THE KINGDOM OF THAILAND

FEASIBILITY REPORT
ON
RURAL LONG DISTANCE
PUBLIC TELEPHONE SERVICE

FEBRUARY, 1979

JAPAN INTERNATIONAL COOPERATION AGENCY

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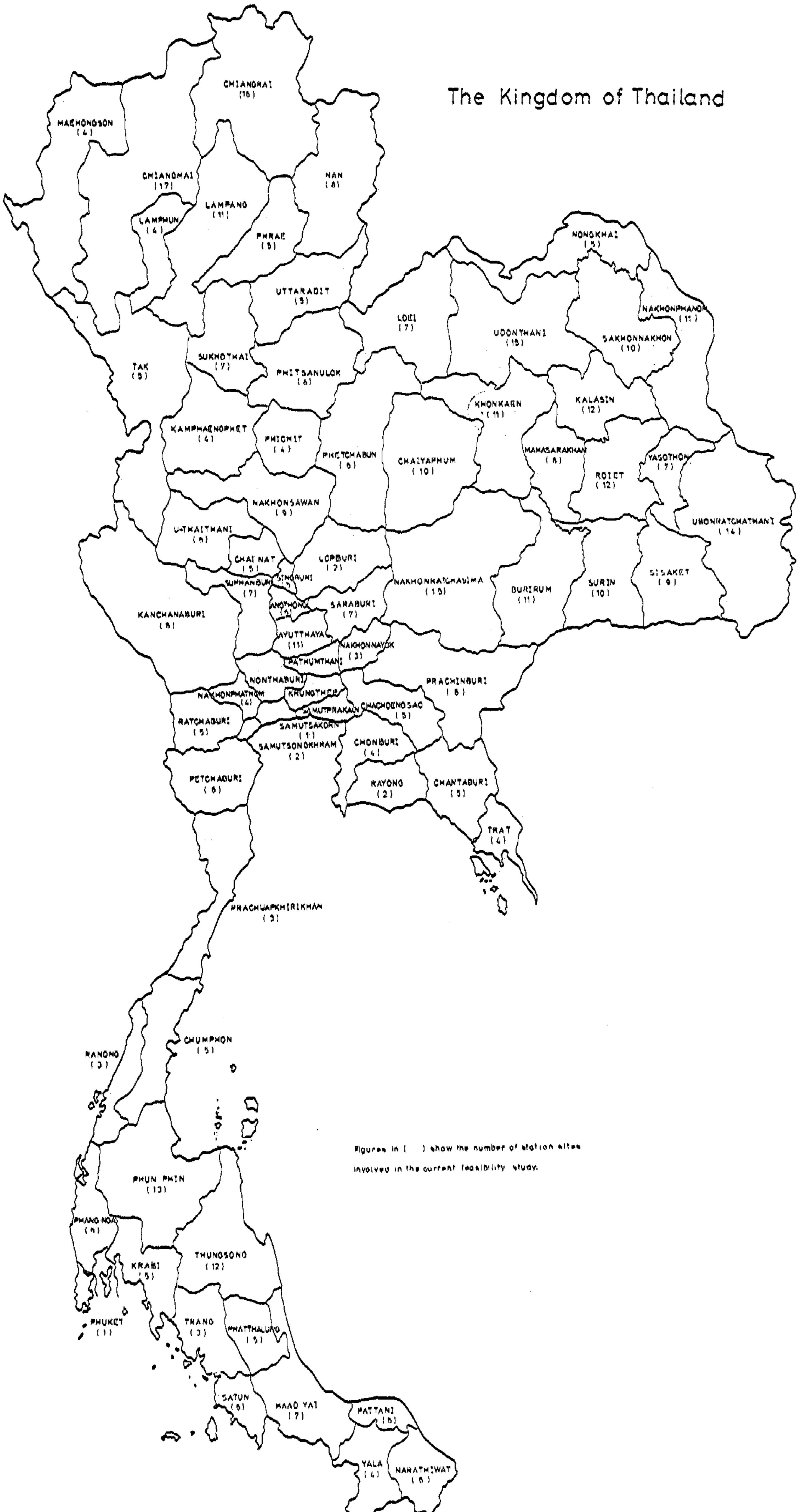
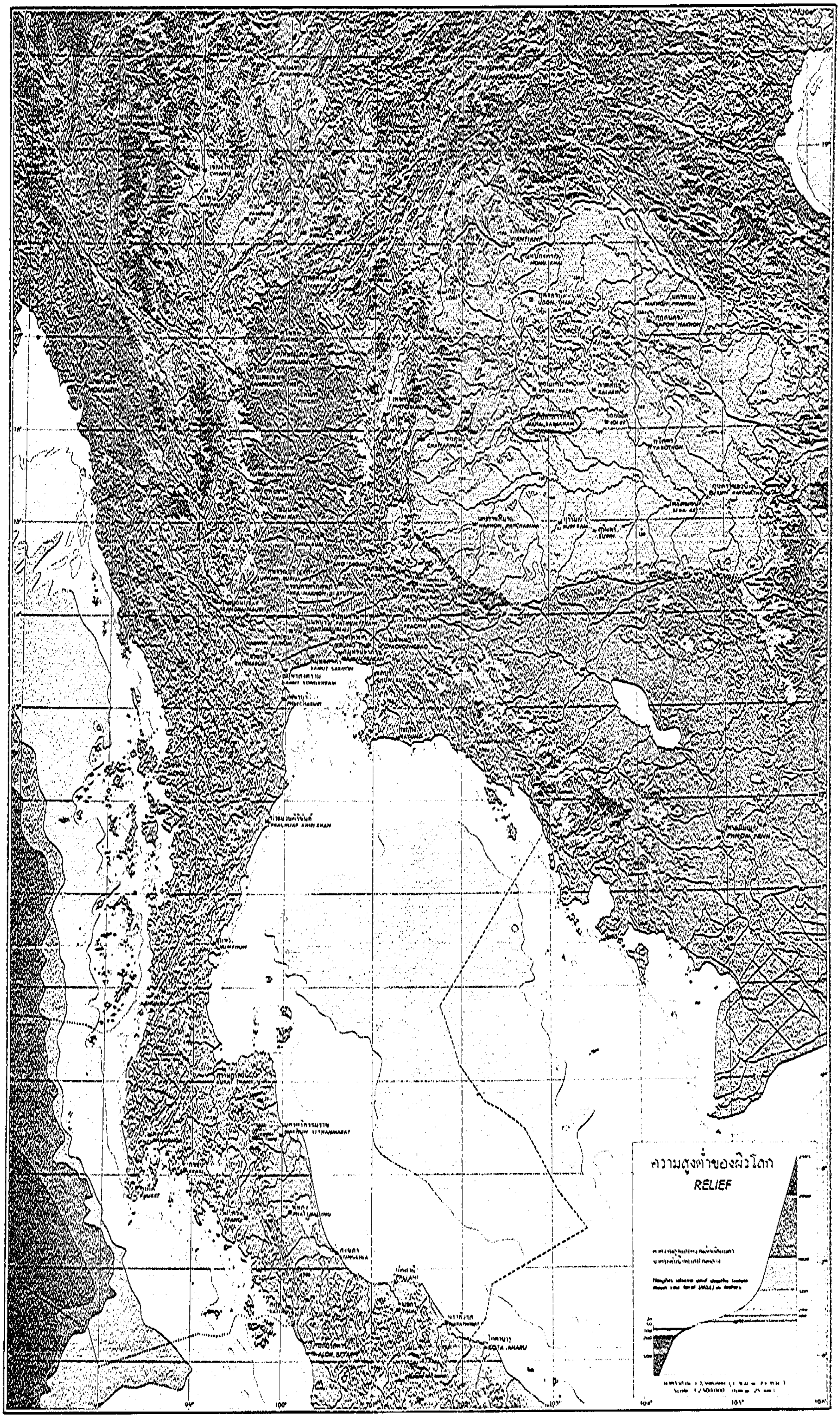
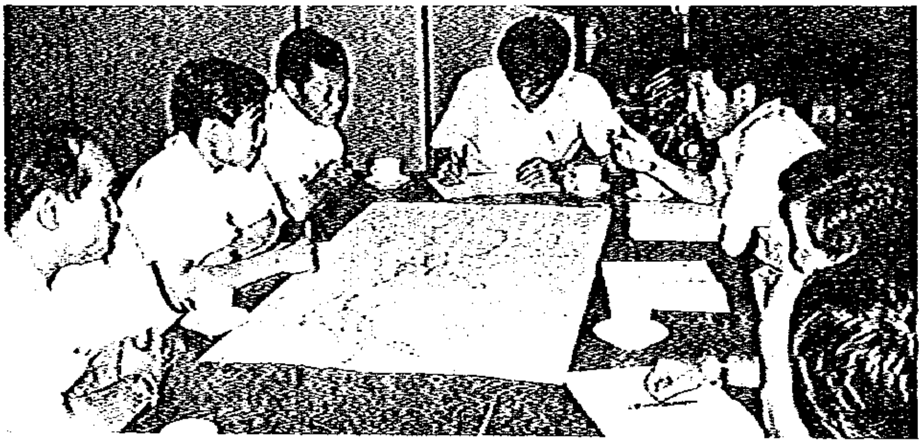


Figures in ( ) show the number of station sites involved in the current feasibility study.


ความสูงต่ำของผิวโลก
RELIEF

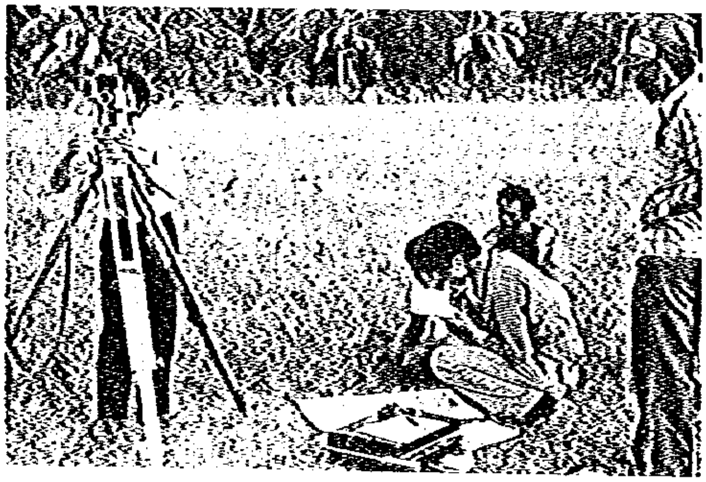
Discussion with TOT key persons



Discussion at Bangkok Maintenance Center

Rural district (Chok Chai)

Field survey at Kham Thale So



Field survey at Pha Ngan Island

Interview at radio shop in U-Thai district

PREFACE

In response to the request of the Government of the Kingdom of Thailand, the Government of Japan decided to carry out a study on the Rural Long Distance Public Telephone Service Project of Thailand, which constitutes an integral part of that country's Fourth National Economic and Social Development Plan (1977-1981), as part of Japan's overseas technical cooperation programme, and this study was executed by Japan International Cooperation Agency (JICA).

JICA dispatched a study team of six experts to Thailand from August 10, 1978, to January 9, 1979, and made a feasibility study on the project.

The study findings were compiled into documents and submitted as an interim report to the Government of Thailand by the study team during their stay in Thailand. After their return to Japan, the team reviewed and analyzed the data and information collected in Thailand and examined the project carefully. As a result, this report is prepared and now submitted as the final report.

I hope that this report will contribute to the progress of the project, to the economic development of Thailand and to the friendly relations between Thailand and Japan.

Finally, I should like to express my deep appreciation to all the officials concerned of the Government and the Telephone Organization of Thailand for their unstinted cooperation and assistance offered in this study.

February, 1979

Shinsaku Hogen

President

Japan International Cooperation Agency

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Summary of Study; Conclusion and Recommendations

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1. Outline of Study

The Telephone Organization of Thailand (hereafter called TOT), the sole public corporation in charge of domestic telephone service management in Thailand, plans to establish the long distance telephone service inclusive of public telephone service, covering 469 rural districts throughout the country. This plan, known as the Rural Long Distance Public Telephone Service Project, constitutes an integral part of the National Economic and Social Development Plan, 1977-1981, of the Government of the Kingdom of Thailand.

TOT requested the Government of Japan to carry out the feasibility study with respect to the selection of technically and economically optimum system to implement the Project. The selection is to be made from among the three proposed systems named below.

1) UHF (900 MHz band) terrestrial radio system;
2) SHF (11/13 GHz band) terrestrial radio system;
3) Domestic satellite system.

Responding to the request from TOT, the Government of Japan dispatched to Thailand the Feasibility Study Team for Rural Long Distance Public Telephone Service (hereafter called the Study Team) for a period of approximately five months beginning August 10, 1978.

Main study items comprised circuit requirements forecast, transmission route selection by systems, detailed studies of selected systems, and economic comparison among those systems. The conclusion reached is that UHF (900 MHz band) terrestrial radio system provides an optimum transmission system for Rural Long Distance Public Telephone Service.

The map that appears at the beginning of this Report indicates the Provinces to which the 469 rural districts respectively belong, as well as the number of rural districts in each Province.

2. Results of Study

Results of study according to main study items are summarized below.

2-1 Circuit Requirements

Based on TOT data forecasting telephone demand potential up to 1990, total circuit requirements in the 469 rural districts, including 47 districts where mobile exchanges will be introduced, in 1984, 1989 and 1994 were forecasted. The year 1984 is the year in which this Project is scheduled to begin full operation. The years 1989 and 1994 are five years and 10 years after the Project service-in in 1984. The result of forecast follows:

	1984	1989	1994
Circuit requirements	2,513	3,763	8,218

The above forecast leads to judgment that, in 1989, telephone exchanges be introduced in 18 districts and, 1994, in 187 more districts.

2-2 Optimum Transmission System

Based on the transmission route plan formulated by TOT, selection of optimum transmission routes was made, one for terrestrial radio system and the other for domestic satellite system.

(1) Terrestrial Radio System

In accordance with the TOT principle, two terrestrial radio system plans were selected. They are:

1) UHF (900 MHz band) system plan;

2) SHF (11/13 GHz band) system plan.

For each system, study was made with emphasis on FDM (Frequency Division Multiplex) system. PCM (Pulse Code Modulation) system application feasibility was also studied. Study of UHF system included study of over-the-horizon communication system application feasibility. This latter study was aimed at system construction cost curtailment by means of elimination of through repeater stations.

Comparative study of UHF and SHF systems in the performance and cost aspects led to this conclusion: For a terrestrial radio system comparable to domestic satellite system, UHF (900 MHz band) system is optimal.

(2) Domestic Satellite System

With regard to domestic satellite system, one transponder of PALAPA satellite of Indonesia is to be leased. On this condition, study was made mainly about transponder capacity and radio interference to the existing microwave system, in addition to traffic forecast. The finding is that optimum domestic satellite system comparable to UHF (900 MHz band) terrestrial radio system is a system that features the following:

1) DAMA (Demand Assigned Multiple Access) system using SCPC (Single Channel Per Carrier) system be applied. This is because the domestic satellite system of Thailand involves a large number of rural earth stations and the number of circuits per station is small.

2) Control of DAMA, such as for circuit connection and tariff rate determination, be centralized at master earth station to be established in the suburbs of Bangkok.

3) In consideration of transponder capacity, radio interference with the existing terrestrial microwave system and so forth, terrestrial radio system be applied to 129 rural districts out of a total of 469 rural districts.

4) 146 districts, where telephone demand is so large that telephone exchanges will have to be introduced in the future, be changed over to terrestrial radio system in 1994, i.e., 10 years after the service-in of this Project.

2-3 Detailed Study of Objective Systems of Comparison

Detailed study of terrestrial radio system and domestic satellite system, with emphasis on their respective site selection requirements, design criteria, system configurations and system performances, proved that the principal design paramenters of the two systems are as follows:

(1) Terrestrial Radio System

Radio frequency band	:	900 MHz
Transmission capacity	:	24 ch/120 ch
Transmitting power	:	5 W
Standby system	:	Equipment standby
Power supply	:	Battery floating

(2) Domestic Satellite System

		Master Earth Station	Rural Earth Station
Radio frequency band	:	(Up-link: 6GHz;	down-link: 4GHz)
Transmitting power	:	700 W	50 W
Antenna size	:	11 mϕ	4.5 mϕ
Power supply	:	ac non-break	Battery floating

2-4 Economic Comparison

The present worth of annual cost of the two systems is as follows:

Terrestrial Radio System	Domestic Satellite System
22,333	38,205
(124,072)	(212,250)

Unit: Million Japanese Yen

Parenthesized is the equivalent in thousand U.S. Dollars.

Economic comparison by present worth of annual cost demonstrates that terrestrial radio system commands greater advantage by a broad margin.

2-5 All-round Evaluation

Together with system cost evaluation by present worth of annual cost, system performance, system reliability, system extension flexibility and so forth were also evaluated. The result shows that, in all-round evaluation, terrestrial radio system predominates.

2-6 Economic and Financial Evaluations

The Internal Rates of Return (IRR) produced by economic and financial analyses present the reasonable values for project in the infrastructural field.

3. Conclusion and Recommendations

(1) Optimum Transmission System

Conclusion can be drawn in favor of UHF (900 MHz band) terrestrial radio system as optimum transmission system for Rural Long Distance Public Telephone Service.

Regarding modulation system, no much difference can be found between FDM system and PCM system from technical and economic viewpoints.

(2) Re-investigation of Telephone Demand

There is need for re-investigation of telephone demand potential throughout Thailand, including user consciousness survey with respect to telephone utility. This re-investigation must be intensive, and should preferably be carried out by 1989.

And, based on the findings in this re-investigation, the type of telephone service required and the number of telephone circuits required should be reassessed so that they can suit actual needs among the user public.

At present, local government offices in rural districts maintain communications by their in-house system of low performance level. It is desirable that such in-house communication system be changed over to high performance circuits of TOT through negotiations with the Ministry of Interior.

(3) Study of Over-the-Horizon Communication System Application Feasibility

In this Project, the number of telephone circuits required in each rural district is limited. Therefore, for the purpose of system cost economy, intensive study should be made concerning feasibility of rural over-the-horizon UHF system application.

(4) Use of Equipment Shelter

Use of equipment shelters as housing structures for communication equipment inclusive of power plant is desirable. This is to reduce construction cost and civil work period to the possible minimum.

(5) System Maintenance

In the aspect of system maintenance, the existing maintenance organization and practices can be applied to each Maintenance Center by increasing maintenance staffs to some extent when this Project is completed.

At the same time, it is desirable to introduce centralized supervisory system at each Maintenance Center so that it can have troubles at supervised stations under its control automatically recorded.

(6) Reinforcement of Project Implementation Organization

This Project not only covers the whole territory of Thailand but also comprises various divisions of engineering expertises in a long period.

Therefore, in order to ensure satisfactory progress of project implementation, it is recommended to reinforce the organization of project implementation.

(7) Protection by Government Policy

Considering that this Projct constitutes an integral part of the national economic development plan, it is preferable to so arrange that the project implementation will be protected by the Government policy. Such governmental protection includes application of low interest loan(s) and issuance of subsidy from the national treasury.

PART I Overview

PART I Overview

1. Background and Objectives

The Government of Thailand is now carrying out the Fourth National Economic and Social Development Plan (1977 - 1981). This development plan, in its 10-point integral development strategies, envisages the decentralization of basic economic services.

This decentralization policy aims at integration of social overhead capital, such as transportation, communication and electric supply. At the same time, it purports to distribute such social overhead capital among rural areas and thereby assist the rural population in the improvement of their standard of living and the promotion of their production activities.

TOT, for its part, is putting into practice the Economic Development Project of TOT (1977 - 1984) based on the Fourth National Economic and Social Development Plan of the Government of Thailand. The Economic Development Project of TOT embraces as one of its objectives the construction of long distance telephone circuits, including public telephones, in major rural districts without telephones for the purpose of improving the telephone service in rural areas.

As the transmission route for the abovementioned telephone circuits to be constructed, TOT intends to adopt the most economical system out of the undermentioned three systems:

1) UHF (900 MHz band) terrestrial radio system;
2) SHF (11/13 GHz band) terrestrial radio system;
3) Domestic satellite system.

TOT requested the Government of Japan to arrange the feasibility study for these three systems in order to make the best possible selection.

The study, this time, was carried out for a period of approximately five months so as to recommend the optimum transmission system to TOT in connection with its intended telephone service provision in rural districts of Thailand.

2. Outline of Project

At present, principal cities in all parts of Thailand are connected by the trunk microwave links. Cities in rural districts are to be connected by the spur microwave links now being constructed.

Survey Team

However, in the 524 districts (amphoes) throughout the country, which are located at the extreme end of the central administrative organization, the telephone facilities of TOT for both local and long distance services seldom or never exist.

For this reason, TOT plans to construct the long distance telephone networks, including public telephones, in 422 rural districts out of a total of 524 rural districts and to construct mobile telephone exchanges and long distance telephone circuits in 47 other rural districts, in order to improve the telephone service in rural areas.

As the transmission route for such intended long distance telephone networks, TOT is inclined to adopt the terrestrial radio system (UHF) and is already carrying out the preliminary study for the major part of districts where the intended terrestrial radio system will be operated. In the case of adopting the domestic satellite system, TOT contemplates to utilize the satellite launched by Indonesia in 1976. In this case, TOT will have the PALAPA satellite transponder leased.

As the Phase I work, TOT plans to complete by 1984 the construction of long distance telephone networks, including public telephones, in 235 rural districts (out of the previously mentioned 422) and the construction of mobile exchanges and long distance networks in 25 other rural districts.

3. Study Guidelines

As stated previously, TOT has already begun preliminary studies, including field surveys, for the current Project. Furthermore, the funds for Project implementation financing are already available. In view of such concretely set Project implementation schedule, the decision has been made for the following study guidelines:

(1) With respect to the system design, the Study Team carries out technical discussions with TOT to the greatest possible extent and, based on the conclusion agreed upon between both parties, continues to work.

(2) Data, drawings and all related information obtained or produced in the course of the feasibility study are so prepared that TOT can utilize them in the detail design to be executed after the Study Team has submitted its report.

(3) The study work, this time, includes traffic forecast and system design covering as many as nearly 500 stations, and this work has to be completed in a limited period of five months. Therefore, for necessary computations, the extra-large capacity computer and programmable small-sized calculators are used for the purpose of labor saving to the greatest possible extent and, at the same time, to produce accurate basic data which TOT can utilize to the best advantage.

4. Scope of Study

Based on the Scope of Work agreed upon between the Government of Thailand and the Preliminary Study Team, the scope of study consists of the following:

1) Formulation of basic engineering standards as the basic requirement of the current Project.
2) Forecast of telephone circuit demand.

3) Selection of transmission route for terrestrial radio system.
4) Selection of transmission route for domestic satellite system.
5) Detail study of transmission route and related field surveys.
6) Estimation of construction cost and economic comparison for construction plans.
7) Overall evaluation of optimum transmission system plan.
8) Project implementation plan.
9) Economic and financial evaluations.

According to the aforementioned Scope of Work, the number of rural stations, for which the study was to be made, was 422. However, at the subsequent request of TOT, it has been decided that the study be carried out for 47 other stations also where the mobile exchanges are scheduled to be introduced. Thus the total number of stations, for which the study was required, has increased to 469.

PART II Basic Engineering Plan for Rural Long Distance Public Telephone Service

PART II Basic Engineering Plan for Rural Long Distance Public Telephone Service

1. General

For the optimum transmission route plan for Rural Long Distance Public Telephone Service, either the terrestrial radio system or the domestic satellite system can be considered, as is stated in Part IV and Part V.

In this study, the system designs for the said two systems were made in parallel, and the performance comparison and evaluation were carried out for the two systems. This Part II presents the result of study with respect to the basic engineering plan as the basic requirement for the two system designs, from the viewpoint of connection to the national network of Thailand and transmission engineering standard.

Study from the viewpoint of connection to the national network was made in the form of an overview of the basic telephone network plan of Thailand. At the same time, study was also made concerning how the Rural Long Distance Public Telephone Service should be operated.

Study from the viewpoint of transmission engineering standard was made in the form of study of the transmission loss assignment plan and the noise distribution plan, based on the National Transmission Plan and the pertinent CCITT/CCIR recommendations. Transmission criteria for Rural Long Distance Public Telephone Service were thus determined.

2. Connection of Rural Long Distance Public Telephone to National Network

Rural Long Distance Public Telephone Service means the extension of public telephone service to the areas where no telephone service exists. How and in what manner to connect such rural long distance public telephone to the national network is described below, based on the basic telephone network plan of Thailand.

2-1 Telephone Network Configuration in Thailand

2-1-1 Exchange Office Ranks

Telephone exchange offices in Thailand are divided into four ranks as shown in Figure 2-1.

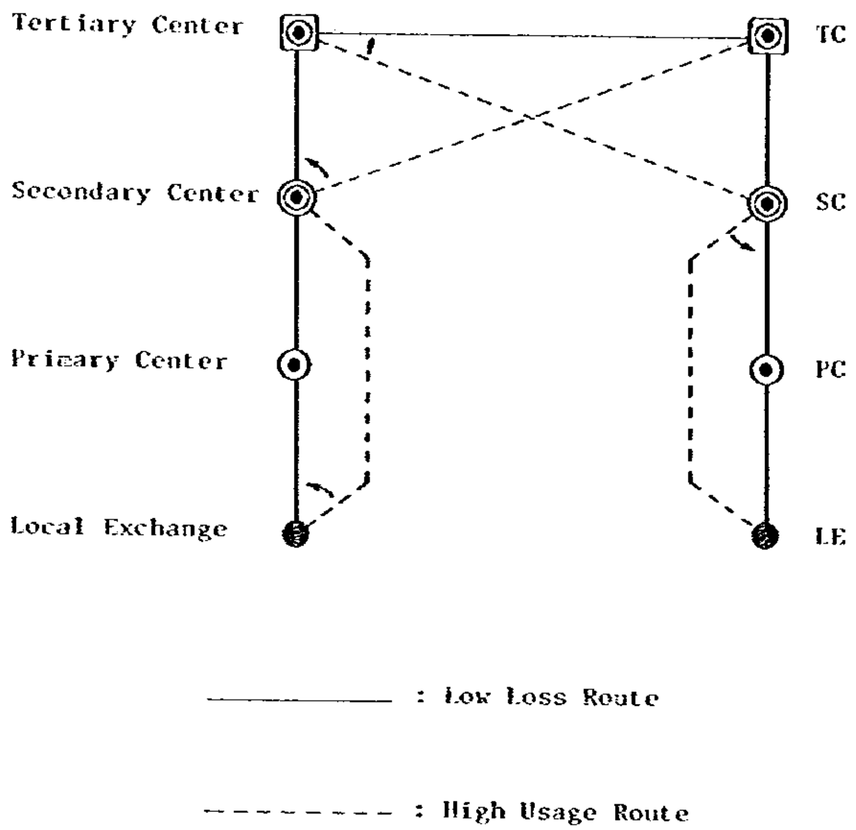


Figure 2-1 Exchange Office Rank & Routing Arrangement

There are four Tertiary Centers (TC) covering the whole of Thailand. Tertiary Areas (TA), however, number five. The Bangkok Metropolitan Area and the Central Area are served by the Bangkok TC, the Northeastern Area by the Nakhon Ratchasima TC, the Northern Area by the Phitsanulok TC, and the Southern Area by the Phun Phin TC.

2-1-2 Routing Arrangement

The long distance circuit is composed of the high usage route and the low loss route as shown in Figure 2-1.

2-1-3 Numbering Plan

The national numbering plan in Thailand is composed as follows:

Trunk prefix .... "0"

Area code .... 1-2 digits

Office code .... 2-3 digits

Subscriber number .... 4 digits

The digit allocations to the Bangkok Metropolitan Area subscribers and the subscribers in other areas are shown below.

For Bangkok Metropolitan Area Subscribers:

"0" + A + BCD + EFGH

- "0": Trunk prefix
- A: Area code
- BCD: Office code
- EFGH: Subscriber number

For Provincial Subscribers:

"0" + AB + CD + EFGH

- EFGH: Subscriber number
- CD: Office code
- AB: Area code
- "0": Trunk prefix

Area Code "2" is allocated to the Metropolitan Area, "3X" to the Central Area, "4X" to the Northeastern Area, "5X" to the Northern Area and "7X" to the Southern Area.

2-1-4 Charging System and Tariff Rate

(1) Charging System

In Thailand, message recording after the introduction of STD (Subscriber Toll Dialing) service will be carried by two methods. One is the detailed billing system. The other is the bulk billing system.

The detailed billing system applies to toll calls to the outside of SA (Secondary Area). The bulk billing system is applicable to other calls.

(2) Tariff Rate

The local call tariff rate is 1.5 Baht per call (as of the end of 1978). Tariff rates applicable to long distance calls are listed in Table 2-1. Regarding the STD service tariff rate, detailed information could not be obtained because STD service is to be put into practice in or after 1980 and the related study is now being made by TOT. Only the relationship between the charging rank and the charging pulse interval has already been determined as shown in the above quoted table.

