5.1.3 Microscopic Demand

A field survey was conducted in the three provinces primarily through interviews held with village chiefs and representatives of the local agencies of government-related institutions or social service organizations (such as missions). All of them requested that at least one pay phone be installed in each village for use by the residents.

Major telephone usage is:

- Contact with family members, friends, etc., living in other areas, such as those working away from home;
- Collection of information concerning the supply of products to neighboring urban markets;
- Contact with local administrative organizations (in villages where there are no local administrative agencies);
- Emergency communications with medical institutions (in villages where no medical service is available).

In selecting objective villages for this study, we chose those occupying a central position in terms of social and economic activities in each area and those with a high potential for development. Thus, there is a strong possibility that the communications volume will increase by promoting information exchange between public institutions or distribution-related organizations and those in other areas. Therefore, it will be necessary to also consider the installation of private phones in each of such organizations.

The following criteria were determined based on the average demand per village calculated from the above results and telephone density. Data from the 1980 National Population Census were used to decide the numbers for the demand matrix in villages where on-site investigations were not conducted.

(1) In principle, one pay phone should be installed in each village.

(2) Private phones should be installed in villages where there are local offices of government-related organizations, post offices, police stations, hospitals and/or missions. However, small villages, those with 500 to 700 people, are not included in initial demand because few functions are performed by public institutions, etc.

As a result of adding up microscopic demand for each of the 892 objective villages, the total demand amounted to 1,660, which almost corresponds with the penetration target in rural areas in 1997. Using this number for each village as the initial demand, technical studies, such as economic and construction feasibility, were made by taking all objective villages into account. Based on these studies, we finally selected 374 villages as objective villages for the feasibility study.

Table 5-1-5 indicates the initial demand in objective villages for the feasibility study. A breakdown indicating the number for each village is shown in Annex 1.

Table 5-1-5 Initial Demand in Objective Villages

Province Name	Number of Villages	Pay Phones	Private Phones	Total
Western	9	9	5	14
Morobe	17	20	15	35
New Ireland	14	16	10	26
West Sepik	10	10	9	19
East Sepik	23	23	19	42
Madang	13	13	8	21
Southern Highlands	59	59	41	100
Enga	41	41	48	89
Western Highlands	51	51	61	112
Chimbu	25	25	24	49
Eastern Highlands	20	20	24	44
Gulf	16	16	17	33
Central	25	25	28	53
Northern	7	7	9	16
West New Britain	2	2	2	4
East New Britain	19	19	17	36
Milne Bay	8	8	7	15
North Solomons	13	13	13	26
Manus	2	2	2	4
Total	374	379	359	738

The future demand after telephones are installed according to this project will be almost the same as that of the nationwide macroscopic demand. This figure indicates that one telephone will be installed in each objective village within about ten years.

5.2 Traffic

5.2.1 Traffic Forecast

A traffic forecast for rural telephone service is generally difficult because accurate data are hard to obtain. Since traffic data on rural telephone service in Barakau Village were collected, it was decided to analyze these data and utilize them to forecast traffic in the objective villages. Also, the flow of traffic will be estimated based on the results of on-site interviews and data on the flow of mail at post offices.

5.2.2 Traffic at Barakau Village

Barakau is a fishing village with a population of 676 in the Central Province. It is located 25 Km from Port Moresby. PTC installed one pay phone in this village. Based on an investigation of this pay phone for about two months (March 9 ~ May 4, 1989), various data were obtained.

These data include: the number of calls for each day of the week, which is shown in Figure 5-2-1; daily total holding time shown in Figure 5-2-2; and the number of calls per hour shown in Figure 5-2-3. The average number of calls per day calculated from Figure 5-2-1 is 24.7. The average daily total holding time calculated from Figure 5-2-2 is 94.8 minutes. Accordingly, the average holding time per call is about 3.8 minutes (94.8 min/24.7 call) and the average total traffic is 0.089 erl (2.15 hour/24 hour). According to Figure 5-2-3, busy hour calls (BHCs) occur from 9 to 10 A.M. and the number of BHCs per hour is 4.8. Thus, busy hour traffic (BHT) is 0.30 erl (4.8 call/h x [3.8 min/ 60 min]).

These data are shown in Table 5-2-1. Although these traffic data were obtained from one pay phone installed in Barakau Village, it is understood that these figures represent the total traffic of Barakau Village. If multiple telephone sets are installed, these figures would be distributed among each telephone set.

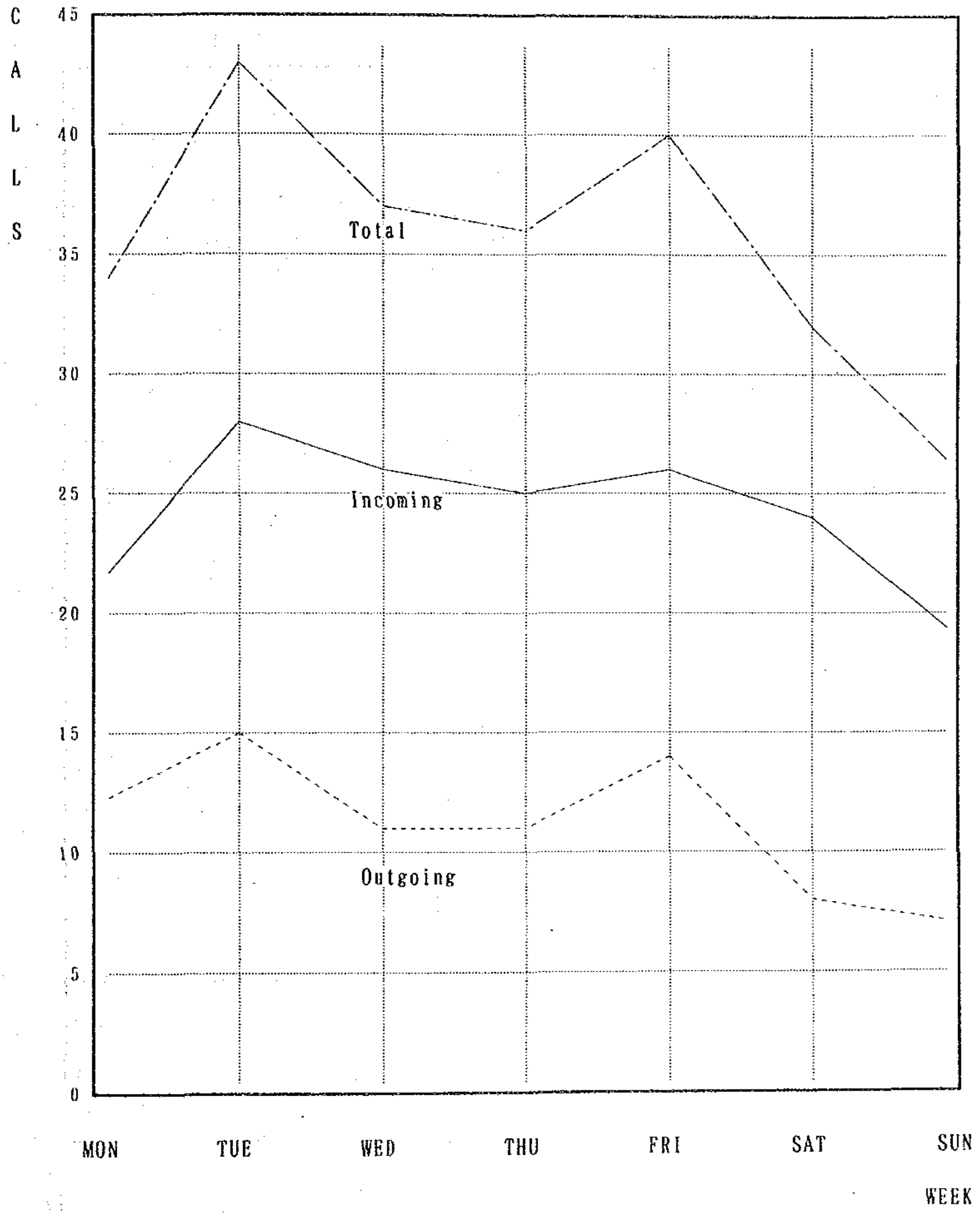


Fig. 5-2-1 Average No. of Calls for Each Day of the Week

(Answered Call)

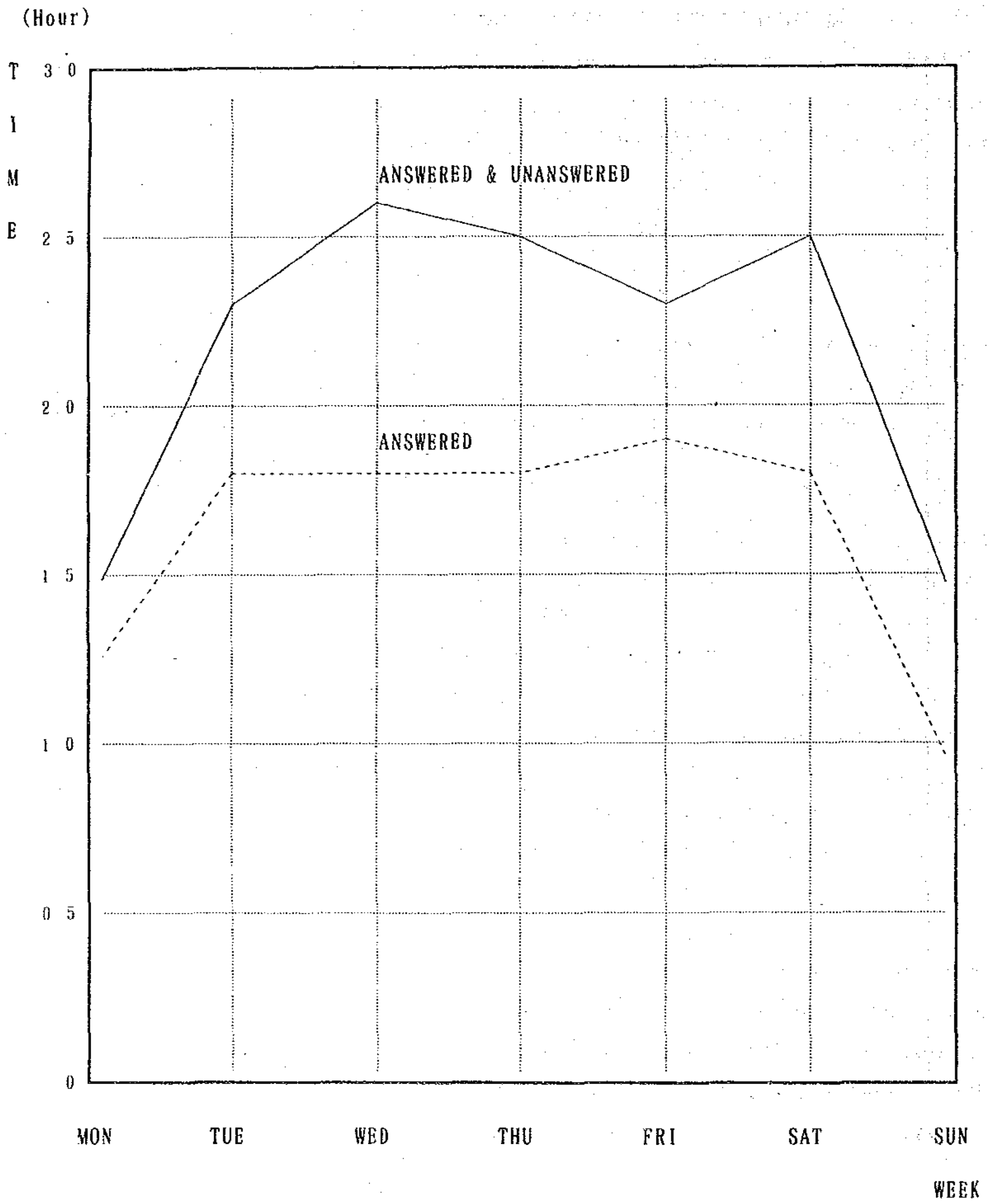


Fig. 5-2-2 Daily Total Holding Time

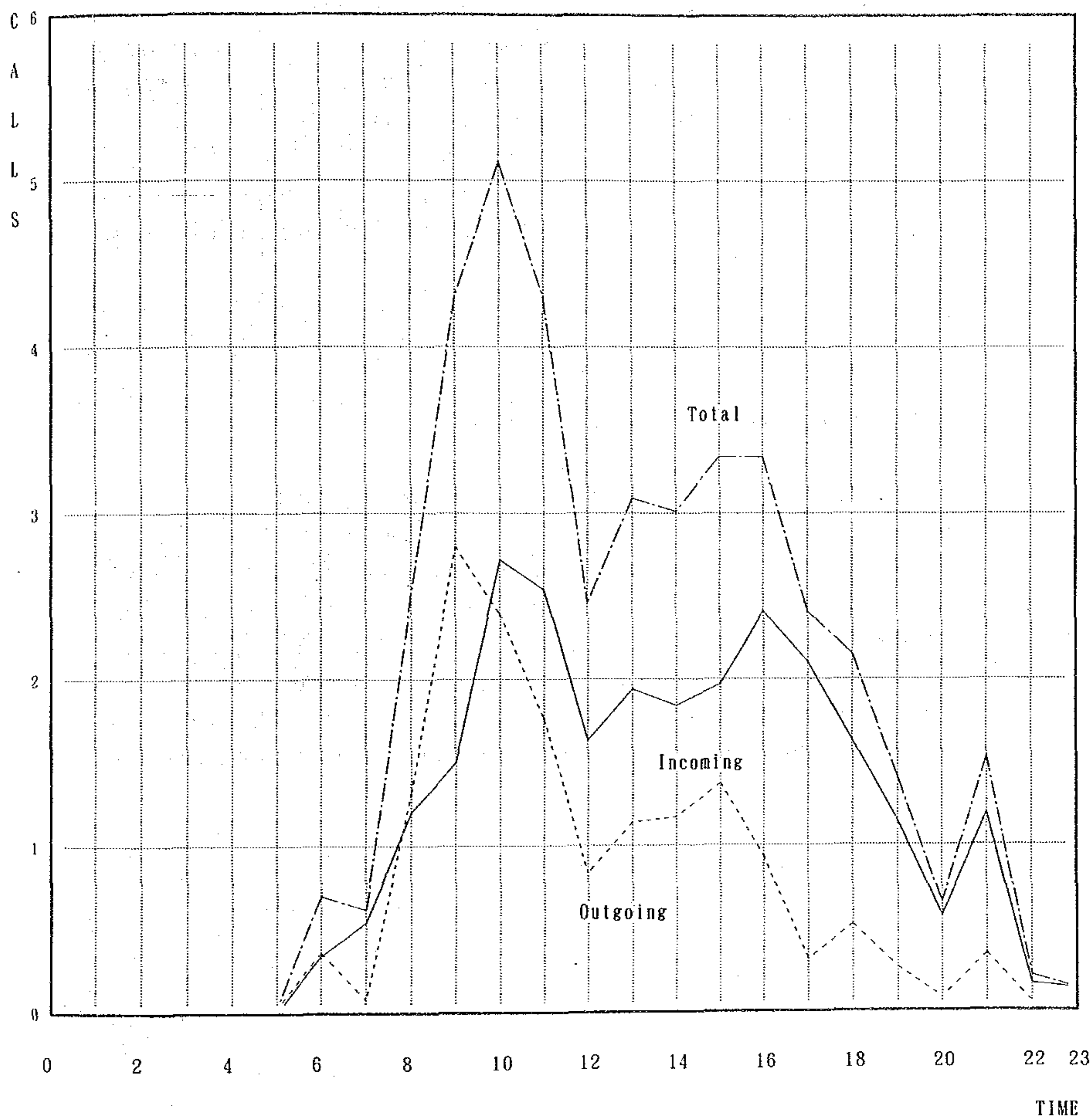


Fig. 5-2-3 Average No. of Calls per Hour

(Answered & Unanswered Call)

Table 5-2-1 Traffic Data in Barakau Village (incoming + out going call)

Average Number of Calls	Busy Hour Calls	Average Holding Time for All Calls	Busy Hour Traffic	Average Traffic
24.7 (call/day)	4.8 (call/h)	3.8 min	0.30 erl	0.089 erl

5.2.3 Traffic Forecasts for Objective Villages

Traffic in objective villages is influenced by various factors, such as population, existence of government organizations or factories, size of neighboring cities, etc. In this section, the traffic forecast flow described in Figure 5-2-4 will be used. It is assumed that the relationship between the traffic of Barakau Village ($T_{Barakau}$) and the calling rate (CR_{Boroko}) at the Boroko switching office to which the telephone in Barakau is connected is equal to the relationship between the traffic of objective villages (T_o) and the calling rate at the switching office to which relevant telephones are connected (CR_{oe}).

$$T_{Barakau} : CR_{Boroko} = T_o : CR_{oe}$$

Accordingly, the traffic of objective villages can be obtained by Formula (1).

$$T_O = T_{Barakau} \times \frac{CR_{Oe}}{CR_{Boroko}} \qquad \text{------ (1)}$$

T_O: Traffic of objective villages

$T_{Barakau}$: Barakau traffic

CR_{Boroko}: Calling rate at Boroko switching office

CR_{Oe}: Calling rate at switching offices to which telephones of the objective villages are connected.

The figure obtained in this formula will be appropriate if the size of the objective village is equal to that of Barakau Village. However, when the size of the village differs, some revisions become necessary. Such revisions can be made by dividing the population of objective villages into three groups as shown in Table 5-2-2.

Table 5-2-2 Village Ranking

Rank	Population (including surrounding villages)	Average Population
A	Over 2,000	2,500
B	1,000 - 2,000	1,500
C	Under 1,000	800

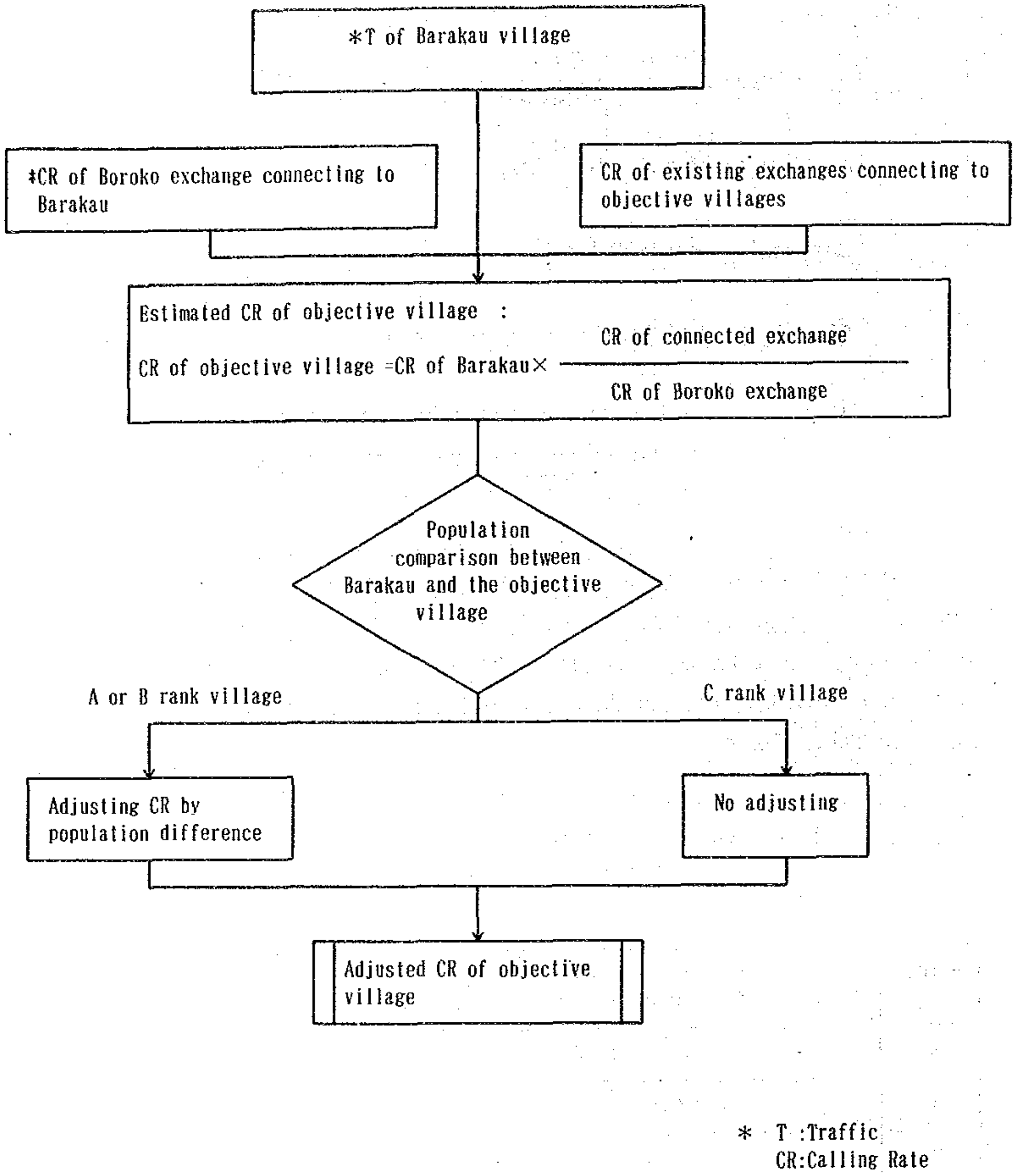


Fig. 5－2－4 Flow Chart of Traffic Forecast for Objective Villages

Barakau Village belongs to the C Rank as it has a population of under 1,000, even after including that of surrounding villages. Accordingly, the traffic forecast obtained using the Formula (1) will be applicable to the objective villages at the C rank. With regard to objective villages at the A and B Ranks, Formulas (2) and (3) can be applied using average population.

$$T_A = T_O \times \frac{2,500}{800} \quad \text{------- (2)}$$

$$T_B = T_O \times \frac{1,500}{800} \quad \text{------ (3)}$$

T_A: Traffic of objective villages at A Rank

T_B: Traffic of objective villages at B Rank

Using these formulas, traffic forecasts were made for all objective villages. As a result, the average traffic forecasts for villages at A, B and C ranks are as follows:

Villages at A Rank: 0.74 (BH) 0.22 (Mean)

Villages at B Rank: 0.44 (BH) 0.13 (Mean)

Villages at C Rank: 0.24 (BH) 0.07 (Mean)

Total traffic of all 374 objective villages was estimated to be 32.34 erl using the above mentioned traffic forecast method. Detail results are included in Annex 3.

