FEASIBILITY STUDY REPORT

ON

RURAL TELECOMMUNICATIONS NETWORK

IN

YEMEN ARAB REPUBLIC

MARCH 1985

THE JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Yemen Arab Republic, the Japanese Government decided to conduct a feasibility study on the Rural Telecommunications Network Project and entrusted the study to the Japan International Cooperation Agency (JICA).

The JICA sent to Yemen a 7-man survey team headed by Mr. Shigeto Kimura, Nippon Telecommunications Consulting Co., Ltd. from 11th September to 10th December, 1984.

The team exchanged views with the officials concerned of the Yemeni Government, and conducted a field survey in the Project area. After the team returned to Japan, further studies were made 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 deep appreciation to the officials concerned of the Government of the Yemen Arab Republic, for their close cooperation extended to the team.

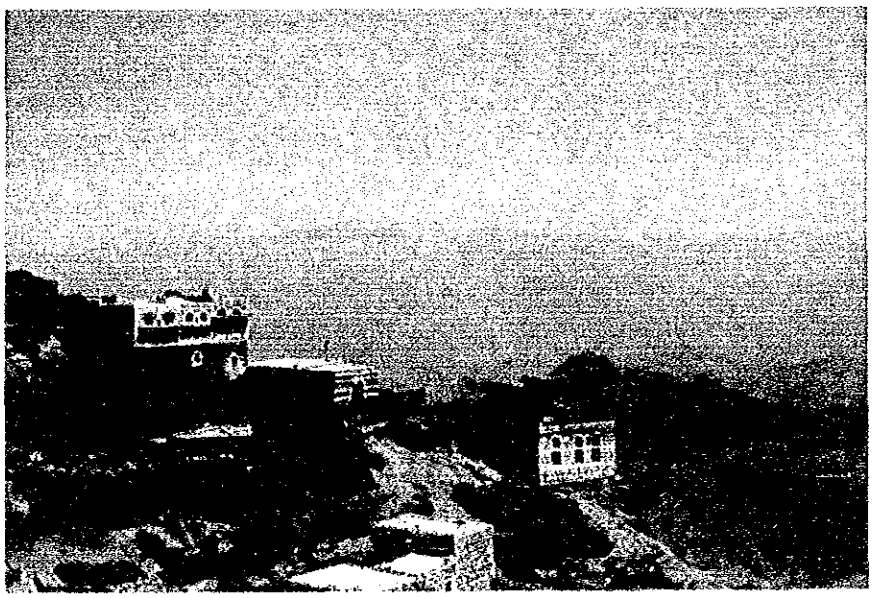
March, 1985

Keisuke Arita

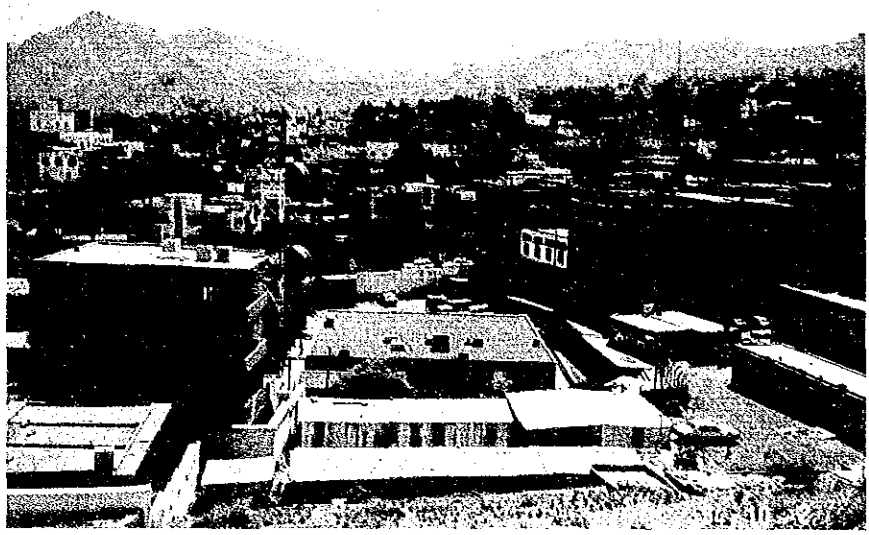
Keisuke Arita
President
Japan International Cooperation Agency

Meeting on Inception Report (TTI/SANA'A)

Survey at Existing Radio Repeater Site
MASAR in SANA'A Governorate



Typical Mountaintop Village
MASAR in SANA'A Governorate



TAIZZ New Exchange Office

Landscape near Proposed Radio Repeater Site
(AL AKHTUR in TAIZZ Governorate)

Proposed Radio Repeater Site and Village
(J. KIBAH in DHAMAR Governorate)

Villages surrounding Proposed Radio Repeater Site
(AD DANN in DHAMAR Governorate)

Proposed Radio Repeater Site
(DAYR MAKHRASH in HUDAYDAH Governorate)

Survey at Proposed Radio Repeater Site
(AL BULAYH in HUDAYDAH Governorate)

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SUMMARY AND RECOMMENDATIONS

SUMMARY AND RECOMMENDATIONS

1 Background of Study

The Yemen Arab Republic (hereinafter called "Yemen A.R.") telecommunications network improvement was carried out in the First National Development Five-Year Plan (1977 - 1981). The improvement was for the backbone transmission routes interconnecting three main cities, i.e., SANA'A, TAIZZ and HUDAYDAH, as well as transmission routes between the three cities and their respective satellite cities, and junction network in each of those cities.

As of the present, rural villages inhabited by nearly 90% of the whole population are almost completely without communication facilities. Those rural villages are widely scattered in hilly and mountainous areas so that the contacts with the central part of the country and among themselves are extremely difficult.

Therefore, in the Second National Development Five-Year Plan (1982 - 1986), the Government of Yemen A.R. gives top priority to telecommunications network upgrading so as to promote social and economic development of rural areas, and requested the Government of Japan to provide technical assistance for that purpose.

The Government of Japan decided to accept the request. As the consequence, Japan International Cooperation Agency (hereinafter called "JICA") dispatched a five-member preliminary survey team to Yemen A.R. in May 1984 and, through the team, consulted with the Government of Yemen A.R. concerning the scope and items of main survey to follow.

JICA dispatched its seven-member main survey team to Yemen A.R. for a period from September 11, 1984, to December 11, 1984. The team carried out feasibility study pertaining to Yemen A.R. rural telecommunications network improvement plan and formulated a draft implementation plan.

This report presents main study results. Following is a summary of findings in the study.

2 Results of Study

The study was made for six Governorates of Yemen A.R. selected out of a total of 11 Governorates as objective areas of the rural telecommunications network improvement plan. About 80% of the country's whole population inhabit those six Governorates.

In those six Governorates, villages, each with a relatively large population and located at a key site, were selected as objective villages of the plan. For each such villages, subscriber demand was forecasted from its social and economic status. The number of objective villages and the number of initial stage subscribers were determined as under.

No. of villages : 456

No. of subscribers: 2,453 (Telephone density: 0.5%)

Rural telecommunications network basic designs were prepared for Plan-A to utilize the existing switches and line concentrators, and for Plan-B to install new switches for rural network use. Based on these basic designs, estimates were made for construction cost, operating expense and operating revenue. Finally, financial and economic analyses were carried out.

Conclusion obtained by these analyses stands in favor of Plan-A as being worth full evaluation, provided that the tariff system be partly modified. That is to say, invested capital depreciation can be fully expected while the impact on social and economic development of rural communities is large.

More precisely, financial internal rate of return (IRR) is 7.43% and, even in case where initial investment increases by 20% or revenue decreases by 15%, financial IRR still exceeds the opportunity cost of capital. Even if loan is invited to finance this project implementation, no problem is foreseen in principal plus interest repayment.

For economic IRR, 11.91% can be expected. Besides, social and economic benefits that cannot be quantitatively determined exist.

Plan-A outline is as under.

(1) Outline of Network Configuration

a) To be composed of six sub-rural networks. (Each sub-rural network generally corresponds to one Governorate.)

b) To apply digital radio concentrator system (DRCS) to each sub-rural network in consideration of engineering economy, system expansibility and foreseeable future technical trend.

c) To accommodate subscriber's lines of each sub-rural network in the existing switch or line concentrator of sub-rural network concerned.

(2) Outline of Telecommunication Facilities

Base station	:	6 sites	(23 base units)
Repeater station	:	38 "	(55 repeater units)
Subscriber station	:	436 "	

System equipment of each station is to be installed in shelter type building or conventional building, to be finalized at the detailed design stage, without affecting the work schedule.

To facilitate maintenance, solar cell system is used for power supply to equipment except in case where the existing repeater station and/or telephone exchange office sites are utilized, subject to availability of spare capacity.

(3) Outline of Construction Cost (Based on system configuration presented in this report)

Construction cost estimate is by price level as of December 1984 and average price rise rate of 5% annually. Construction cost estimate thus obtained is as under. (Exchange rate: YR 1 = ¥ 41.42)

		Foreign Currency Portion (in million yen)	Local Currency Portion (in million YR)
1)	Rural telecommunications network construction (including equipment and materials purchase, construction service, site and access road land acquisition and related construction)	5,083	40.1
2)	Training and maintenance services	60	-
3)	Consulting services	400	1.7
4)	Contingency	554	4.2
	Total	6,097	46.0

3 Recommendations

Recommendations intended for modification of telephone tariff system for and after 1990 are as under.

(1) To introduce countrywide uniform tariff system by applying the present telephone installation charge and call charging system for urban subscribers to rural network subscribers also.

Public call office telephone users are exempted from installation charge by reason of utility service.

(2) To consider the revision of monthly rent applicable to rural network subscribers (including public call office telephones). This revision, though intended for wholesome service management, is to be carried out in such manner as will not impede telephone demand growth.

That is, recommended monthly rent is YR 600 for rural subscribers.

(3) To revise consignment fee to public call office telephone service consignees so that the amount of consignment fee will be proportional to service volume. One typical example: 10% of calling charge.

The rural tariff system recommended above is to aim at the telephone diffusion rate of 0.5% to the objective villages of this project. In other words, telephone diffusion rate of over 0.5% may not be realized by the adoption of the said tariff system. Therefore, nationwide and systemwide revision of tariff system will be required for further diffusion of telephone service in Yemen A.R.

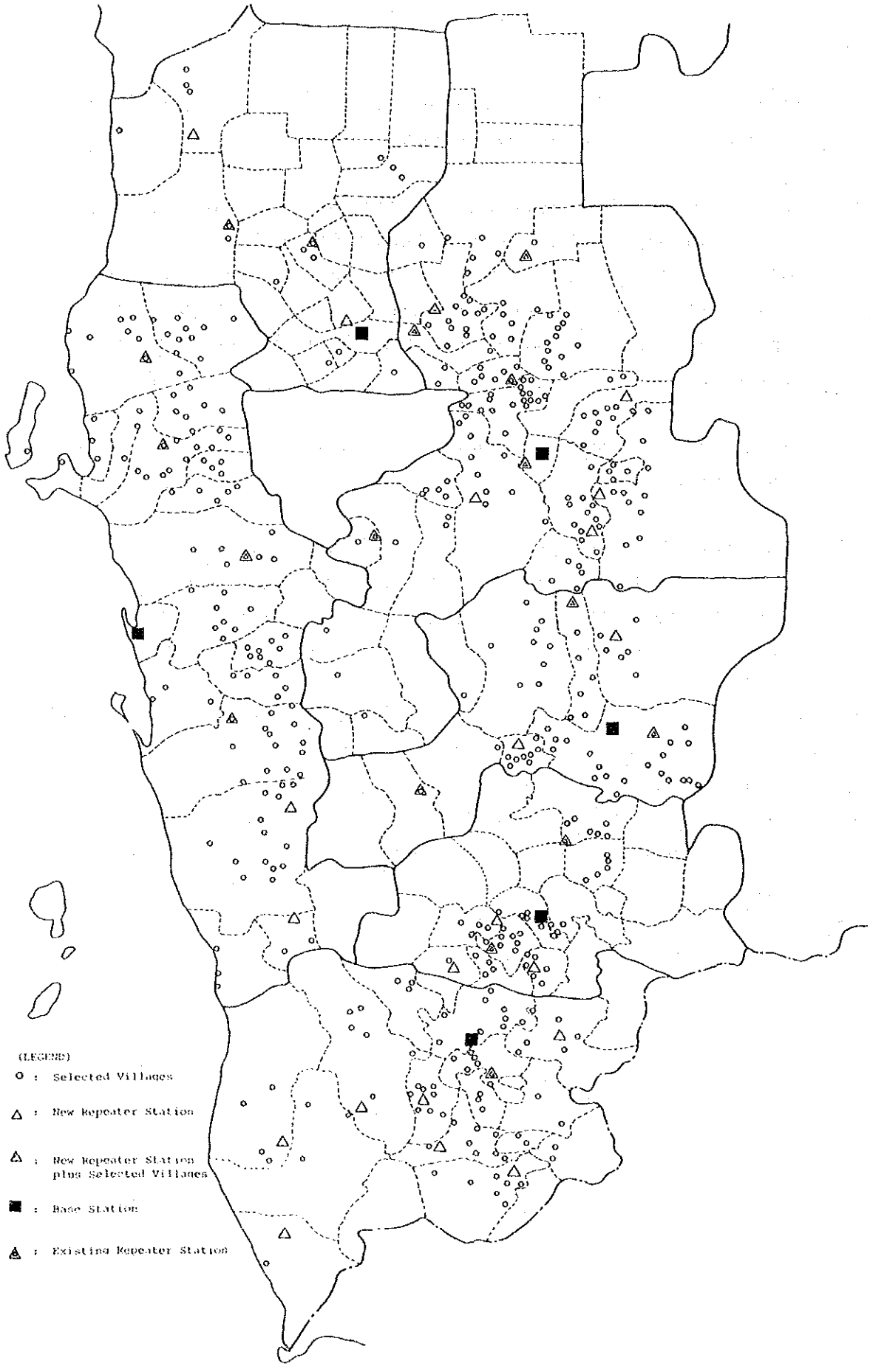

Figure 1 DISTRIBUTION OF SELECTED TOWNS/VILLAGES

CHAPTER 1 INTRODUCTION

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1-1 General Background

Telephone service in Yemen A.R. is of extremely low utility value at the present stage. In the whole network, only the backbone routes that interconnect main cities are developed. Up to 87% of population who inhabit rural villages are in no position to benefit by telephone service. Those rural villages are widely scattered throughout the country with heavily accidented topography. For this reason, the rural villages are denied traffic convenience to/from the central part of the country and among themselves.

Rural telecommunications network improvement as a means of solution to such inconvenience is an urgent requirement. The Government of Yemen A.R. itself attaches special importance to the rural telecommunications network improvement plan as a key item in the Second National Development Five-Year Plan (1982-1986), and recently requested the Government of Japan to provide technical assistance for successful implementation of the plan.

In response to the request, the Government of Japan dispatched two experts for short-term basic investigation to Yemen A.R. in 1983. The technical report made by those experts while staying in Yemen A.R. and submitted to the Government of Yemen A.R. was highly evaluated.

Consequently, the Government of Yemen A.R. decided to implement the rural telecommunications network improvement plan on top priority in accordance with the proposals in the technical report referred to above, and requested the Government of Japan to carry out the feasibility study.