Table 2-1 Long Distance Call Charge

Manual Service (As of the end of 1978)

Distance (km)	First 3 Minutes (¢)	Additional Minute (¢)
Up to 25	3	1
25 - 50	6	2
50 - 75	9	3
75 - 125	12	4
125 - 200	15	5
200 - 350	18	6
350 - 600	24	8
600 - 900	30	10
Over 900	36	12

(During the night period (7 p.m. to 6 a.m.), each call charge is half the rate listed above.)

STD Service

Rank	Charging Pulse Interval (sec.)
1	15
2	10
3	7.5
4	6
5	5
6	4

(As of the end of 1978, detailed call charge plan for STD service has not yet been decided.)

2-2 Types of Rural Long Distance Public Telephone Service

The conceivable types of Rural Long Distance Public Telephone Service are as follows:

(1) To build simple cottages, each with a telephone booth and a TOT clerk who will respond to the demand for calls from users.

(2) To install STD public telephone sets at main places of each city/town so that the public can use the nearby public telephone set.

(3) To install subscriber telephone sets on the counters of individual merchant houses which have concluded such contract with TOT, so that the shop keepers assume responsibility for telephone service operation and, at the same time, respond to the demand for calls from users.

In the case of (1), if a simple manual switching equipment to cater for calling/called users is installed in the cottage, long distence telephone service to/from several special subscriber premises (such as governmental offices) becomes possible. This signifies the operational flexibility of Rural Long Distance Public Telephone Service. Although the service cost increases in the form of manpower cost and switching equipment cost, such cost increase can possibly be compensated by the increased revenue from the circuit operation efficiency improvement, as well as the increased fringe benefit of telephone service in rural areas.

In this study, however, major emphasis is placed on the types (2) and (3) because these types are better suited for public telephone service.

In the case of (2), the multi-coin box becomes necessary as terminal equipment. In the case of (3), the ordinary telephone set or the multi-coin box as in (2) is the necessary terminal equipment. These telephone set terminals are to be connected by distribution wire to a mid-town radio terminal station or rural earth station.

The connection from an outlying mountain-top radio terminal station is firstly by entrance cable to be terminated at a mid-town distribution box and then by distribution wire.

In case where direct cable from a telephone exchange office is used, the cable is to be terminated at a distribution box and from there the distribution wire is used for connection.

These connection configurations are illustrated in Figure 2-2.

2-2-1 Application of Terrestrial Radio System

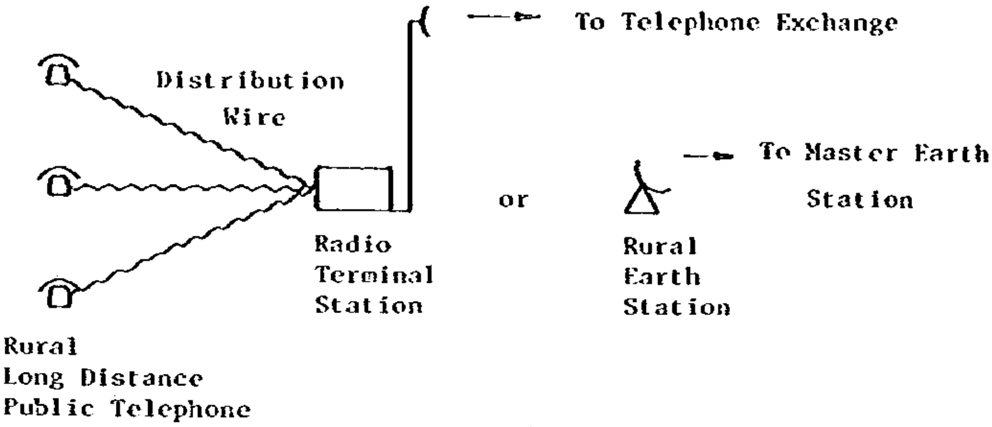
When the terrestrial radio system is applied, the telephone set terminal is to be accommodated in the subscriber terminal of the local exchange. In this case, the radio transmission route can be considered to be a set of subscriber lines. Therefore, the system can be handled in the same way as the general public telephone service.

2-2-2 Application of Domestic Satellite System

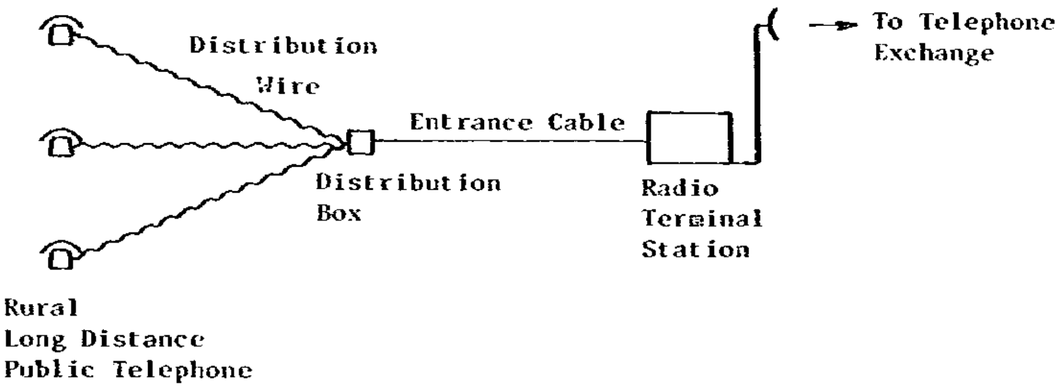
The domestic satellite system is operated by the DAMA system as is explained later. The DAMA system enables the master earth station to hold a kind of switching function. Calls from rural long distance public telephone are collected at the master earth station. Then the calls are connected to their respective destinations through Bangkok TC (Tertiary Center).

Coin collecting pulse transmission via satellite circuit becomes difficult due to speech path noise because the out-band of the speech path frequency band cannot be used so that the in-band has to be used. Therefore, the following method will be adopted:

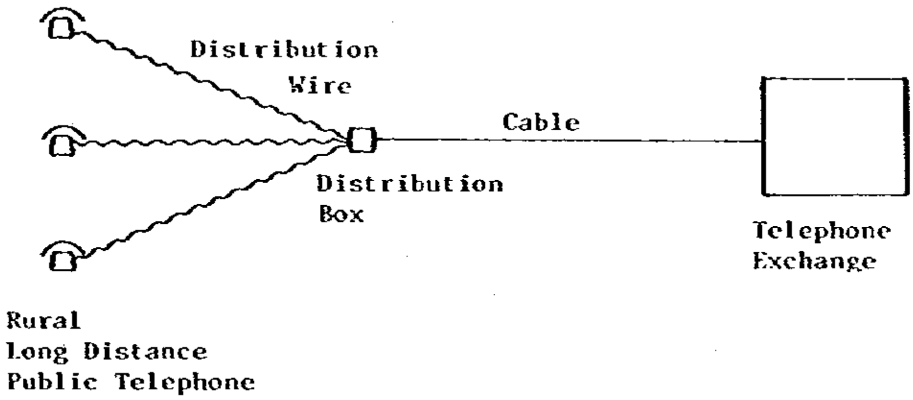
At the master earth station the called party information is received from the rural earth station through the data channel. The tariff rank obtained from analysis of the call destination is sent back to the calling rural earth station where, based on the tariff rank received, the coin collecting pulse is sent out periodically to the public telephone set.



Case - 1



Case - 2



Case - 3

Figure 2-2 Rural Long Distance Public Telephone Service

3. Transmission Loss Assignment Plan

The transmission loss assignment based on the National Transmission Plan of TOT appears in Figure 2-3.

Transmission circuits to be established for this Project are the PC-LE and LE-SUB (Subscriber) circuits. For the transmission loss assignment, the standard value of 4.5 dB (including the intra-office loss of 0.5 dB) for the PC-LE circuit is to be applied to both circuits. In this Project, the transmission circuit comprises the radio link and cable link.

There are two cases with respect to transmission loss assignment. One is the case where the automatic telephone exchange is introduced at LE and the other is the case where the subscriber is directly connected to PC. Even the latter is the case where the exchange (automatic or manual) will be introduced at LE in the future. Although at some stations the exchange will not be introduced in the future either, there are possibilities that even such stations may be equipped with the manual exchange in consideration of circuit operation efficiency. This is why the transmission loss assignment is set at the standard value of 4.5 dB.

1) Transmission Loss for Cable Link

The transmission loss limit common to all kinds of cables can be obtained as follows:

Cable loss + Coil loss + Lo_1 + $Lo_2 \leq 4.5$ dB

where

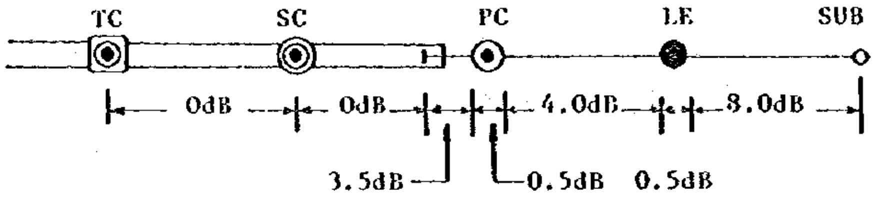
Lo_1 , Lo_2 : intra-office loss (= 0.25 dB)

therefore

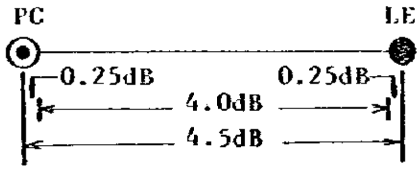
$$\text{Cable loss} \leq 4.5 - (0.4 + 0.25 + 0.25)$$
$$\leq 3.6 \text{ dB}$$

2) Transmission Loss for Radio Link

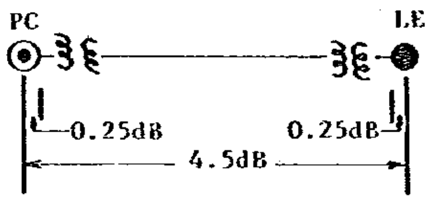
The minimum transmission loss calculated with near-singing condition applied appears in Figure 2-3 (b).



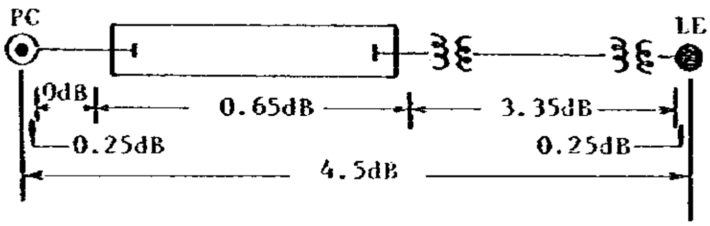
(1) National Transmission Plan



(2) Loss Assignment for PC-LE



(a) Cable Link



(b) Radio Link

Figure 2-3 Transmission Loss Assignment Plan

4. Noise Distribution Plan

With respect to the noise distribution plan on the transmission route, TOT adopts and applies the CCITT-recommended value to the PC-PC circuit. (Refer to Figure 2-4.) However, since the noise standard on the PC-LE circuit could not be known exactly, the Study Team discussed with TOT and reached the decision that the noise be distributed as described below, based on the relevant CCITT recommendation.

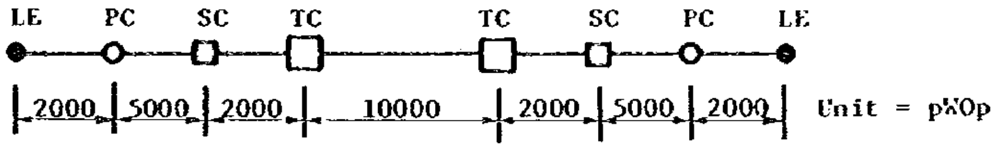


Figure 2-4 Noise Distribution Plan

(1) In the case of terrestrial radio system

1) When the transmission circuit is composed of a single radio path without obstacle to radiowave propagation (or with such obstacle, if any, that can minimize the propagation loss) 2,000 pW0p

2) When the transmission circuit is composed of a single mountain diffraction propagation path 10,000 pW0p

3) When the transmission circuit is composed of two or more radio propagation paths, the value shall not be specified but be determined as the situation requires on condition that the value adopted will not lead to an uneconomical design.

(2) In the case of domestic satellite system

In this case, the PC-LE transmission route consists of LE (rural earth station) — satellite — master earth station — terrestrial radio system (existing microwave system). Since this route includes the existing microwave system where the system performance is not exactly constant, it has been decided not to specify the noise objectives for the existing circuit but to assume a hypothetical reference circuit for the satellite link only and assign the CCIR-recommended value to this latter circuit. (For noise objectives of the satellite communication system, refer to Part IV.)

PART III Circuit Requirements Forecast

PART III Circuit Requirements Forecast

1. General

This PART III presents the result of analysis in regard to the uptrend of telephone demand in the whole rural districts to be taken up in the study, the telephone exchange introduction plan in the case of telephone demand having exceeded a certain limit, the criteria for estimation of required telephone circuits, and the community survey result.

The circuit requirements forecast to prepare for the introduction of Rural Long Distance Public Telephone Service and of mobile exchanges has been carried out by the method described below. The reasons are that the study had to be made for vast territories covering the whole of Thailand and the period of study was limited so that the circuit requirements had to be forecasted not long after the study was commenced. District by district field investigations were omitted.

In the first place, the telephone demand forecasts as of 1984, 1989 and 1994 were made, based on the forecast data prepared by TOT. From the telephone demand potential thus obtained the traffic volume was estimated, taking into consideration the eventual changeover from the Rural Long Distance Public Telephone Service to the ordinary telephone service by introduction of telephone exchange. Furthermore, in accordance with the connection criteria, the circuit requirements were estimated.

On the occasion of site survey and path survey in four areas the community survey was also conducted to the extent the time schedule permitted. The background of telephone demand estimation, telephone exchange introduction plan, traffic forecast and circuit requirements forecast, which were carried out on the basis of relevant TOT data, is presented. Finally, in Chapter 5, the community survey result is clarified and, at the same time, the estimates and forcasts made in Chapter 2 through Chapter 4 are evaluated.

2. Telephone Demand Forecast

Telephone demand forecast in Thailand is undertaken by TOT's Analysis and Forecasting Unit, Planning and Project Division, Office of Planning and Project. "Forecast of Telephone Demand 1977-1990", which the Study Team obtained, is the data published in August 1977. The long term planning of TOT now in progress is based on this data.

The forecast methodology used in this report consists of:

1) Field survey;
2) Questionnaire to local inhabitants;
3) Collection of information from commercial and industrial circles and governmental agencies.

Information collected under Category 3) above includes information from the Housing Corporation concerning the residential land formation plan, infomation from building contractors concerning new office building construction plan, information from the Department of Local Administration and the National Statistical Office concerning the population, number of households, salary distribution and land usage, and information from the National Economic and Social Development Board concerning GNP (Gross National Product) and related affairs.

The forecasts are made, based on the information thus collected and in comparison with the corresponding situations in other countries, as well as considering the behaviors of national politics and economy plus the TOT bond issue for telephone network construction and call tariffs.

The forecasts are made for a total of 10 years, i.e., for each year during the period from 1977 through 1984 plus 1978 and 1990.

The Study Team required the telephone demand expected in the service-in year of 1984 for the Project and the fifth and tenth years after the service-in year, i.e., 1989 and 1994. Since the telephone demand forecast of TOT is presumed to be in full consideration of all factors which will arouse the telephone demand, the demand estimates for the required years are calculated through the analysis of the telephone demand uptrend.

2-1 Analysis of Telephone Demand Uptrend

The study of "Forecast of Telephone Demand 1977-1990" published by TOT leads to a finding that the telephone demand uptrend can be divided into seven steps. The seven steps are as follows:

1) As seen in Figure 3-1, the initial low rate increase (r_1) is followed by the high rate increase (r_2)
.... ($r_1 < r_2$)

2) As seen in Figure 3-2, the initial low rate increase (r_1) is followed firstly by the medium rate increase (r_2) and then by the high rate increase (r_3)
.... ($r_1 < r_2 < r_3$)

3) As seen in Figure 3-3, the initial high rate increase (r_1) is followed firstly by the low rate increase (r_2) and then by the high rate increase (r_3) again
.... ($r_1 > r_2 < r_3$)

4) As seen in Figure 3-4, the initial high rate increase (r_1) is followed firstly by the low rate increase (r_2), then by the medium rate increase (r_3) and finally by the high rate increase (r_4)
.......($r_1 > r_2 < r_3 < r_4$)

5) As seen in Figure 3-5, the fixed rate increase continues.

6) As seen in Figure 3-6, the initial high rate increase (r_1) is followed by the low rate increase (r_2)
.... ($r_1 > r_2$)

7) As seen in Figure 3-7, the initial low rate increase (r_1) is followed firstly by the high rate increase (r_2) and then by the low rate increase (r_3) again
.... ($r_1 < r_2 > r_3$)

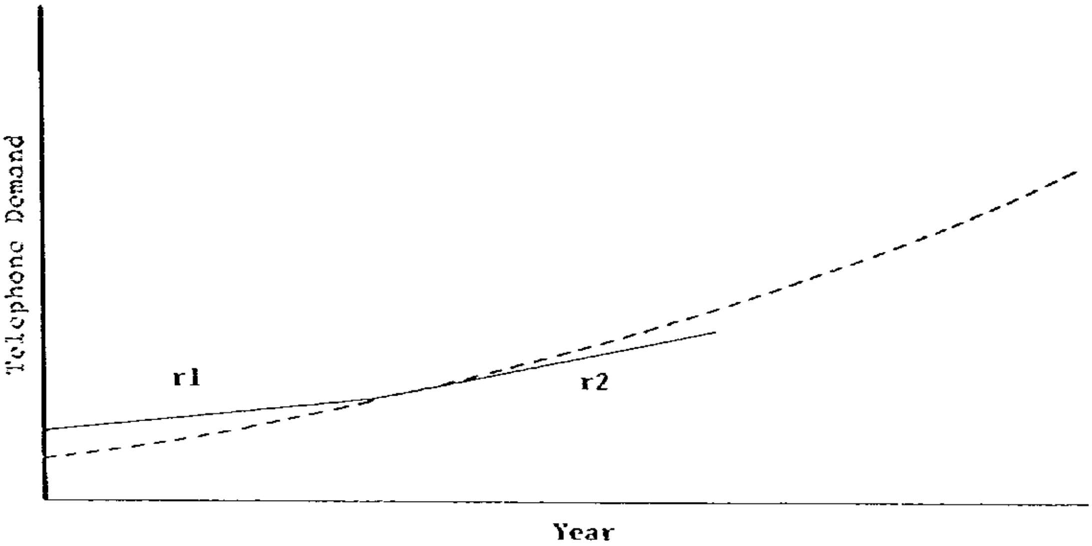


Figure 3-1 Telephone Demand Uptrend (E1)

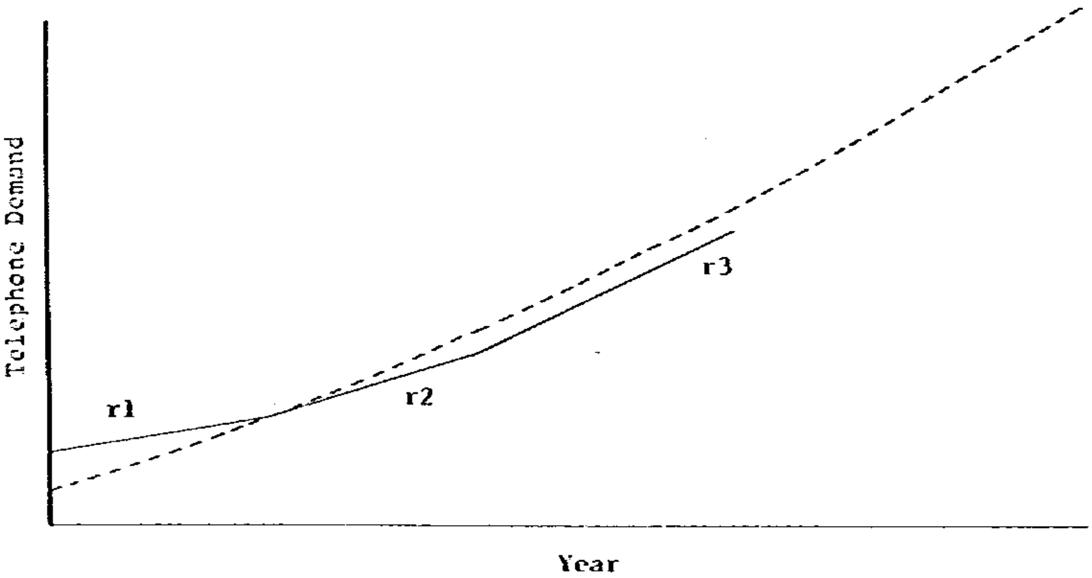


Figure 3-2 Telephone Demand Uptrend (E2)

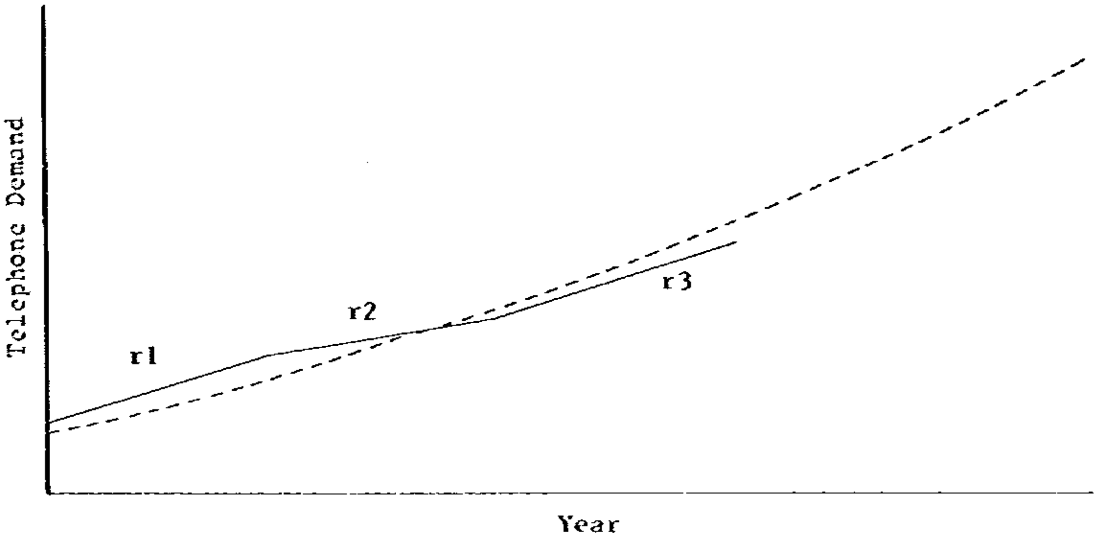


Figure 3-3 Telephone Demand Uptrend (E3)

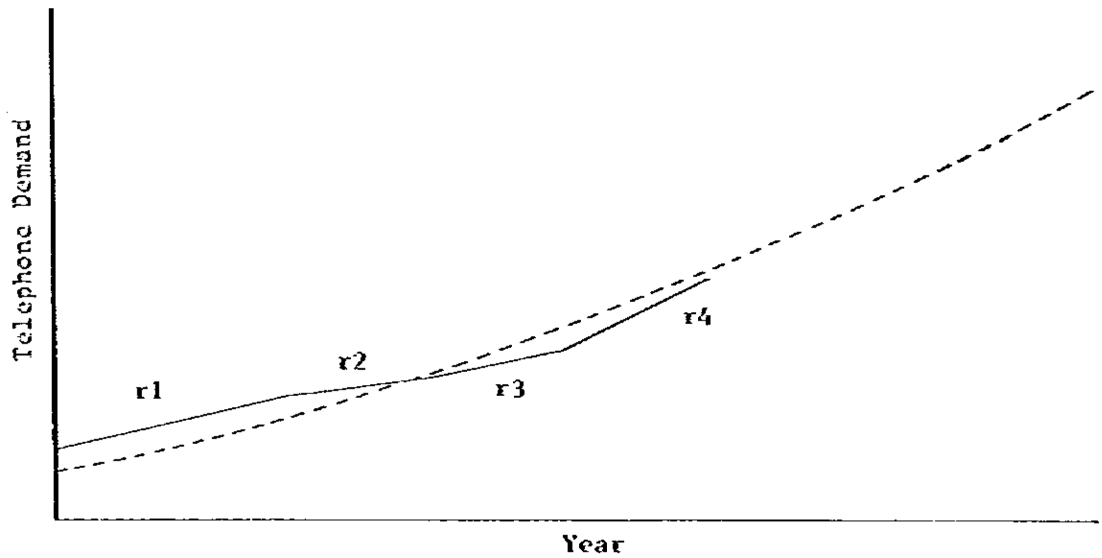


Figure 3-4 Telephone Demand Uptrend (E4)

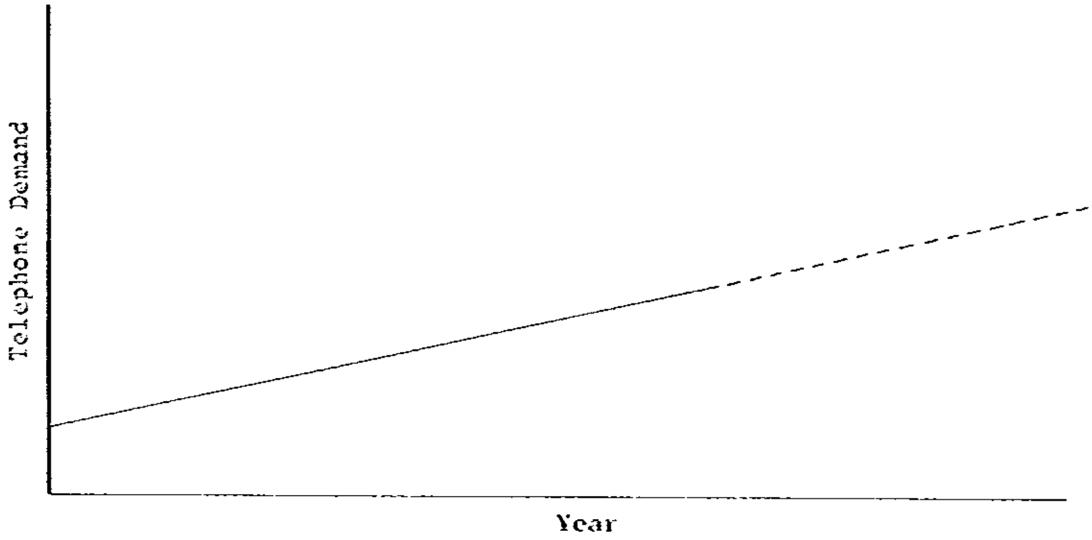


Figure 3-5 Telephone Demand Uptrend (L1)

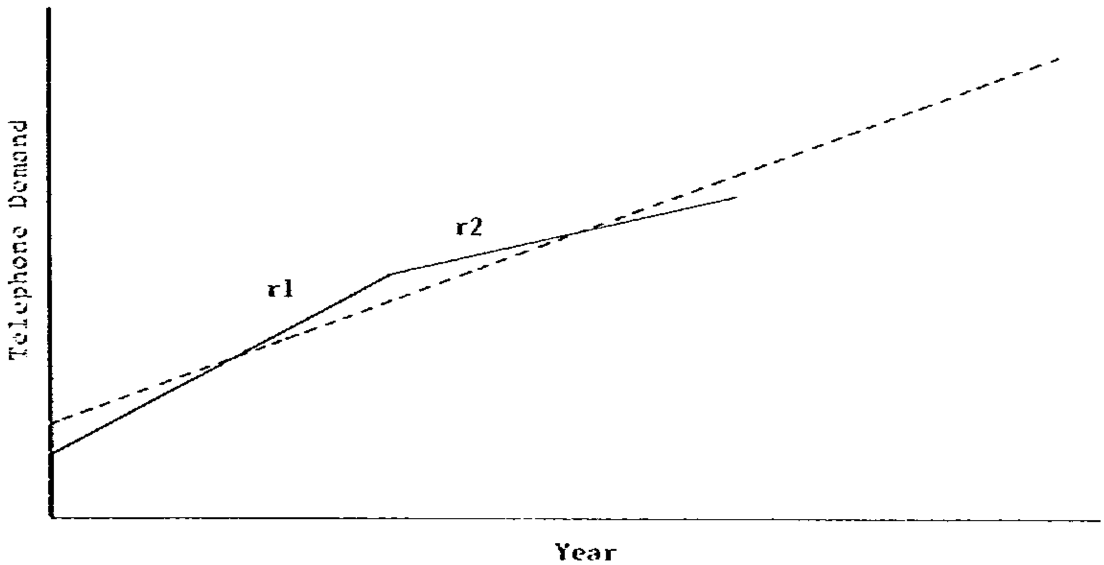


Figure 3-6 Telephone Demand Uptrend (L2)

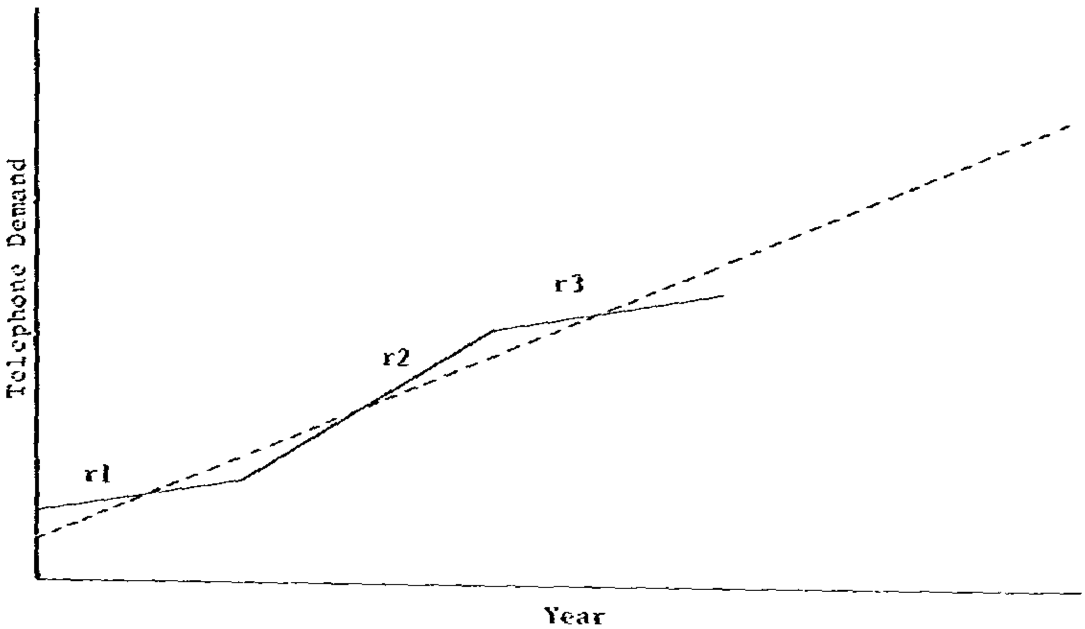


Figure 3-7 Telephone Demand Uptrend (L3)

2-2 Telephone Demand Forecast

The telephone demand in 1984 is set at the value used in "Forecast of Telephone Demand 1977-1990" published by TOT. The demand estimates for years of 1985, 1986, 1988 and 1989 are not shown in the TOT publication so that the demand estimate for the year of 1989 is calculated from the demand uptrend mentioned in Paragraph 2-1 and the demand estimates for 1984, 1987 and 1990.