5.2.4 Traffic Dispersion

In order to forecast traffic flow when telephone sets are installed in each village based on the Rural Telecommunication Development Plan, a survey was made via interviews with people living in objective villages and

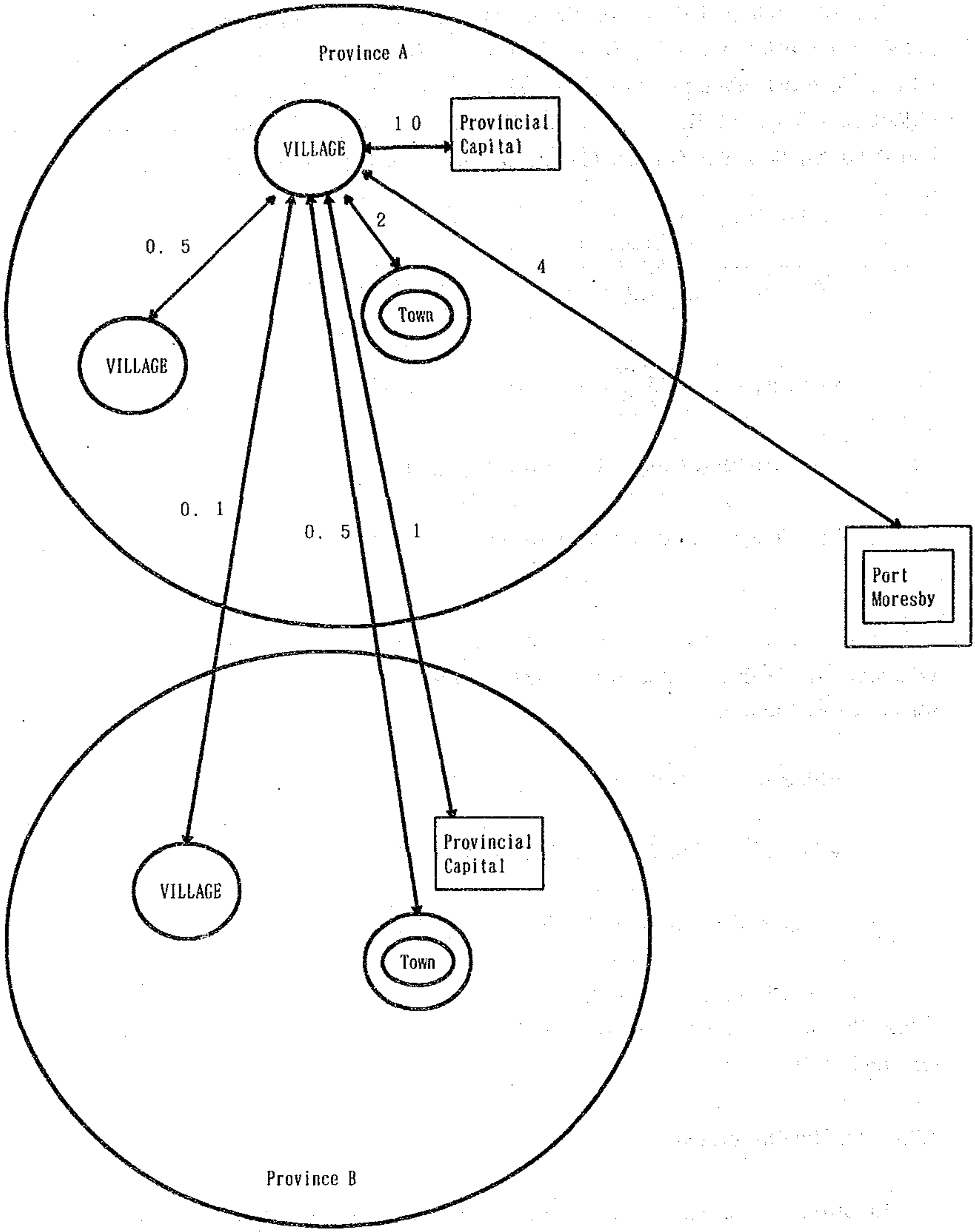


Fig. 5－2－5 Forecasted Traffic Dispersion surrounding villages, and by paying attention to the flow of mail at post offices. The result of this survey is shown in Figure 5-2-5. This figure shows that when telephone sets are installed in rural villages, most of the traffic flows to the capital of the province in which villages are located, then, to the capital (Port Moresby) and to relatively big towns within the same province. Even within the same province, calls between villages are few and this trend becomes more obvious when the villages in other provinces are involved.

As a result, in terms of switching equipment from the standpoint of network configuration, it is estimated that it is more efficient to install switching equipment having a medium capacity and above in towns where large traffic is expected, rather than to install switching equipment having a small capacity on a decentralized basis.

Accordingly, it will be desirable to connect the subscribers of the objective villages to existing switching equipment installed at the provincial capital, or at relatively big towns within the same province.

5.3 Verification of Traffic Forecast

5.3.1 Calculation of Traffic Based on Data on Revenues from Call Charges for Menyamya Village

(1) Objective Village for Verification

Since data on revenues from call charges in the past for Menyamya Village in Morobe Province could be obtained, an attempt is made to confirm whether these data match those of the traffic forecast. Menyamya Village is located about 100 km from Lae and has a population of 2,260 within a radius of five kilometers.

(2) Revenues from Call Charges

The data collected for this village include only revenues from automatically dialed call charges, but traffic data are not included. Therefore, these data cannot be compared "as is". Five private phones and one pay phone have been installed in this village. The revenues from call charges from the respective telephone sets are shown in Table 5-3-1.

Table 5-3-1 Revenues from Call Charges from Menyamya Village
(March 5, 1987 — July 4, 1989)

Telephone Number	Metered Call Charges (k)	Measured Months	Metered Call Charges/ Month (K)	Remarks
42 5211	11,630.01	25	465.20	BUSINESS PHONE
42 5212	9,621.62	24	400.90	BUSINESS PHONE
42 5215	2,702.18	25	108.10	PAY PHONE
42 5216	250.40	9	27.82	BUSINESS PHONE
42 5218	8,397.30	27	311.01	BUSINESS PHONE
42 5219	7,003.71	26	269.37	BUSINESS PHONE
Total	39,605.22		1,582.39	

As shown in this table, revenues of 1,582.39 (K/Month — six direct exchange lines) are obtained per month. Average daily revenues of 52.75 (K) are calculated by dividing this figure by 30.

(3) Traffic Flow

The traffic flow shown in Figure 5-3-1 can be estimated if the traffic flow given in Figure 5-2-5 is applied to Menyamya Village.

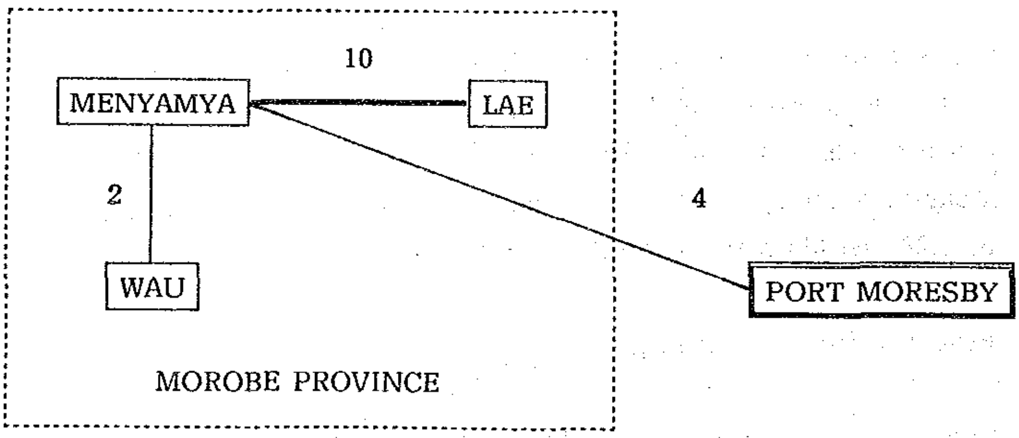


Figure 5-3-1 Traffic Flow in Menyamya Village

From this figure, the traffic ratio between Lae, Port Moresby and Wau is as follows:

LAE : PORT MORESBY : WAU = 10 : 4 : 2 = 62.5(%):25.0(%):12.5(%)

(4) Charging

Calls to Wau and Lae from Menyamya Village are charged 22 toea per minute since these districts are in the same call zone. Calls to Port Moresby are charged 44 toea per minute since such calls are categorized as calls to an adjoining call charge zone. If the average holding time of 3.8 minutes obtained from the data for Barakau Village is applied, the revenue per one call from Menyamya to each destination is as follows:

WAU:	0.22 (K/min)	X	3.8 (min/call)	=	0.84 (K/call)
LAE:	0.22 (K/min)	X	3.8 (min/call)	=	0.84 (K/call)
PORT MORESBY:	0.44 (K/min)	X	3.8 (min/call)	=	1.67 (K/call)

(5) Average Call Unit Charge

As shown by the traffic flow, there is a difference in traffic depending on destination, and therefore the charging amount differs. Accordingly, the traffic ratio for each destination is multiplied by the respective charging amount to obtain the weighted average revenue per destination.

Destination:	Average Revenue Per Call	X	Traffic Ratio	=	Weighted Average Revenue
WAU:	0.84 (K)	X	0.125	=	0.105 (K)
LAE:	0.84 (K)	X	0.625	=	0.525 (K)
PORT MORESBY:	1.67 (K)	X	0.250	=	0.418 (K)

As a result, the average revenue per call is estimated as follows:

0.105 (K) + 0.525 (K) + 0.418 (K) = 1.048 (K/Call)

(6) Number of Calls and Traffic

According to Item (2), revenues per day are 52.75 (K) in this village. Therefore, the number of originating calls per day is 50.33 [52.75(K)/ 1.048(K)].

When an average holding time of 3.8 min is applied, originating traffic is as follows:

[{50.33(call) X 3.8(min)}/60(min)]/24(hour) = 0.133(erl)

Since the traffic and the number of calls obtained from the actual data reflect only outgoing revenues, it is necessary to get the total traffic considering the proportion of outgoing and incoming traffic ratio (42.9% : 57.1%), as with the Barakau data. Therefore, the total number of calls and traffic are calculated as follows:

Number of Calls:	50.33/0.429 = 117.3 (call)
Traffic:	0.133/0.429 = 0.310 (erl)

5.3.2 Calculation of Traffic Based on Traffic Forecast

The traffic in Menyamya is calculated using the traffic forecast formula previously mentioned. With a population of 2,260 people, this village is classified as an A-Rank village connected to the Lae switching office.

According to Formula (1) in Item 5-2-3,

$$T_O = T_{Barakau} \times \frac{CR_{oe}}{CR_{Boroko}}$$

$$T_O = 0.089 \times \frac{0.1431}{0.1449} = 0.879$$

Using the necessary revision to apply this formula to A-Rank villages, the traffic in Menyamya, $T_{Menyamya}$, is:

$$T_{Menyamya} = 0.0879 \times \frac{2500}{800} = 0.274 \text{ [erl]}$$

The number of calls in this case is:

$$\{0.274(erl)/(3.8(min)/60(min))\} \times 24(h) = 103.8 \text{ (call)}$$

The traffic and the number of calls thus obtained are shown in Table 5-3-2.

Table 5-3-2 Traffic and Number of Calls of Menyamya

	Traffic (erl)	Number of Calls/Day
Results Using Menyamya Revenue Data	0.310	117.3
Results Using Traffic Forecast Formula	0.274	103.8

When the above figures are compared, both figures coincide well even though the forecast results are slightly lower than the Menyamya revenue data, showing that the traffic forecast method for the objective village is appropriate.

CHAPTER 6

RURAL TELECOMMUNICATION DEVELOPMENT PLAN

CHAPTER 6. RURAL TELECOMMUNICATION DEVELOPMENT PLAN

6.1 Selection of Objective Villages

In PNG, 87% (2.6 million) of the population lives in rural areas, which are the target of this rural telecommunication development plan. The telecommunications situation in these areas is so poor that most villages do not have any means of telecommunications. In larger villages, privately supplied or PTC operated radio stations are in operation in provincial government offices, churches or medical facilities, but the operating conditions and management are quite poor, so only a limited number of persons can receive the benefit of communications.

Since the telecommunications status in the rural area is as described above, the following points are basically taken into consideration in selecting objective villages for feasibility studies of this rural telecommunication development plan covering the whole of PNG.

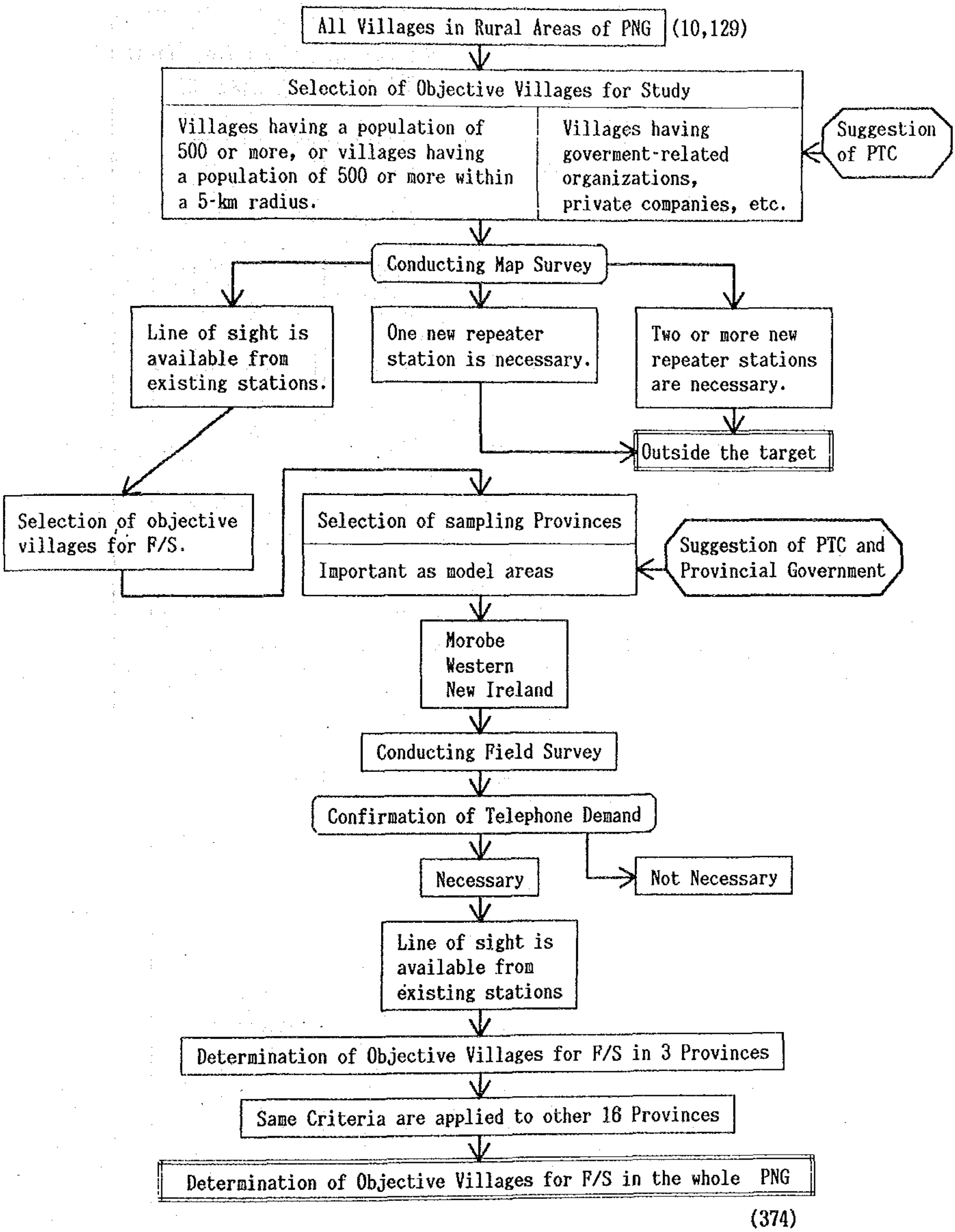
- Places where as many people as possible can obtain benefits from the telephone;
- Places where there is sufficient social and economic infrastructure that allows telephone usage;
- Places that enable relatively easy construction, maintenance and operation.

Based on above viewpoints, the method shown in Figure 6-1-1 was adopted to select the objective villages for study.

That is, the necessity of telephone installation was studied with regard to the total 10,129 villages in rural districts of PNG in terms of (1) whether or not a population is more than 500; and (2) whether or not government-related organizations and private companies exist. As a result, 892 villages were selected. Then, a map survey was conducted for these villages to study whether it was possible to get line of sight from existing stations.

Based on the results of the map survey, villages where it is possible to utilize facilities of existing stations or villages themselves can serve as repeater points to the next village, were basically selected as objective villages for the feasibility study. With regard to three provinces which are important as model areas and specified by PTC, a field survey was additionally carried out. In this field survey, the possibility of utilization of facilities of existing stations, and the necessity of telephone installation were confirmed, and the final objective villages for the feasibility study was determined. Also, construction of new repeater stations is considered as exceptions, for the villages that were found to have no possibility of existing facility utilization after a field survey, but where telephone installation is absolutely necessary.

As a result, 374 objective villages for feasibility study throughout the entire PNG were selected. Tables 6-1-1 and 6-1-2 list the number of objective villages by province. Annex I shows the selected village names.



( ):Number of Villages

Fig.6-1-1 Objective Village Selection Flow

Table 6-1-1 No. of Objective Villages for F/S in 3 Provinces

Province	Exchange Office	Existing Repeater Station	No. of Objective Village	Total
WESTERN	DARU		1	9
	KIUNGA		4	
	TABUBIL	Mt. ROBINSON	1	
	Mt.HAGEN	Mt. KEREWA Mt. KAROMA Mt.IALIBU KUTA	3	
MOROBE	LAE	NAMBAMATI OMSIS Mt. MISSION WIDERU	16	17
	WAU		1	
NEW IRELAND	KAVIENG		6	14
	RABAUL	TOMAVATUR KONOKALANG	8	
Total				40

Table 6-1-2 No. Of Objective Villages For F/S In 16 Provinces

(1/2)

Province	Exchange Office	Existing Repeater Station	No. of Objective Village	Total
1. WEST SEPIK	AITAPE	Mt. SAPAU NUKU	8	10
	VANIMO		2	
2. EAST SEPIK	WEWAK	NAWEEN ALBOWAGI TURU	6	23
	ANGORAM		6	
	MAPRIK	AMBUNTI	11	
3. MADANG	MADANG	HANSEMAN DIBUN TARITE	13	13
4. SOUTHERN HIGHLANDS	TARI	KEREWI Mt.HAREP LAMAYA	35	59
	MENDI	OGUSUMBA IALIBU Mt.KERAISA Mt.WANAMU	24	
5. ENGA	TARI	KEREWA PORGERA ALUPAI WANA Mt.LAMAVA	27	41
	WABAG	KEGUM TAKAMANDA	14	
6. WESTERN HIGHLANDS	Mt.HAGEN	KEGUM KUTA KAGAMUNGA	29	51
	BANZ	KAJMUNGA MINJ	22	
7. CHIMBU	KUNDIAWA	KULSIMAU KERIGOMNA KUNDIAWA	25	25

Table 6-1-2 No. Of Objective Villages For F/S In 16 Provinces

(2/2)

Province	Exchange Office	Existing Repeater Station	No. of Objective Village	Total
8. EASTERN HIGHLANDS	GOROKA	Mt.YANGUTEGA Mt.GOSOPOMPOFO OKAPA YONKI KAINANTU	20	20
9. GULF	KEREMA	CUPOLA	16	16
10. CENTRAL	BEREINA		8	25
	KWIKILA	BOREGORO	8	
	KUPIANO		9	
11. NORTHERN	POPONDETTA	Mt.FALA HOSKIN	7	7
12. WEST NEW BRITAIN	KIMBE	LIAPO HOSKIN	1	2
	BIALLA		1	
13. EAST NEW BRITAIN	RABAUL	TUNNEL HILLS KEREVAT TOMAVATUR	19	19
14. MILNE BAY	ALOTAU	Mt.BOBO SAMARAI	5	8
	BWAGAOIA	Mt.SISA	3	
15. NORTH SOLOMONS	BUKA	Mt.NOTUKU TAKANIAT	12	13
	BUIN		1	
16. MANUS	LORENGAU	SALASEA	2	2
Total				334

6.2 Telecommunications System

6.2.1 Various Rural Telecommunications Systems

(1) Technical Considerations

In general, the term "rural telecommunications system" is used as a synonym for "small-capacity telecommunications system". The following presents representative rural telecommunications systems, and compares their advantages and disadvantages. The systems include (1) a TDMA radio system, (2) an FDMA radio system, (3) a single channel system, (4) a digital microwave system, (5) a PCM Cable System, and (6) a metallic subscriber cable system, each of which is schematically outlined in Figure 6-2-1.

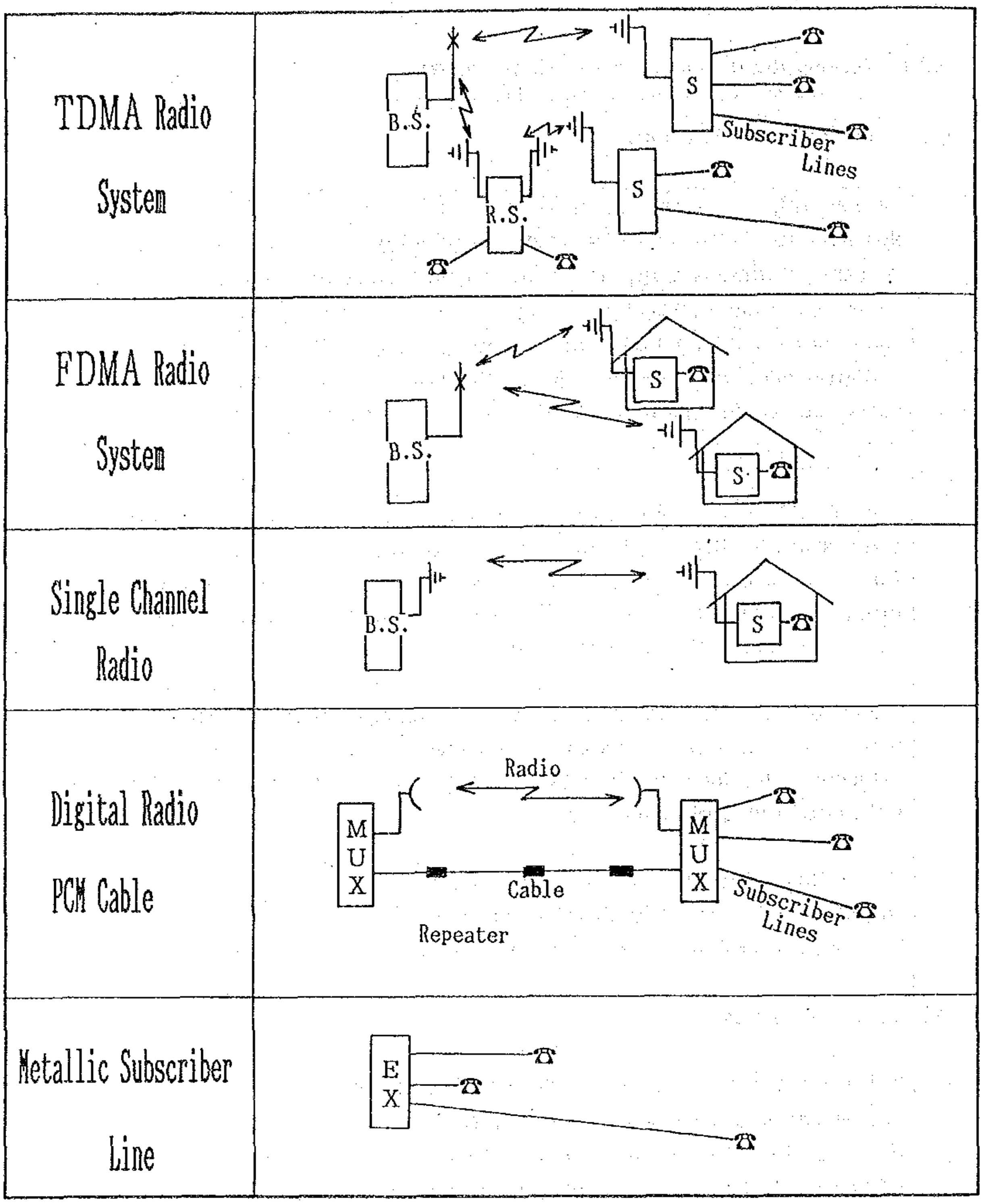
The TDMA and FDMA radio systems are subscriber line concentrating radio systems that enable the common use of a fixed number of circuits (m) by a number of subscribers (n) that is greater than the number of circuits (m<n). The other rural telecommunications systems have a 1:1 correspondence between circuits and subscribers.

