

No. 1

JAPAN INTERNATIONAL COOPERATION AGENCY  
MINISTRY OF COMMUNICATIONS  
THE KINGDOM OF BHUTAN

BASIC DESIGN STUDY REPORT  
ON  
THE PROJECT  
FOR  
THE DOMESTIC TELECOMMUNICATION NETWORK  
IN  
THE WESTERN REGION  
IN  
THE KINGDOM OF BHUTAN

MARCH 1995

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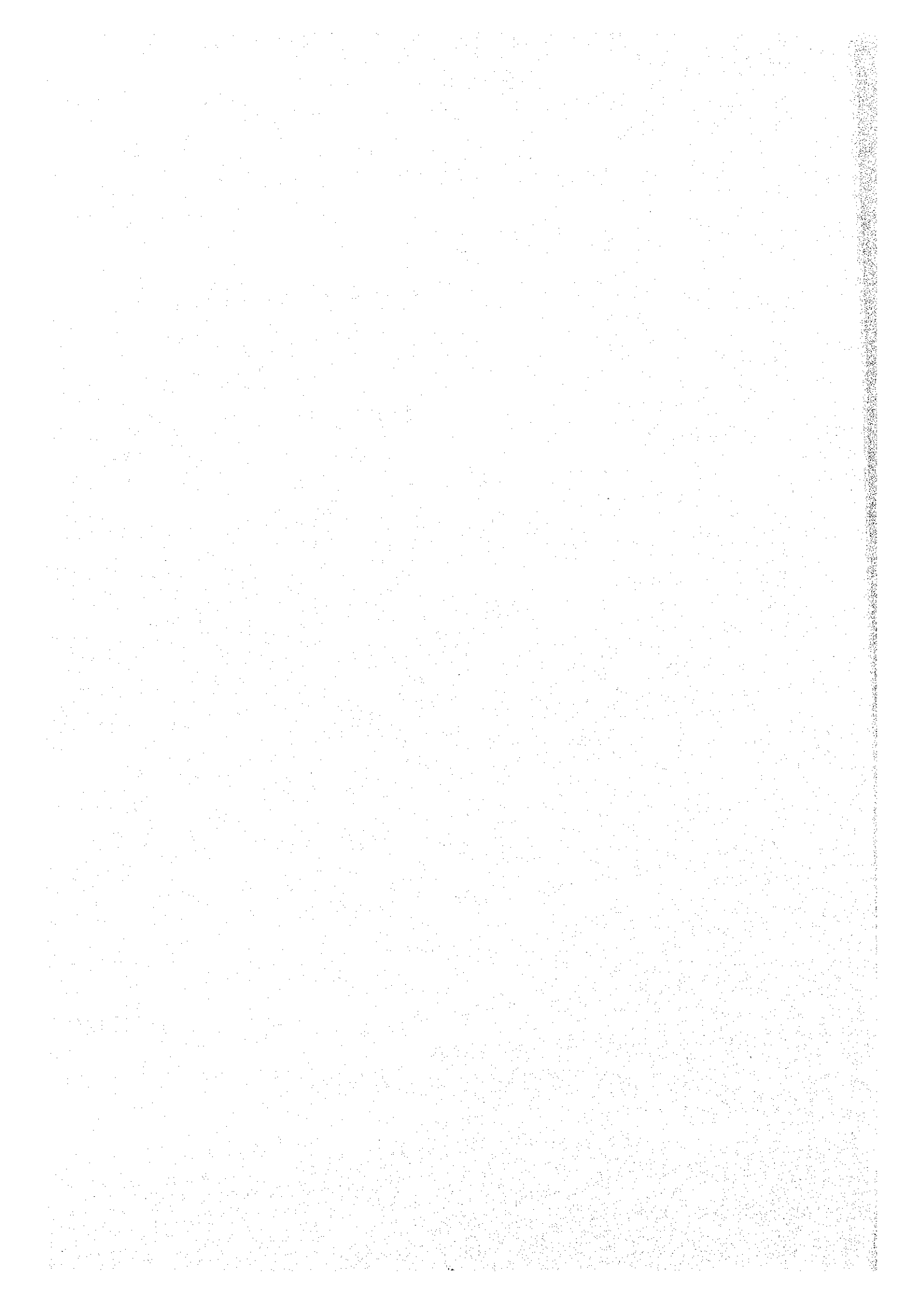
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JICA BASIC DESIGN STUDY REPORT ON THE PROJECT FOR THE DOMESTIC TELECOMMUNICATION NETWORK IN THE WESTERN REGION IN THE KINGDOM OF BHUTAN

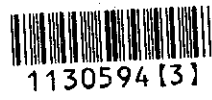
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**MARCH 1995**

**NIPPON TELECOMMUNICATIONS CONSULTING CO., LTD.**

## PREFACE

In response to a request from the Government of the Kingdom of Bhutan, the Government of Japan decided to conduct a basic design study on the Project for the Domestic Telecommunication Network in the Western Region and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Bhutan a study team headed by Mr. Shigemaro Aoki, Development Specialist of JICA and constituted by members of Nippon Telecommunications Consulting Co., Ltd., from October 4 to November 10, 1994.

The team held discussions with the officials concerned of the Government of Bhutan, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Bhutan in order to discuss a draft report, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Royal Government of Bhutan for their close cooperation extended to the teams.

March 1995



Kimio Fujita  
President

Japan International Cooperation Agency

March 1995

Mr. Kimio Fujita  
President  
Japan International Cooperation Agency  
Tokyo, Japan

Letter of Transmittal

We are pleased to submit to you the basic design study report on the Project for the Domestic Telecommunication Network in the Western Region in the Kingdom of Bhutan.

This study was conducted by Nippon Telecommunications Consulting Co., Ltd., under a contract to JICA, during the period September 19, 1994 to March 31, 1995. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Bhutan and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

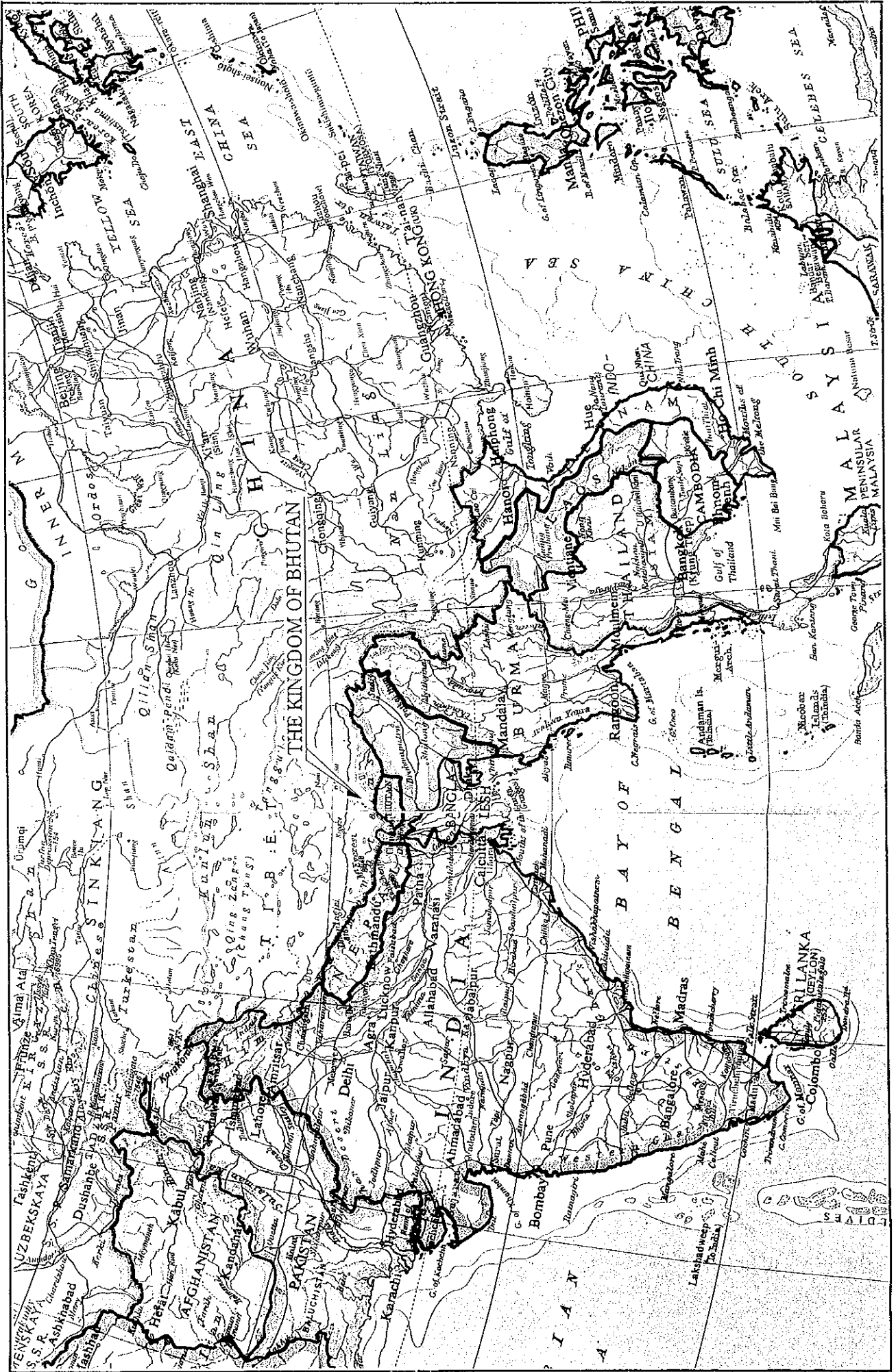
We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and the Ministry of Posts and Telecommunications. We would also like to express our gratitude to the officials concerned of the Division of Telecommunications, JICA India Office, and the Embassy of Japan in India for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

