THE FEASIBILITY STUDY
ON
RURAL TELECOMMUNICATION DEVELOPMENT PLAN
IN
PAPUA NEW GUINEA

VOLUME II

November 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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CONTENTS

1. INTRODUCTION

The Rural Telecommunication Development Plan of Papua New Guinea (hereafter called PNG) is to introduce pay and private phones to 374 villages in the 19 provinces of PNG. Because of its large scale, this plan will be implemented by dividing the entire process into five phases in consideration of the funds and man power that are available to PTC.

This initial plan presents the fundamental design of the implementation plan for the three provinces — Morobe, Western and New Ireland, that are scheduled in Phase I. These three provinces represent the characteristic terrain of PNG, respectively — i.e., Morobe is a mountainous region, Western is an extensive swamp area and New Ireland is an island region. It is therefore desirable if the results of the implementation in the three provinces of Phase I are reflected in Phase II and subsequent phases, thereby contributing to the smooth implementation of the entire project. Under this concept, the three provinces that will be dealt with in this initial plan can be considered model areas. As such, they have a special significance among the 19 provinces of PNG.

2. DESIGN POLICY

The system design for the construction of a rural telecommunications network in PNG was made based on the following concepts.

(1) Design Range

This rural telecommunications network will connect existing exchanges to pay phones to be installed in villages in rural areas and private phones that will be installed in public organizations, such as branch offices of provincial governments and public health centers scattered in rural areas, and in private companies, such as plantations.

Accordingly, the design of this network covers from the main distributing frame (MDF) installed inside the switching office to the telephone sets.

(2) Utilization of Existing Telecommunications Facilities

In designing this rural telecommunications network, an attempt is made to efficiently utilize steel towers and buildings of existing telephone offices and radio repeater stations in order to realize an economical design concept.

(3) Method of Handling Subscribers

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.

3. NETWORK DESIGN

3.1 Communications System

Since PNG has a land area 1.3 times as large as Japan with many widely dispersed and sparsely populated villages, demand distribution is decentralized and low volume.

Therefore, it is important to adopt a communications system that can cover a wide area, permit economic network construction for a low-volume telephone demand, and provide flexibility for future demand fluctuations.

As suggested in the Report on the Rural Telecommunication Development Plan of PNG, the TDMA radio system, with its repeater and line-concentrating functions that offer the following features, is an optimal communications system for constructing a rural telecommunications network:

(1) Permits construction of transmission paths connecting areas remote from radio equipment.

(2) Permits efficient concentration of lines connecting scattered telephone sets.

(3) Permits flexible response to the future increases in demand.

From the economic standpoint, the single-channel radio system is also to be used in principle for villages that are estimated to require only one telephone circuit. The application of this system will be determined by considering the possibilities in allocating radio frequencies and radio wave propagation conditions.

3.2 Frequency Allocation

(1) TDMA Radio System

According to the PNG frequency usage plan, the radio frequencies used in the TDMA system are between 1,427 MHz and 1,528 MHz on the 1.5 GHz band.

As shown in Figure 3-2-1, the transmitting and receiving frequencies are divided into an upper group and a lower group, with up to sixteen frequencies being allocated to each group. The interval between the transmitting and receiving frequencies is 60.5 MHz.

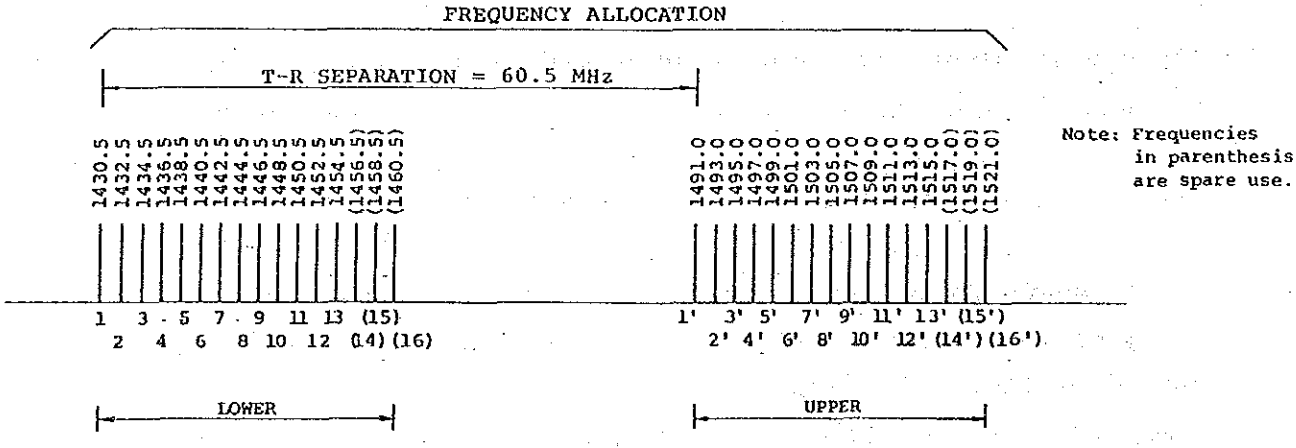


Figure 3-2-1 Frequency Allocation at 1.5GHz

(2) Single-Channel System

The following three frequency bands are available for the single-channel system.

(a) 79 - 82 MHz/83 - 86 MHz (120 Channels)
(b) 150.4 - 151.4 MHz/155.0 - 156.0 MHz (40 Channels)
(c) 450.6 - 451.5 MHz/460.1 - 461.0 MHz (36 Channels)

For the VHF and UHF bands, in general, the lower the frequency, the smaller the influence from fading over prolonged propagation distances due to the diffraction effect. The PNG frequency-allocation policy is that the lower frequency bands will be assigned first to sections with adverse propagation conditions. In selecting the frequency band for this system, therefore, the first priority must be placed on the study of selecting the higher frequency band.

Based on this policy, the first priority will be given to a study of the 450-MHz band application for this system, with the possibility of using the 150-MHz band depending upon propagation path conditions.

3.3 Circuit Quality

In consideration of the facts that the circuit quality and standards of the existing telecommunications network in PNG conform to CCIR standards, and that even the rural telecommunications network will form part of the internationally connected telecommunications network, the target circuit quality of the subscriber radio section in the rural telecommunications network will be in accordance with international standard as follows:

(1) For digital links, if the bit error rate (BER) exceeds 10^{-3}, it will be considered an outage, and outages in any month should be fewer than 5.88×10^{-7}/km (0.015×10^{-2}/255 km).
(CCITT Report 1053)

(2) For analog links, a circuit quality of S/N $\geq$ 30 dB must be obtained even in the worst case.

3.4 Standard Circuit Design

The circuit design values for radio sections vary depending on system parameters, propagation path conditions and the combination of antenna systems. An example of circuit design using the estimated system parameters shown in Table 3-4-1 is as follows:

Figure 3-4-1 shows the relationship between propagation distance and applicable range in the TDMA radio system for the 1.5-GHz band. Figure 3-4-2 shows such relationship in the single-channel system for the 450MHz/150MHz bands.

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

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

(3) The standard line-of-sight propagation distance for the single-channel system is 45 - 60 km.

