BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR EXPANSION
OF
RURAL TELECOMMUNICATION NETWORK
IN
YEMEN ARAB REPUBLIC

APRIL, 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of Yemen Arab Republic, the Government of Japan has decided to conduct a Basic Design Study on the Project for the Expansion of Rural Telecommunication Network in Yemen Arab Republic and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Yemen Arab Republic a survey team headed by Mr. Akira OKURA, Senior Official, International Cooperation Division, Communications Policy Bureau, Ministry of Post & Telecommunications from 26th November to 27th December, 1988.

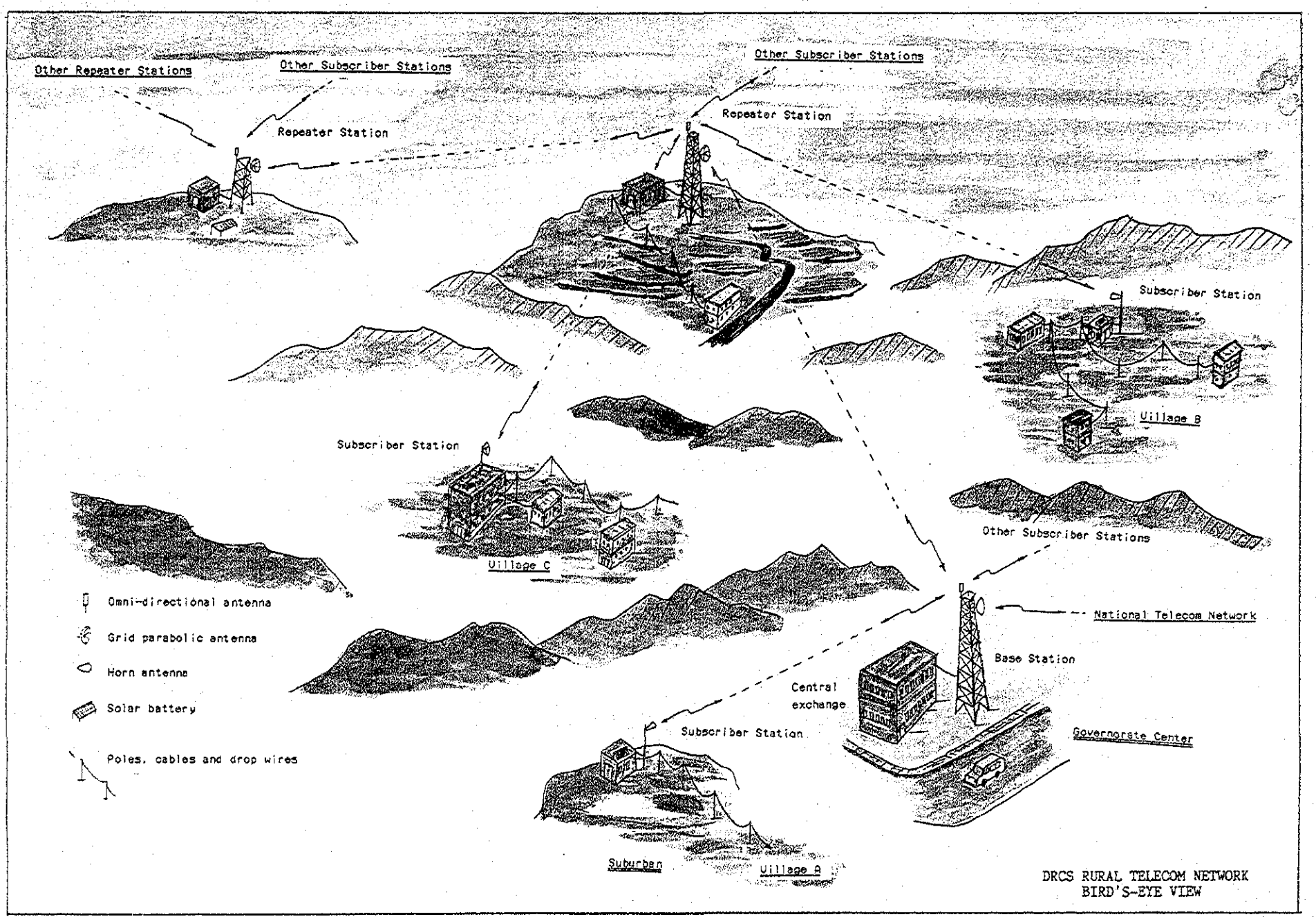
The team exchanged views with the officials concerned of the Government of Yemen Arab Republic and conducted a field survey in the five Governorates of Sana'a, Dhamar, Ibb, Taizz and Hudaydah. After the team returned to Japan, further studies were made. Then, a mission was sent to the Yemen Arab Republic in order to discuss the draft report and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

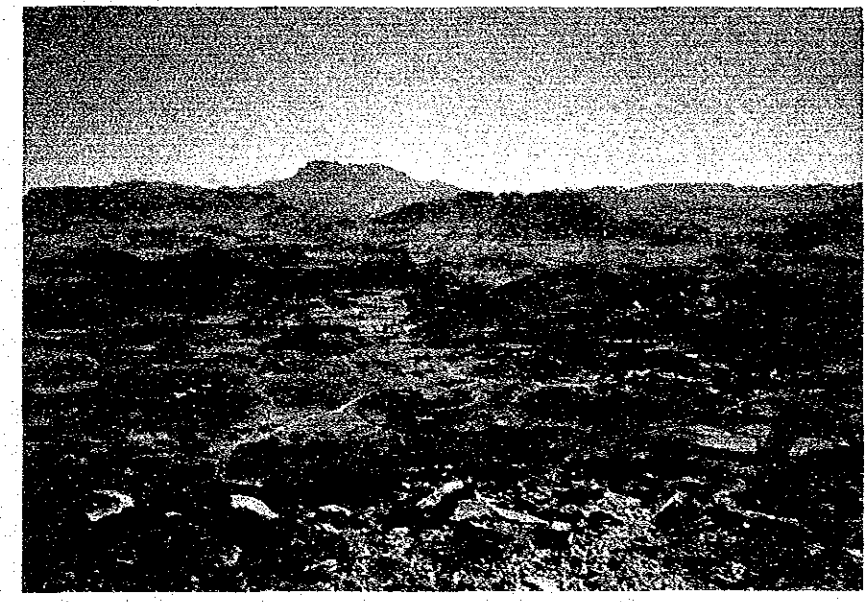
I wish to express my sincere appreciation to the officials concerned of the Government of Yemen Arab Republic for their close cooperation extended to the team.

April, 1989

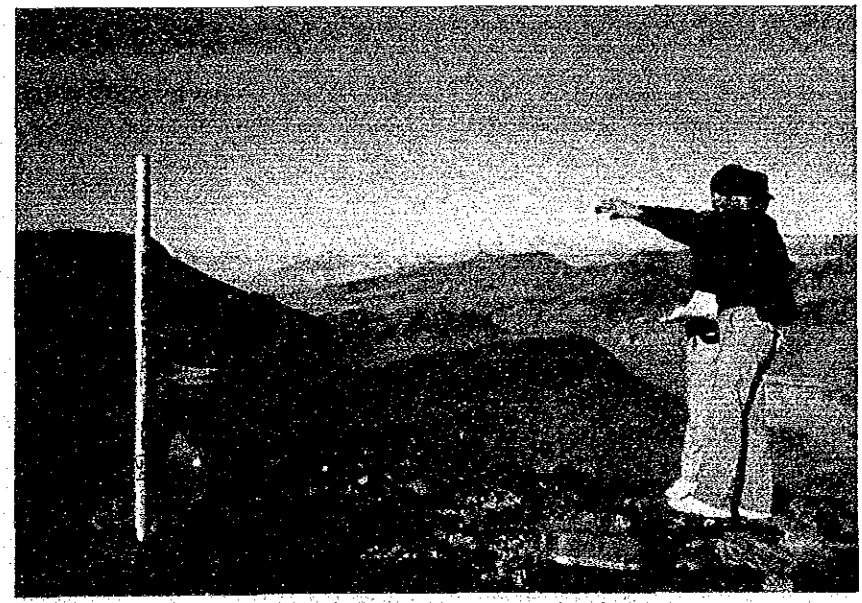
Kensuke Yanagiya
President
Japan International Cooperation Agency


Other Repeater Stations
Other Subscriber Stations
Other Subscriber Stations
Repeater Station
Repeater Station
Subscriber Station
Village B
Subscriber Station
Village C
Other Subscriber Stations
National Telecom Network
Base Station
Central exchange
Governorate Center
Subscriber Station
Suburban
Village A
Omni-directional antenna
Grid parabolic antenna
Horn antenna
Solar battery
Poles, cables and drop wires
DRCS RURAL TELECOM NETWORK
BIRD'S-EYE VIEW

Landscape near proposed DAYR AKHRASH Repeater Station
(HUDAYDAH Governorate)

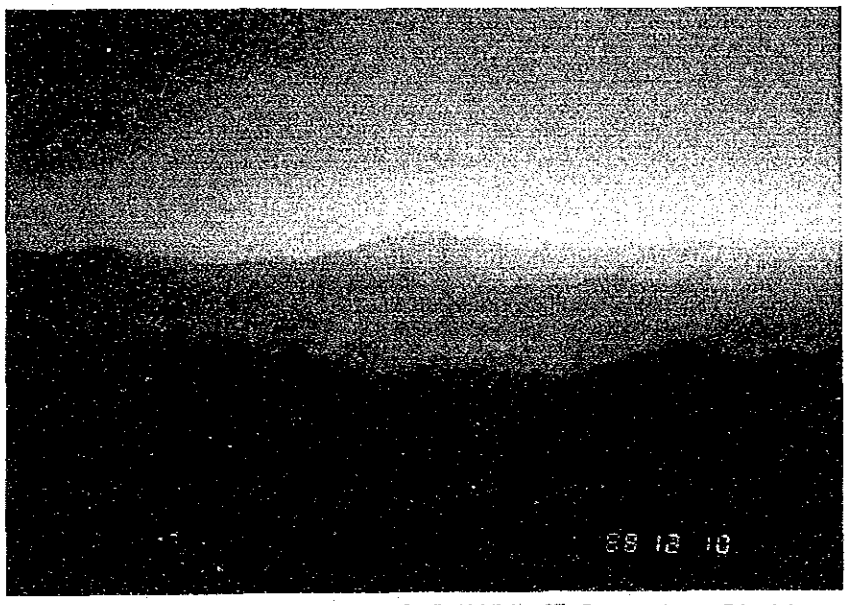


Landscape near proposed J.HRWAH RepeaterStation
(SANA'A Governorate)

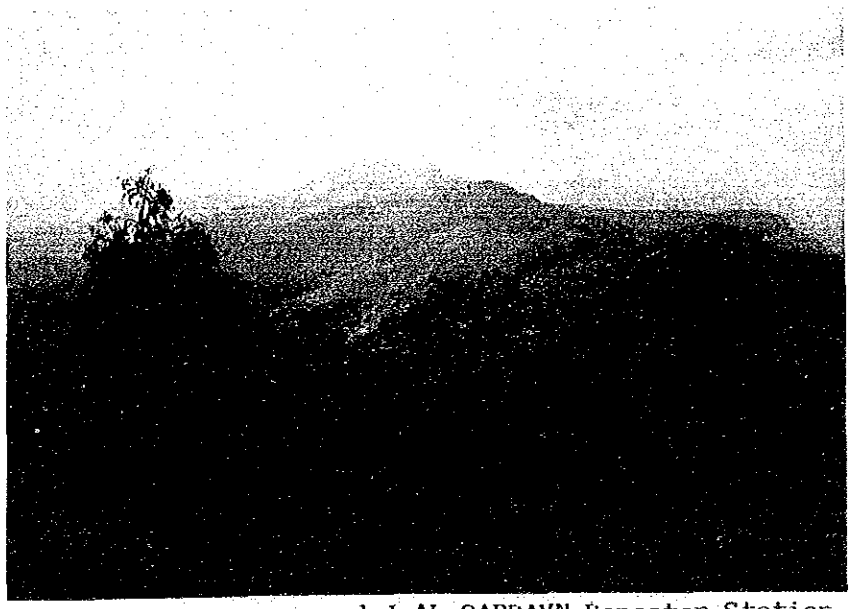


Landscape near proposed BAYT ASH SHAMI Repeater Station
(DHAMAR Governorate)

Landscape near proposed J.AYBAN Repeater Station
(SANA'A Governorate)



