BASIC DESIGN STUDY REPORT
ON
THE PROJECT FOR THE REHABILITATION
OF
TELEPHONE NETWORK IN KHARTOUM
THE REPUBLIC OF THE SUDAN

MAY 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of the Sudan, the Government of Japan has decided to conduct a Basic Design Study on the Rehabilitation Project for the Telephone Network in Khartoum and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to the Sudan a survey team headed by Mr. Satoru Itoh, Special Advisor for International Cooperation, Ministry of Posts and Telecommunications, from November 26th to December 25th, 1988.

The team exchanged views with the officials concerned of the Government of the Sudan and conducted a field survey in the Khartoum area. After the team returned to Japan, further studies were made. Then, a mission was sent to the Sudan in order to discuss the draft report, and the present report has been prepared.

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

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

May, 1989

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan Inteternational Cooperation Agency

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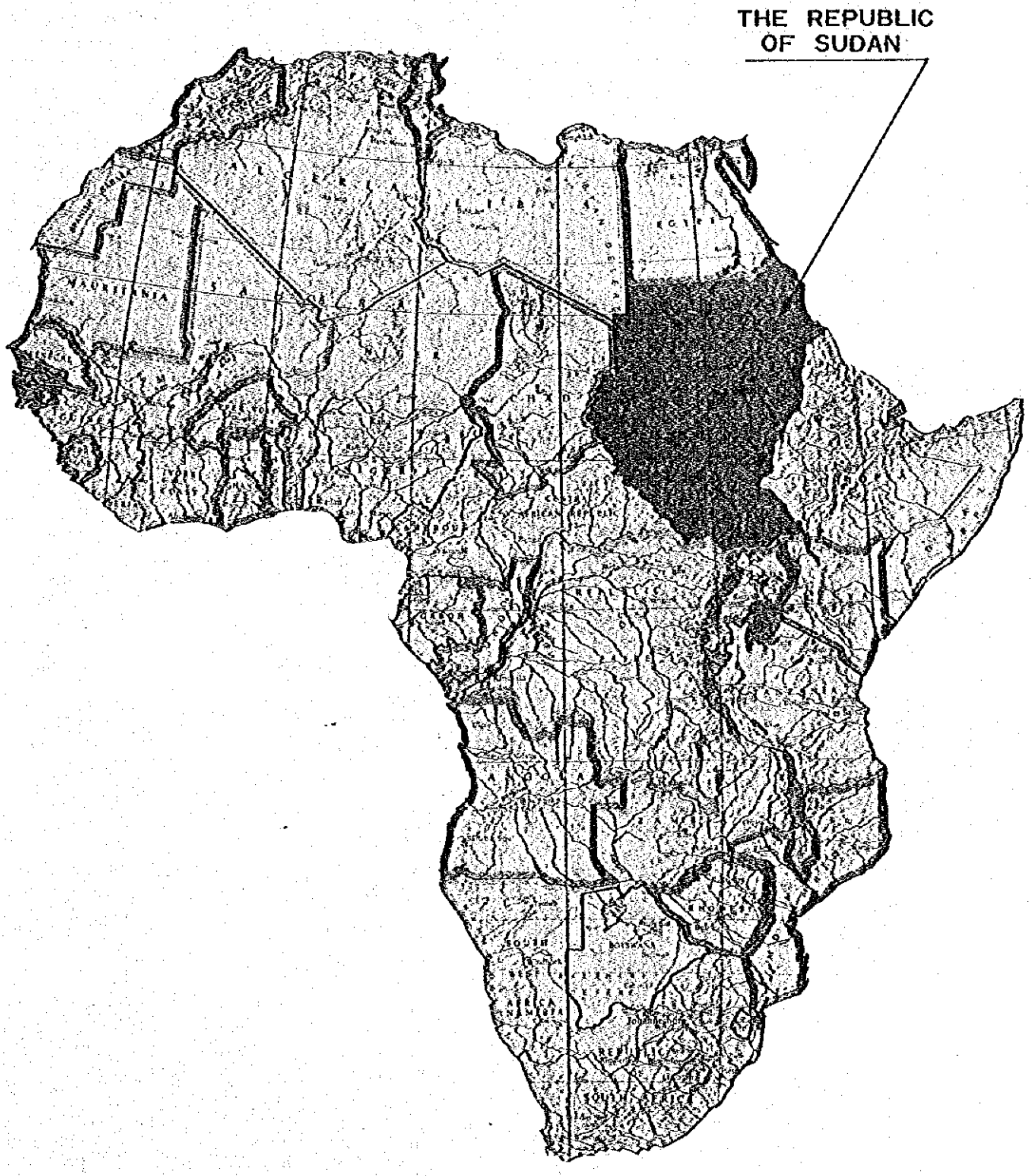

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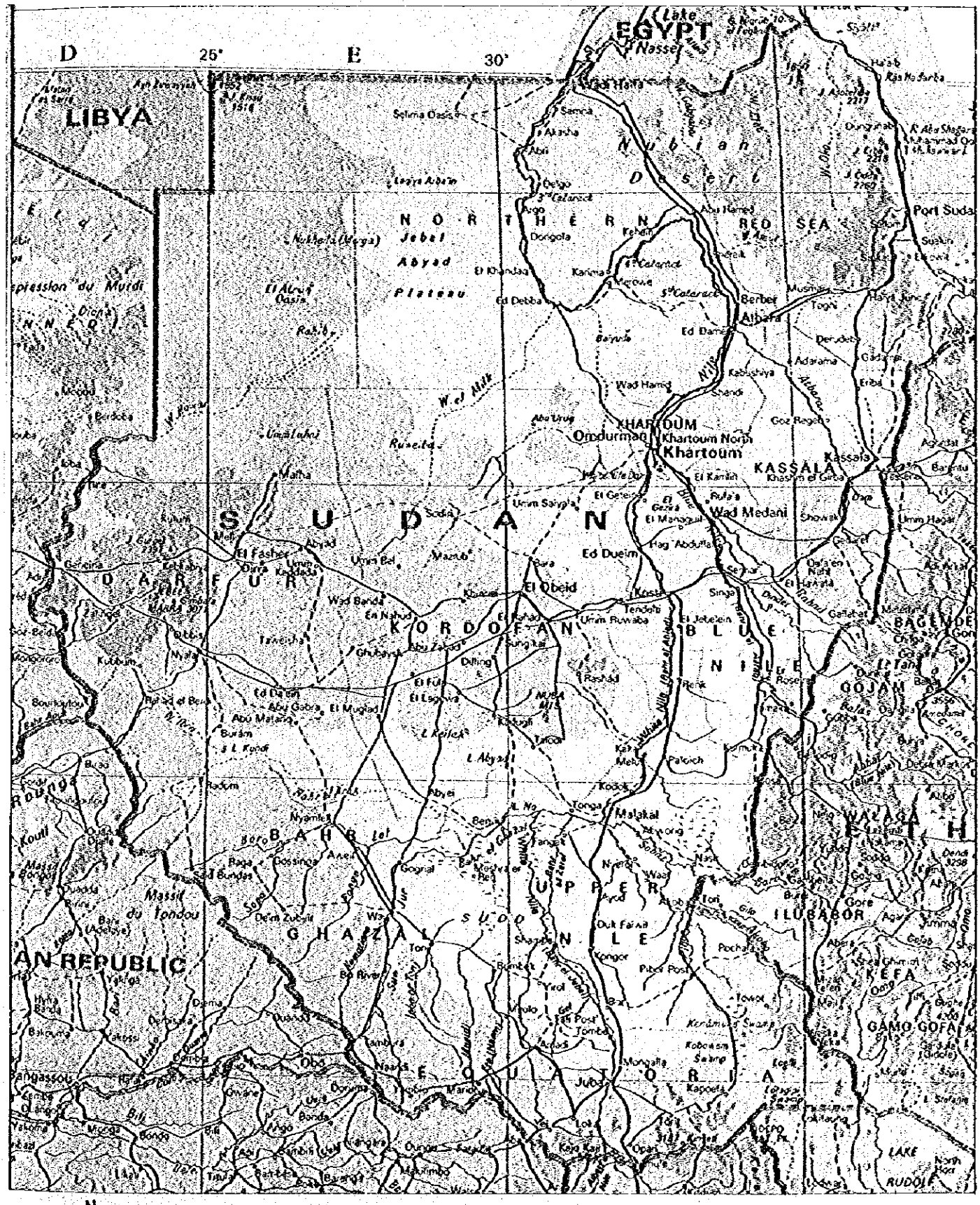
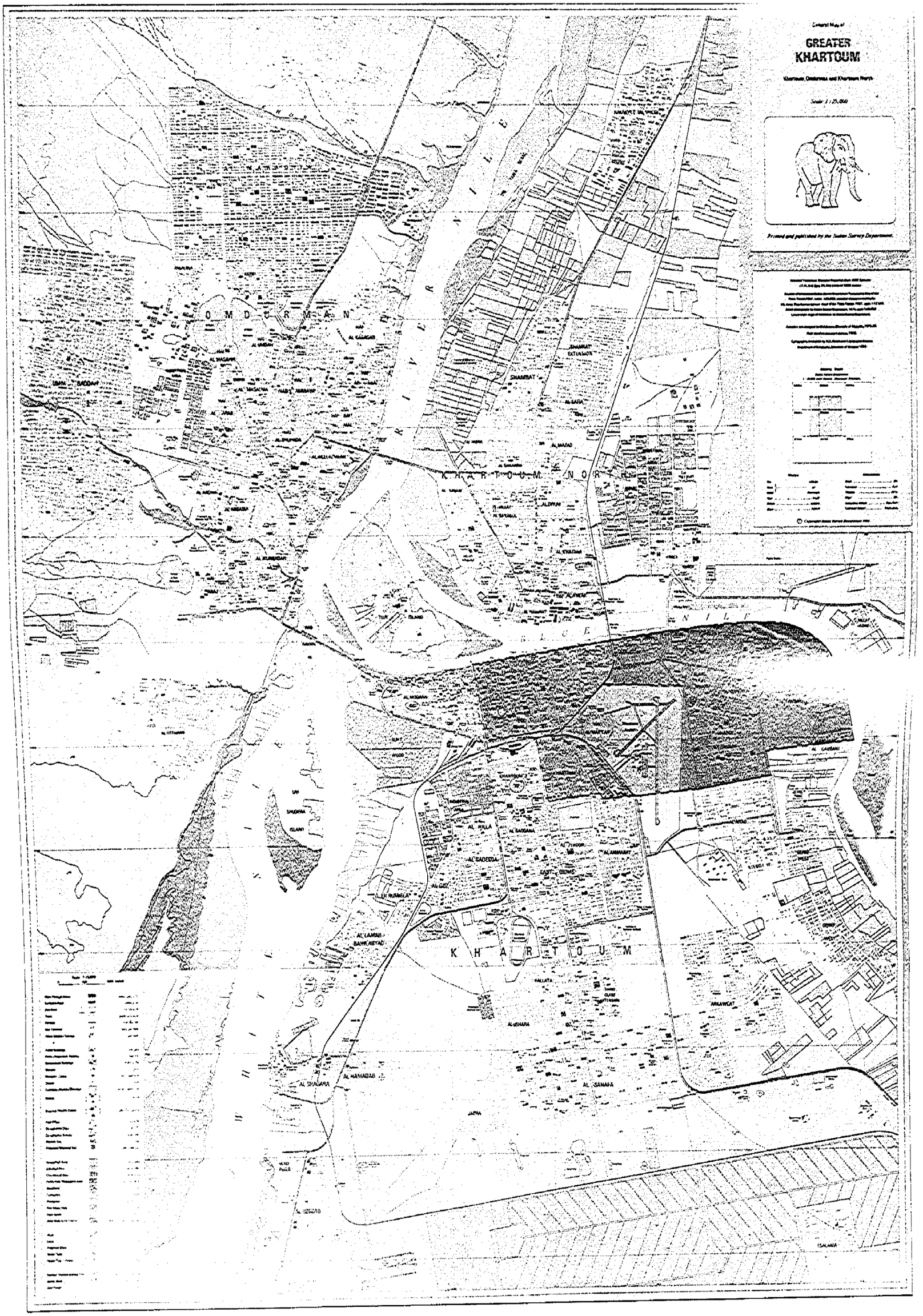


THE REHABILITATION PROJECT FOR THE TELEPHONE NETWORK IN KHARTOUM



SUMMARY

Summary

Since the Republic of the Sudan won its independence in 1956, the government has been endeavoring to raise the nation's socio-economic standing through national development programmes. In July 1987, the Government formulated the national Four-Year Salvation, Recovery and Development Programme (1988/89 to 1991/92) to establish and expand the economic base of the nation. This plan put the emphasis on the structure of infrastructure, and it is currently being implemented.

In accordance with the goals and aims of the aforementioned programme, the Sudan Telecommunications Public Corporation (STPC), the entity in charge of telecommunications in the Sudan, has prepared a short-term development plan (1987 to 1991) so as to satisfy the growing and ever increasing demand for telecommunications services in Sudan. In this plan, the greater Khartoum urban complex rehabilitation and development project was given the highest priority for implementation. The plan is currently being implemented in a certain limited area of Khartoum, with the cooperation of the Governments of West Germany and the Netherlands. STPC has prepared plans for the rehabilitation of the telephone network in some of the Khartoum Central Exchange and the Khartoum South Exchange Areas. For early realization of improvement for the telephone services, the Government of Sudan requested the Government of Japan to extend cooperation in the form of Grant Aid.

