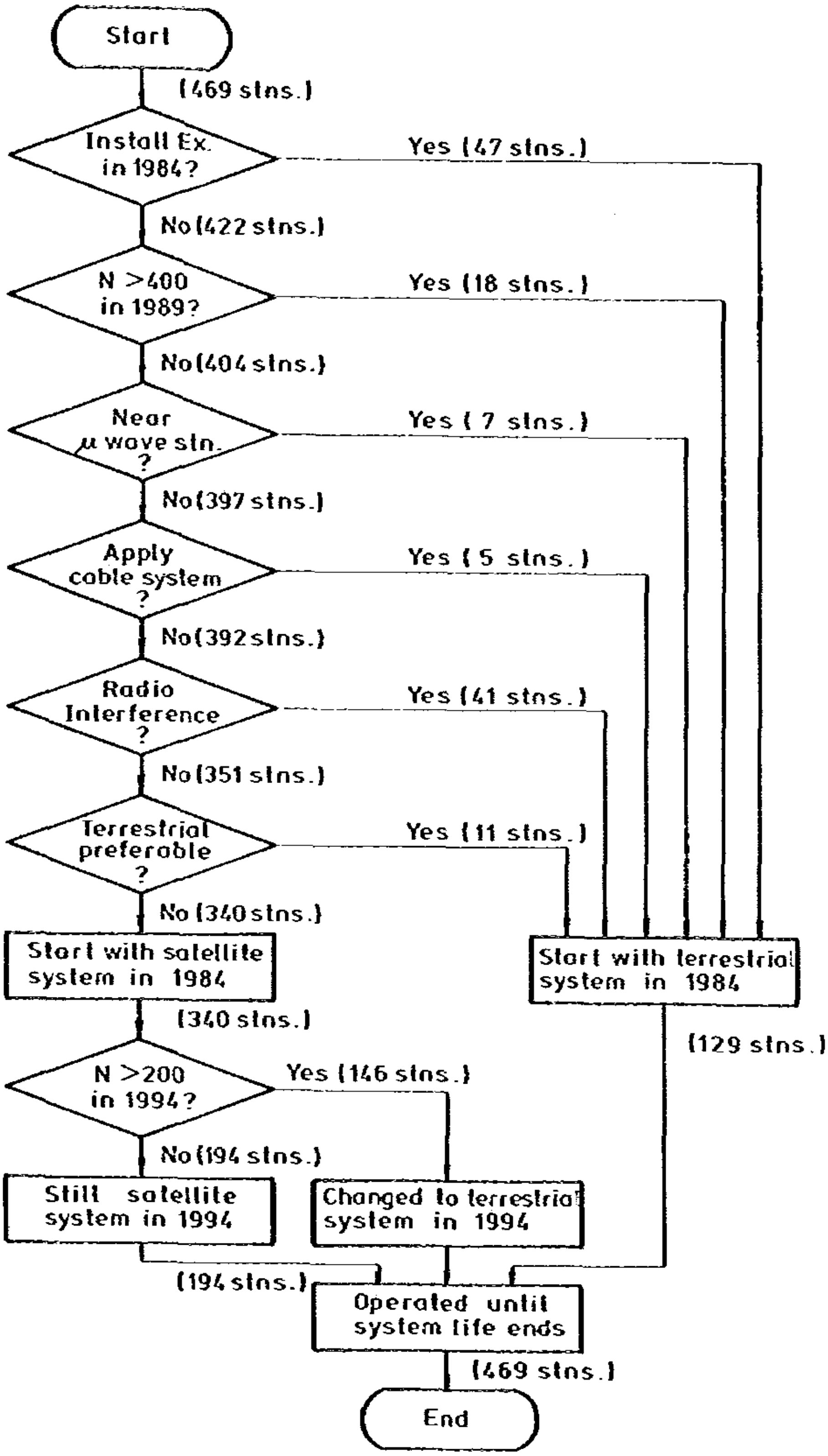
Figure 5-2 is the flow chart of the foregoing basic requirements. When these basic requirements are applied, the optimum route plan for the domestic satellite system in Thailand turns out to be the compound route plan consisting of the satellite system plus the terrestrial radio system for part of the route. By this route plan, 129 stations out of the 469 objective stations of this Study are to be incorporated in the terrestrial radio system.
The study of cable system application, including entrance cable, shares the same philosophy as the terrestrial system study in Part IV 3-4. (Refer to Table 5-2.)
The route plan formulated by the basic routing requirements clarified in the foregoing is shown in Figure 5-3. An example of circuit assignment diagram for satellite system appears in Figure 5-4. The channel accommodation plan for the same four areas as of the terrestrial system route plan is shown in Figure 5-5.

3-2 Channel Plan

3-2-1 Scale of Domestic Satellite System in Thailand

(1) Number of Earth Stations
The number of sites required for Rural Long Distance Public Telephone Service by the satellite system is, in the first half of the Project period, 340 rural earth stations and one master earth station. The similar number in the latter half of the period is 194 rural earth stations and one master earth station, excluding 146 stations where the equipment replacement to facilitate the incorporation to the terrestrial radio system is expected pursuant to the introduction of telephone exchange in and after 1994.



N : Number of telephone subscribers estimated

Figure 5-2 Basic Philosophy of Route Plan for Satellite System

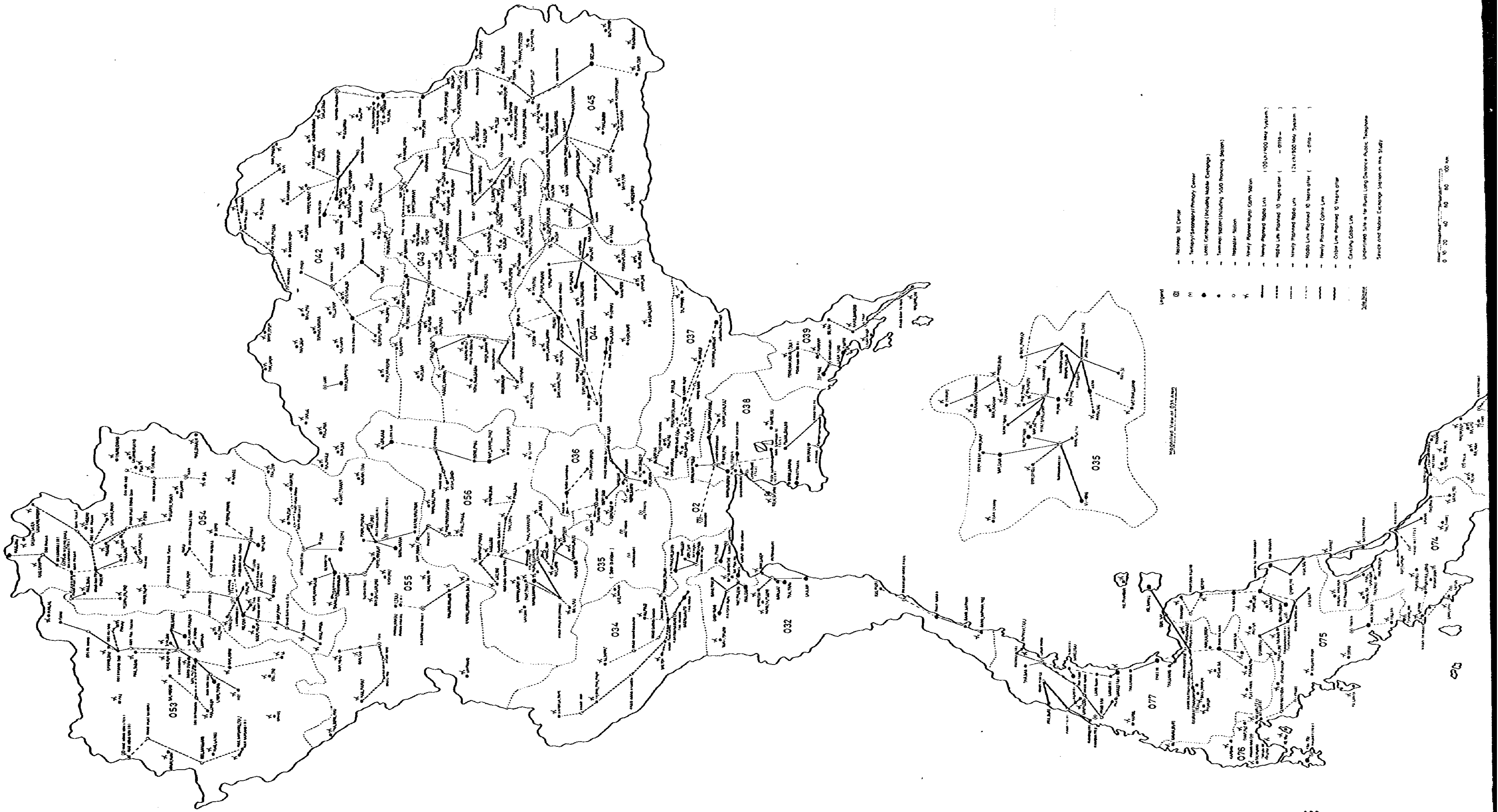
Table 5-2 Cable System Plan for Domestic Satellite System (1/2)

Area (Code)	Section	Dist. in Km	Circuit Requirements in 1984/1989/1994	Required Trans. Loss in dB	Cable System Applied in 1984	Cable System Applied in 1994	Remarks
Kanchanaburi (3413)	Saeng Chuto -Kanchanaburi	28.5	36/50/64	4.0	PCM 2 SYS	PCM 1 SYS	Note 1
Rayong (3808)	Ban Khai - Rayong	12.0	4/5/20	4.0	54 - .9L	-	
Chanburi (3815)	Ban Lamung-Phatthaya	6.5	2/3/3	4.0	-	-	Note 2
Chantaburi (3905)	Pong Nam Ron -Pong Nam Ron (R)	2.9	-/-/20	3.35	-	100 - .65NL	Note 3 & 4
Mae Hong Son (5301)	Mae Sariang -Mae Sariang (R)	3.3	-/-/26	3.35	-	150 - .65L	Note 3 & 4
Lamphun (5322)	U-Mong - Lamphun	9.0	3/4/5	4.0	28 - .9L	-	
Chiangrai (5401)	Phan - Khao Ban Doi	2.0	8/30/40	3.35	150 - .65NL	-	Note 3 & 4
Khamphaeng Phet (5523)	Phran Kratai -Phran Kratai (R)	2.1	-/-/30	3.35	-	150 - .65NL	Note 3 & 4
Narathiwat (7314)	Rangae - Tan Yong Mas	1.8	2/3/3	4.0	-	-	Note 5
Narathiwat (7314)	Tak Bai - Tak Bai (R)	1.5	-/-/20	3.35	-	100 - .65NL	Note 3 & 4

Table 5-2 Cable System Plan for Domestic Satellite System (2/2)

Area (Code)	Section	Dist. in km	Circuit Requirements in 1984/1989/1994	Required Trans. Loss in dB	Cable System Applied in 1984	Cable System Applied in 1994	Remarks
Krabi (7501)	Ao Luk - Ao Luk (R)	3.0	-/-/20	3.25	-	100 - .65NL	Note 3 & 4
Phuket (7609)	Kra Too - Phuket	8.0	20/26/30	4.0	54 - .9L	-	
Chum Phon (7701)	Pathiu - Pathiu (R)	4.0	-/-/26	3.35	-	150 - .65L	Note 3 & 4
Chum Phon (7701)	Sawi - Sawi (R)	4.5	26/30/40	3.35	150 - .65L	-	Note 3 & 4
Chum Phon (7701)	Lamae - Lamae (R)	1.4	-/-/26	3.35	-	150 - .65NL	Note 3 & 4
Ranong (7707)	La-Un - La-Un (R)	3.0	-/-/26	3.35	-	150 - .65NL	Note 3 & 4

Note 1 : Existing cable is available for PCM system.
Note 2 : Subscriber cable has been installed from Phatthaya exchange.
Note 3 : Cable circuit is used as entrance circuit between radio terminal and distribution point or exchange.
Note 4 : Entrance circuit between radio terminal and exchange is on 6-wire basis.
Note 5 : Subscriber cable has been installed from Tan Yong Mas exchange.



Legend
– National Toll Center
– Tertiary/Secondary/Primary Center
– Local Exchange (Including Mobile Exchange)
– Terminal Station (Including 500 Branching Station)
– Repeater Station
– Newly Planned Rural Earth Station
– Newly Planned Radio Link (120 ch/900 MHz System)
– Radio Link Planned 10 Years after (– ditto –)
– Newly Planned Radio Link (24 ch/900 MHz System)
– Radio Link Planned 10 Years after (– ditto –)
– Newly Planned Cable Link
– Cable Link Planned 10 Years after
– Existing Cable Link
Site Name Underlined Site is for Rural Long Distance Public Telephone Service and Mobile Exchange Station in the Study
Magnified View of 035 Area
042
043
044
045
037
038
039
036
035
034
032
02
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074
075
076
077

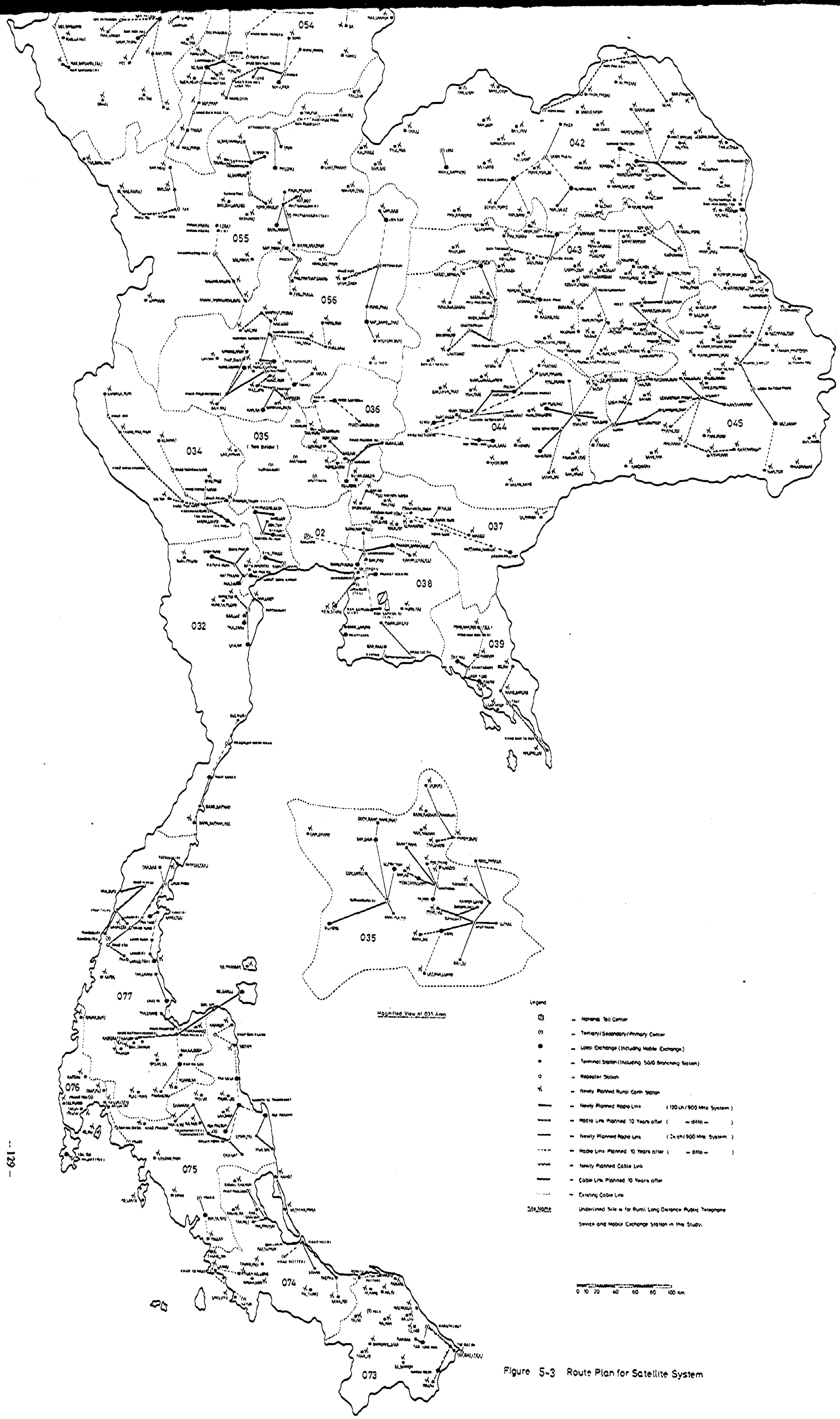


Figure 5-3 Route Plan for Satellite System

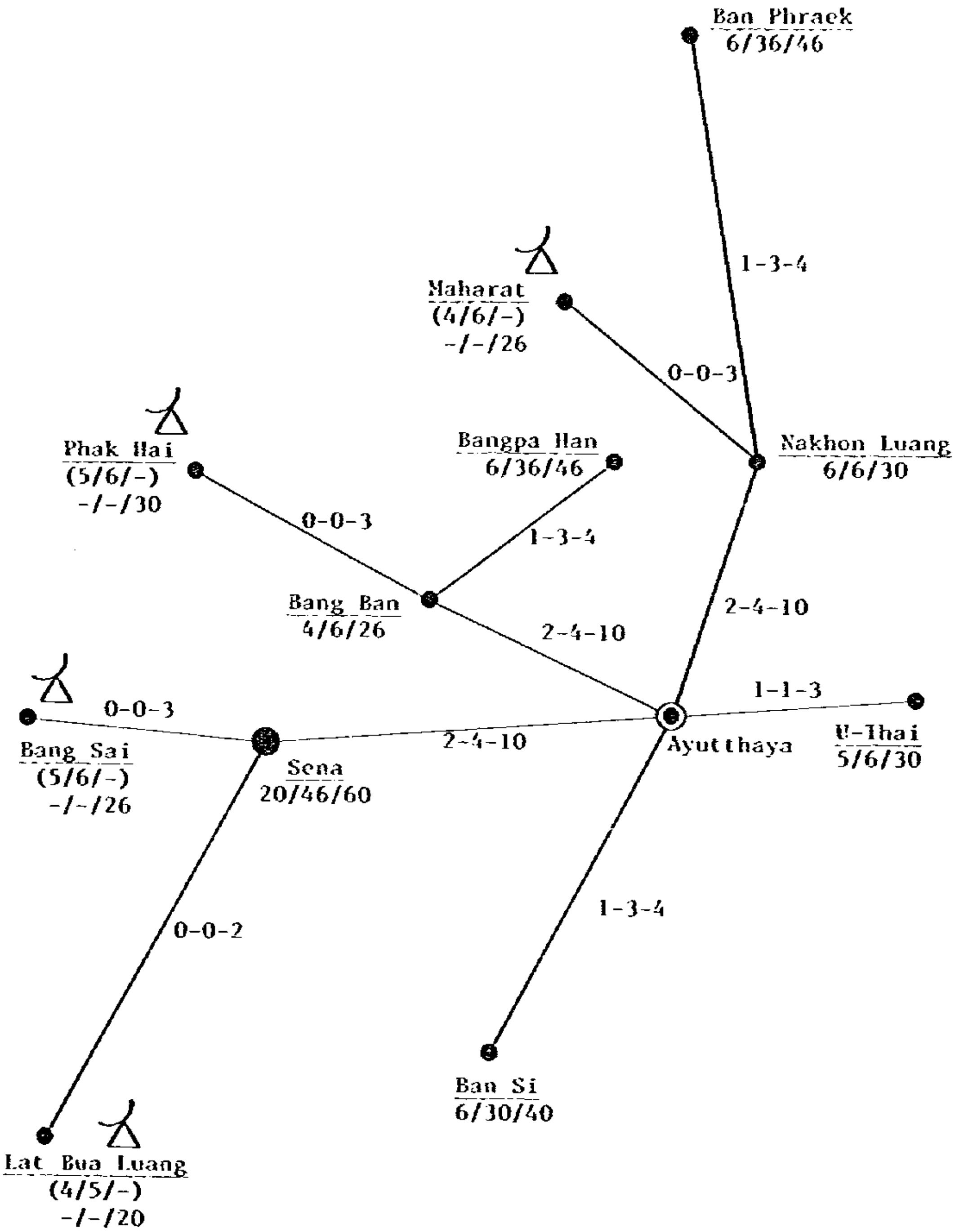


Figure 5-4

Ayutthaya Area(3516)

Circuit Assignment Diagram for Satellite System(1/5)

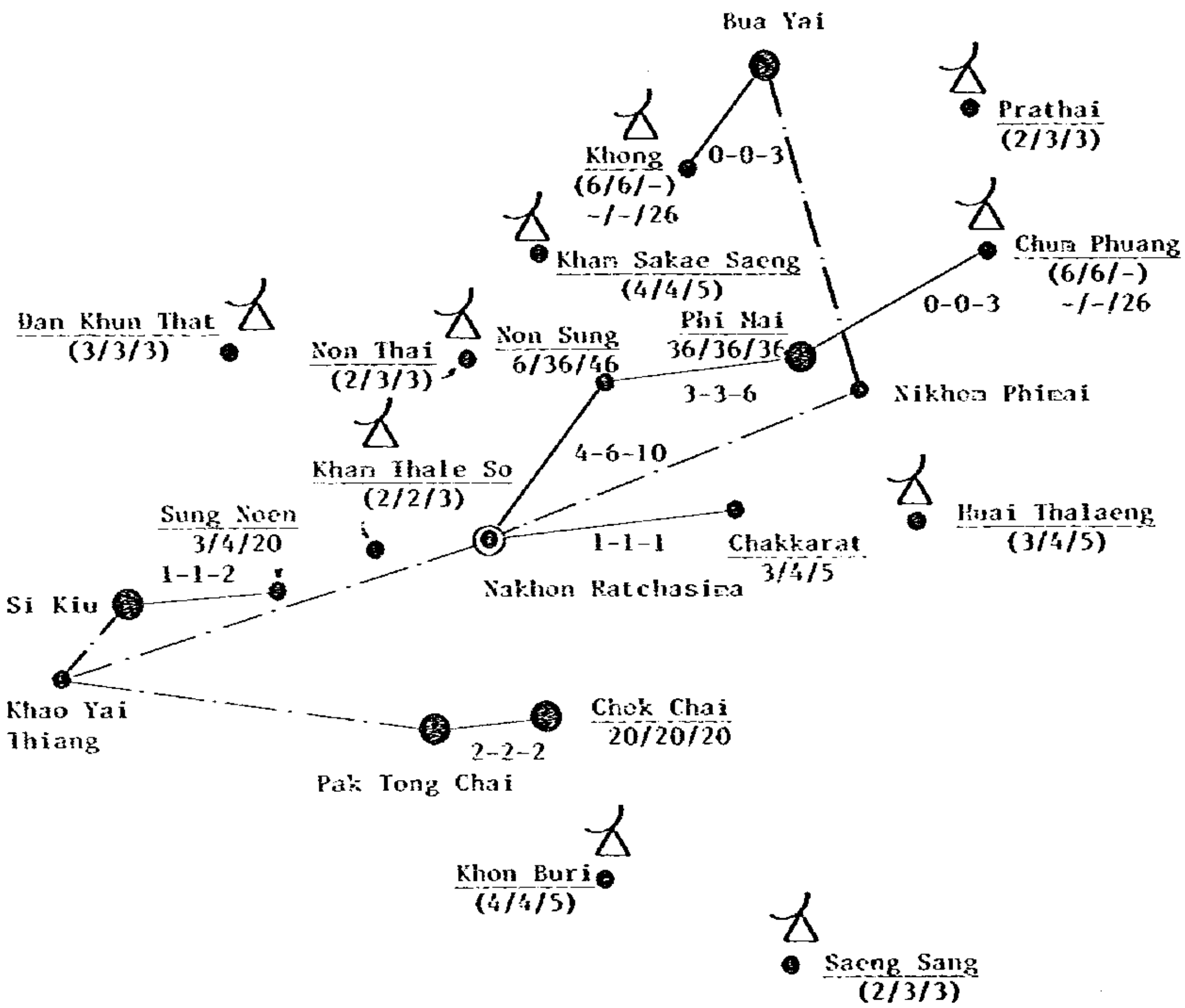
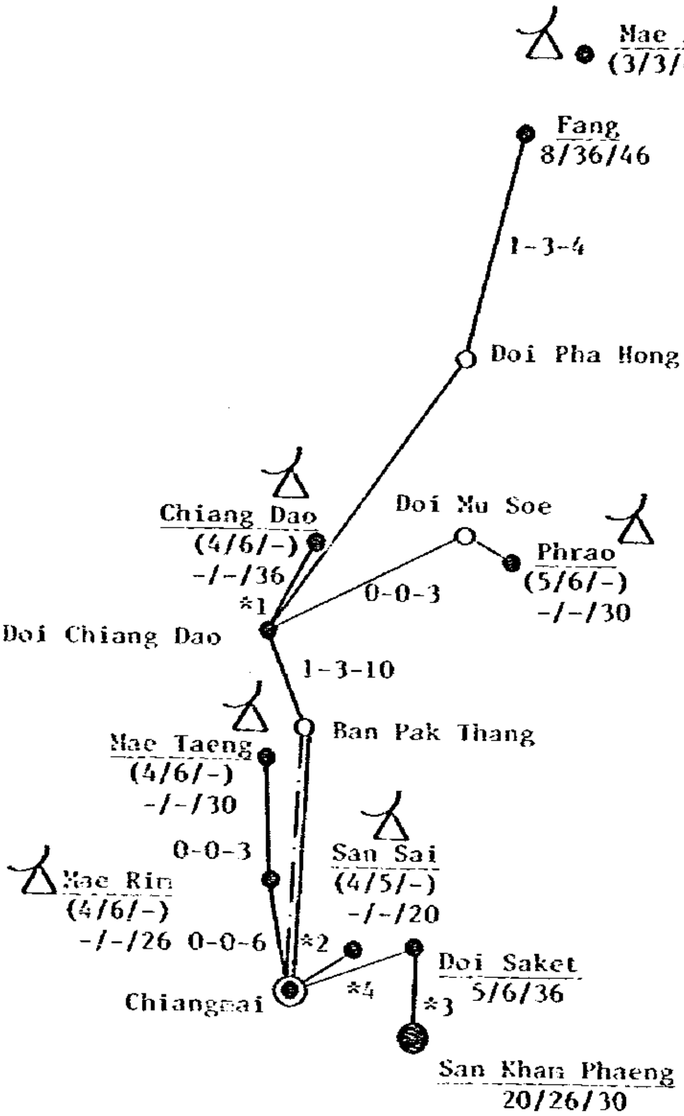


Figure 5-4

Nakhon Ratchasima Area(4421)

Circuit Assignment Diagram for Satellite System(2/5)



*1: 0-0-3
*2: 0-0-2
*3: 2-3-3
*4: 3-4-6

Figure 5-4

Chiangmai Area(5313)1/2

Circuit Assignment Diagram for Satellite System(3/5)

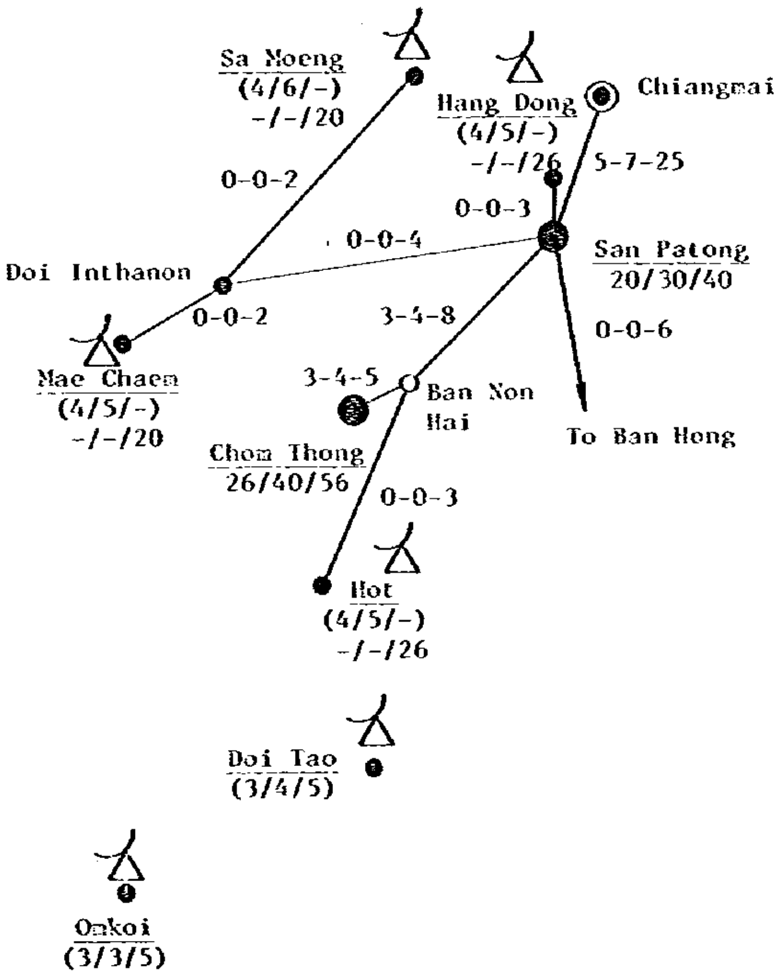


Figure 5-4 Chiangmai Area(5313)2/2

Circuit Assignment Diagram for Satellite System(4/5)

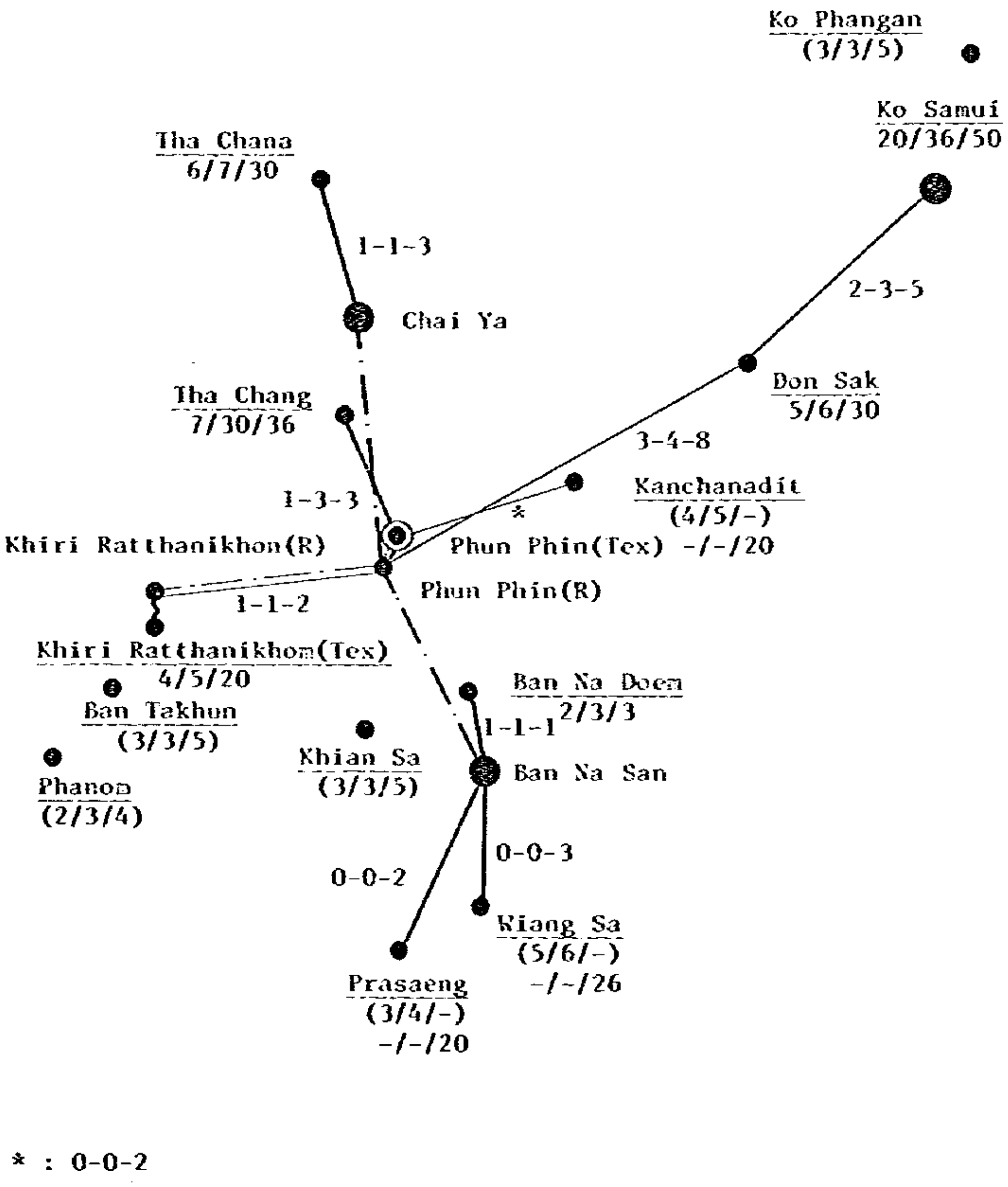


Figure 5-4

Phun Phin Area(7711)

Circuit Assignment Diagram for Satellite System(5/5)

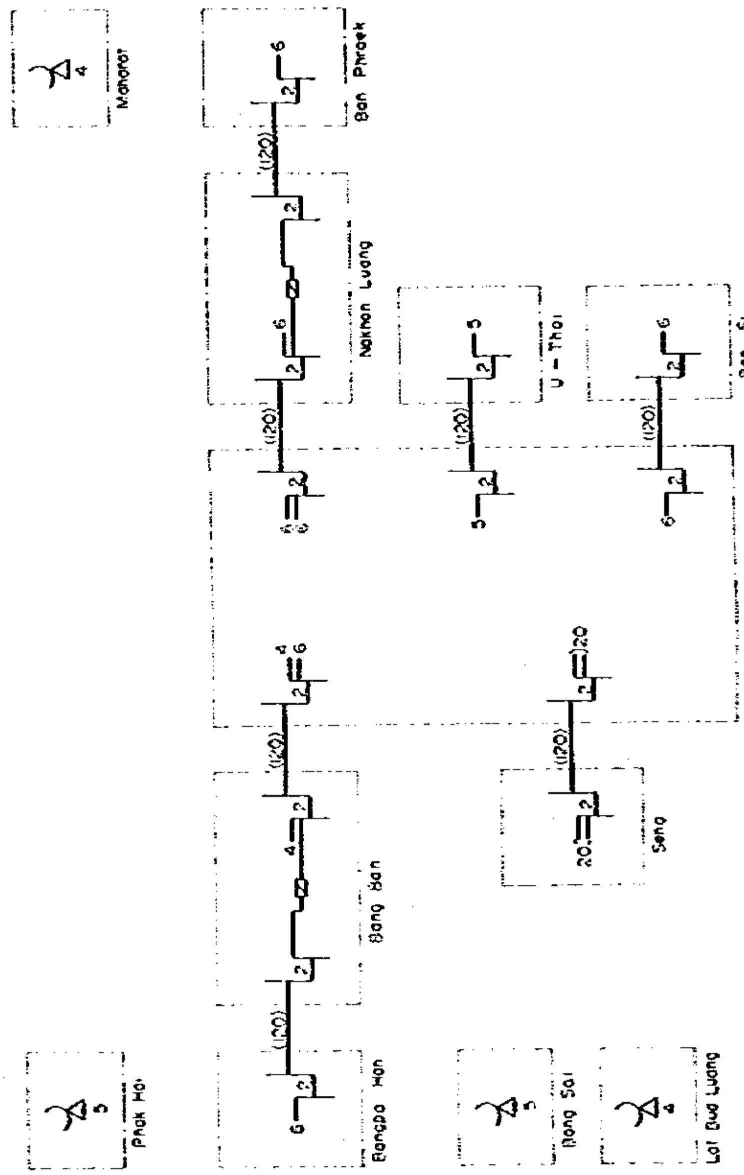


Figure 5-5 Ayutthaya Area (3516)

Typical Channel Accommodation Plan for Satellite System (Initial Stage)(1/10)

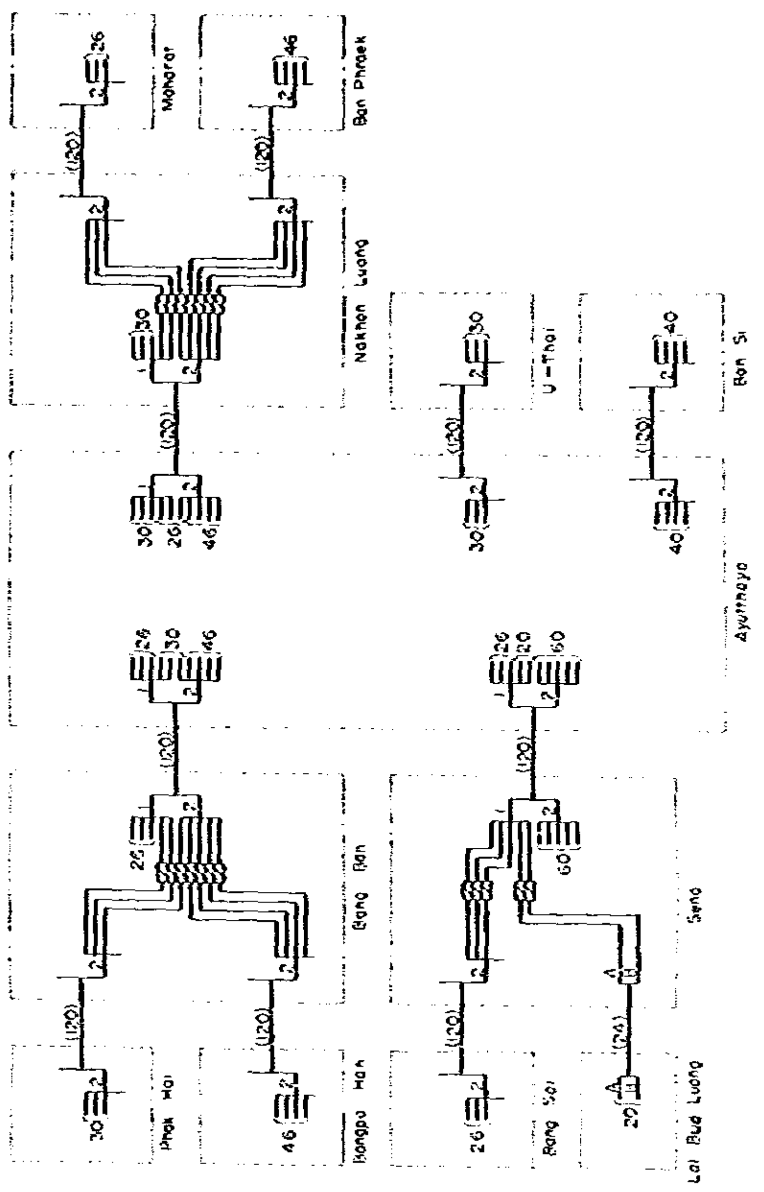


Figure 5-5

Ayutthaya Area (3516)

Typical Channel Accommodation Plan for Satellite System (Final Stage) (2/10)

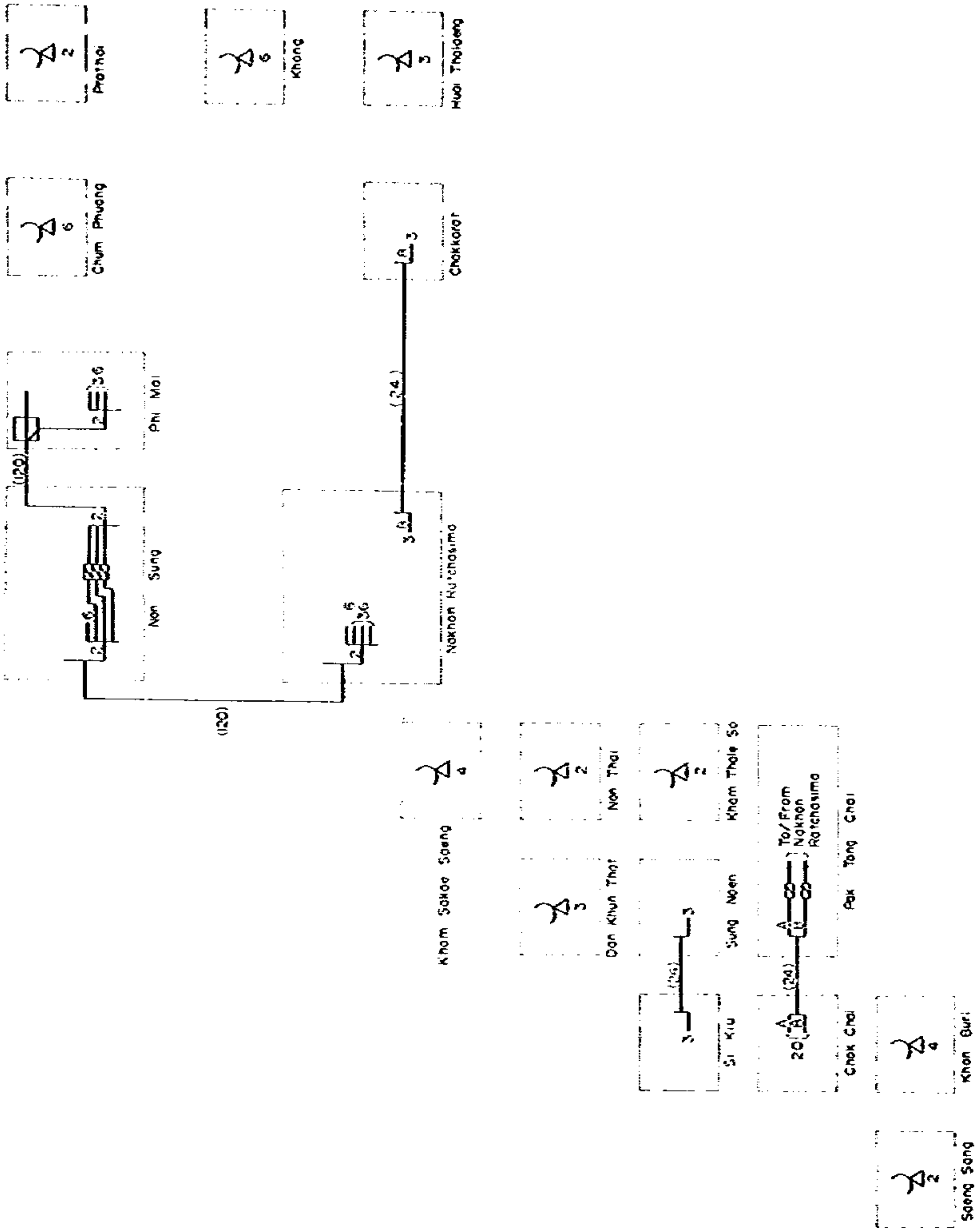


Figure 5-5 Nakhon Ratchasima Area (4421)

