No. 4

BASIC DESIGN STUDY
FOR
GEZIRA TELECOMMUNICATIONS NETWORK PROJECT
IN
THE DEMOCRATIC REPUBLIC OF THE SUDAN

November, 1984

JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to the request of the Government of the Democratic Republic of the Sudan, the Government of Japan decided to conduct a Basic Design Study on the Gezira Telecommunications Network Project and entrusted the study to the Japan International Cooperation Agency (JICA).
JICA sent to the Sudan a study team headed by Mr. Kenichi Ando, Second Economic Cooperation Division, Economic Cooperation Bureau, Ministry of Foreign Affaires, from May 13 to June 11, 1984. The team had discussions with the officials concerned of the Government of the Sudan and conducted a field survey in Gezira area. After the team returned to Japan, further studies were made and the present Report has been prepared.

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

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

November, 1984

Keisuke Arita

Keisuke ARITA
President
Japan International Cooperation Agency

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SUMMARY

In Gezira Area, the public telephone system established by Sudan Telecommunications Public Corporation (STPC) was in operation until recently. However, due to shortage of spares and defective operation and maintenance, the system is not working satisfactory at present.

Main telephone users in Gezira Area are Sudan Gezira Board (SGB) and Ministry of Irrigation (MOI). The most part of telephone demand in the area consists of inter-office communications of SGB and MOI, business liaison among ginning factories, workshops and fire brigades, canal water indent report, Light Railway operation, as well as hospital, clinic and police services.

Since STPC public telephone system does not function almost completely, SGB and MOI have to keep their in-house radio circuits, barely filling communications demand at key points only.
However, those in-house circuits have quantitative shortage for facilities and they became bottleneck to Gezira Area development promotion.

On the other hand, STPC as the sole public telecommunications managing entity in Sudan has formulated Master Plan for telecommunications system improvement up to the year 1992, covering the whole country. However, since this Master Plan places primary emphasis on telephone service improvement and expansion in big cities, the priority of development envisaged by Master Plan for Gezira Area, the rural area, falls far behind. Therefore, even if the plan was implemented on schedule, the completion of the telephone network system will be after 1990. This means a serious impediment to Gezira Rehabilitation Project implementation. Thus, for establishment of Gezira telecommunications network, it will become indispensable to formulate a separate plan from STPC Master Plan.

With the foregoing situation in the background, field survey was carried out. As a result of survey, it was found out that subscriber telephone demand, whereby to smoothen Gezira Rehabilitation Project implementation, was 1,677 sets, consisting of 894 sets and 516 sets from SGB and MOI, respectively, plus 267 sets for social services facilities (hospitals, clinics and police). When SGB's mobile telephones are added, grand total becomes 1,827 sets.

Based on demand and traffic forecasts, Gezira telecommunications network will be constructed according to the following policies.

- To establish degital local switching equipments at four places (Barakat, Bagier, Hasaheisa and Gorashi) where subscribers are concentrated. Connection of one switching equipment to another is by UHF link and connection to public telecommunications network will be at Barakat.

- To establish Radio Concentrator System (RCS) base stations at seven places in the area, wherein to accommodate scattered remote area subscribers (including mobile telephones). RCS connection to switching equipment is by UHF link.

- To connect subscriber telephones located at short distance from switching equipment by cable.

- To adopt solar battery system in all cases for power supply to RCS subscriber stations where commercial power supply is not available.

- To adopt container/shelter type for buildings where to install switching equipment, radio equipment and power supply equipment. This is to execute construction work at high efficiency and complete it in short period.

- To construct Maintenance Centers at four places in the area. This is to strengthen maintenance and operation organization.

For the construction of above telecommunications network, the following work items are required to be undertaken by the Government of Sudan:

- Acquisition of lands for telephone exchanges and radio stations.

- Ground levelling and removal of obstacles at all sites.

- Distribution of power lines to the sites.

Although Gezira Rehabilitation Project as a whole is being implemented by Management Committee of Gezira Rehabilitation Project composed of SGB, MOI, STPC, MOA (Ministry of Agriculture) and Ministry of Health, telecommunications project implementation is mainly by STPC and SGB. Maintenance and operation of telecommunications network after its completion are the responsibility of STPC.

Construction work for Gezira telecommunications network extends over the whole range of communication technology including switching, radio, multiplex and outside plant. Thus, for purpose of work execution at top efficiency, it is desireble to be on turn key base after contractor selection by competitive bidding.

Project implementation is estimated to be 22 months after contract signing.

In Gezira Area, rainy season starts from June and ends in October. During rainy season, access to work sites will be extremely difficult so that, the field survey and construction work should be conducted in dry season.

This Gezira telecommunications network project constitutes an integral part of infrastructure that supports steady progress of Gezira Rehabilitation Project as a whole. Once the proposed telecommunications network was established, the following benefits and effects can be derived therefrom:

- Effective utilization of irrigation water by means of pertinent and expeditious water control management.

- Brisk routine activities of field inspectors.

- Saving in fuel consumption by Gezira Light Railway as a result of its effective operation.

- High efficiency operation of ginning factories and workshops.

- Strengthening of fire brigade activities in the area.

- Contribution to high efficiency management of SGB.

- Improvement of social and welfare services to inhabitants of the area.

For the success of the project and for the satisfactory maintenance and operation of telecommunications network after its completion, SGB and STPC are required to exchange and coordinate views to a full extent.

As of the present, Gezira Rehabilitation Project implementation is making smooth progress in general in accordance with the basic concept formulated by the World Bank.

According to economic analysis made by the World Bank, internal rate of return (IRR) of the whole project is 35.8%. This figure of IRR by far exceeds the standing of opportunity cost of capital in Sudan, i.e., 12.5%, and it is concluded that the project is sufficiently and economically feasible.

In view of serious food shortage in African countries today, the project, whose keynote is to rehabilitate Gezira Area as future granary of Arab-African community of nations, is a timely project.
Therefore, it is very significant to implement the Project by Japanese Grant Aid.

CHAPTER I INTRODUCTION

The Democratic Republic of the Sudan, a country with the biggest national territory in African Continent (Figure I-1), has been engaged in large scale agricultural development in order to cope with food shortage resulting from rapid population growth. Among all agricultural development projects, Gezira Area development project is of longest history and largest scale, and the Sudanese Government puts top priority on the project.

Gezira Area, sandwiched between Blue Nile and White Nile (Figure I-2) covers about 0.9 million hectares tract of land. Main products are cotton, dura, peanuts and wheat. Cotton, in particular, is reputed for high quality in world market also; it constitutes an important means for the country to earn foreign currencies.

However, in recent years, poor export performance plus national financial deficit and employment difficulties began to pose problems more seriously for the country. This fact is reflected in the sharp decrease of agricultural products and productivity in Gezira Area.

Thus, to relieve the deteriorated agricultural productivity and bring it to a higher level, the Sudanese Government formulated an all-round Gezira Rehabilitation Project and requested international organizations including the World Bank and governments of other countries for financial assistance to implement the project.

The objectives of the Gezira Rehabilitation Project mainly consist of i) improvement of irrigation and drainage system; ii) upgrading of social infrastructure and improvement of production equipments including agricultural equipment, and improvement of transport and telecommunications system; iii) establishment of new public sanitation facilities and improvement of existing facilities; and iv) organizational and management renovation for the promotion of the Project.

In 1979, responding to the Sudanese Government request, a joint study mission of United Nations Food and Agriculture Organization and World Bank investigated feasibility of the Gezira Rehabilitation Project and admitted significance of the project. The World Bank promised loan grant and approached the governments of several countries including Italy, the United Kingdom and Saudi Arabia, asking them to follow suit. The approach aroused favorable response.

Subsequently, in 1982, Euroconsult (of the Netherlands), aided by co-financing from the World Bank and Kuwaiti Fund, formulated Gezira Rehabilitation and Modernization Program. Main points of this program were adopted in the appraisal report of the Gezira project made by the World Bank in 1983, and it is finally formulated as the Gezira Rehabilitation Project as an integral development plan.

As part of international cooperation, Japan is requested to extend assistance in Gezira telecommunications network construction.

The requested telecommunications network referred to above forms part and parcel of all-round Gezira rehabilitation program. Being an institutional telecommunications network, it will be used for report of irrigation water indents at water control points, transmission of water flow information, farmland management, farmer activity instruction, and so forth. It will also constitute part of public telecommunications network, such as hospital and police telephones.

In response to Sudanese Government request, the Japanese Government decided to carry out a basic design study pertaining to Gezira telecommunications network project.
Based on this decision, study team headed by Mr. Kenichi ANDO (Second Economic Cooperation Division, Ministry of Foreign Affairs) was dispatched, through Japan International Cooperation Agency (JICA), for a period from May 13 through June 13, 1984.

The study team, assisted by Sudanese Government personnel concerned, carried out field survey and collected social, economic and technical information and data required in the formulation of basic design for the aforementioned telecommunications network.

After the field survey, the study team exchanged views with Sudanese Government officers in charge concerning the scope of the said basic design and, after reaching agreement, signed the Minutes. Attached to this Report as annexes are the Minutes, as well as the study team organization, list of Sudanese Government officers in charge, and synopsis of field collected data, as well as essential technical data used.

After the return to Japan, the study team conducted careful analysis of study results for about two months. This Report has thus been completed.

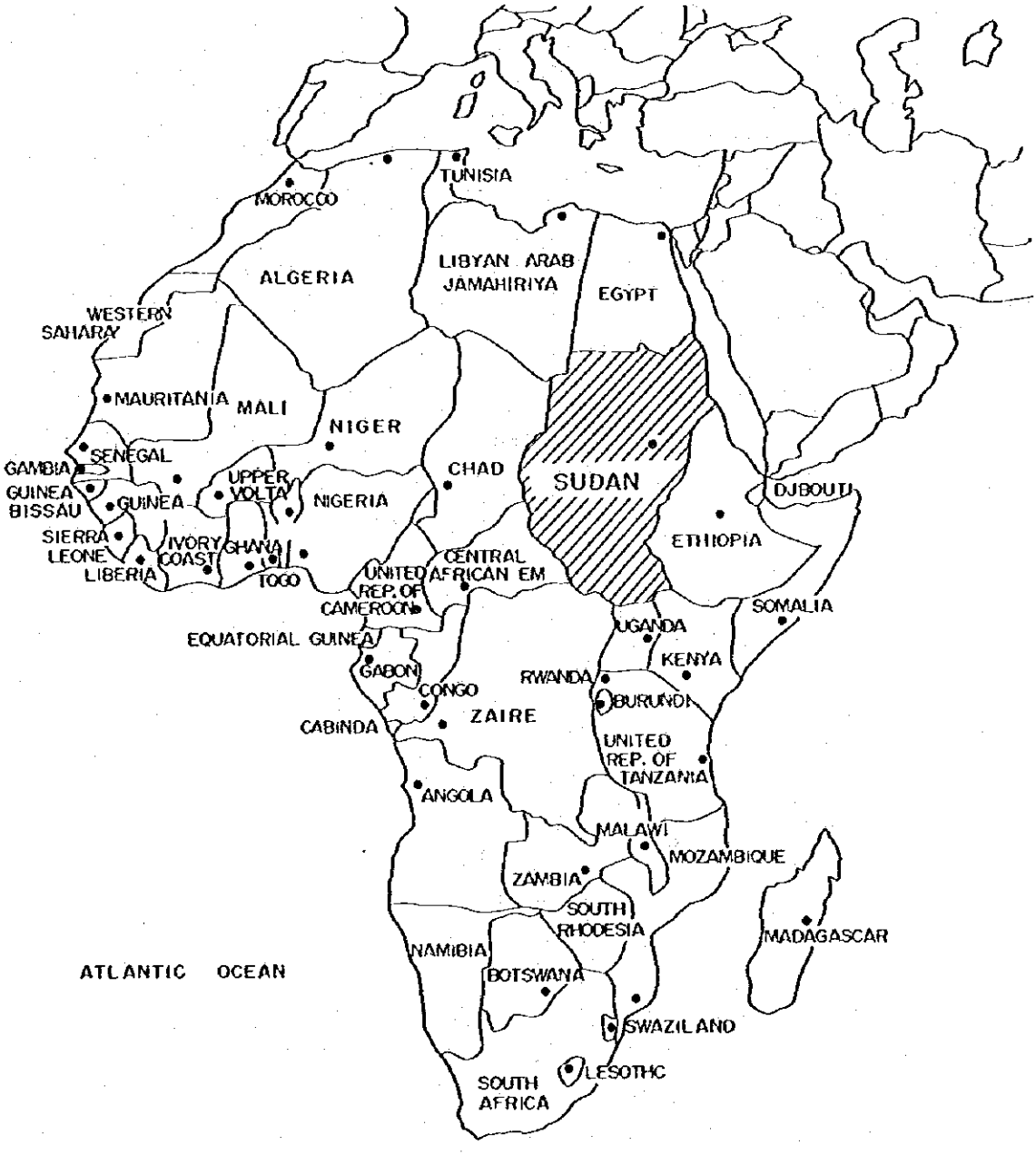


Figure I-1 The Democratic Republic of the Sudan

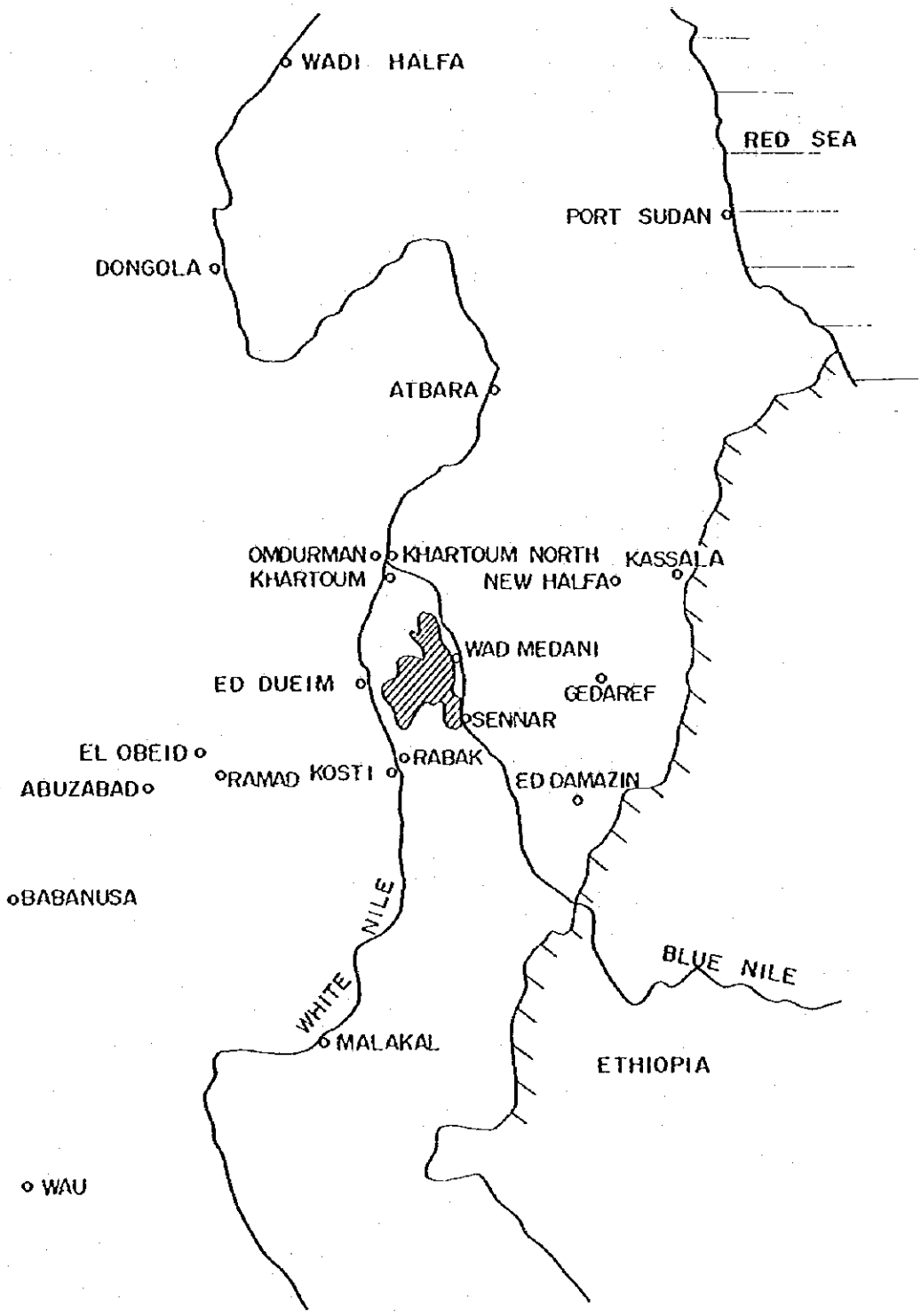


Figure I-2 Locatiohn of Gezira Area

CHAPTER II BASIC ARCHITECTURE OF PROJECT

1. Demand and Traffic Forecasts

1-1 Type of Demand

The Gezira telecommunications network objective is not the public telecommunication network; the coverage is restricted to subscribers who belong to SGB and MOI in charge of irrigation control, harvesting/shipment adjustment, etc., as essential items of the Gezira Rehabilitation Project. The number of those subscribers is to be determined in due consideration of SGB and MOI office allocation and office staff composition.

Unlike in the case of public telecommunications network wherein the future demand forecast (macroscopic forecast) can be made from correlation with GDP/GNP, the demand forecast, this time, is by careful study of such cases as under.

(1) Case where irrigation land expansion causes the number of telephone installations to increase (as in newly established water control points and field inspector's offices).

(2) Case where SGB and MOI activities pull up momentum, requiring additional office telephone installations.

(3) Case where new organization and new facilities, such as factory, have been established, necessitating additional telephone installations.

(4) Case where improvement of distribution mechanism and technical innovations result in multi-purpose utilization of communications system, e.g., for telemetering, facsimile and data service circuits.

(5) Case where the number of mobile subscriber units in institutional-use mobile radiotelephone system has increased.

(6) Case where demand for public telephones arises spontaneously from among Gezira Area tenants. (Such demand for public telephones should be catered for by STPC's public telecommunications network.)

As regards the cases (1) to (5) above, it must be noted that in the number of SGB- and MOI-requested subscribers (Table II-1) is included the subscriber growth estimate pertaining to expansion plans scheduled to be implemented by the Gezira Rehabilitation Project. For other expansion plans, nothing concrete is available at present, nor exists any correlative item worth consideration in demand forecast. Thus, for switching equipment/facilities, the initial installation is to be so designed that 80-100% expansion will be possible at final stage. For transmission and radio equipment/facilities, basic installations, such as antenna towers and power supply system, are designed in final stage requirements.

1-2 Number of SGB-, MOI-Requested Subscribers

The number of SGB- and MOI-requested subscribers appears in Table II-1. The total is 1,410. There are 267 other requested subscribers, and these include hospitals, clinics and police facilities as welfare services for field inspectors and water control point personnel whom SGB and MOI keep on duty in an extensive area. Therefore, the grand total of SGB- and MOI-requested subscribers reaches 1,677.

Also requested by SGB and MOI are institutional-use mobile radiotelephones by which field inspectors on duty trip can communicate with block office and group office concerned.

Items aligned horizontally at top in Table II-1, i.e.,

Barakat HQ (SGB)
Meringan GF (Ginning Factory)
Hasaheisa GF
Bagier GF
Gorashi Area

present subscribers directly accommodated in the switching equipment by local cable network. Shown by 1-14 are group areas of SGB organization, indicating the number of subscribers to be accommodated in radio system. (Refer to Figure II-1.)