In response, the Japanese Government decided to carry out a basic design study of this Project, and the Japan International Cooperation Agency (JICA) conducted a study in Sudan for the basic design of the Project between November 26 and December 25, 1988.

The study covered the collection of such relevant information as the state of telecommunications in Sudan and related facts, as well as the background and details of the Project. The study team held repeated discussions with those officials of the Sudanese Government who are in charge of the Project, and they collected relevant facts regarding existing telecommunications facilities, including data on their use. The team also carried out the field survey in project sites.

The telephone network facilities in Khartoum, the capital city of the Republic of the Sudan, are obsolete with the lapse of about 40 years after installation. In addition, these facilities have not been maintained properly due to problems in the management system of maintenance and operation, and difficulties in spare parts procurement. As a result, approximately 30% of all subscribers in the metropolitan area constantly fail to utilize the telephone service, and during the rainy season in particular, the water penetration into communication cables causes service interruption to a majority of the lines. Therefore, the situation of telephone facilities in Khartum is serious.

This Project is to rehabilitate the telephone network in Khartoum city, which consists of subscriber cable facilities, switching facilities and junction cable facilities, and to provide stable telephone services.

The results of the study conducted in Sudan and the analysis subsequently carried out in Japan led to the conclusion that the following items need to be addressed:

(1) Subscriber cable facilities need to be improved by replacing the gas pressurized system, which was used in the past, with jelly-filled, polyethylene-insulated cables, which are more reliable and easier to maintain. By this means, service will be restored to telephone lines in which it has been interrupted, and at the same time trouble caused by water penetration into communication cables will be eliminated.

(2) With regard to the switching facilities, digital local switching systems with a capacity of 2,000 line unit will be installed in Khartoum South Exchange (the existing switching systems have a capacity of 10,000 terminals) and the Burri area. Khartoum South Exchange will accommodate the important subscribers for administrative institutions in the area covered by Khartoum South Exchange and will provide stable communications services. Burri Exchange will accommodate some of the subscribers of the Khartoum Central Exchange. The new system will reduce the load on the existing switching system in Khartoum Central Exchange, and lead to economy in the construction of the subscriber cable facilities.

In the Burri area, a new telephone office will be built in order to install the digital local switching facilities.

(3) For junction cable facilities, there are existing radio transmission facilities between Khartoum Central Exchange and the Khartoum South Exchange, but the radio signal interference caused by high-rise buildings is posing a problem. Replacing or improving the existing radio towers is therefore necessary in order to provide stable communication services. Due to the difficulties involved in the securing of radio transmission propagation paths and in the procurement of construction funds and sites, this project will involve the construction of junction cable facilities which would use optical fiber cables to improve communication with the Central Exchange. Other junction cable facilities, also incorporating optical fiber cables, will be installed between the Khartoum Central Exchange and the Burri Exchange to connect both switching systems.

An outline of this project is given in Table 1.

Table 1 Outline of Project

Facilities	Exchange	System
Subscriber Cable Facilities	Khartoum Central Exchange Khartoum South Exchange Burri Exchange	Flexible network system (Jelly filled cables) Duct system
Switching Facilities	Khartoum South Exchange Burri Exchange	Digital local switching system
Junction Cable Facilities	Khartoum Central Exchange - Khartoum South Exchange Khartoum Central Exchange - Burri Exchange	Optical Fiber cable system

The total amount of funds required for this project is estimated at 0.12 billion yen by the Government of Sudan.

The time frame for the project is estimated to be a total of 24 months after the signing of the Exchange of Notes by both governments, consisting of 4.5 months for preparation of detailed design and bidding procedures, and 19.5 months for construction.

STPC will be the contractee of the Project for both its administration and implementation. A portion of the national development funds of the Sudanese government is expected to be appropriated to cover its share of the cost.

When the objectives of the Project are achieved, some 3,600 subscribers will be able to utilize the telephone service which is currently interrupted due to faulty facilities, and the unstable communications facilities, which are susceptible to even more trouble during the rainy season, will be improved.

It is expected the provision of stable communications services will improve communications with government offices and other public institutions, and thus this project will enrich the lives of residents not only in the target areas of the project but also in the entire metropolis of Khartoum. Increased speed in transmission of information will increase the efficiency of administrative operations, stimulate the economy, and reduce traffic congestion in the cities. In this manner, the project, when it is completed, is expected to contribute greatly to the socio-economic development of the country, and also to improve the standard of living of the Sudanese people by providing a part of the nation's infrastructure.

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CHAPTER 1 INTRODUCTION

CHAPTER 1 INTRODUCTION

In Khartoum, the capital city, the telephone exchanges comprise a total of 48,550 line units, and the number of telephone subscribers amounts to approximately 40,000, approximately 70% of the national total.

Other telephone facilities in the metropolitan area of Khartoum, however, are obsolete, and with defective parts being left as they are, 30% of the subscribers in the metropolitan area are constantly unable to utilize the telephone service. During the rainy season, a majority of the services are suspended. Therefore, the telephone service in the metropolitan area of Khartoum is in a serious situation.

To improve the above situation, the Sudan Telecommunications Public Corporation (STPC),which is in charge of telecommunication services in the Republic of the Sudan, is now implementing the rehabilitation and improvement of telephone networks and expansion of switching systems in a part of Khartoum with the cooperation of KfW, a governmental agency for developing countries assistance in West Germany, and the Government of Netherlands.

The Government of the Republic of the Sudan intends to upgrade the telephone networks in other areas in Khartoum at the earliest possible time and requested the Government of Japan to provide the Grant Aid for this purpose.

In response to this request, the Government of Japan decided to execute the basic design study for the Project, and entrusted its execution to the Japan International Cooperation Agency (JICA). JICA dispatched the basic design study team headed by Mr. Satoru Itoh, Special Advisor for International Cooperation, Ministry of Posts and Telecommunications, to the Sudan from October 26, 1988 to December 25, 1988.

The team studied the existing telecommunications facilities, including conditions on their usage, maintenance and operation, and gathered facts on personnel training programs and the current condition of the nation's infrastructure in order to assess the appropriateness of this project for Grant Aid, and to determine the details and the scale of the actual

cooperation. The issues on which officials of both governments agreed were again compiled into the minutes of discussions, which were duly signed by both sides.

After the team returned to Japan, all relevant information was analyzed and examined on the basis of the results of the study conducted in the Sudan, and it was confirmed that the project is indeed appropriate for Grant Aid. Then the plans for the basic design, operation, execution, maintenance, control and evaluation of the undertaking, together with suggestions, were compiled into the Basic Design Study Report (draft). The team, again headed by Mr. S. Ito of the Ministry of Posts and Telecommunications, returned to the Sudan between March 19 and March 30, 1989, to explain this Report (draft) to the Sudanese officials and to discuss its contents. Based on the abovementioned results, this report was compiled into the Final Basic Design Study Report.

The names of the members of the team, the study schedule, the list of individuals whom they met, the minutes of discussions and other information are provided herein as "ANNEXES".

CHAPTER 2 PROJECT BACKGROUND

CHAPTER 2 PROJECT BACKGROUND

2-1 General Outline of the Republic of the Sudan

2-1-1 Geographic Features and Population

The Republic of the Sudan is surrounded by Egypt and Libya to the north, by Chad and the Central African Republic to the west, by Zaire, Uganda and Kenya to the south, and by Ethiopia to the east. It also faces Saudi Arabia across the Red Sea. The nation has a total area of about 2.5 million square kilometers, which is the largest in Africa and equivalent to about 7 times the total area of Japan.

The Sudan has a population of 23,290,365 (1986), of which 2,971,842 (1986) reside in its capital, Khartoum. (Source: the information provided by the Ministry of Financial Planning of the Sudan)

2-1-2 National Economy

The Sudan suffers from the considerable economic hardships created by over 1.5 million refugees, a slump in cotton exports (cotton is the nation's major export item), insufficient food caused by droughts, and the limitations imposed on the nation by the ever-increasing amount of its cumulative deficits.

Agriculture accounts for 34% of the gross domestic product (GDP) (1986/87) and for approximately 80% of the export revenues of the Sudan. In addition to cotton, the country's major export items consist of gum arabic, peanuts and sesame seeds. Together, these items account for over 80% of the total export revenue of the country.

As far as imports are concerned, the nation depends almost entirely on imports of development materials and equipment as well as consumable goods needed for daily life.

Consequently, increased investment activities in development projects have led to sharp increases in the volume of imports, which have served to

swell the already substantial trade deficit. In 1985, the nation's imports amounted to US$771 million while its exports amounted to US$374 million.

In order to cope with the deficiency in foreign capital, the Government of the Sudan has conceded since December 1987 to having an open market exchange rate in addition to the official rate. As of December 1988, while the official rate for the US dollar stands at 4.5 Sudanese pounds, the open market rate stands at 10 to 13 Sudanese pounds.

2-1-3 National Development Plan

A Four-Year Salvation, Recovery and Development Programme is currently being implemented. This covers the period from 1988/89 up to 1991/92.

The major objectives of the plan are to rehabilitate the agricultural sector and industrial sector. Moreover the plan places emphasis on the rehabilitation of the infrastructure so as to satisfy the nation's basic human needs (BHN).

In accordance with the goals and aims of the plan, STPC has prepared a short-term development plan and is implementing the greater Khartoum urban complex rehabilitation and development project with the highest priority.

2-2 General Outline of Telecommunications in the Sudan

2-2-1 General Conditions

A submarine cable was laid between Suakin Port and Jeddah, and a telegraph line constructed between Suakin Port and Suez as early as 1859. Telephone communications started with the advent of manual telephone exchanges in 1896 and the introduction of automatic telephone exchanges in 1936. The network of transmission lines has been modernized at a rapid pace since 1976 as micro routes were opened and a domestic satellite system constructed. At this time telephone and telegraph services as well as TV broadcasting began between the major cities of the Sudan.

However, it suffered recently from certain technical constraints and lack of spares.

With regard to international calls, direct telephone connections and telexing have been possible with 80 countries -- in Europe, the Near and Middle East, Africa and North America -- and trunk connections with countries in the Far East have been made via England since the operation of satellite earth stations commenced in 1974.

2-2-2 The Condition of the Existing Situation

(1) Local telephone exchanges

The present situation of local telephone exchanges in Sudan (as of June 1988) is as follows:

1)	Local Exchange	141
	Automatic exchange	65
	Manual exchange	76
2)	Exchange Capacity (l.u.)	73,330
	Automatic exchange	69,550
	Manual exchange	3,780
3)	Telephone Service	
	Direct	59,093
	Station	76,623
	Waiting list	29,334
	Density (per hundred inhabitants)	0.35
	Call box	598
4)	Telex Service	
	Subscriber	1,380
	Waiting list	900

As of December 1988, seven types of automatic switching systems are operating in the Sudan. Their model names and line capacities are listed below.

Type of Exchange	Number of Units	Capacity
Strowger (SXS)	6	5,920
Type-17 (SXS)	2	11,000
UR-49a (SXS)	6	22,000
Rulax (SXS)	30	2,330
NC-100 (XB)	13	3,800
NC-230 (XB)	5	2,500
NC-400 (XB)	3	22,000

In the capital city of Khartoum, 13 automatic telephone exchanges exist. These exchanges have a total of 48,550 line capacity and a total of 39,336 connections. 70% of these connections are in Khartoum area. The number of subscribers, the number of subscription applicants on waiting lists (as of the end of June 1988), and the capacity of the automatic switching systems are shown in Table 2-1.

Table 2-1 Switching Line Unit, Telephone Subscriber and Waiting List

Exchange Name	Switching Line Unit	Government		Private		Total	Waiting List
		Office	Res.	Shop	Res.		
Khartoum Central	15,000	3,950	265	6,593	1,127	11,935	3,500
Khartoum South	10,000	388	180	3,164	3,983	7,715	6,382
Khartoum Extension	5,000	160	57	332	4,048	4,597	5,878
Khartoum North	4,000	362	89	983	1,530	2,964	1,657
Omdurman	7,000	427	116	2,901	3,402	6,846	3,050
Mahadia	4,000	37	30	79	2,760	2,906	1,440
Shambat	3,000	91	50	422	1,418	1,981	458
Al Muluk	300	20	11	1	214	246	152
Hog Yusuf	50	3	0	5	15	23	23
Gerief East	50	8	0	8	24	40	21
Geili	50	6	0	2	16	24	0
Eilafun	50	9	0	4	6	19	12
Jebel Aulia	50	24	2	9	5	40	0
TOTAL	48,550	5,485	800	14,503	18,548	39,336	22,573
		6,285		33,051			

(2) Toll telephone

A general outline of toll telephone as of 1988 is given below.

1) National subscriber trunk dialling (STD)

National subscriber trunk dialling facilities have been introduced in Khartoum, Wad Medani, Sennar, Port Sudan, Atbara, Shendi, El Obeid, Gedaref, Kassala, New Haafa and Kosti

The service effectiveness of these facilities has been limited by the number and quantity of circuits available.

2) Digtal national/international switching

A digital national/international switching centre was established in 1983. The performance of this centre is quite satisfactory.

3) Domestic satellite system (SUDOSAT)

A domestic satellite system (SUDOSAT) comprising 15 earth stations started operation in 1978. This greatly enhanced the central facilities for telephone, telex and television services. However, performance of this system is not satisfactory due to various technical and financial constraints.

(3) International communications

1) INTELSAT standard "A" earth station

STPC has been operating INTELSAT Standard-A Earth Station at Umm Haraz for international telecommunication since 1974. This earth station was built by Northrop Page of the U.S. Existing parabora antenna installed on the building has started declining, making it difficult to track the satellite due to an unexpected ground subsidence of the site. Land subsidence has thrown the foundation and floors of the building out of alignment, causing failures in

the automatic tracking system. Extensive repair of the structure is needed.