The Government of Japan consented to the request and decided to carry out the feasibility study for the rural telecommunications network improvement plan, covering principal rural villages in six Governorates out of a total of 11 Governorates in Yemen A.R. Based on this decision, JICA dispatched the preliminary survey team in May 1984; then, for the technical and economic feasibility study concerning the construction plan, dispatched the main survey team in September 1984.

1-2 Objective and Outline of Study

1-2-1 Objective of Study

The objective of study is to examine the technical and economic feasibility of the rural telecommunications network improvement plan, based on the request from the Government of Yemen A.R.

1-2-2 Scope of Study

The coverage area of study consists of principal rural villages in six Governorates including SANA'A out of all rural villages which are without telephone facilities almost completely. The six Governorates are:

(1) SANA'A Governorate
(2) DHAMAR "
(3) IBB "
(4) TAIZZ "
(5) HUDAYDAH "
(6) HAJJAH "

For HAJJAH Governorate, the study covers part of it.

The objective Governorates illustration appears in Figure 1-1.

The study includes necessary field survey for formulation of rural telecommunications network improvement plan covering the aforementioned six Governorates and for collection of related data and information, as well as survey report making in Japan.

Note: The 11 Governorates include AL JAWF Governorate recently separated from MARIB Governorate.

1-2-3 Staff Lineup for Study

Personnel seated in the survey team are as follows:

(1) JICA Advisory Committee

Post (Assignment)	Name in Full	Employment
Chairman (General Administration)	Masami KATO	Special Advisor for International Cooperation, Ministry of Posts & Telecommunications
Committee Member (Telecommunications Network)	Eiichi WASHIZU	Manager, International Affairs Bureau, Nippon Telegraph and Telephone Public Corporation (NTT)
Committee Member (Telecommunications System)	Osamu MAKINO	Development Specialist, Institute for International Cooperation, Japan International Cooperation Agency (JICA)
Committee Member (Rural Telecommunications Network)	Satoshi AKABORI	Senior Staff Engineer, International Affairs Bureau, NTT
Coordinator	Minoru TATEMATSU	Special Assistant to Director, Social Development Cooperation Department, JICA

(2) Survey Team

Post (Assignment)	Name in Full	Employment
Team Leader (Communication Network)	Shigeto KIMURA	International Operation Division, Nippon Telecommunications Consulting Co., Ltd. (NTC)
Team Member (Radio Engineering)	Susumu YAMAGATA	"
Team Member (Transmission and Radio Engineering)	Muneo KURONO	"
Team Member (Outside Plant Engineering)	Eitaro YAGI	"
Team Member (Switching Engineering)	Junichi KOMADA	"
Team Member (Building and Tower Engineering)	Tadashi HARA	"
Team Member (Economist)	Yoshio KOSUGI	"

1-2-4 Itinerary of Field Survey

A summary of field survey itinerary during 91 days from September 11, 1984, the date of departure from Tokyo, to December 10, 1984, the date of return to Tokyo, is as under.

September 1984:		Consultations with Ministry of Communications and Transport (hereinafter called "MOC") and Public Telecommunications Corporation Headquarters (hereinafter called "PTC"), and preparations for field survey
October	" :	Field survey and study on basic requirements concerning project implementation
November	" :	Field survey and preparations for Progress Report making
December	" :	Progress Report making, and exchange of views with MOC/PTC concerning Progress Report

In-depth details of work itinerary appear in ANNEX-I.

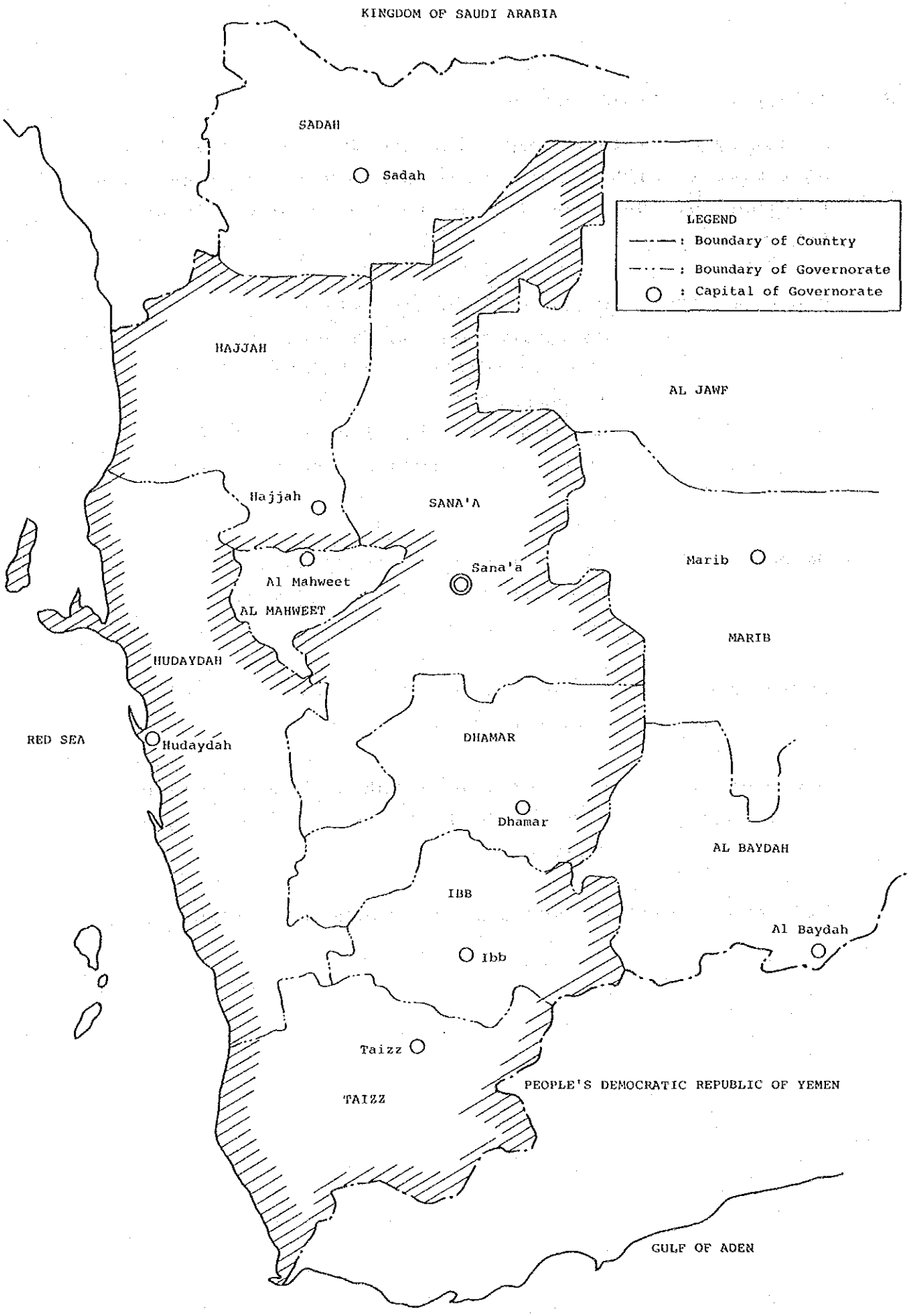

Figure 1-1 OBJECTIVE GOVERNORATES

CHAPTER 2 BACKGROUND OF PROJECT

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2-1 General Information on Yemen A.R.

Official Name	:	The Yemen Arab Republic
Form of Government	:	Republican Government
Date of Independence	:	1918 (as the Kingdom of Yemen); September 26, 1962 (as Yemen Arab Republic)
Capital City	:	SANA'A
Total Area	:	195,000 km^2
Total Population	:	7,251,000 (as of 1981, excluding overseas Yemen nationals)
Currency	:	Yemen Rial (YR) US$ 1 = YR 4.5625 (1982) US$ 1 = YR 5.860 (November 15, 1984) The floating rate system is adopted now.
GDP	:	YR 12,949 million (1981) Per capita, US$ 397 (1981) (at US$ 1 = YR 4.5)
GNP	:	Per capita, US$ 456 (1981) (-ditto-)

2-1-1 Topography

Yemen A.R. is situated in the southwestern part of Arabian Peninsula and lies lengthwise from north to south. The national boundaries are with the Kingdom of Saudi Arabia on the north and with the People's Democratic Republic of Yemen (South Yemen) on the south. On the west is the Red Sea.

The hinterland behind the coastal plain constitutes the mountain region. The whole territories can be divided into four different sectors topographically. (See Figure 2-1.) First is the Tihama Plain with an elevation of 0 - 200 m that extends north to south, forming a 30 - 40 km wide belt land along the Red Sea. Second is the mountain area located between the Tihama Plain and the Central Highlands. Third is the Central Highlands where the elevation is from 1,500 to 2,500 m. In this area, several more than 3,000 m high mountain chains extend east to west. Fourth is the Eastern Desert east of the Central Highlands.

The climate changes, sometimes drastically, from year to year, and differs between the plain and the highlands. In the plain, temperature rises close to 40°C during summer season and falls below 20°C during winter. In the Central Highlands, the winter atmosphere is cool and the summer heat is moderate. In SANA'A, the capital city, temperature varies between 13°C and 30°C in summer and between 0°C and 25°C in winter.

The annual rainfall changes broadly from 0 mm in the desert zone to 900 mm in the mountain region. In SANA'A, the rainy season recurs biannually, i.e., in April and August, and the annual rainfall measures about 400 mm. In the extreme southwest, about 900 mm annual rainfall is on record.

From the viewpoint of geopolitics, Yemen A.R. occupies strategic importance as it lies at the Red Sea doorway and holds the Red Sea - Indian Ocean link under its control.

2-1-2 Race, Language and Religion

The most part of inhabitants are Arabs (of Semitic lineage). They are the natives since ancient times (about 1200 B.C.), earning their livelihood by farming.

The official language is Arabic. The language used in the present-day Yemen A.R. retains a strong influence from ancient Arabic which was used in ancient kingdom eras, i.e., before the permeation of Islamism.

For religion, Islamism is adhered to since the 7th century. In the coastal area and in the southern part of Central Highlands, the sectarians mostly consist of Shafiiyas of Sunni line. In the northern and central parts of Central Highlands, Zaydiyas of Shiah line predominate.

2-1-3 Society

For a country in Arabian Peninsula, Yemen A.R. enjoys relatively much rainfall and prospers as an agricultural country since olden times. It maintains a powerful united nation since around 1200 B.C.

However, scant rainfall recurs periodically, hitting agriculture hard. The shortage of food causes starvation to supervene. On such occasions, many inhabitants transmigrate to other places in Arabian Peninsula and even to Mesopotamia and Syria. The past such transmigration resulted in the Semitic race diffusion in Southwestern Asia. Nowadays, a large number of Yemeni reside in oil-producing countries of Arabian Peninsula.

The inhabitants who did not transmigrate and stayed in Yemen A.R. formed their villages in the mountain area of Central Highlands, a natural defense against invasion by external powers. Those villages remain as farming villages today.

The population density is high in Central Highlands where rainfalls are plenty and agriculture thrives, but low in the Tihama Plain and Eastern Desert where rainfalls are scant.

Villages formed in the mountains and at mountaintops utilize mountain slopes for farmlands. Naturally, farm operations on a large scale are difficult. Small villages, each with a population of not more than 500, occupy the overwhelming majority. (Refer to Figures 2-2 and 2-3.)

2-1-4 Economy

Yemen A.R. with a relatively large population and relatively much rainfall commands greater advantage than other Arab countries.

However, by reason of per capita GNP amounting to not more than US$ 456 (as of 1981), Yemen A.R. remains to be one of 36 LLDC (Least Less Developed Countries) since 1975. Reasons for delay of economic development are manifold. They include, firstly, the retardation of development planning due to political instability since the introduction of republican government; secondly, the shortage of skilled labor; thirdly, the slow pace of natural resources development; and fourthly, the delay of infrastructural improvement.

Recently, economic development began to make progress though gradually. The Three-Year Plan for 1974 through 1976 and the ensuing First National Development Five-Year Plan (1977-1981) have already been completed. Now in progress is the more comprehensive Second National Development Five-Year (1982-1986).

At the newly discovered oil field in AL JAWF Governorate, east of SANA'A, the capital city, production was started in July 1984. For the national development of Yemen A.R. from now forward, there is much to expect from this oil production.

2-2 Telecommunications Services in Yemen A.R.

Telecommunications services in Yemen A.R. are supplied and maintained by MOC and PTC. MOC is the responsible organization for wholesome growth of telecommunications business. Its main duty consists of telecommunications development planning. PTC was separated from MOC in 1982 and became as independent organization responsible for maintenance and operation of telecommunications facilities. (MOC and PTC organizational charts appear in Figure 2-4 and 2-5.)

Telecommunications services in Yemen A.R. comprise telephone, telegraph, telex and facsimile services. For international telephone, telegraph and telex services, the operation is entrusted to C&W (Cable & Wireless Limited) of Great Britain.

Domestic telephone network is composed of urban network and rural network. At the present stage, subscriber long distance dialling (SLDD) service is available to urban network subscribers only. Facsimile communication also is permitted on urban network only.

Telephone service on rural network is provided by either one or both of the undermentioned two systems:

- Small-capacity local switches
- Analog/Digital multi-access system (MAS)

Small-capacity local switches are only for automatic connection of calls in each village where they are installed. Small-capacity local switches constitute specialized local exchange network completely separated from urban network, the main telephone network in Yemen A.R.

As for MAS, though telephone sets are installed in villages distant from main cities, its subscriber lines are accommodated in switching equipment or line concentrators, the urban network component, so that the subscribers concerned can receive the same call connection service as urban network subscribers can.

Transmission systems among the three main cities of SANA'A, TAIZZ and HUDAYDAH are composed of analog microwave system. Connection between switching equipment and its line concentrators as urban network components is by digital technology.

Also for local cities and rural villages, troposcatter system and UHF system are operated. Furthermore, as backup system to cope with trouble in rural network, equipment utilizing single sideband (SSB) transmission system are installed at telephone exchange offices that belong to rural network.

In Yemen A.R., subscriber telephones of urban network number 52,602. (See Table 2-1.) For rural network subscribers, those accommodated in local switches total 1,990. (See Table 2-2.) Subscribers accommodated in analog/digital MAS are estimated at 200. Therefore, the ratio of urban network subscriber telephones to the total number of telephones reaches as much as 96%.

One outstanding feature of Yemen A.R. is in a large number of emigrants to neighbor countries as aforementioned. The population excluding those emigrants totals 7,251,000 according to 1981 census. In the Second National Development Five-Year Plan, the rate of population growth during 1981-1986 is set at 2.8% and, at this rate, the domestic population in 1984 is estimated at 7,879,000. Thus, for 1984, telephone density per population of 100 can be estimated at 0.7.

2-2-1 Existing Switching System

(1) Urban Network

The existing switching systems in urban network mainly consist of digital switching equipment of CIT-Alcatel, France, make installed at telephone exchange offices in three main cities (SANA'A, TAIZZ and HUDAYDAH) and line concentrators using those digital switching equipment as parent exchanges and installed in the said three main cities or in local cities. Step-by-Step (SxS) switching equipment of German make are also in operation in some cities. For further details, refer to Table 2-1.

Telephone switching network consists of six areas. This arrangement is based on the numbering plan. Each area does not exactly coincide with each Governorate presumably because at the primary diffusion stage of telephone service was introduced as economical system as possible.