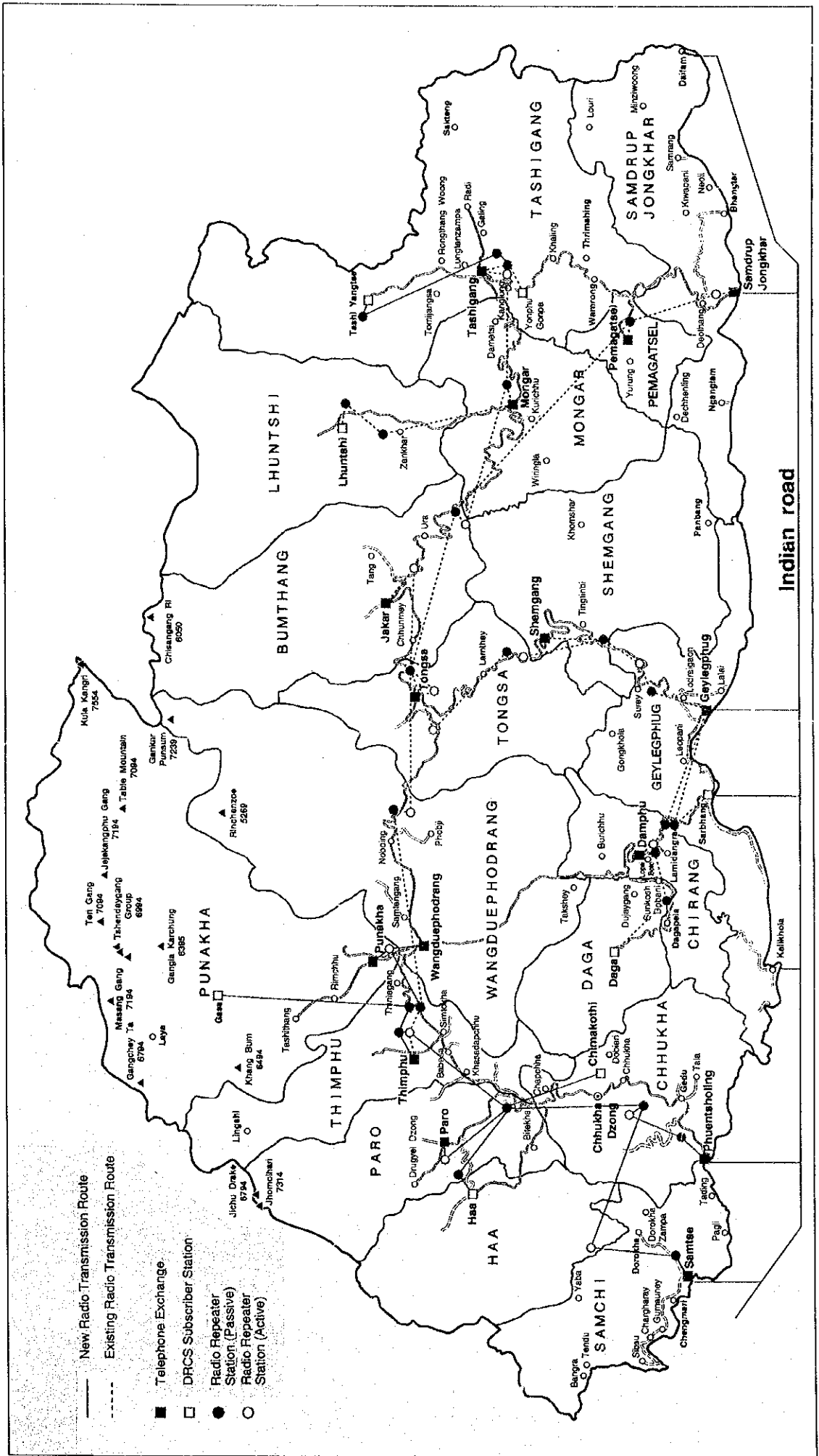


Takeshi Komiya  
Project manager  
Basic design study team  
on the Project for  
the Domestic Telecommunication  
Network in the Western Region  
Nippon Telecommunications  
Consulting Co., Ltd.

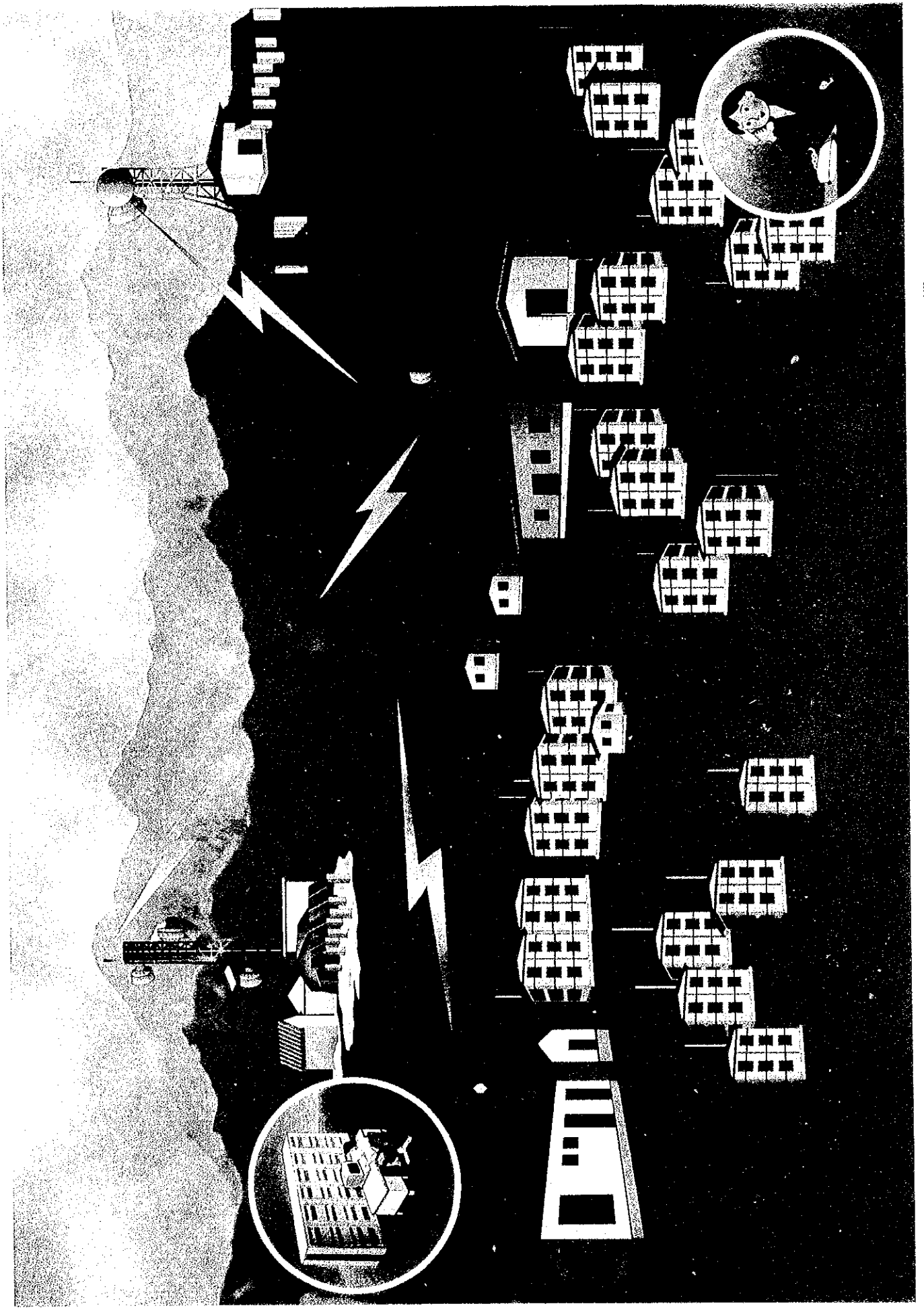


THE KINGDOM OF BHUTAN





PROJECT SITE MAP



THE PROJECT FOR THE DOMESTIC TELECOMMUNICATION NETWORK

## SUMMARY



## SUMMARY

The Kingdom of Bhutan is extremely mountainous for the most part, and geographically it is divided into three regions, i.e., Western, Central and Eastern regions, by mountains extending from north to south. The inhabitants (approx. 600,000) of the Kingdom are similarly divided into three regional groups. The Western region is the nucleus of the country and embraces Thimphu, the capital, Paro, an international airport city, and Phuentsholing, a commercial and industrial center.

All the telecommunications services in the Kingdom are under the control and supervision of the Ministry of Communications (MOC). MOC installed small capacity analogue switching systems manufactured in 1974 through 1975 mainly in the Western region, with the aid from India. In 1990, under the 6th National Development 5-Year Plan (1987-1992), MOC rehabilitated the telecommunications network in and around Thimphu, based on the Master Plan prepared by ITU (International Telecommunication Union) experts. As a result of this project, a local network, an international switching system and an earth station were installed and the telecommunications services in the Thimphu Exchange area have been substantially improved.

Practically no telephone services were available in the Central and Eastern regions. To cope with this problem, the Royal Government of Bhutan requested a Japan's grant aid for the rehabilitation of telecommunication networks in these regions. In response to this request, Japan International Cooperation Agency (JICA) conducted a basic design study on the telecommunications in these regions in 1991. Then, in accordance with the study results, the Project for the Domestic Telecommunication Network (hereinafter referred to as the "previous project") was implemented also with the Japan's grant aid, commencing in 1991 and completed in December 1994. The new systems installed by this project and connected to Thimphu and are now being operated satisfactorily, and the telecommunications services in the Central and Eastern regions have been remarkably improved.

