2. Construction Work Plan

RCS subscriber stations to be constructed in this project number as many as 1,200. Furthermore, the project itself covers the whole area of communication engineering including radio, transmission, switching and outside plant sectors. In order to carry out all these works at top efficiency and complete the projected communications network in a short period, it is desirable that the whole project implementation be on turn key basis.

Implementation procedures are described below.

1) Conclusion of Mutual Agreement

Mutual agreement in the form of Exchange Notes (E/N) providing for Japanese Grant Aid is to be concluded between the Government of Sudan and the Government of Japan.

2) Bank Designation

The Government of Sudan is to designate foreign exchange bank authorized by the Government of Japan.

3) Consultant Contract

The Government of Sudan is to select consultant (Japanese consultant only) who will supervise execution of designs, and to conclude consultant service contract with that consultant. This contract will become effective when approved by the Government of Japan.

4) Field Survey and Preparation of Tender Documents

Consultant selected by the Government of Sudan will carry out field survey of all project sites in Gezira Area and, based on survey findings, product detailed designs. Tender document preparation is also the duty

of consultant. Tender documents made by consultant must be approved by the Government of Sudan.

5) Tender Evaluation, and Conclusion of Construction Work Contract with Successful Tenderer

Tender evaluation will be made by the method previously proposed by the consultant to and duly approved by the Government of Sudan.

Tender evaluation results will be arranged in the report. After the report is approved by JICA, Tenderer with whom to negotiate for conclusion of work contract will be recommended.

Consultant will carry out contract negotiations with top ranking Tenderer, clarifying such items in his tender contents that require modifications, and, based on contract making guidelines of JICA, formulate contract. By this means, consultant assists the Government of Sudan in the preparation of work contract. The contract will become effective when approved by the Government of Japan.

6) Examination of Installation Drawings

Consultant, acting on behalf of the Government of Sudan, will examine installation drawings submitted by the contractor, determine B/Q (Bill of Quantity) and report it to the Government of Sudan.

7) Witness to Factory Tests

Prior to equipment shipment by the contractor, consultant will carry out factory tests of such equipment and examine whether mechanical and electrical characteristics are as specified in contract document, or not. After approval by consultant, the contractor will make equipment shipment.

8) Supervision of Installation Work

Consultant will examine work schedule submitted by the contractor and issue instructions where necessary. During the work, consultant will visit work site periodically and supervcise work progress as required.

9) Delivery of Completed System

Consultant will witness to acceptance tests and, after confirming that test results are in accordance with Tender Specifications and that the quantity of spare parts and components, measuring equipment, instruction manuals, etc., coincides with the provisions of contract document, recommend the Government of Sudan to accept the system constructed.

3. Scope of Work and Implementation Schedule

The current project comprises the sector to be constructed by Japanese Grant Aid and the sector to be constructed by fund raised by the Government of Sudan. Main work items of each sector are:

(1) Scope of Work to be financed by Japanese Grant Aid

1) Construction of telephone exchanges at four places in Gezira Area.

2) Construction of seven RCS radio base stations with combined capacity for about 1,200 subscribers, in Gezira Area.

3) Construction of UHF links to connect telephone exchanges (as per 1) above) and to connect radio base stations (as per 2) above).

4) Installation of 150 institutional use mobile telephones in the RCS network.

5) Construction of outside plants for four telephone exchanges (as per 1) above).

6) Construction of Maintenance Centers at four places.

(2) Scope of Work to be financed by the Government of Sudan

1) Acquisition of site lands for telephone exchanges and radio base stations.

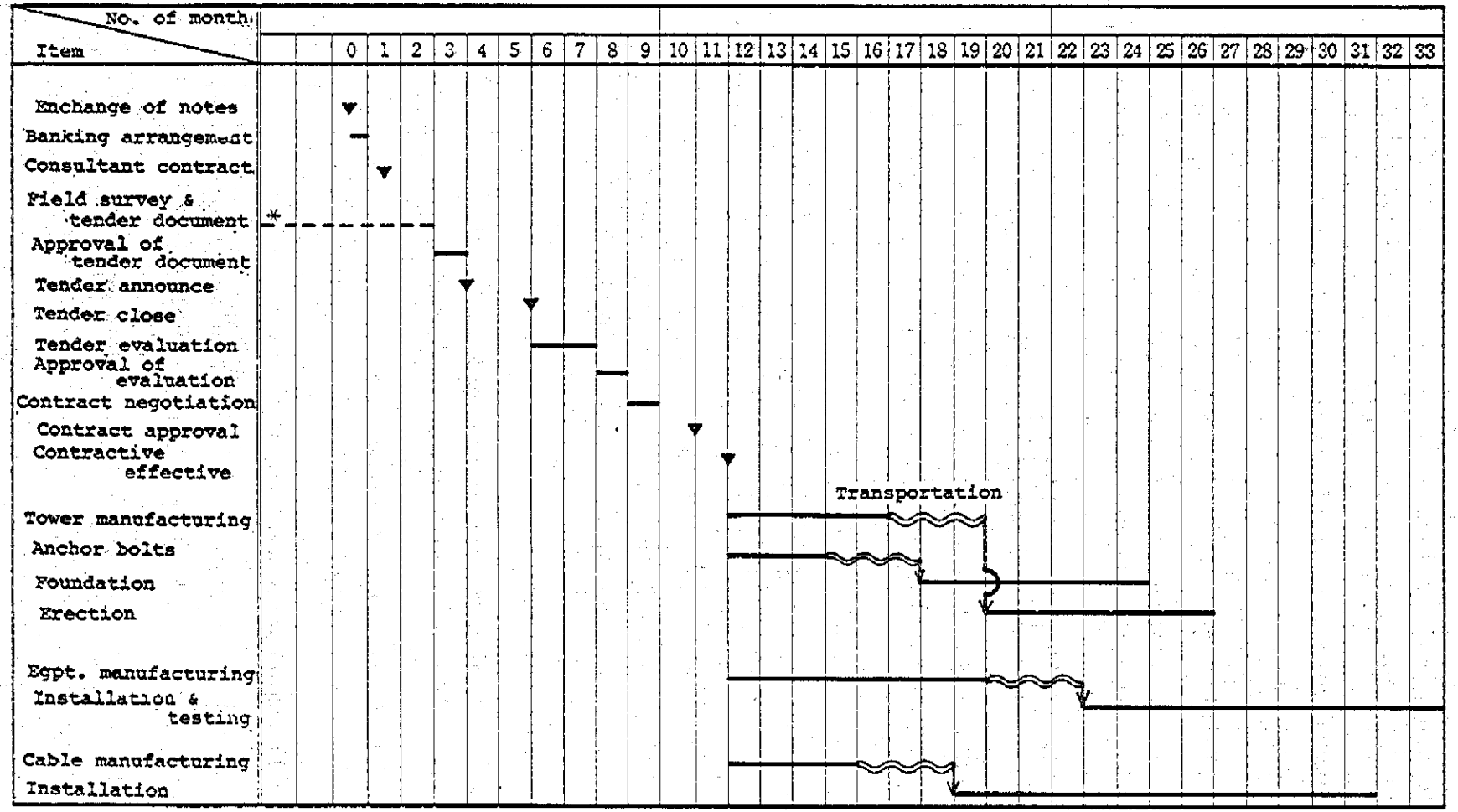
2) Ground levelling and land formation at each site before commencement of construction work.

3) Lead-in work for power line at site where commercial power supply is available.

For construction work covered by Japanewe Grant Aid, turn key base contract arrangement by competitive bidding will be adopted. Work period is 22 months after the coming into force of work contract. Project implementation schedule is given in Table III-2.

Gezira Area is in rainy season during June-October, every year. In this period, roads in the Area are flooded and the most part of sites become inaccessible. Therefore, this period should be avoided for field survey and construction work.

Table III-2 Project Implementaion Schedule



4. Maintenance and Operation

4.1 Maintenance and Operation Work

Maintenance and operation work is classified into the following categories:

(1) Maintenance of Facilities

1) Preliminary maintenance
(Test, inspection, patrol, repair/replacement)

2) Posterior maintenance
(Trouble-shooting, rehabilitation)

3) Safety management
(Custody of facilities, plant record keeping)

(2) Maintenance of Service

1) Operation of facilities
(Operation, as well as supervising and control of operation)

2) System management
(Control of abnormal troubles)

(3) Collateral Work

1) Staff personnel management
(Assignment plan, duty regulation)

2) Capability improvement
(Training/education)

3) Equipment control
(Safe-keeping of machines and implements, measuring equipment, vehicles, etc.)

For maintenance and operation of communications network to be constructed by the current project, rational and effective executive organization and personnel assignment plan covering the whole range of maintenance and operation are essential. To attain this purpose, SGB and STPC must make full studies including re-education of maintenance staff for the existing SGB-managed radio communications system. Following are recommendations for maintenance and operation organization and staff personnel considered to be essential for the projected communications network, as well as training of those personnel.

4.2 Recommendation for Maintenance and Operation Organization

The recommended maintenance and operation organization for Gezira telecommunications network is as follows:

(1) To establish Central Maintenance Center in Barakat.
Purpose: Maintenance management for Barakat Master Exchange and its slave unattended radio facilities (slave exchanges, RCS base stations and UHF radio repeaters, plus overhead cable facilities). Main duties of Central Maintenance Center are:

1) Transmission and Radio Systems

- Supervisory control of the whole systems in the maintenance coverage area by remote supervision and control system.
- Patrol of unattended facilities for inspection.
- Location of fault point, probe into cause of fault, and repair work.
- General periodical tests of the systems.
- Safe-keeping of measuring equipment and maintenance parts.

- Updating and safe-keeping of standard practices and plant records.

- Training and education of maintenance and operation personnel.

2) Switching System

- Traffic measurement (periodical and non-periodical)

- System operation monitoring and traffic control.

- Subscriber data modification.

- Monthly billing management.

- Failure complaint acceptance (by service number "92").

- Automatic fault detection and automatic fault prevention system monitoring.

- Automatic diagnosis and after-treatment.

- Tests of all kinds.

- Reception of alarms of all kinds and analysis thereof.

- Safe-keeping and supply of and order placement for interchangeable parts and components.

- Updating and safe-keeping of standard practices and plant records.

- Arrangement for repair/replacement of faulty equipment/parts.

- Safe-keeping of maintenance tools and measuring equipment.

- General service (through special service desk) including directory service, life related information service and medical information service.

3) Overhead Cable Facilities

- Preparation and safe-keeping of line number list that indicates the state of MDF connections.
- Installation work for new subscribers.
- Fault prevention and fault discovery at early stage by means of periodical patrol of facilities.
- Failure point detection and repair work.
- Safe-keeping and supply control of maintenance use measuring equipment and interchangeable parts and components.

4) Maintenance and operation of power supply system for all the foregoing facilities.

(2) To establish Maintenance Centers in Bagier, Hasaheisa and Gorashi. Main duties of each Maintenance Center are:

- Safe-keeping of consumable spares (fuses, lamps, etc.)
- Safe-keeping of handy measuring equipment.
- Safe-keeping of instruction manuals for equipment.
- Attendance to minor faults.
- Maintenance and operation of power supply equipment (equipment operation monitoring, battery solution replenishment, and diesel engine maintenance).

Minor repair work, such as replacement of electro-magnetic parts, is done at SGB Workshop. However, faulty electronic parts and packages, for instance, are to be sent back to Japanese manufacturer for repair.

4.3 Recommendation for Staff Personnel and Their Training

(1) Staff Personnel

Maintenance and operation staff personnel are to be assigned as recommended below.

1) Barakat Central Maintenance Center

a) Transmission;, radio systems
3 engineers, plus 7 technicians by 3 shifts

b) Switching equipment
3 engineers, plus 7 technicians by 3 shifts

c) Outside plant
2 engineers and 3 technicians

d) Power supply system
2 engineers and 3 technicians

2) Maintenance Center (Bagier, Hasaheisa, Gorashi)

a) Transmission, radio systems
1 engineer and 2 technicians (at each Center)

b) Switching equipment
2 technicians (at each Center)

c) Outside plant
2 technicians (at each Center)

d) Power supply system
2 technicians (at each Center)

(2) Training

Telephone exchanges and transmission lines envisaged in the basic design are of digital type so that their maintenance is difficult for technical staff whose knowledge and experience are based on analog technology.

Furthermore, in the case of digital switching equipment and digital multiplex and radio equipment, both the technical system adopted and the type of equipment differ from manufacturer to manufacturer. Therefore, in the current project, the manufacturer of the equipment to be adopted is to be obligated to undertake training of the operation and maintenance staff.

The objective of training, this time, is to provide technical knowledge required for operation and maintenance of the system to be constructed by the current project. Training on switching equipment planning and design is not in the objective.

Thus, for digital communication technology in general, training will be administered, based on JICA's training principles. In this case, training comprises collective training and special training by veteran engineer specifically dispatched. As for training about how to handle equipment exclusive to the current project, the manufacturer of such equipment is to assume responsibility.

4.4 Maintenance and Operation Cost

4.4.1 Calculation of Operation, Maintenance and Power Costs

Calculation method is as follows:

(1) Operation Cost

Operation cost calculation is by the number of operation personnel multiplied by average personnel expense in operation division.

Maintenance and operation personnel required for the projected system are proposed in Paragraph 4.3. Breakdown of maintenance and operation personnel classified by engineering sections follows:

1) Radio Section

	Engineer	Technician
Total	6	13
Maintenance	3	9
Operation	3	4

2) Switching Section

Total	3	13
Maintenance	1	6
Operation	2	7

3) Outside Plant Section

Total	2	9
Maintenance	1	9
Operation	1	

4) Power Supply Section

Total	2	9
Maintenance	1	9
Operation	1	

Thus, for all sections,

Maintenance	6	33
Operation	7	11

Average annual personnel expenses are

Engineers: Approx. 5,000 Sudanese Pounds

Technicians: Approx. 2,200 Sudanese Pounds

(2) Maintenance Cost

Maintenance cost is expressed by the sum of maintenance personnel expenses and cost of maintenance related supplies. According to the past record in Japan, personnel expenses versus cost of supplies ratio in maintenance cost is 7 : 3. By this ratio, the following assumption is established:

Average wage ratio between Sudanese and Japanese engineers 1 : 10

Therefore, the aforementioned personnel expenses versus cost of supplies ratio is corrected as follows:

Personnel expenses : Cost of supplies = 2.1 : 3

Then, maintenance cost can be obtained by the following formula:

$$\text{Maintenance cost} = \text{Cost of supplies} \times \left(1 + \frac{3}{2.1} \right)$$

(3) Power Cost

For power cost, or, more precisely, electric power cost, the charge system of National Electricity Co. of Sudan is referred to.