Switching network configuration follows:

Trunk Prefix and Trunk Code	Area	Governorate
02	SANA'A	SANA'A, DHAMAR and part of AL BAYDAH
03	HUDAYDAH	HUDAYDAH
04	TAIZZ	TAIZZ and IBB
051	SADAH	SADAH
061	AL BAYDAH	AL BAYDAH
07	HAJJAH	HAJJAH and part of SANA'A

Trunk calls from the above six areas are handled at SANA'A, TAIZZ and HUDAYDAH exchanges.

(2) Rural Network

Main switching systems in rural network are for local switch. These switching systems are mostly digital switches, each with 200 subscriber line units, of MITEL, Canada, make. Crossbar switches of LM. Ericsson make are also used at some exchanges. Crossbar switches are those deactivated when digital switches were introduced in urban network and re-used. Further details of installation are in Table 2-2.

Local switch is for local connections only and is not capable of automatic access to urban network. Therefore, analog/digital MAS terminals are installed at telephone exchange offices to realize operator-assisted access to urban network.

For digital switches of MITEL make, software updating is now in progress for the purpose of direct access to urban network.

Subscribers covered by the existing MAS are accommodated in switching equipment of urban network or their line concentrators.

2-2-2 Existing Transmission System

(1) Urban Network

Transmission systems in urban network comprise main transmission route and regional transmission route. The former is for interconnection of combined local/trunk switches of SANA'A, TAIZZ and HUDAYDAH exchanges. The latter is for connection between digital switches of the said three exchanges and their line concentrators.

Main transmission route is composed of analog microwave system. Regional transmission route consists of digital microwave system, cable PCM system (which uses intervened paired cable in coaxial cable) or troposcatter system.

Each transmission route configuration appears in Figure 2-6. Table 2-3 presents an outline of those systems.

(2) Rural Network

Transmission system for rural communication now in operation mainly consists of analog system of ITALTEL, Italy, make which uses 400 MHz/2 GHz band. TDMA system to operate by 1.5 GHz band has also been introduced. This TDMA system is of SRT, Canada, make. Similarly, digital system of TRT, France, make is now under construction. Table 2-4 contains further information about these systems.

2-3 Telecommunications Development Plan

Full scale national development plans in Yemen A.R. include the Three-Year Plan (1974-1976) and the First National Development Five-Year Plan (1977-1981). Now in progress is the Second National Development Five-Year Plan (1982-1986).

Project for telecommunications development was carried out during the First National Development Five-Year Plan implementation, with technical assistance from France. By this project, the existing urban network as a backbone of nationwide telephone network was completed. Principal facilities in urban network are:

- Large capacity analog microwave network that interconnects three main cities of SANA'A, TAIZZ and HUDAYDAH.

- Digital switching equipment and line concentrators installed in the said three cities and their satellite cities.

- Digital microwave network that connects digital switching equipment and line concentrators.

As the result, subscriber line capacity that numbered not more than 15,915 in 1976 increased broadly to 90,350 in 1981. In the growth list for all kinds of infrastructure, the growth rate of subscriber line capacity is the second highest coming after the similar rate in the construction of feeder roads. This fact reflects the importance attached to telecommunications network improvement and expansion in Yemen A.R. Uptrend in the number of telephones installed during 1976 through 1982 is as under.

Year	No. of Telephones	Annual Growth Rate (%)
1976	9,022	-
1977	12,687	40.6
1978	14,099	11.1
1979	16,072	14.0
1980	17,734	10.3
1981	27,374	54.4
1982	41,125	50.2

In the table above, the number of telephones installed in 1980-1982 corresponds to a growth rate of more than 50%, a figure worthy of special mention. Considering that the period was immediately after the urban network completion and that after 1982 the growth rate in the number of telephones installed is slowing down or, more precisely, being stabilized, the remarkable growth rate in 1980-1982 can be taken for the indisputable merit of urban network formation by the First National Development Five-Year Plan.

In the Second National Development Five-Year Plan now in progress, as many as 13 telecommunications projects are to be implemented. They are:

1) Completion of Underground Telephone Network
(budget: YR 59 million)
2) Telephone Lines for New Subscribers
(YR 5 million)
3) Strengthening of Main Internal Networks
- SANA'A, DHAMAR, IBB and HUDAYDAH
(YR 160 million)
4) Long Distance Rural Telephone Network
(YR 15 million)
5) Local Rural Telephone Network - Near Cities
(YR 90 million)
6) Inter-City Microwave System - All Regions
(YR 70 million)

7) National Trunk Call Services
(YR 5 million)

8) Regional Project - The Arab Plan
(YR 45 million)

9) International Telephone Exchange
(YR 18 million)

10) International Telex Exchange - SANA'A
(YR 24 million)

11) Technical and Administrative Buildings
- Various Cities (YR 36 million)

12) Central Warehouses - SANA'A and HUDAYDAH
(YR 10 million)

13) Telecommunications Institute - SANA'A
(YR 30 million)

As a matter of course, the above series of projects are for improvement and expansion of urban network, including local network, for the most part. Worthwhile to note is that rural network improvement and expansion plans (Project Nos. 4 and 5) are also included. Project No. 4 covers rural villages distantly located from urban network whereas Project No. 5 caters to rural villages at a relatively short distance to urban network.

2-4 Project Identification

For the fact that the competent authorities in Yemen A.R. have begun to show major concern for improvement and expansion of rural telecommunications network, the following background factors are considered:

- Urban network improvement and expansion have generally achieved success.

- Up to 87% of population inhabit rural villages.

- Rural villages are small sized and widely scattered.

- Due to topography, many rural villages are experiencing difficulty in promoting mutual contacts.

- To vitalize primary industry as main support of rural villages assumes utmost importance in national development program.

- Rural villages are almost completely without telephones.

Certainly, rural telecommunications network holds a vital role to play for economic development of Yemen A.R. This fact is evident in the introduction of analog/digital MAS for telephone service improvement. And, in so doing, Yemen A.R. keeps ahead of other countries in need of telephone service improvement.

In the Second National Development Five-Year Plan, financial investment apportioned to two projects for rural network upgrading amounts to YR 105 million. Out of this amount, only YR 15 million goes to Project No. 4 that covers rural villages distantly located from urban network, i.e., a project considered to take higher priority. Judging from this fact, new rural telecommunications improvement plan is to be worthy to implement.

Furthermore, it is generally said that the impact of communication network improvement in distant areas from urban network upon social and economic development of the areas concerned is greater than that of the improvement in urban network or its proximity.

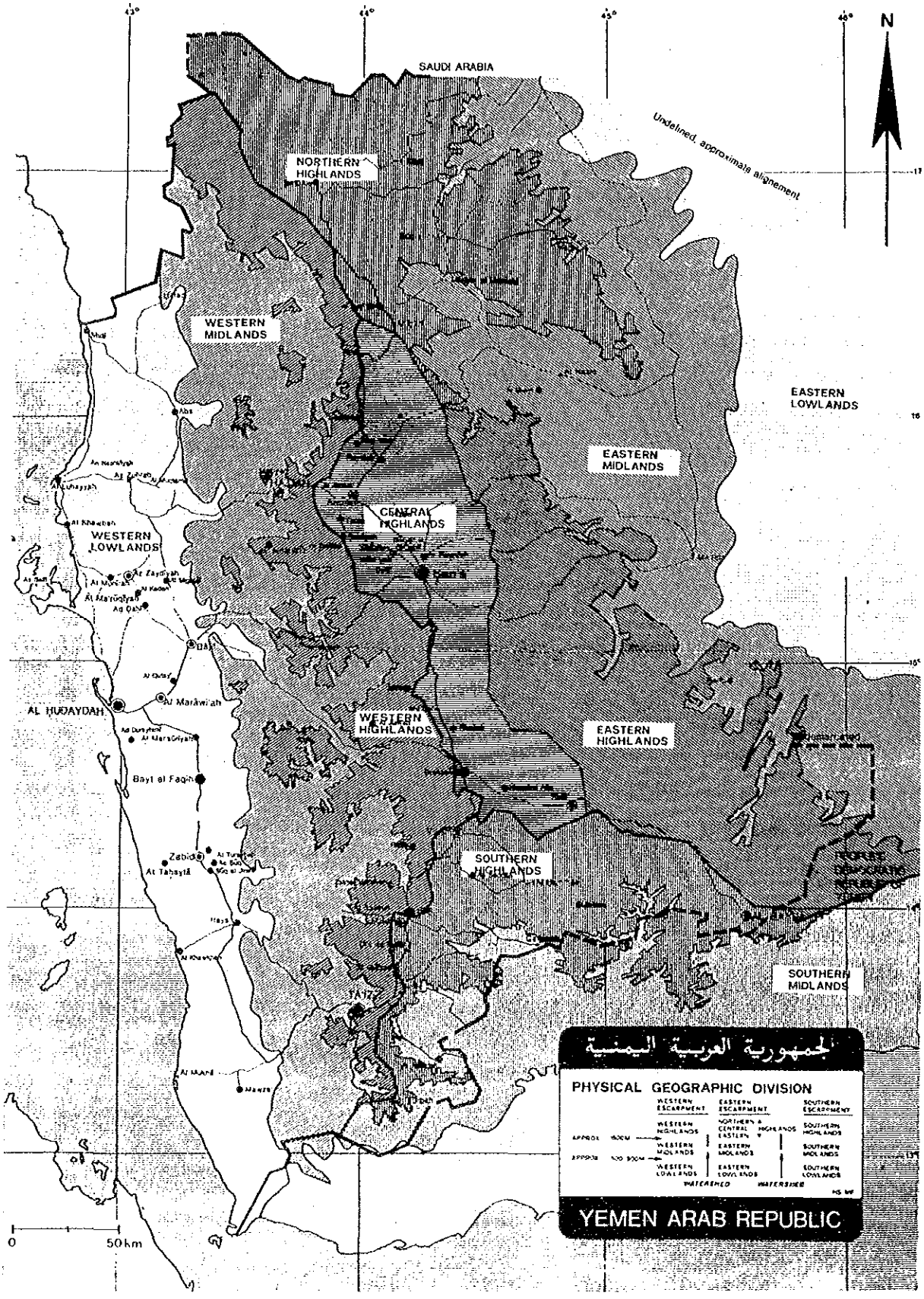


Figure 2-1 PHYSICAL GEOGRAPHIC DIVISION

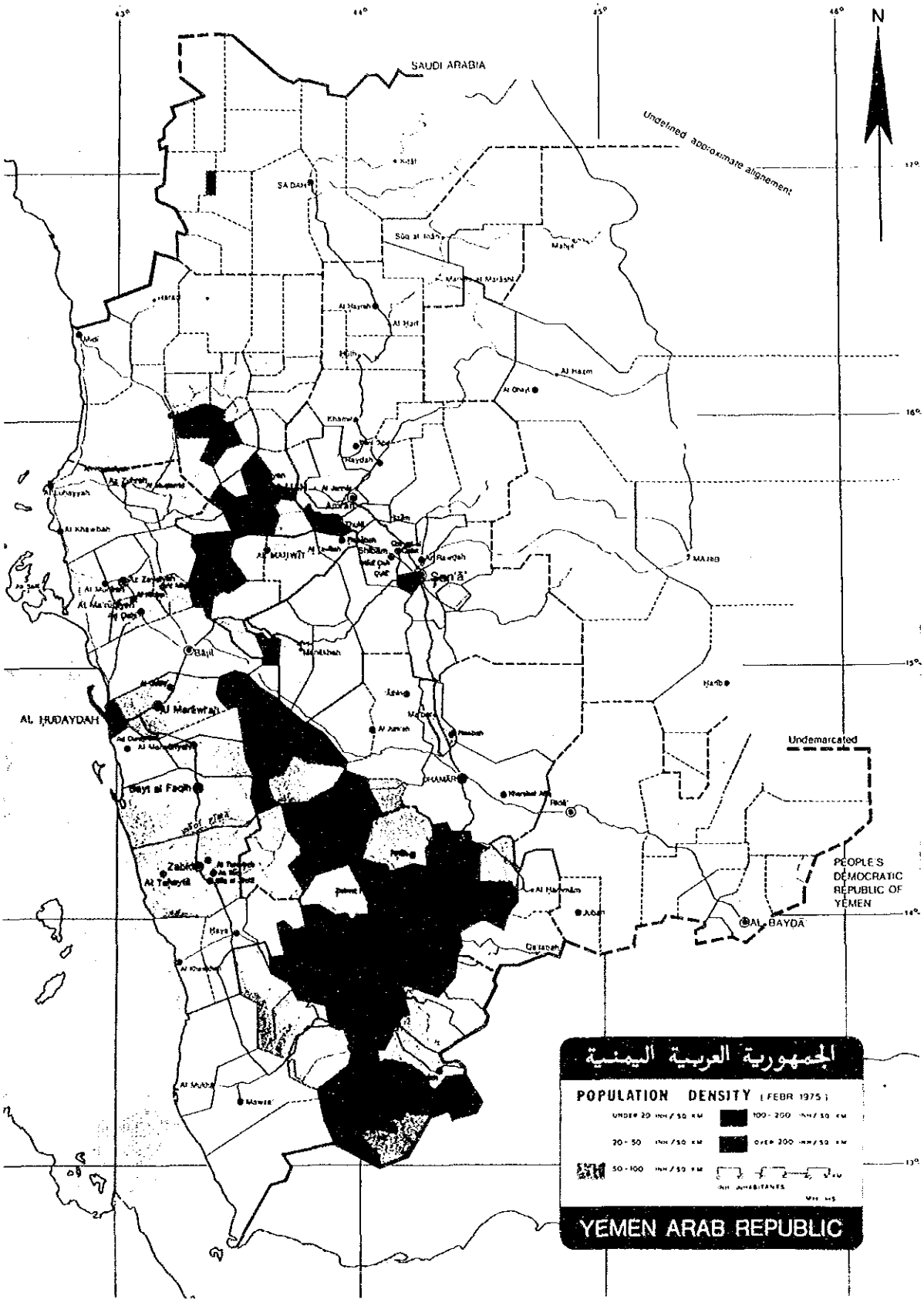


Figure 2-2 POPULATION DENSITY (1975)