In the Western region, the nucleus of the Kingdom, the telecommunications facilities are extremely inadequate: services are often broken down and new connections are very difficult to obtain, resulting in serious constraints in administrative and commercial activities. In two new provinces, namely, Gasa and Tashiyangtse, which were divided from Punakha and Tashigang, respectively, in 1992, no telephone services are available at all, and even administration communication is very difficult.

The Royal Government of Bhutan is now proceeding with well balanced development in the political, economic and social sectors of the nation. To ensure the success in this plan, the establishment of a high quality telecommunication network to cover the whole country is indispensable and, for this purpose, the rehabilitation of telecommunications in the Western region is the most pressing need.

In view of the above, the Royal Government of Bhutan intends to implement the Project for the Domestic Telecommunication Network in the Western Region following the previous project, and requested the Japan's grant aid for this Project, according it the top priority in the 7th National Development 5-Year Plan (1992-1997).

In response to this request, the Government of Japan decided to conduct a basic design study of the Western region, and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent a study team to the Kingdom for a period of 38 days from October 4 to November 10, 1994. The team held discussions with the officials concerned of the Royal Government of Bhutan and conducted field surveys in the study areas. A basic design study was made, based on the discussion results and field survey findings. On the basis of the study results, the basic design has been drawn up in a scale suitable for a Japan's grant aid project and compiled into a draft Basic Design Study Report.

The study team was again sent to the Kingdom for 15 days from March 11 to March 25, 1995, to explain and discuss the draft final Report with the Bhutanese staff concerned.

An outline of the Basic Design Study is as follows:

The telecommunications network to be constructed is to be composed of the following facilities, with components compatible with the equipment installed during the previous project.

- Digital switching system
- Digital radio concentrator system (DRCS)
- Digital radio transmission system
- Outside plant (OSP) (supply of equipment and materials only)
- Power supply system
- Other facilities

(1) Digital Switching System

- Telephone exchanges showing the number of line units to be installed are listed below.

Telephone Exchanges	Number of Line Units
Phuentsholing	2,200
Samtse	400
Paro	900
Wangdue Phodrang	300
Punakha	300
Total	4,100

- Transit (Tandem) Switching System Facilities  
To be installed at Thimphu Exchange.
- Magnetic Tape Reader and Bill Printer  
To be installed at Thimphu Exchange
- Switching System Simulator  
To be provided at the Training Unit in Thimphu Exchange

(2) Digital Radio Concentrator System (DRCS)

Base stations, subscriber radio terminal stations and the number of repeater stations and line units to be installed are as follows:

Base Station ~ Subscriber Radio Terminal Stations	No. of Repeater Stations	No. of Line Units
Tashigang ~ Tashiyangtse	3	50
Thimphu ~ Gasa	1	40
Paro ~ Chimakoti	1	200
Paro ~ Haa	1	200
Total	6	490

(3) Digital Radio Transmission System

The number of radio repeater stations to be installed is as listed below.

Routes	No. of Radio Terminal Stations	No. of Radio Repeater Stations		No. of Reflectors	Total
		Active Repeater	Passive Repeater		
Phuentsholing ~ Thimphu	2	3	1	1	7
Samtse ~ Takti	1	1	-	1	3
Paro ~ Japjekha	1	-	-	1	2
Wangdue Phodrang ~ Thimphu	1	1	1	-	3
Punakha ~ Limuti	1	-	-	-	1
Total	6	5	2	3	16

For radio transmission system, 8 GHz band and 8.3 GHz band digital systems are to be used. Transmission capacity is designed to be 34 Mbit/s, 1+1 system (1 standby system) for Phuentsholing and Paro routes, and for other routes, 8 Mbit/s, 1+1 system (1 standby system).



(4) Outside plant (OSP)

The number of terminated cable pairs and the total cable pair length to be installed by exchange area is as follows:

Exchange Area	No. of Terminated Cable Pairs	Total Cable Pair Length (pair-kilometer)
Phuentsholing (New)	1,800	2,691
(existing)	+1,200	
Samtse	400	502
Paro	650	3,264
Tashiyangtse	60	20
Gasa	60	20
Chimakoti	300	957
Wangdue Phodrang	350	467
Punakha	400	1,459
Haa	250	975
Total (existing)	4,270 +1,200	10,355

(5) Power Supply System

Power supply systems to be installed in various exchanges/stations of are as follows:

Power Supply Systems	Exchanges/Stations	No. of Exs/Stns
Full-floating system (automatic voltage regulator, diesel engine generator, rectifying equipment and storage batteries)	Thimphu, Phuentsholing, Samtse, Paro, Wangdue Phodrang, Punakha, Takti	7
Hybrid system (solar cells, diesel engine generator, rectifying equipment and storage batteries)	Japjekha, Pepchu, Saureni	3
Solar power supply system (solar cells and storage batteries)	Tashiyangtse, Gasa, Chimakoti, Haa, Gangadung, Samchiling Gompa, Chelela	7
Total		17

The number of backup power supply systems is as follows:

System	No. of Systems
Mobile type diesel engine generator	1
Portable type diesel engine generator	2
Portable type rectifier	2

(6) Other Facilities

Items	Stations	No. of Stations
Prefabricated Shelter	Japjekha, Takti, Pepchu, Saureni, Chelela, Gangadung, Samchiling Gompa,	7
Antenna tower	Phuentsholing, Samtse, Paro, Wangdue Phodrang, Punakha, Japjekha, Takti, Pepchu, Saureni, Limuti	10
Reflector	Takti-P, Paro-P, Kapdane	3
Mast	Tashiyangtse, Gasa, Chimakoti, Haa, Gangakung, Samchiling Gompa, Chelela	7

The time schedule for this Project has been prepared taking into consideration the number of sites and their locations, the items and scale of the work to be undertaken by the Bhutan side, physical conditions at sites, particularly climatic conditions during the monsoon from June to September and the hard winter season from December to February during which outdoor work and transportation of equipment and materials are very difficult, as well as the shortage of labor force during the farmers' busy season. That is, the schedule is so planned that outdoor work and equipment transportation can be done avoiding the rainy and hard winter seasons, while the labor intensive work, avoiding the farmers' busy season. Based on the above consideration,

6 months for detail design and 24.5 months for construction work have been estimated.

Costs to be borne by the Royal Government of Bhutan are approx. Bhutanese Ngultrum 51.7 million.

Land procurement	Nu. 0.2 million
Access road construction	Nu. 21.4 million
Land levelling	Nu. 1.3 million
Building construction	Nu. 6.5 million
Building remodeling	Nu. 0.9 million
OSP work and purchase of miscellaneous materials	Nu. 12.2 million
Purchase of telephone sets	Nu. 9.2 million

With the implementation of this Project, 4,190 subscribers in the Western region including new district capitals, Gasa and Tashiyangtse, can be connected to a high quality telecommunications system, and an integrated domestic digital telecommunications network can be established covering the whole country. This means that "anytime available" telephone services will be realized in main cities throughout the country. The number of beneficiaries of this Project is estimated to be approx. 100,000 in the objective areas. The telephone density will be remarkably improved from 0.9% as of 1994 to 2.0% when telephone installations have reached the capacity of the switching facilities including those installed by the previous project.

In addition to the above, the following effects can be expected:

- (1) In times of emergencies, such as natural disaster, necessary information and instruction can be transmitted promptly, so that quick action can be taken for emergency measure. Thus social security can be enhanced.
- (2) In the case of sudden illness or injury, urgent communication can be made with hospitals or Basic Health Unit (BHU), leading to the saving of the lives of inhabitants in the objective areas.

- (3) Productivity of administration services can be enhanced through the rapid transmission of information between the central and local offices by the use of, among others, facsimile service, compared with the conventional information transmission by mail which used to require several days.
- (4) Information on road blocking due to rainfall, snowfall, etc., can be transmitted promptly to relevant agencies, so that they can take any necessary action quickly, and transportation can be managed efficiently and effectively.
- (5) In the commercial and industrial sectors, rapid transmission of information on commodity distribution will permit manufacturers to make "planned" production, through "planned" material purchase and product transportation. This means enhanced productivity and more efficient stocking, leading to the saving of storage space and efficient sales.
- (6) In the tourism business, improved communication services will permit smooth hotel reservation and transportation arrangement, that is, efficient tourism services. Tourists including those from abroad also can enjoy benefits from improved communications as they will be able to make telephone calls to any place at any time.

As described above, far reaching benefits can be derived from the construction of a digital telecommunication network in the Western region and two new, no telephone district capitals, Gasa and Tashiyangtse, with which a highly reliable integrated telecommunication network can be established covering the whole country. That is, this Project will contribute to the upgrading of the basic human needs of the people of the Kingdom of Bhutan and the expected benefits from this Project will conform with the objective of Japan's grant aid system. In addition, operation and maintenance costs to be required after the completion of the system can sufficiently be covered by the income from this Project, and materialization of this Project will contribute to the promotion of the National Development Five-Year Plan. In view of the above, this Project is judged appropriate as a grant aid project.

In order to ensure satisfactory operation and maintenance of the facilities provided by this Project, it is recommended that the Royal Government take action on the following:

- (1) At present, Division of Telecommunications (DOT) is conducting training of technical staff for the operation and maintenance of the facilities to be provided by this Project. It is recommended, however, that the training system be reinforced both qualitatively

and quantitatively so that the required number of operation/maintenance staff can be procured in advance of the commencement of the operation of these facilities.