Electric power charges in Sudan consists of four segments. That is,

Segment 1: For general households

Segment 2: For commercial and light industry users

Segment 3: For small factories

Segment 4: For heavy industry and large scale agricultural users

For power consumption by the projected system, this time, charge is by Segment 4.

Segment 4 is further divided by capacity into the following three sub-segments:

a) 2,500 kVA or more (35 kV power received)
b) 500 kVA or more (11 kV power received)
c) 50 - 500 kVA (415 V power received)

Communication equipment for the projected system will be installed inside SGB/MOI facilities. Therefore, power for such equipment will be received commonly with power for SGB/MOI facilities and then distributed to the equipment.

Power consumption by the whole network is less than 200 kVA even when the consumption by RCS subscriber station is included. This means that even if the receive contract for the whole system is of a) or b) above, power cost of communication equipment only will probably come under c). In this case, charge is for 500 kVA or less, i.e., 4.5 Sudanese Pounds/kVA/month.

Assume that power consumption by the whole system is 200 kVA. Then, the charge is 900 Sudanese Pounds/month. Annual total is 10,800 Sudanese Pounds.

Where commercial power supply is not available, power supply to equipment installed is by diesel engine generator (DEG). In this case, annual DEG fuel cost accounts for power cost. Where commercial power supply is usually available and DEG is installed for emergency power supply, DEG fuel cost is regarded as being included in power cost.

a) Basic Power Consumption (annual)

1) 5.4 kVA : 34.32 ℓ/day x 365 days = 12.5 k
2) 15.0 kVA : 93.6 ℓ/day x 365 days = 34.2 k
3) 25.0 kVA : 156 ℓ/day x 365 days = 56.9 k

b) Annual Power Consumption by Whole Network

(5.5 kVA x 1 place) + (15.0 kVA x 6 places) + (25.0 kVA x 2 places)
= (12.5 kℓ x 1) + (34.2 k x 6) + (56.9 kℓ x 2) x 1.2*
(* is a reserve for trial operation/slow speed operation)
= 397.8 ≒ 106 k gal

c) Fuel Cost

DEG fuel cost is 3.75 Sudanese Pounds/gallon. Annual total is 397,500 ≒ 400,000 Sudanese Pounds.

4.4.2 Annual Cost of Operation and Maintenance

Here, annual cost for operation cost and power cost is obtained in the sum of operation cost, maintenance cost and power cost.

a)	Annual operation cost	59,200 Sudanese Pounds
b)	Annual maintenance cost	249,200 Sudanese Pounds
c)	Power cost	410,800 Sudanese Pounds
	Total	719,200 Sudanese Pounds

For maintenance use parts and components, five-year stock after service-in is included in initial investment. Therefore, the above annual cost is to be reduced by the amount of those parts and components for maintenance use.

CHAPTER IV PROJECT EVALUATION

Gezira Rehabilitation Project comprises many sub-projects that are organically interrelated. Therefore, quantitative project evaluation in terms of telecommunications network construction only is extremely difficult. Worth consideration in project evaluation, however, is the loss sustained in cotton transport by Gezira Light Railway. According to SGB data of 1982/83, useless locomotive operations on account of ineffective information exchange number as many as 205 times, mileage of those unnecessary locomotive operations reaches 12,997 km, and the loss suffered amounts to 79,541 Sudanese Pounds. This kind of waste can be eliminated once the telecommunications network has been completed to provide means for prompt transmission of correct information.

Other benefits that can be expected from telecommunications network project implementation in Gezira Area are:

1) Effective utilization of irrigation water by means of pertinent water control.

   At present, water indent report from each water control point is supplied mainly by bicycle. When the use of telephones becomes possible, water indent report can be made more correctly and more rapidly, improving the irrigation effect remarkably. Furthermore, the volume of water to be released into Egypt, the neighboring country, on the lower reaches of the Nile.

2) Brisking of Field Inspectors' Routine Activities

   In the whole Gezira Area, several hundred field inspectors are on permanent duty, engaged in farm management and agricultural guidance. At present, the area is almost completely without means of communication. When the

telephone network is established in the area, field inspectors can use telephones to make close contact with their Headquarters and can fulfill their duty much more effectively.

3) Effective Operation of Ginning Factories and Workshops

When the telecommunications network is established, SGB Headquarters can collect up-to-date information about facilities at ginning factories and about the stock maintenance parts and components at Workshops. Therefore, they can respond quickly to the actual requirements.

4) Raising of Fire Brigade Efficiency

Contiguous to four ginning factories in Gozira Area, fire brigades are established. Telecommunications network, once completed in the area, will enable those fire brigades to take necessary actions at higher efficiency. During summer season, spontaneous ignition of cotton takes place 10-15 times per day at ginning factories.

5) Liaison with Khartoum

In City of Khartoum, Khartoum Office of SGB is located. By telephone contacts with this office, price information of agricultural products can be obtained with expedition. This convenience will make contributions to SGB's economic management activities at high efficiency.

6) Emergency Contact with Hospitals and Police Stations

Completion of Gezira telecommunications network leads to availability of emergency telephone contacts with hospitals and police stations in the area on round-the-clock basis. This will improve social welfare service to the local population.

As described in the foregoing, the current project constitutes an integral part of infrastructural requirements in the promotion of Gezira Rehabilitation Project. In the event of successful implementation of this rehabilitation project, farmlands in the area will increase from the present 1,470,000 feddans (1 feddan = 0.42 hectares) to 1,550,000 fedans, and the production of cotton and wheat as main products will increase to 341,000 tons and 260,000 tons, respectively, from the present 259,000 tons and 156,000 tons. For peanuts also, about 40% increased crop can be expected.

As of the present, Gezira Rehabilitation Project is considered to be in progress in general accordance with the development plan established by the World Bank. According to the economic analysis by the World Bank, internal rate of return (IRR) of the project as a whole is 35.8%. This figure by far exceeds the rate of opportunity cost of capital in Sudan that stands at 12.5%. Hence the judgment that the project is feasible from the economic viewpoint also.

CHAPTER V CONCLUSION AND SUGGESTIONS

In Gezira Area, main products consist of cotton, wheat and peanuts. These agricultural products, besides filling domestic demand in Sudan, are exported to neighboring countries also, contributing a great deal to foreign currency earnings of Sudan. Gezira Rehabilitation Project itself is aimed at re-development of Gezira Area, which, in turn, is directed toward improvement of agricultural production in both its quantity and productivity. In this Project, telecommunications network constitutes as important an infrastructure as motorization and railway service.

At present, in Gezira Area, SGB operated HF and VHF radio equipment provide practically the sole telecommunications media. Due to paucity of information transmission implement, water volume control at water control points and technical instructions toward farming population cannot be carried out as effectively as desired. As a matter of fact, incomplete communications system proves to be a serious bottleneck to Gezira Area re-development.

As stated in Chapter IV - Project Evaluation, the current Gezira telecommunications network project is worthwhile to be implemented so as to realize economic development of the area and to improve social welfare of the inhabitants.

These days, the food shortage in African countries is posing a difficult problem to the world. Against this background, Gezira Rehabilitation Project, planned as it is to incarnate future granary of Arab-African community, is only to increase its importance. The Grand Aid from the Government of Japan will provide a strong support to this timely project.

Following are the points that require special consideration from technical viewpoint with respect to the project implementation:

(1) Implementation Schedule

During June through October, every year, Gezira Area is in the rainy season. In this period, access to work sites becomes extremely difficult. For field survey and construction work, this period must be avoided.

(2) Radio Frequency Plan

Use of 2 GHz band for UHF radio links and of 400 MHz band for RCS is recommended. However, for final decision of frequency plan, exchange of views with Sudanese organizations concerned at the time of detailed design formulation is prerequisite.

(3) *Training of Personnel*

Digital switching/transmission system is a new technology to be introduced for the first time in Gezira Area. Therefore, to maintain required system performance, training of personnel in charge to enable them to operate digital system as required is indispensable. This training will consist of on-the-job training at work site during construction work period.

CHAPTER VI ANNEX

1. Minutes of Discussion
2. Survey Itinerary
3. Members of Basic Design Study Team
4. Names of Sudanese Officials Involved in the Current Project
5. Collected Data/Information
6. Power Supply Situtation in Gezira Area
7. Technical Information for Basis Design Study
   (1) Conceptual Outline of Switching Network Plan
   (2) Method of Calculation for Circuit Required
   (3) Comparison between Alternative and Original Plans
   (4) Radio System Design
   (5) Solar Battery System Application
   (6) Outside Plant Design
   (7) Institutional-Use Mobile Communication System

ANNEX 1 Minutes of Discussion

Minutes of Discussions
on
the Gezira Telecommunications Network Project
in
the Democratic Republic of the Sudan

In response to the request by the Government of the Democratic Republic of the Sudan, the Government of Japan has sent, through the Japan International Cooperation Agency, a team headed by Mr. Kenichi Ando, Second Economic Cooperation Division, Ministry of Foreign Affairs, to conduct a Basic Design Study on the Gezira Telecommunications Project (hereinafter referred to as "the Project"), from May 13 to June 11, 1984.

The Team has conducted the field survey, held a series of discussions and exchange views with the authorities concerned of the Democratic Republic of the Sudan.

As a result of the survey and discussions, both sides have agreed to recommend to their respective Government to examine the result of the study attached herewith towards the realization of the Project.

Khartoum, May 28, 1984

Yusri M. Gabr
for Under Secretary (Planning)
Ministry of Finance and Economic Planning

Kenichi Ando
Team Leader
Japanese Study Team

Hassan A. Hidirbi
Director General
Sudan Telecommunications Public
Corporation

REMARKS

1. The objective of the Project is to provide and commission facilities and equipment for the establishment of telecommunications network in the Gezira area in order to enhance activities of the Ministry of Irrigation and the Sudan Gezira Board such as control of irrigation water supply, administration, operation of field, railway, ginning factories, etc.

2. The Sudan Telecommunications Public Corporation and the Sudan Gezira Board are responsible for the execution of the Project on Sudanese side.

3. The telecommunications network is used by the following organizations;

(1) Sudan Gezira Board
   1) Head quarters
   2) Group office
   3) Block office
   4) Field inspector's office and housing
   5) Workshop
   6) Gezira Light Railway
   7) Ginning factory
   8) Fire brigade

(2) Ministry of Irrigation
   1) Sennar dam
   2) Division office
   3) Sub-division office
   4) Section office
   5) Water control point

(3) Other governmental organizations
   1) Post office
   2) Police office
   3) Hospital and clinic

In order to provide the above-listed organizations with the telephone service, the following facilities and equipment are installed;

(1) Telephone exchange
(2) UHF radio link
(3) Point-to-multipoint UHF radio system
(4) Power plant including solar power system
(5) Prefabricated equipment shelter and container
(6) Outside plant associated with the telephone exchanges and point-to-multipoint terminals

4. The Japanese Team will convey to the Government of Japan the intention of the Democratic Republic of the Sudan that the former takes necessary measures to cooperate in implementing the Project and provide the necessary facilities and equipment based on the philosophy shown in Annex I to cover the entire projected area within the scope of Japanese economic cooperation in grant form.

5. The Government of the Democratic Republic of the Sudan will take the necessary measures listed in Annex II on condition that the grant assistance by the Government of Japan is extended to the Project.

6. Both sides confirmed that the Japanese Study Team explained the Japanese Grant Aid Programme and Sudanese side understood it.

ANNEX I

1. Telephone exchange

The main telephone exchange is installed at Purakat and integrated into the public telecommunications network.
The remote switching units (slave telephone exchange) are installed in the principal sites in the projected area where the telephone subscribers are concentrated.
The subscribers located close to the telephone exchanges or remote switching units are connected by cables or overhead wires, whereas the remote area subscribers are accessed by the point-to-multipoint UHF radio system.
The main exchange and remote switching units are interlinked by UHF radio link.

2. Point-to-multipoint UHF radio system

The point-to-multipoint UHF radio system recommended by the International Telecommunications Union is installed to provide telephone service to the remote area subscribers scattered in the projected area.
This system consists of 9 to 11 base stations and hundreds of terminal and repeater stations to cover the whole remote area subscribers.

Power plant

In principle, solar power system is used for self-powered terminal and repeater stations of point-to-multipoint system.

4. Prefabricated equipment shelter and container

The prefabricated equipment shelters and containers are used for the base stations/UHF links and telephone exchanges including remote switching units, respectively.

Note: The location of remote switching units and radio station are subject to further study together with exchange capacity after the telephone demand is fixed by the organisations concerned.

ANNEX II

1. To provide data and information necessary for basic design.

2. To secure the lands necessary for the telephone exchanges and the base stations of point-to-multipoint UHF radio system.

3. To carry out site preparation such as clearing and leveling before commencement of installation works.

4. To provide facilities for distribution of electricity.

To ensure prompt unloading, tax exemption, custom clearance at the ports of disembarkation in Sudan and prompt internal transportation of the products purchased under the grant.

6. To exempt the Japanese nationals concerned from custom duties, internal taxes and other fiscal levies imposed in Sudan with respect to the supply of the products and services for the Project.

7. To provide necessary permissions, licences and other authorizations for carrying out the Project.

MINUTES OF DISCUSSIONS

At the request of the Government of the Democratic Republic of the Sudan, the Government of Japan has sent a team to carry out the Basic Design Study for the Gezira Telecommunication Project through Japan International Cooperation Agency (JICA) for 30 days from 13th June to 11th July 1984.

As the result of the study, JICA has prepared the Draft Report of the Basic Design Study and has sent a team to submit and explain the Report for 12 days from 16th to 27th September 1984.

Both parties have had a series of discussions on the Report and the Sudanese side has principally agreed to the basic design proposed in the Report as far as it satisfies the requirements of Sudan Gezira Board which is the beneficiary of the Project.