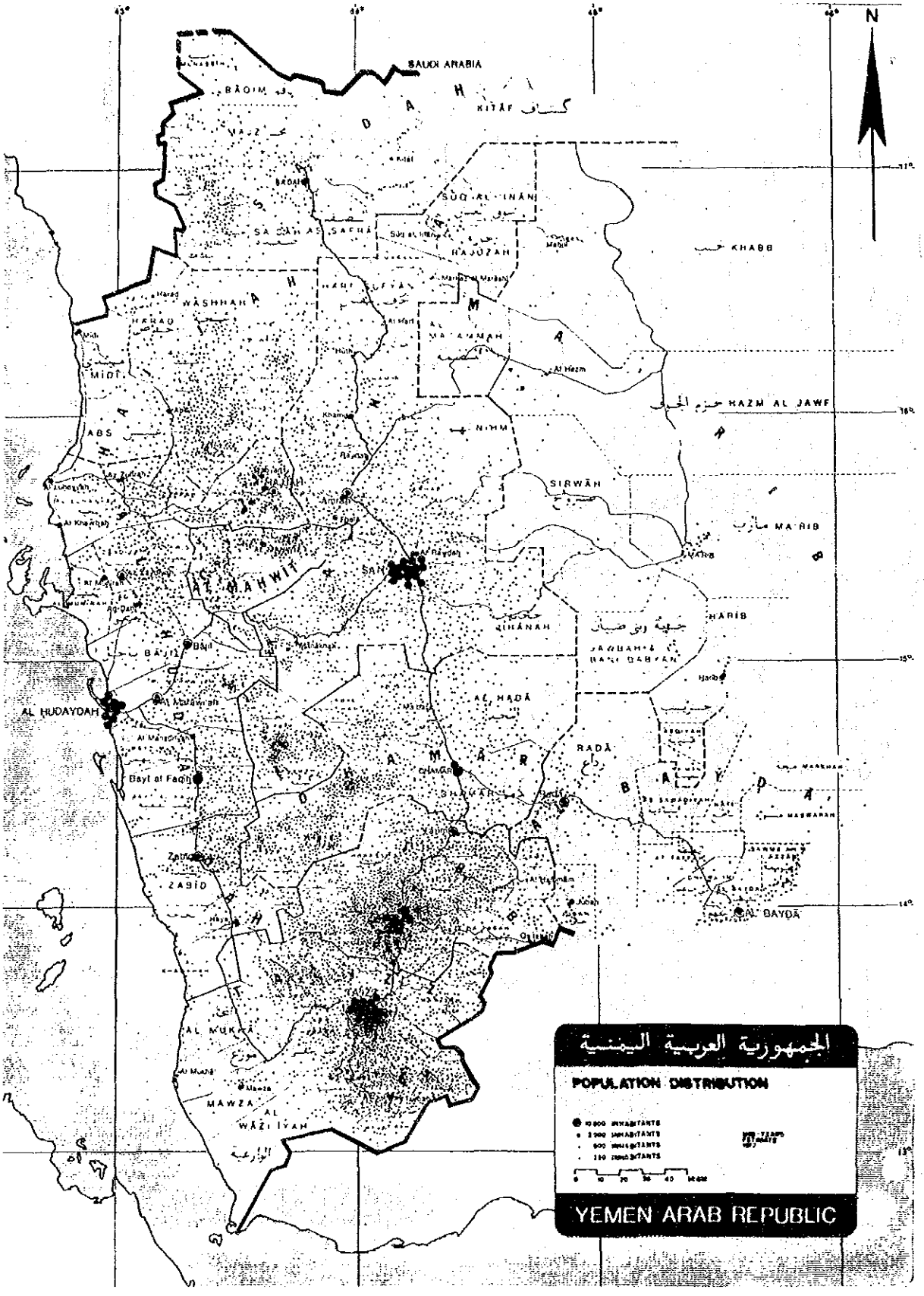


Figure 2-3 POPULATION DISTRIBUTION

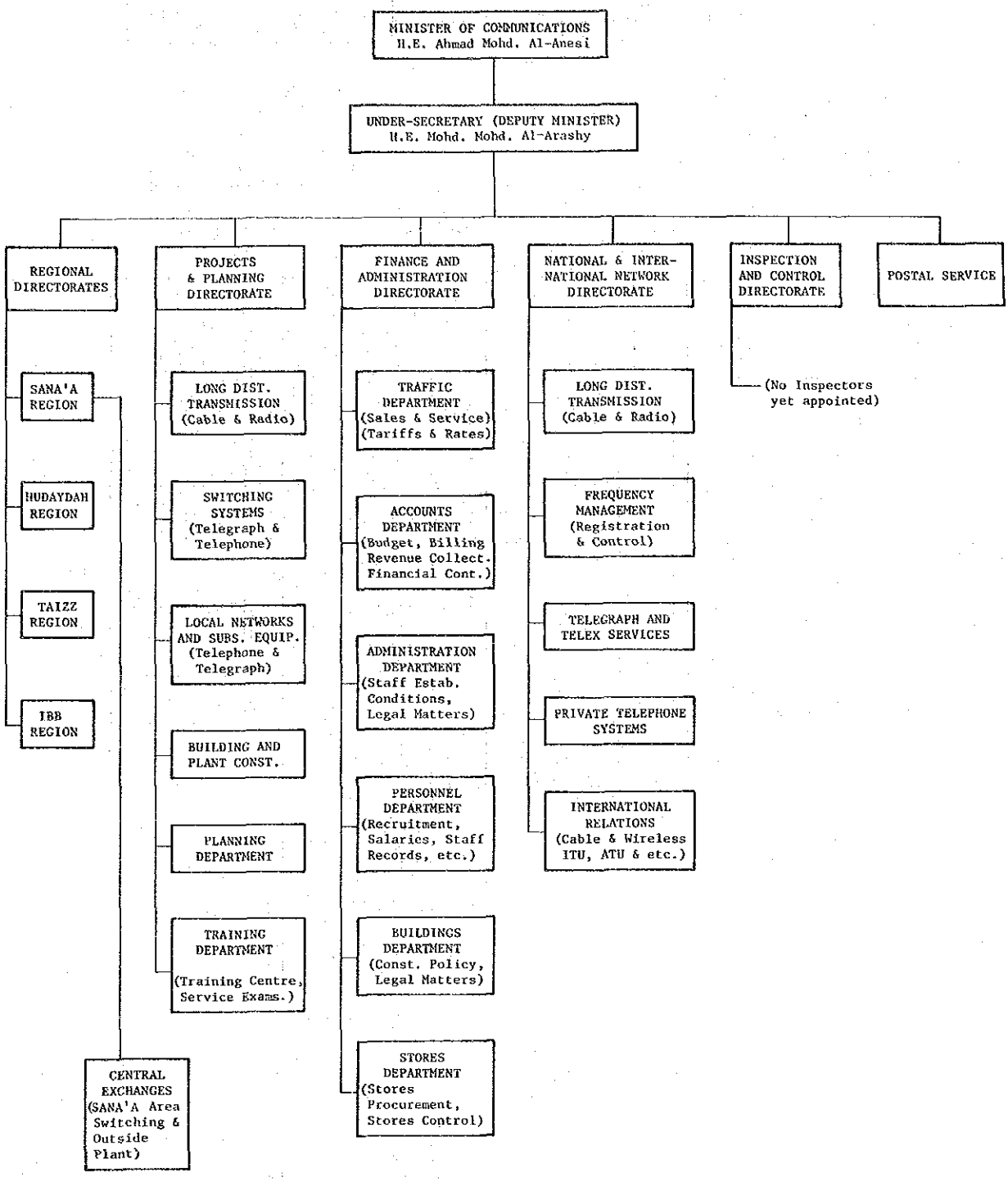


Figure 2-4 ORGANIZATION OF MOC

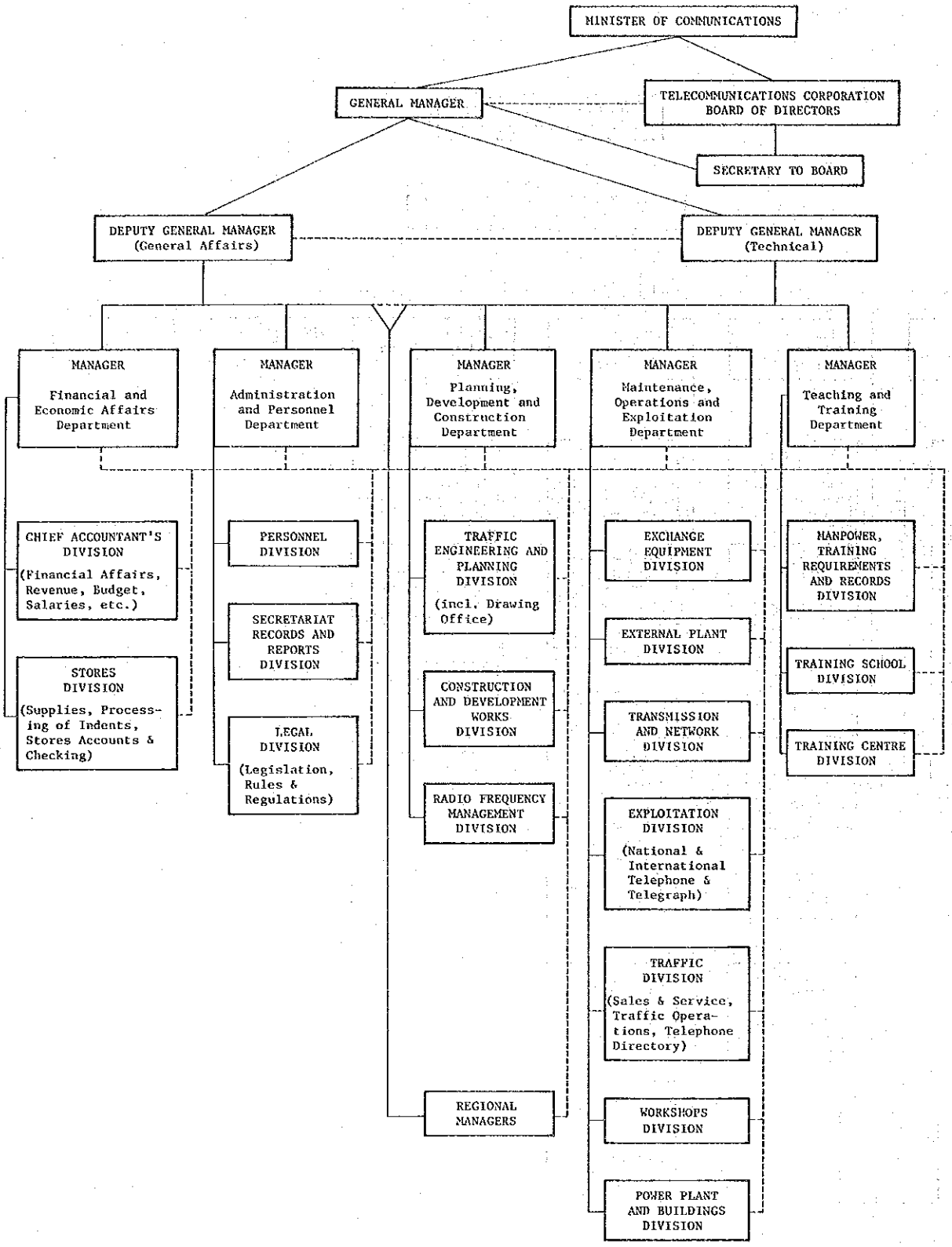


Figure 2-5 ORGANIZATION OF PTC

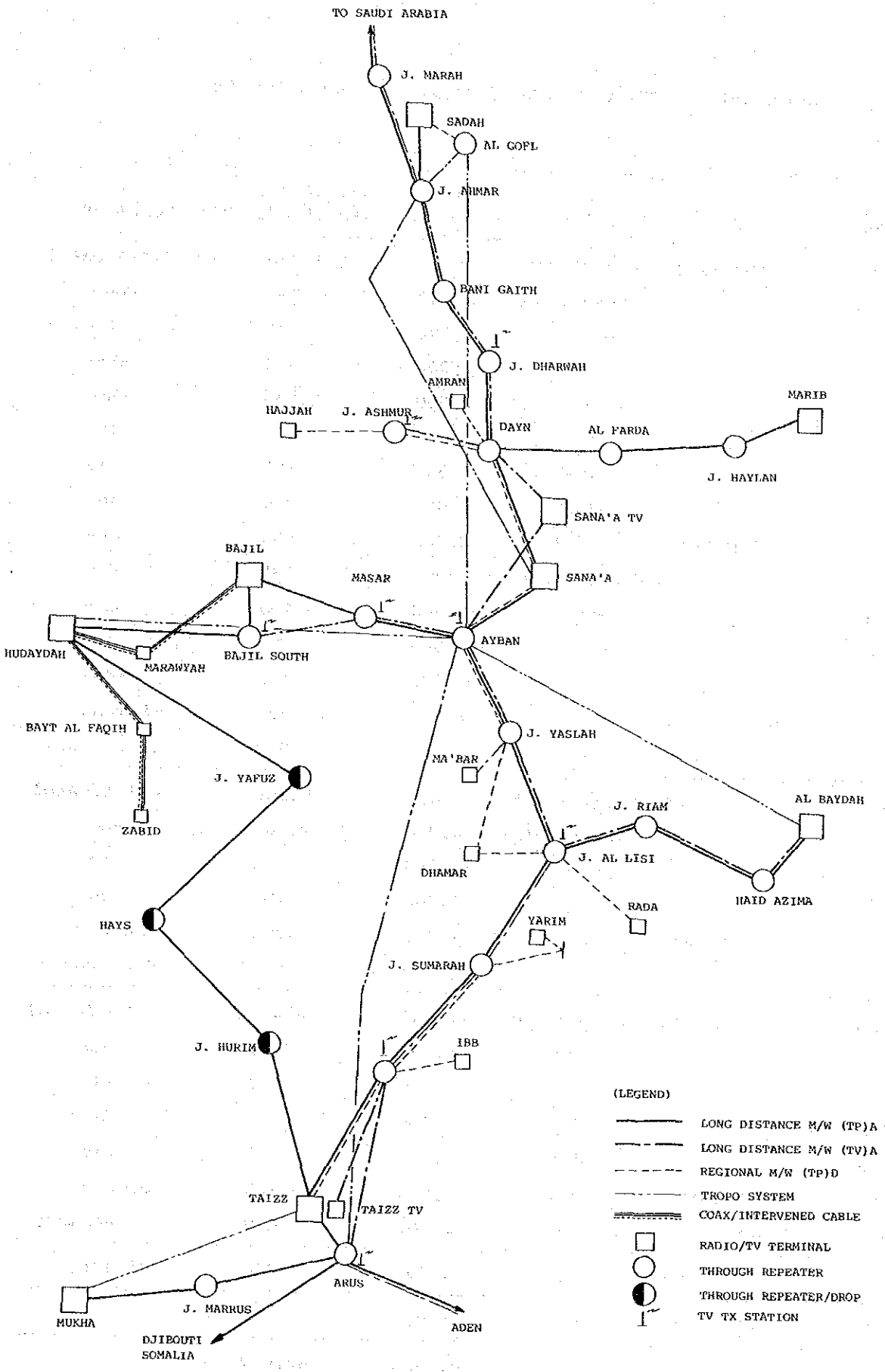


Figure 2-6 EXISTING LONG DISTANCE TELECOMMUNICATIONS NETWORK

Table 2-1 EXISTING SWITCHING SYSTEM IN URBAN NETWORK

Exchange	Type	Function	Line Capacity	No. of Sub. (As of Oct, 84)	Supplier
SANA'A D	E-10B (TD)	Local/Trunk	11,000	6,750	CIT-Alcatel
RAWDAH		Concentrator	1,500	512	-do-
AIR PORT		-do-	500	95	-do-
HAJJAH		-do-	1,000	635	-do-
DHAMAR		-do-	2,000	1,335	-do-
RADA		-do-	1,000	662	-do-
MA'BAR		-do-	500	181	-do-
AMRAN		-do-	1,000	700	-do-
SANA'A C	E-10B (TD)	Local	8,000	5,030	-do-
SANA'A A		Concentrator	3,000	935	-do-
SANA'A B		-do-	6,000	3,700	-do-
SANA'A E		-do-	2,000	660	-do-
SANA'A F		-do-	2,000	680	-do-
SANA'A	EMD (SxS)	Local	6,000	4,700	Siemens
SANA'A	RFT (SxS)	-do-	2,000	900	E. Germany
TAIZZ	E-10B (TD)	Local/Trunk	7,000	9,100	CIT-Alcatel
IBB		Concentrator	4,000	2,600	-do-
YARIM		-do-	1,000	412	-do-
AL QAIDAH		-do-	1,000	497	-do-
TAIZZ	EMD (SxS)	Local	2,000	1,700	Siemens
TAIZZ	RFT (SxS)	-do-	1,000	600	E. Germany
HUDAYDAH	E-10B (TD)	Local/Trunk	21,000	4,411	CIT-Alcatel
BAJIL		Concentrator	2,000	411	-do-
ZABID		-do-	2,000	217	-do-
BAYT AL FAQIH		-do-	1,000	262	-do-
MARAWYAH		-do-	1,000	52	-do-
HUDAYDAH	EMD (SxS)	Local	4,000	3,100	Siemens
HUDAYDAH	RFT (SxS)	-do-	1,000	630	E. Germany
SADAH	EMD (SxS)	-do-	1,000	730	Siemens
AL BAYDAH	EMD (SxS)	-do-	1,000	405	-do-
Total			107,500	52,602	