Table 6-2-1 lists the results of a technical study of various rural telecommunications systems conducted by GAS7 (Rural telecommunications) of the CCITT and which will be included in the 1989 edition of the GAS7 handbook.

Since this table provides a general guideline of each system, it is not targeted for a specific district; however, it appears obvious that the TDMA radio system will play a major role in rural telecommunications.

(2) Cost Comparison

Table 6-2-2 and Figure 6-2-2 show the results of cost comparison of the various rural telecommunications systems. This cost comparison was also discussed by GAS7 of the CCITT and will be included in the 1989 edition of the GAS7 handbook. This cost comparison was performed to estimate the relative cost of each system using a unit price; however, the actual cost for each item of equipment differs by manufacturer, and thus may not always fit the relative cost given in the table.



cf. B.S.=Base Station
R.S.=Repeater Subscriber Outstation
S =Subscriber Outstation
EX =Exchange
MUX =Multiplexer

Fig.6-2-1 Rural Telecommunication Systems

Table 6-2-1 Technical Comparison for Rural Telecommunication Systems

FACTOR \ SYSTEM	PCM CABLE	DIGITAL MICROWAVE SYSTEM	TDMA RADIO SYSTEM	FDMA RADIO SYSTEM	SINGLE CHANNEL RADIO	METALLIC SUBSCRIBER LINE
POSSIBILLTY OF SHARING CHANNELS BETWEEN SUBSCRIBER	NO	NO	YES	YES	NO	NO
EFFICIENT USE OF RADIO SPECTRUM	NOT APPLICABLE	FAIR	GOOD	BETTER	FAIR	NOT APPLICABLE
POTENTIAL FOR ADDING REPEATERS	GOOD	GOOD	BETTER	POOR	POOR	POOR
BASE OF ADDING SUBSCRIBERS	GOOD	GOOD	BETTER	FAIR	FAIR	FAIR
BASE OF ADDING NEW REMOTE LOCATIONS TO NETWORK	FAIR	FAIR	BETTER	GOOD	GOOD	FAIR
FACILITY FOR EVOLUTION TO ISDN	BETTER	BETTER	GOOD	NO	NO	POOR
MAINTENANCE CONSIDERATIONS (QUANTITY AND RELIABILITY OF HARDWARE, NO. OF SITES)	GOOD	GOOD	GOOD	FAIR	FAIR	GOOD

RELATIVE MERIT LOWEST TO HIGHEST IS POOR, FAIR, GOOD, BETTER.

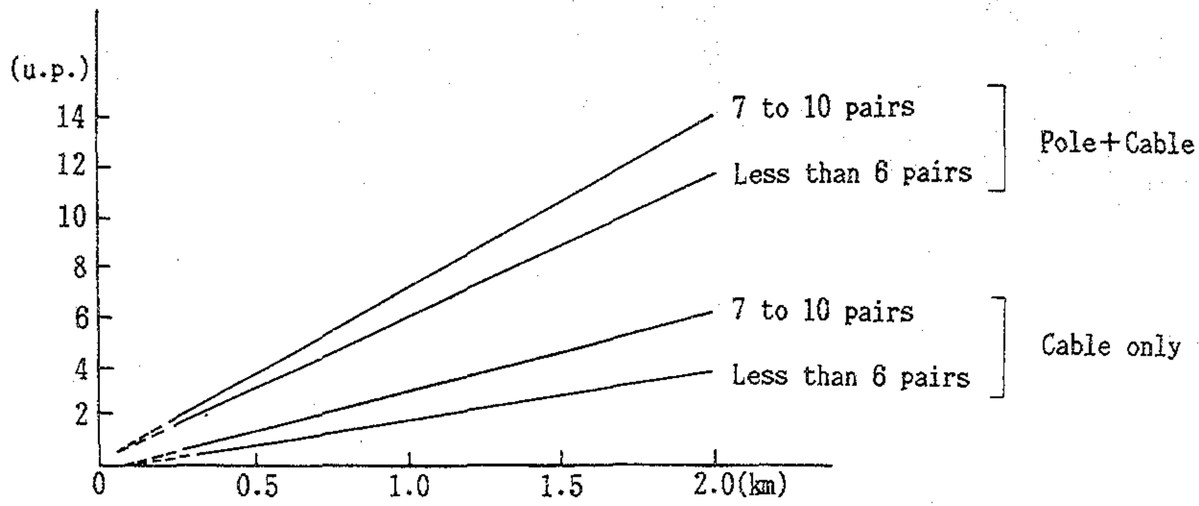
Table 6-2-2 Estimated Cost of Rural Telecommunication Systems

		COST IN UNIT PRICE(U.P.)	
		INCLUDING SOLAR POWER	EXCLUDING SOLAR POWER
TDMA RADIO SYSTEM	BASE STATION	—	120.0
	REPEATER STATION	40.0	25.0
	SUBSCRIBER OUTSTATION	10.0	6.0
	SUBSCRIBER LINE UNIT	0.5 PER SUBSCRIBER	0.5 PER SUBSCRIBER
FDMA RADIO SYSTEM	BASE STATION	—	120.0
	SUBSCRIBER OUTSTATION	5.0	4.0
SINGLE CHANNEL RADIO(BOTH SIDES)		6.0	5.0
PCM CABLE SYSTEM (30 CH PCM)	TERMINAL(ONE SIDE) OR DROP/INSERT REPEATER	—	10.0
	REPEATER UNIT (BOTH WAY)	—	0.2
	REPEATER HOUSING	—	1.0
DIGITAL MICROWAVE (R.S.=50km, UP TO 30 CH)	RADIO TERMINAL (ONE SIDE)	80.0	70.0
	RADIO REPEATER (BOTH WAY)	140.0	120.0
	SUBSCRIBER MULTIPLEX (FOR 30 CH)	12.0	8.0

Note 1 THESE COSTS INCLUDE:
- EQUIPMENT COST
- MATERIAL COST SUCH AS MASTS. ANTENNAS, ETC.
- CONSTRUCTION COST, I.E. LOCAL CIVIL WORK.

Note 2 R.S.=REPEATER SPACING

Fig.6-2-2 **Estimated Cost of Subscriber Line**
(Incl. Construction Fee)



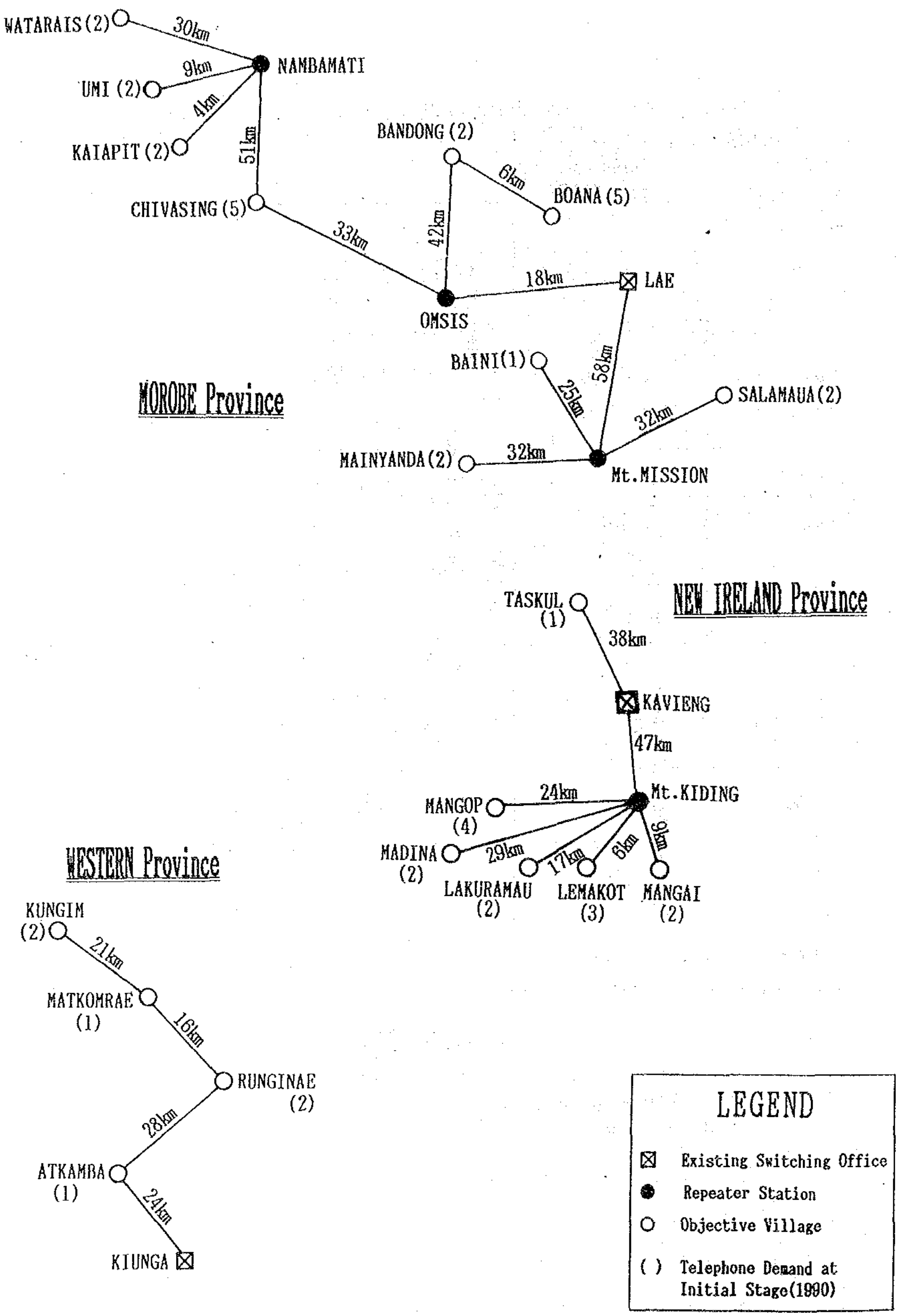


Fig.6-2-3 Model Areas to Determine the Most Suitable Rural Telecommunication Systems

6.2.2 Determination of the Most Suitable Rural Telecommunications Systems

The previous section discussed technical and economic aspects of the various rural communications systems. The following discusses which systems are most suitable for use in this rural telecommunication development plan.

The study was conducted by picking typical rural areas in PNG as models, then determining the most suitable telecommunications systems for those areas, assuming that those systems would be the most suitable ones for all rural areas in PNG. The model provinces were chosen in consideration of the geographic characteristics of PNG, and they are Morobe, a mountainous region, New Ireland, an island area, and Western, a flat swampy area. Typical areas were then selected as model areas in each model province based on characteristic village distribution and demand for telephone service. Figure 6-2-3 shows these model areas.

From this figure, it can generally be estimated that the characteristics of villages in PNG are:

(i) Villages with demand for telephone service are located far from other villages.

(ii) Overall telephone demand in each village is low.

Various telecommunications systems mentioned before, were used to calculate the cost per telephone set in each model area, with the results shown in Figure 6-2-4.

Since it is difficult to provide repeater functions for the FDMA radio system at present, it was excluded from the study of this cost comparison. Moreover, since it is geographically impossible to effectively utilize a PCM Cable System in model areas of Morobe and Western Provinces, it was considered only in a model area of New Ireland Province.

Cost comparison was performed for two periods, that is, the initial stage of telephone introduction (1990) and 10 years later (2000). This cost comparison was made on a per-telephone-set basis, assuming, for convenience, that demand for telephone service in 2000 will be twice that in 1990 in the same objective villages.

The following results were obtained from the study of the most suitable rural telecommunications system for each model area, based on both cost comparison and technical considerations.

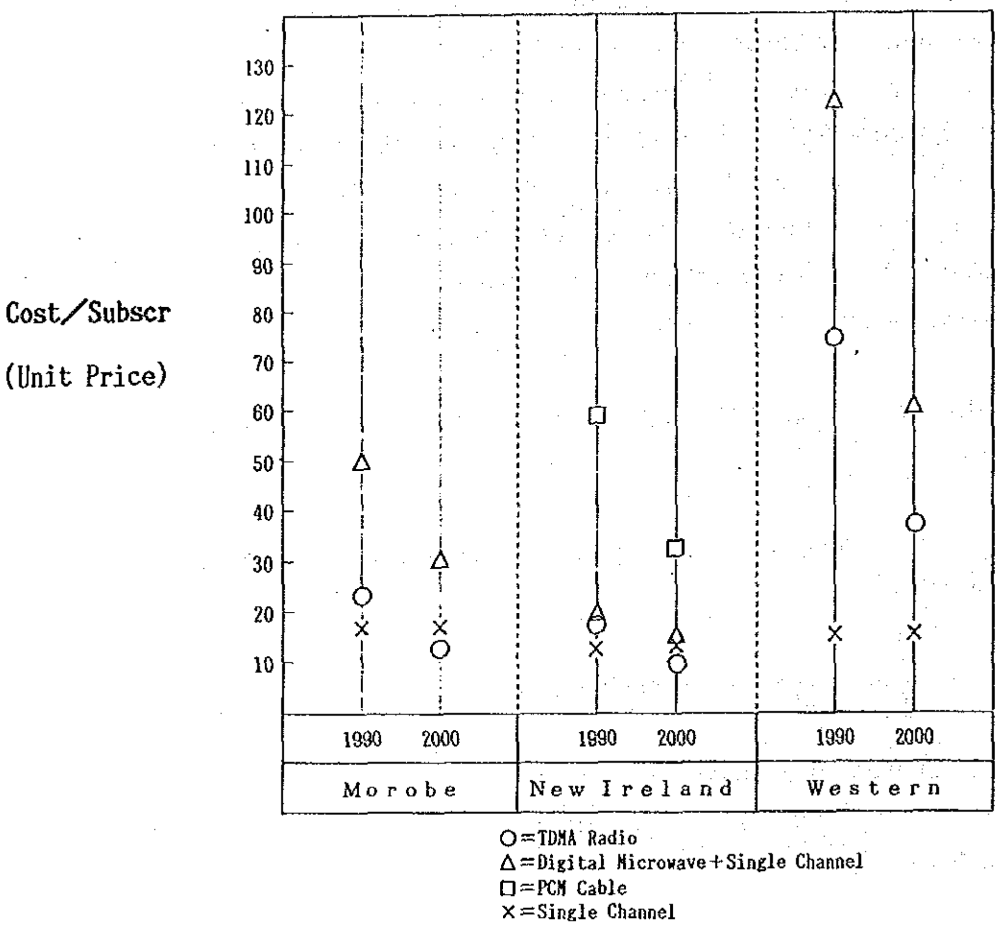


Fig.6-2-4 Cost/Subscriber Comparison between Model Areas

(1) Model area in Morobe

The single channel system is economical during the initial period of introduction (1990), but 10 years later, the TDMA radio system is more economical. Since many subscribers are to be connected to Lae switching office even in an initial stage of introduction, if single channel systems are provided for all subscribers, there would be a problem with the allocation of frequencies.

Therefore, in consideration of increased demand in the future, it would be better to construct a network based on the TDMA radio system during the initial stage of introduction. However, for villages which do not serve as repeater points and have only one subscriber during the initial period, utilization of the single channel system should be considered.

(2) Model area in New Ireland

This area is not as physically complicated as the other two model areas, so it would be possible to utilize the PCM cable System. However, as shown in Figure 6-2-4, since the cost of the PCM cable system is very high, it is not desirable to use this system. The digital microwave system is not either desirable for the same reason. Therefore, the most suitable systems for use are the TDMA radio system and the single channel system, and they should be utilized in the same way as in Morobe Province.

(3) Model area in Western

Telephone demand in this model area is not so high when compared to its large area as shown in Figure 6-2-3. Therefore, the results of cost comparison indicate that a single channel system would be better for initial introduction (1990), and would still be economical 10 years later (2000). In addition, since demand is expected to remain low in this model area even in the year 2000, there should be no problems with regard to frequency allocation. For these reasons, the single channel system should be the most suitable one for this model area.

To summarize the above, for this rural telecommunication development plan, it would be best to construct a network based on utilization of the TDMA radio and single channel systems. The selection of these two systems must be determined in consideration of future trend, flexibility for increased demand, frequency allocations and so on.

6.3 Network Configuration

6.3.1 Features of PNG Telecommunications Network

The purpose of the Rural Telecommunication Development Plan is to install telephone sets in villages scattered throughout the country using the existing telecommunications network as the base. Therefore, the conditions for access from villages to existing telephone offices or radio repeater stations will be a major point for construction of an efficient rural telecommunications network.

When the telecommunications network in PNG is looked from the viewpoint of expansion of the rural telecommunications network, the following features can be listed up.

(1) PNG is composed of various islands grouped around four islands of New Guinea, New Britain, New Ireland and Bougainville, and has mountains of the 1000 - 4000 meters high running through its central area, almost like a spine. The existing telecommunications network constitutes basic trunk connecting repeater stations set up on top of this spine of those mountains via 6 GHz and 2 GHz microwave.

The distance between repeater stations is 50 - 150 km, and this contributed to the construction of an efficient network. However, it will be difficult to utilize this existing network in the construction of a rural telecommunications network based on use of TDMA radio system because of the shorter transmission distances required.

(2) Plantations and private companies scattered throughout the rural areas are offered telephone service utilizing 400 MHz, 150 MHz or 60 MHz in the VHF band. However, some of these subscribers are located far from telecommunications facilities set up within their message area, so they are handled by another message area (numbers and charges are different) for practical economy.

(3) For villages in a mountainous region, along the coast or in remote places of islands, telephone service is provided using 3 to 7 MHz in the HF band

with manual switching. Base stations of HF band radio systems are installed in 10 major towns and connected to about 700 subscriber stations in rural areas with about 100,000 to 120,000 calls handled per year. Thus, this is an important part of the rural telecommunications network.

(4) There are 52 switching offices throughout the country, and they have terminal capacities ranging from small to large, that is from 100 to 9,000 circuits, so they are capable of meeting city-size demand, and 80% of those switching offices provide 100 - 500 terminals with an average terminal utilization rate of 70%.

6.3.2 Standard System Configuration

In Section 6.2, it was stated that TDMA radio and single-channel systems are generally effective as telecommunications systems for use in rural areas. In studying the PNG rural telecommunications network as well, it was decided to use TDMA radio and single-channel systems for construction of the network. Figure 6-3-1 shows the standard system configuration.

(1) The base station for the TDMA radio system is installed close to the switching system, and connects to nearby subscriber station S1. It is also linked to repeater station R1.

(2) Repeater station R1 is installed on top of a mountain where an existing repeater station is located, and connects to subscriber stations S2 and S3. It is also linked to the next repeater station R2.

(3) Repeater station R2 is installed in a village, and it is connected to subscriber station S4 in that village. It is also linked to subscriber stations S5 through S7, which are located in the surrounding area.

(4) A single-channel system will be introduced in villages (subscriber stations S8 through S10) considered to have demand for telephone service that can be handled by one line both now and in the future, and where expansion of the network beyond the village itself is not expected.

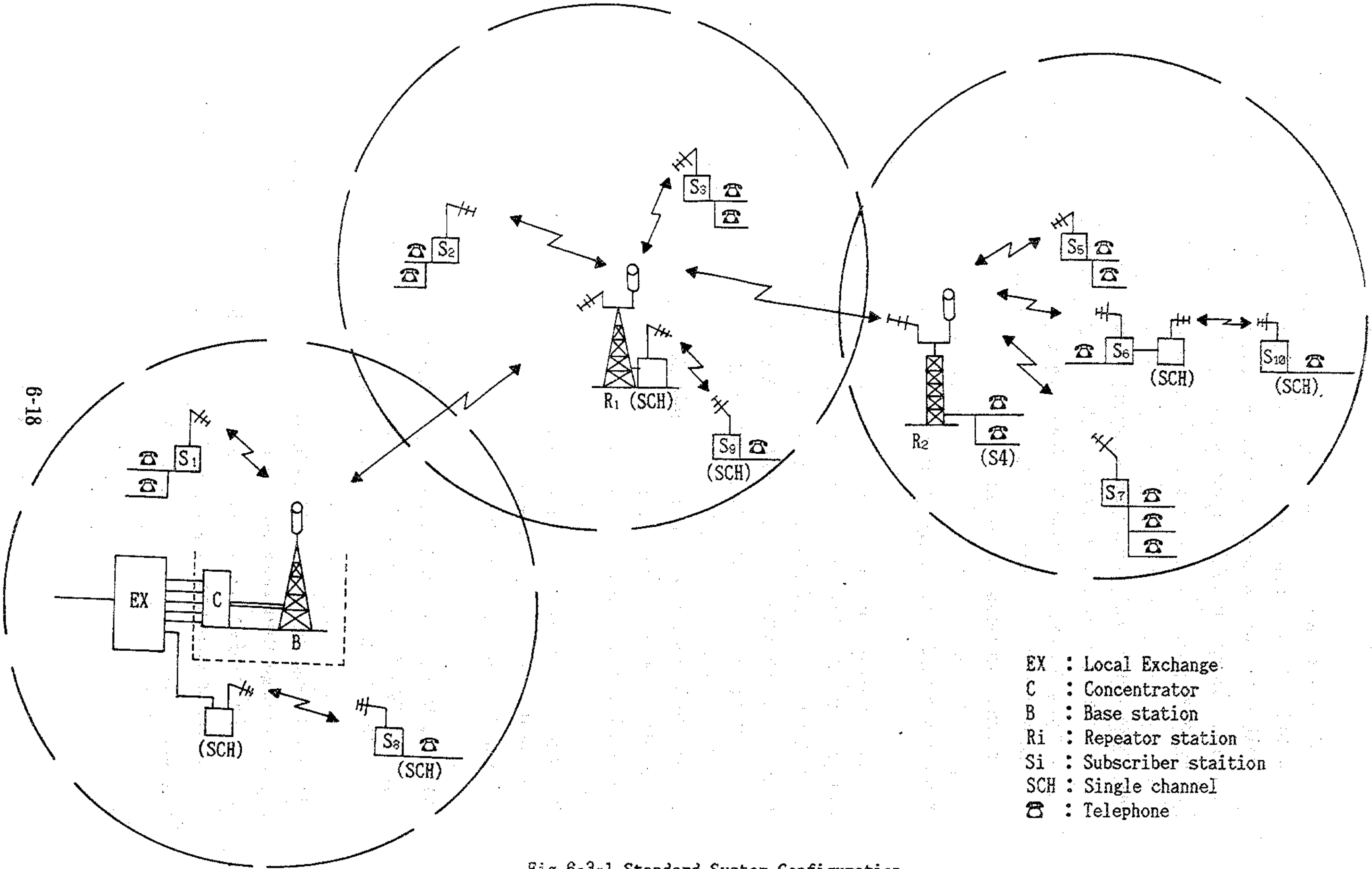


Fig.6-3-1 Standard System Configuration

6.3.3 System Design

(1) Basic Policies for Construction of Network

The basic policies for construction of the network in this rural telecommunication development plan are as follows.