2) ARABSAT earth station

Operation of the ARABSAT earth station commenced in September 1987. International radio transmission lines have been installed for ten Arab nations, and this has served to improve telecommunications services to these countries greatly.

(4) Telex

A digital domestic and international telex switching system installed in the Khartoum Central Exchange was commissioned in early 1980. In 1986, the switching systems handled about 690,000 domestic telexes and about 1,230,000 international telexes. There are about 1,200 telex subscribers in the Sudan, and 99% of them are concentrated in Khartoum. Its performance is reasonable.

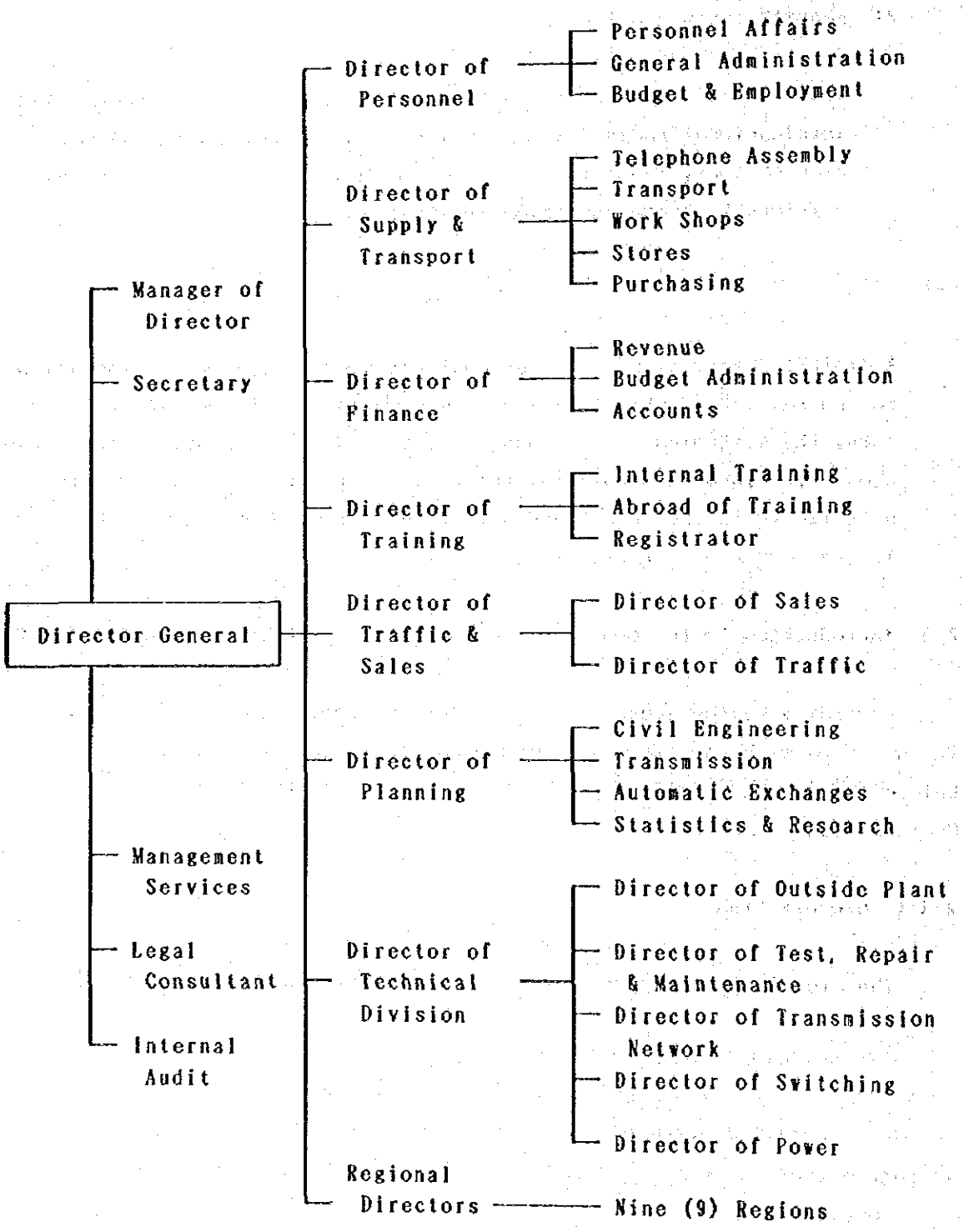
2-3 Introduction to the Sudan Telecommunications Public Corporation (STPC)

According to the Sudan Telecommunications Public Corporation Act, STPC is entrusted with the execution of the national and international telecommunication services under the supervision of the Ministry of Communications (MOC).

2-3-1 Organization

The organizational structure of STPC is shown in Table 2-2.

Table 2-2 Organization of STPC



2-3-2 Expenditure for Maintenance and Operation

The revenue of STPC is telephone and telex services. The total revenue from these services for the last financial year (1987/1988) is as follows:

Unit: Million LS

Revenue		Expenditure	
Telephone calls	39.3	Salaries and wages	35.6
Telex	23.2	Maintenance and operation	23.1
Other services (including leased circuits)	14.9	Material	1.6
		Development Project	2.2
		Balance	14.9
Total	77.4		77.4

2-3-3 Budget for Development Projects

The planning department in STPC prepares the budget for development projects and these proposals are submitted to the Ministry of Finance and Economic Planning for approval.

The budget for each financial year is shown in the following table:

1000 LS

Year	1980/81	81/82	82/83	83/84	84/85	85/86	86/87	87/88
Allo.	17,450	17,040	11,531	21,268	15,199	17,950	17,000	18,700
Exp.	4,150	5,606	1,766	3,372	6,702	2,200	2,000	3,400

2-3-4 Number of Personnel

The number and breakdown of personnel of STPC as of November 1988 is shown in the following table.

Personnel administration	405
Accounts and finance	189
Engineers	2,447
Traffic and sales	1,624
Operator	16
Supplies and Transport	168
Unclassified personnel	3,745
Total	8,594

2-4 General Outline of Existing Facilities

2-4-1 Cable Facilities

Most of the existing cable facilities in Khartoum passed their nominal life years ago, and are beyond repair and maintenance due to a lack of replacement parts. Such conditions contribute to the poor telecommunication services in Khartoum. Table 2-3 shows the number of telephone subscribers in Khartoum whose services were interrupted due to cable failures.

Table 2-3 Number of Cable Failures in Khartoum Area (1988)

	Aug.	Sep.	Oct.	Nov.
Khartoum Central	7,533 (63.0%)	6,198 (51.9%)	3,782 (31.7%)	2,235 (19.0%)
Khartoum South	4,694 (60.8%)	4,987 (64.6%)	4,552 (59.0%)	3,696 (47.8%)
Khartoum Extension	2,235 (48.6%)	2,364 (51.0%)	1,968 (42.8%)	815 (17.7%)
Khartoum North	2,253 (76.0%)	2,255 (76.0%)	2,040 (68.8%)	1,749 (59.0%)
Omdurman	4,291 (62.6%)	4,497 (65.6%)	4,577 (66.0%)	4,054 (59.2%)
Shambat	487 (24.5%)	414 (20.8%)	391 (13.0%)	137 (6.9%)

2-4-2 Civil Facilities

Existing manholes were built about 35 years ago; upper and lower floorboards are made of steel-reinforced concrete, and sidewalls are made of layers of brick. Some of the steel pipes used for the floors are exposed and extensively corroded. Damage to the brick walls is also severe. The soil pressure has caused some bricks to collapse. Overall, civil facilities have become largely obsolete.

Asbestos conduits (with a 6-inch inner diameter) are used for duct routes, but they are broken in many areas, again due to aging.

2-4-3 Subscriber's premises facilities

Dropwires which extend from the telephone poles to the houses of subscribers are old and suffer from deterioration. Some of the deteriorated dropwires, which are no longer in use, are left in the open, sometimes causing trouble as they come into contact with power cables. The current state of these facilities is extremely poor. Protectors for the facilities inside the homes of the subscribers have not been installed.

2-4-4 Switching Facilities

(1) Khartoum Central Exchange

The electronic switching systems made by Teletola of Italy and installed in 1983 provide international and toll telecommunications services. They are equipped with automatic dialling and charging functions.

- For local calls, step-by-step switching systems (UR-49a) made by Philips of the Netherlands and installed 17 years ago are in full operation. They employ a rotary-type common control system and have a capacity of 12,000 line units.

The construction of additional switching systems with a capacity of 3,000-terminals has almost been completed by NEPOSTEL, and there is

also a plan to construct more switching systems with a capacity of 1,000 line unit.

(2) Khartoum South Exchange

This exchange is located approximately 2.8 km south of the Khartoum Central Exchange. For local calls, the crossbar switching system (with a capacity of 10,000 line units) made by NEC Corporation of Japan was installed nine years ago. The number of subscribers in the Khartoum South Exchange is 7,715, but the lines to some of these subscribers are disconnected to the switching systems due to defective cable facilities and other problems. Currently only 6,200 subscribers are being accommodated by the switching systems in this exchange.

2-4-5 Transmission Facilities

Digital radio systems using the 2 GHz band are used for the junction network between the Khartoum Central and Khartoum South Exchanges. Installed are four systems which are operational and one which is a spare, and they are provided with 34 Mbits for the digital tertiary group (CEPT system). The capacity is equivalent to 1,920 channels.

These systems were installed by Teletola of Italy in 1979, and a lack of replacement parts has prevented the proper repair of these systems. Moreover, the problems affecting the performance of the existing microwave are mainly high buildings on the radio propagation paths, resulting in constant congestion of the traffic.

Consequently, the telecommunications service between the Khartoum Central and the Khartoum South Exchanges, where 52% of all junction circuits in Khartoum are concentrated, is greatly affected.

2-5 General Outline of Related Programme

2-5-1 Telecommunications Development Project

In accordance with the goals and aims of the 4-Year Salvation, Recovery and Development Programme of the Sudan, STPC has prepared a short-term telecommunications development plan in order to upgrade the performance of the existing telecommunications facilities and effect reasonable network development.

In this plan, STPC gives the highest priority to projects for improving and expanding telecommunications facilities so as to satisfy the growing and ever increasing demand for telecommunications services in Khartoum.

2-5-2 Related Projects

Projects related to this project are described below.

(1) Project for improving the local telephone network in Khartoum

1) Financial Source

The Government of West Germany

2) Objective

Rehabilitation and improvement of outside plant facilities in the western part of the Khartoum Central Exchange Area and the industrial area and the Amarat area of Khartoum South Exchange Area.

3) Scale

The scale of the project for improving outside plant facilities is shown below in terms of the total number of pairs to be terminated at MDF of exchanges:

The western part	:	4,000 pairs
The industrial area	:	2,400 pairs
The Amarat area	:	2,300 pairs

4) Implementation Status

DETECON, a West German consulting firm, prepared the specifications for the bid. In August 1988 the Sudanese government signed an agreement with Siemens of West Germany for the project, and a detailed design is currently being prepared.

5) Relationship to the Current Project

The two projects, the current project and the above-mentioned West German project, deal with the areas covered by Khartoum Central and Khartoum South, but the areas for each project are clearly defined and do not overlap.

a) Khartoum Central Exchange Area

West of Malik Street: West Germany

East of Malik Street, including the middle area, Hai Al Mattar: Japan

b) Khartoum South Exchange Area

Industrial and Amarat areas: West Germany

Khartoum-2 areas : Japan

West Germany was planning to invest the excess funds created by the results of the bidding into improving the outside plant facilities in the eastern part of the Khartoum Central Exchange Area and the existing radio transmission line between the Khartoum Central Exchange and the Khartoum South Exchange. However, as these improvements overlap with those covered by the project which the Japanese government was requested to undertake, the Sudanese Government asked West Germany to earmark the excess funds for provision of spare parts and for improving outside plant facilities in the Khartoum North Exchange Area.

(2) Project for expansion of the switching capacity for the Khartoum Central Exchange

1) Financial Source

The Government of the Netherlands

2) Objective

Installation of additional step-by-step switching systems (UR-49a) in the Khartoum Central Exchange

3) Scale

The project involves the addition of 3,000 line unit and subsequently 1,000 more line unit to the capacity of existing step-by-step switching systems, which at present have a capacity of 12,000 line unit.

4) Implementation Status

The installation of the 3,000 line unit mentioned above has been completed. They are currently being tested for operation in the near future.

5) Relationship to the Current Project

Initially, the Sudanese government requested the Japanese Government to install electronic switching systems for 2,000 line unit in the Khartoum Central Exchange. However, since it managed to complete the installation of an additional 3,000 line unit with cooperation from the Dutch government, and there were plans for even 1,000 more additional line units after that, the Sudanese Government changed its request to Japan and asked instead for installation of electronic switching systems for the same number of line units in the Khartoum South Exchange.

