2.3.4 Operation and Maintenance Plan

(1) Operation and Maintenance Area

To ensure satisfactory operation and maintenance of the integrated nationwide telecommunications system to be realized with the completion of this Project following the previous ones, DOT plans to reinforce its operation and maintenance organization by establishing the following six maintenance areas, with the designation of an operation/maintenance center for each area (refer to Figure 2-4).

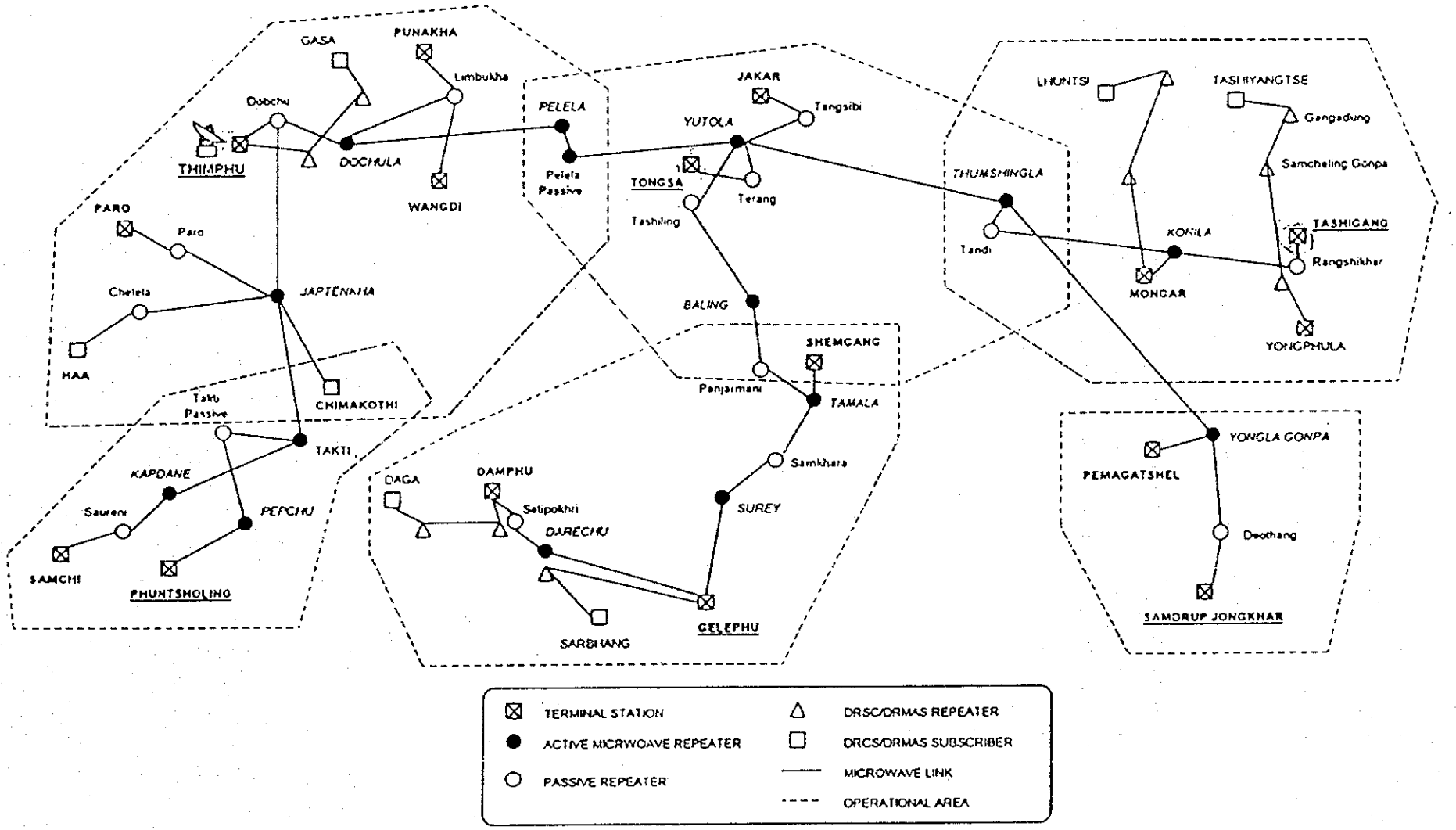


Figure 2—4 Operation/Maintenance Area

Area 1:	Operation/Maintenance Center	Thimphu
	Exchanges and repeaters to be covered	Dobchu, Dochula, Limuti, Punakha, Wangdue Phodrang, Japjekha, Paro-P, Paro, Chelela, Haa, Gasa, Chimakoti.
Area 2:	Operation/Maintenance Center	Tongsa
	Exchanges and repeaters to be covered	Jakar, Pelela, Pelela-P, Yutola, Tangsbi, Terang, Tashiling, Baling, Panjarmani, Shemgang
Area 3:	Operation/Maintenance Center	Tashigang
	Exchanges and repeaters to be covered	Thumshingla, Tandi, Korila, Monger, Thimmung, Wangbur, Mungung, Lhuntsi, Rangshikar, Yongphula, Samchiling Gompa, Gangadung, Tashiyangtse
Area 4:	Operation/Maintenance Center	Samdrup Jogkar
	Exchanges and repeaters to be covered	Doethang, Yongla Gompa, Pemagatsel
Area 5:	Operation/Maintenance Center	Geylegphug
	Exchanges to be covered	Tamula, Samkala, Surey, Darechu, Setipokhali, Damphu, Namychela, Daga, Sarbhang
Area 6:	Operation/Maintenance Center	Phuentsholing
	Exchanges and repeaters to be covered	Taki, Taki-P, Pepchu, Kapdane, Saureni, Samtse, Sisni, Penden Cement, Tala-R, Tala, Gedu, Pasakha

(Note) Objective exchanges of this Project are those underlined.

Judging from the geographical features and roadway conditions in the Kingdom, this plan is considered most appropriate: it will facilitate the efficient distribution of technical staff and maintenance materials, leading to reduction of the time for repairs in case of a system failure. Hence, this Project will support the realization of this plan.

(2) Personnel Plan

The staffing plan for the 6 maintenance areas described above to achieve the most efficient and effective operation and maintenance of the expanded facilities is shown below:

	Area1	Area2	Area3	Area4	Area5	Area6	Total
Responsible Operation/Maintenance Staff							
Regional Staff	1	1	1	1	1	1	6
Switching Engineer	12	4	3	3	3	6	31
Radio/Tx Engineer	11	3	2	2	2	3	23
OSP Engineer	6	3	2	2	2	2	17
DRCS Engineer	6	-	4	-	3	-	13
Total	36	11	12	8	11	12	90
Others							
OSP Maintenance Staff	36	6	8	4	8	5	67
Operator	17	4	-	4	8	12	45
Charge Collector	1	-	-	-	1	1	3
Telex Maint. Staff						2	2
Guardsmen	7	3	4	2	4	2	22
Total	61	13	12	10	21	22	139
Grand Total	97	24	24	18	32	34	229

With the materialization of this plan, the operation and maintenance institution can be rationalized and the number of employees can be reduced from 331 to 229. The necessary number of technical staff for satisfactory operation and

maintenance of the facilities as a whole after the completion of this Project is 90, of which 28, i.e., half the number of staff for Area 1 and the total number of Area 6, are the staff necessary for the operation and maintenance of the facilities of this Project. The facilities completed at the end of 1994 by the previous project are now being operated without any serious trouble, with the support from the contractor. As mentioned in 1.3, DOT is now conducting training of technical staff with the support of ITU/UNDP. However, the reinforcement of the training system is requisite for operation and maintenance of the facilities of this Project. That is, for the staff to support the existing operation and maintenance staff, much more intensified and practical training should be conducted with respect to operation and maintenance of switching systems, DRCS, radio transmission facilities, power supply systems, and OSP to be supplied by this Project. Under this Project, switching system simulator indispensable for the required training will be provided in addition to class room training and on-the-Job training at every stage of construction work, adjustment and tests.

(3) Financial Status of DOT

According to the national accounting regulations, DOT's revenues (income from telephone charges) go directly to the national treasury, and its expenditures (ordinary expenditures and development investments) are disbursed from the treasury.

After the completion of this Project, the facilities expanded by the previous project will be further developed, leading to the increase in income, and hence in budget also. This will facilitate further reinforcement of the operation and maintenance organization of DOT. DOT's expenditures during five years from 1992 under the 7th 5-Year National Development Plan are as follows.

(Unit: million Nu.)

	Ordinary Expenditure	Development Investment*			Total
FY 1992	5.0	Previous Project	:	345.0	350.0
FY 1993	10.0	Previous Project	:	108.0	118.0
FY 1994	17.51	This Project	:	241.0	258.51
FY 1995	34.66	This Project	:	85.0	119.66
FY 1996	45.0	Future Project	:	78.0	123.0

Note* : Main Items
Local portion : access road and building construction.
Foreign portion : equipment purchase

On the other hand, DOT's real income and expenditure in and after fiscal 1991 are as follows:

(unit: Nu.1,000)

Fiscal Year (July-June)	Income from Telephone Charges	Expenditure			Balance
		Ordinary Expenditure	Development Investment	Total	
1991/1992	37,981	140	6,192	6,332	+31,649
1992/1993	51,310	1,010	21,049	22,059	+29,251
1993/1994	75,235	1,125	13,095	14,220	+61,015

Prior to the fiscal 1990/91, the income from telephone charges was almost constant, i.e., in the range of several hundred thousand Ngultrum per year. However, after the improvement of the services in Thimphu and its surrounding area with the installation of a digital switching system and an earth station and the introduction of DRCS, the income increased to the range of 18 million Ngultrum. Then with the completion of the previous project, the number of subscribers was swelled and, in addition, the tariff system was modified in a large scale in the fiscal 1991/1992, in correspondence to the

expansion of the facilities. As a result, the income from telephone charges increased remarkably.

On the other hand, ordinary expenditures marked a sharp increase in the fiscal 1992/1993 as a result of a large scale pay raise for public service personnel and the expansion of the DOT's operation and maintenance staff to take care of the new facilities installed by the previous projects, both of which were effectuated in the fiscal 1991/1992. Currently the expenditures are increasing moderately in the range of a little bit over one million Ngultrum.

The development investments in the above table were mainly for the construction of access roads and buildings for the previous project, and they do not include the foreign currency portion. For the fiscal 1994/1995, the development investments in the amount of 34,726 thousand Ngultrum are estimated, mainly to cover the access road and building construction for the development of the Western region.

(4) Financial Study on this Project

1) Revenues

The operating revenue of each exchange after the completion of this Project is estimated as follows:

Exchange	The number of Subscribers Accommodated	Revenue Thousand Nu.)
Thimphu	3,640	61,741
Phuentsholing	2,200	37,316
Tongsa	616	13,774
Geylegphug	480	10,927
Tashigang	834	18,955
S. Jongkar	816	18,289
Samtse	400	9,029
Paro	900	20,315
Total		190,344

Of the above, the revenues of Phuentsholing, Samtse, and Paro are mostly those to be obtained from this Project.

Thimphu Exchange is a parent exchange of Wangdue Phodrang, Punakha and Gasa. Therefore, of the revenues of Thimphu Exchange, those from new 640 subscribers accommodated in these three exchanges are considered as the income from this Project. The same can be said with respect to Tashigang Exchange which is a parent exchange of Tashiyangtse Exchange in which 50 subscribers are accommodated by this Project. The income from this Project from Thimphu and Tashigang should be calculated by applying the subscriber ratio to the total income of respective exchanges.

As for the revenues from long distance calls at Thimphu Exchange where only functional improvement is made by expansion of switching and relevant transmission facilities, with no new subscriptions, a study was made as follows:

According to the ITU-T Handbook, distribution percentage of investments in a telephone network is in general 30% for switching equipment, 30% for transmission system and 40% for OSP. The same percentage will be applicable to the distribution of revenues from a telephone network.

For calculation of the income from this Project with respect to long distance calls at Thimphu Exchange, it is assumed that half the revenue from switching and transmission facilities will be the income from the Project. Then by applying the ITU-T Handbook description, it is considered that half the revenue from switching facilities, i.e., 15% of the total revenue of Thimphu Exchange, plus half the revenue from transmission facilities, i.e., 15% of the total revenue, that is, 30% of the total revenue can be taken into account as the income from this Project.

For other exchanges than the objective exchanges, 10% of the total revenue of each exchange is taken into account as the pervasive effect of this Project.

By applying the above to the revenues of respective exchanges, the total revenue from this Project is calculated to be approx. Nu.100.0 million, i.e.,

approx. 53% of the total revenue of DOT.

Preconditions employed in calculating the operating revenue are as follows:

- Traffic per subscriber at busy hour:	0.1 erl.
- Concentration ratio of traffic at busy hour:	20%
- Call completion ratio:	50%
- Average holding time:	
Local calls	90 sec
Long distance calls	120 sec
International calls	180 sec
- Tariff collection ratio:	85%

2) Expenditures

Expenditures to be required for the facilities constructed by this Project, including operation and maintenance costs and repairing expenses, etc. are estimated to be 67.8 million Nu., as listed below.

Item	Amount (MNu.)
- Personnel Expenses	2.2
- Operation/Maintenance Costs Fuel, Spare Parts, etc.	40.3
- Depreciation	21.8
- Others	3.5
Total	67.8

For personnel expenses, the number of operation/maintenance staff is estimated to be 82 in total.

Exchange	Manager	Engineers	Technicians	Total
Thimphu	1	4	12	17
Phuentsholing	1	6	12	19
Samtse	1	4	8	13
Paro	1	4	10	15
Wangdue Phodrang	1	2	6	9
Punakha	1	2	6	9
Total	6	22	54	82

Salaries for DOT staff are estimated as follows, excluding special allowances:

Manager	:	7,000 Nu./month
Engineer	:	4,000 Nu./month
Technicians	:	1,000 Nu./month

Operation and maintenance costs are estimated to be 5% of the Project cost.