Typical Channel Accommodation Plan for Satellite System (Initial Stage)(3/10)

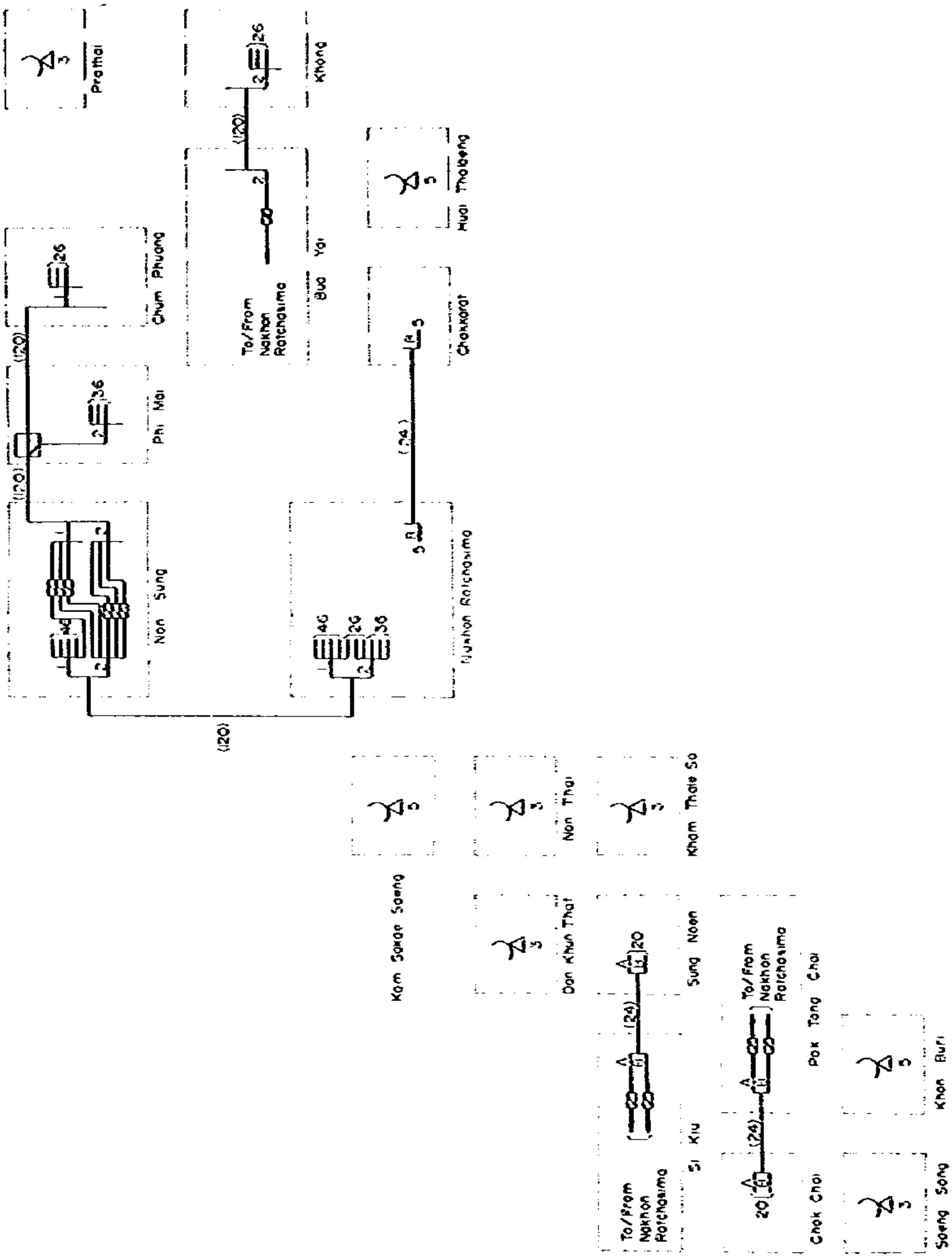


Figure 5-5 Nakhon Ratchasima Area (4421)

Typical Channel Accommodation Plan for Satellite System (Final Stage)(4/10)

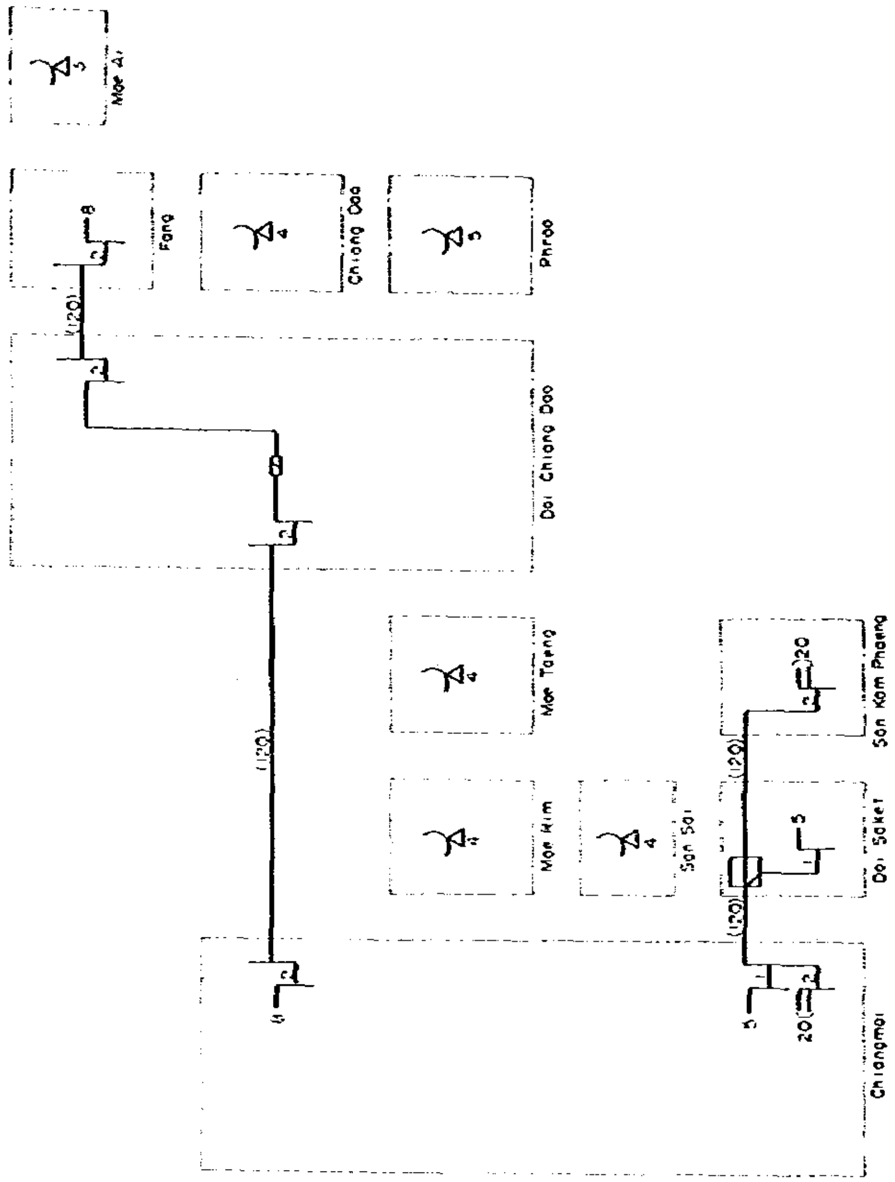


Figure 5-5 Chiangmai Area (5313) 1/2

Typical Channel Accommodation Plan for Satellite System (Initial Stage)(5/10)

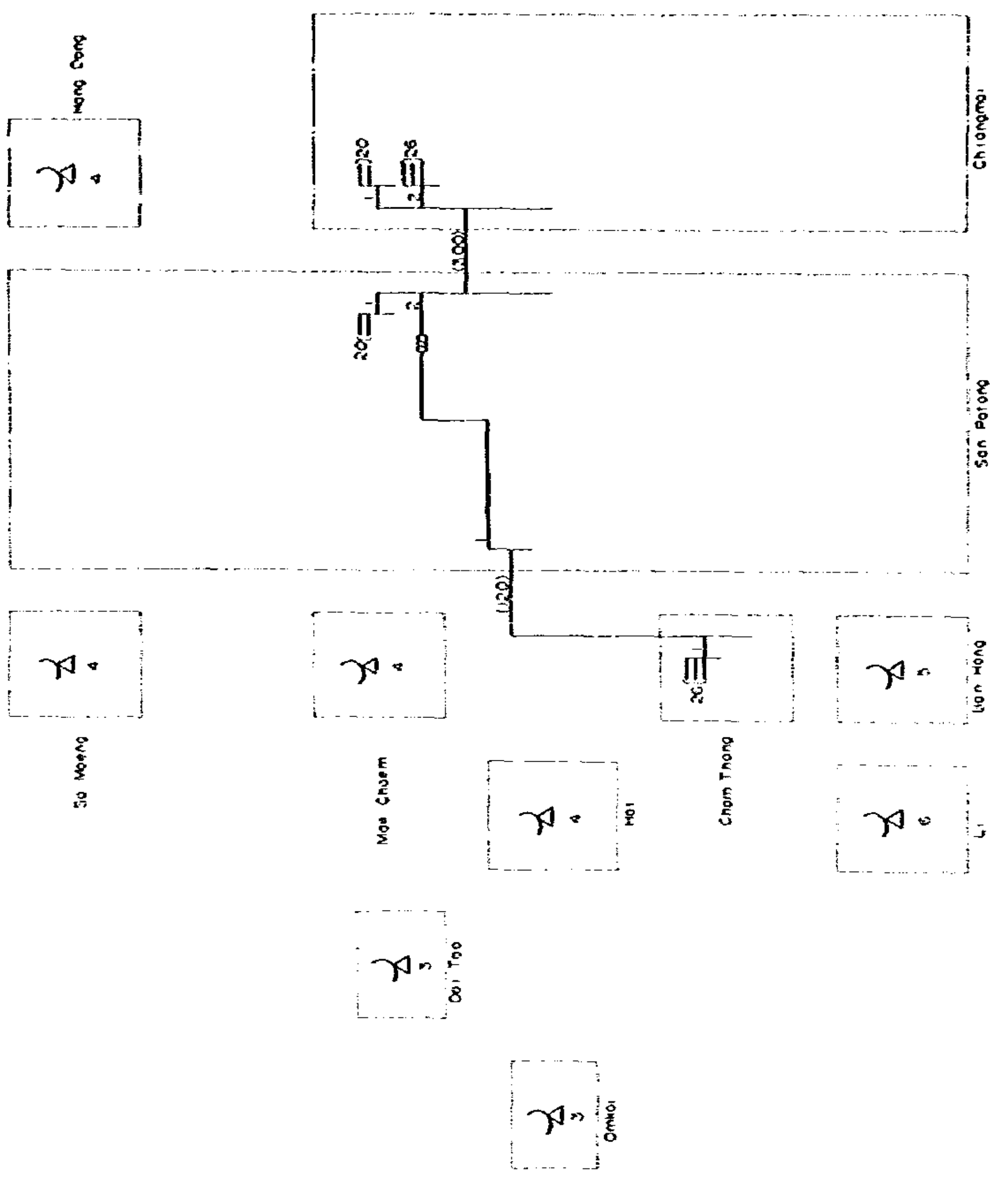


Figure 5-5 Chiangmai Area (5313) 2/2

Typical Channel Accommodation Plan for Satellite System (Initial Stage) (6/10)

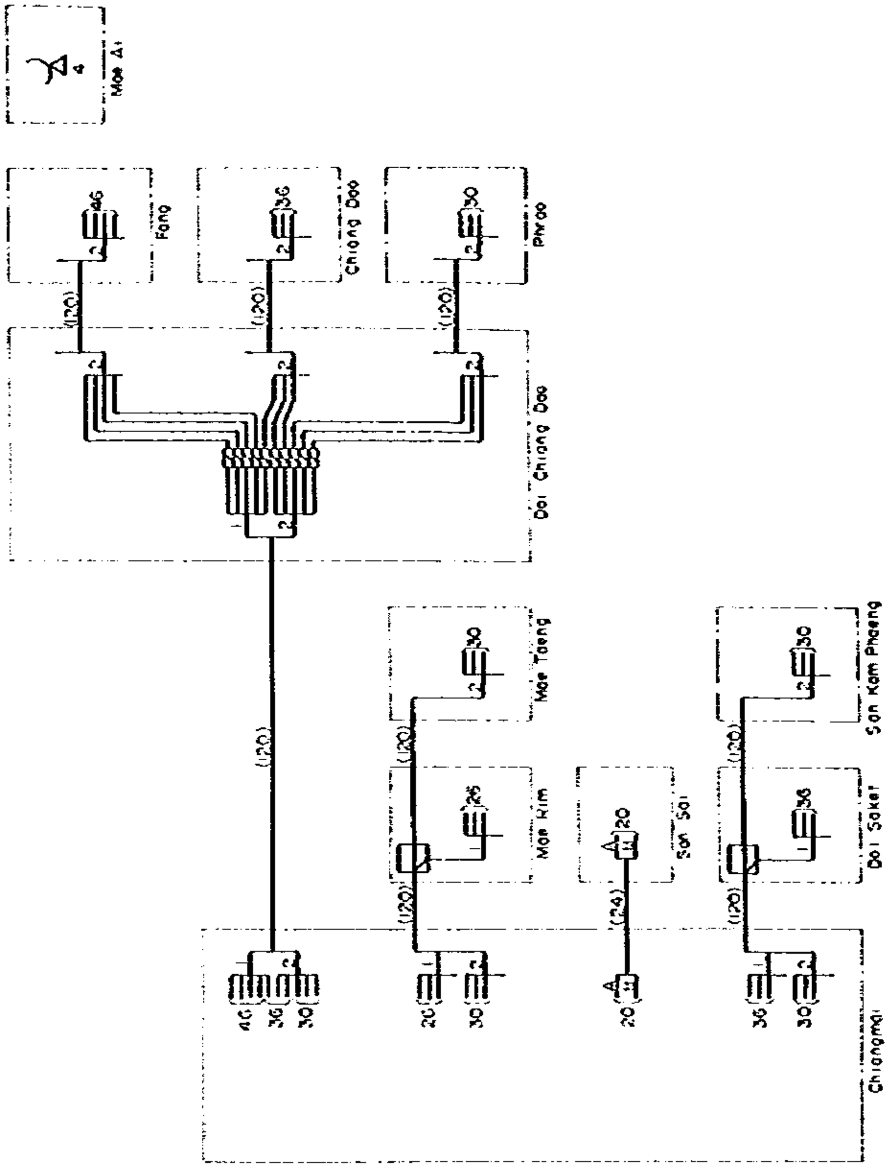


Figure 5-5 Chiangmai Area (5313) 1/2

Typical Channel Accommodation Plan for Satellite System (Final Stage)(7/10)

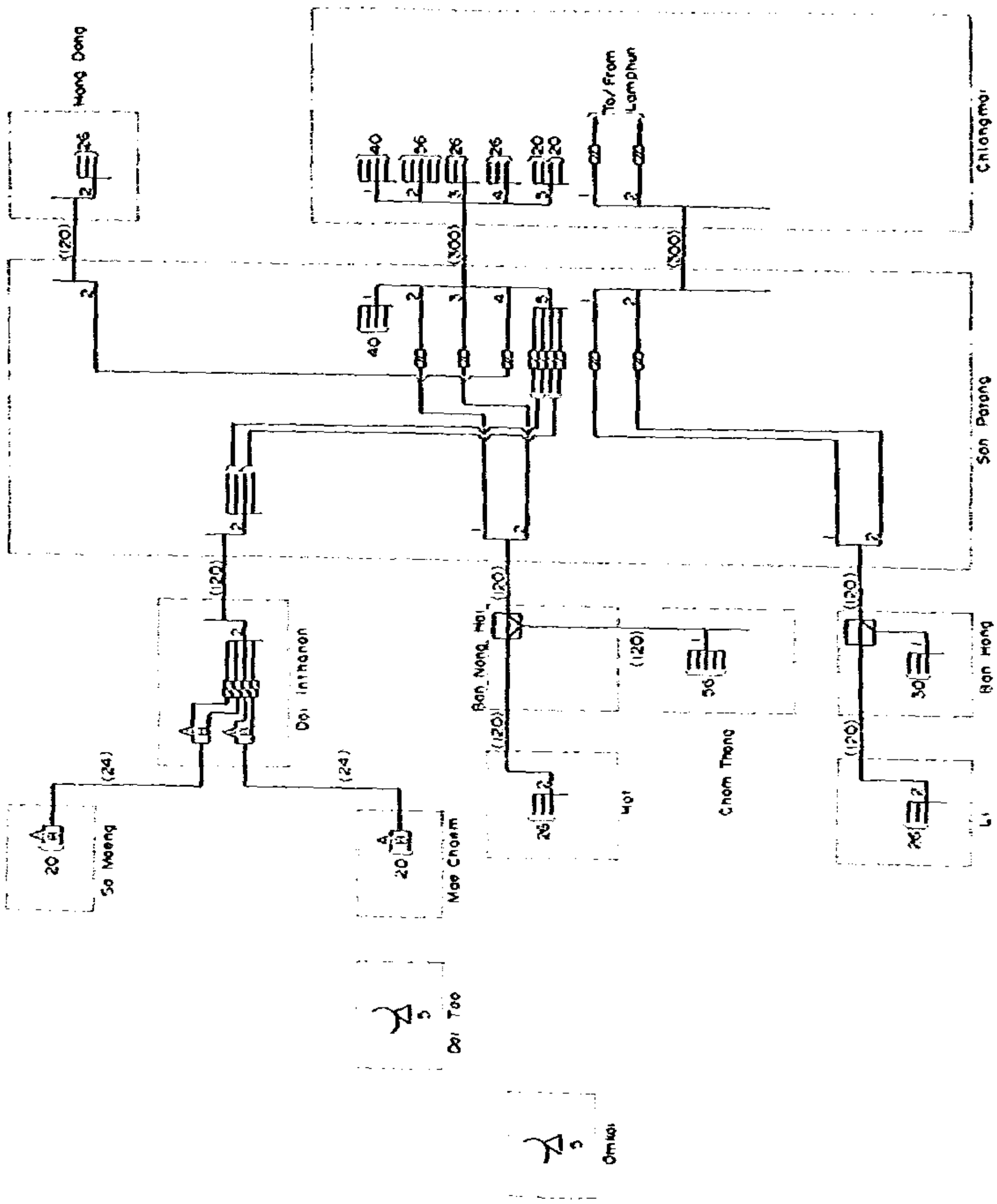


Figure 5-5 Chiangmai Area (5313) 2/2

Typical Channel Accommodation Plan for Satellite System (Final Stage)(8/10)

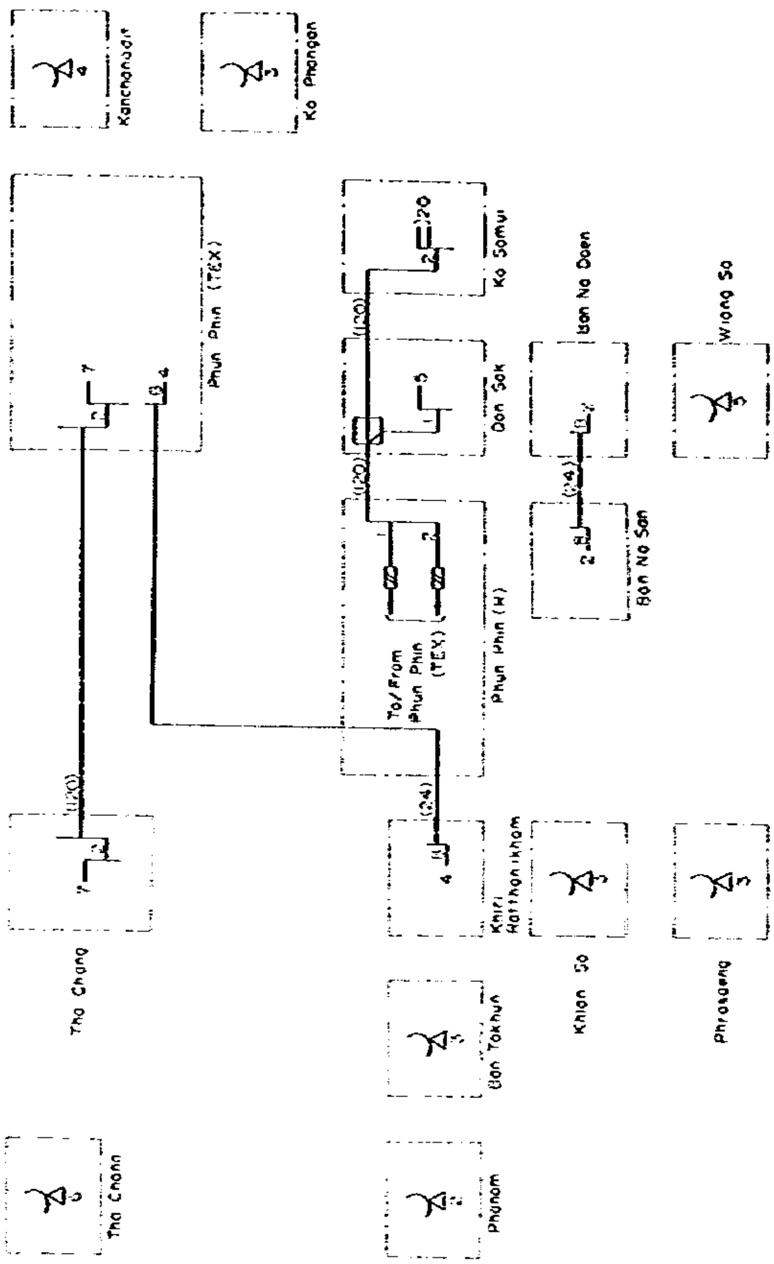


Figure 5-5 Phun Phin Area (7711)

Typical Channel Accommodation Plan for Satellite System (Initial Stage)(9/10)

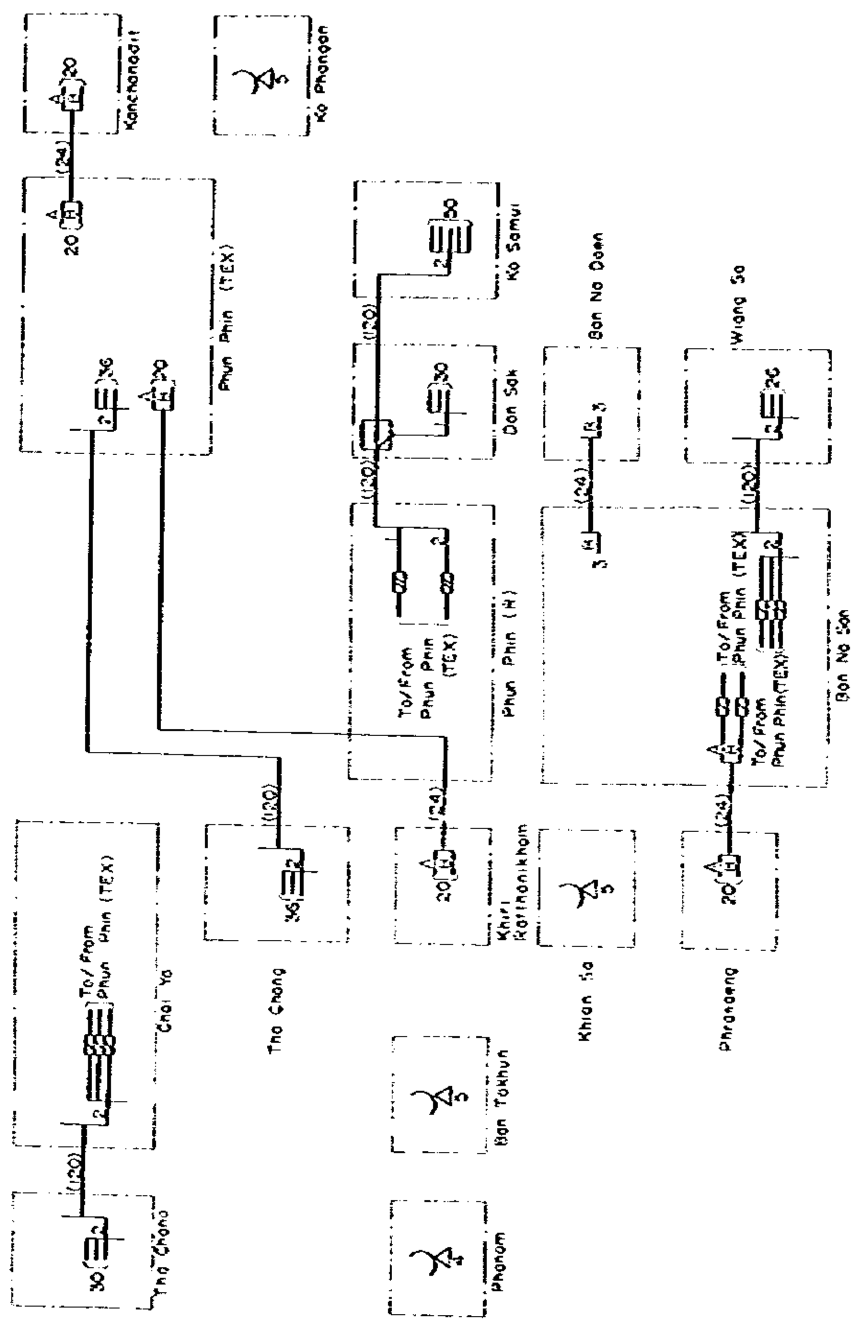


Figure 5-5 Phun Phin Area (7711)

Typical Channel Accommodation Plan for Satellite System (Final Stage)(10/10)

(2) Traffic Volume

Forecasted traffic volume originating from rural earth stations is:

1984	406.0 Erl. (1.19 Erl./RS)
1989	560.0 Erl. (1.65 Erl./RS)
1994	275.5 Erl. (1.42 Erl./RS)

The decrease in 1994 is because, in that year, not a few objective stations of the service will be transferred to the terrestrial radio system and only the small scale rural earth stations will continue to be operated by the satellite system.

(3) Number of Speech Channel Units to Be Installed in Rural Earth Stations

The total number of speech channel units to be installed in rural earth stations is:

1984	1,144 CHU (3.36 CHU/RS)
1989	1,413 CHU (4.16 CHU/RS)
1994	749 CHU (3.86 CHU/RS)

The number of channel units appearing above is the number of speech channel units only. In addition to these speech channel units, two channel units per rural earth station are required. One is for signal transmission/receiving to/from the master earth station, and the other for engineering service channel (order wire).

3-2-2 Channel Capacity Required for Satellite

(1) For Speech Channel

Rural earth stations are scattered all over Thailand. They number as many as 340 in the first half of the Project period and 194 in the latter half. To apply the satellite system to Rural Long Distance Public Telephone Service is to use the satellite as a kind of subscriber line concentrator. The busy hour traffic from earth stations will vary from station to station. The channel capacity required for the satellite depends upon the variation of busy hour traffic from one rural earth station to another. This is the key point for economic operation of the domestic satellite system.

In this Study, the station to station busy hour variation could not be fully ascertained. However, it cannot be considered that any two rural earth stations share exactly the same busy hour, so that the busy hour variation coefficient is set at 0.8 whereby to obtain the channel capacity required for the satellite.

Based on the busy hour variation coefficient of 0.8, the busy hour traffic that passes the satellite is calculated to be

1984	406.0 x 0.8 = 324.8 Erl.
1989	560.0 x 0.8 = 448.0 Erl.
1994	275.5 x 0.8 = 220.4 Erl.

When the grade of service is set at 1/100, the number of speech channels required for the satellite is calculated to be

1984	349 ch
1989	474 ch
1994	242 ch

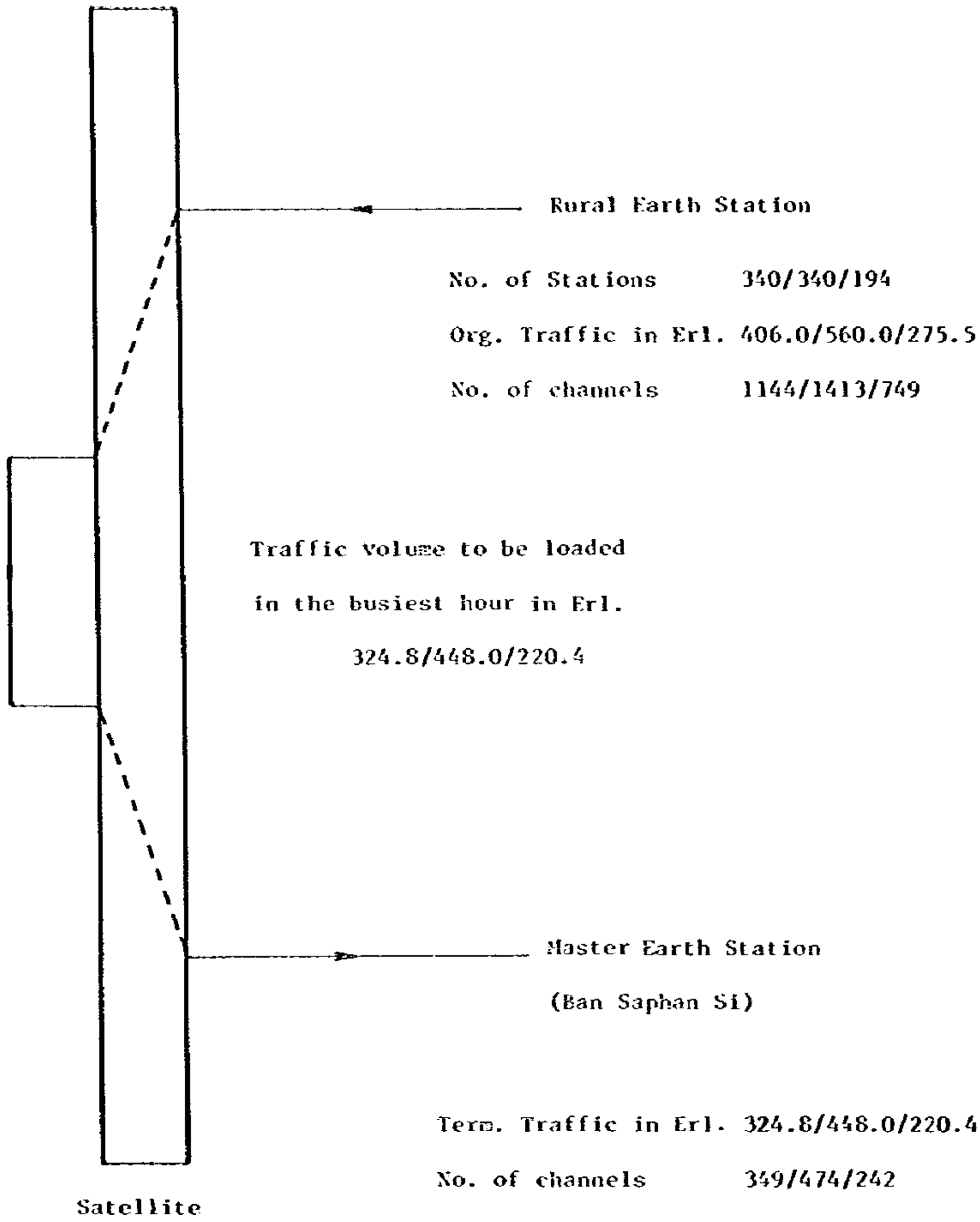
Meanwhile, the number of channels shown above is equal to the number of speech channel units to be installed in the master earth station.

This relationship is explained in Figure 5-6.

(2) For Data Channel

The DAMA system introduction necessitates data channels for sending and receiving of necessary information between each rural earth station and the master earth station, besides the speech channels.

In case the FM-SCPC modulation system is adopted, it is considered that the data channel with the working speed of approximately 2,400 BPS will be employed. Concerning the burst format for data transmission, there is no internaional standard. Therefore, on the assumption that



Note 1. Figures are for 1984/1989/1994

Note 2. No. of channels indicated does not include the data channels for demand assignment control, and the engineering service channels.

Figure 5-6 Traffic Flow and Channel Plan for Domestic Satellite System the 120 BPS or thereabouts is necessary for the burst which will comprise front guard, carrier detection, bit synchronization, data, check code and back guard, and in consideration of the fact that the traffic volume from one rural earth station may sometimes be small, it is so arranged that one data channel be commonly used by 30 rural earth stations.

Hence, the number of necessary data channels is 12. Although it is possible to reduce the number of data channels in accordance with the reduction of the number of rural earth stations, the arrangement this time is to maintain 12 data channels at all times. For, reducing the number of data channels requires the data alteration of the DAMA system, and, moreover, a rural earth station, if withdrawn from the rural sites where the terrestrial radio system will be introduced, may be used for another area where telephone service will not be provided even then.

(3) Number of Channels Required for Satellite

As the result of the preceding (1) and (2) studies the number of channels required for the satellite will be

1984	349 + 12 = 361 ch
1989	474 + 12 = 486 ch
1994	242 + 12 = 254 ch

For engineering service (order wire), idle channels are assigned.

3-3 PALAPA Transponder

The Indonesian communication satellite, PALAPA I, was launched in 1976. At present, two units, one operational and the other spare or backup, are in the geostationary satellite orbits. They are located at 83° and 76°, East Longitude, respectively. Antenna coverage and G/T contours are shown in Figures 5-7 and 5-8, respectively. They cover five ASEAN countries. The satellite attitude and position on the orbit are periodically regulated from the master earth station. Each satellite unit holds 12 transponders, each having 36 MHz transmission bandwidth. The 6 GHz broad band receiver unit holds the spare system though the output unit holds no spare system. The design life span of the PALAPA satellite is seven years. Figure 5-9 and Figure 5-10 present the PALAPA satellite radio frequency arrangement and functional block diagram, respectively.

Nine transponders (Channel Nos. 1 - 8 and No. 11 of the operational satellite unit) are used for domestic communication in Indonesia. Idle transponders of the spare satellite unit will be leased to the ASEAN countries. At present, the Philippines uses half transponder by lease.

The long term lease rates for PALAPA satellite transponders are as follows:

For a minimum period of 1 year : US$850,000 per year
For a minimum period of 3 years: US$800,000 per year
For a minimum period of 5 years: US$750,000 per year

The partial transponder lease rate is proportionate to the bandwidth used.

In case of trouble with any leased transponder of the spare satellite unit, the operation will be switched over to another transponder of the same satellite unit. When all transponders of the spare satellite unit come into trouble, the operation will be switched over to the transponders of the operational satellite unit. Indonesian authorities will do their utmost for smooth functioning of such emergency arrangement.

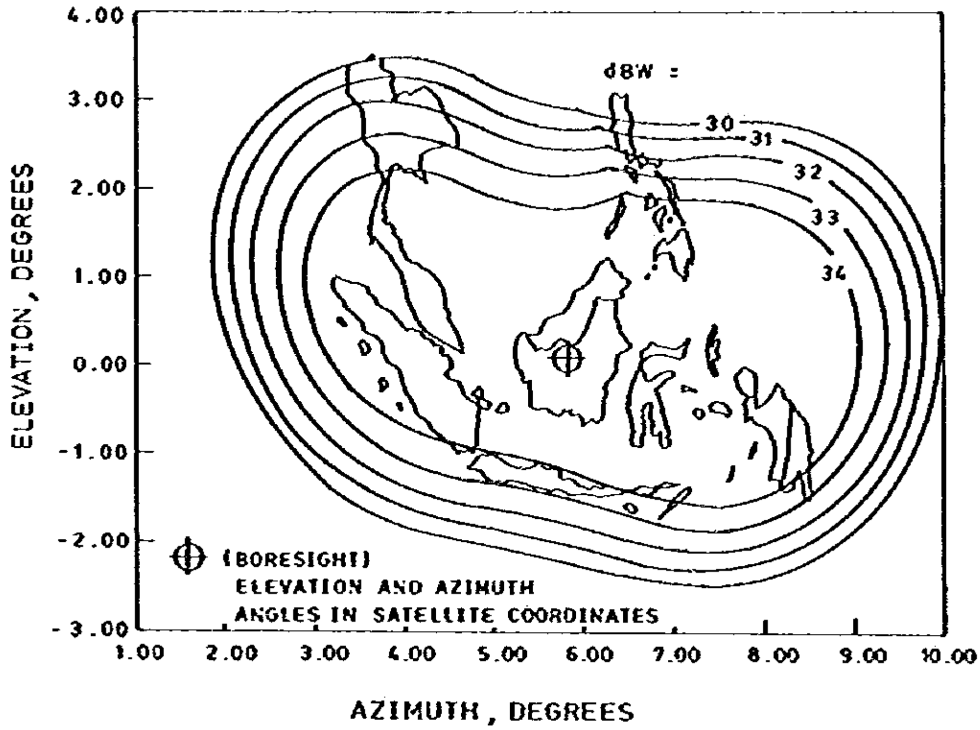


Figure 5-7 PALAPA Satellite Transmit Antenna Coverage Contours

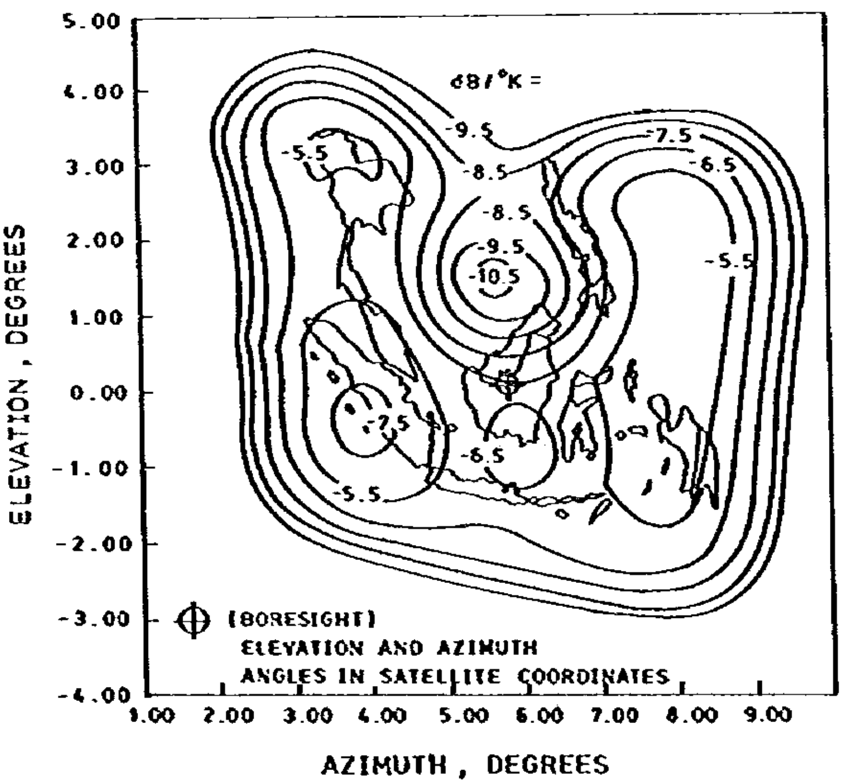


Figure 5-8 PALAPA Satellite G/T Contours

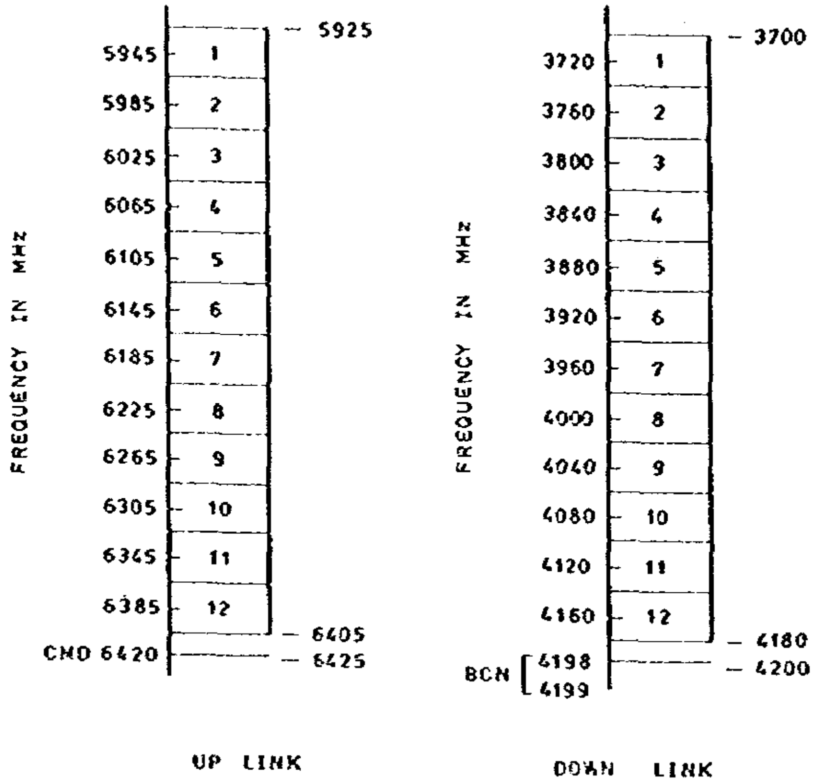
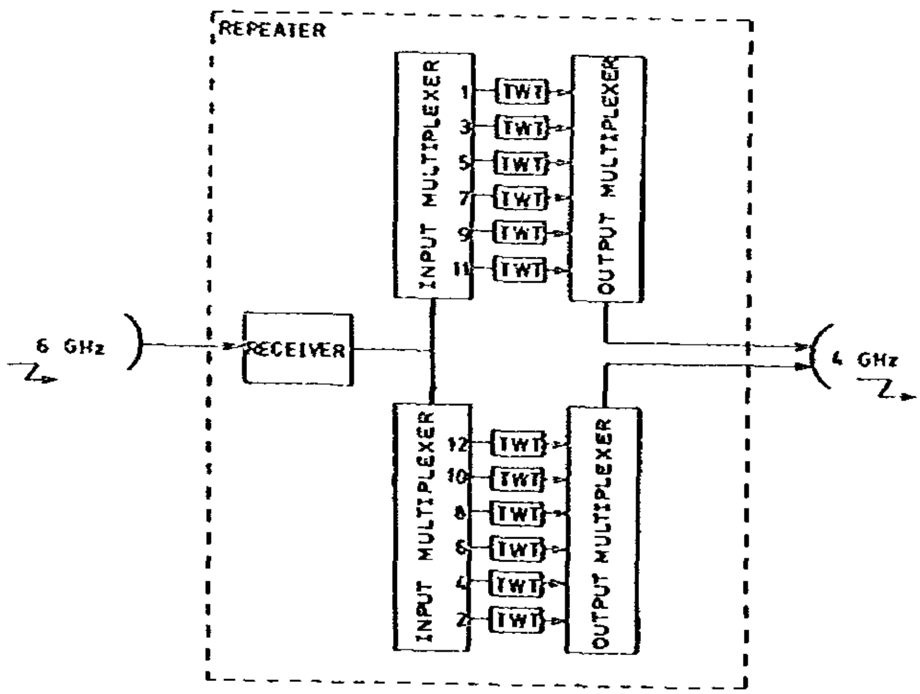


Figure 5-9 Radio Frequency Arrangement of PALAPA Satellite



Note : Redundant receivers are provided, but the output stages are not redundant.