Table II-1 Breakdown of Requested Subscribers

		Wire lines					RCS													
		Barakat HQ	Merigan C.F	Hasa-Heisa	Bagier C.F	Gorashi Area	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
SGB	Group Office (2)					8	4	10	10	2	6	4	2	8	5	4	4	GOR (8)	9	8	(76) 84
	Block Office (2)						16	30	18	12	12	14	16	21	21	21	21	33	24	27	(286) 286
	Inspector's House (1)						12	(Ea.3) 15	17	9	11	13	11	(Ea.3)	(Ea.3)	(Ea.3)	(Ea.3)	(Ea.4)	(Ea.3)	(Ea.3)	(88) 88
	Workshop					6		(GLR) 5		(GLD) 1								GOR (6)			(6) 12
	Gezira Light Railway					6		(GLR) 5	5	(GLD) 2	2				5	5	4	GOR (6)			(28) 34
	Ginning Factory		50	60	20																130
	Fire Brigade																				
	Managil Area HQ					10															10
	Barakat Headquarters	250																			250
	Sub-Total	250	50	60	20	30	32	65	50	26	31	31	29	29	31	30	29	33	33	35	(484) 894
MOI	Divisional Headquarters	(Medani) 14				10	(SR) 10														(10) 34
	Sub-divisional Headquarters						16	12	12	6	6	6	12	10	5	5	5	5	10	10	(120) 120
	Asst. Engineer's Station						8	6	3	4	4	4	3	(5 sites) 8	4	4	1	2	4	2	(57) 57
	Deputy Director's Office	(Medani) 6				5															11
	Water Control Point						43	23	11	10	15	25	11	30	17	19	23	16	27	21	(291) 291
	Work shop					3															
	Sub-Total	20				18	77	41	26	20	25	35	26	48	26	28	29	23	41	33	(478) 516
Social Services	Hospital			1		1	-	1	1	-	2	4	3	-	1	1	-	-	-	-	(13) 15
	Clinic & Dispensary			1			17	21	28	26	22	15	17	7	13	10	12	8	7	13	(216) 217
	Police Station					1	2	2	2	3	2	3	4	1	3	1	3	1	3	3	(33) 34
	Others					(Council) 1															1
	Sub-Total			2		3	19	24	31	29	26	22	24	8	17	12	15	9	10	16	(262) 267
	Total	270	50	62	20	51	128	130	107	75	82	88	79	85	74	70	73	65	84	84	(1224) 1677

* Figures in bracket show subscribers accomodated in RCS

Figure II-1 Distribution of Telephone Subscribers Accommodated in RCS

Breakdown of subscribers to be accommodated in radio base stations shown in Figure II-1 appears in Table II-2.

1-3 Decision of Number of Subscribers

To examine whether the grand total, 1,677, of SGB- and MOI-requested subscribers was reasonable or not, field survey was carried out. Findings were that in some cases the request for two telephones (one in office; one in residence) could be reduced to one telephone if changeover switch was used; conversely, there were cases where the request in Table II-1 was for two telephones but the actual necessity confirmed by field investigation was for four telephones. Thus, on the whole, the primary request for 1,410 subscribers was considered to be reasonable.

As for institutional-use mobile radiotelephones, the number requested is not specified. However, considering that field inspectors are duty-bound to perform technical instructions and other routines at fields for 08:00 to 14:00 hours, each day, necessity for mobile radiotelephones leaves no room for doubt. In Gezira area, there are 104 block offices where field inspectors are permanently stationed. The number of field inspectors stationed is 2-4 per office. In consideration of the number of vehicles owned by those offices, the required number of mobile radiotelephones is assessed at 150.

All things considered, it can be safely assumed that the number of SGB- and MOI-requested subscribers and facilities is reasonable or, more precisely, the necessary minimum for attainment of SGB and MOI activities for successful implementation of the Gezira Rehabilitation Project.

Table II-2 Breakdown of RCS Subscribers Accommodated in Each Base Station

		Office Groups															RCS Base Stations							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	Ttl	1	2	3	4	5	6	7	Total
S G B	Group Office	4	10	10	2	6	4	2	8	5	4	4	-	9	8	76	6	2	23	20	4	13	8	76
	Block Office	16	30	18	12	12	14	16	21	21	21	21	33	24	27	286	30	24	43	51	24	69	45	286
	Inspector's House	12	15	17	9	11	13	11								88	24	18	8	25	13			88
	Workshop		5 (G.L.R)		1 Guneid											6		1		5				6
	Gezira Light Railway		5	5	2	2				5	5	4				28		12	2	10		4		28
	Sub-Total	32	65	50	26	31	31	29	29	31	30	29	33	33	35	484	60	57	76	111	41	86	53	484
M O I	Divisional Headquarters	10 Sennar														10								10
	Sub-divisional Headquarters	16	12	12	6	6	6	12	10	5	5	5	5	10	10	120	18	6	26	24	16	20	10	120
	Asst. Engineer's Station	8	6	3	4	4	4	3	8	4	4	1	2	4	2	57	6	7	12	11	9	7	5	57
	Water Control Point	43	23	11	10	15	25	11	30	17	19	23	16	27	21	291	30	21	48	54	45	52	41	291
	Sub-Total	77	41	26	20	25	35	26	48	26	28	29	23	41	33	478	54	34	86	89	80	79	56	478
Social Services	Hospital		1	1		2	4	3		1	1					13	5	5	2	1	0	0	0	13
	Clinic & Dispensary	17	21	28	26	22	15	17	7	13	10	12	8	7	13	216	38	48	36	36	19	21	18	216
	Police Station	2	2	2	3	2	3	4	1	3	1	3	1	3	3	33	5	8	4	5	2	4	5	33
	Sub-Total	19	24	31	29	26	22	24	8	17	12	15	9	10	16	262	48	61	42	42	21	25	23	262
	Total	128	130	107	75	82	88	79	85	74	70	73	65	84	84	1224	162	152	204	242	142	190	132	1224

* Figures in bracket show subscribers accomodated in RCS

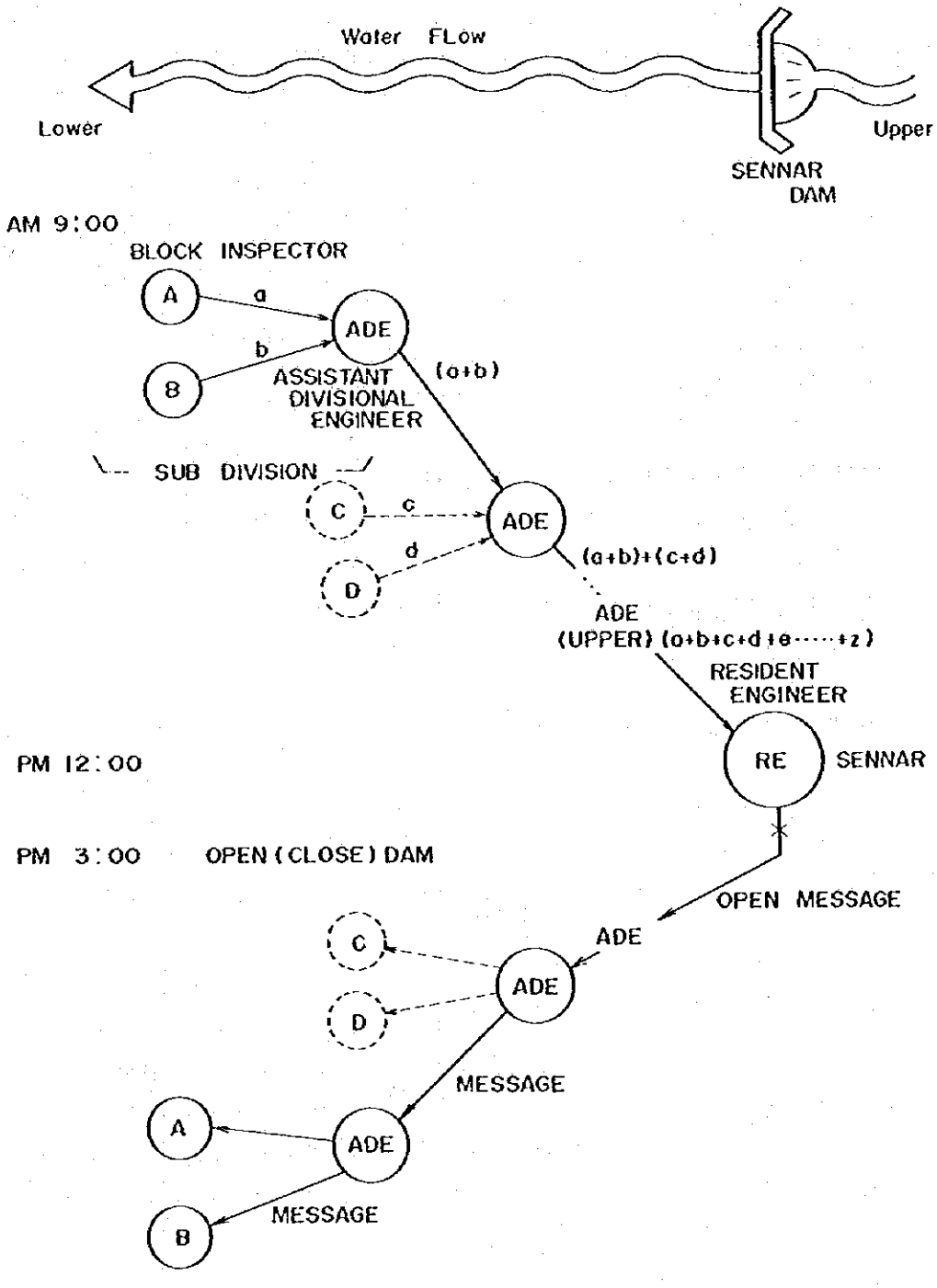
1-4 Traffic Forecast

The existing communication facilities are superannuated or trouble-ridden for the most part. There seldom or never exist facilities in satisfactory condition. Hence no records or statistics worthwhile to use for traffic forecast.

The Gezira telecommunications network is wholly for institutional use of SGB and MOI. SGB uses the network for report of agricultural operations, harvesting and shipments from fields and factories to SGB office and for transfer of instructions from SGB office to fields. MOI uses the network for report of water indents measured at 09:00, 12:00 (noon) and 15:00 hours, every day, at each water control point to upstream control points one after another so that, finally, all information of the whole irrigation area can be collected at Sennar Dam where dam gates are either opened or closed as required.

Information collected at Sennar Dam is then supplied back to each water control point. (Refer to Figure II-2.) Therefore, the mean calling rate of subscribers scattered in the whole irrigation area can be assumed to be practically equal to that of ordinary rural telephone network.

Thus, for originating calling rate of remote area subscribers is used the value which STPC uses in the Master Plan as rural telephone subscribers' calling rate. For subscribers concentrated in one place as in Barakat, the calling rate among telephone subscribers in urban area is used. That is to say:



DURING RAINY SEASON (MID. JULY – MID. OCTBER)

REPORT TO RE PM 12:00 & AM 7:00 (NEXT MORNING)

Figure II-2 Outline of Water Indent Report

1) Subscribers' originating calling rate in Barakat, Bagier, Hasaheisa, Gorashi and environs: 0.055 Erl.

(In the Master Plan, Group Center and Zone Center calling rate.)

2) Remote area subscribers' originating calling rate: 0.045 Erl.

(In the Master Plan, calling rate of local exchanges, each with 500 or less terminals.)

Call connections from other personnel than senior SGB and MOI officials to public communications network are restricted. Therefore, call outflow from Gezira telecommunications network to public telecommunications network is considered to be extremely small. (For estimate of such call outflow, see ANNEX 7-(2): Calculation Method for Circuits Required.)

1-5 System Configuration

Based on the foregoing demand and traffic forecasts, an optimum system for Gezira telecommunications network is formulated. The system is featured as follows:

(1) For local call switching, the master exchange be established in Barakat where SGB Headquarters are located, and slave exchanges in Bagier, Hasaheisa and Gorashi, the three places where subscribers will be concentrated. Mutual connection of exchanges be by UHF link. Interlinking with public telecommunications network be performed in Barakat.

(2) Remote area subscribers scattered in Gezira Area be accommodated in Radio Concentrator System (RCS). Connection of these subscribers to the exchange be by UHF link. 150 terminals of institutional-use mobile radiotelephone system be accommodated in RCS network.

(3) Subscribers located near the exchange (within 5 km or thereabouts) be connected by cable.

Conceptual system configuration appears in Figure II-3 and radio transmission route plan in Figure II-4.

1-6 Calculation of Circuits Required

The number of circuits required in each section of the system described above is given below. Details of calculation appear in ANNEX 7-(2).

A. Master Exchange - Satellite Exchange (junction line)

Barakat	Bagier	Incoming:	5
Barakat	Bagier	Outgoing:	6
Barakat	Hasaheisa	Incoming:	32
Barakat	Hasaheisa	Outgoing:	36
Barakat	Gorashi	Incoming:	31
Barakat	Gorashi	Outgoing:	34

B. Exchange Office - RCS Base (subscriber's line)

Barakat	Hag Abdalla	Incoming:	15
Barakat	Hag Abdalla	Outgoing:	17
Barakat	Beika	Incoming:	35
Barakat	Beika	Outgoing:	40
Gorashi	Gamusi	Incoming:	14
Gorashi	Gamusi	Outgoing:	16
Hasaheisa	Fadagoba	Incoming:	16
Hasaheisa	Fadagoba	Outgoing:	18

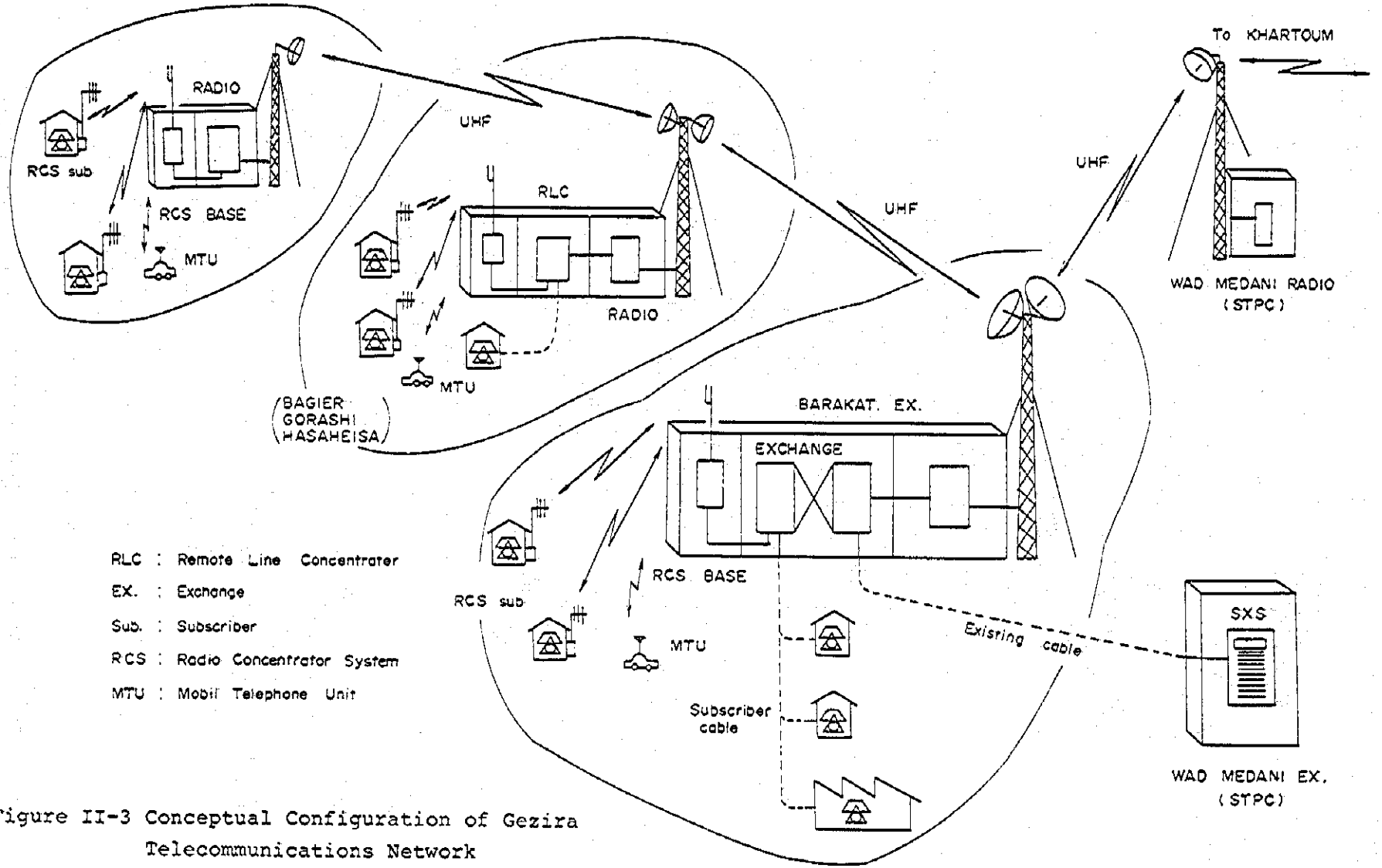


Figure II-3 Conceptual Configuration of Gezira Telecommunications Network

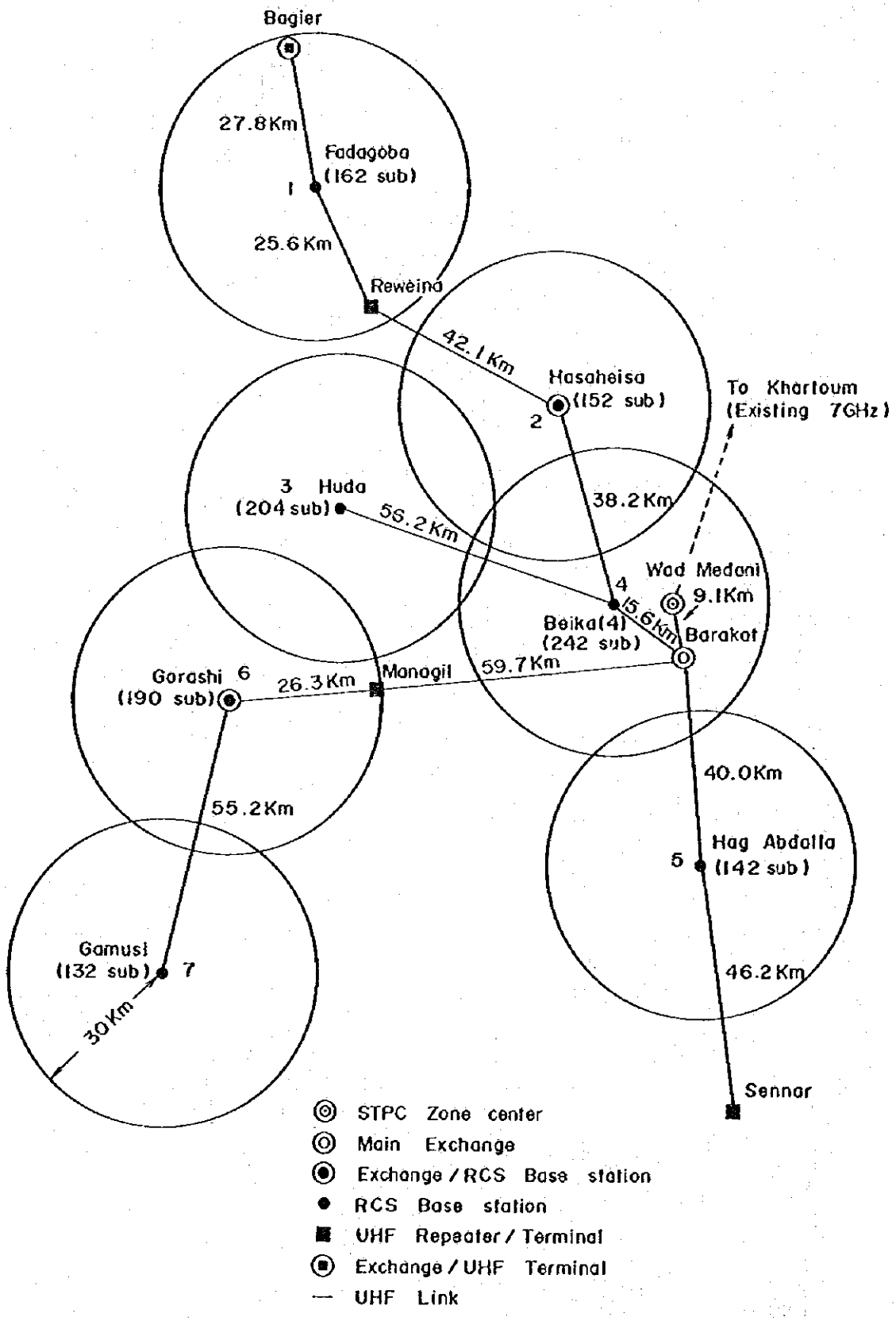


Figure II-4 Route Layout of Radio Transmission System

C. RCS Base - RCS Base

Hag Abdalla -- Sennar	Incoming:	4
Hag Abdalla -- Sennar	Outgoing:	4
Barakat -- Huda	Incoming:	20
Barakat -- Huda	Outgoing:	23

D. Barakat intra-office circuits 40

E. Barakat-Wad Medani local	Incoming:	5
	Outgoing:	5
F. Barakat-Khartoum toll	Incoming:	9
	Outgoing:	9

All circuits by destinations, as calculated above, are illustrated in Figure II-5.