As regards the telephone demand forecast for 1994, two kinds of regression analysis are made for each of the seven steps of demand uptrend. More precisely:

1) In case the demand uptrend is of four kinds as shown in Figures 3-1 to 3-4, the demand in 1994 is forecasted by means of exponential regression.

2) In case the demand uptrend is of three kinds as shown in Figures 3-5 to 3-7, the demand in 1994 is forecasted by means of linear regression.

Exponential regression and linear regression were conducted by the method of least squares. For all regressions, the decision factor was greater than 0.95.

As regards the demand estimates in the areas not covered by the telephone demand forecast of TOT, the rate of increase in 1989 as compared with 1984 and the rate of increase in 1994 as compared with 1984 were obtained by referring to the telephone demand uptrend in the whole of Thailand except the Bangkok Metropolitan area. The increase rates thus obtained for the years 1989 and 1994 were respectively multiplied to the demand estimate for 1984.

Examples of demand estimates by areas for the years of 1984, 1989 and 1994 appear in Table 3-1. In the Remarks column are shown the demand uptrends by areas. E1, E2, E3 and E4 correspond to Figures 3-1 to 3-4 and L1, L2 and L3 to Figures 3-5 to 3-7. In case the demand uptrend could not be known from TOT data, the Provincial average increase rate was used for those areas.

Table 3-1 Telephone Demand Forecast

Code	Name	1984	1989	1994	Remarks
32 01 00	Petcha Buri				
01	Nong Ya Plong	60	100	180	E1
02	Ban Lat	230	360	640	E1
03	Khao Yoi	230	340	500	E4
04	Ban Laem	210	310	500	E1
05	Tha Yang*	360	510	770	E1
06	Cha Am*	390	600	900	E2
32 07 00	Ratcha Buri				
01	Suan Phung	60	85	110	L1
02	Wat Phleng	100	170	240	E2
03	Bang Phae	290	470	840	E2
04	Pak Tho*	260	390	640	E1
05	Chom Bung*	340	520	930	E1
32 15 00	Prachuap Khiri Khan				
01	Bang Saphan Noi	85	135	250	E1
02	Bang Saphan	180	340	610	E2
03	Kui Buri	290	440	790	E1
34 01 00	Samut Sakhon				
01	Ban Phaeo*	290	440	790	E1
34 04 00	Samut Song Khram				
01	Bang Khonthi	150	230	350	E1
02	Am Pha Wa*	340	550	890	E2
34 07 00	Nakhonpathom				
01	Bang Len	290	440	790	E1
02	Don Tum	340	550	890	E2
03	Nakhon Chaisi*	470	640	820	L3
04	Kam Phaeng Saen*	340	520	930	E1

NOTE:

1. Site name marked with * shows the site where mobile exchange is to be introduced at initial stage.
2. E1 - E4 & L1 - L3 in Remarks column show kinds of telephone demand uptrends. Refer to Paragraph 2-2, Telephone Demand Forecast.

3. Telephone Exchange Introduction Plan

According to the TOT policy, Rural Long Distance Public Telephone Service will be introduced in the telephoneless districts if the demand in 1984 does not exceed 400 telephones, whereas ordinary telephone service with telephone exchange will be provided in no-telephone districts should the demand exceed 400 telephones.

This study also includes the telephone exchange introduction plan aimed at the realization of transmission system that satisfies required transmission capacity even if telephone exchange is introduced among the 422 target districts of Rural Long Distance Public Telephone Service, based on the telephone demand forecast made in the preceding Chapter 2.

Years in which telephone exchange will be introduced are set to be 1989 and 1994, i.e., fifth and tenth years after 1984 when Rural Long Distance Public Telephone Service is scheduled to come into being.

Telephone exchange to be introduced in 1989 is to satisfy the estimated demand for 400 telephones or more, the same as envisaged by TOT at present.

Telephone exchange to be introduced in 1994 is to satisfy the estimated demand for 200 telephones or more in consideration of quantitative and qualitative improvement of telephone service as the result of the advancement of national economy.

More specifically, in 1989, telephone exchange will be introduced in 18 districts out of the 422 districts where Rural Long Distance Public Telephone Service is to be provided in 1984, and, in 1994, in further 187 districts. By this arrangement, ordinary telephone service by use of telephone exchange will be put into practice in those districts.

In Table 3-2, examples of exchange introduction plan by years by districts are presented in the number of telephone exchange terminals. The number of terminals mentioned here does not specify the number of terminals to be installed for the purpose of introducing telephone exchange but is intended to determine the transmission route capacity.

Table 3-2 Exchange Introduction Plan

Code	Name	1984	1989	1994
32 01 00	Petcha Buri			
01	Nong Ya Plong	R	R	R
02	Ban Lat	R	R	1000
03	Khao Yoi	R	R	800
04	Ban Laem	R	R	800
05	Tha Yang*	400	800	1200
06	Cha Am*	400	1000	1400
32 07 00	Ratcha Buri			
01	Suan Phung	R	R	R
02	Wat Phleng	R	R	400
03	Bang Phae	R	1000	1400
04	Pak Tho*	400	800	1000
05	Chom Bung*	400	1000	1400
32 15 00	Prachuap Khiri Khan			
01	Bang Saphan Noi	R	R	400
02	Bang Saphan	R	R	1000
03	Kui Buri	R	800	1200
34 01 00	Samut Sakhon			
01	Ban Phaeo*	400	800	1200
34 04 00	Samut Song Khram			
01	Bang Khonthi	R	R	600
02	Am Pha Wa*	600	1000	1400
34 07 00	Nakhonpathom			
01	Bang Len	R	800	1200
02	Don Tum	R	1000	1400
03	Nakhon Chaisi*	600	1000	1400
04	Kam Phaeng Saen*	400	1000	1400

NOTE:

1. Site name marked with * shows the site where mobile exchange is to be introduced at initial stage.
2. "R" shows the Rural Long Distance Public Telephone Service.
3. Figure shows the number of exchange terminals assumed for calculation of transmission capacity according to telephone demand forecast.

In other words, the number of terminals mentioned is the number of terminals that matches the estimated telephone demand five years after the introduction of telephone exchange. And this is to secure the sufficient transmission route capacity on the presumption that the number of terminals to be installed on telephone exchange introduced still remains undecided.

Therefore, the number of telephone exchange terminals given for the year 1989 is the number of terminals that matches the telephone demand estimate for 1994 or five years after 1989, and the number of terminals given for the year 1994 is the number of terminals that matches the telephone demand estimate for 1999 or five years after 1994.

The telephone demand estimate for the year of 1999, instead of being forecasted district-wise, has been obtained by multiplying to the demand forecast for the whole of Thailand except Bangkok the rate of increase of 1.5 times for the period from 1994 to 1999.

As for the districts where the mobile exchanges are to be introduced in 1984, the number of terminals to be installed at the time the exchanges are introduced has been determined but the plan for subsequent increase of terminals remains undecided. Hence, the number of terminals installed is shown on the assumption that the terminals will be increased in 1989 and 1994.

4. Estimation of Telephone Circuits Required

4-1 Estimation Criteria for Telephone Circuits Required for Rural Long Distance Public Telephone Service

For Rural Long Distance Public Telephone Service, only the originating traffic from public telephones has to be considered. However, it is difficult to know to what extent the public telephones installed in the districts where no telephone service is provided will be utilized.

Therefore, on the presumption used by TOT to the effect that for each unit of the demand for 50 telephones the originating traffic of 0.5 Erl. takes place, the district by district traffic estimations are carried out. Table 3-3 presents the traffic volume breakdown by disticts.

In Rural Long Distance Public Telephone Service, the number of circuits is equal to the number of public telephones to be installed, so that the number of circuits required is estimated by the delay system. For calculation, Erlang C Formula is used. The probability of delay is set at 0.1.

Table 3-5 shows the relationships among telephone demand, originating traffic volume, and number of circuits required. The number of telephone circuits required by districts, estimated from Table 3-5, can be found in Table 3-4.

4-2 Estimation Criteria for Telephone Circuits Required for Ordinary Telephone Service by Use of Telephone Exchange

Telephone demand in the areas where telephone exchange will be introduced can be expected mainly from governmental and related offices and the sectors of commerce and industry where the rate of telephone utilization is considered to be high. Demand for residential house telephones can seldom be expected. Therefore, the originating and terminating traffic estimation is based on the assumption that the calling rate per subscriber is 0.1 Erl. (Originating calling rate: 0.05 Erl.; terminating calling rate: 0.05 Erl.)

The traffic volume from the districts with telephone exchange introduced to their parent Primary Centers and vice versa is assumed to be 20% of the total originating and terminating traffic volume, and on this assumption the number of circuits required has been estimated. The traffic volume between the districts with telephone exchange introduced and their parent Primary Centers is given in Table 3-3.

Also used in the estimation of the number of circuits required is the assumption that service be on lost call cleared basis. Erlang B Formula is used at the probability of loss set to 0.01. Table 3-6 presents the relationships among the number of telephone exchange terminals, the total originating and terminating traffic volume, the outgoing and incoming traffic volume to/from Primary Centers, and the number of circuits required estimated by the conditions mentioned above. The number of circuits required is given in Table 3-4.

Table 3-3 Telephone Traffic Forecast (OG/IC in Erl.)

Code	Name	1984	1989	1994
32 01 00	Petcha Buri			
01	Nong Ya Plong	1.0/ -	1.0/ -	2.0/ -
02	Ban Lat	2.5/ -	4.0/ -	10.0/10.0
03	Khao Yoi	2.5/ -	3.5/ -	8.0/8.0
04	Ban Laem	2.5/ -	3.5/ -	8.0/8.0
05	Tha Yang*	4.0/4.0	8.0/8.0	12.0/12.0
06	Cha Am*	4.0/4.0	10.0/10.0	14.0/14.0
32 07 00	Ratcha Buri			
01	Suan Phung	1.0/ -	1.0/ -	1.5/ -
02	Wat Phleng	1.0/ -	2.0/ -	4.0/4.0
03	Bang Phae	3.0/ -	10.0/10.0	14.0/14.0
04	Pak Tho*	4.0/4.0	8.0/8.0	10.0/10.0
05	Chom Bung*	4.0/4.0	10.0/10.0	14.0/14.0
32 15 00	Prachuap Khiri Khan			
01	Bang Saphan Noi	1.0/ -	1.5/ -	4.0/4.0
02	Bang Saphan	2.0/ -	3.5/ -	10.0/10.0
03	Kui Buri	3.0/ -	8.0/8.0	12.0/12.0
34 01 00	Samut Sakhon			
01	Ban Phaeo*	4.0/4.0	8.0/8.0	12.0/12.0
34 04 00	Samut Song Khram			
01	Bang Khonthi	1.5/ -	2.5/ -	6.0/6.0
02	Am Pha Wa*	6.0/6.0	10.0/10.0	14.0/14.0
34 07 00	Nakhonpathom			
01	Bang Len	3.0/ -	8.0/8.0	12.0/12.0
02	Don Tum	3.5/ -	10.0/10.0	14.0/14.0
03	Nakhon Chaisi*	6.0/6.0	10.0/10.0	14.0/14.0
04	Kam Phaeng Saen*	4.0/4.0	10.0/10.0	14.0/14.0

NOTE:

Site name marked with * shows the site where mobile exchange is to be introduced at initial stage.

Table 3-4 Telephone Circuit Requirements

Code	Name	1984	1989	1994	Planned Earth Station
32 01 00	Petcha Buri				
01	Nong Ya Plong	3	3	5	S*
02	Ban Lat	6	8	36	
03	Khao Yoi	6	7	30	S
04	Ban Laem	6	7	30	S
05	Tha Yang*	20	30	40	
06	Cha Am*	20	36	46	
32 07 00	Ratcha Buri				
01	Suan Phung	3	3	4	S*
02	Wat Phleng	3	5	20	
03	Bang Phae	6	36	46	
04	Pak Tho*	20	30	36	
05	Chom Bung*	20	36	46	
32 15 00	Prachuap Khiri Khan				
01	Bang Saphan Noi	3	4	20	S
02	Bang Saphan	5	7	36	
03	Kui Buri	6	30	40	
34 01 00	Samut Sakhon				
01	Ban Phaeo*	20	30	40	
34 04 00	Samut Song Khram				
01	Bang Khonthi	4	6	26	S
02	Am Pha Wa*	26	36	46	
34 07 00	Nakhonpathom				
01	Bang Len	6	30	40	
02	Don Tum	7	36	46	
03	Nakhon Chaisi*	26	36	46	
04	Kam Phaeng Saen*	20	36	46	

NOTE:

1. Number of circuits indicated here shows the total requirements for outgoing and incoming traffic.
2. Site name marked with S* in Planned Earth Station column shows the site where satellite system is considered even after 1994.
3. Site name marked S in Planned Earth Station column shows the site where satellite system is considered before 1994 and then replaced by terrestrial system.

Table 3-5 Circuit Requirements Standard for Rural Long Distance Public Telephone Service

Telephone Demand	OG Traffic in Erl.	Circuit Requirements
0 - 50	0.5	2
51 - 100	1.0	3
101 - 150	1.5	4
151 - 200	2.0	5
201 - 250	2.5	6
251 - 300	3.0	6
301 - 350	3.5	7
351 - 400	4.0	8

OG : Outgoing

Table 3-6 Circuit Requirements Standard for Telephone Exchange

Line Capacity	ORG/TRM Traffic in Erl.	OG/IC Traffic in Erl. to/from PC	Circuit Requirements Total (OG + IC)
200	10.0/10.0	2.0/2.0	14 (7 + 7)
400	20.0/20.0	4.0/4.0	20 (10 + 10)
600	30.0/30.0	6.0/6.0	26 (13 + 13)
800	40.0/40.0	8.0/8.0	30 (15 + 15)
1000	50.0/50.0	10.0/10.0	36 (18 + 18)
1200	60.0/60.0	12.0/12.0	40 (20 + 20)
1400	70.0/70.0	14.0/14.0	46 (23 + 23)
1600	80.0/80.0	16.0/16.0	50 (25 + 25)
1800	90.0/90.0	18.0/18.0	56 (28 + 28)
2000	100.0/100.0	20.0/20.0	60 (30 + 30)
2200	110.0/110.0	22.0/22.0	64 (32 + 32)

ORG : Originating

TRM : Terminating

OG : Outgoing

IC : Incoming

5. Community Survey Result and Forecast Result Evaluation

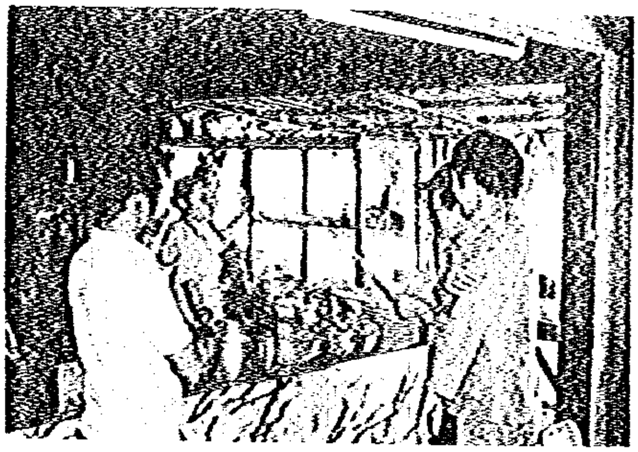
At the beginning, it must be noted that the community survey was conducted when time was available during the field survey. The objective was to collect reference data for the correct evaluation of various parameters required for the circuit requirements forecast.

The community survey was made by two methods. One was to collect information of general nature. The other was to sound views among the sectors where the telephone demand was considered to be relatively large. Those sectors included shopkeepers, restauranteurs and banking business managers.

5-1 Community Survey

Information of general nature was collected at District Offices and Post & Telegraph Offices, using the format shown in Table 3-7. The sounding of views concerning the telephone service was carried out by asking the following questions:

1) At present, no telephone system exists here. By what means do you communicate with people in the Provincial center and Metropolitan area?
2) When telephone service is commenced, do you utilize it?
3) For what purpose do you use the telephone?
4) When telephone service - not ordinary telephone service but Rural Long Distance Public Telephone Service - is commenced, do you utilize it?



Interview at Restaurant in Chom Thong District

As mentioned previously, time available for the community survey was limited so that a full survey could not be made. The collected

Table 3-7 Community Survey Format

(1) Population

(2) Number of families

(3) Number of houses

(4) Number of shops (including restaurants)

(5) Number of business offices, hotels

- Governmental offices
- Police stations
- Military stations
- Private company offices
- Hotels, and number of rooms
- Banks

(6) Number of factories

(7) Rural Development Plan

- Road
- Housing
- Factory
- Irrigation
- Electric power supply
- Potable water supply

(8) Number of mails delivered and collected per day

(9) Number of telegraphs sent and received per day

(10) Percentage of people who own TV set

(11) Number of cars

(12) Number of motor bicycles

(13) Existing private or governmental use telecommunication facilities

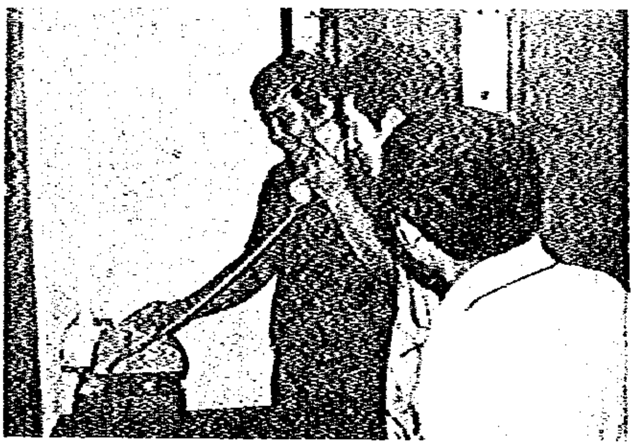
views, though not numerically sufficient as samples for analysis, are considered to have reflected the trend of thinking among inhabitants toward telephone service. The survey result is summarized in Table 3-8. The points clarified by this survey are as follows:

1) In the areas where banks exist, economic activities are brisk. Telephone demand is also large.

2) The major part of telephone demand originates from business fields. Demand for residential house telephones is scarce.

3) Governmental offices, such as District Offices, hold the in-house communication system. However, the system performance is inferior in many cases. For those offices, therefore, telephone service of good performance provided by TOT is necessary.

4) For Rural Long Distance Public Telephone Service, the majority opinion considers it to be better than no telephone. However, since telephones are to be utilized primarily to gain convenience in doing business, there is a strong request for ordinary telephone service instead of Rural Long Distance Public Telephone Service. For, the former can be used whenever necessary and it can also handle terminating calls from other parties.



People who desire to have telephone service opened are people who, at present, proceed to the nearby telephone office by car, autobicycle or bus every time they want to use telephones.

Table 3-8 Summary of Community Survey (1/3)

Site Name (Code)	Population	Families	Houses	Shops	Offices NOTE 1	Rural Develop Plans	Mails IN/OUT	Telegraphs IN/OUT	TV Set (%) NOTE 2	Cars	Motor-Cycles	Private Telecom. Systems	Interviewed Persons
Bang Ban (351601)	8,655	1,500	1,515	48	7	6	U.A.	U.A.	4.0	60	130	2	U.A.
Lat Bua Luang (351602)	1,690	400	342	57	6	3	200 NOTE 3	10 NOTE 3	25.0	15 NOTE 4	20	3	1
Maharat (351603)	2,859	551	U.A.	45	9	1	30/30	5/7	14.5	30	40	3	1
Nakhon Luang (351604)	7,325	1,500	1,340	35	9	8	180 NOTE 3	10 NOTE 3	50.0	(30%) NOTE 2	(30%) NOTE 2	4	1
Ban Phraek (351605)	2,561	475	U.A.	40	7	U.A.	50/85	2/2	80.0	(5%) NOTE 2	(90%) NOTE 2	3	2
Bangpa Han (351606)	2,414	603	412	88	8	2	200/50	6/3	32.8	41	60	3	U.A.
Bang Sai (351607)	6,776	1,315	U.A.	84	7	1	70/30	2/2	95.0	10 NOTE 5	50	4	1
Phak Hai (351608)	19,901	2,047	2,014	120	17	3	300/100	10/10	34.2	40	55	3	1
U-Thai (351609)	3,105	754	511	76	7	8	120 NOTE 3	4 NOTE 3	20.0	40	100	3	1
Khon Buri (442101)	8,124	1,269	U.A.	462	31	6	400/500	16/15	80.0	300	1,269	3	U.A.
Prathai (442102)	4,706	746	681	57	12	3	300/300	10/10	100.0	200 NOTE 6	1,500 NOTE 6	3	1
Non Thai (442103)	5,055	1,615	847	63	16	7	300/250	3/3	10.0	40	100	5	1
Khong (442104)	3,000-6,000	U.A.	U.A.	200	10	U.A.	200/150 -160	4/6	20.0	10-15	100	2	1
Dan Khun That (442106)	5,321	700	U.A.	150	28	1	360/320	15/10	80.0	(25%) NOTE 2	(80%) NOTE 2	4	4
Khan Thale So (442107)	3,199	511	U.A.	40	42	U.A.	100/100	5/3	20.0	(10%) NOTE 2	(30%) NOTE 2	4	U.A.

U.A. : Unavailable

Table 3-8 Summary of Community Survey (2/3)

Site Name (Code)	Population	Families	Houses	Shops	Offices NOTE 1	Rural Develop Plans	Mails IN/OUT	Telegraphs IN/OUT	TV Set (%) NOTE 2	Cars	Motor-Cycles	Private Telecom. Systems	Interviewed Persons
Kham Sakae Saeng (442108)	6,564	836	U.A.	100	12	2	90/65	6/6	15.0	(25%) NOTE 2	(25%) NOTE 2	3	U.A.
Huai Thalaeng (442109)	4,228	775	U.A.	110	17	4	170/150	6-7 NOTE 3	6.5	20	120	4	1
Saeng Sang (442110)	3,143	478	U.A.	100	9	6	200/100	1 NOTE 3	20.0	50	150	4	U.A.
Sung Noeng (442111)	8,076	1,459	U.A.	108	14	2	300/300	10/10	80.0	(10%) NOTE 2	(30%) NOTE 2	5	3
Chakkarat (442112)	4,019	500	374	250	8	5	200/150	7/3	60.0	150	450	3	1
Non Sung (442113)	7,968	1,276	U.A.	100-150	21	U.A.	U.A.	U.A.	7.8	50	100	2	2
Omkoi (531302)	2,000	270	U.A.	5	4	2	U.A.	U.A.	NONE	7-8	NONE	2	U.A.
Doi Tao (531303)	11,279	2,496	2,907	37	11	5	150/100	13 NOTE 3	0.4	16	100	5	2
San Sai (531305)	12,595	U.A.	U.A.	20	6	5	200/300	7/7	20.0	(20%) NOTE 2	(60%) NOTE 2	1	1
Doi Saket (531306)	9,000	2,200	U.A.	30	16	4	400/250	10 NOTE 3	60.0-70.0	(10%) NOTE 2	(90%) NOTE 2	2	3
Mae Taeng (531308)	6,000	1,200	U.A.	6	7	1	300/200	10/10	50	150	1,600	2	1
Chiang Dao (531309)	7,973	1,263	1,148	26	17	15	300 NOTE 3	8/8	2.7	21	105	2	1
Sa Moeng (531310)	3,417	616	U.A.	5	6	12	15 NOTE 3	1 NOTE 3	NONE	25	65	3	-
Mae Rim (531311)	10,486	1,900	2,012	92	12	3	1,200 NOTE 3	30 NOTE 3	10.0	100	300	3	1
Hot (531312)	4,506	1,000	728	71	15	4	250-300 NOTE 3	20 NOTE 3	2.0	100	300	4	2

U.A. : Unavailable

Table 3-8 Summary of Community Survey (3/3)

Site Name (Code)	Population	Families	Houses	Shops	Offices NOTE 1	Rural Develop Plans	Mails IN/OUT	Telegraphs IN/OUT	TV Set (%) NOTE 2	Cars	Motor-Cycles	Private Telecom. Systems	Interviewed Persons
Hang Dong (531313)	18,766	9,388	U.A.	20	8	2	230/200	10/10	80.0-90.0	(20%) NOTE 2	(90%) NOTE 2	2	1
Mae Chaem (531314)	2,460	300	U.A.	22	7	5	120 NOTE 3	7-8 NOTE 3	NONE	20	160	3	U.A.
San Kam Phaeng (531315)	16,746	2,693	U.A.	141	11	U.A.	700/400	30/20-30	80.0	(15%) NOTE 2	(90%) NOTE 2	3	2
San Patong (531316)	6,144	1,460	U.A.	50	9	U.A.	800/900	25/25	80.0	U.A.	U.A.	3	2
Chom Thong (531317)	11,834	2,200	U.A.	258	32	5	500/500	30/30	5.5	(10%) NOTE 2	(90%) NOTE 2	3	3
Don Sak (771106)	10,500	1,500	1,400	1,200	9	4	220 NOTE 3	8 NOTE 3	30.0	100	1,100	3	U.A.
Ko Phangan (771109)	5,399	950	U.A.	20	7	1	U.A.	U.A.	0.7	5	200	4	U.A.
Ko Samui (771113)	6,084	1,137	1,018	U.A.	25	U.A.	U.A.	U.A.	26.4	70	500	5	U.A.

Note 1 : Governmental offices and private company offices including factories.
Note 2 : Percentage to number of houses.
Note 3 : Total number of IN and OUT.
Note 4 : Number of boats is 30.
Note 5 : Number of boats is 1,300.
Note 6 : Number in whole district.
U.A. : Unavailable.

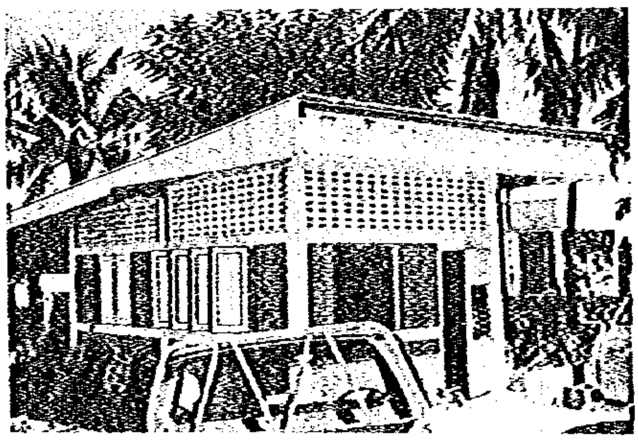
Following is the introduction of rural long distance public telephones in service at San Kam Phaeng and San Patong in Chiangmai area. This service was witnessed during the community survey.

At San Kam Phaeng, two rural long distance public telephones are installed, one in the District Office and the other in the market. Both these public telephones are accommodated in the toll board of Chiangmai Exchange Office by the telegraph circuit of the Post & Telegraph Office.

System performance is extremely poor because the telegraph circuit is utilized so that, for both public telephones, the rate of use is not high: reportedly four times per day on the average. However, on the days when the system performs well, the rate of utilization is said to reach as many as 100 times per day. The tariff rate is two Baht per call regardless of the duration of call.