Table 3-4-1 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)

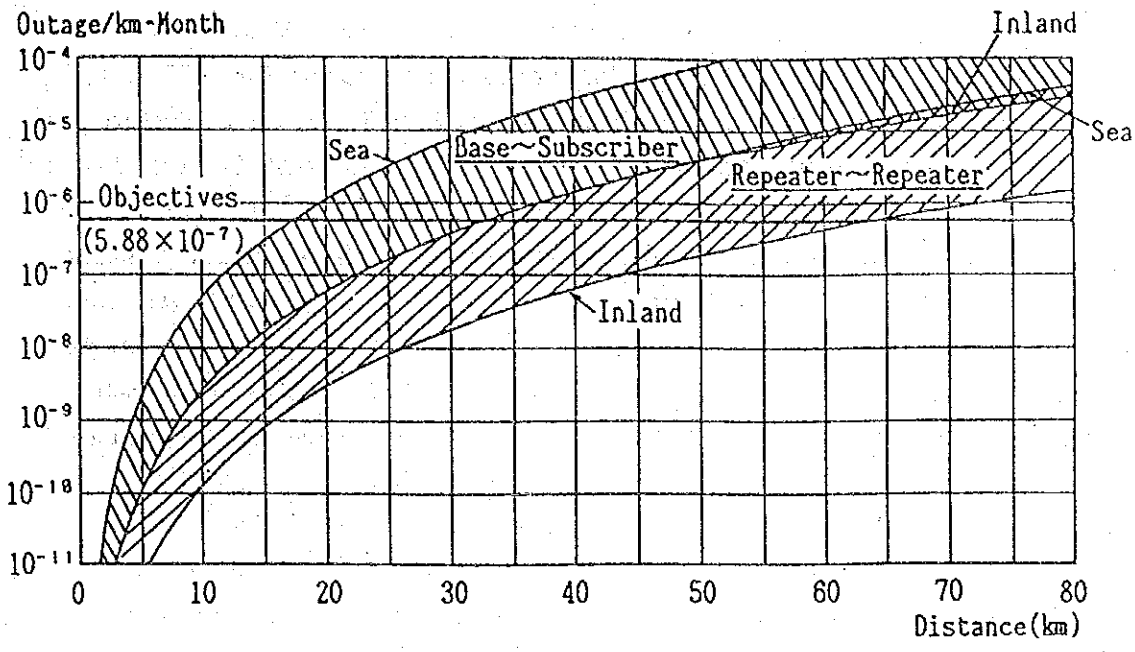


Figure 3-4-1 TDMA Radio Propagation Characteristics
(1.5 GHz)

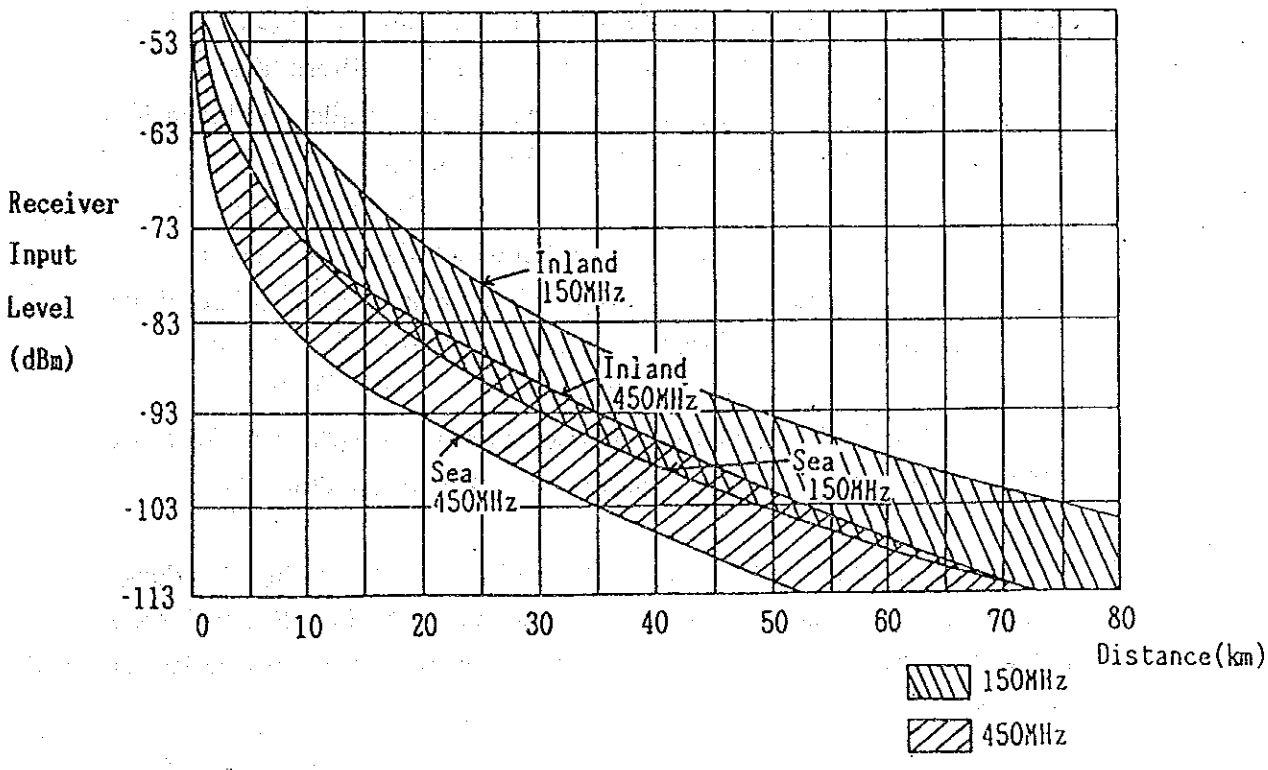


Figure 3-4-2 Single-Channel Propagation Characteristics
(450 MHz/150 MHz)

3.5 Circuit Design

The results of circuit design for each section using the TDMA radio system and the single-channel system in Morobe, New Ireland and Western are presented in the following annexes:

Radio Section Profile and Circuit Design:	Annex 1
Azimuth Angle of Each Section:	Annex 2
Site Sketch:	Annex 3
Equipment and Antenna Installation Sketch at the Existing Office:	Annex 4
Calculation of Photovoltaic Capacity:	Annex 5

3.6 Network Configuration

(1) Morobe Province

Figure 3-6-1 outlines network configuration and Table 3-6-1 lists objective villages.

(a) Morobe Province is located in the central part of New Guinea. Since this Province is a mountainous area, and there are several existing telecommunications facilities, the radio propagation condition is better than the other two Provinces.

(b) Service is provided to sixteen (16) villages with one base station and eight repeater stations (of these, four stations also function as subscriber stations).

(c) The Lae Base Station provides circuits connecting Omsis in the east, Wideru in the west and Mt. Mission located in the south.

(d) Repeater stations constructed at four villages — Chivasing, Bandong, Zenguru and Silimana, handle the telephone sets installed in these villages themselves and provide circuits connected to the adjacent villages.

(e) Since a line-of-sight from nearby Mt. Mission is not available, Wandumi Village is connected to the Wau Switching Office directly using a single-channel system.

(2) New Ireland Province

Figure 3-6-2 outlines network configuration and Table 3-6-2 lists objective villages.

(a) A mountainous spine several hundred meters to more than one thousand meters in height divides this slender island into two sections. The foot of this mountain range closes in on the coast line. This causes adverse conditions generally in obtaining line-of-sight transmission paths between objective villages. Because of this, the network is divided into the two parts covering the north and south coasts, respectively.

(b) Telephone service is provided to fourteen (14) villages with two base stations and five repeater stations (of these, two stations also function as subscriber stations).

The Kavieng Base Station located in the north handles the northern part of this province, and the Rabaul Base Station serves villages in the southern part.

(c) The Rabaul Base Station to be constructed on East New Britain Island will provide telephone service to villages located in the southern part of New Ireland. As a result, these villages will be connected to a switching office other than that determined by the current numbering plan.

(3) Western Province

Figure 3-6-3 outlines network configuration and Table 3-6-3 lists objective villages.

(a) Since the wide central area of this province is covered with swamps, many of the villages are clustered around areas centered in Kiunga and Tabubil in the north and Daru in the south. The objective villages of this rural telecommunications network are also gathered in these areas.

(b) The villages in this province will be connected to the four switching offices of Daru, Kiunga, Tabubil and Mt. Hagen, because of the conditions of existing telecommunications facilities and propagation paths.

(c) Ningerum Village is connected to the existing carrier terminal equipment installed at Mt. Robinson on the voice band, and then connected to the Tabubil Switching Office.

(d) Three villages — Debepare, Suabi and Mogulu, are connected to the existing carrier terminal equipment installed at Mt. Karoma on the voice band, and then connected to the Mt. Hagen Switching Office. As a result, these villages will be managed by a switching office other than that determined by the current numbering plan.