Depreciation is calculated as follows:

$$Dt = (C-S) \, x \frac{i}{(1+i)^{n-1}}$$

where	Dt	:	depreciation expenses
	c	:	Project cost
	s	:	Salvage value (5%)
	i	:	Annual interest (8%)

For other miscellaneous costs, 3% of the total revenue is taken into account.

3) Project Revenue and Expenditure

As described above, the revenues and expenditures as a result of this Project are estimated to be as follows:

Revenue	:	Nu.100.0 million
Expenditure	:	Nu.67.8 million

That is, the profit in the amount of Nu.32.2 million can be expected per year. Hence the operation and maintenance costs of the facilities constructed by this Project can be sufficiently covered by the revenue of this Project.

2.4 Technical Cooperation

Japan Overseas Cooperation Volunteers have been sent to the Kingdom since fiscal 1990 as described below, for the transfer of basic telecommunications technologies to DOT staff and also for the practical support to the staff concerned in their operation and maintenance of the facilities installed by the previous project. Their activities are highly appreciated by the Kingdom.

Fiscal Year	Fields	Number of Volunteers
1990-1992	Outside Plant	1
1991-1993	Earth Station	1
	Switching	1
1992-1994	DRCS	1
1993-	Radio & Transmission	1
	Outside Plant	1
	Switching	1

In addition, two or so DOT engineers have underwent technical training in Japan every year since 1989, through the technical cooperation by JICA, as described below, aiming to transfer more advanced telecommunications technologies related to the previous project so as to ensure satisfactory operation and maintenance of the facilities installed by the previous project. After returning to the Kingdom, they have been assigned to operation and maintenance work. With their activities, the telecommunications facilities are now satisfactorily operated and maintained.

Fiscal Year	Fields	Number of Trainees
1992	Outside Plant	1
	Radio & Transmission	1
1993	Switching	3
1994	Outside Plant	1
	Radio & Transmission	1
	Switching	1

CHAPTER 3 BASIC DESIGN

CHAPTER 3 BASIC DESIGN

CHAPTER 3 BASIC DESIGN

3.1 Design Policy

The design policy for this study is as follows:

3.1.1 Size and Contents

Telephone demands in objective areas are estimated, on the basis of the demand forecast in FY 2002 given in the Master Plan and the field survey results. Then the capacities of switching systems and OSP facilities are calculated, based on the estimated demand. Taking into account the calculated switching system capacities, optimum switching systems (including DRCS) are selected. Then transmission capacities are calculated, based on the traffic forecast obtained through the study of switching capacities and the existing traffic data.

3.1.2 Geographic and Meteorological Situation

Since objective areas of this Project are mostly located at altitudes relatively lower than those of the previous project, there will be no fear of deep snowfall at almost all sites. On the other hand, in areas along the border with India, a large quantity of rainfall will be inevitable in the rainy season.

These factors should be dully taken into account in planning the schedule for transportation of equipment and materials, civil work for construction of access roads and building/tower foundations, outdoor work for shelter construction and antenna tower assembly, etc.

An unloading port for equipment and materials of this Project is Calcutta in India. It will be preferable to change the place for storing equipment and materials from Thimphu (adopted for the previous project) to Phuentsholing which is located along the border with India, so that the transportation distance can be shortened, avoiding the adverse effect of rainfall. In addition, the construction work should be so scheduled that transportation of equipment and materials, civil work and outdoor assembly work, etc., can be performed avoiding the rainy season as much as possible.

3.1.3 Social Conditions

The Kingdom is a country of pious Buddhists. For Bhutanese, mountains and rivers are holy places. A lot of temples are found at mountaintops. It is a national policy to accord high priority to the reservation of nature, e.g., deep forests and woods.

Under this Project construction of radio transmission facilities is one of major items. Technical and economical requirements often necessitate the installation of radio repeater stations and reflectors at the top of mountains, including the construction of access roads, resulting in timber felling and excavation at sites.

Then, matters to be taken into consideration in designing, particularly in site selection, are as follows:

(a) Those mountains that are religiously important should be excluded from the list of objective sites.

(b) The length of an access road should be as short as possible.

(c) Sites where excavation is difficult should not be selected.

(d) Due attention should be paid so that constructed structures, such as buildings and antenna towers, will suit to scenery in the neighborhood.

To sum up, radio transmission routes should be designed, in due observation of the intention of the DOT's staff in charge and giving high priority to the reservation of nature and cultural inheritance.

3.1.4 Utilization of Local Contractors and Local Materials

For the previous project, local contractors were employed for civil works for land readjustment of objective sites, construction of buildings and access roads, etc. Their performance was acceptable and served for considerable cost reduction. Hence, for this Project also, local contractors will be employed.

Also for the previous project, local products, such as cement, sand, crushed stone, reinforcing bar, etc. were purchased, after a careful examination of their quality. They have proved that they can meet the specified requirements. Hence such local

products be employed for this Project also.

3.1.5 Operation and Maintenance System of the Implementing Agency

As mentioned in 2.3.4, an adequate budget has been made for the reinforcement of O/M system, and there will be no financial problem.

As for the manning plan, it is so designed that, also as mentioned in 2.3.4 the human resources will be developed through the reinforcement of the Training Unit, to obtain the staff trained into highly qualified engineers who can practically take care of the operation and maintenance of the introduced systems and, further in future, can conduct the training of younger generations.

The telephone charge collecting system will also be reinforced to improve reliability and efficiency of the charge collection system.

3.1.6 Determination of Scope of Facilities/Materials to be Supplied and Objective Grade of Services

In order to establish an integrated nationwide telecommunications network which is highly reliable and capable of international connections, main facilities and materials should, in principle, comply with, or equivalent to, the relevant recommendations of ITU-T (ITU Telecommunication Standardization Sector), ITU-R (ITU Radiocommunication Sector), as required under the previous project.

Main facilities and materials of this Project consist of digital radio transmission equipment, digital switching equipment, DRCS, power equipment, and OSP facilities, including structures and civil works related to the above. For the sites where considerable snowfall and low temperature can be expected in winter, measures should be taken to protect antennas, prefabricated shelters, engine generators, fuel tanks, etc. from deep snow and low temperature. On the other hand, in the southern area where high humidity can be expected in the rainy season, countermeasures against humidity be taken.

3.1.7 Construction Work Schedule

There will be no restriction on the work schedule of the Japanese side in connection with the work to be undertaken by the Bhutan side because the necessary budget has

already been made by the Government.

However, due attention should be paid to the severe physical conditions in Bhutan, particularly those in the rainy season from June to September and the hard winter season from December to February.

It is estimated that approx. six months will be required for the detail design, which is scheduled to be started in the latter half of September when the raining season ends.

For the construction work to be started following the detail design, the period of approx. 24.5 months is estimated. The construction work schedule should be so planned that the outdoor work can be done avoiding the above seasons to evade the work under severe conditions in the rainy season and low temperature in the hard winter. That is, the civil work and transportation of equipment and materials should be started after the end of the rainy season, i.e., in October.

3.2 Study and Examination on the Design Criteria

The design criteria of each component of the Project are as follows:

3.2.1 Digital Switching System

(1) Capacity

The optimum capacities of the objective switching systems have been calculated, through the study of the requested capacities and the field survey findings, as well as data given in the Master Plan.

For Phuentsholing of which necessary capacity is estimated in the Master Plan, a comparative study was made between the estimation by the Master Plan and the requested capacity by the Government (the former being half the requested capacity). A further study was made to obtain the optimum capacities, based on the comparative study results and field survey findings, taking into account the following:

- The population and the number of important subscribers in each coverage area (refer to 2.3.2).

- A comparison between the visible demand (the number of existing subscribers plus waiting applicants) and the requested capacity.
- Demand survey in the coverage area (refer to Figure 3-1 through Figure 3-10).

Demand survey was conducted as follows:

In principle, a cabinet area was assumed for each cabinet (mainly for the existing one) along the existing cable route, and the demand in each cabinet area was assumed taking into account the number of important subscribers and residences. In this study, the number of telephones of each subscriber was estimated as follows:

Governmental agencies and banks	:	Phuentsholing is a rather large city but there exists no DZONG. The function of DZONG is performed by branch offices. Each branch office and bank are organizationally divided into 8 sections on an average. Including those for a manager and a deputy manager, the number of telephones to be required at each branch office and bank is estimated at 10. In other cities, administrative functions are concentrated on DZONG. One set each for prefectural governor and deputy governor and 1 set for every 5 staff are assumed, and depending upon the scale of DZONG, 5 - 30 telephones are estimated.
Police stations	:	A police station in Phuentsholing is located near the Indian border. Hence it has a large organization consisting of 3 headquarters. Each headquarters is staffed with approx. 50 officials and policemen who are grouped into 7 by function. In view of the above, 1 set for emergency

		use, and 1 set each for chief, deputy chief and each functional group, i.e., a total of 10 sets are estimated. For other cities, police stations are not so large in scale. Therefore, 1 set for emergency use and 1 set each for chief and deputy chief, and 2 sets for policemen (10-15) for business use are estimated.
Fire stations	:	One set for emergency use, 1 set each for chief and deputy chief, and 2 sets for staff, totaling 5 sets, are estimated.
Schools	:	One set each for schoolmaster and deputy schoolmaster, 2 sets for teachers and 1 set for dormitory, totaling 5 sets, are estimated.
Hospitals	:	For a large hospital, 1 set each for director and deputy director, 3 sets for doctors, 1 set for nurse room, 2 sets for reception desk, and 1 set each for pharmacists' room and for emergency use, totaling 10 sets, are estimated. For a middle or small hospital, half the quantity of the large hospital, i.e., 5 sets are estimated. For BHU where one doctor is stationed, 1 set is estimated.
Hotels (large)	:	One set for hotelier, 3 sets each for staff and reception desk, 1 set for restaurant, 2 sets for shops, and 10 sets for guest rooms, totaling 20 sets, are estimated.
Hotels (small)	:	One set for hotelier, 2 sets for staff, 1 set each for reception desk and restaurant and

5 sets for guest rooms, totaling 10 sets, are estimated.

For hotels having guest rooms of less than 20, 2-5 sets are estimated, depending on their respective scales observed at the field survey.

Stores	:	One set for each store is estimated for business use.
Factories	:	One set for manager and 1 set each for reception desk and business use, totaling 3 sets, are estimated.
Industrial housing complex (small factories)	:	One set for manager, and 1 set for reception desk and business use, totaling 2 sets, are estimated.
Residences	:	In the Master Plan, the number of telephones for residential use in 2002 is estimated, on the basis of the population index of governmental officials accounting for 15%, agricultural population 1.3%, labourers 0.6%, commercial 20% and others 30%.

However, it was difficult to confirm occupation of individual households at the time of field survey. In addition, objective areas of this Project are located in the vicinity of respective prefectural seat. In view of the above, an interview survey was made on a sampling basis, instead of the method employed by the Master Plan.

As a result, one third of the households in each objective area expressed their

intention of telephone subscription. A further study was made, on the basis of the survey results and the data on waiting applicants of each existing exchange, and it is judged suitable to install 1 set of telephone for each 5 households. Hence, 1 set for each 5 doors is estimated.

For the calculation of the number of doors, the fact that in Phuentsholing, most of the people live in apartments is taken into consideration, assuming that an apartment is five-storied, with 4 doors on each floor, on an average, that is, an apartment accommodates 20 doors.

Through the above study, the demand in Phuentsholing was estimated to be 2,045, which is almost equal to the requested capacity, 2,000, and also the Master Plan's demand forecast, 2,000. Hence the capacity requested for Phuentsholing Exchange is judged appropriate. However another factor is also taken into consideration in our study, that is, four new factory areas constructed in the vicinity of Phuentsholing Exchange after the preparation of the Master Plan. To cover the demand in these areas an optimum capacity is set at 2,200 (refer to Figure 3-1 Demand Survey in Phuentsholing).

For other objective exchanges a study was made as follows:

For the exchanges of which capacities are estimated in the Master Plan, a comparative study was made among the requested capacities, demand forecast in the Master Plan and the demand estimated based on field survey results. As a result, the demand estimated by the field survey findings are judged most appropriate, and based on this demand, optimum capacities were determined.

For the exchanges not studied in the Master Plan, a comparative study was made between the requested capacity and the field survey results. Since the field survey results were judged appropriate, optimum capacities were determined, based on such data.

The survey results were rounded in calculation of optimum capacities.

Capacities requested by DOT, demand forecast in the Master Plan, current visible demand, survey results, optimum capacities, etc. are list in the following:

Objective Exchange	Requested Capacity	Master Plan (Y2002)		Visible Demand			Survey Results	Optimun Capacity	Switching System	No. of Terminated Cable Pairs*2
		Demand Forecast	Switch. L/U	Existing Subs.	Waiting Applicants*1	Total				
Phuentsholing	2,000	1,801	1,000 +1,000	764	1,216	1,980	2,045	2,200	LS	1,800 +1,200
Penden Cement	-	-	-	-	-	-	50	50	DRCS	-
Tala	-	-	-	-	-	-	50	50	DRCS	-
Gedu	-	-	-	-	-	-	50	50	DRCS	-
Pasaka	-	-	-	-	-	-	52	50	DRCS	-
Samtse	1,000	1,293	500	76	306	382	402	400	LS	400
Paro	500	595	300	236	249	485	509	900	LS	650
Tashiyangtse	-	-	-	-	38	38	49	50	DRCS	60
Gasa	-	-	-	-	32	32	44	40	DRCS	60
Chimakoti	200	-	-	37	147	184	206	200	DRCS	300
Wangdue Phodrang	300	273	-	75	213	288	301	300	RSU	350
Punakha	200	192	-	40	244	284	310	300	RSU	400
Haa	200	221	-	45	138	183	213	200	DRCS	250

Note *1: Waiting Applicants ..... Based on the waiting lists of the existing exchanges and the data obtained by interviews at sites.

*2: Number of Terminated Cable Pairs ..... Based on the field survey results.