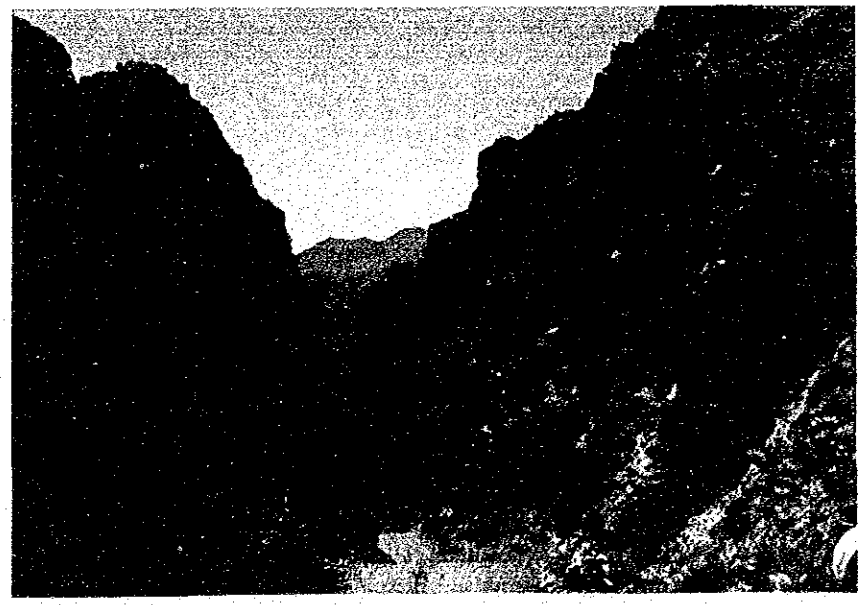
Landscape near proposed J.HABASHI Repeater Station
(TAIZZ Governorate)



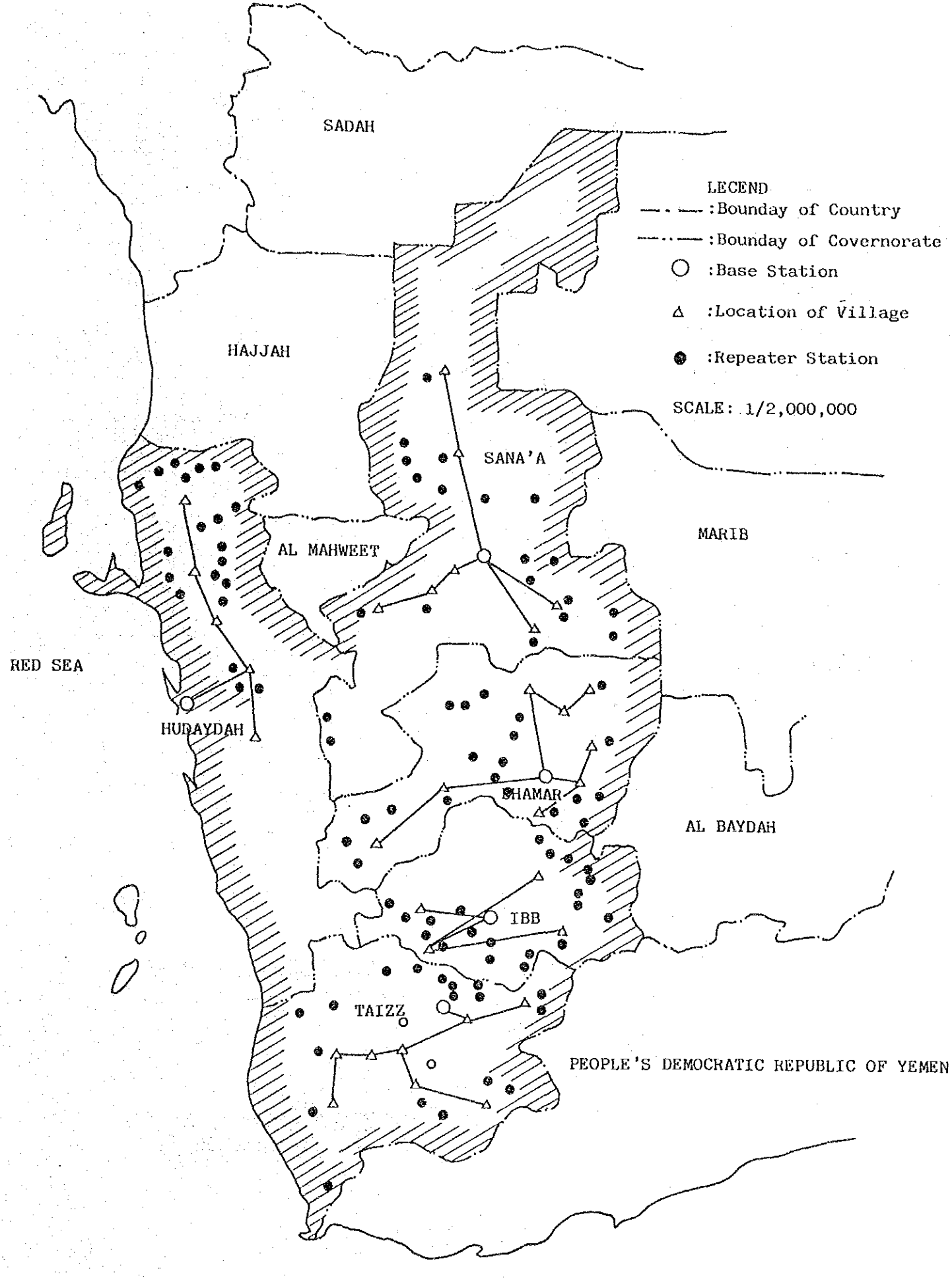
Landscape near proposed J.AL QABRAYN Repeater Station
(IBB Governorate)

Landscape near proposed J.SUMARAH Reapeater Station
(IBB Governorate)

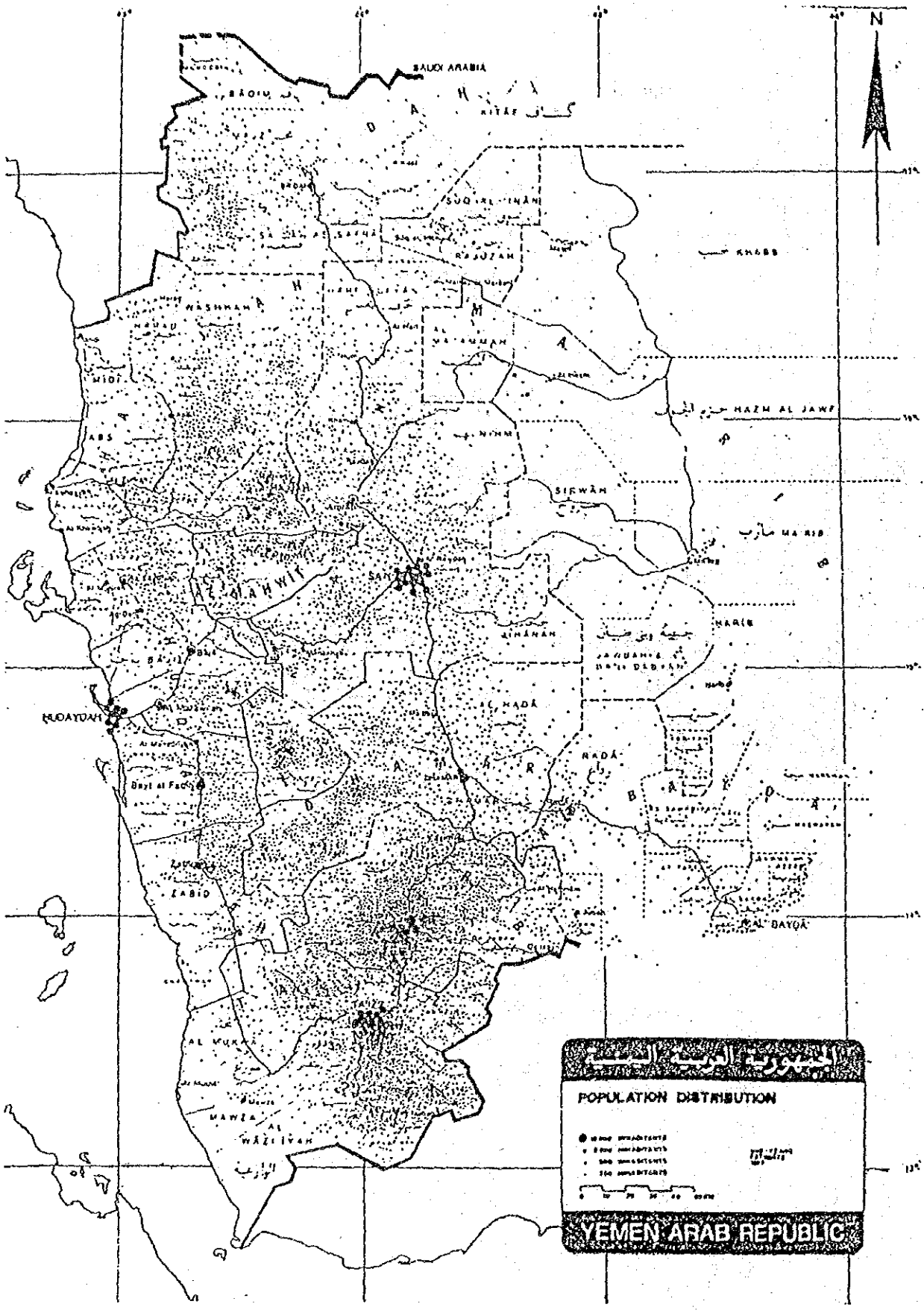
Landscape near proposed J.AN NAR Repeater Station
(TAIZZ Governorate)



Access to J.MANARA Repeter Station
(DHAMAR Governorate)



OBJECTIVE GOVERNORATES



POPULATION DISTRIBUTION

SUMMARY

The Yemen Arab Republic (hereinafter abbreviated Y.A.R) has implemented the development of rural telecommunication network programmed in the Second National Development Five-Year Plan (1982-1986). The development and expansion of network is continuing in the Third National Development Five-Year Plan (1987-1991) as there is a large demand of telephones all over Y.A.R. The Government of Japan, according to a request from Y.A.R, carried out a feasibility study for the rural telecommunication network development program of the said Five-Year Plan and drawn up the Study Report in March 1986. The Y.A.R requested the Government of Japan a Grant Aid in June, 1988, to implement a part of the rural telecommunication network program in accordance with the Study Report.

The Government of Japan, in response to the request, performed a Basic Design Study after study of the various aspects of the Project viz. effectiveness of the Project and for propriety of the Grant Aid, and survey and analysis on optimum contents and scale for the Grant Aid cooperation. The results of the Basic Design Study are as described in the succeeding chapters and are summarized below.

The planned rural telecommunication network is to install 500 telephone lines in 100 villages in rural areas (average 5 lines per village) of the following 5 Governorates out of 11 Governorates of Y.A.R.

Sana'a
Dhamar
Ibb
Taizz
Hudaydah

These 5 Governorates account for about 76% of the total inhabitants of 8.1 million and for 96% of the total villages of about 7,000 in Y.A.R. The planned objective 100 villages are chosen taking 20 villages from each of the five Governorate and they hold an important place with respect to industrial, political and social aspects in the rural areas. These villages are scattered on an average road distance of approximately 54.0 km from the Governorate centre. The communications between the villages and the

Governorate centre are done by post mail service, vehicle transport and on foot. The villages are mostly located in the mountainous regions (altitude of 1,500 m-3,500 m in case of central mountainous region).

Considering the topographies of the villages, telecommunication demand, existing nation-wide telecommunication network, operation and maintenance procedures for facilities, the objective rural telecommunication network will be established by a Digital Radio Concentration System (DRCS) as an optimum system. This telecommunication network will to offer national/international direct dialling calls with transmission qualities based on the CCITT recommendations. Solar power plant will be installed for the power supply facilities in view of maintenance and operation.

The telecommunication facilities will be installed in the following burden sharing.

Facilities	Japan	Y.A.R
Land of site and access		118
DRCS base station equipment	5	
Arrangement of base station switching equipment		5
DRCS repeater station equipment (including power supply)	32	
DRCS subscriber station equipment (including power supply)	100	
Repeater station building		21
Subscriber station building		100
Tower for repeater station		22
Mast for subscriber station		100
Subscriber line and telephone set		500

The burden sharing of Y.A.R listed in the above will be highly appreciated in showing the perception by Y.A.R for importance of the Project and incentive spirit toward the achievement of the Project.

Since the installation time of more than 12 months will be required, it is a practical way to divide the installation into two phases. The phasing is as follows;

Phase I Sana'a and Dhamar Governorates
Phase II Hudaydah, Ibb and Taizz Governorates

The profitability and benefits of the Project are as follows;

1) An economical internal rate of return, that is considered a consumer surplus by the best-alternative method, is supposed to be 3 times of the financial internal rate of return or more.

2) This telecommunication network will cover almost all parts of the five Governorates as its service area. Namely, it is a back-bone telecommunication network for the five Governorates. After completion of the Project, it is possible to expand the number of subscribers easily with less investment for approximately 5,000 or more lines (dependign on the traffic conditions) by new installation of subscriber stations at other villages than the 100 villages, or by adding more lines in a particular village.