MOROBE Province

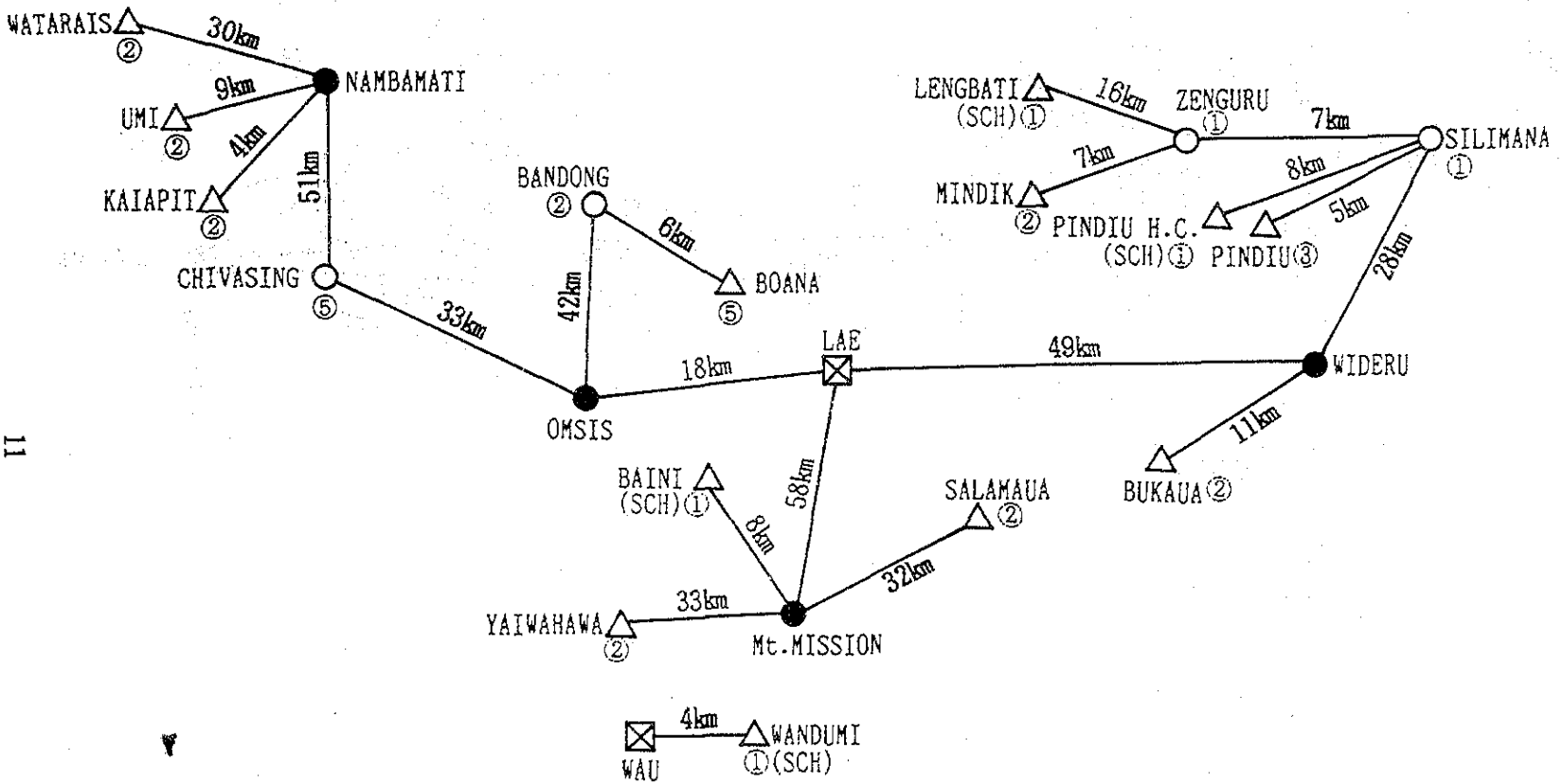


Fig. 3-6-1 Network Configuration in MOROBE Province

NEW IRELAND Province

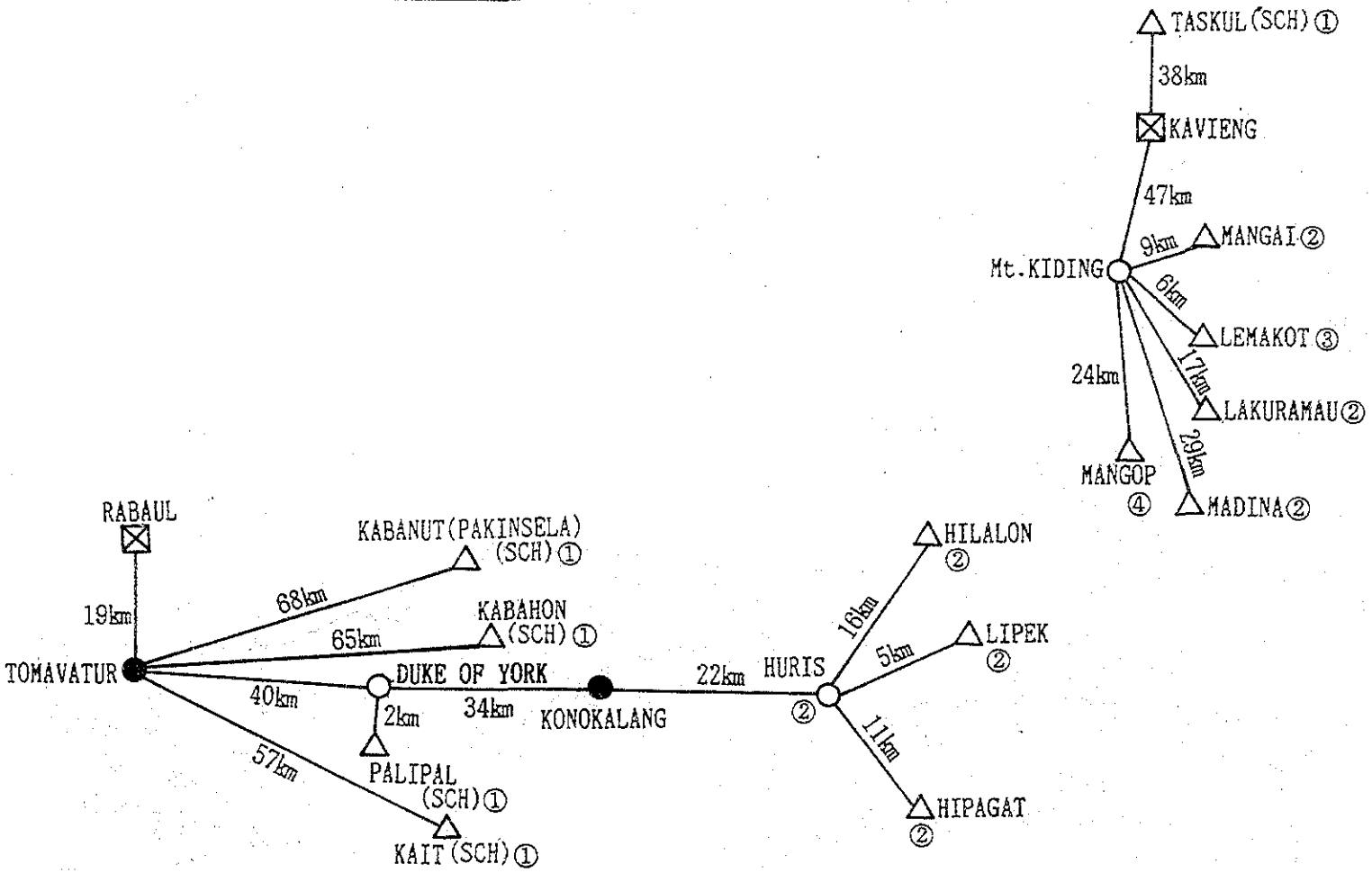


Fig. 3-6-2 Network Configuration in NEW IRELAND Province

WESTERN Province

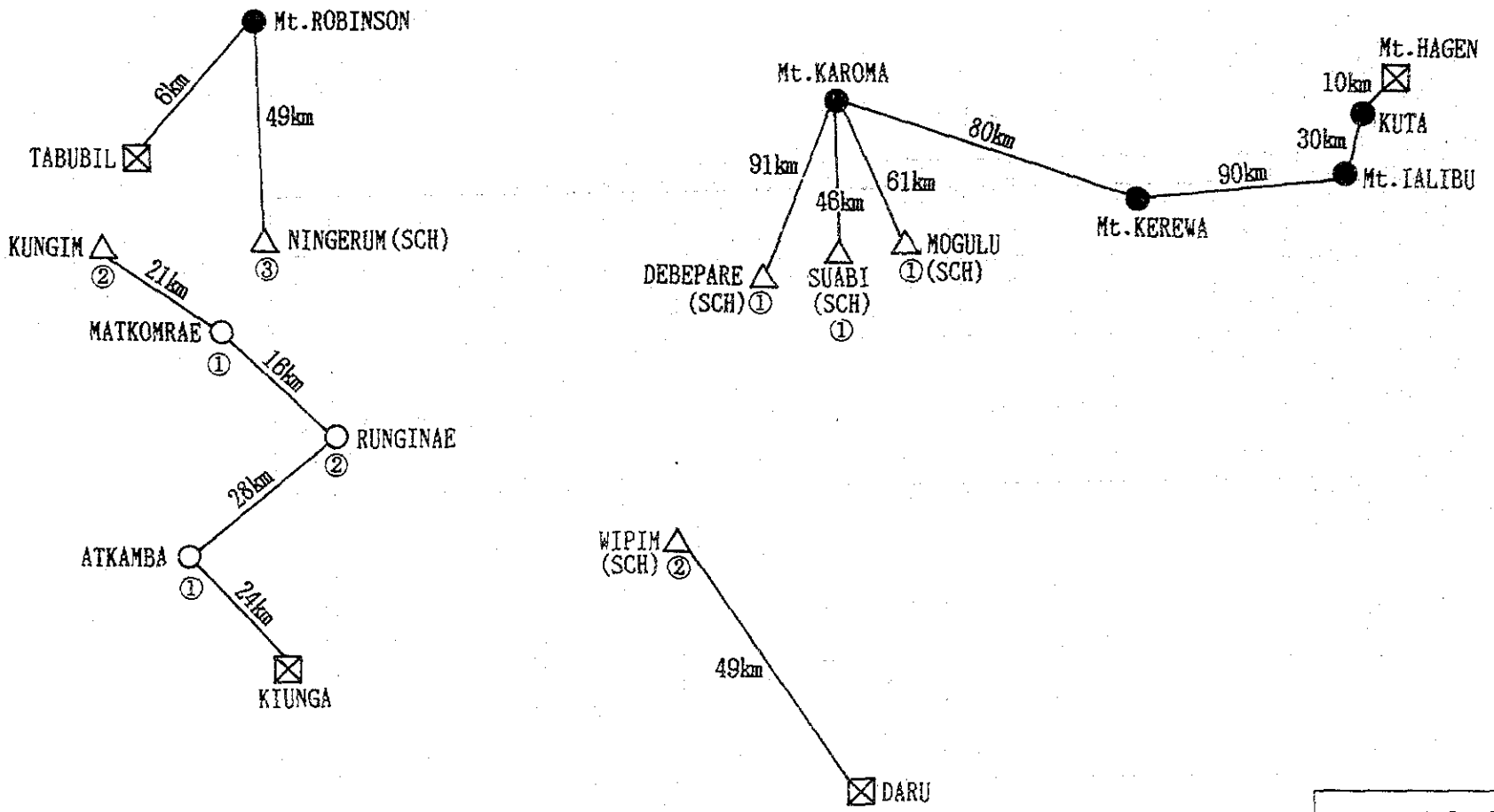


Fig. 3-6-3 Network Configuration in WESTERN Province

Table 3-6-1 Objective Villages in Morobe Province

Name of Object Village	Number of Telephone	
	Pay	Private
BUKAUA	1	1
BAINI	1	
WANDUMI	1	
YAIWAHAWA	1	1
SARAMAUA	1	1
BOANA	2	3
BANDONG	1	1
WATARAIS	2	
KAIAPIT	1	1
CHIVASING	2	3
UMI	1	1
SILIMANA	1	
LENGBATI	1	
ZENGURU	1	
MINDIK	1	1
PINDIU H. C	1	
PINDIU	1	2
17	20	15

Table 3-6-2 Objective Villages in New Ireland Province

Name of Object Village	Number of Telephone	
	Pay	Private
KABANUT	1	
KABAHONG	1	
KAIT	1	
PALIPAL	1	
HILALON	2	
LIPEK	1	1
HIPAGAT	2	
TASKUL	1	
MANGAI	1	1
LEMAKOT	1	2
LAKULAMAU	1	1
MADINA	1	1
MANGOP	2	2
HURIS		2
14	16	10

Table 3-6-3 Objective Villages in Western Province

Name of Object Village	Number of Telephone	
	Pay	Private
WIPIM	1	1
ATKAMBA	1	
RUNGINAE	1	1
MATKOMRAE	1	
KUNGIM	1	1
NINGERUM	1	2
DEBEPARE	1	
MOGULU	1	
SUABI	1	
9	9	5

4. FACILITIES DESIGN

4.1 Standard Design