The public telephone at San Patong is operated by 150 MHz single channel radio system. One male operator is in charge of system operation. This public telephone system is installed in a cottage which, together with an antenna tower, is located in the leased land of TOT.

In the cottage are the reception desk and the telephone booth. The tariff rate here is the same as that for general toll calls or, more precisely, the basic rate for the first three minutes and the additional rate for each additional one minute. Payment is made to the operator at the end of each call.



Telephone Office in San Patong District

System performance is not exactly good because of no small noise and transmission loss. A trial call to Bangkok, however, was devoid of special difficulty.

The average rate of utilization is 30 times per day. One half of calls is to Chiangmai and the other half to Bangkok.

5-2 Forecast Result Evaluation

As seen in Table 3-8, the community survey carried out this time ended to a large extent in the collection of general information. However, from such general information could be obtained more or less contributory data to the forecasts made in Chapters 2 through 4 of this Part III on the basis of TOT data. Following is the evaluation of the forecast results, based on the community survey findings.

The community survey was made at 38 sites. For at least six sites out of the 38 sites, where Rural Long Distance Public Telephone Service is expected to be introduced, the forecast results are considered to be rather too conservative.

The six sites are as follows:

1) Ayutthaya Area - Phak Hai
2) Nakhon Ratchasima Area - Khon Buri, Dan Khun That, Sung Noen
3) Chiangmai Area - San Sai, Mae Rim

The fact common to five sites excluding San Sai of Chiangmai area is that the economic activities are considerably brisk. At each of these five sites, two banks exist and merchant houses number approximately 100. The volume of mails and telegraphs handled at these five sites is much larger than at other sites.

Community survey interviewees expressed strong desire for early construction of telephone system, attesting to a considerably large telephone demand potential.

San Sai in Chiangmai area is a town with a large number of big income earners. According to a report, it is a town second only to Chiangmai in the amount of tax payment. Near the town is a university. It is reported that at least 100 residents desire to have telephones installed for personal use. Therefore, in this town, large telephone demand can be expected from the different angle from the five sites earlier mentioned.

Contrarily, at some of mountain districts in Chiangmai area, telephone demand is considered to be not so large as forecasted. Omkoi is one of such sites.

The District Offices maintain their in-house radio communication system. However, in view of the poor system perfomance of such system and the ever-increasing information traffic volume on the system, it is worth consideration to replace the system with TOT's leased circuit or the telephone system. This is all the more important from the viewpoint of preventing the uneconomical dual operation of the existing system and the projected Rural Long Distance Public Telephone Service.

This Project requires an early implementation, so that it seems to be difficult to complete reappraisal of the contents of Project before its service-in. The remedy will be to carry out a detailed investigation concerning nationwide telephone demand by 1989, i.e., five years after this Project comes into service and, at the same time, to re-scrutinize all aspects of Rural Long Distance Public Telephone Service in the light of findings in the user consciousness survey. No less important will be the exchange of views among the governmental organizations concerned for the purpose of centralization of communication systems.

PART IV Transmission Route Selection for Terrestrial Radio System

PART IV Transmission Route Selection for Terrestrial Radio System

1. General

This Part IV firstly describes the basic requirements for the terrestrial radio system route plan, the selection of optimum transmission route plan based on the plan prepared by TOT, and the circuit assignment on the selected route. Secondly, comparison is made, technically and economically, between UHF system and SHF system, including over-the-horizon communication system, to be applied to the selected route. The result of study concerning the advisability of applying the cable system to part of the route is also stated. Lastly, the optimum terrestrial radio system comparable to the domestic satellite system is identified.

In the study of UHF system to be applied, feasibility assessment is made not only for FDM (Frequency Division Multiplex) system but also for PCM (Pulse Code Modulation) system.

The study of SHF system to be applied includes the investigation of precipitation in all parts of Thailand as referred to radio propagation in 11/13 GHz band in the tropical zone. Consideration is made so that, with the application of investigation result to system design, transmission performance estimate can be conducted accurately in conformity with the local meteorological condition as far as possible.

2. Circuit Assignment and Optimum Transmission Route Selection

By applying the number of telephone circuits estimated in Part III to the original route plan of TOT, area by area circuit assignment and optimum transmission route selection have been carried out. Basic requirements established for such circuit assignment and transmission route selection are as follows:

(1) Transmission route from each rural station is, in principle, located as shown in TOT's route plan except where such is technically difficult.

(2) In case where mobile exchange is to be introduced at nearby rural station in intermediate stage (1989) and final stage (1994), transmission route is established via such rural station.

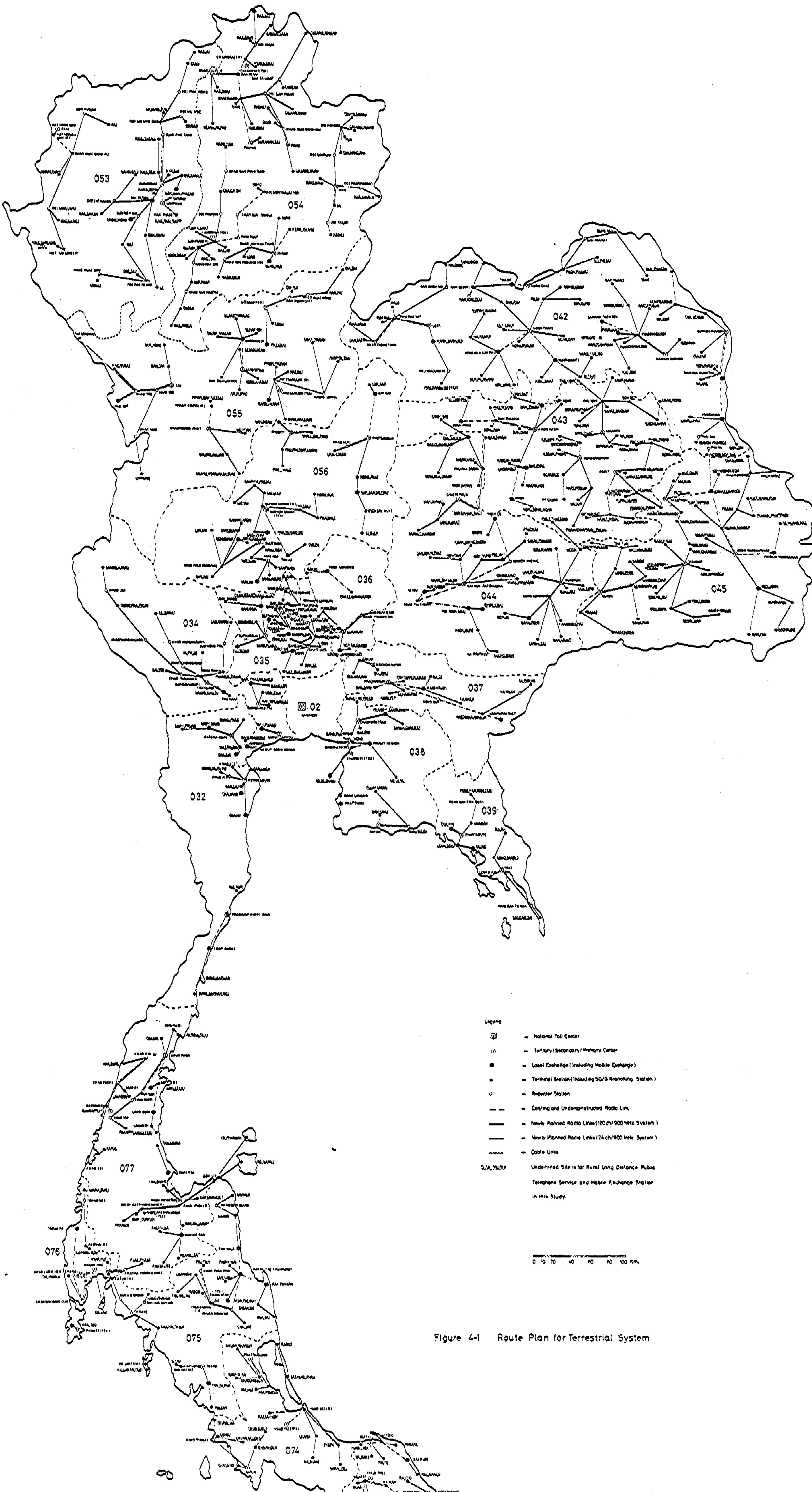


Figure 4-1 Route Plan for Terrestrial System

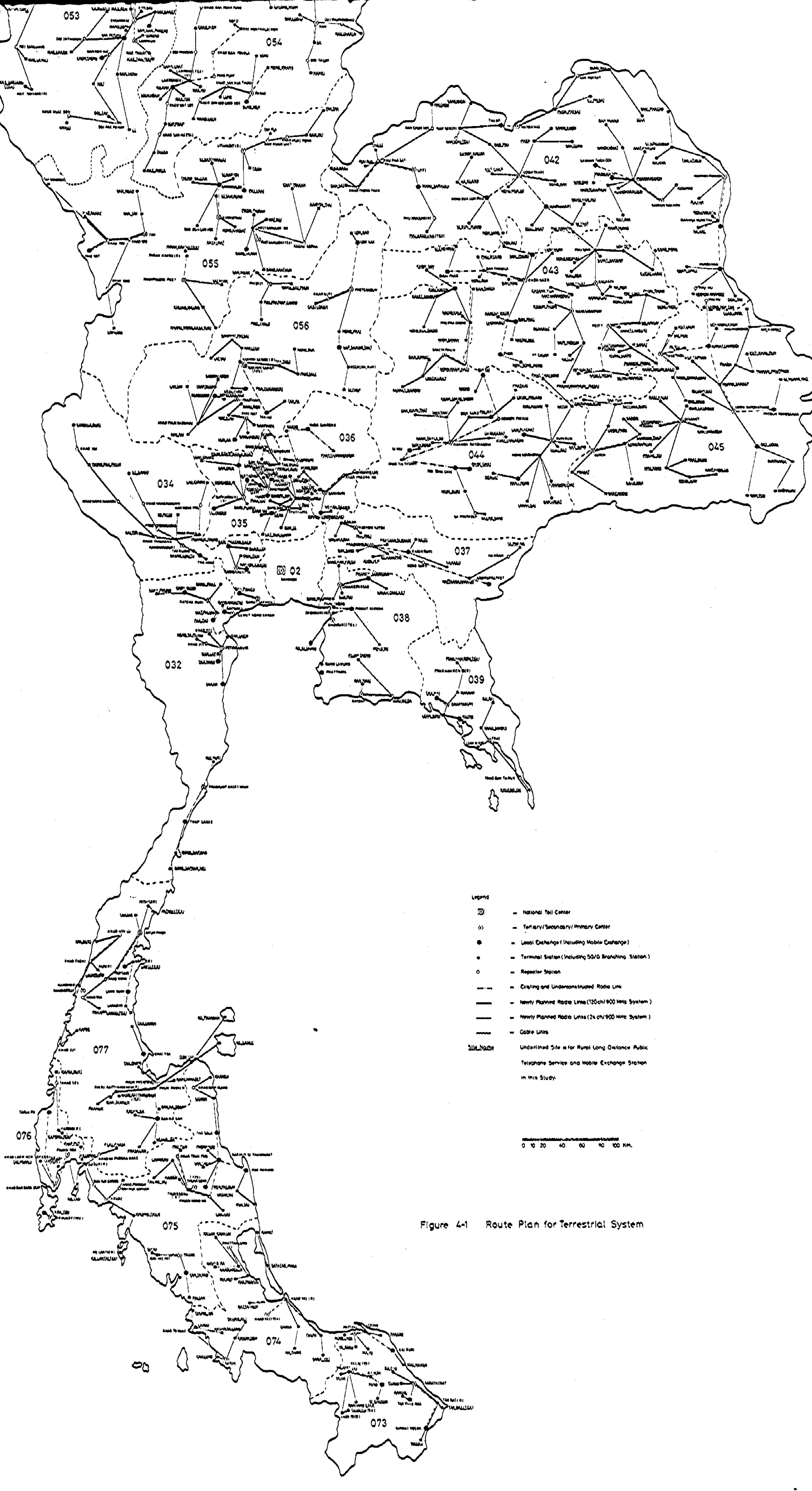


Figure 4-1 Route Plan for Terrestrial System

(3) For mobile exchange transmission route, backbone circuit only is established to PC (SC or TC). High usage circuit is not established.

(4) In case where establishment of direct radio circuit to a PC is difficult but radio circuit establishment to the existing telephone office in another area is possible, the latter is adopted when economic consideration permits.

(5) For transmission route selection in four areas, i.e., Chiangmai, Ayutthaya, Nakhon Ratchasima and Phun Phin areas, the Study Team makes detailed study including field survey. Transmission route selection in other areas is, in principle, based on TOT plan.

(6) Transmission route selection related to the existing microwave system is made by the following principles:

1) Dropping from through repeater station on the existing main route is avoided. UHF system is newly established alongside the existing route.

2) Dropping from repeater station on the existing spur route is made in due consideration of idle circuit availability and circuit demand increase possibility on the existing route. If the branching from the existing route is not advisable, UHF system is newly established alongside the existing route.

3) There are circuits that partly run via existing transmission route. However, the existing equipment modification required for such circuits is not included in this Study.

The transmission route plan selected by the foregoing conditions appears in Figure 4-1. For the aforementioned four areas subject to detailed study, the circuit assignment diagrams and the typical channel accommodation plans are shown in Figure 4-2 and Figure 4-3 respectively.

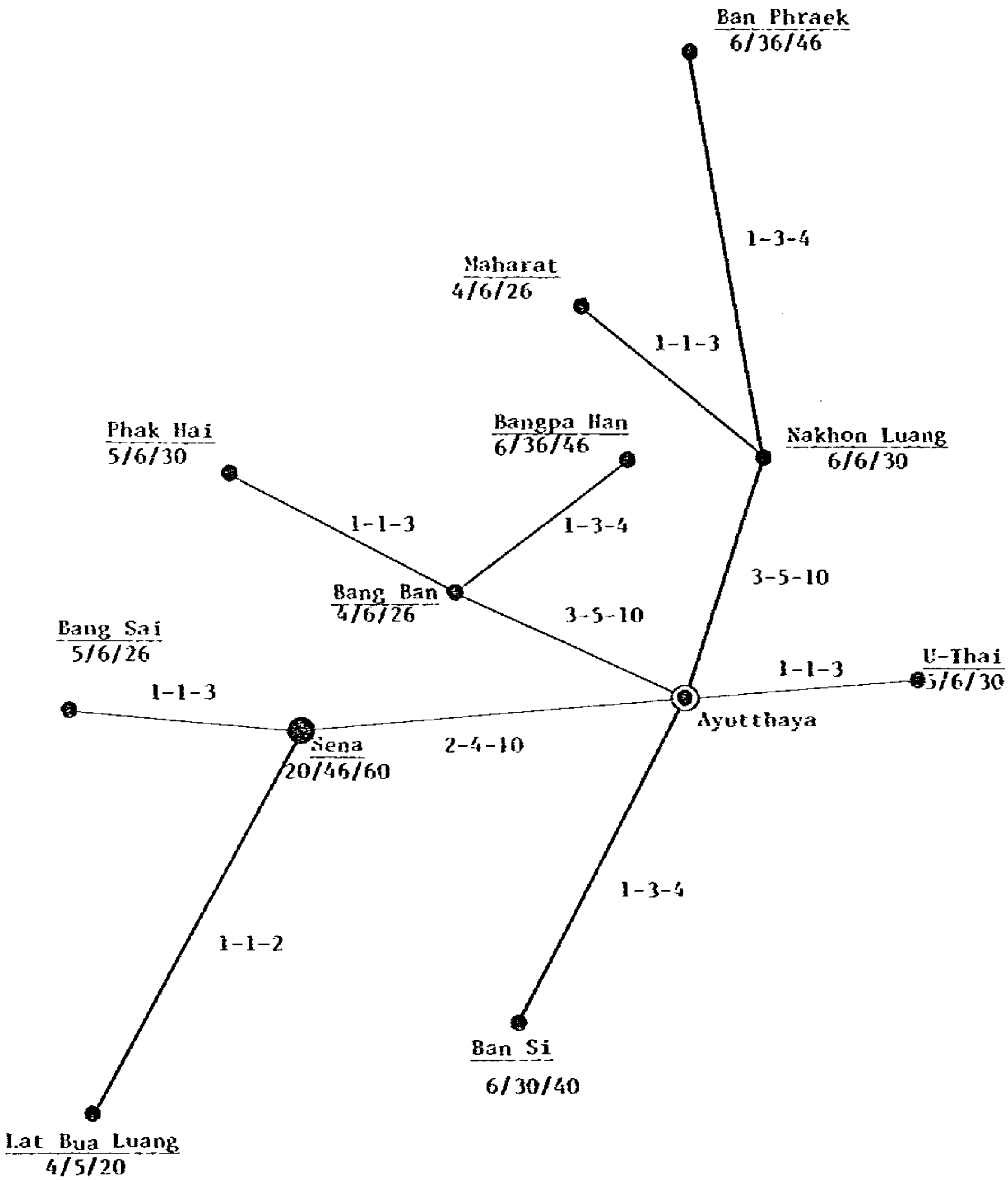
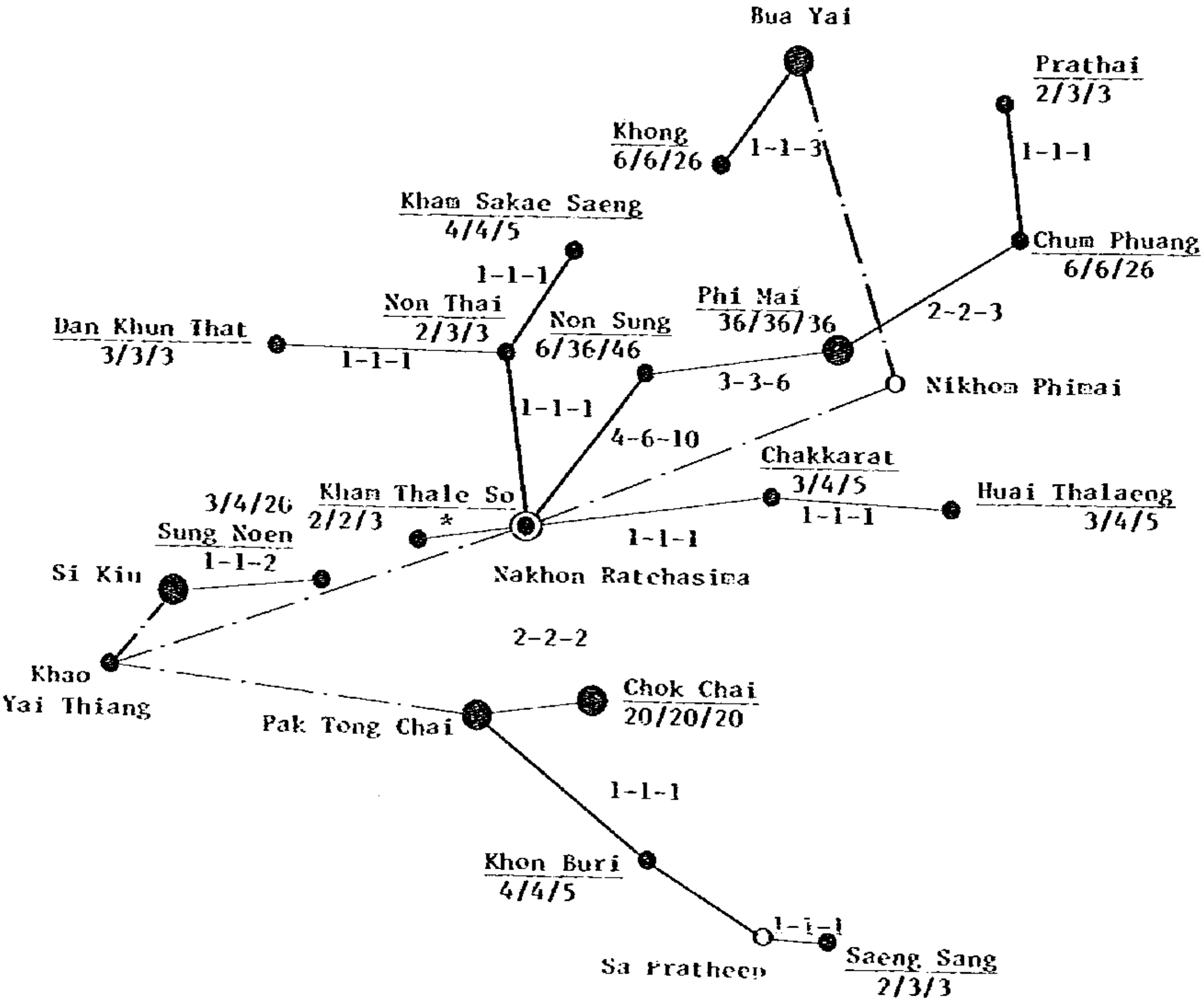


Figure 4-2 Ayutthaya Area(3516)

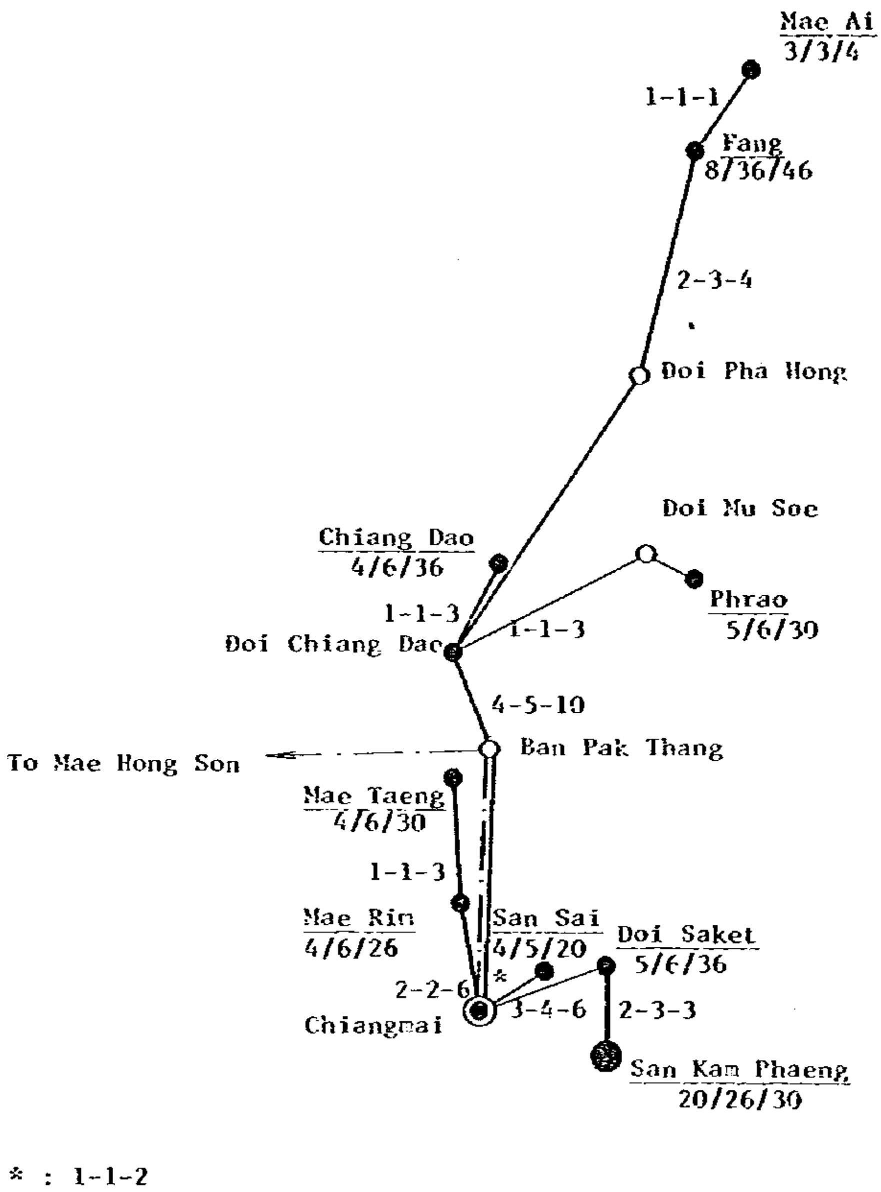
Circuit Assignment Diagram for Terrestrial System(1/5)



* : 1-1-1

Figure 4-2 Nakhon Ratchasima Area(4421)

Circuit Assignment Diagram for Terrestrial System(2/5)



Chiangmai Area(5313)1/2

Figure 4-2
Circuit Assignment Diagram for Terrestrial System (3/5)

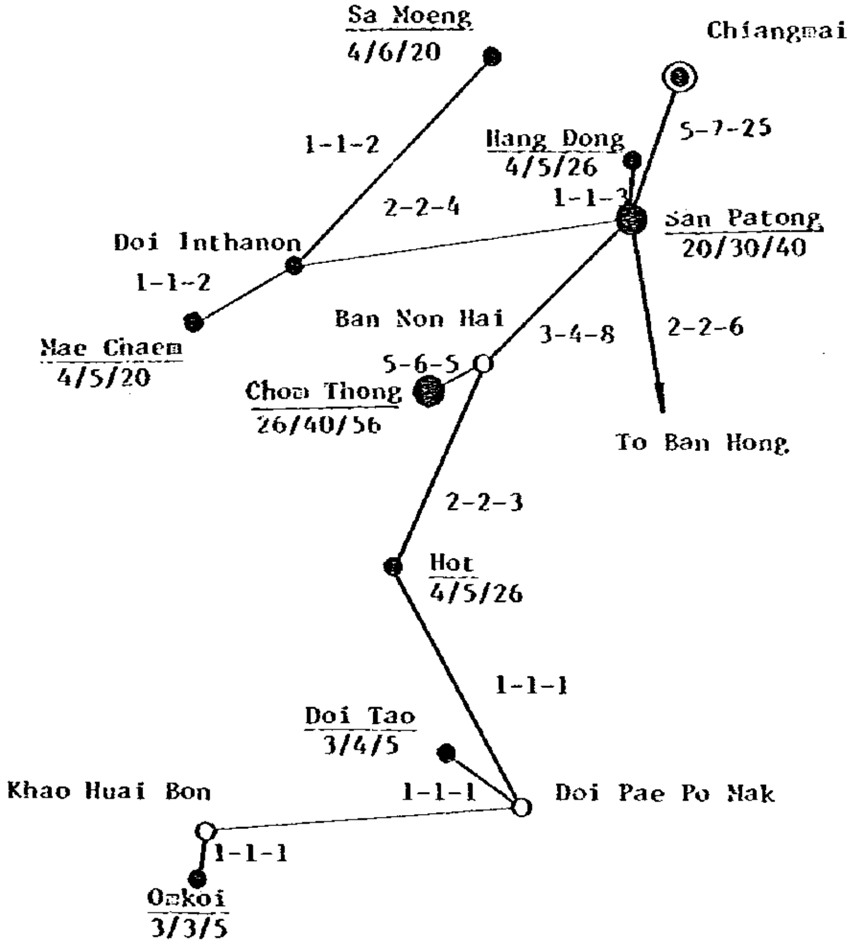
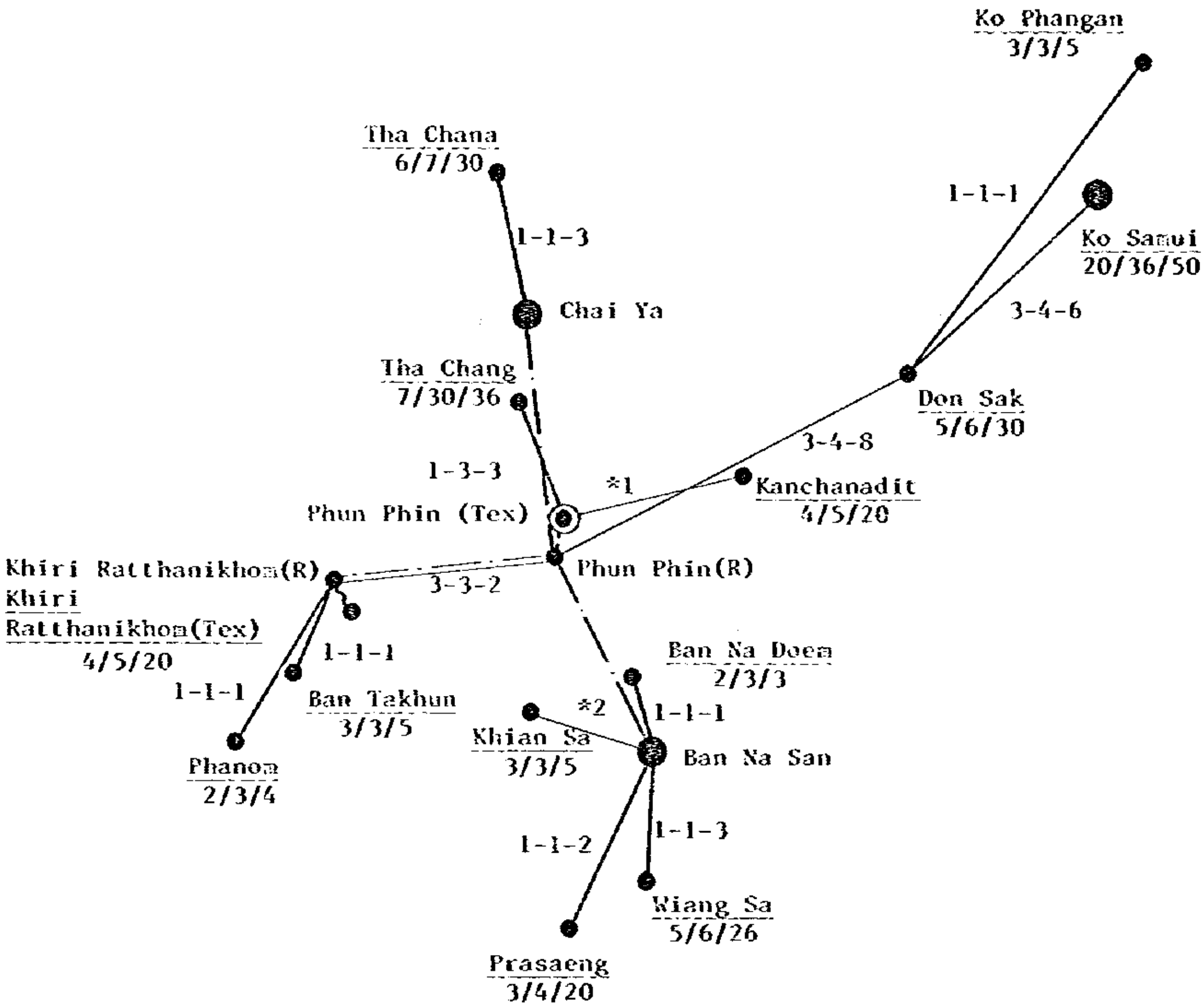