1-7 Accommodation Standard of Radio Concentrator System (RCS)

Assume that one RCS (8 RF channels) be signed to accommodate a maximum of 60 subscribers. Then, supposing that each and every subscriber holds the originating calling rate of 0.045 Erl. as forecasted, the loss probability deteriorates as much as 10%.

On the other hand, as the purpose of communication is defined, the holding time of call is short; furthermore, since the number of calls is also defined and the call distribution by time is smooth, the mean calling rate per subscriber at a certain time is expected to be substantially lower than in the case of public telephone network (local exchange). Therefore, as in the table below, when RCS calling rate is 0.026 Erl. or less, the loss probability degradation does not take place; when the originating calling rate is 0.016 Erl. or less, RCS accommodation to a maximum of 96 subscribers exerts no influence on loss probability.

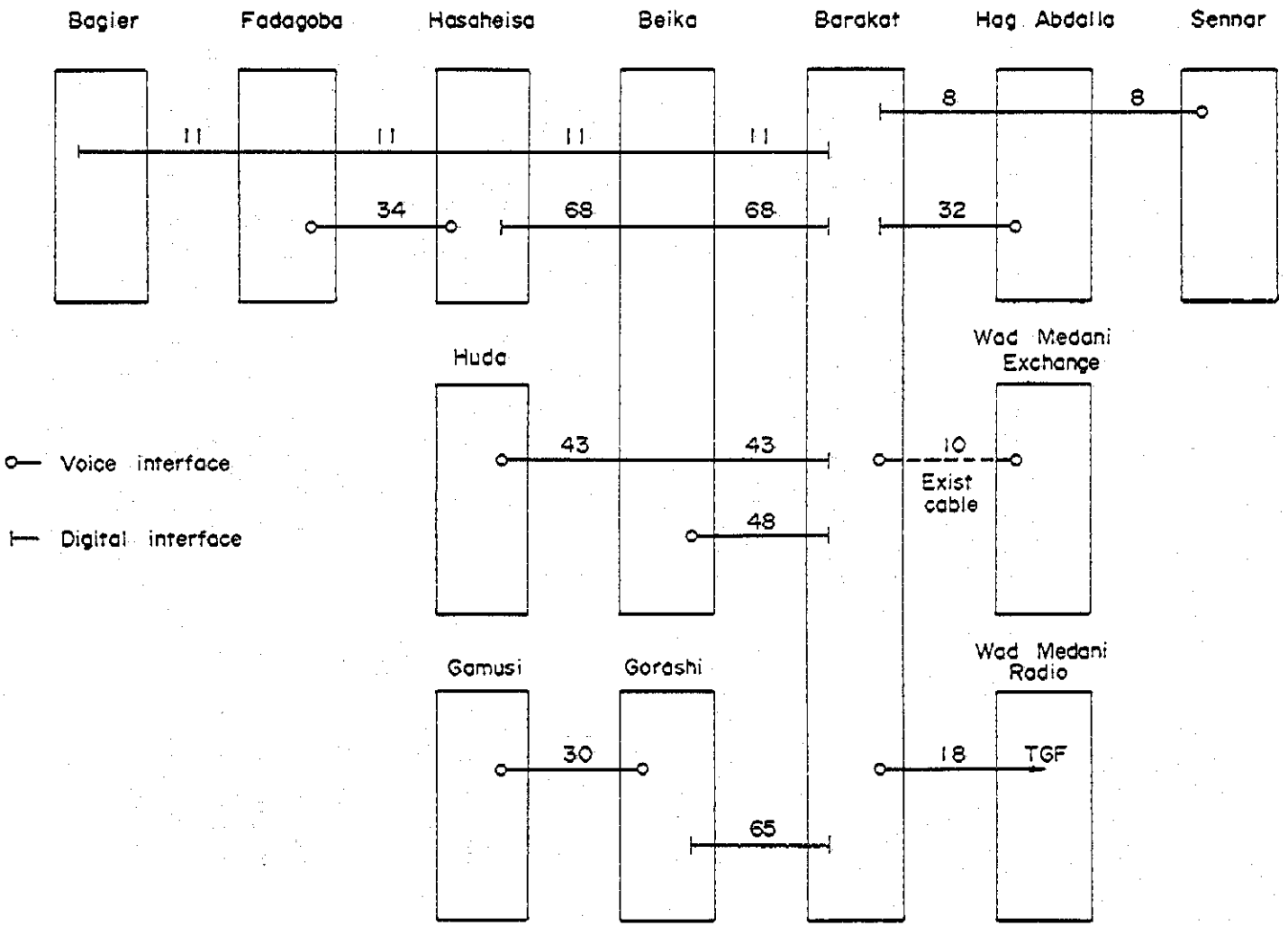


Figure II-5 Number of Circuit, Required

Subscriber's Calling Rate	Grade of Service	Max. No. of Subscribers	Max. Calls per CH
0.045 Erl. (Originating & terminating: 0.09 Erl.)	$\frac{1}{100}$	35	3.13 Erl.
	$\frac{5}{100}$	51	4.54 Erl.
	$\frac{10}{100}$	63	5.60 Erl.
0.026 Erl. (Originating & terminating: 0.052 Erl.)	$\frac{1}{100}$	60	
0.016 Erl. (Originating & terminating: 0.032 Erl.)	$\frac{1}{100}$	96	

This time, for the purpose of economical design, maximum subscriber accommodation in one RCS is set at 60 subscribers.

2. Comparison between Original and Alternative Plans

Alternative plan for RCS base station site selection is given in Figure II-6. In this alternative plan, four base stations are used and coverage radius of each base station is extended to 50 km. In-depth study results appear in ANNEX 7-(3). A summary follows:

	Original Plan	Alternative Plan
1) Construction cost	(No much difference)	
2) Feasibility of mobile radiotelephone system introduction	O	X
3) Maintenance, operation	X	O

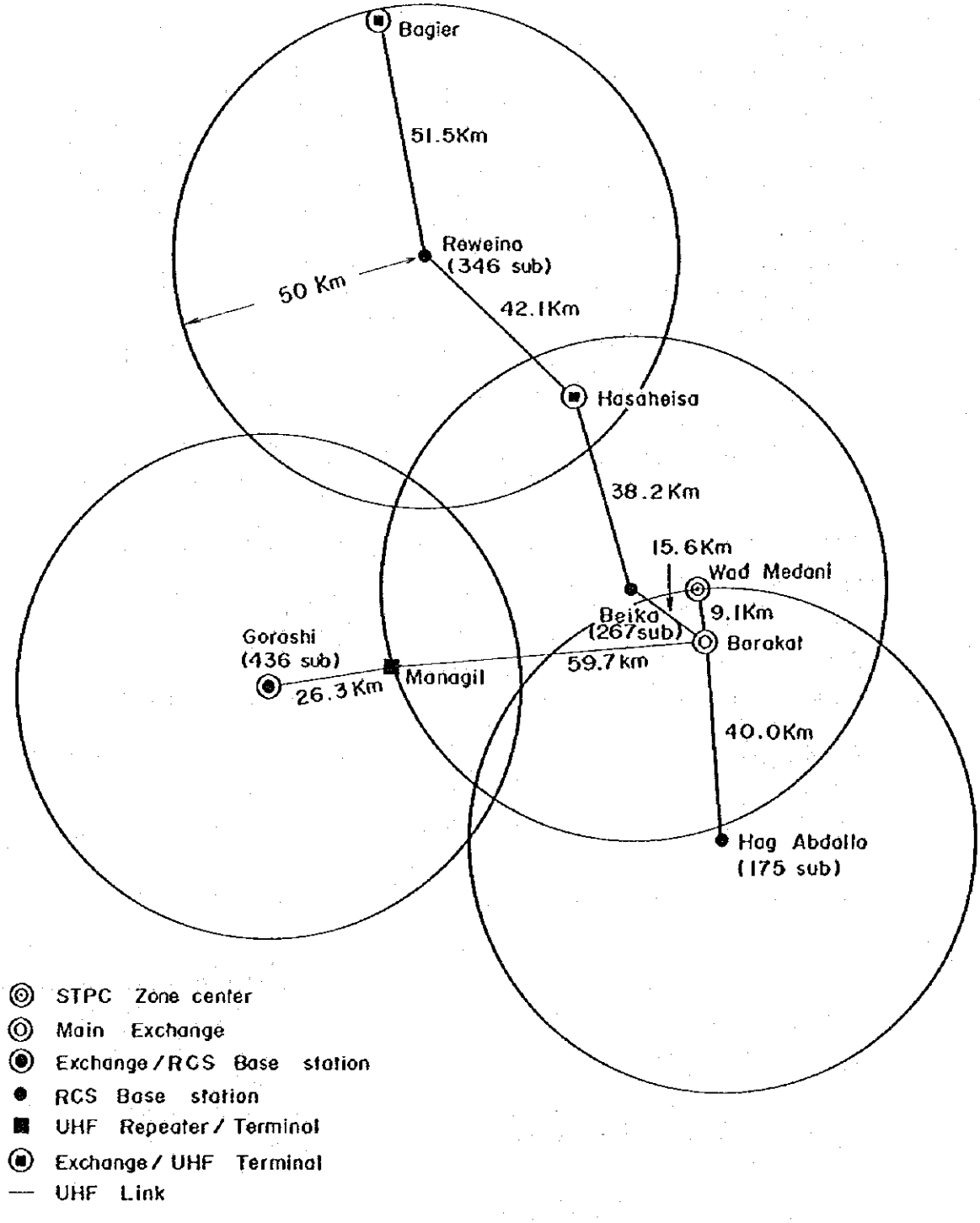


Figure II-6 Alternative Plan for RCS Route Layout

In the original plan, coverage radius of each base station is set at 30 km or shorter than in the alternative plan, so that transmitter output at subscriber station can be reduced; consequently, for power supply, small capacity solar battery system can be used. Hence low cost.

Subscriber stations number as many as 1,224. Therefore, cost reduction of power supply system as main cost consuming item as subscriber station contributes a great deal to cost reduction of the whole system.

On the other hand, the number of radio stations in the original plan is greater than in the alternative plan. Cost increases thus much. Maintenance also requires greater manpower.

As far as construction cost is concerned, no much difference is found between both plans.

In case where mobile radiotelephone system is to be incorporated in the proposed RCS the alternative plan is disadvantageous because coverage radius of each base station, i.e., 50 km, is too long and does not fit the signalling system to be adopted. Such coverage radius makes call connections and talks at zone perimeters difficult.

By all the foregoing studies, decision is made for doption of the original plan for the current project.

3. Design Standard

Gezira telecommunications network should rather be defined as private-use communications network instead of public telecommunications network. For, both the subscriber category and the purpose of utilization are specific. However, for the sake of standardized network maintenance

and operation, the basic design standard is to be adjustable to that of STPC's public telecommunications network.

3-1 Service Quality

Toll call loss probability : To be less than 8%.

o Low probability per stage : To be 0.01

o Loss probability on high usage circuit : To be 0.01.

Local loss probability : To be less than 4%.

o Loss on local tandem circuit is to be 0.01 per stage.

o Loss probability on high usage circuit : To be 0.02.

o Intra-office call loss probability : To be 0.02.

Gezira telecommunications network is to consist of master exchange at Barakat and remote control concentrators for three exchanges, so that all calls in the network may be considered to be intra-office calls.

3-2 Numbering Plan

(1) Existing National Numbering Plan

o Trunk Exchange Numbers

011 : Khartoum
0161: Shendi
021 : Atbara
031 : Port Sudan
041 : Kassala
0441: Gedaref
051 : Wad Medani
061 : Sennar
071 : Kosty
081 : El Obeid

o Subscriber Numbers

Subscribers in Khartoum multi-exchange area:	6-digit numbers
Subscribers in other areas:	5-digit numbers

o Special Numbers

90 : Directory operator
92 : Complaint desk
98 : Toll operator

Special numbers will be changed to 9XX (3 digits) in the future.

(2) Wad Medani Zone Center Numbering Plan

051-2/3: Wad Medani
-4 : Maatuk, Beika, Wad Arab, Messelemiya
-7 : Managil, Wad El Mansi, Huda, Kamel Nomak
-8 : Gorashi, Tanid, Maturi, Gamusi
-9 : (Trunk switching)
052-2&3: Ed Dueim
-6 : Kawa/Spare
-7 : Geteina
053-2/3: Hasaheisa
-4 : Rufa, Abu Usher, Guneid
-5 : Tabat, Meheregiyah, Abu Magid
-7 : Kamlin, W.E. Turabi, Kab El Gedad, Abu Qota
054-2 : El Fau
-4 : (Group 1 HQ, Block 1 & 2)
-5 : (Group 2 HQ, Block 1 & 2)
-6 : (Group 3 HQ, Block 1 & 2)
055-050: Spare

3-3 Changing System

Calls in Gezira telecommunications network are for SGB and MOI business contacts. All these calls are to be free of charge.

Toll calls to Port Sudan, Khartoum, etc., via public telecommunications network are to be charged by STPC's toll tariff system. Such toll call charges, along with network operation and maintenance charges, are to be paid from SGB and MOI to STPC.

STPC's toll tariff system is presented in Table II-3.

Table II-3 STPC's Toll Tariff System

Step	Call Distance (km)	Urgent (3 min.)		Ordinary (3 min.)	
		Day	Night	Day	Night
0	6 - 75	70 (100)	35 (50)	35	17.5
1	76 - 125	120 (150)	60 (75)	60	30
2	126 - 250	150 (200)	75 (100)	75	37.5
3	251 - 375	200 (250)	100 (125)	100	55
4	376	250 (300)	125 (150)	125	62.5

Note: Day Service : 07:00 - 19:00 hours
Night Service: 19:00 - 07:00 hours

Parenthesized are new tariffs to take effect, beginning January 1, 1985.

In and after 1985, the existing fixed local call tariff will be 10 piastres/call. Also, beginning 1985, the "ordinary" class of toll tariff will be discontinued.

3-4 Signalling System

o Line Signal

Loop signalling system

E&M signalling system

o Register Signal

DP signalling system

MFC signalling system (based on CCITT recommendation)

3-5 Transmission Loss Distribution Plan

Toll Channel (in case of 2-wire switching at Group Center)

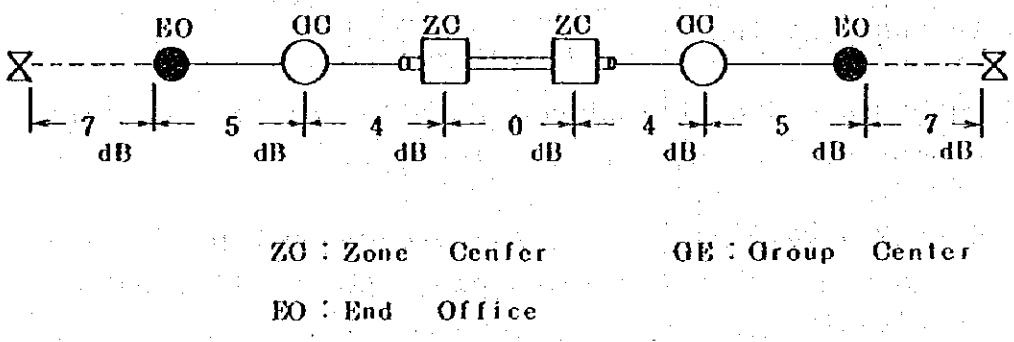


Figure II-7 Transmission Loss Distribution Plan

Barakat Exchange corresponds to Group Center in Gezira Group Area so that, for its subscriber system, 12 dB transmission loss is allowable. MOI HQ in Gezira Province, located in Wad Medani, is about 14 km in line distance from Barakat Exchange and a high loss subscriber so that high loss compensation type telephones (Model: 600-L) will be used there.

3-6 Network Classification

The existing network, excepting Khartoum Toll/International Exchange, is composed of analog system. However, to cope with future service diversification, to facilitate network maintenance and operation, to save floor space for equipment installation, and to ensure long-term supply of parts and components, digital equipments will be introduced positively in the projected network.

3-7 Services to be Provided

- o Toll call origination restriction: To restrict originating toll calls (connections to public telecommunications network) from other parties than authorized specific subscribers.
- o 10 PPS dialling.
- o Push-phone dial telephone installation (For part of senior SGB and MOI officials only.)
- o Abbreviated dials: To provide each push-phone dial telephone with abbreviated dials to 20 different destinations.

4. Basic Design of Project

4-1 Switching Equipment

(1) Switching Equipment Installation Plan

1) Switching Equipment Installation

According to the initial design by Euroconsult (of the Netherlands), all RCS circuits were to be centralized at Wad Medani, and were to be directly accommodated in New Wad Medani Digital Exchange (6,000 terminals) which was to be constructed by STPC's Master Plan, Phase A. This plan was modified by STPC for reasons:

a) New Wad Medani Exchange plan was not being fulfilled;

b) Not only radio subcribers, but other telephone subscribers are also concentrated in workshop sites at Barakat, Hasaheisa, etc., so that the accommodation of those subscribers by cable is preferable both technically and economically. Hence the advantage of installing switching equipment at several places.

STPC plan was of the following contents:

A. Exchanges (500 terminals, each) where to collect RCS circuits: Four (Hag Abdalla, Block 19, Block 41 and Gorashi).

B. Exchanges (PABX with 200 terminals, each) for cable accommodated subscribers: Four (Beika, Abu Uslar, Managil and one other).

STPC plan was further modified, based on field investigation findings, into a system introduced in this report. Reasons for further modification are:

a) Out of the four exchanges where to concentrate RCS circuits, three, i.e., Hag Abdalla, Block 19 and Block 41, are without subscribers that can be accommodated by cable. If they are only for concentration of RCS circuits, they do not need to have switching equipment installed. Furthermore, at those three places, commercial power supply is incomplete.

b) Each exchange for cable accommodated subscribers is also without subscribers that can be accommodated by cable, within a radius of 3 km. In addition, the way whereby PABX is used is not appropriate. That is to say, PABX usually has the subscriber's line resistance (office line resistance) restricted to less than 1,000 ohms so that PABX is not fit for widely scattered subscribers. Furthermore, to make dial pulse sending and receiving method identical with that of local-use switching equipment, no small remodelling is required, and this makes PABX extremely expensive.

Selection of places where to install switching equipment in the system herein introduced is from the following viewpoints:

a) To be the place where to collect RCS circuits and where cable accommodated subscribers can be expected. (Place where cable accommodated subscribers exist in a sizable number is a community, after all, where necessity for radiotelephones diminishes.)

b) To be the place where commercial power supply is available on 24 hours/day basis.

c) To be the place whereto maintenance personnel can proceed easily from Barakat.

2) Special Service Disk Installation

At present, for Barakat Exchange subscribers, directory service by "90", complaint (trouble) acceptance by "92" and toll connections by "98" are via Wad Medani toll board. For Barakat Exchange to Wad Mandani Exchange connections, general circuits (including local, toll and international circuits) are used. Available for such connections are only five out of general circuits, and this means five circuits for about 250 subscribers. The shortage of circuits is evident.

The project, this time, increases subscribers entitled to special services to approximately 1,700. Therefore, Wad Medani - Barakat circuits must be increased considerably. Out of general circuits, toll and international circuits constitute independent circuits serving separate routes of their own, as shown in ANNEX 7-(2). As for Wad Medani local circuits, the aforementioned five circuits should be included in genuine general local circuits because additional circuit establishment at Wad Medani Exchange is extremely difficult. For special services, general service board is to be newly established at Barakat Exchange.

