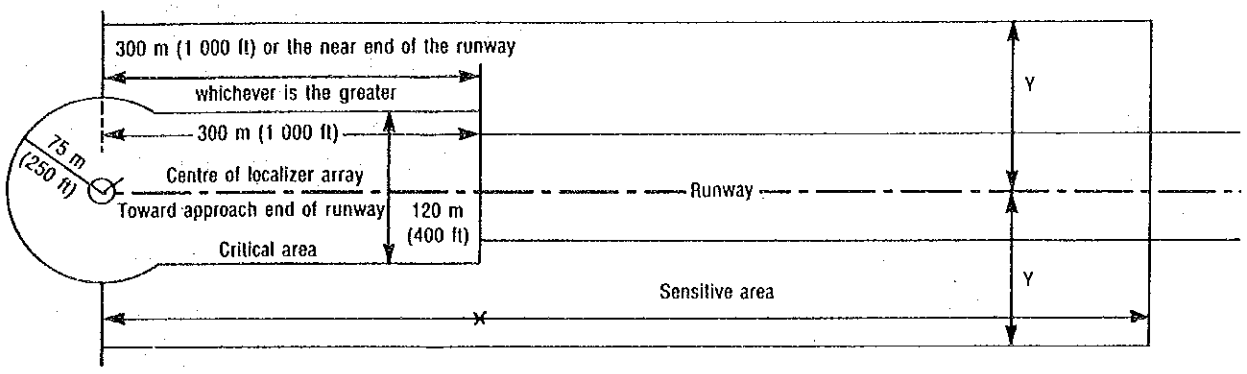
At present, only one VOR/DME, KTM, 112.3 MHz/chn 70X, 27° 40'29"N/085° 21'00"E has been operated at TIA as the main NAVAID for aircraft operations. Taking into consideration the severe geographical features and the bad weather conditions in or surrounding TIA and the possibility an unexpected accident to the existing VOR/DME, the installation of new NAVAIDs to protect against the conditions mentioned above is strongly required to support safe aircraft operations. Hence, in this paragraph localizer approach procedures are studied.

a) General criteria for the localizer antenna site

ICAO Annex 10, Chapter 3, Specifications for Radio Navigation Aids, Paragraph 3.1.3.10 recommends the siting for the localizer antenna as below. Also Attachment C to Part I, Information and Material for Guidance in the Application of the Standard and Recommended Practices, in Annex 10, Paragraph 2.1.10, Figure C-3A explains the Typical Localizer Critical and Sensitive Area Dimensions as also shown.

> **3.1.3.10** *Siting*
>
> 3.1.3.10.1 The localizer antenna system shall be located on the extension of the centre line of the runway at the stop end, and the equipment shall be adjusted so that the course lines will be in a vertical plane containing the centre line of the runway served. The antenna system shall have the minimum height necessary to satisfy the coverage requirements laid down in 3.1.3.3 above, and the distance from the stop end of the runway shall be consistent with safe obstruction clearance practices.

Description for the Location of the Localizer Antenna
ICAO, Annex 10, Chapter 3, 3.1.3.10



		Example 1	*Example 2*	*Example 3*
Aircraft type		B-747	B-747	B-727
Localizer antenna aperture		Typically 27 m (90 ft) (Directional dual freq., 14 elements)	Typically 16 m (50 ft) (Semidirectional, 8 elements)	Typically 16 m (50 ft) (Semidirectional, 8 elements)
Sensitive area (X, Y)				
Category I	X	600 m (2 000 ft)	600 m (2 000 ft)	300 m (1 000 ft)
	Y	60 m (200 ft)	110 m (350 ft)	60 m (200 ft)
Category II	X	1 220 m (4 000 ft)	2 750 m (9 000 ft)	300 m (1 000 ft)
	Y	90 m (300 ft)	210 m (700 ft)	60 m (200 ft)
Category III	X	2 750 m (9 000 ft)	2 750 m (9 000 ft)	300 m (1 000 ft)
	Y	90 m (300 ft)	210 m (700 ft)	60 m (200 ft)

Figure C-3A. Typical localizer critical and sensitive areas dimension variations for a 3 000 m (10 000 ft) runway

Extraction from ICAO Annex 10, Attachment C to Part I

b) Assumptions for the study for offset LLZ approach procedures

i) Application of non-standard localizer alignment

As a result of the study for a suitable LLZ antenna site for Runway 02 in accordance with the criteria mentioned above, it is considered that TIA has no suitable site for the installation of an LLZ antenna due to the geographical conditions north of the airport. Hence, the installation of an offset LLZ antenna for Runway 02 is unavoidable.

ii) Application of PANS-OPS criteria for the offset LLZ approach procedures

ICAO PANS-OPS (Procedures for Air Navigation Services, Aircraft Operations, DOC 8168-OPS/611, Second Edition 1982) describes that the localizer course line shall intersect the runway extended center line at an angle not exceeding 5 degrees and at point where the nominal glide path reaches a height called the intercept height of at least 55 m (180 ft) above the threshold. Figures 10.2.12 and 13 show the plane and profile view of the final approach area for the LLZ approach.

iii) The runway orientation which was calculated in the preceding paragraph is used for this study.

iv) The application of FAA Criteria when the offset angle is exceeds 5 degrees.

ICAO PANS-OPS describes that the intersection angle of the offset LLZ approach procedure is limited to 5 degrees. However, variations due to geographical conditions and operational requirements are permitted. A FAA (Federal Aviation Administration, U.S.A) criteria, called TERPS (Terminal Instrument Procedures) prescribes the criteria for the LDA (localizer type directional aids) approach procedure which permits a maximum intersecting angle of 30 degrees with an offset localizer course and extended runway center line as the VOR approach criteria.

Therefore, when the intersecting angle of offset of the LLZ approach course exceeds more than 5 degrees, the study will be conducted in accordance with the FAA criteria for LDA. Alignment options for the final approach course and final approach segments are as shown in Figures 10.2.13 and 14.