(a) Switching offices that will cover rural telecommunications network subscribers should make use of the existing switching offices in order to promote economic efficiency of the system.

(b) In principle, existing repeater stations should be used as the repeater stations necessary to construct the rural telecommunications network, rather than constructing new facilities. However, if the objective village itself can become a repeater point for the next objective village, consideration should be given to construction of a repeater station in the village concerned.

(c) The method of handling subscribers in a switching office should, in principle, be in conformity with the numbering plan and message area currently in use. However, if it is economically disadvantageous to do so due to geographic conditions, then consideration should be given to handling by switching offices in other message areas.

(2) Circuit Quality

The target quality for subscriber radio transmission lines in this rural telecommunication development plan should be as follows:

(a) For digital links, if the Bit Error Rate (BER) exceeds 10^{-3}, it should be considered an outage, and the outage in any month should be less than 5.88×10^{-7}/km (0.015×10^{-2}/255 km), in accordance with CCITT Report 1053.

(b) For analog links, a circuit quality of S/N > 30 db must be obtained in even the worst case.

(3) Traffic Conditions

As stated in Section 5.2, the average traffic in each village is 0.74 erl/ BHT (population of more than 2,000, including surrounding villages), 0.44 erl/BHT (population between 1,000 - 2,000, including surrounding villages), or 0.24 erl/BHT (population lower than 1,000, including surrounding villages), depending upon the village size.

The number of objective villages in this rural telecommunication development plan, as stated in Section 6.1, is 374 throughout the country. These villages are to be serviced by the existing 35 switching offices. Accordingly, on average, one switching office will service about eleven villages. When this is calculated in terms of busy-hour traffic previously described, 2.7 (0.24 X 11) ~ 8.2 (0.74 X 11) erl per switching office is obtained, depending upon the relevant village size. This traffic is to be handled by the existing switching offices using single-channel and TDMA radio systems under this project. Thus, it is considered that a TDMA radio system with a capacity of about 10 erl will be sufficient.

However, since the above estimation is based on the average figures, it is conceivable that the traffic may actually exceed 10 erl. In such cases, it would be desirable under this project to use plural TDMA radio systems having the capacity of about 10 erl, rather than considering the introduction of a larger capacity system from economic efficiency, maintenance and operation standpoints. The traffic of 10 erl corresponds to about 15 time slots under the condition that loss probability is 0.05. Accordingly, TDMA radio system with 15 time slots will be preferable for network planning under this project.

(4) Radio Frequency Band

According to the CCIR Radio Regulations, the frequency band that can be used for fixed communications in the VHF and UHF bands are as listed in Table 6-3-1. Of these, 500 MHz, 800 MHz, 1.5 GHz and 2 GHz can be used for TDMA radio systems. Although the frequency band to be allocated for rural telecommunications have not been specified by CCIR Radio Regulations, considering the frequency band which is used in other countries, 1.5 GHz is usually allocated for this purpose.

Since PNG plans to use 500 MHz, 800 MHz and 2 GHz for fixed point-to-point communications, 1.5 GHz is allocated for the TDMA radio system. Therefore, the TDMA radio system to be introduced in this project will also use frequency band around 1.5 GHz. In addition, 450 MHz and 150 MHz bands will be used for the single channel system in accordance with PNG's frequency usage plan.

Table 6-3-1 Frequencies Allocated for Fixed Communications (Asia and Oceania)

	Frequency Band
VHF	68.0 - 74.8
	75.4 - 100.0
	136.0 - 144.0
	146.0 - 149.9
	150.05 - 156.7625
	156.8375 - 300
UHF	300 - 328.6
	335.4 - 399.9
	401.0 - 406.0
	406.1 - 430.0
	440.0 - 960.0
	1427.0 - 1535.0
	1660.5 - 1690.0
	1700.0 - 2690.0

(5) System Parameters

Table 6-3-2 lists the estimated system parameters for the radio facilities which constitute the rural telecommunications network.

Table 6-3-2 Estimated System Parameters

Item	TDMA Radio	Single Channel
Radio Frequency Band	1.5 GHz	450 MHz/150 MHz
Transmitting Output Power	3 W	10 W
Modulation	PSK	FM
Circuit Capacity	15 Time Slots	1 Channel
Base Band Signal	Digital	Analog
Required Minimum Receiver Input	-94 dBm (BER = 10^{-3})	-103 dBm (S/N = 30 dB)

(6) Circuit Design

Table 6-3-3 presents the typical circuit design based on the estimated system parameters described in Item (5). In addition, the relationship between propagation distance and applicable range is shown in Figures 6-3-2 and 6-3-3. The propagation distance differs according to propagation path conditions or facility conditions, such as the antenna system. In taking these fluctuating factors into consideration, the standard circuit design values will be set as follows:

(a) The standard propagation distance between repeater stations for the TDMA radio system is 45 km with line of sight.

(b) The standard propagation distance between repeater and subscriber stations for the TDMA radio system is 30 km with line of sight.

(c) The standard propagation distance for the single channel system is from 45 km to 60 km.

Table 6-3-3 Typical Circuit Design

Item	TDMA Radio Between Repeater and Subscriber Stations	Single Channel	
		450 MHz	150 MHz
Transmitting Output Power [1]	34.8 dBm	40 dBm	40 dBm
Antenna Gain [2]	23 dB (39)	28 dB	24 dB
Propagation Loss [3]	125 dB (129)	154.8 dB Note 1	155 dB Note 1
Feeder Loss [4]	17 dB (20)	12 dB	6.5 dB
Receiver Input [5] [5] = [1] + [2] -[3] - [4]	-84.2 dBm (-75.2)	-98.8 dBm	-97.5 dBm
Minimum Receiver Input [6]	-94.0 dBm	-103 dBm	-103 dBm
Margin [7] [7] = [5] - [6]	9.8 dB (18.8)	4.2 dB	5.5 dB
Propagation Distance	30 km (45)	45 km	60 km

Note 1: Allowance of 31.8 dB for 450 MHz and 27 dB for 150 MHz is included for fading and deterioration due to city noise.

Note 2: Numbers in parentheses indicate propagation distance between repeater stations.

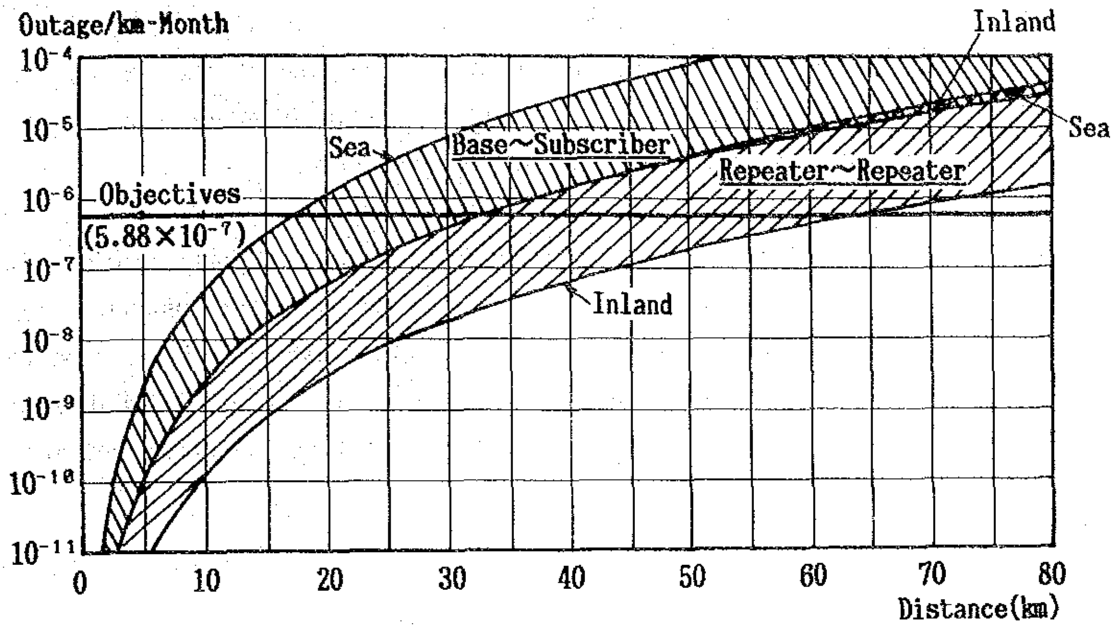


Fig.6-3-2 TDMA Radio Propagation Characteristics

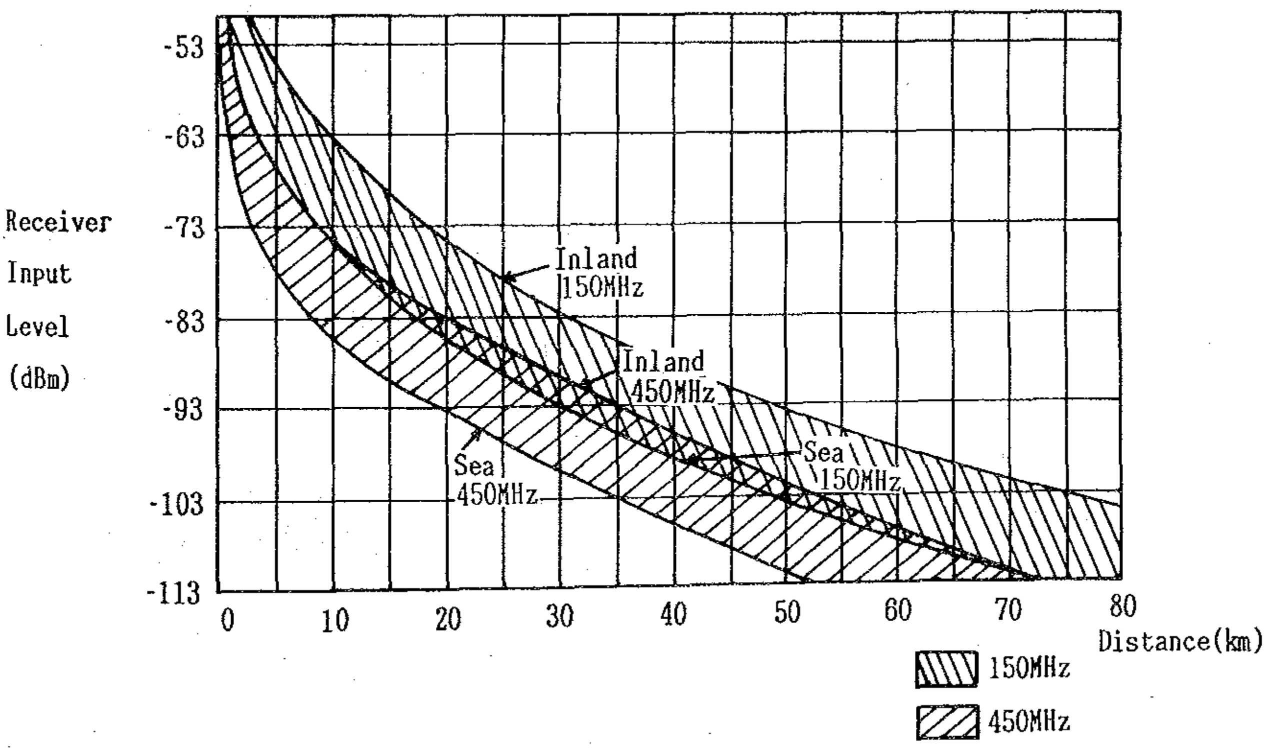


Fig.6-3-3 Single-Channel Propagation Characteristics

6.3.4 Network Plan for Rural Telecommunication Development Plan

With regard to the 374 villages (40 villages in the three provinces and 334 villages in the other 16 provinces) selected as objective villages to be connected to the rural telecommunications network. The study for construction of the rural telecommunications network is made based on the system design conditions described in the previous section.

Figure 6-3-4 shows the network plan between the base station and repeater stations that will be the trunk line of the rural telecommunications network. Annex 2 shows the network plan among base stations, repeater stations and subscriber stations for each province, while Table 6-3-4 lists the number of facilities required for construction of the rural telephone network.

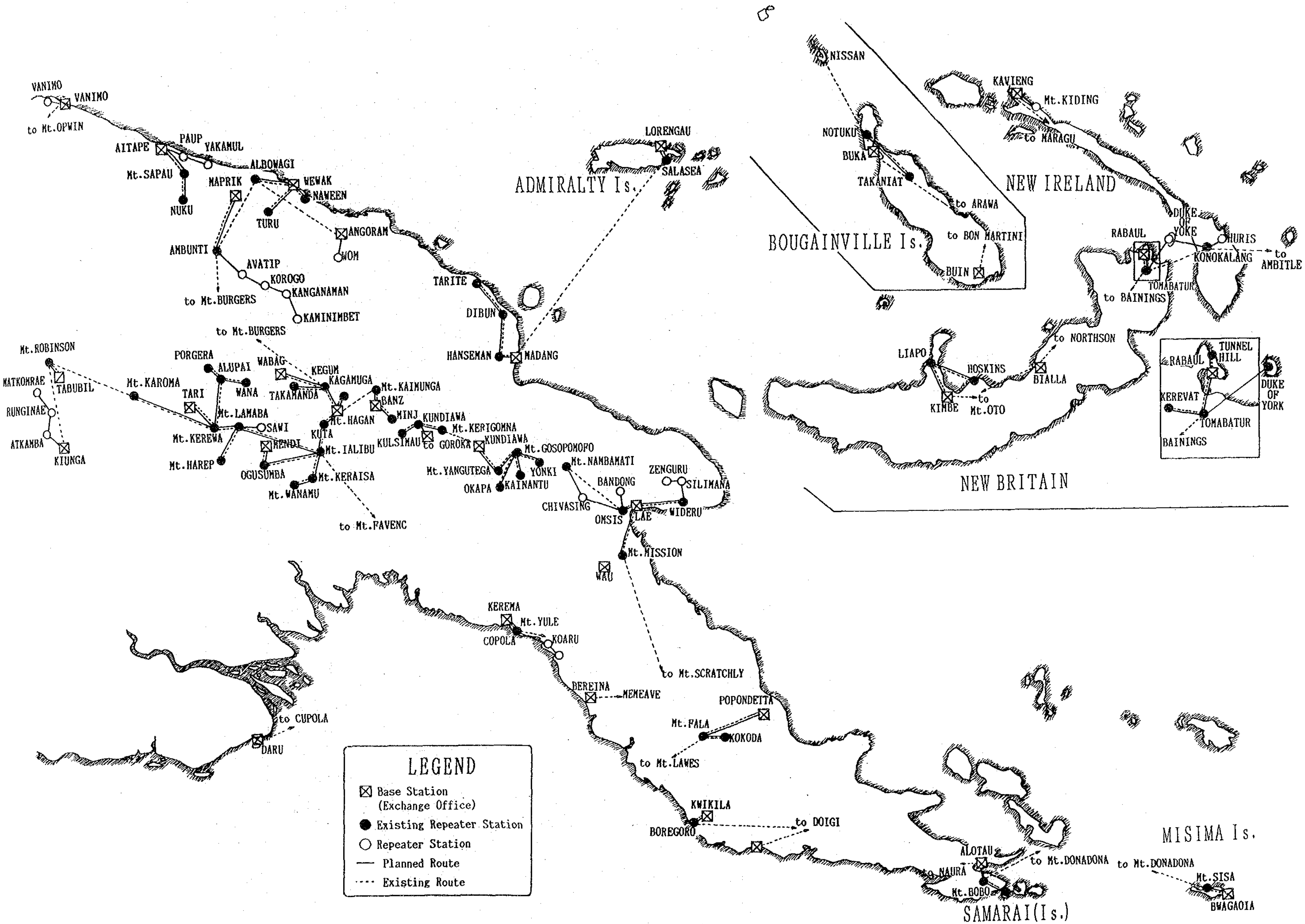


Fig.6-3-4 Network Plan for Rural Telecommunications Development

Table 6-3-4 Number of Facilities Required

Province	Objective Villages	Base Stations (TDMA Radio)	Repeater Stations (TDMA Radio)	Subscribers		Terminals	
				Number of TDMA	Number of SCHs (pairs)	Pay Phones	Private Phones
West Sepik	10	1	4	6	6	10	9
East Sepik	23	3	9	17	1	23	19
Madang	13	1	3	8	5	13	8
S-Highlands	59	1	6	39	20	59	41
Enga	41	2	8	39	1	41	48
W-Highlands	51	2	5	50	1	51	61
Chimbu	25	1	3	23	2	25	24
E-Highlands	20	1	5	20		20	24
Gulf	16	1	3	14		16	17
Central	25	3	1	25		25	28
Northern	7	1	2	7		7	9
W-New Britain	2				8	2	2
E-New Britain	19		2	17	2	19	17
Milne Bay	8	2	3	7	1	8	7
North Solomons	13	1	2	12	2	13	13
Manus	2				8	2	2
Western	9	1	3	1	8	9	5
Morobe	17	1	8	9	4	20	15
New Ireland	14	2	5	11	2	16	10
Total	374	24	72	305	71	379	359

6.3.5 Outline of Facilities

For smooth and economical introduction of rural telecommunications systems, it is necessary to make use of existing telecommunications facilities (switching, power, etc.) and fundamental facilities (office building, sites, towers, etc.). The fields of technology involved in construction of the rural telecommunications network can be roughly classified into switching, outside plant, power and office building, in addition to the radio technology described in Item 6.3.3.

The following describes technical requirements in each technology field and the status of existing facilities.

(1) Switching Facilities

(a) System Configuration

The following types of switching systems are used in the PNG telecommunications network. Figure 6.3.5 shows the network hierarchy.

(i) International Gateway Exchange
(ii) Main Exchange
(iii) Primary Exchange
(iv) Terminal Exchange (Local)

The main exchange is the final route between the primary exchanges, and is located at Lae. The primary exchanges serve as parent stations for the terminal exchanges. They also perform functions of the local switching systems that directly handle the subscriber lines.

The terminal exchanges are located at the lowest network level and are connected to the primary exchanges in a star configuration. The international gateway exchange carries international calls, and has direct links to the primary exchanges. The final route connection will be made via the main exchange. Subscribers to be served by this rural telecommunications network will be connected to terminal exchanges and primary exchanges.

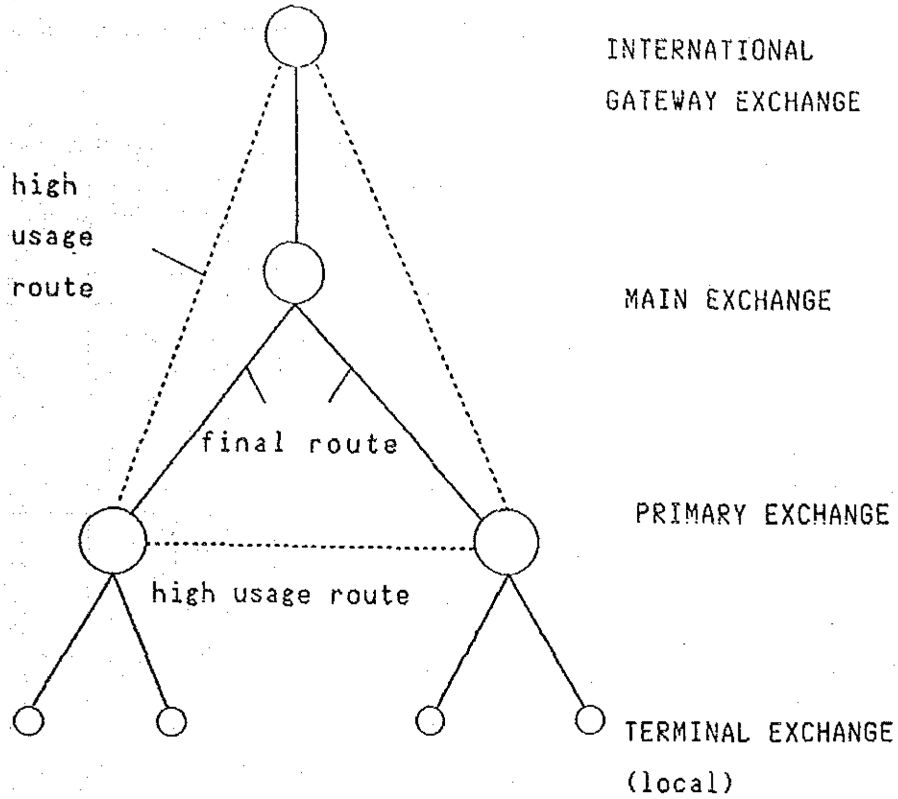


Fig. 6-3-5 Telephone Network Hierarchy

(b) Switching System Terminal Capacity

Table 6-3-5 lists the number of open terminals in the existing switching offices, how many terminals are in use and how many terminals will remain open after introduction of this rural telecommunications network. Since introduction of this system will cause a shortage of terminals at the Tari and Alotau offices, the switching systems at those offices will have to be expanded.

Table 6-3-6 shows the plan for introduction of the digital switching system. As shown in the figure, a digital switching system will be introduced in the Alotau office in 1992 - 1993. Therefore, the capacity will be increased to 640 terminals. Thus, if the introduction plan is implemented on schedule, a terminal shortage will be resolved. Although there will not initially be a shortage of terminals at Maprik and Bereina offices, the number of open terminals will decrease, so expansion work will be required in the future.