This rural telecommunications network will be constructed using the TDMA radio system or single-channel radio system for its major transmission lines connecting switching offices, repeater stations and villages. This section shows the system configuration and the design range of each site, using the TDMA radio system as an example.

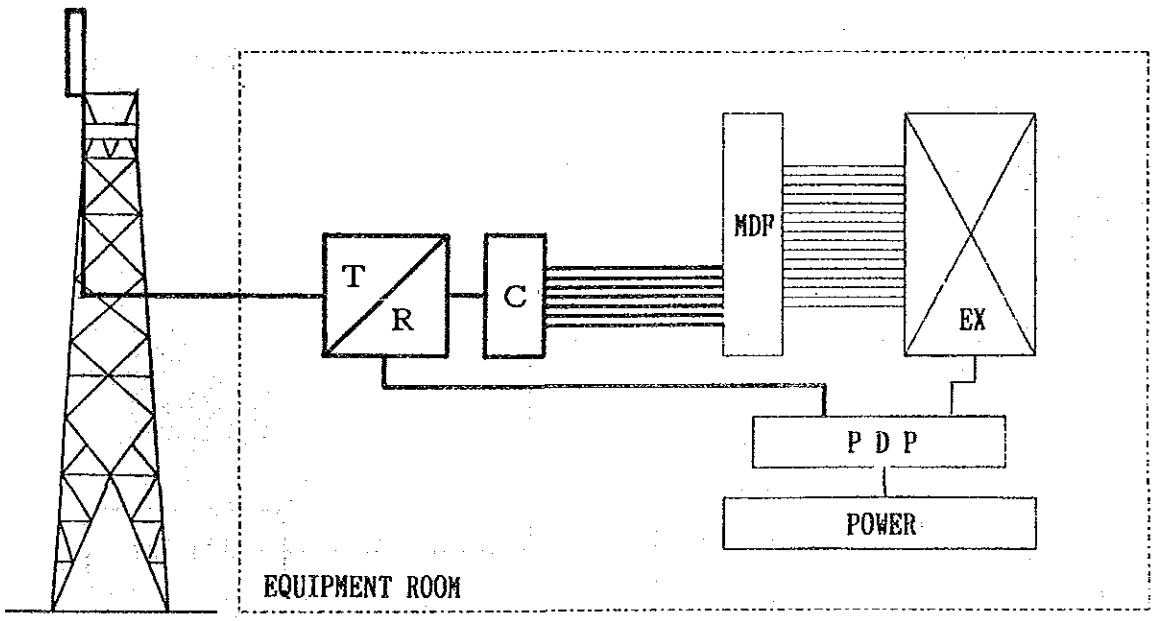
(1) Switching Offices

Figure 4-4-1 presents the configuration of the TDMA radio system base station equipment installed at a switching office, and the design range to be covered in this project.

The base station equipment will be installed in the equipment room of the switching office and connected to the local exchange via MDF.

The minus 48V power necessary for the base station equipment will be supplied through a power distributing panel from the existing power source installed at the switching office.

The antenna-related equipment will be installed on the existing steel tower and connected to the radio equipment via feeder.



EX: Local Exchange
T/R: Transmitter & Receiver
C: Concentrator
MDF: Main Distributing Frame
PDP: Power Distributing Panel
* Bold lines indicate portion covered by this project.

Figure 4-4-1 Base Station Equipment Configuration

(2) Repeater Stations

Figure 4-4-2 introduces the configuration of the TDMA radio system repeater station equipment installed at the existing repeater station, and the design range to be covered in this project.