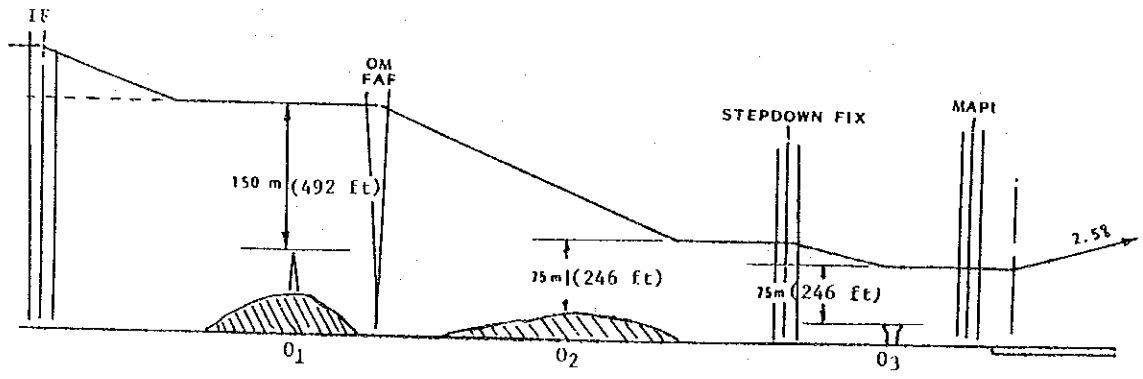


Figure 10.2.12 Profile View of the Final Approach Area for the LLZ approach

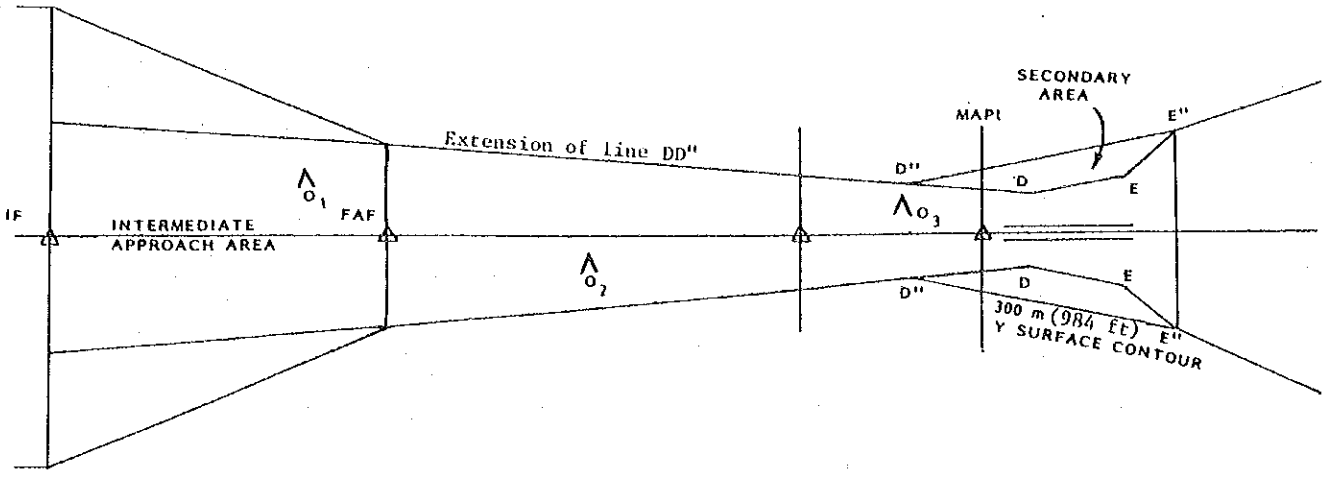


Figure 10.2.13 Plane View of the Final Approach Area for the LLZ Approach

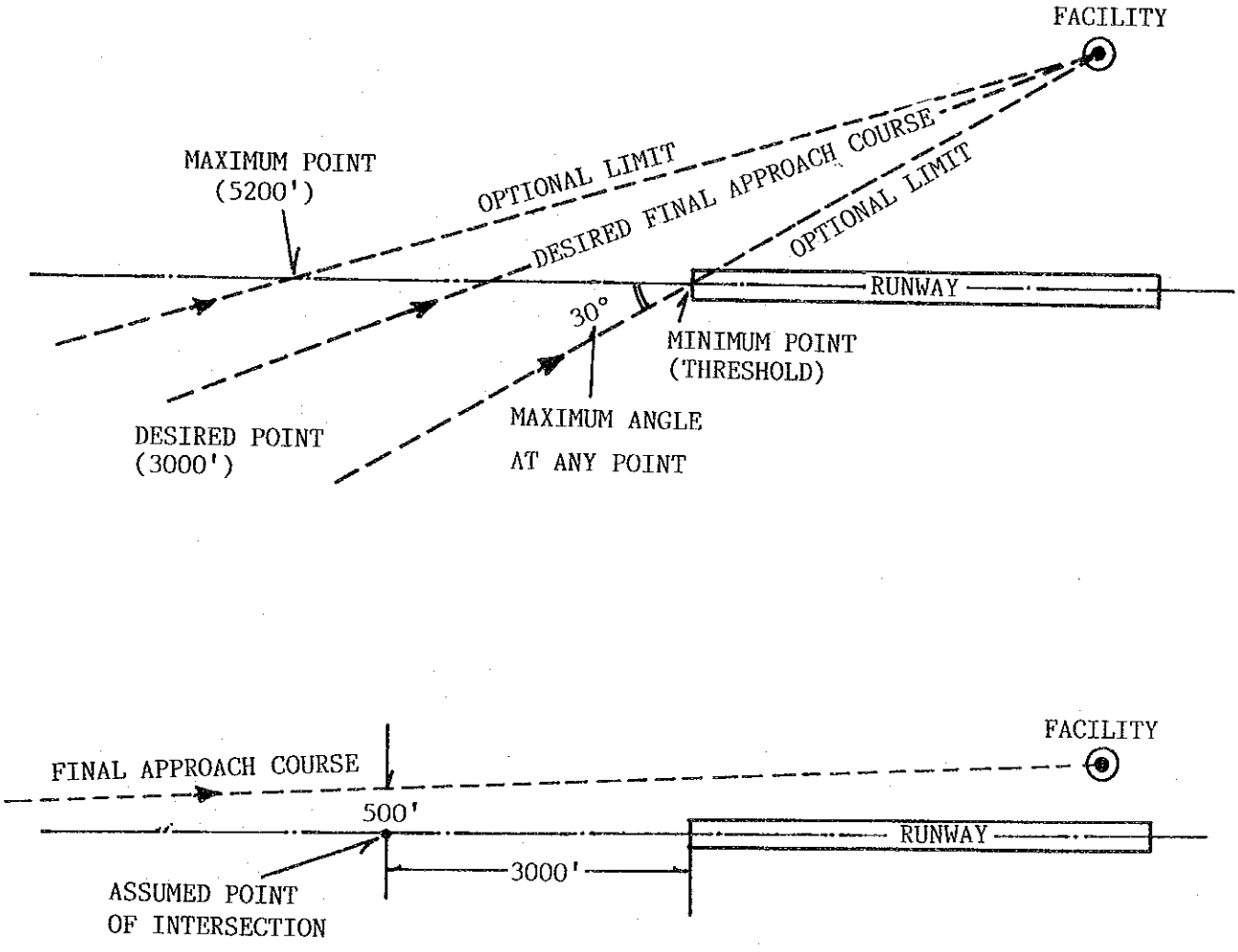


Figure 10.2.14 Alignment Options for the Final Approach Course for the LLZ approach

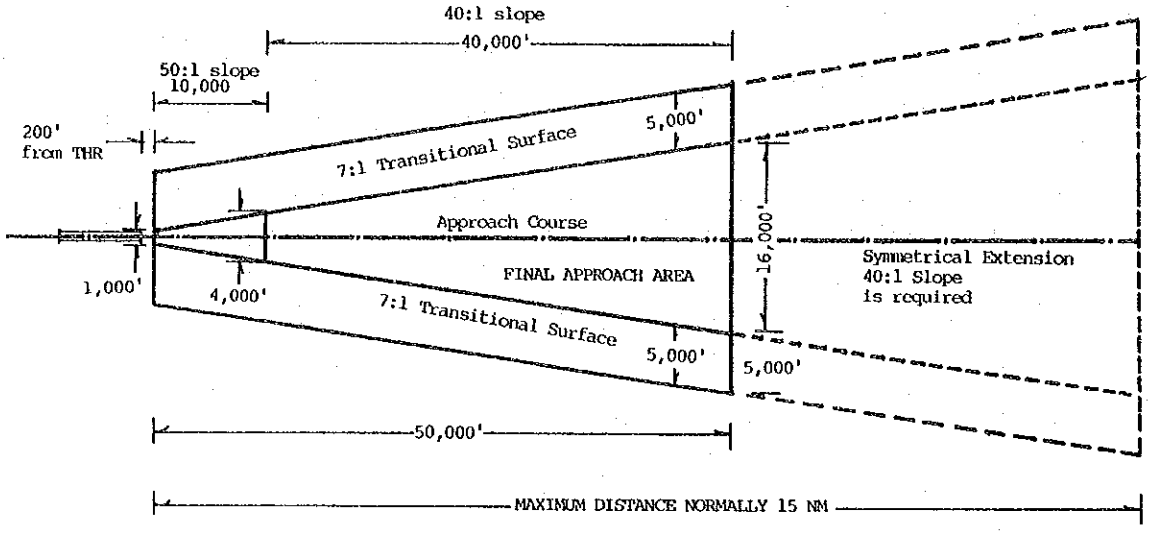


Figure 10.2.15 Plane View of the Final Approach Area for the LLZ Approach (FAA criteria)

c) The Locations of the Offset LLZ/DME Antennas

The locations of the offset LLZ/DME antenna sites were studied as shown in Figure 10.2.16 with the following conditions in the light of the master planning for this airport.

i) The heights of the antennas for LLZ/DME were assumed as 5 meters above the surface of the runway strip taking into account the ground level of the site which is selected to install the antennas.

ii) The width of the runway strip is applied to the existing width of 150 meters.

iii) The intersect point with the LLZ course line and the extended runway centerline is planned at a point 1500 meters from the Runway 02 threshold.

iv) The distance between the LLZ antenna center and the runway centerline is 124 meters, and the distance between the LLZ antenna and the Runway 02 threshold is 1300 meters.

v) From the conditions mentioned above, the offset angle of the offset LLZ is calculated as 2 °32' 09 ".

No vehicles including aircraft are excluded from the critical area during LLZ operations.

The sensitive area is protected against interference caused by large moving objects outside the critical area.

Therefore, these large moving objects should be controlled to prevent the possibility of unacceptable interference to the LLZ signal during operations.

In future when the width of runway strip is expanded to 300 meters, LLZ/DME antennas must be relocated 75 meters outside from the proposed location on this study to keep the sufficient clearance between LLZ/DME antennas and the future transitional surface.

It is considered that no large-scale changes caused by the relocation of the LLZ/DME antennas will occurr on the final approach area, and that the intersect angle with LLZ course line and the extended runway centerline will remain within 5 degrees which is described in PANS-OPS's criteria.

However, a detailed study for the changes mentioned above should be done in future.