By such means, the existing five circuits can be used as genuine general local circuits.

It serves the purposes of circuit increase though to only a small extent, catering for the present keen need for more circuits. Directory service, complaint acceptance and so forth are rather the internal requirments of Gezira telecommunications

network separated from general public telecommunications network. Such special service circuits should, as a matter of course, be terminated at Barakat where Operation and Maintenance Center exists. By this means, the distribution of responsibility between the two networks from the viewpoint of maintenance can be realized.

(2) Type of Switching Equipment

Digital type electronic switching equipment (LS) and digital type remote control line concentrator equipment will be adopted. In-depth study result concerning adoption of such digital system appears in ANNEX 7-(2).

(3) Connection Routes

1)	Local Call	:	Calls within Gezira telecommunications network.
2)	Regional Call	:	Calls to general public telephone network in Wad Medani municipality.
3)	Subscriber Toll Dialling (STD)	:	Calls to all cities in Sudan.
4)	International Call	:	International calls. International switching equipment is in Khartoum Central.
5)	Special Service Call	:	Directory service, complaint (trouble) acceptance, toll connections, etc.

Connections of 2) regional call, 3) STD and 4) international call are permissible when calls are from special subscribers (such as senior SGB and MOI officials). When calls are from other parties, connections are restricted (subject to change) because private calls are prohibited.

(4) Switching Equipment Capacity

Switching equipment installation is by the number of terminals required at initial stage. In this case, to cope with unforeseeable business expansion possibilities, such as coverage area expansion, additional water control point establishment and/or water indent observation point increase, as well as possible introduction of new services including mobile radio-telephone, telemetering and telephone facsimile services, switching equipment capacity is to have room for final stage expansion to about twice the initial stage capacity (in terms of RLC) or for interim expansion before the next capacity improvement stage (at Barakat).

Exchange by exchange switching capacity breakdown follows:

- o Barakat Exchange: 1,200 terminals at initial stage (including terminals for subscriber accommodation and incoming/outgoing line terminals). To be expansible to 2,000 terminals at final stage.

- o Bagier Exchange (RLC): 100 terminals at initial stage. To be expanded to 200 terminals at final stage.

- o Hasaheisa Exchange (RLC): 500 terminals at initial stage. To be expanded to 1,000 terminals at final stage.

- o Gorashi Exchange (RLC): 500 terminals at initial stage. To be expanded to 1,000 terminals at final stage.

(5) Circuit Establishment to Special Service Board

Special service circuits from each RCS base station and RLC to Barakat Exchange are to be separately established from public telecommunications network. This is because the services provided by public telecommunications network are of different type from special services required this time. However, for the purpose of effective utilization of circuits, special service circuits will be established in the same route as general telecommunications circuits. For calculation of the number of circuits required, one circuit per 100 subscribers will be added to general telecommunications circuits.

Shared use of the same route is advantageous in that even when general circuits are in the state of overload, special service circuits can still be used. Likewise, special service circuit overload due to unforeseeable situation does not preclude general circuit operaiton.

(6) Services to be Provided

1) Rotary dial (10 PPS) telephone service

2) Push-phone dial telephone service (to part of senior SGB and MOI officials only)

3) Abbreviated dial service (with push-phone dial telephones)

4) Subscriber classification (toll connections, toll connection restrict, call termination only, others)

(7) Installation of Telephones

To provide the foregoing services, the following types of telephones will be installed. (The number of telephones required includes spare telephones.)

1)	10 PPS rotaty dial telephones	1,800 sets
2)	Ditto (to high transmission loss subscribers) (To be installed in MOI office at Wad Medani)	15 sets
3)	Push-phone dial telephones	100 sets
4)	Ditto (for high transmission loss subscribers) (To be installed in MOI office at Wad Medani)	10 sets

(8) Container and Air Conditioner

Switching equipment is to be the container type. The purpose is to reduce the installation period and for dust-proofing. To maintain temperature in the container in optimum condition for equipment operation, air conditioner is to installed.

(9) Central Maintenance Center

Central Maintenance Center for switching network will be established in the adjoining land of Barakat Exchange. In this Maintenance Center will be installed switching equipment input/output control instruments, such as typewriter and console, as well as centralized line test board and alarm receiving equipment from unattended stations. Special service desk to provide directory service and other special services (corresponding to special number service in public telecommunications network) will also be established.

Central Maintenance Center will take care of centralized inventory of parts and components, as well as consumables, and rehabilitation of trouble ridden equipment and parts, besides monitoring of switching equipment operation.

Easy repair or replacement of electromagnetic parts to restore faulty equipment to normal operation will be carried out at Barakat SGB Workshop. However, for repair of electronic parts and packages, equipment concerned will be transferred to the supplier in Japan. In this case, repair is either with charge or free of charge according to the terms of guarranty offered.

(10) Power Supply Equipment

At each site where switching equipment will be installed, commercial power supply on 24 hours/day basis is essential. However, to prepare against commercial power failure, standby power supply equipment will also be established. Main characteristics of standby power supply system follow:

1) Battery

To be capable of power supply for eight consecutive hours at busy hour traffic during power failure.

2) Diesel Engine Generator

To be capable of automatic start when power supply fails and automatic stop when power supply resumes. Necessary fuel tank will also be established.

4-2 Radio Concentrator System (RCS)

(1) Optimum System Selection

With regard to RCS, CCIR Rep. 380-1 reports two systems: FDMA System and TDMA System. In the current project, FDMA System will be used. Reasons are:

1) For subscribers to be accommodated in Gezira Area RCS, distribution density is relatively high. (in the area of 900,000 hectares, about 1,200 subscribers are scattered.) Therefore, repeating function from one subscriber station to another as main feature of TDMA System is not required.

2) The most part of subscriber stations are distributed as independent entities in the area. Cases are scarce where one subscriber station is connected by cable to a plural number of subscriber telephones. (In case where a plural number of subscriber telephones branch from one subscriber station, TDMA System is better suited than FDMA System.)

3) TDMA RCS, though introduced in CCIR Report, is practiced in only a few cases throughout the world. As a system, it is not yet technically mature. As of the present, FDMA System is technically more stabilized and economically more advantageous.

4) In the current project, institutional-use mobile radiotelephone system is to be accommodated in RCS. At the present level of technology, it is still premature to adopt digital mobile radiotelephone system.

As for radio frequency band to be used, recommendation is for use of 400 MHz band. This is in consideration of Gezira Area topography, radio frequency spectrum allocation to STPC, and production capacity of equipment munufacturer.

(2) Circuit Characteristic Objectives

1) Signal to Noise Ratio

Signal to noise ratio (S/N) between RCS base station and terminal station is to be better than 40 dB.

2) System Parameters

RCS parameters are provisionally determined as follows:

Radio frequency	400 MHz band
Channel frequency separation	25 KHz
Modulation system	FDM
Number of subscribers to be accommodated	60 CH/system
Number of access channels	8 CH
Standard communication distance	30 km
Base station transmitting output power	10 W
Subscriber station transmitting output power	1 W
Base station antenna gain	8 dB
Subscriber station antenna gain	12.5/14 dB
Base station transmitter combiner loss	12 dB
Minimum receiver input power	-93 dBm

RCS service distance calculation by use of the foregoing system parameters appears in Table II-4. This table presents for reference the similar calculation in the case of standard distance of 50 km also.

(3) Radio Frequency Utilization Plan

At present, in Sudan, 400 MHz radio frequency band is used by public enterprises, such as Sudan National Railways and Sudan Airways. The most part of 410-420 MHz frequencies (for fixed/mobile communication) and 440-460 MHz frequencies (ditto) are utilized in and near Khartoum. 420-430 MHz are only used by Shell Oil, etc., in Rahab area.

STPC's Radio Frequency Control Division recommends the use of 420-430 MHz band in Gezira area. Assume that 60 subscribers be accommodated in one RCS and eight access channels be required. Then, for the whole, frequencies equivalent to about 20 systems become necessary. Therefore, in the 420-430 MHz band, such frequency arrangement as shown in Figure II-8 should be studied to obtain the necessary number of channels.

Among seven base stations, the longest distance between two stations is about 150 km, so that, for such station, the use of channel of the same frequency is not absolutely impossible. However, considering that Gezira area is located in the plain where the line of sight is available to observe radio propagation, hence to avoid radio interference, it will be advisable not to use the co-channel at least at an early stage of service.

Table II-4 RCS Noise Performance

Item	1		2	
	Base transmit	Base receive	Base transmit	Base receive
Path distance (km)	30		50	
Antenna height (m)	50	10	110	10
Tx output power (dBm)	40	30	44	40
Tx combiner loss (dB)	-12	-	-12	-
Tx feeder loss (dB)	-3	-1.5	-6	-1.5
Tx Antenna gain (dB)	9	12.5	9	14
Free space loss (dB)	-114.5	-114.5	-118.9	-118.9
Additional loss (dB)	-10	-10	-15	-15
Rx antenna gain (dB)	12.5	9	14	9
Rx feeder loss (dB)	-1.5	-3	-1.5	-3
Duplexer loss (dB)	-1.5	-	-1.5	-
Rx input power (dBm)	-81	-77.5	-87.9	-79.9
Min.Rx input power (dBm)	-	-	-	-
Down side	-93	-	-93	
Up side	-	-93		-93
Rx input margin (dB)	-	-	-	-
Down side	12		5.1	
Up side		15.5		13.1
S/N without fading	-	-	-	-
Down side (dB)	56.6	-	49.7	-
Up side (dB)		60.1		57.7
Fading loss (99.9 %) (dB)	10.8	10.8	13.0	13.0
S/N with fading (99.9%)	-	-	-	-
Down side (dB)	45.8	-	36.7	-
Up side (dB)	-	49.3	-	44.6
Base antenna system	Co-linear		Co-linear	
Sub antenna system	8 ele.Yagi		12 ele Yagi	

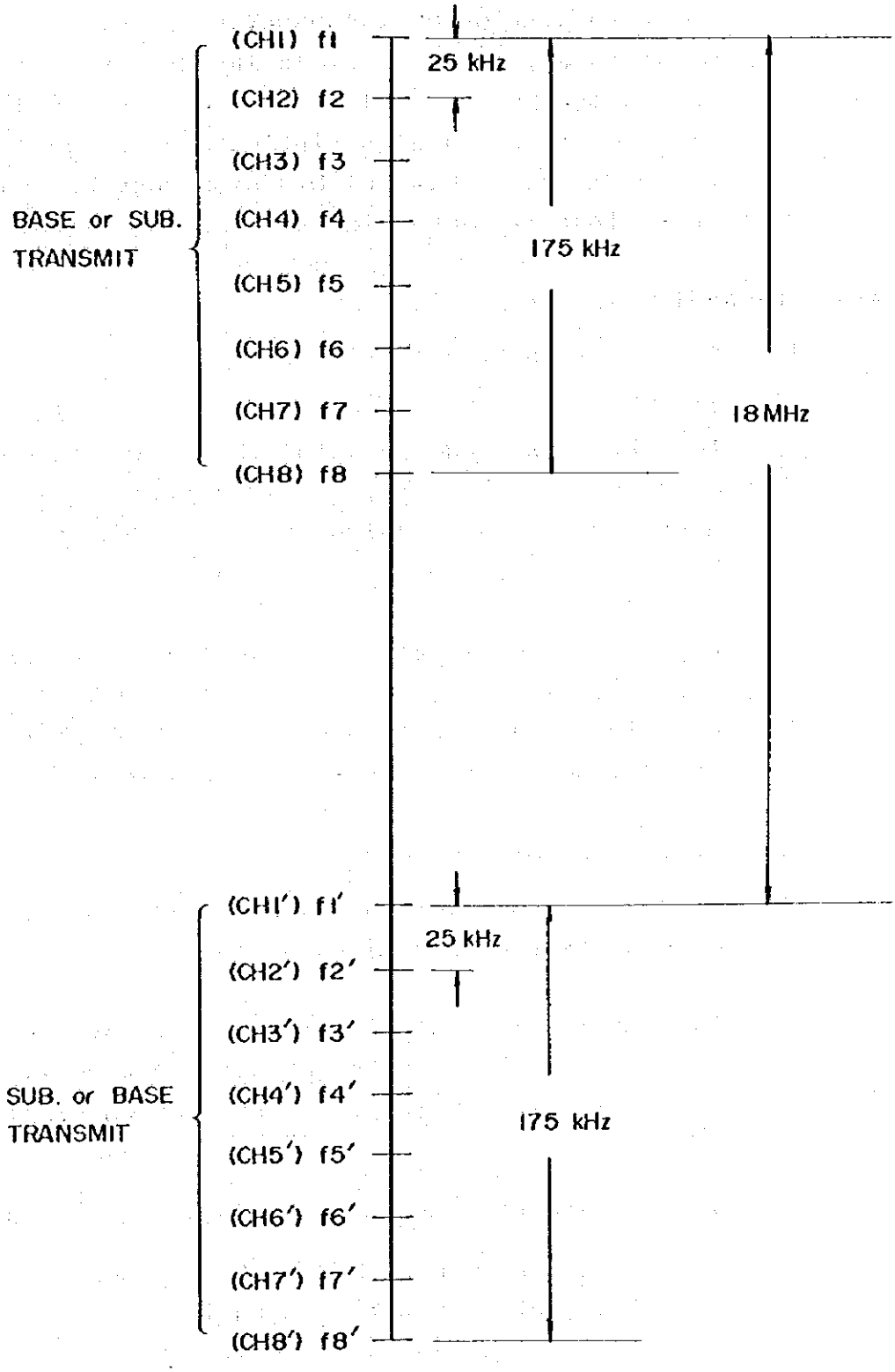


Figure II-8 400MHz Band Frequency Arrangement Plan

For finalization of frequency plan covering the whole Gezira area, in-depth field investigation based on the foregoing principles is necessary. And, at the stage of detail design, intimate contacts with STPC's Radio Frequency Control Division must be made so as to reflect its views in the final decision.

4-3 UHF Radio Link

(1) Transmission System Selection

In consideration of compatibility with digital telephone exchange, digital UHF radio link will be adopted. Furthermore, for transmission with the number of circuits calculated in Paragraph 1.6, 2 GHz band 240 CH system is recommended.

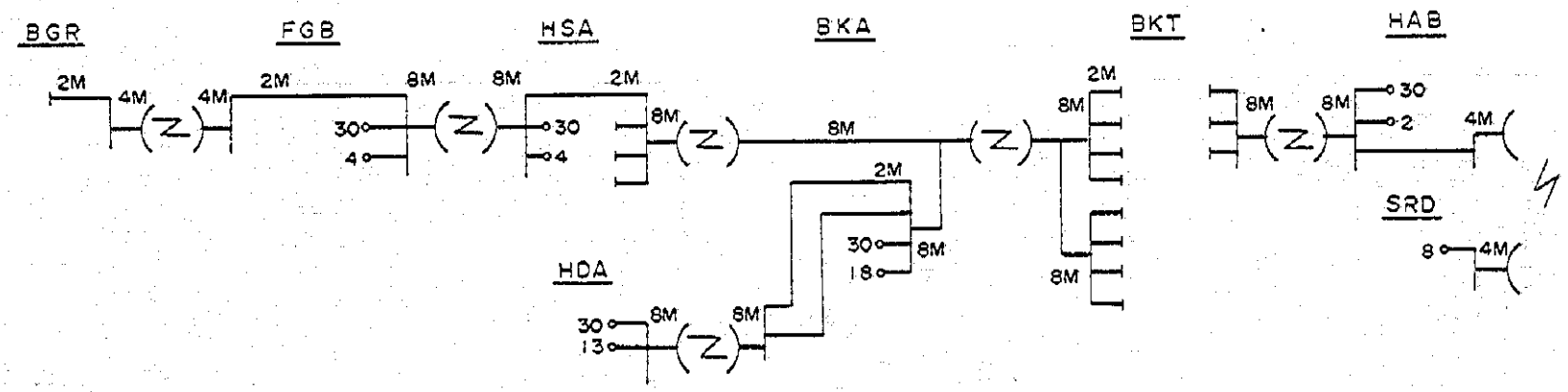
Figure II-9 presents UHF radio link telephone channel accommodation diagram. Shown in Figure II-10 is an example of radio frequency utilization plan. A list of antenna tower heights is in Figure II-11.

(2) System Performance Objectives

Based on CCIR recommendations, system performance objectives are determined as follows:

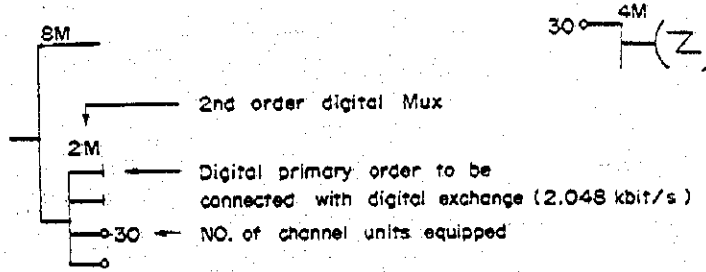
1) For the time of more than 1% of any one month, BER (Bit Error Rate) must not exceed 1.1×10^{-8} ($= 1 \times 10^{-7} \times \frac{280}{2500}$). (Integration time: 1 minute)

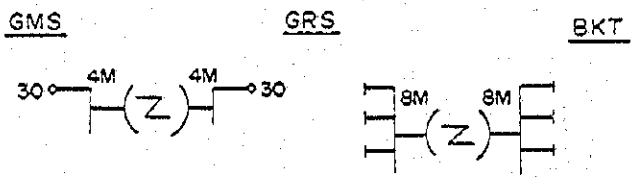
2) For the time of more than 0.0056% ($= 0.05\% \times \frac{280}{2500}$) of any one month, BER must not exceed 1×10^{-3}. (Integration time: 1 second)