As a general rule, the repeater station equipment is to be installed inside the existing equipment room. However, if it is difficult due to limited space in the equipment room, cabins will be installed to house such equipment.

The power for the existing repeater station is generally supplied by solar panels with a capacity designed to meet the present needs only and allowing no room for additional equipment. Therefore, the power required in this project will be supplied by installing new solar panels, except for some repeater stations where a commercial power source or an independent power plant is available.

The antenna-related equipment is installed on the existing steel tower and connected to the radio equipment via feeder.

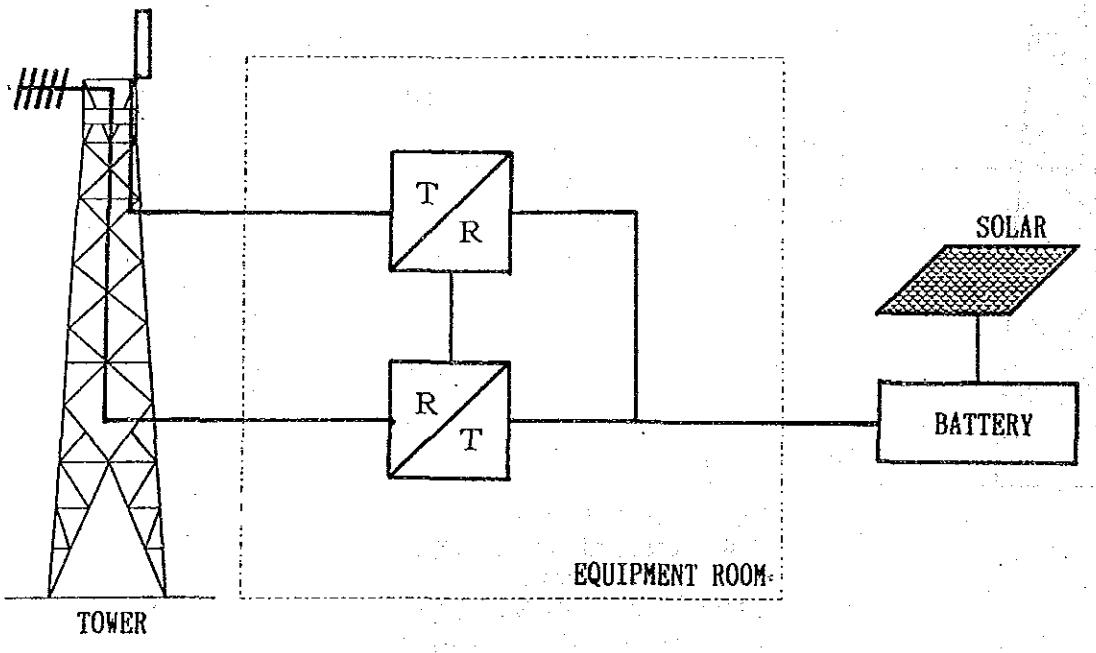


Figure 4-4-2 Repeater Station Equipment Configuration

(3) Villages

Figure 4-4-3 shows the configuration of the TDMA radio system subscriber station equipment. With regard to subscriber stations, everything from securing of construction sites to design and construction of all facilities, including steel towers, will be handled under this project.

The subscriber station equipment will be installed on small hills or their equivalents where a line-of-sight transmission path is available from the adjacent repeater station within the village, and connected to the pertinent telephone set by wire.

The equipment, such as the radio equipment and batteries, will be stored in a box installed on the side of the steel tower. The solar panels will be installed on the steel tower on the upper part of the box, with due attention to avoid any shading by trees.

The wiring from the subscriber station equipment to the pertinent telephone set will be made using direct buried cables by taking into account both the protection of outside plant and economic considerations.

Since the newly constructed repeater stations, including drop repeater stations, require a large power capacity, the solar panels and batteries for them will be installed on the ground and only the radio equipment will be housed in the box installed on the side of the steel tower.

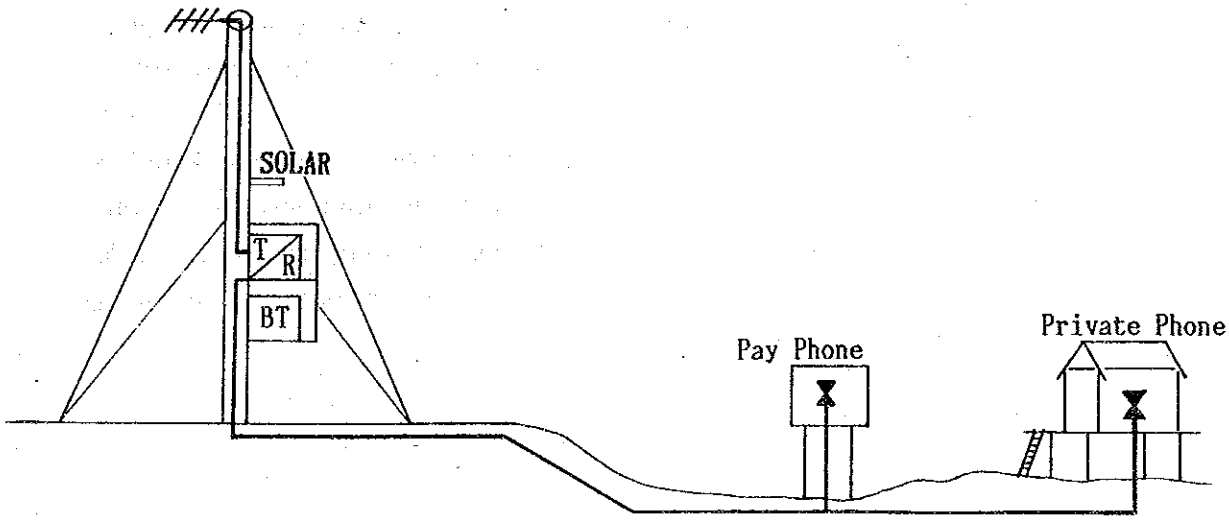


Figure 4-4-3 Subscriber Station Equipment Configuration

4.2 Transmission Facilities

Table 4-2-1 (Nos. 1 - 5) indicates construction details of the radio facilities in each province. The characteristics of the radio facilities in each province are as follows:

(1) Morobe

(a) The Lae office is the only base station using the TDMA system in Morobe Province, and circuits between the Lae office and the repeater stations at Omsis, Wideru and Mt. Mission will each be constructed using an omnidirectional antenna.

(b) As the Wideru repeater station building cannot be used as it is too old, radio equipment will be housed in a cabin to be installed inside the existing steel tower.

A parabolic antenna (1.2m) aimed at Lae will be affixed to a one-meter-long support arm installed on the side of the steel tower. Care will be taken to make sure this antenna does not overlap the existing antenna aimed at Lae.

(c) As the section between Lae and Mt. Mission covers a long distance, low-loss feeder will be used to obtain the necessary field strength.

(d) Line-of-sight vistas from the existing stations in Morobe Province are relatively good despite the area's mountainous topography. Therefore, 10- to 15-meter-tall masts will be used, except for a 20-meter mast to be installed in Baini Village in order to clear an immediately adjacent hill.

(2) New Ireland

(a) Considering the geographical conditions of the objective villages and the conditions of the existing telecommunications facilities in New Ireland Province, base station facilities will be installed at the Kavien switching office and the Rabaul switching office.

(b) Although Palipal Village is located only 2 km from the Duke of York repeater station, it is surrounded by coconut plantations and trees. Considering safety and maintenance of the facilities, service will be provided by a radio system.

(c) Konokalang is an existing radio repeater station, but lacks adequate space in the present equipment room. Therefore, radio equipment will be housed in a cabin to be installed as part of this project.

(d) The Mt. Kiding, Tomabatur and Konokalang repeater stations are all located at high altitudes, some 400 to 1,700 meters above sea level, providing clear line-of-sight vistas. And as the system configuration uses an omnidirectional antenna, it will be easy to respond to future telephone demand of the villages scattered around them.

(3) Western

(a) Base station facilities for the TDMA system will be installed in the Kiunga switching office to serve surrounding villages.

(b) Because of its telephone demand, Wipim Village will be connected to the Daru switching office by a single-channel system.

(c) The villages of Debepare, Suabi and Moguru will each be connected to the Mt. Karoma repeater station using a single-channel system.