3) Reliable and quick information by telecommunication will result in shifting of industries in the rural areas, agriculture sector in particular, to a industry involved in the market economy.

4) Average 5 lines per village can be utilized by about 2,000 inhabitants (360 families) including some inhabitants in the surrounding villages. In addition, there are migrants outside Y.A.R on an average 0.8 person per family and it amounts to 1,170 thousand throughout the country against the population of capital Sana'a of 470 thousand. Since the people in the rural areas were impatient to have not only national but also international telephone calls, their wishes will be realized by this Project.

The Project will be achieved by systematically integrating the installed facilities by burden sharing of the both countries. Therefore, it is necessary to mutually synchronize the implementation schedules and matching of technical matters by authorities concerned with both countries and the persons concerned.

In conclusion, it is expected to increase more subscriber lines by utilization of the basic telecommunication network established by this Project.

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CHAPTER 1 INTRODUCTION

The Yemen Arab Republic (hereinafter abbreviated Y.A.R) is basically an agriculture country and approximately 73 percent of the working population is engaged in farming. The total population is about 8.1 million, and 80 percent inhabit the rural villages. The number of villages having a population of 300 or more is approximately 7,000. The average inhabitants per village are considerably small. Almost all villages are situated on slopes and tops of steep mountain area with variety of topography (2,000 - 3,000 m) and hills (200 - 1,500 m) according to the natural environment and the histories of Y.A.R. Such distribution of inhabitants and topography as the above is a principal feature of Y.A.R. In these conditions, development and expansion of infrastructures such as telecommunication, roads etc. in the rural areas has been delayed due to higher development costs compared with urban areas. Though the urban telecommunication network has been developed relatively in recent years, the progress of the development of telecommunication in the rural areas is far behind the urban areas.

Therefore, under such circumstances, Y.A.R gave major importance to rural telecommunication network development in the Second National Development Five-Year Plan (1982-1986) and requested the Government of Japan to provide a feasibility study for that purpose. In response to the request, the Government of Japan carried out the study and formulated a Feasibility Study Report in March, 1985. The study was made for about 490 important villages selected from 6 Governorates of Y.A.R out of a total of 11 Governorates as the objective villages. As a result of studies and technical analysis, a rural telecommunication network covering 456 villages was planned.

During the interveing period, Y.A.R developed and expanded the rural telecommunication network under aid from Canada and others and achieved about a total of 500 lines' capacity up to the present. However, since the network capacity does not satisfy the increasing telephone demand, Y.A.R prepared a 5,000-line expansion plan in the Third National Development Five-Year Plan (1987-1991).

Y.A.R requested a grant aid from the Government of Japan in June, 1988 to establish a part of the rural telecommunication network which was planned in the Feasibility Study for purpose of realizing the expansion plan in the Third Five-Year Plan.

The Government of Japan, in response to the request, decided to carry out a basic design study for the Project. The Japan International Cooperation Agency organized a Basic Design Study Team and its team carried out field survey in Y.A.R for period from November 26, 1988 to December 27, 1988. The objectives of the Study are to grasp the background of the Project substance, to study effectiveness of the Project and propriety of the Grant Aid, and to draw up a basic design for optimum contents and scale for the Grant Aid cooperation. Stuff line up of the study team, Itinerary of the field survey, Names of Yemeni officials involved, Minutes of Discussions and list of collected data in Y.A.R are attached as ANNEX 1. After the field survey, the Study Team prepared a draft Basic Design Study Report and discussion it with P.T.C for period from 13th March to 23rd March, 1989. Based on the progress in the above, this Report presents the final results for the Basic Desig Study in the following chapters.

CHAPTER 2 BACKGROUND

2-1 Introduction to the Country

2-1-1 General View

Y.A.R is located in the south-eastern part of the Arabian Peninsula, shaping an oblong square area extending from north to south. It is bordered by the Kingdom of Saudi Arabia to the north, the Peoples's Democratic Republic of Yemen to the south, and the Red Sea to the west.

The territory covers an area of approximately 200,000 square kilometers, with the population of 9,270,000 (including 1,170,000 living abroad) as of 1986. It consists of 11 governorates, with Sana'a as its capital city. The population in the capital area accounted for 5.8% of the whole national population in 1975, and 9.8% in 1987. 73% of the working population is engaged in agriculture.

In terms of topography, the nation can be divided into four parts from the Red Sea side towards the east. Tihama Plain, a flat strip about 30-40 kilometers in width, extends from north to south at an altitude ranging from 0 to 200 meters facing the Red Sea. Lying between this plain and the central highlands is a mountainous terraced area (200 - 1,400 meters in altitude). Next to this exist the central highlands (1,500 - 3,000 meters in altitude) and in the eastern part lies the semi-desert area.

Rainfall in the mountainous area is relatively lentiful, averaging approximately 900 mm per year in the south-western area. From the ancient, Y.A.R is an agricultural country. People settled and formed villages in cultivable mountainous area which could serve as a natural fortress, fleeing from expanding desertification and also with a view to protecting themselves from foreign attacks. The population density is high in the highlands and low in Tihama Plain and other eastern semi-desert area. The cultivable areas are found in the mountainous terraced area and, therefore, agriculture there is of small scale in size. Population in each village is relatively small, generally less than 500. Such population distribution and topography characterizes this nation.

2-1-2 Economy

According to the statistics for 1987, GNP of this country is $570 and GDP $489. When classified by sector, GDP for the agriculture, forestry and fisheries sector accounts for 28% and the manufacturing sector 11%. This proves that agriculture is the main industry in this country. GDP increase rate as of 1986 is 13.4 % and that of the agriculture, forestry and fisheries sector, 13.8%, showing steady growth. Increase rate of the manufacturing sector remains only 9%. In 1985, an oil deposit was discovered in the eastern part of Marib area. Oil export is already started but it accounts for only 1% of the national GDP.

As mentioned before, Y.A.R is an agricultural country. Major agricultural products are wheat, maize, millet, beans, grapes, coffee, potatoes, tobacco, cotton, etc. Major animal products are edible birds, beef cattles, rams, wool, eggs, hide and skins, etc. Cultivable areas except those for coffee, have not so much expanded during the past 5 years, but the output has been steadily increasing.

Main processing industries for primary products were conventionally those for bread, buiscuits and food oil. Presently, processing of beans, tomatoes and potatoes and manufacturing of flour and soft drinks are on the increase.

Quarrying out of architectural rocks and mining and refinery of plaster stones are one of cash earning regional industries. They are important architectural materials indispensable for the traditional Yemen architecture. In 1987, production of building stones recorded 247,000 cubic meters and plaster stones 44,000 tons. Production of these materials, however, is declining due to recent mushrooming concrete building construction.

Of the export amounting to $325,000,000 in total as of 1987, agricultural products account for 70%, amounting to $235,000,000. On the other hands, amount of import for foods and tobacco far exceeds the agricultural export. That is, the import mainly covering cereals, meats, sugar and tobacco, etc. accounts for 34%, i.e., $318,000,000, of the total import which amounts to$936,000,000, as of 1987. Foreign trade in 1987 was

in the deficit of $1,306,000,000, taking into account the import by the Government amounting to $5,190,000,000. The current account balance in 1987 also recorded the deficit of $580,000,000. The deficit due to commodity import is less than the Government import amount. For this, the money transfer from the people abroad has greatly contributed. The number of people living abroad amounted to 1,170,000 in 1987, who sent $793,000,000 to their motherland, Y.A.R. The national economy thus greatly depends upon the money remittance from abroad, though a recent stagnation of economy in the Middle-East oil countries has caused a decline in the number of people abroad and the amount of money to be sent back. The oil export was $18,200,000 in 1987.

2-1-3 Infrastructure

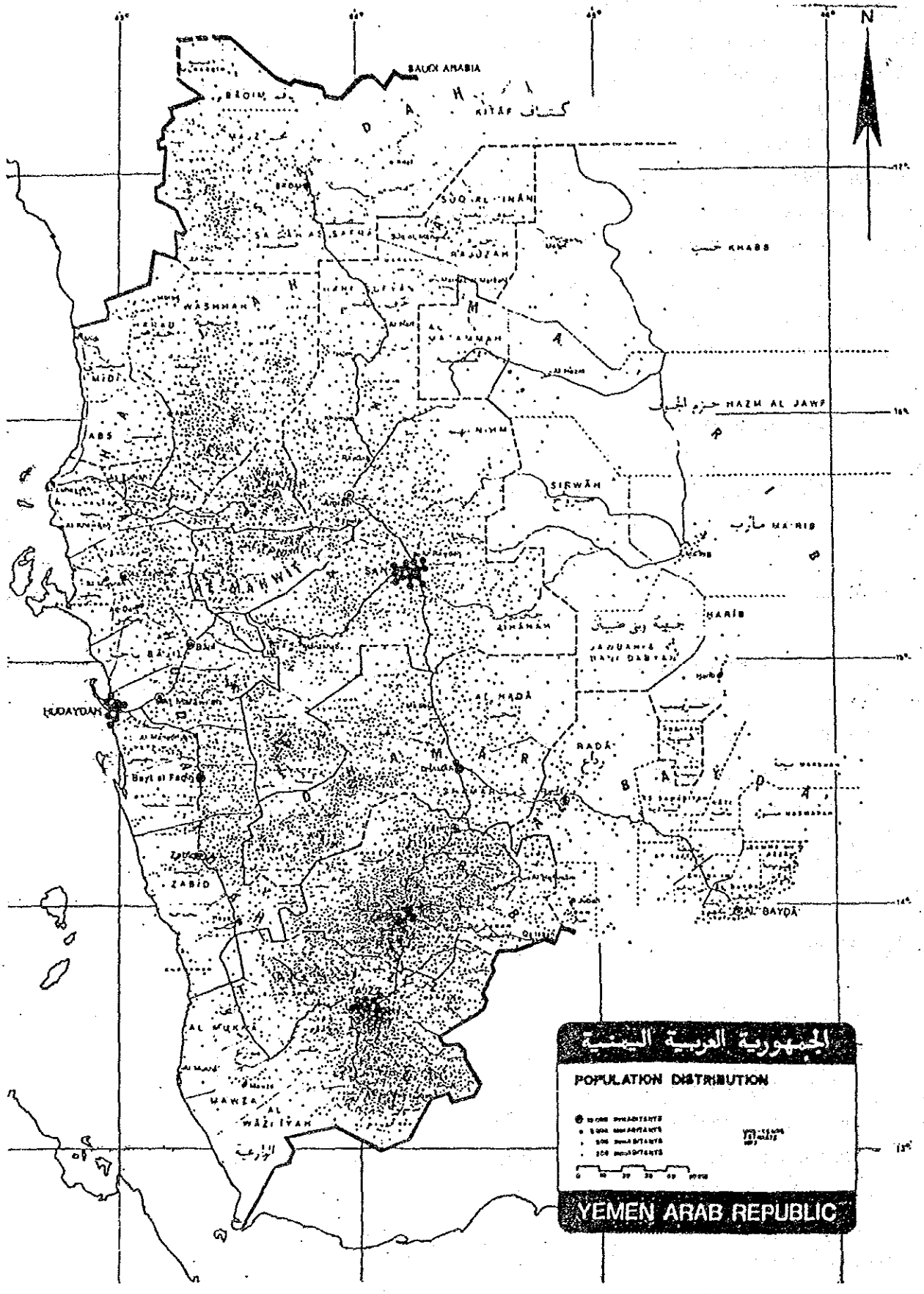
In the following is outlined the status quo of other infrastructure than the telecommunications.

(1) Roads

Main highways connecting local governorate capitals are well paved and maintained. In the rural areas, however, most of the villages are scattered far and wide in hilly and mountainous areas and, therefore, roads are long, steep, rugged, and scarcely paved. Most of the villages, however, are accessible by 4-wheel vehicles. The total distance of the roads throughout the country is 3,900 kilometers, 2.2 times increase during the past 10 years.

(2) Electricity and Water

According to the survey findings in 1981, diffusion rate of power supply is 63.5%, and water supply 29%. That is, power and water are relatively well supplied. In the remote rural areas, each village has an engine generator to supply power to villagers only at night time. Besides the water supply, construction of common-use wells is being promoted. Recently, conventional water transportation by water tank, etc. is becoming to be required only for short distance.



POPULATION DISTRIBUTION

(3) Medical Care

The survey in 1986 shows that the number of medical facilities is increasing throughout the country. During the past 9 years, the Rural Health Unit has increased by 3.8 times reaching 399 in number, and the Health Centers 4.4 times totaling 289, hospitals 1.5 times amounting to 35, the number of beds 1.8 times totaling 5,986, and drug stores 3.9 times reaching 673.