24th September 1984

Mr. Norio Shimomura
Leader, Basic Design Study Team, JICA

Mr. Hassan A. Hidirbi
Director General
Sudan Telecommunications Public Corporations

ANNEX 2 Survey Itinerary

May 15 (Tuesday):	Arrival at Khartoum.
May 16 (Wednesday):	Courtesy visit to Japanese Embassy and briefing of Embassy staff. Visit to World Bank office, and collection of information.
May 17 (Thursday):	Visits to STPC, MOI and SGB.
May 18 (Friday):	Discussions among survey team members, and assortment of data.
May 19 (Saturday):	Consulation with STPC.
May 20 (Sunday):	Transfer to Barakat (SGB Hq.)
May 21 (Monday):	Consulation with STPC, MOI and SGB at SGB Hq.
May 22 (Tuesday):	Field survey (covering Wad Medani, Beika, Wad El Burr, etc.; whole travel mileage: 100 km).
May 23 (Wednesday):	Field survey (Barakat Telephone Exchange); transfer to Khartoum.
May 24 (Thursday):	Consultation at STPC Khartoum, and assortment of collected data.
May 25 (Friday):	Map study and assortment of data.
May 26 (Saturday):	Preparation of Minutes copies.
May 27 (Sunday):	Discussion with STPC and SGB.
May 28 (Monday):	Signing of Minutes, and report to Japanese Embassy. Team leader Ando and team members Osawa and Suzuki depart for Japan.
May 29 (Tuesday):	Transfer to Barakat, and collection of MOI related data.
May 30 (Wednesday):	Field survey. Group A: Gorashi/Maatug and surroundings Group B: Gorashi/Managil area
May 31 (Thursday):	Field survey. Group A: Huda and surroundings Group B: Hag Abdulla/Sennar area

June 1 (Friday):	Assortment of data, and discussion among survey team members.
June 2 (Saturday):	Field survey. Group A: Kab El Gidad and surroundings Group B: Abu Usher/Hasaheisa area
June 3 (Sunday):	Field survey. Group A: Barakat and surroundings Group B: Barakat/Wad Medani area
June 4 (Monday):	Report to SGB and STPC.
June 5 (Tuesday):	Field survey of Bagier area. Transfer to Khartoum.
June 6 (Wednesday):	Survey of STPC Khartoum Repeater Station, and assortment of collected data.
June 7 (Thursday):	Report to STPC and SGB. Report to Japanese Embassy.
June 8 (Friday):	Assortment of collected data. Preparation for return to Japan.
June 9 (Saturday):	Survey team return to Japan.

ANNEX 3 Members of Basic Design Study Team

Name	Duty in charge	Affiliated to
Kenichi ANDO	Team Leader	2nd Economic Cooperation Devision, Economic Cooperation Bureau, Ministry of Foreign Affairs
Kazutomo OSAWA	Network Engineering	Senior Staff Engineer, International Affairs Bureau, Nippon Telegraph & Telephone Public Corporation (NTT)
Tatsuo SUZUKI	Coordinator	Basic Design Division, Grant Aid Department, Japan International Cooperation Agency (JICA)
Kenichi HATANO	Radio Engineering	Assistant to General Manager, The Nippon Telecommunications Consulting Co., Ltd. (NTC)
Ryushi SUENAGA	Traffic & Switching Engineering	Assistant Manager, NTC
Eitaro YAGI	Civil Engineering	Assistant Manager, NTC
Yuichi NAKAJIMA	Outside Plant Engineering	Staff Engineer, NTC
Hideaki KIMURA	Radio Engineering	Staff Engineer, NTC

ANNEX 4 Names of Sudanese Officials Involved in the Current Project

SPTC

SUDAN TELECOMMUNICATION PUBLIC CORPORATION

MR. HASSAN AHMED HIDIRBI
/Director General

MR. ABDEL WAHAB GAMAL
/Director Technical Administration

MR. MOUTASIM MOHAMED YOUSIF
/Director Planning Switching

MR. MOHAMED MAHGOUB OSMAN
/Switching Department

MR. GASH ELSID MOHAMED EL BASHIR
/Transmission Department

MR. ABD ALLA KHALID IDRIS
/Traffic Department

MR. IBRAHIM A. MURSAL
/Director of Northern Region

MR. MOHI ELDIN AHMED ELMEKKI
/Outside Plant Department, Cable Eng.

MR. MUSTAPHA ELTAHIR BESHIR
/Outside Plant Department

MR. AWAD NAYIL MUSTAFA
/Zone Manager for Telecommunication, Wad Medani

MR. ABDEL RHMAN EL KHIDR MOHMED
/Assistant Technical Rigon Manager, Wad Medani

RPMU

REHABILITATION PROJECT MANAGEMENT UNIT

DR. ABDELGALIL ABDEL GABAR

/Executive Director of Gezira Rahabilitation Project

MR. EL RASHEID MAHMOOD SHADDAD

/Relation Director of Gezira Rehabilitation Project

MOA

MINISTRY OF AGRICULTURE

MR. YOUSIF AHMED DASH

/Undersecretary of MOA

MR. MUTASIM ELNOUR IBRAHIM

/Director of Documentation & Information

MR. EL ZEIN MUSTAFA

/Staff of MOA

MOI

MINISTRY OF IRRIGATION

MR. SEIF ELNASR MIRGHANI

/Director Mechanical & Electrical Administration

MR. DASOUGI

/Manager of Irrigation Affairs

THE WORLD BANK

MR. MAHFOUZ E TADROS
/Resident Representative

SGB
SUDAN GEZIRA BOARD

MR. SAYED ABDEL AZEEN MOHAMAD HUSSEIN
/Chairman & Managing Director

DR. NASR ELDIN MOHAMED NASR ELDIN
/Acting Managing Director

DR. ADAM ABDALLA DAFFALLO
/Head of Engineering Administration

MR. AHMED EL BADAWI
/Head of Social Economic Unit

MR. ABU BAKR ISMAIL KARAR
/Second of Social Economic Unit

MR. SAAD EL TAYIB
/Public Relations

MR. HUSSEIN ABU GUSSEISA
/Director Administration

MR.ABDEL WAHAB MOHAMED ALI
/Acting Manager Mechanical Engineering Department

MR. EL AMIN EL SHARIF
/Project Senior Engineer

MR. BASHIR MOHAMED KABBASHI

/Senior Wireless Engineer

MR. MOHAMED ABDEHAMID MOHAMED

/Manager of Electrical Engineering Department

MR. KHALID MUKHTAR

/Deputy Manager of Electrical Engineering Department

MR. EL ABID EL SIDDIG

/Cheif Civil Engineer

MR. MOHAMED TAYIB HASSAN

/Manager of Maintenance Department

ANNEX 5 Collected Data/Information

1. Bank of Sudan"Annual Report" (1981)
2. Bank of Sudan"Annual Report" (1982)
3. Bank of Sudan"Economic and Financial Statistics Review" (1983)
4. Bank of Sudan"Foreign Trade Statistic Digest" (1983)
5. Ministry of National Planning "The Six Year Plan of Economic and Social Development" (1977)
6 Ministry of Financial & Economic Planning"Prospects, Programmes and Policies for Economic Development" 1982/83-1984/85
7. World Bank"Sudan Gezira Rehabilitation Project Implementation Volume"
   - Volume I/Annex I-VI
   - Volume II/Annex V
8. STPC 5-years Development Plan
9. Map of Irrigation in Gezira Area
10. Detail Map of Irrigation in Gezira Area
11. Sudan Year Book
12. SGB"Improvement of Transportation System in Gezira Light Railway" (1983)
13. Detail Maps (Scale 1/2500)
   - Barakat Headquarters Area
   - Meringan Ginning Factory
   - Hasaheisa Ginning Factory
   - Bagier Ginning Factory
   - Gorashi Area

ANNEX 6 Power Supply Situation in Gezira Area

GROUP Name.	BLOCK Name.	Supplier.	Supp.hours.	Capacity.
1. SOUTH.	EL RUF.	SGB.	6h.	25KVA.
	1. HAG ABDALLA.	"	"	10KVA.
	2. FAHL.	"	"	10KVA.
	3. GHUBSHAN.	NIL.	-	-
	4. WADNAAMAN.	SGB.	6h.	10KVA.
	5. EL HOSH.	NIL.	-	-
	6. EL REMETAB.	"	-	-
	7. WAD EL ATAIA.	"	-	-
	95. WAD EL HADDAD.	SGB.	6h.	10KVA.
2. CENTRE.	WEOSHAFI.	SEPC.	24h.	-
	10. BARAKAT.	"	"	-
	11. DARWISH.	"	"	-
	12. EL KUMOR.	NIL.	-	-
	13. EL RADMA.	"	-	-
	14. ABD EL HAKAM.	SEPC.	24h.	-
	15. EL MEDEINA.	"	"	-
	8. HAMAD EL NIL.	SGB.	6h.	10KVA.
	9. SEED FARM.	SEPC.	24h.	-
	106. HURGA.	SGB.	6h.	10KVA.
	107. NUR EL DIN.	"	"	10KVA.
	*. BEIKA.	SEPC.	24h.	-
3. MESSELLEMIA.	MESSELLEMIA.	SEPC.	24h.	-
	20. ABD EL GILIL.	"	"	-
	21. WAD SAADALLA.	NIL.	-	-
	22. ABDEL RAHMAN.	"	-	-
	23. WAD HUSSEIN.	SEPC.	24h.	-
	24. EL NIDIANA.	"	"	-
	16. TAYIBA.	"	"	-
	17. EL SILEIMI.	"	"	-
	18. EL TEBUB.	NIL	-	-
	19. WAD EL BUR.	"	-	-
4. WAD HABOUBA.	WAD HABOUBA.	SEPC.	24h.	-
	25. WAD SULEB.	"	"	-
	26. DOLGA.	"	"	-
	27. ISTARIHNA.	"	"	-

GROUP Name.	BLOCK Name.	Supplier.	Supp.hours.	Capacity.
	28. EL RUKN.	SEPC.	24h.	-
	104. WAD EL FADL.	SGB.	6h.	15KVA.
	105. HADDAF.	"	"	15KVA.
	*. HASAHEISA.	SEPC.	24h.	-
	*. TANBUL.	"	"	-
5. WAD SHAIR.	WAD SHAIR.	SEPC.	24h.	-
	29. EL NUIELA.	NIL.	-	-
	30. FETEIS.	SGB.	4h.	15KVA.
	31. AMARA KASSIR.	SEPC.	*under construction.	
	32. KETEIR.	NIL.	-	-
	33. TURIS.	"	-	-
	34. FAWAR.	"	-	-
6. NORTH.	NORTH.	SGB&MOI.	6h.	35KVA.
	35. UMDEGARSI.	SEPC	* in future.	
	36. DEBEIBA.	NIL.	-	-
	37. TURABI.	NIL.	-	-
	38. MEILIG.	SGB.	6h.	10KVA.
	39. KABEL GIDAD.	NIL.	-	-
	40. LAOTA.	SEPC.	24h.	-
	92. RUWEINA.	SGB.	6h.	*under cont.
	*. BAGEIR.	SEPC.	24h.	-
7. NORTH WEST.	FADAGOBA.	SGB.	6h.	25KVA.
	41. ABU GIN.	"	"	18KVA.
	42. EL GUEIZ.	"	"	12KVA.
	43. EL SUDEIRA.	* in future.		
	44. EL FARAGIN.	NIL.	-	-
	45. ABU IDEINA.	* in future.		
	46. BAGIGA.	SGB.	6h.	18KVA.
	94. WAD EL KEREIL.	* in future.		
	98. ABU QUTA.	SEPC.	24h.	-
8. MIKASHFI.	MIKASHFI.	SEPC.	24h.	-
	47. HAMADNALLA.	"	"	-
	48. ABU DIGIN.	SGB.	6h.	15KVA.
	49. MURAD.	"	"	15KVA.
	84. WAD ABID.	SEPC.	24h.	-

GROUP Name.	BLOCK Name.	Supplier.	Supp.hours.	Capacity.
	85. TONSA.	SGB.	6h.	15KVA.
	96. EL KERATIEB.	"	"	15KVA.
	97. EL NASEIH.	SEPC.	24h.	-
9. HUDA.	HUDA.	SGB.	6h.	25KVA.
	50. WAD EL ZEIN.	"	"	15/18KVA.
	51. EL MALAN.	"	"	"
	52. SHANDI.	"	"	"
	90. FEREIGAB.	"	"	"
	91. SURHAN.	"	"	"
	93. GOZ EL REHEID.	"	"	"
	103. ABD EL MAGID.	"	"	"
10. WAD EL MANSI.	WAD EL MANSI.	SGB.	6h.	15/18KVA.
	53. EL GELEI.	"	"	"
	54. RAS EL FIL.	"	"	"
	55. EL NEIMA.	"	"	"
	56. MABROUK.	"	"	"
	58. EL GADID.	"	"	"
	59. EL TAYIF.	"	"	"
	83. EL KEREMIT.	"	"	"
11. TAHAMID.	TAHAMID.	SGB.	6h.	15/18KVA.
	60. BEIDA.	"	"	"
	61. EL TARFA.	"	"	"
	86. SHEWEIRIF.	"	"	"
	87. UMSHADIDA.	"	"	"
	88. MEHEILA.	"	"	"
	89. EL NALA.	"	"	"
	57. SHAKIR.	"	"	"
	*. MANAGIL TOWN.	SEPC.	24h.	-
12. MAATUG.	GORASHI.	SEPC.	24h.	-
	62. MATURAB	"	"	-
	63. EL NUR.	SGB.	6h.	15/18KVA.
	64. ABU HAWA.	"	"	"
	65. KARTOUB.	"	"	"
	66. EL HASHABA.	"	"	"
	67. UMHIGLEIGA.	"	"	"
	71. AFFAN.	"	"	"

GROUP Name.	BLOCK Name.	Supplier.	Supp.hours.	Capacity.
	72. EL HGEIRAT.	SGB.	6h.	15/18KVA.
13. MATURI.	MATURI.	SGB.	6h.	15/18KVA.
	68. AGOUBA.	"	"	"
	69. EL TAMAD.	"	"	"
	70. EL ZAFIR.	"	"	"
	73. EL NAYIR.	"	"	"
	74. EL GEBEL.	"	"	"
	75. RAHAMA.	"	"	"
	76. UMSINEITA.	"	"	"
	77. DISHEINAT.	"	"	"
14. GAMUSI.	GAMUSHI.	SGB.	18h.	Two Engines.
	78. EL RADI.	"	6h.	15/18KVA.
	79. GABOUGA.	"	"	"
	80. ABU EL KEILIK.	"	"	"
	81. RANJOUK.	"	"	"
	82. TUWEMAT.	"	"	"
	99. KUWAIT.	"	"	"
	100. WAGEIALLA.	"	"	"
	101. SAGADI.	"	"	"
	102. EL WAHA.	"	"	"

* SGB.: SUDAN GEZIRA BOARD.
SEPC.: SUDAN ELECTRIC POWER CORPORATION.