Figure 5-10 Functional Block Diagram of PALAPA Satellite

PART VI Detailed Transmission Route Study and Field Survey

PART VI Detailed transmission Route Study and Field Survey

1. General

This Part VI carries out the sampling review of the UHF system design so far made by TOT and the confirmation thereof by the field survey findings. The establishment of design criteria and the system performance estimation are also made. Furthermore, studies are conducted for the typical RF channel arrangement plan with respect to the UHF system as well as the radio system configuration and the capacity of power plants required.

The route plan for the cable system that constitutes part of the terrestrial system is illustrated on a map of a scale of 1 to 50,000.

The site selection for earth stations of the projected domestic satellite system, design criteria for earth stations, and system performance are also described. Regarding the radio interference from earth stations, the forecast was made, using an extra-large capacity computer, and the methodology of forecast and the result obtained are introduced in this Part VI.

In the detailed system study by sampling, consideration is made in order that the design procedures, calculation results, drawings and related data will be fully usable to TOT.

2. Terrestrial Radio System

2-1 TOT Survey Result Review and Field Survey

In accordance with the Scope of Work arrangement with TOT, the Study Team has carried out a detailed review of UHF system route plan, path profiles and system designs in the representative four areas with a total of 75 radio stations. These four areas have been picked up from TOT's preliminary study of the UHF system plan, for which TOT has carried out the survey for the whole districts of Thailand. The four areas are the Chiangmai area (northern area), Ayutthaya area (central area), Nakhon Ratchasima area (northeastern area) and Phun Phin area (southern area). Figure 6-1 is the detailed study flow chart.

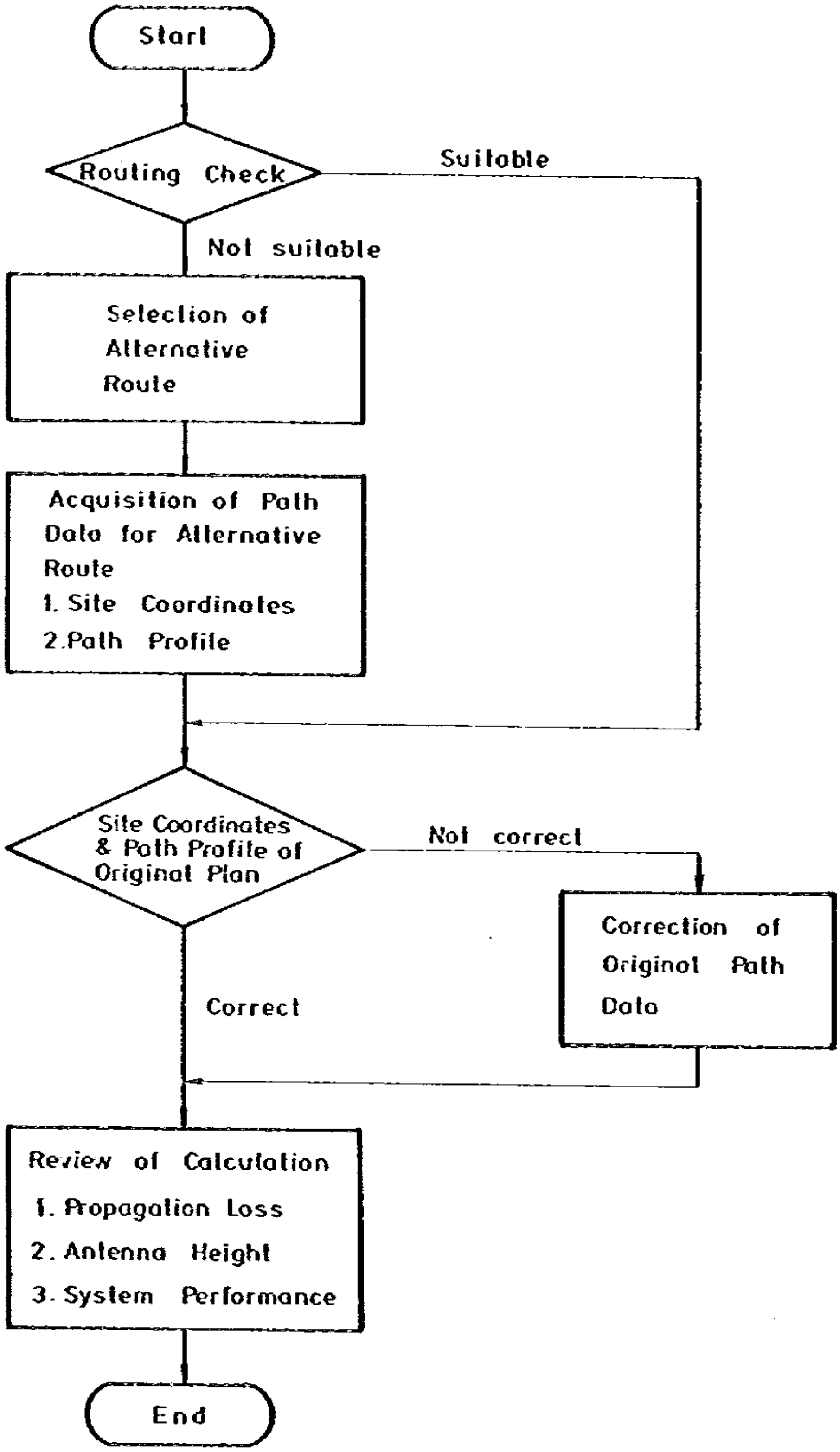


Figure 6-1 Study Flow of UHF Radio Relay System Planned by TOT

The four areas were selected, based on the agreement between the Study Team and TOT to the effect that a review be made by the Study Team on TOT's survey result, with major emphasis on the following subjects:

1) Site selection in mountain district - Chiangmai area

2) Radio frequency interference - Ayutthaya area

3) Site selection in plain land - Nakhon Ratchasima area

Survey at Samui Island

4) Over-the-sea propagation path design - Phun Phin area

The detailed review of TOT's study result and the corroborative field survey by the Study Team were carried out according to the following basic principles:

(1) TOT would rearrange in good order the findings in its detailed investigations and deliver those data to the Study Team. Based on those data, the Study Team would make its own detailed study.

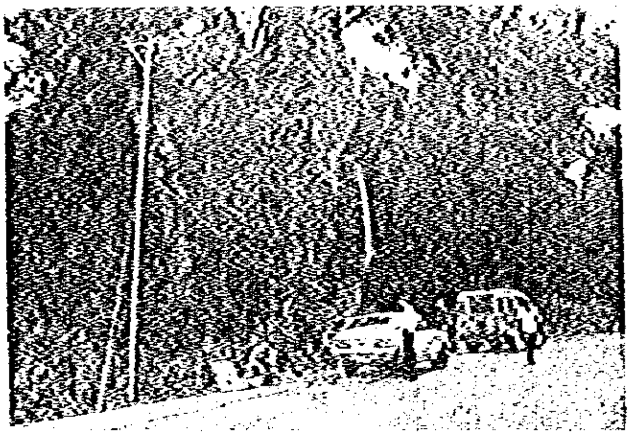
(2) For the terrestrial radio system design, the Study Team would propose to TOT what it considered to be optimal, based on its experiential data. This proposal would be discussed jointly by the Study Team and TOT from the technical viewpoint in order to have the final design methodology agreed upon between both parties.

(3) System performance determined by the mutual discussion between the Study Team and TOT should satisfy the relevant CCITT/CCIR recommendations or conform with other authoritative standard.

(4) Efforts should be made to achieve the system construction economy by reducing the number of repeater stations to the possible minimum with the adoption of over-the-horizon system also.

(5) Field survey items should include, besides technical investigations, the interviews with local inhabitants (community survey) to know the telephone demand among them, in order to use information obtained as reference data for forecast and financial evaluation. (Refer to Part III-5.)

Following are the findings in the review of TOT study result and in the newly conducted field survey:



Contact Test at Doi Inthanon Site

(1) TOT field survey has so far been completed for approximately 160 stations out of a total of 422 scheduled rural sites and 47 scheduled mobile exchange stations. For the remaining stations, only the map study has been completed.

(2) Many of rural sites where TOT has so far completed the field survey do not have the locations finally decided. However, the most part of rural sites are scheduled to be constructed in plain land towns so that, wherever in the towns their final locations may be, the radio propagation will in no way be disturbed.

(3) The UHF route plan made by TOT is considered to be generally acceptable as it is based on the experience of site selection for the existing microwave system. However, when the UHF band radio propagation characteristics are taken into account in system design, greater system operation economy can be realized with the elimination of through repeater stations, for instance.

(4) As regards the telephone demand forecast in and after 1989 for this Project, there is need for reinvestigation aimed at demand forecast readjustment. (Refer to Part III-5.)

In the following Chapter 2-2 through Chapter 2-5 appears the detailed study result for the terrestrial radio system.

2-2 Design Criteria Establishment and System Performance Estimation

2-2-1 Determination of Radio Station Location and Antenna Height

From the optimum transmission route obtained in Part IV-2 (refer to Figure 4-1) the four areas, i.e., Chiangmai area, Ayutthaya area, Nakhon Ratchasima area and Phun Phin area, have been picked up and the locations of all 75 radio stations in these four areas have been plotted on the map of a scale of 1 to 50,000. The coordinates have been read out and from their values the basic propagation path parameters, including path distance and azimuth, have been calculated with the aid of a small sized, programmable calculator. A calculation example appears in Table 6-1. The typical revised path profile maps are shown in Figures 6-2 through 6-5.

For the antenna height determination criteria, the following have been decided as the result of technical discussion with TOT:

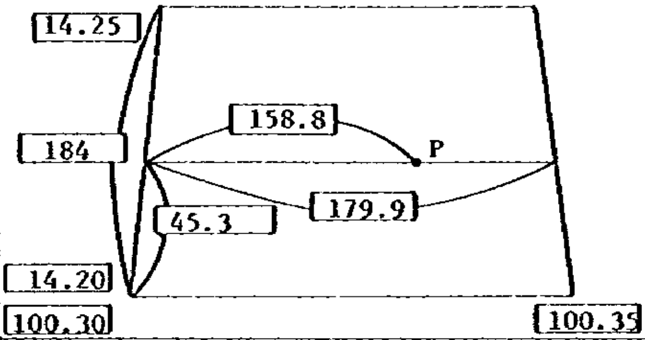
(1) To use 4/3 for coefficient of effective earth's radius (K).

(2) To set the minimum antenna height at 30 m in urban and plain areas and 15 m at mountain-top repeater stations.

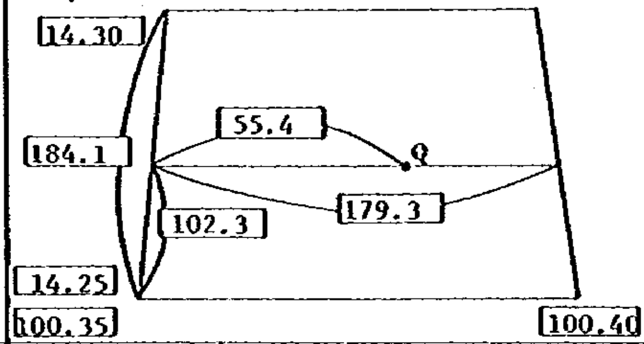
Table 6-1 PROPAGATION PATH DATA (1/2)	Path No. 3516-1

Site P	Site Q
Ayutthaya	Nakhon Luang

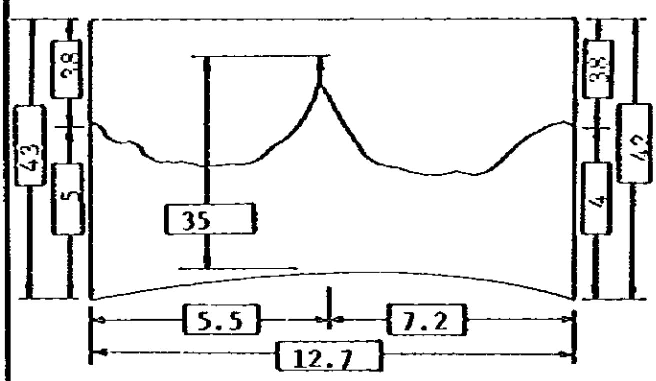
Map No. 5137 IV



Map No. 5137 IV



Site P		Site Q	
Long-1(D.MS)	100.3000	Long-1(D.MS)	100.3500
Long-2(D.MS)	100.3500	Long-2(D.MS)	100.4000
Lati-1(D.MS)	14.2000	Lati-1(D.MS)	14.2500
Lati-2(D.MS)	14.2500	Lati-2(D.MS)	14.3000
X 1-2(mm)	179.9	X 1-2(mm)	179.3
X 1-0(mm)	158.8	X 1-0(mm)	55.4
Y 1-2(mm)	184.0	Y 1-2(mm)	184.1
Y 1-0(mm)	45.3	Y 1-0(mm)	102.3
Long. (D.MS)	100.3425	Long. (D.MS)	100.3633
Lati. (D.MS)	14.2114	Lati. (D.MS)	14.2747
G.Elevation	5 (m)	G.Elevation	4 (m)
Profile No.	5 - 3516 - 1	Type of Path	L/S (no reflection)



Path Distance & Azimuth

Long-P (D.MS)	100.3425
Lati-P (D.MS)	14.2114
Long-Q (D.MS)	100.3633
Lati-Q (D.MS)	14.2747
d (km)	12.7
α P→Q(D.MS)	17.3556
α Q→P(D.MS)	197.3627

Antenna Height & Diffraction Loss

d	(km)	12.7
d1	(km)	5.5
hm	(m)	35.0
hg1	(m)	5.0
hg2	(m)	4.0
ha1	(m)	33.0
ha1	(m)	38.0
ha2	(m)	38.0
(k = 4/3)		
hp	(m)	40.2
Rs	(m)	32.2
Cs	(m)	5.2
U		0.16
M		8.
		Ld50 = 10 dB
(k = 1)		
U		0.14
M		9.
		Ld99.9=12 dB

Table 6-1 PROPAGATION PATH DATA (2/2)	Path No. 3516-1
Site P: Ayutthaya ——	Site Q: Nakhon Luang

Reflection Area(011A-1/3)

f (MHz)	900.00
K	1.333
hg1 (m)	5.0
hg2 (m)	4.0
d (km)	12.7
ha1′ (m)	38.0
ha2′ (m)	38.0
hr′ (m)	5.0
hr (m)	
d1 (m)	6.4
d2 (m)	6.3
ψ (D.MS)	0.1857
T1 (km)	5.9
Dv	0.94
ρe	0.7
Φr (deg)	180.0
Lr min(dB)	-4.6
Lr max(dB)	10.5

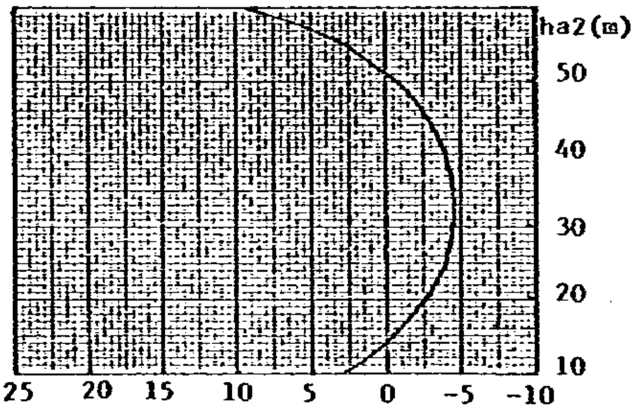
Variation of Reflection Loss(011A-3/3)

$K^{99.9}$	1.000
K^{50}	1.333
$K^{0.1}$	3.000
ha1′ (m)	38.0
ha2′ (m)	38.0
$Lr^{99.9}$ (dB)	-4.5
Lr^{50} (dB)	-4.3
$Lr^{0.1}$ (dB)	-3.9
ha1′ (m)	
ha1′ (m)	
$Lr^{99.9}$ (dB)	
Lr^{50} (dB)	
$Lr^{0.1}$ (dB)	
ha1 determined	38 (m)
ha2 determined	38 (m)

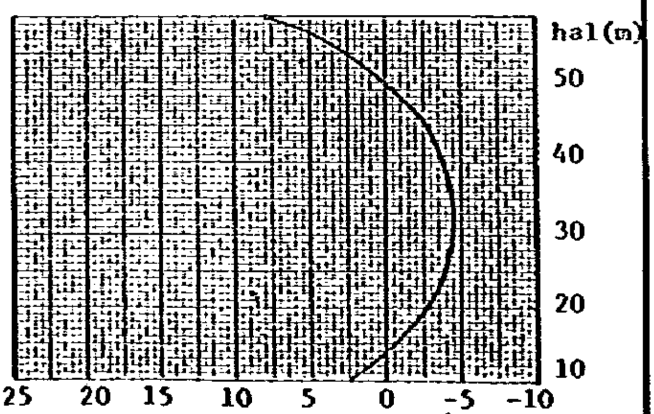
Reflection Loss(011A-2/3)

ha1′ (m)	38.0
Lr60m(dB)	8.6
55	2.8
50	-0.7
45	-2.8
40	-4.0
35	-4.6
30	-4.5
25	-3.9
20	-2.6
15	-0.5
10	2.7
ha2′ (m)	38.0
Lr60m(dB)	7.9
55	2.5
50	-0.9
45	-2.9
40	-4.0
35	-4.6
30	-4.5
25	-3.9
20	-2.7
15	-0.8
10	2.2

Height Pattern



Lr Pattern at Q (dB, ha1′ = 38 m)



Lr Pattern at P (dB, ha2′ = 38 m)

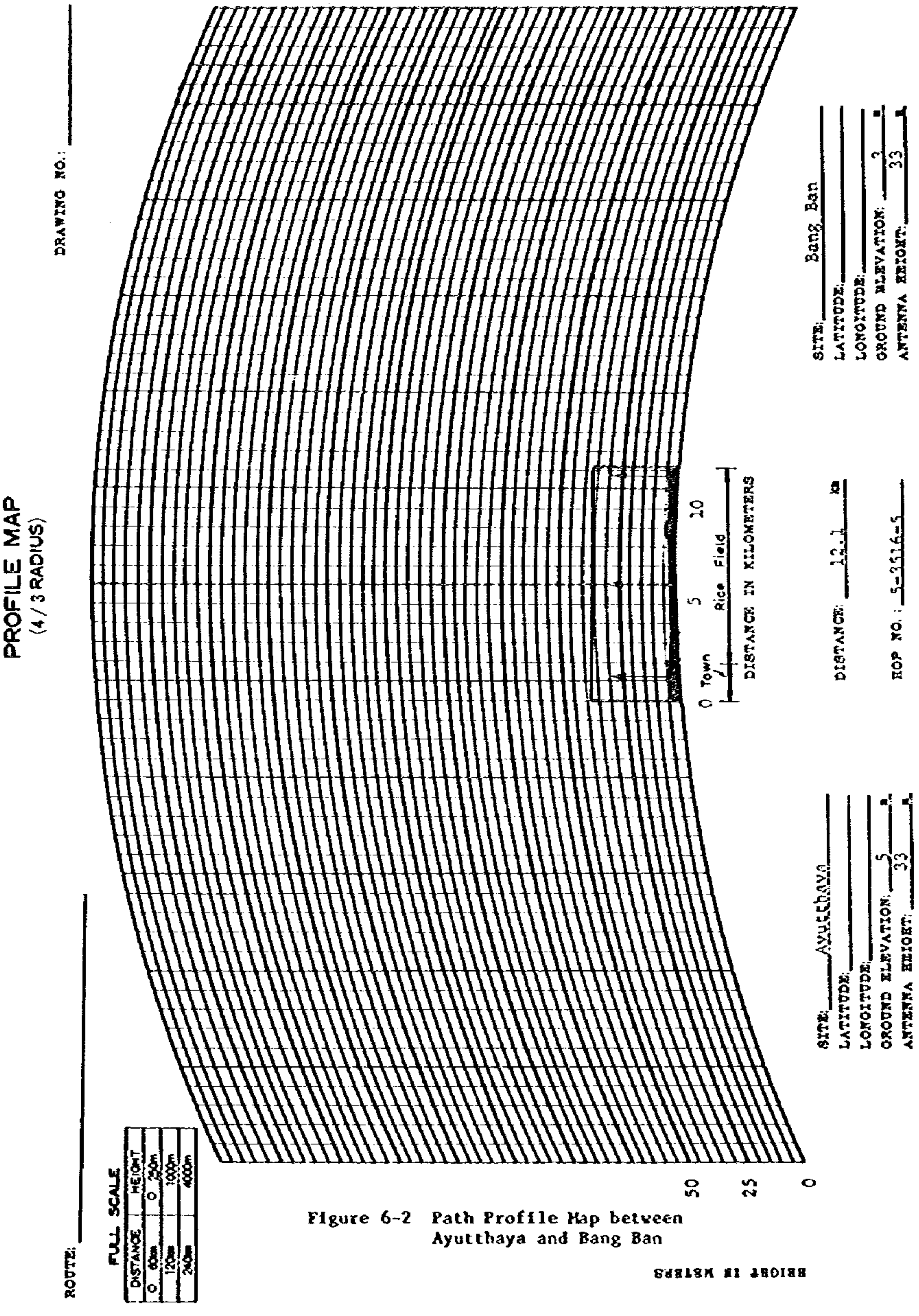


Figure 6-2 Path Profile Map between Ayutthaya and Bang Ban

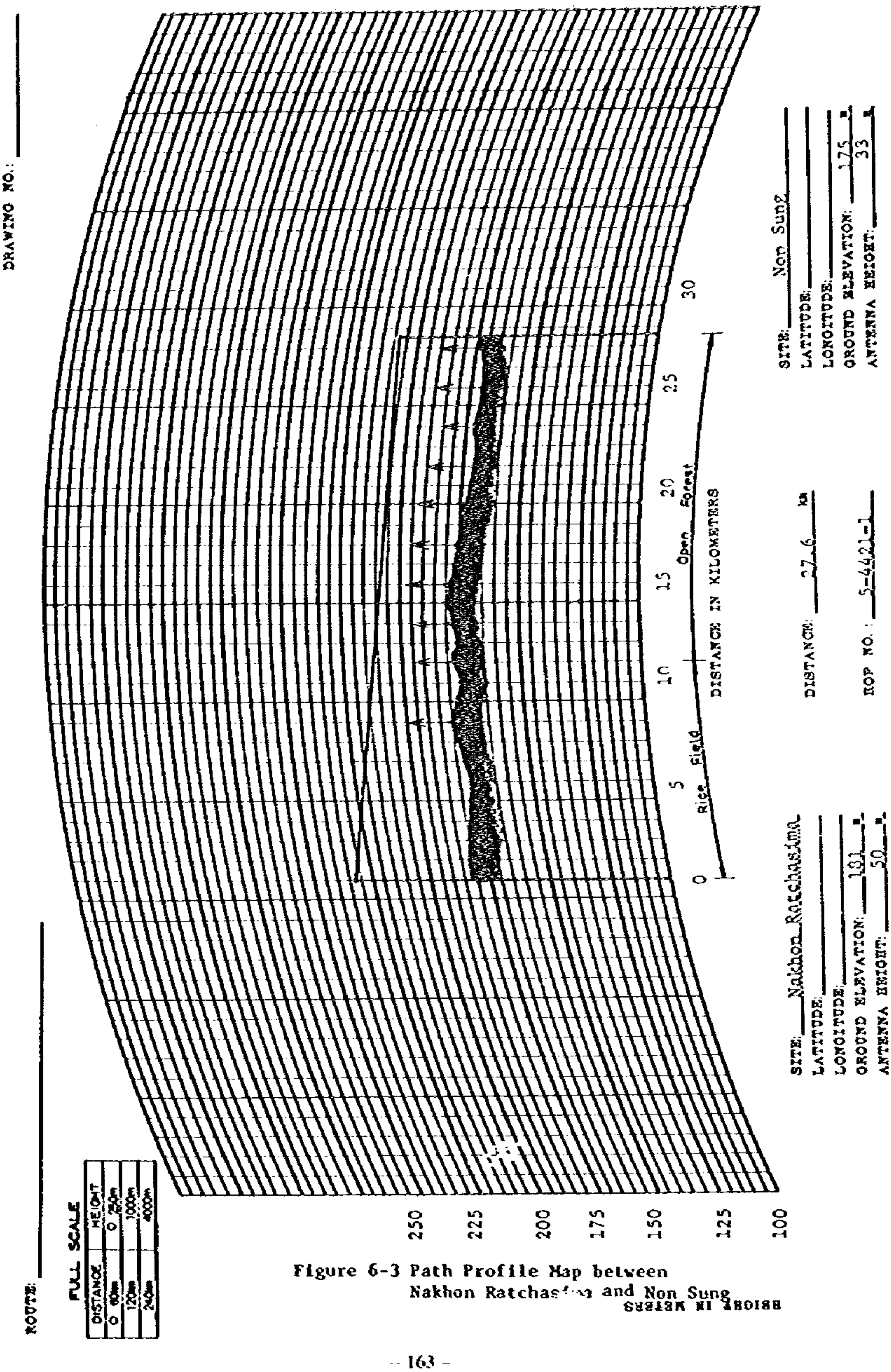


Figure 6-3 Path Profile Map between Nakhon Ratchas[illegible] and Non Sung

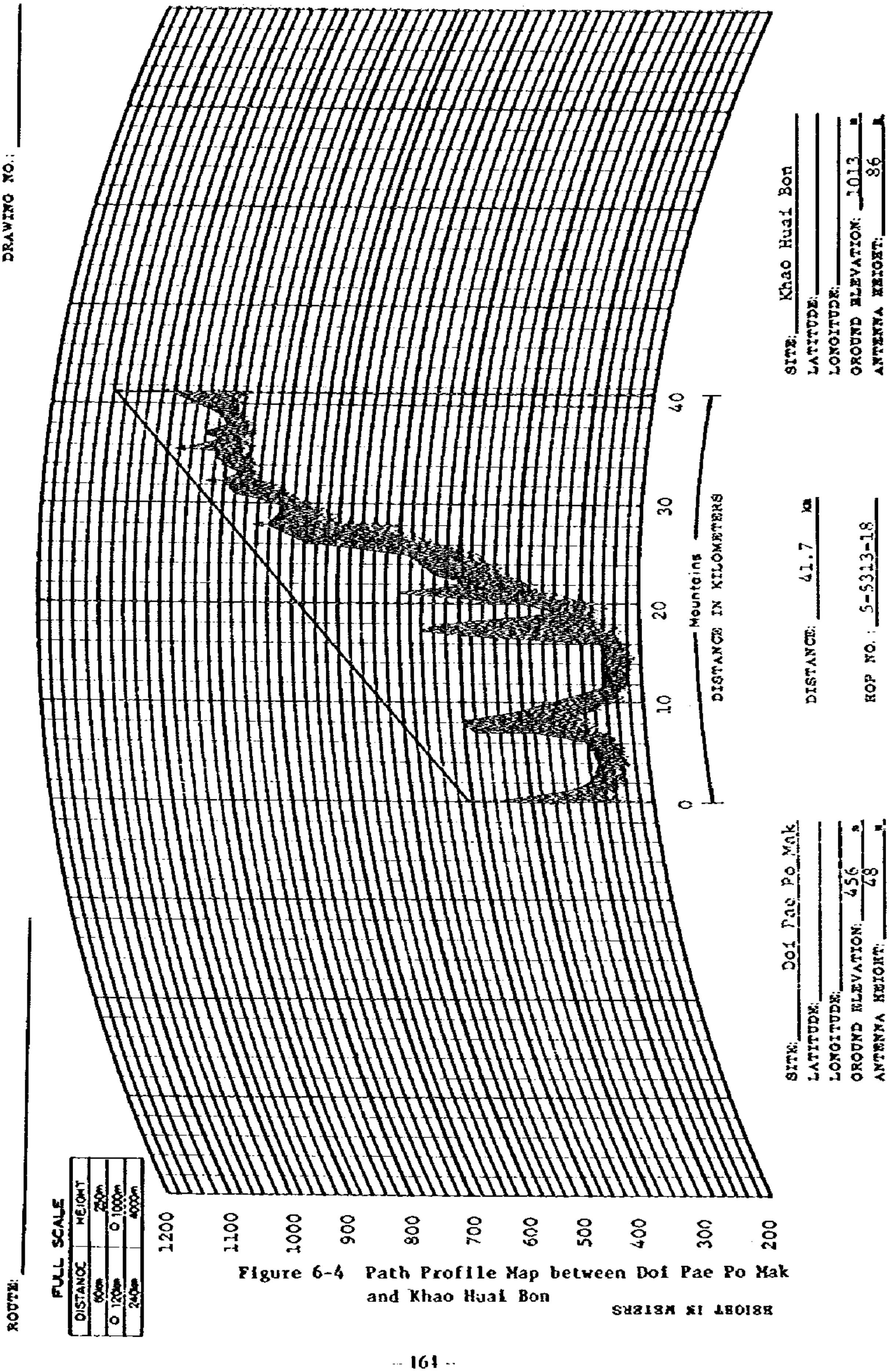


Figure 6-4 Path Profile Map between Doi Pae Po Mak and Khao Huai Bon

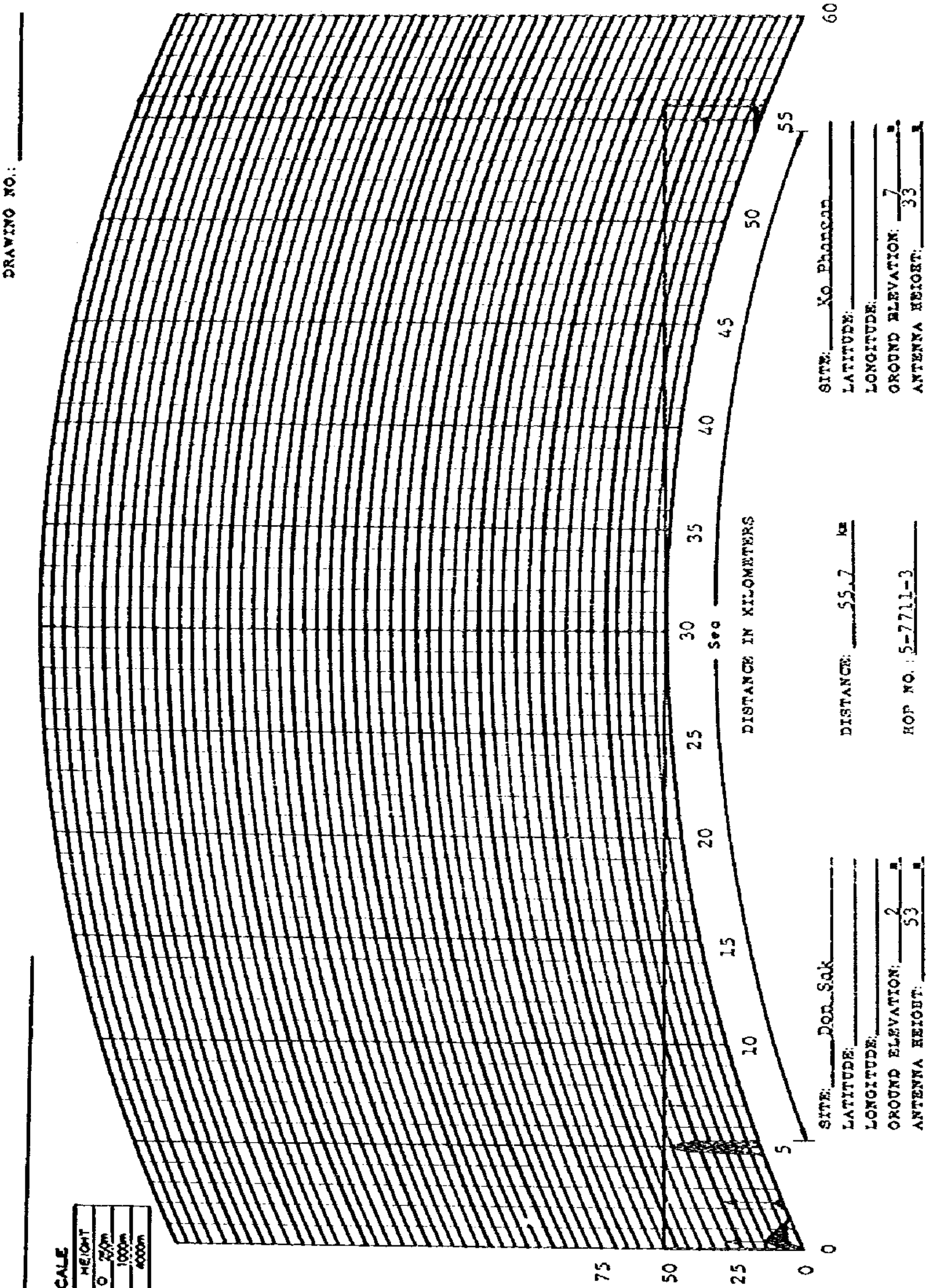


Figure 6-5 Path Profile Map between Don Sak and Ko Pangan

(3) To set path clearance at the obstruction point at 5 m when the path distance is 30 km or less and at zero when the path distance exceeds 30 km.

(4) To calculate the height pattern in case the strong reflected wave exists on the propagation path and determine the optimum antenna height in due consideration of the variation of K (K = 1 to 3).

(5) To consider the height of obstacle, such as trees or buildings, in the neighborhood of the radio station when determining the antenna height, in case the propagation path is the mountain diffraction path.

A list of antenna heights in the four areas, calculated by the above criteria, appears in Table 6-2. Meanwhile, the average antenna tower height in the four areas is 46 m.

2-2-2 System Performance Estimation

(1) Allowable Noise and Noise Distribution

The noise objectives established in Part II-4 are to be distributed as follows per radio hop:

Allowable median noise: 2,000 pW0p for single hop

- 2,000 pW0p (S/Np ≈ *57 dB)
  - Radio link 1,540 pW0p (58.1 dBm0p)
    - Thermal noise at RX input — 1,000 pW0p (60 dBm0p)
    - Equipment thermal noise — 100 pW0p (70 dBm0p)
    - Intermodulation noise — 200 pW0p (67 dBm0p)
    - Interference noise — 240 pW0p (66.2 dBm0p)
    - Echo & propagation distortion noise — Negligible
  - MUX noise 460 pW0p (63.4 dBm0p)

Table 6-2 List of Antenna Heights for 4 Areas (1/3)

Radio Path	Antenna Height (m)
(Ayutthaya area)	
3516-1 Ayutthaya - Nakhon Luang	38 - 38
-2 Nakhon Luang - Ban Phraek	33 - 33
-3 Nakhon Luang - Maharat	33 - 33
-4 Ayutthaya - U-Thai	43 - 43
-5 Ayutthaya - Bang Ban	33 - 33
-6 Bang Ban - Bangpa Han	33 - 33
-7 Bang Ban - Phak Hai	33 - 33
-8 Ayutthaya - Sena	45 - 33
-9 Sena - Bang Sai	33 - 33
-10 Sena - Lat Bua Luang	33 - 33
-11 Ayutthaya - Ban Si	33 - 33
(Nakhon Ratchasima area)	
4421-1 Nakhon Ratchasima - Non Sung	50 - 33
-2 Non Sung - Phi Mai	33 - 33
-3 Phi Mai - Chum Phuang	33 - 33
-4 Chum Phuang - Prathai	33 - 33
-5 Bua Yai - Khong	40 - 43
-6 Nakhon Ratchasima - Non Thai	55 - 33
-7 Non Thai - Kham Sakae Saeng	33 - 33
-8 Non Thai - Dan Khun That	43 - 43
-9 Nakhon Ratchasima - Chakkarat	55 - 63
-10 Chakkarat - Huai Thalaeng	63 - 58
-11 Kham Thale So - Nakhon Ratchasima	33 - 35
-12 Si Kiu - Sung Noen	33 - 33

Table 6-2 List of Antenna Heights for 4 Areas (2/3)

Radio Path	Antenna Height (m)
-13 Pak Thon Chai - Chok Chai	43 - 48
-14 Pak Tong Chai - Khon Buri	38 - 38
-15 Khon Buri - Sa Pratheep	38 - 68
-16 Sa Pratheep - Saeng Sang	63 - 73
(Chiangmai area)	
5313-1 Chiangmai - Ban Pak Thang	40 - 15
-2 Ban Pak Thang - Doi Chiang Dao	30 - 18
-3 Doi Chiang Dao - Doi Pha Hong	18 - 18
-4 Doi Pha Hong - Fang	18 - 33
-5 Fang - Mae Ai	33 - 33
-6 Doi Chiang Dao - Chiang Dao	18 - 33
-7 Doi Chiang Dao - Doi Mu Soe	18 - 18
-8 Doi Mu Soe - Phrao	18 - 33
-9 Mae Rim - Chiangmai	68 - 40
-10 Mae Rim - Mae Taeng	68 - 57
-11 Chiangmai - San Sai	38 - 33
-12 Chiangmai - Doi Saket	35 - 33
-13 Doi Saket - San Kam Phaeng	33 - 33
-14 Chiangmai - San Patong	40 - 58
-15 San Patong - Ban Non Hai	78 - 78
-16 Ban Non Hai - Hot	50 - 45
-17 Hot - Doi Pae Po Mak	63 - 48
-18 Doi Pae Po Mak - Khao Huai Bon	48 - 86
-19 Khao Huai Bon - Omkoi	63 - 78
-20 San Patong - Hang Dong	60 - 33

Table 6-2 List of Antenna Heights for 4 Areas (3/3)

Radio Path	Antenna Height (m)
-21 Ban Non Hai - Chom Thong	30 - 33
-22 Doi Pae Po Mak - Doi Tao	15 - 33
-23 San Patong - Doi Inthanon	40 - 33
-24 Mae Chaem - Doi Inthanon	58 - 58
-25 Doi Inthanon - Sa Moeng	58 - 33
(Phun Phin area)	
7711-1 Phun Phin (R) - Don Sak	10 - 33
-2 Don Sak - Ko Samui	33 - 33
-3 Don Sak - Ko Phangan	53 - 33
-4 Phun Phin (Tex) - Kanchanadit	47 - 43
-5 Phun Phin (Tex) - Tha Chang	36 - 33
-6 Chai Ya - Tha Chana	45 - 33
-7 Phun Phin (R) - Khiri Ratthanikhom	10 - 35
-8 Khiri Ratthanikhom - Ban Takhun	58 - 33
-9 Khiri Ratthanikhom - Phanom	68 - 43
-10 Ban Na San - Khian Sa	55 - 63
-11 Ban Na San - Ban Na Doem	55 - 48
-12 Ban Na San - Wiang Sa	43 - 33
-13 Ban Na San - Prasaeng	58 - 33
-14 Phun Phin (Tex) - Phun Phin (R)	25 - 10

*50 dB in the case of mountain diffraction path. For short term noise, no specification is provided. Suffice it to say that the 99.9% value is estimated as a reference value for system design.

(2) Equipment Parameters

Equipment parameters used in the system design are as follows:

Transmission capacity	:	24 ch, 120 ch
Radio frequency	:	900 MHz
Transmitting power	:	37 dBm
Frequency deviation	:	35 kHz r.m.s./ch (24 ch)
		100 kHz r.m.s./ch (120 ch)
Baseband frequency	:	12-108 kHz (24 ch)
		60-552 kHz (120 ch)
Noise figure	:	7 dB
IF bandwidth	:	1.5 MHz (24 ch)
		5 MHz (120 ch)
Threshold level	:	-95 dBm (24 ch)
		-90 dBm (120 ch)
Equipment thermal noise	:	100 pW0p
Equipment intermodulation noise	:	200 pW0p
MUX equipment noise	:	80 pW0p (SG TR)
	:	80 PW0p (G TR)
	:	300 pW0p (CH TR)

(3) Noise Calculation

Median noise in the radio section including carrier multiplex equipment is calculated by the following expression:

$$N_p = N_{ta} + N_{te} + N_{im} + N_{if} + N_{pm}$$

where

N_p : Total noise (psophometrically weighted)

N_{ta}: Thermal noise

$$N_{ta} = 10^a$$

$$\text{where} \quad a = \frac{(90 - S/N_{ta})}{10}$$

N_{te}: Equipment thermal noise

N_{im}: Equipment intermodulation noise

N_{if}: Interference noise

N_{pm}: Carrier multiplex noise

Signal to thermal noise ratio, S/N_{ta}, can be obtained by the following expression:

$$S/N_{ta} = F_m - L_n$$
$$= P_t - F + 20 \log (S_o/f_p) + 141.6 + K_{emp} - L_n$$

where

F_m: Figure of merit (dB)

P_t: Transmitting power (dBm)

F : Noise figure (dB)

S_o: Frequency deviation (kHz r.m.s./ch)

f_p: Highest baseband frequency (kHz)

K_{emp}: Emphasis improvement factor (= 4 dB)

L_n: Net loss between transmitter and receiver (dB)

(4) Propagation Loss Calculation

From Figure 6-6 the additional propagation loss to the free space loss can be obtained.