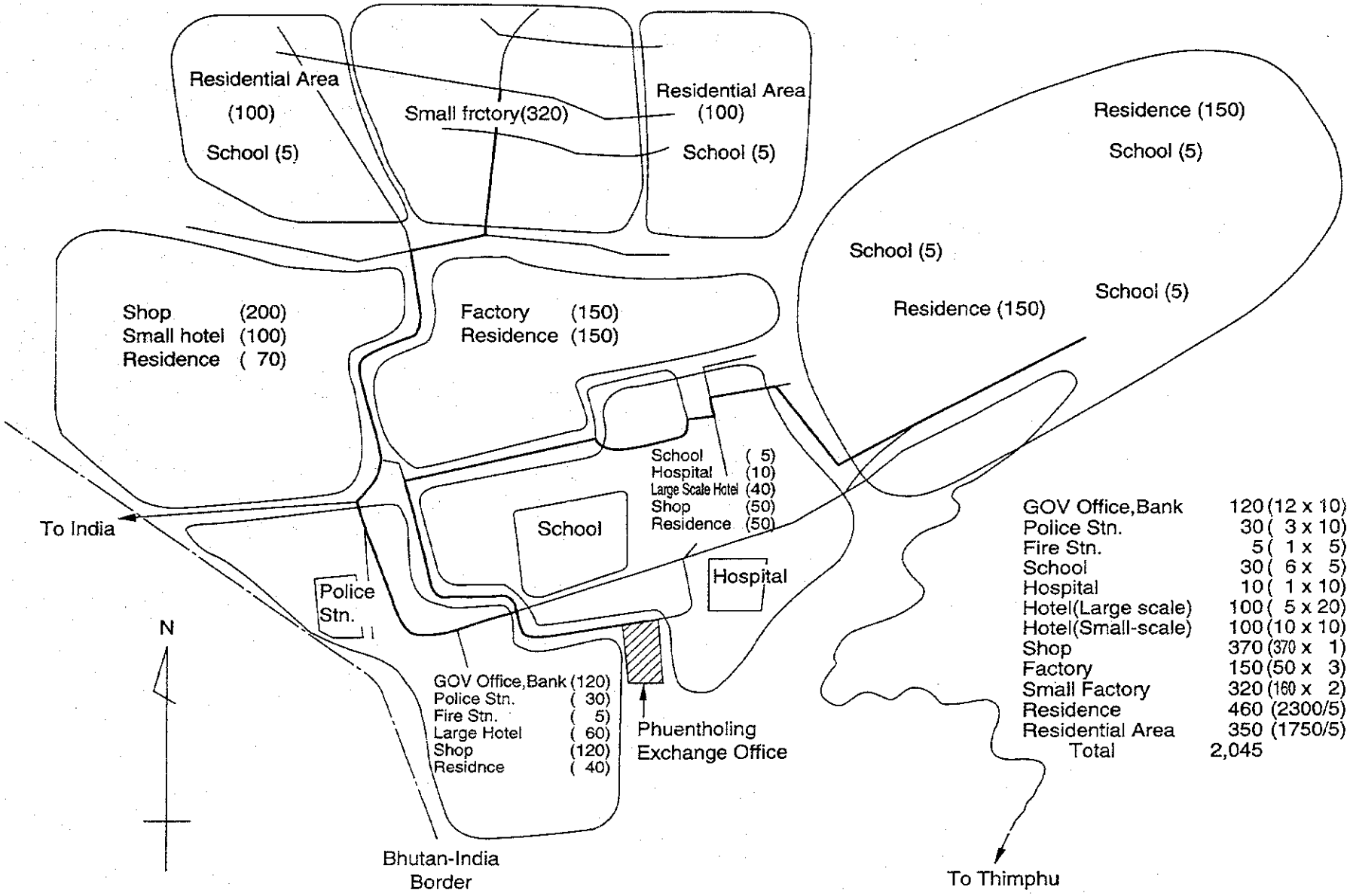
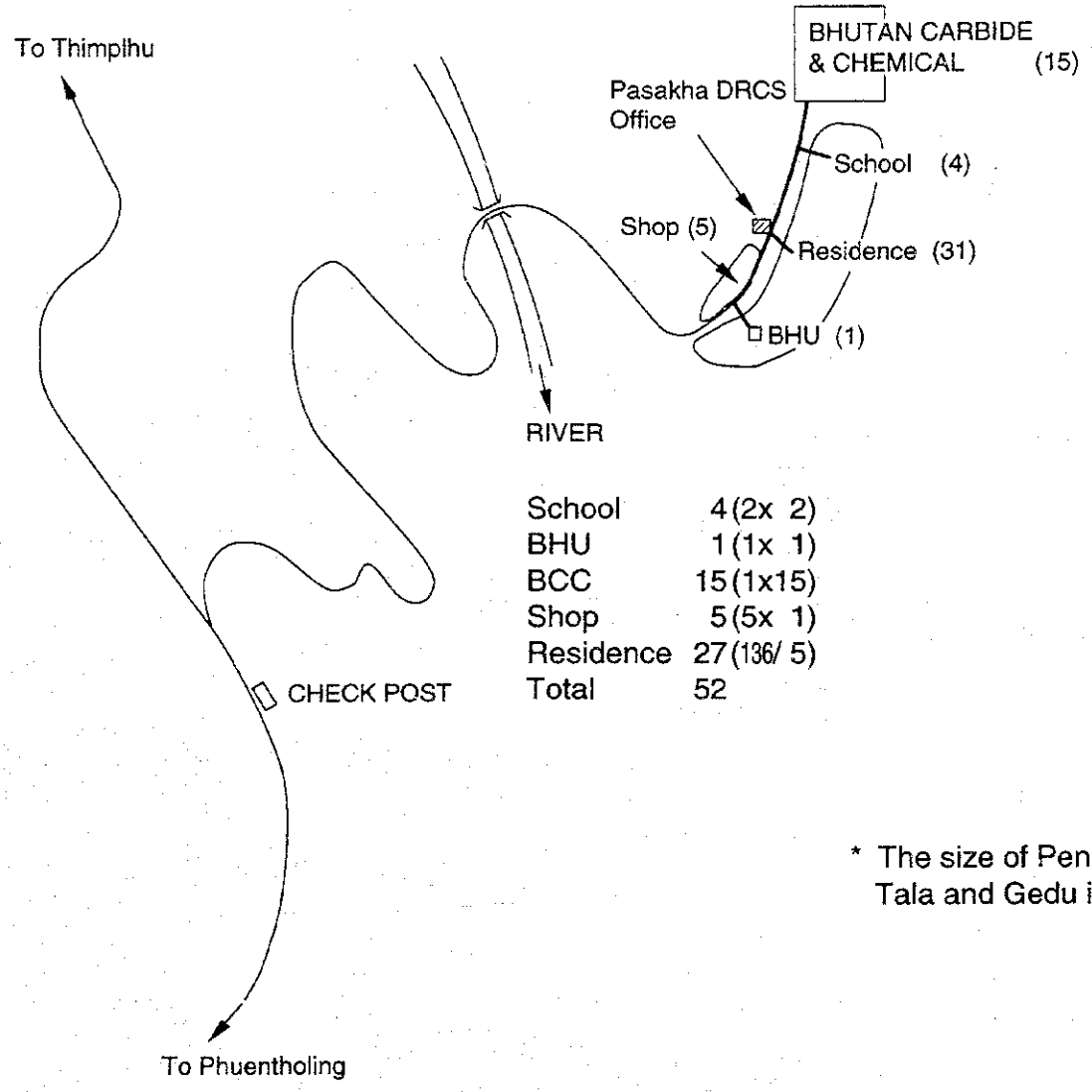


Figure 3-1 Demand Survey in Phuentsholing



* The size of Penden Coment ,
Tala and Gedu is same as that of Pasakha.