Average life expectancy in Y.A.R is 43.3 years for men, and 40.8 years for women, with an overall average being 42.1 years. The number of persons who have received medical care (including injection) at the Rural Health Units amounts to approximately 1,000,000, i.e., 3 times increase during the past 9 years.

(4) Education

According to the survey in 1975, those who have reading and writing ability accounted for 10.6%, and those reading only 5.3%, with the illiteracy rate being 82.5% which, however, has now been improved to 74.9%.

2-1-4 National development plan

Y.A.R has already accomplished the First National Development Five-Year Plan (1977-1981) and the Second National Development Five-Year Plan (1982-1986), and now is implementing the Third National Development Five-Year Plan. As for the Five-Year Plan for the telecommunications sector, the following improvement and expansion are being planned to meet the recent rapidly increasing demands, as stated in the materials issued by the PTC:

(1) Urban Area Telephones

Addition of 49,000 L.U. to the existing 98,000 L.U. for expansion of the capacity up to 146,000 L.U. in total, through construction of new telephone exchanges and expansion of existing switching facilities (expansion is to be made by digital switching systems).

(2) Rural Area Telephones

Expansion of capacity from the existing 500 L.U. to 5,000 L.U. (expansion is to be made by digital facilities).

(3) Transmission Network

Digitalization and expansion of the existing analogue trunk microwave transmission routes and expansion of existing regional transmission routes (digital).

2-2 Outline of the Telecommunication Service

2-2-1 Organization and operation

The telecommunication service in Y.A.R is provided by PTC, and the MOC as controller. The PTC was separated in 1982, from MOC, and independent. The operation and maintenance of telecommunication facilities for the international service is entrusted to the British C & W. The organization of PTC is as shown in Figure 2-1.

2-2-2 Telecommunication network

At present, the telephone exchange capacity in urban areas is 98,000 lines. For the Third Five-Year Plan the expansion of 49,000 lines is being implemented and at the end of the Third Five-Year Plan the total capacity will reach 146,000 lines. The expansion for each site is as in Table 2-1, and the switching configuration as in Figure 2-2.

In the year 1987, the number of subscribers in 34 urban areas are as given in Table 2-2. 17 urban areas will total 67,974 lines and in 16 rural areas 1,929 lines, a total of 69,903. 17 urban areas will be covered by a "Nationwide Direct Dialling Telecommunication Network", but 16 rural areas are not capable of automatic access to other networks.

For the part of 7,000 villages in the rural areas (excluding the abovementioned 17 rural areas), telephone services by means of digital radio concentration system (DRCS) were introduced to connect with the nationwide telecommunication network. The equipment is Canada manufactured SRT and French TRT type which have total capacity of 500 lines to cover 73 villages. This DRCS network configuration (between base station and repeater station) is as shown in Basic Design 1.

Assuming that 12% of 8,100,000 inhabitants are populated in 17 urban areas, 2% in 16 rural areas and 86% in remote villages, the telephone density as of 1987 is as given in the table below.

	Population	Telephone subscriber	Telephone density (per 100)
17 urban areas	972,000	67,974	7.0
Rural areas	7,128,000	2,429	0.03
Local 16 cities	162,000	1,929	1.2
Village	6,966,000	500	0.007

As seen in the table above, the difference in telephone density among the urban areas and the rural areas is particularly high.

2-2-3 Telephone tariff

(1) Call charge (one metering unit is 0.3 Y.R)

Local call	Urban area:	360 sec/metering unit	
	Rural area:	9 sec/metering unit	
Trunk call	Urban area:	25 km or less	360 sec/metering unit
		25 - 50 km	180 sec/metering unit
		50 - 100 km	90 sec/metering unit
		100 km or more	9 sec/metering unit
	Rural area:	9 sec/metering unit	

(2) Basic charge Urban area: 30 Y.R.
Rural area: 2,500 Y.R.

(3) Installation charge Urban area subscription: 2,500 Y.R.; but additional drop wire per 100 m requires 7 Y.R. and additional telephone pole 675 Y.R./pole.

Government agencies
in urban area : 1,168 Y.R.
Rural area : nil

(4) Consignment fee for public telephone : 1,200 YR. per month

2-3 Status of International Cooperation in Telecommunication Field

For the development of telecommunication in the Second and Third Five-Year Plans, France and Canada has contributed mostly. As for the Third Five-Year, telephone exchange expansion of 49,000 lines, digitalization of the trunk line and its expansion are extended by France. After the completion, the telecommunication service condition will substantially improve. The rural network expansion of 500 circuit was extended by Canada. However, as stated in the paragraph 2-2-2, the telephone density is still very low, such as 0.03 and 0.007.

2-4 State of Affairs Prior to Request and Its Content

2-4-1 State of Affairs Prior to Request

The development of socioeconomic infrastructures is now being progressed under the condition that 98% of the total population inhabit in rural areas and engage in agriculture which plays important role in the state economy. As represented in terms of telephone density, the telecommunication services in the rural areas are particularly poor. The government of Y.A.R has planned to balance the development of infrastructures, and to promote the efficiency of administrative activity and the socioeconomic development by means of the telecommunications development in the rural areas; and thereupon requested to the Government of Japan Grant Aid for the first-priority telecommunication development project covering 100 out of 490 villages which were objective areas of "Feasibility

Study Report on Rural Telecommunications Network in Yemen Arab Republic, March 1985, JICA".

The 100 villages are selected from 5 Governorates who have higher population and larger number of villages among 6 Governorates that was objective areas of the survey for the abovementioned feasibility study.

2-4-2 Content of request

To establish such telecommunication network consisting of digital radio concentration system (DRCS) that for the 100 villages as given in Annex 1-1 Minutes of Discussions, an average of 5 subscriber lines per village is extended to the telephone exchange in the respective Governorate Centres (Sana'a, Dhamar, Ibb, Taizz and Hudaydah) by means of DRCS, the Government of Y.A.R requested as follows:

(1) Installation of basic facilities in the rural telecommunication network

1) all DRCS facilities (base station, repeater station and subscriber station)
2) a power supply equipment for all DRCS stations excluding base station
3) aerial facilities for all DRCS stations

(2) Supply and installation of operation and maintenance facilities

1) tools, measuring equipments
2) spares
3) DRCS network model facilities for repair

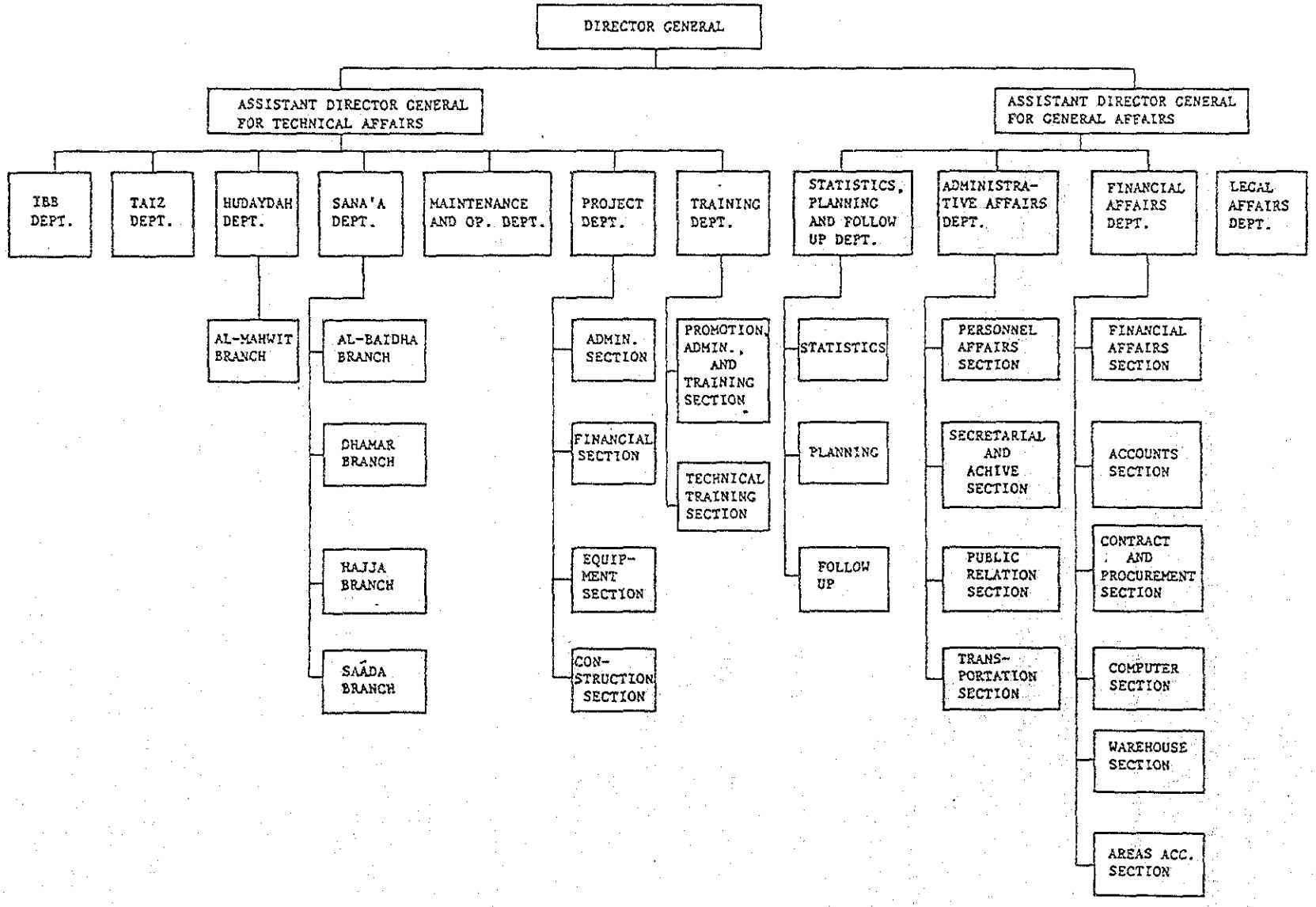


Fig2－1 Organization Structure of PTC

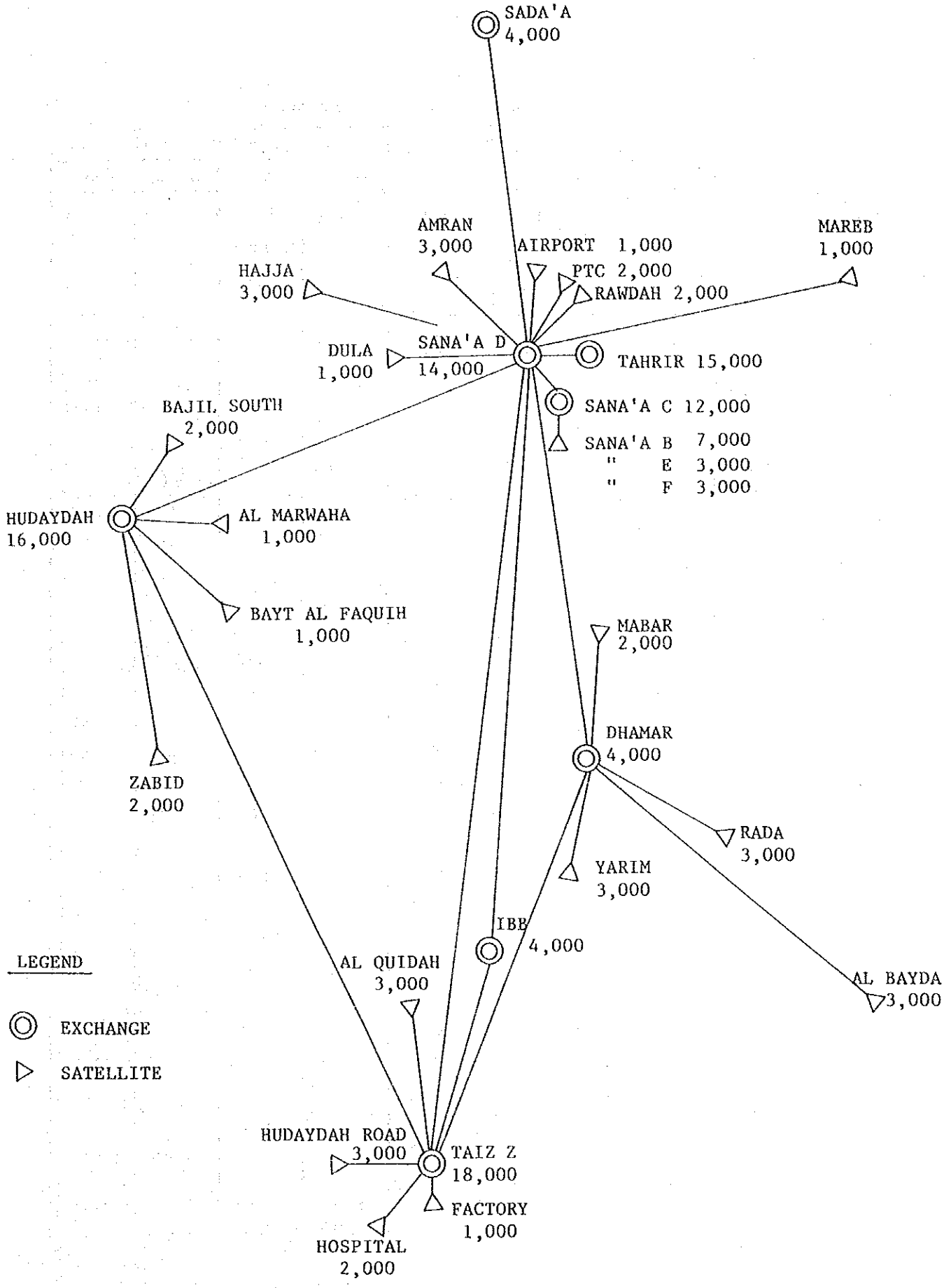


Fig.2-2 URBAN SWITCHING NETWORK
(The end of 3rd Five-Year Plan)