(5) Threshold Margin

The objective threshold margin on each path is 33 dB or more.

(6) Short Term Noise Calculation

Fading depth, A_F (99.9%), is obtained by the following expression to estimate short term noise, N_{ta} (99.9%):

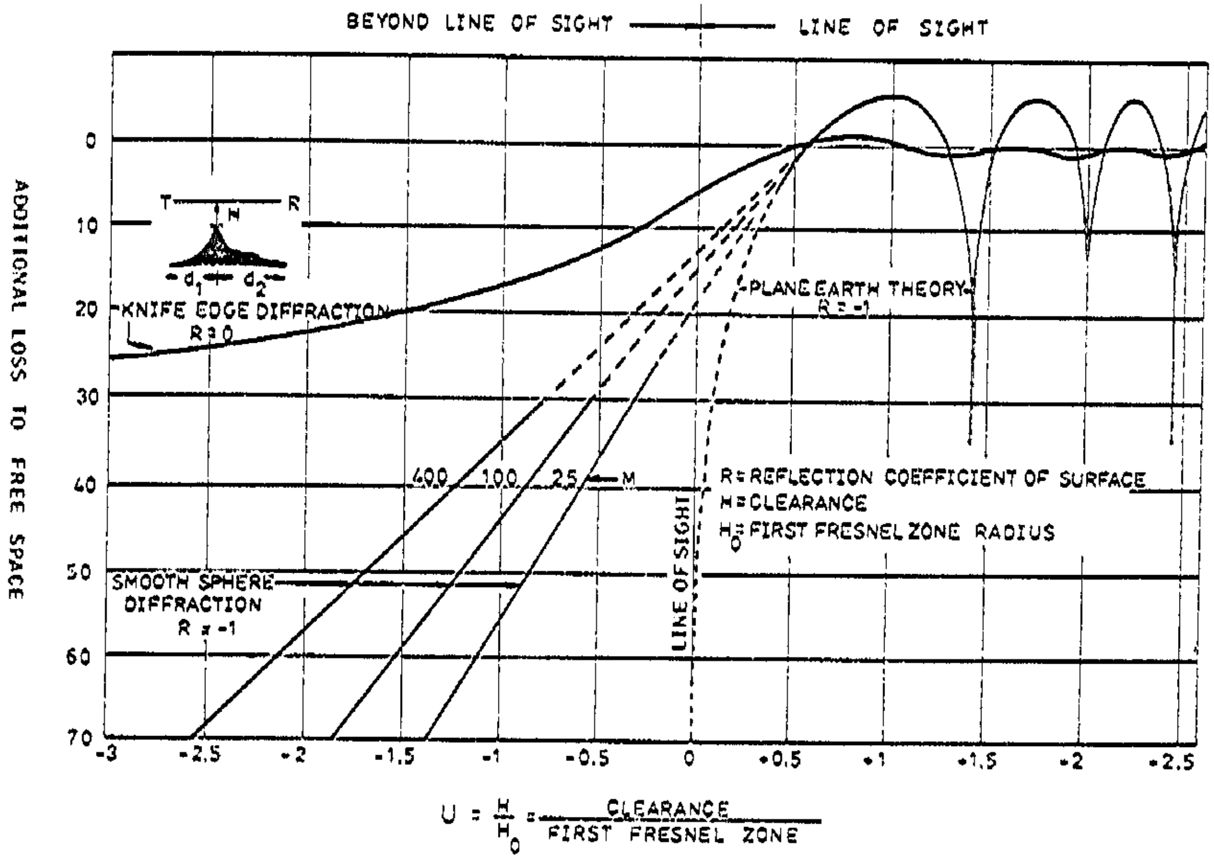
A_F (99.9%) = 10 log L x f (dB)

where

L : Path distance (km)

f : Radio frequency (GHz)

A system performance calculation example by the foregoing conditions appears in Table 6-3. The list of system performances for the four areas appears in Table 6-4.



Source : "Antenna Engineering Handbook"

Figure 6-6 Transmission Loss vs Clearance

Table 6-3 UHF SYSTEM PERFORMANCE CALCULATION (900 MHz, ~~24 ch~~/120 ch, 5 W/ ~~50 W~~)			Path No. 3516-1	
Station P: Ayutthaya	T.~~R~~		Station Q: Nakhon Luang	T.~~R~~

Path Type: L/S (~~no~~ reflection), ~~Mt. Diffraction~~			P	Q
Antenna Height	ha	m	38	38
Antenna Type & Size (Yagi, Parabolic)			1.8	1.8
Antenna Gain	Ga	dBi	21	21
Feeder Type			H20	H20
Feeder Length	lf	m	48	48
Feeder Loss(ha + 10) x ΔLf	Lf	dB	2.5	2.5
Antenna Height at P	ha1	m	38.0	
Antenna Height at Q	ha2	m	38.0	
Path Loss				
Path Distance	d	km	12.7	
Free Space Propagation Loss	Lo	dB	113.6	
Additional Propagation Loss(50%)	La	dB	10.0	
Total Propagation Loss(50%)	Lp	dB	123.6	
Required Antenna Gain	Ga	dB	39.6	
Antenna Gain at P	Ga1	dBi	21.0	
Antenna Gain at Q	Ga2	dBi	21.0	
Branching Loss	Lb	dB	5.0	
Feeder Loss at P	Lf1	dB	2.5	
Feeder Loss at Q	Lf2	dB	2.5	
Net Loss(50%)	Ln	dB	91.6	
Median Noise(50%)				
Figure of Merit	Fm	dB	160.0	
Signal/Thermal Noise	S/Nta	dB	68.4	
Thermal Noise	Nta	pWOp	145.0	
Equipment Thermal Noise	Nte	pWOp	100.0	
Intermodulation Noise	Nim	pWOp	200.0	
Interference Noise	Nif	pWOp	240.0	
Radio Link Noise	Npr	pWOp	685.0	
Carrier Multiplex Noise	Npm	pWOp	460.0	
Total Noise	Np	pWOp	1145.0	
Signal/Total Noise(≧ 57/50 dB)	S/Np	dB	59.4	
Short Period Noise(99.9%)				
Fading Depth	Af	dB	11.0	
Signal/Thermal Noise	S/Nta	dB	57.4	
Thermal Noise	Nta	pWOp	1820.0	
Radio Link Noise	Npr	pWOp	2360.0	
Total Noise	Np	pWOp	2820.0	
Signal/Total Noise	S/Np	dB	55.5	
Fading Margin				
Tx Output Power	Pt	dBm	37.0	
Rx Input Level(50%)	Pri	dBm	-54.6	
Threshold Level	Pth	dBm	-90.0	
Margin to Threshold(50%)(≧ 33/23dB)	Mth	dB	35.4	

Program No.
- 120 ch, 5 W : T301 *
- 24 ch, 5 W : T302
- 24 ch, 50 W : T303

Mux Noise(pWOp)

CH G SG SG G CH-TR
150+40+40+40+40+150 = 460

Antenna Gain(dBi)		
14 ele. Yagi		15
1.2 mØ Para.		18
1.8	"	21 *
2.4	"	23.5
3.0	"	26
4.2	"	28.5
6.0	"	32
8.0	"	34.5

Feeder Loss(dB/m)	
RG-17/U	0.14
F13	0.091
F20	0.052 *
A20	0.048
A39	0.026

Table 6-4 List of System Performances for 4 Areas (1/3)

Radio Path	S/N_p (50%) dB	S/N_p (99.9%) dB
(Ayutthaya area)		
3516-1 Ayutthaya - Nakhon Luang	59.4	55.5
-2 Nakhon Luang - Ban Phraek	60.1	54.7
-3 Nakhon Luang - Maharat	59.8	54.7
-4 Ayutthaya - U-Thai	59.3	55.8
-5 Ayutthaya - Bang Ban	59.4	55.4
-6 Bang Ban - Bangpa Han	59.7	55.2
-7 Bang Ban - Phak Hai	59.6	54.1
-8 Ayutthaya - Sena	59.2	52.8
-9 Sena - Bang Sai	59.2	55.4
-10 Sena - Lat Bua Luang	59.5	52.9
-11 Ayutthaya - Ban Si	59.0	53.1
(Nakhon Ratchasima area)		
4421-1 Nakhon Ratchasima - Non Sung	59.1	51.6
-2 Non Sung - Phi Mai	59.7	51.8
-3 Phi Mai - Chum Phuang	59.3	52.1
-4 Chum Phuang - Prathai	60.1	53.1
-5 Bua Yai - Khong	59.2	52.8
-6 Nakhon Ratchasima - Non Thai	59.6	52.9
-7 Non Thai - Kham Sakae Saeng	60.7	54.8
-8 Non Thai - Dan Khun That	60.3	51.3
-9 Nakhon Ratchsima - Chakkarat	59.7	52.4
-10 Chakkarat - Huai Thalaeng	60.5	53.3
-11 Kham Thale So - Nakhon Ratchasima	59.4	53.6
-12 Si Kiu - Sung Noen	59.5	54.6
-13 Pak Tong Chai - Chok Chai	60.3	54.8

Table 6-4 List of System Performances for 4 Areas (2/3)

Radio Path	S/N_p (50%) dB	S/N_p (99.9%) dB
-14 Pak Tong Chai - Khon Buri	59.4	50.9
-15 Khon Buri - Sa Pratheep	60.3	53.9
-16 Sa Pratheep - Saeng Sang	60.4	55.2
(Chiangmai area)		
5313-1 Chiangmai - Ban Pak Thang	60.4	51.7
-2 Ban Pak Thang - Doi Chiang Dao	61.2	54.0
-3 Doi Chiang Dao - Doi Pha Hong	61.0	48.8
-4 Doi Pha Hong - Fang	60.4	52.6
-5 Fang - Mae Ai	60.4	55.0
-6 Doi Chiang Dao - Chiang Dao	59.6	53.4
-7 Doi Chiang Dao - Doi Mu Soe	61.3	51.7
-8 Doi Mu Soe - Phrao	60.1	56.1
-9 Mae Rim - Chiangmai	59.2	55.2
-10 Mae Rim - Mae Taeng	60.4	53.5
-11 Chiangmai - San Sai	59.5	55.1
-12 Chiangmai - Doi Saket	59.5	54.3
-13 Doi Saket - San Kam Phaeng	60.4	55.8
-14 Chiangmai - San Patong	62.4	50.8
-15 San Patong - Ban Non Hai	59.9	51.5
-16 Ban Non Hai - Hot	60.1	51.2
-17 Hot - Doi Pae Po Mak	61.2	50.4
-18 Doi Pae Po Mak - Khao Huai Bon	61.5	51.3
-19 Khao Huai Bon - Omkoi	60.2	56.6
-20 San Patong - Hang Dong	59.2	55.7

Table 6-4 List of System Performances for 4 Areas (3/3)

Radio Path	S/N_p (50%) dB	S/N_p (99.9%) dB
-21 Ban Non Hai - Chom Thong	60.2	57.0
-22 Doi Pae Po Mak - Doi Tao	60.4	55.1
-23 San Patong - Doi Inthanon	59.9	51.3
-24 Mae Chaem - Doi Inthanon	60.5	55.5
-25 Doi Inthanon - Sa Moeng	55.3	43.5
(Phun Phin area)		
7711-1 Phun Phin (R) - Don Sak	60.1	49.2
-2 Don Sak - Ko Samui	59.8	50.4
-3 Don Sak - Ko Phangan	60.3	50.7
-4 Phun Phin (Tex) - Kanchanadit	59.5	52.1
-5 Phun Phin (Tex) - Tha Chang	59.1	52.5
-6 Chai Ya - Tha Chana	59.2	53.1
-7 Phun Phin (R) - Khiri Ratthanikhom	59.8	50.7
-8 Khiri Ratthanikhom - Ban Takhun	60.1	53.8
-9 Khiri Ratthanikhom - Phanom	60.5	54.0
-10 Ban Na San - Khian Sa	59.4	53.4
-11 Ban Na San - Ban Na Doem	59.7	56.2
-12 Ban Na San - Wiang Sa	59.2	52.9
-13 Ban Na San - Prasaeng	59.7	53.0
-14 Phun Phin (Tex) - Phun Phin (R)	61.2	60.6

2-2-3 Radio Frequency Assignment Plan

Radio frequency assignment must be accomplished in such a way that noise due to radio interference between radio links will be smaller than the allowable value. Radio interference includes the following types:

1) Co-channel interference
2) Adjacent channel interference
3) Transmitter spurious interference
4) Receiver spurious interference
5) Interference due to intermodulation
6) Transmitter to receiver interference

Out of these types of interference, types (1) and (5) require special consideration in the case of radio links that use UHF band.

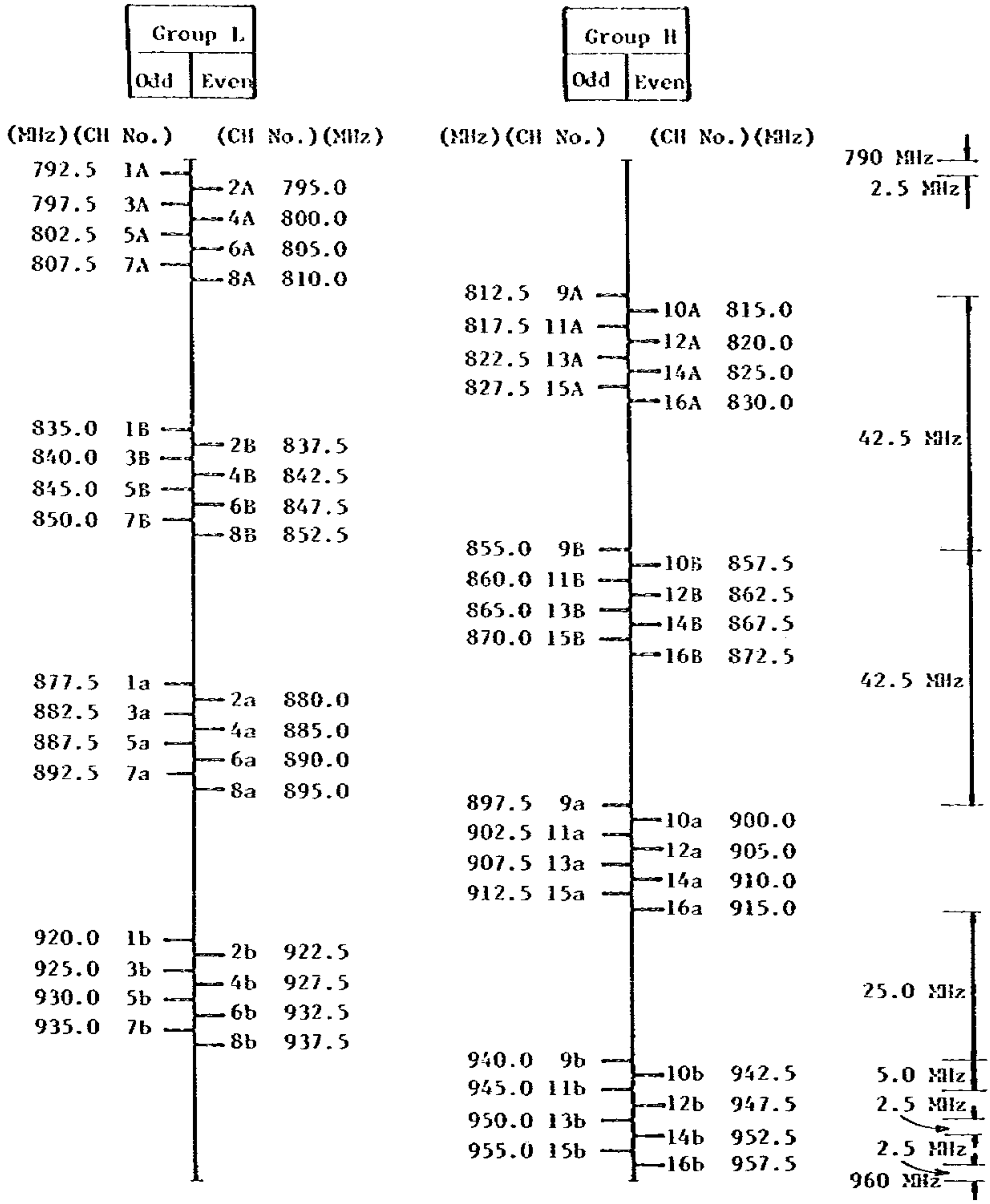
Since antenna directivity characteristic in UHF band is inferior to that in SHF band, it is inevitable to use different radio frequencies between stations that do not have the interference radiowave attenuated to a great extent by intermediate obstacle. In this Project, 10 or so different radio frequencies per area are required for transmitting and receiving, respectively.

Study of TOT's RF channel arrangement plan (808.2 to 873.7 MHz and 900.5 to 958.5 MHz) has revealed that the number of RF channels that can be used in one area is 8 or thereabouts, and this number is not sufficient in this Project. Therefore, the TOT plan mentioned above has to be altered to such RF channel arrangement as shown in Figure 6-7. This channel arrangement uses 790 to 960 MHz frequency band.

When assigning these radio frequencies among radio links, attention must be paid to the following points:

(1) In principle, one Primary Center area constitutes one zone. Either frequency group, L or H, is assigned to each zone.

(2) Different frequency groups are used between adjacent zones.



Note : A and B or a and b of channel number should be combined and used for transmitting and receiving and vice versa.

Figure 6- 7 Radio Frequency Channel Arrangement in 900 MHz Band

(3) In case the odd and even numbers of RF channels are commonly used in one zone, minimum spacing between RF channels which are used at one station must be 5 MHz.

(4) Consideration must be made so that interference due to intermodulation will not take place between RF channels which are used at one station.

(5) It is essential to calculate interference noise volume of each radio link and make sure that the noise volume is below the allowable limit.

(6) Transmitting and receiving frequencies to be used at the same radio station should be 25 MHz or more apart even where they are mutually nearest.

The radio frequency assignment plan applicable to Ayutthaya area, for example, is presented in Figure 6-8.

2-3 Study of Power Plant

2-3-1 Power Plant Type

In order to know the capacity of essential load (communication equipment load) at each station to be constructed in this Project, the essential load analysis has been made for 75 stations in the four sample areas.
The result of analysis is as follows:

Type of Station	Essential Load
TC/SC/PC (4)	1,000 - 3,600 W
Multiplex terminal (21)	500 - 1,100 W
Single terminal (43)	400 - 900 W
Baseband repeater (7)	400 - 500 W

In this Project, power plant will be installed at 639 stations. Out of them, 518 stations can have commercial power supply for 24 hours. Usually, when commercial power is available, the commercial power plus battery (BATT) floating

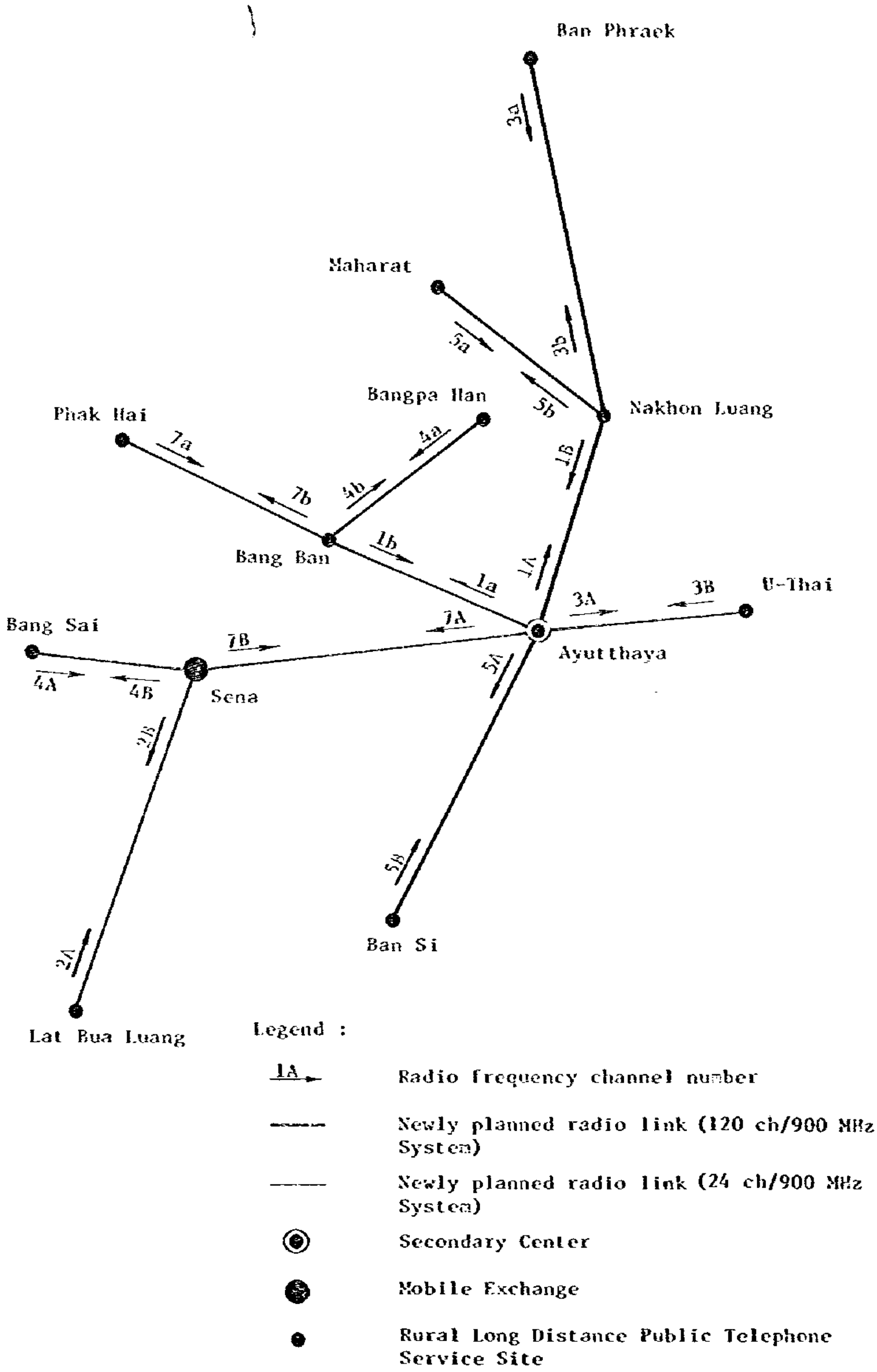


Figure 6- 8   Frequency Assignment Plan for Ayutthaya Area

system is adopted. This system is to float BATT with commercial power while it is being rectified and supplied to the load. In this Project, the adoption of this system is advisable. For power supply to 121 stations (70 terminal stations and 51 repeater stations) where commercial power is unavailable for 24 hours, various systems can be considered. Power supply systems to small capacity load now in common use are as follows:

1) Solar battery system;

2) Thermoelectric generator system;

3) EG plus BATT floating system.

1) and 2) are suitable for power supply to load of up to 300 W. When the load power exceeds 300 W, it is economical to use 3) system. Therefore, the adoption of EG plus BATT floating system even in case the commercial power supply is unavailable is preferable in this Project. When this system is adopted, it is advisable to install two EG units so that they can operate alternately at weekly intervals, for instance.

Out of 639 stations where dc power source is to be installed in this Project, 147 are the existing radio stations. Each of these 147 stations is equipped with a standby engine generator even if commercial power is available. On the other hand, out of 492 stations to be newly constructed, 371 can expect commercial power supply, but this commercial power supply is subject to failure due to supply system trouble, electric work and so forth. Fact-finding at several places disclosed that 10 minutes to one hour power failure would occur from time to time.

This fact notwithstanding, it is not advisable from the viewpoint of Project cost economy to have all 371 stations equipped with standby engine generators. Instead, it will be preferable to have trailer type engine generators, which can be drawn by maintenance vehicles, distributed among 35 Maintenance Centers except the Bangkok Maintenance Center. An average of one such trailer type engine generator should preferably be assigned to each maintenance center.

The ac power requirement at each station to be newly constructed in the four sample areas is calculated to be 1.8 - 6.9 kVA. Therefore, the capacity per unit of trailer type engine generators to be assigned to the 35 Maintenance Centers can be safely calculated to be 7.5 kVA, barring few exceptions.

2-3-2 Power Plant Capacity

Power plant capacity has been calculated by the following conditions:

(1) Holding time of storage battery should be four hours at the attended station and eight hours at the unattended station.

(2) Storage battery should be of lead acid type.

(3) Battery should be charged by the maximum 12 hours charging rate current.

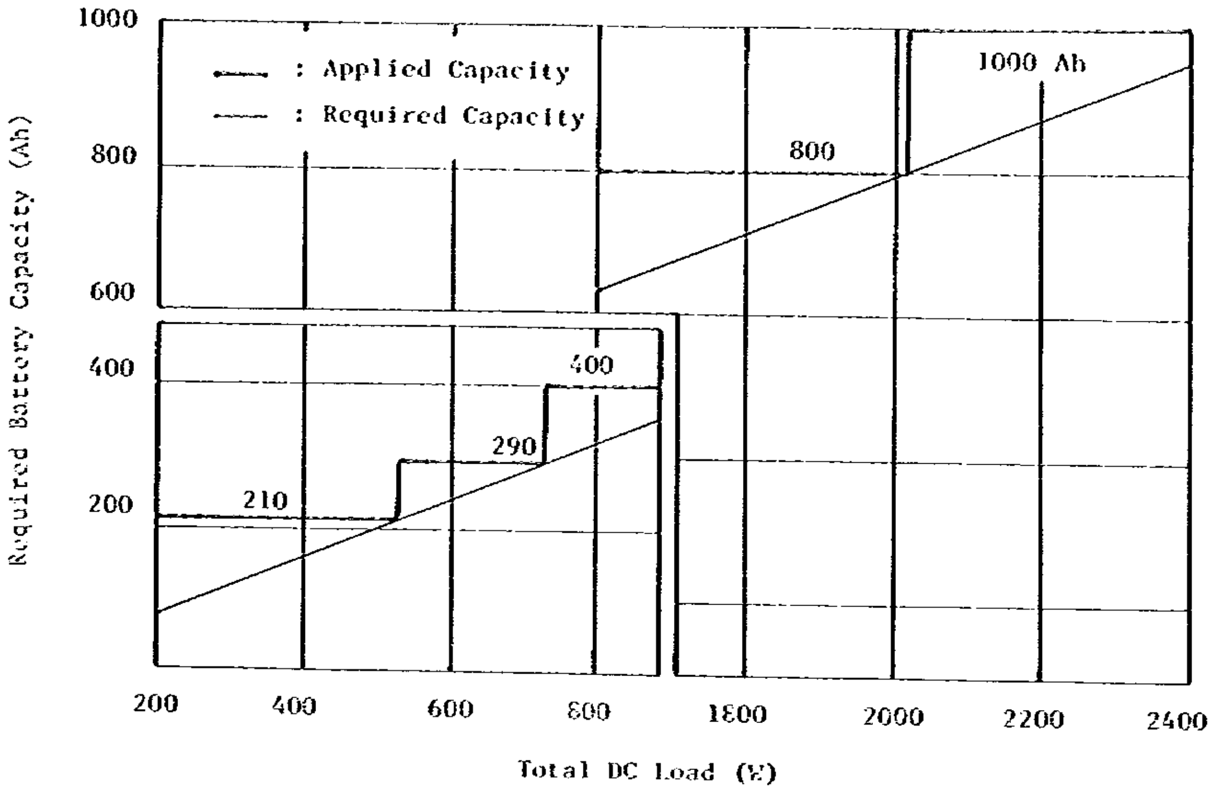
(4) Rectifier should be of half-redundant type and should have capacity large enough to endure the charging current or the load current, whichever the larger.

(5) Since the ac load at each station in the four sample areas, where commercial power is unavailable, is in the range of 4.2 - 6.9 kVA, each engine generator unit should have capacity of 7.5 kVA.

Figure 6-9 and Figure 6-10 are the charts by which to obtain the required battery capacity and rectifier capacity to meet the total dc load. Power plant capacities of 57 stations in the four sample areas, calculated by the foregoing conditions, are shown in Table 6-5.

2-4 Typical Radio System Configuration and Site Layout

Figure 6-11 presents typical terrestrial radio system configuration. Figure 6-12 and Figure 6-13 carry typical site layout and equipment floor layout, respectively, for the terrestrial radio system.



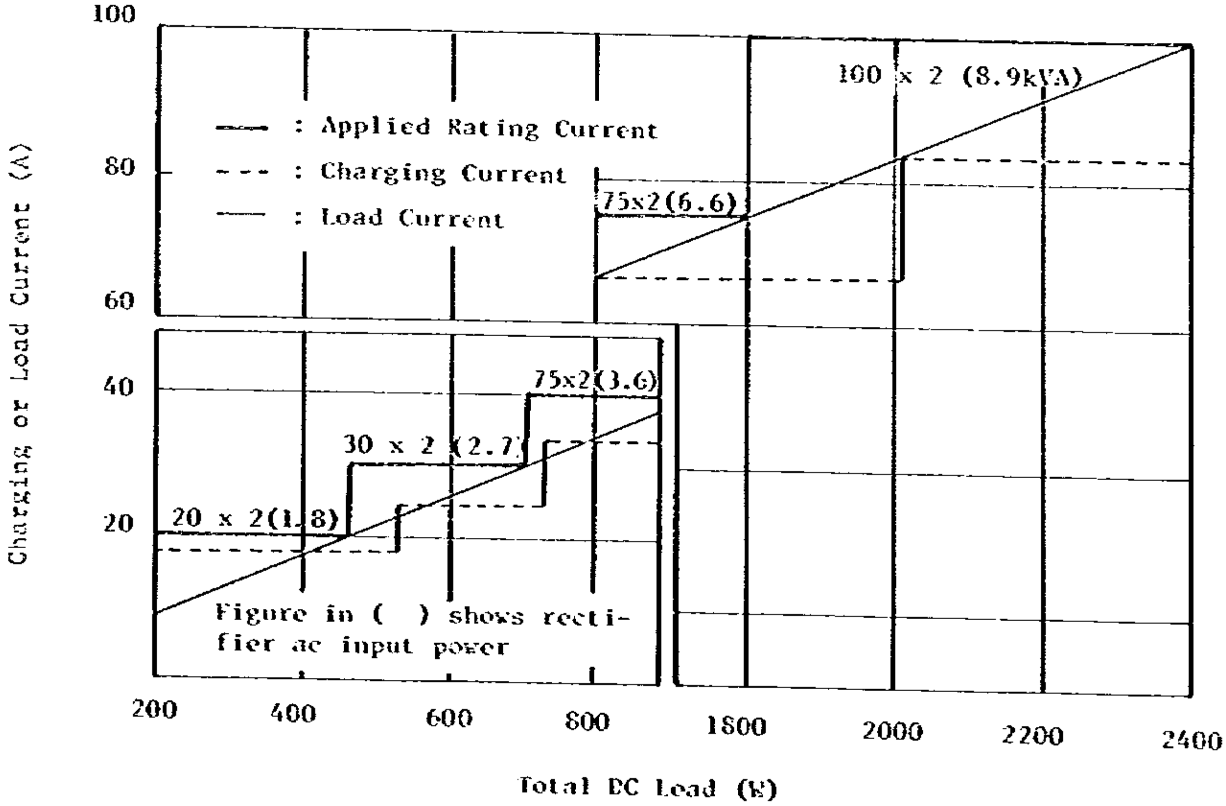


Figure 6-9 Battery and Rectifier Capacities for Attendant Station

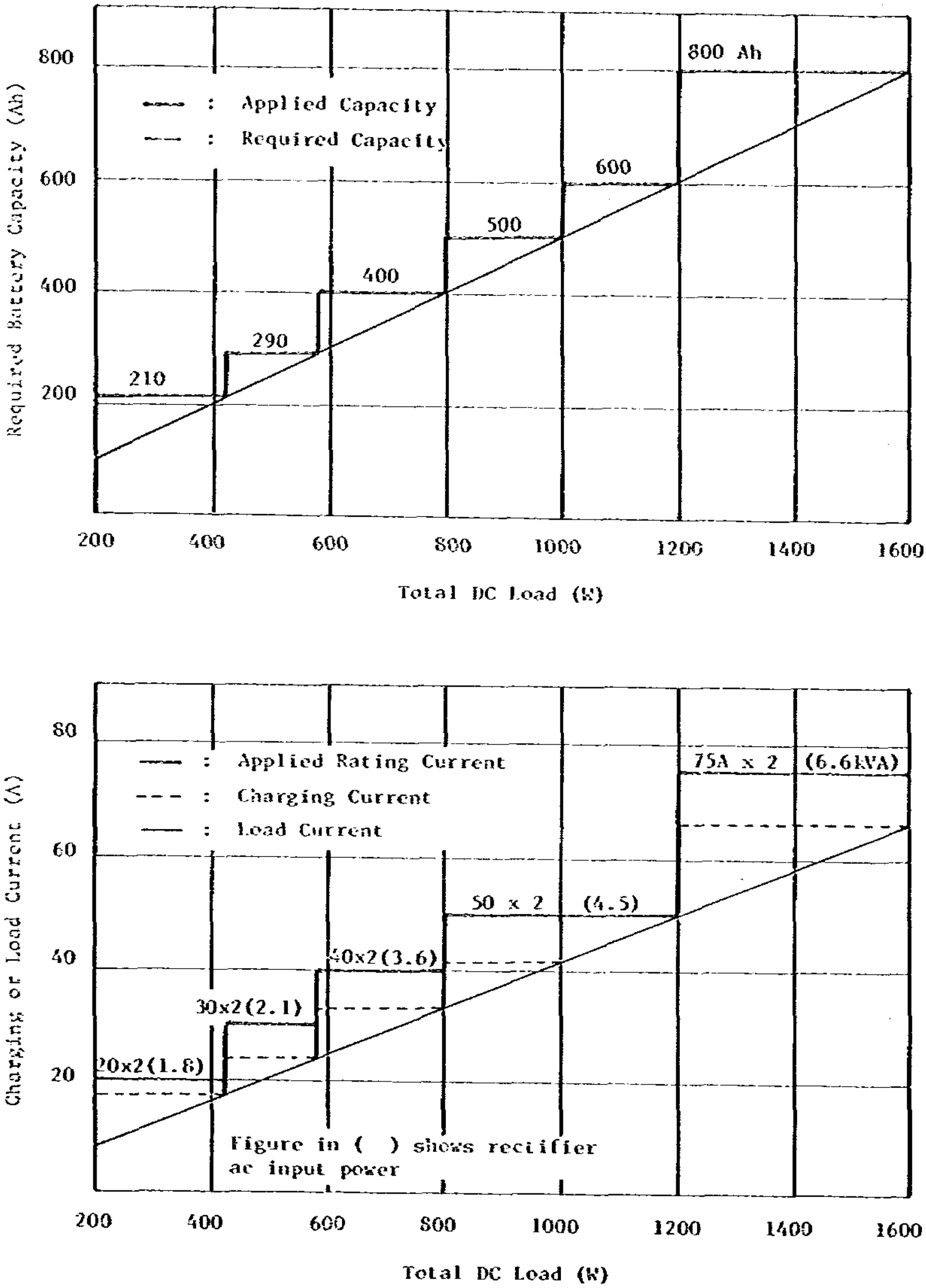


Figure 6- 10 Battery and Rectifier Capacities for Unattendant Station

Table 6-5 List of Power Plants for 4 Areas (1/4)

Station	Total DC Load (W)	Battery Cap.(Ah)	Rectifier Cap.(Ax2)	AC Load (kVA)		
				Essential	Non-ess.	Total
(Ayutthaya area)						
Ayutthaya	2563	1200	150	13.3	Existing	13.3
Bang Ban	1070	600	50	4.5	1.7	6.2
Lat Bua Luang	510	290	30	2.7	2.4	*5.1
Maharat	780	400	40	3.6	1.7	5.3
Nakhon Luang	1070	600	50	4.5	1.7	6.2
Ban Phraek	830	500	50	4.5	1.7	6.2
Bangpa Han	830	500	50	4.5	1.7	6.2
Bang Sai	780	400	40	3.6	1.7	5.3
Phak Hai	780	400	40	3.6	1.7	5.3
U-Thai	780	400	40	3.6	1.7	5.3
Ban Si	830	500	50	4.5	1.7	6.2
Sena	940	500	50	4.5	1.7	6.2
(Nakhon Ratchasima area)						
Nakhon Ratchasima	2167	1000	100	8.9	Existing	8.9
Khon Buri	560	290	30	2.7	1.7	4.4
Prathai	440	290	30	2.7	1.7	4.4
Non Thai	680	400	40	3.6	1.7	5.3
Khong	780	400	40	3.6	1.7	5.3
Chum Phuang	970	500	50	4.5	1.7	6.2
Dan Khun That	440	290	30	2.7	1.7	4.4
Kham Thale So	440	290	30	2.7	1.7	4.4
Kham Sakae Saeng	440	290	30	2.7	1.7	4.4
Huai Thalaeng	440	290	30	2.7	2.1	4.8

Note: Figure with * mark shows that the station requires engine generators (7.5 kVA x 2).

Table 6-5 List of Power Plants for 4 Areas (2/4)

Station	Total DC Load (W)	Battery Cap.(Ah)	Rectifier Cap.(Ax2)	AC Load (kVA)		
				Essential	Non-ess.	Total
Saeng Sang	440	290	30	2.7	2.1	4.8
Sung Noen	510	290	30	2.7	1.7	4.4
Chakkarat	560	290	30	2.7	2.1	4.8
Non Sung	1020	600	50	4.5	1.7	6.2
Phi Mai	740	400	40	3.6	1.7	5.3
Chok Chai	390	210	20	1.8	1.7	3.5
Bua Yai	600	290	30	2.7	Existing	2.7
Si Kiu	370	210	20	1.8	Existing	1.8
Pak Tong Chai	580	290	30	2.7	Existing	2.7
Sa Pratheep	390	210	20	1.8	2.8	*4.6
(Chiangmai area)						
Chiangmai	3564	1400	150	13.3	Existing	13.3
Mae Ai	440	290	30	2.7	1.7	4.4
Omkoi	440	290	30	2.7	2.8	*5.5
Doi Tao	440	290	30	2.7	2.4	*5.1
Fang	1000	500	50	4.5	1.7	6.2
San Sai	510	290	30	2.7	1.7	4.4
Doi Saket	920	500	50	4.5	1.7	6.2
Phrao	780	400	40	3.6	2.4	*6.0
Mae Taeng	780	400	40	3.6	2.1	5.7
Chiang Dao	780	400	40	3.6	1.7	5.3
Sa Moeng	510	290	30	2.7	2.4	*5.1
Mae Rim	920	500	50	4.5	2.1	6.6
Hot	950	500	50	4.5	2.1	6.6

Note: Figure with * mark shows that the station requires engine generators (7.5 kVA x 2).

Table 6-5 List of Power Plants for 4 Areas (3/4)

Station	Total DC Load (W)	Battery Cap.(Ah)	Rectifier Cap.(Ax2)	AC Load (kVA)		
				Essential	Non-ess.	Total
Hang Dong	780	400	40	3.6	1.7	5.3
Mae Chaem	510	290	30	2.7	2.8	*5.5
San Kam Phaeng	620	400	40	3.6	1.7	5.3
San Patong	2112	1200	100	8.9	2.1	11.0
Chom Thong	670	400	40	3.6	1.7	5.3
Doi Pha Hong	390	210	20	1.8	2.4	*4.2
Doi Mu Soe	390	210	20	1.8	2.4	*4.2
Doi Chiang Dao	850	500	50	4.5	2.4	*6.9
Ban Pak Tang	390	210	20	1.8	Existing	1.8
Doi Inthanon	710	400	40	3.6	2.8	*6.4
Ban Non Hai	510	290	30	2.7	2.8	*5.5
Doi Pae Po Mak	510	290	30	2.7	2.4	*5.1
Khao Huai Bon	390	210	20	1.8	3.8	*5.6
(Phun Phin area)						
Phun Phin (Tex)	1030	500	50	4.5	Existing	4.5
Khian Sa	440	290	30	2.7	2.1	4.8
Prasaeng	510	290	30	2.7	1.7	4.4
Phanom	440	290	30	2.7	1.7	4.4
Tha Chang	780	400	40	3.6	1.7	5.3
Tha Chana	780	400	40	3.6	1.7	5.3
Don Sak	1070	600	50	4.5	1.7	6.2
Khiri Ratthanikhom	1070	600	50	4.5	Existing	4.5
Ban Na Doem	440	290	30	2.7	1.7	4.4
Ko Phangan	440	290	30	2.7	2.4	*5.1

Note: Figure with * mark shows that the station requires engine generators (7.5 kVA x 2).

Table 6-5 List of Power Plants for 4 Areas (4/4)

Station	Total DC Load (W)	Battery Cap.(Ah)	Rectifier Cap.(Ax2)	AC Load (kVA)		
				Essential	Non-ess.	Total
Ban Takhun	440	290	30	2.7	1.7	4.4
Wiang Sa	780	400	40	3.6	1.7	5.3
Kanchanadit	510	290	30	2.7	1.7	4.4
Ko Samui	680	400	40	3.6	1.7	5.3
Phun Phin (R)	560	290	30	2.7	Existing	2.7
Chai Ya	600	290	30	2.7	Existing	2.7
Ban Na San	990	400	50	4.5	Existing	4.5

Note: Figure with * mark shows that the station requires engine generators (7.5 kVA x 2).