Figure 4-2 Chiangmai Area(5313)2/2
Circuit Assignment Diagram for Terrestrial System (4/5)



*1 : 1-1-2

*2 : 1-1-1

Figure 4-2 Phun Phin Area(7711)

Circuit Assignment Diagram for Terrestrial System (5/5)

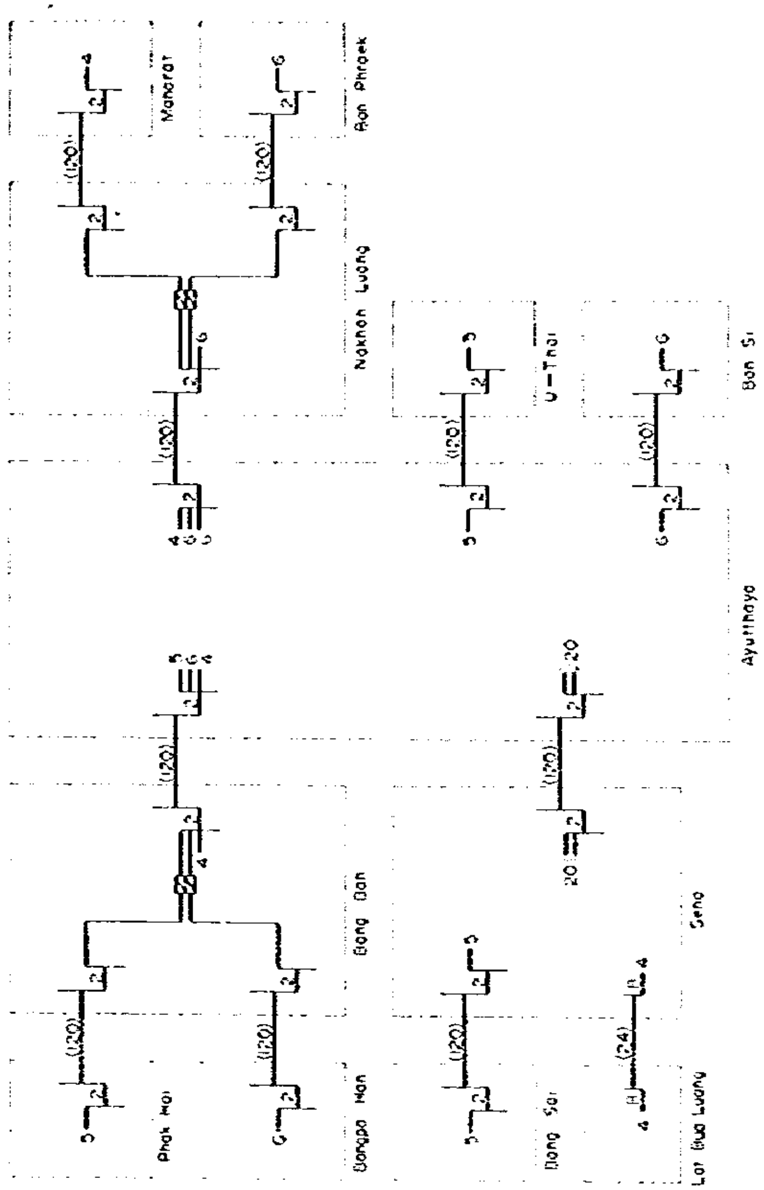


Figure 4-3 Ayutthaya Area(3516)

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

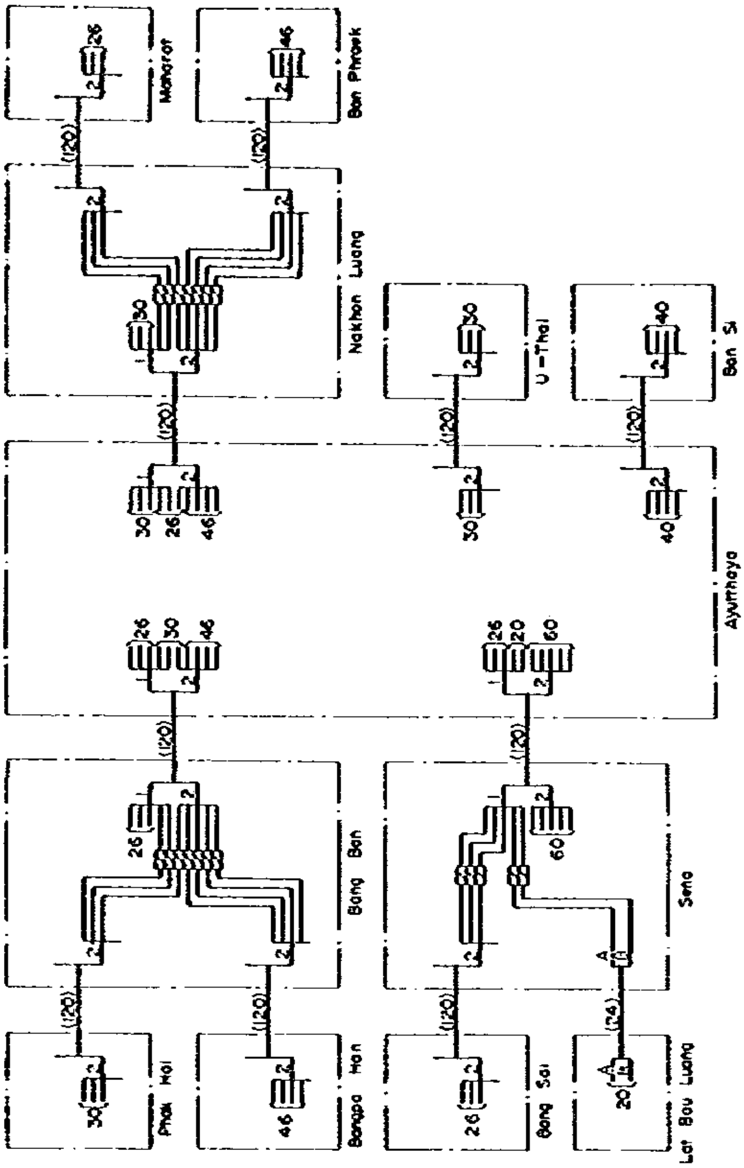


Figure 4-3 Ayutthaya Area(3516)

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

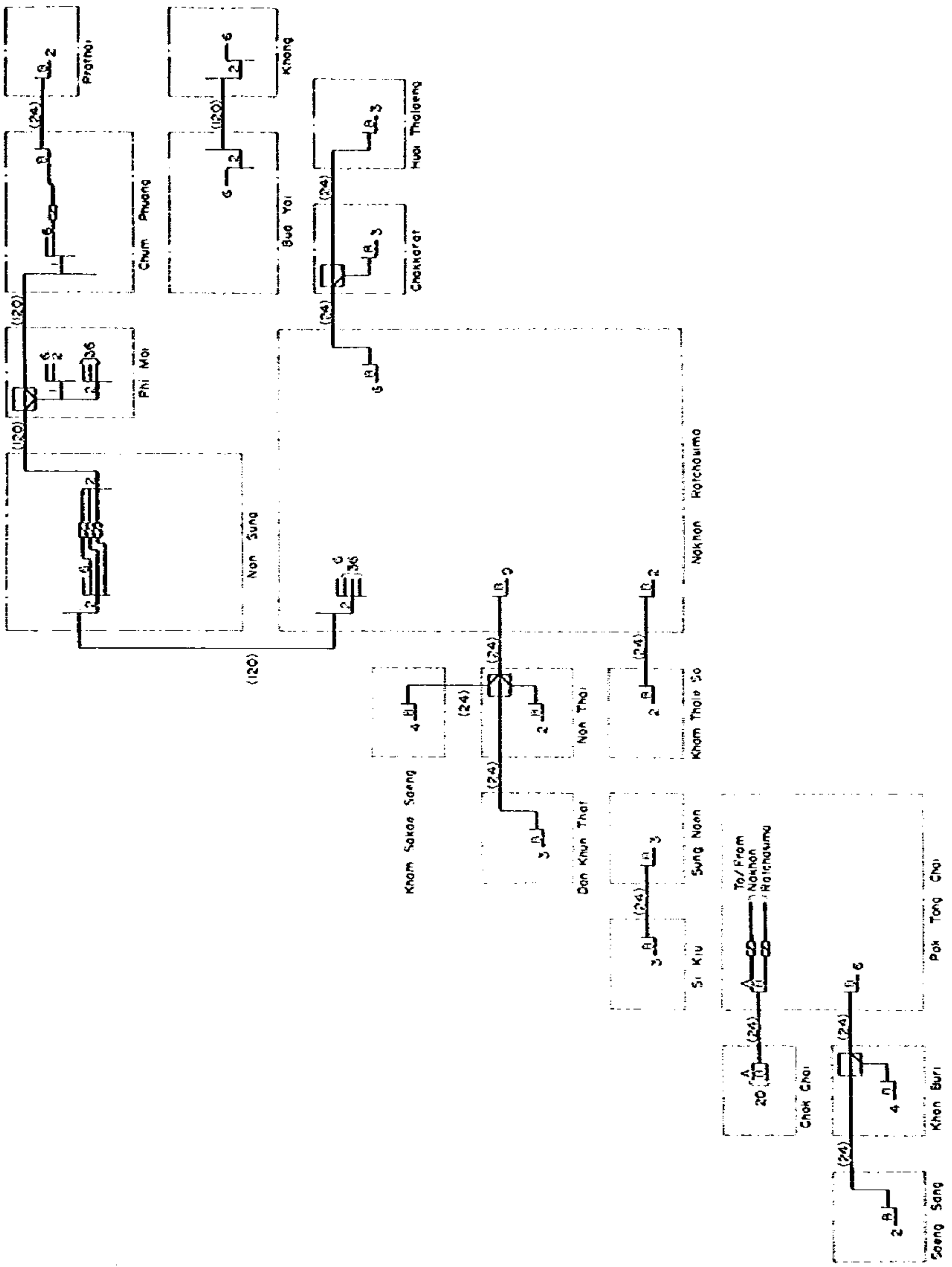


Figure 4-3

Nakhon Ratchasima Area (4421)

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

Figure 4-3 Nakhon Ratchasima Area (4421)

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

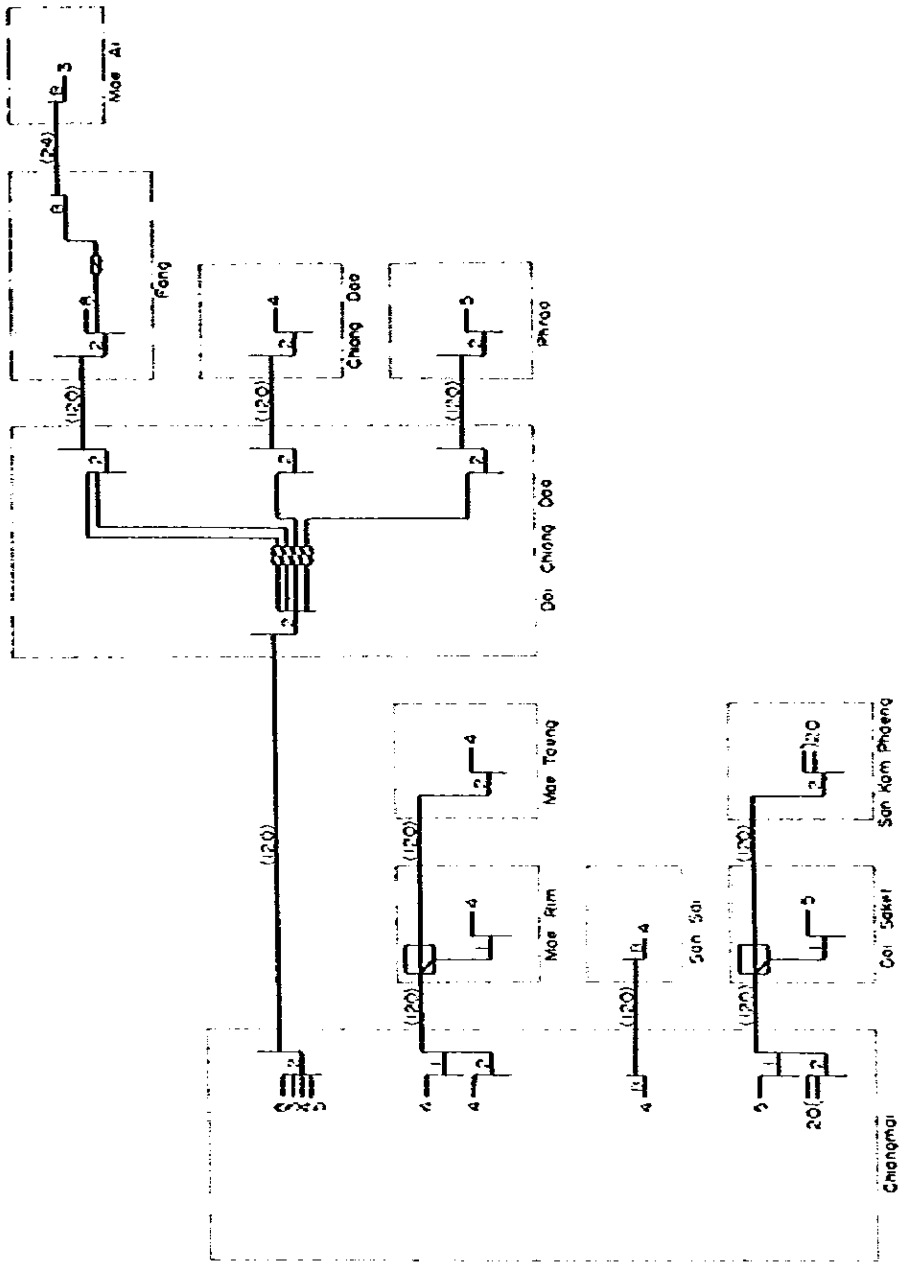


Figure 4-3 Chiangmai Area (5313) 1/2

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

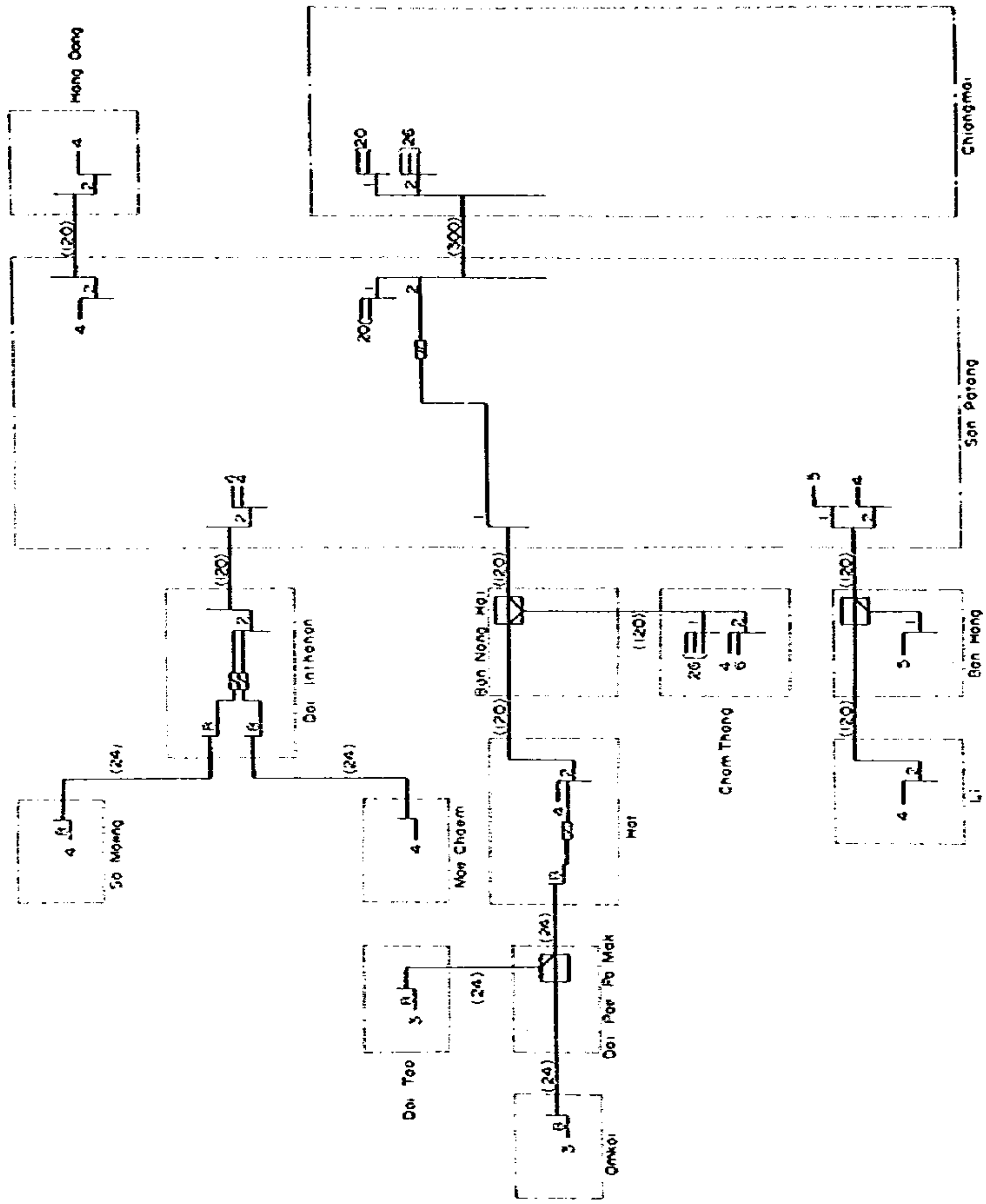


Figure 4-3 **Chiangmai Area (5313) 2/2**

Typical Channel Accommodation Plan for Terrestrial System (Initial Stage)' /10)