Table.2-1 Capacity of Urban Exchanges

Excange	Satellite	Existing		The end of 3rd Five-Year Plan			
		CSEL	CSED	CSEL	CSED	SCNL	CSND
Sana'a D		14,000		14,000			
	Airport		1,000		1,000		
	Rawda		2,000		2,000		
	Amran		1,000 (※)				3,000
	Hajja		1,000 (※)				3,000
	PTC						2,000
	Mareb						1,000
	Dula				1,000		
Sana'a C		12,000		12,000		1,000	
	Sana'a A		4,000 (※)				
	Sana'a B		6,000		7,000		
	Sana'a E		3,000		3,000		
	Sana'a F		3,000		3,000		
Tharir						15,000	
Dhamar			2,000		2,000	4,000	
	Mabar		1,000		2,000		
	Al Bayda						3,000
	Rada		1,000 (※)				3,000
	Yarim		1,000 (※)				3,000
Ibb			4,000		4,000	4,000	
Taizz		18,000		18,000			
	Factory		1,000		1,000		
	Al Quida		1,000 (※)				3,000
	Hospital				2,000		
	Hudeida Road				3,000		
Hudaydah		16,000		16,000			
	Al Marwaba		1,000		1,000		
	Bayt Al Faguin		1,000		1,000		
	Zabid		2,000		2,000		
	Bajie		2,000		2,000		
Sana'a D						4,000	
Total		60,000	38,000	60,000	37,000	28,000	21,000
Spare		1,000		1,000	1,000		

※ To be shifted

Table.2-2 Number of Telephone Holder in Cities 1987

City	Urban network (Exchange and satellite)	Rural network (Small capacity local exchange)
Sana'a	30,376	
Manakha		80
Amran	734	
Khamer		259
Taizz	13,629	
Mackha		124
Hugariah		140
Hagda		52
Al-Rahida		142
Ibb	3,565	
Al-Sada		80
Al-Nadra		80
Qatba		80
Yareem	952	
Al-Radma		80
Gibla		130
Dhi-Al-Sobal		139
Al-Qa'da	861	
Dhamar	2,000	
Doran		58
Ma'aber	499	
Hudaydah	9,238	
Al-Maraw'a	197	
Bagie	772	
Al-Salib		54
Baib-Albagih	484	
Zabrid	618	
Hajja	870	
Mahabisha		307
Mahweet	262	
Sa'adah	1,200	
TL-Talehi		124
Al-Beida	1,000	
Rada'a	717	
Total 69,903	67,974	1,929

CHAPTER 3 OUTLINE OF THE PROJECT LOCATION

3-1 Project Location

(1) Y.A.R consists of 11 Governorates (states). The objective area of this Project covers 5 Governorates where population in large and many villages exist. The number of objective villages will count 20 for each Governorate. The following is a table for Governorate versus village population.

Governorate	Population (x1000)	No. of House (x1000)	No. of Villages more than 300 inha.	No. of Villages more than 700 inha.	No. of objective villages
(5 Objective Governorates)					
Sana'a	1,810	156	1,828	488	20
Taizz	1,500	177	632	121	20
Hudaydah	980	139	1,157	316	20
Ibb	1,100	160	1,344	280	20
Dhamar	730	90	741	196	20
(Sub total)	(6,120)	(722)	(5,732)	(1,401)	(100)
Other Governorates					
Hajjah	950	78	449	114	
Sadah	290	31	228	39	
Al-Mahweet	250	35	130	25	
Al-Bayda	300	31	334	101	
Marib	110	8	65	20	
Al-Jawb	80		162	79	
Total	8,100	905	7,070	1,779	100

The Governorate, its capital and objective village locations are as shown in Figure 3-1.

(2) The project area for the villages, population and geographic altitude is as shown in Table 3. The spellings of the villages are in accordance with the maps issued by the Government of Y.A.R.

3-2 Social and Economic Situation

The social and economic situation in whole Y.A.R and rural areas is as stated in CHAPTER 2. The situation of the 100 villages in this project is as follows;

(1) each village plays an important role in state administration, rural economics and society, but no telephones.

(2) the average distance away from Governorate Centre is 54 km, and no public transportation means such as bus service exists. The inhabitants are obliged to use private vehicles (4-wheel drive car or truck).

(3) the domestic or international telephone service are available at Governorate Centre or in limited major cities (1 - 3 cities).

(4) the access road conditions to Governorate Centre or major cities are bad, requiring a long time to reach destination (no paved road except in flat land area and rugged with rocky soil).

(5) communication to the village is made through post mail service.

3-3 Natural Conditions

In the capitals of Governorates, Sana'a, Taizz, Hundaydah and Dhamar, the weather data of 1979 - 1987 for sunshine duration, solar radiation, temperature, humidity, precipitation and wind speed are given in Annex 2-3.

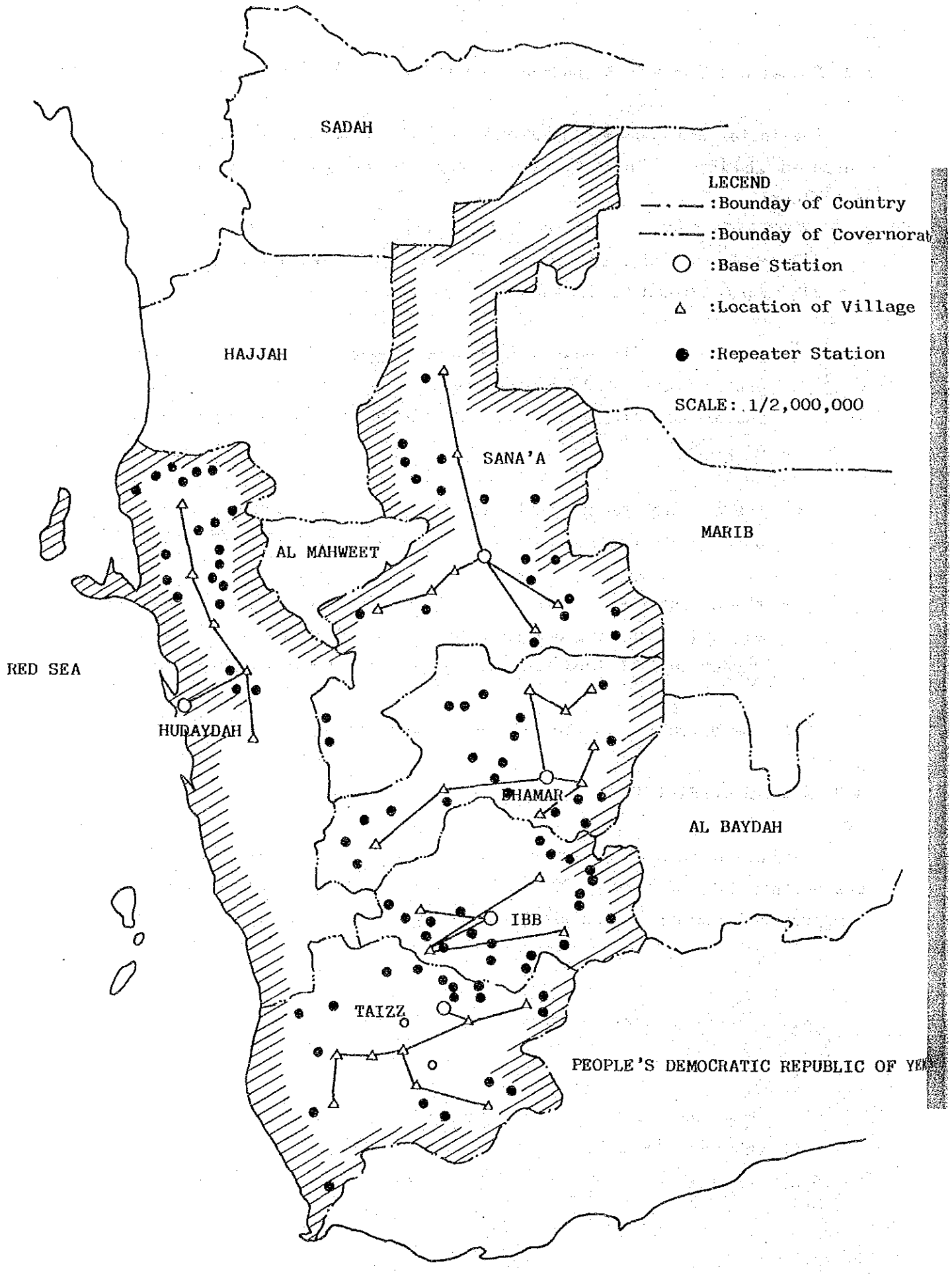


Fig 3-1 OBJECTIVE GOVERNORATES

Table 3 SITE NAME, ALTITUDE AND POPULATION

BASE STATION NAME	SITE NAME	ALTITUDE	POPULATION
HUDAYDAH	AD DAWM	100	1509
	AZ ZUBAYRIYAH	90	838
	DAYR AL MUDAWWAR	130	843
	AL MUGHAYDIFIYAH	40	1074
	AL QANAWIS	90	1384
	DAUDIYAH	80	1007
	DAYR AL MAHADI	80	1168
	DAYR AL WALI	100	1123
	AL MIGHLAF	130	1053
	AL HASHABIRAH	50	1240
	AL MUNIRAH	40	3872
	AL LUHAYYAH	5	2029
	AL HUMASIYAH	40	1607
	AL QANAMAH	60	1811
	MAWR	60	1577
	AZ ZUHRAH	60	3695
	AL MUTARID	80	1989
	DAYR DUKHNAH	100	1312
	DAYR KUZABAH	80	1206
	DAYR ABDALLAH	70	1450
IBB	AL WAQASH	2240	1218
	AD DUHRAH	2360	704
	MABARI	2400	807
	AL HAMMAMI	2040	821
	AL MABAR	2520	730
	AL JAHSHI	2440	744
	AR RABAI	2400	730
	QARYAT AS SANAHI	2400	1484
	NAJD AL JUMAI	1960	852
	MURRAYSI	2200	752
	AL UDAYN	1320	1776
	AL MARAKIB	1520	803
	AKAMAT AS SAFANI	2000	765
	DAKHLAT UWAYDAYN	2640	847
	DHI SARIF	2560	842
	J.MUTAYR	2840	852
	HADDAT ULAYS	2660	1008
	BAYT AL ASHWAL	2760	904
	AL MISQAH	2800	884
	AL MAQALIH	2760	1301

Table 3 SITE NAME, ALTITUDE AND POPULATION

BASE STATION NAME	SITE NAME	ALTITUDE	POPULATION
SANA'A	THILA	2780	3343
	KHALAQAH	2560	1632
	AL MUNAQQAB	2720	1020
	GHADRAN	2220	1170
	BANI MAYMUN	2660	1210
	HAZ	2580	1521
	AL HAWIRI	2230	1146
	AL KHADARAH	2700	952
	AL MARBAK	2680	1047
	BAYT HADIR	2400	1044
	AR RAWNAH	2480	1511
	ZALA	2040	1051
	AL KHAMIS	2280	1121
	GHAYMAN	2460	983
	JIHANAH	2250	1553
	AL KIBS	2320	1151
	SAYYAN	2460	909
	SHABAN	2760	1141
	KUSMA	2680	1231
	MARKAZ BILAD ATTAAM	1680	856
DHAMAR	AITHAYN	2440	2529
	ASAM	2330	1196
	AL MADARAH	2340	772
	BAYHAN	2200	1050
	AHLAL	2480	1248
	AL HARF	2280	1142
	HIJRAT ADH DHARI	2200	750
	BANI MUWALLAD	1920	830
	BANI AS SAMHI	2680	956
	BANI MUSLIM	2120	793
	BANI ALI	1520	860
	ATH THULUTH	1120	753
	AD DARAH	2600	1782
	ABASIR	2500	1110
	ASH SHAQB	2540	799
	AMID	2540	1296
	AS SANAM	2400	1143
	SANAH	2520	991
	AL MUGHADIYAH	2280	743
	ARAM	2400	1341

Table 3 SITE NAME, ALTITUDE AND POPULATION

BASE STATION NAME	SITE NAME	ALTITUDE	POPULATION
TAIZZ	HADNAN	2400	1101
	AL HUSAYN	1160	836
	AL AMAKIR	1640	715
	AL AMAQI	1480	1144
	QARAMAH	1440	897
	AS SAMKAR	1440	848
	AZ ZAHRAH	1420	847
	ARABAH	1420	1093
	BAYT UBAYDAN	1380	804
	QARYAT JARANI	1420	1103
	YUFRUS	1240	1306
	AL MUDAYHIS	1040	744
	ASH SHARAF	1850	853
	HAYFAN	1680	910
	SHAWHAT	1480	736
	J.WADI BISYAN	240	868
	YAKHTUL	5	2007
	ATH THAWBANI	140	812
	DHUBAB	5	1446
	BAB AL MANDAB	5	708

CHAPTER 4 CONTENTS OF PROJECT

4-1 Objectives

The Project is to relieve no-telephone situation in the most important 100 villages located in the rural areas. It also increases efficiency of administrative control and enable to develop rural socioeconomic potential. For this purpose the Government of Japan has extended a Grant Aid to Y.A.R. The Project will provide installation of DRCS telecommunication facilities and supply of ancillaries.