Table 2-2 EXISTING SWITCHING SYSTEM IN RURAL NETWORK

Exchange	Type	No. of Sub.	Supplier
AL MAHWEET	TD	180	MITEL
MAHABISHAH	XB	210	LM. Ericsson
MANAKHAH	TD	160	MITEL
AS SADDAH	-do-	90	-do-
AN NADIRAH	-do-	50	-do-
QA'TABAH	-do-	50	-do-
AL TALF	-do-	160	-do-
DAWRAN	-do-	50	-do-
AS SALIF	XB	50	LM. Ericsson
MUKHA	TD	90	MITEL
HAGDAH	-do-	50	-do-
KHAMIR	XB	210	LM. Ericsson
AL HAJRIEH	TD	160	MITEL
AL RAZMAH	-do-	160	-do-
JABLEH	-do-	160	-do-
DHI SUFAL	-do-	160	-do-
Total		1,990	

Source: STATISTICAL YEAR BOOK 1982
Central Planning Organization, April 1983

Table 2-3 EXISTING TRANSMISSION SYSTEM IN URBAN NETWORK

Route	Type	Configuration	Channel Capacity
SANA'A - TAIZZ	MW ANALOG	1+1	960 TPH
SANA'A - BAJIL	-do-	1+1	960 TPH
*TAIZZ - HUDAYDAH	-do-	1+1	960 TPH
TAIZZ - MUKHA	-do-	1+1	120 TPH (On MEDARABTEL spur)
SANA'A - MA'BAR	MW HYBRID	1+1	120 TPH
SANA'A - DHAMAR	-do-	3+1	360 TPH
DHAMAR - RADA	-do-	1+1	120 TPH
SANA'A - AMRAN	-do-	1+1	120 TPH
SANA'A - HAJJAH	-do-	1+1	120 TPH
TAIZZ - IBB	-do-	4+1	480 TPH
TAIZZ - YARIM	-do-	1+1	120 TPH
HUDAYDAH - BAJIL	-do-	0+1	120 TPH
*SANA'A - MARIB	MW DIGITAL	1+1	480 TPH
*DHAMAR - AL BAYDAH	-do-	1+1	480 TPH
*SANA'A - SADAH	MW ANALOG	-	120 TPH (On MEDARABTEL spur)
SANA'A - SADAH	-do-	1+1	TV
SANA'A - ASHMUR	-do-	1+1	TV
SANA'A - TAIZZ	MW ANALOG	1+1	TV
SANA'A - BAJIL SOUTH	-do-	1+1	TV
*SANA'A - MARIB	-do-	1+1	TV
*SANA'A - AL BAYDAH	-do-	1+1	TV
HUDAYDAH - BAJIL	Composite small tube coax. quad. cable	-	2700 TPH
HUDAYDAH - BAYT AL FAQIH	-do-	Coax. cable	Junction ccts on
HUDAYDAH - ZABID	-do-	not utilized	quad

MEDARABTEL

*SANA'A - MARAH (To SOUDI ARABIA)	MW ANALOG	2+1	TV + 960 TPH
*SANA'A - TAIZZ	-do-	2+0	TV + 960 TPH
*TAIZZ - ARUS	-do-	2x(1+1)	960 TPH + 960 TPH
TAIZZ - ARUS	-do-	1+1	TV
ARUS - PICDELONCLE (FOR DJIBOUTI AND SOMALIA)	-do-	1+1	960 TPH + NP TV
ARUS - DUBBAYYAT (FOR ADEN)	-do-	2+1	960 TPH +TV

TROPOSCATTER (TPH)

Route	System Capacity	Equipped Capacity
HUDAYDAH - SANA'A	120 CHs	60 CHs
SANA'A - AL BAYDAH	24 CHs	12 CHs
SANA'A - TAIZZ	120 CHs	60 CHs
SANA'A - SADAH	60 CHs	24 CHs
TAIZZ - ADEN	24 CHs	10 CHs
TAIZZ - MUKHA	24 CHs	6 CHs

Note *: Under Construction

Table 2-4 EXISTING TRANSMISSION SYSTEM IN RURAL NETWORK

Main Exchange	Concentrator	Base Station	Repeater Station	Analog or Digital	Frequency Band	Modulation	Transmission Capacity	System Capacity	Supplier	Remarks
SADAH (EMD)	-	SADAH	AL GOFL	Analog	400 MHZ	FM	6 CH	60 Sub.	ITALTEL	
SANA'A (E-10B)	-	SANA'A	AYBAN	-do-	2 GHz 400 MHz	-do-	-do-	-do-	-do-	
	-	SANA'A	J. HAYLAN	-do-	2 GHz	-do-	-do-	-do-	-do-	Before Commissioning
	HAJJAH	HAJJAH	ZAFIN	-do-	400 MHz	-do-	-do-	-do-	-do-	
	DHAMAR	DHAMAR	DAMIGH	Digital	1.5 GHz	PCM	15 TS	128 Sub.	TRT	Under Construction
TAIZZ (E-10B)	-	TAIZZ	QABRAIN	Analog	400 MHz	FM	6 CH	60 Sub.	ITALTEL	
	-	TAIZZ	ARUS	-do-	2 GHz 150 MHz	-do-	-do-	-do-	-do-	
	IBB	IBB	SHAMAHI	-do-	400 MHz	-do-	-do-	-do-	-do-	
	AL QAIDAH	AL QAIDAH	ARUS	Analog (TDMA)	1.5 GHz	PWM*	15 TS	94 Sub.	SRT	
	AL QAIDAH	AL QAIDAH	AT TURBAH	-do-	1.5 GHz	-do-	-do-	-do-	-do-	
HUDAYDAH (E-10B)	-	HUDAYDAH	-	Analog	2 GHz	FM	6 CH	60 Sub.	ITALTEL	
	-	HUDAYDAH	MASAR	-do-	-do-	-do-	-do-	-do-	-do-	

* PWN: Pulse Width Modulation

CHAPTER 3 RURAL TELECOMMUNICATIONS NETWORK DEMAND

CHAPTER 3 RURAL TELECOMMUNICATIONS NETWORK DEMAND

3-1 Present Population Distribution

(1) Demographically classified population density as of 1975 is as under. High population density in highlands stands out. (Refer to Figures 2-1, 2-2 and 2-3.)

Demographic Classification	Population Density (per km^2)
Western Escarpment	58
Highlands	96
Midlands (*1)	57
Lowlands (*2)	32
Southern Escarpment	69
Highlands	76
Midlands	40
Eastern Escarpment (*3)	14
Northern Highlands	11
Eastern Highlands	9
Eastern Midlands	3
Eastern Lowlands	0
Central Highlands (*4)	59
Whole Yemen	35

Note:

*1: Excluding TAIZZ City

*2: Excluding HUDAYDAH City

*3: Including SANA'A City and Central Highlands

*4: Excluding SANA'A City

(2) Population density by Governorate is as under. Density in TAIZZ and IBB Governorates is especially high.

Governorate	Population Density (per km^2)
SANA'A	40.1
TAIZZ	83.0
HUDAYDAH	49.6
IBB	122.8
DHAMAR	52.5
HAJJAH	41.4
SADAH	12.4
AL MAHWEET	80.9
AL BAYDAH	14.2
*MARIB	1.0

Note: * Including AL JAWF Governorate.

(3) Villages are distributed as under.

Population of Villages	No. of Villages	% to Total	No. of inhabitants	% to Total
Up to 50	28,000	53.1	681,613	14.5
50 - 499	24,000	45.5	2,986,192	63.5
500 - 999	600	1.1	403,098	8.6
1,000 - 1,999	83	0.2	110,026	2.3
2,000 - 4,999	34	0.1	99,723	2.1
5,000 - 49,999	14		122,334	2.6
Over 50,000	3		302,250	6.4
Total	52,734	100.0	4,705,336	100.0

3-2 Selection of Project-Covered Villages

(1) Villages, each having a relatively large population, i.e., over 300, and assuming importance socially, economically and geopolitically, qualify for coverage by project. Breakdown of villages, each with a population of over 300, follows:

Governorate	Over 300	Over 500	Over 700	Over 800	Over 900	Over 1,200	Over 1,500
SANA'A	960	380	198	137	97	38	18
HUDAYDAH	600	241	122	82	48	41	23
IBB	794	270	116	79	55	22	8
DHAMAR	409	136	79	56	38	15	8
TAIZZ	396	115	48	37	25	7	4
HAJJAH	234	101	48	28	18	11	9
(Sub-Total)	(3,393)	(1,243)	(611)	(419)	(281)	(134)	(70)
AL BAYDAH	172	61	33	28	20	12	8
SADAH	144	45	14	8	7	5	5
AL MAHWEET	82	23	8	7	6	2	2
AL JAWF	54	29	24	20	18	10	7
MARIB	33	12	7	6	4	2	1
(Sub-Total)	(485)	(170)	(86)	(69)	(55)	(31)	(23)
Total	3,878	1,413	697	488	336	165	93

(2) Based on request from MOC, selection is made for 490 villages as candidates for coverage by project. Out of those 490 villages, 456 are final selections. A list of 456 final selections appears in ANNEX-II. The remaining 34 villages are disqualified for coverage by project, this time. Reasons are:

- To cover a single village or two, one additional repeater station is required.
- Maps are not fully informative so that technical study is impossible.
- Cables from urban areas are already installed.

The disqualified 34 villages are listed in ANNEX-III.

3-3 Telephone Demand in Project-Covered Villages

(1) In part of villages, each with a population of 1,000 - 2,000, rural telephones (e.g., automatic system by analog MAS with 6 channels for shared use by 20 subscribers) are operated at present. Those rural telephones number about 200 in total. The rate of utilization is high in spite of high service tariff. Hence strong demand for additional installation of ordinary telephones.

Project-covered villages are centres of their respective areas in the aspect of social and economic activities. Thus they command high development priority. Special consideration is necessary concerning the activities of public utilities including local government organizations and distribution system components. Not less important are the roles played by village chiefs and landowners in social and economic performances.

Concentration trend of population to main cities is noticeable. For 1975 through 1981, population growth rate in rural areas was 2.5% in annual average whereas the corresponding rate in urban areas was 3.8%. Also to be noted is a large number of emigrant laborers from Yemen A.R. to the neighboring Middle and Near East countries.

In 1981, those emigrant laborers numbered approximately 1,390,000. Since the most part of such migrant population are from rural areas, their influence on telephone demand in rural villages must be duly considered.

From the foregoing viewpoint, the demand fulfilment plan is to be such as will satisfy at least the following requirements:

a) To install public call office telephones available to the general public also, at the rates of minimum one circuit per village and two circuits in each big village, with the average of 1.5 circuits per population of 1,000. In this case, telephone density is 0.15%. Meanwhile, public call office telephones are so managed that the general public can utilize them by paying the required tariffs while, in the case of terminating calls, messages are delivered to the called persons by each public call office consignee.

b) To install ordinary telephones for local government and public offices, as well as village chiefs, landowners and distribution system components, at the rates of 2-3 circuits in each small village and 4-5 circuits in each big village, with the average of 3.5 circuits per population of 1,000. In this case, telephone density is 0.35%.

Telephone densities shown above are not underestimated. By way of reference, in the rural telephone network plan of Indonesia, telephone density is 0.5% as of 1982 and in the similar plan of Nepal, 0.51% as of 1985.

(2) Average population of project-covered villages is estimated at 1,070. Therefore, the number of circuits required per village, i.e., per subscriber station, is 5.35 circuits. Provided, in the case of UTMAH village in DHAMAR Governorate, about twice the above number of circuits is provided. This is because the village spreads widely on both sides of the mountain so that subscriber station is to be established on each side.

On the assumption that initial telephone density be 0.5%, telephone demand by Governorate in terms of quantity is estimated as under.

Governorate	No. of Project-Covered Villages	Initial Telephone Demand in 1989 (in number)
HAJJAH	16	86
SANA'A-NORTH	68	364
SANA'A-SOUTH	69	369
DHAMAR	70	386
IBB	31	166
TAIZZ	82	439
HUDAYDAH-NORTH	69	369
HUDAYDAH-SOUTH	51	274
Total	456	2,453

(3) Future telephone demand is to be macroscopically forecasted from correlation between per capita GDP and telephone density. Calculation formula obtained by regression analysis of correlation between per capita GDP and telephone density in 56 countries as of 1981 is given below. It is graphically presented in Figure 3-1.

$$\text{Telephone Density} = 0.000113 \times (\text{per capita GDP})^{1.372}$$

Correlation Factor: 0.952

Correlation between per capita GDP and telephone density is an effective instrumentality to forecast telephone demand on urban telecommunications network that interconnects main cities. However, to apply this correlation by itself so as to obtain telephone density in rural areas is not realistic. For, the differential between telephone density in urban areas and that in rural areas is conspicuous. And this fact reflects the reality that in all countries the majority of telephone installations are concentrated in urban areas.