Table 6-3-5 Number of Open and Connected Terminals by Switching Office

Province	Switching Office	Terminal Capacity	Connected Terminals	Open Terminals	Project Objectives		Remaining Terminals
					Subscriber Stations	Telephones	
West Sepik	Aitape Vanimo	128 300	72 235	56 65	8 2	15 4	41 61
East Sepik	Wewak Angoram Maprik	1000 100 128	780 31 97	220 69 31	6 6 11	12 11 19	208 58 12
Madang	Madang	1600	1398	202	13	21	181
Southern Highlands	Tari Mendi	128 400	57 253	71 147	35 24	56 44	15 103
Enga	Tari Wabag	128 300	57 177	15 (71) 123	27 14	57 32	-42 91
Western Highlands	Mt. Hagen Banz	2000 256	1344 90	656 166	29 22	65 47	591 119
Chimbu	Kundiawa	400	257	143	25	49	94
Eastern Highlands	Goroka	2000	1431	569	20	44	525
Gulf	Kerema	200	128	72	16	33	39
Central	Bereina Kwikila Kupiano	50 100 100	20 34 51	30 66 49	8 8 9	16 16 21	14 50 28
Northern	Popondetta	500	357	143	7	16	127
West New Britain	Kimbe Bialla	935 200	600 123	335 77	1 1	2 2	333 75
East New Britain	Rabaul	2400	2010	390	19	36	354
Milne Bay	Alotau Boagaoia	400 ---	391 ---	9 -	5 3	9 6	0 -
North Solomons	Buka Buin	200 100	111 39	89 61	12 1	24 2	65 59
Manus	Iorengau	400	244	156	2	4	152
Western	Daru Kiunga Mt. Hagen Tabubil	300 320 2000 384	171 120 1344 270	129 200 591 (656) 114	1 4 3 1	2 6 3 3	127 194 588 111
Morobe	Lae Wau	5600 200	3757 140	1843 60	16 1	34 1	1809 59
New Ireland	Kavieng Rabaul	400 2400	370 2010	30 390	6 8	14 12	16 378

Table 6-3-6 Plan for Digital System Introduction

Fiscal Year	Location	Size (lines/trunks)	Remarks
1990 - 1991	Lae	6144/1860	*
	Kimbe	896/210	*
	Lihir	256/60	
	Training Exchange	64/30	
	Operator System Equipment	15 positions	
	Exchange Maintenance Center		
1991 - 1992	Boroko	9216/2280	*
	Bomana	512/90	*
	Arawa	2560/870	*
	Birempa	256/60	*
	Kieta	768/150	*
	Nadzab	128/30	
	Bwagaoia	128/30	
	Bogia	256/60	
1992 - 1993	Goroka	2048/960	*
	Mt. Hagen	2048/1080	*
	Aiyura	256/90	
	Panguna	384/90	*
	Alotau	640/150	*
	Tomavatur	128/480	
1993 - 1994	Madang	1920/660	*
	Wewak	1536/540	*
	Wabag	384/90	*
	Wau	384/90	*
	Restoration Exchange	256/60	
1994 - 1995	Kundiawa	512/90	*
	Popondetta	640/120	*
	Kainantu	512/90	*
	Mendi	512/90	*
	Ela Beach	512/90	*
	Gerehu	384/60	*

Note: Asterisk (*) indicates replacement

(c) Subscriber Line Signaling System

The following pulsing signals are output by telephone sets.

(i) Dial Pulse (DP) Signals (decadic pulses)

(ii) Push-Button (PB) Signals (DTMF code)

Registers for both DP and PB signals are installed in all existing PNG facilities. Therefore, it is possible to respond to either DP or DTMF system subscriber terminals. In addition, there is an adequate number of registers, so no expansion will be necessary.

(d) Handling of Subscribers Outside the Message Area

In principle, subscribers should be covered by the switching office located in that message area, however, some subscribers will have to be covered by a switching office outside of the subscriber's own area due to geographic conditions. This could cause two problems:

(i) Different Charging System

(ii) Inconsistency between Area Code and Actual Area

To resolve these problems, construction work to increase the number of charging areas in the switching system and the number of area codes becomes necessary. However, most of the existing switching systems are of the cross-bar type, which means the necessity of construction work in terms of hardware. Considering costs and time required for such work, this method is not realistic. PTC already has some subscribers being served by switching offices outside of their own message area for more efficient subscriber service, and no problems have been encountered so far. Therefore, it has been decided not to provide any measures in this rural telecommunication plan concerning subscribers served by an office outside their subscriber area for the moment. When the switching system is changed from a cross-bar type to a digital switching system, however, steps should be taken to resolve this problem by updating the software system.

(2) Outside Plant

(a) Subscriber Distribution

According to the results of a rural field survey covering the three provinces, the distance between subscriber stations and subscribers is less than 150 meters for 80% of all subscribers, with an average of two subscribers connected to one subscriber station in the initial stage. (The maximum is five.) In other words, one to three subscribers are scattered within an average radius of 100 meters. The situations of the above are shown in Figures 6-3-6 and 6-3-7.

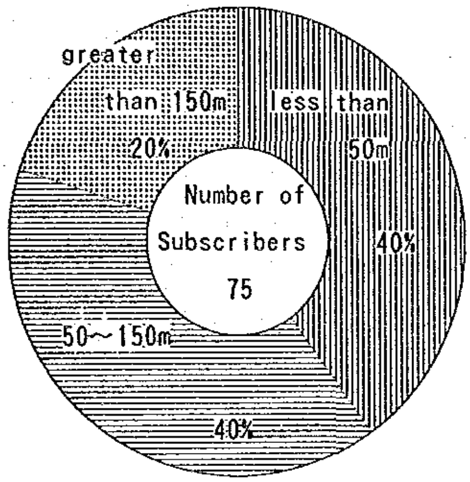


Fig. 6-3-6 Distance from Subscriber Station to Subscriber in The Three Provinces

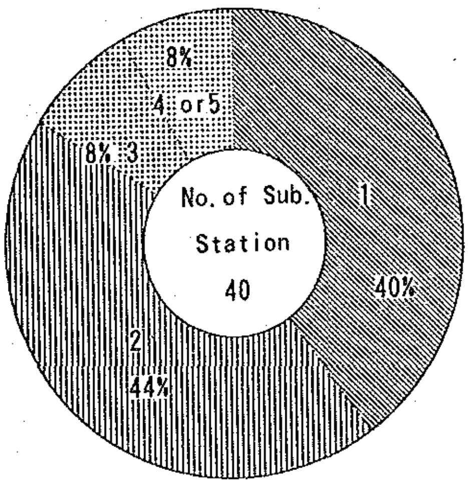


Fig. 6-3-7 Number of Subscriber per Subscriber Station

(b) Line Configuration Study

Various line configurations for connection of subscribers to subscriber stations were considered for the subscriber distribution described above. A comparison of those configurations is given in the following table.

Table 6-3-7 Comparison of Line Configurations
(Distance of 150 m)

Conditions	Underground Line		Aerial Line	
	Wire	Cable	Wire	Cable
Construction Cost	A	B	B	C
Difficulty of Construction	A	B	A	B
Reliability of Facilities	A	A	C	B
Demand-Trend Flexibility	B	B	B	A

Wire: 2-pair
Cable: 10-pair

A: Excellent
B: Fair
C: Poor

According to the above comparison, it is optimal to employ underground lines using underground drop wires for objective villages of this survey. As an exception, however, it is desirable to apply aerial cable lines for subscribers who require long-distance lines, in consideration of the reliability of facilities and flexibility required for demand fluctuation. It is also conceivable in rare cases that geographical conditions, such as rivers and valleys, may require application of aerial lines to some sections. In such cases, timber which can be produced domestically will be used for telephone poles, and as a general rule, wire will be applied to aerial lines as it is economical and enables easy construction method.

Regardless of whether underground or aerial lines are used, a terminal box is to be installed at the subscriber premises in order to provide the termination point for a spare pair and to enable the separation of the lines from a telephone set side in the event of failure.

When aerial lines are used, an arrestor will be installed between a terminal box and a telephone set in order to prevent mixture of abnormal electric current caused by lightning. The arrestor will be connected to earth via the earthing conductor.

(c) Line Loss Standard

(i) Recommended maximum CRE values for the PNG network

Taking account of the need to approach the CCITT short-term objective, as well as the desirability for improvements to the local networks when digital switching is introduced, the following maximum values of CRE (Corrected Reference Equivalents) are recommended for the PNG network.

- Sending CRE: 22 dB
- Receiving CRE: 11 dB

These values are distributed as shown in the following diagram:

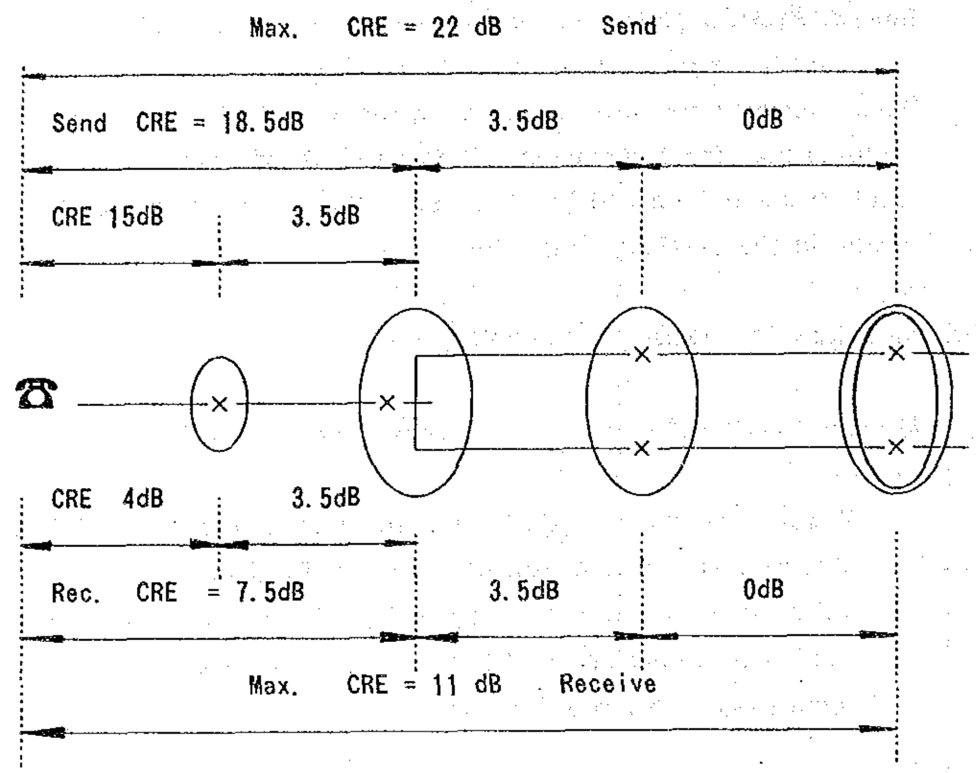
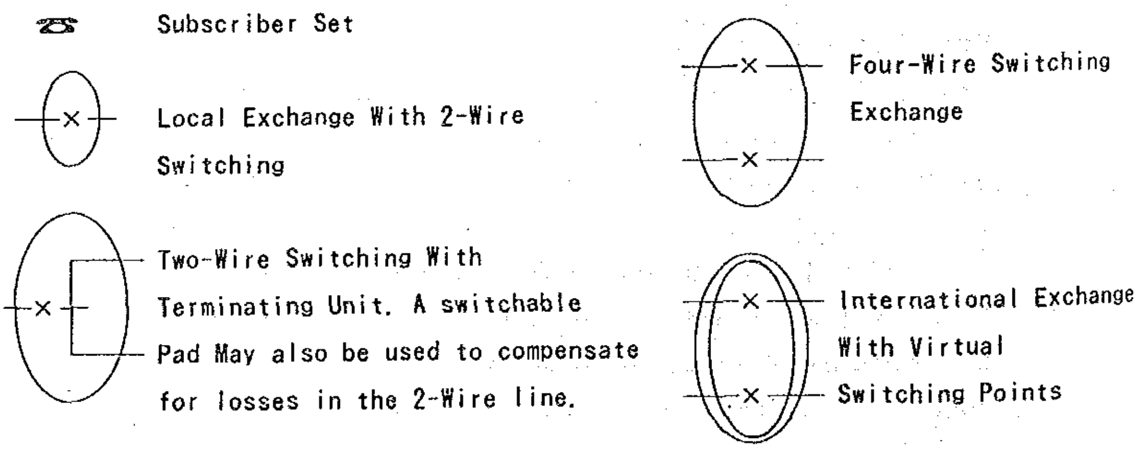


Fig. 6-3-8 Allocation of Nominal Maximum CRE Values (PNG network)

Legend For Fig. 6-3-8



It is seen that there is a margin of 6 dB on the maximum overall CRE recommended by the CCITT and that 18.5 dB CRE is available in the send direction with 7.5 dB CRE in the receive direction for allocation to the local (2-wire) sections of the network. It should be remembered that each of them includes 1 dB loss for the local 2-wire switching.

As far as the subscriber network is concerned, if the present fixed allocation of 3.5 dB is retained for the junction between the local and primary exchanges, we see that CREs of 15 dB in the sending direction and 4 dB in the receiving direction are available for the subscriber line and telephone set combination.

(ii) Minimum values of CRE

Provisionally a nominal value of 7 dB sending CRE referred to the virtual analogue switching point of the international circuit is recommended in order to limit the peak values of the speech power applied to the international system.

(iii) Nominal CRE of local networks

These are normally estimated using the expressions given in Annex A to Recommendation G. 111. The CRE is calculated from the sum of the (uncorrected) reference equivalents of the subscribers telephone, the subscribers line, the local 2-wire switching loss and the corrected loss of the physical 2-wire circuit to the primary centre (if used). The characteristics of the subscribers telephone sets are of critical importance if the CRE objectives are to be met. The maximum CREs available to and from the primary exchange have already been defined as 18.5 dB in the sending direction and 7.5 dB in the receiving direction as indicated in Figure 6-3-8. (For the subscriber section, 15 dB and 4 dB CRE respectively). These limits are used to define the line lengths and types for a given RE of the telephone sets proposed.

The limits for the subscriber section have also to be met taking account of the limited receive efficiency reported for many of the telephone sets in use on the PNG network. In this respect is should be noted that the original objective of 2.2 dB for receiving RE specified in the original plan has now been changed to 3 dB (equivalent CRE = 4 dB) so that the limiting line lengths given in the APO report on the standard type telephone can be adopted. For this type, the line limits are:

Conductor diameter (mm)	Line length (Km)
0.40	4.5
0.51	5.9
0.64	6.6

Naturally, for telephones with improved characteristics these limits can be appreciably extended.

In the case of direct connections between local exchanges, the loss already allowed should be retained for the present network configuration. Similarly, for connections via the same local exchange, the present 6 dB loss should also be maintained.

(3) Power Facilities

(a) Facility Outline

(i) Power for TDMA Radio Base Stations

The TDMA radio base stations will be installed close to the existing switching facilities. Table 6-3-8 lists the current capacities of the power facilities at existing switching offices.

During field investigations, the working current of rectifiers was measured, and often found to be significantly lower than the rated current. Since the power consumption of the TDMA radio system is as low as 150 W, the increase in load current due to its connection to the existing switching office should be very little.

Thus, the existing stations will be able to supply fully enough power for the TDMA radio base station. Power will be supplied by a branch line from the power facility for the existing switching station.

(ii) Power Facilities for TDMA Radio Repeater Stations

Existing radio repeater stations are now provided with solar batteries allocated to each equipment. Therefore, repeater stations for this rural telephone network should initially be provided with solar cells and batteries, with charging consistent with the amount of working power required.

(iii) Power Facilities for TDMA Radio Subscriber Stations and Single Channels.

Power facility conditions in the villages of PNG for which studies were made are shown in Table 6-3-9. Since the availability of the commercial power is low, power is supplied to the villages primarily by power generators set up in the relevant villages, but they are normally operated only at night, so they would not be suitable for communications power sources.

Some villages, where HF communications facilities, etc. are available, use solar batteries as their power source for communications, and they have proven to be highly reliable. Therefore, solar batteries will be suitable for use as the communications power source at subscriber radio stations.

(b) Design Methods for Solar Power System

(i) Weather Conditions

Table 6-3-10 lists the average hours of sunlight per day for each month in three provinces, Western, Morobe and New Ireland. As shown in that table, the number of hours of sunlight per day decreases from Western Province, which has the longest sunshine hours, to New Ireland to Morobe. In particular, the number of hours of sunlight in Morobe is very short in February and September, so batteries of larger capacity than for the other two provinces need to be installed there. Moreover, consecutive no-sunshine days must be taken into consideration for battery capacity design. Based on the past data, there were five to six no-sunshine days at the maximum. Therefore, a battery capacity that permits seven consecutive no-sunshine days is required.

Table 6-3-8 Power Capacities by Switching Office

Switching Office	Year Set Up (FY)	Terminals Handled	Rectifiers (A)	Batteries (Ah) X 2	Generators (KVA)
Alotau	1978	400	30	500	37.5
Bereina	1977	50	12	200	3.5
Daru	1976	300	35	500	12
Kerema	1974	200	25	200	15
Kupiano	1978	100	15	225	8
Kwikila	1979	100	17	200	5
Popondetta	1974	500	45	200	3.5
Buin	1978	100	20	200	7.5
Buka	1977	200	14	200	-
Goroka	1973	2000	180	500	62.5
Kundiawa	1974	400	35	500	37.5
Mt. Hagen	1973	2000	210	560	80
Banz	1982	256	40	500	7.5
Kiunga	1983	320	10	500	-
Mendi	1974	400	25	200	5
Tabubil	1984	384	50	500	-
Tari	1983	128	20	675	2 X 15
Wabag	1977	300	20	200	-
Lae	1972	5000	1500	2170	2 X 250
Finschhafen	1972	100	35	200	-
Lorengau	1977	400	25	200	37.5
Madang	1967	1600	125	660	55
Rabaul	1974	2400	200	560	65
Bialla	1981	200	30	200	20
Kavieng	1977	400	40	200	12
Kimbe	1974	600	60	560	37.5
Wau	1967	200	17	200	-
Wewak	1972	1000	80	560	90
Aitape	1983	128	12	560	35
Angoram	1980	100	10	225	8
Maprik	1984	128	35	560	17
Vanimo	1976	300	20	200	15

Table 6-3-9 Commercial Power, Solar Batteries and Generators Available in Villages

Province	Villages Surveyed	Commercial Facilities	Solar Power Facilities	Power Generation Facilities
Western	21	1	3	10
Morobe	30	0	5	20
New Ireland	24	2	10	17

Table 6-3-10 Average Hours of Sunlight

Province	Village	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Western	Daru	4.6	5.0	4.7	5.8	7.1	7.8	6.5	7.6	5.1	8.7	8.4	6.0	6.5
Morobe	Lae	6.3	3.6	6.5	5.3	7.2	5.1	5.2	5.4	3.8	6.1	7.5	4.4	5.5
New Ireland	Kavieng	5.8	4.6	6.9	7.8	6.1	5.9	7.4	6.7	8.3	5.8	6.6	4.4	6.4

(ii) Location of Solar Cells

When solar panels are set up, it is necessary to select a location where they can get adequate sunlight for efficient output because any obstruction, such as a tower, can adversely affect them. Figure 6-3-9 gives an idea of where solar panels can be set up, keeping a certain distance from obstructions, depending on the height of the obstruction. An (a) or (b) in the figure is applied according to whether a solar panel is set up on the north or south side of a tower, respectively. As shown in that figure, when a solar panel is set up at the north side of an obstruction, the minimum distance from the obstruction is shorter than when the panel is set at the south side.

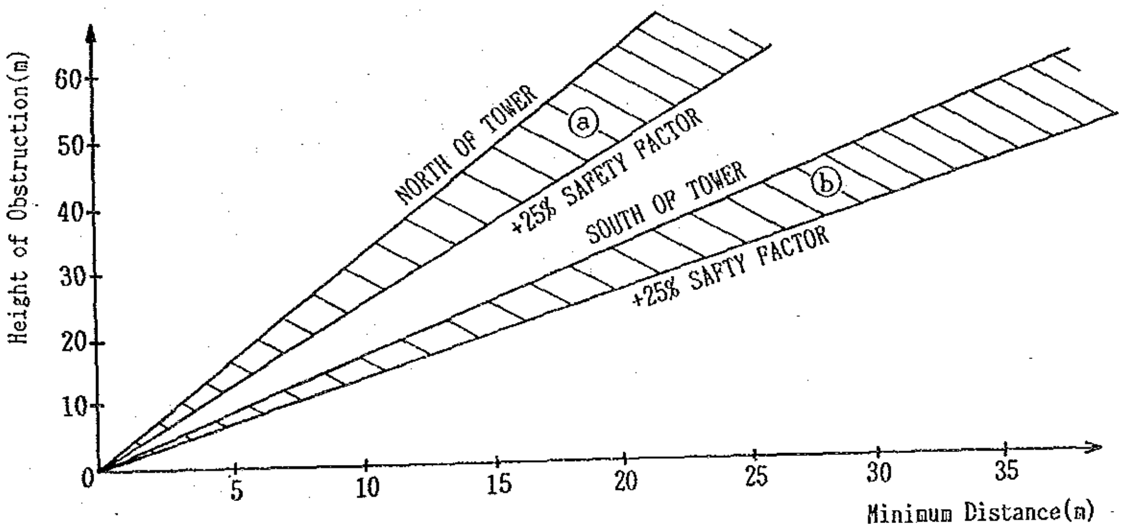


Fig.6-3-9 Minimum Distance from Obstructions

(iii) Solar Panel Installation Method

Solar panels should be set up as shown in Figure 6-3-10. Considering the illuminating angle to the sun and the cleaning effect of rain, panels are normally set up facing north by an angle 15 degrees from horizontal.

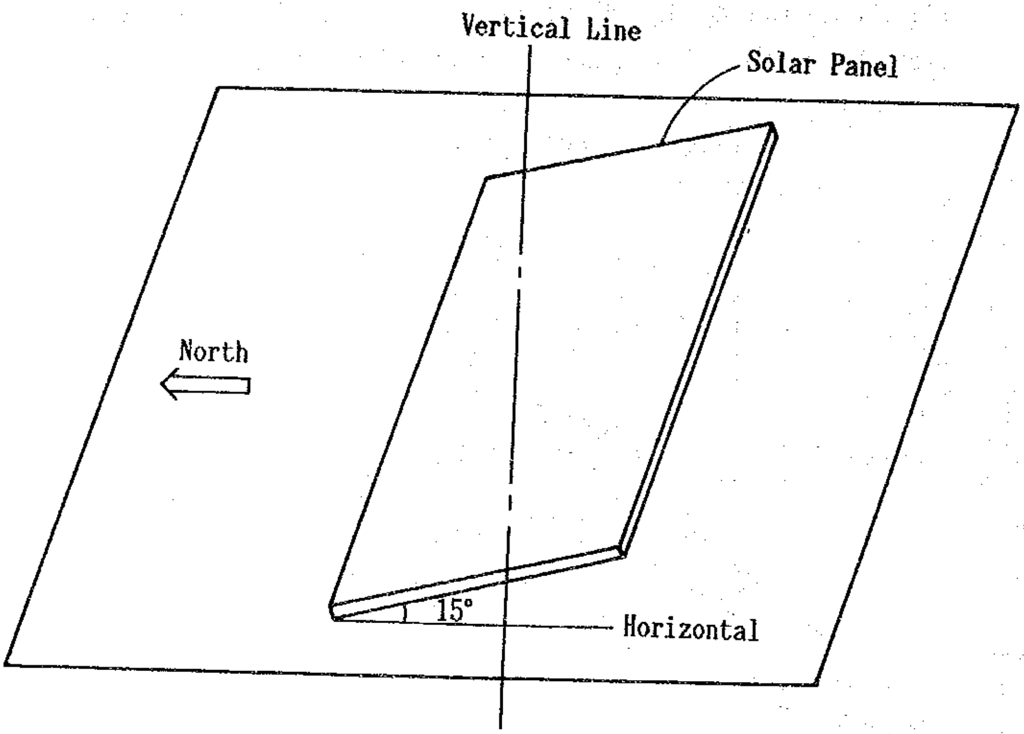


Fig.6-3-10 Solar Panel Installation Angle

(iv) Number of Solar Panel Facilities

Solar panels used in PNG can provide an output of 42 W per panel, and the capacity required for subscriber radio facilities can be obtained by changing the number of panels set up. Generally, each facility should be provided with one spare panel.