4-2 Study of the Request

4-2-1 Study of the request

The basic objective of the Project is to provide telecommunication services for most inhabitants as much as possible in the project area. The number of villages categorized by two population sizes, i.e. 300 or more and 700 or more within 5 Governorates is counted 5,700 and 1,400, respectively. The ratios of the objective 100 villages to the two groups of villages as categorized above are 2% and 7%. Population is ranging from 700 to 3,900 and average population comes to 1,000.

According to the village distribution data, it can be assumed that 1,000 of inhabitants as average live within the surrounding area (e.g., about 30 minutes access time) of the objective village, consequently about 2,000 of inhabitants per village are able to receive the benefit of the telecommunication services. Installation of five (5) subscriber lines per village effects the telephone density of 0.25%.

The equipment capacity for the rural telecommunication network in Y.A.R is 1,000 lines as a total, which consists of existing 500 lines and a new additional 500 lines. By the end of Third Five-Year Plan the total equipment capacity installed will reach 5,000 lines. At the time of completion of the Project, Third Five-Year Plan will progress 20%.

4-2-2 Study of the requested equipments and materials

(1) The requested telecommunication facilities are as explained in paragraphs 2-4, consisting of a basic telecommunication equipment to form DRCS network to be constructed and ancillaries for operation and maintenance. The construction of rural telecommunication network also requires telephone exchange facilities, subscriber network (telephone sets and wiring) in villages and civil works (land lot, access roads, building and rehabilitation of tower) For these items, the Y.A.R will prepare.

Considering geographical situation such as the average distance 54 km between the Governorate Centre and the objective villages, and five (5) subscriber lines per villages, the most appropriate applicable system is DRCS.

The DRCS network provides telephone connection between remote subscribers and telephone exchange by means of digital radio concentration system. To keep an adequate transmission quality in digital radio path, radio repeater (or repeaters) may be required due to the geographical features of the area.

(2) The reason for most appropriateness of DRCS

1) Because of long distance between telephone exchange and remote subscribers, radio transmission system is cheapest.

2) For a subscriber capacity of 5 lines per village (initial provision), from a cost point of view, DRCS is cheapest.

3) New subscription of other villages and expansion of subscriber lines can be made up to the maximum system capacity of DRCS without channel expansion of radio transmission link (hereinafter called basic radio transmission link) between telephone exchange and repeater station.

4) The radio frequency between telephone exchange and the village requires only one radio frequency for each repeater section. This provide a nationwide frequency saving.

5) One radio terminal can cover all subscribers in the village. No expansion is required except wiring in the village.

(3) 20 villages within each Governorate is widely distributed, so the necessary radio repeater stations also consequently be distributed in the objective areas. Therefore basic radio transmission link serves as backbone of rural telecommunication network to cover the wide service area of 5 Governorates, and also it brings high efficiency of investment and easy-to-add subscriber.

(4) As for the power equipment required in radio repeater station and subscriber radio terminal equipment in villages, taking into account of the climate and commercial power situation in Y.A.R, the application of solar cell power supply system is the most appropriate as undermentioned.

1) no stable commercial power is available in villages;
2) full of sunshine within the country which provide stable solar energy;
3) maintenance and operation is simple and no spare is required; and
4) operation cost is considerably low taking into account of the present road conditions.

(5) In general, the traffic originated from rural areas are mostly to Governorate Centre and foreign countries. If the telecommunication service in the cities are improved, the traffic will enormously increase and contributing to the revenue. The telecommunication service in cities and international telecommunication service in Y.A.R are relatively in good order. The project is matched with the whole telecommunication development of Y.A.R.

4-3 Outline of Project

4-3-1 Competent Authorities

The competent authority for this project is the Public Telecommunication Corporation PTC as shown in Figure 2-1 and its subordinate main organizations concerned are as shown below.

Planning Department
Project Department
Financial Affairs Department
Training Department
Maintenance and Operation Department

4-3-2 Project Implementation Program

(1) DRCS base station is installed at the existing telephone exchange offices of Sana'a, Dhamar, Ibb, Taizz and Hudaydah so as to cover 20 villages in each Governorate (total of 100 villages) and five (5) subscriber lines as average are provided in each village.

(2) The construction of basic telecommunication equipment of DRCS network in the rural telecommunication network will be borned by grant aid from Japan.

(3) The switching, subscriber cable network, land, access buildings and tower for the rural telecommunication network will be borne by Y.A.R for rehabilitation and installation.

(4) After completion of the Project the maintenance and operation will be integrated into and done by the present organization.

(5) After completion of project, the immediate necessary maintenance spares will be purchased within the grant aid capital. Later after this, the spares will be borned by Y.A.R.

(6) For the operation, maintenance and repair of the DRCS facilities, a technical transfer will take place for training 4 selected PTC engineers.

The personnel of the present organization is able to maintain, operate and repair the switching equipment and the subscriber cable facilities.

CHAPTER 5 BASIC DESIGN

5-1 Guiding Principle

The Project aims to establish a most suitable rural telecommunications network in due consideration of the local conditions such as social circumstances, economic activities, topographic condition as well as telephone demand.

Further, existing telecommunication facilities, trend of technical innovation and maintenability are also taken into consideration. The guiding principle for establishment of the rural telecommunications network is as follows:

(1) All the subscriber terminal equipments installed in villages are connected to the nationwide public telecommunications network and the same telephone service which is being provided in urban areas will be provided to rural areas.

(2) Provision of telephone service is only scheduled under the Project. However, other none-voice services such as telex, data transmission, etc. will be provided in future.

(3) Subscriber line network between subscriber station and subscriber telephone instruments is defined as the local network of local exchange which composes the nationwide public telecommunication network.

(4) The subscriber line network is connected to a convenient local exchange in Sana'a, Dhamar, Ibb, Hudaydeh and Taizz through DRCS network.

(5) The DRCS network is composed of three types of DRCS stations, i.e., subscriber, base and repeater stations. The subscriber station accommodate subscriber lines in village and the base station inter-work with local exchange. The repeater station will be provided between subscriber and base stations in case the both station cannot inter-work directly due to some reason.

(6) PTC planned to install two sets of DRCS base station equipment for each base station which accommodates about 128 subscriber lines for each base station against 128 of initial subscriber lines.

However, in due consideration of efficient utilization of radio frequency and effectiveness of investment as well as extent of rural telecommunications network in future, the DRCS provides the capabilities for more than 500 subscriber lines at total traffic of 45 Erl.

(7) DRCS Network

1) To conform the transmission quality specified in CCITT Recommendation G-821.

2) To utilize 2.4 GHz band and 4.0 MHz spacing.

3) To maintain average waiting probability for multi-access channels as of 0.02 or less in Erlang's C-formula.

4) To duplicate transmitter/receiver and control systems.

(8) Power Supply for DRCS

1) To supply DC 48V to DRCS equipment installed at base station from existing DC power supply facility of telephone exchange.

2) To provide DC 48V to DRCS equipment installed at new repeater station by combination of solar and storage batteries. The capacity of storage battery satisfies for three days operation of the DRCS equipment continuously. DC 48V to DRCS equipment installed at existing repeater stations will be taken from DC power supply facilities of the existing equipment.

3) To provide DC 12V to DRCS equipment installed at subscriber station by combination of solar and storage batteries. The capacity of storage battery satisfies for seven days operation of the DRCS equipment continuously.

(9) A remote supervision and control system is introduced for operation and maintenance of the rural telecommunications network.

(10) Existing support facilities such as sites, buildings, access roads, antenna towers, etc. are utilized as much as possible for establishment of the DRCS network.

5-2 Basic Design Condition

The basic design condition for establishment of the DRCS network is as follows:

5-2-1 Radio transmission

(1) The following performance objectives for radio transmission link between base and subscriber stations shall be maintained as specified in CCITT Recom. G-821 (Local Grade).

1) Percentage of available minutes under BER is worse than 10^{-6} shall be less than 1.5% (10% x 15%) in any month (averaging period = 1 minute)

2) Percentage of available minutes under BER worse than 10^{-3} shall be less than 0.015% (0.1% x 15%) in any month (averaging period = 1 second)

(2) Fading depth shall be estimated based on CCIR Report 338-5.

(3) In case a repeater station is needed, BER performance objective for each radio link is given by the following formula basically.

$$p = \frac{P}{N + 1}$$

where p: BER performance objective for each radio link
P: BER performance objective between base and subscriber stations

N: Number of repeater stations

The number of repeater stations between base and subscriber stations as design conditions are categorized as the followings in consideration of distance between base and subscriber stations, characteristic of radio path (probability of fading occurrence) as well as future expansion.

- DRCS to be connected to Hudaydah: 3
- Other DRCS : 5

5-2-2 Antenna Height

(1) Antenna height is determined based on the method described in "Rules for Determining Antenna Height" published by ITU basically.

(2) Antenna height for radio link between base and repeater stations, and between repeater stations.
Higher one shall be selected from obtained antenna heights through computation under the following conditions.

- Effective radius of earth (K) = 4/3 and clearance factor (U) $\geq$ 1.0
- Effective radius of earth (K) = 2/3 and clearance factor (U) $\geq$ 0.3

(3) Antenna height in case of the radio links between base and subscriber stations, and repeater and subscriber stations shall be determined by the above-mentioned method (2) basically. This rule, however, does not apply to the case that the receiving input level is enough to achieve the objective performance by lower antenna height.

(4) Minimum antenna height shall be such that if clears all obstacles such as trees, buildings, etc. in the vicinity of site.

5-2-3 Parameters/Factors for Basic Design

The basic design is carried out utilizing parameters and factors shown below.

- Radio frequency : 2.4 GHz band
- Frequency spacing : 4.0 MHz
- Number of multi-access channel : 60
- Modulator type : 4PSK
- Demodulation method (Upward) : Differential detection
- Demodulation method (Downward) : Coherent detection
- Tx output power level : 31.5 dBm
- Internal noise of receiver (KTBF) : -106 dBm
- Required minimum receiving level (10^{-3} BER): -92.0 dBm
- Branching circuit loss;
  - Transmitter side : 2.5 dB
  - Receiver side : 1.5 dB
- Antenna gain;
  - Omni-directional type : 10 dBi
  - Horn type : 20 dBi
  - Grid parabolic 1.2 m dia. : 27.5 dBi
  - Grid parabolic 1.8 m dia. : 31.3 dBi
  - Grid parabolic 2.4 m dia. : 32.9 dBi
  - Grid parabolic 3.0 m dia. : 34.8 dBi
- Feeder loss
  - 1/2 inches type : 0.1 dB/m
  - 7/8 inches type : 0.06 dB/m

However, the transmission performance of the links will be reconfirmed to CCIR Report 380 with the parameters of the equipment selected.

5-2-4 Subscriber signalling

(1) Metallic two wire circuit is applied for ordinary and discriminated subscriber line between base station and local exchange, and between subscriber station and subscriber telephone instrument. Subscriber signalling introduced to the system is as follows:

	Ordinary subscriber	Discriminated subscriber (Pay phone)
- Call initiate signal	Loop of 2-wire	- do -
- Register signal	Loop disconnection or MF	- do -
- Answer signal	Nil	Polarity revesal
- Charging signal	Nil	16 KHz pulse
- Clear signal	Loop disconnection	- do -
- Ringing signal	16 - 25 Hz	- do -

(2) The signalling on junction circuits (2-wire or 4-wire speach path) is E & M.