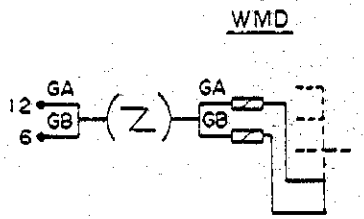


LEGEND

1. Digital system







2. Analog system

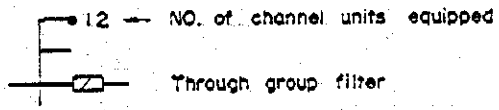


Figure II-9 Channel Accommodation Plan

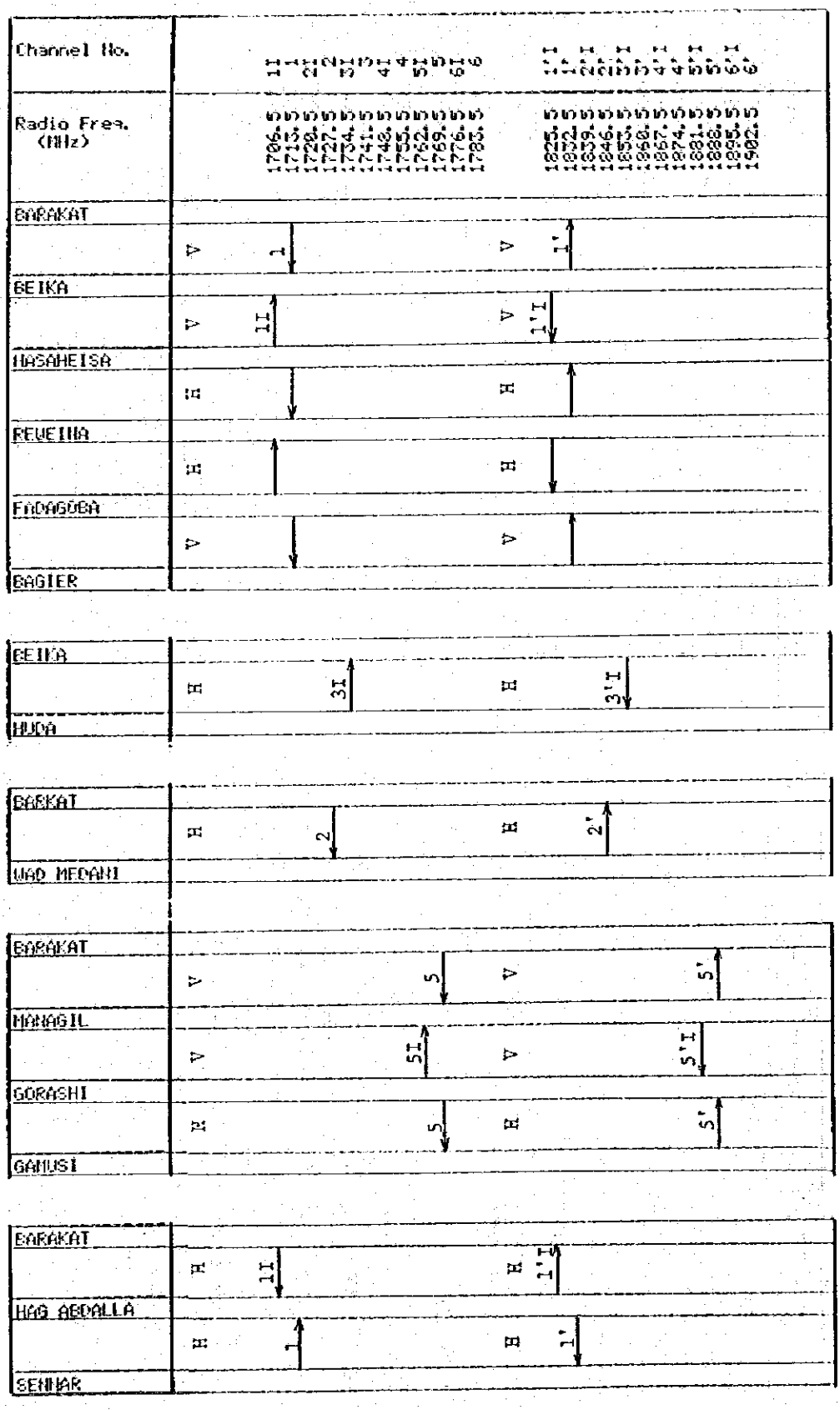


Figure II-10 UHF Link Frequency Assignment Plan

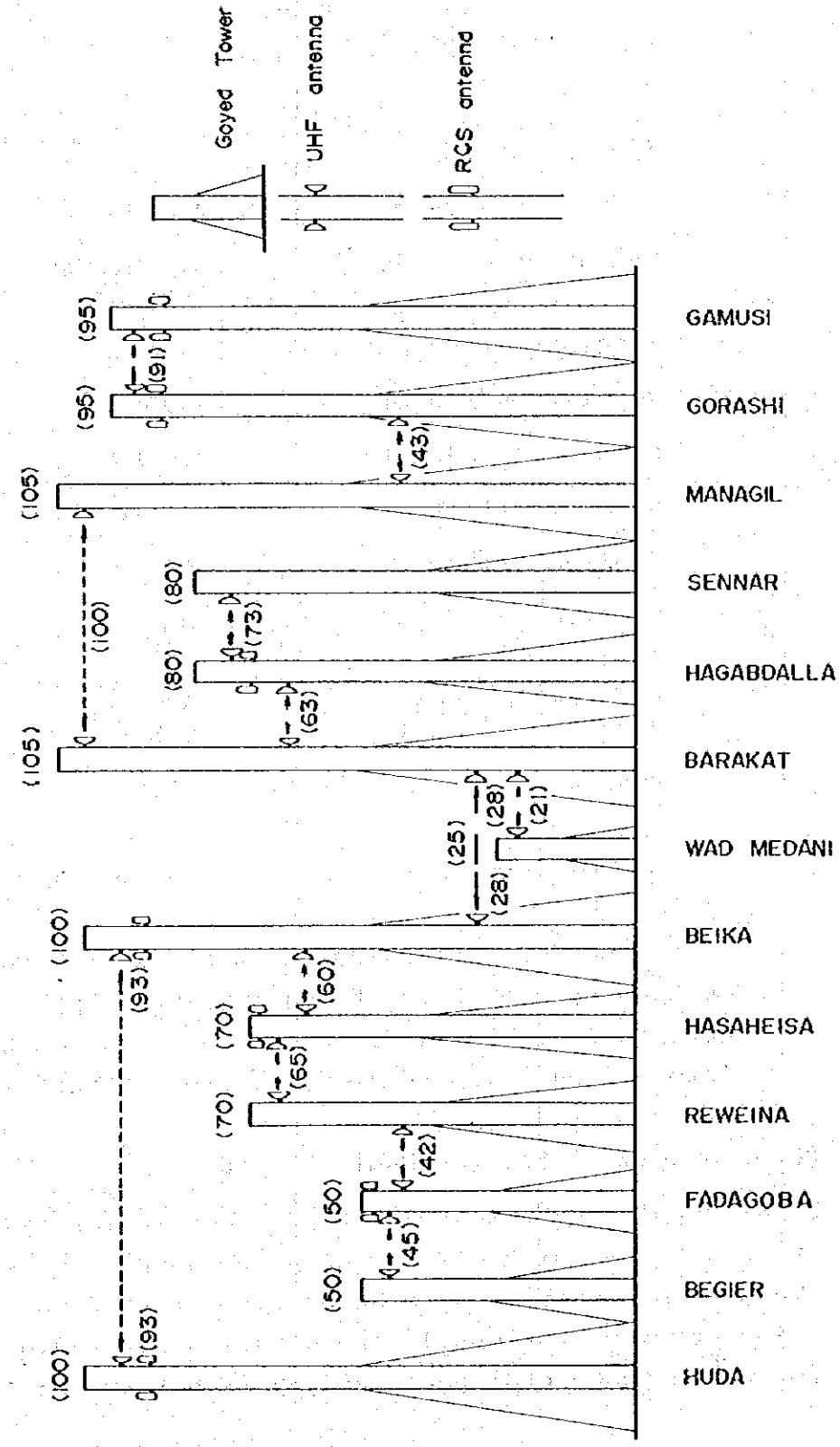


Figure II-11 Antenna Tower Height

3) System is to be 17 Mbit/s twin path system.

System parameters are:

Radio frequency	2 GHz band (CCIR Rec. 283-4)
Transmission capacity (per RF channel)	17 Mbit/s
Modulation system	4-DPSK
Demodulation system	Synchronous detection, Instantaneous detection
Transmitter output power	25 dBm
Receiver noise figure	4 dBm
Occupied bandwidth	9.0 MHz
Spectrum limit	50% roll-off
Receiver KTBF	-100.3 dBm
Receiver changeover level	-82.9 dBm (1 E - 5 BER)
Minimum receiver input power (10^{-3} BER)	-80.3 dBm (C/Nth = 20dB)
Standard receiver input power	-49.0 dBm
RF combiner loss	4.5 dB (twin path)

System performance calculation result for each radio section by use of the foregoing system parameters appears in Table II-5. Each radio station site information and path profiles are in ANNEX 7-(4).

4-4 Power Supply System for Radio Station

Power supply systems are twofold. One is for radio stations, for which commercial power supply is available. (These radio stations are hereafter referred to as mains-powered stations.) The other is for radio stations, for which commercial power supply is not available so that

Table II-5 UHF Link Noise Performance (1/4)

Path Number		1	2	3
Item	Unit	BAGIER KEKEINA	KEKEINA KASAKEISA	KASAKEISA 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	131.6	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

Table II-5 UHF Link Noise Performance (2/4)

Path Number		4	5	6
Item	Unit	BEIKA BARAKAT	BARAKAT HAGABDALLA	GORASHI HAHAGIL
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

Table II-5 UHF Link Noise Performance (3/4)

Path Number		7	8	9
Item	Unit	HAGABDALLA SENNAR	GAHUSI GORASHI	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	46.20	55.20	26.30
Path Condition	-	Plain	Plain	Plain
Free Space Loss	dB	131.8	133.3	126.9
Antenna Diameter (1)	m	4.0	4.0	3.3
Antenna Diameter (2)	m	4.0	4.0	3.3
Antenna Gain (1)	dBi	34.0	34.0	32.5
Antenna Gain (2)	dBi	34.0	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	83.0	101.0	53.0
Feeder Length (2)	m	83.0	101.0	53.0
Feeder Loss	dB	7.5	9.1	4.8
Rx Input Level	dBm	-51.2	-54.4	-46.6
C/N in Free Space (thermal)	dB	49.0	45.9	53.6
Required Thermal C/N	dB	20.0	20.0	20.0
Fading Margin	dB	29.0	25.9	33.6
Fading Probability	-	1.49E-03	2.77E-03	2.07E-04
Reliability	-	3.71E-06	1.43E-05	1.79E-07

Table II-5 UHF Link Noise Performance (4/4)

Path Number		10	11	12
Item	Unit	HAMAGIL BARAKAT	HUDA BEIKA	HADHEDAHI BARAKAT
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	59.70	56.20	9.10
Path Condition	-	Plain	Plain	Plain
Free Space Loss	dB	134.0	133.5	117.7
Antenna Diameter (1)	m	4.0	4.0	2.0
Antenna Diameter (2)	m	4.0	4.0	2.0
Antenna Gain (1)	dBi	34.0	34.0	28.0
Antenna Gain (2)	dBi	34.0	34.0	28.0
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	110.0	103.0	31.0
Feeder Length (2)	m	110.0	103.0	31.0
Feeder Loss	dB	9.9	9.3	2.8
Rx Input Level	dBm	-55.9	-54.7	-44.4
C/N in Free Space (thermal)	dB	44.4	45.5	55.6
Required Thermal C/N	dB	20.0	20.0	20.0
Fading Margin	dB	24.4	25.5	35.8
Fading Probability	-	3.65E-03	2.95E-03	5.05E-06
Reliability	-	2.66E-05	1.65E-05	2.63E-09

self-powered system is unavoidable. (These radio stations are hereafter referred to as self-powered stations.)

(1) Mains-powered Stations

Power supply system for mains-powered stations is subdivided into three systems according to the way the storage batteries are used. The three systems are the alternate charge-discharge system, partial floating system and full floating system.

The full floating system holds many advantages including:

a) Storage battery capacity can be reduced.
b) Storage battery life can be extended.
c) Maintenance is easy.
d) Power conversion efficiency is high. Hence economical.

Because of these advantages, the full floating system is commonly used as standard power supply system for mains-powered stations. In the current project also, the full floating system will be adopted as power supply system for mains-powered stations. For standby power supply system at the time of commercial power supply failure, diesel engine generators will be installed.

(2) Self-powered Stations

Self power supply systems comprise the following:

1) Internal Combustion Engine System

This system is for power generation by alternate operation of 2-3 internal combustion engines (mainly diesel engines) at fixed time intervals. This system is technically stable and of high reliability. When alternate charge-discharge

system is adopted for power supply to communication load, the rate of operation of internal combustion engines can be reduced though the required storage battery capacity increases and control circuits become somewhat complicated. This arrangement proves to be economically advantageous when power consumption is less than 1,000 W or thereabouts.

In the current project, alternate charge-discharge system will be adopted at RCS base stations and UHF radio stations. This decision is in consideration of power consumption at radio stations, as well as fuel supply situation in Sudan.

2) Solar Battery System

This system is for power generation by direct conversion of optical energy into electric power. These days, solar battery price is being reduced rapidly. This fact, plus ease of maintenance, low maintenance cost and no need of fuel, stands witness to solar battery system as an effective power supply system for stations where load power is 300 W at a maximum.

Almost all RCS subscriber stations in the current project are self-powered stations, and in each case, power consumption is as small as several W. Thus, for all subscriber stations, solar battery system will be adopted.

Presented in ANNEX 7-(5) are typical examples of solar battery system applied.

3) Wind Power Plant System

This system is for power generation by the turning of propeller type of Dalius type windmill by wind energy. However, in the current project area, places where stable wind energy required for wind power plant system can be obtained are extremely few. Hence te judgement that the introduction of wind power plant system is impracticable.

4) Thermal Power Plant System

This system is for power generation by the Seebeck effect of combustion heat by solid, liquid or gaseous fuel. In case where load capacity exceeds 300 W, internal combustion engine system is economically more advantageous, hence more commonly used, than thermal power plant system.

As the result of comparative study of all the foregoing systems for self power supply, decision is made that internal combustion engine system or solar battery system be adopted for self-powered stations in the current project. A list of power supply systems by exchanges is in Table II-6.

(3) Design Parameters

Main design parameters of facilities are as follows:

1) Mains-powered Stations

- DC power supply system:

  Battery full floating system

- Standby power supply system:

  Diesel engine generator

- Battery holding time:

  8 hours

Table II-6 Power Supply System for Each Station Site

Telephone Exchange/ Base Station	AC Mains Power	Type of Power Plant Applied
Bagier	Available	1 EG + 1 REC + 1 BATT
Fadagoba	Unavailable	2 EG + 2 REC + 2 BATT
Reweina	Ditto	Ditto
Hasaheisa	Available	1 EG + 1 REC + 1 BATT
Huda	Unavailable	2 EG + 2 REC + 2 BATT
Beika	Available	1 EG + 1 REC + 1 BATT
Barakat	Ditto	Ditto
Hag Abdalla	Unavailable	2 EG + 2 REC + 2 BATT
Managil	Available	1 EG + 1 REC + 1 BATT
Gorashi	Ditto	Ditto
Gamushi	Unavailable	2 EG + 2 REC + 2 BATT
Sennar	Available	1 EG + 1 REC + 1 BATT
Wad Medani	Ditto	Ditto
(RCS terminals)	Unavailable	Solar Battery

Note.

EG : Engine Generator

REL : Rectifier

BATT: Storage Battery

2) Self-powered Stations

a) RCS Base Stations, UHF Radio Stations

- Power generation system:

  Dual prime mover system by diesel engine

- DC power supply system:

  Battery full floating system

- Battery holding time:

  8 hours

- Mobile engine generator

  4 (One each at Barakat, Bagier, Hasaheisa and Gorashi)

b) All RCS subscriber stations

- Power generation system:

  Solar battery system

- DC power supply system:

  Battery partial floating system

- Battery holding time:

  10 days

ANNEX 6 introduces the power supply situation in the whole Gezira area.

4-5 Outside Plant

(1) Work Area

Areas where to install overhead cable lines are as follows:

1) Gorashi area
2) Meringan Ginning Factory area
3) Hasaheisa Ginning Factory area

4) Bagier Ginning Factory area
5) Between existing Wad Medani Exchange and MOI's Wad Medani Office

For about 250 existing subscribers in Barakat area (SGB headquarters and associated establishments presently accommodated in NC230), entrance cable cutover will be carried out at the time of Barakat master exchange cutover in the current project. This is because the primary cable installed at the time the existing exchange was established (i.e., in 1981) is still new, and especially because no new subscriber accommodation is on schedule. On the occasion of the said entrance cable cutover, two lines of ø100 mm, thick, polyvinyl chloride (PVC) pipes will be laid from the manhole beside the existing exchange foundation to the new exchange foundation, wherein to install riser cables to the new exchange.

(2) Basic Design Conditions

Line Formation	:	Overhead line by steel pipe poles. Maximum pole to pole span not to exceed 50.0 mm.
Cable	:	PE insulated, PE sheathed aerial cable. To be self-supporting type.
Conductor Diameter, Number of Pairs	:	Conductor Dia. / Pairs 0.4 mm / 10,20,30,50,100 0.6 mm / 30

Pole:

Pole length	8.0 m, 9.0 m
Tip end	8.0 cm
Taper	1/75
Design strength	200 kg

Required minimum road clearance of cable: 5.0 m

Note: In ginning factory compounds, Sudan National Railways and Gezira Light Railway tracks extend in all directions. All cars used are diesel rail cars so that no overhead lines are used. Tracks are somewhat elevated and the surface of tracks is about 50 cm above ground. Minimum road clearance of cable is to be 5.0 m for both tracks and general ground; therefore, in the sections where cable is to extend across the tracks, pole length is to be 9.0 m and, in flat land sections, 8.0 m.

(3) Cable Work Breakdown

Overhead cable work breakdown by areas appears below. For further details, refer to Figures III-12 through III-16.

1) Gorashi Area (Figure II-12)

Type of Cable	Cable Work Length (m)
0.4 mm - 10 P	3,300
0.4 mm - 20 P	250
0.4 mm - 30 P	400
0 4 mm - 50 P	300
0 4 mm - 100 P	1,200
2 SD	550
6 SD	100

2) Meringan Ginning Factory Area (Figure III-13)

Type of Cable	Cable Work Length (m)
0.4 mm - 10 P	1,350
0.4 mm - 20 P	1,100
0.4 mm - 30 P	600
0.4 mm - 50 P	400
0.4 mm - 100 P	2,200
2 SD	950
6 SD	650

3) Bagier Ginning Factory ARea (Figure II-14)

Type of Cable	Cable Work Length (m)
0.4 mm - 10 P	1,000
0.4 mm - 20 P	250
0.4 mm - 30 P	50
0.4 mm - 50 P	10
2 SD	600
6 SD	400

4) Hasaheisa Ginning Factory Area (Figure II-15)

Type of Cable	Cable Work Length (m)
0.4 mm - 10 P	2,950
0.4 mm - 20 P	850
0.4 mm - 30 P	1,100
0.4 mm - 50 P	450
0.4 mm - 100 P	50
2 SD	1,200
6 SD	1,350