ANNEX 7-(1) Conceptual Outline of Switching Network Plan

1. Selection of Digital Switching Equipment

The existing telecommunication network in Sudan is composed of analog equipment except for Khartoum international/ national switching system.

For Gezira communications network switching equipment, selection is for digital switching equipment. The reasons are:

A. Application

1) Required floor space is small.
2) Mechanical moving elements are almost nil. Hence high proofing to dirt and dust including sand dust.
3) Remote line concentrator can be used (provided that transmission line also is digitalized).
4) Adaptability to new services.
5) Technical compatibility with PCM transmission.

B. Functions

1) Self-diagnosis system.
2) High reliability of parts and components, as well as whole system.
3) Dialogic maintenance with man-machine language.

STPC's Master Plan, for its part, indicates that switching equipment to be newly introduced in Sudan from now forward will be the digital type.

2. Switching Equipment Classification

Switching equipment is divided functionally into the following two main categories:

- o Master Exchange, to be established in Barakat.
- o Satellite Exchange, as digital concentrator to be remote controlled by Master Exchange's central control system. Satellite Exchange is to held necessary minimum stand-alone function.

All switching equipment will be the container type.

ANNEX 7-(2) Method of Calculation for Circuits Required

1. Preconditions of Calculation

1) Subscriber Originated Calling Rate
(By STPC's Master Plan)

o Barakat, Hasaheisa, Bagier and Gorashi area

Subscribers: 0.055 Erl.

Breakdown:

Calls in the same area: 0.038 Erl.

Calls in Gezira telecommunication network : 0.005 Erl.

Calls in public communication network (toll calls) : 0.012 Erl.

o Other RCS accommodated subscribers: 0.045 Erl.

Breakdown:

Calls in Gezira telecommunication network : 0.045 Erl.

Calls in public communication network (toll calls) : See note below.

Note: Toll connections are admitted to only 5% of total subscribers. Calling rate (20%) is to rank next to that of Barakat subscribers, but is negligible at present.

2) Call Loss Probability

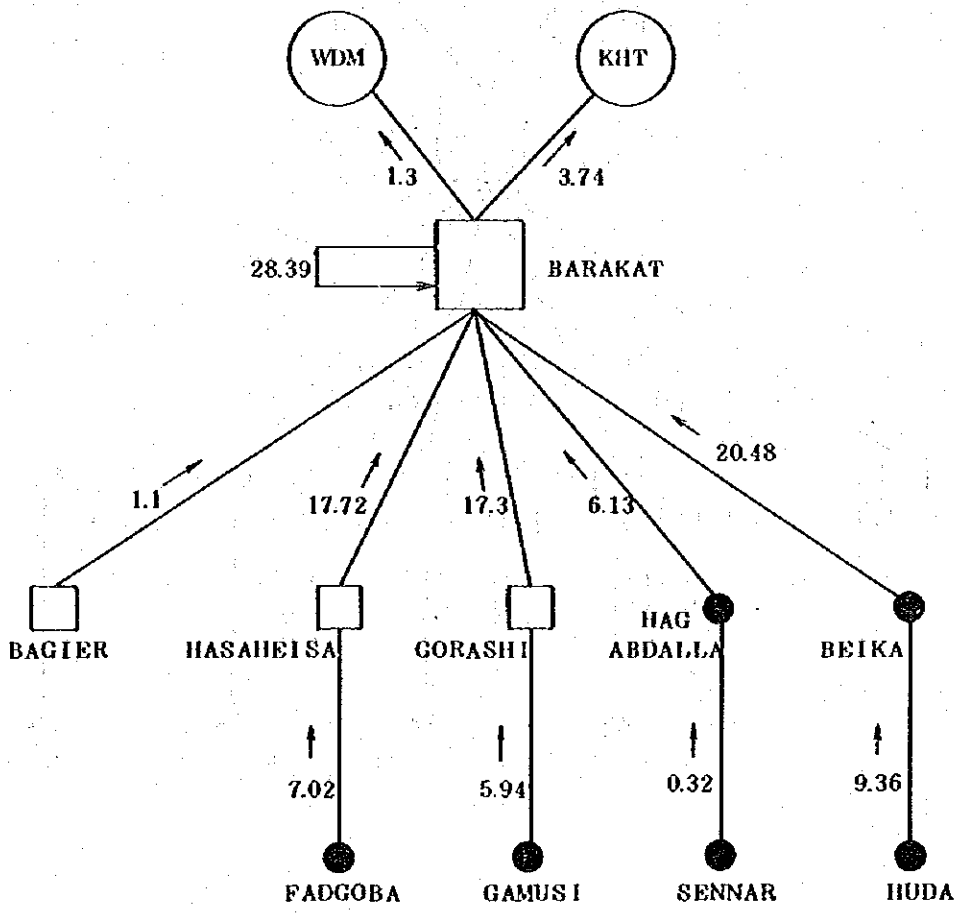
o Between RLC (Remote Line Concentrator) and Master Exchange: 0.01
(To all originating and terminating calls)

o Outgoing and incoming circuit at Master Exchange: 0.01

3) Number of Terminals Installed

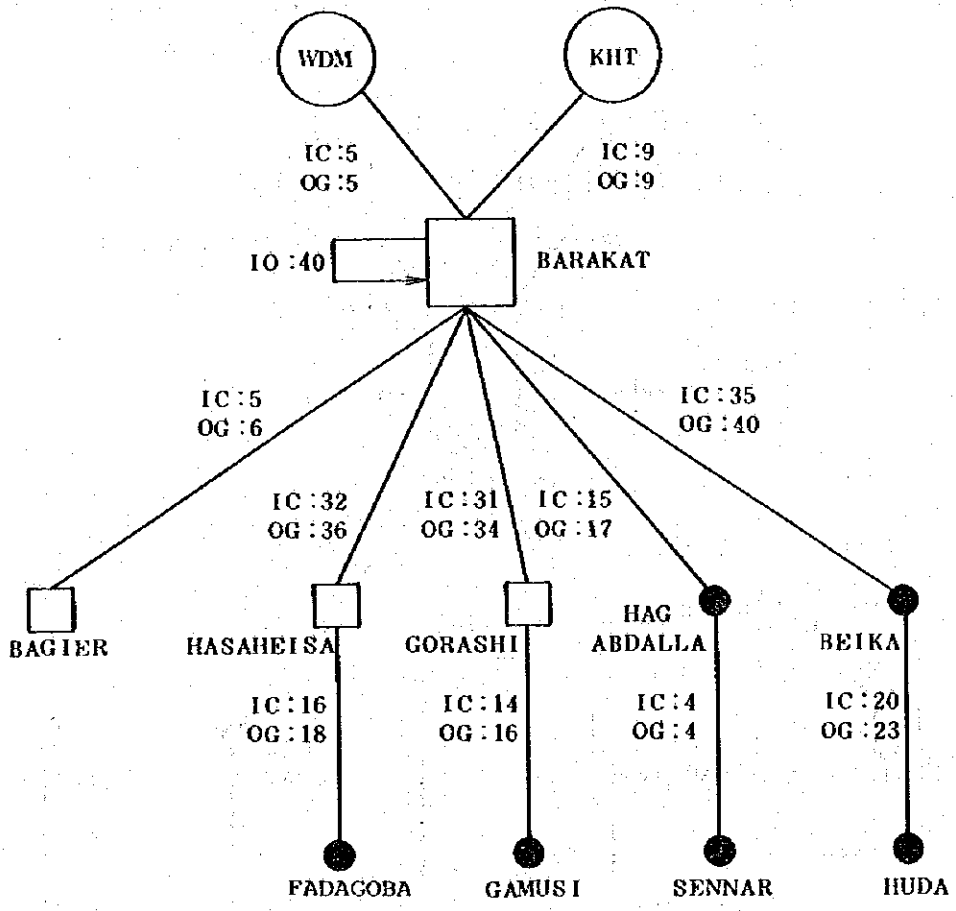
o Bagier RLC:	20	(Cable Sub)
(Total)	(20)	
o Hasaheisa RCL:	162	(Hasaheisa RCS - Sub)
	156	(Fadgode RCS - Sub)
	62	(Cable Sub)
(Total)	(380)	
o Gorashi RLC:	132	(Gamusi RCS - Sub)
	190	(Gorashi RCS - Sub)
	51	(Cable Sub)
(Total)	(373)	
o Barakat (Master):	208	(Huda RCS - Sub)
	247	(Beika RCS - Sub)
	7	(Sennar UHF - Sub)
	129	(Hag Abdalla RCS - Sub)
	250	(Barakat SGB HQ)
	50	(Meringan Area)
	20	(Wad Medani MOI)
(Total)	(911)	

4) Traffic Flow



Note: The same traffic volume is applied to outgoing and incoming calls

5) Circuit Requirement Diagram



Supplement

1. OG circuits from all exchanges are to have one spare circuit per 100 subscribers. This spare circuit is to be used as OG circuit to General Service Desk (directory service, etc.) to be established in Barakat Master Exchange (though not granted special circuit class).

2. Sennar is the main dam point in Gezira irrigation area and maintains intimate contacts with Khartoum and Barakat. Therefore, both OG and IC circuits are to hold capacity to spare.

3. Calls between terminals in the same remote exchange area are via Barakat if RLC is without switching function. This means that intra-RLC calls go and return on the transmission line to/from Barakat. Business messages by telephone are usually transferred to higher and higher positions so that intra-RLC business calls are supposed to be few. However, in the calculation of circuits required, call traffic is increased 20% and call loss rate of 0.01 is used. (Calls, this time, are considered to be intra-office calls so that the applicable call loss rate is 0.02.)

ANNEX 7-(3) Comparison between Alternative and Original Plans

This ANNEX presents comparison, in initial expenses required, between RCS system alternative plan as shown in Chapter II, Figure II-6, and the original plan.

1. Technical Conditions

When all RC system subscribers (1,224) are accommodated in four base stations, each having coverage area of 50 km in radius, as shown in Figure 1, the result is as per Table 1. Circuits diagrams formulated, based on the number of circuits required obtained by the same conditions as in the original plan, appear in Figure 2 and Figure 3.

For RCS system tower height also, the height that covers 50 km in radius is calculated under the same radio propagation conditions as in the original plan. The result obtained is given in Figure 4. Path profile and system performance calculation result are in Figure 5 and Table 2, respectively.

2. Comparison of Initial Expenses

Calculation of initial expenses required is made, excluding the following items common to both the original and alternative plans:

1) Telephone exchanges
2) Outside plant
3) Spare parts
4) Measuring equipment
5) Inland transportation
6) Field survey expense
7) Training expense

As far as initial expenses required are concerned, there is no much difference between both plans.

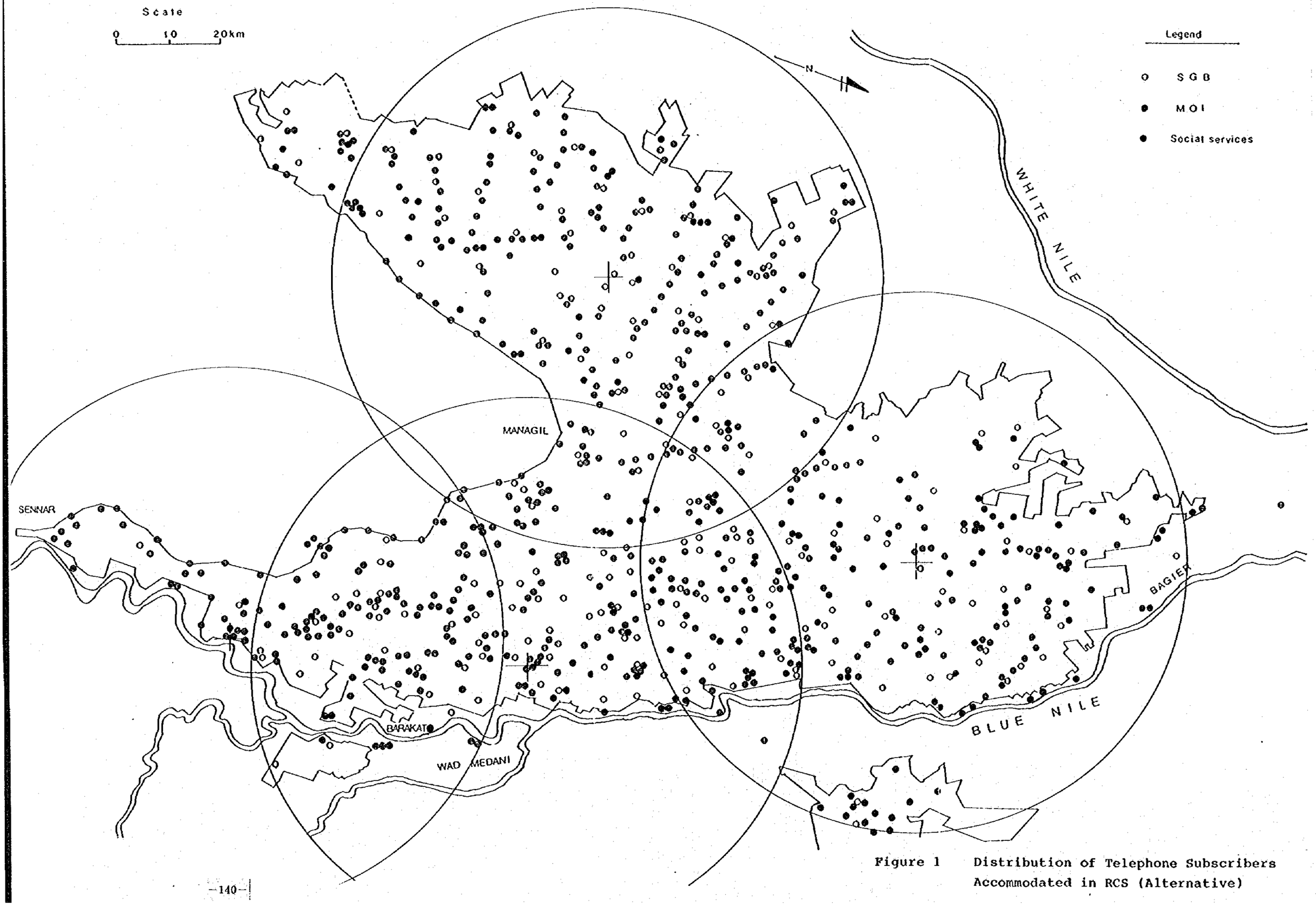


Figure 1 Distribution of Telephone Subscribers Accommodated in RCS (Alternative)