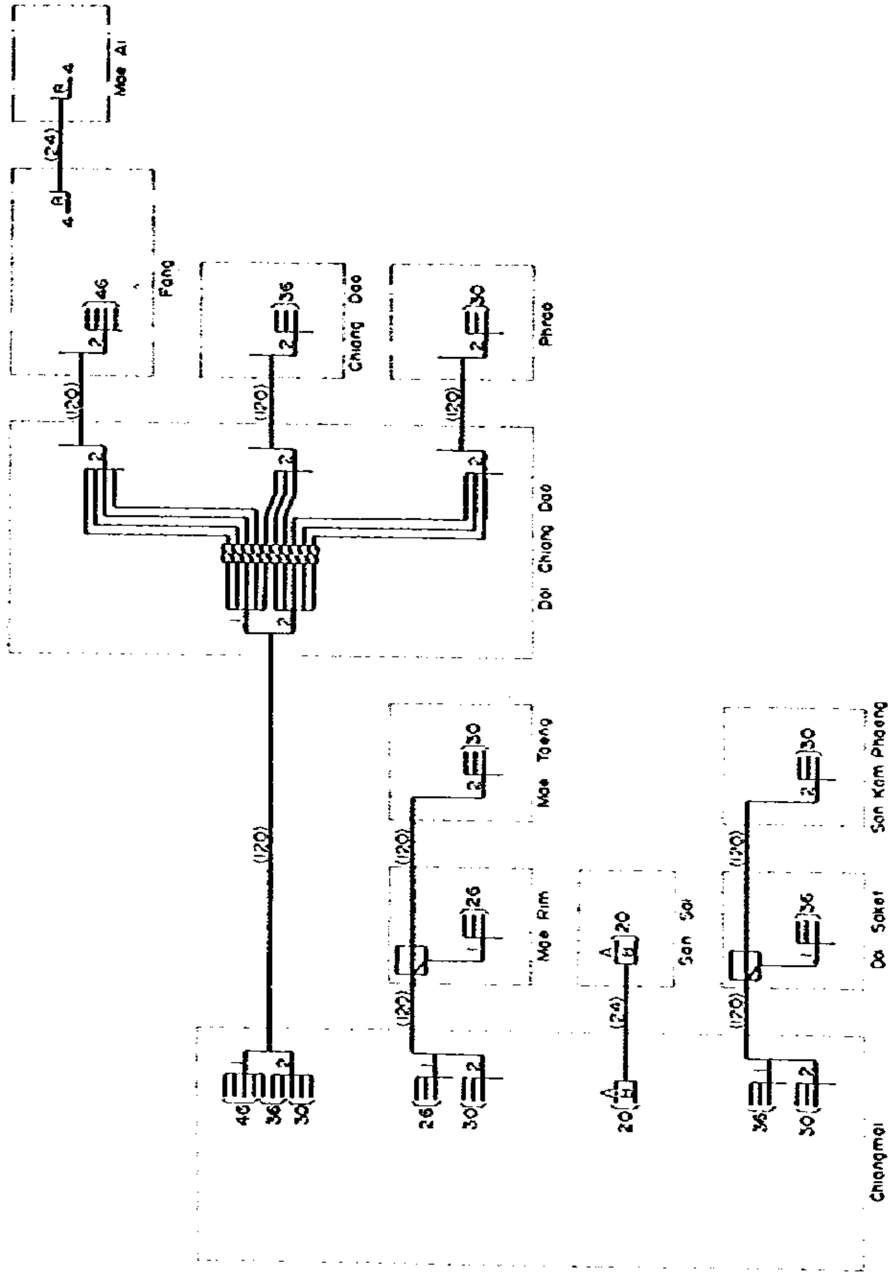


Figure 4-3 Chiangmai Area (5313) 1/2

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

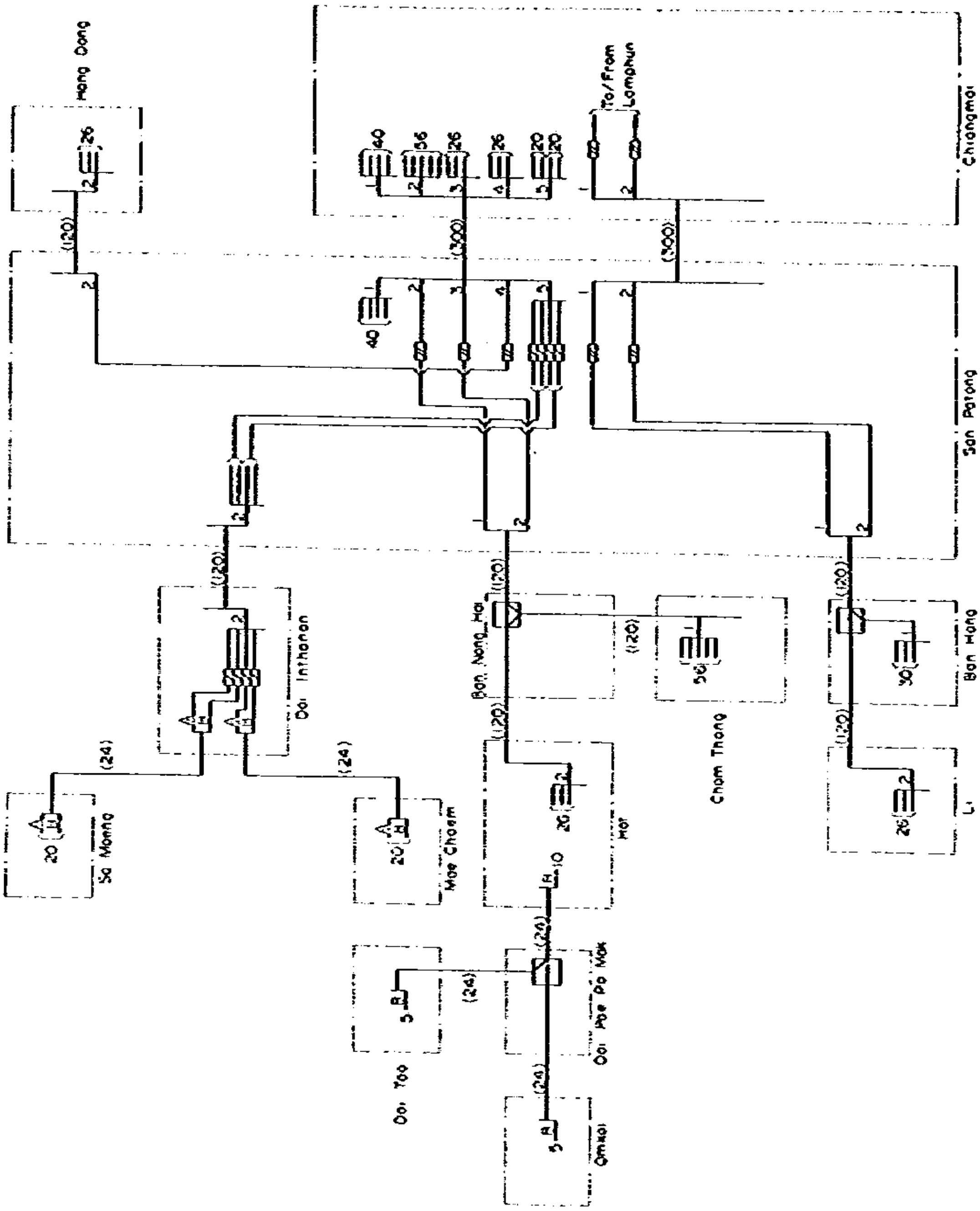


Figure 4-3 Chiangmai Area (5313) 2/2

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

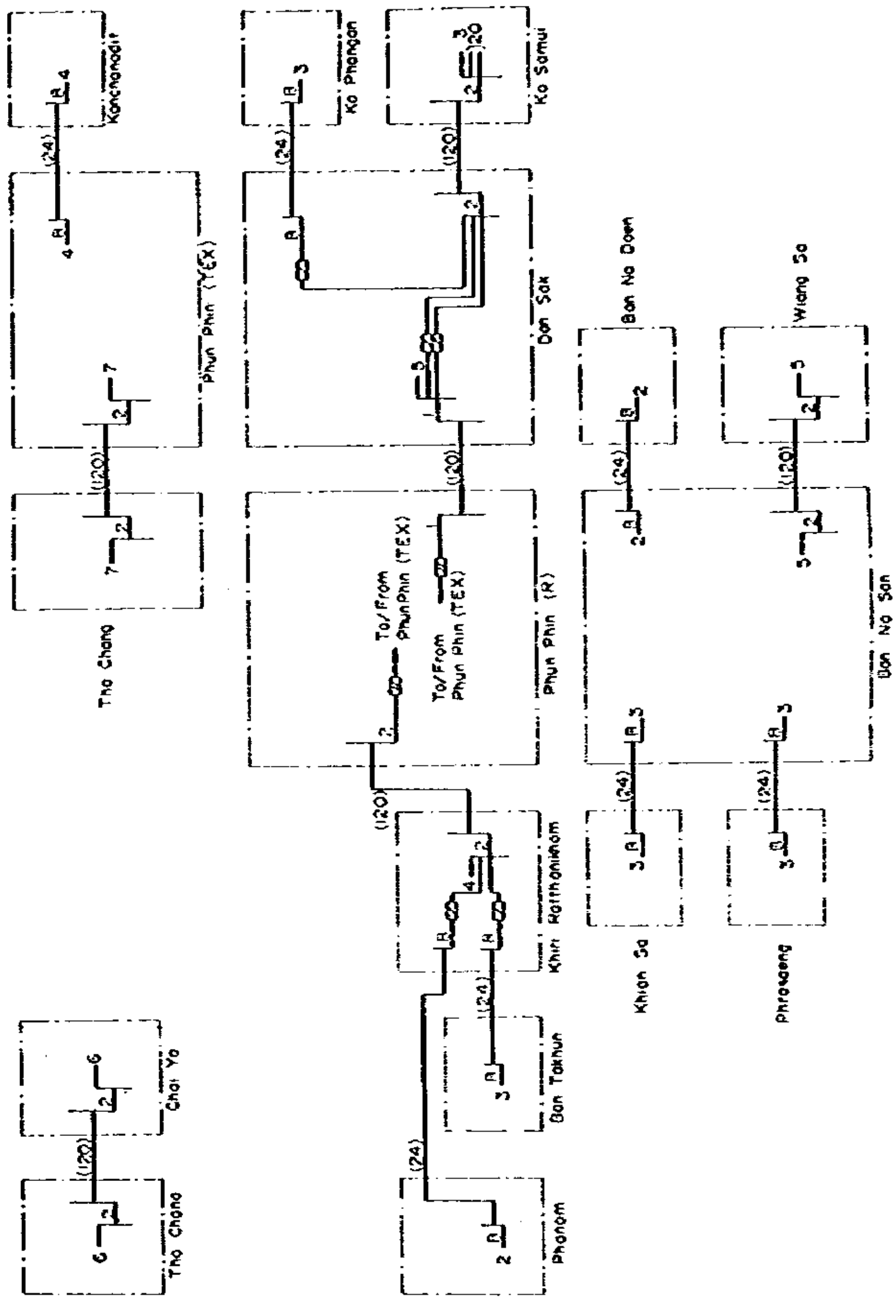


Figure 4-3 **Phun Phin Area (7711)**

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

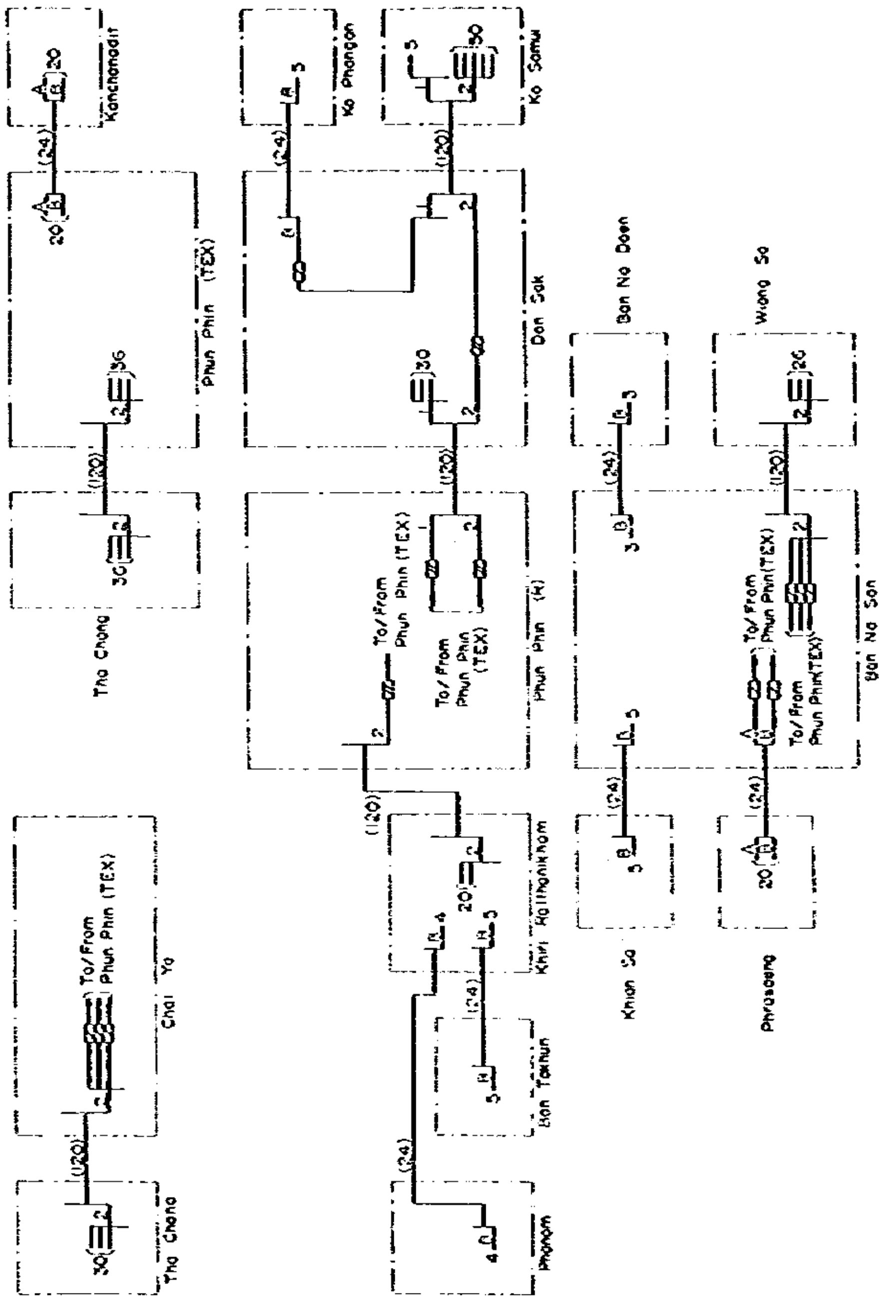


Figure 4-3 **Phun Phin Area (7711)**

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

3. Comparative Study of Transmission Systems to Be Applied

According to the circuit assignment diagram for all areas, the required final stage transmission capacity per transmission route in the case of terrestrial radio system is 20-120 channels. (Exceptions of approximately 10 sections are excluded.) Out of radio systems which can be used for small capacity transmission route, UHF system and SHF system are taken up for study. These two systems are designated in the Scope of Work as the objective items of this Study. Applications of both systems now in use are introduced below.

	Frequency Band	Transmission Capacity
(1) UHF System		
1) FDM System	400/900/1,500 MHz	24/60/120 ch
2) PCM System	900/1,500 MHz	48/60/120 ch
(2) SHF System		
1) FDM System	2/7 GHz	60/120/300 ch
	11/13 GHz	120/300/600 ch
2) PCM System	2/7 GHz	192/240/480 ch
	11/13 GHz	192/240/480 ch

Out of the systems mentioned above, 900 MHz band UHF system and 11/13 GHz band SHF system are taken up in this Study for technical and economic comparisons. These two are the items, of which TOT requested the Study Team to make special study for application to this Project. Meanwhile, technical and economic conditions that apply to 11 GHz band and 13 GHz band are nearly the same so that 11 GHz band is taken up in this Study.

3-1 Comparison between UHF System and SHF System

UHF system and SHF system differ greatly in two respects: radio propagation characteristics and radio spectrum utilization method. Technical and economic aspects of both systems in due consideration of the said differences are compared in the case of FDM-FM system.

3-1-1 Technical Comparison

In the radio system, transmission capacity per RF channel varies, depending upon radio frequency used. In 900 MHz band the capacity is around 120 channels. In 11 GHz band the capacity is as large as 2,700 channels. CCIR recommends RF channel arrangements for 11 GHz band in case where transmission capacity per RF channel is 600 to 1,800 channels. Thus, generally, 11 GHz band is fit for large capacity circuits. Needless to say, 11 GHz band radio equipment of small capacity, such as 120 and 300 channels, is also available. However, such equipment is rather an exception for special use.

Radio propagation characteristics differ between UHF band and SHF band. Free space propagation loss in 11 GHz band is approximately 20 dB greater than that in 900 MHz band. The variation range of received power due to fading is also greater in SHF band than in UHF band. Therefore, to produce transmission performance of similar level, SHF band requires greater antenna capability and greater transmission power than UHF band.

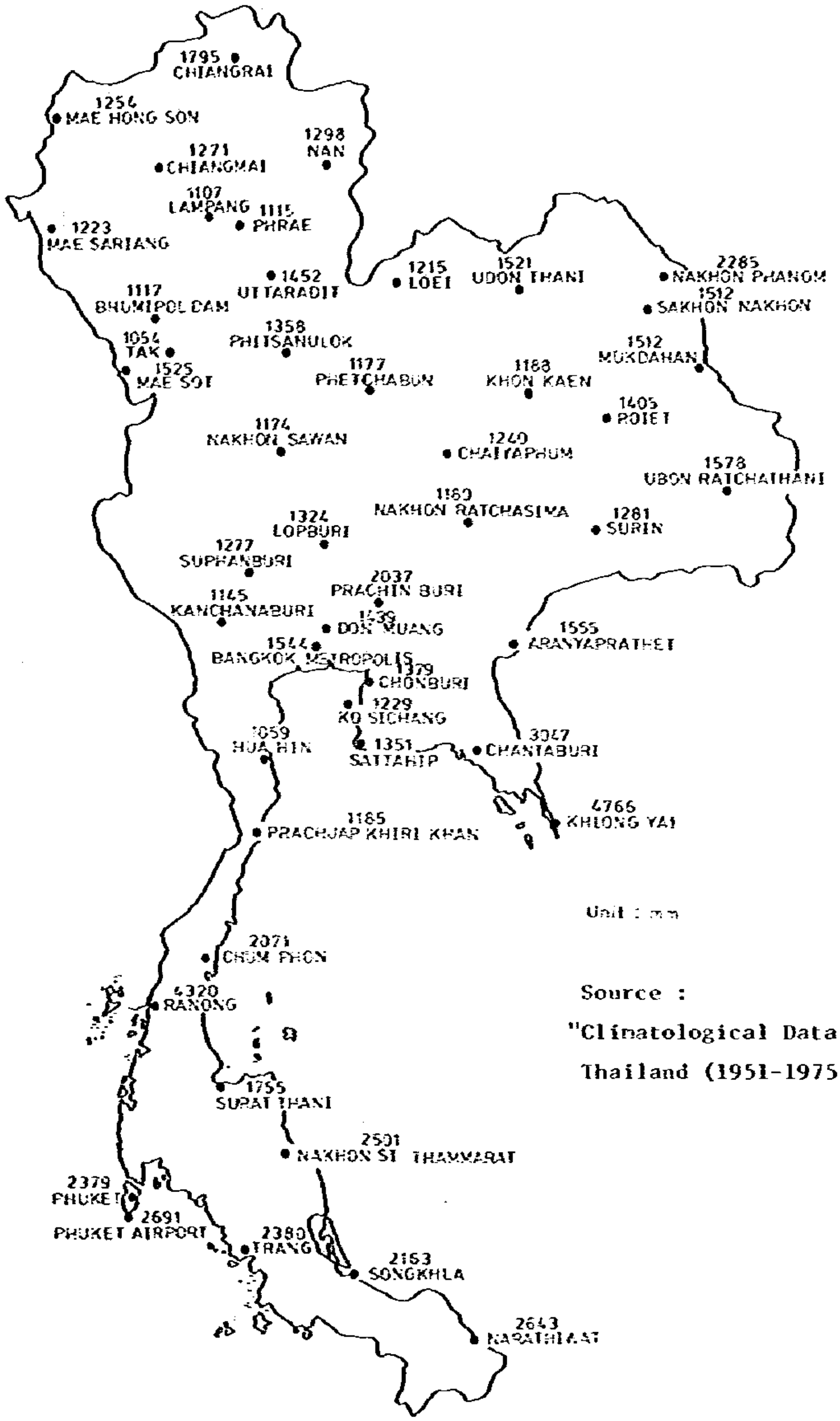
In the system design that uses radio frequency of 10 GHz or more, radio absorption by rainfall cannot be ignored. For this reason, radio hop distance becomes limited to the extent the standard hop distance depends upon the number of times of circuit interruptions during heavy rain. The influence of rainfall on radio propagation is described later.

The difference between UHF system and SHF system is found in the types of equipments that constitute the respective systems also. The difference in the types of antennas, feeders and radio equipments required is rather conspicuous.

Judging from the foregoing, it can be said that, technically, UHF band is better suited than SHF band for small capacity transmission of up to 120 channels or thereabouts. On the other hand, SHF band is suitable for medium and large capacity transmission of 600 channels or more. Especially 11 GHz band is best qualified for short distance, large capacity transmission.

3-1-2 Influence of Rainfall on Radio Propagation

Annual precipitation in Thailand is shown in Figure 4-4. The precipitation is extremely large, ranging from 1,000 mm to 4,000 mm per year.



Source :
"Climatological Data of Thailand (1951-1975)"

Figure 4- 4 Annual Precipitation in Thailand

Generally, rainfall can be divided in two types. One is squall with thunder (Mode 1). The other is rainfall of other type (Mode 2). Each mode features exponential distribution. It is in the case of Mode 1 rainfall that above 10 GHz radiowave attenuation on radio path due to rainfall reaches several tens of dB. Usually, this phenomenon continues for several minutes to several tens of minutes.

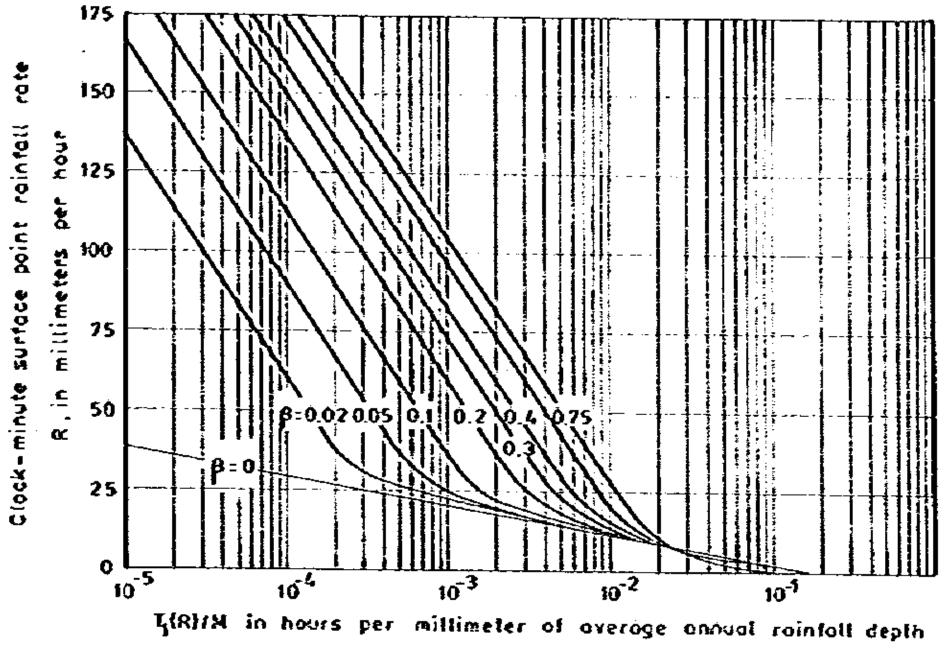
Observatories where short-time rainfall rate, e.g., one-minute rainfall rate, is being observed constantly are not many. The Metropolis Observatory in Bangkok is the sole such observatory that exists in Thailand. There, five-minute rainfall rate is being observed. Therefore, short-time rainfall rate in all parts of Tailand cannot be known unless it is presumed by some means. One example of how to presume short-time rainfall rate from annual precipitation is made known in an article entitled "Cumulative Time Statistics of Surface-Point Rainfall Rates" that recently appeared in IEEE Transactions.

According to this literature, one-minute rainfall rate R_1 (mm/h) is related to annual rainfall depth M and Mode 1 rainfall ratio to the total depth, i.e., parameter β, and is distributed as shown in Figure 4-5. As is evident in this illustration, when $R_1 \geq 40$ mm/h and $\beta \geq 0.02$, Mode 2 rainfall can be ignored and R_1 can be obtained by the following equation:

$$R_1 = (\ln (0.03\ \beta M/T_1(R_1)))\ /\ 0.03\ \text{(mm/h)}$$

where $T_1(R_1)$ denotes the time (h) of one-minute rainfall rate exceeding R_1. It is also reported that parameter β at various places in the world is as seen in Figure 4-6. One-munite rainfall rate in Thailand, estimated by the foregoing methodology, is given in Table 4-1.

Radiowave attenuation due to rainfall is described fully in CCIR Rep. 233-3. According to this report, it is possible to estimate radiowave attenuation on radio path of arbitrarily chosen length, using two kinds of charts. When attenuation in

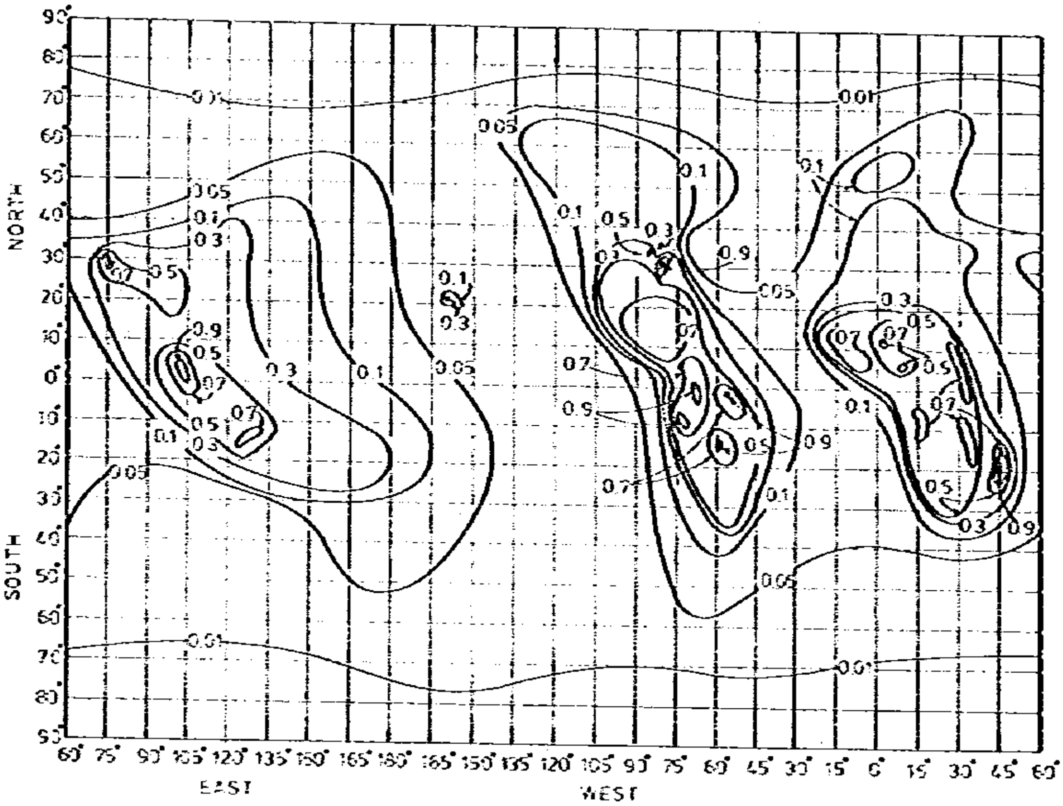


$T_1(R)$ is the number of hours of rainy minutes for which the surface point rainfall rate exceeds R mm/hr in an average year at a median location. The ordinate is R_1 and the abscissa is $T_1(R)/M$, where M is the annual mean rainfall depth in mm.

$\beta = M_1/M$ = the ratio of Mode 1 rainfall depth, M_1, to the total depth, M

(Source : "Cumulative Time Statistics of Surface-Point Rainfall Rates")

Figure 4-5 Normalized Cumulative Time Distributions of Rainfall Rates



THE PARAMETER $\beta = \frac{M_1}{M}$, THE RATIO OF "THUNDERSTORM" RAINFALL, M_1, TO TOTAL RAINFALL, M

(Source : "Cumulative Time Statistics of Surface - Point Rainfall Rates")

Figure 4-6 The Parameter β for Annual Precipitation

Table 4-1 Estimated One-minute Rainfall Rates in Thailand

Place	Precipitation M (mm)	Parameter β	One-minute Rainfall Rate R1 (mm/h) 0.01%	0.02%	0.05%
Chiangrai	1795	0.6	120	97	67
Chiangmai	1271	0.5	103	80	49
Uttaradit	1452	0.5	107	84	53
Nakhon Sawan	1174	0.5	100	77	46
Udon Thani	1521	0.5	109	86	55
Khon Kaen	1188	0.5	100	77	47
Ubon Ratchathani	1578	0.4	102	79	49
Nakhon Ratchasima	1180	0.4	93	70	39
Prachin Buri	2037	0.4	111	88	57
Don Muang	1439	0.4	99	76	46
Bangkok	1544	0.4	102	79	48
Chantaburi	3047	0.5	132	109	78
Prachuap Khiri Khan	1185	0.4	93	70	39
Chum Phon	2071	0.5	119	96	65
Surat Thani	1755	0.5	113	90	60
Phuket	2379	0.7	135	112	81
Songkhla	2163	0.7	132	108	78
Narathiwat	2643	0.7	138	115	85

11 GHz band of Don Muang area at percent time of 0.02%, for instance, is estimated, based on the foregoing rainfall rate estimation result, the following values can be obtained:

Path distance (km)	Attenuation (dB)
10	24
15	34
20	43
25	50
30	58

Thus, when it is assumed that the allowable circuit interruption rate per year per radio hop is 0.02%, the threshold margin required in 11 GHz is 34 dB for radio path of 15 km and 43 dB for radio path of 20 km.

3-1-3 Economic Comparison

Radio relay system is composed of the following segments:

1) Antenna tower
2) Antenna
3) Feeder
4) Radio equipment
5) Carrier multiplex equipment
6) Power plant
7) Building
8) Access road

For economic comparison between UHF system and SHF system, costs of component 3) and of components 5) through 8) of each system can be safely assumed to be on practically the same level.

For antenna tower, when guyed tower is used, cost increases in proportion to tower height. In UHF system design, obstruction loss to a certain degree can usually be allowed, so that antenna height for UHF system can be somewhat less than for SHF system. Hence the cost can also be reduced that much.

For UHF system, either Yagi antenna or grid type parabolic antenna is usually adopted. This type of antenna costs 30% to 50% lower, compared with plate type parabolic antenna which is used for SHF system.

For radio equipment, solid type equipment is now used for both UHF system and SHF system. In both cases, the equipment is almost the same in outward appearance and size. However, the equipment which is used for SHF system requires technique of higher level than that for UHF system. This is because SHF system uses high radio frequency and requires waveguide circuit. Naturally, equipment cost increases.

Judging economically from the foregoing, the conclusion is that, in the case of small capacity transmission, cost per channel is higher with SHF system than with UHF system. As an aid in determining the system to be adopted in this Project, UHF system cost and SHF system cost (main equipment costs on FOB base) for Ayutthaya area were estimated. Result obtained is shown in Table 4-2.

Table 4-2 Cost Comparison between UHF and SHF Systems (for Ayutthaya area at initial stage)

(Unit: Million Japanese Yen)

	Item	UHF System	SHF System
A.	Radio System	83	263
B.	Supervisory System	19	19
C.	Carrier Multiplex System	80	80
D.	Tower	25	25
E.	Power Plant	57	61
F.	Installation Material	9	16
G.	Shelter for Equipment	33	33
	Total FOB cost	306	497

3-2 Comparison between FDM System and PCM System

Signal multiplexing methods differ completely between FDM system and PCM system. For this reason, both systems hold merits and demerits in many respects. Such merits and demerits, as seen from technical and economic viewpoints, were identified for radio relay system using 900 MHz band.

3-2-1 Technical Comparison

Technical features of FDM system and PCM system can be found in Table 4-3. Descriptions in this table, however, are of general nature so that, for small capacity radio links used in this Project, some of descriptions require circumspection when comparison is made.

For PCM system, the multi-level modulation research has been carried out, aimed at improvement of radio spectrum utilization efficiency. This research is to elevate the modulation level as from the basic two-level PSK modulation to four-level and eight-level modulations. Nowadays, the four-level PSK modulation is most popular. It is adopted in the 60/120 channels, small capacity PCM radio system also. In the frequency bandwidth occupied in small capacity radio link, there is no much distinction between FDM system and PCM system (four-level PSK modulation) as shown below.

	FDM System	PCM System
60 ch system	2.5 MHz	2.0 MHz
120 ch system	3.2 MHz	4.1 MHz

For both FDM system and PCM system, adjacent RF channel spacing in small capacity radio link of 120 channels or thereabouts is almost the same. The reason is that, in the frequency bandwidth occupied in small capacity radio link, no much difference exists between the systems as previously stated.

With regard to cross polarization in PCM system, it must be pointed out that in SHF band it is possible because cross polarization discrimination of parabolic antenna is available to the extent of 15 dB or more whereas in UHF band it is impossible because available cross polarization discrimination of antenna is usually not more than few dB. For this reason, in UHF band, the interleaved frequency plan becomes necessary.

In FDM system, system performance is evaluated by noise volume in signal. Thus, on short distance circuits as in this Project, 1,000 or 2,000 pWOp noise volume is allowed. (Refer to CCITT Rec. G123 and CCIR Rec. 379-2.) In PCM system, system

Table 4-3 Technical Comparison between FDM and PCM Systems

Item	FDM System	PCM System
1. Method of multiplexing	Frequency division multiplexing (FDM)	Time division multiplexing (TDM)
2. Type of multiplex signal	Analog	Digital coded from analog
3. Type of modulation	Frequency modulation (FM)	Phase modulation (PSK)
4. Method of relay	Amplification of analog signal	Regeneration of digital signal
5. Frequency bandwidth occupied per telephone channel	Narrow	Broad
6. Adjacent RF channel spacing (Δf)	Small: 3 fm (fm: top frequency of baseband)	Large: $1.5S < \Delta f \leq 2S$ (S: digital symbol rate)
7. To use one frequency to make 2 systems by cross polarization	Impossible	Possible
8. Required C/N or transmitting power	Large	Small
9. Noise increase due to relay	Yes	No
10. Signal processing to baseband	Simple	Complex
11. Filter for multiplex equipment	Necessary	Not necessary

performance is evaluated by B.E.R. (Bit Error Rate), and B.E.R. in small percentage of time becomes an especially important factor to determine system performance. PCM system still has a much shorter history of utilization than FDM system. Therefore, no international recommendation has yet been made concerning allowable B.E.R. in radio link where PCM system is adopted. Commonly, for the values of allowable B.E.R. and the percentage of time, 10^{-3} to 10^{-6} and 0.1% to 0.01% are respectively used. (Refer to CCIR Rep. 378-2.)

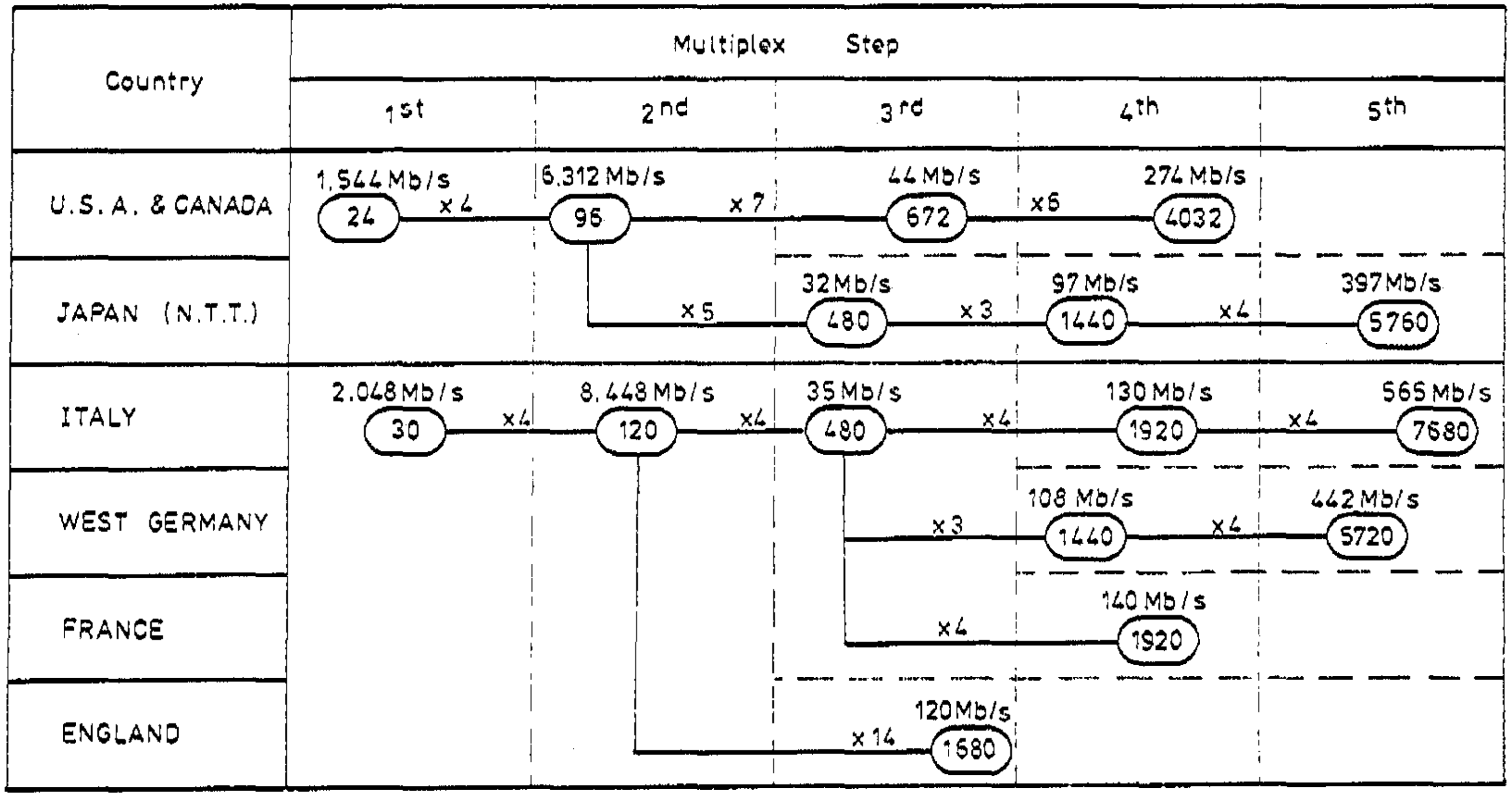
In this Study, 10^{-6} and 0.01% per hop are respectively used as design objectives.