Figure 3-2 Demand Survey in Pasakha

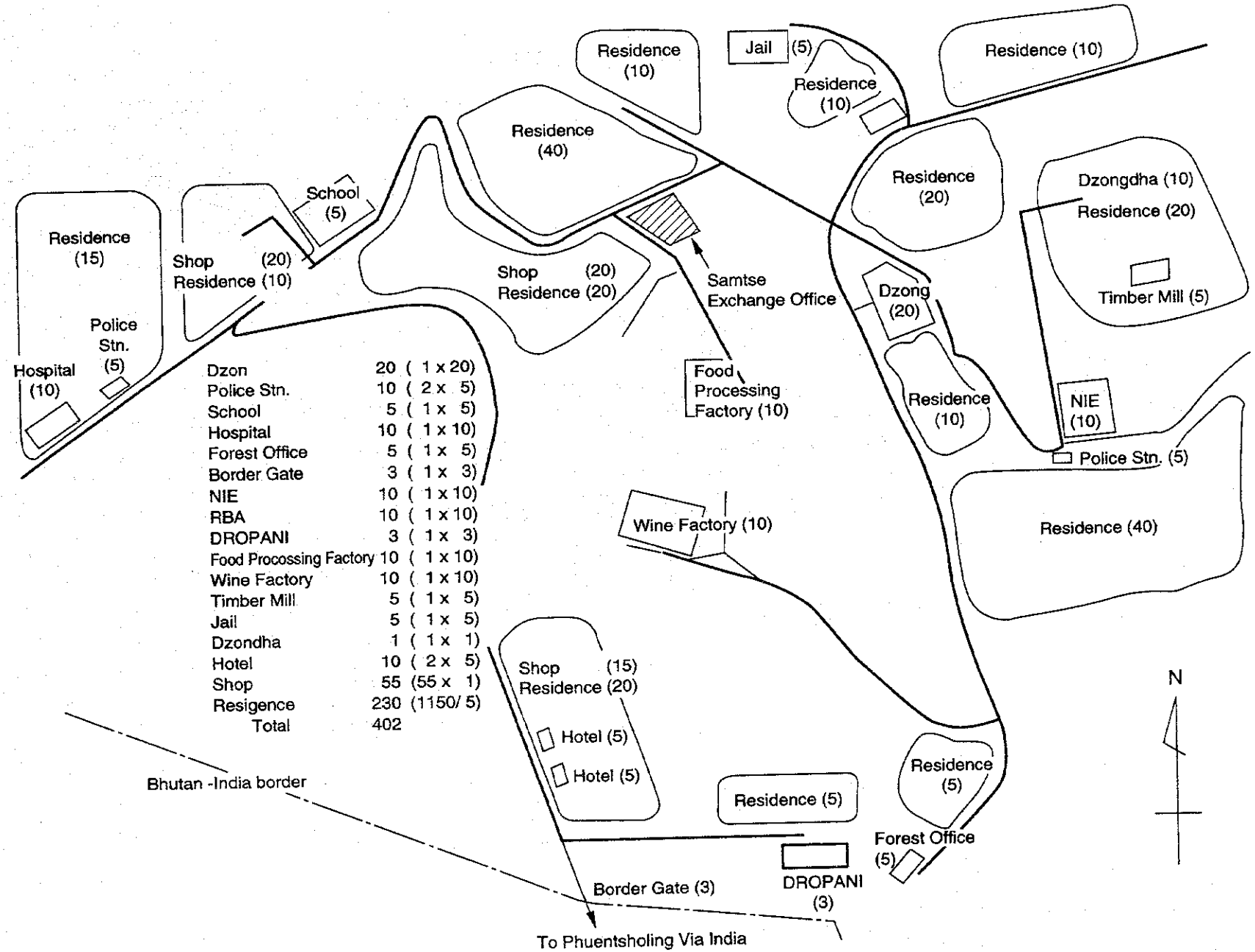


Figure 3-3 Demand Survey in Samtse

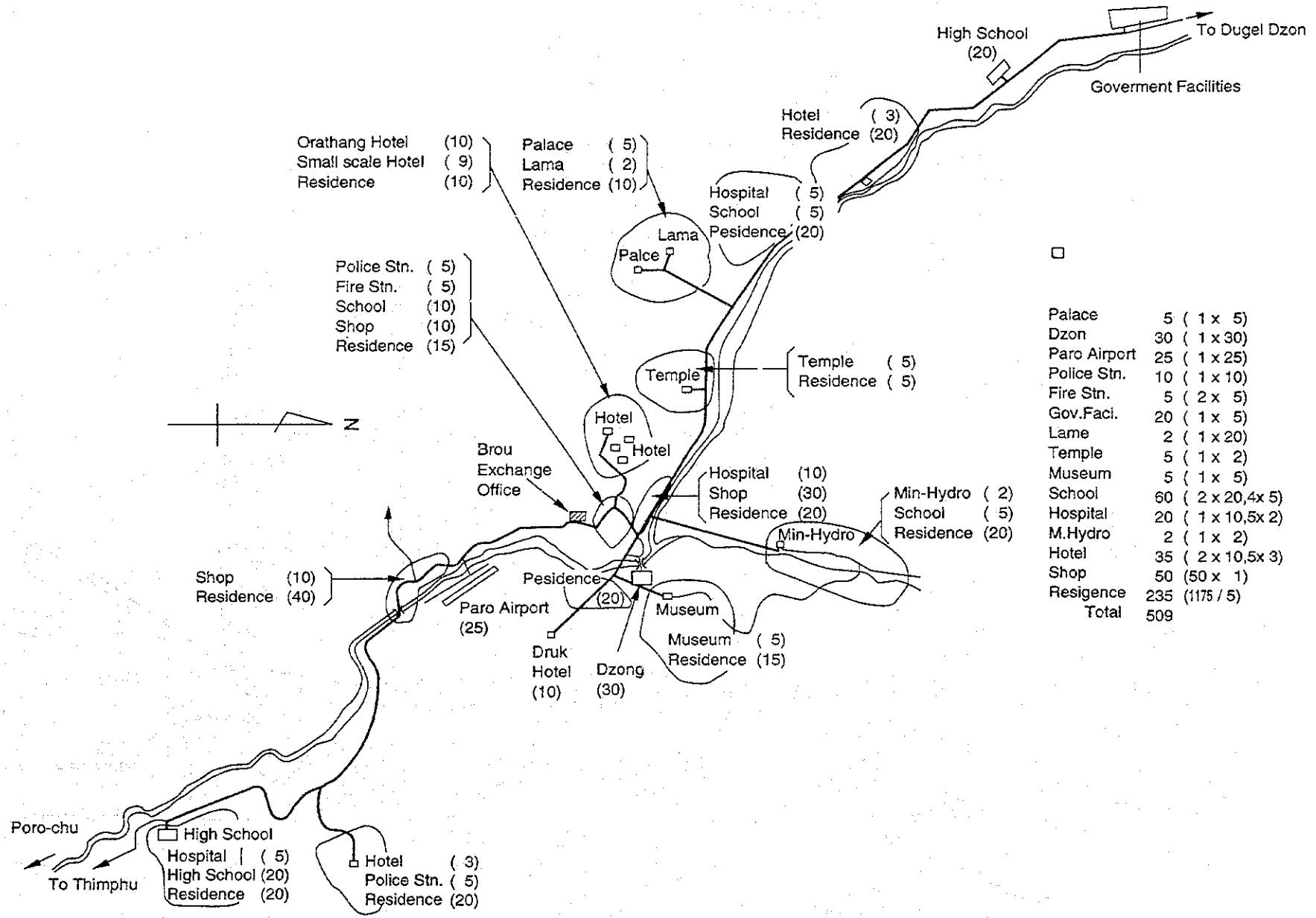


Figure 3-4 Demand Survey in Paro

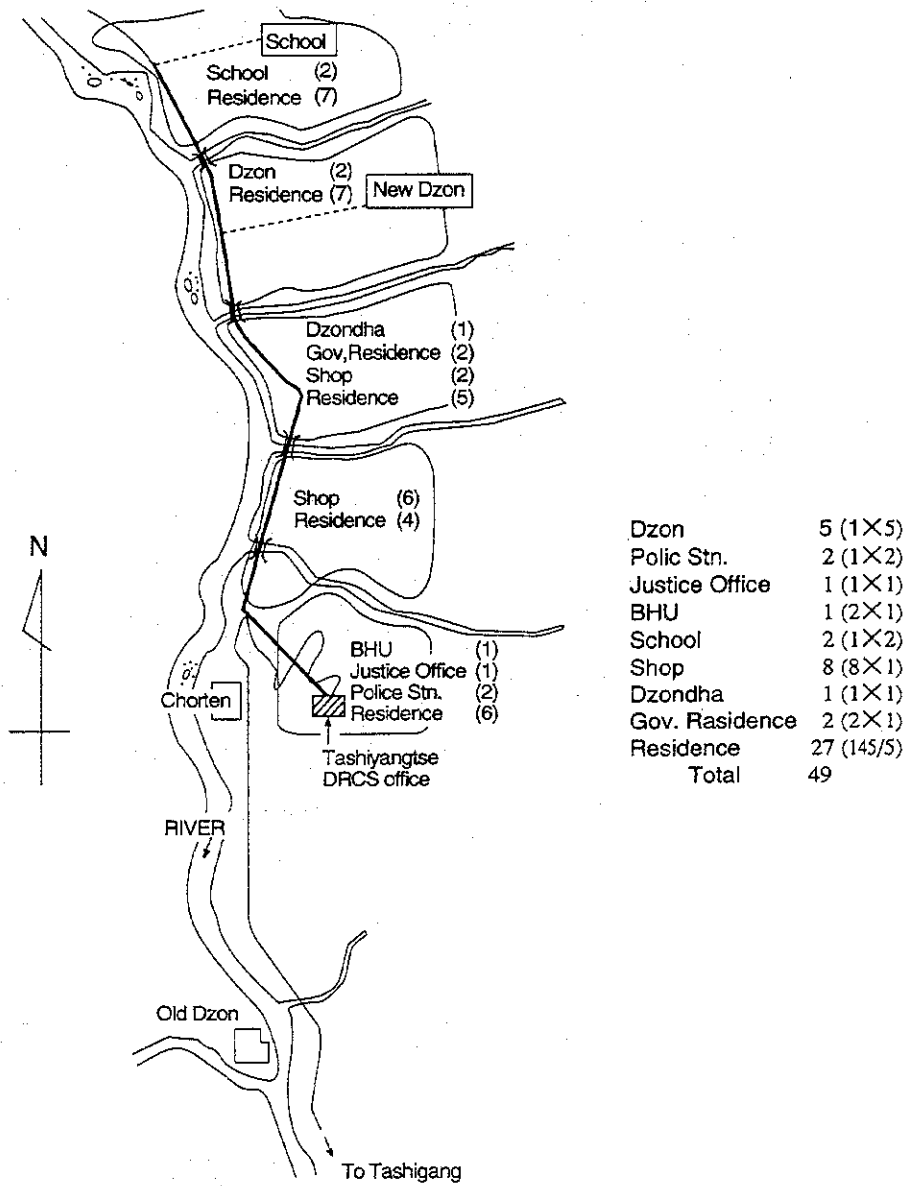


Figure 3-5 Demand Survey in Tashiyangtse

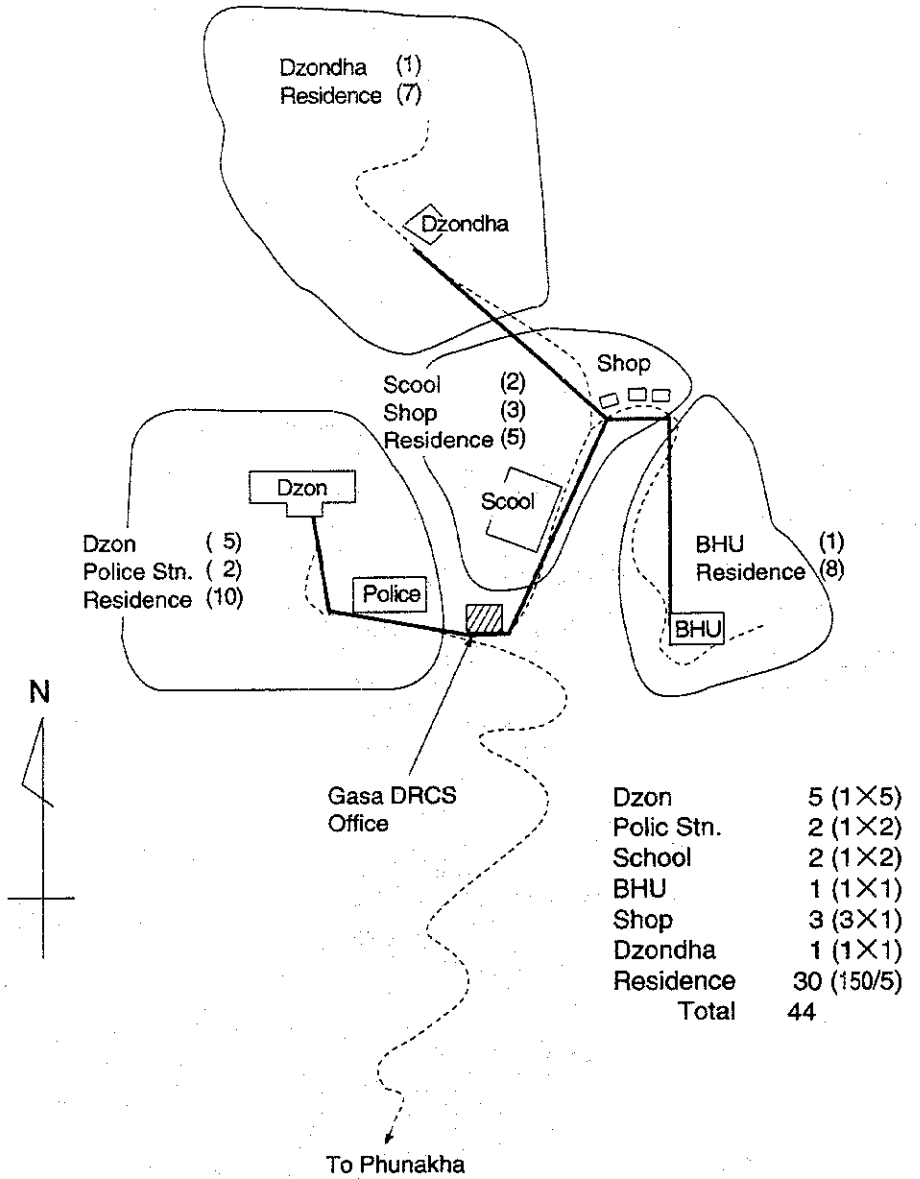


Figure 3-6 Demand Survey in Gasa

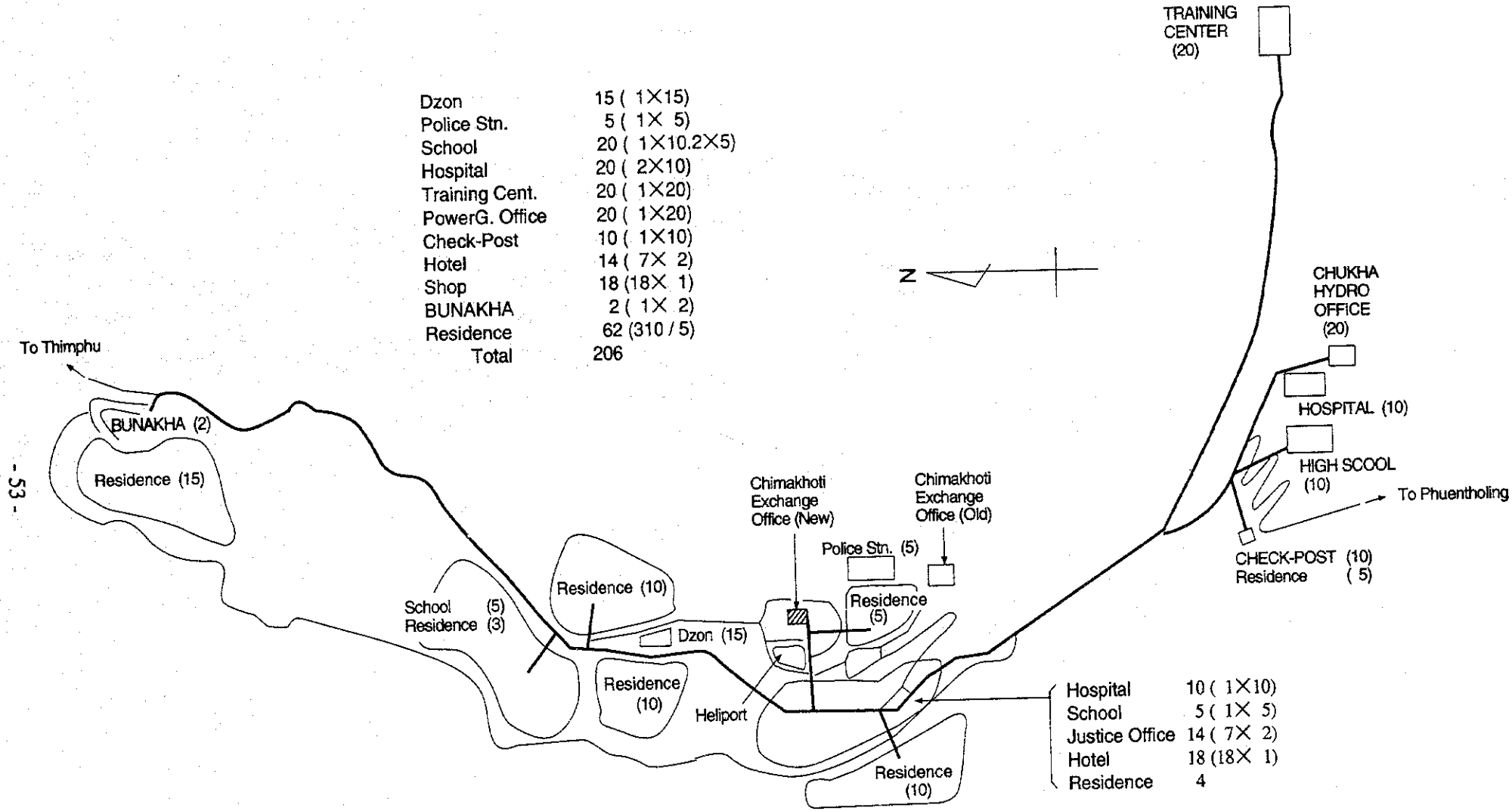
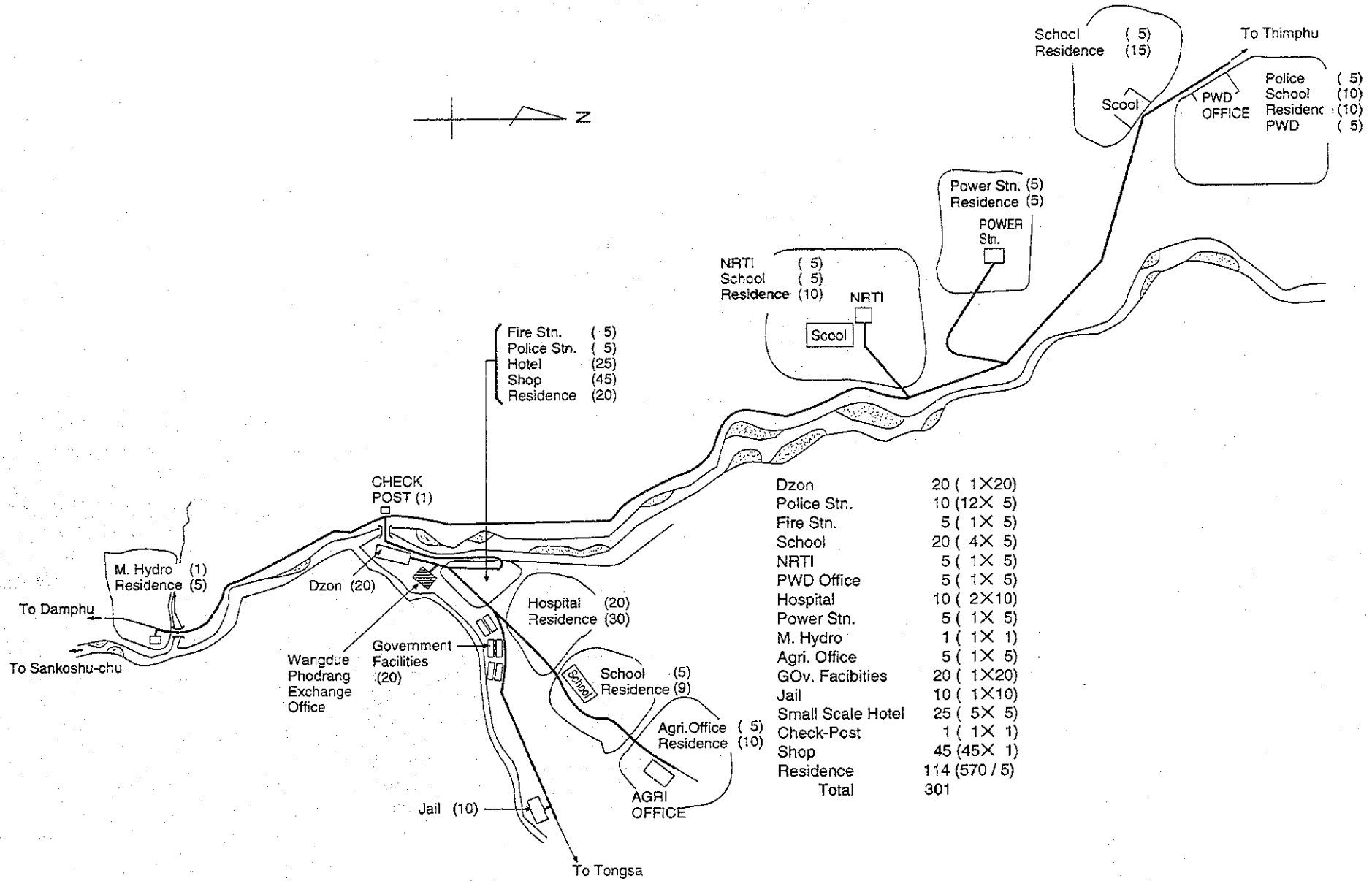