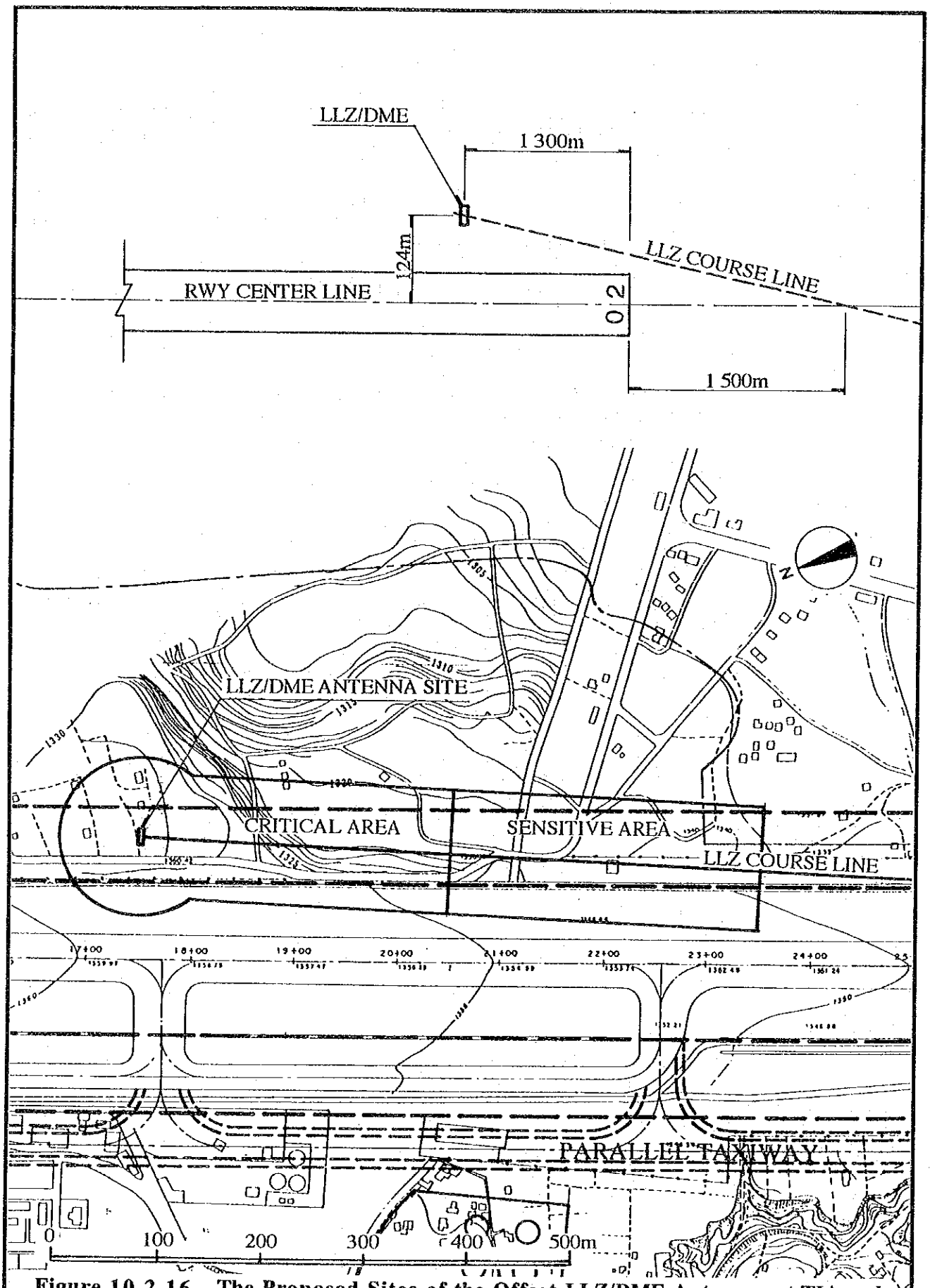


Figure 10.2.16 The Proposed Sites of the Offset LLZ/DME Antennas at TIA and Critical and Sensitive Areas for LLZ

d) An LLZ approach with offset to Runway 02 at TIA

Figure 10.2.17 shows the plane view of the LLZ approach at 2°32'09" offset to Runway 02 at TIA commencing over Simra NDB and at an intersecting point with an extended offset LLZ approach course and ATS route R-581.

(i) Initial Approach Segment

The initial approach segment between IAF and IF(20 nm south of runway 02 threshold on the offset LLZ approach course) has no significant obstacle against safe aircraft operations.
The course of the initial approach segment will be established by KTM VOR/DME and Simara NDB.

(ii) Intermediate Approach Segment

The intermediate approach segment between IF and FAF (8 nm south of Runway 02 threshold on the offset LLZ approach course) has many mountains with peaks above 7500 feet AMSL.
Generally, obstacle clearance on the intermediate approach segment is 500 feet above the highest obstacle in this segment. However, more clearance should be added taking into consideration that this segment is deemed a mountainous area.

(iii) Final Approach Segment

Figures 10.2.18 and 19 show the plane and profile views of the final approach segment.

Figure 10.2.17 shows that 7000 feet AMSL class mountains surround the FAF and a 6000 feet AMSL mountain is located at 6.2 nm south of Runway 02 threshold in this segment. However, no significant obstacle exists on the approach end area. Figure 10.2.18 shows the profile view of the final approach segment and the descending profile.

A descending rate from FAF to 3 nm is 600 feet per mile, next 2 nm is 500 feet per mile and the last is 300 feet per mile to Runway 02. These steep descents are unavoidable due to the high mountain located 8 nm from the Runway 02 threshold. MDA which is studied based on the final approach segment will be 5100 feet AMSL and flight visibility will be 2800 m.

(iv) Missed Approach Area

The missed approach procedure for the existing Sierra Approach is applicable to the offset localizer approach. Figure 10.2.20 shows the missed approach area. The values of the parameters used for the turning missed approach area are calculated as follows.
The missed approach point is assumed to be 1.6 nm from the Runway 02 threshold which is the same as the Sierra Approach. From this Figure, it is considered that the missed approach course has sufficient clearance between obstacles.

IAS (kt)	TAS (5000 ft, ISA + 15) IAS X Conversion factor* (kt)	e 10 seconds $TAS \times \frac{10}{3600}$ (NM)	f 16 seconds $TAS \times \frac{10}{3600}$ (NM)	c 6 seconds $(TAS + 30) \times \frac{10}{3600}$ (NM)	R $\frac{29.3}{TAS}$ (deg/s)	r $\frac{TAS}{62.8\ R}$ (NM)	E $\frac{0.75}{R}$ (NM)
185	205	0.57	0.91	0.39	1.42	2.29	0.52