Table 1 Number of RCS Subscribers Accommodated in Each Base Station (Alternative)

Base St Name	SGB	MOI	Social Services	Total
Roweina	128	111	107	346
Beika	115	94	58	267
Hag Abdalla	53	92	30	175
Gorashi	188	181	67	436
Total	484	478	262	1224

Table 2 UHF Link Noise Performance (Alternative)

Path Number		1	2	3
Item	Unit	BAGIER RENEINA	RENEINA HASAHEISA	HASAHEISA BEIKA
Radio Frequency	MHz	2000.0	2000.0	2000.0
Ch Capacity	Ch	240	240	240
Rx Noise Figure	dB	4.0	4.0	4.0
Br Filter Loss	dB	5.0	5.0	5.0
IF Bandwidth	MHz	9.00	9.00	9.00
Path Distance	km	51.50	42.10	38.20
Path Condition	-	Plain	Plain	Plain
Free Space Loss	dB	132.7	131.0	130.1
Antenna Diameter (1)	m	4.0	4.0	4.0
Antenna Diameter (2)	m	4.0	4.0	4.0
Antenna Gain (1)	dBi	34.0	34.0	34.0
Antenna Gain (2)	dBi	34.0	34.0	34.0
Tx Output Power	dBm	25.0	25.0	25.0
Feeder Loss per meter	dB/m	0.045	0.045	0.045
Feeder Length (1)	m	92.0	75.0	70.0
Feeder Length (2)	m	92.0	75.0	70.0
Feeder Loss	dB	8.3	6.8	6.3
Rx Input Level	dBm	-53.0	-49.7	-48.4
C/N in Free Space (thermal)	dB	47.3	50.6	51.9
Required Thermal C/N	dB	20.0	20.0	20.0
Fading Margin	dB	27.3	30.6	31.9
Fading Probability	-	2.18E-03	1.07E-03	7.65E-04
Reliability	-	8.12E-06	1.88E-06	9.95E-07

Path Number		4	5	6
Item	Unit	BEIKA BARAKAT	BARAKAT HAGABDALLA	GORASHI HANAGIL
Radio Frequency	MHz	2000.0	2000.0	2000.0
Ch Capacity	Ch	240	240	240
Rx Noise Figure	dB	4.0	4.0	4.0
Br Filter Loss	dB	5.0	5.0	5.0
IF Bandwidth	MHz	9.00	9.00	9.00
Path Distance	km	15.60	40.00	26.30
Path Condition	-	Plain	Plain	Plain
Free Space Loss	dB	122.3	130.5	126.9
Antenna Diameter (1)	m	2.0	4.0	3.3
Antenna Diameter (2)	m	2.0	4.0	3.3
Antenna Gain (1)	dBi	28.0	34.0	32.5
Antenna Gain (2)	dBi	28.0	34.0	32.5
Tx Output Power	dBm	25.0	25.0	25.0
Feeder Loss per meter	dB/m	0.045	0.045	0.045
Feeder Length (1)	m	38.0	73.0	53.0
Feeder Length (2)	m	38.0	73.0	53.0
Feeder Loss	dB	3.4	6.6	4.8
Rx Input Level	dBm	-49.8	-49.1	-46.6
C/N in Free Space (thermal)	dB	50.5	51.2	53.6
Required Thermal C/N	dB	20.0	20.0	20.0
Fading Margin	dB	30.5	31.2	33.6
Fading Probability	-	3.33E-05	8.99E-04	2.07E-04
Reliability	-	5.90E-08	1.36E-06	1.79E-07

Path Number		7	8	
Item	Unit	MANAGIL BEIKA	WADMEDANI BARAKAT	
Radio Frequency	MHz	2000.0	2000.0	
Ch Capacity	Ch	240	240	
Rx Noise Figure	dB	4.0	4.0	
Br Filter Loss	dB	5.0	5.0	
IF Bandwidth	MHz	9.00	9.00	
Path Distance	km	50.00	9.10	
Path Condition	-	Plain	Plain	
Free Space Loss	dB	132.5	117.7	
Antenna Diameter (1)	m	4.0	2.0	
Antenna Diameter (2)	m	4.0	2.0	
Antenna Gain (1)	dBi	34.0	28.0	
Antenna Gain (2)	dBi	34.0	28.0	
Tx Output Power	dBm	25.0	25.0	
Feeder Loss per meter	dB/m	0.045	0.045	
Feeder Length (1)	m	90.0	31.0	
Feeder Length (2)	m	90.0	31.0	
Feeder Loss	dB	8.1	2.8	
Rx Input Level	dBm	-52.6	-44.4	
C/N in Free Space (thermal)	dB	47.7	55.8	
Required Thermal C/N	dB	20.0	20.0	
Fading Margin	dB	27.7	35.8	
Fading Probability	-	1.96E-03	5.05E-06	
Reliability	-	6.62E-06	2.63E-09	

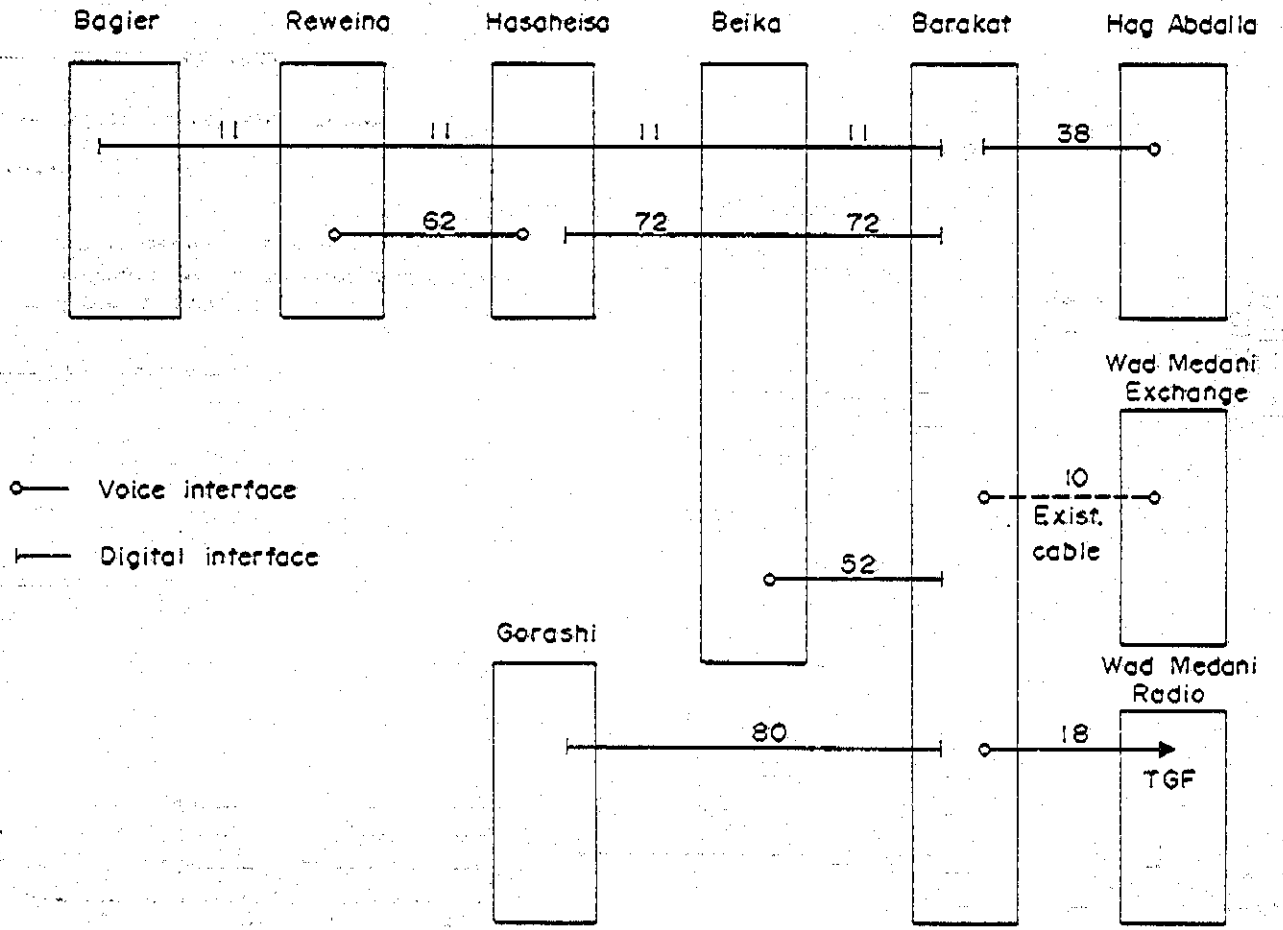


Figure 2 Number of Circuits Required (Alternative)

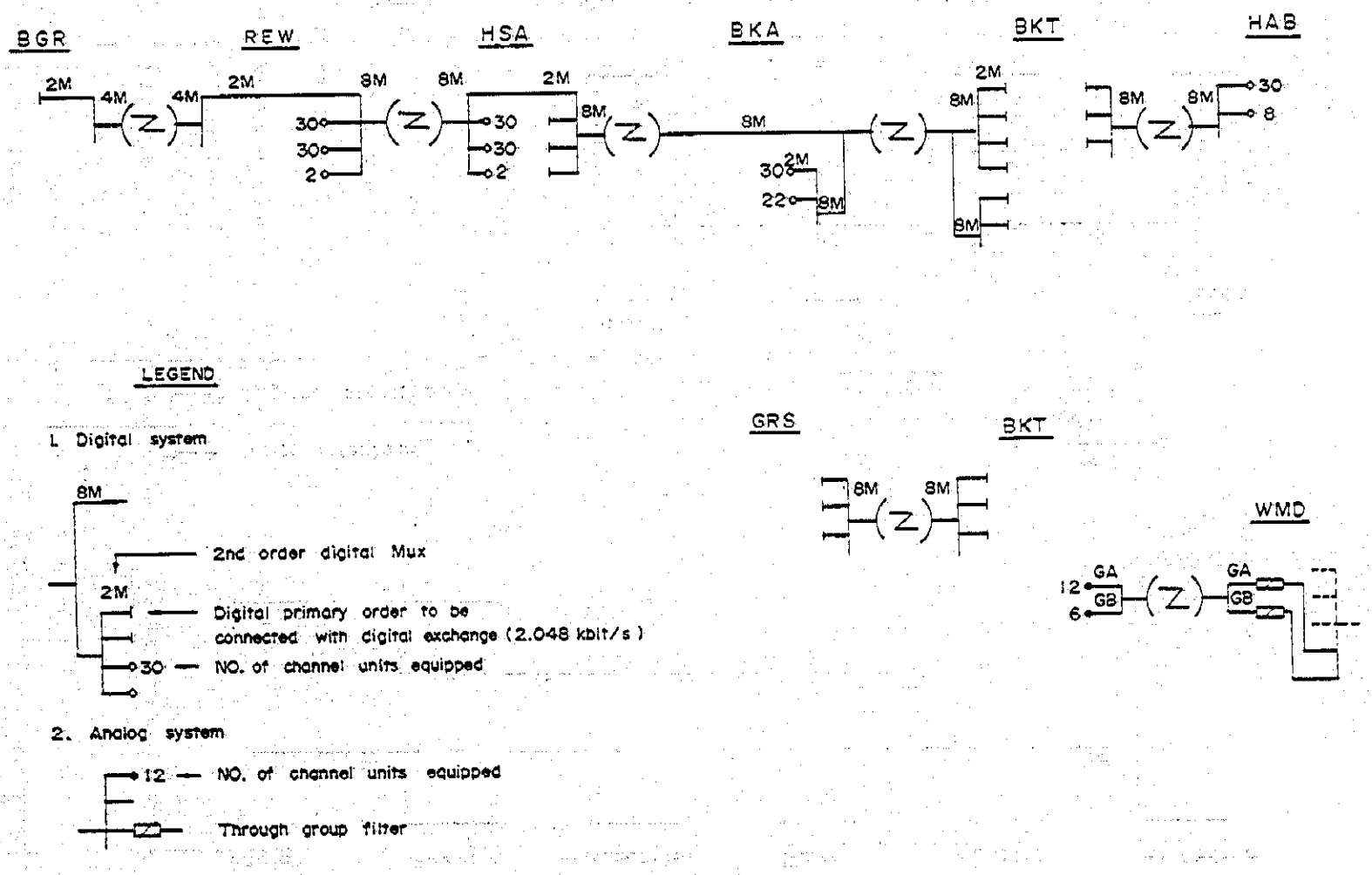


Figure 3 Channel Accommodation Plan (Alternative)