(3) Emergency Flood Reconstruction Project

The Government of the Sudan requested the World Bank to undertake an assessment of the reconstruction requirements resulting from the floods and to coordinate donor reconstruction efforts in August 1988. The World Bank, in response to this request and with the financial support

from the UNDP and ODA undertook a mission to the Sudan to survey the reconstruction needs and to outline a reconstruction program which could be supported by donors. The financing plan for the project is given below:

	US$ Million
Government of the Sudan	7.5
IDA	75.0
Others	1.6
TOTAL	84.1

The estimated project costs are as follows:

(US$ million)

Sector	Local Costs	Foreign Costs	Total Costs
Agriculture	7.90	9.50	17.40
Education	3.80	4.90	8.70
Power	1.50	8.50	10.00
Telecommunications		10.00	10.00
Urban development	4.60	11.30	15.90
Flood warning studies		0.50	0.50
Program Coordination	0.20	1.70	1.90
Others	2.90	8.60	11.50
Contingencies	3.50	4.70	8.20
TOTAL	24.40	59.70	84.10

The program for telecommunications sector is to supply the following items: (US$ million)

Equipment and Spare Parts	: 4.4
Replacement of Manual Exchanges	: 1.0
Tools and Test Equipment	: 1.1
Motor Vehicles	: 2.0
Consultancy Services	: 1.5
	10.0

2-6 Background and Details of Request

2-6-1 Background of Request

The 40,000 or so subscribers of the metropolitan Khartoum telephone network account for about 70% of all telephone subscribers in the Sudan. Due to deterioration of the antiquated outside plant facilities and inadequate maintenance, however, service to about 30% of these subscribers has been interrupted. Moreover, penetration of water into cables during the rainy season reduces the insulation resistance of the cables, resulting in interruption of service to about 50% of subscribers. Altogether, telephone service in this country is in critical condition.

The Sudan Telecommunications Public Corporation (STPC) is currently implementing a project for improving the telephone network and installing additional switching systems in Khartoum on the basis of the master plan for telecommunications in the Sudan, which was laid out by DETECON, a consulting firm of West Germany. STPC obtained the cooperation of the Rehabilitation Fund Foundation (KfW), a West German organization for supporting developing countries, and also of the Government of the Netherlands for the project. The projects involve the western side of the Khartoum Central Exchange Area and the industrial and the Amarat areas which are covered by the Khartoum South Exchange.

The Government of the Sudan asked the Japanese government to provide Grant Aid for rehabilitation of outside plant facilities, digital switching systems and junction lines (optical fiber cables) for early realization of telephone network improvement in the areas outside of areas covered by the project undertaken with the cooperation of West Germany.

During negotiations between the Japanese basic design study team and the Sudan Telecommunications Public Corporation (STPC), the latter requested that a part of the initial plans for the project be changed. The details of the initial request made by the Government of the Sudan to Japan, and those of the revised request, are as follows:

(1) Initial request

1) Rehabilitation of subscriber line facilities (cables)
   - Central and eastern parts of the Khartoum Central Exchange Area
   - Khartoum-2 area the Khartoum South Exchange Area

2) Installation of digital switching systems
   - In the Khartoum Central Exchange
   - In the Burri Area

3) Installation of junction line facilities (optical fiber cables)
   - Between the Khartoum Central Exchange and the Khartoum South Exchange
   - Between the Khartoum Central Exchange and the Burri Exchange

4) Installing new external facilities (cables)
   In the Burri area

(2) Revised request

1) Rehabilitation of subscriber line facilities (cables)
   - The airport and Hai Al Mattar area are added to the central and eastern parts the Khartoum Central Exchange Area.
   - Khartoum-2 area the Khartoum South Exchange Area (no change)

2) Installation of new digital switching systems
   - In the Khartoum South Exchange
   - In the Burri Exchange (no change)

3) Installation of junction line facilities (optical fiber cables) (no change)
   - Between the Khartoum Central Exchange and the Khartoum South Exchange
   - Between the Khartoum Central Exchange and the Burri Exchange

4) Installation of subscriber line facilities (cables)

As the map showing the Burri area attached to the initial statement of request was inadequate, the boundary line defining the Burri area was partially modified.

(3) Background of the revision of the request

The partial revision of the request was made with regard to the areas in which outside plant facilities are to be improved and to the exchange in which the digital switching systems are to be installed. The background of the revision is described below.

1) Revision of objective area boundary

The map attached to the initial request was inadequate. Consequently, STPC made the following requests for revision of objective area boundaries:

- Khartoum Central Exchange

  A request was made to include the airport and the Hai Al Mattar in addition to the central and the eastern parts of this exchange area. Existing telephone subscribers in these areas belong to the Khartoum Central Exchange. Their line facilities, including important circuits to the airport, have deteriorated considerably, and penetration of water often causes trouble with the paper-insulated cables. For these reasons, it was decided that these areas will also be included in the current project.

- Burri area

  Existing telephone subscribers in the Burri area belong to the Khartoum Central Exchange. Since a Burri Exchange is going to be established, all existing telephone subscribers in the Burri area will be served by this new exchange, and a new service area will be instituted.

2) Change of the exchange for digital switching installation

STPC changed its request for the installation of digital switching systems in the Khartoum Central Exchange to a request which calls for the installation of the same in the Khartoum South Exchange for the following reasons:

- Khartoum Central Exchange

  In 1983, the total capacity of existing switching systems in the Khartoum Central Exchange was 12,000 terminals. Since then, an additional 3,000 terminals are being built with the cooperation from the Dutch government, and this project is nearing completion. Moreover, there is another project involving the construction of 1,000 more terminals. When all these terminals have been built, the total capacity of the switching systems at the Khartoum Central Exchange will amount to 16,000. On the other hand, the number of existing subscribers is 11,935 and the number of subscription applicants is 3,500. Of these subscribers and applicants, some 1,200 will be accommodated by the new Burri Exchange, reducing the total of subscribers and applicants to some 14,200. This means that the new switching capacity of 16,000 terminals will suffice for the time being. For this reason, it was decided that the initial plan for installing digital switching systems with the capacity of 2,000 terminals at the Khartoum Central Exchange should be halted.

- The Khartoum South Exchange

  After examination of the request, it was decided that the important lines served by this exchange will be accommodated by the new switching systems as an emergency measure to improve and maintain the service.

The existing crossbar switching systems have a terminal capacity of 10,000, which is sufficient. However, since the traffic capacity of the frame where the crossbar switches which constitute the channels and the signal connection routes are collectively located is insufficient, it is necessary to install additional frames and related common equipment.

The project shall install digital electronic switching systems, which will be less expensive than installing more of the existing crossbar switching systems.

Digital switching systems are capable of handling high-traffic subscribers efficiently. They can also improve the switching efficiency of existing switching systems if they are installed parallel to them. Furthermore, they are easier to maintain and service than the crossbar types. Today, digital switching systems are less costly to build than analog crossbar systems. Considering these and other advantages, as well as their future potential, it is clear that digital switching systems should be introduced to the Khartoum South Exchange.

2-6-2 Details of the Request

The details of the final request which the Government of the Sudan has made, as ascertained by the basic design study, are as follows:

(1) Implementing organization

The Sudan Telecommunication Public Corporation (STPC)

(2) General outline of the project

The present project will improve the following facilities in the Khartoum areas covered by the Khartoum Central Exchange and the Khartoum South Exchange, as well as the Burri area:

- Subscriber cable network
- Switching system (including building)
- Junction network

(3) Facilities requested

1) Improvement of subscriber facilities in the following areas

- Central and eastern areas covered by the Khartoum Central Exchange, including the airport and the Hai Al Mattar district
- Khartoum (2) area covered by the Khartoum South Exchange

2) Installation of new junction line facilities (optical fiber cables) between the Khartoum Central Exchange and the Khartoum South Exchange

3) Installation of new junction line facilities (optical fiber cables) between the Khartoum Central Exchange and the Burri Exchange

4) Installation of new switching facilities (digital local switching systems)

- The Burri Exchange
- The Khartoum South Exchange

5) Installation of new subscriber facilities in the Burri area

(The area in Burri where the installation of the external facilities is envisaged may change depending on the results of the basic design study.)

CHAPTER 3

GENERAL INFORMATION OF THE OBJECTIVE AREAS

CHAPTER 3 GENERAL INFORMATION OF THE OBJECTIVE AREAS

3-1 Outline of the Objective Areas

An outline of the objective areas is described below. Fig. 3-1 presents a map of objective areas of this project.

(1) Khartoum Central Exchange Area

The objective area in the Khartoum Central Exchange Area consists of the districts on the Eastern side of the Malik street, the Khartoum Airport and the Hi Al Matal.

(2) Khartoum South Exchange Area

The Khartoum-2 area, the objective area in the Khartoum South Exchange Area, is located south of the Khartoum Central Station, west of the Khartoum airport.

(3) The Burri Area

The Burri area is located east of the Khartoum airport. It is surrounded by the Blue Nile River on the northern and eastern side, and its southern boundary borders the Riyad District.

3-2 Social and Economic Conditions

(1) The Khartoum Central Exchange Area

Along the Blue Nile River in this area are located governmental agencies, such as the Ministry of Finance, Economic Planning, Ministry of Building and Construction, official residence of the President, etc. In the central district of this area, the Bank of the Sudan, Municipal Bank, and the Central Market and important private offices are concentrated, constituting the center of the trade and economic activities. In addition, the Khartoum airport is located in the southeastern portion of this area. This region can be said to represent the center of the Sudan.

Approximately 80% of this area consists of office buildings. The proportion of residential buildings in this area is small. According to the census in 1983, the population of the objective area is approximately 4,700, with an area of about 6.5 square kilometers.

(2) The Khartoum South Exchange Area

This is an area where many foreign embassies, including the embassies of Japan, Ethiopia and others, are located. There are also many public institutions, such as youth associations, the Fire Department, charitable organizations, etc.

According to the census, the population of the objective area is approximately 10,000, with an area of 1.6 square kilometers.

(3) The Burri Exchange Area

This is an area where future economic development is expected. At present it belongs to the Khartoum Central Exchange Area. According to a population census, some 41,000 people live in the area, which is 8.0 square kilometers.

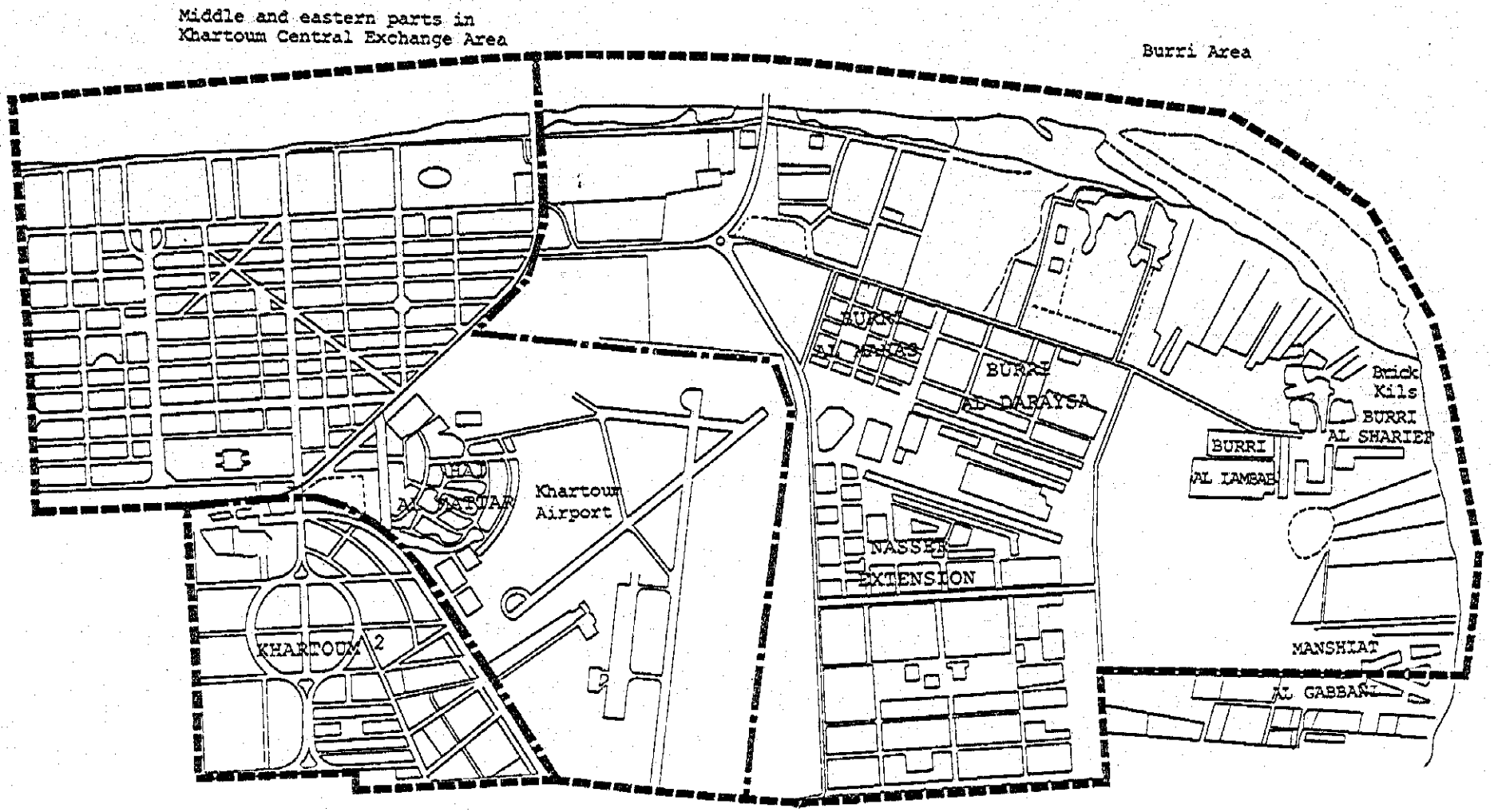


Fig. 3-1 The Rehabilitation Project Area for the Telephone Network in Khartoum

CHAPTER 4 CONTENTS OF PROJECT

CHAPTER 4 CONTENTS OF PROJECT

4-1 Objectives

The Project is to rehabilitate and improve the telephone network in extremely poor condition in Khartoum city. It will also contribute to the activation of Sudanese socio-economic activities and promotion of the National Development Plan by securing a reliable telecommunication services. For these reasons the Government of Japan has extended Grant Aid to the Sudan. The Project will provide the installation of telephone network facilities in Khartoum.