These circuits will be connected to the existing microwave terminal equipment at the Mt. Karoma repeater station, and then connected to the Mt. Hagen switching office through a microwave transmission path.

(d) In the same manner as c) above, Ningerum Village will be connected to the Tabubil switching office by connections to the existing terminal equipment at the Mt. Robinson repeater station using a single-channel system.

(e) As the topography of Western Province is flat, appropriate sites for repeater stations near the objective villages are not available. To secure line-of-sight transmission paths, therefore, the required height of the steel towers used will be 50 meters in Runginae and 30 meters each in Wipim, Atkamba, Matkomrae and Kungim. Because of the long feeder required, low-loss feeder will be used to obtain the necessary field strength.

Table 4.2.1 Construction Details of Raidio Facility (NO.1)

Province: MOROBE(1/2)

Name of Station	Facing Station	Trans-missi-on	Frequ-ency (MHz)	Pow-er (W)	Ante-nna	Feeder		Tower	
						Type	L (m)	Type	H (m)
LAE	OMSIS	TDMA	1,500	3	omni	L-loss	32	EXIST-ING TOW.	37
	WIDERU								
	MT. MISSION								
OMSIS	LAE	TDMA	1,500	3	6yagi	normal	15	EXIST-ING TOW.	20
	BANDONG	TDMA	1,500	3	omni	normal	25		
	CHIVASING								
BANDONG	OMSIS	TDMA	1,500	3	6yagi	normal	15	MAST	10
	BOANA	TDMA	1,500	3	omni	normal	15		
BOANA	BANDONG	TDMA	1,500	3	6yagi	normal	15	MAST	10
CHIVASING	OMSIS	TDMA	1,500	3	6yagi	normal	20	MAST	15
	NAMBAMATI	TDMA	1,500	3	omni	normal	20		
NAMBAMATI	CHIVASING	TDMA	1,500	3	6yag-R	normal	28	EXIST-ING TOW.	23
	KAIAPIT	TDMA	1,500	3	omni	normal	37		
	UMI								
	WATARAIS								
KAIAPIT	NAMBAMATI	TDMA	1,500	3	6yagi	normal	15	MAST	10
UMI	NAMBAMATI	TDMA	1,500	3	6yagi	normal	15	MAST	10
WATARAIS	NAMBAMATI	TDMA	1,500	3	6yagi	normal	15	MAST	10
WIDERU	LAE	TDMA	1,500	3	p-1.2m	normal	5	EXIST-ING TOW.	15
	BUKAUA	TDMA	1,500	3	omni	normal	10		
	SILIMANA								
BUKAUA	WIDERU	TDMA	1,500	3	6yagi	normal	20	MAST	15
SILIMANA	WIDERU	TDMA	1,500	3	6yagi	normal	20	MAST	15
	PINDIU	TDMA	1,500	3	omni	normal	20		
	ZENGURU								
	PINDIU H.C	S-CH	450	1	8yagi	normal	20		

Table 4.2.1 Construction Details of Raidio Facility (NO.2)

Province: MOROBE(2/2)

Name of Station	Facing Station	Trans-missi-on	Frequ-ency (MHz)	Pow-er (W)	Ante-nna	Feeder		Tower	
						Type	L (m)	Type	H (m)
PINDIU	SILIMANA	TDMA	1,500	3	6yagi	normal	15	MAST	10
PINDIU H.C	SILIMANA	S-CH	450	1	8yagi	normal	15	MAST	10
ZENGURU	SILIMANA	TDMA	1,500	3	6yagi	normal	15	MAST	10
	MINDIK	TDMA	1,500	3	omni	normal	15		
	LENGBATI	S-CH	450	1	8yagi	normal	15		
MINDIK	ZENGURU	TDMA	1,500	3	6yagi	normal	15	MAST	10
LENGBATI	ZENGURU	S-CH	450	1	8yagi	normal	15	MAST	10
MT.MISSION	LAE	TDMA	1,500	3	6yag-R	L-loss	35	EXIST-ING TOW.	33
	SALAMAUA	TDMA	1,500	3	omni	normal	42		
	YAIWAHAWA								
	BAINI	S-CH	450	1	8yagi	normal	39		
SALAMAUA	MT.MISSION	TDMA	1,500	3	6yagi	normal	15	MAST	10
BAINI	MT.MISSION	S-CH	450	1	8yagi	normal	25	MAST	20
YAIWAHAWA	MT.MISSION	TDMA	1,500	3	6yagi	normal	15	MAST	10
WAU	WANDUMI	S-CH	450	1	8yagi	normal	27	EXIST. TOW.	21
WANDUMI	WAU	S-CH	450	1	8yagi	normal	15	MAST	10

Table 4.2.1 Construction Details of Raidio Facility (NO.3)

Province: NEW IRELAND (1/2)

Name of Station	Facing Station	Trans-missi-on	Frequ-ency (MHz)	Pow-er (W)	Ante-nna	Feeder		Tower	
						Type	L (m)	Type	H (m)
KAVIENG	MT.KIDING	TDMA	1,500	3	p-1.2m	normal	50	EXIST-ING TOW.	30
	TASKUL	S-CH	450	10	12yagi	normal	50		
MT.KIDING	KAVIENG	TDMA	1,500	3	6yag-R	normal	25	TOWER	20
	MANGAI	TDMA	1,500	3	omni	normal	35		
	LEMAKOT								
	LAKURAMAU								
	MADINA								
	MANGOP								
MANGAI	MT.KIDING	TDMA	1,500	3	6yagi	normal	15	MAST	10
LEMAKOT	MT.KIDING	TDMA	1,500	3	6yagi	normal	25	MAST	20
LAKURAMAU	MT.KIDING	TDMA	1,500	3	6yagi	normal	25	MAST	20
MADINA	MT.KIDING	TDMA	1,500	3	6yag-R	normal	25	MAST	20
MANGOP	MT.KIDING	TDMA	1,500	3	6yagi	normal	25	MAST	20
RABAUL	TOMAVATUR	TDMA	1,500	3	omni	normal	50	EXIST. TOW.	30
TOMAVATUR	RABAUL	TDMA	1,500	3	6yagi	normal	37	EXIST-ING TOW.	22
	DUKEofYORK	TDMA	1,500	3	omni	normal	35		
	KABANUT	S-CH	150	10	8yagi	normal	35		
	KABAHONG	S-CH	150	10	8yagi	normal	35		
	KAIT	S-CH	150	10	8yagi	normal	35		
DUKE OF YORK	TOMAVATUR	TDMA	1,500	3	p-1.8m	normal	35	TOWER	20
	KONOKALANG	TDMA	1,500	3	6yagi	normal	35		
	PALIPAL	S-CH	450	1	8yagi	normal	35		
KONOKALANG	DUKEofYORK	TDMA	1,500	3	6yagi	L-loss	30	EXIST-ING TOW.	23
	HURIS	TDMA	1,500	3	omni	normal	38		

Table 4.2.1 Construction Details of Raidio Facility (NO.4)

Province: NEW IRELAND (2/2)

Name of Station	Facing Station	Trans-missi-on	Frequ-ency (MHz)	Pow-er (W)	Ante-nna	Feeder		Tower	
						Type	L (m)	Type	H (m)
HURIS	KONOKALANG	TDMA	1,500	3	6yagi	normal	45	TOWER	30
	HILALON	TDMA	1,500	3	omni	normal	35		
	LIPEK								
	HIPAGAT								
HILALON	HURIS	TDMA	1,500	3	6yag-R	L-loss	35	TOWER	30
LIPEK	HURIS	TDMA	1,500	3	6yagi	normal	15	MAST	10
HIPAGAT	HURIS	TDMA	1,500	3	6yagi	normal	25	MAST	20
TASKUL	KAVIENG	S-CH	450	10	12yagi	normal	25	MAST	20
PALIPAL	DUKEofYORK	S-CH	450	1	8yagi	normal	15	MAST	10
KABAHONG	TOMAVATUR	S-CH	150	10	8yagi	normal	25	MAST	20
KABANUT	TOMAVATUR	S-CH	150	10	8yagi	normal	25	MAST	20
KAIT	TOMAVATUR	S-CH	150	10	8yagi	normal	25	MAST	20

Table 4.2.1 Construction Details of Raidio Facility (NO.5)