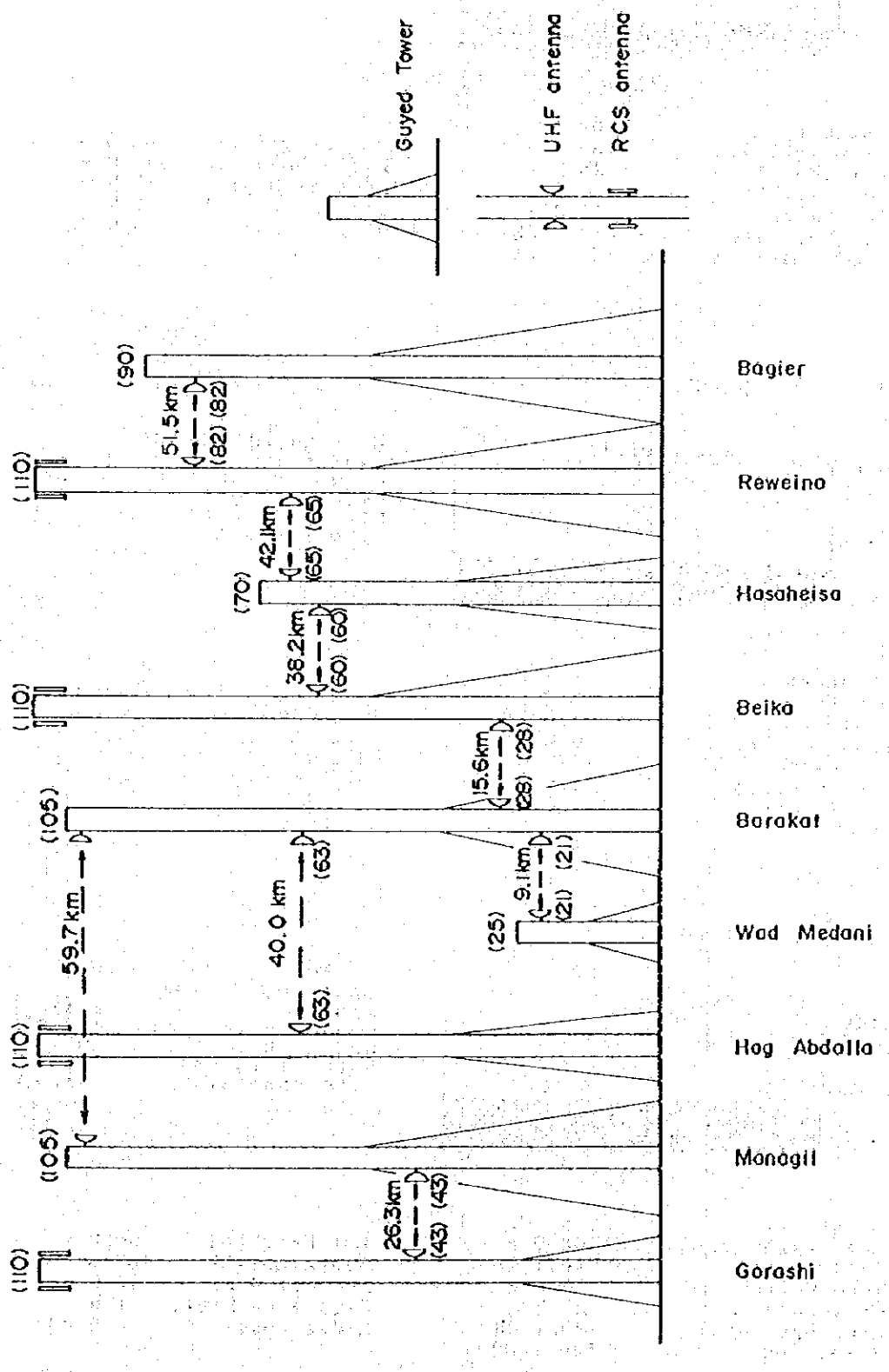
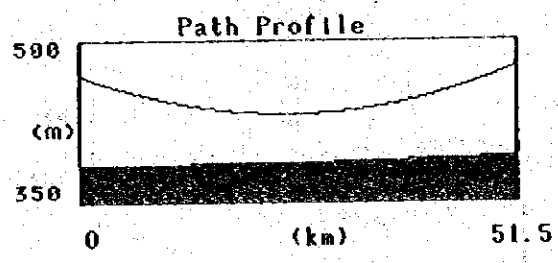


Figure 4 Antena Tower Height (Alternative)

File Name:BGRREN

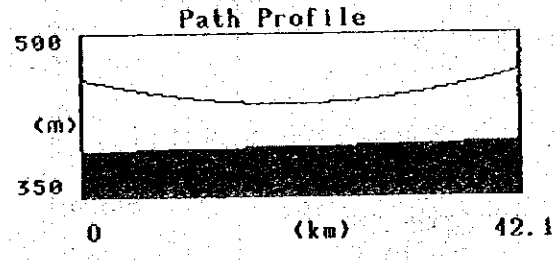


BAGIER--RENEINA

Radius :	1.33
Ground Height 1:	385.0m
Ground Height 2:	393.0m
Path Distance:	51.5KM
T.Roughness:	1.0m

Frequency:	2000 MHz		
Ant Height 1:	82.0 m	Ant Height 2:	82.0 m
Critc Point:	25.6 km	Ridge Height:	387.0 m
Tree Height:	0.0 m	Fresnel Dip:	43.9 m
Clearance:	44.8 m	Clearance Fact:	1.0
Free Spc Loss:	132.7 dB	Ridge Loss:	0.0 dB
Total Loss:	132.7 dB		

File Name:RENHSA

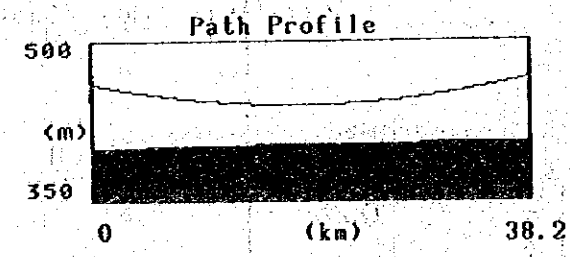


RENEINA--HASAHEISA

Radius :	1.33
Ground Height 1:	393.0m
Ground Height 2:	400.0m
Path Distance:	42.1KM
T.Roughness:	1.0m

Frequency:	2000 MHz		
Ant Height 1:	65.0 m	Ant Height 2:	65.0 m
Critc Point:	21.1 km	Ridge Height:	396.5 m
Tree Height:	0.0 m	Fresnel Dip:	39.7 m
Clearance:	38.9 m	Clearance Fact:	1.0
Free Spc Loss:	131.0 dB	Ridge Loss:	0.0 dB
Total Loss:	131.0 dB		

File Name:HSABKA



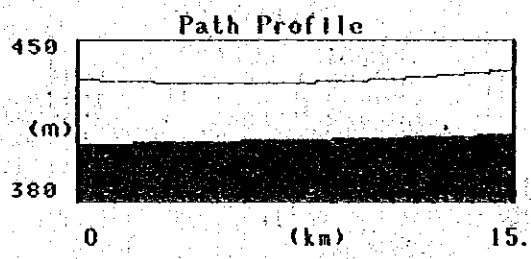
HASAHEISA--BEIKA

Radius :	1.33
Ground Height 1:	400.0m
Ground Height 2:	405.0m
Path Distance:	38.2KM
T.Roughness:	1.3m

Frequency:	2000 MHz		
Ant Height 1:	60.0 m	Ant Height 2:	60.0 m
Critc Point:	19.1 km	Ridge Height:	402.5 m
Tree Height:	0.0 m	Fresnel Dip:	37.8 m
Clearance:	38.5 m	Clearance Fact:	1.0
Free Spc Loss:	130.1 dB	Ridge Loss:	0.0 dB
Total Loss:	130.1 dB		

Figure 5 Path Profiles (Alternative)

File Name:BKABKT

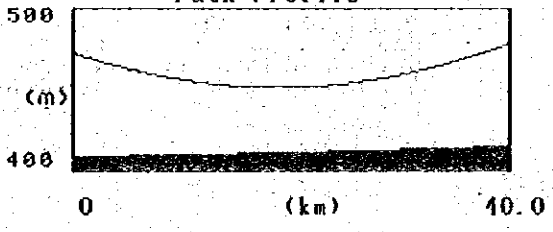


BEIKA--BARAKAT

Radius :	1.33
Ground Height 1:	405.0m
Ground Height 2:	409.0m
Path Distance:	15.6KM
T.Roughness:	1.0m

Frequency:	2000 MHz		
Ant Height 1:	28.0 m	Ant Height 2:	28.0 m
Crite Point:	7.8 km	Ridge Height:	407.0 m
Tree Height:	0.0 m	Fresnel Dip:	24.2 m
Clearance:	24.4 m	Clearance Fact:	1.0
Free Spc Loss:	122.3 dB	Ridge Loss:	0.0 dB
Total Loss:	122.3 dB		

File Name:BKTHAB

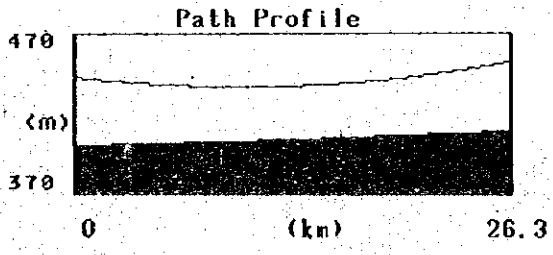


BARAKAT--HAGABDALLA

Radius :	1.33
Ground Height 1:	409.0m
Ground Height 2:	415.0m
Path Distance:	40.0KM
T.Roughness:	1.5m

Frequency:	2000 MHz		
Ant Height 1:	63.0 m	Ant Height 2:	63.0 m
Crite Point:	20.0 km	Ridge Height:	412.0 m
Tree Height:	0.0 m	Fresnel Dip:	38.7 m
Clearance:	38.4 m	Clearance Fact:	1.0
Free Spc Loss:	130.5 dB	Ridge Loss:	0.0 dB
Total Loss:	130.5 dB		

File Name:GORMNG

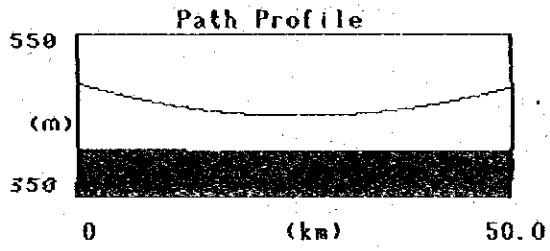


GORASHI--MANAGIL

Radius :	1.33
Ground Height 1:	400.0m
Ground Height 2:	409.0m
Path Distance:	26.3KM
T.Roughness:	2.3m

Frequency:	2000 MHz		
Ant Height 1:	43.0 m	Ant Height 2:	43.0 m
Crite Point:	13.2 km	Ridge Height:	404.5 m
Tree Height:	0.0 m	Fresnel Dip:	31.4 m
Clearance:	32.8 m	Clearance Fact:	1.0
Free Spc Loss:	126.9 dB	Ridge Loss:	0.0 dB
Total Loss:	126.9 dB		

File Name:MNGBKA

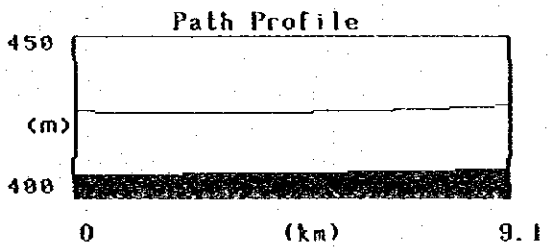


MANAGIL--BEIKA

Radius :	1.33
Ground Height 1:	409.0m
Ground Height 2:	405.0m
Path Distance:	50.0KM
T.Roughness:	1.0m

Frequency:	2000 MHz		
Ant Height 1:	80.0 m	Ant Height 2:	80.0 m
Crite Point:	25.0 km	Ridge Height:	407.0 m
Tree Height:	0.0 m	Fresnel Dip:	43.3 m
Clearance:	43.1 m	Clearance Fact:	1.0
Free Spc Loss:	132.5 dB	Ridge Loss:	0.0 dB
Total Loss:	132.5 dB		

File Name:NMBKT

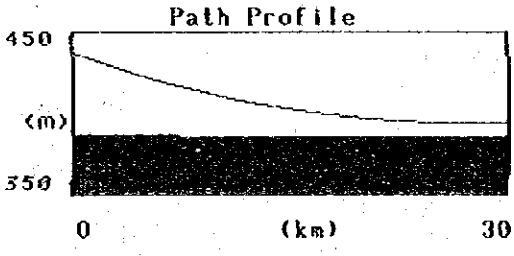


NADXEDANI--BARAKAT

Radius :	1.33
Ground Height 1:	407.0m
Ground Height 2:	409.0m
Path Distance:	9.1KM
T.Roughness:	0.5m

Frequency:	2000 MHz		
Ant Height 1:	20.0 m	Ant Height 2:	20.0 m
Crite Point:	4.6 km	Ridge Height:	408.0 m
Tree Height:	0.0 m	Fresnel Dip:	18.5 m
Clearance:	18.8 m	Clearance Fact:	1.0
Free Spc Loss:	117.7 dB	Ridge Loss:	0.0 dB
Total Loss:	117.7 dB		

File Name:FADSUB

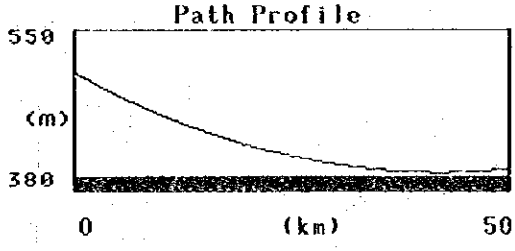


FADGOBA--SUB

Radius :	1.33
Ground Height 1:	387.0m
Ground Height 2:	385.0m
Path Distance:	30.0KM
T.Roughness:	0.5m

Frequency:	400 MHz		
Ant Height 1:	50.0 m	Ant Height 2:	10.0 m
Critc Point:	15.0 km	Ridge Height:	386.0 m
Tree Height:	0.0 m	Fresnel Dip:	75.0 m
Clearance:	16.7 m	Clearance Fact:	0.2
Free Spc Loss:	114.0 dB	Ridge Loss:	3.3 dB
Total Loss:	117.4 dB		

File Name:SAMSUB



SAMPLE--SUB1

Radius :	1.33
Ground Height 1:	395.0m
Ground Height 2:	395.0m
Path Distance:	50.0KM
T.Roughness:	0.0m

Frequency:	400 MHz		
Ant Height 1:	110.0 m	Ant Height 2:	10.0 m
Critc Point:	25.0 km	Ridge Height:	395.0 m
Tree Height:	0.0 m	Fresnel Dip:	96.8 m
Clearance:	23.1 m	Clearance Fact:	0.2
Free Spc Loss:	118.5 dB	Ridge Loss:	3.1 dB
Total Loss:	121.6 dB		

Coordinater and Elevation of Station Site

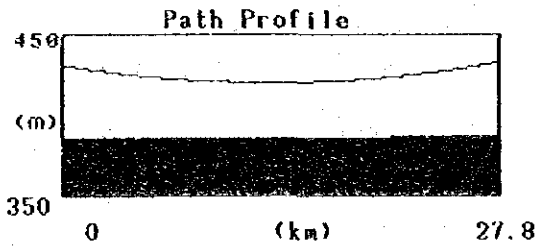
Site No.	Site Name	Elevation (m)	Coordinates	
			Longitude	Latitude
1	Bagier	385	32°45'08"E	15°20'42"N
2	Fadgoba	387	32°48'21"E	15°05'58"N
3	Reweina	393	32°58'12"E	14°55'49"N
4	Hasaheisa	400	33°17'59"E	14°43'31"N
5	Beika	405	33°25'42"E	14°24'11"N
6	Barakat	409	33°32'38"E	14°19'02"N
7	Hag Abdalla	415	33°35'07"E	13°57'34"N
8	Sennar	423	33°38'01"E	13°32'42"N
9	Gamusi	390	32°36'07"E	13°45'24"N
10	Gorashi	400	32°45'00"E	14°14'03"N
11	Managil	409	32°59'35"E	14°14'48"N
12	Huda	397	32°55'42"E	14°32'46"N
13	Wad Medani	407	33°33'38"E	14°24'12"N