4-2 Study of the Request

4-2-1 Study of the Plan

The Project is to rehabilitate and improve the telephone network, consisting of subscriber cable facilities, switching system and Junction cable network, in Khartoum.

(1) Subscriber Cable Facilities

Subscriber cable facilities, which consist of cable, as well as civil facilities such as manholes, ducts and their accessories, will be rehabilitated and improved.

The following table shows the number of subscribers and the number of cable pairs which will be rehabilitated and improved by this Project.

(2) Switching Facilities

1) The switching system at the Khartoum Central Exchange, installed by the Dutch company Philips, can be utilized in this Project. Since the existing subscriber accommodation ratio is 73.3%, and 94.8% if waiting applicants are connected, the switching capacity of the Khartoum Central Exchange presents no problem. In addition to the above, the expansion of 1,000 switching line units has been planned. See also paragraph 2-5-1, (3), 2), and a).

2) The Khartoum South Exchange, as described in Section 2-5-1, (3), 2), b), will have a new switching system with a capacity of 2,000 line units.

The existing switching system in the Khartoum South Exchange is a C400-type crossbar installed in 1980, and it has a capacity of 10,000 line units.

If about 1,700 lines of the 7,715 lines for subscribers currently being served by this Exchange are transferred to the new switching system, then approximately 4,000 line unit will be left.

The Government of the Sudan requested a digital-type exchange. As a result of these studies, as indicated below in Section 4-2-2, manufacturing considerations also contributed to the decision to adopt a digital exchange as requested.

3) The Burri Area belongs at present to the Khartoum Central Exchange, the center of the Burri area is separated from the Khartoum Central Exchange by a distance of approximately 7 kilometers. Therefore, new subscriber cable installations in this area would not be economical. Estimates suggest that in the future the telephone demand in this area could reach approximately 9,277 by the year 2004 (Note 1). The relationship between the scale of subscriber cables and the size of exchange area exhibits a general trend that the higher the density of subscribers the smaller the area encompassing them. According to CCITT (The International Telegraph and Telephone Consultative Committee) (including documentation from NTT), it will be found that the Khartoum Central Exchange area is too big.

It is appropriate to divide the Khartoum Central Exchange Area and establish independent exchange area (i.e., installation of new switching system).

The switching capacity of the new exchange is to be 2,000 to cover the actual demand at the end of 1988 of 1,208 subscribers (934 existing subscribers plus 274 waiting applicants).

Note 1: From interrelation among population (population growth rate: 4.8% per year), gross domestic product (GDP growth rate: 4.76% per year) and telephone density (CCITT manual, Local Network Planning, Chapter 5, ANNEX A-Method of forecasting the number of subscribers), in 15 years hence in 2004, telephone density will be 11.76 and telephone demand 9,277.

Note 2: CCITT Manual, Local Network Planning, Chapter 6-Design of Local Network in Long Term Planning, and CCITT Manual, National Telephone Network for the automatic service, Chapter 5-Japanese standard for calculating the optimum size of a local exchange area.

(3) Junction Cable Facilities

The existing radio transmission paths between the Khartoum Central Exchange and the Khartoum South Exchange, as described in Section 2-3-4 (5), are subject to interference due to high-rise buildings. In order to secure continuously stable radio propagation paths, it is necessary to renovate the existing radio tower, but there does not exist sufficient space above the Central Exchange to increase the height of the steel tower.

Thus, instead of a radio transmission system, a cable transmission system should be adopted in order to secure continuously stable junction circuits. Applicable cable transmission systems are the optical fiber cable system and the PCM metallic cable system. An economic comparison of both systems (140 Mb/s and with cable length at 7 kilometers) shows that the total cost involved for initial investment, and the maintenance costs for operating of the optical fiber cable system are cheaper than that of PCM system, and consequently the optical fiber cable system will be adopted. The junction cable routes from the Burri Exchange to the other exchange will, for economic reasons based on interstation traffic and topographical conditions, be provided through the Khartoum Central Exchange. That is, all the junction circuits to the other exchanges will be installed between the Burri Exchange and the Khartoum Central

Exchange and branched toward the directions of the other exchanges at the Khartoum Central Exchange. Digital radio and the optical fiber cable systems were considered for the transmission system for the junction circuits between the Burri and Khartoum Central Exchange. (Following the economic comparison, the cable PCM system was eliminated on economic grounds.) Applying the same analytical methods to the economic comparison of the optical fiber cable and the cable PCM system reveals that there is practically no difference in cost between the digital radio and the optical fiber cable systems, but to avoid interference from the high-rise buildings that may be constructed in the future, it was decided to adopt the optical fiber cable system.

4-2-2 Study of Requested Facilities

(1) Subscriber Cable Facilities

The existing cables are not only extremely obsolete, but also suffering from the following problems:

1) Because the non-armoured cables are laid according to the direct burial system (30 to 50 cm directly underground), many problems arise, caused by the work on water pipes, road construction, etc.

2) The gas pressurization system was applied for the cable maintenance. However, at present the equipment is not working. That explains why the insulation of the existing cable, which is protected by paper insulation, has been damaged by water, or why water vapour penetrates into the cable.

The Project proposes to apply a jelly-filled polyethylene insulated cable, which is easy to maintain and highly reliable, and to apply the steel armoured cables for the direct burial system.

(2) Switching Facilities

As a result of technological innovations in recent years, in the field of manufacture of the switching equipment, just as with other communications equipment, digital technology has come to predominate

around the world. The existing switching system in the Sudan are the step-by-step and the crossbar systems. As for the step-by-step technology, spare parts supply is now almost completely unavailable; and the crossbar technology is also in dire straits. Even in Japan, the crossbar switching equipment is only manufactured by a few companies, and only to specific orders, and the manufacturing of this technology looks like ceasing altogether within a few years. (Apart from some special circuit parts, NTT has already stopped purchasing the crossbar switching equipment.) NTT has also stopped purchasing the analog electronic switching equipment, and so this technology, too, cannot be chosen. These considerations lead to the conclusion that maintenance and operation in the future require adoption of the digital switching system.

(3) Junction Cable Facilities

As explained in paragraph 4-2-1, item (3), a digital transmission system using the optical fiber cable, which is more economical and has a higher transmission quality, will be introduced for rehabilitation and improvement of the junction network.

Furthermore, in order to prevent damage to the optical fiber cable by water pipes, road construction, etc., the optical fiber cable is contained in the conduit.

4-2-3 Organization for Project Implementation

The main administrative entity responsible for telecommunications in the Sudan is the Ministry of Communications (MOC), whose executive branch for telecommunication services is the Sudan Telecommunications Public Corporation (STPC).

Since the implementation of this Project will be under the guidance of the Ministry of Communications, it will be carried out by STPC. In order to ensure smooth implementation of the Project, STPC will elect a project manager, who will maintain close reciprocal business contacts with the consultants and prepare administrative and other measures necessary to implement the Project.

CHAPTER 5 BASIC DESIGN

CHAPTER 5 BASIC DESIGN

5-1 Guideline of Basic Design

5-1-1 Subscriber Cable Network

This Project aims at the rehabilitation of subscriber cable network in the important part of the Khartoum Central and South Exchange Areas. In other parts of the same exchange area, the West Germany project is being implemented also for the rehabilitation of outside plant.

In order to maintain ease in the operation and maintenance of the facilities and to avoid unnecessary confusion by STPC staff after completion of this project, the installation and materials specifications should be standardized through close coordination with the West Germany project team.

The rehabilitation under this Project covers from the main distribution frame (MDF) in the telephone exchange office to the protector on the wall of the subscriber's building. The rehabilitation of the subscriber's premise facilities, which consist of a telephone set, internal wiring, etc., is to be the responsibility of STPC. (Configurations of subscriber cable facilities and subscriber premise facilities are shown in Fig. 5-1 and Fig. 5-2, respectively)

The abandonment of the existing facilities which will become disused after the transfer of the existing subscribers to new facilities installed under this project is also to be executed by STPC, and is not included in the scope of this Project.

The guideline of the basic design of subscriber cable network will be as follows:

1) A cable distribution system that uses cross-connecting cabinets will be adopted for this Project. This arrangement is advantageous for economical and effective use of the cables installed, as well as for ease in their operation and maintenance, and future expansion.

2) Jelly-filled polyethylene insulated and sheathed cables will be adopted for both the primary and secondary cables so as to prevent water penetration into the cables and to reduce cable trouble due to low insulation resistance. Hence the gas pressurization system will not be necessary for the new cables.

3) Primary cables will be installed in the underground conduit in order to protect the cables from any damage due to such works as road, water or power supply construction.

4) Secondary cables will be steel armoured and double PE sheathed, and will be installed directly under the ground.

5) For cable conductor splicing, the mechanical splicing method which is adopted by the West German team and requires no special skill will be applied instead of conventional manual twisting.

6) For cable sheath splicing, the non-heating Universal Closure method that is adopted by the West German team will be applied.

7) Since most of the existing cables have deteriorated electrically and physically, they cannot be reused. However, the existing cabinets, terminal boxes and poles may be used again, if available.

8) In order to construct the underground conduit system in an economical manner, PVC pipes with a small coefficient of the friction enabling long intervals between the manholes will be used. Since the existing asbestos pipes are damaged at many places, reutilization of these pipes would not be economical. For road and railway crossing, the steel pipes will be used.

9) It will be necessary to repair broken manholes and handholes in order to use them again. Since repairs which would not cause any damage to the working cables would be difficult and uneconomical, manholes and handholes will be installed anew.

10) In principle, underground conduit or direct-buried cable routes will be selected under side walks so as to cause the least disturbance to traffic and minimize damage to the pavement.

11) Sand, gravel, cement and reinforcing steel bars needed for the construction of manhole or handhole will be procured locally.

12) Drop wire will be used from the pole and wall type distribution box to the subscriber's premise. Subscriber's protector with an earthing will be installed at the connection point of the drop wire and the internal wire at the subscriber's premise in order to bypass the strong current directly to the earth and protect the telephone sets.

5-1-2 Switching System

1) Based on studies of the requests described above, a new switching system with capacities of 2,000 line unit will be installed at the Khartoum South and Burri Exchange.

2) The traffic figures for the traffic originated per subscriber line used for this Project are as follows:

Residential subscriber :	0.05 Erl.
Commercial subscriber :	0.06 Erl.
Governmental subscriber:	0.07 Erl.

Based on the composition of the existing subscribers (See Table 2-1), the average originated traffic per subscriber line of each exchange at busiest hour has been assumed. (See Table 5-1)

3) The junction routes and the number of circuits between the exchanges in a multi-exchange area will be arranged according to CCITT Manual (the theory of R.I. Wilkinson and Y. Rapp). Since there is no capacity for junction switching equipment at the Khartoum North and Ondoruman Exchange, the direct junction route to these two exchanges will not be installed, and the connections will be established via the Khartoum tandem exchange.

4) To keep any changes to the equipment in the existing switching system to a minimum, apart from establishing the following local telephone office numbers for the new switching system established by this Project, no change will be made to current number planning.

Khartoum South Exchange office number: 45
Burri Exchange office number : 27

Sufficient capacity will be provided to ensure that it is easy to move to accommodate future plans for extending the number of digits in local exchange office numbers to six (currently they are either five or six), and the special service numbers to three digits (currently they are two digits) in Khartoum multi-exchange area.

5) Existing signalling system (CCITT Standard R2 signalling system, also called MFC system) will be adopted for the new signalling system for the junction circuits installed to avoid modification of the existing equipment. In the future, basic functions that are capable of facilitating the introduction of common channel signalling system will be provided.

6) Charges on the cables originating from the new switching system will be applied at each individual exchange for local calls, and at the existing national and international exchange for long distance and international calls.

5-1-3 Junction Network

(1) Optical Fiber Cable

A single mode type of optical fiber cable will be applied to the junction cable network. Optical fiber cable shall be laid in all sectors in a conduit line, which is effective in preventing disruption of the cable by water pipes, road construction, and other mechanical causes such as building construction and engineering work. The conduit line shall be buried carrying warning tape, which shall draw attention to damage hazards.

A special protective material shall also be used to protect the cable and cable connection point in manholes.

(2) Transmission Capacity

System transmission capacity will be provided by a digital multiplex system capable of expansion to a maximum capacity of 140 Mb/s in order to ensure that expansion of the junction circuits in the future does not become uneconomical.

5-1-4 Auxiliary Facilities

(1) Power Supply Facility (Khartoum South and Burri Exchange)

Commercial power is supplied by the Sudan National Electricity Corporation (NEC). Voltage fluctuation ratio is as high as ±20%, the power supply being unstable, with frequent blackouts. Even though a commercially available power source will be used to supply electricity to Burri Exchange, it is still necessary to create a backup system to be used as an emergency power source during power outages of the commercial source of power. Existing power supply facilities at the Khartoum South Exchange have no capacity whatsoever for supplying the new switching system, and consequently new power supply equipment of the same type as at the Burri Exchange will be installed (note that only the method of receiving the power from the commercial power line differs). The power supply equipment will be configured from the following main systems. (Fig. 5-3 shows the configuration of such a system)

1) Automatic voltage regulation device

Because the supply of commercial power is unstable, and there are frequent voltage fluctuations, an automatic voltage regulation device will be provided in order to control voltage fluctuations.