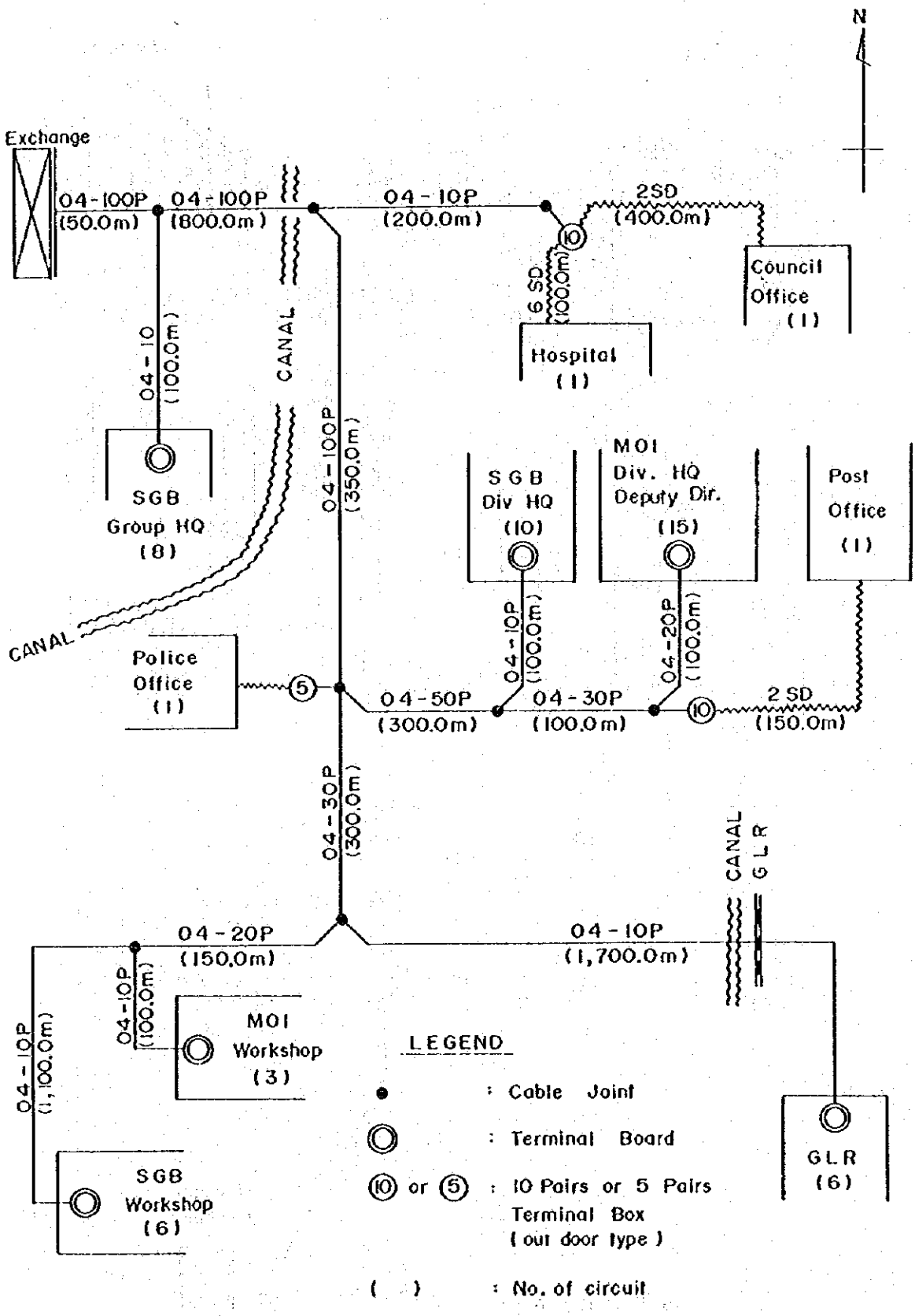


Figure II-12 Gorashi Area Cable Distribution

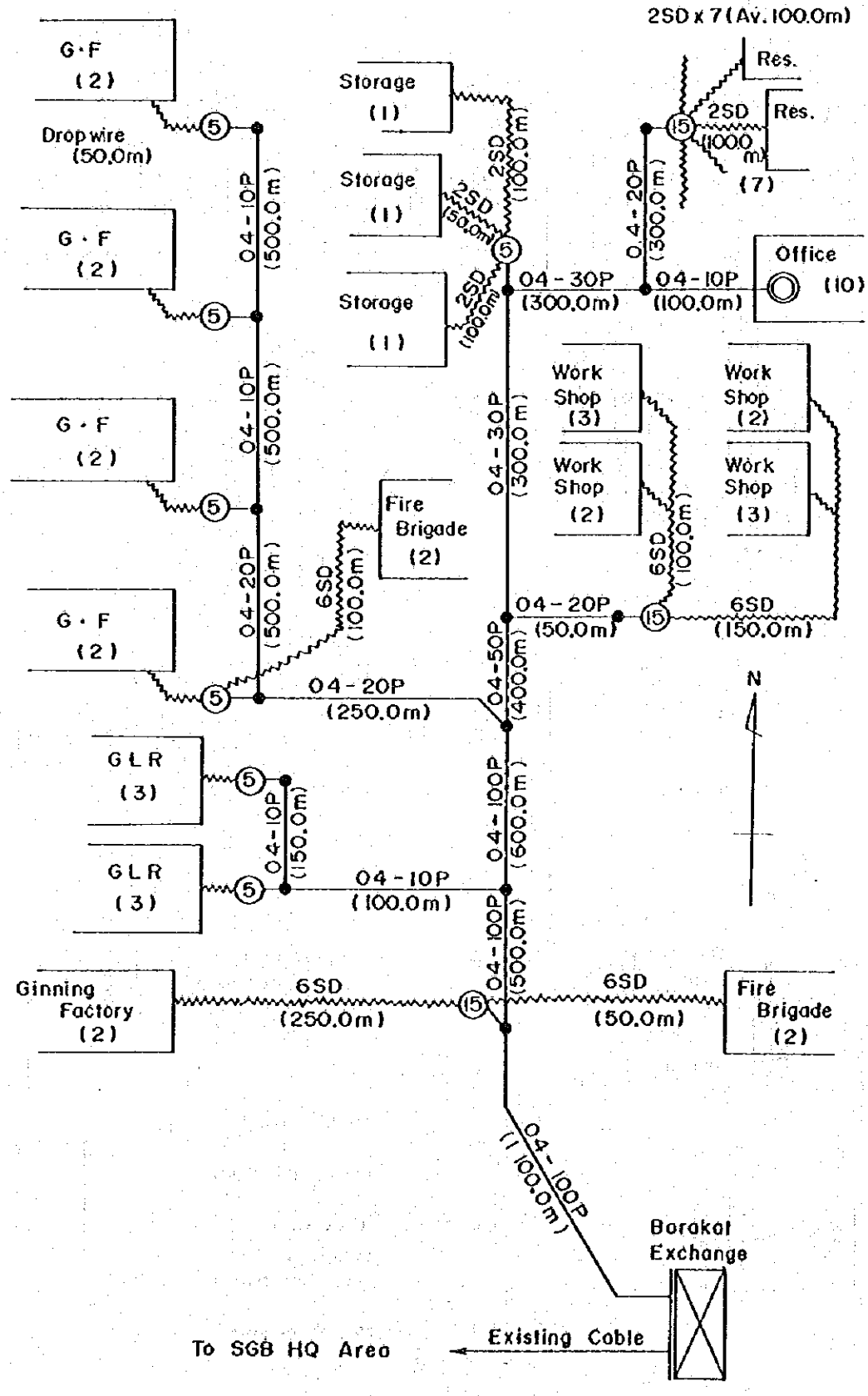


Figure II-13 Meringan GF Cable Distribution

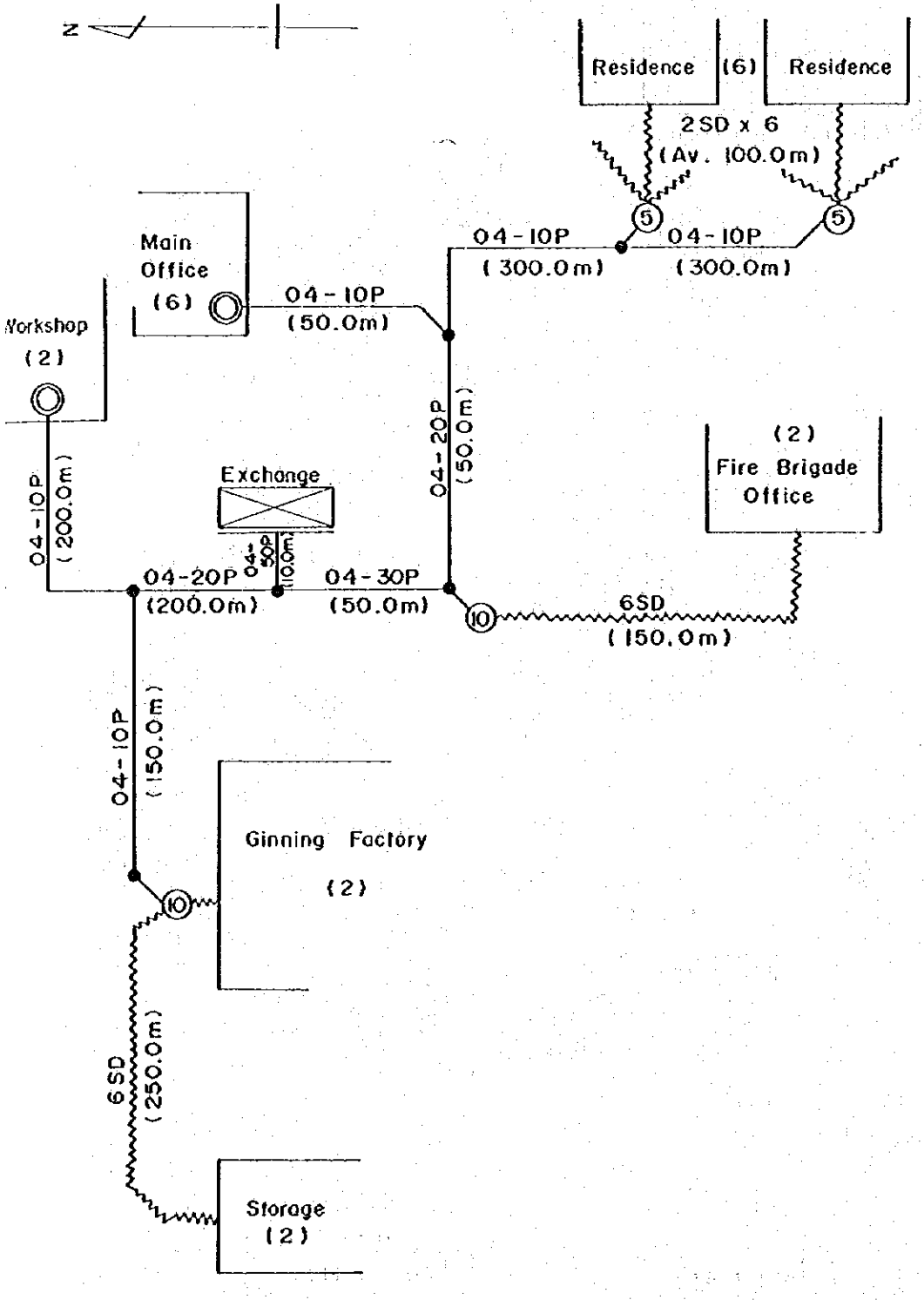


Figure II-14 Bagier GP Cable Distribution

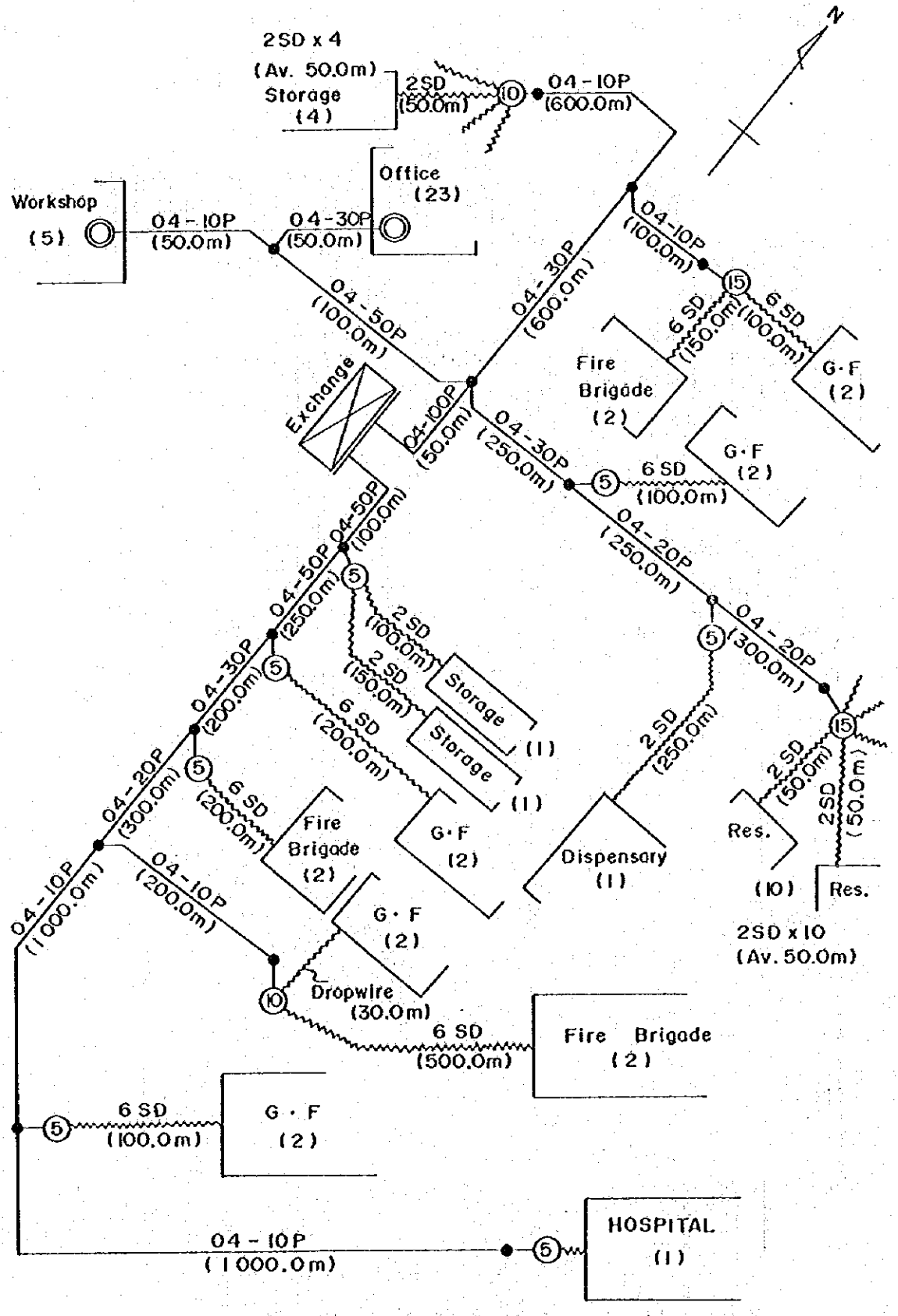


Figure II-15 Hasaheisa Cable Distribution

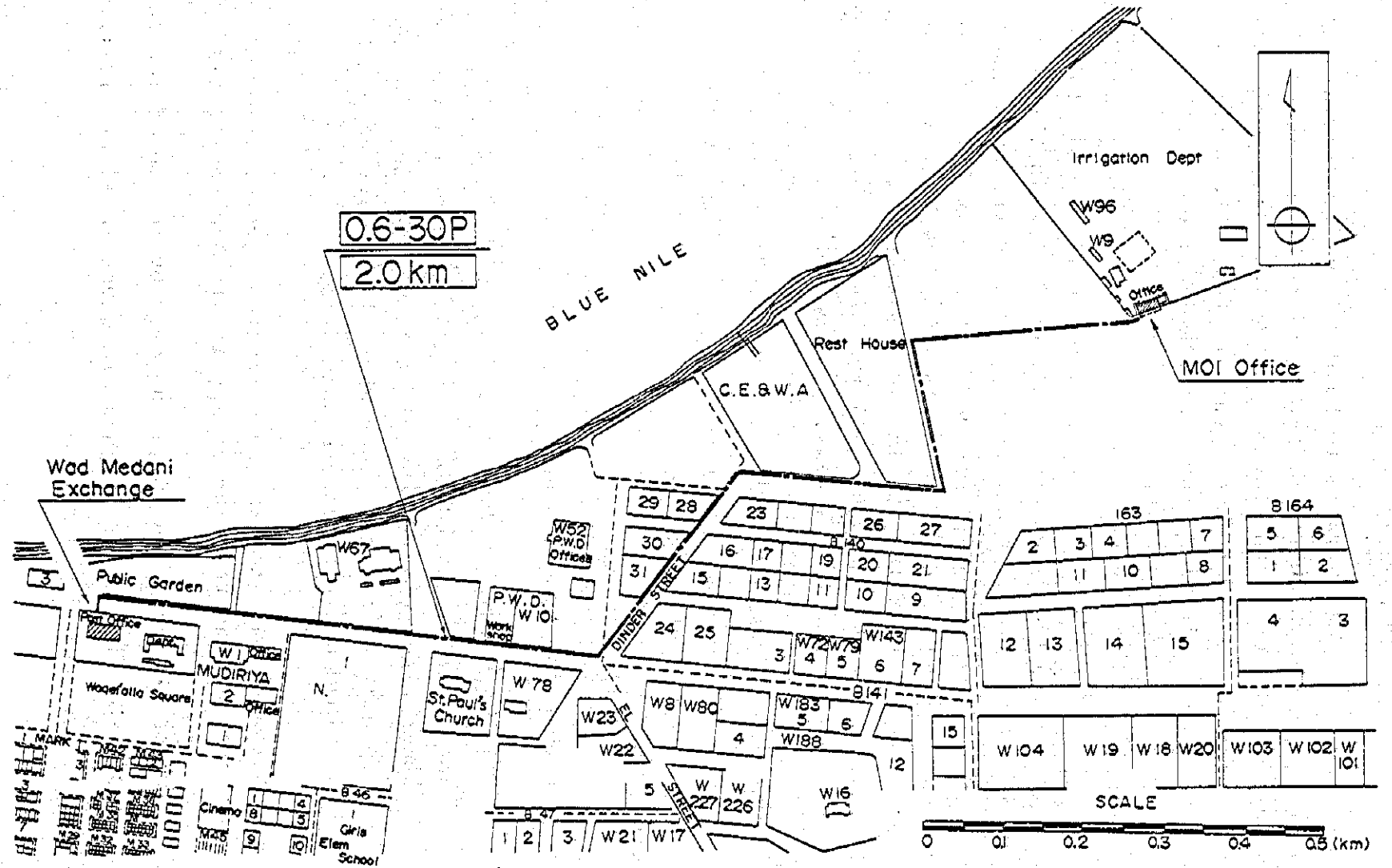


Figure II-16 Cable Route between Wad Medani and MOI Headquarters

5) Wad Medani Exchange - MOI Wad Medani Office (Figure II-16)

This work is to have MOI Office (Divisional Headquarters; Deputy Director's Office), located on north side of Wad Medani City, accommodated in the pertinent project area. The number of circuits required at MOI Office is 20.

At present, between Barakat Exchange and Wad Medani Exchange, direct buried cable (0.6 mm - 100 P) exists. Idle conductor in this cable is to be connected by jumper to the existing MDF in Wad Medani Exchange and then to MOI Office. One end of new cable is to be terminated on the existing MDF in Wad Medani Exchange, and the other end on wall type indoor terminal block to be newly installed in MOI Office.

Type of Cable	Cable Work Length
0.6 mm - 30 P	2.0 km

4-6 Tower

Towers for communication use comprise two types: Self-supporting type and guyed type.

Self-supporting tower costs more than guyed tower; however, land space required can be small. Therefore, the self-supporting type is convenient to use at mountain-top radio repeater or in such place where large site cannot be obtained as in densely housed area.

All station sites in the current project area on flat land, and no restriction applies to land availability.

Hence the adoption of guyed tower by reason of low cost.

Site by site tower heights are given in Figure II-11.

(1) Schematic Design of Guyed Tower

1)	Type of Tower	:	Guyed tower
2)	Wind Velocity	:	120 km/h
3)	Soil bearing power	:	20 t/m^2
4)	Type of Antenna	:	2-4 mø parabolic antenna Quantity: 1-3 Antenna for RCS Quantity: 0-1
5)	Accessories	:	Laddar, platform (at each 20 m), cable rack, aircraft obstruction lamp, daytime aircraft warning painting, anticorrosive plating, MIL seat sign, earthing work
6)	Foundation Work	:	Guy foundation work, guy anchor work

(2) Pole Brace for RCS Subscriber Station

At RCS subscriber station, pole brace on which to mount antenna does not need to be very high because radio frequency is of 400 MHz band. In view of a large number of RCS subscriber station, pole brace standardization is essential in order not to protract work period.

Two kinds of pole braces, 10 m and 20 m high above ground, will be used, in consideration of ground obstacle and radio propagation characteristic. Types of pole braces are also twofold: panza mast type and pole type. Concrete reinforcement for pole braces will not be considered except for places where drastic irregular ground settlement occurs.

4-7 Building

4-7-1 Basic Design Conditions

Telecommunication facilities, represented by telephone exchanges, are "architectures for safety of telecommunications and for satisfactory service performance." Therefore, top design condition for those architectures is to keep them safe against disasters.

Communication equipments of many kinds to be introduced by the current project are of high precision; they require carefully maintained indoor environment. To protect them from trouble and malfunction, dust-proofing and temperature/humidity control assume primary importance. Basic requirements for such purpose are:

1) Buildings be strong in construction.

2) Buildings be designed to be incombustible.

3) Fixtures in and around machine room be of steel make.

4) Machine room be as far separated as possible from office, service yard, etc.
(To use machine room as night duty room, or to do cooking or take rest in machine room is deleterious to normal function of equipment installed.)

5) Automatic switching room and radio room be air-conditioned.

The most part of buildings, this time, are to be the shelter type or container type. This is because the equipments to be introduced by the current project are not big sized and because the time available for the whole work is not necessarily long when the period required for equipment installation and tests is taken

into consideration. Exceptions are Central Maintenance Center to be established at Barakat and Maintenance Centers to be established at Hasaheisa, Bagier and Gorashi. For these maintenance centers, solid type structures will be brought from Japan for assembly at site.

All these works are included in the project contract. The project itself is to be fulfilled on turn-key basis as stated in Implementation Schedule.

4-7-2 Room by Room Design Conditions

1) Switching Equipment Room

a) Switching equipment room is to be the van type/ container type, equipped with automatic exchange, MDF, rectifiers, batteries, plug socket for measuring equipment, as well as lighting equipment.

b) Communication cable and power cable entrance is to be considered.

c) Anteroom is to be provided so as to prevent dirt and dust ingress.

d) Room is to be air-conditioned.

e) Door is to be steel made, with lock, and of air tight construction.

f) Container itself is to be protected, with cover, from direct exposure to sunlight.

g) Foundation work is to be done, based on separately prepared shelter and container foundation work requirements.