However, it is also true that per capita GDP exerts an influence, to some extent, on telephone demand in rural areas, the following method is used, this time, to know telephone demand in rural areas:

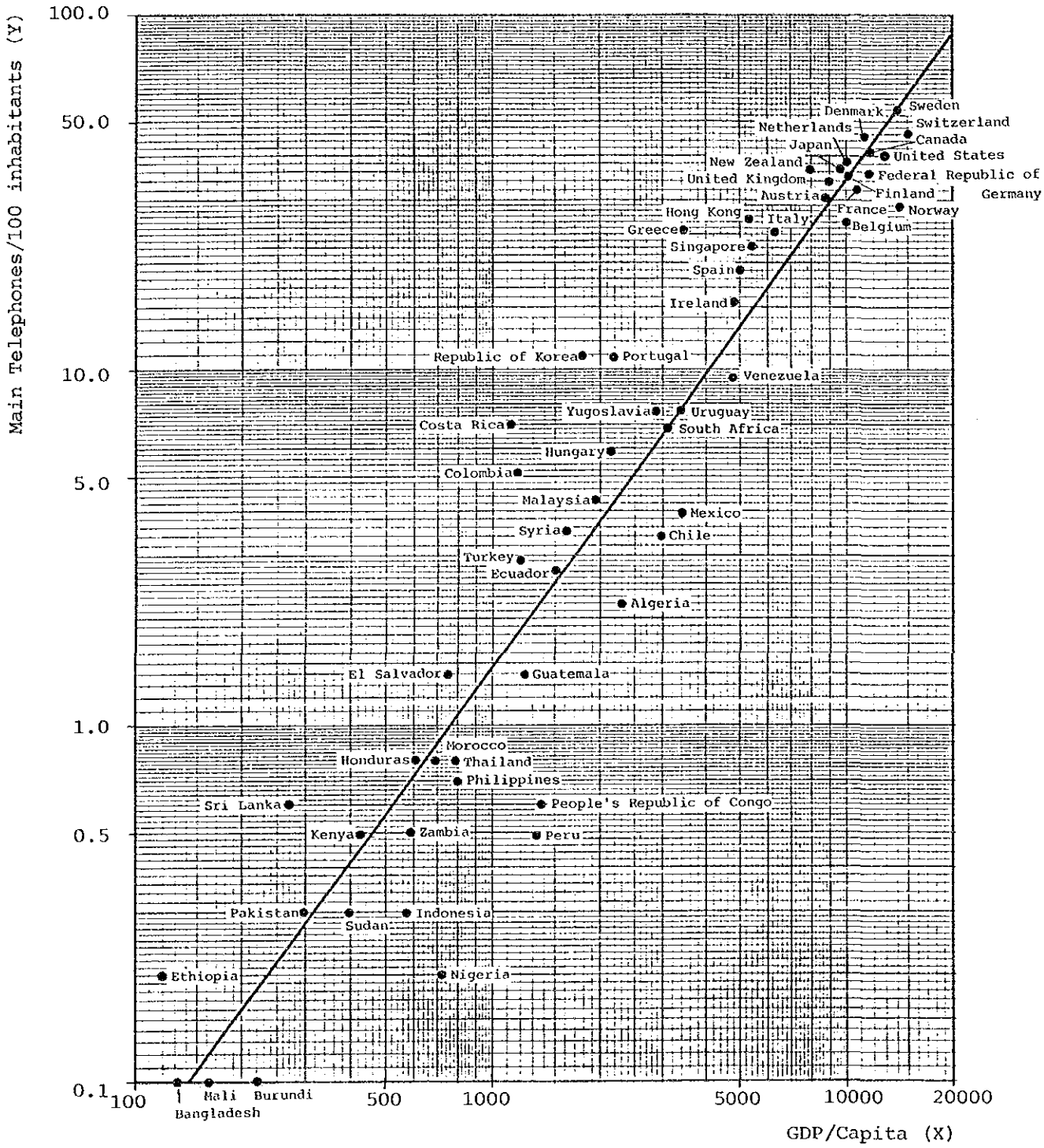
> To estimate future telephone density for the whole of Yemen A.R. from the result of the aforementioned regression analysis, and to use the growth rate of such telephone density as the growth rate of telephone demand in rural areas.

According to the on-going Second National Development Five-Year Plan, per capita GDP in 1986 is estimated to reach YR 2,181, equivalent to US$ 485. This per capita GDP growth can be attained by average annual growth rate of 4.2% wherein 1981 is used as the standard year. Now, assume that this growth rate of 4.2% per year does apply for the future. Then, per capita GDP, telephone density and its magnification obtained for three reference years are as under.

Year	Per Capita GDP (annual)	Telephone Density (%)	Magnification
1989	$485 \times 1.042^{3} = 549$	0.65	1
1994	$549 \times 1.042^{5} = 674$	0.86	1.32
2004	$674 \times 1.042^{10} = 1,017$	1.51	2.32

Following are telephone demand estimates by Governorates obtained by the above magnifications:

Governorate	1989 (1)	1994 (1.32)	2004 (2.32)
HAJJAH	86	114	200
SANA'A-NORTH	364	480	844
SANA'A-SOUTH	369	487	856
DHAMAR	386	510	896
IBB	166	219	385
TAIZZ	439	579	1,018
HUDAYDAH-NORTH	369	487	856
HUDAYDAH-SOUTH	274	362	636
Total	2,453	3,238	5,691



$Y = 0.000113\ X^{1.372}$ (Correlation Factor: 0.952)

Source: World Development Report 1983 (Data as of 1981)
The World's Telephones 1982 (Data as of Jan. 1, 1982)

Figure 3-1 TELEPHONE DENSITY AND PER CAPITA GDP IN 56 COUNTRIES IN 1981

CHAPTER 4 RURAL TELECOMMUNICATIONS NETWORK IMPROVEMENT PLAN

CHAPTER 4 RURAL TELECOMMUNICATIONS NETWORK IMPROVEMENT PLAN

4-1 Network Configuration and Design Criteria

4-1-1 Overview

(1) In consideration of the characteristic topography of Yemen A.R., as well as the distribution of villages, telecommunications demand prospect and existing telecommunications facilities, the rural telecommunications network of the country is to be composed of the following three elements:

a) Digital radio concentrator system (DRCS)
b) Local cable network
c) Digital telephone exchanges

(2) In this report, a rural network parallel to the existing network has been proposed. This network is commonly known as overlay network. However, questions relationg to possible usage of part of the existing transmission network and providing the infrastructure for this rural telecommunications project, in full coordination with other network development plans of MOC are to be considered at the detailed design stage.

This time, for the construction of rural telecommunications network, the future network configuration as it ought to be and the existing telephone exchanges as they are actually installed are to be duly considered. From this viewpoint, the following two plans are taken up for study:

Plan-A: 6 Sub-Rural Networks Configuration

In the administrative municipal entity of objective Governorates, urban switching equipment and line concentrators already exist. That is to say, in the municipalities of HAJJAH, SANA'A, DHAMAR, IBB, TAIZZ and HUDAYDAH, telephone exchanges with sufficient switching capacity to cover the new rural telecommunications network are installed. Those telephone exchanges are utilized to organize the sub-rural network for each Governorate concerned.

Plan-B: 3 Sub-Rural Networks Configuration

In 3 big municipalities, i.e., SANA'A, TAIZZ and HUDAYDAH, rural telephone exchanges are to be newly installed. The existing exchanges are to be used to accommodate new subscribers in those 3 urban areas. Three sub-rural networks thus formed are to cover 6 objective Governorates of the project in the following way:

- SANA'A sub-rural network to cover SANA'A, HAJJAH and DHAMAR Governorates
- TAIZZ sub-rural network to cover TAIZZ and IBB Governorates
- HUDAYDAH sub-rural network to cover HUDAYDAH Governorate

(3) DRCS network consists of base stations, repeater stations and subscriber stations.

The base station is to be established contiguous to the telephone exchange. The base station and repeater station allocation plan appears in Figure 4-1 (Plan-A) and Figure 4-2 (Plan-B).

The repeater station and subscriber station connection diagram is in ANNEX-IV. The allocation plan for villages and subscribers to be covered by each repeater station is in Table 4-1.

(4) Subscriber Categories

In the new rural network, telecommunications service is only for telephone in the initial stage. DRCS, however, should have the capability to add telex and telegraph lines without any modification of the system.

The following are subscriber categories taken into consideration:

- Ordinary subscriber
- PABX subscriber
- Public call office telephone

In this study, PABX presupposes the ordinary use, i.e., Private Automatic Branch Exchange, literally. Therefore, if such kind of switches is used for public purpose and connected to the proposed DRCS, attention should be paid not to have significant influence to the service grade of other rural subscribers.

4-1-2 Switching Network

(1) Network Hierarchy

The present nationwide telephone network consists of Primary Centres and lower hierarchy components. Primary Centres are only three, i.e., SANA'A, TAIZZ and HUDAYDAH, each equipped with combined local/trunk switches. SANA'A Primary Centre accommodates HAJJAH and DHAMAR line concentrators' subscribers. TAIZZ Primary Centre accommodates IBB line concentrators' subscribers.

Sub-rural network switches are to handle both local and trunk calls so that they are designed to hold Primary Centre hierarchy. In the foregoing Plan-A, Primary Centres are the existing SANA'A, TAIZZ and HUDAYDAH exchanges while in Plan-B, Primary Centres for the rural network are to be newly established. Both cases are taken up for study in switching network plan.

In Plan-A, operation is so managed that the message area can be adjusted within the framework of trunk call charging arrangement of the existing switches. That is to say, HAJJAH, DHAMAR and IBB line concentrators accommodate the rural network subscribers to whom they respectively correspond.

In Plan-B, from the viewpoint of engineering economy, combined local/trunk switches are installed at SANA'A, TAIZZ and HUDAYDAH. To newly install combined local/trunk switches at HAJJAH, DHAMAR and IBB is not advisable economically because additional transmission routes have to be established and the number of Primary Centres necessarily increases.

On the other hand, the existing switches are used to accommodate new subscribers in urban areas where they are respectively installed. New Primary Centre switches are to hold full handling capability, especially charging function, for all kinds of traffic on the rural network.

(2) Numbering Plan

The present numbering plan consists of the open numbering system. This numbering system divides the whole country into 6 trunk areas and to each trunk area is accorded 1-digit or 2-digit trunk code.

For trunk prefix, "0" is used. Directory number is composed of 4 to 6 digits according to the type of operating switches as exhibited below.

Trunk Code	Directory No.	Switching System	Remarks
2	2xxxxx	E-10B or Concentrator	SANA'A City
	3xxxxx		SANA'A Governorate
	4xxxxx		DHAMAR Governorate
	5xxxxx		Part of DHAMAR and AL BAYDAH Governorates
	7xxxx	EMD/RFT	SANA'A City
3	2xxxxx	E-10B or Concentrator	HUDAYDAH City
	3xxxxx		HUDAYDAH Governorate
	5xxxxx		
	7xxxx	EMD/RFT	HUDAYDAH City
4	2xxxxx	E-10B or Concentrator	TAIZZ City
	3xxxxx		TAIZZ Governorate
	4xxxxx		IBB Governorate
	5xxxxx		
	7xxxx	EMD/RFT	TAIZZ City
51	xxxx	EMD	SADAH City
61	xxxx	EMD	AL BAYDAH City
7	2xxxxx	Concentrator	HAJJAH City and part of SANA'A Governorate

For special services, the following services are provided:

Code	Service	Remarks
10	National Booking	
11	Police	Free of charge
12	Fire Brigade	"
13	EMD Complaint	"
15	International Booking	
17	Complaint	Free of charge
18	Directory Inquiry	

14x and 16x are reserved for future new services.

Directory number assignment to the project-covered villages is planned as under. Special services remain the same as at present.

Sub-Rural Network	Trunk Code	Directory No.
SANA'A	2	2xxxxx
		3xxxxx
		7xxxx
HAJJAH	7	2xxxxx
DHAMAR	2	5xxxxx
TAIZZ	4	2xxxxx
IBB	4	43xxxx
HUDAYDAH	3	2xxxxx

(3) Signalling System

1) Subscriber Line Signalling System

Multi-frequency signalling system by pushbutton telephone set is used.

2) Inter-Exchange Signalling System

In Plan-B, when introducing new switches, new interface circuits are required between the new and existing switches. In this case, the applicable inter-exchange signalling system comprises the digital signalling system for line signal and R2 multi-frequency compelled (MFC) signalling system for register signal.

(4) Charging System

The tariff system now in force applies mutatis mutandis. That is to say, local call charging is for every 360 seconds and trunk call charging is by the periodic pulse metering method (charging system depending on both call duration and distance).

(5) Grade of Service

For the grade of service in DRCS network, loss probability of 0.01 applies.

(6) Estimation of Traffic Intensity

For the guideline of traffic intensity (originating and terminating) on the rural network, CCITT Manual provides that the traffic intensity is between 0.01 and 0.1 Erlang and the variation depends on the type of subscriber. The Manual further states that in exceptional cases the traffic intensity increases to the extent of 0.3 Erlang.

By the field survey, this time, actual traffic data pertaining to the existing rural network subscribers was obtained. The data obtained are from 8 telephone sets installed in 7 villages of HAJJAH Governorate. Those 8 telephone sets are of MOC/PTC facilities (exchange) and are used practically as public call office telephones. The collected data are one-day data for October 31, 1984. In spite of scant statistical value, the data themselves are considered to be greatly useful for traffic intensity estimation.

The data show that for effective calls the busy hour traffic intensity is in the range of 0.032 - 0.249 Erlang. The mean value is as under.

For 8 telephones: 0.121 Erlang
For 7 villages : 0.129 "

Generally, on the rural network, originating calls occupy a greater part of traffic than terminating calls. Now, assume that the originating and terminating call ratio is 6:4. Then, traffic per village is 0.23 Erlang.

If the number of telephone sets per village increases, the traffic per village will be distributed to all telephone sets. At the same time, traffic of the whole village will increase. From the foregoing assumption, the mean traffic intensity, this time, is estimated at 0.06 - 0.04 Erlang.

4-1-3 Radio Concentrator Telephone Network

(1) Applicable Transmission System

CCIR Report 380-1 proposes two systems applicable to radio concentrator telephone system. One is frequency division multi-access (FDMA) system. The other is time division multi-access (TDMA) system.

The former is commonly called analog MAS and the latter, digital MAS or digital radio concentrator system (DRCS).

In this project, DRCS is to be adopted. Reasons are as under.

1) In the coverage area of project, a large number of villages are scattered and telephone demand per village at initial stage is more than several circuits. In the case of analog MAS, radio telephone equipment has to be installed for each subscriber. However, DRCS makes it possible for one radio subscriber station system to accommodate a maximum of 20 subscribers. Therefore, DRCS is economically more advantageous than analog MAS. Furthermore, it can easily cope with the increase of subscribers.

2) Call signal from subscriber station proceeds via repeater station to base station where it is connected to the switch. In the case of analog MAS, repeater station to base station radio transmission system (approach link) is necessary. However, in the case of DRCS, hierarchically lower repeater station (distantly located from base station) performs as one subscriber station of hierarchically higher repeater station so that approach link is not necessary.

3) Therefore, when telephone demand arises in new rural area in the future, repeater system can be extended to such new area without modification of the existing repeater station.

4) Radio frequency which is used at repeater station is only a pair of radio waves per system so that the number of equipment required is small. Therefore, the scale of power supply system can be reduced. Hence small floor space required. In the case of analog MAS, plural pairs of radio waves are necessary.

(2) Outline of DRCS

DRCS is a conceptually new radio concentrator system to provide telephone service at small cost and at high efficiency in the rural area. DRCS is composed of base station, repeater station and subscriber station. Figure 4-3 presents the typical DRCS configuration.

At base station, telephone switches are installed. Subscriber telephone sets are first connected to subscriber station by dropwire and cable, and then to the switches by digital radio link via repeater station in the service area. Repeater station transmits calling signals and speech signals for subscribers in its service area to one hierarchically higher repeater station (nearly located to base station) to another, causing base station switches to operate.

Radio emission uses one pair of radio waves per system for both transmission and reception. This pair of radio waves is divided by time to provide 15 communication channels which are commonly used by all subscribers in the service area. In other words, 127 subscriber stations make the shared use of 15 channels. Channel assignment to each call is automatically carried out by TDM control equipment installed at base station.

Radio signal from subscriber station received by repeater station and transmitted to hierarchically higher repeater station is of the same frequency as that used in the service area of the latter repeater station. Therefore, the hierarchically higher repeater station can receive radio signal from hierarchically lower repeater station and radio signal from subscribers in its service area at the same time with one omni-directional antenna. This means that the hierarchically lower repeater station can be regarded as subscriber station of the hierarchically higher repeater station. Hence no need for establishing separate approach link between repeater stations themselves. This fact constitutes one outstanding feature of DRCS.

(3) DRCS System Parameters

DRCS system parameters are listed below.