(v) Power Supply System

Average daily amounts of solar radiation in the three provinces and Port Moresby are listed in Table 6-3-11.

Table 6-3-11 Average Daily Solar Radiation

District	Amount of solar radiation per day (mW)
Port Moresby	483 (July) - 683 (November)
Daru	425 (July) - 625 (October)
Lae	400 (July) - 550 (October)
Rabaul	462 (July) - 552 (September)

Based on the above data and power consumption for each radio station shown in Table 6-3-12, solar cell capacity for each station should be determined. Consideration must also be given to the data previously mentioned concerning sunshine hours, etc., to determine the storage battery capacity. The results of these calculations are shown in Table 6-3-12.

Table 6-3-12 Necessary Solar Power for Each Radio Station

Item / Terminal Equipment	Power Consumption		Normal Operation		Average Power Consumption(W)	Capacity of Solar Cell	Capacity of Battery
	Idle Condition	Speech Condition	Idle Condition	Speach Condition			
TDMA (Subscriber terminal)	12(V) 20(W)	30(W)	21(hours/day)	3(hours/day)	21.3(W)	200(W)	290(AH)
TDMA (Repeater equipment)	24(V) 50(W)	60(W)	8(hours/day)	16(hours/day)	56.7(W)	500(W)	400(AH)
Single Channel	12(V) 6(W)	30(W)	21(hours/day)	3(hours/day)	9.0(W)	100(W)	170(AH)

(4) Buildings and Towers

(a) Buildings

In PNG, there are 52 switching offices and 78 repeater stations. Most of the switching offices are of office building type, while most of the repeater stations are of trailer type.

Base station facilities to be introduced in this rural telecommunications network will be installed in switching offices and repeater station facilities will be installed in repeater stations. The results of on-site investigation in the three provinces, indicate that there is enough space to install these facilities inside switching offices and repeater stations.

Therefore, in principle, all facilities to be introduced to compose the rural telecommunications network, excluding power facilities and subscriber station facilities, should be installed in existing buildings. The subscriber station facilities to be installed in villages should be stored in cabinets.

(b) Towers

The existing towers at switching offices and repeater stations are generally installed on the ground, and generally have a height of from 20 to 40 meters. They are constructed of steel angle type, and most of them are built solidly, so there will be no strength or space problems when installing new antennas on existing towers, in principle.

(5) Telephone Sets

(a) Private Phones

This radio system permits the use of various telephone sets that PTC currently offers for service. The following types of telephone sets can be used for private telephone service.

- Rotary Dial Telephone Sets

- DTMF Push-Button Telephone Sets

(b) Pay Phones

(i) Coin Phone

The merit of this type of telephone is that it allows the use of coins, which are widely distributed throughout society. That is, it easily fits with the general economic concept of being compensated with pay for the service you receive.

The price of this equipment is about 2/3 that for a card phone, so there is lower initial cost for introduction. In addition, the equipment for identifying coins is not as complicated as that for a card phone, so it has excellent maintainability.

On the other hand, the demerit of this system is that it contains a cash box inside the telephone set, which can be easily broken into and robbed. In addition, the placing of long distance calls requires the use of many coins.

(ii) Card Phone

The primary merit of this system is that there is no cash box inside the telephone, so there is almost no danger of the telephone set being broken into. In addition, it is not necessary to provide someone to collect the money. Moreover, no additional coins are required when making long-distance calls.

As a pre-paid system is adopted for telephone cards (hereafter called cards), the telecommunications operating entity can receive its income from calls at the point cards are sold. For users, it also provides convenience of carrying around a card, rather than maintaining a supply of coins all the time.

On the other hand, the demerit of this system is that, if the card sales network is not generally spread throughout society, the value of the pay phone is significantly reduced. Particularly in rural districts, it is not easy to expand the card sales network, and a large amount of time and publicity activity is necessary before convenience of cards and their usage purpose are recognized.

In addition, as data is input to a card by magnet or laser, it is subject to damage from heat, water, dirt or shock. Therefore, it requires better maintenance and more careful handling than coins. Since rural districts are subject to problems with modified or bent coins, it would be difficult to expect careful handling of cards.

(iii) Selection of Suitable Pay Phone

The comparison of these two types of pay phone sets is described in Table 6-3-13.

Since pay phones in rural districts are located far from the telephone office, it is difficult to provide instructions on maintenance, management and usage. Therefore, importance must be placed on characteristic items 1, 2, 3 and 7 in the table shown below, when selecting the type of pay phone to be installed. It is obvious that the coin pay phone is most advantageous in this situation.

Currently, PTC is conducting a study on the introduction of card pay phones and is taking a careful approach to their introduction on a nationwide scale. PTC has strong intentions to introduce them on a trial basis.

Therefore, it is appropriate to initially select a coin system for public telephone sets to be installed in rural districts. Moreover, it would be convenient for users if telephones that accept multiple denominations of coins are introduced, since it can save the time necessary to exchange or supply specific denominations of coins.

Table 6-3-13 Comparison of Coin and Card Phones

Characteristics	Coin system	Card system
1. Protection against Robbery	x	*
2. Distribution of Inserted Articles (Coins, Cards)	* (Coins)	x (Cards)
3. Expected Lifetime of Inserted Articles (Coins, Cards)	* (Coins)	x (Cards)
4. Convenience of Making Long-Distance Calls	x	*
5. Lower Introduction Cost	*	x
6. Ease of Charge Collection	x	*
7. Maintenance Capability	*	x
8. Convenience of Payment	x	*

Notes: * indicates strength.
x indicates weakness.

6.4 Maintenance and Operation

6.4.1 Maintenance/Operation

(1) Current State of Maintenance

For the existing telecommunications facilities, maintenance management stations have been set up in eight district offices (at Lae, Boroko, Rabaul, Arawa, Wewak, Madang, MT. Hagen and Goroka) and staffed with maintenance personnel. As shown in Figure 6-4-1, each maintenance management station handles 1 to 5 provinces as its maintenance area, covering all 19 provinces throughout the country.

Table 6-4-1 lists the number of maintenance staff members assigned to each maintenance management station.

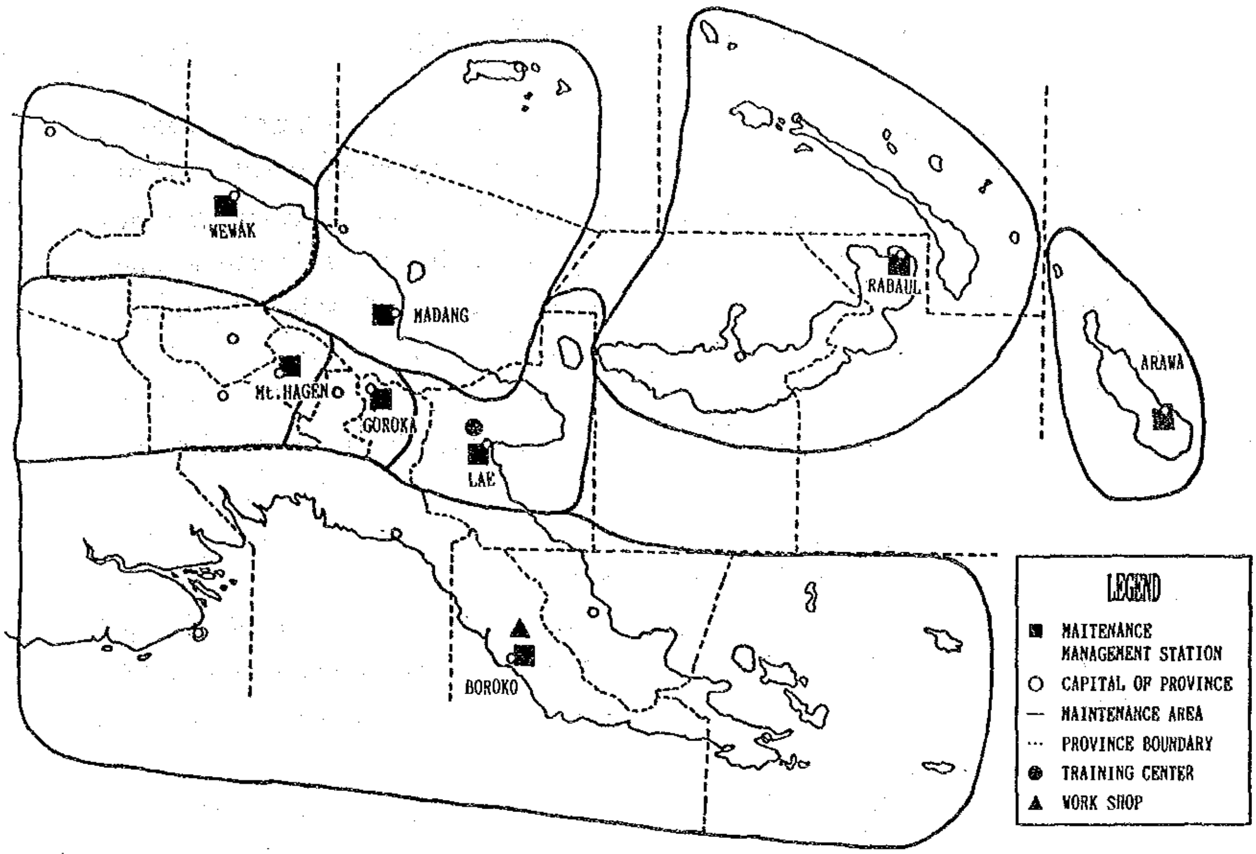


Fig.6-4-1 Maintenance Area and Support Organizations

Table 6-4-1 Number of Maintenance Staff Members

	LINE	RADIO	SWITCH	DATA	MUX	TOTAL
LAE	52	10	7		8	77
GOROKA	20	9	3	2		34
MADANG	12	4	4	1	4	25
WEWAK	13	5	6	1		25
ARAWA	21	6	5	1	1	34
RABAUL	27	18	10	3		58
HAGEN	11	9	6	2		28
SOUTHERN	137	23	16	25	8	209
TOTAL	293	84	57	35	21	490

(2) Maintenance System for Base and Repeater Stations

In this rural telecommunication development plan, base stations (excluding those in the same building as the maintenance management station) and repeater stations are unattended, thus requiring staff members of the district maintenance stations to carry out centralized maintenance and operations. The district maintenance station offers the following major services for base and repeater stations.

- Monitoring the entire system in its territory using a remote supervisory system;
- Periodic remote function tests for all facilities;
- Location of fault parts, determination of failure causes and recovery of circuits;
- Recording and analyses of faults;
- Management of measuring equipment and spare panels.

(3) Maintenance System for Subscriber Stations

Subscriber stations are also unattended, as are base and repeater stations. No periodic maintenance is provided for subscriber stations due to the excessive transportation costs involved, mainly by helicopters. Instead, remote function tests are performed from the district maintenance station.

In the event of trouble, the maintenance personnel in charge of radio will first be dispatched to locate the fault section. It is desirable if this person can make simple repairs even in outside plant or telephone sets, not only in the radio section.

(4) Monitoring and Supervision Systems

For system supervision, monitoring equipment is installed in attended stations to monitor system conditions regularly and to conduct remote function tests periodically.

If a fault occurs at a base station, repeater station or subscriber station, the maintenance personnel will be informed of such breakdown by an alarm display on the monitoring equipment. They will then test to locate the trouble section and make arrangements for repair.

As an alarm is not displayed for faults in subscriber terminal equipment, necessary measures will be taken after receiving a report from the subscriber. Figure 6-4-2 outlines this supervisory system.

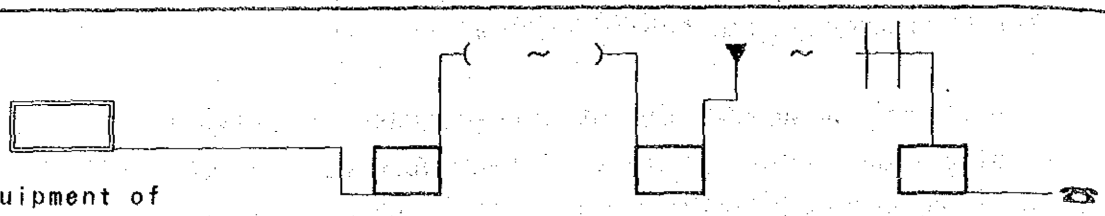
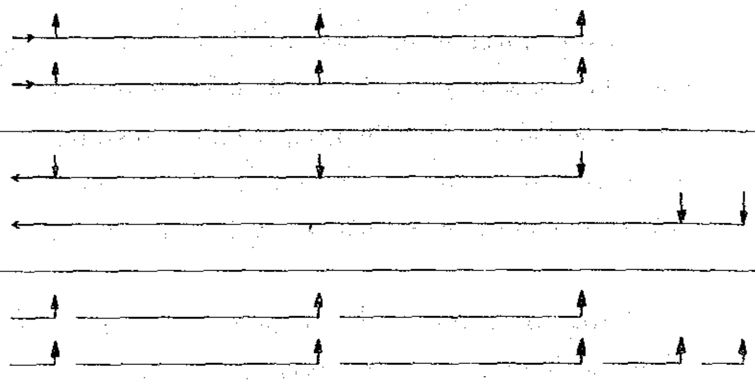
(5) Assignment of Maintenance Personnel

Two or three maintenance technicians who are well versed in rural telecommunications technology should be assigned to each district maintenance station. Since the rural telecommunications system to be introduced in this plan provides a direct dialing system, there is no need for operators. In principle, billing work can be performed by current employees in the billing section.

(6) Repair of Equipment and Management of Facilities Records

Currently, PTC performs all work related to telecommunications, such as printing of papers, manufacture of office facilities, repair of communications equipment, and creation and management of design diagrams on a centralized basis in Workshops. Therefore, with regard to rural telecommunications systems to be introduced under this plan, it is desirable that these workshops handle the repair of measuring equipment and spare panels, as well as management of facilities records to be controlled by engineering operations staff.

Fig. 6-4-2 Outline of Supervisory System

System Configur-ation	Equipment of Supervisory District Maintenance Station	 Base Station Repeator Station Subscriber Station
Normal	Remote Monitoring Status Check	
Trouble	Alarm Information Report from Subscriber	
Recovery	Remote Check of Trouble Maintenance Personnel	

6.4.2 Training

Since the direct dialing system is to be introduced in this plan, it is not necessary to give consideration to operator training. Therefore, proposal will be made only for training of maintenance personnel.

Upon completion of construction under this plan, the following training programs will be required for smooth implementation of maintenance and operations duties.

(1) Training at Facilities Supplier Plant

Trainees should be acquainted with the outline of each facility composing the rural telecommunications network and have the general knowledge of the entire system through training by instructors of facilities suppliers. At the same time, efforts should be made to increase knowledge of peripheral and manufacturing technologies. This training should be conducted while the concerned equipment is being manufactured.

Trainees who complete this training program should be placed in charge of overall management of maintenance. Therefore, the senior engineers should be selected for this training from among the personnel to be assigned to the district maintenance station.

The following numbers of personnel should be dispatched during the period of this plan, for a period of about two weeks.

- Responsible Person in the Maintenance Management Station:

  8 (1 person from each district)

- Workshop Engineers: 2

- Instructors: 2

(2) On-the-Job Training

All maintenance personnel should participate in the construction work in order to gain knowledge necessary for maintenance, such as testing methods and handling the measuring equipment.

Since, as previously mentioned, the maintenance personnel in charge of radio are to perform simple repair work in the event of trouble in outside plant and telephone sets, they should acquire the techniques related to these fields.

(3) Training at the PTC Training Center

After rural telecommunications service starts, it is desirable if a training course about two weeks long and focused on rural telecommunications systems be established to improve the technical skills of maintenance personnel. It is suggested that a total of eight persons participate in one training course, with one person per year from each maintenance management station attending.

The center is located in the central part of PNG, at Lae, the capital of Morobe Province. On its broad site, it provides a complete range of class rooms, practice rooms and accommodations. Also, sufficient staff members are assigned to the Center, such as instructors and engineers from support sections.

6.4.3 Maintenance and Operations Costs

Table 6-4-2 lists maintenance, operations and training costs per fiscal year after implementation of this plan.

(1) Maintenance costs consist of transportation costs in the event failure or disaster, commercial power charges and costs for replacement of equipment parts.

(2) Operations costs normally include commissions for pay phone contractors and indirect personnel costs. Indirect personnel costs are required to handle billing work and indirect clerical work. Since current employees can handle such work, indirect personnel costs are not included in cost calculation.

(3) Training costs consist of the expenses required for dispatch of maintenance personnel to the training center in Lae from each district maintenance station on a one-person-per-year basis to improve the technical skills of maintenance personnel.

Table 6-4-2 Maintenance Costs

Cost	Per 1 District	(8 Districts)	Reference
Labour costs	K6.000/man, year×2persons/maint.area ×0.2 = K2.400	K 19.200	* telecom technicians K4.000 - K8.000 /year * 0.2 :20% of the working time is allocated: * maint.area : 8 areas
Incidental costs	(Accommodation) K156/man ×2persons× 6/year = K1.872	K 15.000	* K80(accom.)+K(4(allow)+34(food))×2days=K156
	(Transportation) K700/Hr× 2Hr× 6/year = K8.400	K 67.200	* heli.charges: K700/Hr
Procurement costs	(Spares) K686/pannel×16equipments/route÷10years = K1.098	K 8.800	* trouble : 1/10years
Over head costs	(Power) K0.1/KWHr×0.3KW/Hr×24Hr×365days ×3.4stat/dis.=K894	K 7.200	* 0.3KW/Hr: Power Consumption of TDMA Base St. * 27stations/8districts=3.4stat/dis.
Training costs	(Trainee) K 0(accom.)+ K(4+15) ×14days+K152 = K418	K 3.300	* Airplane: K152 (LAE - POM a round trip) * K(4 +15) : allowance +food
	(Instructor) K10/Hr ×14days ×8Hr ×2persons = K2.240	K 2.200	* Training: 1/year
Total		K122.900	

6.5 Project Plan

6.5.1 Order of Priorities

The rural telecommunication development plan is a nationwide project. Therefore, it cannot be implemented all at once due to various conditions, such as funding, ensuring the work implementation system, training of maintenance personnel and establishment of an operating system.

It is better to divide the project into several phases to facilitate the smooth introduction and operation of the entire system based on experience and results obtained in each phase. To be specific, this project should be divided into five phases, ending in 1997. It is also suggested that a one-year assessment period be provided after completion of Phase I to collect basic materials to quantitatively evaluate the social and economic benefits. Besides the direct effects of telephones themselves, the social and economic changes caused by the introduction of telephones to villages without such service should be studied in detail during this assessment period. It is desirable if the results of such studies are reflected in the telephone introduction plan in Phase II and subsequent phases.

Accordingly, the objective provinces for Phase I have a significance as model areas in this regard. After investigating the 19 provinces of PNG, it was found that Morobe, which is a mountainous region, New Ireland, which consists of a group of islands, and Western, which is a flat area having extensive swamps, are optimal for Phase I.

The selection of provinces for each phase after Phase I was made considering the following points.

(1) Construction should be adjusted to PNG's construction plan and the condition of existing telecommunications facilities.

(2) The work should not be slanted towards a certain area, and should provide a balanced work scale in each phase.

(3) The maintenance and facility management system should be established smoothly.

Table 6-5-1 lists the objective provinces of Phase I to phase V and outlines expected process. Figure 6-5-1 shows the district offices which play a pivotal role in construction, maintenance and operation, and their management area.

Among villages in Morobe, Western and New Ireland provinces for which PTC requested a study, those that were not included in Phase I, should be reconsidered in the following implementation stage.