2) Radio Equipment Room

a) Radio equipment room is to be the shelter type, equipped with radio equipment, concentrator, multiplex equipment, outlets for measuring equipment, as well as lighting equipment.

b) Entrance is to be considered for radio equipment feeder cable, tie cable to connect radio equipment to switching equipment, and power cable.

c) Room is to be air conditioned.

d) Door is to be steel made, with lock, and of air tight construction.

e) Shelter itself is to be protected, with cover, from direct exposure to sunlight.

f) Foundation work is to be done, based on separately prepared shelter and container foundation work requirements.

4-7-3 Power Room

a) Power room is to be equipped, in principle, with incoming panel, control panel, rectifiers, batteries, and, when necessary, diesel engine generator and day tank. Equipment items differ according to power supply system.

b) Batteries and other equipment should be installed in separate rooms as far as possible. When installed in the same room unavoidably, batteries are to be isolated from other equipment.

c) Diesel engine generator room and battery room are to be equipped with forced ventilation system.

d) Doorway is to be so considered that equipment to be installed can be easily carried into the room.

e) Floor should preferably be acid- and oil-proof vinyl tile floor.

f) Lighting facilities and outlets are to be provided.

g) Incombustible gas extinguisher is to be provided.

h) Foundation work is to be done, based on separately prepared shelter and container foundation work requirements.

i) Power room is to be the shelter type or solid type structure according to the size.

4-7-4 Shelter and Container Foundation Work

a) Foundation is to be built of reinforced concrete.

b) Foundation is to be strong enough to support shelter or container.

c) Concrete strength is to be 28 days strength of 180 kg/cm^2 or more.

d) Shelter/container floor level is to be higher than possible flood level in the area concerned.

e) For foundation work, earthing work is also to be considered.

f) In case where diesel engine generator is installed in power room, special care is to be directed to foundation work.

4-7-5 Solid Type Structure

(1) Barakat Central Maintenance Center (Figure II-17)

1) Structure is to be built of structural members, mainly H-steel, and external siding mainly composed of glass fiber and reinforced cement.

2) Assembly is to be easy.

3) Total floor area is to be 200 m^2 or less.

4) Size and function of each room, as well as accessories, are given in Table II-7.

(2) Maintenance Center (Figure II-18)

1) Hasaheisa, Bagier and Gorashi Maintenance Centers are to be structures built of structural members, mainly light gauge steel, and external siding mainly composed of calcium silicate board and flexible board.

2) Assembly is to be easy.

3) Total floor area is to be 40 m^2 or less.

4) Size and function of each room, as well as accessories, are given in Table II-8.

(3) Diesel Engine Room (Figure II-19)

1) Construction is to be the same as that of Maintenance Center.

2) Assembly is to be easy.

3) Total floor area is to be 30 m^2 or less.

4) Foundation work includes, besides room foundation, special foundation to support diesel engine.

5) Forced ventilation equipment is to be provided.

6) Room size and accessories are given in Table II-9.

4-7-6 Equipment, Site Layout Plans

(1) Equipment Layout Plan

Typical equipment layout plans are given in Figure II-20 through Figure II-22.

(2) Site Layout Plan

Typical site layout plans are given in Figure III-23 through Figure III-25.

4-8 Mobile Communication System

Mobile radiotelephone systems developed and practiced in Japan are as follows:

1) Multichannel Access (MCA) mobile radiotelephone system

2) Personal radiotelephone system
(This is not exclusively for mobile radiotelephone, but can be used for mobile communication.)

3) General public mobile radiotelephone system

MCA system consists of several thousand users who belong to special organization and who co-use 10 odd radio channels. Conversation time is limited to one minute, each time. This system does not suit Gezira tele-communications network because of difference in the number of subscribers and conversation time limitation.

Personal radiotelephone is otherwise called CB (Citizen Band) telephone. A kind of simple mobile telephone, it is mainly utilized for communication between cars on the move. Radio propagation distance is short, i.e., not more than several km. This system also is not appropriate to use in the current Gezira project.

Public mobile radiotelephone system is the best now available for mobile radiotelephony. Technically, it is highest developed. For institutional-use mobile telephone system contemplated in Gezira Rehabilitation Project, it certainly is an extravagance.

For the fittest choice for the current project, the following plan is recommended:

1) Mobile radiotelephone subscribers in the whole Gezira area be estimated at 150.

2) Mobile radiotelephone subscribers be ranked as RCS network accommodated subscribers.

3) Radio equipment to be used by mobile subscriber units be basically the same as radio equipment used by land fixed telephone subscribers, whereas for cubicle, antenna and handset, those for mobile telephony be used.

4) The number of mobile radiotelephone base stations be exactly the same as the number of land fixed RCS network base stations. When a mobile subscriber unit moves from one base station coverage area to another base station area, hand off is not carried out. The mobile subscriber concerned is to dial the called subscriber number again from inside the new base station area.

5) For radio equipment at each base station, 1-2 radio channel increase be carried out and transmitting output power also be increased.

6) System adopted be such that all subscribers in Gezira area can make mutual contact for telephone conversation.

Fundamental design of institutional use mobile communication system is given in ANNEX 7-(7).

Institutional-use mobile telephone communication system projected, this time, is an RCS network-based summary version of land-fixed subscriber to/from land-mobile subscriber unit radiotelephone system. Therefore, compared with the latter, the projected system is subject to several restrictions in operational aspect. That is to say,

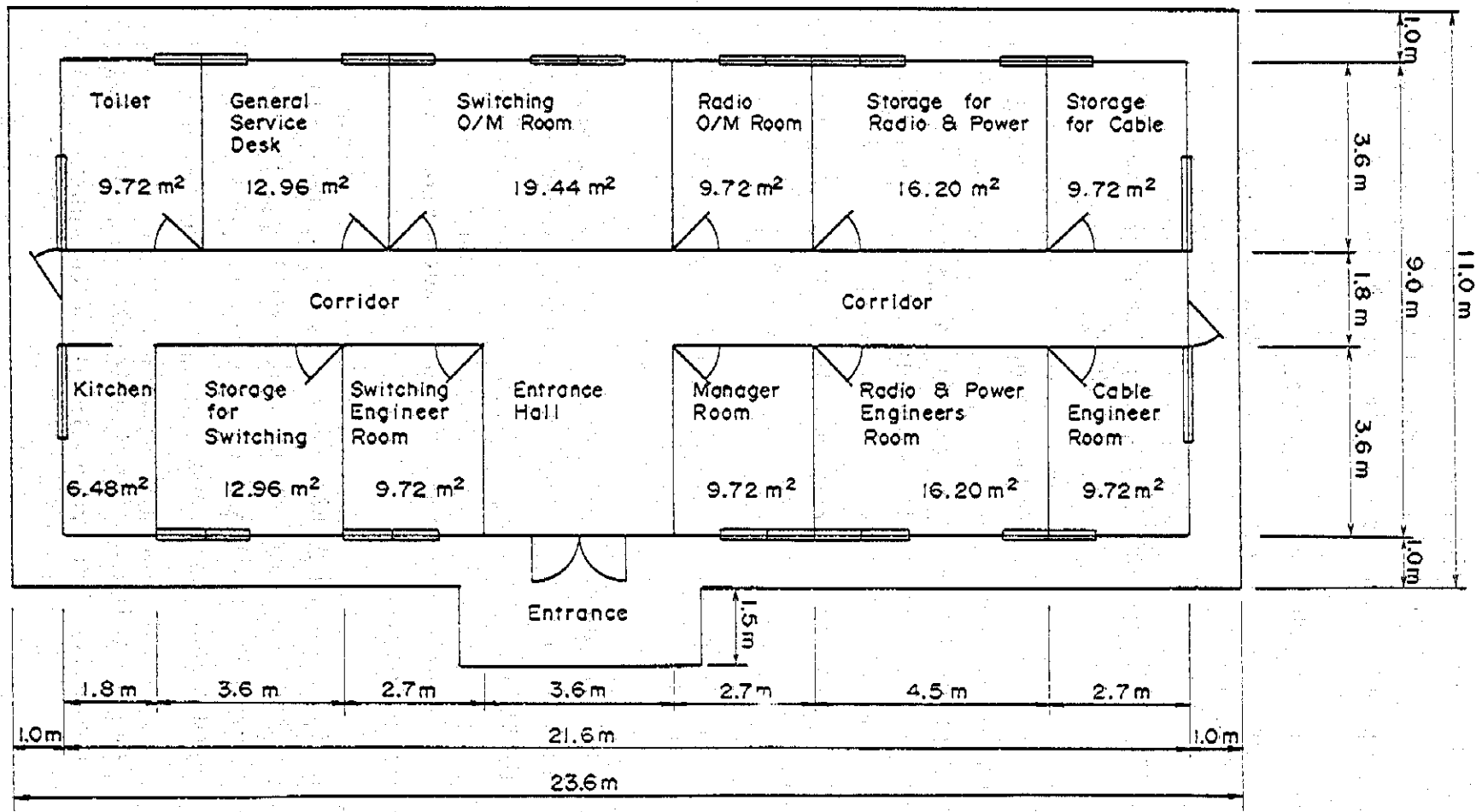
1) Service area is smaller than that of fixed subscriber station.

2) Mobile subscriber units on the move in service area periphery must stop when making telephone communication.

3) Communication between mobile subscriber units is not possible.

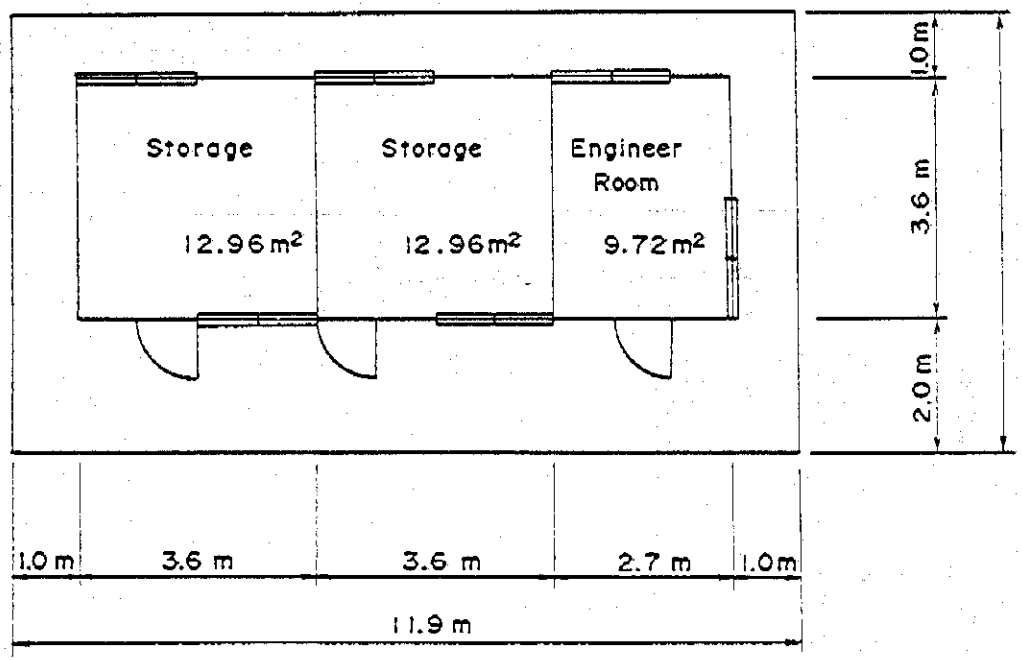
4) Ring-up from land-fixed subscriber to mobile subscriber unit is by group calling, in principle. Specified mobile subscriber units only are entitled to individual ring-ups.

Basic design of institutional-use mobile telephone communication system is given in ANNEX 7-(7).



Total Floor space ----- 194.40 m² Foundation area ---- 266.5 m²

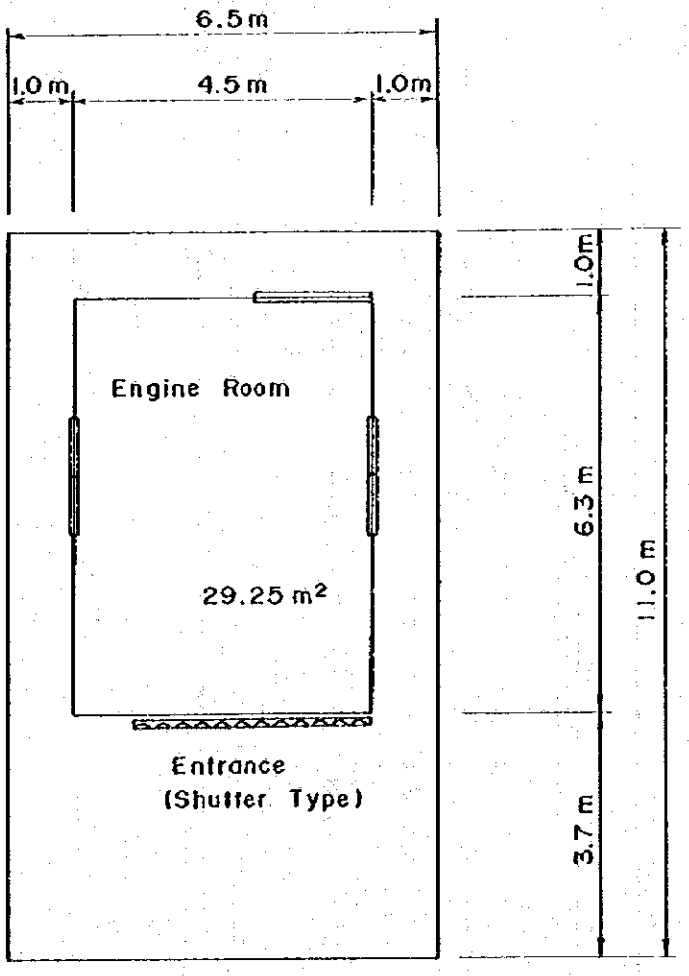
Figure II-17 Barakat Central Maintenance Center



Total Floor space ------ 35.64 m²

Foundation area. ------ 78.54 m²

Figure II-18 Maintenance Center



Engine Room space ------ 29.25 m²
Foundation area ----- 71.50 m²

Figure II-19 Engine Room

Table II-7 Barakat Central Maintenance Center

Group	Function and Floor space		Condition
Switching Group	1. O/M Room. (Operation & Maintenance)	20 m^2	1. Air Condition 2. Light & Wall outlet
	2. General Service Desk Room	12 m^2	1. Air Condition 2. Light & Wall outlet
	3. Engineers Room	10 m^2	1. Electric Fan /Ceiling Type 2. Light & Wall outlet
	4. Storage	12 m^2	1. Electric Fan /Ceiling Type 2. Light & Wall outlet
Radio and Power Group	1. O/M Room	10 m^2	1. Air Condition 2. Light & Wall outlet
	2. Engineers Room	16 m^2	1. Electric Fan /Ceiling Type 2. Light & Wall outlet
	3. Storage	16 m^2	1. Electric Fan /Ceiling Type 2. Light & Wall outlet
Outside Plant Group	1. Engineers Room	10 m^2	1. Electric Fan /Ceiling Type 2. Light & Wall outlet
	2. Storage	10 m^2	1. Electric Fan /Ceiling Type 2. Light & Wall outlet
Others	1. Manager Room	10 m^2	1. Electric Fan /Ceiling Type 2. Light & Wall outlet
	2. Toilet	10 m^2	1. Light & Wall outlet 2. Water facilities 3. Sewage facilities 4. Sanitary facilities

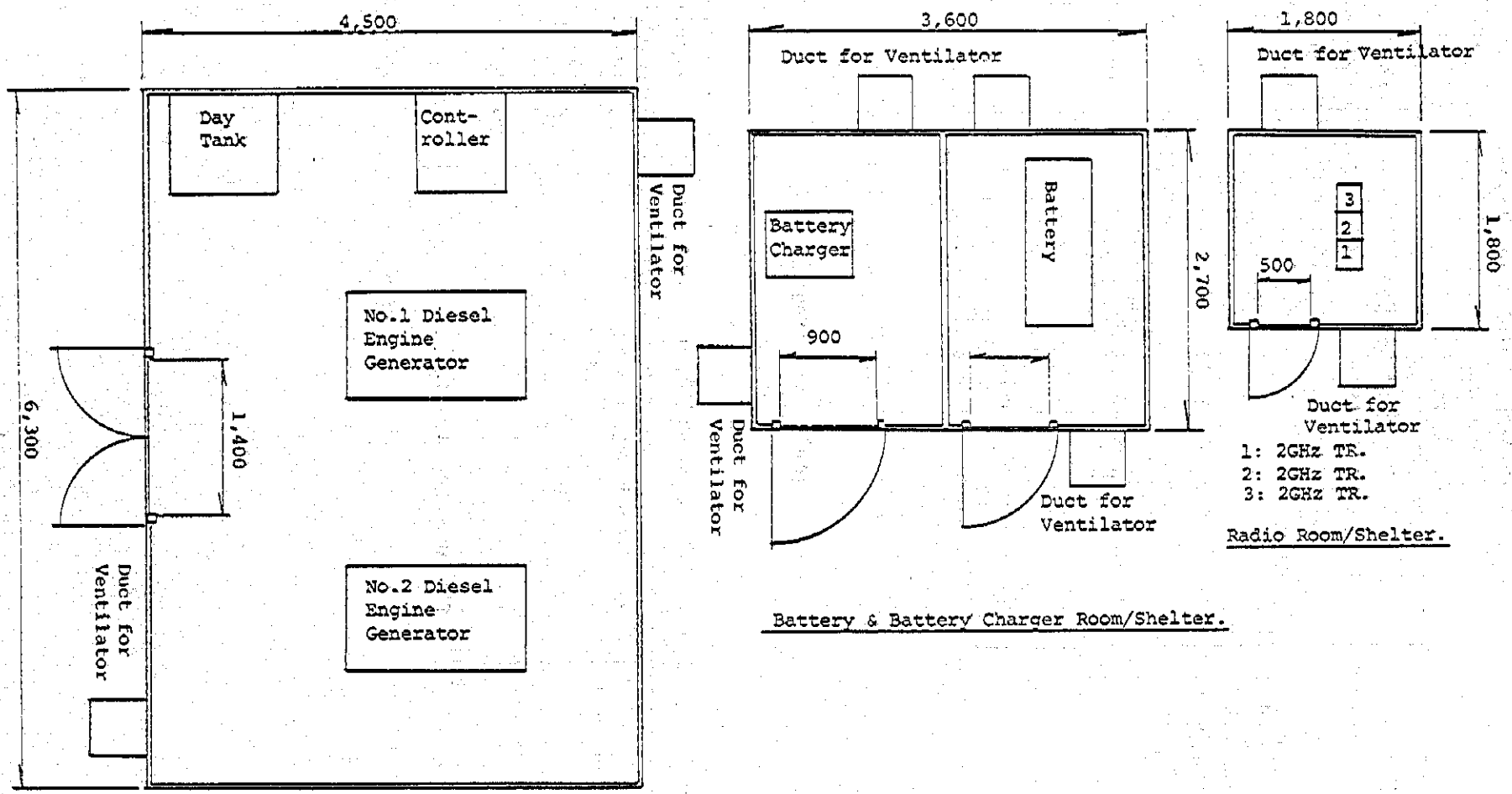
Group	Function and Floor space		Condition
Others	3. Kitchen	6 m^2	1. Light & Wall outlet 2. Water facilities 3. Sewage facilities 4. Cooking facilities
	4. Entrance Hall	12 m^2	1. Light & Wall outlet
	5. Corridor	40 m^2	1. Light & Wall outlet
	* See attached Reference Drawing.		

Table II-8 Maintenance Center

Group	Function and Floor Space		Condition
Switching, Radio, Power and Outside Plant	1. Engineer Room	10 m^2	1. Light and Wall outlet 2. Electric Fan /Ceiling Type
	2. Storage Room (A)	12 m^2	1. Same as above 2. "
	3. Storage Room (B)	12 m^2	1. Same as above 2. "
	* See attached drawings		

Table II-9 Engine Room

Group	Function and Floor Space		Condition
Engine Room	1. Diesel Engine Room	30 m^2	1. Light & Wall outlet 2. Ventilator 3. Spacial Foundation 4. Special Entrance
	* See attached drawings.		