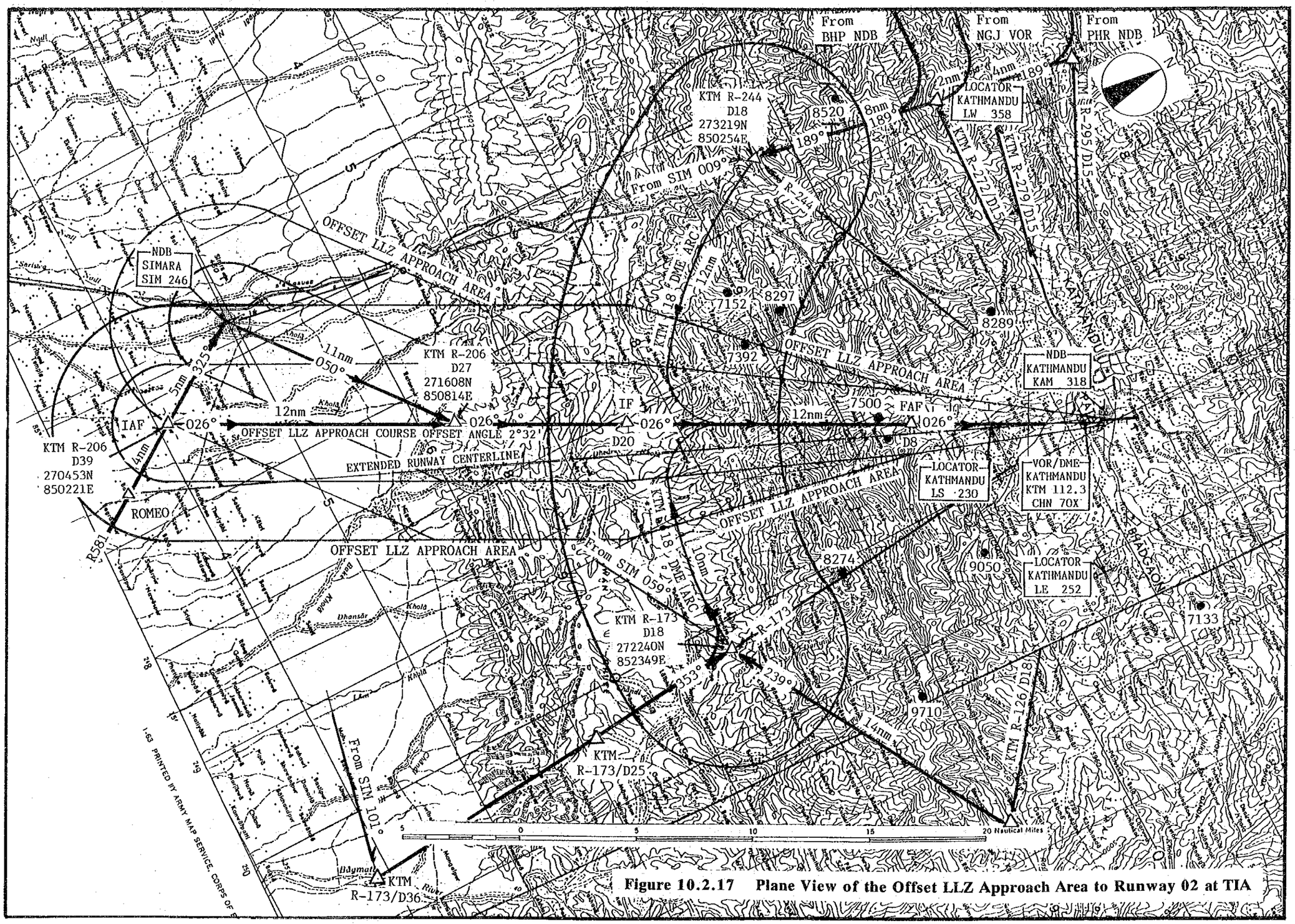


Figure 10.2.17 Plane View of the Offset LLZ Approach Area to Runway 02 at TIA

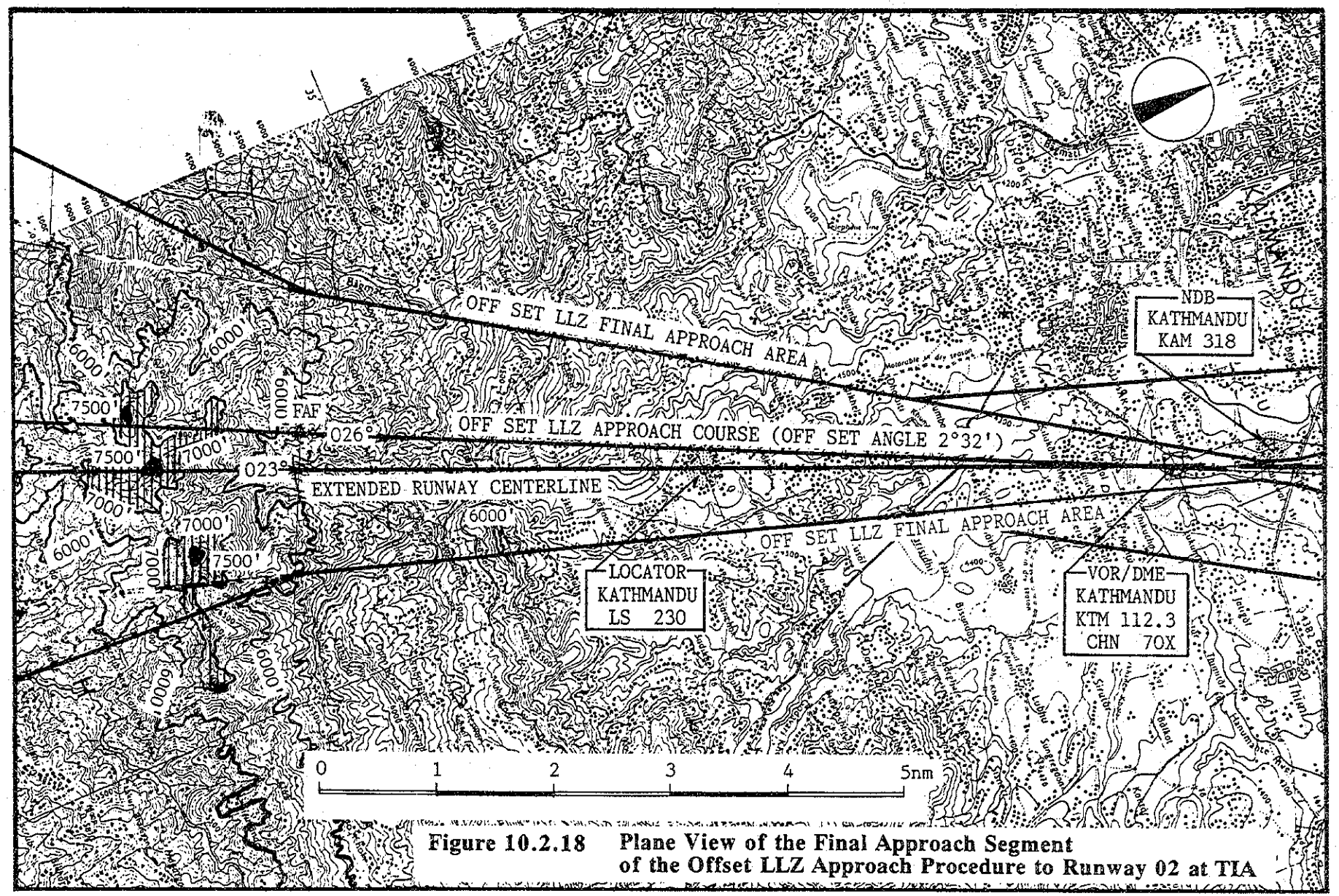


Figure 10.2.18 **Plane View of the Final Approach Segment of the Offset LLZ Approach Procedure to Runway 02 at TIA**

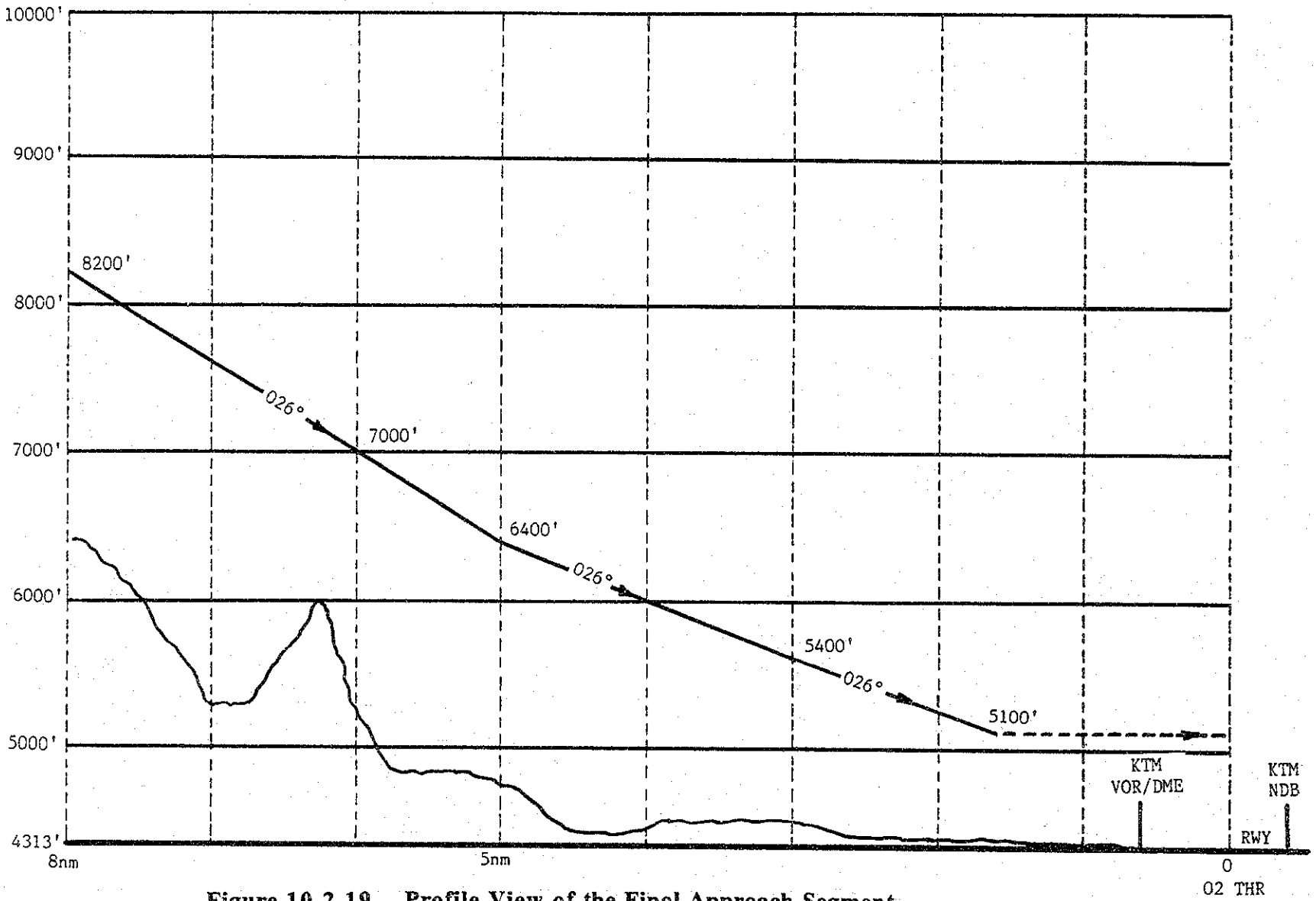


Figure 10.2.19 Profile View of the Final Approach Segment of the Offset LLZ Approach Procedure to Runway 02 at TIA