Table 6-5-1 Phase Classification and Facilities Required

Phase	Number of Objective Villages	Number of TDMA Base Stations	Number of TDMA Repeater Stations	Subscriber Stations		Telephone Sets		Provinces
				Number of TDMA Sub Stations	SCHs (Pair)	Pay Phone	Private Phone	
I	40	4	16	21	14	45	30	<Three Provinces> Western, Morobe, New Ireland
II	69	5	14	60	18	69	76	<Five Provinces> Milne Bay, Manus, Gulf, Enga, West New Britain
III	102	5	20	76	21	102	84	<Three Provinces> Southern Highland, East Sepik, Eastern Highland
IV	87	7	14	75	15	87	84	<Six Provinces> West Sepik Madang, Central, North Solomons, East New Britain, Northern
V	76	3	8	73	3	76	85	<Two Provinces> Chimbu, Western Highland
Total	374	24	72	305	71	379	359	19

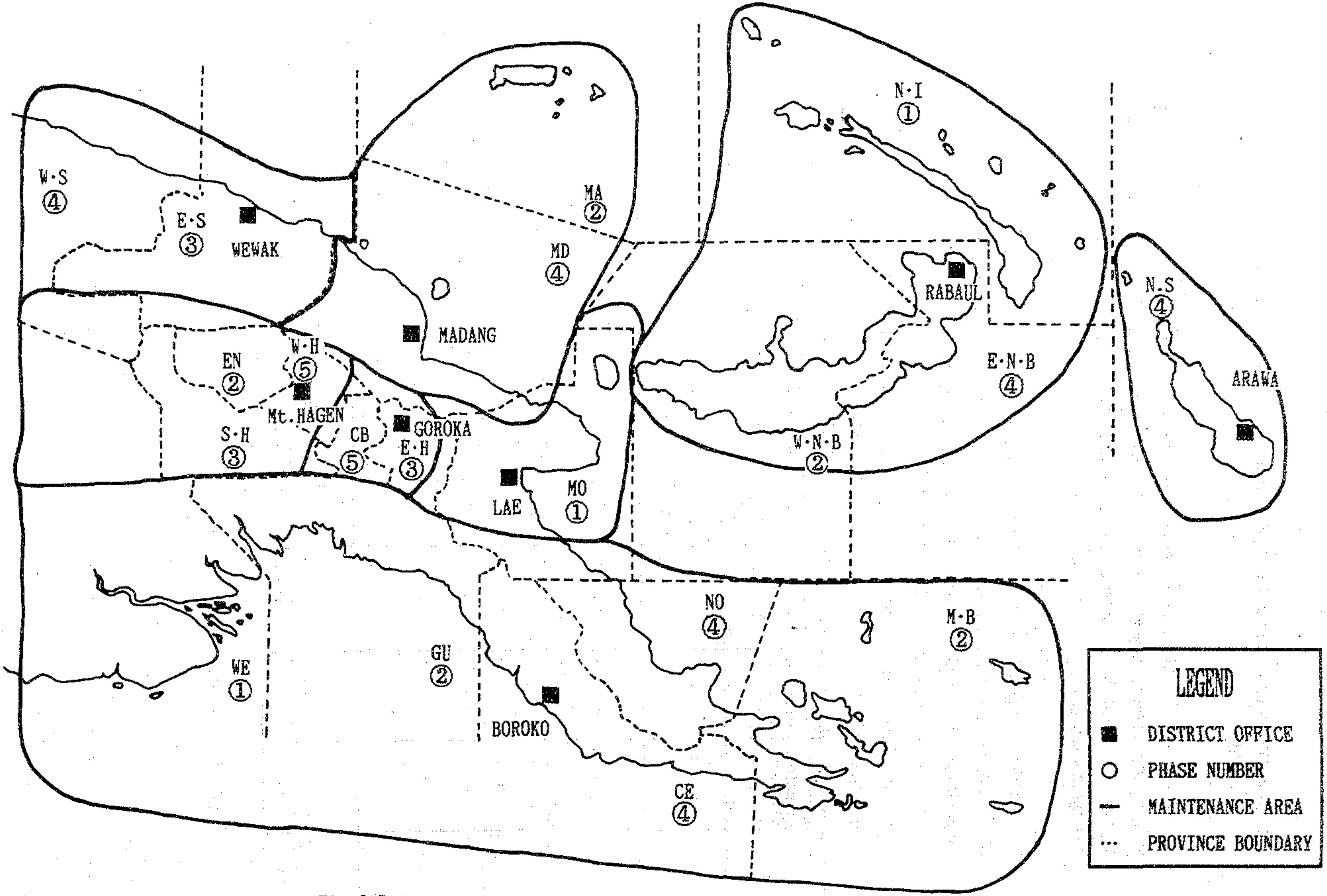


Fig.6-5-1 District Offices and Their Management Area

6.5.2 Implementation Schedule

Figure 6-5-2 presents the implementation schedule of the project. This schedule was developed in consideration of the following points.

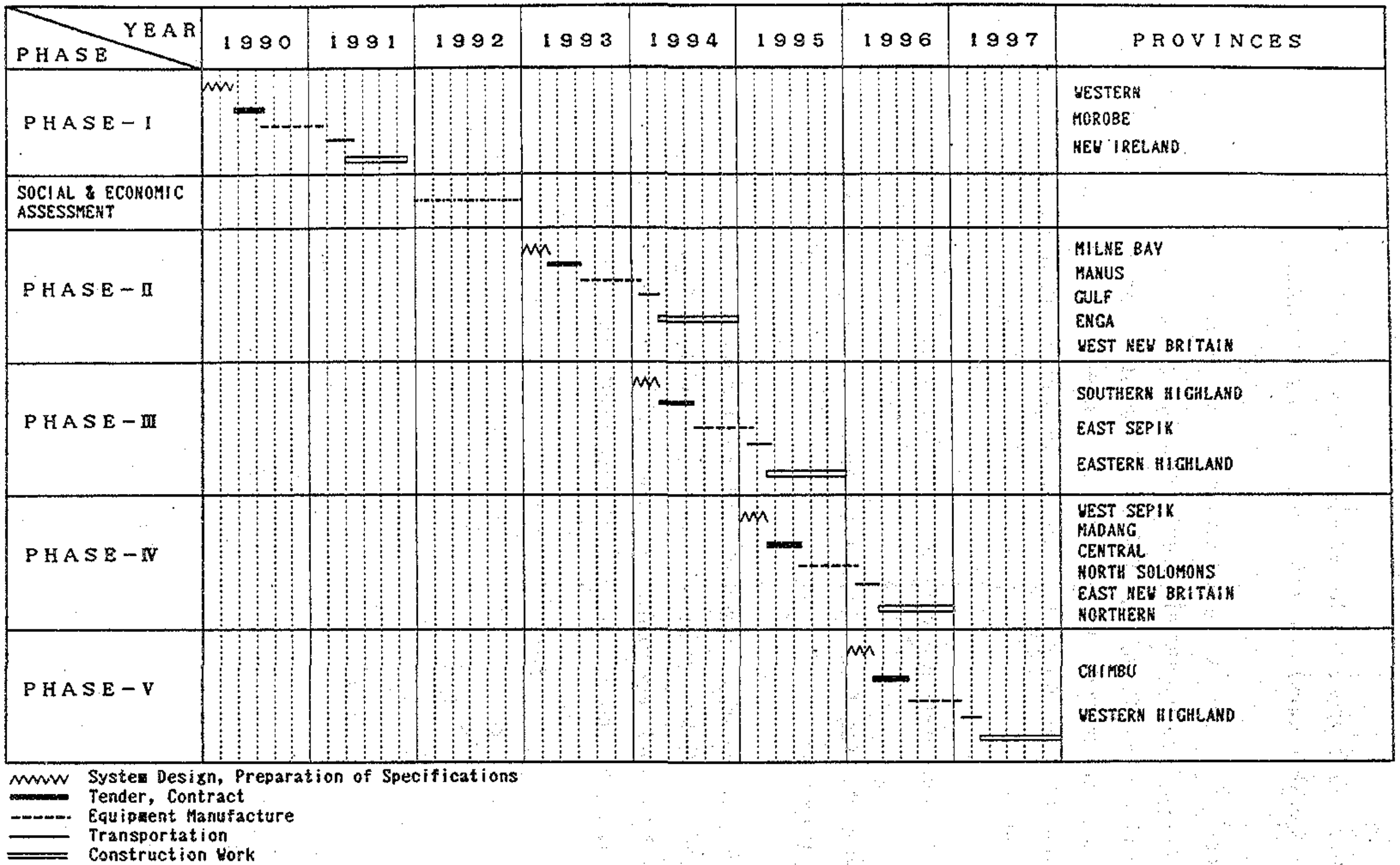
(1) Since as many as 374 villages are involved in the PNG rural telecommunication development plan, the entire project was divided into five phases extending to 1997 by giving attention to the provision of an appropriate operations plan that is necessary for funding and work implementation, as well as to the establishment of a smooth operating system.

(2) The implementation period of each phase is two years.

(3) Before shifting from Phase I to Phase II, a one-year assessment period was provided.

During this period, research and evaluation are to be conducted on a number of fields, including the impact of introducing telephones on the societies and economic activities of rural areas, as well as the construction and operation of related facilities.

Fig.6-5-2 IMPLEMENTATION SCHEDULE



6.6 Project Costs

6.6.1 Pre-Conditions

Construction costs for this project were estimated based on Sections 6.3 through 6.5. The estimate was made based on the following pre-conditions.

(1) The exchange rate between the Japanese Yen and the PNG kina is set at

1 kina = 153.63 yen,

according to the average exchange rate of the last 12 months.

(2) Construction work should be carried out by PTC under the supervision of engineers from the manufacturer(s) and/or consultant (SV basis).

(3) Maintenance parts for one year should be stored, and their costs are included in the estimate.

(4) Existing facilities and equipment, such as office buildings, power facilities and antenna masts at base and repeater stations, should be utilized as much as possible.

(5) This estimate includes a price contingency of 5% (annual rate) for the domestic currency required for this project; however, no price contingency is provided for foreign currency, since any price increase is expected to be offset by technical renovation. In addition, a physical contingency of about 10% is included in project costs for both foreign and domestic currencies.

(6) Table 6-6-1 defines the duties assigned to the consultant and the engineers dispatched by the manufacturers.

6.6.2 Construction Costs

Construction costs are estimated as shown in Table 6-6-2.

Table 6-6-1 Duties Assigned to Consultant and Engineers Dispatched by Manufacturers

Duty	Engineers Dispatched by Manufacturers		Consultant
	Radio Equipment	Steel Tower	
Instruction and Supervision of Construction and Installation Work	○	○ Duke of York & Wipim	
Training, Short-Term Course and OJT	○	○ Duke of York & Wipim	
Detail Design, Field Survey			○
Preparation of Tender Specifications, Approval of Tender Specifications			○
Evaluation of Tenders, Approval of Tender			○
Contract Negotiation			○
Factory Inspection			○
Construction Supervision (Acceptance Inspection)			○
Process Control			

Table 6-6-2 Budgetary Cost of Construction

(Unit:Thousand Kina)

PHASE / CURRENCY / ITEM	PHASE-I		PHASE-II		PHASE-III		PHASE-IV		PHASE-V		SUB TOTAL		GRAND TOTAL
	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL	FOREIGN	LOCAL	
1, EQUIPMENT													
RADIO	1,243	—	1,295	—	1,530	—	1,427	—	1,106	—	6,601	—	6,601
POWER PLANT	327	2	592	4	749	6	588	5	497	5	2,753	22	2,775
TOWER	209	10	333	15	485	24	423	22	362	19	1,812	90	1,902
TELEPHONE & LINE	117	—	183	—	267	—	229	—	201	—	997	—	997
EQPT TOTAL (FOB)	1,896	12	2,403	19	3,031	30	2,667	27	2,166	24	12,163	112	12,275
EQPT TOTAL (CIF)	1,965	(* 12)	2,490	(* 19)	3,140	(* 30)	2,763	(* 27)	2,244	(* 24)	12,602	(* 112)	12,714
2, INSTALLATION	167	856	211	1,198	267	1,590	235	1,468	191	1,248	1,071	6,360	7,431
3, TRAINING	24	33	16	24	16	25	8	13	—	—	64	95	159
4, CONSULTANT	367	149	457	209	576	279	507	256	412	217	2,319	1,110	3,429
SUB TOTAL (1+2+3+4)	2,523	1,050	3,174	1,450	3,999	1,924	3,513	1,764	2,847	1,489	16,056	7,677	23,733
5, PHYSICAL CONTINGENCY	252	105	317	145	400	192	351	176	285	149	1,605	767	2,372
TOTAL (1+2+3+4+5)	2,775	1,155	3,491	1,595	4,399	2,116	3,864	1,940	3,132	1,638	17,661	8,444	----------
GRAND TOTAL	3,930		5,086		6,515		5,804		4,770		---------------		26,105

(Unit:Million Yen)

GRAND TOTAL	694	781	1,000	892	733	---------------	4,010

* : Equipment/Material sourced within PNG are not subject to CIF

6.6.3 Construction Cost Estimation Range

Construction costs will be calculated in both foreign and domestic currencies.

(1) The following equipment and materials will be purchased with foreign currencies.

(a) Radio Communications Systems

- Radio Communications Equipment
- Antennas and Feeders
- Antenna Duplexers
- Construction Materials

(b) Power Equipment

- Solar Cells
- Batteries
- Regulators

(c) Equipment Containers

- Shelters for Repeater Stations (for Radio Equipment and Power Units)
- Shelters for Subscriber Stations (for Radio Equipment and Power Units)

(d) Maintenance Equipment

- Measuring Equipment for Maintenance
- Spare Parts

(e) Antenna Masts

- Self-Supporting Towers
- Guyed Towers
- Cylindrical Masts

(f) Subscriber Outside Plants

- Cables and Connectors
- Terminal Boxes and Earthing Materials

(g) Subscriber Terminal Equipment
- Interior Wiring
- Subscriber Arresters
- Subscriber Telephone Sets

(2) The following will be purchased with domestic currency:

(a) Articles Related to Various Equipment Containers
- Materials that can be locally procured, such as cement for foundation construction.

(b) Articles Related to Masts
- Materials that can be locally procured, such as cement for foundation construction.

(3) The following work will be carried out using foreign currencies.

(a) Construction work related to radio communications systems, power units, various equipment containers and transmission masts.
- Assembly, installation, wiring, adjustment and testing;
- Field survey including confirmation by sight;
- Work management during implementation;
- Tools required for work and brought in from outside the country, and test equipment.

(b) Marine transportation (between materials/equipment supply countries and PNG)

(c) Training
- Training for construction and maintenance personal
- Training materials

(d) Consultation Services
- Consultation service
- Materials required for consultation service

(4) The following work will be carried out using domestic currency.

(a) Construction work related to radio communications systems, power equipment, various equipment containers and masts.

- Assembly, installation, wiring, adjustment and testing;
- Field survey, including confirmation by sight;
- Work management during implementation;
- Vehicles and drivers required for work, and maintenance costs;
- Coast and inland transportation of materials;
- Expenses, such as accommodations for work personnel

(b) Subscriber Outside Plant Work

- All cable work, including cable laying, connection and earthing;
- Expenses, such as accommodations for personnel.

(c) Subscriber Terminal Equipment Work

- All work, including lead-in and connection of cable, installation of arrestors, earthing, house wiring and installation of telephone sets
- Expenses, such as accommodations for personnel.

(d) Training

- Training Staff
- Travel expenses necessary for participation in training.

(e) Consultation Services

- Expenses, such as for accommodations for consultants;
- Local staff hired by consultants;
- Materials purchased or rented by consultants in PNG.

CHAPTER 7

CHARGING PLAN

CHAPTER 7. CHARGING PLAN

7.1 Current Charging System

Both the current telephone and postal charging systems were revised on April 3, 1989. The old charging system had last been revised in January 1988.

The charges levied for subscriber telephone service consist of an installation fee, a basic fee (every 4 weeks) and call charges. Also, if an extension phone or extension sets of PABX are additionally installed, separate installation and basic fees are also applied. Telephone set accessories (plugs, variable-volume bells, etc.) are rented, or the subscriber can buy them outright from PTC.

7.1.1 Urban Charging Structure

(1) Installation Fee

The installation fee for a private phone is K50. However, in order to increase the number of subscribers, promote the efficient use of equipment and thereby increase revenues, "Economy Phone" service is offered only to PNG customers for household use. The installation fee for this service is K25, with an additional K25 required as a security deposit. This deposit is returned when the subscriber cancels the subscription contract.

(2) Basic Fee

The basic fee system utilizes a 28-day cycle. It is K5.25 for household use and K9.00 for office use. For "Economy Phone" service, it is K4.00. Rental charges fall into 26 categories by functions provided by telephone sets and additional equipment, starting at K1.5 for a basic rotary-dial or push-button telephone.

7.1.2 Rural Charging Structure

Currently, subscriber telephone service is offered by using the radio system in rural areas. An outline of the charges for this service is given in Table 7-1-1. The installation fee and basic fee are determined by the system applied and who supplied the equipment (e.g., by PTC, or by the subscriber). In addition, applicable charges differ according to whether or not a repeater is required.

Table 7-1-1 Radio Telephone Charges

(Unit: Kina)

	Installation Fee	Basic Fee
RSS (Radio Subscriber System)	300	45
VHF/UHF Automatic Service (Single Channel)		
Equipment procured from PTC	500	45
Equipment provided by subscriber	500 *1)	15
When repeater is required		
Equipment procured from PTC	300	+45
Equipment provided by subscriber	300 *2)	+15
VHF/UHF Automatic Service (2 and 4 Channels)		
Equipment procured from PTC	2,000 *3)	45/line
Equipment provided by subscriber	2,000 *4)	15/line
When repeater is required		
Equipment procured from PTC	2,000 *5)	+45
Equipment provided by subscriber	2,000 *6)	+19

Note 1: 1) - 2) minimum required amount
3) - 6) approximate amount

Note 2: A "+" in front of a number indicates the amount added per repeater.

7.1.3. Call Charges

Domestic call rates, as shown in Figure 4-3-1 in Chapter 4, are divided into 14 charging districts. Calls are classified into four types, as shown in Table 7-1-2.

Local calls are 15 toea per call, with no differential for time of day. Toll calls are classified as: (1) within same zone, (2) to an adjoining zone and (3) to a non-adjoining zone, and periodic pulse metering is adopted to determine charges for those calls.

International calls can be either direct dialed or operator assisted. Direct dialed calls are, of course, given a lower rate for the fixed-period charge.

A nighttime 50% discount for all toll calls is applied to rates for calls placed between 6:00 P.M. to 6:00 A.M. This discount is designed to promote easing of call traffic concentrated in the daytime, and to better balance operation of facilities.

Table 7-1-2 Call Charges

Domestic Calls	Directly Dialed	Operator Assisted	
	Per Minute	Per 3 Minutes	Particular Person Fee
Local call	t 15	-	-
Within the same zone	t 22	t 80	t 45
To an adjoining zone	t 44	K 1.6	t 90
To a non-adjoining zone	t 66	K 2.4	K 1.35
International Calls	**Directly Dialed**	**Operator Assisted**	
To near Commonwealth and Pacific Countries	K 1.8	Divided into 6 classes by circuit employed	
To other Commonwealth and near foreign countries	K 2.4		
To countries other than the above	K 3.6		

Note: K 1 = t 100

7.1.4 Telephone Usage Tax

The Telephone Tax Act of 1983 imposed a tax of K3.0 on each telephone billing, starting in January 1984, but that was increased to K4.0 in January 1989. This amounts to a collected tax of K830,000 per year (1988), and is expected to reach one million kina in 1989.

7.1.5 Private Leased Pay Phone Charges

The installation fee for a private leased pay phone has been set at K100 when various denominations of coins can be used, and the basic fee has been set at K12. The charge for a local call is 20 toea per call, without regard to time, although periodic pulse metering is applied to toll calls in the same fashion as for general subscriber telephone calls.

7.1.6 Collection of Charges

A time limit of 28 days from the date of billing is imposed on payment of telephone bills. If payment default occurs, measures are taken to stop telephone service without prior notification. Payment can be made at the counter of the nearest telephone office or post office. Payment can also be sent directly to the PTC cashier in Port Moresby.

CHAPTER 8

PROJECT EVALUATION

CHAPTER 8. PROJECT EVALUATION

8.1 Preconditions for Analysis

8.1.1 Project Life

In consideration of the physical and economic life of radio equipment, the project life has been set at 15 years. The project life is from 1991, which is when operations are scheduled to start, to the year 2005.

8.1.2 Salvage Value

Since the project life is determined based on the useful life of the equipment to be installed at Phase I in this analysis, the equipment to be installed at Phase II and subsequent phases is assumed to have a salvage value even after termination of the project life.

On the other hand, when the equipment installed under this project is removed or used for other purposes after expiration of the useful life, the use of helicopters becomes necessary. The expenses required for such transfer are expected to be quite high compared to ordinary telecommuinications facilities.

In basic cases, therefore, it is assumed that the salvage value of the equipment installed is offset by the expenses for such transfer. In the sensitivity analysis, however, the salvage value is calculated as a minus cost at the last year of the project life, and the profitability in this case is also examined.

8.1.3 Estimate of Revenues and Expenses

Trial calculations on estimated revenues are made according to the charging system used for the existing radio system (radio subscriber system and single channel system). For an estimate of annual expenses, reference is made to the previous financial practices of PTC.

The financial internal rate of return (hereafter called FIRR) is applied to the analysis to confirm the profitability of the project.

8.1.4 Exchange Rate

The exchange rate applied to this analysis is 153.63 yen per Kina, with all revenues and expenses converted to domestic currency.

8.1.5 Installation Plan

Telephone sets will be installed in Phases I ~ V according to the schedule in Table 8-1-1. Figures in the upper row indicate the number installed in the given year; those in the lower row indicate the cumulative total unit demand.

Table 8-1-1 Telephone Installation Plan (Phases I ~ V)

		1991	1992	1993	1994	1995	1996	1997
Pay Phones	Number Installed	45	--	--	69	102	87	76
	Cumulative Total	45	45	45	114	216	303	379
Private Phones	Number Installed	30	--	--	76	84	84	85
	Cumulative Total	30	30	30	106	190	274	359
Total	Number Installed	75	--	--	145	186	171	161
	Cumulative Total	75	75	75	220	406	577	738

At the completion of each phase, it will be necessary to increase the number of telephone sets in order to respond to the growth in demand. At the same time, therefore, consideration is given to the case that additional telephone sets equal to an annual 5% demand increase will be installed once every four years in each phase.

Table 8-1-2 is the telephone installation plan up to the year 2005, with this demand increase taken into consideration. Figures in the upper row indicate the number installed in the given year; those in the lower row indicate the cumulative total unit demand.

For example, demand for 1991 is 75 sets. In case demand increases by 5% annually, the cumulative total demand for the fourth year, 1995, will be: $75 \times 1.05^4 = 91$ units. As 75 units will already be installed in 1991, the required number of additional units installed in 1995 will be: 91 - 75 = 16 units.

Table 8-1-2 Telephone Installation Plan (Up to 2005)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Phase I	Number Installed		75				16				20				24		
	Cumulative Total		75				91				111				135		
Phase II	Number Installed					145				31				38			
	Cumulative Total					145				176				214			
Phase III	Number Installed						186				40				49		
	Cumulative Total						186				226				275		
Phase IV	Number Installed							171				37				45	
	Cumulative Total							171				208				253	
Phase V	Number Installed								161				35				42
	Cumulative Total								161				196				238

8.2 Revenue Estimate

Revenues from telephone service consist of installation fees, basic fees and call charges. As described in the preconditions used for analysis, estimates are based on the charging system for radio telephone service currently in service.

These estimates are based on revenues accruing under this project. However, trial calculations are also carried out for revenues accruing from additional private telephone phone sets PTC installs every four years as mentioned above.

8.2.1 Installation Fee Revenues

(1) Installation Fee Revenues in Each Phase

The number of telephones in each system, and the number of repeaters subject to charge, scheduled to be installed by the end of Phase V are shown in Table 8-2-1.

As the current charge system does not levy charges on RSS repeaters, estimates are based on the assumption that only the repeater installation fees for private phones in the single channel system will be charged.

Table 8-2-1 Number of Private Phones in Each System

Year / System	1991	1992	1993	1994	1995	1996	1997
TDMA	28	--	--	72	84	81	85
SCH	3	--	--	4	0	3	0
Total	31	--	--	76	84	84	85
Number of Circuits Subject to Repeater Charges	2	--	--	3	0	1	0

Installation fees applied to private phones will be K300, or the same amount applied in the current RSS system, for TDMA service, and K500 for single channel service. The repeater installation fee will be K300. Installation fee revenues by the end of Phase V are calculated by multiplying the installation charge per set by the number of telephone sets. Installation revenues accrued from this project are shown in Table 8-2-2.