2) Rectifier

The output capacity of the rectifier will be adjusted so as to be sufficient for the electric power required in the initial stages for the switching equipment and transmission equipment. In order to secure supply of continuous current, enabling stable operation of the communication equipment, the redundant configuration of the equipment number will be n + 1.

3) Batteries

The scale of the battery equipment will correspond to the scale of the switching and transmission equipment in the initial stages of the Project. Since it will be necessary to provide maintenance, inspection, and similar operations when the commercial power is down, the capacity of the equipment must be sufficient to supply electric power for 8 hours under peak operational load.

4) Emergency Generator

When the commercial power fails or deviates from the specified limits, the emergency generator will start automatically. When the commercial power has recovered from failure or has been restored to normal conditions, the emergency generator will stop automatically. An emergency generator will be also provided with the necessary fuel tank.

5) Power Receiving and Distribution Equipment

The power receiving and distribution equipment must have a capacity that is sufficient to accommodate the items listed below:

- Input of the rectifier
- Electric power required for the air conditioning system
- Electric power required for illumination and electric outlets

Reception of power at the Khartoum South Station (II) is three-phase, four-wire 415/240V (50 Hz), and a receiving transformer will not be installed. For the Burri Exchange it has been decided that SPTC will cooperate with the Electricity Supply Public Corporation

to provide three-phase, three-wire, 11-kV high tension power receiving facilities, and new high tension power receiving facilities will be installed by this Project, while a complete set of power receiving facilities will be installed by SPTC (including transformers, main switch gear, watt-hour meter and other equipment such as low tension switch gear and power cables).

(2) Power Supply Equipment (Existing Exchanges)

Power supply for the extensions to the interface equipment at the existing exchanges will be provided by the power supply facilities currently in use at each individual exchange, with the exception of the Khartoum Central Exchange. At the Khartoum Central Exchange, the capacity of the existing DC power supply facilities is insufficient, although that of the other facilities is sufficient, and consequently new rectifiers and batteries will be provided for the optical fiber cable transmission equipment.

(3) Air Conditioning Facilities

The room containing the exchange and transmission equipment must be provided with air conditioning facilities. Each device must be used evenly, in order to maximize the service life of the equipment.

Design conditions for the air conditioning system are as follows:

- Temperature ..... 0 - 45°C
- Humidity ..... maximum 90%

(4) Exchange Building Facility

As a result of a site survey, it was decided to modify the room of the existing exchange and to install new telecommunications equipment in the modified room. Note that the new emergency generator to be installed at the Khartoum South Exchange will be installed in the existing building.

An exchange building consisting of rooms for the telecommunications equipment and for the maintenance and operation staffs and a separate facility for the emergency generator will be built at the Burri Exchange. (The emergency generator will be housed separately to eliminate the effect of the noise of the generator from the exchange building.)

To shorten the period of construction for this Project, the exchange building at the Burri Exchange will be constructed with prefabricated materials, and both of the independent generator buildings will be constructed with cinder blocks.

There are no earthquakes in the Sudan, which is relatively free from geological instability. The standards planned for the building must take into account local construction conditions, the possibilities for procurement of construction materials from local sources, and the local climate and natural features of the area, as well as way of life and similar conditions.

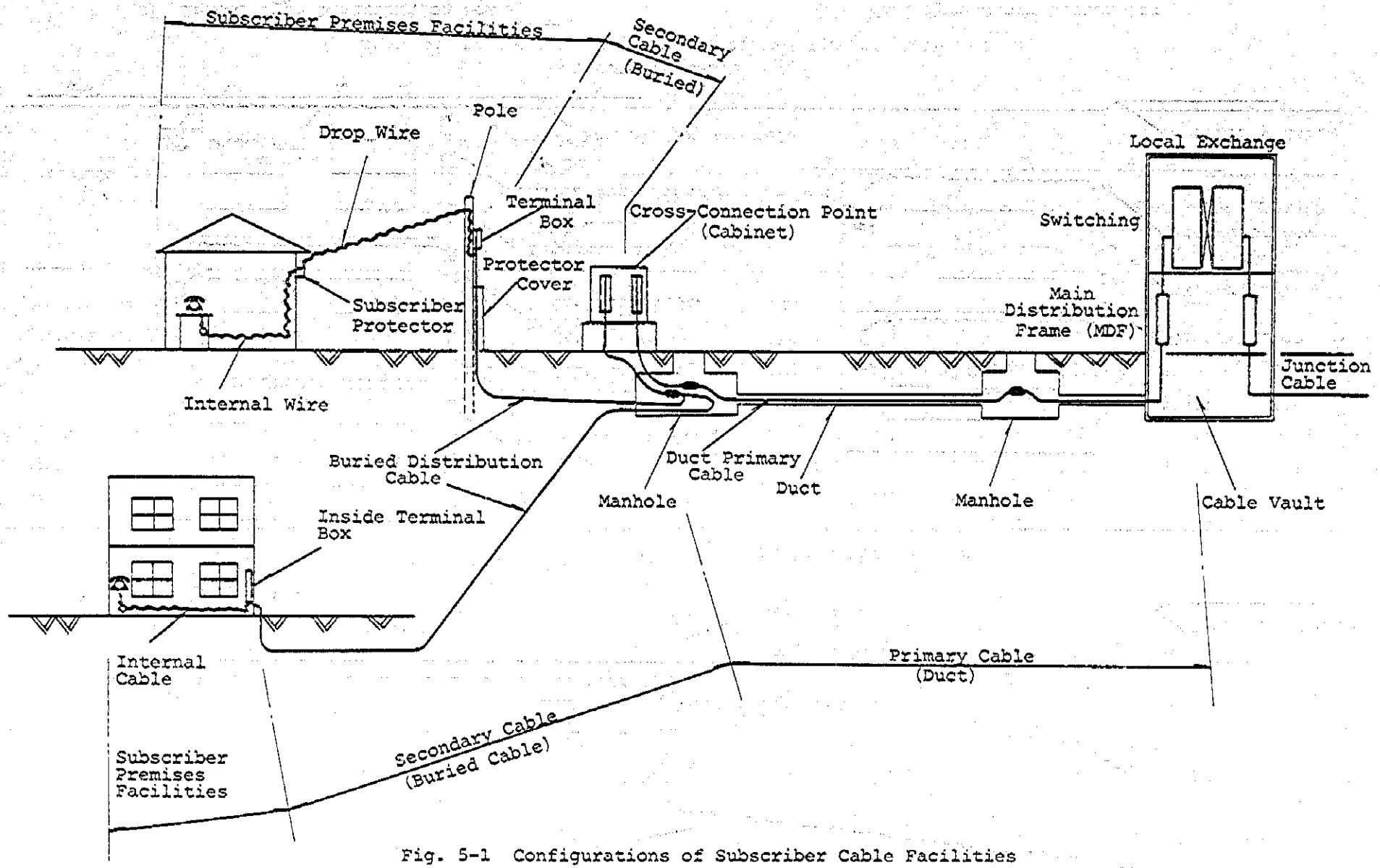


Fig. 5-1 Configurations of Subscriber Cable Facilities

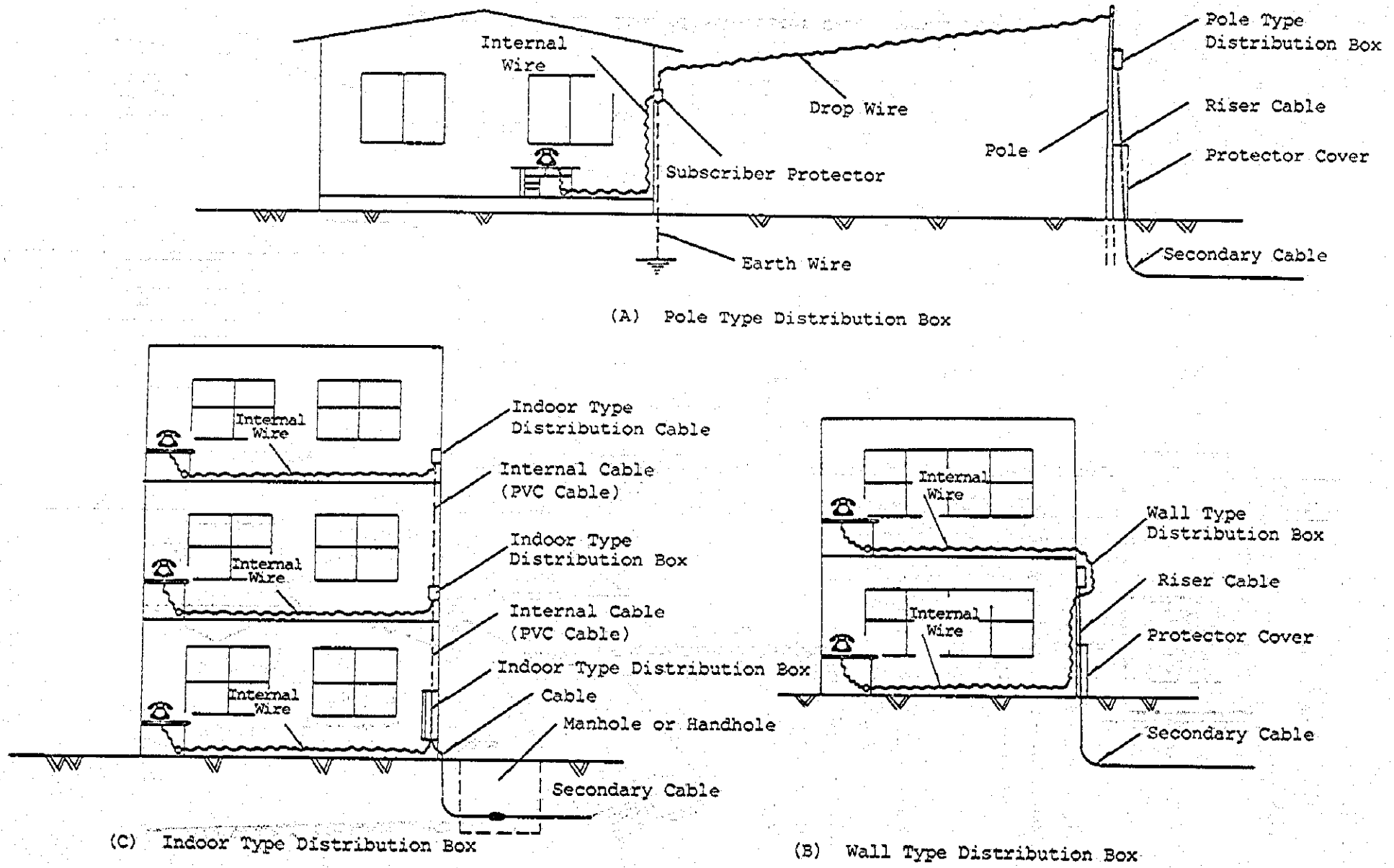


Fig. 5-2 Configurations of Subscriber Premise Facilities

Table 5-1 Originated Traffic per Subscriber Line (at busy hour)

Exchange Name	Switching Line Unit	Government Users				Private Users				Total	
		Office ①	Erl/Sub ②	Resident ③	Erl/Sub ④	Business ⑤	Erl/Sub ⑥	Resident ⑦	Erl/Sub ⑧	Subscriber ⑨	Erl/Sub ⑩
Khartoum Central	15,000	3,950	0.070	265	0.050	6,593	0.060	1,127	0.050	11,935	0.062
Khartoum South	10,000	388	0.070	180	0.050	3,164	0.060	3,983	0.050	7,715	0.055
Khartoum Extension	5,000	160	0.070	57	0.050	332	0.060	4,048	0.050	4,597	0.051
Khartoum North	4,000	362	0.070	89	0.050	983	0.060	1,530	0.050	2,964	0.056
Omdurman	7,000	427	0.070	116	0.050	2,901	0.060	3,402	0.050	6,846	0.055
Mahadia	4,000	37	0.070	30	0.050	79	0.060	2,760	0.050	2,906	0.051
Shambat	3,000	91	0.070	50	0.050	422	0.060	1,418	0.050	1,981	0.053