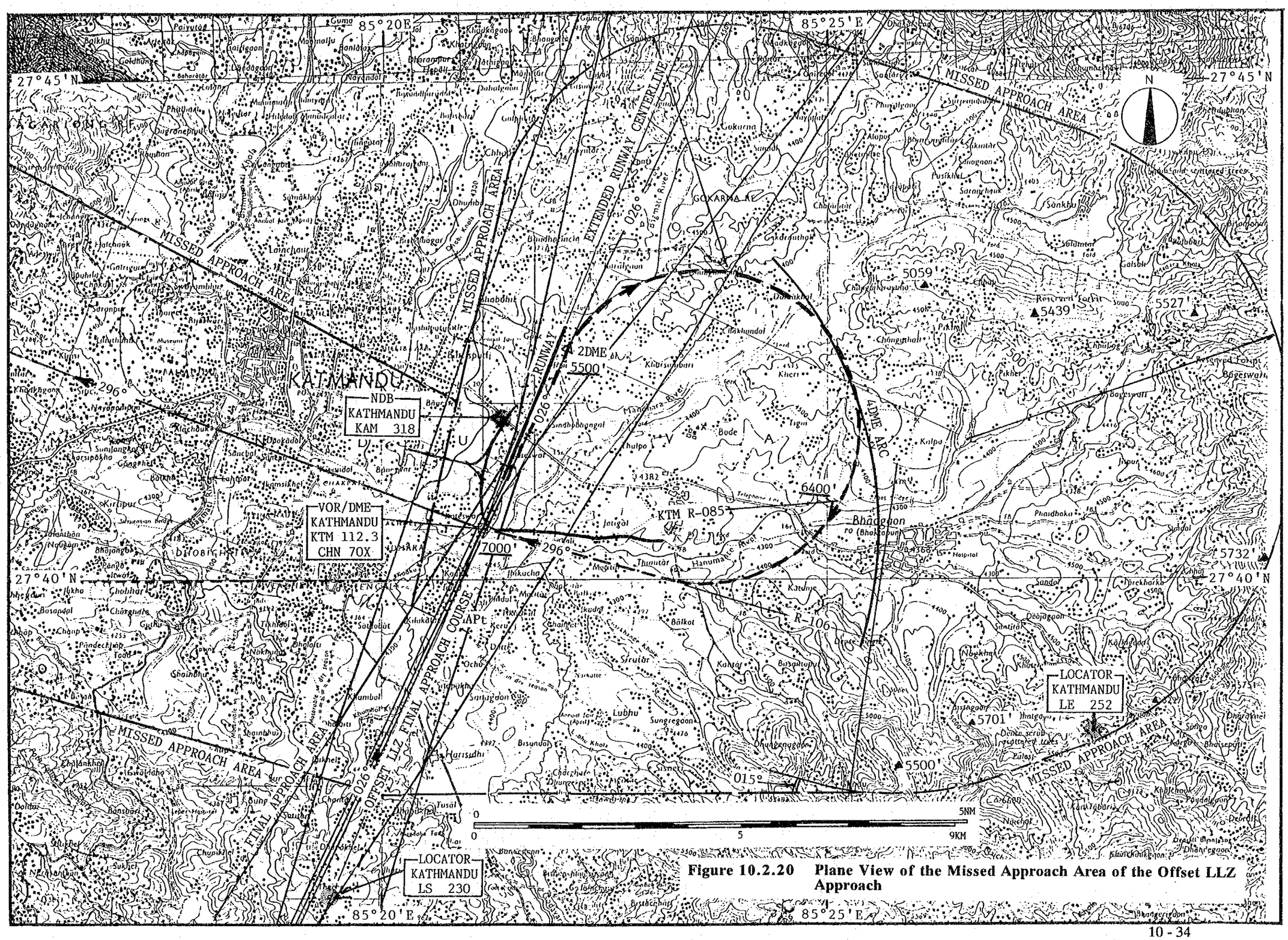


Figure 10.2.20 Plane View of the Missed Approach Area of the Offset LLZ Approach

10.2.3 The Study of IGS approach Procedures for RWY 20 at TIA

(1) General

IGS stands for the Instrument Guidance System. In the case of the existence of many obstacles on the straight-in approach course to the runway, an IGS approach procedure is adopted with the offset approach course from the extended runway centerline using an ILS component to avoid the obstacles. Aircraft make the approach along an offset approach course, then make a visual right or left turn and line up with the intended runway after reaching the decision height and runway in sight, and then land by circling. At present, Hong Kong International Airport has IGS approach procedures for Runway 13. In those procedures, approach courses are established by an ILS component but is offset from the landing direction within 47 degrees.

(2) Study of IGS Approach Procedures for runway 20 at TIA

The four (4) drafts of IGS approach procedures were made with the assumptions as shown in Table 10.2.4. Assumed sites for the LLZ/DME and GP antennas are shown in Figure 10.2.21.

Table 10.2.4 The Assumed Conditions for the Study of IGS Approach Procedures for Runway 20 at TIA

	The Angle of GP	Proposed Sites for LLZ/DME and GP Antennas	The Elevation of Proposed Sites for LLZ/DME and GP Antennas	Intersecting Point with Extended Runway Centerline	Offset Aproach Course	Offset Angles from the Landing Direction
Plan A	3.0°	See Figure 10.2.20	1,570 m 5,150'	5,300 m	249° T	047°
Plan B			1,300 m 4,265'	1,000 m	249° T	
Plan C			1,310 m 4,300'	1,000 m	155° T	
Plan D			1,374 m 4,500'	3,700 m	155° T	

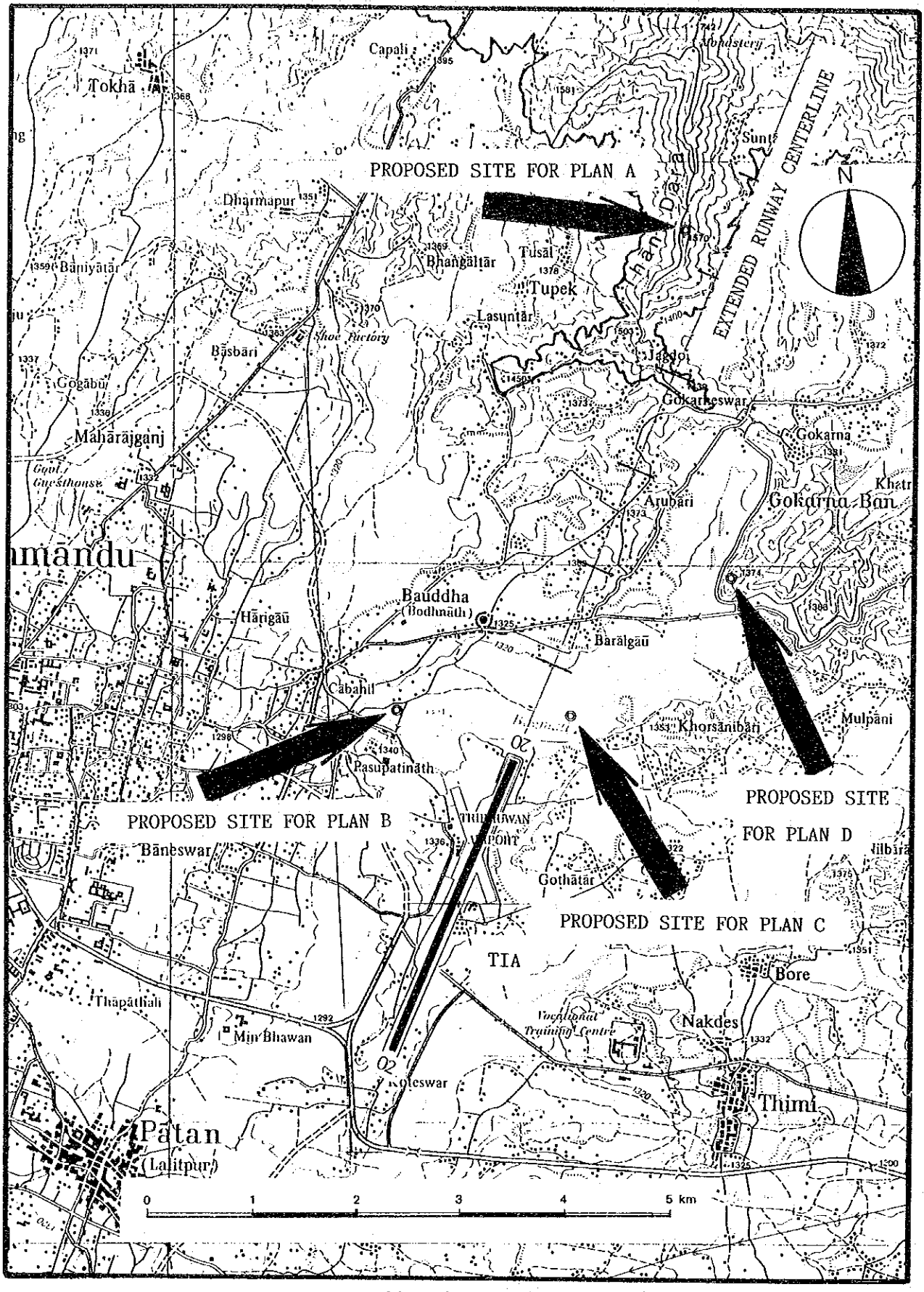


Figure 10.2.21 The Proposed Sites for LLZ/DME and GP Antennas for IGS Approach Procedures of Plans A, B, C and D

a) Figure 10.2.22 shows the final approach segments of Plans A and B for IGS approach procedures from the NE to Runway 20 at TIA.

i) Plan A

The site for the LLZ/DME and GP antennas is assumed to be on top of the hill, 1,570m/5,150' AMSL, located at 5,300m from the Runway 20 threshold along the extended runway centerline as shown in Figure 10.2.21.