- (2) In planning the system for this Project, there were no actual traffic data; even data concerning the previous project were not available, and traffic forecast had to be estimated based on certain assumptions. In order to achieve satisfactory management of the telecommunication network in the Kingdom, it is recommended that the traffic management system be reinforced.
- (3) According to the financial regulation of the Royal Government, DOT's income goes directly to the national treasury, and DOT's expenditures are disbursed from the treasury. With the materialization of this Project, DOT's income is expected to increase and, therefore, it is recommended that some of the operational income be utilized as funds for small scale telecommunications development.

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**DESIGN DATA**

## **CHAPTER 1 BACKGROUND OF THE PROJECT**

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### **1.1 Background of the Project**

The Kingdom of Bhutan is extremely mountainous for the most part, and communication and transportation are very difficult there. Urgent development of telecommunications therefore was a pressing need for the country.

The Royal Government of Bhutan prepared its 1st National Development 5-Year Plan in 1961 and now the 7th National Development 5-Year Plan is under way. The 1st and 2nd Plans aimed at the rehabilitation of fundamental infrastructure, 3rd and 4th Plans, rehabilitation of industrial foundation, 5th and 6th Plans, self-reliance in national economy and materialization of development plans mainly in power and tourism industries.

Now under the 7th National Development 5-Year Plan, the following are aimed at:

- To establish an economic foundation for realization of self-reliance in coming years, putting emphasis on mobilization of national resources.
- To keep continuous development of the national economy, paying due attention to environmental protection and family planning.
- To utilize natural resources efficiently
- To encourage the people to participate in national development actively.
- To promote decentralization.
- To develop human resources.
- To promote balanced regional development.

To realize the above, targets to be attained by each sector have been set up. The target of the telecommunications sector is "to promote continuously the construction of domestic telecommunications networks since the rehabilitation of telecommunications facilities is vital to the development of the national economy and the promotion of

foreign investments." This target is given the highest priority in the 7th National Development 5-Year Plan. When this target has been attained, the following effects will be produced, greatly contributing to political, economic and social development of the nation:

- Improvement in efficiency of administrative services and promotion of the development of commercial, industrial, mining, agricultural and forestry industries, through the realization of rapid information transmission.
- Elimination of imbalance among regions in political, economic and social functions through the establishment of an integrated nationwide telecommunication network.
- Promotion of decentralization through the realization of the share of the same information by both the central and local offices.

In the Kingdom, the necessity of the telecommunications development was began to be recognized in 1970, and in early 1980 a master plan was prepared by India. In August, 1987, a telecommunications rehabilitation plan was began to be studied by ITU (International Telecommunication Union) experts, and the rehabilitation plan for the international services was submitted by ITU to the Government in November 1987. This plan was materialized by the self-finance of the Government and put into service in March 1990. For domestic telecommunications services, Telecommunications Development Plan (Master Plan) was studied by ITU experts with the fund of UNDP in 1988 through 1989, and the study report was submitted to the Government in 1990. This Plan aims to establish an advanced telecommunications network to cover, at the final stage, the whole country, so as to promote political, economic and social development in the nation. Telecommunications development in the Kingdom is now being proceeded with, step by step, in accordance with this Plan.

For the rehabilitation of telecommunication facilities in the Central and Eastern regions which were then the non-telephone area, a basic design study was made by Japan International Cooperation Agency (JICA) in 1991, in accordance with the Master Plan, and based on the study results, the Project for Domestic Telecommunication Network in the Central and Eastern Regions was implemented, starting in 1991 and ending in December 1994.

With the completion of this project, telephone density is expected to be improved

twice the current level, i.e., from 0.75% to 1.5%, as a national average. However, in the Western region which is an economic and social nucleus of the nation, existing telecommunications facilities consist of, as mentioned above, overage and small capacity analogue facilities, with which demand for high quality telecommunication services can hardly be satisfied.

Under the above circumstances, the Royal Government of Bhutan has requested the Japan's grant aid for the construction of the Domestic Telecommunication Network in the Western Region.

## **1.2 Outline of the Request and Main Components**

### **1.2.1 Outline of the Request**

The Western region is a center of the political, economic and social activities of the nation, and embraces such major cities as Phuentsholing, a commercial and industrial center, and Paro, an international airport city. However, the telecommunication services in this region are extremely poor. The existing network was established in 1987 with small capacity components which were made in India in 1964-1975 and transferred to Bhutan after their use in India. Their service lives have already been expired and they are no longer manufactured in India, so that it is difficult to expand the facilities to meet new demand. Procurement of additional spare parts is also difficult. Fault ratio is high and repair of faulty facilities can hardly be made. Satisfactory telecommunications services can scarcely be expected with these facilities.

Under the above situation, the objective of the request is to construct a digital telecommunication network in the Western region and new district capitals in the same quality and reliability with that constructed in the Central and Eastern regions, so as to realize a well-balanced telecommunication network covering the whole country.

Objective areas of this Project are:

Phuentsholing, Samtse, Chimakoti, Paro, Haa, Punakha, Wangdue Phodrang, Gasa, and Tashiyangtse

## 1.2.2 Main Components

### (1) Implementing Agency

The telecommunications facilities in the Kingdom are managed and operated by the Division of Telecommunications (DOT) under the supervision of the Ministry of Communications (MOC). The implementing agency of this Project is DOT. Their respective organizations are given in Figures 1-1 and 1-2.