- Radio frequency band : 850 MHz (790 - 879 MHz)
- Radio frequency assignment: CCIR Rep. 380-1, Annex I, Figure 5
- Modulation system : Time division (TDM)
- No. of time slots/system : 15
- Subscriber capacity/system: 127 + 1 (for maintenance)
- Radius of repeater station service area: Within 30 km (standard)
- Repeater section distance : 45 km (standard)
- Transmitter output power : 1 W, 5 W or 10 W
- Omni-directional antenna gain : 10 dBi - 13 dBi
- Directional antenna gain : 11 dBi - 20 dBi
- Antenna duplexer loss;
  - 2 duplexers: 7 dB
  - 4 " : 10 dB

(4) Radio Frequency Plan

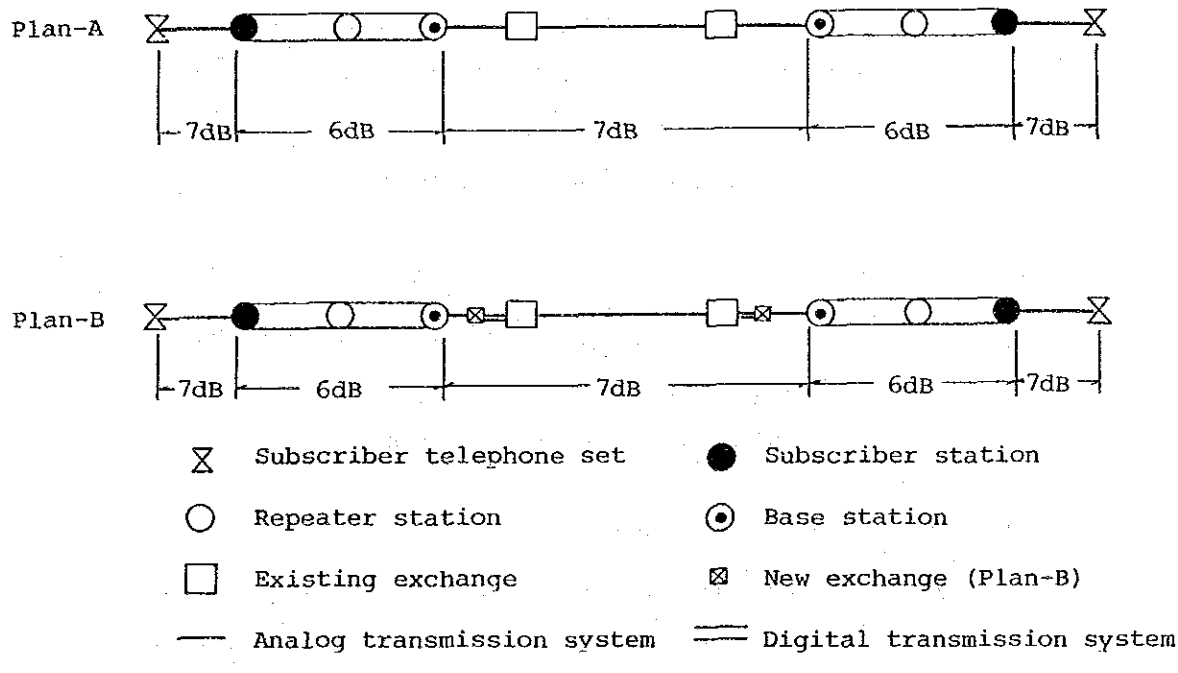
As the result of consultation with MOC's Frequency Management Division, radio frequency band of 790 MHz - 879 MHz (bandwidth: 89 MHz) is to be used in this project. According to ITU Radio Regulation, this frequency band is assigned to broadcasting stations and fixed radio stations in Region 1 (Europe, Africa, Arabian Peninsula and the Soviet Union).

The above frequency band is to be arranged as shown in Table 4-2 according to the frequency plan described in CCIR Rep. 380-1, Annex I.

Radio frequencies to be allocated to individual base stations and repeater stations have to be determined in careful consideration of radio interference study results.

(5) Transmission Loss Distribution

Transmission loss distribution in Plan-A and Plan-B is illustrated below.



Transmission Loss Distribution

(6) Station Site Selection

All station sites are to be so selected that line-of-sight propagation paths can be obtained except in case where the distance between repeater station and subscriber station is less than 15 km. Even if the line-of-sight cannot be obtained between repeater station and subscriber station but if sufficient receiver input power can be obtained, the sites concerned are included in the selection list.

Path profiles between repeater stations themselves and between repeater station and base station appear in ANNEX-V.

(7) DRCS Circuit Design

1) Objective Transmission Performance

Allowable value of bit error ratio (BER) on digital radio circuit is determined as under, based on CCIR Rec. 594.

- For the time of more than 1% of any one month, BER must not exceed 1.1×10^{-8} ($= 1 \times 10^{-7} \times \frac{280}{2,500}$).
(Integration time: 1 minute)

- For the time of more than 0.0056% ($= 0.05\% \times \frac{280}{2,500}$) of any one month, BER must not exceed 1×10^{-3}.
(Integration time: 1 second)

2) Design Requirements

In the circuit design between repeater stations themselves and between repeater station and base station, the required receiver input power is calculated, using the estimated fading margins shown below.

Antenna duplexer loss is estimated by these criteria:

- When the number of systems at initial stage is 3 or less, 1 additional system be considered for the future.
- When the number of systems at initial stage is 4, separate antenna system be constructed in the future to cater for additional circuit demand.

Repeater Section Distance	Fading Margin	Required Receiver Input Power
Up to 20 km	7 dB	-80 dBm
20 - 25 km	9 dB	-78 dBm
25 - 30 km	10 dB	-77 dBm
30 - 35 km	11 dB	-76 dBm
35 - 40 km	12 dB	-75 dBm
40 - 50 km	13 dB	-74 dBm

3) Circuit Design

Based on the aforementioned system parameters, schematic design of DRCS is to be prepared, showing station by station requirements concerning antenna tower height, type of antenna to be adopted, type of feeder line, transmitter output power and so forth. Table 4-3 presents typical circuit design calculations. For type of antenna and feeder parameters, refer to Paragraph 4-2-2.

4-1-4 Local Network

(1) Local network is to be constructed in the order of subscriber station, aerial cable, distribution point, dropwire, subscriber's arrester, house wire, and telephone set.

(2) For aerial cable, 10 pairs are the standard. However, in consideration of subscriber distribution and future demand growth possibility in each village, 20 pairs are used in some cases.

(3) Cable and dropwire conductor diameters are to be determined from the viewpoint of maintaining transmission loss assigned to local network and ensuring correct signal transmission and reception between subscriber station and telephone set. Items to be considered are:

Transmission loss	:	7 dB
Loop resistance	:	800 ohms (including telephone set resistance)

(4) Cable and dropwire are to be extended on steel poles. When appropriate structure to substitute steel poles is available, such structure may be used.

(5) Standard spacing between each two steel poles is 50 m or thereabouts.

(6) In each village, aerial cable distribution point with capacity for 10 pairs is to be provided on steel pole. Standard spacing between each two distribution points is 200 m or thereabouts.

(7) Each subscriber is to have pushbutton telephone set (multi-frequency signalling) installed. For public call office telephone, charging pulse counter to facilitate tariff calculation is to be installed.

4-2 Outline of Equipment

4-2-1 Switching Equipment

Rural switches to be newly introduced by Plan-B for this project are stored program control (SPC) system, time division (TD) switches. This is in consideration of worldwide technical development trend and from the viewpoint of easy interface with the existing urban network.

Exchanges where switches are to be newly introduced are 3, i.e., SANA'A, TAIZZ and HUDAYDAH. All those switches are to be dedicated to the projected new rural network and not to accommodate general subscribers. This arrangement is to fulfill no small demand growth expected from now forward. Judging from the topographic features, village distribution and telephone density in Yemen A.R., necessity for rural telecommunications system upgrading is considered to continue for a considerably long time to come.

Dedicated rural network switches are to be combined local/trunk switches with charging capability as required in network configuration. Those switches are to satisfy the undermentioned requirements in terms of capacity and functions.

(1) Subscriber Line Capacity

Switching capacity is so determined as can serve villages, each with a population of 300 or more, widely scattered in the coverage areas of switches, instead of serving the objective villages of this project only. The number of telephones at demand ratio of 0.5% in each sub-rural network is estimated as under.

Sub-Rural Network	No. of Villages	Estimated Population	Total Demand Size	Demand Size in Project-Covered Villages
HAJJAH	234	134,000	670	86
SANA'A	960	539,000	2,695	733
DHAMAR	409	223,000	1,115	386
IBB	794	417,000	2,085	166
TAIZZ	396	201,000	1,005	439
HUDAYDAH	600	349,000	1,745	643
Total	3,393	1,863,000	9,315	2,453

In Plan-A, subscribers in objective villages of this project are accommodated on sub-rural network basis in the existing switches or line concentrators. In Plan-B, those subscribers are accommodated in 3 newly installed switches, each having the undermentioned capacity.

Exchange	Subscriber Line Capacity	Sub-Rural Network
SANA'A	4,500	SANA'A HAJJAH and DHAMAR
TAIZZ	3,000	TAIZZ and IBB
HUDAYDAH	2,000	HUDAYDAH

(2) Junction Line Capacity

For all 3 new exchanges, i.e., SANA'A TAIZZ and HUDAYDAH, interface point with the existing network is to be provided between each exchange and E-10B parent exchange. Therefore, new outgoing/incoming junction line becomes necessary for such interface point.

The number of outgoing/incoming junction lines required is to be calculated by the rural network subscriber traffic conditions mentioned below.

- Busy-hour traffic intensity: 0.05 Erlang
- Originating and terminating: 6 : 4 call ratio

The most part of total originating and terminating calls are assumed to be to/from the urban network or the existing rural network. In this study, the number of circuits required is calculated on the assumption that 90% of total originating and terminating calls of subscribers to be accommodated in each switch are to/from the existing network.

Calculation results at grade of service (GOS) of 0.01 are as under. Actually, with a view to effective use of transmission route, circuit establishment by the unit of 30 circuits is desirable.

Exchange	Outgoing Circuits	Incoming Circuits
SANA'A	140	97
TAIZZ	97	68
HUDAYDAH	68	48

(3) Interface Conditions

1) Subscriber's Line Interface

For interface with DRCS, 2-wire subscriber's line interface which is the same as with ordinary subscribers is to be adopted. For public call office telephone, transmitting capability of metering signal be available.

2) Junction Line Interface

For transmission system of junction line with the existing E-10B exchange, 30-channel PCM system of CEPT standard is to be introduced. Interface with newly installed switches is to be 2 Mbit/s digital interface.

(4) Charging and Billing System

For originating calls from rural network subscribers to be handled by 3 new exchanges, charging is by each exchange. Charging data billing system is to have expansibility so that, in addition to bulk billing system, detailed billing system also can be easily introduced when necessary.

For charging on special service calls, the existing tariff system is to apply. That is to say, calls to police (code: "11") and fire brigade (code; "12"), as well as complaints (code: "17"), only are to be free of charge.

for charging data processing, the existing system is to remain intact, in principle. That is to say, charging data by month are produced in magnetic tape (MT) output and carried to the billing centre at SANA'A for processing. For the future system, however, automatic data transfer to the billing centre by data transmission circuit is worth consideration.

(5) Maintenance and Operation

Three new exchanges are to establish maintenance and operation systems separately. Each exchange is to procure sufficient manpower and materials. Switches are to hold minimum maintenance functions mentioned below.

- Man-machine interface
- Testing control
- System supervision
- Overload control
- Trouble-shooting
- Traffic measurement

Out of special services, complaints from new rural network subscribers only are to be accepted by the new exchanges.

Full-time maintenance staff are to be appointed.

Building for switches is to be the shelter type. Since this building is to be established in the existing exchange site, maintenance staff for switches do not need to stay on duty in the shelter. Therefore, complaint line and alarm indication are to be transferred to the existing exchange also.

(6) Network Synchronization

For network synchronization, master-slave system using the existing E-10B switches as master is to be adopted.

4-2-2 Radio Equipment

(1) Radio Transmission System Configuration

Radio transmission systems by Plan-A and Plan-B are to have configurations shown in Figure 4-4 and Figure 4-5. In Plan-B, the number of repeater stations that belong to base station increases so that the number of repeaters on the route to base station is larger than in Plan-A.

(2) Scale of DRCS Plan

Scale of DRCS plan based on circuit designs by Plan-A and Plan-B is as under.

	Plan-A	Plan-B
Base station	6	3
Repeater station	38	33
Subscriber station	436	436
No. of base units	23	23
No. of repeater units	55	68
New exchange	-	3
Total distance (km)	1,065.4	1,143.6
No. of villages	456	456
No. of subscribers	2,453	2,453

(3) Radio Station Equipment

For towers, antennas, feeders and radio station equipment as components of DRCS organized by the previously introduced network configuration, overview description appears below.

1) Towers

a) Effective Use of Existing Towers

In case where DRCS facilities are established in the same site as the existing exchange site so as to reduce project related construction period and economize construction cost, the existing towers are to be utilized as much as prossible. Stations for which the utilization of existing towers is scheduled are as under.

Station	Existing Tower Height (m)	DRCS Antenna Height (m)
J. ASHMUR	80 (guyed)	20
HAJJAH	20 (self-supporting)	20
J. DHARWAH	32 (")	15
DAYN	32 (")	20
SANA'A	50 (")	20
AYBAN	126 (guyed)	18
MASAR	66 (")	30
J. YASLAH	15 (self-supporting)	15
J. AL LISI	48 (guyed)	40
J. SUMARAH	30 (")	20
BAJIL SOUTH	80 (")	25

For shared use in rural telecommunications to be upgraded, this time, those existing towers must have additional platform or antenna mount newly installed. DRCS antenna position must be such as will not exert adverse influence on the existing antenna performance.

b) New Tower Construction

For DRCS antennas to be mounted on newly constructed towers, the relatively lightweight type which will not suffer heavy wind load must be chosen, except for multi-feed type antenna. For towers to be used at subscriber stations, either 6-20 m high masts or lightweight towers are preferred. For repeater station and base station towers, the optimum type is to be chosen from among the self-supporting type, guyed type and built-up colum type composed of steel plates.

All towers to be newly constructed must be provided with lightning arrester and earthing. Towers with height of 45 m or more must carry aeronautical mark also.

Tower design conditions are mainly as under.

- To comply with relevant Japan Industrial Standard (JIS)
- Allowable wind speed : 150 km/hour
- Ground pressure endurance;
  - Against sandy silt : 10 tons/m^2
  - Against gravel : 20 "
  - Against rocks : 50 "

Required tower height at base stations and repeater stations is in Figure 4-6.

2) Antennas

Antennas to be used are of 2 kinds, i.e., omni-directional antenna and directional antenna.

Omni-directional antenna is to be mounted at tower top, in principle. In case where TV antenna or the like is already mounted at tower top of the existing tower, multi-feed type antenna which can be mounted on tower side is to be used.

Omni-directional and directional antennas' parameters are as under.