Province: WESTERN(1/1)

Name of Station	Facing Station	Trans-missi-on	Frequ-ency (MHz)	Pow-er (W)	Ante-nna	Feeder		Tower	
						Type	L (m)	Type	H (m)
DARU	WIPIM	S-CH	150	10	8ystk	normal	35	EXIST. TOW.	30
	WIPIM	S-CH	150	10	8ystk	normal	35		
WIPIM	DARU	S-CH	150	10	8ystk	normal	35	GUYED	30
	DARU	S-CH	150	10	8ystk	normal	35		
KIUNGA	ATKAMBA	TDMA	1,500	3	p-4m	L-loss	35	EXIST. TOW.	30
ATKAMBA	KIUNGA	TDMA	1,500	3	p-4m	L-loss	35	GUYED	30
	RUNGINAE	TDMA	1,500	3	p-1.2m	L-loss	35		
RUNGINAE	ATKAMBA	TDMA	1,500	3	p-1.8m	L-loss	55	GUYED	50
	MATKOMRAE	TDMA	1,500	3	6yagi	L-loss	55		
MATKOMRAE	RUNGINAE	TDMA	1,500	3	p-1.2m	L-loss	35	GUYED	30
	KUNGIM	TDMA	1,500	3	6yag-R	L-loss	35		
KUNGIM	MATKOMRAE	TDMA	1,500	3	p-1.2m	L-loss	35	GUYED	30
MT. ROBINSON	NINGERUM	S-CH	450	1	12yagi	normal	25	EXIST-ING TOW.	30
	NINGERUM	S-CH	450	1	12yagi	normal	25		
	NINGERUM	S-CH	450	1	12yagi	normal	25		
NINGERUM	MtROBINSON	S-CH	450	1	12yagi	normal	15	MAST	10
	MtROBINSON	S-CH	450	1	12yagi	normal	15		
	MtROBINSON	S-CH	450	1	12yagi	normal	15		
MT. KAROMA	DEBEPARE	S-CH	450	10	12yagi	normal	20	EXIST-ING TOW.	30
	SUABI	S-CH	450	1	12yagi	normal	20		
	MOGULU	S-CH	450	10	12yagi	normal	20		
DEBEPARE	MT. KAROMA	S-CH	450	10	12yagi	normal	15	MAST	10
SUABI	MT. KAROMA	S-CH	450	1	12yagi	normal	15	MAST	10
MOGULU	MT. KAROMA	S-CH	450	10	12yagi	normal	15	MAST	10

4.3 Power Facilities

(1) Fundamental Design of Power Facilities

In case of base stations, electric power will be provided from rectifiers at existing switching offices. For existing repeater stations, electric power will be provided from rectifiers in case commercial power sources or private generators are used. Otherwise, a combination of solar panels and batteries will be used.

At new repeater stations and subscriber stations, electric power will be provided by the combination of solar panels and batteries as no commercial power is available.

Tables 4-3-1 and 4-3-2 indicate the fundamental design of power facilities for each station and each objective village, respectively.

Table 4-3-1 Fundamental Design for Power Facilities

Station	Solar Panel (Unit)	Battery (Unit)	Voltage (V)	Structure for Solar (Unit)	Remarks
Base Station	--	--	48		Supplied from existing rectifier.
Repeater Station (with commercial power supply)	--	--	48		Supplied from existing rectifier.
Repeater Station (without commercial power supply)	1 (500W)	1 (400AH)	24	1	
Subscriber Station (TDMA)	1 (200W)	1 (290AH)	12		
Subscriber Station (Single Channel)	1 (100W)	1 (170AH)	12		

Table 4-3-2 Capacity of Power Facilities of Objective Villages

Objective Village	Radio Equipment	Power Consumption	Capacity of Solar Cell	Capacity of Battery
Morobe Province Omsis, Bandong, Nambamati, Wideru New Ireland Province Mt. kiding, Konokalang Huris Western Province Atkamba, Runginae, Matkomrae	TDMA (Repeater)	24 (V), 56.7(W)	500 (W)	400 (AH)
Morobe Province Silimana, Zenguru, Mt. Mission New Ireland Province Duke of Yoke	TDMA (Repeater) Single Channel	24 (V), 56.7(W) 12 (V), 9.0(W)	500 (W) 100 (W)	400 (AH) 170 (AH)
Morobe Province Boana, Kaiapit, Umi, Watarais, Bukaua, Pindiu, Mindik, Salamaua, Yaiwahawa New Ireland Province Mangai, Lemakot, Lakuramau, Madina, Mangop, Hilalon, Lipek, Hipagat Western Province Kungim	TDMA (Subscriber)	12 (V), 21.3(W)	200 (W)	290 (AH)
Morobe Province Pindiu H.C, Lengbati, Baini, Wandumi New Ireland Province Taskul, Kabanut, Kabahon, Kait, Palipal Western Province Mogulu, Debepare, Suabi	Single Channel	12 (V), 9.0(W)	100 (W)	170 (AH)
Western Province Wipim	Single Channel×2	12 (V), 9.0 (W)×2	100W×2	170 (AH)×2
Western Province Ningerum, Mt. Karoma	Single Channel×3	12 (V), 9.0 (W)×3	100W×3	170 (AH)×3

(2) Determining Capacity for Solar Panels and Batteries

Annex 5 indicates the process for calculating solar panel and battery capacity.

(a) Weather Data

The weather data used to determine solar panel capacity are based on the maximum and minimum average daily insolation in representative cities in the three provinces. Data for these cities of Daru, Lae and Rabaul are presented in Table 4-3-3.

Table 4-3-3 Maximum and Minimum Average Daily Insolation

City	Insolation ($mW\text{-}h/cm^2$)	
	Minimum	Maximum
Lae	400	550
Daru	425	625
Rabaul	462	552

(b) Designed Solar Panel Capacity

Designed solar panel capacity is determined on the basis of average insolation and average power consumption of radio equipment in objective areas. Electric power capacity calculations for TDMA subscriber stations, TDMA repeater stations and single-channel systems in each area are shown in Annex 5.

Designed capacity resulting from these calculations is shown in Table 4-3-4.

Table 4-3-4 Calculation Results and Designed Values of Solar Capacity

System	Calculation Results			Designed Value
	Lae	Daru	Rabaul	
TDMA (Subscriber Station)	180.9 [W]	170.4 [W]	156.6 [W]	200 [W]
TDMA (Repeater Station)	481.7 [W]	453.6 [W]	417.0 [W]	500 [W]
Single Channel	76.5 [W]	72.0 [W]	66.2 [W]	100 [W]

(c) Designed Battery Capacity

Designed battery capacity is determined by the average power consumption of radio equipment and the longest period of consecutive days without sunshine.

As a result of analyzing weather data, the longest consecutive period of days without sunshine was set at seven days. This can be determined as an appropriate assumption as PTC also set it as seven days. Calculations are based on this assumption, and the calculation process and results are shown in Annex 5.

Calculation results and designed values are presented in Table 4-3-5.

Table 4-3-5 Calculation Results and Designed Values of Battery Capacity

System	Calculation Results	Designed Value
TDMA (Subscriber Station)	298.2 (AH)	290 (AH)
TDMA (Repeater Station)	396.9 (AH)	400 (AH)
Single Channel	126.0 (AH)	170 (AH)

4.4 Outside Plant and Terminal Facilities

(1) Outside Plant

In principle, underground cables will be used for outside plant connecting the radio equipment for subscriber use and the terminal telephone set. The type of wire used is the 2-pair or 5-pair underground outdoor wire. This wiring method has traditionally been adopted in PNG as the most economical method in providing high safety in cases of sporadic demand.

The outside plant to be constructed under this project is the lead-in wire to the subscriber premises, and thus the amount of construction work involved is insignificant. It is assumed therefore that PNG has sufficient capacity to implement this construction from the economic and technical standpoints. We understand that the procurement of materials and construction work will all be carried out by PNG.

(2) Terminal Facilities

The terminal equipment to be installed under this project includes pay and private phones. The type of pay phone to be used is the coin pay phone. For the purpose of safety, most pay phones will be installed inside buildings where all-day monitoring is possible.

Since these telephone sets are widely used in PNG, and thus PNG has the sufficient experience in handling such terminals, the procurement and installation of the terminals required under this project will be conducted by PNG.