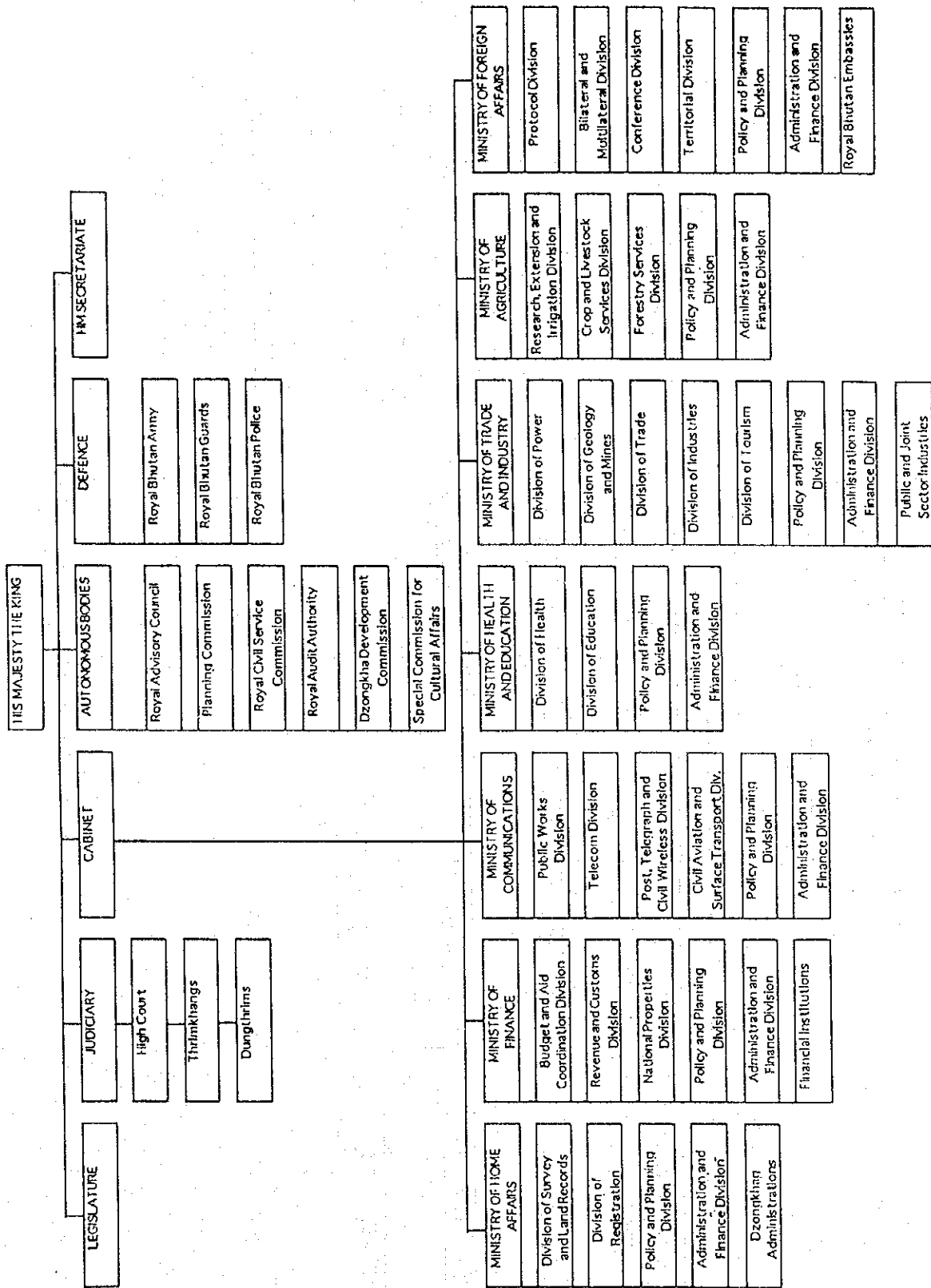


Figure 1-1 Organization of MOC



**ORGANIZATION STRUCTURE**  
**DIVISION OF TELECOM (374)**

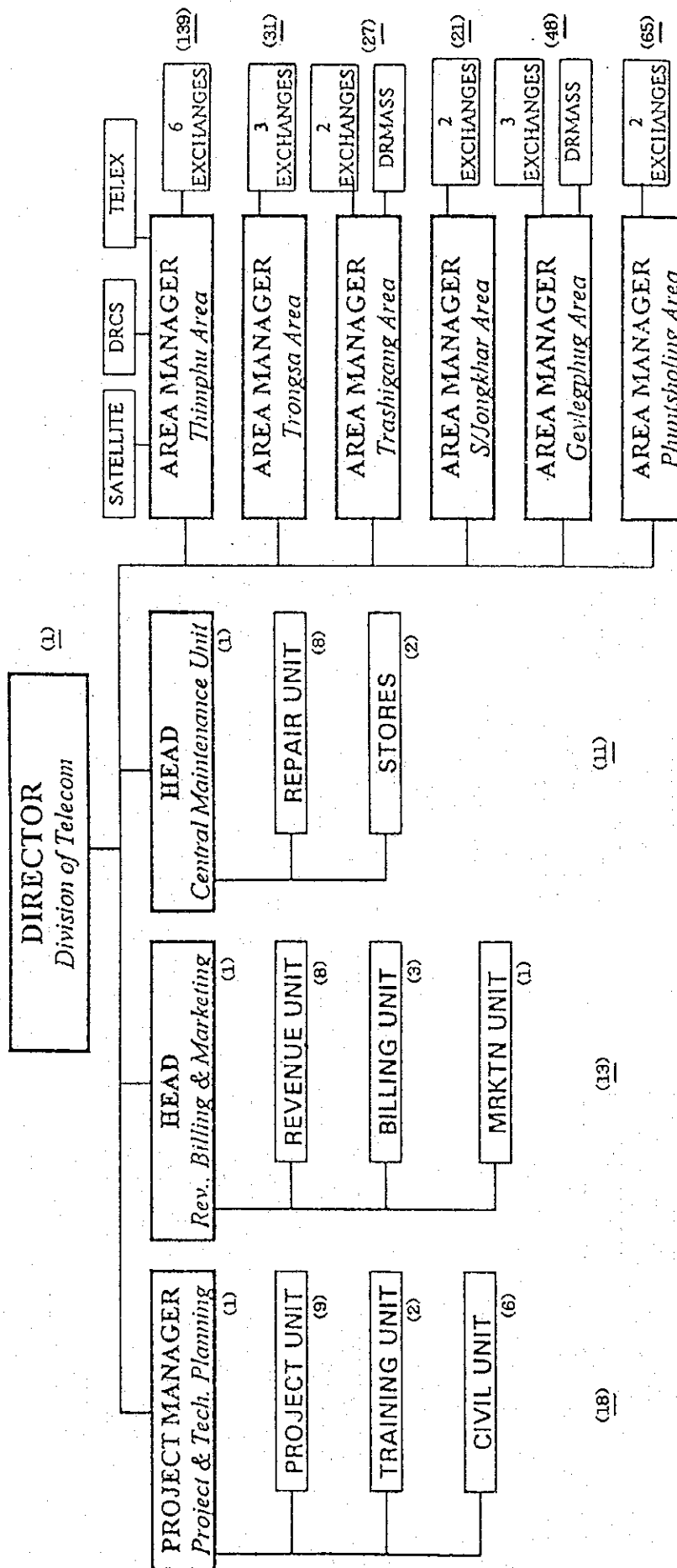


Figure 1-2 Organization of DOT (Number of the Staff)

(2) Components

Main components requested by the Royal Government of Bhutan are as follows:

1) Digital radio transmission links

For the following links:

Thimphu - Phuentsholing, Paro, Haa, Chimakoti and Samtse

Thimphu - Punakha, Wangdue Phodrang

2) Digital switching system

To be introduced in the following exchanges:

Telephone Exchanges	Capacity
Phuentsholing	2,000
Samtse	1,000
Chimakoti	200
Paro	500
Haa	200
Punakha	200
Wangdue Phodrang	300

3) Digital Radio Concentrator System (DRCS)

To be introduced in the following two cities which are recently designated as district capitals in accordance with the decentralization policy:

Gasa

Tashiyangtse

4) Outside Plant (OSP)

In the covering areas of the telephone exchanges and subscribers radio terminal stations where digital switching system or DRCS is introduced.

### 1.3 Project and/or Program of Other Donors

With the aid from the Government of India, a total of 13 small capacity analogue type telephone exchanges were installed over the country up to 1987. No other particular aid has been provided from India since then.

In 1990, "Telecommunications Development Plan (Master Plan)" was prepared by the cooperation of ITU/UNDP.

At present, one expert is being sent from ITU to assist the activities of the Training Unit provided in a 40m<sup>2</sup> lecture room in DOT, where 3 DOT staff are at work. The Training Unit supported by ITU experts started its activities in 1993. Since then the following training courses have been given:

Training Courses	Number of Courses	Total Number of Trainees
Basic Telecommunications	4	24
Telecommunication Regulations	3	25
Digital Transmission Equipment (Basic Course)	4	27
Digital Radio Equipment (Basic Course)	4	28
Transmission facilities (Advanced Course)	1	9
Radio Facilities (Advanced Course)	2	20
Switching System (Advanced Course)	1	8
Switching Equipment (Advanced Course)	1	9
Power System for Telecom. (Advanced Course)	1	9

For each course, lectures are given by utilizing the training materials prepared by ITU. For training of equipment and facilities newly introduced by the previous project, lectures are made, utilizing the manuals and catalogues supplied by the previous project.

### 1.4 Previous Project by Japan's Grant Aid

In 1991, JICA conducted a basic design study, on the basis of the Telecommunication Development Plan (Master Plan) prepared by ITU, and the study results were compiled into the "Study Report on the Project for the Domestic Telecommunication

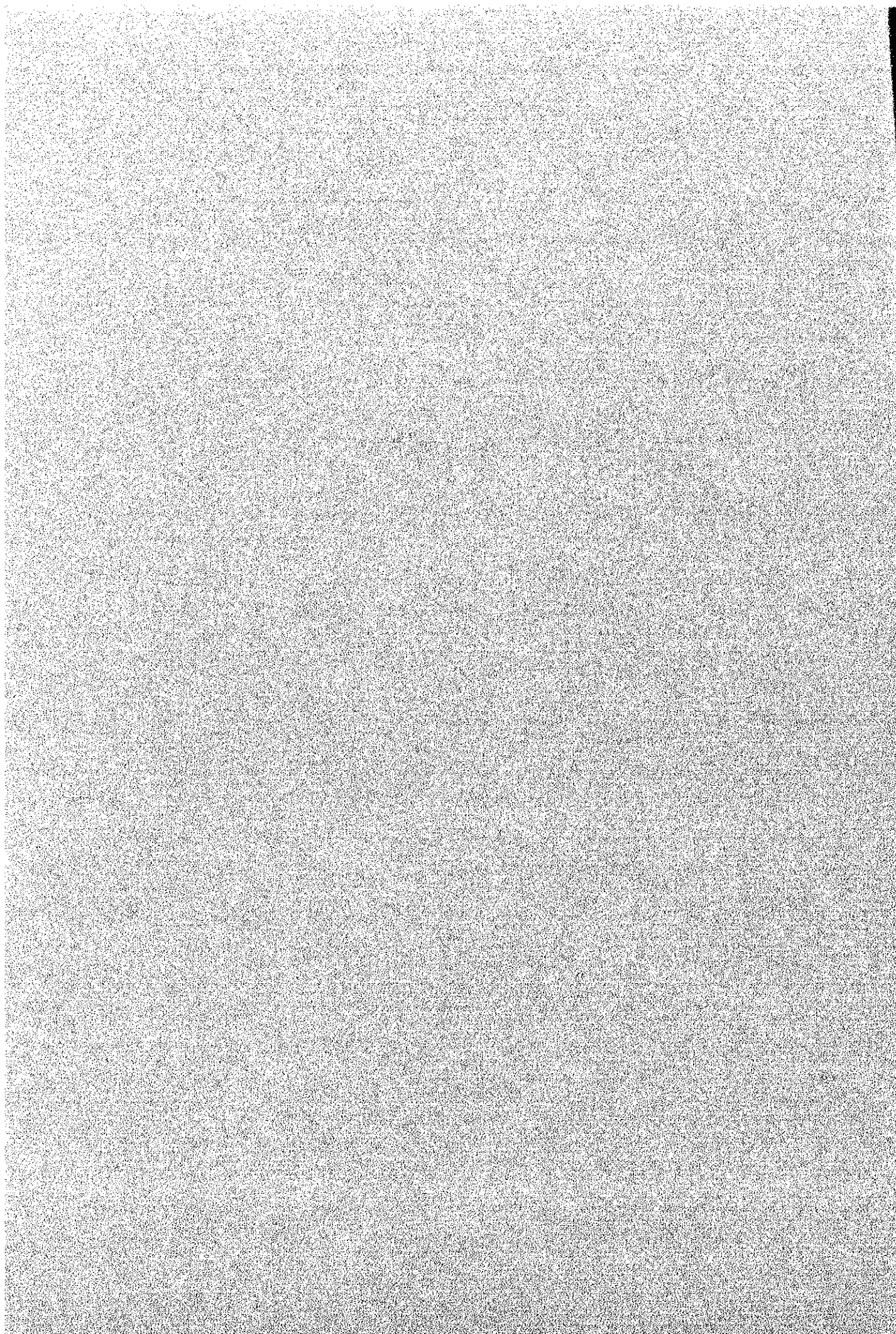
Network in the Central and Eastern Region."

On the basis of this Report, the rehabilitation of the Central and Eastern regions was materialized with the grant aid from Japan, in 1991 through December 1994, and a backbone transmission route, independent exchanges, RSU exchanges and a DRCS network were established. In addition, subscriber cables were supplied in quantities corresponding to capacities of respective switching systems. Objective radio terminal stations, independent exchanges, RSU exchanges and DRCS subscriber stations are listed below.