Figure 3-7 Demand Survey in Chimakoti



Dzon	20 (1X20)
Police Stn.	10 (12X 5)
Fire Stn.	5 (1X 5)
School	20 (4X 5)
NRTI	5 (1X 5)
PWD Office	5 (1X 5)
Hospital	10 (2X10)
Power Stn.	5 (1X 5)
M. Hydro	1 (1X 1)
Agri. Office	5 (1X 5)
GOv. Facibities	20 (1X20)
Jail	10 (1X10)
Small Scale Hotel	25 (5X 5)
Check-Post	1 (1X 1)
Shop	45 (45X 1)
Residence	114 (570 / 5)
Total	301

Figure 3-8 Demand Survey in Wangdue Phodrang

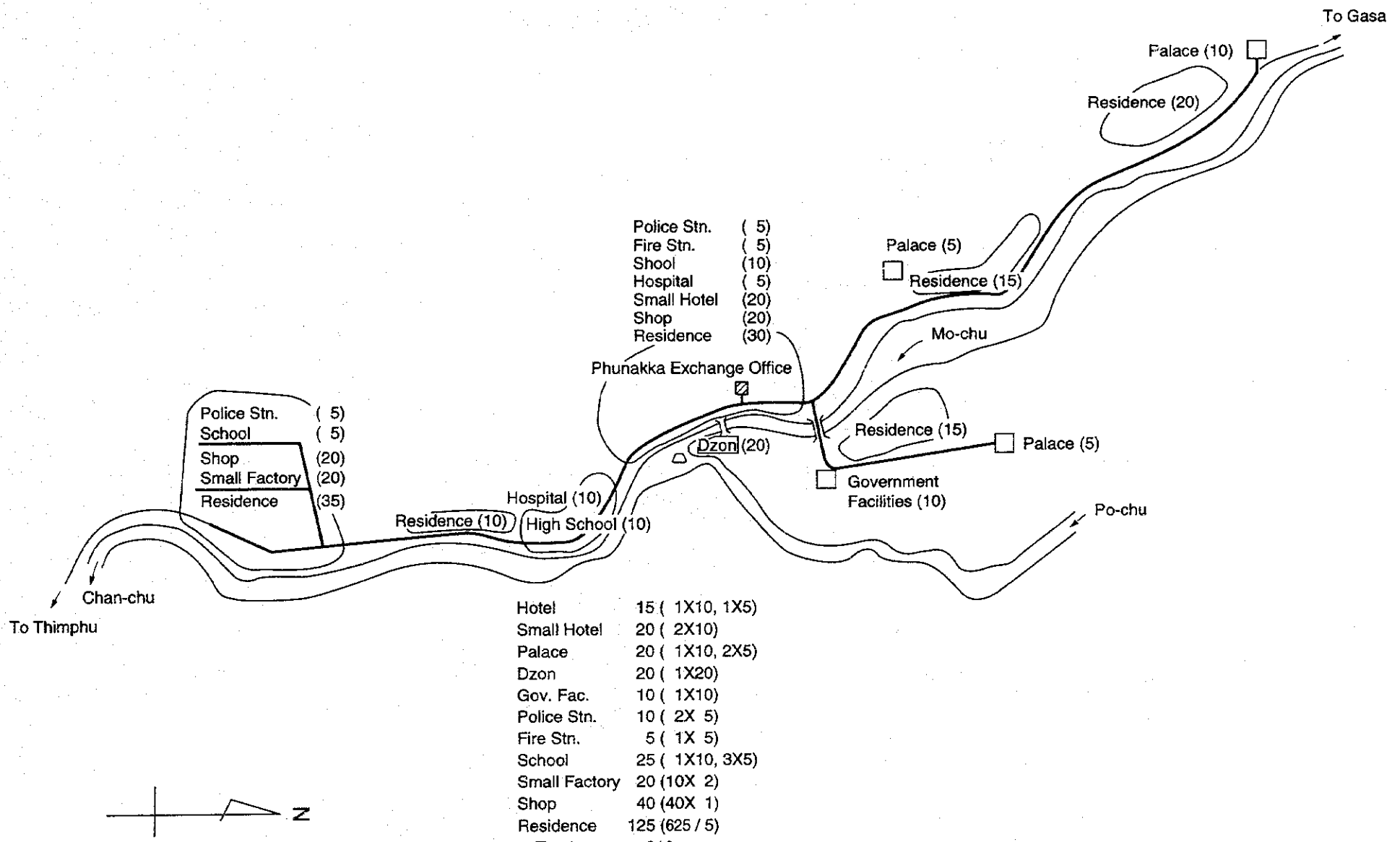


Figure 3-9 Demand Survey in Punakha

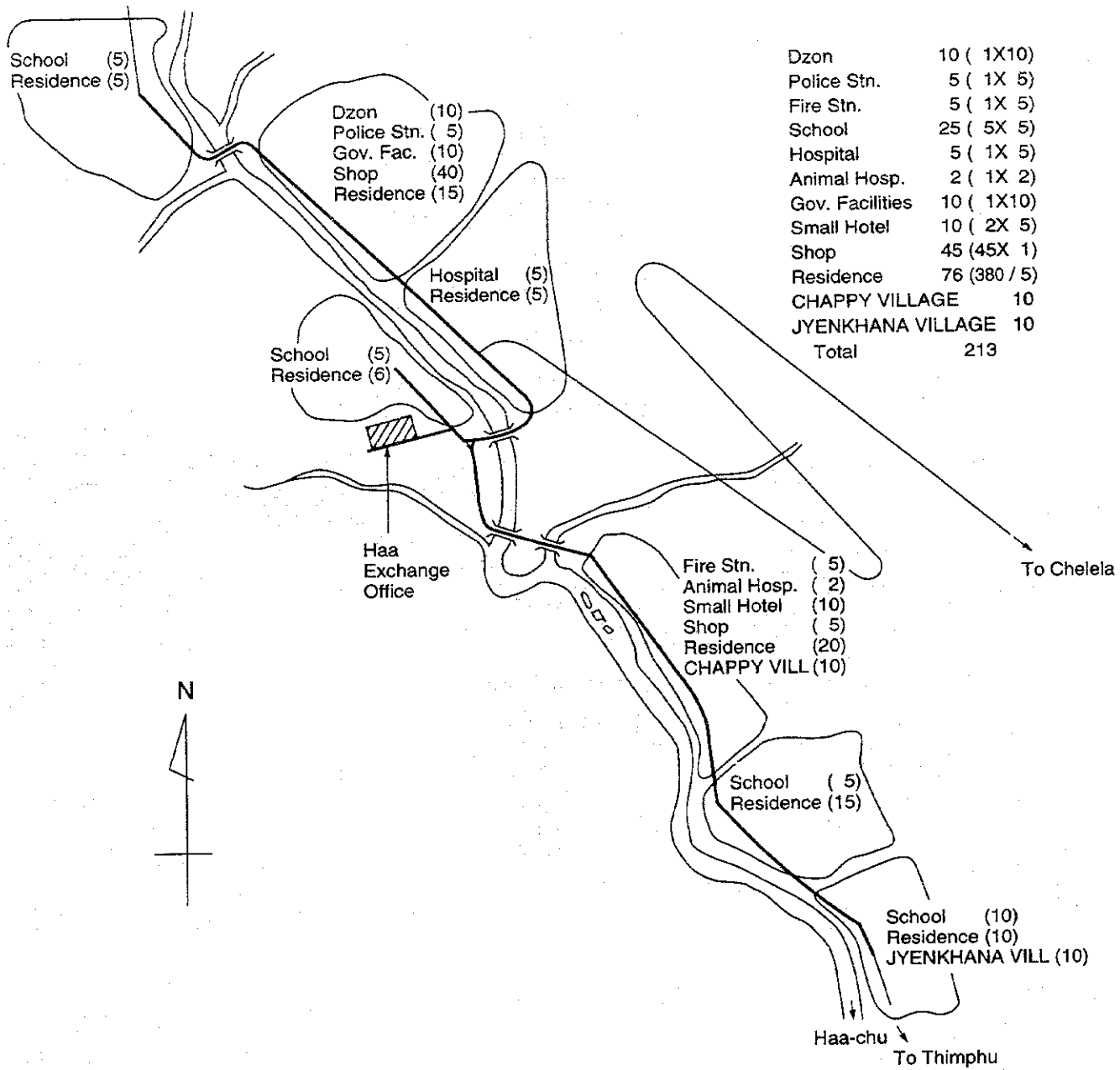


Figure 3-10 Demand Survey in Haa

(2) Switching System

On the basis of the optimum capacity of each exchange obtained through the foregoing study and by referring to the table of switching system application given in Figure 3-11, local switch (LS) will be adopted for Phuentsholing, Samtse and Paro, RSU for Wangdue Phodrang and Punakha, and DRCS for Tashiyangtse, Gasa, Chimakoti and Haa.

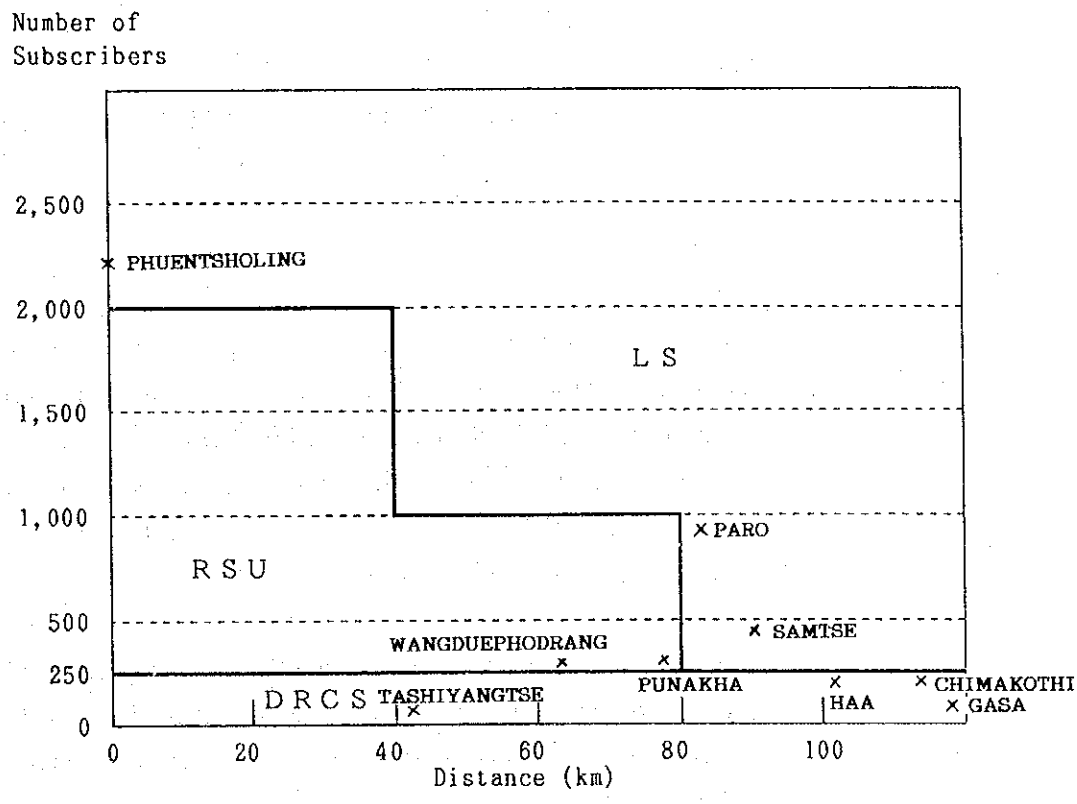


Figure 3—11 Switching System Application

(3) Calling Rate

A study on the calling rate per subscriber at the busy hour after the completion of this Project was made as follows, based on the data obtained through the field survey, the Master Plan prepared by ITU, CCITT (The International Telegraph and Telephone Consultative Committee) GAS Handbook issued by ITU, etc.:

1) Actual traffic data measured at Tongsa Exchange (total number of subscriber lines: 120) at the time of the field survey are as shown below:

Investigation Date	Number of Originating Calls	Number of Completed calls	Call Completion Ratio
Oct. 29, 1994	3,624	1,013	28.0%
Oct. 31, 1994	3,764	1,125	29.9%
Nov. 1, 1994	3,705	1,106	29.9%

As can be seen from the above, the average call completion ratio per day is approximately 30%. Such low completion ratio is probably due to subscribers' habitual mal-operation in dialling and poor telecommunications facilities in the Western region. The ratio at the busy hour is expected to be improved to 50% with the provision of new facilities under this Project.