Figure 10.2.22 shows that many obstacles which project above the obstacle assessment surfaces (OAS) are scattered along the W surface.

Table 10.2.5 shows the relationship between the OAS and the obstacles mentioned above. From this Table, it is considered that Plan A is not suitable for operational use.

ii) Plan B

The site for the LLZ/DME and GP antennas is assumed to be at position approximately 1200m west of the Runway 20 threshold as shown in Figure 10.2.21.

The elevation of the site is assumed as 1,300 m/4265' AMSL. The IGS approach direction for Plan B is the same as Plan A as shown in Figure 10.2.23.

Table 10.2.6 shows the relationship between the OAS and the obstacles. From this Table, it is confirmed that the mountains around FAF (final approach fix, 7 nm from GP antenna) project above the OAS.

To clear these mountains, the reasonable angle of GP should be 4°30'{arctan (1,800-1,300)÷ 11,800÷ 0.54}.

Moreover, when the approach course for Plan B is drawn as shown in Figure 10.2.23, the MEAs at intermediate fixes are 11,500', and 7,500' at FAF. However, the altitude of 3 degrees of GP at FAF will be 6,537' (7 nm· tan 3.0 + EC + site elevation).

Thus, approaching aircraft along this approach course are unable to capture the GP successfully. Accordingly, Plan B is also not suitable for operational use.

Figure 10.2.22 The Final Approach Segment of IGS Approach Procedures for Plans A and B

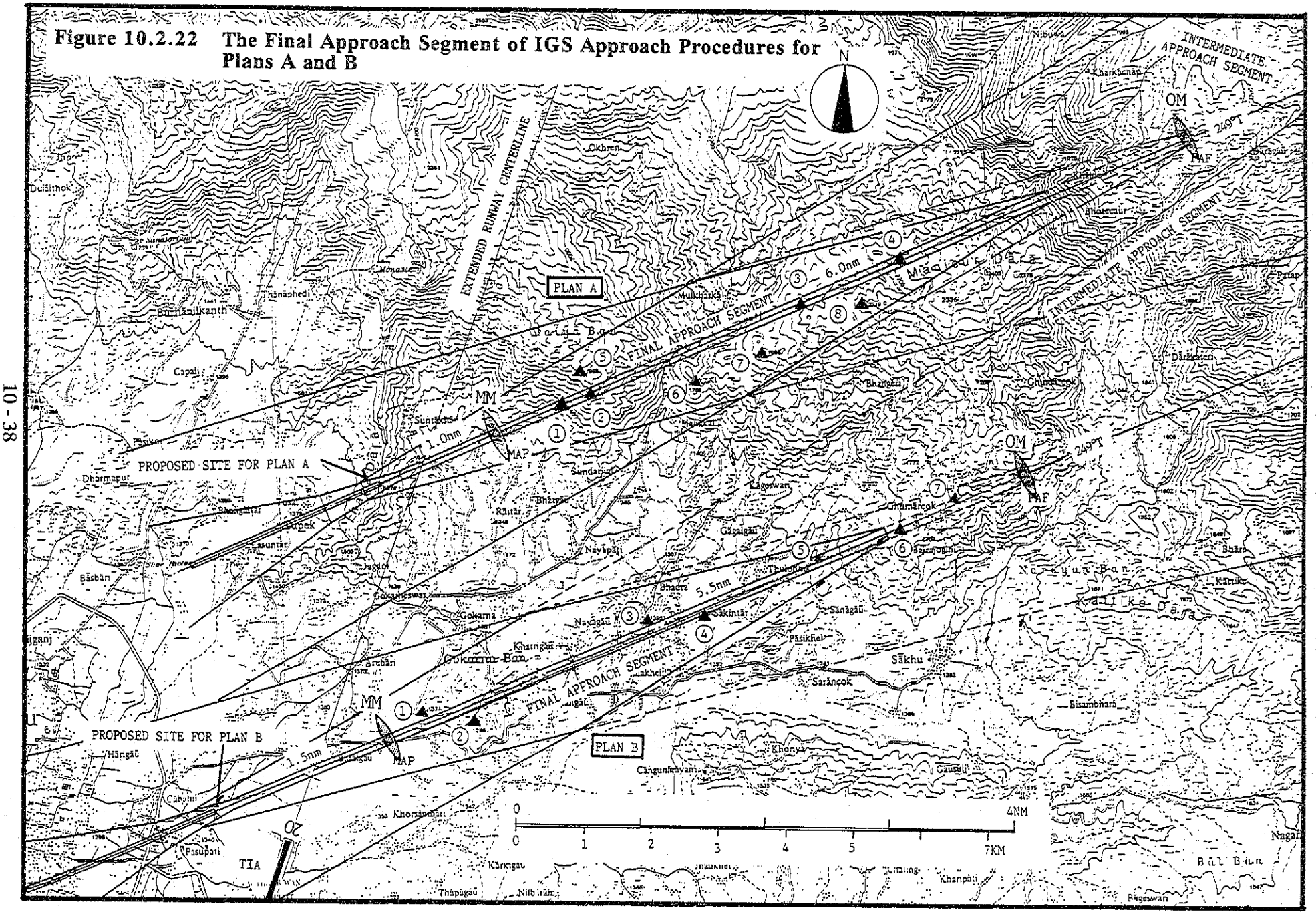


Table 10.2.5 The Relationship between OAS and Obstacles in the Final Approach Area for Plan A

OBSTACLES				HEIGHT OF OAS AMSL AT OBSTACLE'S LOCATION	PENETRATION	REMARKS
NR	HEIGHT AMSL	LOCATIONS EXPRESSED BY X AND Y COORDINATES	OAS CONCERNED			
	m	m		m	Yes/No	
1	1,600	x = 2,900 y = -	W	(1) 1,644	No	
2	1,800	x = 3,400 y = -	W	(1) 1,659	Yes	GP COR TO 7°10'
3	2,000	x = 6,800 y = -	W	(1) 1,755	Yes	GP COR TO 6°43'
4	2,200	x = 8,350 y = -	W	(1) 1,800	Yes	GP COR TO 8°00'
5	1,908	x = 3,400 y = 350	X	(2) 1,713	Yes	GP COR TO 10°31'
6	1,709	x = 4,900 y = 450	X	(2) 1,773	No	
7	1,896	x = 6,000 y = 450	X	(2) 1,804	Yes	GP COR TO 5°46'
8	2,219	x = 7,600 y = 350	X	(2) 1,830	Yes	GP COR TO 9°03'

Table 10.2.6 The Relationship between OAS and Obstacles in the Final Approach Area for Plan B

OBSTACLES				HEIGHT OF OAS AMSL AT OBSTACLE'S LOCATION	PENETRATION	REMARKS
NR	HEIGHT AMSL	LOCATIONS EXPRESSED BY X AND Y COORDINATES	OAS CONCERNED			
	m	m		m	Yes/No	
1	1,374	x = 3,400 y = 150	X	(1) 1,406	No	
2	1,386	x = 4,080 y = 475	X	(1) 1,485	No	
3	1,393	x = 7,000 y = 150	X	(1) 1,506	No	
4	1,383	x = 7,800 y = 100	X	(1) 1,520	No	
5	1,400	x = 9,700 y = -	W	(2) 1,568	No	
6	1,600	x = 10,900 y = -	W	(2) 1,602	No	
7	1,800	x = 11,800 y = -	W	(2) 1,628	Yes	GP COR TO 4°30'