Radio Terminal Stations	:	Thimphu, Tongsa, Jakar, Mongar, Tashigang, Shemgang, Damphu, Pemagatsel, Geylegphug and Sandrup Jongkhar
Independent Exchanges	:	Tongsa, Tashigang, Geylegphug and Sandrup Jongkhar
RSU Exchanges	:	Jakar, Mongar, Shemgang, Damphu and Pemagatsel
DRCS Terminal Stations	:	Lhuntshi, Sarbhang, Daga and Yongphula



## **CHAPTER 2    OUTLINE OF THE PROJECT**



## **CHAPTER 2 OUTLINE OF THE PROJECT**

### **2.1 Objectives of the Project**

The objectives of this Project are to construct a fundamental telecommunication network in the Western region which is a political and economic center of the Kingdom, and also in new district capitals, Gasa and Tashiyangtse, and thereby establish a nationwide domestic telecommunication network, integrating the facilities provided by the previous project. The construction of this network is indispensable for successful materialization of the 7th National Development Five-Year Plan.

### **2.2 Study and Examination on the Requests**

The requests from the Royal Government of Bhutan were studied, item by item. The study results are as follows:

#### **2.2.1 Digital Switching System**

Originally the Royal Government requested the installation of switching systems in Phuentsholing, Samtse, Chimakoti, Paro, Haa, Punakha, and Wangdue Phodrang. However, after the comparative study of the demands in objective areas based on the field survey findings and the discussions with the staff concerned of the Bhutan side, it was agreed upon that local switches (LS) be introduced for Phuentsholing, Samtse and Paro, remote switching units (RSU) for Punakha and Wangdue Phodrang where not so large demand is expected, and digital radio concentrator systems for Chimakoti and Haa where less demand is expected. (For further details of this study, refer to Item 3.2.1 (2) Switching System.)

As for the transit (tandem) switching system, no expansion was planned by the previous project, considering that demand for trunk call will be not so large and the existing combined exchange equipped with multi-function of local, long distance and international switching can meet the demand for international calls. However, as a result of the construction of a telecommunication network in the Western region, demand for long distance and international calls will increase remarkably. To cope with such demand, provision of a transit (tandem) switching system at Thimphu Exchange is planned.



### 2.2.2 DRCS

The Royal Government requested the introduction of DRCS in Gasa and Tashiyangtse where demand for telephone services is extremely small. As a result of the study on field survey findings and discussions with the counterpart staff, it is concluded that DRCS which is an optimum system to cover a small demand area be introduced in Gas and Tashiyangtse, in addition to abovementioned Chimakoti and Haa. A base station for Chimakoti and Haa is to be installed in Paro, that for Gasa, in Thimphu, and for Tashiyangtse, in Tashigang.

Factory areas in Penden Cement, Tala, Gedu and Pasakha are located approx. 20 Km away from Phuentsholing Exchange and are to be accommodated in this exchange. However, judging from the terrain in these areas, it is not desirable, both technically and economically, to connect them with Phuentsholing Exchange by cable.

A solution to this problem is to connect each factory area with Phuentsholing Exchange by DRCS. Since these areas accommodate major factories earning foreign exchange, it is advisable that a DRCS network be introduced in these areas, with the utilization of a part of the facilities removed from Wangdue Phodrang, Punakha and Paro for a certain portion of the network, and with the Kingdom's efforts to supplement the rest.

### 2.2.3 Digital Radio Transmission Routes

Digital radio transmission links are established for the following routes to connect Thimphu with these areas:

- 1) Thimphu - Phuentsholing, Paro, Samtse
- 2) Thimphu - Punakha, Wangdue Phodrang

### 2.2.4 OSP

OSP facilities in the objective areas where digital switching systems or DRCS are newly introduced are rehabilitated.

The OSP construction works are to be carried out by DOT who has considerable experience with good performance in such works including those for the previous project. Equipment and materials necessary for the OSP will be provided by the

Japanese side.

#### 2.2.5 Power Supply System

Power supply systems are required to feed power, without any instantaneous interruption, to telecommunications facilities, such as switching systems, radio and transmission equipment, etc., to have them operate stably. Power supply systems are installed in objective exchanges, DRCS subscriber stations, active radio repeater stations, and DRCS repeater stations.

#### 2.2.6 Reinforcement of Training Unit

"Training Unit" has been established in Thimphu Exchange, and ITU experts and DOT engineers are conducting the training of operation and maintenance staff. However, the available facilities are inadequate and the current curriculum covers only the class room training on the basic telecommunications. The reinforcement of the Training Unit was requested by the Royal Government at the time of the field survey, and the status quo of the training and the necessity of its reinforcement were investigated by the study team. In accordance with the results of field investigation and discussion with the counterpart staff, basic training equipment and materials (switching system simulator) are to be supplied to the Training Unit, with a view to training DOT staff for operation and maintenance of the facilities to be provided by this Project.

#### 2.2.7 Telephone Charge Accounting System

The telephone charge collection system is now administered by the tariff center in Thimphu covering the whole nation. According to the investigation finding, the tariff center is equipped with only a magnetic tape reader and a printer for bills. When the printer is out of order, a magnetic tape having the charge record is sent to India for printing. As a result of the network expansion in the Western region, telephone charge accounting work will increase in volume. To cope with this problem, one set of telephone charge accounting system is to be added to the existing one.

#### 2.2.8 Subscribers' Premises Facilities

Under the previous project, installation of subscribers' premises facilities were undertaken by the Bhutan side, with no problem. Hence for this Project also, drop

wire, indoor wiring, and terminal equipment (telephone sets, facsimiles, etc.) installation will be undertaken by the Bhutan side.

### 2.2.9 Access Road

The capability of the implementing agency of the Kingdom for access road construction has been well proved by the previous project. Hence, the access road construction under this Project will also be undertaken by the Bhutan side.

### 2.2.10 Prefabricated Shelters and Buildings

Prefabricated shelters of unattended radio repeater stations must be strong and solid enough in structure, since they are usually built at locations where geographical conditions are severe.

Buildings of telephone exchanges which are usually built in urban areas are required to meet the standards adopted in the Kingdom.

In view of the above, the construction of prefabricated shelters for radio repeater stations and DRCS repeater stations is to be undertaken by the Japanese side, while that of telephone exchange buildings, by the Bhutan side, in the same way as adopted by the previous project.

## 2.3 Project Description

### 2.3.1 Executing Agency and Operational Structure

The organization of DOT, an implementing agency of this Project, is shown in Figure 1-2. The number of employees is 374 of which only 32 is equipped with technologies and expertise necessary for operation and maintenance of telecommunications systems.

After completion of the previous projects, DOT has positioned its available small number of technical staff to key exchanges to have them engage in operation and maintenance of the new systems. Efforts are now being made by DOT for human resource development.

### 2.3.2 Location and Condition of the Project Site

#### (1) Topographic and Geologic Features

Topographically, the country is featured by steep mountains and deep valleys. Even sites for telephone exchanges in urban areas are not flat, and all the radio repeater stations and reflectors for the Project will have to be constructed on mountain summits or steep slopes, which are located at heights between 1,000 and 4,000 m.

Geologically, the soil of the objective sites are generally hard silts or silts with gravel. Many of the sites for radio repeater stations and reflectors are of bedrock. In such areas, landslide is apt to take place, leading to road blocking, particularly in the rainy season.

#### (2) Climate

There are four seasons in the Kingdom like Japan.

Spring	:	March through May
Summer (Monsoon)	:	June through August
Autumn	:	September through November
Winter	:	December through February

The Research Division of the Ministry of Agriculture, the Royal Government of Bhutan, has the data on the average temperature and rainfall in January through December measured at 71 and 52 locations, respectively, throughout the country.- They are the only national meteorological data available in the Kingdom. In addition, Bhutan Urban Development Bureau is in possession of its own data concerning sunshine hours, wind speed, temperatures in 4 cities (Thimphu, Paro, Bhumtan, and Phuentsholing) for each month of the years from 1979 through 1982.

Meteorological conditions in the objective areas of telephone exchanges, DRCS terminal stations, radio repeater stations, and reflectors obtained through the above data and the interviews at sites are listed below.

### Meteorological Data for Objective Sites

Objective Sites	Altitude (m)	Snow-fall (m)	Temperatures (°C)		Annual Rainfall (mm)
			Highest	Lowest	
Telephone Exchanges & DRCS Terminal Stations	225	-	40	10	2,500 - 5,000
Phuentsholing	370	-	35	10	2,500 - 5,000
Penden Cement	1,440	-	30	5	2,500 - 5,000
Tala	1,540	-	25	0	2,500 - 5,000
Gedu	260	-	40	10	2,500 - 5,000
Pasakha	405	-	35	10	2,500 - 5,000
Samtse	2,280	-	25	-5	500 - 1,000
Paro	1,770	-	25	0	500 - 1,500
Tashiyangtse	2,780	-	20	-5	500 - 1,000
Gasa	2,245	-	25	0	1,000 - 1,500
Chimakoti	1,240	-	30	0	500 - 1,500
Wangdue Phodrang	1,220	-	30	5	1,000 - 2,000
Punakha	2,729	-	25	-5	1,000 - 2,000
Haa					
Radio Repeater Stations & Reflectors					
Takti	3,329	0.5	25	-10	-
Takti-P	3,388	0.5	25	-10	-
Pepchu	1,759	-	30	0	-
Kapdane	1,550	-	30	0	-
Saureni	1,080	-	30	5	-
Japjekha	3,440	0.5	25	-10	-
Paro-P	2,316	-	25	-5	500 - 1,000
Rangshikhar	2,080	-	20	0	-
Samchilling Gompa	2,520	-	20	-5	-
Gangadung	2,080	-	20	0	-
Dobchu	3,880	1.0	20	-10	-
Dochula	3,129	0.5	25	-10	-
Limuti	1,930	-	25	0	-
Chelela	4,110	1.0	20	-20	-
Sisni	1,340	-	30	0	-
Tala-R	2,460	-	20	-5	-

(3) Earthquake

The Kingdom is located in the Asian seismic zone but no official seismic data exist.