The calling rates per subscriber when the call completion ratio has been improved to 50% and 60% after the completion of this Project can be estimated to be 0.080 Erl. and 0.107 Erl., respectively, by the following formula:

$$CR = TC \times BCR \times CCR \times MT \times CD \div TS \div 3{,}600 \text{ sec}$$

where

CR : Calling rate (in Erlang)
TC : Total number of calls
BCR : Busy hour concentration ratio
CCR : Call completion ratio at busy hour (%)
MT : Mean holding time of completed calls
CD : Call distribution ratio by type (local, toll, and

international)

TS : Total number of subscribers

For the above, the following has been assumed:

Calls		Mean Holding Time	Busy Hour
Type	Percentage	of Completed Calls	Concentration Ratio
Local	60%	90 sec	20%
Toll	38%	120 sec	20%
International	2%	180 sec	20%

In the World Telecommunications Development Report, 1994, published by ITU, the local call completion ratio in Bhutan is reported as 56%.

2) In the Master Plan, the calling rate was estimated to be 0.1 Erl., in consideration of the following, since there were no actual traffic data and, in addition, the facilities were being operated independently of each other, not composing a network as a whole:

- Almost all the telephones are for business use, with a small percentage of residential use telephones.

- The number of calls by public telephones is relatively large and even residential telephones are often used like "public telephones." Under such circumstances, the busy hour of public, residential and business use telephones concentrates in the same time zone.

- The busy hour for administration service calls is also the same with that for business use calls.

3) In CCITT GAS 9 Handbook B, 1988, issued by ITU, there is a description that in some area the originating calling rate per subscriber reaches 0.08 Erl.

4) In the Report by the Study Committee for Rural Telecommunications System in Developing Countries (March 1986), organized jointly by the Ministry of Posts and Telecommunications and a number of

telecommunications companies in Japan, it is mentioned that "in the rural areas, calling rate of public telephones is 3 times the rate of the business use telephones in general, with higher calling rate per subscriber as compared with urban areas."

5) According to CCITT GAS 10 Handbook (Planning Data and Forecasting Methods - Case Studies) 1987, the calling rate per subscriber at Kiunga Exchange in Papua New Guinea accommodating 184 subscriptions is 0.102 Erl. and that at Tabubil Exchange having 516 subscriptions is 0.110 Erl. These exchanges are similar to the objective exchanges of this Project in demand volume.

From the above it can be seen that when the number of subscribers is small, the calling rate tends to increase.

According to the results of our field investigation, main subscribers of the objective exchanges are governmental agencies, banks and police stations which are closely related to public services, and enterprise and factory owners. In addition, residential telephones also are usually used like public telephones by nearby inhabitants.

In view of the above study results, the calling rate per subscriber is set at 0.1 Erl., i.e., at a rather high rate, considering that call completion rate of better than 50% can be achieved.

As for toll calls, 20% of 0.1 Erl. is estimated for Thimphu and Phuentsholing, and 40% for other exchanges in rural areas. For special service calls, a constant of 0.001 Erl., and for outgoing international calls, a constant of 0.002 Erl. are estimated. Both, however, are considered to be included in the abovementioned 0.1 Erl.

(4) Inter-Office Traffic Matrix

The inter-office traffic matrix necessary for calculation of the number of circuits between exchanges is given in the following page.

The matrix has been prepared in accordance with the gravity models given in the Formulation of Traffic Matrix in CCITT GAS Handbook, General Network Planning, 1983, issued by ITU.

That is, coefficients of affinity, C (i,j) between exchanges, i and j, are calculated from the distance between exchanges, by applying the following formula (1), and traffic flows f (i,j) are calculated by the formula (2):

$$C(i,j) = \frac{1}{d^{a}(i,j)} \quad \ldots\ldots (1)$$

$$f(i,j) = \frac{C(i,j) \cdot Di \cdot Dj}{\sum_{j} C(i,j) \cdot dj} \quad \ldots\ldots (2)$$

where

C (i,j) : Coefficients of affinity between Exchange i and Exchange j
f (i,j) : Traffic flows between Exchange i and Exchange j
Di : Outgoing toll traffic of Exchange i (calling rate x number of number of subscriber lines x toll call ratio)
Dj : Outgoing toll traffic of Exchange j (calling rate x number of subscriber lines x toll call ratio)

INTER-OFFICE TRAFFIC MATRIX

(unit: Erlang)

		Incoming								
		Thimphu	Phuentsholing	Samtse	Paro	Tongsa	Geylegphug	Tashigang	S. Jongkhar	Total
O	Thimphu		14.91	4.47	34.17	6.88	4.34	4.17	3.87	72.80
u	Phuentsholing	16.61		8.52	8.84	3.03	2.79	2.42	1.80	44.00
t	Samtse	4.01	6.87		2.41	0.75	0.67	0.64	0.65	16.00
g	Paro	23.21	5.40	1.82		1.87	1.28	1.27	1.16	36.00
o	Tongsa	8.46	3.34	1.02	3.39		2.71	3.14	2.58	24.64
i	Geylegphug	5.37	3.10	0.92	2.32	2.72		2.25	2.53	19.20
n	Tashigang	7.24	3.78	1.23	3.24	4.43	3.15		10.28	33.36
g	S. Jongkhar	7.03	2.93	1.32	3.09	3.81	3.71	10.75		32.64
	Total	71.94	40.34	19.29	57.46	23.49	18.64	24.62	22.86	278.64

The number of required circuits between objective exchanges is estimated, based on these traffic data and by applying loss probability of Erlang B formula, 1/100, as follows:

Number of Circuits between Exchanges

	Thimphu	Phuentsholing	Samtse	Paro	Tongsa	Geylegphug	Tashigang	S-Jongkhar
Thimphu	-	24	11	46	14	10	10	10
Phuentsholing	26	-	16	16	8	8	7	6
Samtse	10	14	-	7	4	4	4	4
Paro	34	12	6	-	6	5	5	5
Tongsa	16	9	5	9	-	8	7	8
Geylegphug	12	8	5	7	8	-	7	8
Tashigang	14	9	5	9	10	9	-	18
S-Jongkhar	14	8	5	8	10	9	19	-

Long distance calls of 4 routes, i.e., Thimphu~Phuentsholing, Paro~Phuentsholing, Paro~Samtse, and Thimphu~Samtse, are transmitted via Thimphu and Phuentsholing Exchanges. Hence, the required number of circuits between Thimphu and Phuentsholing becomes 112, as shown below:

Thimphu ~ Phuentsholing	:	24
Phuentsholing ~ Thimphu	:	26
Paro ~ Phuentsholing	:	12
Paro ~ Samtse	:	6
Thimphu ~ Samtse	:	11
Phuentsholing ~ Paro	:	16
Samtse ~ Paro	:	7
Samtse ~ Thimphu	:	10
Total	:	112

The number of circuits for Phuentsholing~Samtse and Thimphu~Paro routes was calculated in the same way. As a result, the number of required circuits between the objective exchanges becomes as follows:

Thimphu - Phuentsholing	:	112
Phuentsholing - Samtse	:	100
Thimphu - Paro	:	175

(5) Transit (Tandem) Switching System (Thimphu)

The existing switching system in Thimphu Exchange is a combined exchange equipped with such multi-function as local, long distance, and international switching.

Since it is physically difficult to add a toll transit function to this system to connect the Western region, the installation of a new tandem system is planned to cater for toll transit.

In addition, it is recommendable from the operation and maintenance standpoint to transfer the international switching function to this tandem switching.

(6) Signalling System

For the subscriber signalling system, both the dial pulse (DP) and push button (PPB) systems are adopted, in consideration of the compatibility with the telephones used in the Kingdom. For the inter-office signalling system, CCITT R2 system is adopted since the existing system is based on this system and the adoption of other system which necessitates the modification of the existing facilities is not advisable. It is so designed that, No. 7 system can be introduced in the future.

(7) Numbering Plan

The following numbering plan is adopted, in consideration of the compliance with the existing numbering system adopted by DOT and also the population in the Kingdom.

International call prefix	:	00
Domestic long distance call prefix	:	0 (+Y)
Y	:	Area code (1 digit)
Western region	:	02
Central region	:	03

Eastern region	:	04
Subscriber number	:	ZZXXXX (6 digits)
ZZ	:	Exchange code (2 digits)
Special number	:	1XX (emergency calls for ambulance, police station, and others)

(8) Charging System

A detailed billing system is now adopted by DOT for charging. By this Project, a standard charging system, i.e., the automatic message accounting (AMA) system is to be employed. Data of detailed bills of each exchange are recorded on magnetic tapes (MT) and sent to Thimphu, where the data are processed. The data thus processed are printed in the form of bill and sent back to each exchange.

(9) Service Grade

The switching system to be introduced is capable of accommodating PBX (private branch exchange), public telephones, and general subscribers. Public telephones are of either coin or card type.

(10) Modification of Existing Switching Systems

In order to interconnect the switching systems installed under the previous project and those to be installed under this Project, modification of the software of all the existing systems is taken into account.

(11) Switching Equipment Block Schematic

Switching Equipment Block Schematic is given in the Design Data (pages 14 through 20).

3.2.2 DRCS

(1) DRCS to be installed is in compliance with the local grade of ITU-Recommendation in circuit quality. The occurrence probability of fading is also in compliance with ITU-R Recommendation.

(2) For DRCS, frequency band, 1.5 - 2.6 GHz, is utilizable. However, 2.4 GHz band is adopted for the system installed by the previous project, and the same 2.4 GHz band will be employed for this Project also for the purpose of frequency management.

(3) Antenna height above the ground is calculated, based on the following A and B, in accordance with ITU-R Report, and whichever higher is adopted.

A: K = 4/3, Clearance coefficient > 0.6
B: K = 2/3, Clearance coefficient > 0.3

(4) Each base station is equipped with the function of remote control and supervision of repeater stations and subscriber radio terminal stations belonging to it.

(5) The basic design is made, based on the following specifications, which are the same with the previous project:

Radio frequency	:	2.4 GHz
Transmitter output power	:	31.5 dBm
Minimum receiver input level	:	-92 dBm (10^{-3}BER)
Non-directional antenna gain	:	10 dB
Horn antenna gain	:	20 dB
Channel frequency spacing	:	4 MHz
Spacing between transmitting and receiving frequencies	:	94 Mhz
Modulation system	:	4 PSK

(6) DRCS Equipment Block Schematic is given in the Attached Data (pages 11 through 13).

3.2.3 Digital Radio Transmission System

(1) The required number of circuits between objective exchanges calculated in 3.2.1 (4) above can be converted in terms of transmission bit rate, 2 Mbit/s (30 circuits), as follows:

<u>For Local switches in Phuentsholing, Samtse and Paro</u>

Thimphu - Phuentsholing	4 x 2 Mbit/s
Phuentsholing - Samtse	4 x "
Thimphu - Paro	6 x "

For Punakha and Wangdue Phodrang which are RSU with Thimphu as their parent exchange

Thimphu - Punakha	3 x 2 Mbit/s
Thimphu - Wangdue Phodrang	3 x 2 Mbit/s

For Chimakoti and Haa which are terminal stations of DRCS connected to their base station, Paro, via Japjekha

Paro - Japjekha	4 x 2 Mbit/s

For Gasa which is a terminal station of DRCS connected to its base station, Thimphu, via Dochula

Thimphu - Dochula	2 x 2 Mbit/s

The optimum transmission capacity between objective exchanges obtained based on the above is as follows (refer to Figure 3-12):

Thimphu	- Japjekha	- Takti - Phuentsholing	34 Mbit/s
	Japjekha	- Paro	8 Mbit/s
		Takti - Samtse	8 Mbit/s
Thimphu	- Dochula		34 Mbit/s
	Dochula - Punakha		8 Mbit/s
	Dochula - Wangdue Phodrang		8 Mbit/s

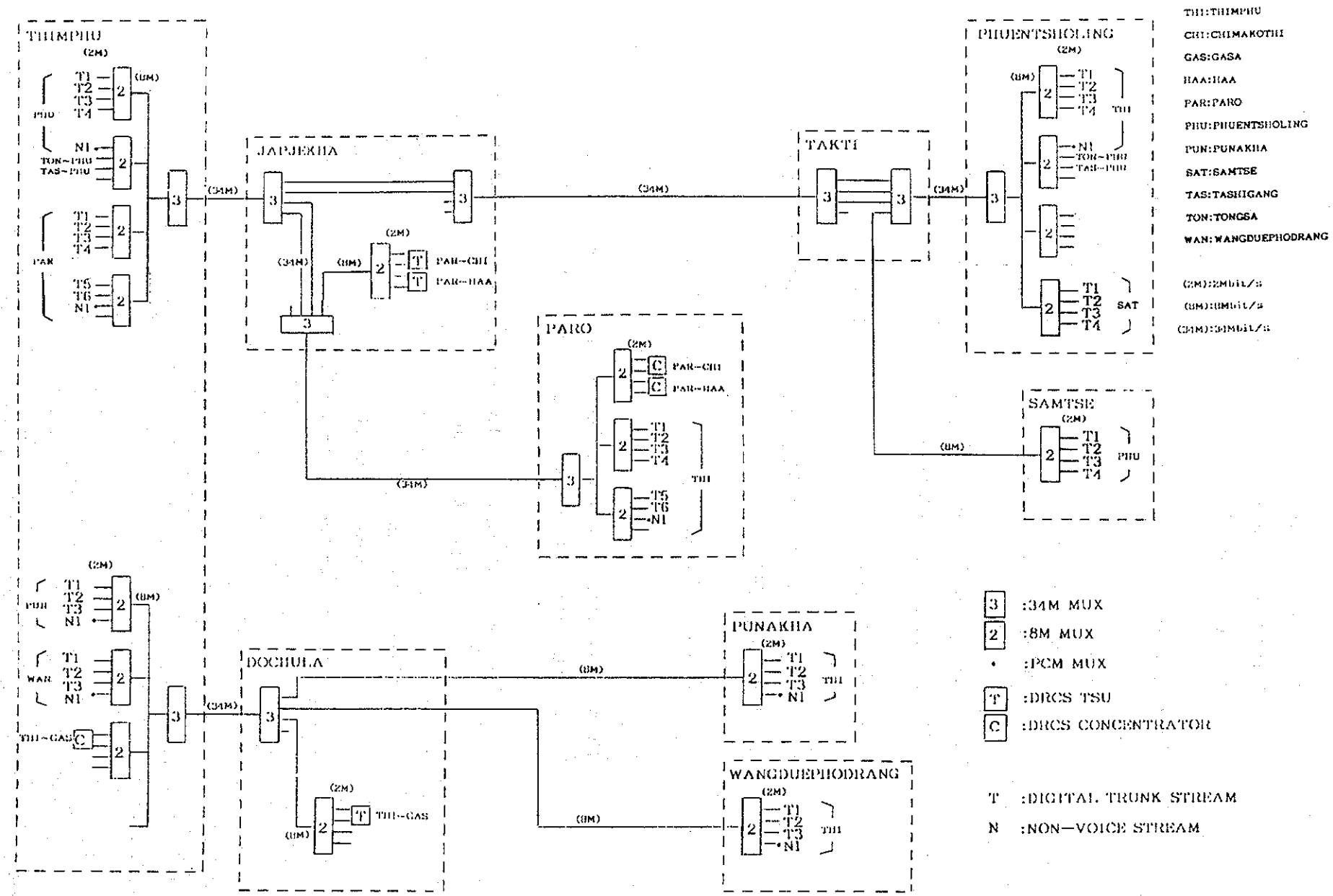


Figure 3—12 Multiplex Arrangement Plan

(2) For transmission system, the line-of-sight digital radio system is adopted.