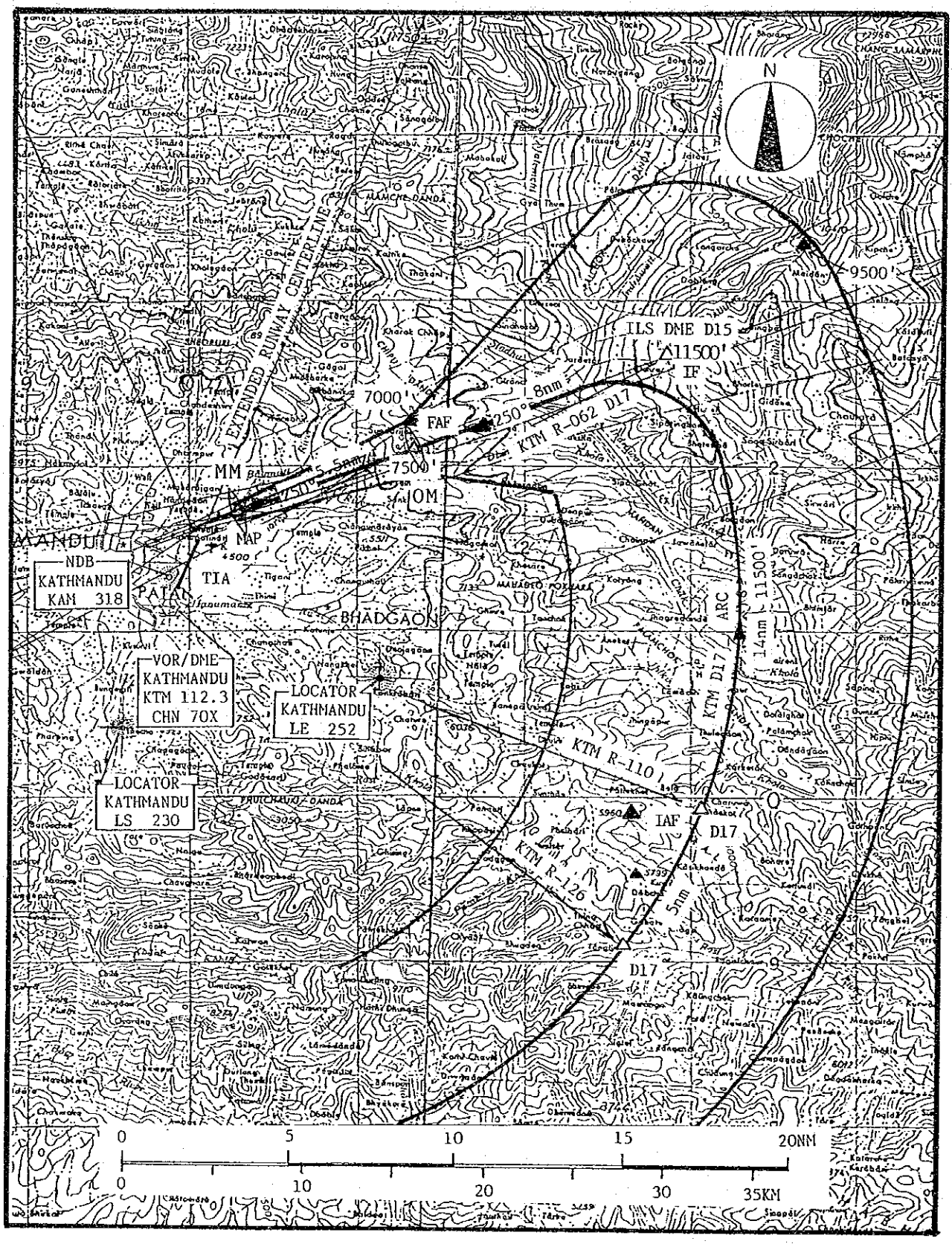


Figure 10.2.23 The Study of IGS Approach Procedures Based on Plans B

b) Figure 10.2.24 shows the final approach segments of Plans C and D for IGS approach procedures from the NW to Runway 20 at TIA.

i) Plan C

The site for the LLZ/DME and GP antennas is assumed to be at a position approximately 700m NE of the Runway 20 threshold as shown in Figure 10.2.21.

The elevation of the site mentioned above is assumed to be 1,310 m/4,300' AMSL.

The final approach segment of Plan C which intersects with the extended runway centerline at 1 km from Runway 20 threshold, lies 155 degrees from True bearing maintaining a 47 degrees offset from the extended runway centerline.

Table 10.2.7 shows the relationship between the OAS and the obstacles. From this Table, it is confirmed that many mountains located around 8.5 km (4.5 nm) from the GP antenna site project above the W surface.

To clear the highest obstacle of 1,800m AMSL, located at 8,650m from the GP antenna site, the GP angle of 3 degrees should be corrected to 6°01'.

Thus, it is considered that Plan C is not suitable for operational use.

ii) Plan D

The final approach segment of Plan D with the same approach direction of Plan C is shown in Figure 10.2.24. The site for the LLZ/DME and GP antennas is assumed to be on top of the hill, 1,374 m/4,500' AMSL, located at 2,700 m NE of the Runway 20 threshold as shown in Figure 10.2.21.

Table 10.2.8 shows the relationship between the OAS and the obstacles. From this Table, it is verified that many obstacles project above the OAS.

To clear the most influential obstacle to a GP angle of 3 degrees, which has a height of 2,160 m AMSL, located at 9,050 m from GP antenna site in the W surface, the GP angle should be corrected to 9°12'.

Thus, this approach procedure is not suitable for operational use.

c) Evaluation on the establishment of an IGS approach Procedure for Runway 20

The four drafts of the final approach area for the IGS approach procedures were studied in this section.

However, each draft has many obstacles in the final approach area.

Accordingly, it is considered that the establishment of a practical IGS approach procedure for Runway 20 is very difficult.

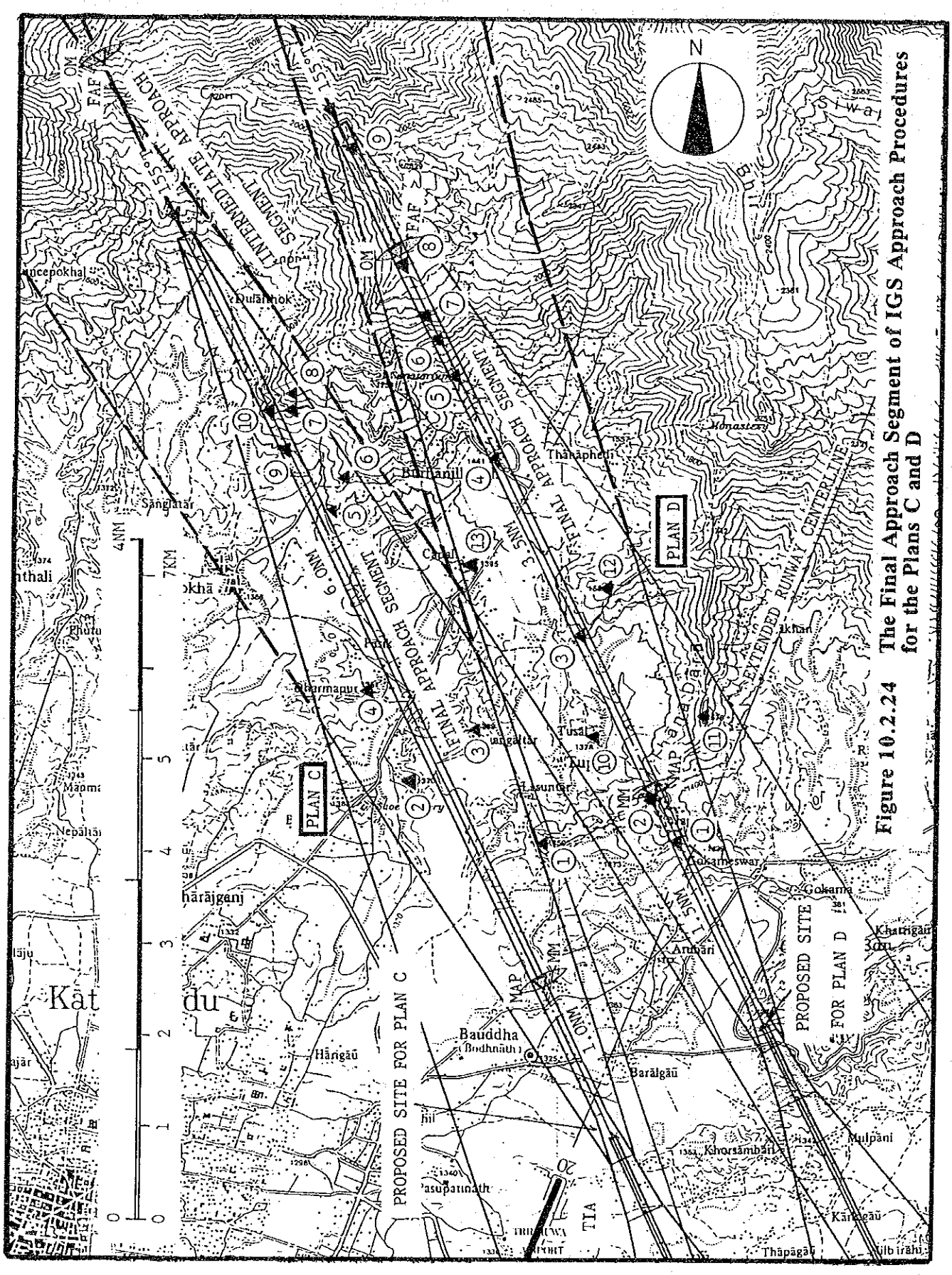


Figure 10.2.24 The Final Approach Segment of IGS Approach Procedures for the Plans C and D

Table 10.2 7 The Relationship between OAS and Obstacles in the Final Approach Area for Plan C

OBSTACLES				HEIGHT OF OAS AMSL AT OBSTACLE'S LOCATION	PENETRATION	REMARKS
NR	HEIGHT AMSL	LOCATIONS EXPRESSED BY X AND Y COORDINATES	OAS CONCERNED			
	m	m		m	Yes/No	
1	1,450	x = 3,200 y = 600	Y	1,493 (1)	No	
2	1,370	x = 4,400 y = 300	X	1,471 (2)	No	
3	1,369	x = 4,700 y = 600	X	1,535 (2)	No	
4	1,351	x = 5,500 y = 300	X	1,502 (2)	No	
5	1,400	x = 7,400 y = 100	X	1,518 (2)	No	
6	1,480	x = 7,650 y = 450	X	1,590 (2)	No	
7	1,600	x = 8,550 y = 250	X	1,578 (2)	Yes	GP COR TO 3°36'
8	1,680	x = 8,700 y = 300	X	1,591 (2)	Yes	GP COR TO 4°31'
9	1,600	x = 8,200 y = -	W	1,535 (3)	Yes	GP COR TO 3°46'
10	1,800	x = 8,650 y = -	W	1,548 (3)	Yes	GP COR TO 6°01'