(4) Features of Objective Sites in Urban Areas

In the objective sites for telephone exchanges and DRCS terminal stations, urbanization is in progress as summarized in the following page, according to the data obtained through the interviews at the time of field investigations.

Maps to objective sites with locations of important subscribers are given in Figure 3-1 through Figure 3-10 in Chapter 3, 3.2.1.

Objective Sites	Population (*1)	Dzong	Police Stations	Hospi- tals	Hotels	Fire Stations	Schools	Features
Phuentsholing	23,000	-	3	1	5	1	6	A commercial and industrial city along the Indian border, and a nucleus of economic activities in the Kingdom.
Pendent Cement	3,000	-	1	1	2	2	2	An important area embracing cement factories.
Tala	2,500	-	1	1	1	2	2	An area known by sawmills.
Gedu	2,500	-	1	1	1	2	2	An area known by wooden work factories.
Pasakha	4,000	-	1 <sup>*2</sup>	1 <sup>*2</sup>	2	2	2	An area known by advanced chemical factories and ferro-silicon factories.
Samtse	7,000	1	2	1	2	1	1	Capital of Samtse District and an industrial city along the Indian border for cement and food processing, with no domestic overland connection with other cities in the Kingdom.
Paro	16,000	1	2	3	7	1	6	Capital of Paro District and only one international airport city; agricultural products collection and distribution center.
Tashiyangtse	2,000	1	1	1 <sup>*2</sup>	1	1	1	Capital of Tashiyangtse District, newly separated from Tashigang District.
Gasa	1,500	1	1	1 <sup>*2</sup>	1	1	1	Capital of Gasa District, newly separated from Punakha.
Chimakoti	4,000	1	1	2	7	3	3	Capital of Chimakoti, embracing Chukka Power Station for power supply to the Western region, and for export of power to India.
Wangdue Phodrang	20,000	1	2	2	5	1	4	A town known by the agricultural production and a key location for transportation to interconnect the east and the west.
Punakha	20,000	1	2	2	10	1	5	Capital of Punakha District (former Capital of the Kingdom), an important area in terms of religion and agriculture,
Haa	5,000	1	1	1	2	1	6	Capital of Haa District known by agricultural production.

Note \*1: The population in the coverage area.

\*2: Basic Health Unit

(5) Road

All the objective sites for telephone exchanges and DRCS terminal stations except for Gasa are located near by paved roads, posing no transportation problem for construction work and operation/maintenance work after the inauguration. The site in Gasa is 2-day distant from the area where vehicles are available. In Samtse, there is no overland road to connect Samtse with other domestic areas. To get to other areas in the country, inhabitants have to pass through India.

For radio repeater stations and reflectors, no access roads are available except for Takti, Takti-P, Pepchu, and Paro-P. The site for an active radio repeater station, namely, Japjekha, is approx. 3 Km away from a highway, while the sites for passive radio repeater stations and reflectors are 2 ~ 12 Km away from highways.

Almost all the roads are mountain roads winding up and down along steep cliffs, with no straight road of longer than tens meters. An average speed of vehicles is in the rage of 20-30 Km/h. At corners, traffic accidents, such as crashes and falling over precipices, are apt to take place. In the rainy season, road is often blocked because of landslide, rockfall, etc.

(6) Power

Hydroelectric power or diesel engine generator is generally adopted. Commercial power is supplied to main cities and towns in each district but unstable: fluctuation in voltage and frequency is large and power is often interrupted.

For telephone exchanges and DRCS terminal stations of this Project, commercial power is available since relatively stable power is being supplied from Chukka Power Station (336 MW) to the Western region. Chukka Power Station is now exporting most of its output to India to earn foreign exchange.

For almost all the radio repeater stations, commercial power is not available.

(7) Water Supply and Sewage Systems



Water supply systems are provided in main cities, though most of them are too small in capacity to maintain stable supply. Water necessary for construction of telephone exchange buildings in urban areas can be obtained from these systems. However, for radio repeater stations and reflectors to be located on mountain top or slope, utilization of spring water along access roads or transportation from the nearby water source will have to be considered.

For a sewage system, construction work is under way in Thimphu and Phuentsholing with the aid from Holland.

(8) Fuel

Most popular fuel in the Kingdom is wood. In Thimphu and other urban areas, liquidated propane gas, kerosene, light oil, gasoline, etc. imported from India are available. Light oil supplied from India contains much paraffin component, which is apt to choke a fuel supply system when used in a vehicle or diesel engine generator in winter.

(9) Education

The development of the Kingdom is constrained by a limited human resource. As of 1994, there are 145 primary schools with 100 branch schools, 18 junior high schools, 8 high schools, 1 university and 6 vocational schools, which are definitely too small in quantity for education of the people in the Kingdom. Qualifying examinations are conducted at the time of graduation by each school and university mentioned above, and only those who have passed the examination can be employed as the public service personnel. Since the number of qualified personnel is limited, individual governmental agencies are endeavouring for human resource development by themselves.

(10) Health and Sanitation

Diseases from which Bhutanese often suffer are various types of parasites, hepatitis, typhoid, and dysentery, and in the southern area, malaria. Hospitals are located in major cities throughout the country. In other areas, only Basic Health Units (BHU) are available. BHU is a kind of public health center where only popular medicines are obtainable.

## (11) Environmental Problems

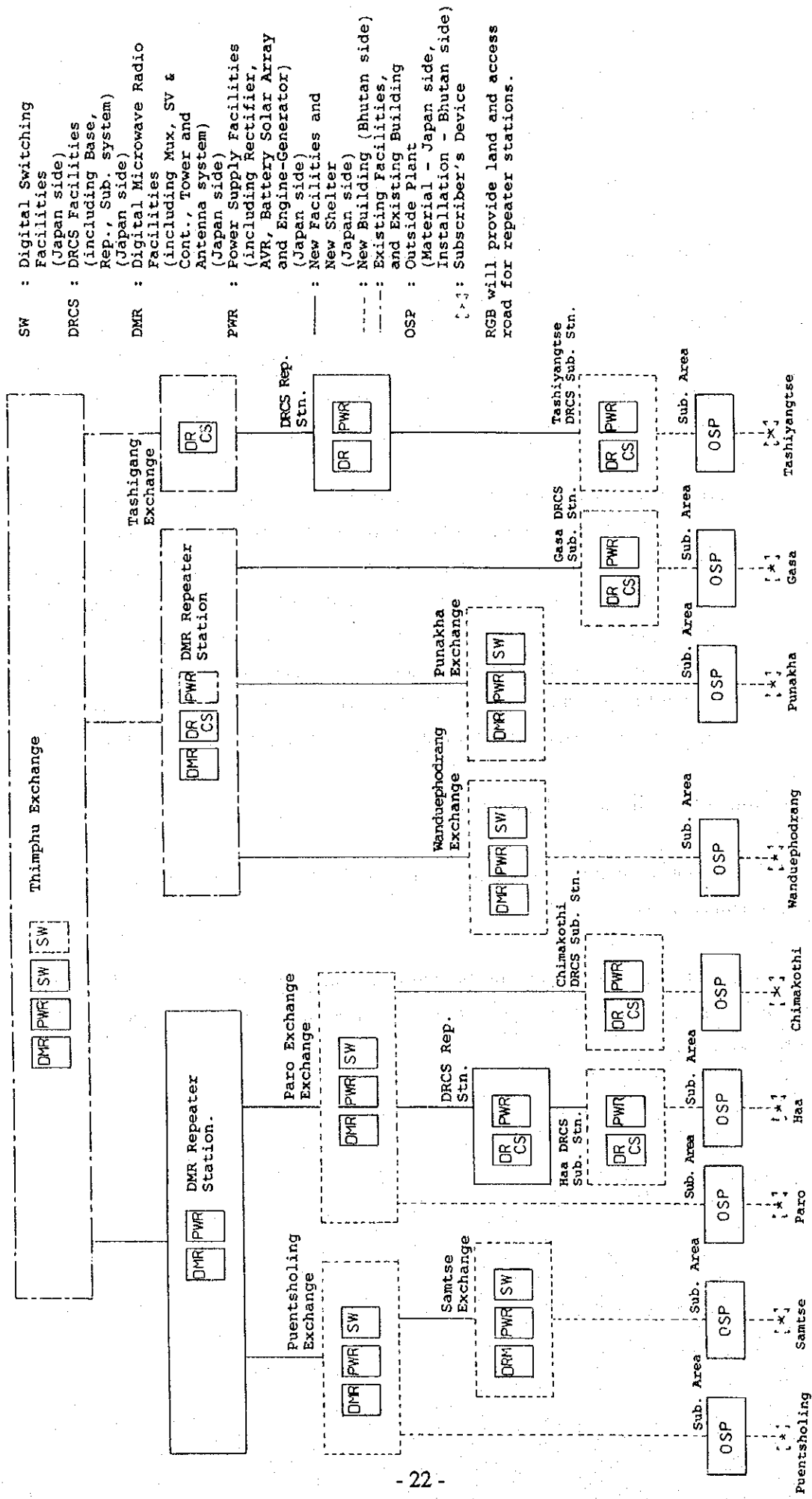
The state religion is Buddhism. Buddhism has exerted a great influence over the history of the Kingdom and deeply penetrated in daily life of the people. People believe that fierce gods and departed souls dwell in mountain tops, ridges, rocks and trees, and once offended, they will bring misfortunes and disasters. A lot of religious structures are observed not only in densely populated areas but also at deserted mountain tops. Thus religious Bhutanese wish to get along in good harmony with fierce gods and souls which are equipped with might beyond human power.