5-2-5 Subscriber service functions

- Telex & data
- Intra-call
- Centralized remote supervision & control
- Centralized remote line testing
- 4w and 6w E & M Junctions

5-2-6 Power supply facility

(1) Base station

Required DC power (48V) for DRCS is provided by the existing power supply facility since the existing facility has enough capacity as shown in Basic Design Drawing-5 (Hudaydah station for example).

(2) Repeater and subscriber stations

1) The following environment conditions and autonomy of facilities are applied for determination of the equipment capacities.

Area	Solar (R) Radiation (Cal/cm^2)	Temperature (^oC)	Humidity (%)	Autonomy (A) Repeater Station (day)	Autonomy (A) Subscriber Station (day)
Sana'a	495	18.2	44	3	4
Dhamar	434	16.1	48	3	4
Ibb	452	22.2	58	3	4
Taizz	452	22.2	58	3	4
Hudaydah	445	30.2	72	3	4

2) The following traffic conditions are applied for determination of the equipment capacities.

- Busy hour traffic (Tr) : 1.4 Erl.
- Number of subscriber line (Nl) : 8
- Traffic concentration ratio (Cr) : 10%
- Average idle duration (Id)
  Repeater station : 5 hours/day
  Subscriber station : 14 hours/day

3) Power consumption for air-craft warning lamp is included.

(3) Solar cell is required an element which supplies a maximum power output (Po) at 100 mW/cm^2 for sunshine incident energy and at 25^oC for cell-element temperature, and is formed of one module by connection of several element.

(4) Capacity of solar power system is determined in consideration of the following factors:

1) Solar cell (Pm)

- Compensative factor for solar array angle (Kl) : 0.95
- Charging efficiency for storage battery (K2) : 0.9
- Transmission loss of sunshine energy for module case-glass (K3) : 0.95
- Safety factor for various items (K4) : 0.73

2) Storage battery (Bc)

- Capacity safety factor for temperature, humidity and other various items (K5): 0.8

(5) Storage battery is set by one (1) bank for each station, one bank consists in 24 cells for repeater station and 6 cells for subscriber station.

(6) Calculation formulas for the equipment cpacities required are as below;

$$\text{Solar cell Pm} = \frac{100\ \text{mW/cm}^2 \times 24}{R \times 1.16 \times K1} \times P1 \times \frac{1}{K2 \times K3 \times K4}$$

$$\text{Number of solar cell array} = \frac{Pm}{4 \times Po}$$

$$\text{Storage battery Bc} = \frac{P1 \times 24 \times A}{V1 \times K5}$$

Where, V1 indicates the nominal operation voltages of equipment. Namely, 48 V for repeater and 12 V for subscriber station.

(7) Estimation formula for power consumption (P1) of equipment

$$\text{Power consumption } P1 = Ti\ (Pbas + Plin \times Np) + Te\ (P'bas + P'lin \times Np + Pinc \times Nlin)$$

where, Ti : Propotion of average idle time of the equipment in a day

Te : Proportion of average engaged time of equipment in a day

Pbas : Basic poer consumption in an idle hour

P'bas : Basic power consumption in an engaged hure

Plin : Additional power consumption by line circuit package in an idle hour

P'lin : Additional power consumption by line circuit package in an engaged hour

Np : Number of line circuit package

Pinc : Incremental power consumption by an engaged line circuit

Nlin : Number of engaged line circuit

$$= \frac{Tr}{N1 \times Cr \times (24 - Id)}$$

5-3 Basic Design

5-3-1 Site and radio transmission link

(1) Locations, coordinates and other information of all the sites are shown in ANNEX 2-2 and ANNEX 2-1 respectively. The proposed site plan has no problem for satisfaction of the objective performance and other conditions described in Paragraph 5-1 and 5-2.
The sites for subscriber stations, however, will be finally selected through site survey and consultation with the PTC.

(2) Transmission configuration and antenna system are shown in Basic Design Drawing-2 and 3, and Basic Design Drawing-4 respectively.

5-3-2 Radio Frequency Assignment Plan

In consideration of effectual utilization of radio frequency, 2.4 GHz band is applied for the DRCS network in accordance with CCIR Rep-933.

The allocation of radio frequencies are shown in Table 5-1.

The variance of radio transmission hops in distance is shown below:

Distance (km)	Number of Radio Hop
- 10	25
10 - 20	56
20 - 30	29
30 - 40	15
40 - 45.5	6

Table 5-1 Allocation of Radio Frequencies

Frequency	Channel Number	Engaged
2.308	1	Sana'a Base Station - Dayn Repeater Sation
2.312	2	
2.316	3	
2.320	4	Dayn Repeater Sation - Subscriber Station
2.324	5	
2.328	6	
2.332	7	
2.336	8	
2.340	9	
2.344	10	
2.348	11	
2.352	12	
2.356	13	
2.360	14	
2.364	15	
2.368	16	
2.372	17	
2.376	18	
2.380	19	
2.384	20	
2.402	1'	Sana'a Base Station - Dayn Repeater Station
2.406	2'	
2.410	3'	
2.414	4'	Dayn Repeater Station - Subscriber Station
2.418	5'	
2.422	6'	
2.426	7'	
2.430	8'	
2.434	9'	
2.438	10'	
2.442	11'	
2.446	12'	
2.450	13'	
2.454	14'	
2.458	15'	
2.462	16'	
2.466	17'	
2.470	18'	
2.474	19'	
2.480	20'	

5-3-3 Accommodation plan for subscriber line

A subscriber station is established providing five (5) subscriber lines in average for each village at the first stage. Actual number of subscriber lines to be installed for each village will be determined finally through the detailed design.

Telephone service will also be provided to the villages in the vicinity of the specific repeater stations where are indicated in Basic Design Drawing-2 (20 repeater stations). For the abovementioned service, two sets of subscriber line interface are additionally equipped at the initial stage. The number of subscriber line interface to be provided in the cetral stations is 500 for each.

5-3-4 Power supply facility

(1) The outline of power supply facilities is shown in Basic Design Drawings-5.

(2) The following functions are provided for supervision and control of the power supply facilities.

Function	Repeater Station	Subscriber Station
1) ON and OFF control for over charging of battery	o	o
2) Indication of above status	o	o
3) Protection for excessive current	o	
4) Protection for excessive voltage	o	o
5) ON and OFF control for over discharge	o	o
6) Indication of above status	o	o
7) Alarm for over discharge	o	o
8) Indication of voltages including solar battery	o	o
9) Indication of solar battery current	o	
10) Indication of load current	o	

(3) Type and capacity (per cell) of the storage battery shall be of enclosed lead acid and ten (10) hour rate current with two (2) volt of final discharging voltage.

(4) The following portable engine generators and rectifiers are provided for emergency use at repeater and subscriber stations and those emergency equipments are stored at base stations. The capacity and rating of those equipments, and the quantity are as follows:

Category	Rectifier	Engine Generator	Q'ty
For Subscriber Station	DC 12V 50A	1φ 50 Hz 220/110V 3.0KVA	10
For Repeater Station	DC 48V 30A	1φ 50 Hz 220/110V 5.0KVA	5

5-3-5 Supervising and control

DRCS network has a function to supervise and control remotely the status on operation of the DRCS equipments and other associated facilities. Summary of the functions is shown below:

(1) Supervision of base station

1) DRCS

- fault of radio link
- fault of master oscillator/reference clock
- fault of central processor unit
- fault of concentrator
- fault of CPU
- fault of TDMA
- fault of radio equipment
- fault of power supply unit

2) Status of other associated facilities

(2) Supervision of repeater and subscriber stations

1) DRCS

- fault of radio equipment
- fault of TDMA
- fault of power supply unit
- fault of subscriber unit

2) Status of other associated facilities

(3) Testing of subscriber line

(4) Measurement of traffic

- Number of originating and terminating calls for each station basis
- Traffic volume for each base station and repeater station basis

(5) Information and data from the supervisory system are indicated on CRT

(6) The following parallel supervising/control is introduced for efficient operation and maintenance.

DRCS Network	Supervising/Control Base Station	Parallel Supervising/ Control Base Station
Sana'a	Sana'a	
Dhamar	Dhamar	Sana'a
Ibb	Ibb	Taizz
Taizz	Taizz	
Hudaydah	Hudaydah	

5-3-6 Building plan

All the base station facilities are installed in a room of existing local exchange or buildings under construction. All the buildings for repeater and subscriber stations are newly constructed and the required spaces are shown below.

- Repeater station : Minimum 3 m x 3 m
- Subscriber station: Minimum 1.5 m x 1.5 m

The typical site layout plans are shown in Basic Design Drawing-5.

5-3-7 Model DRCS Network

For the purpose of repairing of DRCS equipment and training of maintenance staff, a Model system of DCRS network is provided in Sana'a. The summary of the composition of model is as follows:

1) One set of DRCS base station facilities with 5 subscriber line interfaces
2) Two sets of DRCS repeater station facilities
3) Two sets of DRCS subscriber station facilities with 5 subscriber line interfaces for each set
4) One set of power supply facilities for subscriber station (Solar battery and storage battery DC 12V)

5-3-8 Burden sharing

The Project will be implemented by the both Governments under burden sharing as scheduled below and Basic Design Drawing-7.

(1) Burden sharing by Japanese Government

1) Procurement and Installation of DRCS facilities including antennas, feeders, etc.

2) Procurement and installation of power supply facilities for repeater and subscriber stations.

3) Procurement of test equipment, tools and spares for operation and maintenance of DRCS network.

4) Procurement and installation of model DRCS network.

5) Provision of manual for operation and maintenance.

(2) Burden sharing by Y.A.R

1) Acquisition and/or securing of sites

2) Site development (filling, cutting, construction of gate and fence, etc.) prior to comencement of installation of facilities

3) Construction and restoration for the following:

a) All of the buildings where DRCS facilities are installed.
b) All of the antenna towers and masts including lightning earth and arrester rod.
c) Subscriber line networks consist of pair cables, drop wires and subscriber telephone instruments.

4) Provision of warehouse and yard for DRCS facilities and installation materials at the Governorate centre concerned.

(3) Boundary of burden sharing

The physical boundaries of burden sharing are illustrated in Basic Design Drawing-8.

5-3-9 Requirements on site, building, antenna tower, etc.

(1) Site and access

All the sites and access shall be developed and/or restored to avoid any trouble for installation and maintenance works of DRCS facilities. Basic Design Drawing-6 is provided for the purpose of reference.

(2) Building

All the new buildings shall be constructed comply with the site layout plan (Basic Design Drawing-6), and hole(s) shall be provided on the building wall to bring over antenna feeders and cables. Abovementioned hole(s) shall also be furnished to the existing building concerned.

(3) Antenna tower and mast

All the antenna towers and masts have enough height to mount antenna as specified ground height shown in Basic Design Drawing-4.

1) The wind loading on antenna towers and masts on structural design shall be based on ground wind velocity of 50 knot (92.6 km) per hour and the sway and twist of antenna mounted to those towers and masts shall be $\pm 1.25^{\circ}$ or less.

2) Earthing system (resistance: less than 10 ohm) and lightning system shall be included.

3) Ladders and platforms shall be provided to the antenna tower for easy installation and maintenance.

(4) Subscriber line network

Subscriber lines shall be terminated at the 10-line terminal box with protectors which is provided on the outer wall of subscriber station building.

CHAPTER 6 PROJECT IMPLEMENTATION PLAN

6-1 Organization for Project Implementation

(1) Considering the mechanism of Grant Aid from Japanese Government and the sharing of installation burden between both countries, the following organization for the project implementation is recommended.

PTC ---- Consultant for the burden of Japan side

-- Contractor for the burden of Japan side

-- Contractor for the burden of Y.A.R side

- -- A land and access
- -- B building (including rehabilitation of existing building)
- -- C tower
- -- D mast
- -- E cable and dropwire

-- PTC installation team for installation burden of Y.A.R side

- -- A rearrangement for telephone exchange (base station)
- -- B subscriber telephone set

-- Service planning for new subscriber

-- Preparation for maintenance and administration

(2) The maintenance and administration for the nationwide telecommunication network and the business operation including the implementation of the Third Five Year Plan in Y.A.R are going smoothly. Therefore, we consider that organization, technology, personal staff and administration necessary for the project implementation are sufficient.

6-2 Implementation and Supervision Plan

(1) The system of Grant Aid by the Government of Japan consists of Exchange of Notes, Procurement Contract (consultant and implementing contractor) and payment of monetary capital aid. The fund is found within one accounting fiscal year (ending in 31 March each fiscal year in principle). The project is implemented by Japan and Y.A.R each sustaining the implementation.

The Project should without delay be implemented smoothly for completion. In order to reach this objective, each implementing section should coordinate the contents and schedule of the Project to avoid any discrepancies.

For this purpose, PTC and the consultant of the Japanese side should at the beginning of implementation exchange technical views and schedule information with each other to reach a close precise plan. From purchase to completion, both sides will contact each other and reach a practical adjustment.