Note: Erl: Erlang Sub: Subscriber

⑨＝①＋③＋⑤＋⑦

⑩＝（①×②＋③×④＋⑤×⑥＋⑦×⑧）／⑨

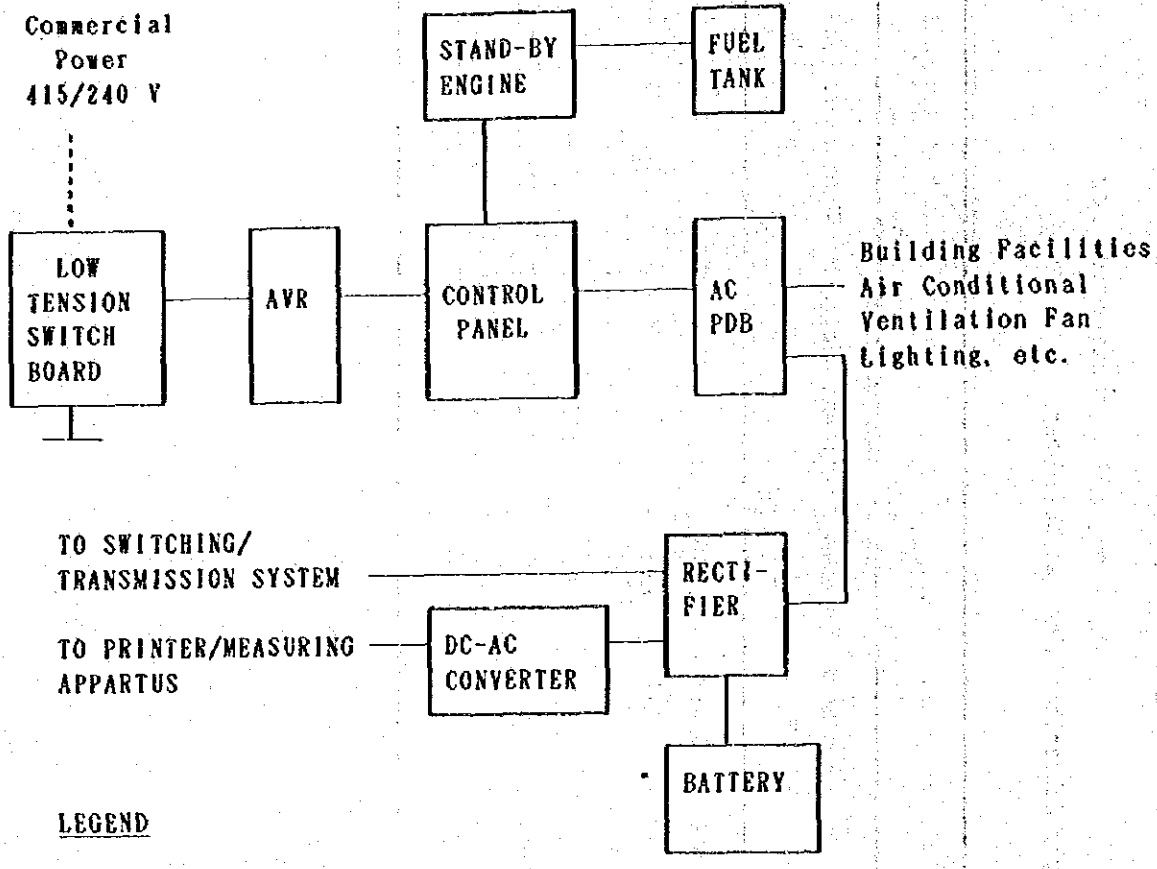


Fig. 5-3 Configuration of Power Supply Equipment

5-2 Basic Design Standards

5-2-1 Subscriber Cable Network

(1) Cable Facilities

1) Duct Selection

The selection of the duct to lead the primary cable and/or junction cable into an exchange building must be made in a manner not to disturb future primary and/or junction cable installation for extension, and without forced cable bending and crossing on the way from the duct entrance to the cable rising point.

2) Cable Termination

The primary cables are spliced with the terminating cables in the exchange building. The terminating cables are terminated on the main distribution frame (MDF). The splicing point of the primary cable and terminating cable must be filled with compound in order to make their humidity-proof.

3) MDF

The primary cable pairs and office cable pairs (from switching equipment) are both terminated on the main distribution frame (MDF) in the telephone exchange. It is arranged so that any cable pair can be cross-connected to any office cable pair by use of jumper wires.

4) Primary and Secondary Cables

The primary and secondary cables to be used in this Project will comply with international standards, and will follow the specifications applied by the West German team, in order to avoid any difficulties regarding STPC's operation and maintenance of the completed facilities.

5) Type of Primary and Secondary Cable

a) Primary Cable

The primary cable to be used is polyethylene insulated and sheathed, unit-twin and jelly filled.

b) Secondary Cable

The secondary cable to be used is polyethylene insulated and double sheathed, unit-twin and jelly filled, and steel tape armoured.

6) Determination of Conductor Gauge

Cable conductor gauge is determined by two limitation factors. One is the subscriber line loss for the subscriber system. The other is d.c. resistance limitation by the switching equipment. Both are determined from the viewpoint of the transmission losses.

Subscriber line loss	8.0 dB (telephone set is included)	
D.C. resistance ..... limitation	1,500 ohms (new switch)	
	1,200 ohms (old switch)	

The most economical design is made in consideration of the primary and secondary cable conductor gauge combination. However, in primary or secondary cable section, the combination of different conductor gauge is not carried out.

7) Primary Cable Network

Primary cable network design highlights the following points:

a) Cable units to be distributed to cross-connecting cabinet

The number of primary cable units (100 pair unit) to be distributed and terminated to each cross-connecting cabinet is enough to accommodate the existing subscribers.

b) Grouping of Cable Units

Cable units distributed to each cross-connecting cabinet along the primary cable route are to be grouped together by conductor gauge on the way from the side of remote cable route to the telephone exchange.

c) Cable Pairs

Cable pairs are to be commensurate with cable units grouped together by sections.

8) Secondary Cable Network

Secondary cable network design highlights the following points:

a) Grouping of Cable Pairs

Cable pairs distributed from the side of the remote cable route to the distribution box along cable route in the unit distributing section are to be grouped down to the cross-connecting cabinet.

b) Cable Pairs Decision

Cable pairs are to be commensurate with the cable pairs grouped by sections.

c) Depth of Direct Buried Cable

For the secondary cable to be direct-buried underground, the depth from the ground surface to upper part of the cable is to be as described below.

- Side walk ..... 80 cm or more
- Carriageway .... 90 cm or more
- Across railway tracks ..... 100 cm or more

9) Cable Pairs

Primary Cable:

Conductor Gauge	Primary Cable Pairs
0.4 mm	2,400, 2,000, 1,600, 1,200, 800, 600, 400, 300
0.6 mm	1,000, 800, 600, 400

Secondary Cable:

Conductor Gauge	Secondary Cable Pairs
0.4 mm	200, 150, 100, 50, 30, 20, 10
0.6 mm	200, 150, 100, 50, 30, 20, 10

10) Electrical Characteristics

Conductor Gauge	Loop Resistance (ohm/km)	Attenuation Coefficient, 800 Hz (dB/km)
0.4 mm	270 + 30	1.49
0.6 mm	120 + 10	0.91

11) Cross-Connecting Cabinet

a) Each cross-connecting cabinet area constitutes a unit area for management of the existing subscribers and waiting applicants, as well as demand control and system maintenance, aiming at an effective use of the outside plants and pertinent plant expansion.
As such, each cross-connecting cabinet area will remain fixed for a long time.

b) Location of Cross-Connecting Cabinet

One cross-connecting cabinet will be established in each cross-connecting cabinet distribution area. The cabinet location will be selected on the telephone exchange side in the area. The location was selected in view of keeping the primary and secondary cable installation costs to a minimum and to avoid the need for any future modifications.

c) Cabinet Types

Cross-connecting cabinet capacity will be 1,200 pairs and terminal block capacity will be 100 cable pairs with the stub cable of a standard cable length.

12) Distribution Box

The distribution box capacity will be such that it can accommodate the required number of cable pairs for active subscribers. For the pole type, the capacity will be 10 cable pairs, and for the wall type, 10 and 20 cable pairs. For the indoor type, the capacity will be 30, 50, 100 and 200 cable pairs. Distribution box without a stub cable will be used and the distribution cable will be connected to the distribution box at the installation site.

a) Pole Type Distribution Box

The pole on which to mount the distribution box should preferably be located on the sidewalk where a drop wire installation into subscriber's premise is easy, without interfering with traffic. It is important that the distribution box location, once selected, does not need to be changed for a long time and, at that location, the cable maintenance is easy.

b) Wall Type Distribution Box

The wall type distribution box is mounted on the external wall of a building. It is important that at the location selected, the distribution of the drop wire into the subscriber's premise and the neighboring premises is easy, that the building concerned is strong and the distribution box mounted is least likely to be damaged by third parties, and that the location selected will not be changed for a long time.

c) Indoor Type Distribution Box

For the indoor type distribution box to be mounted inside a building, it is important that at the location selected, wiring to the telephone set is easy, and that the location is convenient for maintenance work, permitting easy access by the maintenance personnel.

d) Protection of Pole Type Distribution Box Stub Cable

The vertical run of a stub cable to the pole type distribution box is to be protected with a 50 mm steel pipe.

e) Protection of Wall Type/Indoor Type Distribution Box Stub Cable

"U-guard" is used for protection of vertical run of the stub cable or distribution cable to the wall type or indoor type distribution boxes.

(2) Civil Engineering Facilities

The construction of civil engineering facilities requires considerable financial investment. Therefore, in underground conduit design, the optimum conduit route selection and calculation of the number of ducts required, as well as the determination of the type and size of manhole to be adopted, are important factors. In other words, the construction must be at the minimum cost, while the conduit constructed must ensure safety of the installed cables and allow easy cable laying and maintenance.

1) Types of Manholes and Handhole

Manholes will be built at the cable splicing points, cable branching points, and other points where manholes are necessary for the cable installation and maintenance. Each manhole must be large enough to contain the following:

a) Necessary number of ducts
b) Working space
c) Cable splicing closure

d) Satisfactory radius of cable curvature

Type	Length (m)	Width (m)	Depth (m)	Number of Conduits
Handhole H1	1.2	0.6	0.9	1 - 2
Manhole S1	1.5	1.0	1.2	1 - 4
Manhole S2	2.3	1.3	1.5	5 - 9
Manhole S3	3.0	1.4	1.7	10 - 16
Manhole T3	3.4	1.4	1.8	10 - 16

2) Route selection

For conduit route selection, consideration must be given to technical problems in construction and maintenance, based on the field survey results, as well as the town planning and related data.

3) Number of Ducts

The number of new ducts to be installed will consist of those required for new cable lines, plus one emergency-use spare duct (to be used for cable change in case of system failure).

4) Type of Duct

In the underground conduit to be newly constructed, ducts will be composed of PVC pipes. In cases where the use of PVC pipes is inappropriate, as in the case of crossing a river and/or railway, steel pipes will be used. Both PVC pipes and steel pipes will be 100 mm in inner diameter.

5) Manhole Spacing

Manhole spacing will be determined in consideration of cable branching, cross-connecting cabinet locations, and topographic conditions. For manhole spacing, the following are the maximum limits.

- Straight section : 200 m

- Curved section : 150 m

6) Conduit Location

In cases where a carriageway and side walk are clearly distinguishable, conduit route will be constructed under a sidewalk. If there is no distinction between a carriageway and sidewalk, the road shoulder will be the location for conduit route construction.

7) Manholes to be Abandoned

The abandonment of the existing manholes which will not be used in this project will be done by STPC.

8) Underground Conduit Depth

The depth from ground surface to the upper part of underground conduit must be the following:

- Side walk ..... 80 cm or more
- Carriageway and road crossing ..... 90 cm or more
- Railway track crossing ..... 100 cm or more

9) Warning Tape Burying

To prevent damage on the underground conduit or direct-buried cable due to a ground excavation in the future for power line or water supply installation, a warning tape will be buried midway between the ground surface and underground conduit. Furthermore, the conduits to accommodate the junction cables should be protected with a concrete slab in order to maintain the safety of the junction cables.

(3) Subscriber's Premise Facilities

The wiring from the subscriber's protector to the telephone set, including the installation of other subscriber's premise facilities, will be conducted by STPC.

1) Dropwire

Dropwire will be used between the pole type or wall type distribution box and the subscriber's premise.

2) Subscriber's Protector

The subscriber's protector will be mounted on the external wall of the building so as to protect the internal facilities electrically. The subscriber's protector will be earthed.

5-2-2 Switching System

The basic design of the switching system should comply with the CCITT recommendation G.3 and Economic and Technical Aspects of the Choice of the Telephone Switching System, and the technical standards applied to the existing facilities of the public telecommunications network.

(1) Service Quality

A call loss probability of 0.01 will be applied for all connections.

(2) Numbering Plan

The numbering plan in this Project should be the same as the existing system.

1) Special number services

90: Enquiry
91: Complaints
92: Line test desk
93: National trunk booking
94: Faultman line
95: International trunk booking

96: Emergency

The special number services will be modified to 9XX (three digits) in the future.

2) The present numbering plan in the Sudan is as follows:

Trunk Numbering Plan

Trunk Prefix	Area
011	Khartoum
0161	Shendi
021	Atbara
031	Port Sudan
041	Kassala
0441	Gedaref
051	Wad Medani
061	Sennar
071	Kosti
081	El Obeid

Local Numbering Plan (Khartoum Multi Exchange Area)

Exchange	Subscriber Number	Number of Digits
Khartoum Extension	22XXXX	6
Mahadia	23XXXX	6
Omdurman Central	(2)5XXXX	5 (6)
Burri	27XXXX	6
Awdha	(28XXXX)	(6)
Omdurman West	(29XXXX)	(6)
Khartoum North	(3)3XXXX	5 (6)
Riad	(42XXXX)	(6)
Khartum South		
Existing	(4)4XXXX	5 (6)
New	45XXXX	6
Shambat	61XXXX	6
Khartoum Central	(7)7XXXX	5 (6)
	(7)8XXXX	5 (6)
Shegara	(88XXXX)	(6)
Kalakla	(89XXXX)	(6)

3) Charging System

The charging system to be adopted in this Project should meet the present tariff system employed by STPC. The STPC's tariff system is as follows:

a) Local call charge

The local call charge is not related to the duration of a call but counted 1 on the subscriber meter for each call. Special calls are also charged in the same way, and the charge per call is 0.25 Sudanese Pounds.

b) Toll and international call charges

The toll calls are charged through the toll call charging equipment, and the international calls, through the international call charging equipment. The details of the traffic charging records are compiled in the toll/international switching system (CTN/CTX) in the Khartoum Central exchange. The following provides the toll call charging system as of Dec. 1988.