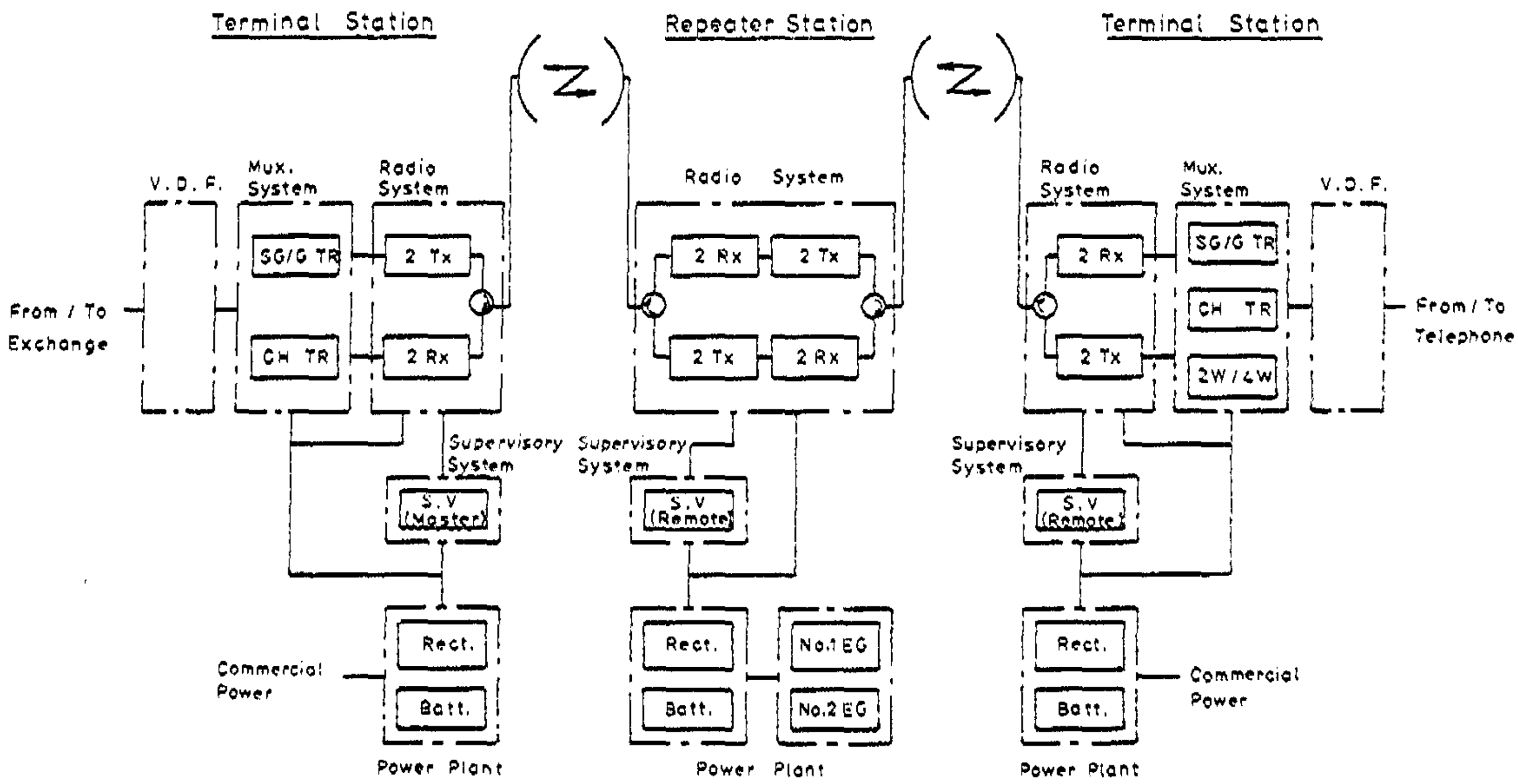
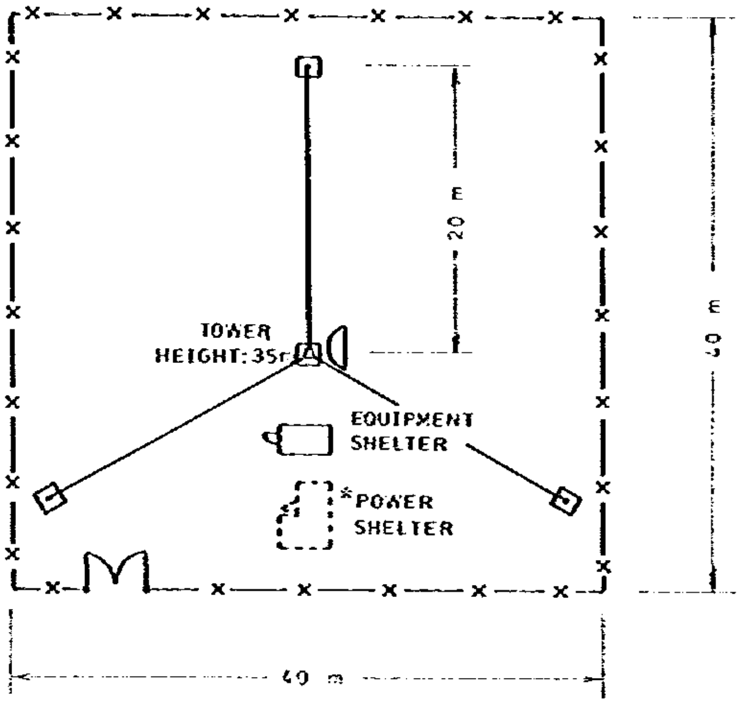
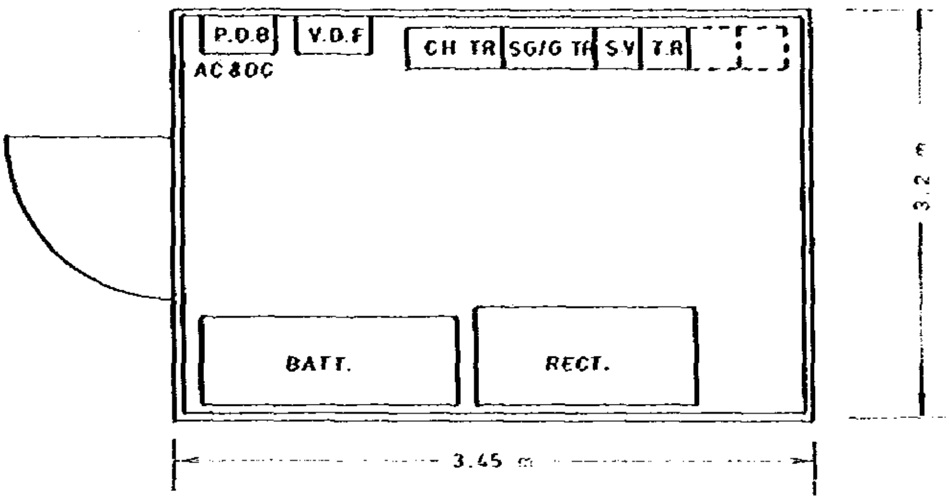


Figure 6-11 Typical Terrestrial Radio System Configuration

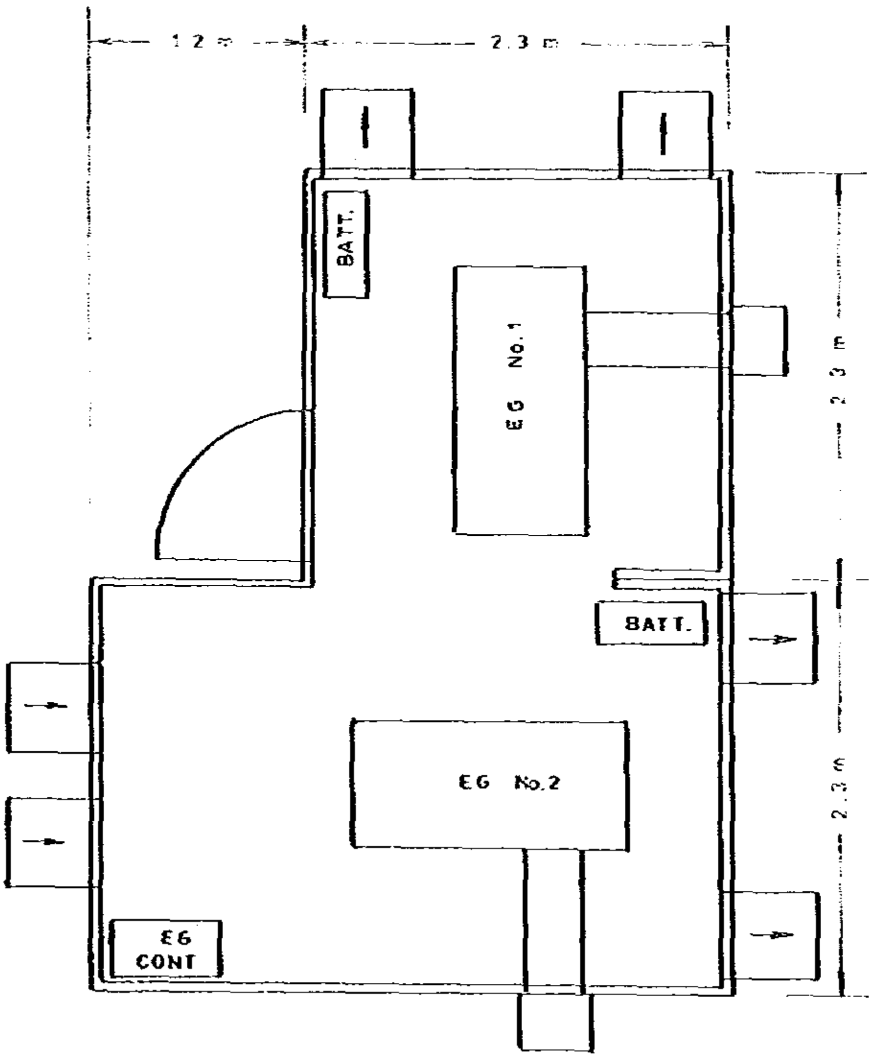


Note : * Power shelter with dual engine-generator will be installed where the commercial power is not available.

Figure 6-12 Typical Site Layout for Terrestrial System



(a) Equipment Shelter



(b) Power Shelter

Figure 6-13 Typical Equipment Floor Layout for Terrestrial System

2-5 Cable Route Study

The Study Team had no time to carry out field survey to determine optimum cable route. Therefore, map study based on TOT data was conducted to select the route where cable length required could be the minimum. In case where access road would have to be newly constructed, on-the-map route selection was made in consideration of the difference of elevation and gradient (not exceeding 1/10) between the existing road and the mountain-top terminal radio station site.

Figure 6-14 shows a typical cable layout plan.

3. Domestic Satellite System

3-1 Master Earth Station Site Selection

At present, in Bangkok, the existing terrestrial microwave systems (6 GHz lower band) extending to northern, northeastern and southern parts of Thailand are concentrated. Therefore, in order to avoid mutual radio interference between these existing systems and the projected domestic satellite system, the master earth station of the latter has to be established sufficiently distant from the Bangkok Metropolitan area.

TOT holds a plan to construct a new microwave system that extends from Bangkok to Rayong southeast of Bangkok. From the viewpoint of saving the domestic satellite system construction cost and of avoiding radio interference with the existing terrestrial radio system, it is desirable to utilize part of the planned Bangkok - Rayong microwave system as a terrestrial approach link between Bangkok and the master earth station.

For this purpose, however, the planned microwave system should be of different frequency band from that to be used in the domestic satellite system. The field survey carried out this time placed special emphasis on this point. For the selection of the master earth station site, the field survey was conducted for two locations in the neighborhood of the land where the Ban Saphan Si radio repeater station (the second radio repeater station from Bangkok) is scheduled to be constructed. These two locations can be connected by

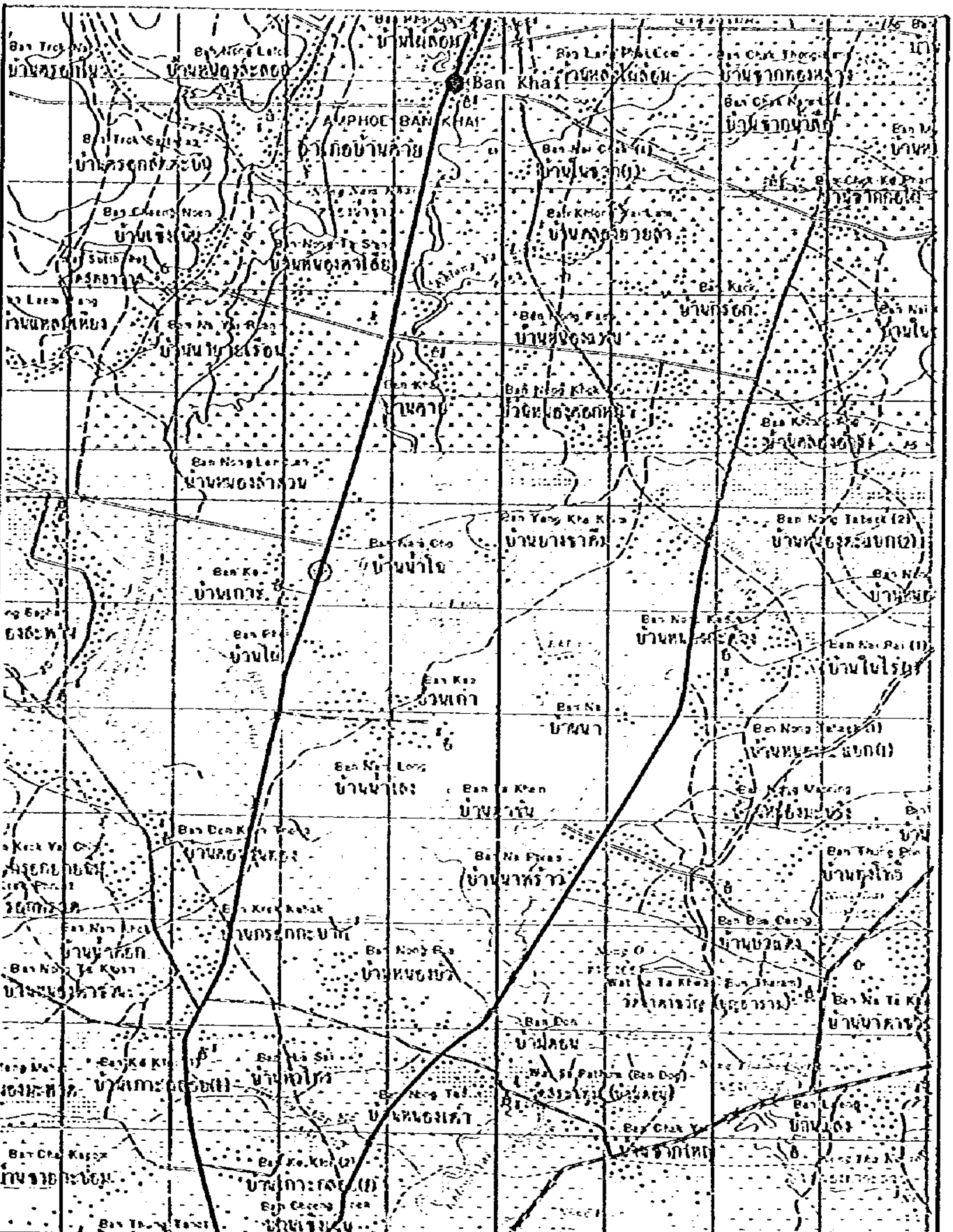
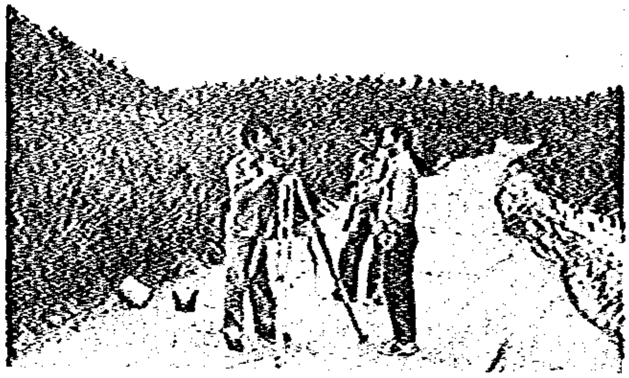


Figure 6-14 **Cable Layout Plan**	**Ban Khai - Rayong** **Rayong Area(3808)**

coaxial cable to the abovementioned radio repeater station. The proposed site A (Ban Saphan Si shown in Figure 6-15) commands greater advantage than the other in the undermentioned respects, though there is no much difference between the two as far as the radio interference to the existing microwave system is concerned.



Survey at Ban Saphan Si

(1) To gain the access road, the existing road has only to be repaired. This means small access road construction cost.

(2) Coaxial cable length required to connect the radio repeater station and the master earth station is short.

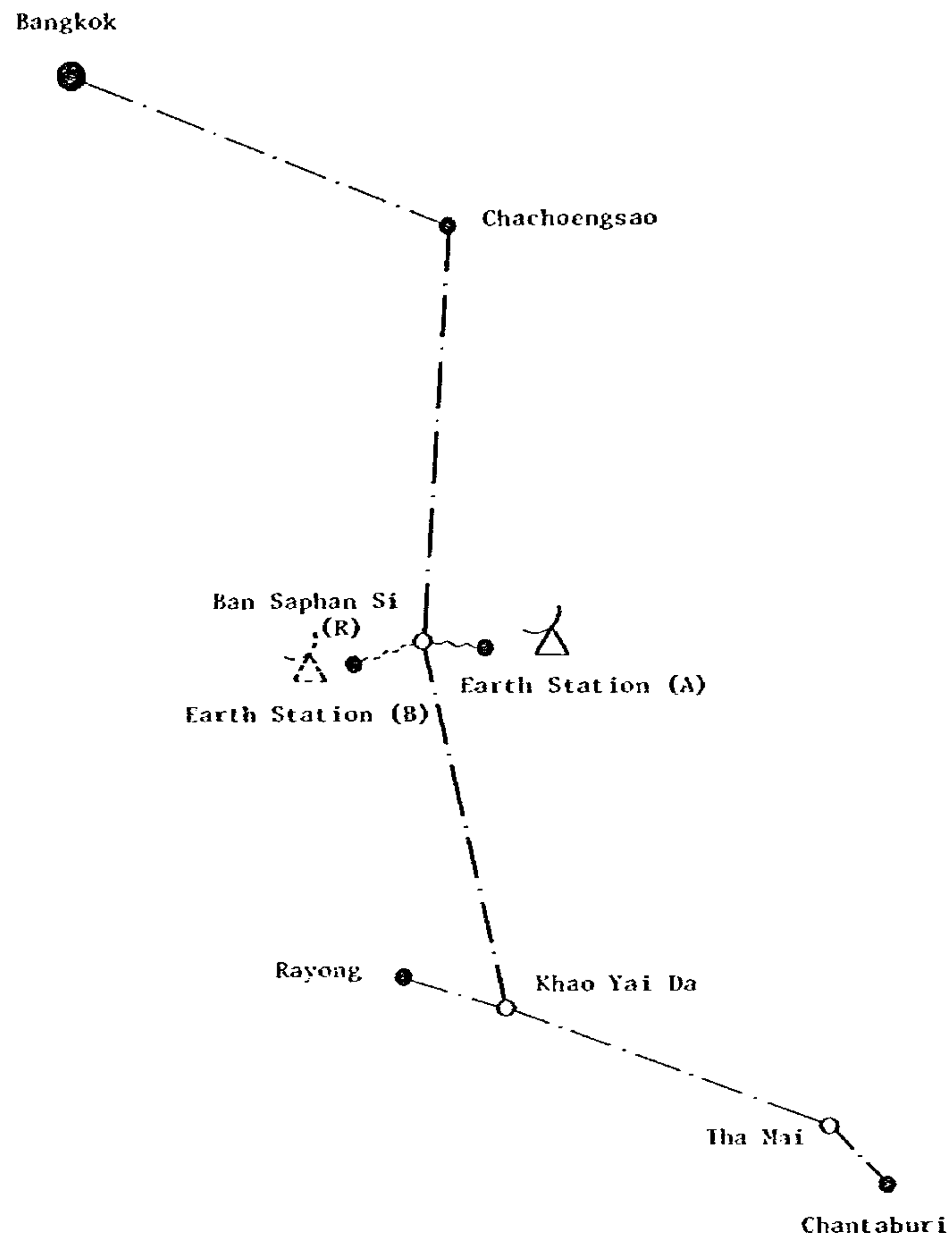
(3) Drainage in the rainy season is good.

However, no information could be obtained with respect to the site location, radio frequency, transmitter output and so forth of the radio system operated by other administration than TOT. If the domestic satellite system is to be adopted in this Project, such information is essential for the radio interference study.

It is desirable to make the field survey for other site or sites than the aforementioned two for the purpose of determining the technically and economically optimum site for the master earth station.

3-2 Rural Earth Station Site Selection

Field survey result shows that the most part of rural station sites selected by TOT on the assumption that the terrestrial radio system be introduced for the projected Rural Long Distance Public Telephone Service are located in plain town areas without obstacles to radio propagation. Therefore, even if the rural earth stations are established at those sites, it seems that no problem relating to radio propagation to and from the satellite will arise.



Earth Station (A) : Ban Saphan Si (E/S)
-Ditto- (B) : Ban Hin Lat (E/S)

Figure 6-15 Terrestrial Approach Link for Bangkok Master Earth Station

However, with regard to the possible radio interference from the rural earth stations to the existing microwave system that uses the same radio frequency band as the rural earth stations, there is need for a thorough study aimed at the selection of proper sites for rural earth stations. (Refer to Section 3-4 of this Part VI.)

As in the case of the site selection for the master earth station, information concerning the communication system of other administration than TOT must be obtained when introducing the domestic satellite system and, based on such information, a complete study on inter-system radio interference must be made.

3-3 Design Criteria Establishment and System Performance Estimation

3-3-1 Circuit Performance Requirements

For the designing of domestic satellite system, hypothetical reference circuit and system performance requirements must be specified. However, there is no CCIR recommendation applicable to the domestic satellite link.

System establishment and maintenance costs for the satellite communication service depend critically upon overall signal to noise performance requirements. Therefore, the performance requirements for telephone circuits recommended by CCIR are referred to as the sole system performance standards for the domestic satellite system.

(1) Hypothetical Reference Circuit for Telephony

CCIR recommends the hypothetical reference circuit for use in the intercontinental telephony transmission via communication satellite, which is as follows:

1) The hypothetical reference circuit for the satellite system consists of one earth-satellite-earth radio link as shown in Figure 6-16.

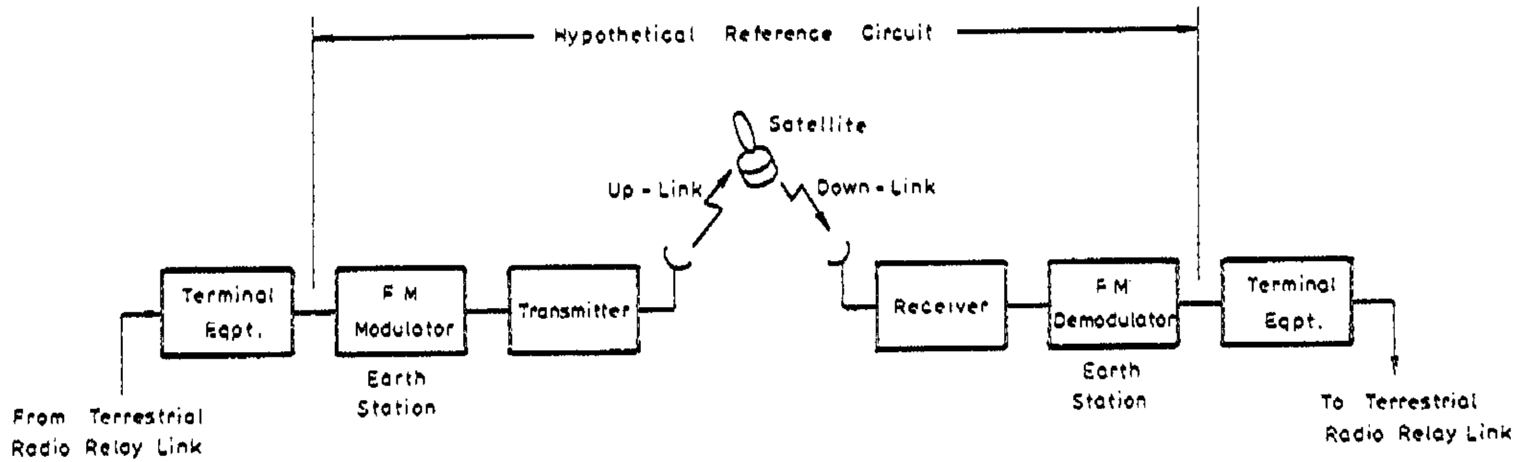


Figure 6-16 Hypothetical Reference Circuit for Satellite System

2) The circuit includes one pair of modulator and demodulator. The modulator translates the baseband to the radio frequency carrier. The demodulator translates the radio frequency carrier to the baseband. However, the circuit does not include frequency division multiplex equipment.

(2) Noise Objectives for Frequency Division Multiplex Telephony
CCIR recommends that in the hypothetical reference circuit for the satellite link the allowable noise power at the zero relative level point on a telephone channel should not exceed:

1) 10,000 pW psophometrically weighted mean power in any hour;
2) 10,000 pW psophometrically weighted one-minute mean power for more than 20% of any month;
3) 50,000 pW psophometrically weighted one-minute mean power for more than 0.3% of any month; and
4) 1,000,000 pW unweighted (with an integrating time of 5 ms) for more than 0.3% of any month.

The overall noise in a hypothetical reference circuit includes thermal noise produced in the up-link and down-link, noise caused by the transmitter/receiver at the earth station and by the satellite transponder, and interference noise from a terrestrial microwave link.

(3) Noise Budget Allowable to Domestic Satellite System
The noise power of 10,000 pW allowable to the domestic satellite telephony circuit is to be assigned to the satellite link and equipment listed in Table 6-6.

Table 6-6 Noise Budget Allowable to Domestic Satellite System.

Item	Noise Power (pW0p)
Satellite link	
Up-link thermal noise	
Intermodulation noise in satellite	7,500
Down-link thermal noise	(-51.3 dBm0p)
Equipment noise in transmitting and receiving earth stations	1,500 (-58.2 dBm0p)
Interference noise from other system	1,000 (-60.0 dBm0p)
Total noise	10,000 (-50.0 dBm0p)

3-3-2 System Performance Estimate

(1) Noise Produced in Satellite Link

Signal to total weighted noise performance on the satellite link is given by

$$(S/N)_t = (C/T)_t - 10 \log k + 10 \log \frac{3f_r^2}{f_m^3 - f_a^3} + E_m + W \text{ (dB)} \quad \ldots\ldots\ldots\ldots(6.1)$$

where

$(S/N)_t$: Signal to total weighted noise ratio (51.3 dB)

$(C/T)_t$: Carrier to total noise temperature (dBW/°K)

K : Boltzmann's constant (1.38×10^{-23} J/°K)

f_r : Test tone r.m.s. frequency deviation (4,310 Hz r.m.s.)

f_m : The highest frequency of telephone channel (3,400 Hz)

f_a : The lowest frequency of telephone channel (300 Hz)

E_m : Emphasis improvement factor (5.8 dB)

W : Psophometric weighting factor (2.5 dB)

By the application of actual parameters the above equation can be reduced to

$$(S/N)_t = (C/T)_t + 208.4 \text{ (dB)} \quad \ldots\ldots\ldots\ldots(6.2)$$

Required $(S/N)_t$ for the satellite link is 51.3 dB.

Accordingly, carrier to total noise temperature at operating point (where total noise temperature corresponds to 7,500 pWOp) is

$$\begin{aligned}(C/T)_t &= (S/N)_t - S - 208.4 \quad \ldots\ldots\ldots\ldots(6.3)\\ &= 51.3 - 17 - 208.4\\ &= -174.1 \text{ (dBW/°K)}\end{aligned}$$

where

S : Gain of syllabic compander (dB)

There are three kinds of noises which must be considered in the satellite link in order to satisfy the assigned noise power of 7,500 pWOp. The three kinds of noises are:

1) Up-link Thermal Noise

The up-link thermal noise is given by substituting the up-link C/T as defined in Equation (6.4) with that in Equation (6.2). The up-link C/T is given by

$$(C/T)_U = (EIRP)_E - L_U + (G/T)_s \text{ (dBW/°K)} \quad \ldots\ldots\ldots(6.4)$$

$$= W_s - BO_i - ((EIRP)_{s\ sat} - BO_o - (EIRP)_{sat})$$

$$-10 \log \frac{4\pi}{\lambda^2} + (G/T)_s$$

where

$(EIRP)_E$: Earth station EIRP (dBW)

L_U : Up-link transmission loss including satellite and earth station pointing errors, and atmospheric absorption (dB)

$(G/T)_s$: Figure of merit of satellite transponder (dB/°K)

W_s : Input flux density of a single carrier for saturation of satellite transponder (dBW/m^2)

BO_i : Input back-off of satellite transponder (dB)

$(EIRP)_{s\ sat}$: EIRP at saturation of satellite transponder (dBW)

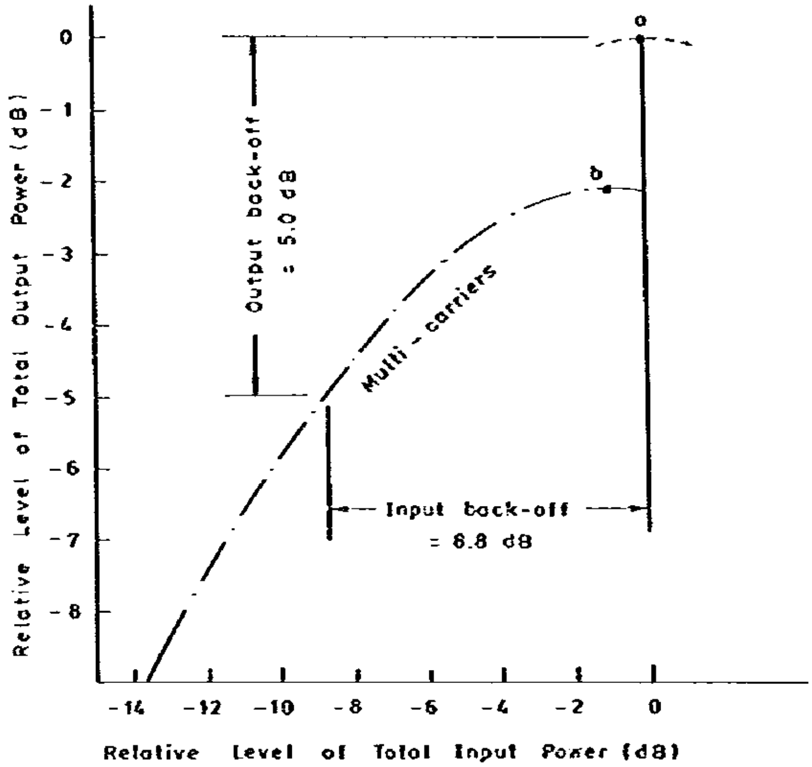
$(EIRP)_{sat}$: Satellite EIRP per carrier (dBW)

BO_o : Output back-off of satellite transponder (dB)

(For BO_i and BO_o, refer to Figure 6-17.)

2) Satellite Intermodulation Noise

In the multiple-access operation by SCPC-FM carriers, a number of carriers are simultaneously amplified by a common amplifier in the satellite transponder. In this case, the amplifier must be operated near its saturated output power for the purpose of efficient use of



Note

a : Saturation Power at Single Carrier Input

b : Saturation Power at Multi-Carrier Input

Figure 6-17 Input-Output Characteristics of Transponder satellite EIRP. As a consequence, intermodulation noise due to multi-carrier operation is produced in the satellite transponder. This intermodulation noise is caused by amplitude non-linearity and by AM/PM conversion. In the SCPC-FM system, the carrier start-stop system, whereby a carrier is transmitted only during voice activities, is adopted so as to use the available satellite power efficiently. The voice activity factor is approximately 40% in the case of 1,000 carriers. This means that 400 carriers are accessed and amplified simultaneously in the transponder. Therefore, the necessary total EIRP of all earth stations can be given by

$$(EIRP)_{Et} = W_s - BO_i + L_U - 10 \log \frac{4\pi}{\lambda^2} \text{ (dBW)} \quad \ldots\ldots(6.5)$$

where

W_s : Input flux density which gives saturated output power of satellite transponder

BO_i: Level difference between W_s and operational point. Amplifier of satellite transponder is operated below its saturation output power so as to keep intermodulation noise low.

L_U : Up-link transmission loss

Input back-off is the ratio of the single carrier input power which yields the saturated output power to the total input power of the multi-carriers at their operating point. Output back-off is the ratio of the saturated output power by the single carrier input to that by multi-carriers input.

$(C/T)_{IM}$ is given by

$$(C/T)_{IM} = (EIRP)_{sat} - N_o + K \quad (\text{dBW}/^\circ\text{K}) \ldots\ldots\ldots(6.6)$$

where

N_o : Intermodulation noise power density (dBW/Hz)

(Refer to Figure 6-18.)

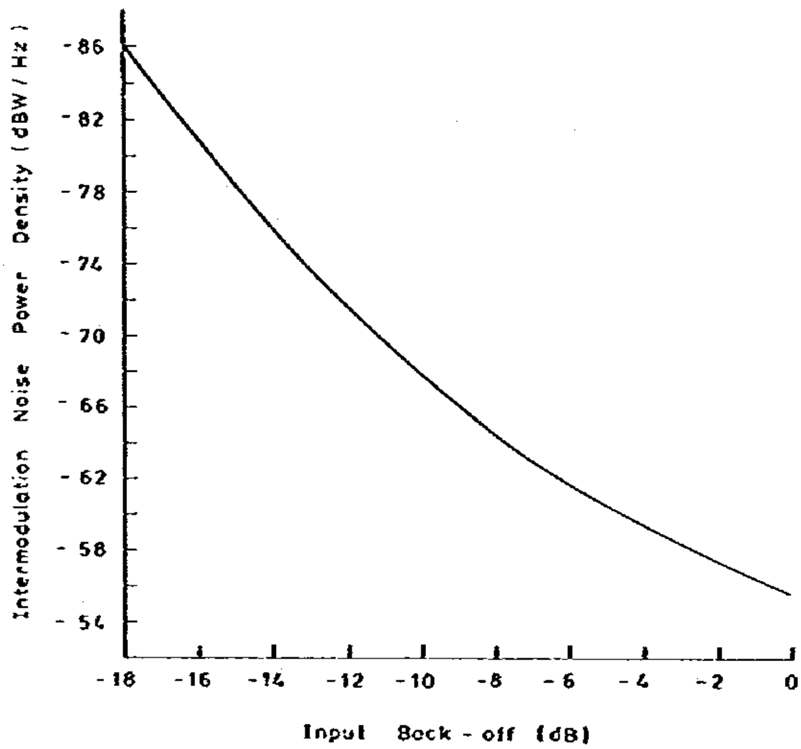


Figure 6-18 Intermodulation Noise Power Density Produced in PALAPA Satellite Transponder

3) Down-link Thermal Noise

The down-link thermal noise consists of the thermal noise of antenna, feeder and receiver of a receiving earth station. It is given by

$(C/T)_D = (EIRP)_{sat} - L_D + (G/T)_D$ ....(6.7)

where

$(EIRP)_{sat}$: Satellite EIRP per carrier (dBW)

L_D : Down-link transmission loss including satellite and earth station pointing errors (dB)

$(G/T)_D$: Figure of merit of receiving earth station (dB/°K)

(2) Total Carrier to Noise Temperature Ratio in Satellite Link $(C/T)_t$

$(C/T)_t$ is expressed by

$$(C/T)_t = \log \frac{1}{(T/C)'_U + (T/C)'_{IM} + (T/C)'_D} \quad ....(6.8)$$

where $(T/C)'_U$, $(T/C)'_{IM}$ and $(T/C)'_D$ are inverse numbers of values which are expressed in antilogarithm of $(C/T)_U$, $(C/T)_{IM}$ and $(C/T)_D$, respectively.

(3) Overall Signal to Noise Ratio in Satellite System

Estimated overall noise can be obtained by the following equation:

$N_T = N_t + N_E + N_I$ ....(6.9)

where

N_t : Noise produced in up-link, transponder and down-link

N_E : Equipment noise produced at the earth station

N_I : Interference noise from other system(s)

(4) Threshold Margin

Threshold margin is a tolerance of received carrier level to the threshold level.

In the satellite system, carrier to noise ratio varies according to the meteorological condition, especially the rainfall. Therefore, it is necessary to have appropriate threshold margin.

Thershold level of threshold extended demodulator is expressed by

$$(C/T)_{TH} = 5 \log f_{rms} - 181.3 \text{ (dBW/°K)} \qquad (6.10)$$

where

f_{rms} : r.m.s. frequency deviation of telephone signal (kHz)

Accordingly, the threshold margin M (dB) is defined by

$$M = (C/T)_t - (C/T)_{TH} \text{ (dB)} \qquad (6.11)$$

(5) Rain Margin

The rain margin M_R is expressed by the following equation:

$$M_R = 10 \log \frac{(T/C)'_{TH} - (T/C)'_t - (T/C)'_D}{(T/C)'_D} \qquad (6.12)$$

where each $(T/C)'$ is an inverse number of the value which is expressed in antilogarithm of (C/T).

3-3-3 System Design Examples

The telephony transmission performance estimates in the direction from Bangkok master earth station to rural earth station and in the opposite direction are shown below. Estimates are made for transmission performance expected when the system parameters shown in Table 6-7 are used.

(1) Carrier to noise temperature ratio in each circuit (master earth station to rural earth station circuit)

1) Up-link thermal noise

$$(C/T)_U = (EIRP)_{EM} - L_U + (G/T)_s$$

$$= W_s - BO_i - ((EIRP)_{s\ sat} - BO_o - (EIRP)_s)$$

$$-10 \log \frac{4\pi}{\lambda^2} + (G/T)_s$$

$$= -80 - 8.8 - (30 - 5.0 - 0.8) - 37 + (-6.5)$$

$$= -156.5 \text{ (dBW/°K)}$$

(where $(EIRP)_{EM}$ is EIRP of master earth station.)

Table 6-7 System Design Parameters

Satellite

Maximum EIRP	: 30 dBW
Saturation flux density	: -80 dBW/m^2
Input-output characteristics of transponder	: Refer to Figure 6-17
Intermodulation noise power density produced in a transponder of PALAPA Satellite	: Refer to Figure 6-18
G/T	: -6.5 dB/°K (Refer to Figure 5-8)
Input back-off	: 8.8 dB (Output back-off: 5.0 dB)
Transponder bandwidth	: 36 MHz/Transponder (Available bandwidth: 30 MHz)

Earth Station

	Master Satation	Rural Station
EIRP (dBW)	50	45
Antenna diameter (mϕ)	11	4.5
G/T (dB)	31.7	21.9
LNA noise temperature (°K)	55	90

Satellite Communication System

System	: SCPC-FM with carrier start-stop system
Number of carriers	: 1,000 (Carrier separation: 30 kHz)
Voice activity factor	: 40%
r.m.s. test tone freq. deviation	: 4.31 kHz r.m.s.

2) Satellite intermodulation noise

$$(C/T)_{IM} = (EIRP)_{sat} - N_o + K$$
$$= 0.8 - (-65.5) - 228.6$$
$$= -162.3 \text{ (dBW/°K)}$$

3) Down-link thermal noise

$$(C/T)_D = (EIRP)_{sat} - L_D + (G/T)_{ER}$$
$$= 0.8 - 196.4 + (21.9)$$
$$= -173.7 \text{ (dBW/°K)}$$

(where $(G/T)_{ER}$ is G/T of rural earth station.)

4) Carrier to total noise temperature ratio

$$(C/T)_t = \log \frac{1}{(T/C)'_U + (T/C)'_{IM} + (T/C)'_D}$$
$$= -174.1 \text{ (dBW/°K)}$$

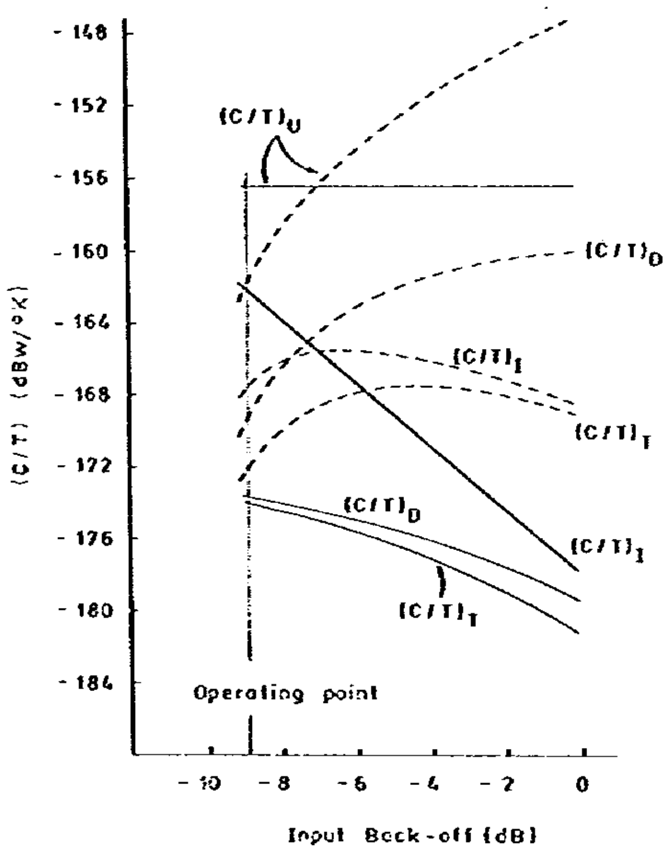
$(S/N)_t$ = 208.4 - 174.1 + 17 = 51.3 dB (7,415 pWOp)

The result of system performance calculations in the direction from rural earth station to master earth station, made by the same method as aforementioned, appears in Table 6-8.