Overall technical judgment from the foregoing arrives at a conclusion that no much difference can be found between FDM system and PCM system. Meanwhile, in PCM system, as in FDM system, signal multiplexing requires several steps. The hierarchy plan for this purpose, which is now used in each country of the world, is given in Figure 4-7. If PCM system is adopted in this Project, it is appropriate, considering required transmission capacity, to use 2.048 Mb/s (30 channels) in the first stage.

3-2-2 Economic Comparison

For FDM system and PCM system, trial cost estimates at various transmission capacities are made in Figure 4-8. These costs do not include such items as supervisory equipment, antenna tower, and building, wherein no difference in terms of cost can be recognized between the two systems.

As is evident in Figure 4-8, items wherein the cost difference between the two systems is great are two: radio equipment and multiplex equipment. In the case of small capacity radio link, radio equipment cost is greater in PCM system, being 1.5 to 1.6 times the cost that is incurred in FDM system. Contrarily, multiplex equipment cost is smaller in PCM system, the cost this time being 1.0 to 0.6 times the cost incurrable in FDM system. The reason is that, in FDM system, the filters of good performance and various kinds of carrier generators are required at each step of signal multiplexing, whereas in PCM



Note : Figure in circle means equivalent number of telephone channels.

Figure 4-7 Hierarchy Plan for PCM System in Each Country

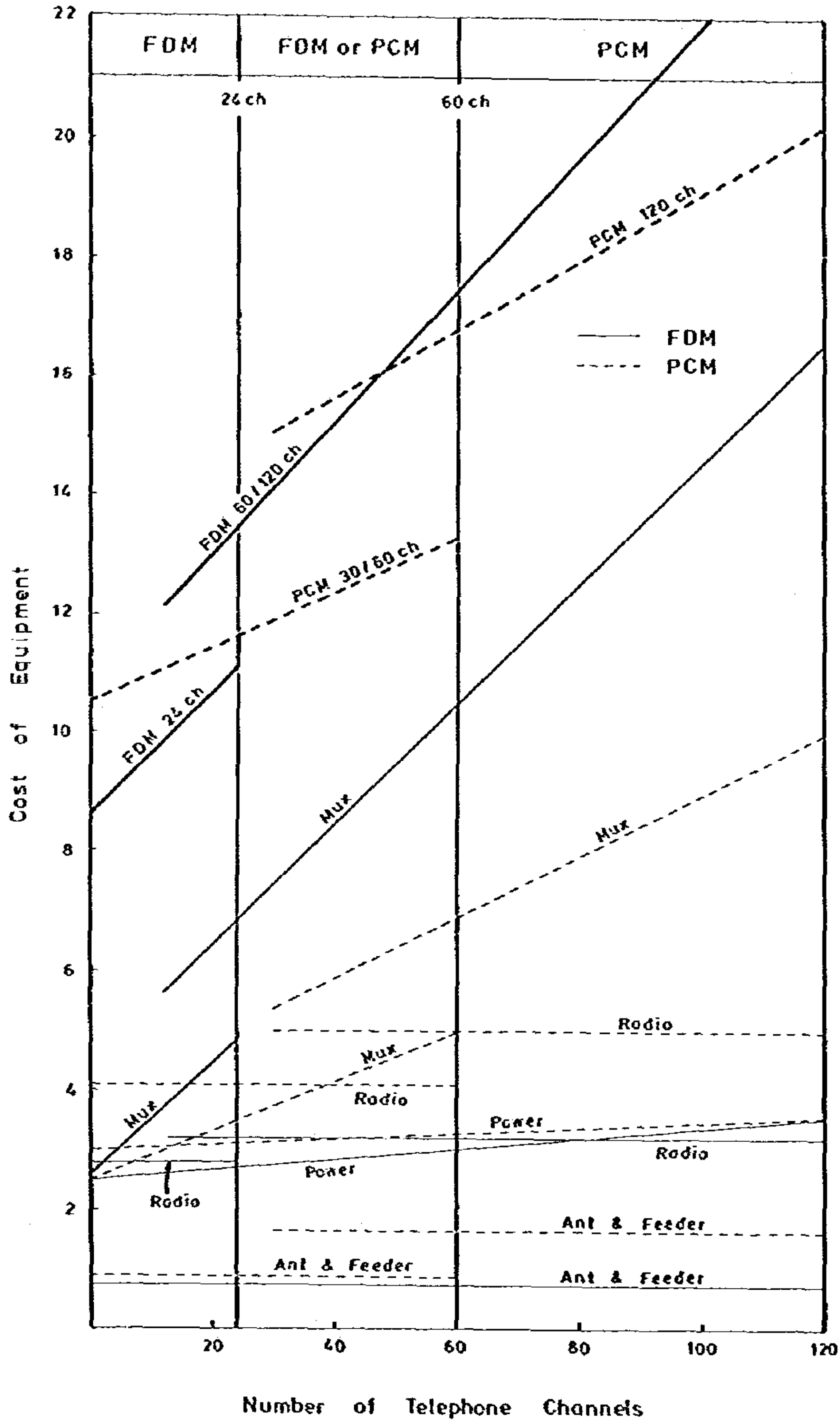


Figure 4- 8 Cost Comparison between FDM and PCM Systems in 900 MHz Band

system signal multiplexing requires only one simple pulse generator.

A conclusion that is reached from the foregoing is that, in the cost aspect, there is no great difference between FDM system and PCM system though, as seen in Figure 4-8, up to transmission capacity of 24 channels the cost is smaller in FDM system and, when transmission capacity exceeds 60 channels, the cost is smaller in PCM system.

Cost estimates for both systems in Ayutthaya area as an exemplary case appear in Table 4-4.

Table 4-4 Cost Comparison between FDM and PCM Systems (for Ayutthaya area at initial stage)

(Unit: Million Japanese Yen)

Item	FDM System	PCM System
A. Radio System	83	112
B. Supervisory System	19	19
C. Multiplex System	80	59
D. Tower	25	25
E. Power Plant	57	55
F. Installation Material	9	9
G. Shelter for Equipment	33	33
Total FOB cost	306	312

Cost estimates in this table consist of principal equipment costs (FOB base) at initial stage (1984). Figures quoted above indicate that the cost difference between FDM system and PCM system is only 2%. Thus, economically, no difference can be recognized between the two systems.

In this Project, two additional investments are required, one at middle stage (1989) and the other at final stage (1994). Overall study of three investments required to complete this Project, i.e., initial investment plus two additional investments, has disclosed practically no cost difference between the two systems.

3-3 Study of Over-the-Horizon (O/H) System

This Project involves no small number of cases where several telephone channels will be established from the Primary Center to a rural site several hundreds km distant. Such sections are located in mountain areas for the most part. If all radio paths are to be line-of-sight paths, a considerable number of repeater stations are required. Therefore, feasibility study was carried out to see whether the application of over-the-horizon (O/H) system on transmission routes in mountain areas where required transmission capacity is up to 24 channels is advantageous or not.

3-3-1 System Parameters

Since recently, many kinds of O/H equipments have been developed. Especially the equipment that uses UHF band radiowave can now be obtained at relatively low cost.

Generally, O/H system requires large transmitting power. These days, transmitting power of 100 W or thereabouts can be obtained by use of all solid state power amplifier. Shown below is one example of system parameters for the equipment which is considered to be usable in this Project.

1)	Frequency	:	900 MHz band
2)	Transmission capacity	:	24 ch (SS-FM)
3)	Transmitting power	:	47 dBm (50 W)
4)	Noise figure	:	3 dB
5)	IF bandwidth	:	1.5 MHz
6)	Threshold level	:	-105 dBm
7)	Baseband frequency	:	12 - 108 kHz
8)	Frequency deviation	:	100 kHz r.m.s./ch
9)	Figure of merit	:	188 dB
10)	Objective threshold margin	:	23 dB with FD
11)	Standard antenna	:	6mϕ parabolic
12)	Branching loss	:	5 dB

3-3-2 System Design Examples

Radio paths where the application of O/H system was considered to be possible in detailed studies made in four sample areas are the following three:

1) Sa Moeng - Mae Rim (24.9 km)

2) Mae Chaem - San Patong (57.5 km)

3) Khon Buri - Saeng Sang (28.0 km)

Each of these radio paths corresponds in distance to two line-of-sight paths as shown in Figure 4-9. These radio paths need no repeater station when O/H system is applied.

1) Propagation Loss

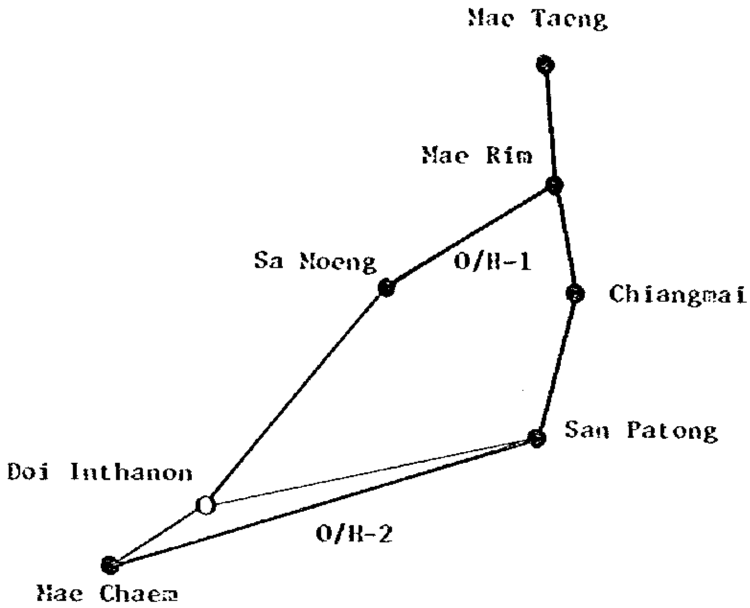
Path profiles of the three radio paths appear in Figure 4-10 through Figure 4-12. All of them are mountain diffraction paths. Diffraction loss is considered to be fairly large. Diffraction loss can be estimated by different methods. One of such methods, which produces the value close to the measured value, is the NBS Technical Note technique. Result of propagation loss estimation by this technique for the three radio paths are as follows:

Path	Free Space Loss (dB)	Diffraction Loss (dB)	Total Loss (dB)
Sa Moeng - Mae Rim	119.4	85	204.4
Mae Chaem - San Patong	126.7	64	190.7
Khon Buri - Saeng Sang	120.4	56	176.4

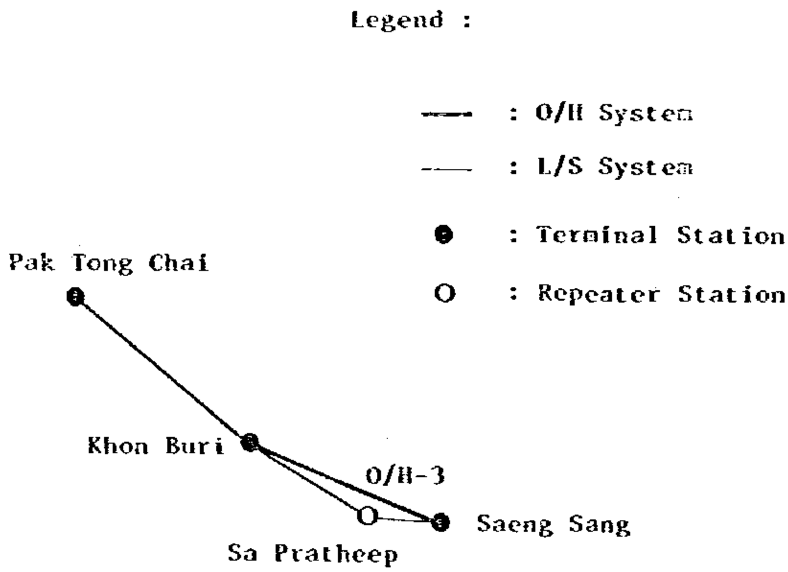
2) System Performance

To obtain the same degree of system performance in O/H system as in line-of-sight (L/S) system, large scale equipment is required. Therefore, in this Study, the objective signal to noise ratio per radio hop is set at 50 dB (N_p = 10,000 pW0p).

Result of system performance calculation for the aforementioned three radio paths appears in Table 4-5. For two paths out of the three, antenna size is not very large, or, more precisely, 6 mϕ or 8 mϕ. However, for Sa Moeng - Mae Rim path, antenna size is as large as 16 mϕ and hence, facility is considered to be too large for small capacity radio link of 24 channels.



(a) Chiangmai Area



(b) Nakhon Ratchasima Area

Figure 4-9 Route Plan for O/H System

PROFILE MAP
(4 / 3 RADIUS)

ROUTE: ____________

DRAWING NO.: ____________

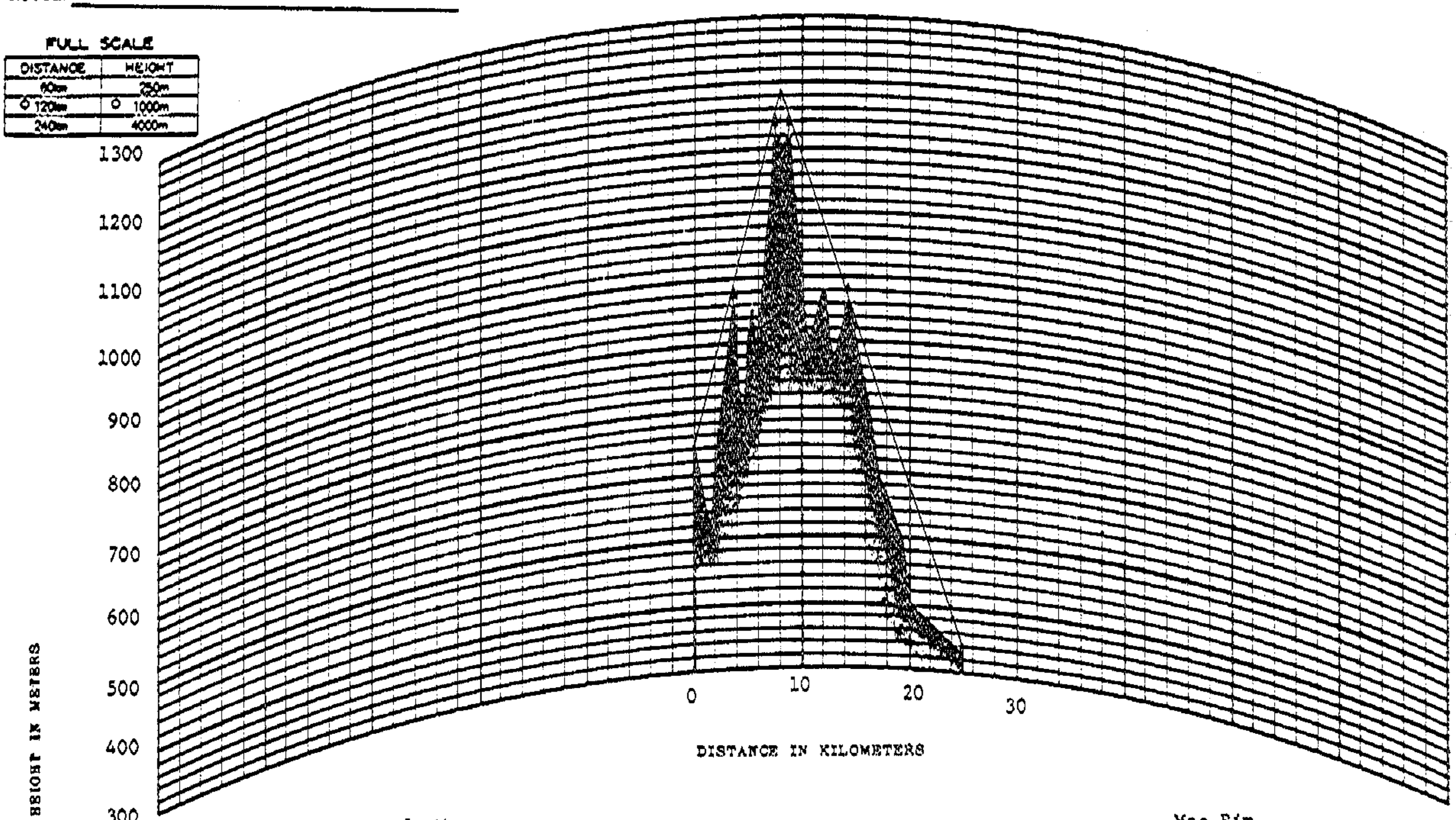


Figure 4- 10

SITE: Sa Moeng
LATITUDE: ____________
LONGITUDE: ____________
GROUND ELEVATION: 630 m
ANTENNA HEIGHT: 5 m

DISTANCE: 24.9 km
HOP NO.: O/H-1

SITE: Mae Rim
LATITUDE: ____________
LONGITUDE: ____________
GROUND ELEVATION: 330 m
ANTENNA HEIGHT: 5 m

PROFILE MAP
(4 / 3 RADIUS)

ROUTE: ____________

DRAWING NO.: ____________

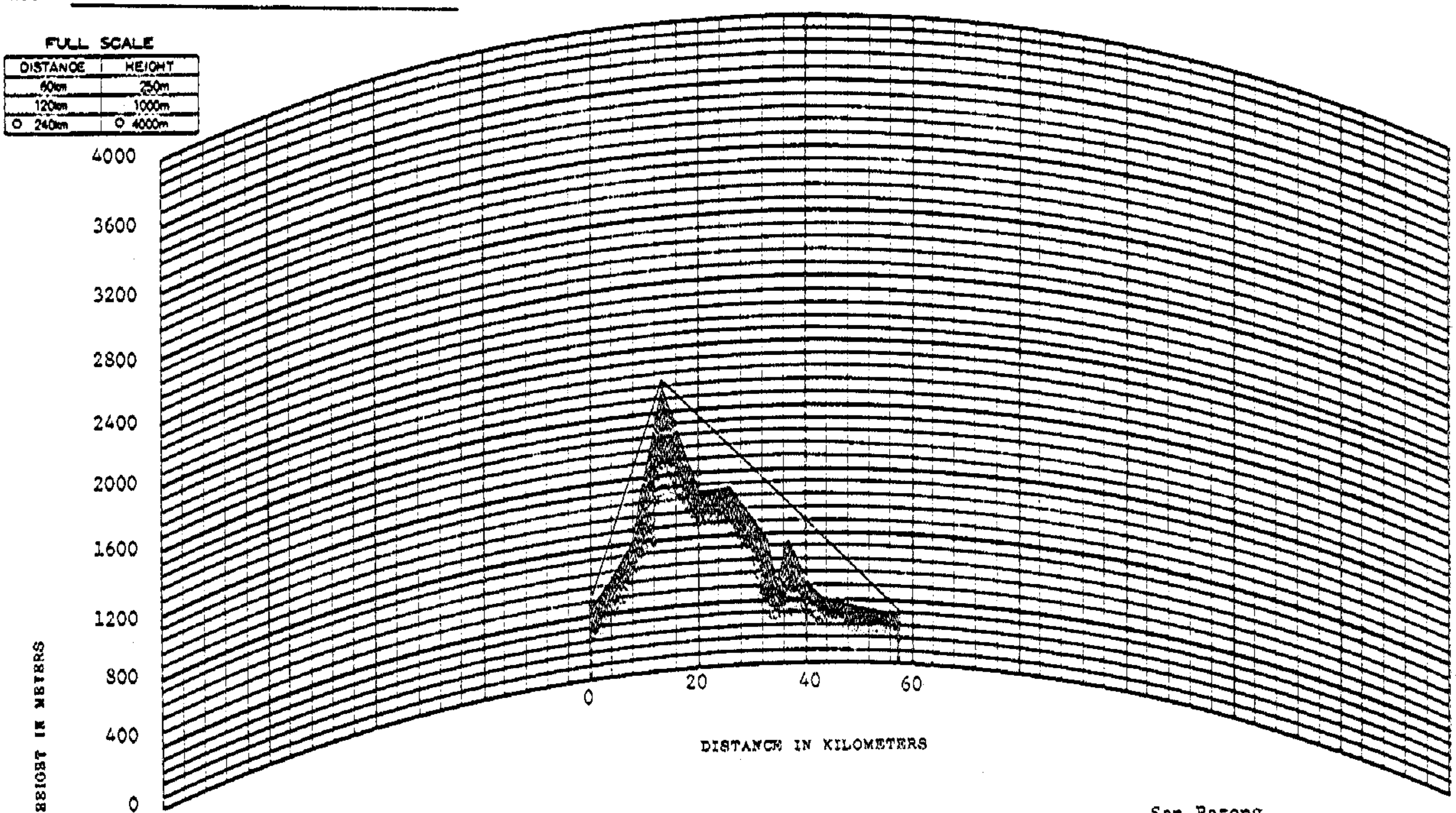


Figure 4-11

SITE: Mae Chaem
LATITUDE: ____________
LONGITUDE: ____________
GROUND ELEVATION: 467 m
ANTENNA HEIGHT: 5 m

DISTANCE: 57.5 km

ROP NO.: O/H-2

SITE: San Patong
LATITUDE: ____________
LONGITUDE: ____________
GROUND ELEVATION: 297 m
ANTENNA HEIGHT: 5 m

PROFILE MAP
(4 / 3 RADIUS)

ROUTE: ______ DRAWING NO.: ______

FULL SCALE

DISTANCE	HEIGHT
0 60km	0 250m
120km	1000m
240km	4000m

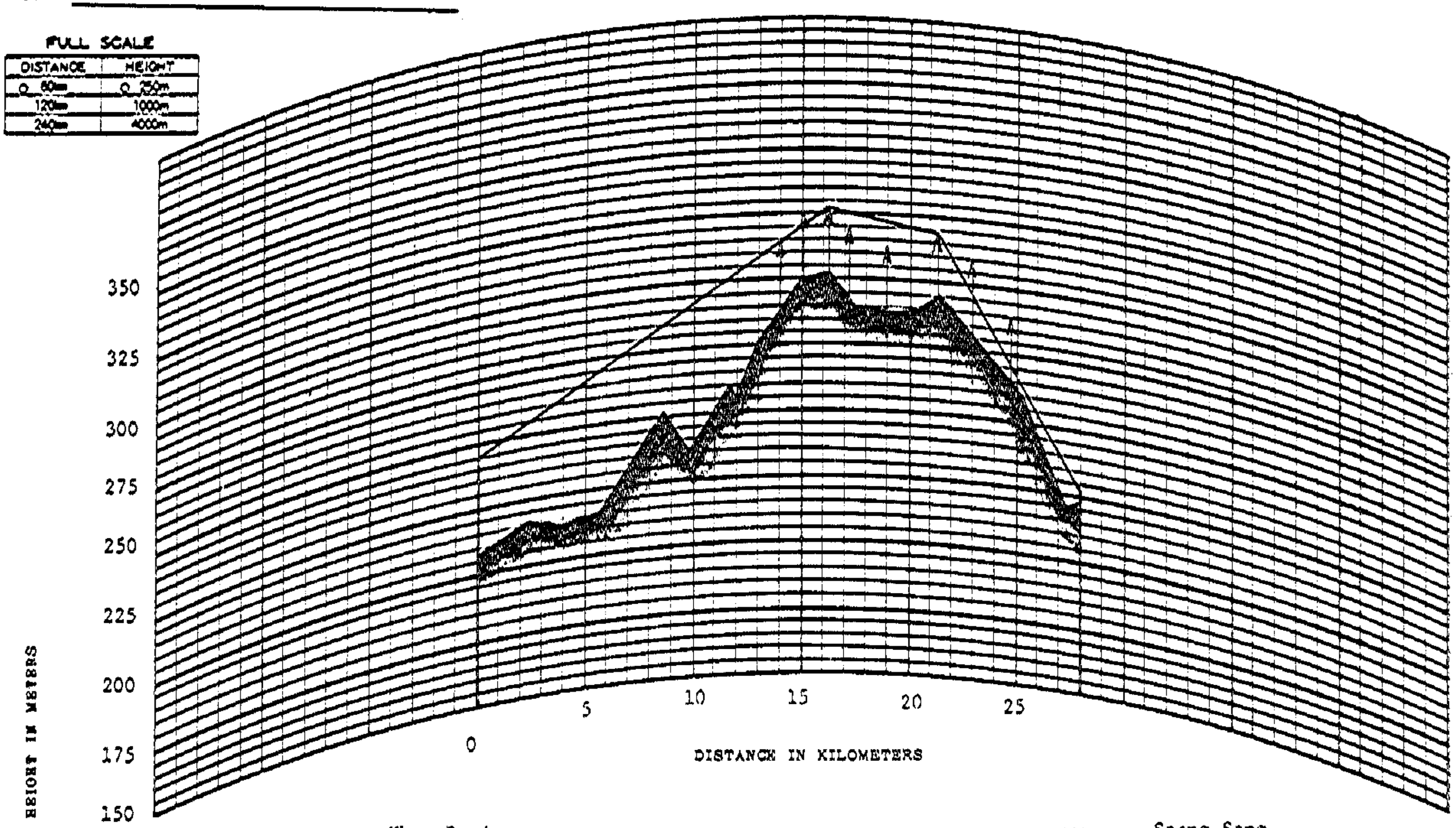


Figure 4- 12

SITE: Khon Buri
LATITUDE: ______
LONGITUDE: ______
GROUND ELEVATION: 207 m
ANTENNA HEIGHT: 38 m

DISTANCE: 28.0 km

HOP NO.: O/H-3

SITE: Saeng Sang
LATITUDE: ______
LONGITUDE: ______
GROUND ELEVATION: 223 m
ANTENNA HEIGHT: 5 m

Table 4-5 System Performance of O/H Link

Item \ Path	Sa Moeng - Mae Rim	Mae Chaem - San Patong	Khon Buri - Saeng Sang
Antenna Size	16 mØ / 16 mØ	8 mØ / 8 mØ	2.4 mØ / 6 mØ
Path Distance	24.9 km	57.5 km	28.0 km
Total Propagation Loss (50%)	204.4 dB	190.7 dB	176.4 dB
Net Loss (50%)	128.4 dB	127.5 dB	128.8 dB
Figure of Merit	188.0 dB	188.0 dB	188.0 dB
Signal / Thermal Noise	59.6 dB	60.5 dB	59.2 dB
Signal / Total Noise (50%)	55.3 dB	55.6 dB	55.2 dB
Fading Depth (99.9%)	14.0 dB	18.0 dB	14.0 dB
Signal / Total Noise (99.9%)	45.3 dB	42.4 dB	45.2 dB
Tx Output Power	47.0 dBm	47.0 dBm	47.0 dBm
Rx Input Level (50%)	-81.4 dBm	-80.5 dBm	-81.8 dBm
Margin to Threshold	23.6 dB	24.5 dB	23.2 dB

3-3-3 Comparison with Line-of-Sight System

System construction costs by line-of-sight (L/S) system and over-the-horizon (O/H) system for two radio sections of Mae Chaem - San Patong and Khon Buri - Saeng Sang are given in Table 4-6.

Table 4-6 Cost Comparison between L/S and O/H Systems

(Unit: Thousand Japanese Yen)

Name of Section	Mae Chaem - San Patong		Khon Buri - Saeng Sang	
Kind of System	L/S System	O/H System	L/S System	O/H System
Number of Radio Hops	2	1	2	1
Cost:				
Telecom. Facility	88,000	177,500	77,000	140,000
Access Road	7,000	-	14,500	500
Land	5,000	4,000	4,500	3,000
Total	100,000	181,500	96,000	143,500

For both sections mentioned in the above table, O/H system costs 1.5 to 1.8 times more than L/S system. Thus, in the economic aspect, the former commands no advantage. Worthwhile to note in this comparison is that in the said two sections, access roads to through repeater stations required for L/S system are short, i.e., 0.3 km and 0.7 km, respectively. Usually, in the mountain area, through repeater station requires 2 - 5 km access road. In this Project also, the average access road length per repeater station is 2.4 km. In Thailand, access road construction cost amounts to an equivalent of some 20 million Yen/km. Therefore, when the length of access road to through repeater station exceeds 3 km, O/H system sometimes costs less than L/S system.

In the case of Mae Chaem - San Patong section, Doi Inthanon repeater station required for L/S system is a branching station in the direction of Sa Moeng. This fact poses problem in relation to route establishment if O/H system is adopted in this section.

In view of the foregoing, in none of four sample areas where detailed studies were conducted, the application of O/H system is considered to be appropriate. However, for the application of

O/H system in other areas than the said four areas, positive studies will have to be made at the stage of detail design in the future.