Toll Call Charges

Distance	Charges (Sudanese Pounds) per 3 Min.
6 - 75 Km	2.00
76 - 150 Km	3.00
151 - 250 Km	4.00
251 - 375 Km	5.00
more than 376 Km	6.00

(4) Junction Circuits

The circuits between the exchanges in Khartoum multi-exchange area can be arranged according to the following direct and tandem routings:

1) Direct routing

The entire traffic is carried directly from one exchange to another.

2) Tandem routing

The entire traffic between two exchanges is passed via a tandem stage in the Khartoum Central exchange.

(5) Maintenance and Operation Facility

- Operation and maintenance desk for supervisory, control and test of the switching equipment will be provided.

- CRT, keyboard and printer for operation and maintenance will be provided.

- Testing position for the subscriber lines will be provided.

5-2-3 Transmission System

(1) Transmission loss

Transmission loss is to accord with the STPC standard, with the value of the transmission loss distribution being 12.0 dB from a local exchange to another local exchange (2 wire switching).

(2) Bit error rate

The bit error rate in junction sections using the optical fiber cable is to be 1×10^{-6} or less which is according to the CCITT recommendation (G.821).

(3) Digital hierarchy

The digital hierarchy adopted for the optical fiber cable transmission system implemented in this Project is to be as the following CCITT recommendations.

Digital 1st order	(2,048 Kbit/s):	CCITT recommendation G.732
Digital 2nd order	(8,448 Kbit/s):	CCITT recommendation G.742
Digital 3rd order	(34,368 Kbit/s):	CCITT recommendation G.751
Digital 4th order	(139,264 Kbit/s):	CCITT recommendation G.751

Note: Hierarchy: Refers to the multiplexing step applied when multiplexing various types of information.

(4) Electrical connection conditions

The respective electrical connection conditions in the digital hierarchy are to accord with the CCITT recommendation G.703.

5-2-4 Exchange Building

The basic plan for the new Burri exchange building to be constructed under this Project at the site owned by the Government is outlined below.

(1) Site Layout

The proposed site is of almost rectangular in shape, with an area of about 3,326.26 square meters, which is twice as large as the area to be required in the future.

Telephone and power (11 KV) cables are to be led into the exchange building from the road on the east side. The front entrance of the building should also face this road.

In view of the above requirements and in consideration of probable future expansion of the building and efficient utilization of the land, the building should be constructed in the northern part of the site. On the north side of the building, an emergency engine generator room and a fuel tank will be provided.

(2) Room layout

In preparing layout of each room and space of the building where important telecommunications facilities are accommodated, due attention

should be paid to the weight of the equipment/facilities to be installed, the easy access to/from outside, the protection of "off-limit" areas from an entry of third persons, etc., as well as the efficient wiring and connection of the equipment/facilities, liaison to the maintenance personnel, and functional room arrangement.

(3) Cross Section Design

Depending on the equipment to be accommodated, the beam hight and the floor weight will differ. In this project, the beam size was determined according to the equipment weight to be accommodated. The floor height was determined by the equipment height over the flood level. The heights of the beam bottom and floor weights in each room is shown in the following table.

Equipment Room	Floor Weight (Kg/m)	Height of Ceiling (mm)
Switching Room	350	2,800
Transmission Room	1,250	3,400
Power Room	1,500	2,500
Battery Room	1,500	2,500
Engine Room	2,000	4,500 (Note 1)

Note 1: Considering the carry-in of the engine generator to the building.

(4) Structure, Material and Construction Specification

A knock down method will be applied on site so that the construction period is shortened and the works on site are simplified. The materials will be manufactured and prefabricated in Japan. However, the foundation structure is of steel reinforced concrete, and the local procurement for those materials is considered. Structural calculations will be done in accordance with the standards of the Japan Building Institute, excluding earthquake considerations. The quality of the materials which require the structural strength shall be in accordance with the JIS standard in Japan or better.

(5) Building Foundation

For the design of a foundation for the building to accommodate the telecommunications facilities, the following items will be taken into consideration:

1) The foundation should be made of a steel enforced concrete material, and the concrete strength should be 180 kg/cm^2 for a period of 28 days.

2) The foundation should withstand and hold the upper structure of the building or the shelter. It must also tolerate any vibration generated by the diesel engine for power generation.

3) The foundation level of the shelter should be arranged to be over the highest level of the heaviest diurnal rainfall.

4) The earthing system must be taken into consideration in the foundation work.

(6) Switching/Transmission Equipment Room Design Standards

1) Materials should all be nonflammable to protect the facilities from fire.
2) Shelter should be provided on the windows to protect the equipment from direct sunlight.
3) Airtightness is required for the efficient use of air-conditioning.
4) A front room will be provided to prevent any dust from entering the room.
5) Ducts shall be provided to lead-in the telecommunications cable and the power cable.
6) A.C. outlets should be provided for measuring equipment and lighting.
7) Doors should be of steel, airtight and provide a key lock structure. The entrance should be large enough to allow the equipment to be carried in.

(7) Power Room Design Standard

1) The power supply system consists of the power receiving panel, transformer, rectifier, storage battery, an emergency generator and a fuel service tank.
2) The storage battery should be installed apart from the other equipment.
3) The air ventilation fan should be installed in the emergency generator and storage battery rooms. Room lighting for the battery room should be anti-explosion type.
4) The floor for the battery room should be furnished with vinyl tiles. The metal parts in the battery room should be coated with acid resistant paint.
5) Room lighting and sockets should be prepared.

(8) Fire Extinguishers

For the existing exchange building, the new exchange building, which is small in size, and the unit type of new exchange building, the following portable type fire extinguisher will be furnished in each room.

1) Switching/Transmission Equipment Room

Portable extinguisher of Hallon 130l/dioxide conform

2) Clerical Office

Portable extinguisher of phosphor chloride power (ABC extinguisher)

3) Generator Room

Both of the above portable extinguishers

(9) Earthing

Electrical protection of the telecommunications facilities in the exchange building will be provided. The earthing resistance shall be less than 10 ohm, which is according to the International Standard.

(10) Water Supply and Drainage Facilities

1) Water Supply

The water supply facility is necessary in the Burri exchange building in two places, the sulpur acid liquid washing place in the storage battery room and washing place in the kettle room.

The plumbing from the foundation to the faucet and the apparatus installation to the building will be included in the building works. The plumbing from the main water pipe to the building will be carried out by STPC (the National Water Corporation, NWC).

2) Drainage Facilities

Drain pipes from the above-mentioned two places to the water cleaning facility (to be implemented by STPC) will be included in the building works including the outlet pipe. The water from the outside device of the air-conditioner can be exhausted into the drain surrounding the building.

3) Material of Pipe

Water supply pipes, which should be strong against corrosion and easy to plumb, will be of hard polyethylene chloride material and can be purchased locally.

5-2-5 Training

(1) Training for Maintenance of Outside Plant Facilities

The outside plant completed by this project contains some new technologies which require proper training for maintenance staff. Classroom and on-site training will be conducted by the instructors of the STPC training center. The subjects of the training are the

installation and splicing of new type of cables, the cable fault localization method and the management system of maintenance works for the outside plant.
During the installation work, the contractor will provide the training for the new technology to the instructors of the STPC training center and the maintenance leaders.

(2) Training for Maintenance of Inside Plant Facilities

Operation and maintenance training for switching, transmission and ancillary switching components are divided into two categories.

- on-site training in the training center (old KHM South exchange) classroom, mainly of service order disposition, and maintenance outlines as desk training.

- on-the-job training using the completed facility will be carried out in on-the-job routine test, checking during operation, and emergency procedures and trouble-shooting.

CHAPTER 6 IMPLEMENTATION PLAN

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6-1 Project Implementation Organization

According to the system of Grant Aid from the Government of Japan, Japanese contractor(s) for the procurement of products and services should be selected by open tender, and a Japanese consultant should be employed by the Government of the Sudan for supervision of the implementation work.

The Project will be implemented on a turn-key basis, however, STPC, the competent authority for the project implementation, will assign STPC's project manager responsible for both the technical and administrative matters for the project and will supervise the implementation work in cooperation and assistance with the above mentioned consultant, in order to implement this Project smoothly.

6-2 Division of Work

The basic design study team conferred with STPC's Director General and the personnel concerned with the project regarding the division of work between Japan and the Sudan in the case of the Project's implementation by Japan's Grant Aid. The results of conference are kept on record in the MINUTES OF DISCUSSIONS (ANNEX-I).

Followings are (1) the scope of work to be borne by Japan's Grant Aid and (2) the scope of work to be borne by the Sudan at its expense and the scope of grant-of-benefits from the Sudan to Japan.

(1) Scope of Work to be Borne by Japan's Grant Aid

1) Rehabilitation of Outside Plant Facilities

a) Middle and eastern parts in Khartoum Central exchange
b) Khartoum II area in Khartoum South exchange
c) Burri exchange

2) Installation of New Digital Switching Equipment

a) Khartoum South exchange
b) Burri exchange

3) Installation of New Optical Fiber Cable

a) Between Khartoum Central exchange and Khartoum South exchange
b) Between Khartoum Central exchange and Burri exchange

4) Supply of Interface Switching Equipment

5) Construction of New Exchange Building

a) Burri exchange

6) Supply of Tools, Measuring Equipment and Materials for Maintenance

a) Supply of tools, measuring equipment and materials for maintenance of the equipment and facilities completed by this project.

(2) Scope of Work to be Borne by the Sudan

1) Supply of information, drawings and documents required for the detailed design for the project

2) Land acquisition for the new Burri exchange building construction

3) Construction of the gate and concrete fence for the Burri exchange

4) Provision of office, work space and materials storehouse necessary for this project

5) Acquisition of necessary permits and licenses for the project implementation

6) Installation of the commercial power supply and the water supply into the new Burri exchange building

7) Payment authorization notice fee and payment commission of the Japanese Foreign Currency exchange bank, based on the banking agreement

8) To ensure prompt unloading, tax exemption and customs clearance at the port of disembarkation in the Sudan and prompt internal transportation therein of the products purchased under the grant.

9) Grant of benefits, such as entry and/or departure to and from the Sudan of Japanese national for the purpose of project implementation, as well as their stay in the Sudan and their exemption from taxes and dues of the Sudan.

10) Proper and effective maintenance and operation of facilities, and the equipment and materials purchased and constructed and installed by Japan's Grant Aid.

11) Settlement of disputes with local inhabitants during the period of project implementation.

12) Bearing of expenditure other than that to be borne by Japan in connection with Grant Aid.

13) Implementation of the following construction works:

a) Withdrawal of all the existing defective facilities after transfer of the existing telephone lines

b) Rehabilitation work for subscriber's premise facilities

c) Rehabilitation work for PBX internal wiring

6-3 Implementation Plan

6-3-1 Implementation Policy

This project is aimed to rehabilitate the outside plant facilities of 14,000 existing subscribers in the important service areas in Khartoum and to introduce the new digital switching equipment and the new optical fiber junction system. The project itself covers the whole area of telecommunications engineering including the cable work, civil work, switching, optical fiber transmission, power plant and building sectors, except for the radio transmission system. In order to carry out all these works at top efficiency and to complete the projected telecommunications network in a short period, it is desirable that the whole project implementation be on turn-key basis.

The project implementation is considered to require 24 months after the conclusion of the Exchange of Notes, including the detailed design formulation and tender procedures.

6-3-2 Supervision Plan

For supervision of implementation work, STPC and the Consultant employed by the Government of the Sudan is to carry out the following items.

(1) Check of Implementation Drawings

To check, on behalf of the Government of the Sudan, implementation drawings submitted by the contractor, establish the Bill of Quantity, and report it to STPC.

(2) Witness Inspection in Factory

To carry out witness inspection of the major equipment and materials in the factory prior to shipment by the contractor and to make sure that the requirements of the equipment and materials to be shipped conform to contract specifications. Only after STPC or consultant approval can the contractor ship the equipment and materials. Two (2) engineers will attend

to the witness inspection in the factory using the Sudanese budget to confirm the contract specification by themselves.

(3) Work Management

To study work implementation method and schedule submitted by the contractor and give necessary instructions, if any. Consultant members must stay in the Sudan during the work implementation period so as to verify and check periodically whether the work implementation at the work site is inaccordance with the contract specifications, and thereby manage the work progress.

(4) System Handover

To witness the final acceptance test when the work is completed, make sure that the test results conform to the contract specifications, and then recommend the Government of the Sudan to accept the completed system.

6-3-3 Procurement of Equipment and Materials

At the time of the basic design study in the Sudan, it was found that the necessary equipment and materials for the Project implementation, especially those for the cable, switching and transmission equipment installation, could not be procured locally. All must be supplied from Japan.

Civil work necessaries, except for the manhole covers and its accessories, PVC pipes and steel reinforcements bars, are locally procurable. These materials include cement, sand, gravel, macadams, timber and some kinds of construction machines.

6-4 Implementing Schedule

For this project, the work design and tender document formulation will be started after the conclusion of the Exchange of Notes. The construction contract is done based on the competitive bidding. The implementation schedule is shown in Table 6-1.

6-5 Project Cost Borne by Sudanese Side

The cost to be borne by Sudanese side for implementation of this Project is estimated at 4.3 million Sudanese Pounds.

Outside plant	2,840 thousand Sudanese Pounds (80.8 million Yen)
Switching facilities	778 thousand Sudanese Pounds (22.1 million Yen)
Power supply facilities	550 thousand Sudanese Pounds (15.6 million Yen)
Exchange Building	178 thousand Sudanese Pounds (5.1 million Yen)

Table 6-1 Project Implementation Schedule