(3) The circuit quality of a digital radio transmission link is in compliance with ITU-R Recommendations. Occurrence probability of fading should also meet ITU-R Report.

(4) The antenna height (including a reflector) above the ground can meet the requirements that clearance coefficient should be 1.0 or better with K=4/3, in compliance with ITU-R Report.

(5) Design Specifications

The basic design is made, based on the following specifications, which are the same with the previous project:

Radio frequency	:	8 GHz (backbone route) 8.3 GHz (spur routes)
Transmission capacity	:	34 Mbit/s (backbone route) 8 Mbit/s (spur routes)
Modulation system	:	4 PSK
Transmitter output power	:	+30 dBm or +20 dBm
Minimum receiver input level	:	-83 dBm (10^{-3}BER) (backbone route) -89 dBm (10^{-3}BER) (spur route)

(6) With a view to minimizing the number of operation and maintenance personnel to the least, a remote control system is introduced. Transmission systems of local exchanges and repeater stations are remotely supervised and controlled from Thimphu Exchange (Master Supervisory Station) installed by the previous projects, and Phuentsholing Exchange (Sub-Master Supervisory Station) to be installed by this Project, for detection of faulty circuits, control of circuit switchover, etc.

(7) In the Design Data, the following are presented:

- System Configuration of Order Wire System 10
- Coordinates of Objective Sites ..... 54 ~ 55
- Antenna Information ..... 56 ~ 57
- Transmission Engineering ..... 58 ~ 62
- Path Profile ..... 63 ~ 85
- Site Location ..... 86 ~101

3.2.4 OSP

(1) Cables are manufactured in such types as 10, 20, 30, 50, 100, 150 and 200 pairs. This means that cables which are precisely the same in capacity with the requirements can not necessarily be obtained. In addition some margin to cover cable faults should be taken into account

Hence optimum quantity of cables is considered to be such that it corresponds to 1.2-1.5 times the switching system capacity. For terminated cable pairs of each exchange, the necessary number of cable pairs is calculated as shown in the list given in 3.2.1 above.

Local Cable Plan based on the survey results is given in the Design Data (pages 102 through 110).

(2) In the same way as the previous project, only the supply of necessary equipment and materials is undertaken by the Japanese side. The quality of cables to be supplied is in compliance with ITU-R Recommendations.

(3) The construction work and maintenance services for the telecommunications systems in the Kingdom are being carried out inefficiently, with inadequate consideration for safety. Insufficiency in transportation means and necessary goods for safety is also observed. To cope with this problem, transportation means and necessary goods will be supplied to cover the basic necessities.

3.2.5 Power Supply System

Power supply system is required to feed power to telecommunications facilities to ensure continuous and stable operation of the facilities. Design criteria of the power supply system are described below:

The following three types of power supply systems are adopted for the objective

sites, depending on the availability of commercial power at each site. Power Supply Equipment Block Schematic is given in the Design Data (pages 21 through 25).

Full floating system with commercial power as the primary power source

This system is adopted for each telephone exchange where commercial power is available and composed of the following:

- Automatic voltage regulator
- Diesel engine generator
- Rectifying equipment
- Storage batteries

Hybrid system with combined use of solar cells and diesel engine generators

This system is adopted for a radio repeater station where a large capacity power source is required while commercial power is unavailable. Its composition is as follows:

- Solar cells
- Diesel engine generator
- Rectifying equipment
- Storage batteries

Solar power supply system of which primary power source is solar cells

This system is adopted for a DRCS station where a small capacity power source is required and composed of the following:

- Solar cells
- Storage batteries

In addition to the above, the following backup power system is supplied to provide for the emergency cases.

- Mobile diesel engine generator
- Portable diesel engine generator and rectifying equipment

Design criteria for the above systems are as described in the following. Future

system expansion and meteorological conditions are also taken into consideration. The commercial power supplied in the Kingdom is nominal 415V, 50 Hz, 3-phase 4-wire, or 240 V, 50 Hz, single-phase 4-wire.

(1) Automatic voltage regulator

Automatic voltage regulator is capable of satisfying the maximum input capacity requirement to feed power to such loads as telecommunications facilities and other ancillary facilities including lighting.

(2) Diesel engine generator

Air-cooling type engine generator, a.c. 415 V, 50 Hz, 3-phase 4-wire or a.c. 240 V, 50 Hz, single-phase 2-wire, is adopted. Power consumption for telecommunications facilities and other ancillary facilities such as lighting is taken into account in calculating its capacity.

(3) Rectifying equipment

For calculation of the capacity of control panel, future expansion of telecommunications facilities is taken into account. One unit of rectifier equipment consists of N+1 including standby equipment. The total capacity of the unit excluding the standby one is to cover the requirements at the initial stage.

(4) Storage batteries

Two banks of 24 cells are considered necessary to provide for emergency. Battery holding time is designed to be as follows, assuming that power consumption for telecommunications facilities at the busy hour will continue without interruption:

1) Telephone exchange
(commercial power + one set of engine generator)

..... 12 hours

To keep operation until the arrival of the mobile engine generator at the time of commercial mains failure, diesel engine trouble (out of order or

overhaul, etc.), rectifier failure, AVR failure due to sudden voltage fluctuation of commercial mains, etc.

2) Radio repeater stations
(commercial power + 2 sets of engine generators)

..... 10 hours

To provide for the case of AVR failure due to sudden voltage fluctuation of commercial mains, and to keep operation even when both engine generators become inoperable, one for overhauling and the other being faulty, until one of them becomes operable.

3) Radio repeater stations
(solar cells + one set of engine generator)

..... 8 days

To provide for the case of continuous non-sunshine due to heavy fog or the rainy season, or engine generator failure (out of order or overhaul, etc.), to keep operation until the arrival of the mobile engine generator.

4) DRCS repeater stations & subscriber terminals
(solar cells only)

..... 12 days

To provide for the case of continuous non-sunshine due to heavy fog or the rainy season.

(5) Solar power supply system

No insolation data are available in the Kingdom. Under the previous project, insolation was measured in July 1994, at Yutola Repeater Station by utilizing automatic measuring equipment. Obtained data can be employed as one of useful data at the time of detail design of the solar power supply system. For this study, the capacity of the solar power supply system is designed, based on the following data employed for the previous project:

unit: Laughingly (Cal/cm^2)

Months	1	2	3	4	5	6	7	8	9	10	11	12
Insolation	216	224	256	304	344	320	296	304	272	272	248	224

(6) Mobile diesel engine generator

One set of mobile diesel engine generator is prepared to serve for several stations to supply power at the time of the commercial mains failure or non-operation of engine generator for overhaul, etc.

(7) Portable diesel engine generator and rectifier equipment

In order to supply power for maintenance work at sites where commercial power is not available, portable type, small capacity diesel engine generators are provided. For sites where solar cells only are the primary power source, rectifying equipment also is provided to enable charging of storage batteries at site.

3.2.6 Other Facilities

Main items are antenna supporting structures, prefabricated shelters and buildings. Design criteria for these items, based on the experience of the previous project are as follows:

(1) Antenna supporting structures

1) Type of structures

The results of field surveys at objective sites indicate that guyed type antenna supporting structure is not suitable, and the self-supporting type is adopted, except for the antenna for DRCS. All the self-supporting type structures are erected on the ground. For the supporting structure for DRCS antenna which is small in size, light in weight and low in height above the ground (approx. 10 m), a steel mast to be assembled at site is employed.

2) Height

For each antenna height of this Project except for DRCS antenna, 2 m is added to the height obtained through the radio transmission system analysis, in consideration of antenna size and required function as a lightning arrester.

For each reflector at a site rising to higher than 3,500 m, the height above the ground of its supporting structure is set at 3 m to avoid the propagation failure due to snow drifted in font of the reflector. Similar arrangement is made where necessary depending on the terrain of the site.

3) Composition of antenna supporting structure

Antenna supporting structure is composed of antenna tower, feeder rack, ladder, platform, lightning arrester, and earthing lead wire. A steel mast of DRCS antenna is composed of step bolts, lightning arrester and earthing lead wire only, and no feeder rack and ladder are provided.

(2) Prefabricated Shelters and Buildings

1) Objective structures

Structures to be provided by the Japanese side are prefabricated shelters to accommodate radio repeater station facilities. Facilities of telephone exchanges and DRCS base stations are to be accommodated in the buildings to be prepared by the Bhutan side (construction of new buildings and expansion of the existing buildings).

2) Type and floor space of structures for radio repeater stations

A prefabricated shelter which is easy to build in a rather short period is employed. The floor space of the shelter is enough to accommodate the necessary facilities with sufficient work space for operation and maintenance when occasion demands.

(3) Design requirements for antenna supporting structure

1) Azimuth of antenna

In order to maintain the desired grade of digital telecommunications

services, transmission loss must be set at less than 3 dB when the wind speed is 90 Km/h (25 m/s), and less than 20 dB when the wind speed is 150 Km/h (42 m/s). Hence, the antenna is so designed that its sway against azimuth is within allowable range for the above. To reduce unfavorable effect of wind and snow, antenna is equipped with radome.

2) Wind pressure load

No meteorological data are available concerning wind speed in the Kingdom. Even the maximum instantaneous wind speed is unknown. The Meteorological Bureau in Japan also has no such data. Hence the maximum instantaneous wind speed in Nepal, i.e., 160 Km/h (44.4 m/s) is adopted as the base for the design for this Project. This value is considered appropriate and can satisfy safety requirements, judging from the physical and geographical conditions of each objective site, and the past wind damage record on the existing structures, as well as the experience of the previous project.

3) Snow coating load

Snow coating load is taken into consideration for the sites located at an altitude of over 2,500 m. For basic design, 70% of the snow load is taken into account. Since the objective sites are located in mountainous areas, special attention must be paid to the load due to snow coating and sliding. Since no data is available on the snowfall in the Kingdom, 10 mm snow coating with the density 0.6g/cm^3 (corresponds to the wet type snowfall standard in Hokkaido and the inland area of Japan) is assumed, since it is known from the experience of the previous projects and field survey findings that the snow in the Kingdom is wet and they have much snow at sites at an altitude of over 3,000 m. Sliding load is taken into account for a site on a mountain slope where snowfall to a depth of more than 2 m is expected. It will be requested to the Bhutan side to readjust the land at sites as flat as possible.

4) Seismic load

The Kingdom lies in the earthquake zone in Asia. For this study, therefore, "Earthquake Danger Map in World Earthquake Active Area" published by Architecture Laboratory, the Ministry of Construction, Japan,

is referred to. Horizontal seismic coefficient in elastic design is set at k=0.1, assuming that the service life of antenna supporting structure is 30-50 years and the seismic return period is 2 or 3 times the life, and adopting the expected seismic return period of 100 years, i.e., 100gal, and considering response magnification, ratio of elasticity to the strength at the final stage, etc.

5) Bearing power of ground

Geologically, most of the objective sites are of hard silt or silt with gavels. It is also known from the experience of the previous project that mountain summits are usually consist of bedrock. According to the foundation structure design criteria published by the Ministry of Construction in Japan, bearing power of ground is calculated to be 13 - 15 tons/m^2.

Geographically, the Kingdom features in steep mountains and landslide often takes place. Actually some evidences of landslide were observed in the vicinity of the objective sites and along the high roads. In view of the above, the expected bearing power of ground is estimated at approx. 10 tons/m^2 at the minimum. This value is adopted as the design bearing power of ground.

6) Concrete strength

In the Kingdom, cement is mainly supplied by Penden Cement Factory located in the suburbs of Phuentsholing, near to the western border of the country. Access to this factory is rather difficult because of poor road and transportation conditions. Several days will be required for the transportation of cement from this factory to each objective site, during which cement may get wet. As for the quality of cement and its storage conditions, there will be no problem as proved by the previous project. For the objective sites mostly locating at high altitudes, crushed stones for concrete will be prepared at sites. Under such circumstances, uniform strength of concrete can hardly be expected. In other words, it will be difficult to obtain the cement which has the same strength as that available in Japan. Concrete compression strength for this Project is set at 150 Kg/cm^2 (28-day strength).

7) Temperature and humidity

Objective sites of this Project are scattered in the Western region of the Kingdom, each having different climatic conditions. At sites near the border with India, both temperature and humidity are high, and humidity-proof arrangements are required for materials and equipment to be used. On the other hand, at sites at an altitude of over 3,000 m where the temperature goes down to -10°C in winter with the ground freezing, a sufficient depth of the foundation and firm concrete casting are required.