Table 8-2-2 Installation Revenues Accrued from This Project

(Unit: Thousand kina)

Year / System	1991	1992	1993	1994	1995	1996	1997
TDMA	8.4	--	--	21.6	25.2	24.3	25.5
SCH	1.5	--	--	2.0	0	1.5	0
Sub-Total	9.9	--	--	23.6	25.2	25.8	25.5
Repeater	0.6	--	--	0.9	0	0.3	0
Grand Total	10.5	--	--	24.5	25.2	26.1	25.5

(2) Installation Fee Revenues from Additional Telephone Sets

As described in Section 8.1.5, telephone sets responding to the demand increase will be installed every four years at the completion of each phase. As it is necessary to also estimate the revenues such installation fees will produce, the TDMA installation fee (K300) is applied to all such additional telephone sets. The repeater installation fee revenue is not estimated. In the same way as (1) above, installation fee revenues are calculated by multiplying the installation charge per set by the number of additional telephone sets.

However, pay phones are not subject to installation fee charges. Therefore, as the ratio of pay phones to private phones in each village is almost the same, it is assumed that half of these additional telephone sets will be subject to installation charges. Revenues from installation fees for additional private phones sets installed by the year 2005 are shown in Table 8-2-3.

Table 8-2-3 Installation Fee Revenues from Additional Private Phone Sets

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Phase I	Additional Number						16				20				24		
	Installation Fee Revenue						2.4				3.0				3.6		
Phase II	Additional Number									31				38			
	Installation Fee Revenue									4.7				5.7			
Phase III	Additional Number										40				49		
	Installation Fee Revenue										6.0				7.4		
Phase IV	Additional Number											37				45	
	Installation Fee Revenue											5.6				6.8	
Phase V	Additional Number												35				42
	Installation Fee Revenue												5.3				6.3
Total	Additional Number						16			31	60	37	35	38	73	45	42
	Installation Fee Revenue						2.4			4.7	9.0	5.6	5.3	5.7	11.0	6.8	6.3

Note 1: Additional Number Unit: One telephone set.

Note 2: Installation Fee Revenues Unit: 1,000 kina.
(Installation fee calculated at: K300 X Additional Number X 1/2)

(3) Gross Revenues from Installation Fees

Gross revenues from installation fees presented in Table 8-2-4 represent the sum of the installation fee revenues calculated in (1) and (2) above.

Table 8-2-4 Gross Revenues from Installation Fees
(Project and Additional Installations)

(Unit: Thousand kina)

		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Phase I	Installation Fees (1)		10.5														
	Installation Fees (2)						2.4				3.0				3.6		
Phase II	Installation Fees (1)					24.5											
	Installation Fees (2)									4.65				5.7			
Phase III	Installation Fees (1)						25.2										
	Installation Fees (2)										6.0				7.4		
Phase IV	Installation Fees (1)							26.1									
	Installation Fees (2)											5.6				6.8	
Phase V	Installation Fees (1)								25.5								
	Installation Fees (2)												5.3				6.3
Total			10.5			24.5	27.6	26.1	25.5	4.7	9.0	5.6	5.3	5.7	11.0	6.8	6.3

Note: Installation Fees (1): Installation Fees per Project
Installation Fees (2): Installation Fees from Additional Telephone Sets

8.2.2 Revenues from Basic Fees

(1) Cumulative Number Installed Each Year

Basic fees are fixed fees that are charged every month for a private phone. Therefore, the cumulative number of private phones installed by a given year is subject to charging. Consequently, the cumulative number of private phones to be installed each year is calculated. The number of private phones to be installed in Phases I - V of this project is shown in Table 8-1-1.

The number of additional telephone sets per year is shown in Table 8-2-3. However, as this figure includes the number of additional pay phones, about half of this number represents the estimated figure for additional private phones each year.

Although the number of repeaters subject to charging is shown in Table 8-2-1, this number is assumed to remain unchanged after 1997.

Taking the above into account, the cumulative number of private phones to be installed each year is as shown in Table 8-2-5.

Table 8-2-5 Number of Private Phones Installed Each Year (Project and Additional Installations)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Number Installed in Phases I - V	30			76	84	84	85								
Additional Number Installed					16			31	60	37	35	38	73	45	42
Total	30			76	100	84	85	31	60	37	35	38	73	45	42
Cumulative Total	30	30	30	106	206	290	375	406	466	503	538	576	649	694	736
Number of Units Subject to Repeater Charging	2			3	0	1	0								
Cumulative Total of Units Subject to Repeater Charging	2	2	2	5	5	6	6	6	6	6	6	6	6	6	6

(2) Revenues from Basic Fees Each Year

Basic private phone fees for both TDMA and single-channel service are K45 per charge-month. As PTC has established the charge-month as equivalent to four calendar weeks, there are 13 charge-months per year, thus making an annual basic fee K585 per telephone. Basic fees for repeaters are K15 per charge-month, or K195 annually.

For convenience in making estimates, basic fees are calculated from the year following that in which the telephone set is installed. Revenues from basic fees for each year are obtained by multiplying the basic fee charge per telephone by the number of telephone sets. The results for this project only are shown in Table 8-2-6; results including basic fees from additional private phones are shown in Table 8-2-7.

Table 8-2-6 Revenues from Basic Fees Each Year
(Project Installations Only)

(Unit: Thousand Kina)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Basic Fees for Private Phone	2.7	17.6	17.6	62.0	111.2	160.3	210.0	210.0	210.0	210.0	210.0	210.0	210.0	210.0	210.0
Basic Fees for Repeaters	0.1	0.4	0.4	1.0	1.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total	2.8	17.9	17.9	63.0	112.1	161.5	211.2	211.2	211.2	211.2	211.2	211.2	211.2	211.2	211.2

Table 8-2-7 Revenues from Basic Fees Each Year
(Project and Additional Installations)

(Unit: Thousand Kina)

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Basic Fees for Private Phone	2.7	17.6	17.6	62.0	120.5	169.7	219.4	237.5	272.6	294.3	314.7	337.0	379.7	406.0	430.6
Basic Fees for Repeaters	0.1	0.4	0.4	1.0	1.0	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Total	2.8	17.9	17.9	63.0	121.5	170.8	220.5	238.7	273.8	295.4	315.9	338.1	380.8	407.2	431.7

8.2.3 Revenues from Call Charges

The revenue forecasts were made by referring to the revenue results of Menyamya and Aseki Villages. Annual revenues per single set of pay phones and private phones are calculated on the basis of these data.

(1) Revenues from Single Pay Phone Set

As pay phone revenues in Menyamya Village registered a total of K2,702 for the period of 25 months, the annual originating call charge revenue per set, R_O, is calculated as follows:

$$R_O = K2,702 \times \frac{12 \text{ Months}}{25 \text{ Months}}$$

$$= K1,296.96/\text{Year}$$

Revenues for installed telephones, for either pay phones or private phones, generally tend to be considered as originating call charges only, as the switching office charge meters to which the telephones are connected calculate originating call charges only.

Of course, however, incoming calls to said telephone are calculated on their originating sides. Form the viewpoint of PTC revenues, therefore, it is proper to combine both originating and incoming calls when estimating revenues.

According to the results of pay phones in Barakau Village, the ratio of incoming calls to originating calls is 57.1% to 42.9%.

The ratio in Menyamya Village is assumed to be the same as that in Barakau Village. Under this assumption, the annual originating and incoming call charges for a pay phone (R_{O+I}) is calculated as follows:

$$R_{O+I} = K1,296.96/0.429$$

$$= K3,023.22/\text{Year} \cdot \text{Set}$$

(2) Revenues from Single Private Phone Set

In the case of private phones in Aseki and Menyamya Villages, the revenues of originating calls recorded for each private phone are as follows:

<u>Aseki</u> (December, 1988 ~ July, 1989)
K 8,090.25 (Private Phone 1)
K 261.75 (Private Phone 2)
K 3,623.55 (Private Phone 3)
<u>K 1,474.85</u> (Private Phone 4)
K13,449.90/7 Months

<u>Menyamya</u> (1987 ~ 1989)
K11,630.01 (Private Phone 1)
K 9,621.62 (Private Phone 2)
K 7,003.71 (Private Phone 3)
<u>K 8,397.30</u> (Private Phone 4)
K36,652.64/25 Months

In accordance with these revenue records, the average annual revenues from originating and incoming call charges per private phone in both villages are as follows, assuming the ratio of originating calls to incoming calls to be the same as that of pay phones in Barakau Village:

$$R'_{O+I} = \left(K13,449.90 \times \frac{12 \text{ Months}}{7 \text{ Months}} + K36,652.64 \times \frac{12 \text{ Months}}{25 \text{ Months}} \right) \div 8 \div 0.429$$

$$= (K23,056.97 + 17,593.27) \div 8 \div 0.429$$

$$\fallingdotseq K11,844.48/\text{Year} \cdot \text{Set}$$

(3) Single Charges by Rank of Village

Both Menyamya and Aseki Villages have populations exceeding 2,000 persons. As described in Section 5.2.3, the both are classified as A-Rank villages.

As call charge revenues are usually proportional to average traffic, call charge revenues of B-Rank and C-Rank villages are calculated by multiplying the revenues of a single A-Rank telephone by the traffic ratios mentioned in 5.2.3 (A : B : C = 0.22 : 0.13 : 0.07).

Single-phone charges (R_A, R_B, R_C) for <u>pay phones</u> of each rank are calculated as follows:

$$R_A = K3{,}023.22$$

$$R_B = K3{,}023.22 \times \frac{0.13}{0.22} = K1{,}786.45$$

$$R_C = K3{,}023.22 \times \frac{0.07}{0.22} = K961.93$$

In the same way as above, single-phone charges (R'_A, R'_B, R'_C) for <u>private phones</u> of each rank are calculated as follows:

$$R'_A = K11{,}844.48$$

$$R'_B = K11{,}844.48 \times \frac{0.13}{0.22} = K6{,}999.01$$

$$R'_C = K11{,}844.48 \times \frac{0.07}{0.22} = K3{,}768.70$$

(4) Call Charge Revenues Each Year

The number of telephones for each rank classification in this project is shown in Table 8-2-8. The number of telephones, including additional telephones installed, for each rank classification is shown in Table 8-2-9.

Call charge revenues each year are calculated by multiplying the single telephone charges for each rank classification, as calculated in (3).

Call charge revenues for this project only are shown in Table 8-2-10; call charge revenues including those from additional telephones installed are shown in Table 8-2-11.

Table 8-2-8 Number of Telephones by Rank Classification

(Project Installations Only)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Pri.Phone	A Rank	4			1	0	2	4	0	0	0	0	0	0	0	0
	Accum.No.	4	4	4	5	5	7	11	11	11	11	11	11	11	11	11
	B Rank	13	0	0	32	10	7	36	0	0	0	0	0	0	0	0
	Accum.No.	13	13	13	45	55	62	98	98	98	98	98	98	98	98	98
	C Rank	13	0	0	43	74	75	45	0	0	0	0	0	0	0	0
	Accum.No.	13	13	13	56	130	205	250	250	250	250	250	250	250	250	250
	Accum.No.	30	30	30	106	190	274	359	359	359	359	359	359	359	359	359
Payphone	A Rank	3	0	0	1	0	1	4	0	0	0	0	0	0	0	0
	Accum.No.	3	3	3	4	4	5	9	9	9	9	9	9	9	9	9
	B Rank	21	0	0	27	10	8	32	0	0	0	0	0	0	0	0
	Accum.No.	21	21	21	48	58	66	98	98	98	98	98	98	98	98	98
	C Rank	21	0	0	41	92	78	40	0	0	0	0	0	0	0	0
	Accum.No.	21	21	21	62	154	232	272	272	272	272	272	272	272	272	272
	Accum.No.	45	45	45	114	216	303	379	379	379	379	379	379	379	379	379

Table 8-2-9 Number of Telephones by Rank Classification

(Project and Additional Installations)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Pri.Phone	A Rank	4			1	0	2	4	0	0	0	0	0	0	0	0
	Accum.No.	4	4	4	5	5	7	11	11	11	11	11	11	11	11	11
	B Rank	13	0	0	32	10	7	36	0	0	0	0	0	0	0	0
	Accum.No.	13	13	13	45	55	62	98	98	98	98	98	98	98	98	98
	C Rank	13	0	0	43	74	75	45	0	0	0	0	0	0	0	0
	Additional	0	0	0	0	16	0	0	31	60	37	35	38	73	45	42
	Accum.No.	13	13	13	56	146	221	266	297	357	394	429	467	540	585	627
	Accu.Total	30	30	30	106	206	290	375	406	466	503	538	576	649	694	736
Payphone	A Rank	3			1	0	1	4								
	Accum.No.	3	3	3	4	4	5	9	9	9	9	9	9	9	9	9
	B Rank	21			27	10	8	32								
	Accum.No.	21	21	21	48	58	66	98	98	98	98	98	98	98	98	98
	C Rank	21			41	92	78	40								
	Accum.No.	21	21	21	62	154	232	272	272	272	272	272	272	272	272	272
	Accu.Total	45	45	45	114	216	303	379	379	379	379	379	379	379	379	379

Table 8-2-10 Call Charge Revenues

(Project Installations Only)

Unit:Thousand Kina

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Pri.Phone	A Rank	7.9	47.4	47.4	59.2	59.2	82.9	130.3	130.3	130.3	130.3	130.3	130.3	130.3	130.3	130.3
	B Rank	15.2	91.0	91.0	315.0	384.9	433.9	685.9	685.9	685.9	685.9	685.9	685.9	685.9	685.9	685.9
	C Rank	8.2	49.0	49.0	211.0	489.9	772.6	942.2	942.2	942.2	942.2	942.2	942.2	942.2	942.2	942.2
Payphone	A Rank	1.5	9.1	9.1	12.1	12.1	15.1	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
	B Rank	6.3	37.5	37.5	85.7	103.6	117.9	175.1	175.1	175.1	175.1	175.1	175.1	175.1	175.1	175.1
	C Rank	3.4	20.2	20.2	59.6	148.1	223.2	261.6	261.6	261.6	261.6	261.6	261.6	261.6	261.6	261.6
Total		42.4	254.1	254.1	742.7	1197.9	1645.6	2222.3	2222.3	2222.3	2222.3	2222.3	2222.3	2222.3	2222.3	2222.3

Table 8-2-11 Call Charge Revenues

(Project and Additional Installations)

Unit:Thousand Kina

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Pri.Phone	A Rank	7.9	47.4	47.4	59.2	59.2	82.9	130.3	130.3	130.3	130.3	130.3	130.3	130.3	130.3	130.3
	B Rank	15.2	91.0	91.0	315.0	384.9	433.9	685.9	685.9	685.9	685.9	685.9	685.9	685.9	685.9	685.9
	C Rank	8.2	49.0	49.0	211.0	550.2	832.9	1002.5	1119.3	1345.4	1484.9	1616.8	1760.0	2035.1	2204.7	2363.0
Payphone	A Rank	1.5	9.1	9.1	12.1	12.1	15.1	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.2
	B Rank	6.3	37.5	37.5	85.7	103.6	117.9	175.1	175.1	175.1	175.1	175.1	175.1	175.1	175.1	175.1
	C Rank	3.4	20.2	20.2	59.6	148.1	223.2	261.6	261.6	261.6	261.6	261.6	261.6	261.6	261.6	261.6
Total		42.4	254.1	254.1	742.7	1258.2	1705.9	2282.6	2399.4	2625.5	2765.0	2896.9	3040.1	3315.2	3484.8	3643.1

8.2.4 Gross Revenues

Revenues from installation fees, basic fees and call charges mentioned above in case of this project only are shown in Table 8-2-12; those from both this project and additional installations are shown in Table 8-2-13.

Table 8-2-12 Forecast Revenues by Year
(Project Installations Only)

(Unit: Thousand Kina)

YEAR	CASH INFLOW			
	INSTALLATION FEES	BASIC FEES	CALL CHARGES	TOTAL REVENUES
1990				
1991	10.5	2.8	42.4	55.7
1992		17.9	254.1	272.0
1993		17.9	254.1	272.0
1994	24.5	63.0	742.7	830.2
1995	25.2	112.1	1,197.9	1,335.2
1996	26.1	161.5	1,645.6	1,833.2
1997	25.5	211.2	2,222.3	2,459.0
1998		211.2	2,222.3	2,433.5
1999		211.2	2,222.3	2,433.5
2000		211.2	2,222.3	2,433.5
2001		211.2	2,222.3	2,433.5
2002		211.2	2,222.3	2,433.5
2003		211.2	2,222.3	2,433.5
2004		211.2	2,222.3	2,433.5
2005		211.2	2,222.3	2,433.5
TOTAL	111.8	2,276.0	24,137.5	26,525.3

Note: Traffic increase not included.
See Table 8-4-3 for sensitivity analysis.

Table 8-2-13 Forecast Revenues by Year
(Project and Additional Installations)

(Unit: Thousand Kina)

YEAR	CASH INFLOW			
	INSTALLATION FEES	BASIC FEES	CALL CHARGES	TOTAL REVENUES
1990				
1991	10.5	2.8	42.4	55.7
1992		17.9	254.1	272.0
1993		17.9	254.1	272.0
1994	24.5	63.0	742.7	830.2
1995	27.6	121.5	1,258.2	1,407.3
1996	26.1	170.8	1,705.9	1,902.8
1997	25.5	220.5	2,282.6	2,528.6
1998	4.7	238.7	2,399.4	2,642.8
1999	9.0	273.8	2,625.5	2,908.3
2000	5.6	295.4	2,765.0	3,066.0
2001	5.3	315.9	2,896.9	3,218.1
2002	5.7	338.1	3,040.1	3,383.9
2003	11.0	380.8	3,315.2	3,707.0
2004	6.8	407.2	3,484.8	3,898.8
2005	6.3	431.7	3,643.1	4,081.1
TOTAL	168.6	3,296.0	30,710.0	34,174.6

Note: Traffic increase not included.
See Table 8-4-3 for sensitivity analysis.

8.3 Cost Estimate

8.3.1 Construction Cost

Project costs consist of construction costs, installation costs per additional telephone unit, working capital and operations costs. Construction costs include expenses for equipment, installation, training and consultation. All expenses estimated in Item 6.6.1 are converted into local currency and constitute construction costs for which investment between 1990 and 1997 is earmarked.

8.3.2 Additional Telephone Installation Cost

As noted in Item 8.1.5 above, it is assumed that additional telephone sets corresponding to the increase in demand will be installed under PTC's budget every four years at the completion of each phase. Costs for such installation are estimated as follows. If a three-day dispatch, which includes a two-day stay, is required for the installation, the estimate of costs to install one telephone set in one village is determined by:

#	Business Trip Expenses		
	Lodging:	K80 X 2 Days X 2 =	K 320
	Meals:	K30 X 3 Days X 2 =	K 180
	Travelling Allowance:	K 4 X 3 Days X 2 =	K 24
			K 524
#	Helicopter Charges: K700/Hour X 4 Hours		K2,800
#	Telephone Set Cost:		K 30
#	Cable Cost (150 m): K37/100 Meters X 1.5		K 60
#	Labor Costs: K9.09/Day X 2 Days		K 18
	TOTAL		K3,432

The telephone installation plan in Table 8-1-2 indicates the number of additional telephone sets to be installed. Therefore we calculate the additional installation costs by multiplying this additional telephone number by the additional installation costs per unit. The results are presented in Table 8-3-1.

Table 8-3-1 Additional Telephone Installation Costs Each Year

(Unit: Thousand Kina)

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Additional Number	16			31	60	37	35	38	73	45	42
Additional Installation Costs	54.9			106.4	205.9	127.0	120.1	130.4	250.5	154.4	144.1

8.3.3 Working Capital

Working capital can be recovered within a short time through business operations. It includes current deposits as cash on hand, accounts receivable as funds necessary until call charges are collected, and equipment inventory costs. These figures are forecast based on the average ratio of working capital to total telephone revenues at PTC.

Table 8-3-2 indicates cash and deposits, accounts receivable, and inventory costs as ratios of operating revenues over the last seven years for the Telecommunications Division of PTC.

Table 8-3-2 Cash and Deposits, Accounts Receivable, and Inventory Cost Ratios to Operating Revenues

(Unit: Thousand Kina)

	1982	1983	1984	1985	1986	1987	1988
1. Cash and Deposit	6,195	2,871	1,242	6,968	1,359	488	51
2. Accounts Receivable	8,971	9,892	9,007	9,695	7,826	8,672	10,359
3. Inventory	3,875	3,199	3,050	1,768	2,569	1,777	4,746
Total	19,041	15,962	13,299	17,431	11,754	10,937	15,156
4. Operating Revenue	25,375	44,952	50,547	61,182	72,433	76,064	88,781
Ratio (%): (1.+2.+3.)/4.	75.0	35.5	26.3	28.5	16.2	14.4	17.1

Although these ratios have shown a tendency to decrease year by year, there have been large fluctuations during the last seven years. Therefore, a ratio of 15.9%, which is the average ratio for the last three years (1986 - 1988), has been adopted as the ratio of working capital to operating revenues and used to establish the working capital estimate for this project.

It is estimated that the working capital projections will be equivalent to 15.9% of total revenues in 1991. From 1992 onward, 15.9% of the yearly incremental increases is allocated to operating costs. Although working capital is calculated as an annual expense, it should be recovered during the last year of the project life.

Working capital for each year has been calculated by the above method. The results from this project only are shown in Table 8-3-3. Working capital projections in case additional telephones are installed are shown in Table 8-3-4.

Table 8-3-3 Working Capital
(Project Installations Only)

(Unit: Thousand Kina)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Working Capital	8.9	34.4	0	88.8	80.3	79.2	99.5	0	0	0	0	0	0	0	-391.0

Table 8-3-4 Working Capital
(Project and Additional Installations)

(Unit: Thousand Kina)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Working Capital	8.9	43.2	43.2	132.0	223.8	302.5	402.0	420.2	462.4	487.5	511.7	538.0	589.4	619.9	-4,784.9

8.3.4 Operations Costs

Operations costs are related to business operations activities, and generally correspond to maintenance and operations costs. The amount of K110,200 estimated in Chapter 6 is calculated as annual operating costs.

Operations costs for each year, however, are expected to reflect annual increases of 2%. These adjusted figures are presented in Table 8-3-5.

Table 8-3-5 Operation Cost

(Unit: Thousand Kina)

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Phase I *(3)		17.4	17.7	18.1	18.4	18.8	19.2	19.6	20.0	20.3	20.8	21.2	21.6	22.0	22.5
Phase II *(5)					30.7	31.3	32.0	32.6	33.3	33.9	34.6	35.3	36.0	36.7	37.4
Phase III*(3)						18.8	19.2	19.6	20.0	20.3	20.8	21.2	21.6	22.0	22.5
Phase IV *(6)							38.4	39.1	39.9	40.7	41.5	42.3	43.2	44.1	44.9
Phase V *(2)								13.0	13.3	13.6	13.8	14.1	14.4	14.7	15.0
Operation Cost Total		17.4	17.7	18.1	49.2	68.9	108.7	123.9	126.4	128.9	131.5	134.1	136.8	139.5	142.3

Note 1: * Figure in parentheses indicates the number of provinces covered by the phase.

Note 2: Operation costs for each year are calculated as follows.

Operation cost =
Operation Cost for One Province X Cumulative Total of Province

Note 3: Operation costs for the provinces are assumed to increase by 2 % annually.