Table 6-8 Overall Signal to Noise Ratio

Noise / Circuit	Radio Link (pWOp)	Eqpt in E/S (pWOp)	Inter-ference (pWOp)	Total Noise (pWOp)	Objectives (pWOp) Margin (dB)
M/S to R/S	7,415	1,500	1,000	9,915 (50.0 dB)	10,000 (0 dB)
R/S to M/S	4,170	1,500	1,000	6,670 (51.8 dB)	10,000 (1.8 dB)

Figure 6-19 presents the relationship between (C/T) of each component and total circuit $(C/T)_t$ in the event the satellite transponder input back-off is varied. By decreasing the input back-off, i.e., by increasing the



Note : Master Earth Station EIRP is fixed at 50 dBW. Rural Earth Station EIRP varies in the range from 41.2 to 51.0 dBW.

—— : Carrier from Master to Rural Earth Stations

---- : Carrier from Rural to Master Earth Stations

Figure 6-19 Selection of Optimum Operating Point of Transponder transmission power, thermal noise can be reduced. However, intermodulation noise increases and total circuit $(C/T)_t$ varies according to the input back-off. It is important to obtain the input back-off point where $(C/T)_t$ becomes maximal and thereby determine the transmission output of the earth station.

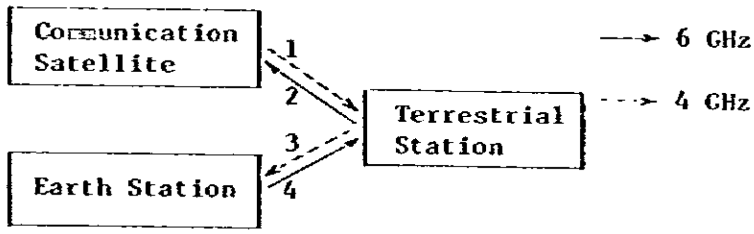
3-4 Study of Radio Interference from Earth Stations

3-4-1 Basic Philosophy

(1) Interference Paths

Radio frequencies to be used at each earth station are 6 GHz for up-link (earth station to satellite) and 4 GHz for down-link (satellite to earth station).

Conceivable interference paths are the following four:



The radio interference study carried out this time pertains to Path 4 in the above illustration. Radio interference on this path is apt to affect public communications. Three other interference paths are not taken up for study here.

(2) Standard Parameters

Parameters of equipment to be installed at each earth station and of equipment already installed at each existing terrestrial radio station are not necessarily uniform. Sometimes they differ from station to station. Therefore, to ease comparison of the degrees of interference suffered and to obtain a macro-perspective of system performance, the standard equipment parameters are specially used.

(3) Paths to be Studied

Reletionships between the earth stations apt to exert harmful radio interference and the existing terrestrial radio stations to suffer such radio interference vary, depending upon the curvature of the earth and the path condition. It follows that not all path combinations between the 423 earth stations and the existing 70 terrestrial stations pose problems.

Therefore, preliminary study is made with regard to the distance between each earth station and each existing terrestrial radio station, as well as the line-of-sight condition. Paths within the predetermined distance between the said two categories of stations and paths in the line-of-sight condition are selected, and detailed analysis is made for interference parameters that exist on such paths.

(4) DU Ratio

The degree of interference is evaluated by the level ratio (dB difference) at the receiving antenna between the desired wave (D) which the existing terrestrial radio station receives from its neighbor stations (1 to 4 stations) and the interference wave, i.e., the undesired wave (U), which the existing terrestrial radio station receives from the earth station. The said level ratio is expressed by "D/U (DU ratio)".

(5) Allowable DU Ratio

Allowable D/U is to be determined, based on the types of communication systems involved and, this time, especially on the international and national standards of the satellite system and existing terrestrial microwave system. The allowable D/U standard for this Project is 79 dB. This value holds true only when the interference propagation path is in free space condition. Actually, the propagation path is bothered by trees and, moreover, the shielding effect of approximately 10 dB can be expected. Therefore, D/U of 79 dB corresponds to D/U of 89 dB.

3-4-2 Preconditions of Study

The preconditions of interference study are as follows:

(1) Scope of Study

1) To study geographic conditions between the 423 earth stations and the existing 70 terrestrial stations for all station-to-station combinations (423 x 70 = 29,610).

2) To select as target stations of radio interference study the existing terrestrial radio stations that belong to either of the following categories in the relationships to each earth station:

a) Being located in a circle with a radius of 100 km from any earth station.

b) Being located on the line-of-sight (K = 4/3: standard refraction) from any earth station.

For details, refer to Figures 6-20 and 6-21.

(2) Radio Frequency

4 GHz...Center frequency : 4,003.5 MHz

6 GHz...Center frequency : 6,175.0 MHz

(3) Earth Station Parameters

Radiation power.....................30 dBm

Antenna height above ground.........4.5 m

Antenna gain........................46.5 dB (4.5 mϕ)

Antenna directivity.................Refer to Figure 6-22

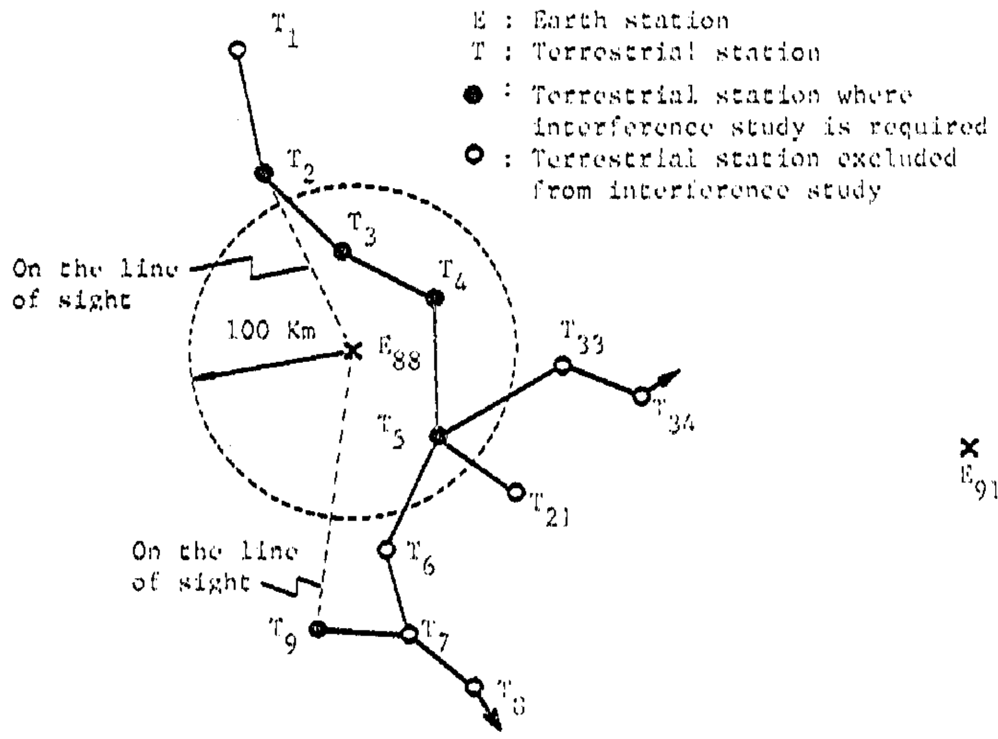
(4) Terrestrial Station Parameters

Radiation power.....................40 dBm

Antenna height above ground.........Possible maximum at each station site is adopted.

Antenna gain........................42.3 dB (3.0 mϕ)

Antenna directivity................Refer to Figure 6-22



Examples of interference path combinations (11 paths)

E_{88}

T_2 : $(T_2 \leftarrow T_1)$, $(T_2 \leftarrow T_3)$

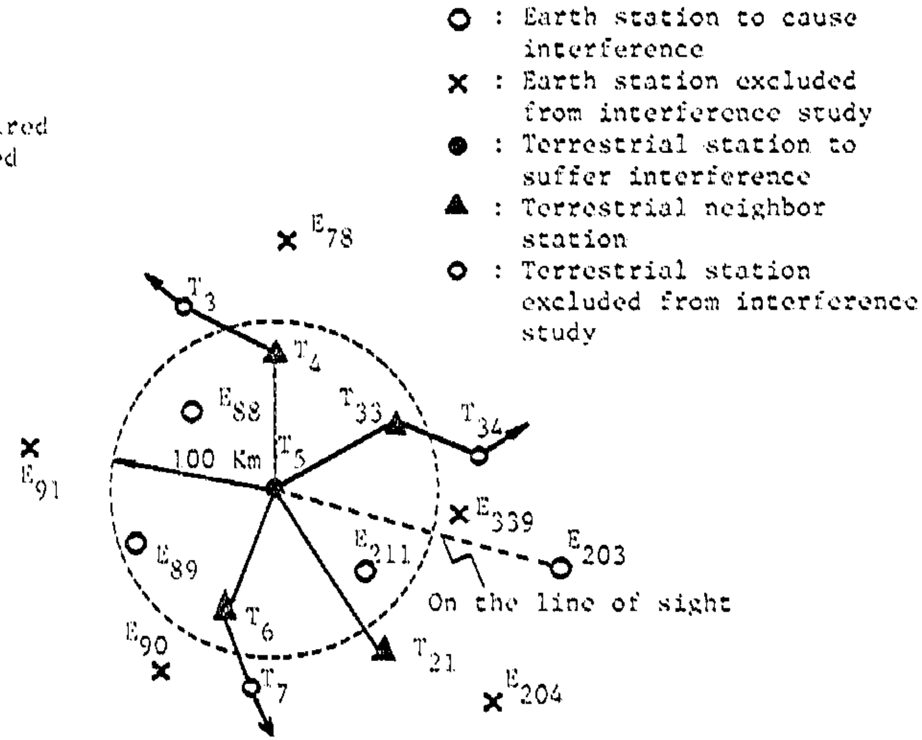
T_3 : $(T_3 \leftarrow T_2)$, $(T_3 \leftarrow T_4)$

T_4 : $(T_4 \leftarrow T_3)$, $(T_4 \leftarrow T_5)$

T_5 : $(T_5 \leftarrow T_4)$, $(T_5 \leftarrow T_6)$, $(T_5 \leftarrow T_{21})$, $(T_5 \leftarrow T_{33})$

T_9 : $(T_9 \leftarrow T_7)$

Figure 6-20 Terrestrial Stations to Suffer Interference from Earth Station



Examples of interference path combinations (16 paths)

T_5: $(T_4 \leftarrow T_5)$, $(T_6 \leftarrow T_5)$, $(T_{21} \leftarrow T_5)$, $(T_{33} \leftarrow T_5)$

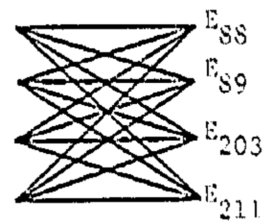


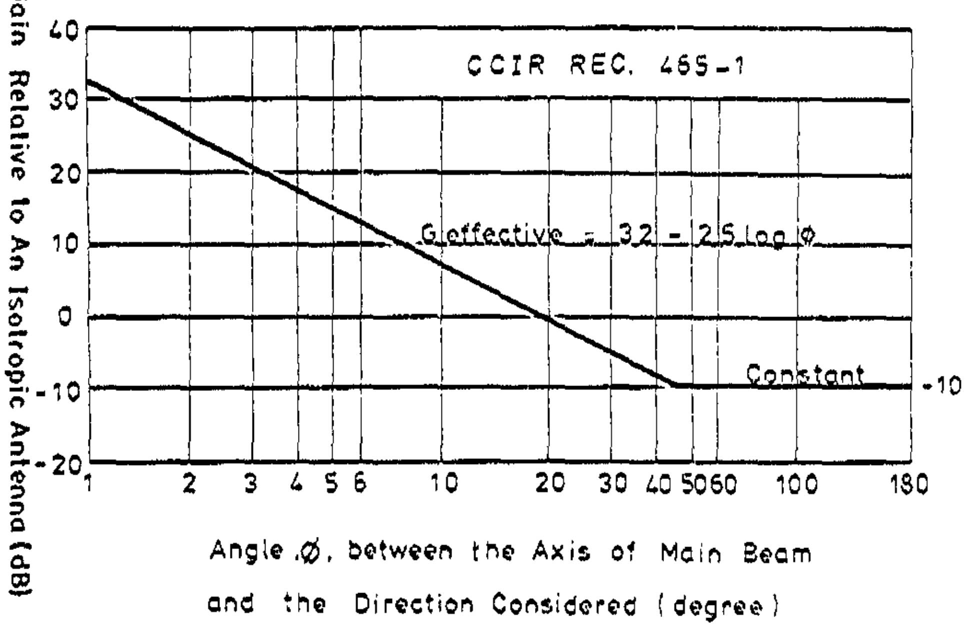
Figure 6-21 Interference Analysis of Terrestrial Stations

Rural Earth Station Antenna Directivity

(1) Frequency 2 ~ 10 GHz

(2) D/λ >100

D : Antenna diameter, λ : Wave length



Standard Directivity Of Terrestrial Station Antenna

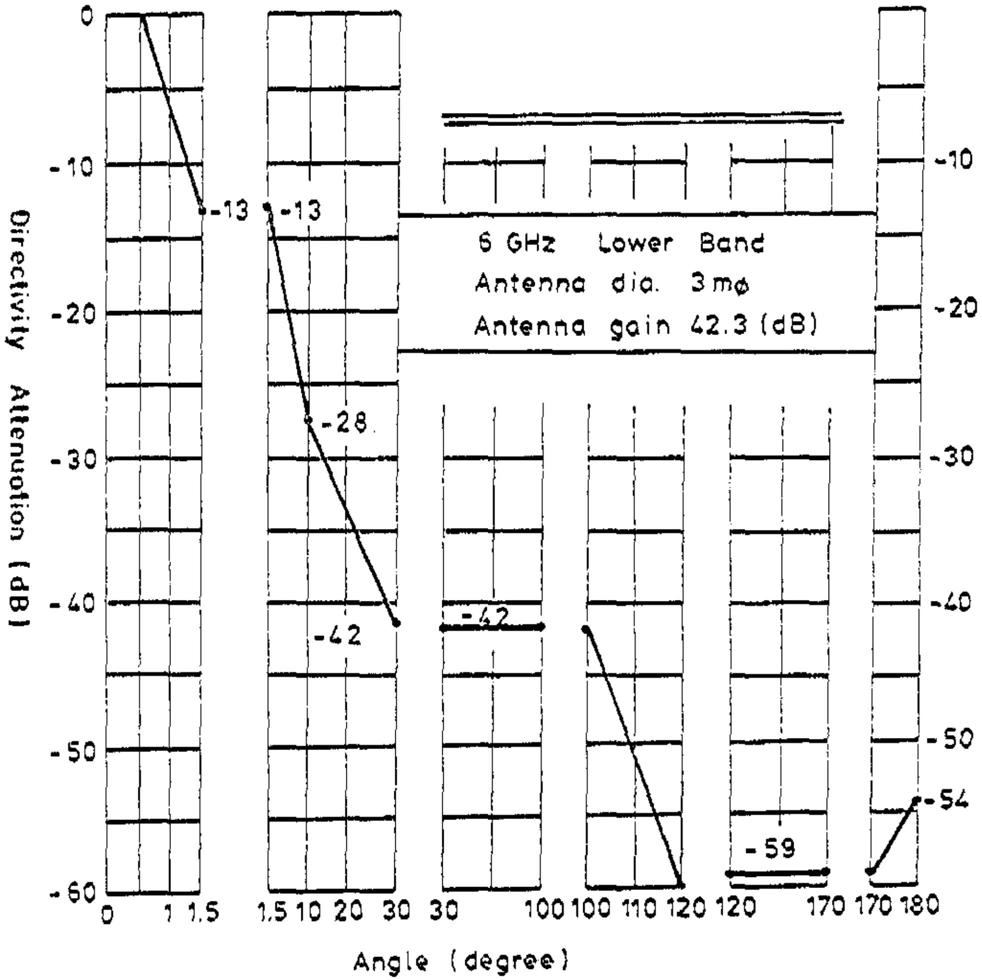


Figure 6-22 Antenna Directivity Used in Interference Study

(5) Radio Propagation Path

All free space.

3-4-3 Result of Study

The result of calculations for a total of 127,746 station-to-station path combinations, using an extra-large capacity computer, discloses that 41 station sites shown in Table 6-9 do not satisfy the requirements described in Section 3-4-1 and hence the earth station construction at those 41 sites is impracticable. Calculation results in terms of computer print-out are voluminous: they produce approximately 1000 pages. Only a part of calculation results are attached hereto in Report A through Report F.

3-5 Typical Earth Station Configuration and Site Layout

Typical master earth station configuration and typical rural earth station configuration are given in Figures 6-23 and 6-24. Typical site layout and equipment floor layout for the said two categories of stations appear in Figures 6-25 to 6-28.

3-6 Cable Route Study

Cable route study was made, using the same methodology as that used in the terrestrial system study.

Table 6-9 Rural Earth Stations to Cause Interference

Area Code	Station Name	Area Code	Station Name
32 01 02	Ban Lat	54 22 05	Mae Mo
32 15 02	Bang Saphan	54 32 01	Long
35 16 09	U-Thai	55 08 02	Si Nakhon
36 13 01	Muang Lek	55 22 02	Bang Krathum
36 13 02	Sao Hai	55 22 04	Phom Phiram
36 13 06	Nong Don	55 27 02	Tron
37 05 01	Na Di	73 13 03	Nong Chik
38 01 01	Bang Nam Prieo	73 13 06	Yaring
38 01 02	Ban Pho	74 01 04	Tra Mot
38 08 01	Pluak Daeng	74 01 07	Khao Chaison
38 15 02	Phan Thong	74 05 01	Rattaphum
42 01 06	Non Sa-at	74 05 02	Thepha
44 01 10	Phen	74 05 05	Chana
44 12 03	Kra Sung	75 05 08	Cha-Uat
44 12 04	Khu Muang	77 01 02	Tha Sae
44 21 11	Sung Noen	77 01 03	Phato
44 21 12	Chakkarat	77 07 01	Kra Buri
45 22 08	Kanthararom	77 11 05	Tha Chana
45 22 09	Uthumphon Phisai	77 11 07	Khiri Ratthanikhom
45 30 09	Samrong Thap	77 11 08	Ban Na Doem
54 22 02	Ngao		

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- PROJECT NAME -                                                                              - REPORT  A -
  RURAL LONG DISTANCE
   PUBLIC TELEPHONE SERVICE                                                                   PAGE(   1 /106)
    IN THAILAND
   (INTERFERENCE STUDY)                                                                         NTC/1978
                                    **   BASIC  DATA  OF  THE  EARTH (SATELLITE COMM.) STATION   **


ID.NO.(   1)    ST.NO.(0101)  ST.NAME( N.YA PLONG    )     LONG.(E)=  99 42  3   LATI.(N)= 13  9  5   SITE ELEV.=   65(M)
    ********************** DISTANCE / G.C.DIST. / TRAV. TIME *** AZIMUTH *** ELEVATION *** BASIC TRANSMISSION LOSS *********
    *                                                                                                                      *
    *  SATELLITE 1  /E-S/   36360(KM) /  2347(KM) /  121(MSEC)  233.00(DEG)   65.39(DEG)   195.7(DB/4GHZ)  199.5(DB/6GHZ)  *
    *               /S-E/                                        51.08(DEG)  -86.58(DEG)                                   *
    *  SATELLITE 2  /E-S/   36013(KM) /  2896(KM) /  122(MSEC)  241.61(DEG)   59.70(DEG)   195.8(DB/4GHZ)  199.5(DB/6GHZ)  *
    *               /S-E/                                        58.98(DEG)  -85.82(DEG)                                   *
    ************************************************************************************************************************


ID.NO.(   2)    ST.NO.(0102)  ST.NAME( HAN  LAT      )     LONG.(E)=  99 55  5   LATI.(N)= 13  3  4   SITE ELEV.=    4(M)
    ********************** DISTANCE / G.C.DIST. / TRAV. TIME *** AZIMUTH *** ELEVATION *** BASIC TRANSMISSION LOSS *********
    *                                                                                                                      *
    *  SATELLITE 1  /E-S/   36365(KM) /  2360(KM) /  121(MSEC)  233.58(DEG)   65.26(DEG)   195.7(DB/4GHZ)  199.5(DB/6GHZ)  *
    *               /S-E/                                        51.65(DEG)  -86.56(DEG)                                   *
    *  SATELLITE 2  /E-S/   36621(KM) /  2912(KM) /  122(MSEC)  242.04(DEG)   59.54(DEG)   195.8(DB/4GHZ)  199.5(DB/6GHZ)  *
    *               /S-E/                                        59.41(DEG)  -85.80(DEG)                                   *
    ************************************************************************************************************************


ID.NO.(   3)    ST.NO.(0103)  ST.NAME( KHAO YOI      )     LONG.(E)=  99 49 52   LATI.(N)= 13 14  1   SITE ELEV.=    6(M)
    ********************** DISTANCE / G.C.DIST. / TRAV. TIME *** AZIMUTH *** ELEVATION *** BASIC TRANSMISSION LOSS *********
    *                                                                                                                      *
    *  SATELLITE 1  /E-S/   36367(KM) /  2364(KM) /  121(MSEC)  233.06(DEG)   65.22(DEG)   195.7(DB/4GHZ)  199.5(DB/6GHZ)  *
    *               /S-E/                                        51.11(DEG)  -86.56(DEG)                                   *
    *  SATELLITE 2  /E-S/   36022(KM) /  2915(KM) /  122(MSEC)  241.62(DEG)   59.53(DEG)   195.8(DB/4GHZ)  199.5(DB/6GHZ)  *
    *               /S-E/                                        58.95(DEG)  -85.80(DEG)                                   *
    ************************************************************************************************************************