1) Omni-Directional Antenna

	Gain (900 MHz)	Weight (kg)
Andrew type	10 dBi	15
Collinear type (8-element)	11 "	50
" (16-element)	13.5 "	120
Multi-feed type	13 "	500

2) Directional Antenna

Grid parabolic (ø 1.2 m)	16 "	40
" (ø 1.8 m)	20 "	65
" (ø 2.4 m)	22.5 "	100
" (ø 3.0 m)	24.5 "	120
Yagi (8-element)	11 "	
" (12-element)	13 "	
" (14-element)	14 "	
Yagi Multi-Stack (8-element)	13.5 "	
" (12-element)	15.5 "	
" (14-element)	16 "	

From the viewpoint of engineering economy, each antenna is to be co-used by a plural number of systems. At the same time, this causes antenna duplexer loss to increase. For example, antenna co-use by 2 systems results in duplexer loss of 4.5 dB while in the case of antenna co-use by 3 systems, duplexer loss reaches 8 dB. (Both include cable loss.) This time, to cope with such duplexer loss, transmitter output power and antenna gain are to be increased.

3) Feeders

For feeders, either coaxial type or low loss type is to be used as the case may be. When antenna height is considerable and distance between transmitter/receiver and antenna is long, low loss type is to be adopted. Types of feeders and loss by type are as under.

a) Normal Type

	Loss at 900 MHz
4/8 inches type	9.5 dB/100 m
7/8 "	5.2 "
10/8 "	4.5 "

b) Low Loss Type

4/8 inches type	7.7 "
7/8 "	4.3 "

4) Radio Concentrator Telephone Equipment

At base stations, time division multiplex (TDM) controller and dedicated DRCS concentrator are to be installed.

TDM controller is to be composed of radio transmitter/receiver (1 working and 1 standby units), time slot control unit, voice CODEC, data control unit, supervisory unit and maintenance order wire. If telex service is required, telex CODEC is to be added. Transmitter/receiver output power is to be 10 watts at maximum.

DRCS concentrator expands CODEC output of 15 channels per system to 127 telephone lines and connects them to switches. On the other hand, 127 telephone lines from switches are concentrated to 15 channels by the concentrator.

At repeater stations, 2 sets of radio transmitter/receiver units (each set having 1 working and 1 standby units) per system, regenerator and subscriber line unit (SLU) are to be installed. SLU consists of voice CODEC and subscriber signal converter. When SLU for telex is added, connection to telex subscribers becomes possible. SLU capacity expansion is to be up to 20 lines.

Subscriber unit is to be composed of radio transmitter/receiver (without standby unit), regenerator and SLU. SLU function is the same as in repeater station.

(4) Maintenance/Operation of Radio Equipment

So as to ensure normal operation of widely scattered DRCS repeater stations and a large number of subscriber station equipment and to keep transmission performance at high level of reliablility, all base stations are to be equipped with centralized alarm/supervisory system covering DRCS network sections which they respectively control.

Maintenance staff assignment is to base stations only. Repeater stations are to be unattended. Minimum equipment requirements are as under.

1) Maintenance order circuits are to be established, interconnecting base stations, repeater stations and subscriber stations. For order circuits among base stations, the existing facilities are to be utilized.

2) Alarm/supervisory performance of each repeater station and subscriber station is to determine whether at least the undermentioned units are operating normally or not.

Repeater Station	Subscriber Station
Power supply unit	Power supply unit
Common control unit	Transmitter
Repeater unit	Subscriber line unit
Transmitter/receiver	
Voice CODEC	

4-2-3 Local Cable Facility

(1) Subscriber station and in-village distribution point are to be connected by 10-pair or 20-pair aerial cable. (Refer to Figure 4-7.)

Aerial cable to be used is color code polyethylene insulated conductor, covered with laminated aluminium polyethylene sheath, self-supporting type. Suspension wire is to hold strength that allows ladder placement at work site. The above-mentioned cable is called CCP-AP-SS cable or CAS cable.

Reasons why this cable is used are as under.

1) Because of color coding, misjoint is scarce and identification is not necessary.

2) For both insulation and sheathing, polyethylene is used. Hence weather-fastness and water-tightness, as well as flexibility for bending and light weight.

3) Aluminum screen with shielding effect.

4) Self-supporting type. Hence no need for suspension wire.

(2) For technical reason in radio propagation, subscriber stations have to be established distantly from project-covered villages concerned in some cases. In the investigation, this time, the number of those villages is assumed to be approximately 90.

To connect each such village and subscriber station concerned also, CAS cable is used. Total length of CAS cable installation for this purpose is estimated at 140 km. Here, this cable is called entrance cable.

As an alternative, engineering of radio hops with ridge loss can be considered in such situations.

This will result in a slightly degraded S/N performance at the subscriber station. This aspect will be examined at the detailed desingn stage.

(3) The number of distribution points per village is set at 3 in average.

Cable to interconnect those 3 distribution points is CAS. Total length of CAS cable installation covering all 456 objective villages of project is estimated at 184 km when calculated at average installation length per village of 400 m. This cable is called distribution cable.

(4) Cable installation is on steel poles. Cable height above ground is about 6 m. Standard pole to pole spacing is 50 m.

(5) For actural cable installation route, i.e., actural locations of poles, guys and distribution points, final decision is to be made, based on field survey results, at the stage of detail design compilation.

4-2-4 Subscriber's Service Line Equipment

(1) Cable from distribution point is taken into subscriber's arrester by dropwire, where it is connected to house wire and extends to subscriber's telephone set. (Refer to Figure 4-7.)

(2) Dropwire is to be steel-reinforced. Length is set at 150 m in average.

(3) Dropwire is to be suspended on steel pole. If appropriate structure which can replace steel pole is available, such structure is to be utilized. Therefore, the required number of steel pole as subscriber's service line component is set at 1 per subscriber.

(4) Subscriber's arrester, besides connecting dropwire and house wire, is connected to grounding rod via grounding wire. The required number of subscriber's arrester and grounding rod is set at 1 each per subscriber.

(5) Subscriber's telephone sets to be used are of 2 kinds. They are:

1) Ordinary Subscriber's Telephone Sets

These are pushbutton type automatic telephone sets. Quantity: 1,723 sets (approx. 70% to total).

2) Public Call Office Telephone Sets

These are pushbutton type automatic telephone sets with charging pulse counters. Quantity: 730 sets (approx. 30% to total).

4-2-5 Power Supply Equipment

(1) Power supply system to communication equipment is described below.

1) Switches and Base Station - Full Floating System

Supply system is to branch from AC power supply system (220 V, 50 Hz) for the existing exchanges. Primary power supply consists of commercial AC power. Emergency power supply is from standby AC engine generator.

2) Repeater Station (located in the existing microwave system repeater site) - Full Floating System

Supply system is to branch from AC engine generator (220 V, 50 Hz) already in operation to supply power to the existing microwave system repeater.

3) Repeater Station (to be constructed at new site) and Subscriber Station - Solar Power System

Configuration of power supply system to base station and repeater station appears in Table 4-4.

(2) Commercial AC power supply parameters in Yemen A.R. are as under.

- Voltage : 180 V - 220 V
- Frequency : 49.5 Hz - 50 Hz
- Reliability: 80%

(3) Solar power system capacity is to be determined in consideration of sunshine availability, service grade (degree of system failure due to power supply capacity shortage), maintenance/operation requirements and equipment reliability.

Sunshine availability varies from area to area. The availability rate is high in SANA'A Governorate and low in HUDAYDAH Governorate. TAIZZ Governorate comes in between.

Based on study results concerning sunshine availability and sunshine hours in the past 3 years recorded by the Observatory (though the record is not consecutive but includes months without data), solar power system is tentatively designed as under by standard equipment criteria.

1) Sunshine availability

- SANA'A Governorate : 590 mW
- TAIZZ Governorate : 505 "
- HUDAYDAH Governorate: 377 "

2) Solar cell initial capacity

To be commensurate with initial stage power requirement, provided that capacity expansion is easy.

3) Storage battery initial capacity

To be equal to initial stage power requirement plus 20%, provided that capacity expansion is easy or replacement with larger capacity equipment is possible.

2 sets of storage batteries at repeater station and 1 set at subscriber station.

Autonomy is for 48 hours at repeater station and for 13 days at subscriber station.

Meanwhile, meteorological data obtained by the survey team leave room to be desired in terms of period and consecutivity of data recording. There is need for additional data collection for the purpose of in-depth study.

4-2-6 Building

(1) At all base stations and all repeater stations except ARUS (O/H) station, equipment is to be preferably installed in shelter. However, the option of constructing conventional buildings will also be kept in view for consideration at the detailed design stage.

ARUS repeater station equipment is to be installed in the existing station building.

Subscriber station equipment is to be installed in public building as far as possible, choosing local office of government organization, school or hospital, for instance. Otherwise, private housing is used. In case where no appropriate building exists or where subscriber station has to be established at a location without building so as not to interrupt radio propagation, shelter is used wherein to install equipment.

(2) Shelter size is to be as under. Provided spare floor space be considered so that additional equipment installation in the future is possible, and size be adequate for shelter transport.

Shelter Classification	Shelter Size
For telephone switches	2.4 m x 12 m
For base station radio equipment	2.4 m x 12 m
For base station power supply equipment	2.4 m x 6 m
For repeater station radio equipment (at the existing repeater site)	2.4 m x 2.2 m
For repeater station power supply equipment (at the existing repeater site)	2.4 m x 2.2 m
For repeater station radio and power supply equipment	2.4 m x 2.2 m
For subscriber station radio and power supply equipment	0.8 m x 0.6 m

4-2-7 Site and Access Road

(1) According to field survey results, land space required for base station (inclusive of switches) can be procured in the existing exchange site in all cases. The existing microwave system radio repeater sites, except ARUS (O/H) repeater site, also hold sufficient spare land space where to establish new DRCS repeater stations.

ARUS (O/H) microwave system repeater site is without spare land space to accommodate shelter for new repeater station so that all DRCS equipment is to be installed in the existing building.

(2) For other repeater stations, site land must be newly procured and readjusted (with ground levelling and enclosure). Station by station required areas are in Table 4-5. Total number of stations is 27. Total land requirement reaches about 11,000 m^2.

(3) Some of new repeater stations require access road construction. Survey results show that more than 50 m long access road must be newly constructed at 16 station sites. Access road breakdown by repeater stations and planned road length is in Table 4-5. Especially long access roads are required at 3 repeater stations as shown below.

Repeater Station	Access Road Length
J. KIBAH	Approx. 3.5 km
J. AN NAR	" 2.2 "
J. AL QULBY	" 2.0 "

(4) For actual site locations and areas, as well as access road routes, final decision is to be made, based on field survey results, at the stage of detailed design.

4-3 Project Implementation Schedule

4-3-1 Implementation Work Allotment

(1) With a view to project implementation according to schedule and at reasonable expense, implementation work is to be allotted to 3 parties, i.e.:

- Foreign contractor
- Foreign consultant
- MOC

Summary of work allotment to each party follows:

1) Foreign Contractor

Foreign contractor fulfils his work allotment on turn-key base. Excluded from work allotment are subscriber's telephone set fixing, wiring between telephone set and distribution point, matters inside the existing exchanges, matters concerning station site and access road, and matters concerning subscribers.

Work allotment breakdown is as under.

a) Field survey including site location checkup
b) Equipment design and site facilities design (including necessary work design for cable installation between subscriber station and distribution point)
c) Equipment manufacture, materials procurement and transport of equipment and materials to each site
d) Assembly, installation, wiring, adjustment and test
e) Acceptance test

f) Supply of maintenance spare parts, measuring equipment for maintenance, equipment instruction manuals and system handbook
g) Maintenance staff training
h) Technical assistance in maintenance work after handover of completed system

2) Foreign Consultant

Foreign consultant fulfils the undermentioned work allotment.

a) Proposed site selection and network detailed design (See Note.)
b) Preparation of the international competitive tender documents to select the foreign contractor
c) Answer to tenderers' inquiries, evaluation of tender proposals and recommendation on award of contractor
d) Assistance to contract negotiation
e) Examination of installation design and drawings
f) Witness to factory test
g) Supervision of installation work
h) Witness to acceptance test
i) General consulting services and cordination with MOC/PTC

Note: For the facilities in the existing telephone exchange offices and projected local cable network, the consultant will make a general design for basic matters. Practical detailed design will be carried out by the contractor and MOC (for the local cable network).

3) MOC

Work allotment for MOC is as under.

a) Acquisition (or lease) of land and access road
b) Site measurement and land formation including ground levelling
c) Work design and execution for the existing exchange capacity expansion (in case of Plan-B) and necessary readjustment
d) Decision on number of circuits required according to villages and subscriber categories, and subscriber selection
e) Telephone set fixing, wiring design between distribution point and telephone set, as well as execution thereof

(2) Delay of readjustment/improvement work for basic facilities, such as station sites and access roads, directly influences project implementation progress. Therefore, selection of site and access road locations and land procurement negotiations with landowners should be carried out ahead of all work programs.

There is need for establishing methodology that makes it possible to expect implementation work progress according to schedule. And such methodology must be established before project implementation begins, in due consideration of the state of affairs in Yemen A.R. (including landowners' position, as well as land survey and related service capabilities).

4-3-2 Purchase of Materials and Services

(1) As stated in the preceding section, foreign contractor undertakes the following work execution in bulk and on turn-key base:

All facilities between MDF terminals of the existing exchanges and newly installed equipment (i.e., for rural and urban network tie cable termination) and cabling between distribution points in villages concerned.

Provided,

a) Out of required materials between distribution points and telephone sets, materials difficult to procure in Yemen A.R. will be supplied by foreign contractor.

b) Terminal blocks for tie cable termination will be purchased by MOC from supplier of the existing terminal blocks. This is to do without troubles relating to terminal block fixing.

(2) As for materials required for capacity expansion of the existing exchanges, MOC will purchase such materials by direct contract with original supplier. Work execution by use of those materials will be carried out by MOC with technical assistance by original supplier.

4-3-3 Project Implementation Time Schedule

Period from the time of foreign consultant employment through project finalization is estimated at 4 years.

Project implementation time schedule on that assumption appears in Figure 4-8.

Usually, final survey of site locations is carried out at full responsibility of contractor. There also is the case where the responsibility is shared by consultant and contractor. A typical example is this: Selection of proposed sites is at consultant's responsibility and all the subsequent responsibility including checkup of proposed sites rests with contractor. Since this responsibility sharing by consultant and contractor contributes to project implementation period curtailment, this method is used in Figure 4-8.

Final decision concerning which method to use should be made prior to project implementation commencement.

4-4 Maintenance and Operation

4-4-1 Maintenance and Operation System

Maintenance and operation system for rural telecommunications network is as under.

(1) At repeater stations and subscriber stations, maintenance/operation staff will not be assigned. SANA'A, TAIZZ and HUDAYDAH base stations are to function as maintenance station, each with its own staff. These 3 base stations are to take care of maintenance/operation of their respective dependent repeater stations and subscriber stations.

Main duty items are:

- Supervision of system operation in maintenance duty area by remote supervision system

- Maintenance itineration of repeater stations and subscriber stations

- Discovery of fault point, probe into cause of fault, and work to restore normal operation

- Service performance monitoring

- Keeping maintenance vehicles in good order

- Services concerning telephone tariffs

(2) At SANA'A base station, maintenance and control centre and central repair centre are to be established in addition to the aforementioned maintenance station. Duty items of maintenance and control centre are:

- Keeping sufficient stock of measuring equipment and maintenance spare parts, and distribution thereof where necessary

- Keeping standard practices and plant records in good order

- Training of maintenance/operation staff

(3) Consignee of public call office telephone are to perform the following duty items:

- Acceptance of call applications and connections to called parties

- Collection of calling tariffs

- Delivery of received messages to addressees, in the case of terminating calls.