3-4 Study of Cable System Application

When determining the section where to apply cable system, economic comparison between radio system and cable system must first be made in consideration of required transmission capacity and transmission route distance. However, decision by economic comparison alone seems to be not practical. There is another factor that must be considered: In Thailand, as in other developing countries, the loss of cable by stealth takes place not infrequently. Nor has the Study Team been specially requested by TOT to examine in which section to apply radio system and in which section to apply cable system. Therefore, the Study is restricted to the selection of optimum kind of cable system to be applied in the sections where TOT has already decided to adopt cable system.

There are seven sections where TOT plans to adopt cable system for Rural Long Distance Public Telephone Service and for introduction of mobile exchanges. There also are 19 sections where, according to TOT plan, entrance cable will be used from the terminal radio station to the center of service area. In three out of the seven projected cable sections the existing cable can be utilized. New cable laying is necessary in four remaining cable sections and 19 entrance cable sections totaling 23 sections.

In Saeng Chuto - Kanchanaburi section in Kanchanaburi area, one of the sections where the existing cable can be utilized, 30 channels PCM equipment only is to be additionally installed.

In 10 out of the 23 new cable laying sections the required final stage transmission capacity is not more than five circuits. Therefore, cable of small number of pairs will be newly laid in those 10 sections. To the remaining 13 sections, decision has been made to apply voice cable system with the number of pairs that fills the final stage requirement. This decision is to simplify the cable system within the range not to affect adversely the result of the aforementioned economic comparison, and this, in turn, is because cable laying distance is short and transmission capacity is relatively small. The decision has resulted from the comparative study of the following three system plans:

1) Voice cable system.
2) Voice cable system in initial stage to be replaced by cable PCM system during the period in which mobile exchanges will be introduced.
3) Cable PCM system.

Cable laying is by direct burying so as to prevent loss by stealth. Entrance cable for Rural Long Distance Public Telephone Service will be terminated in the distributing box to be installed on the pole at the center of service area. Cable to be used is armoured jelly-filled PEF cable. Loading is of H-88 type.

Number of pairs and conductor diameter have been determined, based on the transmission loss assignment plan. Transmission loss of cable (at 1 kHz, 30°C) is calculated as follows:

1) In case of non-loaded system

0.65 mm cable	1.04 dB/km
0.9 mm cable	0.74 dB/km

2) In case of loaded system

0.65 mm cable	0.55 dB/km
0.9 mm cable	0.28 dB/km

The precedence of application is:

0.65 mm cable, non-loaded

0.65 mm cable, loaded

0.9 mm cable, loaded

Transmission loss of impedance matching coil is set at 0.2 dB per piece. Entrance to telephone exchange is by six-wire lead-in. In other cases, four-wire lead-in will be used. Table 4-7 shows the projected cable sections and their distances, as well as the number of circuits and transmission loss of each section and the type of cable to be applied in each section.

Table 4-7 Cable System Plan for Terrestrial Radio System (1/3)

Area (Code)	Section	Dist. in Km	Circuit Requirements in 1984/1989/1994	Required Trans. Loss in dB	Cable System Applied in 1984	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	-	
Chonburi (3815)	Ban Lamung - Phatthaya	6.5	2/3/3	4.0	-	-	Note 2
Chantaburi (3905)	Pong Nam Ron -Pong Nam Ron (R)	2.9	4/4/20	3.35	74 - .65NL	-	Note 3 & 4
Udon Thani (4201)	Nam Som - Nam Som (R)	5.5	3/3/4	3.35	28 - .9L	-	Note 3
Khon Kaen (4309)	Nong Rua - Ban Thasala	6.0	2/3/3	3.35	28 - .9L	-	Note 3
Kalasin (4321)	Sahat Sakhan-Phu Sing	3.4	3/4/5	3.35	28 - .65L	-	Note 3
Burirum (4412)	Huai Rat - Burirum	11.0	3/4/5	4.0	28 - .9L	-	
Mae Hong Son (5301)	Mae Sariang -Mae Sariang (R)	3.3	5/6/26	3.35	100 - .65L	-	Note 3 & 4
Lamphun (5322)	Mae Tha - Mae Tha (R)	2.0	3/3/4	3.35	28 - .65NL	-	Note 3

Table 4-7 Cable System Plan for Terrestrial Radio System (2/3)

Area (Code)	Section	Dist. in Km	Circuit Requirements in 1984/1989/1994	Required Trans. Loss in dB	Cable System Applied in 1984	1994	Remarks
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	6/7/30	3.35	100 - .65NL	-	Note 3 & 4
Yala (7301)	Than To - Than To (R)	3.9	2/3/3	3.35	28 - .65L	-	Note 3
Narathiwat (7314)	Rangae - Tan Yong Mas	1.8	2/3/3	4.0	-	-	Note 5
Narathiwat (7314)	Tak Bai - Tak Bai (R)	1.5	4/6/36	3.35	150 - .65NL	-	Note 3 & 4
Krabi (7501)	Ao Luk - Ao Luk (R)	3.0	4/5/23 (20+3)	3.35	74 - .65L	-	Note 3,4&6
Krabi (7501)	Ko Lanta - Ko Lanta (R)	4.0	2/3/3	3.35	28 - .65L	-	Note 3
Trang (7523)	Sikao - Ban Mai Fat	4.0	3/4/4	3.35	28 - .65L	-	Note 3
Phang Nga (7601)	Kapong - Kapong (R)	5.5	3/4/5	3.35	28 - .9L	-	Note 3

Table 4-7 Cable System Plan for Terrestrial Radio System (3/3)

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
Phuket (7609)	Kra Too - Phuket	8.0	20/26/30	4.0	54 - .9L	-	
Chum Phon (7701)	Pathiu - Pathiu (R)	4.0	5/6/26	3.35	100 - .65L	-	Note 3
Chum Phon (7701)	Sawi - Sawi (R)	4.5	26/30/40	3.35	150 - .65L	-	Note 3 & 4
Chom Phon (7701)	Lamae - Lamae (R)	1.4	3/5/26	3.35	100 - .65NL	-	Note 3 & 4
Ranong (7707)	La-Un - La-Un (R)	3.0	5/6/26	3.35	100 - .65NL	-	Note 3 & 4
Phun Phin (7711)	Khiri Ratthanikhom -Khiri Ratthanikhom(R)	2.5	4/5/29(20+5+4)	3.35	100 - .65NL	-	Note 3 & 7

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.
Note 6 : When exchange will be installed in AO Luk, 3 circuits from Plai Phaya will be accommodated.
Note 7 : When exchange will be installed in Khiri Ratthanikhom, 5 circuits from Ban Takhun and 4 circuits from Phanom will be accommodated.

4. Selection of Optimum Terrestrial Radio System

In order to apply terrestrial radio system in this Project, full consideration is necessary for the fact that the required transmission capacity of each radio route is as small as 20 - 120 channels. As stated in Paragraph 3-1, SHF system application in such small capacity route is less advantageous economically when compared with UHF system application. Especially 11 GHz band is not appropriate choice, considering the way the radio frequency is being utilized internationally. Hence the judgment that UHF system, especially of 900 MHz band, is the optimum system for this Project.

Regarding whether to apply PCM system or not, discussions have been conducted several times during this Study. As stated in Paragraph 3-2, no substantial difference in system economy can be found between PCM system and FDM system as a system for small capacity UHF system.

In the technical aspect also, no specific difference can be recognized between the said two systems. However, FDM system is studied in detail to compare it with the domestic satellite system. For, in the existing backbone microwave route and spur microwave route, FDM system is adopted. The reason is that mutual connection between newly established and existing radio links at group or supergroup stage can more easily be achieved when FDM system only is used. If the connection has to be made between FDM system and PCM system on multiplex signal base, special interface equipment (coder and decoder) is required, and cost naturally increases.

Meanwhile, cost of PCM system is expected to come down as the result of new technical development. Therefore, it is considered to be advisable to so arrange the tender for this Project that the bidders will make their offers for PCM system also as an alternative plan, and to determine at the stage of evaluation of proposals the transmission system to be finally adopted.

Concerning in which section to apply O/H system, decision is withheld in this feasibility study as is stated in Paragraph 3-3. Decision will be made in the course of detail design in the future.

Based on findings in the foregoing study, it has been decided to apply the following systems as optimum systems to realize terrestrial radio system:

(1) 7,000 MHz 300 ch system (route capacity: 3 + 1)

(2) 900 MHz 120 ch system (route capacity: 2 + 0)

(3) 900 MHz 24 ch system (route capacity: 2 + 0)

(4) cable system

(5) 30 ch cable PCM system

Note: System (1) will be applied only in case 120 ch system cannot be applied at the final stage. (One radio hop only.)

System (2) will be applied in case 24 ch x 1 system is not sufficient to deal with final stage traffic.

System (3) will be applied mostly in case final stage capacity is up to 20 ch.

System (4) is based on TOT plan, in principle.

System (5) will be branched from existing Kanchanaburi - Tha Maka route at Saeng Chuto rural site.

Optimum terrestrial radio system selected by the foregoing consideration is given in Figure 4-1.

PART V Transmission Route Selection for Domestic Satellite System

PART V Transmission Route Selection for Domestic Satellite System

1. General

This Part V describes how the domestic satellite system is being utilized in the countries where the system has been adopted, with a view to providing useful information for the operation of Rural Long Distance Public Telephone Service in Thailand if this service is to be put into practice via satellite system. At the same time, explanation is made with respect to the general concept of DAMA (Demand Assigned Multiple Access) which is a relatively new technology.

Description is also made concerning the basic requirements for the decision of route plan for the domestic satellite system in Thailand. In addition, the lease rate, lease conditions and related subjects with regard to the PALAPA transponder of Indonesia are described.

In the transmission route selection, consideration was made so that the selected transmission route would be as realistic as possible with the adoption of terrestrial radio system for part of the route, for instance. This is the result of careful studies including the analysis of traffic forecast until 10 years ahead (ending 1994) and concerning radio interference with the existing microwave links. Transmission capacity of PALAPA transponder to be leased was also duly considered.

2. Domestic Satellite System

2-1 Overview of Domestic Satellite System Operations in Major Countries

As the result of rapid progress of the satellite communication technology, the system construction cost has been reduced to the extent the system can be utilized on the paying basis even for short distance communication. The progress of industries, as well as the development of natural resources and educational/cultural enlightenment, has catapulted the demand for telecommunications and, to meet such demand, the domestic satellite system is being introduced in many countries as part of national telecommunications networks.

The satellites to be exclusively used for domestic communication have been put into service by four countries including Canada, Indonesia, the Soviet Union and U.S.A.

The International Telecommunications Satellite Consortium (INTELSAT) is being managed for international satellite communication business as its principal objective. Leasing of satellite transponders is also on its service line. The leased satellite transponders are being utilized for domestic satellite system by many countries.

The satellite itself is of short life and its transponder costs much. However, by the progress of the satellite attitude and position control technology, the use of spot beam antenna has become possible. The increase of Equivalent Isotropically Radiated Power (EIRP) of the satellite has made it possible to reduce the size of earth station antenna. All this contributes to the greater satallite communication economy.

The satellite transponder utilization efficiency has been improved. This has resulted from the development of the Single Channel Per Carrier (SCPC) system for small transmission capacity link. By the voice activation technique the utilization efficiency for output power of the satellite transponder has been improved, and the channel capacity increase per transponder has become possible. Furthermore, in the case of establishing communication channels among a large number of earth stations where the volume of communication is small, the DAMA system can be applied to improve the satellite channel utilization efficiency remarkably.

The improvement of satellite transponder reliability is reducing the need for maintaining the redundancy configuration. This is the point worthwhile to mention in terms of operation economy of the satellite communication system.

Following is the country by country introduction of domestic satellite systems in operation. Information obtained will be used, wherever applicable, in the planning of domestic satellite system for Thailand.

2-1-1 Algeria

The domestic satellite system in Algeria was constructed for the purpose of interconnection between Algiers, the capital city, and 13 main communities in the Sahara Desert zone. The master earth station is at the same site as the standard INTELSAT earth station approximately 70 km distant from Algiers. This master earth station holds capacity for 12 telephone/telex channels and one television channel. Each of 13 rural earth stations holds capacity for two to four telephone/telex channels and one television channel.

Besides the fixed system mentioned above, there also is the transportable television transmit facility available to a rural earth station for transmission of special programmes of remote origin.

This Algerian domestic satellite system operates via leased one of INTELSAT satellite transponders. This system can accommodate one television channel (PAL system) plus 65 telephone/telex channels (bothway) by use of 36 MHz band transponder. Since it is relatively small in capacity but has to carry telephone traffic in many directions, the SCPC system is adopted.

Furthermore, to improve the telephone channel utilization efficiency and to prepare for telephone transmission system expansion in the future, the DAMA system is also applied.

The DAMA system holds control capacity for a maximum of 31 stations and for a maximum of 16 channels at each station.

System performance in terms of signal-to-noise ratio is 50 dB for telephone, 45 dB for video and 53 dB for television sound.

2-1-2 Canada

The domestic satellite system of Canada started operation in 1973 with 34 earth stations. The principal objective is to provide communication service to the natural resources development areas in the northern part of the country where the severe climatic conditions prevail.

Canada is the first country that put into practice the large scale domestic satellite system. It holds its own communication satellite series nicknamed "ANIK".

"ANIK-I, II and III" (including one for backup use), each operating with 6 GHz band up-link and 4 GHz band down-link, are in the geostationary orbits. In the near future, "ANIK-B" with 14/12 GHz band transponders is scheduled to be launched and, at the same time, approximately 90 new earth stations will also be constructed. When "ANIK-B" joins the existing "ANIK-A" series, the Canadian satellite system capacity will be remarkably augmented.

Services offered include telephone, telex and data transmission services plus television and radio programme transmission.

In the areas where telephone and telex traffic demand is large (in these areas more than 12 channels are assigned), services are being offered by the FDM-FM-FDMA system. In remote areas with small traffic demand (where the number of channels assigned is up to 12) the DELTA-PSK-SCPC system is adopted.

Since the pre-assigned system is employed for transmission circuits to the areas with small traffic demand, the connection between remote stations is via circuit that utilizes the double hop of the satellite link.

2-1-3 Indonesia

The domestic satellite system of Indonesia is composed of its own communication satellite PALAPA. It started with 40 earth stations. The system began operation in 1976.

The PALAPA satellite launching was to meet the increased traffic demand between the main islands and small islands in the neighborhood, and to serve as a backup system for the existing terrestrial radio system. To expand television service was another important objective of the PALAPA launching.

The PALAPA satellite system consists of one operational satellite and one spare satellite. Both are in the geostationary orbits. These satellites are designed to cover the five ASEAN countries. Each satellite holds 12 transponders.

Nine out of 12 transponders of the operational satellite are allocated to the domestic satellite system of Indonesia.

This communication system is capable of wide ranged services including telephone and telegraph signal transmission, data transmission, and television/radio programme transmission. It is operated by Perusahaan Umum Telekomunikasi of Indonesia (PERUMTEL). Besides serving for public communications, it provides leased communication system for governmental agencies, educational communities, and manufacturing plants.

Telephone signal transmission systems are twofold. One is the FDM/FM system for interconnection of cities with large traffic demand. (A total of 19 stations are used.) Circuits are pre-assigned. The other is the SCPC system to serve the sparsely populated areas. (The number of stations used is 21.) The DAMA system is further adopted so as to achieve the effective utilization of satellite transponders and circuits.

The DAMA system introduced holds the control capability for a maximum of 120 remote earth stations with 3,000 channel units in order that it can successfully cope with the telephone demand increase in the future.

Television programme receiving facility is installed at 34 out of 40 earth stations, and two out of those 34 earth stations are equipped with television programme transmit facility also.

2-1-4 Norway

The domestic satellite system is adopted as a means of communication related to the North Sea oil field development.

The oil field zone lies several hundred km distant from the mainland of Norway. As a means of communication to and from such oil field zone, the troposcatter system and the satellite system were studied. The final choice was the latter.

For, the establishment of troposcatter system circuits to the remote, wide spread oil field area requires multiple diversity to improve circuit reliability and this leads to the increase of transmitting output. Consequently, the frequency allocation becomes difficult. This is why the satellite system was chosen.

One half of transponder of the spare unit of INTELSAT is leased to constitute the satellite system. By the SCPC system and the pre-assigned system, the telephone and data transmission services are being carried out. For modulation the DELTA-PSK (2-phase) system is adopted.

This Norwegian satellite system is so designed that in the event the leased transponder comes into trouble, the operation can be changed over to another transponder or a transponder of another INTELSAT system.

2-1-5 The Philippines

The Philippines consists of many islands and its population is widely distributed.

At the time of expansion and improvement of the domestic long distance communication networks, the domestic satellite system was introduced for interconnection between Manila, the capital city, and 11 other densely populated major cities. This system came into service partially in 1978. It is a joint cooperative venture among the three parties, i.e., Philippine Overseas Telecommunications Corporation, Philippine Long Distance Telephone Company and Kanlaon Broadcasting System.

The Philippine domestic satellite system uses one half of PALAPA satellite transponder leased from Indonesia. The SCPC-FM system plus the centralized control type DAMA system are adopted for telephone signal transmission.

Television signal transmission by this satellite system is also planned. When this plan materializes, television service to 80% of urban population becomes possible.

2-1-6 Conditions for Domestic Satellite System Introduction

The countries which have introduced the domestic satellite system include, besides those mentioned above, the Soviet Union, U.S.A. and Malaysia. Many of these countries are the countries where the following conditions apply:

(1) The communication network has to be composed by linking many islands.

(2) For the expansion of the existing terrestrial communication networks, especially for the television signal transmission, the terrestrial system entails much construction and maintenance costs.

(3) The national territories are extensive and the population is not uniformly distributed. There are many sparsely populated districts or the natural resources to be developed are deposited in remote districts, and there is need to establish a communication system to such districts.

(4) The natural environment is severe. Freezing and floods take place frequently to make inland transportation difficult. Hence, the construction work of terrestrial system requires a long period.

(5) In the case of a system wherein the number of channels per circuit between two points is small but the number of points to be connected is large, and if the system is to be constructed by the terrestrial system, the cost per circuit increases and makes the system economically disadvantageous.

When the domestic satellite system is introduced, it can be utilized not only for public communication services, such as telephone and telex services, but also for leased circuits of governmental offices and business organizations, as well as for television programme transmission. Such multilateral service availability makes it possible to reduce the working cost of the satellite system in many cases.

2-2 Outline of DAMA System

DAMA (Demand Assigned Multiple Access) system is a system in good contrast with PA (Pre-assigned) system. When the DAMA system is introduced, the satellite comes to hold a kind of switching function. This makes the effective use of costly satellite channel possible.

When the circuit is established by the PA system, the satellite channel has to be assigned at all times to between the predetermined earth stations. Thus the channel utilization efficiency degrades as the number of circuits becomes small. This kind of circuit establishment is certainly uneconomical.

The DAMA system was developed to remedy such disadvantage of the PA system. It is considered to be the optimum system to handle traffic between many stations where traffic demand is small. Figure 5-1 illustrates the difference between the PA system and the DAMA system.

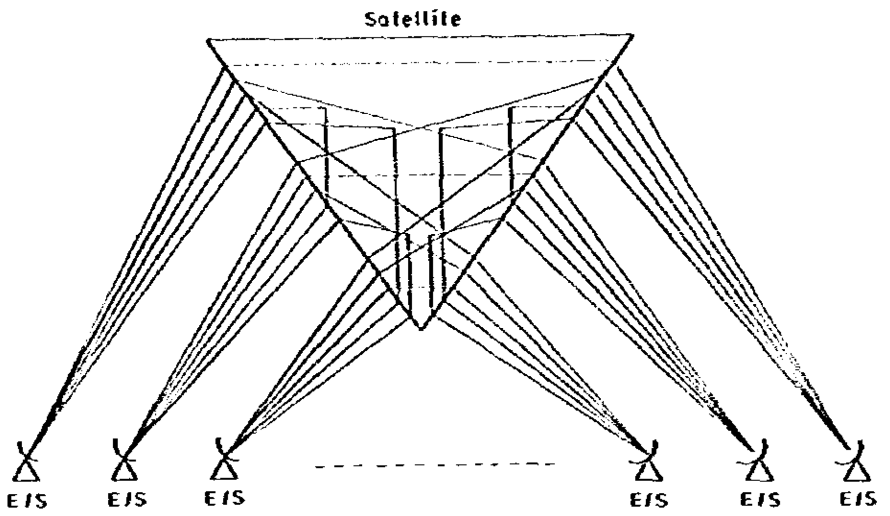
The DAMA system is so featured that all channels which can be used by one transponder be pooled at the master earth station and, only when the circuit establishment between earth stations becomes necessary, the channel required for circuit formation is assigned from among the pooled channels. When the call ends, the assigned channel is returned to the master earth station to be pooled again until it is needed for the next circuit formation. By this means the channel utilization efficiency can certainly be improved.

The channel assignment to between earth stations is made at the master earth station in all cases. Channels on the transponder, which can be used, are registered in the master DAMA facility installed at the master earth station. From the master earth station a signal is sent periodically to rural earth stations to know whether the channel allocation is required or not.

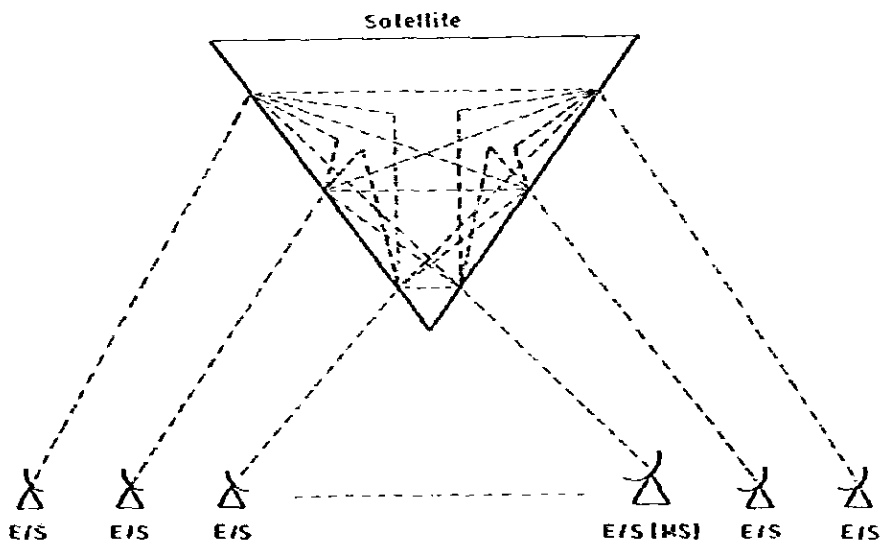
When any rural earth station requires the channel assignment, the rural earth station responds to the inquiry from the master earth station by sending the channel request signal together with necessary information for channel assignment.

The master earth station transmits the channel request signal received to the master DAMA facility where the signal is analyzed to know between which earth stations the circuit assignment is required. At the same time, an idle channel to be assigned is chosen from among the pooled channels, and necessary infomation including the frequency of the chosen channel is sent out to two rural earth stations to be connected.

The rural earth stations control the received information concerning the assigned channel by the rural DAMA facility and establish the circuit. After completion of communication, the channel is returned to the master earth station where it is pooled again as an idle channel in the master DAMA facility.



(A) PA System - Circuits are always assigned between earth stations.



(B) DAMA System - Circuits are assigned between earth stations when required by control from Master Earth Station (MS).

Figure 5-1 Explanatory Illustrations for PA and DAMA Systems

Decision has been made to apply the DAMA system to the domestic satellite system as the study objective in this Project. The reason is that the number of earth stations is large whereas the traffic volume per earth station is small.

2-3 Satellite Transponder

At present, for the domestic satellite system, the satellite that operates with 6/4 GHz bands is used. In many cases, the satellite holds 12 transponders arranged at 40 MHz intervals. Each transponder holds 36 MHz band in the 500 MHz bandwidth.

At the satellite, the received signal of 6 GHz having the 500 MHz band is amplified and converted to a 4 GHz signal. The converted signal, after being amplified, is divided into 36 MHz band signals. Each of these signals is further amplified and transmitted to the earth stations.

In the transponder, many signals are commonly amplified so that intermodulation takes place. To minimize the noise due to this intermodulation the saturation level of the amplifier is set high in order that the sufficient back-off level can be obtained. In the transmitter unit, the input from the receiver unit is separated into the odd number channel group and the even number channel group.

In this case, the center frequency interval between each two adjoining channels of the same group is set at 80 MHz so that the separation is easy.

The COMSTAR system, which is used by the U.S.A., carries 24 transponders and holds twice as large communication capacity as the Canadian and Indonesian satellite systems. This large communication capacity comes from the fact that both vertical polarization and horizontal polarization are used at the same time.

The recent trend is to apply 14/11 GHz and 30/20 GHz frequency bands to the satellite system, and this is to avoid mutual interference between the terrestrial system and the satellite system due to the common use of 6/4 GHz band in the terrestrial system. However, even the newly applied frequency bands cannot keep the satellite system completely free from disadvantages, such as propagation loss due to rainfall and receiver noise temperature rise.

As the result of the improvement of satellite transponder reliability, it has become possible to do without the spare satellite unit and thereby reduce the system cost. A country where communication traffic demand is small can, without launching its own satellite, lease a transponder of the INTELSAT system or the satellite of another country.

The domestic satellite has its antenna directivity adjusted to fit the size of the country that owns the satellite. Therefore, in the neighbor countries, the satellite EIRP somewhat deteriorates.

The INTELSAT transponder for lease is of global beam so that its EIRP is approximately 10 dB lower when compared with the domestic satellite system which is based on spot beam. Hence, the large diameter antennas are necessarily required at earth stations.

Table 5-1 presents the PALAPA satellite characteristics.

3. Route Plan for Domestic Satellite System in Thailand

3-1 Basic Route Plan Requirements

For the route plan for the domestic satellite system in Thailand, two plans can be considered. One is to centralize the system control function at the master earth station in Bangkok. The other is to provide gateway earth stations at several points on the existing microwave route and thereby distribute traffic among such gateways.

When the gateway earth station system is compared with the terrestrial radio system in terms of system economy, it requires much larger initial cost and is not desirable as far as this Project is concerned. Therefore, as the domestic satellite system to be compared with the terrestrial radio system, the master earth station system is adopted.

Insofar as the projected domestic satellite system is to have the same transmission capacity and the same grade of service as the terrestrial radio system, the route plan must satisfy the undermentioned basic requirements. These requirements reflect the result of studies with emphasis on the telephone demand forecast and the radio interference study.

Table 5-1 Characteristics of PALAPA Satellite (1/2)

Weight	
Launch (excluding adapter)	574 kg
End of life weight	255 kg
Satellite longitude service arc	75° to 85°E
Booster	Delta 2914
Communication subsystem	
Number of transmission channels	12
Channel bandwidth	36 MHz
TWT output power (one per channel)	5 W
Frequency bands	
Receive	5927 to 6403 MHz
Transmit	3702 to 4178 MHz
EIRP	See Figure 5-7
G/T	See Figure 5-8
Telemetry subsystem	
Number of telemetry channels (including analog and digital data)	24
Number of telemetry carriers (beacons)	2
Transmit frequency	4198 MHz
Command subsystem	
Number of commands	64
Number of receive frequency (redundant receiver)	1
Receive frequency	6420 MHz

Table 5-1 Characteristics of PALAPA Satellite (2/2)

Electrical power subsystem	
Solar array dc power	
Beginning of life (equinox)	319 W
After 7 years (equinox)	259 W
Batteries	
Number of batteries	2 (7 Ah each)
Power available at rated depth-of-discharge (adequate for 10 transmission channels)	210 W
Reaction control subsystem	
Total hydrazine propellant	65 kg
Stationkeeping	
North-south position control	± 0.1°
correction interval (typical)	4 wk
East-west position control	± 0.1°
correction interval (typical)	4 wk
Attitude control	± 0.17°
correction interval (typical)	2 wk
Despin control subsystem	
Primary system: pilot beacon tracker pointing accuracy	± 0.1°
Backup despin system (BUDS): earth sensor pointing accuracy	± 2°

(1) To apply the DAMA system. This is because, as stated in Paragraph 2-2, the domestic satellite system of Thailand uses a large number of earth stations whereas the number of circuits per earth station is generally small.

(2) To lease the PALAPA satellite (of Indonesia) transponder.

(3) To adopt the terrestrial radio system (partially the cable system) for the transmission route to/from the rural sites specified below. This is based on the result of study of PALAPA satellite transponder capacity and radio interference from earth stations to the existing microwave system.

1) The 47 stations where the mobile exchange is to be introduced from the beginning and the rural stations (RS) where telephone demand is relatively large and where the telephone exchange will be introduced five years after the system construction, i.e., in 1989, based on the telephone demand forecast.

2) RS in the neighborhood of the existing microwave radio stations and RS which can rather be included in the terrestrial radio system from the viewpoint of route layout in relation to 1) above.

3) RS which can be easily accommodated in the adjacent PC or LE by cable.

4) RS where the establishment of earth stations is not feasible by reason of radio interference with the existing microwave system.

(4) To incorporate RS, where the telephone exchange introduction is scheduled 10 years after the system construction, i.e., in 1994, based on the telephone demand forecast, in the terrestrial radio system in that year.