ID.NO.(   4)    ST.NO.(0104)  ST.NAME( BAN LAEM      )     LONG.(E)=  99 59 10   LATI.(N)= 13 12  8   SITE ELEV.=    3(M)
    ********************** DISTANCE / G.C.DIST. / TRAV. TIME *** AZIMUTH *** ELEVATION *** BASIC TRANSMISSION LOSS *********
    *                                                                                                                      *
    *  SATELLITE 1  /E-S/   36371(KM) /  2376(KM) /  121(MSEC)  233.39(DEG)   65.10(DEG)   195.7(DB/4GHZ)  199.5(DB/6GHZ)  *
    *               /S-E/                                        51.42(DEG)  -86.54(DEG)                                   *
    *  SATELLITE 2  /E-S/   36629(KM) /  2926(KM) /  122(MSEC)  241.85(DEG)   59.39(DEG)   195.8(DB/4GHZ)  199.5(DB/6GHZ)  *
    *               /S-E/                                        59.18(DEG)  -85.78(DEG)                                   *
    ************************************************************************************************************************
```

* PROJECT NAME -
RURAL LONG DISTANCE
PUBLIC TELEPHONE SERVICE
IN THAILAND
(INTERFERENCE STUDY)

** BASIC DATA OF THE TERRESTRIAL STATION **

* ID.NO. (1)
* ST.NAME BANGKOK

LONGITUDE	(E 100 30 56)
LATITUDE	(N 13 45 26)
SITE /S.L.	3.0(M)
ANTENNA /G.L.	80.0(M)

* RECEIVING CONDITIONS IN FREE-SPACE (NEIGHBOR ST, 6GHZ RADIATED) *

ITEM / NEIGHBOR ST.	NO.(34)	NO.(2)	NO.(60)	NO.(0)	NO.(0)
DISTANCE (KM)	50.2	42.5	60.7	0.0	0.0
AZIMUTH /T-N/ (DEG)	277.06	15.55	98.15	0.0	0.0
/N-T/ (DEG)	96.95	195.57	278.28	0.0	0.0
ELEV.ANG./T-N/ (DEG)	-0.01	-0.13	-0.20	0.0	0.0
/N-T/ (DEG)	-0.33	-0.16	-0.21	0.0	0.0
B.T.L (DB)	142.3	140.8	143.9	0.0	0.0
E.I.R.P (DBM)	82.3	82.3	82.3	0.0	0.0
REC.ANT.GAIN (DB)	42.3	42.3	42.3	0.0	0.0
REC.ANT.INPUT (DBM)	-17.7	-16.2	-19.3	0.0	0.0

- PROJECT NAME -
RURAL LONG DISTANCE
PUBLIC TELEPHONE SERVICE
IN THAILAND
(INTERFERENCE STUDY)

** ESTIMATION OF INTERFERENCE LEVEL FROM
THE EARTH-STATION TO THE TERRESTRIAL-STATION **

* EARTH-STATION *
ID.NO.(1)
ST.NO.(0101)
STATION NAME N.YA PLONG

LONGITUDE (E 99 42 5)
LATITUDE (N 13 9 5)
SITE.S.L. 65.0 (M)

ANTENNA-G.L. 4.5 (M)
ANTENNA-GAIN 46.5 (DB)
ANTENNA-DIA. 4.5 (M)

RADIATED POWER 30.0 (DBM)
/SATELLITE-1 E 083 (DEG)/
/SATELLITE-2 E 077 (DEG)/

RESULT

INTERFERING ITEM		**	-TERRESTRIAL STATION- 34(1)	34(35)	35(34)	35(36)	36(35)	ID.NO.(NEIGHBOR ID.NO.) 36(37)	37(36)	37(38)	0(0)	0(0)
PATH DISTANCE	/E-T/	(KM)	82.7	82.7	45.4	45.4	25.8	25.8	69.8	69.8	0.0	0.0
TANG.DISTANCE		(KM)	96.5	96.5	65.2	65.2	80.5	80.5	86.9	86.9	0.0	0.0
AZIMUTH	/E-T/	(DEG)	27.64	27.64	15.99	15.99	102.05	102.05	158.03	158.03	0.0	0.0
AZIMUTH	/T-E/	(DEG)	207.73	207.73	196.02	196.02	282.10	282.10	338.09	338.09	0.0	0.0
ELEVATION	/E-T/	(DEG)	-0.17	-0.17	-0.17	-0.17	0.04	0.04	-0.16	-0.16	0.0	0.0
ELEVATION	/T-E/	(DEG)	-0.39	-0.39	-0.12	-0.12	-0.21	-0.21	-0.31	-0.31	0.0	0.0
REFER.ANGLE1	/S1-E-T/	(DEG)	112.5	112.5	109.6	109.6	105.8	105.8	83.9	83.9	0.0	0.0
REFER.ANGLE2	/S2-E-T/	(DEG)	114.9	114.9	110.8	110.8	112.5	112.5	86.9	86.9	0.0	0.0
REFER.ANGLE	/NT-T-E/	(DEG)	110.6	12.5	156.1	51.5	62.4	105.1	20.9	150.0	0.0	0.0
E.I.ANT.GAIN1	/E-T/	(DB)	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	0.0	0.0
E.I.ANT.GAIN2	/E-T/	(DB)	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	-10.0	0.0	0.0
E.I.ANT.GAIN	/T-E/	(DB)	-8.9	12.7	-16.7	0.3	0.3	-2.3	6.7	-16.7	0.0	0.0
DESIRED INPUT	/ T /	(DBM)	-17.7	-16.0	-16.0	-17.4	-17.4	-19.1	-19.1	-18.6	0.0	0.0
UNDESIRED INPUT1	/E-T/	(DBM)	-135.5	-113.9	-137.7	-120.7	-116.2	-118.8	-118.5	-141.8	0.0	0.0
UNDESIRED INPUT2	/E-T/	(DBM)	-135.5	-113.9	-137.7	-120.7	-116.2	-118.8	-118.5	-141.8	0.0	0.0
D/U 1 (DB) (ESTIMATION CODE)			117.8(0)	97.9(1)	121.7(0)	103.3(0)	98.7(1)	99.7(0)	99.3(0)	123.2(0)	0.0(0)	0.0(0)
D/U 2 (DB) (ESTIMATION CODE)			117.8(0)	97.9(1)	121.7(0)	103.3(0)	98.7(1)	99.7(0)	99.3(0)	123.2(0)	0.0(0)	0.0(0)

- NOTE - 1 : OPERATIONAL, 2 : SPARE, E : EARTH-STATION, T : TERRESTRIAL-STATION(NT:NEIGHBOR), S : SATELLITE
ESTIMATION CODE (FREE SPACE ASSUMED) : (0) 99 DB OVER, (1) 99 - 89 DB, (2) 89 - 79 DB, (3) LESS THAN 79 DB

** ANALYZED INTERFERING PATH COMBINATION AND D/U VALUE **

** TERRESTRIAL STATION **

* ID.NO. (1)
* ST.NAME (BANGKOK)

* SATELLITE EARTH STATION ID.NO. *	7	12	24	25	26	29	30	41	42	63
* TERRESTRIAL NEIGHBOR STATION ID.NO. *	34	34	2	2	2	2	2	2	2	60
* D/U RATIO 1 (DB)(OPERATIONAL) *	95.1	96.6	92.6	98.7	97.7	76.9	96.2	66.2	94.4	97.6
* D/U ESTIMATION CODE 1(OPERATIONAL) *	1	1	1	1	1	3	1	2	1	1
* D/U RATIO 2 (DB)(SPARE) *	95.1	96.6	92.6	98.7	97.7	76.9	96.2	66.2	94.4	97.6
* D/U ESTIMATION CODE 2(SPARE) *	1	1	1	1	1	3	1	2	1	1

* SATELLITE EARTH STATION ID.NO. *	66	67	269	0	0	0	0	0	0	0
* TERRESTRIAL NEIGHBOR STATION ID.NO. *	60	60	34	0	0	0	0	0	0	0
* D/U RATIO 1 (DB)(OPERATIONAL) *	95.6	87.0	95.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* D/U ESTIMATION CODE 1(OPERATIONAL) *	1	2	1	0	0	0	0	0	0	0
* D/U RATIO 2 (DB)(SPARE) *	95.6	87.0	95.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
* D/U ESTIMATION CODE 2(SPARE) *	1	2	1	0	0	0	0	0	0	0

- PROJECT NAME -
RURAL LONG DISTANCE
PUBLIC TELEPHONE SERVICE
IN THAILAND
(INTERFERENCE STUDY)

******** SUMMARY RESULTANT (ANNEX REPORT) ********

NTC/1978

** ANALYTICAL CONDITION **

- EARTH-STATION TO TERRESTRIAL-STATION
- PATH IN FREE SPACE (FREQUENCY 6GHZ)
- UP-LINK RADIATION POWER 30.0(DBM)
- UP-LINK ANTENNA GAIN 46.5 (DB)
- WITHIN 100 KM RADIUS RANGE OR LINE-OF-SIGHT RANGE (SPHERICAL EARTH SURFACE ASSUMED AND 100 KM OVER)

** ACCUMULATIVE NUMBER OF SPECIFIC D/U VALUE **

D/U (DB)	OPERATIONAL-SATELLITE	SPARE-SATELLITE
LESS THAN		
99	586	586
97	492	492
95	404	404
93	339	339
91	296	296
89	245	246
87	221	221
85	184	184
83	153	155
81	127	127
79	106	106

- D/U MINIMUM-1 52 (DB) MINIMUM-2 52 (DB)
- ANALYZED E-T PATH TOTAL(EACH SATELLITE) 1966
- ANALYZED E-T-NT PATH TOTAL(EACH SATELLITE) 4026

- PROJECT NAME -
RURAL LONG DISTANCE
PUBLIC TELEPHONE SERVICE
IN THAILAND
(INTERFERENCE STUDY)

- REPORT F -
PAGE(1 / 20)
NTC/1978

******* LIST OF THE RADIO STATIONS (ANNEX REPORT) *******

- PART 1 - * TERRESTRIAL STATION (6GHZ) *

(ID.NO.)	(ST.NO.)	STATION NAME	LONGITUDE-E (D M S)	LATITUDE-N (D M S)	SITE/S.L. (M)	ANT./G.L. (M)	*	NEIGHBOR STATIONS (ID.NO.)			
(1)	( )	BANGKOK	100 30 56	13 45 26	3.0	80.0	*	(34)	(2)	(60)	(0)
(2)	( )	BANG KHAM	100 37 16	14 7 32	2.0	90.0	*	(1)	(3)	(0)	(0)
(3)	( )	SARABURI	100 55 2	14 31 6	16.0	90.0	*	(2)	(4)	(17)	(0)
(4)	( )	LOP BURI	100 37 56	14 47 53	12.0	50.0	*	(3)	(5)	(0)	(0)
(5)	( )	TAKLI	100 20 16	15 14 27	190.0	15.0	*	(4)	(6)	(0)	(0)
(6)	( )	NAKHON SAWAN	100 6 48	15 42 37	122.0	15.0	*	(5)	(7)	(0)	(0)
(7)	( )	BANG MUN NAK	100 23 37	16 1 46	30.0	70.0	*	(6)	(8)	(0)	(0)
(8)	( )	PHICHIT	100 19 26	16 26 49	35.0	70.0	*	(7)	(9)	(0)	(0)
(9)	( )	PITSANULOK	100 16 43	16 48 37	46.0	80.0	*	(8)	(10)	(0)	(0)
(10)	( )	BAN KHUN	100 5 43	17 12 48	47.0	80.0	*	(9)	(11)	(0)	(0)
(11)	( )	UTTARADIT	100 5 51	17 37 36	62.0	80.0	*	(10)	(12)	(0)	(0)
(12)	( )	DEN CHAI	100 0 14	17 55 52	710.0	15.0	*	(11)	(13)	(0)	(0)
(13)	( )	PANG PUAI	99 51 11	18 17 8	658.0	15.0	*	(12)	(14)	(0)	(0)
(14)	( )	LAMPANG	99 33 59	18 14 31	563.0	15.0	*	(13)	(15)	(0)	(0)
(15)	( )	D.K.T.NOI	99 13 7	18 26 4	770.0	70.0	*	(14)	(16)	(0)	(0)
(16)	( )	CHIANG MAI	99 58 15	18 48 15	315.0	45.0	*	(15)	(0)	(0)	(0)
(17)	( )	K.PHAENG MA	101 9 24	14 39 2	540.0	20.0	*	(3)	(18)	(0)	(0)
(18)	( )	K.YAI THIANG	101 33 9	14 47 9	720.0	50.0	*	(17)	(19)	(0)	(0)
(19)	( )	N.RATCHASIMA	102 6 12	14 58 10	192.0	60.0	*	(18)	(20)	(63)	(0)
(20)	( )	NIKHONPHIMAI	102 33 15	15 9 17	218.0	130.0	*	(19)	(28)	(21)	(0)
(21)	( )	BURI RAM	103 6 44	15 0 4	152.0	90.0	*	(20)	(22)	(0)	(0)
(22)	( )	SURIN	103 29 44	14 53 13	142.0	85.0	*	(21)	(23)	(0)	(0)
(23)	( )	SI KHORAPHUM	103 47 38	14 56 39	137.0	85.0	*	(22)	(24)	(0)	(0)
(24)	( )	U.PHISAI	104 10 53	15 7 17	140.0	40.0	*	(23)	(25)	(0)	(0)
(25)	( )	SI SA KET R	104 20 7	15 6 42	125.0	25.0	*	(24)	(26)	(0)	(0)

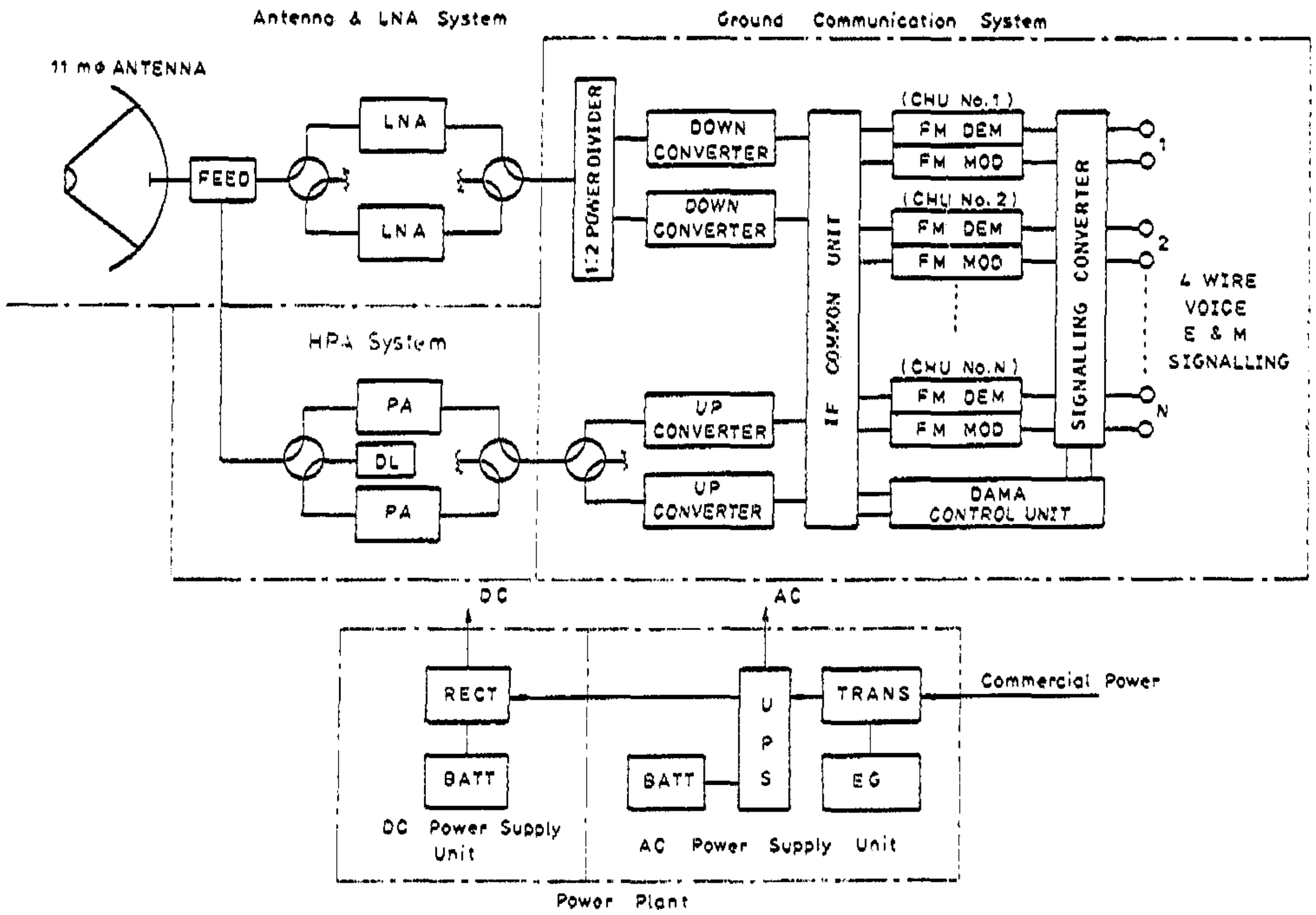


Figure 6-23 Typical Master Earth Station Configuration

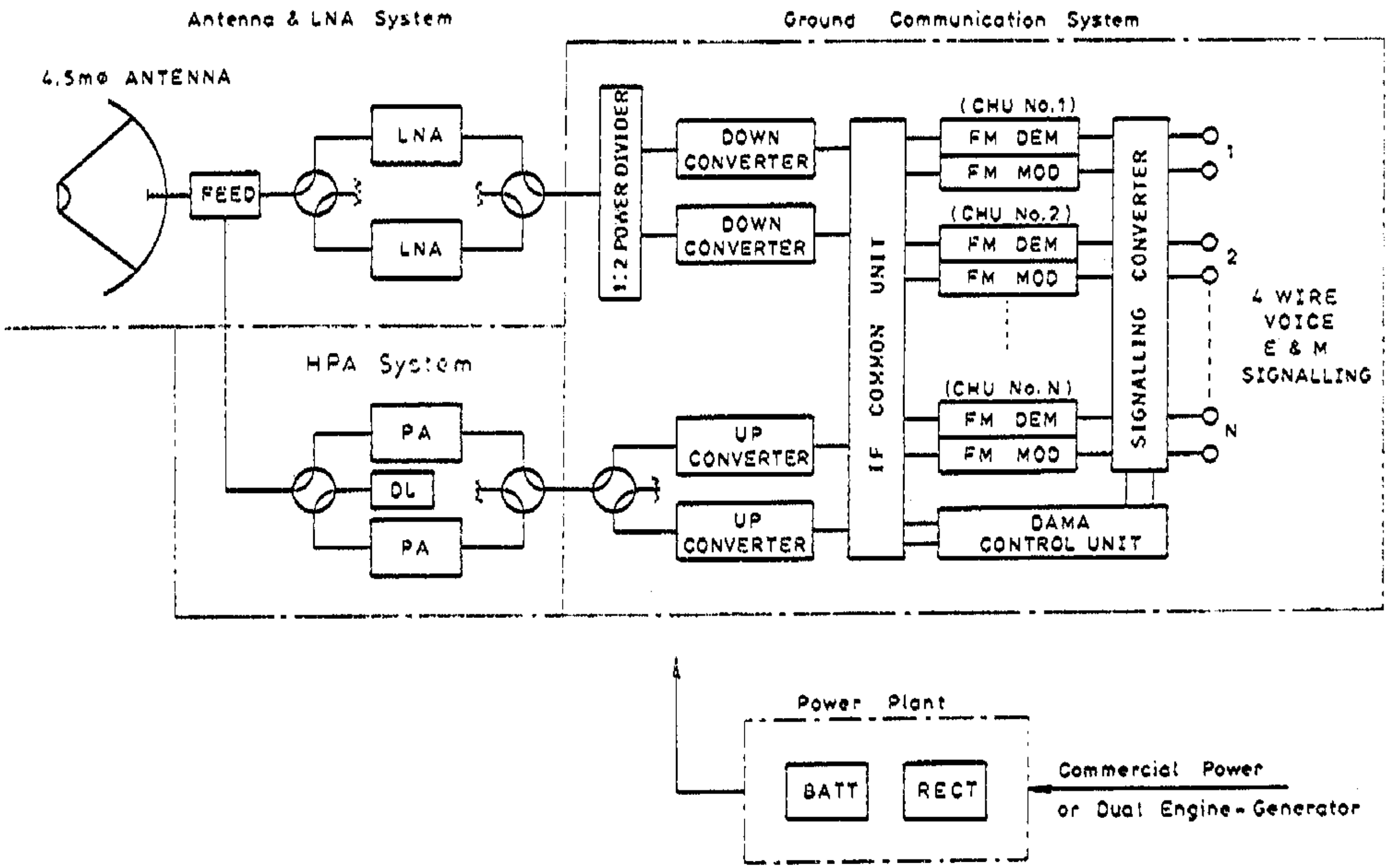


Figure 6-24 Typical Rural Earth Station Configuration

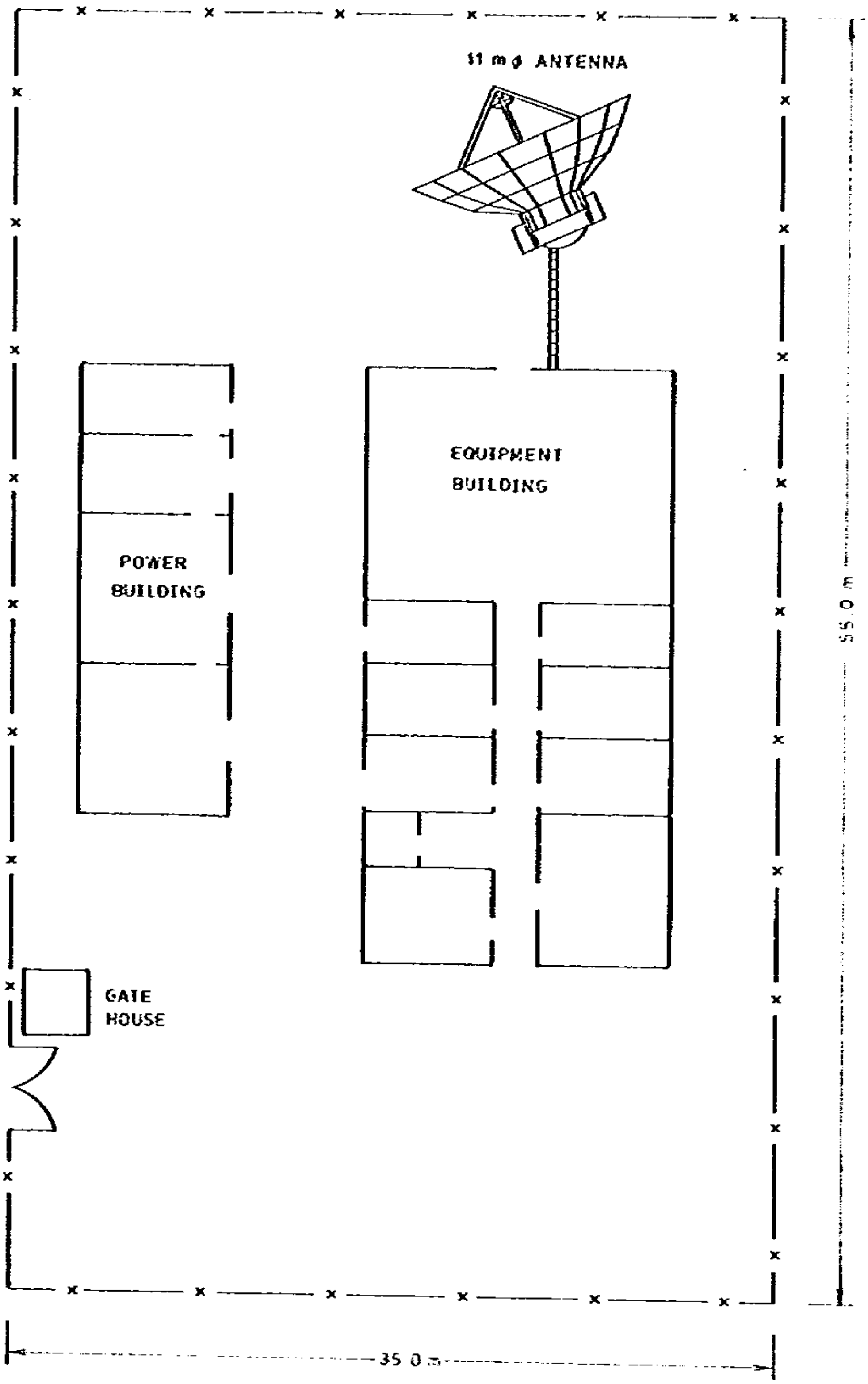
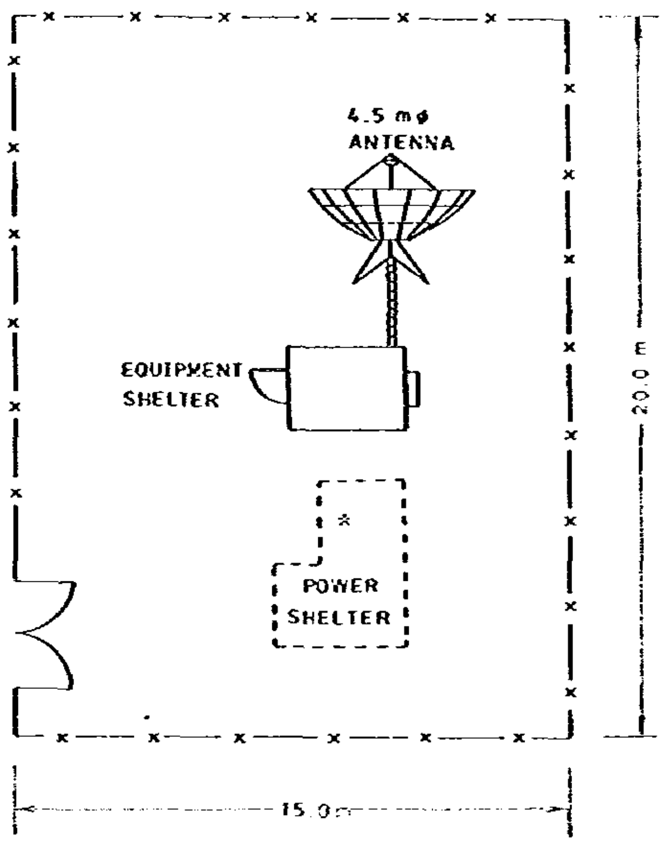
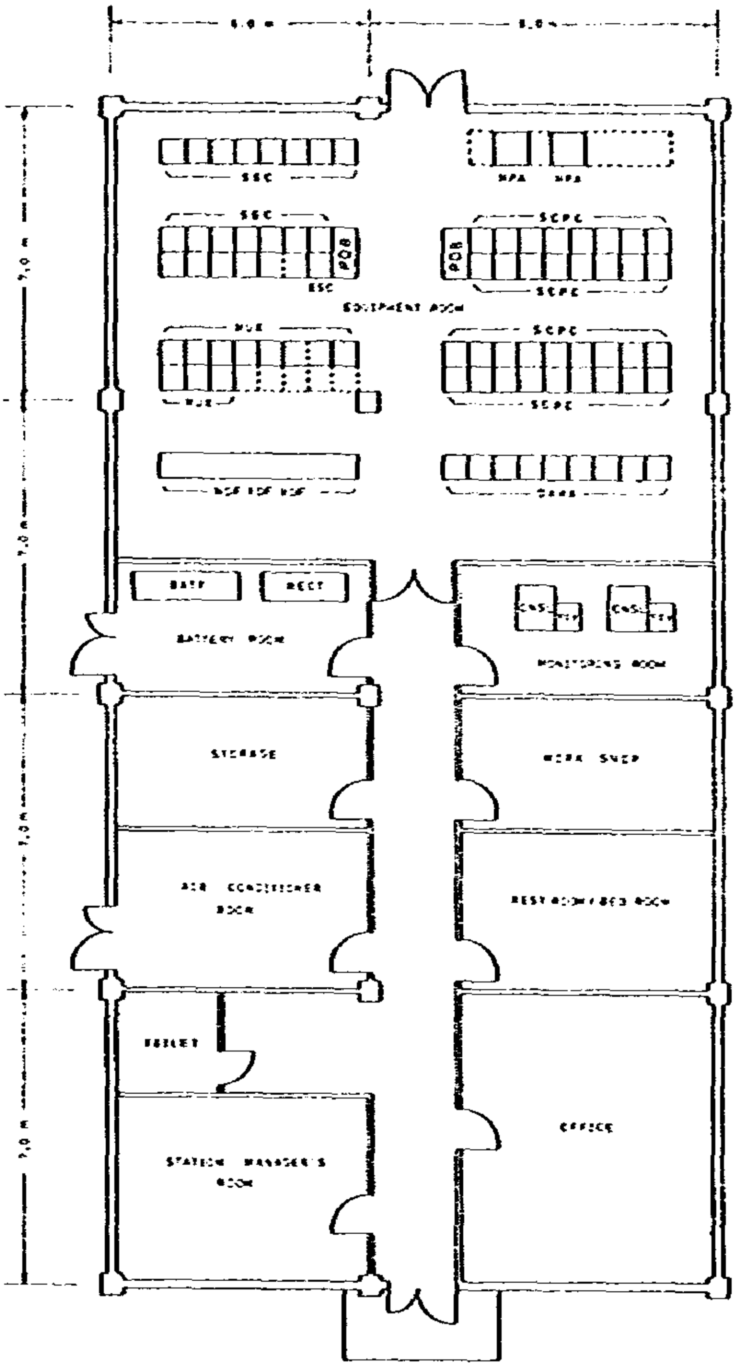


Figure 6-25 Typical Site Layout for Master Earth Station



Note : * Power shelter with dual engine-generator will be installed where the commercial power is not available.

Figure 6-26 Typical Site Layout for Rural Earth Station



NOTE

HPA : HIGH POWER AMPLIFIER
SCPC : SCPC TERMINAL EQPT.
PDB : POWER DISTRIBUTION BOARD
DAMA : DAMA CONTROL EQPT.
SGC : SIGNAL CONVERTER
MTE : MULTIPLEX TERMINAL EQPT. FOR TERRESTRIAL APPROACH LINK
CNSL : CONSOLE.
TTY : TELETYPE
RECT : RECTIFIER.
BATT : BATTERY.

Figure 6-27 Typical Equipment Floor Layout for Master Earth Station (1/2)

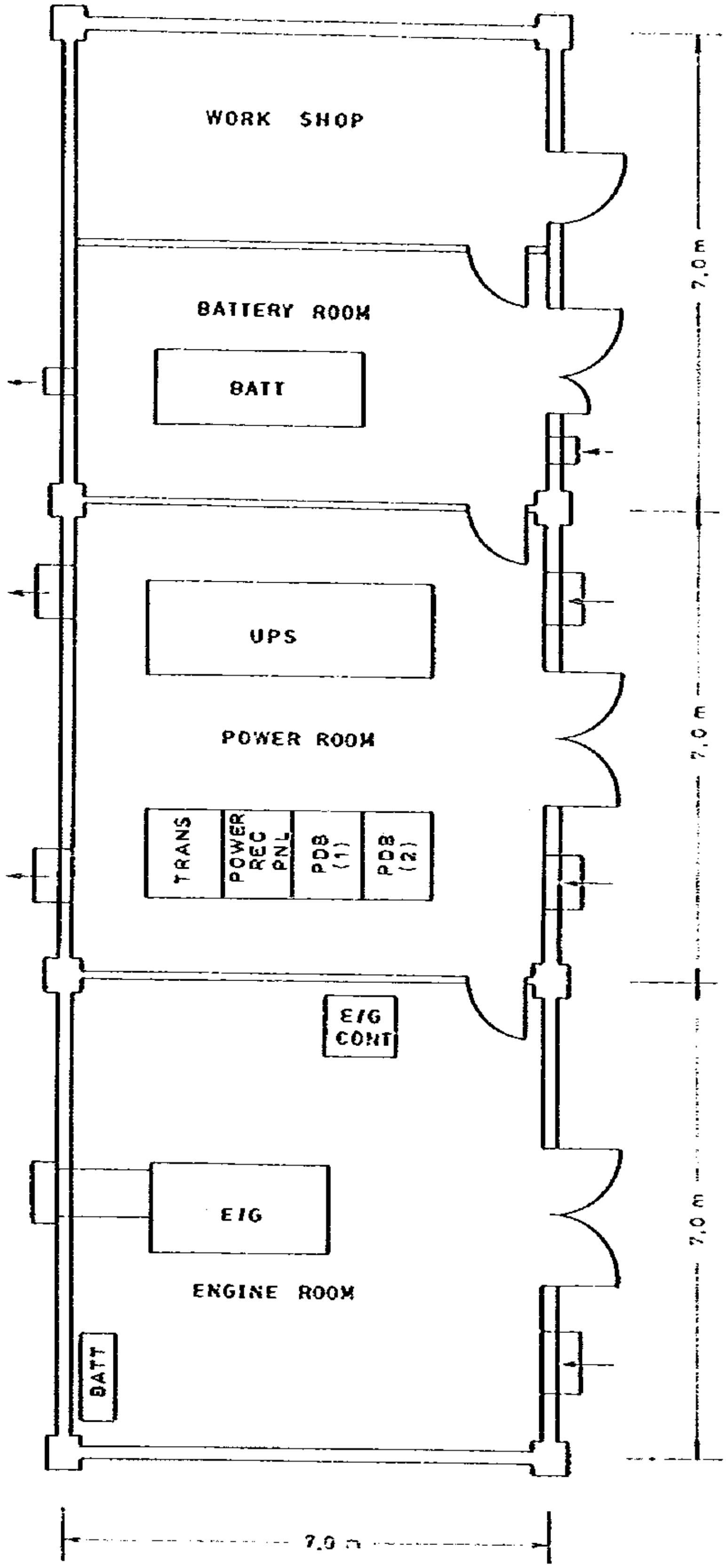
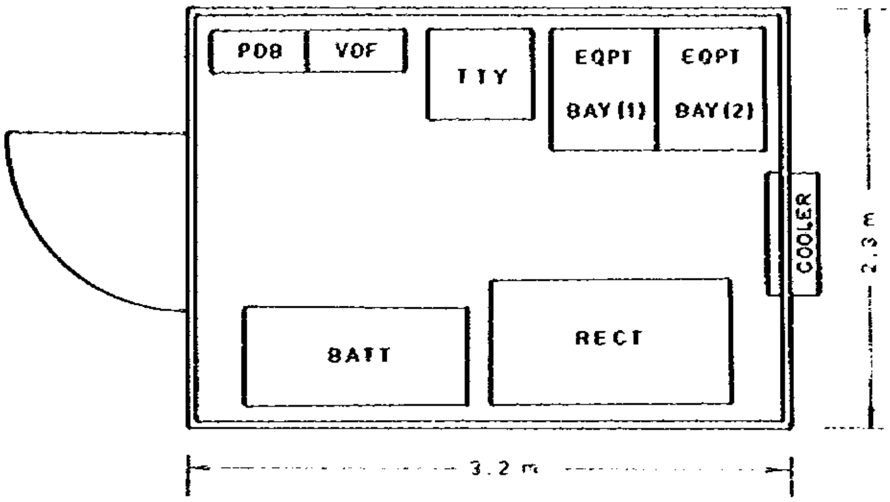
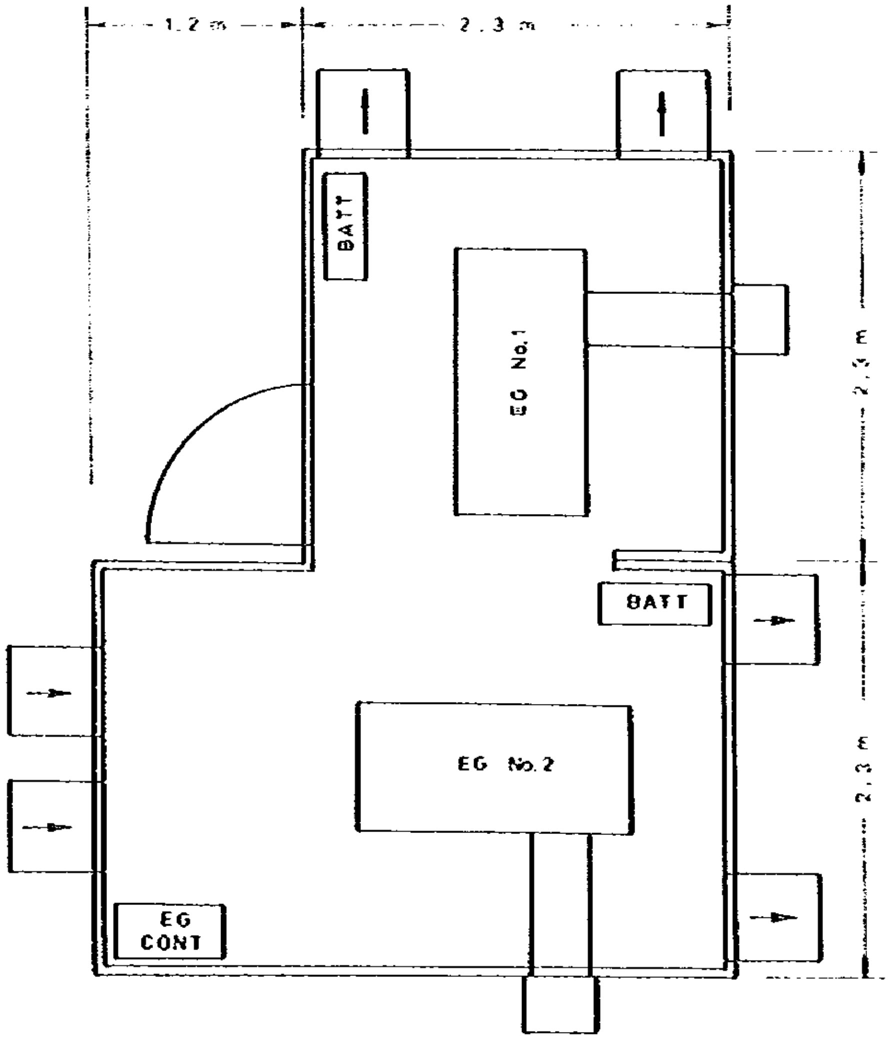


Figure 6-27 Typical Equipment Floor Layout for Master Earth Station (2/2)



(a) Equipment Shelter



(b) Power Shelter

Figure 6-28 Typical Equipment Floor Layout for Rural Earth Station

PART VII System Maintenance

PART VII System Maintenance

1. General

This Part VII describes the maintenance organization and practices for the existing terrestrial microwave system and, based on them, the maintenance philosophy used in this Study.

This projected system, no matter whether it will be implemented by the terrestrial radio system or the domestic satellite system, requires a large number of station sites. For this reason, it is so planned that the unattended operation system be adopted to the possible maximum for the radio stations including the earth stations, not to speak of through repeater stations, so that the effective system maintenance with a minimum manpower requirement will be possible.

Since TOT holds approximately 15 years experience in the maintenance of its existing trunk microwave system, the existing maintenance organization will be utilized as much as possible so that only the necessary personnel recruitment will be sufficient for maintenance service for the projected system.

2. Maintenance Organization and Practices

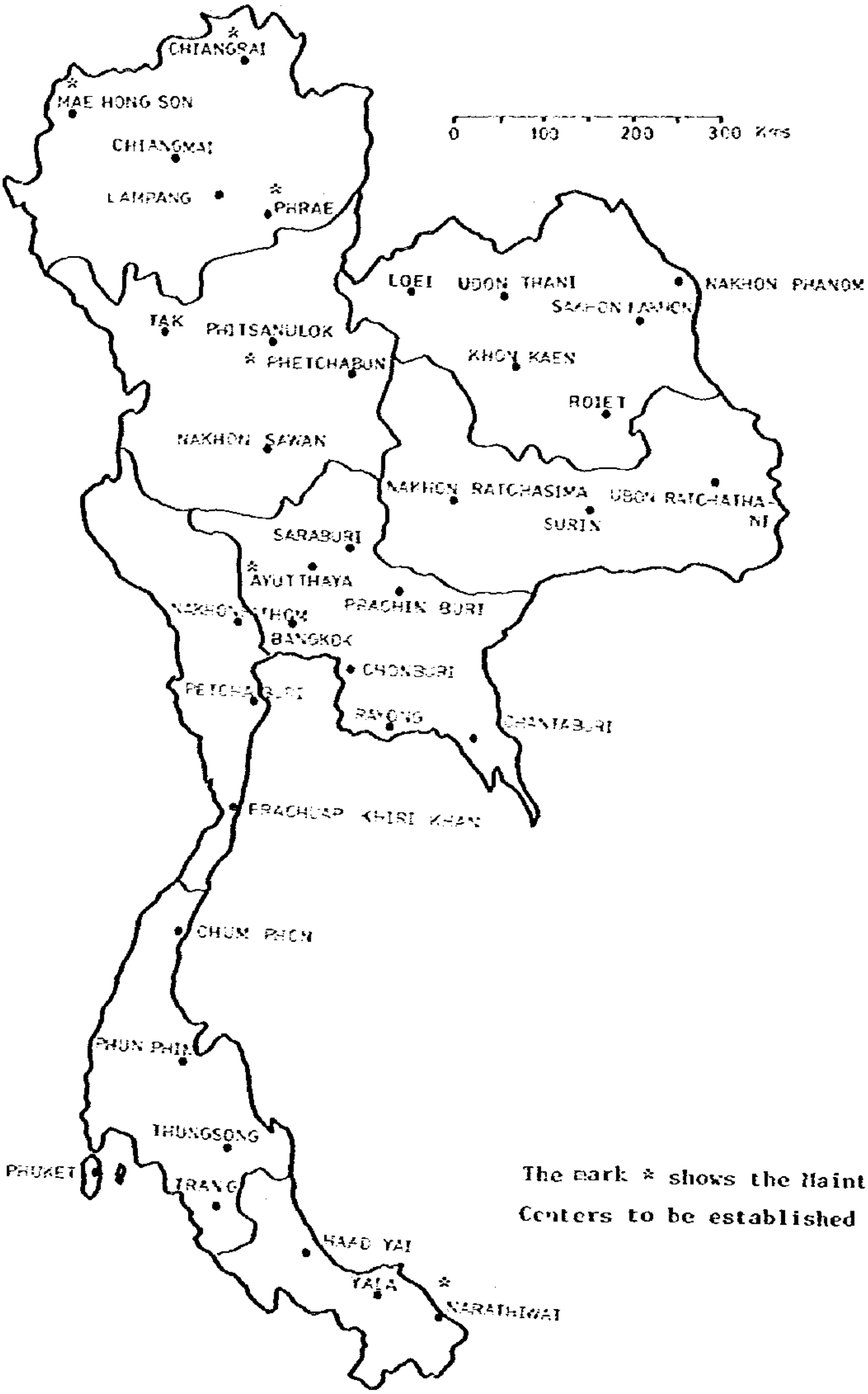
2-1 Existing Maintenance Organization and Practices

TOT's existing maintenance organization for the trunk microwave system consists of eight maintenance districts covering the whole country as shown in Figure 7-1. Each maintenance district holds Maintenance Centers. The total number of Maintenance Centers for the whole country is 30 (which will increase to 35 when the spur link project now in progress is completed in 1979).

Maintenance practices which include the supervision of system operation, keeping of measuring equipment and spare panels in good order, trouble-shooting, and periodic tests, are undertaken by the maintenance staff on permanent duty at the Maintenance Centers.

Remote supervisory items for each Maintenance Center are as follows :

1) Radio equipment failure
2) Multiplex major failure
3) Multiplex minor failure

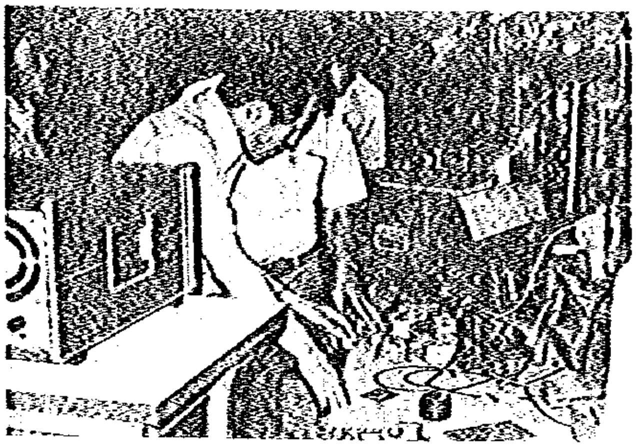


The mark * shows the Maintenance Centers to be established in 1979

Figure 7-1 Locations of Maintenance Centers

4) Power supply failure to repeater
5) Fuse alarm
6) Cable alarm
7) Charger high-low alarm
8) ac power failure
9) Engine generator failure
10) Door open
11) Aircraft warning light failure

At each Maintenance Center, an average of 10 maintenance personnel are on duty on around-the-clock basis in three shifts. After the completion of the spur link project now in progress, the assignment of five additional persons on the average at each Maintenance Center is scheduled. Each unattended repeater station is located within the radius of approximately 50 km from the Maintenance Center. The maintenance team from the Maintenance Center can reach an unattended repeater station in distress within two hours on the average.

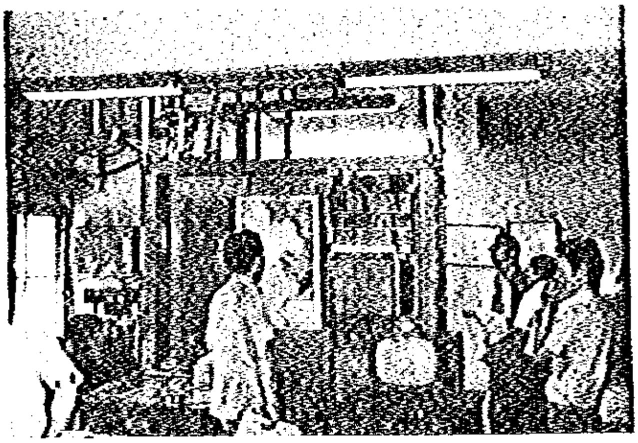


At Chiangmai Maintenance Center

Trouble-shooting beyond the ability of the Maintenance Center, such as replacement of parts in a panel, is carried out at the Repair Center located in the National Toll Center in Bangkok. Equipment unit repaired at the Repair Center is sent back in 48 hours to the Maintenance Center from which it came. The average number of repairs per month at the Repair Center is 100 panels.

At the Repair Center, spare parts of 10,000 kinds are kept in store at all times. Inventory management for such spare parts plus the repair of panels in trouble and annual periodic system test are carried out by 35 staff personnel.

The annual spare parts purchase budget of the Repair Center amounts to approximately 15 million Baht. Spare parts to be purchased comprise radio equipment parts, multiplex equipment parts including PCM equipment parts, and power plant parts. Out of the spare parts purchase budget referred to above, 2 million Baht is set aside for procurement of parts to be used for equipment installed in the Metropolitan Area of Bangkok, the capital city.


Workshop at Repair Center

2-2 Maintenance Philosophy for Rural Long Distance Public Telephone Service

2-2-1 Terrestrial Radio System

The maintenance organization is, basically, to make a full use of 35 Maintenance Centers scattered throughout the country, provided that the necessary additional maintenance personnel will be recruited. The number of stations to be supervised (unattended repeater stations) envisaged in this Project is 17 per Maintenance Center and the average access time required for a maintenance team is two hours.

Therefore, assuming that the periodic inspection of repeater stations is carried out once every three months, the recruitment of not more than several personnel per Maintenance Center will be sufficient. Difficult repairs and overhauls of equipment units, which cannot be performed at the Maintenance Center, are to be undertaken by the Repair Center in Bangkok as in the case of similar repairs and overhauls of equipment units used in the existing microwave system.

The maintenance philosophy adopted in this Study features the following:

(1) Maintenance practices, including system supervision, procurement of measuring equipment and spare units/parts, trouble-shooting, and periodic tests, will be undertaken at 35 Maintenance Centers.

(2) One Maintenance Center will supervise an average of 17 supervised stations (unattended repeater stations) located in 2-3 Administrative Provinces. Maximum access time required for a maintenance team will be six hours.

(3) Engineering service channels for maintenance use will consist of omnibus order wire and remote supervisory circuit, and for each of them one telephone channel will be assigned. To provide the engineering service channel, carrier multiplex equipment will be additionally installed in part of the existing microwave system.

(4) One maintenance vehicle for periodic test/inspection will be assigned at each Maintenance Center.

(5) Two respective sets of measuring equipment, spare units/parts, instruction handbooks and so forth will be distributed to each Maintenance Center, and one respective set of the same to the Repair Center in Bangkok.

(6) One trailer type engine generator of 7.5 kVA capacity to be used during power failure at a supervised station will be assigned at each Maintenance Center.

(7) Though not included in this Study, it is preferable to install centralized supervisory equipment at each Maintenance Center for the purpose of automatic recording of troubles at supervised stations under its control.

2-2-2 Domestic Satellite System

The maintenance philosophy for the domestic satellite system is essentially the same as that for the terrestrial radio system. Engineering service channel is planned as follows:

(1) One dialling order wire channel will be established between each rural earth station and master earth station.

(2) Each Maintenance Center will be equipped with supervisory display unit to facilitate supervision of the operating condition of rural earth stations under its control. Supervisory signal transmission route will consist of RS→Satellite→MS→existing microwave system→MC, where RS stands for rural earth station, MS for master earth station, and MC for Maintenance Center. One telephone channel of the existing microwave system will be assigned to each Maintenance Center for transmission of supervising signals. This telephone channel will be used for order wire circuit also.

(3) Master earth station will make centralized supervision of all rural earth stations. Troubles at rural earth stations will be automatically recorded.

PART VIII Construction Cost Estimates and Economic Comparison by Systems

PART VIII Construction Cost Estimates and Economic Comparison by Systems

1. General

This Part VIII deals with construction cost estimates for Rural Long Distance Public Telephone Service by terrestrial radio system and by domestic satellite system, and presents economic comparison between the two systems.

Construction cost estimates are mainly based on overseas international tender prices. However, for rural communication service by the domestic satellite system, the examples to depend upon for construction cost estimate are few internationally so that the assistance from a Canadian telecommunications consulting firm having substantial experience in the utilization of the domestic satellite system was solicited for part of cost estimate work.

The methodology used in construction cost estimates was firstly to calculate in detail the construction cost for 75 stations included in the four objective areas of detailed study, i.e., northern, central, northeastern and southern areas of Thailand, according to the types of stations. Then, the average cost per station or per radio hop was calculated and by this average cost, in principle, the total construction cost for all stations involved in this Project was calculated.

Economic comparison between terrestrial radio system and domestic satellite system was made in terms of present worth of annual cost. For the satellite transponder lease rate and related lease conditions, data obtained directly from the Directorate General of Posts and Telecommunications of Indonesia was used.

2. Construction Cost Estimates

2-1 Project Size

Parameters that indicate the Project size, which are essential for the construction cost estimates, are shown below. Those parameters include the number of required transmission systems, total number of stations, and total access road length.

2-1-1 Terrestrial Radio System

(1) Terrestrial Radio Link

	1984	1989	1994
1) Radio System:			
New radio station	491	491	491
Existing radio station	137	137	137
Radio hop	529	529	529
Radio system	531	531	543
Total distance of radio hops in km (approx.)	12,000	12,000	12,000
2) Supervisory System:			
Supervised station	604	604	604
Supervising station	35	35	35
3) Carrier Multiplex System:			
Total telephone channels	2,513	3,763	8,218
4) Tower:			
New tower (guyed tower)	491	491	491
Existing tower to be replaced	19	19	19
5) Power Plant:			
dc power plant	639	639	639
Dual engine generator	121	121	121
Trailer type engine generator	35	35	35
6) Building:			
Shelter for radio equipment	491	491	491
7) Access Road:			
Repeater station that requires access road	46	46	46
Total length of access roads in km	111.5	111.5	111.5

2-1-2 Domestic Satellite System

(1) Satellite Link

		1984	1989	1994
1)	Master Earth Station	1	1	1
	Total telephone channels	349	474	242
	Power plant	1	1	1
2)	Approach Link:			
	Total telephone channels (including engineering service channels)	384	509	277
	Coaxial cable length in km	2.5	2.5	2.5
3)	Rural Earth Station	340	340	146
	Total telephone channels	1,144	1,413	749
	dc power plant	340	340	146
	Dual engine generator	65	65	49
4)	Building:			
	Building for master earth station	2	2	2
	Shelter for rural earth station	340	340	146

(2) Terrestrial Radio Link

		1984	1989	1994
1)	Radio System:			
	New radio station	113	113	303
	Existing radio station	77	77	114
	Radio hop	134	134	329
	Radio system	134	134	337
	Total distance of radio hops in km (approx.)	3,000	3,000	7,000
2)	Supervisory System:			
	Supervised station	169	169	391
	Supervising station	33	33	35

		1984	1989	1994
3)	Carrier Multiplex System:			
	Total telephone channels	1,369	2,350	7,469
4)	Tower:			
	New tower (guyed tower)	113	113	303
	Existing tower to be replaced	11	11	16
5)	Power Plant:			
	dc power plant	178	178	351
	Dual engine generator	12	12	66
	Trailer type engine generator	35	35	35
6)	Building:			
	Shelter for radio equipment	113	113	303
7)	Access Road:			
	Repeater station that requires access road	8	8	33
	Total length of access roads in km	26.6	26.6	93.6

2-2 Construction Cost Estimate Conditions

Construction cost estimates are subject to the following conditions:

1) Construction work will be carried out by the Contractor on full turn-key basis.

2) For station buildings except that of master earth station, equipment shelters will be used. This applies to both the terrestrial radio system and the domestic satellite system.

3) For power plant, both TOT information and field survey result concerning commercial power availability are taken into consideration. One trailer type engine generator for emergency use will be assigned to each of 35 Maintenance Centers.

4) In case the UHF system is additionally established on the existing microwave system, the station buildings, towers and ac power source of the existing system will be utilized.

5) Construction cost for extension of the existing microwave system is not included in the cost of this Project.

6) Cable length in the cable section is estimated by selecting cable route on a map of a scale of 1 to 50,000.

7) Entrance cable will be terminated in the distribution box installed on the pole. Drop wire and telephone set costs are not included in the cost of this Project.

8) Access road length required for each radio repeater station is based on data supplied by TOT.

9) At the rural stations where switching equipment will be introduced, 2W/4W terminating set will not be installed on the radio equipment side. It will be installed on the switching equipment side.

10) For civil work cost, such as building and road construction cost, similar cost on TOT record is used.

11) Costs pertaining to access road construction, inland transportation, part of installation, and on-the-job training are defrayed from the local currency budget.

2-3 Cost Estimates

Project cost estimates by terrestrial radio system and by domestic satellite system are given in Table 8-1 through Table 8-3.

3. Economic Comparison by Systems

Economic comparison between terrestrial radio system and domestic satellite system is carried out in terms of present worth of annual cost. Conditions by which the economic comparison is made are as follows:

Table 8-1 Project Cost of Terrestrial Radio System (1/3)

1984

Item	Foreign Currency Portion		Local Currency Portion
	Thousand Japanese Yen	Equivalent US Dollars	Hundred Thai Baht
1. Terrestrial Radio System			
A. Radio, Multiplex & Power	13,293,253	73,879,183	-
B. Tower	1,555,791	8,643,283	-
C. Installation Materials	468,337	2,601,872	-
D. Maintenance Facilities	766,119	4,256,217	-
E. Sub-total (FOB)	16,088,500	89,380,555	-
F. -ditto- (CIF)	16,651,598	92,508,878	-
G. Tower Erection	301,702	1,676,122	703,971
H. Installation & Testing	723,983	4,022,128	1,689,294
I. Training	2,600	14,444	665
J. Access Road	-	-	2,230,000
K. Sub-total	17,679,883	98,221,572	4,623,930
2. Cable System			
A. Cable & Other Materials (FOB)	150,387	835,483	-
B. -ditto- (CIF)	155,650	864,722	-
C. Installation & Testing	39,355	218,639	91,828
D. Sub-total	195,005	1,083,361	91,828
3. Basic Cost	17,874,888	99,304,933	4,715,758
4. Contingency			
A. Physical	536,247	2,979,150	141,473
B. Price	1,787,489	9,930,494	707,364
C. Sub-total	2,323,736	12,909,644	848,837
5. Total Project Cost	20,198,624	112,214,577	5,564,595

Exchange Rate : US$ 1 = 180 Japanese Yen

Table 8-1 Project Cost of Terrestrial Radio System (2/3)

1989

Item	Foreign Currency Portion		Local Currency Portion
	Thousand Japanese Yen	Equivalent US Dollars	Hundred Thai Baht
1. Terrestrial Radio System			
A. Radio, Multiplex & Power	177,349	985,272	-
B. Tower	-	-	-
C. Installation Materials	6,207	34,483	-
D. Maintenance Facilities	-	-	-
E. Sub-total (FOB)	183,556	1,019,755	-
F. -ditto- (CIF)	189,980	1,055,444	-
G. Tower Erection	-	-	-
H. Installation & Testing	8,260	45,889	19,273
I. Training	-	-	-
J. Access Road	-	-	-
K. Sub-total	198,240	1,101,333	19,273
2. Cable System			
A. Cable & Other Materials (FOB)	-	-	-
B. -ditto- (CIF)	-	-	-
C. Installation & Testing	-	-	-
D. Sub-total	-	-	-
3. Basic Cost	198,240	1,101,333	19,273
4. Contingency			
A. Physical	5,947	33,039	578
B. Price	19,824	110,133	2,891
C. Sub-total	25,771	143,172	3,469
5. Total Project Cost	224,011	1,244,505	22,742

Exchange Rate : US$ 1 = 180 Japanese Yen

Table 8-1 Project Cost of Terrestrial Radio System (3/3)

1994

Item	Foreign Currency Portion		Local Currency Portion
	Thousand Japanese Yen	Equivalent US Dollars	Hundred Thai Baht
1. Terrestrial Radio System			
A. Radio, Multiplex & Power	850,152	4,723,067	-
B. Tower	-	-	-
C. Installation Materials	29,755	165,306	-
D. Maintenance Facilities	-	-	-
E. Sub-total (FOB)	879,907	4,888,373	-
F. -ditto- (CIF)	910,704	5,059,467	-
G. Tower Erection	-	-	-
H. Installation & Testing	39,596	219,978	92,391
I. Training	-	-	-
J. Access Road	-	-	-
K. Sub-total	950,300	5,279,445	92,391
2. Cable System			
A. Cable & Other Materials (FOB)	5,846	32,478	-
B. -ditto- (CIF)	6,050	33,611	-
C. Installation & Testing	176	978	410
D. Sub-total	6,226	34,589	410
3. Basic Cost	956,526	5,314,034	92,801
4. Contingency			
A. Physical	28,696	159,422	2,784
B. Price	95,653	531,406	13,920
C. Sub-total	124,349	690,828	16,704
5. Total Project Cost	1,080,875	6,004,862	109,505

Exchange Rate : US$ 1 = 180 Japanese Yen

Table 8-2 Project Cost of Domestic Satellite System (1/3)

1984

Item	Foreign Currency Portion		Local Currency Portion
	Thousand Japanese Yen	Equivalent US Dollars	Hundred Thai Baht
1. Satellite System			
A. Master Earth Station (including Terrestrial Approach Link)	1,555,346	8,640,811	78,000
B. Rural Earth Station	23,201,440	128,896,889	-
C. Maintenance Center (Supervisory System)	129,500	719,444	-
D. Installation Materials	829,370	4,607,611	-
E. Maintenance Facilities	1,313,474	7,297,078	-
F. Sub-total (FOB)	27,029,130	150,161,833	-
G. -ditto- (CIF)	27,975,150	155,417,500	-
H. Installation & Testing	1,364,782	7,582,122	3,184,490
I. Training & System Maintenance	61,000	338,889	665
J. Sub-total	29,400,932	163,338,511	3,263,155
2. Terrestrial Radio System			
A. Radio, Multiplex & Power	3,879,698	21,553,878	-
B. Tower	421,013	2,338,961	-
C. Installation Materials	138,660	770,333	-
D. Maintenance Facilities	355,150	1,973,056	-
E. Sub-total (FOB)	4,794,521	26,636,228	-
F. -ditto- (CIF)	4,962,329	27,568,494	-
G. Tower Erection	88,322	490,678	206,085
H. Installation & Testing	215,753	1,198,628	503,424
I. Training	2,600	14,444	665
J. Access Road	-	-	532,000
K. Sub-total	5,269,004	29,272,244	1,242,174
3. Cable System			
A. Cable & Other Materials (FOB)	65,930	366,278	-
B. -ditto- (CIF)	68,237	379,094	-
C. Installation & Testing	15,571	86,506	36,332
D. Sub-total	83,808	465,600	36,332
4. Basic Cost	34,753,744	193,076,355	4,541,661
5. Contingency			
A. Physical	1,042,612	5,792,289	136,251
B. Price	3,475,374	19,307,633	681,249
C. Sub-total	4,517,986	25,099,922	817,500
6. Total Project Cost	39,271,730	218,176,277	5,359,161

Exchange Rate : US$ 1 = 180 Japanese Yen

Table 8-2 Project Cost of Domestic Satellite System (2/3)

1989

Item	Foreign Currency Portion		Local Currency Portion
	Thousand Japanese Yen	Equivalent US Dollars	Hundred Thai Baht
1. Satellite System			
A. Master Earth Station (including Terrestrial Approach Link)	170,683	948,239	-
B. Rural Earth Station	240,755	1,337,528	-
C. Maintenance Center (Supervisory System)	-	-	-
D. Installation Materials	14,400	80,000	-
E. Maintenance Facilities	-	-	-
F. Sub-total (FOB)	425,838	2,365,767	-
G. -ditto- (CIF)	440,742	2,448,567	-
H. Installation & Testing	19,163	106,461	44,713
I. Training & System Maintenance	-	-	-
J. Sub-total	459,905	2,555,028	44,713
2. Terrestrial Radio System			
A. Radio, Multiplex & Power	146,357	813,094	-
B. Tower	-	-	-
C. Installation Materials	5,122	28,456	-
D. Maintenance Facilities	-	-	-
E. Sub-total (FOB)	151,479	841,550	-
F. -ditto- (CIF)	156,781	871,006	-
G. Tower Erection	-	-	-
H. Installation & Testing	6,817	37,872	15,906
I. Training	-	-	-
J. Access Road	-	-	-
K. Sub-total	163,598	908,878	15,906
3. Cable System			
A. Cable & Other Materials (FOB)	-	-	-
B. -ditto- (CIF)	-	-	-
C. Installation & Testing	-	-	-
D. Sub-total	-	-	-
4. Basic Cost	623,503	3,463,906	60,619
5. Contingency			
A. Physical	18,705	103,917	1,819
B. Price	62,350	346,389	9,093
C. Sub-total	81,055	450,306	10,912
6. Total Project Cost	704,558	3,914,212	71,531

Exchange Rate : US$ 1 = 180 Japanese Yen

Table 8-2 Project Cost of Domestic Satellite System (3/3)

1994

Item	Foreign Currency Portion		Local Currency Portion
	Thousand Japanese Yen	Equivalent US Dollars	Hundred Thai Baht
1. Satellite System			
A. Master Earth Station (including Terrestrial Approach Link)	-	-	-
B. Rural Earth Station	-	-	-
C. Maintenance Center (Supervisory System)	-	-	-
D. Installation Materials	-	-	-
E. Maintenance Facilities	-	-	-
F. Sub-total (FOB)	-	-	-
G. -ditto- (CIF)	-	-	-
H. Installation & Testing	-	-	-
I. Training & System Maintenance	-	-	-
J. Sub-total	-	-	-
2. Terrestrial Radio System			
A. Radio, Multiplex & Power	5,319,096	29,550,533	-
B. Tower	579,690	3,220,500	-
C. Installation Materials	186,508	1,036,156	-
D. Maintenance Facilities	182,559	1,014,217	-
E. Sub-total (FOB)	6,267,853	34,821,406	-
F. -ditto- (CIF)	6,487,228	36,040,156	-
G. Tower Erection	110,044	611,356	256,769
H. Installation & Testing	282,053	1,566,961	658,124
I. Training	-	-	-
J. Access Road	-	-	1,340,000
K. Sub-total	6,879,325	38,218,473	2,254,893
3. Cable System			
A. Cable & Other Materials (FOB)	47,376	263,200	-
B. -ditto- (CIF)	49,034	272,411	-
C. Installation & Testing	12,042	66,900	28,099
D. Sub-total	61,076	339.311	28,099
4. Basic Cost	6,940,401	38,557,784	2,282,992
5. Contingency			
A. Physical	208,212	1,156,733	68,490
B. Price	694,040	3,855,778	342,449
C. Sub-total	902,252	5,012,511	410,939
6. Total Project Cost	7,842,653	43,570,295	2,693,931

Exchange Rate : US$ 1 = 180 Japanese Yen

Table 8-3 Project Cost of Domestic Satellite System with Non-Redundancy

(for 1989 & 1994, refer to Table 8-2)

Item	Foreign Currency Portion		1984 Local Currency Portion
	Thousand Japanese Yen	Equivalent US Dollars	Hundred Thai Baht
1. Satellite System			
A. Master Earth Station (including Terrestrial Approach Link)	1,555,346	8,640,811	78,000
B. Rural Earth Station	16,373,560	90,964,222	-
C. Maintenance Center (Supervisory System)	129,500	719,444	-
D. Installation Materials	590,394	3,279,967	-
E. Maintenance Facilities	960,131	5,334,061	-
F. Sub-total (FOB)	19,608,931	108,938,505	-
G. -ditto- (CIF)	20,295,244	112,751,356	-
H. Installation & Testing	1,046,776	5,815,422	2,442,478
I. Training & System Maintenance	61,000	338,889	665
J. Sub-total	21,403,020	118,905,667	2,521,143
2. Terrestrial Radio System			
A. Radio, Multiplex & Power	3,879,698	21,553,878	-
B. Tower	421,013	2,338,961	-
C. Installation Materials	138,660	770,333	-
D. Maintenance Facilities	355,150	1,973,056	-
E. Sub-total (FOB)	4,794,521	26,636,228	-
F. -ditto- (CIF)	4,962,329	27,568,494	-
G. Tower Erection	88,322	490,678	206,085
H. Installation & Testing	215,753	1,198,628	503,424
I. Training	2,600	14,444	665
J. Access Road	-	-	532,000
K. Sub-total	5,269,004	29,272,244	1,242,174
3. Cable System			
A. Cable & Other Materials (FOB)	65,930	366,278	-
B. -ditto- (CIF)	68,237	379,094	-
C. Installation & Testing	15,571	86,506	36,332
D. Sub-total	83,808	465,600	36,332
4. Basic Cost	26,755,832	148,643,511	3,799,649
5. Contingency			
A. Physical	802,675	4,459,306	113,989
B. Price	2,675,583	14,864,350	569,947
C. Sub-total	3,478,258	19,323,656	683,936
6. Total Project Cost	30,234,090	167,967,167	4,483,585

Exchange Rate : US$ 1 = 180 Japanese Yen

(1) The period of comparison is 15 years.

(2) With respect to the maintenance cost for communication equipment, there is no much difference between the two systems, so that this item is withdrawn from the list of comparison. Only the access road maintenance cost is taken up for consideration.

(3) In the terms of operation and hence in the cost of operation also, there is no much difference between the two systems. Only the satellite transponder lease rate is taken up for consideration.

(4) Service life of communication equipment is based on ITU data.

(5) Both systems need additional financial investment for their respective system extensions five years and 10 years after the service-in.

(6) For interest rate, the interest rate of 7.9% per annum is used.

(7) Although the annual increase of commodity prices and labor cost is the general trend, it is presumed that this price and labor cost uptrend can be offset by the equipment productivity improvement. This presumption is to simplify the comparison.
Present worth of annual cost is given by the following equation:
$P = ((C - S) \times A + S \times i + C_m + C_o) \times B$

where P : Present worth of annual cost
C : Initial cost
S : Net salvage
n : Number of years
i : Interest rate (7.9%)
C_m : Maintenance cost
C_o : Operation cost

A : Annuity from present amount

$$\left(\frac{i (1 + i)^n}{(1 + i)^n - 1} \right)$$

B : Present worth of annuity

$$\left(\frac{(1 + i)^n - 1}{i (1 + i)^n} \right)$$

$$\begin{bmatrix} (C - S) \times A : \text{Amortization cost} \\ (C - S) \times A + S \times i + C_{m} + C_{o} : \text{Annual cost} \end{bmatrix}$$

Present worth of annual cost calculations for terrestrial radio system and domestic satellite system by the above equation appear in Table 8-4 through Table 8-6.

Table 8-4 Present Worth of Annual Cost for Terrestrial Radio System Unit : Million Japanese Yen

Period (year)	Facility	Initial cost	Service life (year)	Net salvage	Annuity from present amount	Amortization cost	Maintenance/ operation cost	Annual cost	Present worth of annuity	Present worth of annual cost