Table 10.2.8 The Relationship between OAS and Obstacles in the Final Approach Area for Plan D

OBSTACLES				HEIGHT OF OAS AMSL AT OBSTACLE'S LOCATION	PENETRATION	REMARKS
NR	HEIGHT AMSL	LOCATIONS EXPRESSED BY X AND Y COORDINATES	OAS CONCERNED			
	m	m		m	Yes/No	
1	1,400	x = 2,200 y = -	W	1,428 (1)	No	
2	1,503	x = 2,650 y = -	W	1,441 (1)	Yes	GP COR TO 5°10'
3	1,400	x = 4,600 y = -	W	1,497 (1)	No	
4	1,441	x = 6,750 y = -	W	1,558 (1)	No	
5	1,600	x = 7,750 y = -	W	1,586 (1)	Yes	GP COR TO 3°06'
6	1,800	x = 8,200 y = -	W	1,599 (1)	Yes	GP COR TO 5°31'
7	2,000	x = 8,500 y = -	W	1,608 (1)	Yes	GP COR TO 7°48'
8	2,160	x = 9,050 y = -	W	1,623 (1)	Yes	GP COR TO 9°12'
9	2,200	x = 10,400 y = -	W	1,662 (1)	Yes	GP COR TO 8°25'
10	1,378	x = 3,600 y = 300	X	1,513 (2)	No	
11	1,570	x = 3,300 y = 800	Y	1,602 (3)	No	
12	1,581	x = 5,000 y = 450	X	1,580 (2)	Yes	GP COR TO 4°24'
13	1,395	x = 5,850 y = 750	X	1,659 (2)	No	

10.2.4 Study of Approach Procedures Alternatives to the IGS Approach for RWY 20 at TIA

(1) General

The possibility of the establishment of IGS approach procedures from the east and west of Runway 20 at TIA was studied in the preceding section, with the provision that the intersecting angle between the final approach course and the extended runway centerline does not exceed 47 degrees. However, difficulties were found in establishing IGS approach procedures with the condition stated above due to the high mountains surrounding the airport.

However, there are some ravines to the east and west of the airport.

Therefore, in this section, the possibilities to establish approach procedures for Runway 20 over the ravine which lies on the east side of the airport were studied.

When an approach procedure is established over the ravine located on the east side of the airport, the intersecting angle between the final approach course and the extended Runway centerline will be exceed 47 degrees.

Thus, it means that a sufficient distance between the landing runway threshold and the turning point is required for the stabilization of landing aircraft and to line up with the landing runway.

(2) The Assumption of the Study for the Alternative Plan E

The following conditions are assumed for the study of Plan E as shown in Figure 10.2.25.

a) The elevation of Runway 20 threshold : 4,313'/1,314 m

b) The elevation of the ILS/LLZ, GP and DME Antenna's sites : 5,150'/1,570 m

(These antenna's sites are assumed to be on top of a hill, 1,570 m AMSL, located approximately 5,300m north of Runway 20 threshold)

c) Angle of GP : 3.0 degrees

(3) The Outline of Plan E

The outline of Plan E is as follows;

a) Fixes

Fixes	Locations
IAF	KTM VOR/DME R-126 D18
I F	KTM VOR/DME R-088 D18/ILS/DME D17
FAF	ILS/DME D7
MAP	ILS/DME D1

b) MEAs

Segments	MEA
Initial Approach	
from IAF to KTM VOR/DME R-110 D18	11,000'
from KTM VOR/DME R-110 to IF	10,000'
Intermediate Approach	
from IF to ILS/DME D12	8,500'
from ILS/DME D12 to FAF	7,300'

c) Approach Courses

Segments	Courses
Initial Approach	KTM VOR/DME 18 DME ARC
Intermediate Approach	284°
Final Approach	284°
Missed Approach	270°

(4) The Study of Plan E

a) The Initial Holding Procedure

The initial holding point is planned at point KTM VOR/DME R-126 D18, right turn, one minute. All obstacles are cleared if the MHA of 11,000 feet is maintained.

b) Initial and Intermediate Approach Segments

The initial approach segment is constructed by the KTM VOR/DME 18 DME arc.

MEAs for the initial and intermediate approach segments are obtained by the adding the margin of 2,000 feet to the highest obstacle in each segment when considering the line of sight of KTM VOR/DME.

c) Final Approach Segment

Figure 10.2.26 shows an enlarged chart of the final approach segment with the inbound course of 284°. All obstacles in the final approach segment do not project above the Obstacle Assessment Surfaces (OAS) of this segment as studied in Table 10.2.9. The final approach fix (FAF) is planned at a point 7 nm from the assumed GP antenna site on the final approach course.

GP capture altitude at FAF will be 7,422 feet by the calculation of the following formula:

$$7 \text{ nm} \cdot \tan 3.0^\circ + \text{earth curvature } (0.024D^2) + 5150' \text{ (GP elevation)}$$

The decision point is planned at a point ILS/DME D1 on the final approach course.

The decision altitude and flight visibility which are studied based on the final approach segment will be 5469 feet and 6000m respectively.

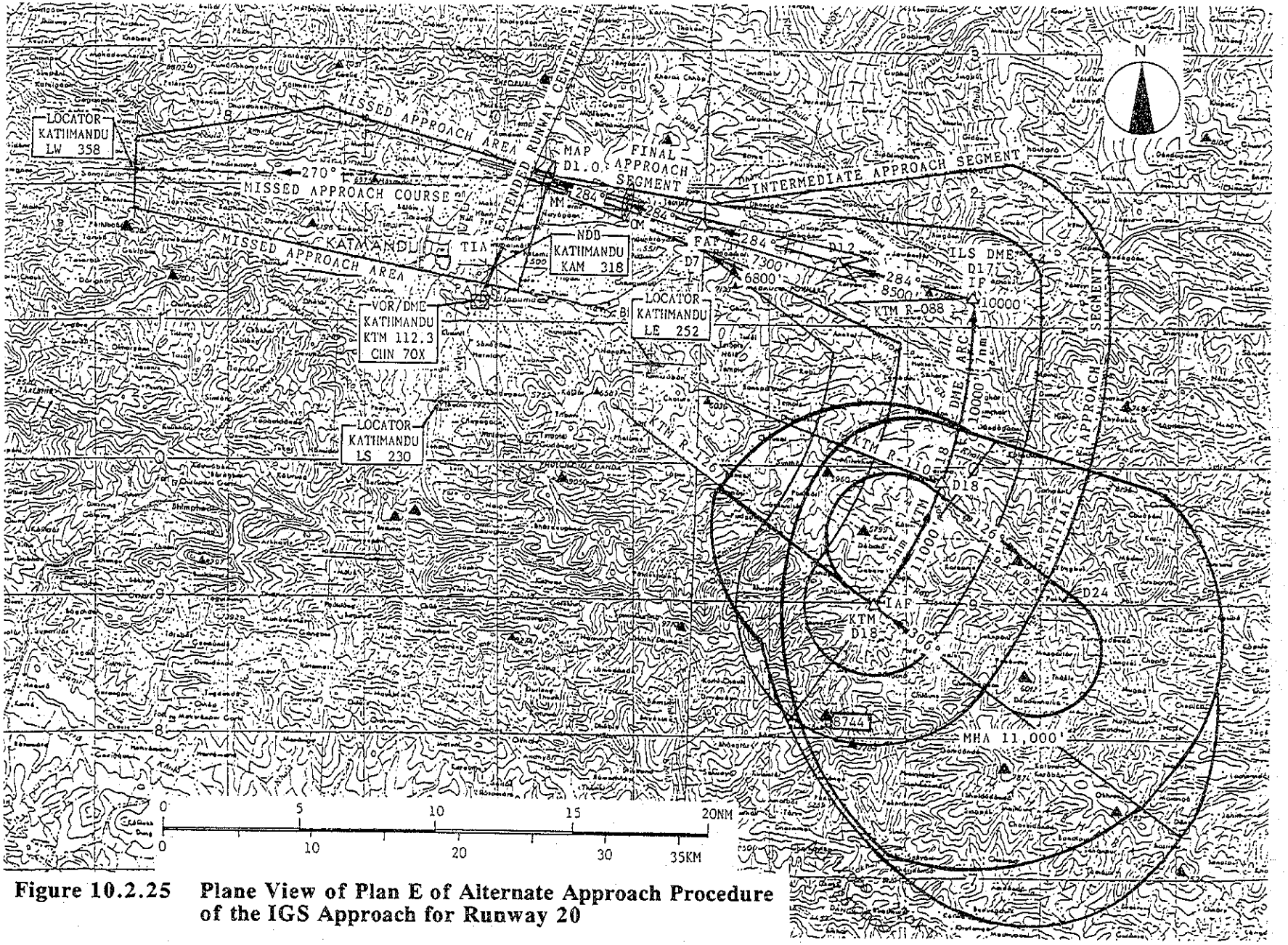


Figure 10.2.25 Plane View of Plan E of Alternate Approach Procedure of the IGS Approach for Runway 20