8) Design standard

The Kingdom largely depends on India geographically and economically. Many of design methods and standards are also based on those adopted in India. However, since most of equipment and materials are to be supplied from Japan, the same as the previous project, EIA (Electronic Industries Association) standards adopted in Japan for export goods will be employed, in addition to BS (British Standard) which is the base of the Indian standards.

(4) Finish of structure member

Finish of structure members made of steel should be made by dissolved zinc plating, with the coating weight of 500g/m^2 or more. The portion damaged during transportation or work at site should be repaired by zinc painting containing 80-90% zinc. There is no fear of salt injury in the Kingdom and fine coating of paint is not necessary. Also there is no need of warning lights or signs for aircraft since the maximum height of an antenna tower is as low as 32 m.

(5) Prefabricated Shelter

In view of severe climatic conditions at objective sites, weather-proof steel plates or aluminum plates (coated by vinyl chloride) are used for the members of shelters. At sites where deep snowfall is expected, the shelter foundation should be high enough to permit easy operation and maintenance of facilities in the shelter. Weather-proof sealing materials should be applied on jointing parts of each panel to protect the panel from intrusion of rainwater and thawing snow.

(6) Layout Plan

Site and Floor Layout Plans are given in the Design Data (pages 26 through 53).

3.3 Basic Plan

The basic plan for digital switching system, DRCS digital radio transmission system, OSP, power supply system, and other facilities to be materialized by this Project is described in the following:

3.3.1 Digital Switching System

(1) Digital switching systems having the undermentioned line units are installed at objective exchanges.

Telephone Exchanges	L/U
Phuentsholing	2,200
Samtse	400
Paro	900
Wangdue Phodrang	300
Punakha	300
Total	4,100

(2) The undermentioned transit (tandem) switching systems are installed in Thimphu Exchange:

The number of trunks of transit (tandem) switching systems:

For toll transit in the Western region	20 DTI*
For toll transit in the Central and Eastern regions	7 DTI
For circuits to India	1 DTI
For international circuits	1 DTI

Note*: 1 DTI = 20 CH (DTI: digital trunk interface)

(3) Training equipment and materials

The undermentioned equipment is supplied to the Training Unit:

- Switching system simulator .... 1 set

(8) Charging system

The undermentioned equipment is supplied to Billing Section of Thimphu Exchange.

- Magnetic tape reader .... 1 set
- Bill printer .... 1 set

3.3.2 DRCS

The number of subscribers of each subscriber radio terminal station is 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

3.3.3 Digital Radio Transmission System

Digital radio links are constructed as listed below:

Routes	No. of Radio Terminal Stations	No. of Radio Repeater Stations		No. of Reflec-tors	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

Note*: Phuentsholing and Thimphu

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 Pro routes, and for other routes, 8 Mbit/s, 1+1 system (1 standby system).

3.3.4 OSP

The following cables and accessories will be supplied by the Japanese side. The construction work is to be undertaken by the Bhutan side.

Telephone Exchanges	Number of Terminated Cable Pairs	Total Cable Pair Length
Phuentsholing	1,800 pairs	2,691 pair-Km
Samtse	400 pairs	502 pair-Km
Paro	650 paris	3,264 pair-Km
Tashiyangtse	60 pairs	20 pair-Km
Gasa	60 pairs	20 pair-Km
Chimakoti	300 pairs	957 pair-Km
Wangdue Phodrang	350 pairs	467 pair-Km
Punakha	400 pairs	1,459 pair-Km
Haa	250 paris	975 pair-Km

3.3.5 Power Supply System

(1) Full-floating system with the combined use of automatic voltage regulator, diesel engine generator, rectifying equipment and storage batteries is adopted for the following 7 sites:

Thimphu, Phuentsholing, Takti, Samtse, Paro, Wangdue Phodrang and Punakha

(2) Hybrid system with the combined use of diesel engine generator, rectifying equipment, storage batteries and solar cells is adopted for the following 3 sites:

Japjekha, Pepchu and Saureni

(3) Solar power supply system with the combined use of solar cells and storage batteries is adopted for the following 8 sites:

Tashiyangtse, Gasa, Chimakoti, Haa, Gangadung, Samchiling Gompa, Rangshikhar and Chelela.

As the emergency equipment for all the above systems, one set of mobile diesel engine generator, two sets of portable diesel engine generators and two sets of portable rectifying equipment are supplied to Sub-Maintenance Center (Phuentsholing).

3.3.6 Other Facilities

As mentioned in the foregoing, main civil work and structures to be constructed under this Project are antenna supporting structures and prefabricated shelters, while the construction of telephone exchange office buildings and subscriber radio terminal station buildings is under the responsibility of the Bhutan side.

In the following are described an outline of prefabricated shelters for radio repeater stations and DRCS repeater stations, antenna supporting structures and reflectors.

(1) Prefabricated Shelter

Prefabricated shelters are constructed as follows:

1) Radio Repeater Station Shelter (4 sites)

Japjekha, Takti, Pepchu and Saureni

2) DRCS Repeater Station Shelter (3 sites)

Chelela, Samchiling Gompa and Gangadung

(2) Antenna supporting structures

Antenna supporting structures are installed as follows:

1) Antenna towers (10 sites)

Phuentsholing, Japjekha, Takti, Pepchu, Samtse, Saureni, Paro, Wangdue Phodrang, Limuti and Punakha

2) DRCS masts (7 sites)

Tashiyangtse, Gasa, Chimakoti, Haa, Gangadung, Samchiling Gompa and Chelela.

3) Reflectors (3 sites)

Paro-P, Takti-P and Kapdane

3.4 Implementation Plan

3.4.1 Implementation Policy

This project is to construct a comprehensive telecommunication network consisting of radio, transmission, switching, power, outside plant and architecture components. These components are systematically co-related with each other and their qualities are required to meet the international standards. In addition, objective areas are in remote areas which require rather long access time. In order to carry out construction work in such areas efficiently, a total of 47 experts consisting of 15 for civil/building, 9 for radio, 5 for transmission, 8 for switching, 7 for power, and 3 others, will be required. That is, a large number of experts in different fields will be required though the scale of this Project is not so large. Hence, the contractor for this Project must be selected from among those having extensive experience in similar projects.

The organization responsible for implementation of this Project on the Bhutan side is Project Department of DOT and that responsible for operation of the facilities provided is Thimphu and Phuentsholing Regional Departments (refer to Figure 1-2 Organization of DOT). Technology transfer to the staff of these departments should be done through on-the-job training.

3.4.2 Matters to be Observed in Construction/Installation

Several objective sites for radio repeater stations of this Project are located at an altitude of over 3,000 m, where a considerable snowfall is expected in December through February. On the other hand, in the rainy season from June to September, a considerable amount of rainfall is expected. These climatic and meteorological conditions are likely to exercise unfavourable effects on the construction work and material transportation schedule. For this Project, therefore, the construction work schedule must be drawn up deliberately so that the Project can be implemented efficiently within the contracted period causing no serious troubles.

Since there is no local construction company for telecommunications facilities in the Kingdom, local labourers should be employed for simple civil work, such as antenna tower foundation work, assembly of prefabricated shelters, etc. under the supervision of Japanese engineers. To procure a required number of labourers, such work should be done avoiding the farmers' busy season. In addition, to support the work by technicians, such as antenna tower assembly and wiring, utilization of labour force in

neighboring countries should also be considered.

3.4.3 Supervision of Construction Work

Objective areas of this Project are located mainly in the Western region and partly in the Eastern region. Since transportation means are poor, move from one site to another will require a long time. Hence it is advisable to adopt a combined supervisory system consisting of "stationed supervision" and "spot supervision." Since technologies to be used are diversified, a "stationed supervisor" is required to be equipped with expertise in coordination and adjustment of all the relevant technologies, while a "spot supervisor" specializing in respective technologies, such as radio, transmission, switching, power, civil and OSP, should be dispatched when occasion demands.

3.4.4 Procurement Plan

Almost all the construction materials and tools, as well as telecommunications equipment and materials, are not manufactured in the Kingdom. Most of them are imported from India. However, those imported from India are not so satisfactory both in quality and performance, and had better not to be used for this Project which aims to construct a highly reliable telecommunication network. Except for cement, iron for reinforcing, gravel, etc. which are rather high in quality and easy to procure in the Kingdom, high quality telecommunication equipment is to be procured from Japan, in consideration of compatibility with the existing facilities, easy in operation and maintenance and exchangeability of spare parts. For cables, procurement from a third country is to be studied.

When imported equipment and materials are unloaded at Calcutta, India, they will have to be transported to Bhutan overland via India. Customs clearance on them will be done in Phuentsholing near the border line, where they will be all unloaded. After the customs clearance, they are put in custody in Phuentsholing Exchange temporarily, and then delivered to each site.

4.4.5 Implementation Work

Works to be done by the Japanese side and those by the Bhutan side are as follows:

Japanese Side

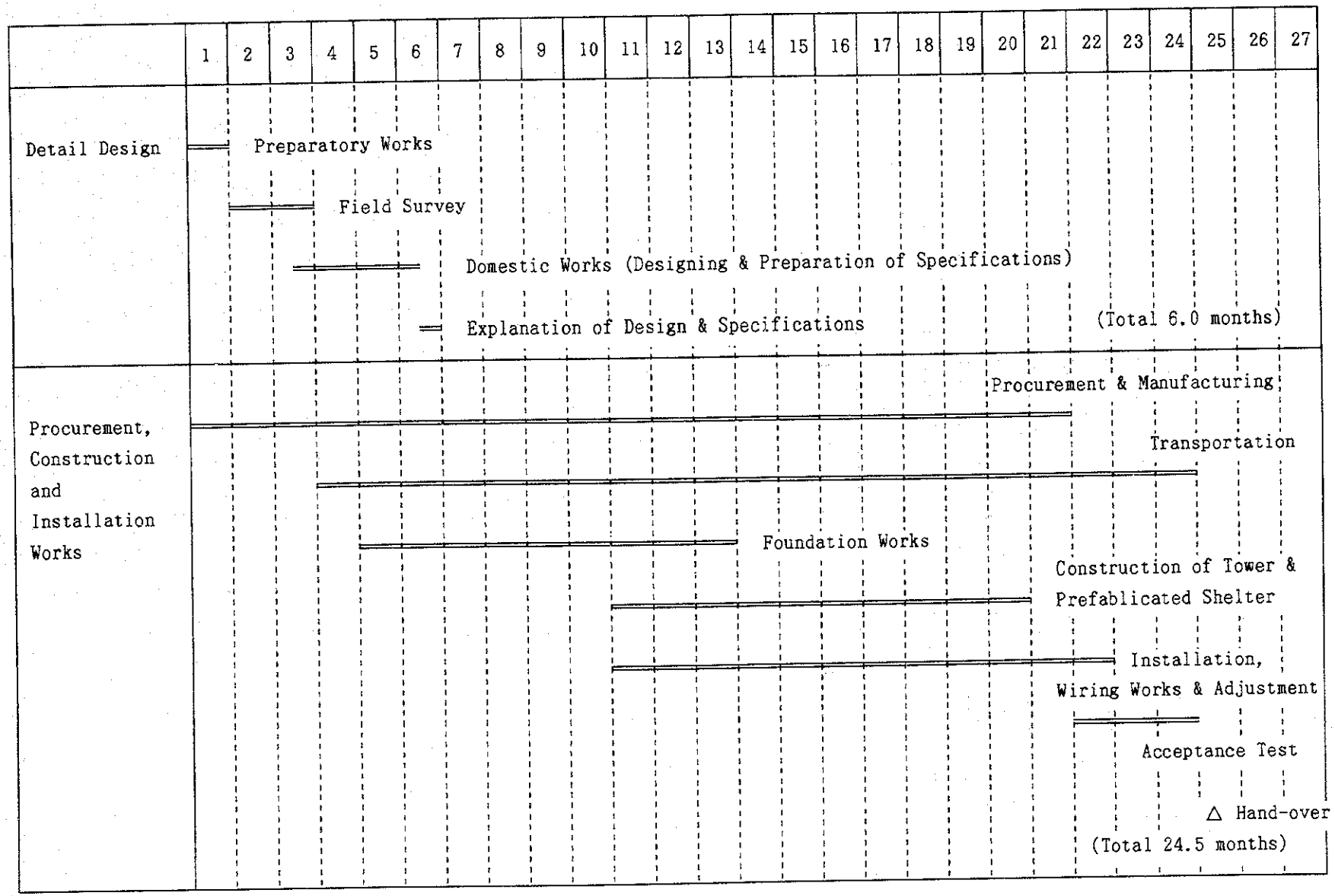
- Procurement and transportation of equipment and materials
- Radio and transmission system installation work
- Switching system installation work
- Power supply system installation work
- Radio repeater station construction work
- Procurement of OSP materials

Bhutan Side

- OSP installation work
- Procurement of sites for objective structures, land readjustment and incidental work
- Construction of access roads
- Telephone exchange building construction work

The capability of fulfilling the responsibilities on the Bhutan side is sufficient in terms of both finance and technology as described in 2.3.4 above.

The implementation time schedule is given in the following:


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27
Detail Design
Preparatory Works
Field Survey
Domestic Works (Designing & Preparation of Specifications)
Explanation of Design & Specifications
(Total 6.0 months)
Procurement, Construction and Installation Works
Procurement & Manufacturing
Transportation
Foundation Works
Construction of Tower & Prefablicated Shelter
Installation, Wiring Works & Adjustment
Acceptance Test
△ Hand-over
(Total 24.5 months)

3.4.6 Cost Estimate

Costs to be Borne by the Bhutanese Side

1)	Land procurement	Nu. 0.2 million
2)	Access road construction	Nu. 21.4 million
3)	Land levelling	Nu. 1.3 million
4)	Building construction	Nu. 6.5 million
5)	Building remodeling	Nu. 0.9 million
6)	OSP work including purchase of miscellaneous materials	Nu. 12.2 million
7)	Purchase of telephone sets	Nu. 9.2 million
	Total	Nu. 51.7 million