1-15	Radio & Mux	20,074	15	0	0.1161	2,331	-	2,331	8.6120	20,075
6-15	(Extension of Mux)	218	15	73	0.1161	23	-	23	4.6087	106
11-15	Radio & Mux	1,043	15	695	0.1161	95	-	95	1.8715	178
1-15	Cable	287	17	0	0.1089	31	-	31	8.6120	267
11-15	-ditto-	7	17	0	0.1089	1	-	1	1.8715	2
1-15	Access road	2,230	Inf.	2,230	0.0790	176	22	198	8.6120	1,705
									Total :	22,333

Table 8-5 Present Worth of Annual Cost for Domestic Satellite System — Unit : Million Japanese Yen

Period (year)	Facility	Initial cost	Service life (year)	Net salvage	Annuity from present amount	Amortization cost	Maintenance/operation cost	Annual cost	Present worth of annuity	Present worth of annual cost
1-15	Earth Stations	19,348	15	0	0.1161	2,246	135	2,381	8.6120	20,505
1-10	-ditto-	13,316	15	4,439	0.1161	1,381	-	1,381	6.7405	9,309
1-15	Radio & Mux	5,979	15	0	0.1161	694	-	694	8.6120	5,977
6-15	(Extension of Mux)	180	15	60	0.1161	19	-	19	4.6087	88
11-15	Radio & Mux	7,794	15	5,196	0.1161	712	-	712	1.8715	1,333
6-15	(Extension of Terminal)	471	15	157	0.1161	49	-	49	4.6087	226
6-10	-ditto-	34	15	23	0.1161	3	-	3	2.7372	8
1-15	Cable	120	17	0	0.1089	13	-	13	8.6120	112
11-15	-ditto-	89	17	0	0.1089	10	-	10	1.8715	19
1-15	Access road	532	Inf.	532	0.0790	42	5	47	8.6120	405
11-15	-ditto-	1,340	Inf.	1,340	0.0790	106	13	119	1.8715	223
									Total :	38,205

Table 8-6 Present Worth of Annual Cost for Domestic Satellite System with Non-Redundancy

Unit : Million Japanese Yen

Period (year)	Facility	Initial cost	Service life (year)	Net salvage	Annuity from present amount	Amortization cost	Maintenance/operation cost	Annual cost	Present worth of annuity	Present worth of annual cost
1-15	Earth Station	14,384	15	0	0.1161	1,670	135	1,805	8.6120	15,545
1-10	-ditto-	9,540	15	3,180	0.1161	990	-	990	6.7405	6,673
1-15	Radio & Mux	5,979	15	0	0.1161	694	-	694	8.6120	5,977
6-15	(Extension of Mux)	180	15	60	0.1161	19	-	19	4.6087	88
11-15	Radio & Mux	7,794	15	5,196	0.1161	712	-	712	1.8715	1,333
6-15	(Extension of Terminal)	471	15	157	0.1161	49	-	49	4.6087	226
6-10	-ditto-	34	15	23	0.1161	3	-	3	2.7372	8
1-15	Cable	120	17	0	0.1089	13	-	13	8.6120	112
11-15	-ditto-	89	17	0	0.1089	10	-	10	1.8715	19
1-15	Access road	532	Inf.	532	0.0790	42	5	47	8.6120	405
11-15	-ditto-	1,340	Inf.	1,340	0.0790	106	13	119	1.8715	223
									Total :	30,609

PART IX All-round Evaluation of Optimum Transmission System Plan

PART IX All-round Evaluation of Optimum Transmission System Plan

1. General

This Part IX makes an all-round comparative study of the terrestrial radio system plan (hereafter called Plan A) and the domestic satellite system plan (hereafter called Plan B) which were reviewed in all their essential aspects in the preceding Parts.

The all-round evaluation of both Plan A and Plan B from economic and technical viewpoints is intended to arrive at a conclusion concerning what the optimum transmission system for Rural Long Distance Public Telephone Service should be.

2. Itemwise Evaluation

For all-round evaluation of relative merits of a transmission system, the economic evaluation in terms of present worth of annual cost and the performance evaluation are necessary. The former takes up for evaluation the annual cost including initial cost, maintenance cost and operation cost. The latter considers transmission quality, system reliability, system extension flexibility and so forth.

Following is the result of item by item comparative study of Plan A and Plan B.

2-1 Comparison by Present Worth of Annual Cost

The present worth of annual cost is:

Plan A : 22,333 million Japanese Yen
(124,072 thousand U.S. Dollars)

Plan B : 38,205 million Japanese Yen
(212,250 thousand U.S. Dollars)

Plan A costs less than Plan B by 15,872 million Japanese Yen.

This advantage of Plan A reflects the fact that Plan B requires higher construction cost per rural station and hence higher amortization cost.

Although the initial cost of earth stations and the satellite transponder lease rate are considered to be remarkably reduced in the future as the result of continued technical renovation and productivity improvement, both these costs will remain at practically the same level as shown in this Study about the time the tender announcement for this Project is made in 1979-80.

If the non-redundant configuration which does not use standby equipment is adopted for the rural earth station system configuration, the present worth of annual cost decreases by 7,596 million Japanese Yen. In this case, however, the comparison cannot be made on equal base to the terrestrial radio system plan that uses standby equipment.

Therefore, in this Study, the non-redundant configuration with its cost estimate is taken up for the purpose of reference only but is not included in the system comparison.

2-2 Transmission Performance and System Reliability

The objective signal to noise ratios of both Plan A and Plan B, established in Part VI, are reproduced below.

	Plan A	Plan B
Terrestrial section	57 dB	57 dB
Satellite link	-	50 dB

As far as the signal to noise ratio is concerned, Plan A commands greater advantage by several dB over Plan B.

Delay time is another demerit of Plan B in the aspect of transmission performance. More precisely, radio propagation from ground to satellite and back to ground takes approximately 0.3 seconds, and this means that the response of the other party is delayed by approximately 0.6 seconds.

As regards the reliability of communication equipment, there is no much difference between Plan A and Plan B because the full redundant configuration is adopted in both plans. Qualitative comparison of system reliability between Plan A and Plan B follows.

Traffic estimation is made on the assumption that one half of originating calls from each RS (rural earth station) is to Bangkok, the capital city, and the other half is to the nearby PC (Primary Center).

In this case, the traffic route configuration is as follows:

Plan A:

(1) Traffic to Bangkok:

RS ——→ PC —existing microwave system→ Bangkok

(2) Traffic to nearby PC:

RS ——→ PC

Plan B:

(1) Traffic to Bangkok:

RS ——→ satellite ——→ MS (Master earth station)

(2) Traffic to nearby PC:

RS ——→ satellite ——→ MS —existing microwave system→ PC

As shown above, in Plan A, calls to Bangkok are through the existing microwave system and calls to nearby PC are via UHF system which uses several repeater stations. However, in Plan B, calls to Bangkok are via satellite link and calls to nearby PC are via one satellite link plus the existing microwave system.

That is to say, in both plans, almost the same volume of calls is carried on the existing microwave system, though the call destinations are different, one being Bangkok and the other the nearby PC.

Therefore, it can be safely presumed that, in the system reliability also, there is little to choose between the two plans.

2-3 Maintenance/Operation Cost

Both Plan A and Plan B contemplate to maintain rural stations as unattended stations and to keep the maintenance staff at 35 Maintenance Centers. Thus, for maintenance personnel cost, no substantial difference can be found between the two plans. Master earth station in Plan B needs some 20 maintenance engineers.

Plan A requires 46 more through repeater stations than Plan B so that the number of maintenance personnel required increases to that extent, resulting in almost the same maintenance manpower level as in Plan B. Hence no major difference between the two plans in the maintenance staff cost.

For other maintenance/operation cost, Plan B envisages higher operation cost corresponding to the satellite transponder lease rate whereas Plan A anticipates road and tower repair/improvement cost increase.

2-4 System Extension Flexibility

Plan A features that the terminal section of transmission route holds transmission capacity of 24 telephone channels and the section where circuits are concentrated holds transmission capacity of 120 telephone channels. Therefore, compared with Plan B wherein not more than several circuits are used, Plan A can more easily cope with a greater increase of circuit demand than expected if it arises in the future.

2-5 Work Period

Both Plan A and Plan B use equipment shelters for rural station buildings so that in the period required for equipment installation at rural stations, no much distinction exists between the two plans.

In Plan A, antenna tower erection work takes time; however, in Plan B, time requirement for master earth station construction is large. After all, in the required work period, neither plan is considered to predominate over the other. Meanwhile, it is hypothesized that by the time the equipment installation at rural stations begins, access roads to all those stations would have been completed by TOT.

Plan A also features that partial system service-in can be expected, beginning in the area where construction work and acceptance test have been completed. However, in Plan B, partial system service-in is impossible before the construction of master earth station and gateway exchange to be established in Bangkok as pivotal facilities of the whole system is completed.

3. All-round Evaluation Result

All-round evaluation of itemwise individual study results arrives at the following conclusions:

(1) For the transmission system of Rural Long Distance Public Telephone Service, UHF terrestrial radio system of 900 MHz frequency band is the optimum system, considered from both technical and economic angles.

(2) For the applicable UHF (900 MHz frequency band) terrestrial radio system, no much difference can be found between FDM system and PCM system.

(3) Domestic satellite system will have its construction cost broadly reduced as the technical research and development make further progress and the greater productivity improvement is achieved. Therefore, when the introduction of domestic satellite system is planned in the future, the most effective use of the satellite must be considered. This can be realized by utilizing the system for wide-range signal transmission, such as telegram, telex, data and television signal transmission, without restricting the system utilization to telephone channel transmission alone.

PART X Project Implementation Plan

PART X Project Implementation Plan

This Project not only covers the whole territory of Thailand but also comprises various divisions of engineering expertises in a long period. Therefore, to ensure satisfactory progress of project implementation, it will be necessary to reinforce the project implementation organization.

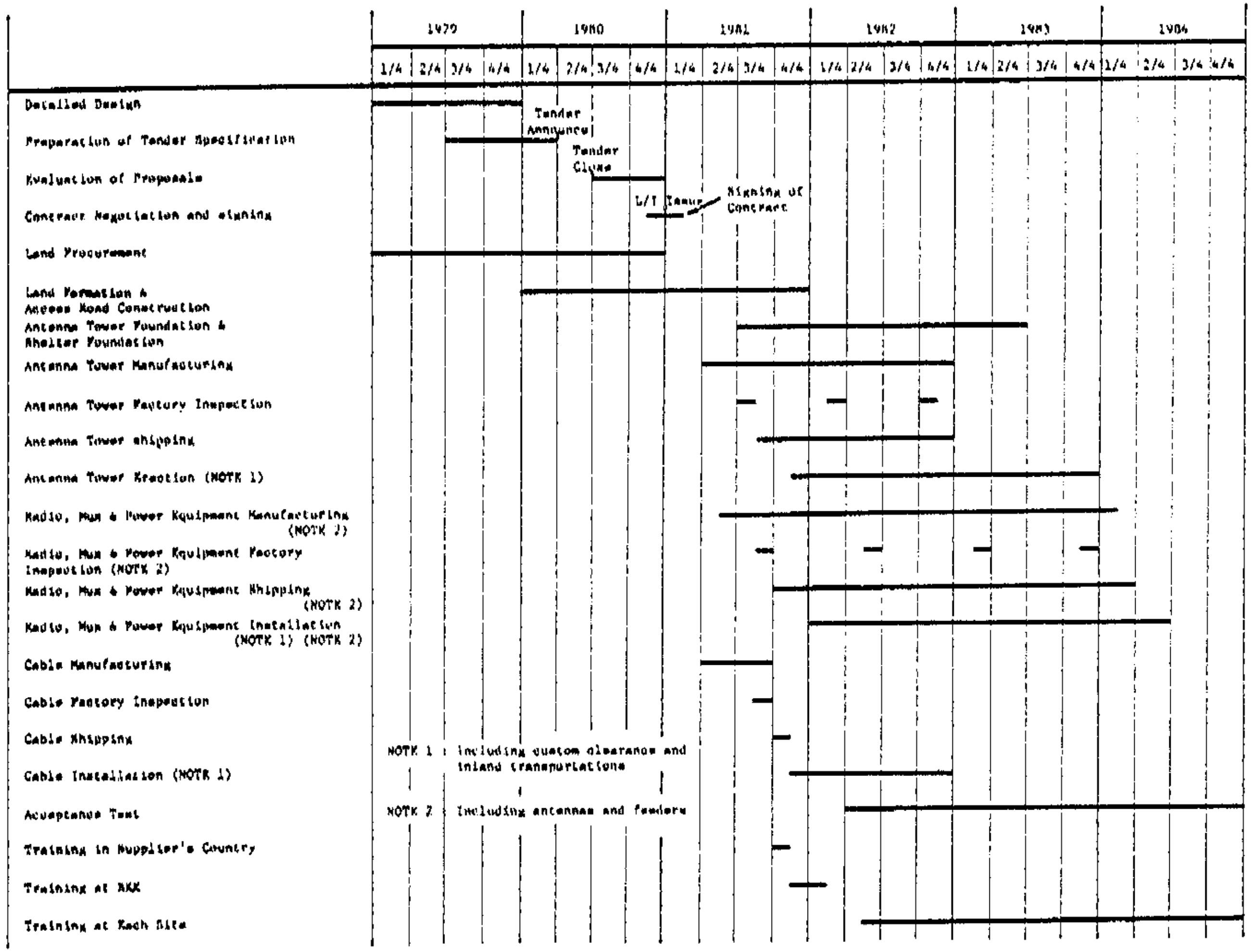
Tentative Work Schedule Chart

A tentative work schedule chart for implementation of Rural Long Distance Public Telephone Service Project is given in Table 10-1. This work schedule chart uses 1984 as the work completion target year in accordance with the TOT plan.

Items considered are as follows:

1) The construction work will be carried out by the Contractor on a full turn-key basis except land formation and access road construction.
2) As much time as required will be spent for detail design by which to make Tender Specifications.
3) In case the traffic reappraisal cannot be completed in time for tender announcement, the result of reappraisal will be taken into account in subsequent extension works.
4) The system will begin service in one area after another where construction work has been completed.

Table 10-1 Tentative Construction Schedule for Rural Long Distance Public Telephone Service



PART XI Economic and Financial Evaluations

PART XI *Economic and Financial Evaluations*

This Part XI presents economic and financial evaluations of Rural Long Distance Public Telephone Service Project, based on the conclusion drawn in Part IX, i.e., the decision in favor of terrestrial radio system as an optimum system.

1. Economic Analysis

1-1 Calculation of Economic Costs and Benefits

Project cost estimates are given in Part VIII. These cost estimates are for comparison between the two systems so that, to facilitate the economic evaluation of the Project, supplementation or streamlining of cost items is required. Project costs for the purpose of analysis are listed in Table 11-1.

For Economic analysis, all costs should be quoted in border prices. Although imported materials and equipments are quoted in border prices (CIF), other costs are quoted in market prices (local currency portion) and they should be converted into border prices, using CF (conversion factor).

1-1-1 Calculation of CF

SCF (standard conversion factor), which is the ratio of market prices to border prices, is calculated by the following equation, based on export and import values in the past five years, as well as import duties and export duties in the same period:

$$SCF = \frac{M + X}{(M + Tm) + (X - Sx)}$$

where

M : Total import value by CIF

X : Total export value by FOB

Tm: Total amount of import duties

Sx: Total amount of export duties

SCF in Thailand has been found to be 0.95. Besides SCF, CFC (conversion factor for consumption) has also to be obtained for economic evaluation. However, since data from

Table 11-1 Project Cost Breakdown (1/3)

Note : LP denotes Local Currency Portion.
FP denotes Foreign Currency Portion.
Year in parentheses is the year in which disbursement will take place.

1. Capital Invesment

1-1 Land Procurement (LP)	16,203,000 Baht
	(1979-1980)
1-2 Land Formation (LP)	16,749,330 "
	(1980-1981)
1-3 Access Road Construction (LP)	223,000,000 "
	(1980-1981)
1-4 Communication Equipment and Maintenance Facilities (FP)	1,680,724,800 "
	(1981-1984)
	18,998,000 "
	(1989)
	91,675,400 "
	(1994)
1-5 Installation and Testing (LP, FP)	355,013,300 "
	(1981-1984)
	2,753,300 "
	(1989)
	13,257,300 "
	(1994)

which to obtain CFC is not sufficient, the following hypothesis is used to set CFC at 0.90. That is to say, the customs tariffs are established generally at high levels for consumers' goods and at low levels for producers' goods. Hence, a smaller value is expected for CFC than for SCF.

1-1-2 Calculation of Economic Costs (Accounting Prices)

(1) Land Acquisition Cost

Land acquisition cost includes land price and land measurement and registration fees collateral to land acquisition. 90% of land acquisition cost constitutes land price and 10% accounts for related skilled labor cost.

Land price calculation requires the accounting price based on the shadow price calculation. Here, for such accounting price, SCF is used because the ratio to total fixed capital cost is small. For skilled labor cost calculation, CFC is applied.

The accounting price for land acquisition cost turns out to be 15,312,000 Baht.

(2) Land Formation Cost

Land formation cost comprises banking work cost, civil work cost including fence, gate and ditch building cost, commercial power lead-in cost, and ground leveling cost.

For imported goods, import tariff and domestic transportation cost have to be considered; however, SCF only is applied here. For domestic goods also, SCF is applied. For unskilled labor, CFC is used whereas, for skilled labor, although the calculation should be based on the value of marginal product to be lost in other field of labor, 0.7 x CFC (0.7 x 0.90 = 0.63) is used here for CF.

The accounting price for land formation cost turns out to be 15,409,000 Baht.

(3) Access Road Construction Cost

Access road construction cost consists of land-for-road acquisition cost and road construction cost.

Cost distribution ratios are 10% for imported goods, 20% for domestic goods, 5% for skilled labor, 15% for unskilled labor, and 50% for land.

CF for each cost item is the same as in the case of land formation cost. However, with respect to land-for-road

acquisition cost, the accounting price calculation is subject to controversy, because the major part of land for road is the wooded land. Nevertheless, SCF is applied here.

The accounting price for access road construction cost turns out to be 149,410,000 Baht.

(4) Communication Equipment Installation Cost

Communication equipment installation cost comprises domestic transportation cost for imported equipment, foundation work cost for towers and shelters, foreign and domestic labor cost, and so forth. All these are the essential costs for equipment installation work.

Cost distribution ratios are 15% for labor to be financed by foreign currency, 10% for domestic goods, 40% for skilled labor, and 20% for unskilled labor.

30% of installation cost is covered by foreign currency. One half of this foreign currency portion is for domestic consumption (including tax payment). And this one half of foreign currency portion is appropriated for labor to be financed by foreign currency. Basides CF for foreign currency labor as unity, the aforementioned CF is applied.

The accounting prices for equipment installation cost are 259,160,000 Baht for initial period, 2,010,000 Baht for middle period, and 9,678,000 Baht for final period.

Table 11-1 Project Cost Breakdown (2/3)

1-6 Training (LP, FP)	326,500 Baht
	(1980-1981)
1-7 Vehicles (LP)	10,150,000 "
	(1981-1984)
	10,150,000 "
	(1990-1993)
1-8 Project Execution (LP)	17,010,000 "
	(1979-1984)
	756,000 "
	(1988-1989)
	1,260,000 "
	(1993-1994)
2. Operating Cost	
2-1 Electricity and Oil (LP)	3,914,175 "
	(1982)
	7,828,351 "
	(1983)
	58,712,630 "
	(1984-1988)
	60,343,540 "
	(1989-1993)
	78,283,512 "
	(1994-1999)
2-2 Spare Parts (FP)	1,166,666 "
	(1982)

Table 11-1 Project Cost Breakdown (3/3)

	2,333,333 Baht
	(1983)
	17,500,000 "
	(1984-1988)
	19,250,000 "
	(1989-1993)
	27,300,000 "
	(1994-1999)
2-3 Maintenance (LP)	2,646,000 "
	(1982)
	5,292,000 "
	(1983)
	139,104,000 "
	(1984-1999)

(Breakdown of cost items 1-4, 1-5 and 1-6 appears in Table 8-1 of Part VIII.)

(5) Work Management Cost

Work management cost includes personnel cost, general administration cost, office supplies cost, and domestic travel cost.

Cost distribution ratios are 10% for imported goods, 35% for domestic goods, and 55% for skilled labor.

CF for each cost item is based on the aforementioned corresponding value.

The accounting prices are 15,648,000 Baht for initial period, 696,000 Baht for middle period, and 1,160,000 Baht for final period.

(6) Vehicles

Vehicles are categorized as imported goods. The accounting price per vehicle turns out to be 276,000 Baht.

(7) Training Cost

CF for foreign currency portion out of total training cost is unity based. Skilled labor training is to be financed by domestic currency portion.

The accounting price for training cost is 320,000 Baht.

(8) Electric Power and Fuel Cost

Since the final calculation requires detailed studies, the provisional decision is to apply SCF.

(9) Maintenance Cost

Maintenance cost includes maintenance personnel cost, office supplies cost, and spares/parts cost, besides maintenance management cost.

Cost distribution ratios are 5% for imported goods, 40% for domestic goods, and 55% for skilled labor.

CF for maintenance cost turns out to be 0.92.

For imported goods, CIF prices quoted in Part VIII are observed. Furthermore, the accounting prices for Paragraphs (1) through (8) above are taken into consideration.

Economic cash outflow is presented in Table 11-3.

1-1-3 Economic Benefits

Benefits in this Project are the sum total of telephone service fees to be paid by users. However, this Project is essentially to construct transmission routes, part of which will be used as subscribers' lines and part as trunk routes. Therefore, it is important to distribute service fees paid by users according to the degrees of their utilization.

Investment required for telephone network construction consists, according to the standard distribution, of 10% for subscriber premise equipment (telephone sets), 35% for subscribers' lines, 25% for local exchanges, 10% for trunk lines, 5% for toll exchanges, and 15% for toll transmission routes.

Therefore, for the benefits in this Project, the revenues from telephone service distributed according to the investment distribution rates as per above are used. That is to say, 35% is for Rural Long Distance Public Telephone Service and 12.5% for junction routes on the assumption that one half of these routes are used as trunk lines and the other half as toll lines ((10% + 15%)/2 = 12.5%). As for call charges, it is estimated that one half of calls are local calls and the charge is two Baht per call, and the other half are toll calls to Bangkok and the charge is 30 Baht per call (distance: 350 km - 500 km; averabe call duration: 3 minutes). Table 11-2 presents the calculation methodology for benefits in this Project.

For conversion of benefits into the accounting prices, it is necessary to determine the rate of speeches for consumption purposes and the rate of speeches for production purposes. This time, benefits in terms of speeches for consumption purposes are set at 30% of all speeches and CFC is applied to those benefits, whereas benefits in terms of speeches for production purposes are set at 70% of all speeches and SCF is applied to those benefits. By this means, the accounting prices for benfits have been obtained.

Table 11-2 Calculation of Direct Benefits (1/2)

Benefits from portion to be used as subscribers' lines

Number of busy hour calls per channel	10 calls
Busy hour concentration rate	20%
Number of calls per channel per day	50 calls
Number of calls per channel per year (365 days)	18,250 calls
Half of calls : 2 Baht per call) Half of calls : 30 Baht per call) Degree of contribution as subscribers' lines : 35%)	102,200 Baht/ch/year

Year	Number of Channels	Benefits (in 1,000 Baht)
1982	432	44,150
1983	864	88,301
1984	1,295	132,349
1985-1988	1,439	147,065 x 4
1989	1,531	156,468
1990-1993	1,623	165,871 x 4
1994	1,225	125,195
1955-1999	827	84,519 x 5

Benefits from portion to be used as junction lines

Number of busy hour calls per channel	12 calls
Busy hour concentration rate	10%
Number of calls per channel per day	120 calls

Table 11-2 Calculation of Direct Benefits (2/2)

Number of calls per channel per year (325 days)		39,000 calls
Half of calls : 2 Baht per call	)	
Half of calls : 30 Baht per call	)	78,000 Baht/ch/year
Degree of contribution as junction lines (junction lines + toll transmission routes) 12.5%	)	

Year	Number of Channels	Benefits (in 1,000 Baht)
1982	322	25,116
1983	644	50,232
1984	967	75,426
1985-1988	1,074	83,772 x 4
1989	1,067	125,346
1990-1993	2,140	166,920 x 4
1994	4,764	371,592
1995-1999	7,387	576, 186 x 5

Benefits from the project as a whole

Year	Benefits (in 1,000 Baht)
1982	69,266
1983	138,533
1984	207,775
1985-1988	230,873 x 4
1989	281,814
1990-1993	332,791 x 4
1994	496,787
1995-1999	660,705 x 5

With respect to the fixed capital at the time of completion of the Project, the balance of benefits minus fixed capital depreciation is to be calculated as the final year benefits.

Economic cash inflow is presented in Table 11-3.

1-2 Calculation of Internal Rate of Return (IRR)

IRR turns out to be 11.32%

$$\sum_{i=1}^{t} \frac{Fi}{(1+r)^i} = 0$$

Where

Fi: Cash flow in year i

i : Year

r : Interest (Internal Rate of Return)

1-3 Sensitivity Analysis

(1) In case of 10% increase of equipment cost, IRR is 10.16%.

(2) In case of 10% decrease of operating revenues, IRR is 10.05%.

(3) In case of combination of the above two variants, IRR is 8.94%.

2. Financial Analysis

2-1 Cash Flow

Table 11-4 presents the cash flow based on market prices and in consideration of taxes. This cash flow features the following points:

(1) Import duties on imported equipments at the rate of 20% of their CIF prices.

Table 11-3 Cash Flow for Economic Analysis (Thousand B)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Revenues				65,110	130,221	195,309	216,987	216,987	216,987	216,987	264,905	312,824	312,824	312,824	312,824	460,980	621,063	621,063	621,063	621,063	621,063
Operating Cost				6,619	13,077	20,311	21,290	21,290	21,290	21,290	22,260	22,260	22,260	22,260	22,200	24,943	24,943	24,943	24,943	24,943	24,943
Electricity, Oil				2,938	5,875	8,813	9,792	9,792	9,792	9,792	10,412	10,412	10,412	10,412	10,412	12,395	12,395	12,395	12,395	12,395	12,395
Spare Parts				1,167	2,333	3,500	3,500	3,500	3,500	3,500	3,850	3,850	3,850	3,850	3,850	4,550	4,550	4,550	4,550	4,550	4,550
Maintenance				2,514	4,869	7,998	7,998	7,998	7,998	7,998	7,998	7,998	7,998	7,998	7,998	7,998	7,998	7,998	7,998	7,998	7,998
Operating Revenues				58,491	117,144	174,998	195,697	195,697	195,697	195,697	242,645	290,564	290,564	290,564	290,564	442,037	596,120	596,120	596,120	596,120	596,120
Project Costs	11,134	92964	572,683	490,145	490,049	488,869				348	21,356	2,760	2760	2,760	1,960	101,933					(506205)
Land Procurement	7,656	7,656																			(15,312)
Land Formation		7,705	7,705																		(15,410)
Access Road Const.		74705	74,705																		(149,410)
Communication Equip.			420,181	420,181	420,181	420,181					18,998					91,675					(324,831)
Installation & Testing			64,790	64,790	64,790	64,790					2,010					9,678					
Training			224	96																	
Vehicles			2,760	2,760	2,760	1,380						2,760	2,760	2,760	1,380						(1242)
Project Execution	3,478	2,898	2,318	2,318	2,318	2,318				348	348				580	580					
Net Cash Flow	△ 11,134	△ 92,964	△ 572,683	△ 431,654	△ 372,905	△ 313,671	195,697	195,697	195,697	195,349	221,289	287,804	287,804	287,804	288,604	340,104	596,120	596,120	596,120	596,120	1,102,325

Internal Rate of Return (IRR) = 11.32%

Table 11-4 Cash Flow for Financial Analysis (Thousand B)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Revenues				69,266	138,533	207,775	230,837	230,837	230,837	230,837	281,814	332,791	332,791	332,791	332,791	496,787	660,705	660,705	660,705	660,705	660,705
Operating Cost				7,138	14,276	22,171	23,201	23,201	23 201	23,201	23,201	24,274	24,274	24,274	24,274	27,201	27,201	27,201	27,201	27,201	27,201
Electricity & Oil				3,092	6,184	9,277	10,307	10,307	10,307	10,307	10,960	10,960	10,960	10,960	10,960	13,047	13,047	13,047	13,047	13,047	13,047
Spare Parts				1,400	2,800	4,200	4,200	4,200	4,200	4,200	4,620	4,620	4,620	4,620	4,620	5,460	5,460	5,460	5,460	5,460	5,460
Maintenance				2,646	5,292	8,694	8 694	8,694	8,694	8,694	8,694	8,694	8,694	8,694	8,694	8,694	8,694	8,694	8,694	8,694	8,694
Operating Revenues				62,128	124,257	185,604	207,636	207,636	207,636	207,636	258,613	308,517	308,517	308,517	308,517	469,586	633,504	633504	633504	633,504	633,504
Interest & Depreciation			29,849	94,600	159,552	224,503	259,806	259,806	257,452	252,745	245,604	236,270	226,856	217,442	208,028	198,614	189,200	179,786	170,372	160,957	151,543
Corporate Tax											3,879	21,674	24,498	27,323	30,147	81,292	133,291	136,115	138,940	141,764	144,588
Project Cost	11,882	131,127	720,451	600,445	600,347	598,897				378	25,929	2,900	2,900	2,900	2,080	123,897					(648,229)
Land Procurement	8,102	8,102																			(16,204)
Land Formation		8,375	8,375																		(16,750)
Access Road Const.		111,500	111,500																		(223,000)
Communication Equip.			506,174	506,174	506,174	506,174					22,798					110,010					(390,970)
Installation & Testing			88,753	88,753	88,753	88,753					2,753					13,257					
Training			229	98																	
Vehicles			2,900	2,900	2,900	1,450						2,900	2900	2,900	1,450						(1,305)
Project Execution	3,780	3,150	2,520	2,520	4,520	2,520				378	378				630	630					
Net Cash Flow	△11,882	△131,127	△720,451	△538,317	△478,090	△413,293	207,636	207,636	207,836	207,258	228,805	283,943	281,119	278,294	276,290	264,397	500,213	497,389	494,564	491,740	[illegible]

Internal Rate of Return (IRR) = 8.22%

(2) Initial period foreign currency portion payment by loan subject to the following terms of loan:

Rate of interest: 7.9% per annum

Repayment: By equal yearly instalments in 20 years (including five-year grace period)

(Above are equal to the terms of loan from the International Bank for Reconstruction and Development in recent years.)

(3) Fixed capital depreciation by straight line method.

$$\left[\frac{C}{t} = \text{Depreciation} \qquad \begin{array}{ll} \text{Where} & \\ C: & \text{Fixed capital} \\ t: & \text{Year} \end{array} \right]$$

(4) Corporate tax rated at 30% of ordinary profit. Ordinary profit is calculated by subtracting interest and depreciation from operating revenues.

2-2 Calculation of Internal Rate of Return (IRR)

IRR is 8.22%.

2-3 Sensitivity Analyses

(1) In case of 10% increase of equipment cost, IRR is 7.42%.

(2) In case of 10% decrease of operating revenues, IRR is 6.98%.

(3) In case of combination of the above two variants, IRR is 5.96%.

Conclusion by Economic and Financial Analyses

This Project is a project to improve telecommunication service in the districts of Thailand, where such service is incomplete. Thus the Project constitutes an integral part of the country's national economic development plan.

Economic and financial analyses have resulted in the economic IRR of 11.32% and the financial IRR of 8.22%, both of which are the reasonable values when it is considered that this Project is in the infrastructural field. However, noteworthy is the fact that the not so high level of IRR resulting from the financial analysis is considered to be attributable to the import tariffs of Thailand.

At present, in Thailand, the industry that produces telecomminication equipments still remains small in scale so that the equipments required for the implementation of this Project cannot help being procured by importation.

Benefits used in the economic analysis are primarily composed of telephone service fees. However, judging from the situation that prevails, or, more precisely, the fact that the people in the districts without telephones proceed by car, bus or other means of transportation to a town where the telephone system exists, it can be safely assumed that the willingness to pay of those people will be of greater value than telephone service fees. Hence, the economic IRR will also be of greater value than that obtained in the economic analysis.

The foregoing observation can be summarized as follows:

1) Economically, this Project is feasible;
2) Financially, also, this Project is a reasonable project.

This Project is to improve telephone service in the rural districts of Thailand along the line of the National Economic Development Plan, so that the project implementation is considered to contribute a great deal to the economic development of the country.

Since this Project is an extremely large-scale project, its implementation will impose a great financial responsibility upon TOT. Therefore, it will be desirable to substantiate State assistance, such as low interest loan(s) and/or subsidization from the national treasury, for the project implementation.

APPENDICES

APPENDIX 1 Study Team Organization

The Study Team is composed of six persons including the Team leader. All Team members are The Nippon Telecommunications Consulting Co., Ltd., employees. The six Team components and their respective responsibilities are listed below.

Name	Responsibility
Kenichi HATANO	Team leader
Hiroshi SEKIKAWA	Carrier transmission engineering
Junichi KUROBE	Radio engineering
Katsuhiko SATO	Radio engineering
Ryoji SASAKI	Satellite communication engineering
Nobuo NAKAJIMA	Network engineering

APPENDIX 2 Work Itinerary

August 10, 1978	:	Departure from Tokyo and arrival in Bangkok.
August 11, 1978	:	Courtesy calls to Japanese Embassy and JICA Office, and consultative meetings. Courtesy visit to Managing Director of TOT.
August 12, 1978 to September 10, 1978	:	Consultations with TOT, collection of data, feasibility study.
September 11, 1978 to September 30, 1978	:	Field survey of four areas by two groups.
October 1, 1978 to December 10, 1978	:	Feasibility study work and compilation of Interim Report (draft).
December 11, 1978 to December 24, 1978	:	Examination of interim Report (draft) by JICA Mission.
December 25, 1978 to December 27, 1978	:	Correction and finalization of Interim Report.
December 28, 1978	:	Presentation of Interim Report to TOT.
December 29, 1978 to January 7, 1979	:	Preparation of Final Report.
January 8, 1979	:	Courtesy visit to Managing Director of TOT.
January 9, 1979	:	Departure from Bangkok and arrival in Tokyo.

APPENDIX 3 Supporting Documents

Data and information used in the Study are listed below.

From Telephone Organization of Thailand

Traffic Distribution for Rural Long Distance Public Telephone Service

Transmission Loss Distribution Plan

Inter-Exchange Signalling Plan

Radio Frequency Assignment for Existing System

Regulation on Telephone Service Charges and Deposit

Statistical Report 1976

Annual Report 1976

Radio Frequency Assignmnt Plan for 900 MHz Band

National Numbering Plan

Basic Concept for Maintenance and Operations

The Economic Development Project of TOT (1977-1984)

The Economic Development Project of TOT (1977-1984), Additional Plan

Radio Link Route Map (Planned up to 1984)

System Channel Diagram for Long Distance Circuit

Coordinates of Existing Radio Stations of TOT

Coordinates of Rural Sites and Population

Traffic and Long Distance Network for STD Project 1977-1984

Forecast of Telephone Demand 1977-1990

Rural Long Distance Public Telephone Service Routing Plan

Basic Distance-Interval for Trunk Call Rates

From Others

National Economic and Social Development Board: "The Fourth National Economic and Social Development Plan (1977-1981)"

Meteorological Department : "Climatological Data of Thailand, 25 Year Period (1951-1975)", Jan. 1977

CCITT Orange Book, Geneva, 1976

CCIR Documents of the XIIIth Plenary Assembly, Geneva, 1974

SWEDTEL : "Radio Link Routes Supervision of System Design and Frequency Planning, Progress Report", May 1977

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T. Akiyama and K. Hatano : "Radio Refractivity Gradient in South-East Asia", Trans. IECE Jap., 60-E, 1, Jan. 1977

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PERUMTEL : "PALAPA Tariff Manual"

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ON RURAL LONG DISTANCE PUBLIC TELEPHONE SERVICE

FEBRUARY, 1979

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