Details of cable construction and terminal installation are shown in Table 4-4-1 (Nos. 1 ~ 3).

For detailed design, attention should be given to the following points.

(a) As each village is located far from a maintenance station, considerable time and labor might be required for restoration of service once a fault occurs. Accordingly, design must be made with

the first priority placed on equipment stability by considering the possibility of human errors and natural disasters.

(b) Judging from social and economic activities and projected increases in population in the objective villages, a sudden demand generation or substantial errors in demand forecast are not expected. Therefore, demand fluctuation was not taken into account when determining the necessary data.

Table 4-4-1 Cable Construction and Terminal Installation Details(No.1)

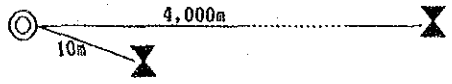
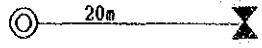
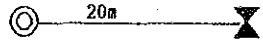
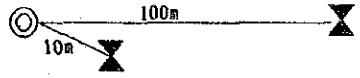
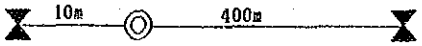
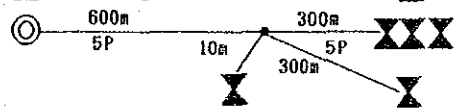
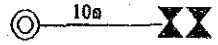
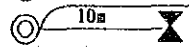
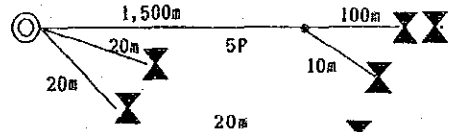
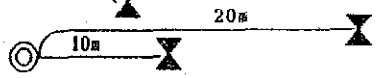
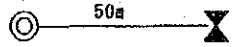
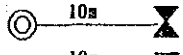
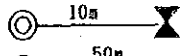
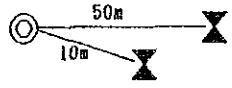
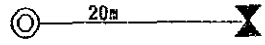
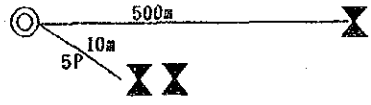
Province	Village	Number of Tel. Pay	Number of Tel. Private	Cable Design Outline
Morobe	BUKAUA	1	1	
	BAINI	1		
	WANDUMI	1		
	YAIWAHAVA	1	1	
	SARAMAUA	1	1	
	BOANA	2	3	
	BANDONG	1	1	
	WATARAIS	2		
	KAIAPIT	1	1	
	CHIVASING	2	3	
	UMI	1	1	
	SILIMANA	1		
	LENGBATI	1		
	ZENGURU	1		
	MINDIK	1	1	
	PINDIU H.C.	1		
	PINDIU	1	2	
Total	17	20	15	Under Ground 2P 6,340 / 5P 2,410 — 8,750
		35		Aerial 2P 20 / 5P ——— — 20

Table 4-4-1 Cable Construction and Terminal Installation Details(No.2)

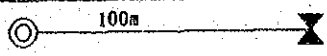
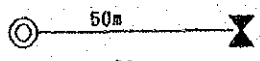
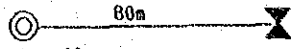
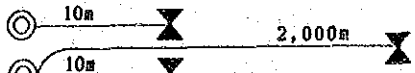
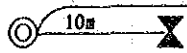
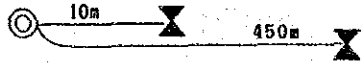
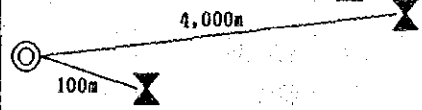
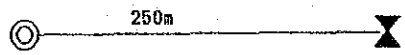
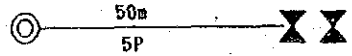
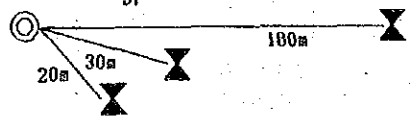
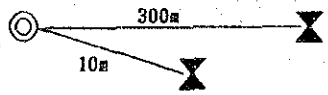
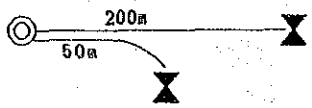
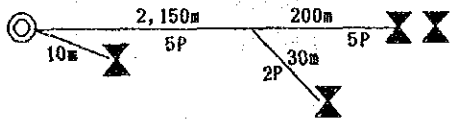
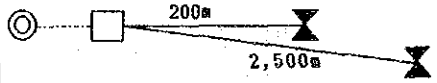
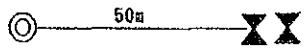
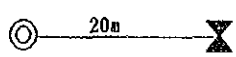
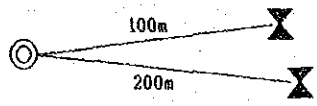
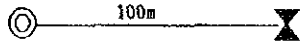
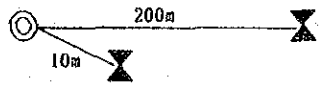
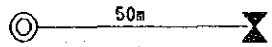
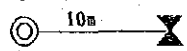
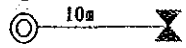
Province	Village	Number of Tel. Pay	Number of Tel. Private	Cable Design Outline
New Ireland	KABANUT	1		
	KABAHONG	1		
	KAIT	1		
	PALIPAL	1		
	HILALON	2		
	LIPEK	1	1	
	HIPAGAT	2		
	TASKUL	1		
	HANGAI	1	1	
	LEMAKOT	1	2	
	LAKULAMAU	1	1	
	MADINA	1	1	
	MANGOP	2	2	
	HURIS	0	2	
Total	14	16	10	Under Ground 2P 10,590 5P 2,400 — 12,990
		26		Aerial ——— ———

Table 4-4-1 Cable Construction and Terminal Installation Details(No.3)

Province	Village	Number of Tel. Pay	Number of Tel. Private	Cable Design Outline
Western	WIPIM	1	1	
	ATKAMBA	1		
	RUNGINAE	1	1	
	MATKOMRAE	1		
	KUNGIM	1	1	
	NINGERUM	1	2	The each subscriber station will be installed in subscriber's house.
	DEBEPARE	1		
	MOGULU	1		
	SUABI	1		
				Legend: Mast or Tower; Telephone Set
Total	9	9	5	Under Ground: 2P 750; 5P —— : 750
		14		Aerial: —— : ——

5. MAINTENANCE

As PTC already maintains telecommunications facilities, maintenance for this project will be carried out following the current maintenance system.

Characteristics for each province are as follows, and the maintenance system is outlined in Figure 5-1-1.

(1) Morobe

(a) Maintenance personnel in charge of Morobe are regularly stationed at the Lae office, which is the base station for the TDMA system in Morobe Province.

(b) It is possible to monitor the system situation in the equipment room of the Lae office by VDU (video display unit). With respect to the master alarm for the system, one circuit will be installed at the maintenance personnel room. The construction of this circuit will be carried out by PTC.

(c) No special monitoring of the Single-channel system between Wau and Wandumi is provided at the Lae office. In case of trouble, personnel will be dispatched to fix it in response to reports from PTC personnel stationed at the Wau office.

(2) New Ireland

(a) As the maintenance personnel in charge of New Ireland Province are regularly stationed in the Rabaul office, monitoring of the system conditions is also carried out here.

(b) It is possible to monitor the TDMA system for which the Rabaul office is the base station in the machine room of the Rabaul office. Monitoring of the TDMA system whose base station is the Kavieng office is handled by VDU through connections to the Rabaul office utilizing modem equipment and the existing trunk circuit.

(3) Western

(a) The southern part of Western Province where the Daru office is located is the maintenance area of the Boroko office, which is in Central Province. The northern part of the province where the Kiunga and Tabubil offices are located is the maintenance area of the Mt. Hagen office, which is in Western Highland Province.

(b) Monitoring of the TDMA system, whose base station is the Kiunga office, is handled by VDU through connections to the Mt. Hagen office utilizing modem equipment and the existing trunk circuit.

(c) No special remote monitoring of the Single-channel systems leading from the Daru and Tabubil offices is provided. In case of trouble, maintenance personnel will be dispatched from the pertinent office to fix it in response to reports from PTC personnel stationed at the above two offices.

Fig.5-1-1 Outline of Maintenance System