Azimuth and Path Distance

Path No.	Radio Path	Distance (km)	Azimuth	
			Forward	Backward
1-2	Bagier Fadgoba	27.8	168°01'26"	348°02'16"
2-3	Fadgoba Reweina	25.6	136°39'03"	316°41'30"
3-4	Reweina Hasaheisa	42.1	122°32'28"	302°37'31"
4-5	Hasaheisa Beika	38.2	158°44'22"	338°46'15"
5-6	Beika Barakat	15.6	127°17'18"	307°19'05"
6-7	Barakat Hag Abdalla	40.0	173°33'14"	353°33'50"
7-8	Hag Abdalla Sennar	46.2	173°29'26"	353°30'07"
9-10	Gamusi Gorashi	55.2	16°49'37"	196°51'45"
10-11	Gorashi Managil	26.3	86°57'01"	267°00'34"
11-6	Managil Barakat	59.7	82°26'57"	262°35'03"
12-5	Huda Beika	56.2	106°18'04"	286°25'31"
13-6	Wad Medani Barakat	9.1	190°41'19"	10°41'04"
11-5	Managil Beika	50.0	69°43'04"	249°49'28"

Path No.	Radio Path	Distance (km)	Azimuth	
			Forward	Backward
1-2	Bagier Padgoba	51.5	152°56'45"	333°00'10"
2-3	Reweina Hasaheisa	42.1	122°32'28"	302°37'31"
3-4	Hasaheisa Beika	38.2	158°44'22"	338°46'15"
4-5	Beika Barakat	15.6	127°17'18"	307°19'05"
5-6	Barakat Hag Abdalla	40.0	173°33'14"	353°33'50"
7-8	Gorashi Managil	26.3	86°57'01"	267°00'34"
8-4	Managil Beika	50.0	69°43'04"	249°49'28"
9-5	Wad Medani Barakat	9.1	190°41'19"	10°41'04"

File Name:BEGFAD

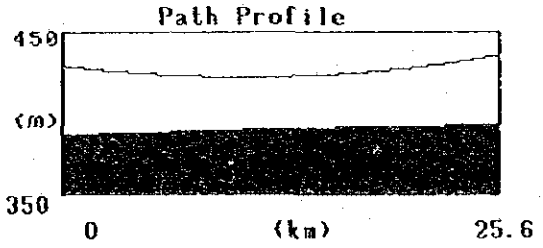


BEGIER--FADGOBA

Radius :	1.33
Ground Height 1:	385.0m
Ground Height 2:	387.0m
Path Distance:	27.8KM
T.Roughness:	0.5m

Frequency:	2000 MHz		
Ant Height 1:	45.0 m	Ant Height 2:	45.0 m
Critc Point:	13.9 km	Ridge Height:	386.0 m
Tree Height:	0.0 m	Fresnel Dip:	32.3 m
Clearance:	33.6 m	Clearance Fact:	1.0
Free Spc Loss:	127.4 dB	Ridge Loss:	0.0 dB
Total Loss:	127.4 dB		

File Name:FADREN

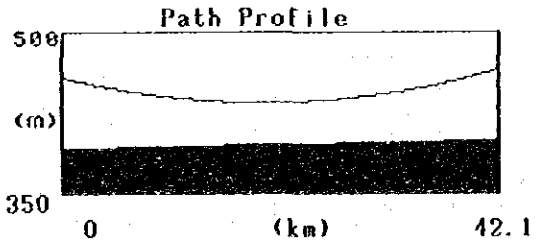


FADGOBA--RENEINA

Radius :	1.33
Ground Height 1:	387.0m
Ground Height 2:	393.0m
Path Distance:	25.6KM
T.Roughness:	1.5m

Frequency:	2000 MHz		
Ant Height 1:	42.0 m	Ant Height 2:	42.0 m
Critc Point:	12.8 km	Ridge Height:	390.0 m
Tree Height:	0.0 m	Fresnel Dip:	31.0 m
Clearance:	32.3 m	Clearance Fact:	1.0
Free Spc Loss:	126.6 dB	Ridge Loss:	0.0 dB
Total Loss:	126.6 dB		

File Name:RENHAS



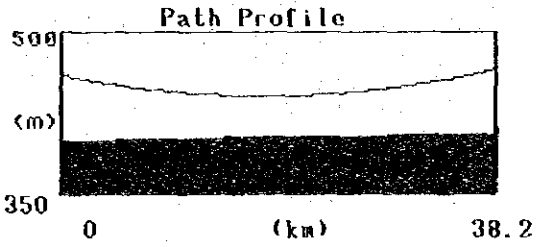
RENEINA--HASAHEISA

Radius :	1.33
Ground Height 1:	393.0m
Ground Height 2:	400.0m
Path Distance:	42.1KM
T.Roughness:	1.8m

Frequency:	2000 MHz		
Ant Height 1:	65.0 m	Ant Height 2:	65.0 m
Critc Point:	21.1 km	Ridge Height:	396.5 m
Tree Height:	0.0 m	Fresnel Dip:	39.7 m
Clearance:	38.9 m	Clearance Fact:	1.0
Free Spc Loss:	131.0 dB	Ridge Loss:	0.0 dB
Total Loss:	131.0 dB		

Path Profiles (Orginal)

File Name:HASBEI

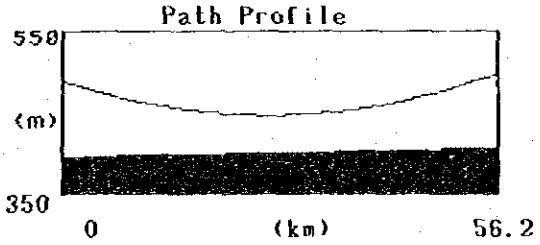


HASAHEISA--BEIKA

Radius :	1.33
Ground Height 1:	400.0m
Ground Height 2:	405.0m
Path Distance:	38.2KM
T.Roughness:	1.3m

Frequency:	2000 MHz		
Ant Height 1:	60.0 m	Ant Height 2:	60.0 m
Critc Point:	19.1 km	Ridge Height:	402.5 m
Tree Height:	0.0 m	Fresnel Dip:	37.8 m
Clearance:	38.5 m	Clearance Fact:	1.0
Free Spc Loss:	130.1 dB	Ridge Loss:	0.0 dB
Total Loss:	130.1 dB		

File Name:HUDBEI

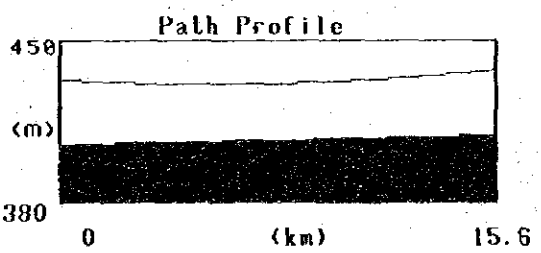


HUDA--BEIKA

Radius :	1.33
Ground Height 1:	397.0m
Ground Height 2:	405.0m
Path Distance:	56.2KM
T.Roughness:	2.0m

Frequency:	2000 MHz		
Ant Height 1:	93.0 m	Ant Height 2:	93.0 m
Critc Point:	28.1 km	Ridge Height:	401.0 m
Tree Height:	0.0 m	Fresnel Dip:	45.9 m
Clearance:	46.4 m	Clearance Fact:	1.0
Free Spc Loss:	133.5 dB	Ridge Loss:	0.0 dB
Total Loss:	133.5 dB		

File Name:BEIBAR

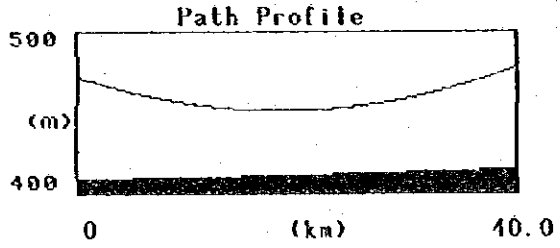


BEIKA--BAKARAT

Radius :	1.33
Ground Height 1:	405.0m
Ground Height 2:	409.0m
Path Distance:	15.6KM
T.Roughness:	1.0m

Frequency:	2000 MHz		
Ant Height 1:	28.0 m	Ant Height 2:	28.0 m
Critc Point:	7.8 km	Ridge Height:	407.0 m
Tree Height:	0.0 m	Fresnel Dip:	24.2 m
Clearance:	24.4 m	Clearance Fact:	1.0
Free Spc Loss:	122.3 dB	Ridge Loss:	0.0 dB
Total Loss:	122.3 dB		

File Name:BARHAG

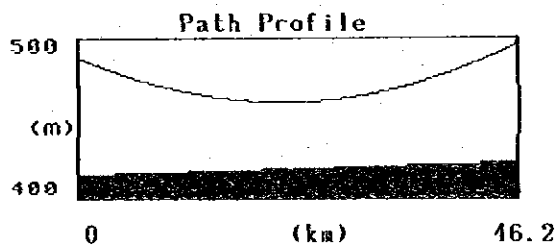


BARAKAT--HAGABDALLA

Radius :	1.33
Ground Height 1:	409.0m
Ground Height 2:	415.0m
Path Distance:	40.0KM
T.Roughness:	1.5m

Frequency:	2000 MHz		
Ant Height 1:	63.0 m	Ant Height 2:	63.0 m
Critc Point:	20.0 km	Ridge Height:	412.0 m
Tree Height:	0.0 m	Fresnel Dip:	38.7 m
Clearance:	39.4 m	Clearance Fact:	1.0
Free Spc Loss:	130.5 dB	Ridge Loss:	0.0 dB
Total Loss:	130.5 dB		

File Name:HAGSEN

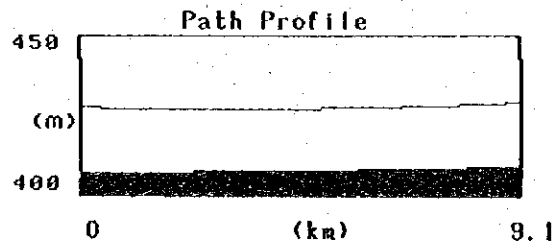


HAGABDALLA--SENNER

Radius :	1.33
Ground Height 1:	415.0m
Ground Height 2:	423.0m
Path Distance:	46.2KM
T.Roughness:	2.0m

Frequency:	2000 MHz		
Ant Height 1:	73.0 m	Ant Height 2:	73.0 m
Critc Point:	23.1 km	Ridge Height:	419.0 m
Tree Height:	0.0 m	Fresnel Dip:	41.6 m
Clearance:	41.5 m	Clearance Fact:	1.0
Free Spc Loss:	131.8 dB	Ridge Loss:	0.0 dB
Total Loss:	131.8 dB		

File Name:NADBAR

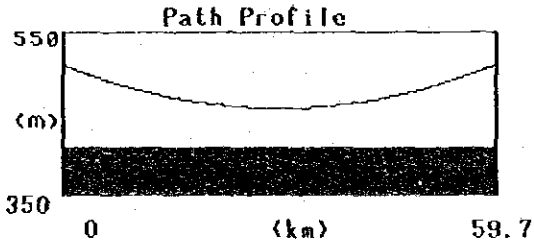


NADVEDANI--BARAKAT

Radius :	1.33
Ground Height 1:	407.0m
Ground Height 2:	409.0m
Path Distance:	9.1KM
T.Roughness:	0.5m

Frequency:	2000 MHz		
Ant Height 1:	20.0 m	Ant Height 2:	20.0 m
Critc Point:	4.6 km	Ridge Height:	408.0 m
Tree Height:	0.0 m	Fresnel Dip:	18.5 m
Clearance:	18.8 m	Clearance Fact:	1.0
Free Spc Loss:	117.7 dB	Ridge Loss:	0.0 dB
Total Loss:	117.7 dB		

File Name:NANBAR

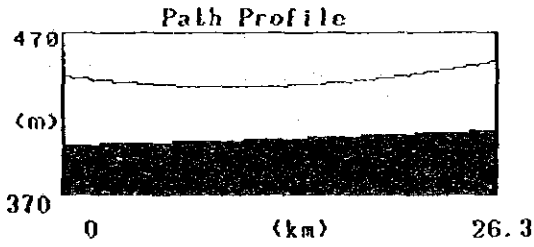


YANAGIL--BAKARAT	
Radius :	1.33
Ground Height 1:	409.0m
Ground Height 2:	409.0m
Path Distance:	59.7KM
T.Roughness:	0.0m

Frequency:	2000 MHz
Ant Height 1:	100.0 m
Critc Point:	29.9 km
Tree Height:	0.0 m
Clearance:	47.4 m
Free Spc Loss:	134.0 dB
Total Loss:	134.0 dB

Ant Height 2:	100.0 m
Ridge Height:	409.0 m
Fresnel Dip:	47.3 m
Clearance Fact:	1.0
Ridge Loss:	0.0 dB

File Name:GORMAN

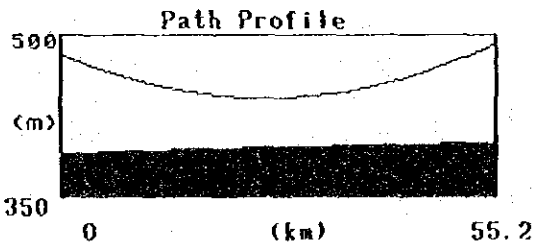


GORASHI--YANAGIL	
Radius :	1.33
Ground Height 1:	400.0m
Ground Height 2:	409.0m
Path Distance:	26.3KM
T.Roughness:	2.3m

Frequency:	2000 MHz
Ant Height 1:	43.0 m
Critc Point:	13.2 km
Tree Height:	0.0 m
Clearance:	32.8 m
Free Spc Loss:	126.9 dB
Total Loss:	126.9 dB

Ant Height 2:	43.0 m
Ridge Height:	404.5 m
Fresnel Dip:	31.4 m
Clearance Fact:	1.0
Ridge Loss:	0.0 dB

File Name:GAMGOR



GAMUSHI--GORASHI	
Radius :	1.33
Ground Height 1:	390.0m
Ground Height 2:	400.0m
Path Distance:	55.2KM
T.Roughness:	2.5m

Frequency:	2000 MHz
Ant Height 1:	91.0 m
Critc Point:	27.6 km
Tree Height:	0.0 m
Clearance:	46.0 m
Free Spc Loss:	133.3 dB
Total Loss:	133.3 dB

Ant Height 2:	91.0 m
Ridge Height:	395.0 m
Fresnel Dip:	45.5 m
Clearance Fact:	1.0
Ridge Loss:	0.0 dB

ANNEX 7-(5) Solar Battery System Application

Following is the case where solar battery system is applied to RCS subscriber station:

(1) Calculation of Required Solar Battery Output (Ps)

Required solar battery output (Ps) is obtained by the following formula:

$$Ps = Vm \times I\ell \times \frac{24\ Hr}{Q/(100\ mW/cm^2)} \times \frac{1}{\eta} \times D \times P \times Sf$$

where

Ps : Required solar battery output (W)

Vm : Optimum operating voltage for solar battery (V)

$I\ell$: Total load current

Q : Annual average of inclined sunlight energy per day ($mWH/cm^2/day$)
(In Gezira area, Sudan: 546)

η : Storage battery charge-discharge efficiency (= 0.9)

D : Correction coefficient for solar battery output degradation due to aging (= 1.05)

P : Light transmission degradation coefficient (= 1.02)

Sf : Safety factor (= 1.2)

On assumption of Vm = 16.6 V and $I\ell$ = 0.25 A, Ps at end office proves to be:

$$Ps = 16.6 \times 0.25 \times \frac{24}{546/100} \times \frac{1}{0.9} \times 1.05 \times 1.02 \times 1.2$$
$$\fallingdotseq 26\ (W)$$

In other words, when mean load power at subscriber station is 3 W (= 12 V x 0.25 A), required solar battery output is 26 W.