S=1/50mm

Figure II-20 Typical Equipment Layout (Reweina)

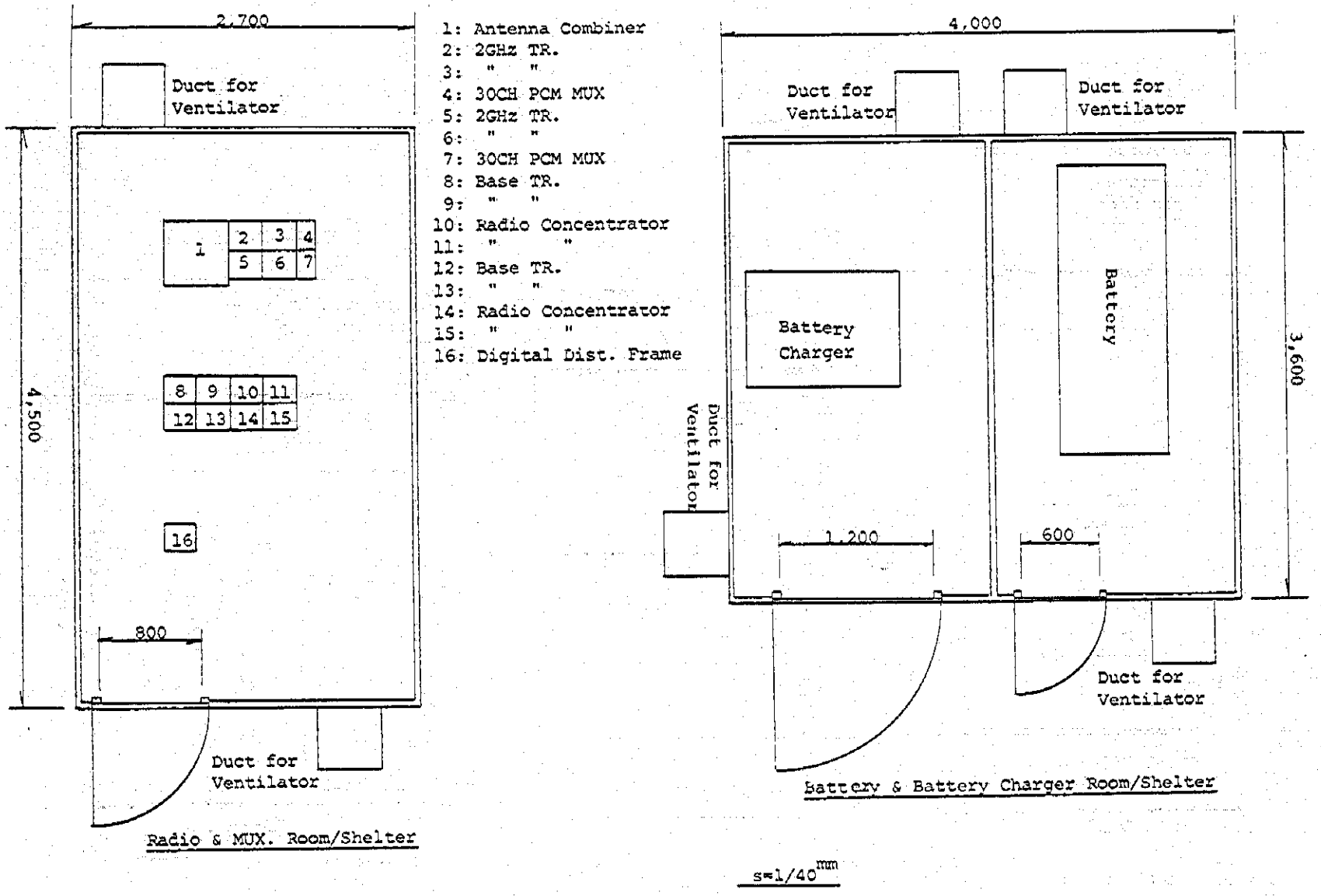


Figure II-21 Typical Equipment Layout (Beika)

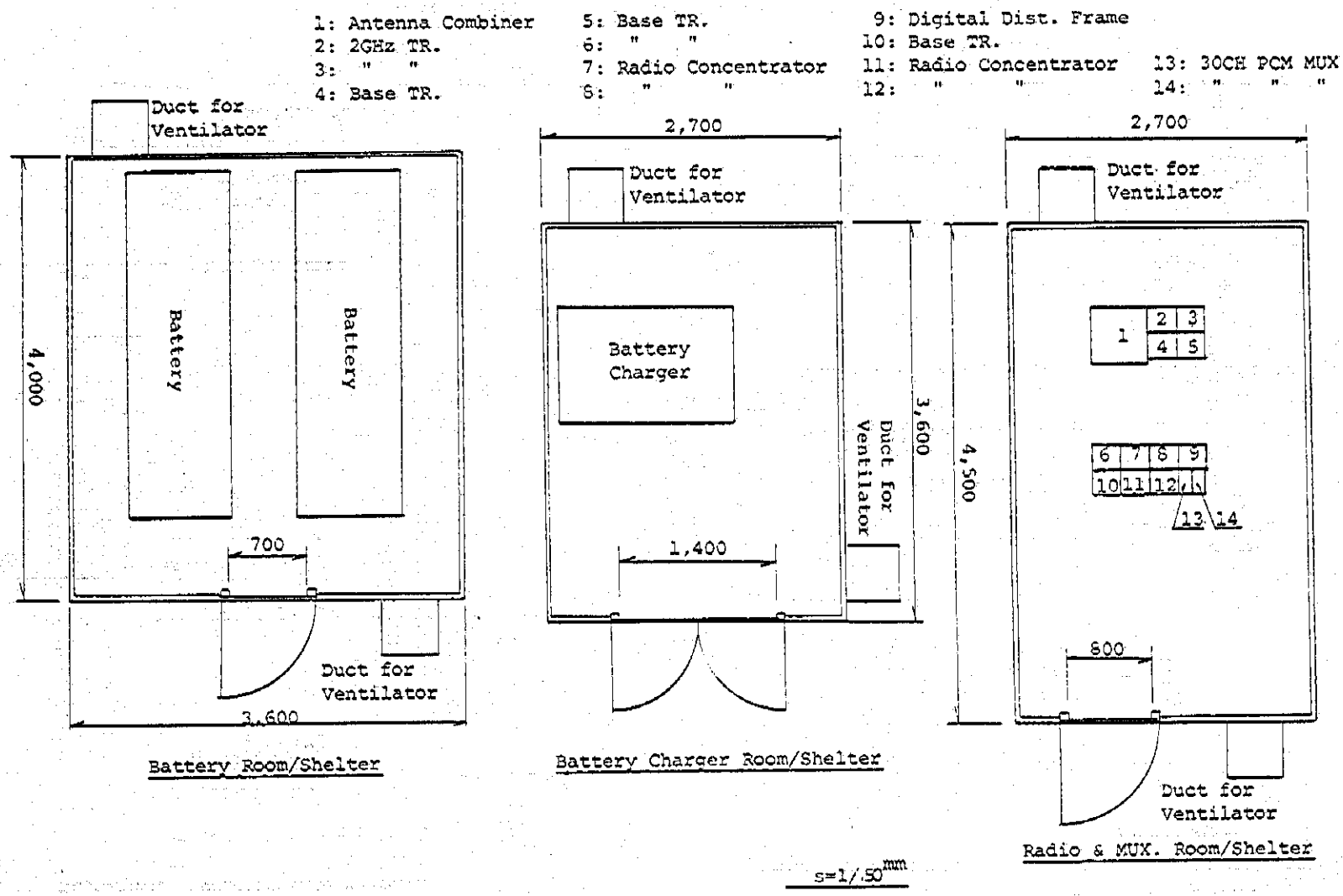


Figure II-22 Typical Equipment Layout (Huda)

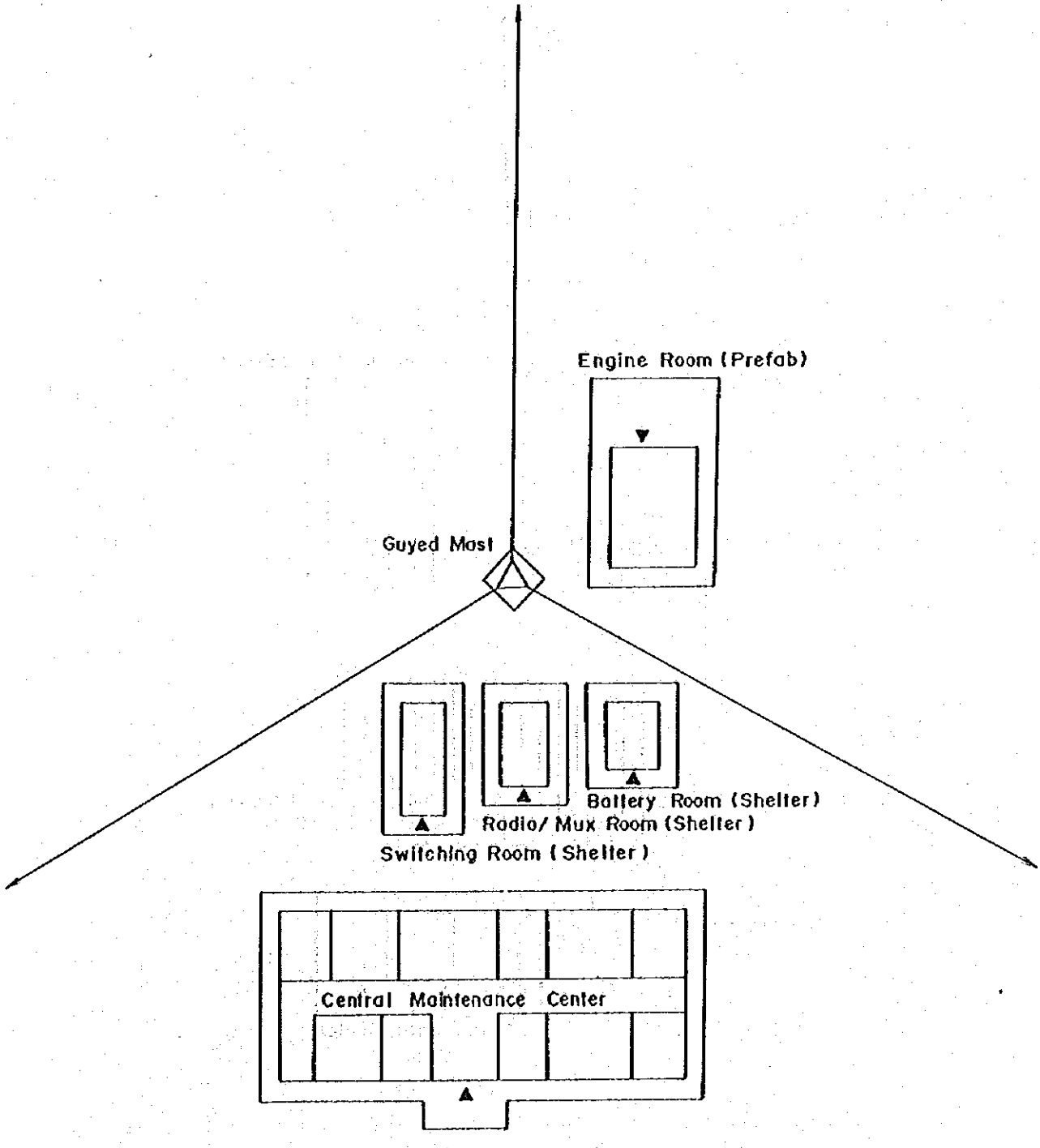


Figure II-23 Typical Site Layout (Barakat)

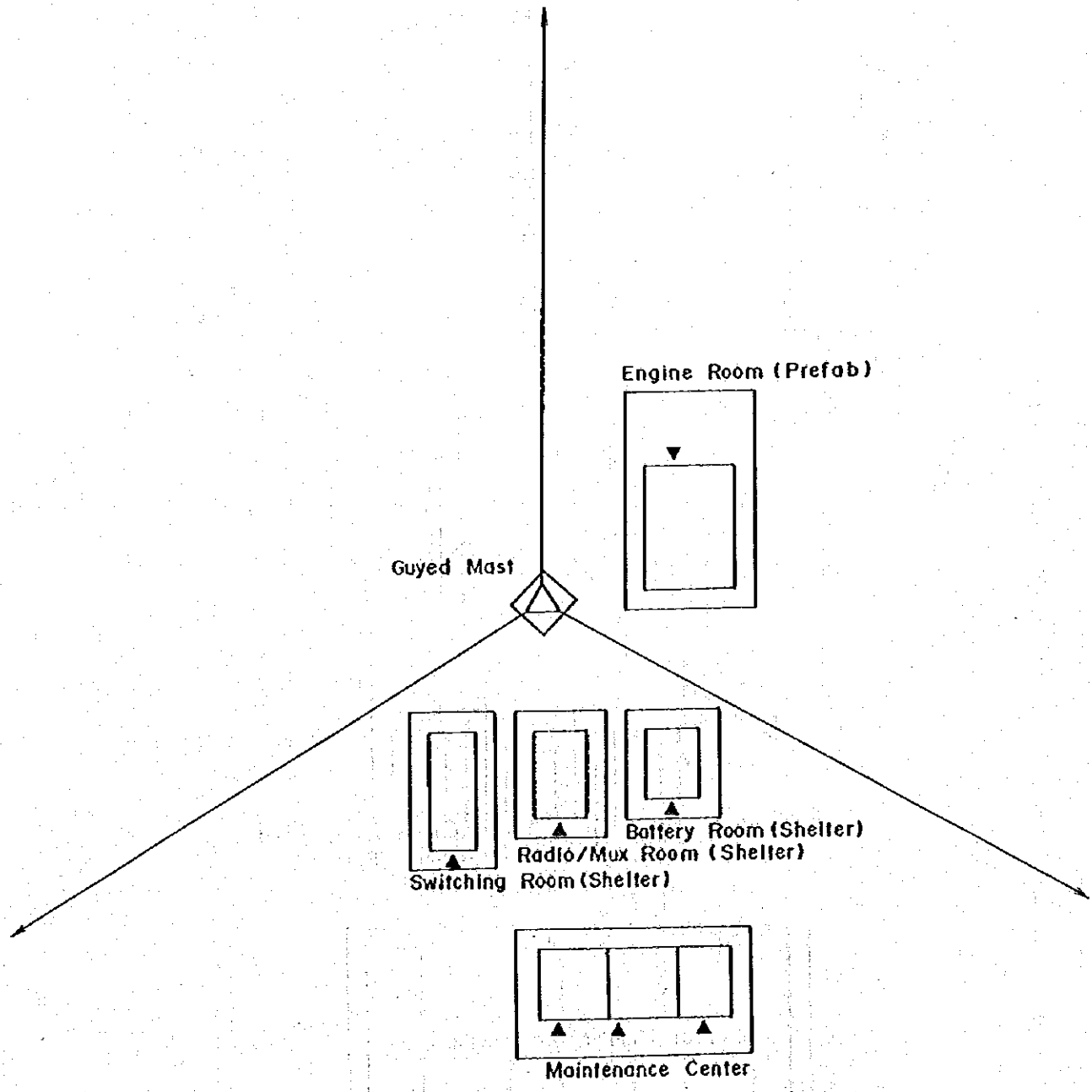


Figure II-24 Typical Site Layout (Hasaheisa)

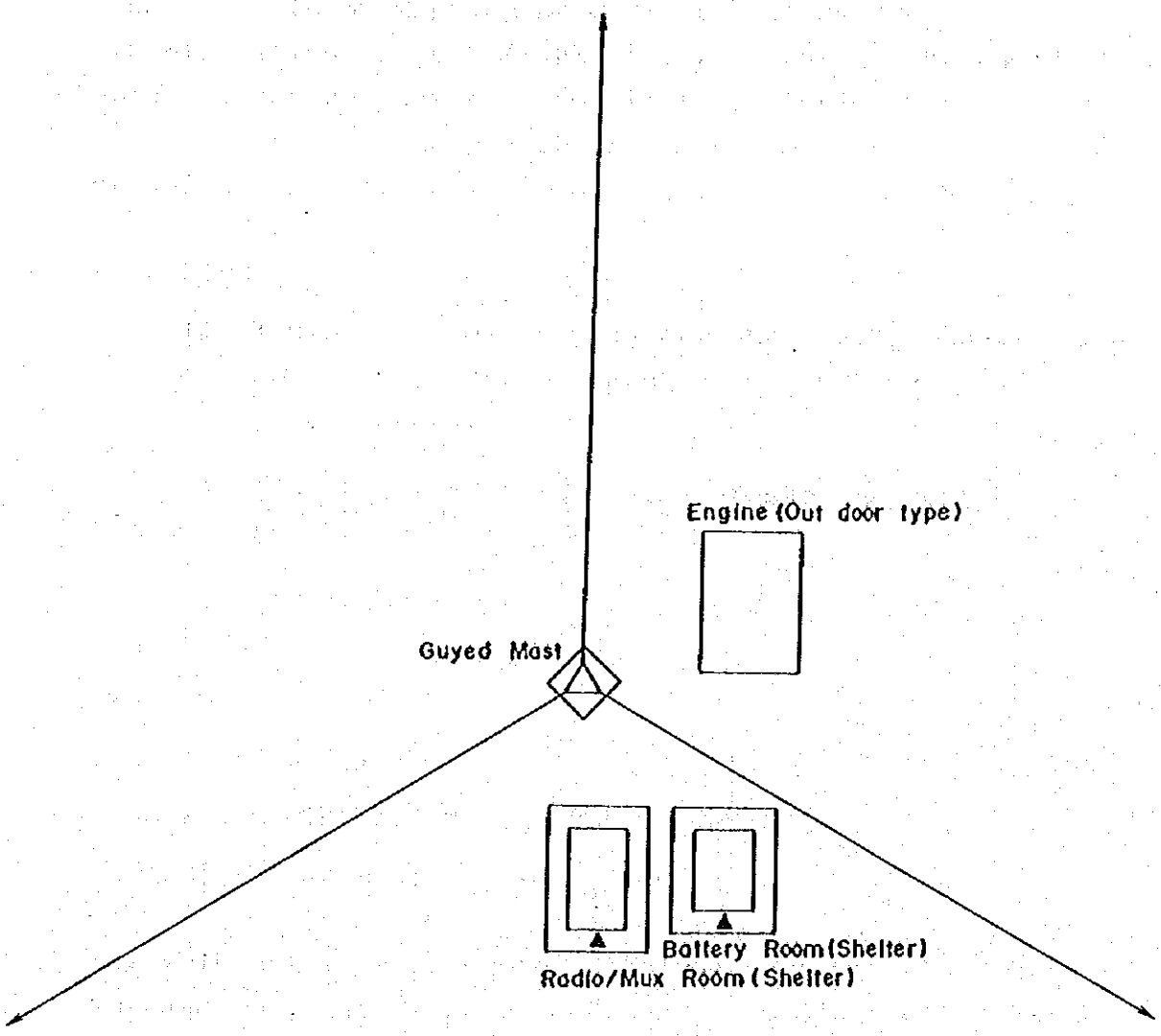


Figure II-25 Typical Site Layout (Beika)

CHAPTER III Organization for Project Implementation

1. Implementation Management Organization

For the whole Gezira Rehabilitation Project, implementation components are Government organizations including SGB, MOI, MOA, STPC and the Ministry of Health. Implementation management is by Management Committee of Gezira Rehabilitation Project (Table III-1). Out of the whole project, communication sector is to be implemented mainly by STPC and SGB. Responsibility spheres of both these organizations are as follows:

(1) STPC

1) Implementation of project, and study, planning and work management pertaining to technical requirements.

2) Operation and maintenance of systems constructed by the project.

3) Training/education of maintenance staff personnel.

(2) SGB

1) Acquisition and readjustment of project site lands.

2) Commercial power supply take-in.

3) Assistance in field survey.

Participants in this project include such organizations as MOI and MOA, besides STPC and SGB. Coordination of all these organizations is by Management Unit of Gezira Rehabilitation Committee in Table III-1.

Table III-1 Organization of Gezira Rehabilitation Scheme Promotion