(2) Japan burdening facilities which require material not found in Y.A.R will all be purchased in Japan except for sand, gravel and cement.

(3) On the Y.A.R burdening facilities which are as given in 5-3-9, the basic technical items and implementation schedule will be discussed in the next stage for detail design.

6-3 Implementation Schedule

The process necessary for the project implementation consists of sign of the Exchange of Notes between Japanese government and Y.A.R, selection of Japanese consulting firm by Y.A.R and contract of design and supervision between Y.A.R and the consulting firm.

The consulting firm prepares detailed designs and tender documents on the Japan burdening facilities, and tenders.

After evaluating the tender documents, Y.A.R and a successful tenderer conclude a implementation contract and begin the installation of the Project. The period for installation would be needed for about 19 months, in the point views of the wide distribution of plan area, natural condition of the environment, and the contents and scales of burdening facilities of Y.A.R. Therefore the period of installation is divided into two phases: the first phase is for the telecommunication network in Sana'a and Dhamar and the second phase is the remained telecommunication network in Hudaydah, Ibb and Taizz.

Detailed designs, tender documents, procurements and implementation supervision on the Y.A.R burdening facilities are implemented by PTC's organization and the Project implementation structure.

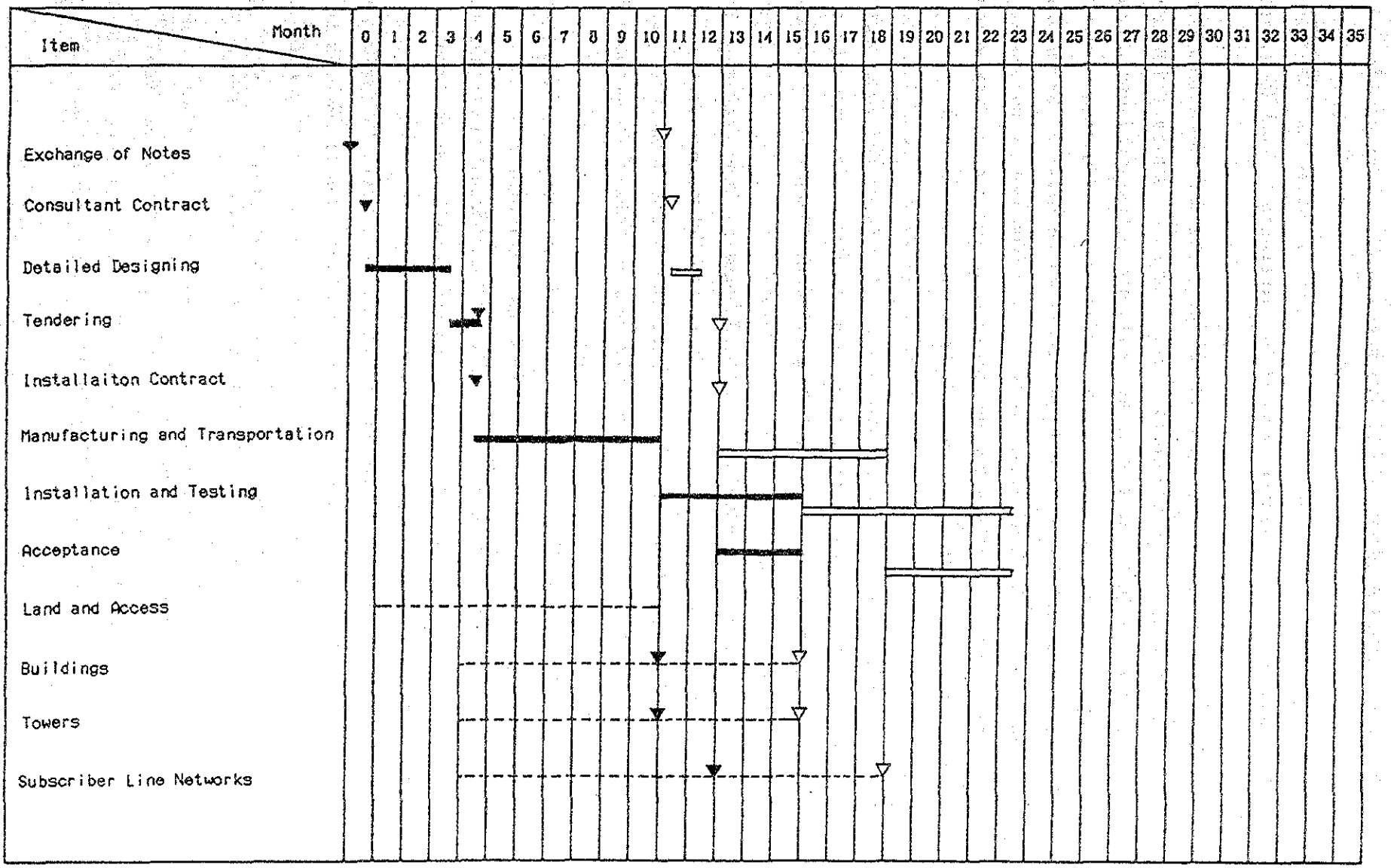
Project implementation schedules are shown in Table 6.

6-4 Project Cost

Project costs to be provided by Y.A.R are estimated as follows:

Phase -I	2,273,000 Y.R +	$80,000
Phase -II	5,389,000 Y.R +	$815,000
Total	7,662,000 Y.R	$895,000

Table-6 Project Implementation Schedule



CHAPTER 7 MAINTENANCE ADMINISTRATION PLAN

7-1 Organization for Maintenance and Administration

(1) The rural telecommunication network provides the domestic and international telecommunication services as a combination network with the existing nationwide telecommunication network. Therefore after the completion of this Project, the operating and maintenance for the telecommunication network is necessary to be provided by the whole policies of the Public Telecommunication Corporation and in its whole organization to attain the performance of service quality which is the subject of the PTC.

(2) The maintenance and administration for the rural telecommunication network is charged by each relational Department Sections in the present organization of the PTC every facilities.

Transmission Section	DRCS Network (Base Station - Repeater Station - Subscriber Station)
Outside Plant Section	Subscriber Line Network (Telephone Exchange - Cable - Dropwire - Telephone Set)
Power Plant Section	Power Plant Equipment (Repeater Station - Subscriber Station)
Rigging Section	Tower Mast (Base Station, Repeater Station, Subscriber Station)

(3) Out of radio transmission engineers in the present PTC, six persons are to be selected and allocated as the charging men of DRCS as follows:

Headquarters of Public Telecommunication Corporation and Repair Center for DRCS	one person
Sana'a Base Station	do
Dhamar Base Station	do
Hudaydah Base Station	do
Ibb Base Station	do
Taizz Base Station	do

Out of six persons mentioned above, it is desirable that four persons to Headquarters of PTC, Sana'a, Hudaydah and Taizz, are to be selected from senior engineers and given OJT during the installation and also trained by manufacturers of DRCS.

7-2 Maintenance and Administration Plan

(1) At each base station, the state of operation of all stations which compose each rural telecommunications networks are displayed on the supervision and control equipment which is installed in base stations. The items on supervision and control is described on paragraph 5-3-5.

(2) Describing on the 5-3-5, parallel devices are installed in Sana'a for Dhamar and Taizz for Ibb so as to supervise and control Dhamar and Ibb parallelly.

(3) The maintenance works for DRCS equipment are to check the function of equipment by using the measurements and test equipments listed on the paragraph 5-3-10, to find out the fault, and to recover the fault by adjusting or replacing spare parts. For the subscriber networks and power plants, the maintenance works are the same as that for the existing ordinary telecommunications network.

7-3 Cost for Maintenance and Administration

A cost for maintenance and administration consists of maintenance cost, operation cost and consignment fee of public telephone. Maintenance cost is a direct cost which is personnel expenses, supplies expenses, electric power expenses and etc. for maintenance of telecommunications network.

Operation cost is indirect personnel expenses for marketing and charging.

In The Feasibility Study Report on Rural Telecommunication Network in Yemen Arab Republic, March 1985, JICA", the operating expenses which is in the case of 2453 subscribers in 456 villages, is estimated. The scale of this Project is 500 subscribers in 100 villages. This corresponds to 20

percent of JICA feasibility study. Then the maintenance and administration cost a year is estimated as about 50,800,000 yen.

CHAPTER 8 PROJECT EVALUATION

(1) The objective villages are scattered at average road distance of 54 km from each Governorate Centre, moreover, the roads are steep and not smooth surface. There is a large number of villages necessiate 4-drive vehicle for access. Accordingly, the people of villages, who depend on vehicles or foot, can obtain various benefits including monetary savings such as costs of transport and the value of time by utilization of telephone. Adding a consumer surplus, the economical internal rate of return is supposed as 3 times of the financial internal rate of return or more.

(2) The objective areas of the Project is for five Governorates in total out of 11 Governorates of Y.A.R. Proportion of the objective 100 villages is only 2% of about 5,700 villages in the five Governorates. However, the rural telecommunication network established by the Project covers almost all parts of the five Governorates as its service areas not for only the objective 100 villages.

Namely, it is a back-bone telecommunication network for the five Governorates.

After completion of the Project, it is possible to expand the number of subscribers easily with less investment by new installation of subscriber stations at new villages in the service areas of the back-bone telecommunication network installed. It is available to serve approximately 5,000 lines or more for the five Governorates depending on traffic conditions of subscribers.

(3) Output of any Industries, in general speaking, does not growth unless a certain size of communications input is made. It is an evidence that the size of communications input coefficients of agriculture is considerably big in developing countries and high productive agricultural sector as general tendency. The agriculture is a core industry of Y.A.R and produces about 30% of gross domestic product at producer's prices. On the other hand, the rural areas to make the products of the soil in Y.A.R situated on practically no telephone

conditions and are isolated from structure of market economy. In such conditions, reliable and quick information by telecommunication which supply by the Project will encourage the agriculture to shift for an agriculture in market economy and increase its productivity in the long run.

(4) CCITT has suggested that correlation between telephone density and GDP as an indication of wealth of nations can indicate the benefits of telecommunications. According to international comparison by the above method, the existing telephone density of rural areas in Y.A.R is extremely low level compared with other developing countries. In view of the above, it is obvious that the Project is necessitated urgently for social and economic development of the rural areas in Y.A.R.

(5) The telephone lines installed by the Project (average 5 lines per village) can be utilized by about 2,000 inhabitants (about 360 families) including some inhabitants in the surrounding villages. There are a lot of migrants outside Y.A.R in average 0.8 person per family and it amounts to 1,170 thousand throughout the country. This value is equivalent to 2.7 times of the population of capital Sana'a. Since the people in the rural areas were impatient to have not only national but also international telephone calls, their wishes will be realized by this Project.

CHAPTER 9 CONCLUSION AND RECOMMENDATION

9-1 Conclusion

From the analysis explained in the previous chapters, it is expected that the Project will contribute largely to the economic and social development of rural areas throughout the five Governorates. Considering the availability of the basic telecommunication network established by the Project for expanding of subscribers in new villages throughout the five Governorates, the effectiveness of initial investment is very big in consideration of future expansion.

The overall capability of PTC including technical and manpower aspects for the Project implementation is satisfactorily, and, it is considered that the maintenance and management on the telecommunication network after the Project will be conducted adequately.

The burden sharing by Y.A.R for the facilities are 121 station buildings, 122 aerial supporting structures consist of towers and masts, and subscriber Line networks for 100 villages in addition to the land and access for the stations. The required finance for the Y.A.R side is estimated as approximately 200 million yen equivalent (900,000 US$ and 7,700,000 Y.R). This burden sharing by Y.A.R shows the perception by Y.A.R for importance of the Project and the intensive toward the completion of the Project, and are to be highly appreciated.

9-2 Recommendation

(1) The Project will be achieved in systematic integration of the respective facilities burdend by the both countries. Accordingly, it is an important key point on the project management to keep mutually synchronization of the implementation schedules and matching of technical matters between the both countries. Therefore, authorities concerned with both countries and related persons are to take following actions;

1) Y.A.R is to inform the Japan Embassy of the situation for securing of finance to the facilities to be provided by Y.A.R immediately after the signing of Exchange of Notes.

2) At the time of contract related to consulting;

- The PTC is to inform the consultant of procurement schedule for the facilities to be provided by Y.A.R (Summary of technical specifications, contractors and implementation time schedule).

- The consultant is to inform the PTC of the implementation time schedule for the facilities to be provided by Japan.

3) After the consultanting contract, practical coordination on the project implementation is to be made through close liaison between the PTC and the consultant.

(2) The effectiveness of initial investment to this Project will produce more fruitful results by full utilization of the system capacities and functions of the basic telecommunication network installed. Therefore, more expansion of villages and subscriber toward satisfying telephone supply targeted in the Third Five-Year Plan will be expected to make more worthwhile project.