(2) Calculation of Secondary Battery Capacity (C)

Secondary storage battery capacity (C) is obtained by the following formula:

$$C = \frac{I\ell \times 24\ H \times D}{Ft}$$

where

C : Secondary storage battery capacity
I ℓ : Mean load consumed current
D : Number of days without sunshine
(In the current project, days without sunshine are assumed to be 10 consecutive days.)
(Since charging current for storage battery is small, active charge as in the case of short time rate charge cannot be expected. Therefore, correction is necessary.)
Ft : Correction coefficient for storage battery capacity decrease due to ambient temperature fluctuation.
(In the case of lead storage battery: 0.85)

On assumption of $I\ell = 0.25$ A, the foregoing calculation formula proves to be:

$$C = \frac{0.25 \times 24 \times 10}{0.85} \fallingdotseq 71 \text{ (AH)}$$

In other words, when mean load consumed power is 3 W, required capacity of 12 V storage battery is 71 AH.

ANNEX 7-(6) Outside Plant Design

1. System Selection for Outside Plant

For the system of outside plant to be adopted in the current project, comparative study was made about overhead cable system and direct buried cable system. Decision is to adopt overhead cable system that uses steel pipe poles.

1) Advantage in Construction Cost

As far as cable cost is concerned, no much difference is found between self-supporting cable to be used for overhead cable system and steel tape armored cable for direct buried cable system. For the former, cost of poles accounts for higher cost.

In the case of direct buried cable system, trench excavation and backfilling are costly. Even if buried cable depth is shallow, and cost is thereby saved, construction cost per unit length is 1.5 to 2 times that of overhead cable system.

2) Safety Study for Line Facilities

Both direct and indirect findings in field survey this time, indicate that the disabled communication network in Sudan reflects to a large extent the collapse of overhead line facilities. In other words, the overhead line facilities that formerly existed were of open wire. When one pole fell down due to line tension, other poles on a considerably long distance also fell down, causing the line to be severed and whole system to be destroyed.

Line facilities to be newly introduced by the current project are of cable system. Furthermore, new line facilities are to be established for a relatively short distance, as in ginning factory compounds, so that collapse hazards are much smaller.

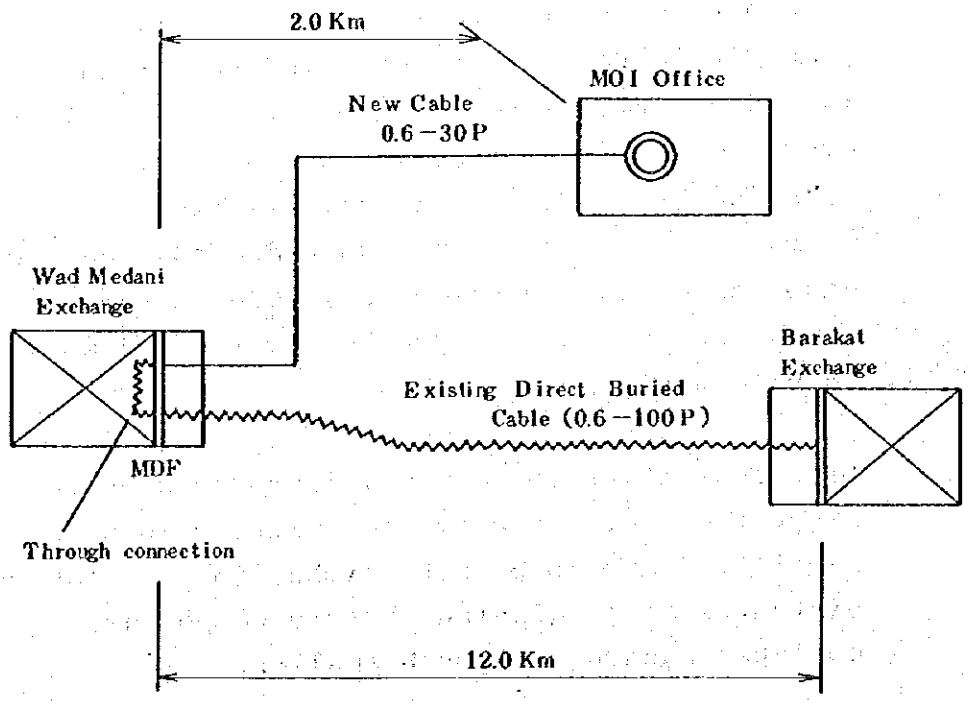
As for direct buried cable system, it is difficult to determine the location where cable burying will not pose impediment for a long time to come. The reason is that no small part of factory sites remain unoccupied at present and nothing definite can be known concerning how such land space will be utilized in the future.

2. Type of Pole

For poles to be used in overhead cable system, STPC's standard practice is to use wooden poles. At present, the most part of those wooden poles are made of imported lumber.

In Japan, Nippon Telephone & Telegraph Public Corporation (NTT) gives first priority to steel pipe poles. This fact shows that steel pipe poles produced in Japan command advantage over wooden poles in both price and quality. Furthermore, considering that in the current project area, no small part of line facilities using wooden poles remain in collapse, it will be advisable to use steel pipe poles, this time, by reason of their long life.

3. Consideration about 20 Circuits for Wad Medani MOI Office



1) Between Wad Medani Exchange and Barakat Exchange, direct buried cable (0.6 mm - 100 P) exists. Out of all 100 P, 75 P are terminated at both ends. (The remaining 25 P are connected to subscribers between both ends.) Out of these 75 P, 33 P are used as trunk circuits, etc., to Was Medani and the remaining 42 P are idle conductors.

2) The existing cable length is about 12.0 km. When the projected new installation for 2.0 km is added, total cable length from Barakat Exchange to MOI Office becomes 14.0 km.

3) With regard to DC loop resistance and line loss, preconditions for the former are conductor diameter: 0.6 mm, non-loaded, and distance: 14.0 km. Line loss is the value at 1,000 Hz.

   a) Study of DC Loop Resistance
      (By approximation formula)

$$R = \frac{1}{58} \cdot \frac{1}{d^2} \times 2 \times 10^3$$ (d: conductor diameter, i.e., 0.6 mm)

$$= 122 \text{ (ohm/km)}$$

$$122 \text{ ohms/km} \times 14.0 \text{ km} \doteqdot 1{,}700 \text{ ohms}$$

Generally, the limit value of subscriber DC resistance of digital electronic switching equipment is 1,800 to 2,000 ohms. Therefore, the above R of about 1,700 ohms is considered not to pose problem.

b) Study of Line Loss
(By approximation formula)

$$a = \sqrt{\frac{\omega \cdot R \cdot C}{2}} \times 8.686 \text{ (dB/km)}$$

where

a : Reduction constant (dB/km)
ω : 2π f (f = 1,000 Hz)
R : 122 ohms/km
C : Electrostatic capacity (50 nF)

$$a = \sqrt{\frac{2\pi \cdot 1{,}000 \cdot 122 \cdot 50 \times 10^{9}}{2}} \times 8.686$$

= 1.202 (dB/km)

1.202 dB/km x 14.0 km = 16.8 dB

Wad Medani MOI Office subscribers will be accommodated directly in Barakat Exchange, a group center, without intermediation of end office.

Therefore, transmission loss distribution between MOI Office and Barakat Exchange consists of 7 dB between subscriber and end office plus 5 dB between end office and group center, totaling 12 dB. The consequent excess of about 5 dB can possibly be eliminated with high loss subscriber relief telephones installed on MOI Office side.

ANNEX 7-(7) Mobile Communication System

(1) Speech Quality

Principal means of speech quality evaluation in mobile radiotelephone system are sound articulation and merit system. In the current project, evaluation by sound articulation, which is commonly used in Japan, will be adopted.

This time, the objective is to secure 80% sound articulation in more than 90% of all Gezira area.

Required receiver input voltage for securing 80% sound articulation is 11 dB μV for down circuit (RCS base station to mobile subscriber unit) and 7 dB μV or more for up circuit (mobile subscriber unit to RCS base station). When 6 dB margin to cope with fading that is caused by mobile subscriber units on the move is taken into consideration, required receiver input voltage becomes 17 dB μV (-96 dBm) for down circuit and 13 dB μV (-100 dBm) for up circuit.

Note: According to experiment in Japan, when city noise is 10 dB μV, required receiver input voltage for dwn circuit is 14 dB μV. However, in Gezira area, noise level is supposed to be extremely low, and is estimated at 5 dB μV. In this case, required receiver input voltage is 11 dB μV.

(2) System Design

System design is practically the same as that of RCS land fixed network. For propagation loss estimation, the following formulas are used:

o Urban area propagation loss, Lp (dB)

$$Lp = 69.55 + 26.16 \log_{10} 10\ fc - 13.82 \log_{10} 10\ hb - a\ (hm) + (44.9 - 6.55 \log 10\ hb) \cdot \log_{10} 10\ R$$

o Suburban area propagation loss, Lps (dB)

$$Lps = Lp - 2 \cdot \{\log_{10} 10\ (fc/28)\}^2 - 5.4$$

o Open area propagation loss, Lpo (dB)

$$Lpo = Lp - 4.78 \cdot (\log 10_{10}\ fc)^2 + 13.88 \log 10_{10}\ fc - 40.94$$

where

fc : *Transmitting frequency (MHz)*
150 MHz $\leq$ fc $\leq$ 1,500 MHz

hb : Transmitting antenna height (m)
30 m $\leq$ hb $\leq$ 200 m

hm : Receiving antenna height (m)
1 m $\leq$ hm $\leq$ 10 m

a(hm): $8.29\ (\log_{10} 10\ 1.54\ hm)^2 - 1.1$ fc $\leq$ 200 MHz

$3.2\ (\log 10_{10}\ 11.75\ hm)^2 - 4.97$ fc $\geq$ 400 MHz

R : Distance from transmitting station (km)
1 km $\leq$ R < 20 km

Gezira Area is supposed to come under the category of suburban area. Therefore, for calculation of radio propagation loss, L_{ps} is used.

From the required receiver input power to secure 80% speech articulation (-96 dBm for down circuit; -100 dBm for up circuit), allowable propagation loss X can be obtained as under.
(Refer to attached table.)

Down circuit:

$X = 44\ dBm - 12\ dB - 3\ dB + 9\ dB + 5\ dB - 1\ dB - 1.5\ dB + 96\ dBm = 136.5\ dB$

Up circuit:

$X = 30\ dBm - 1\ dB + 5\ dB + 9\ dB - 3\ dB + 100\ dBm = 140.0\ dB$

Calculation is made to obtain distance whereat allowable propagation loss for down circuit becomes 136.5 dB when antenna height is 50 m (Fadagoba base station) and 90 m (Gorashi and three other base stations). Calculation results follow:

Equations (1) and (2) be modified to

$$\log_{10}R = [136.5 - 69.55 - 26.16 \cdot \log fc + 13.82 \cdot \log hb + (3.2 (\log_{10}11.75 \times hm) - 4.97) + 2 \times (\log_{10}(fc/28))^2 + 5.4] / (44.9 - 6.55 \log_{10}hb) \quad \ldots\ldots\ldots\ldots\ldots \quad (4)$$

and fc = 400 MHz, hb = 50 m and hm = 1.5 m be substituted. Then, the result is

$$\log_{10}R = [136.5 - 69.55 - 26.16 \cdot \log_{10}400 + 13.82 \cdot \log_{10}50 + (3.2 (\log_{10}(400/28))^2 + 5.4]/(44.9 - 6.55 \cdot \log_{10}50) = 30.43/33.77 = 0.9$$

$$\therefore R = 10^{0.9} = 7.96 \fallingdotseq 8\ (km)$$

Likewise, in the case of hb = 90 m, R proves to be 11 km.

Meanwhile, when speech articulation is lowered to 70%, available propagation distances by antenna heights of 50 m and 90 m are 11 km and 17 km, respectively.

The mobile telephone system, this time, is for institutional use so that speech articulation of 70% or vicinity is supposed to be no impediment to service. This fact shows that the service area of the proposed mobile telephone system is 11-17 km in radius with base station in the center, and that even at a location beyond 17 km mentioned, communication is possible if the mobile subscriber unit is at halt.

Item	1		2	
	Base transmit	Base receive	Base transmit	Base receive
Min.Rx input power	-	-	-	-
Down side (dBm)	-96	-	-96	-
Up side (dBm)	-	-100	-	-100
Antenna height (m)	50	1.5	90	1.5
Tx output power (dBm)	44	30	44	30
Tx combiner loss (dB)	-12	-	-12	-
Tx feeder loss (dB)	-3	-1	-6	-1
Tx antenna gain (dB)	9	5	9	5
Rx antenna gain (dB)	5	9	5	9
Rx feeder loss (dB)	-1	-3	-1	-6
Duplexer loss (dB)	-1.5	-	-1.5	-
Permissible propagation loss (dB)	-	-	-	-
Down side (dB)	136.5		136.5	-
Up side (dB)	-	140.0	-	140.0
Max coverage (km)	8	-	11	-
Base stn. antenna	Co-linear		Co-linear	
Subscriber antenna	Hoip		Hoip