In the Kingdom 71% of the total area is under forests, and according to the national policy, a high priority is given to the natural reservation. This Project will not damage natural environments since only the construction of radio repeater stations (approx. 400m<sup>2</sup>) at mountain tops and access roads to them is being planned. However, such policy of the Kingdom should be carefully observed and, in designing the radio transmission routes, due attention should be paid to preservation of cultural inheritance and environments so that unfavourable effects to environments can be minimized to the least.

### 2.3.3 Outline of Facilities and Equipment

This Project is composed of Digital Switching System, DRCS, Digital Radio Transmission System, OSP and Power Supply System.

Figures 2-1, 2-2 and 2-3 present the configuration of this Project, the telephone switching network plan and radio transmission network plan under this Project, respectively.



SW : Digital Switching Facilities (Japan side)

DRCS : DRCS Facilities (including Base, Rep., Sub. system) (Japan side)

DMR : Digital Microwave Radio Facilities (including Mux, SV & Cont., Tower and Antenna system) (Japan side)

PWR : Power Supply Facilities (including Rectifier, AVR, Battery Solar Array and Engine-Generator) (Japan side)

--- : New Facilities and New Shelter (Japan side)

--- : New Building (Bhutan side) and Existing Facilities, and Existing Building

OSP : Outside Plant (Material - Japan side, Installation - Bhutan side)

☆ : Subscriber's Device

RGB will provide land and access road for repeater stations.

Figure 2-1 Configuration of the Project

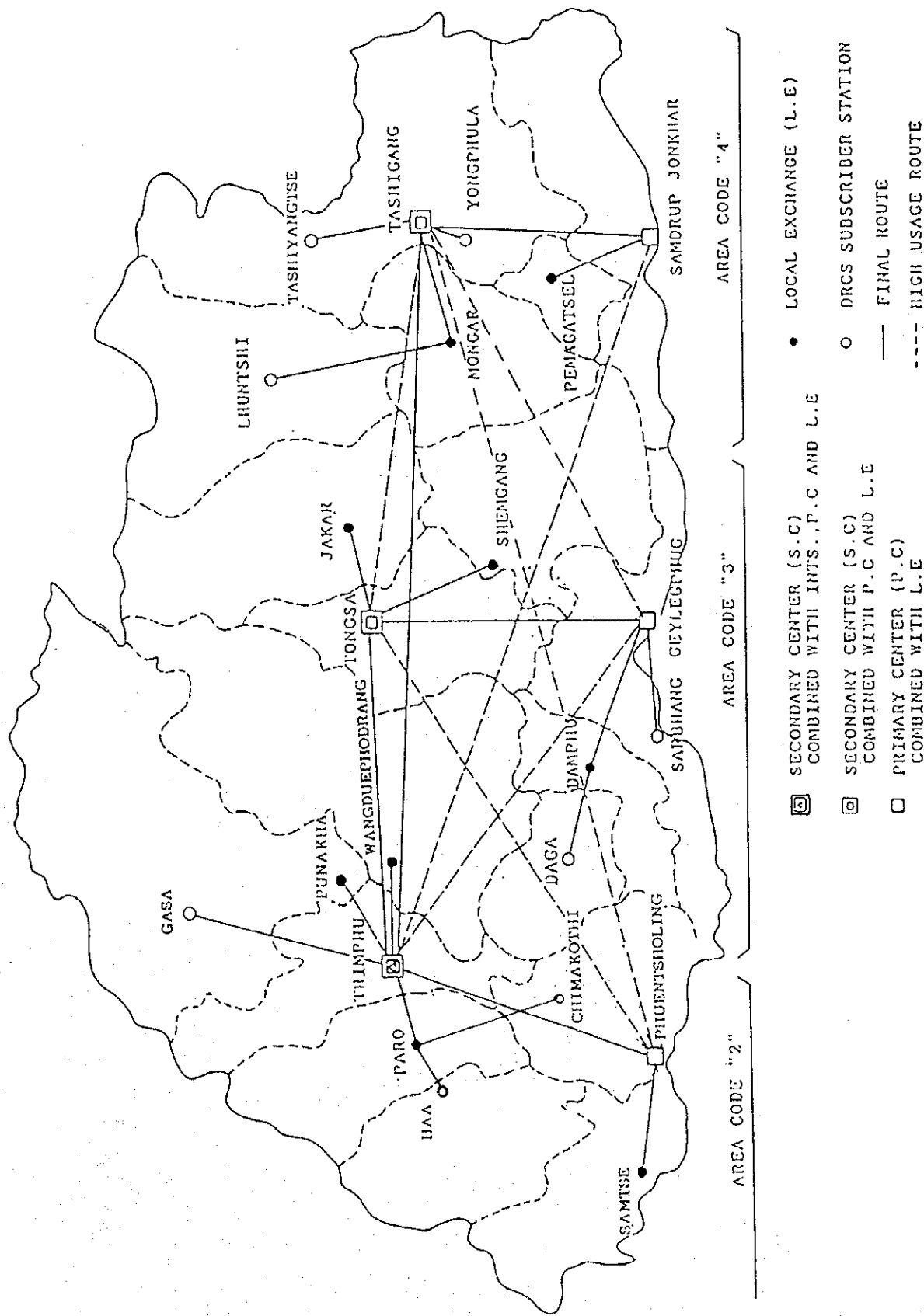


Figure 2-2 Telephone Switching Network Plan

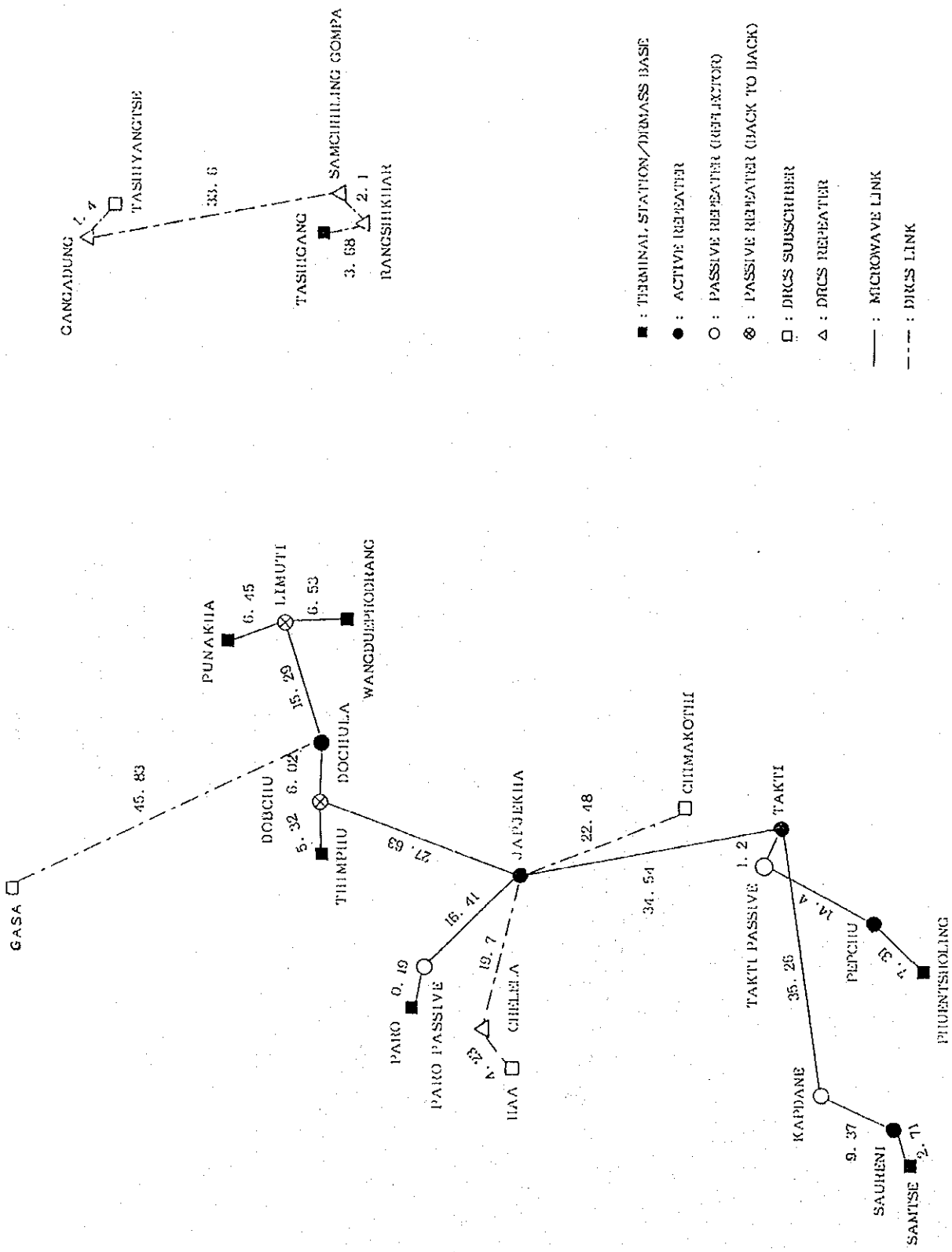


Figure 2-3 Radio Transmission Network Plan