THE FEASIBILITY STUDY
ON
THE RURAL TELELCOMMUNICATIONS NETWORK PROJECT
IN
THE REPUBLIC OF ZIMBABWE

FINAL REPORT
SUMMARY AND RECOMMENDATIONS

October 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

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

JICA sent to Zimbabwe a study team headed by Mr. Takashi Yamamoto, Nippon Telecommunications Consulting Co., Ltd., twice between November 1991 and August 1992.

The team held discussions with the officials concerned of the Government of Zimbabwe, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

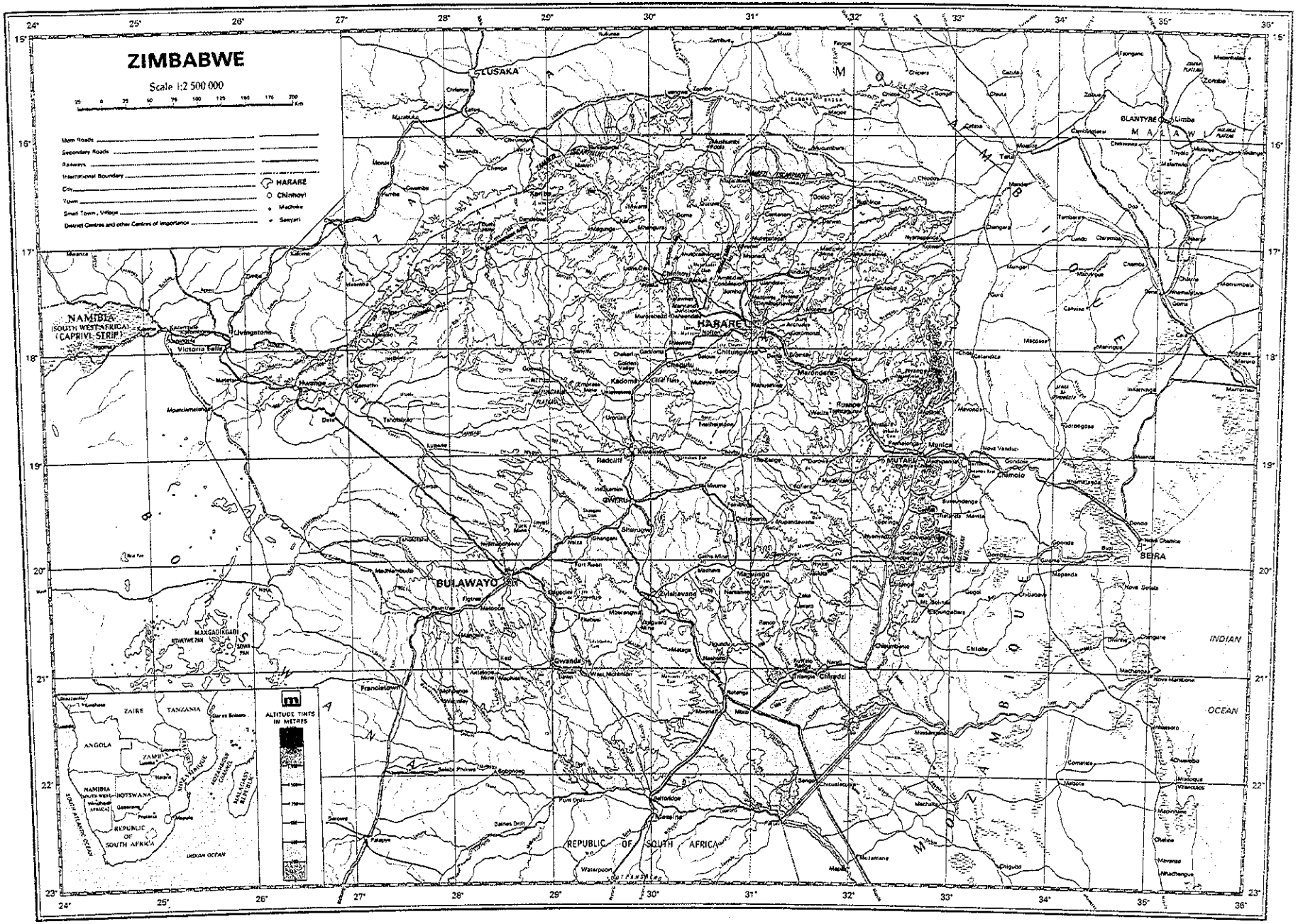
I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Zimbabwe for their close cooperation extended to the team.

October, 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

THE REPUBLIC OF ZIMBABWE



CONTENTS

ACRONYMS AND INITIALS

BER	: Bit Error Ratio
BRA	: Basic Rental Area
CCIR	: The International Radio Consultative Committee
DAMA	: Demand Assigned Multiple Access
DEL	: Direct Exchange Line
EIRR	: Economic Internal Rate of Return
EPL	: Electronic Party Line
FOB	: Free On Board
FIRR	: Financial Internal Rate of Return
GDP	: Gross Domestic Product
GW	: General Worker
IDN	: Integrated Digital Network
ISDN	: Integrated Service Digital Network
JICA	: Japan International Cooperation Agency
MARS	: Multi-Access Radio System
N.A	: Not Applicable
OLR	: Overall Loudness Rating
PCM	: Pulse Code Modulation
PCO	: Public Call Office
P/L	: Party-Line
PTC	: Posts and Telecommunications Corporation
RLC	: Remote Line Concentrator
RLR	: Receiving Loudness Rating
SLR	: Sending Loudness Rating
TT	: Telecoms Technician
TW	: Telecoms Worker
WARC	: World Administrative Radio Conference
WTP	: Willingness To Pay

SUMMARY AND RECOMMENDATIONS

1. OVERVIEW

1.1 Background of the Study

After the independence of the Republic of Zimbabwe in 1980, development of rural areas has been implemented at various areas in the country, i.e., 55 "Growth Points/District Service Centres" and at 460 "Rural Service Centres" defined by the Ministry of Local Governments and Town Planning based on the National Development Plan aiming at stimulating economic activities and improving living standards in the rural areas.

Thereby, demands for telecommunications services have been increased in those rural areas along with the growth of socio-economic activities. However, provision of telecommunications services is still limited in terms of quantity and quality, and difference of the services is getting wider between major cities and rural areas.

The availability of telephone services is of prime importance in promoting the welfare of people living in the rural areas. The expansion of telecommunication services in rural areas is being proposed in the 5-year Telecommunication Development Plan. (1988-1992).

Despite the efforts made by the Posts and Telecommunications Corporation (hereinafter referred to as "PTC"), it would still be very difficult to establish the rural telecommunications network due to financial constraints. At present, disparity between urban and rural living standards is getting wider.

In view of the above, on January 11, 1990, the Government of Zimbabwe requested the Government of Japan to provide technical assistance for the execution of feasibility study on the Rural Telecommunications Network Project.

In response to this request, the Government of Japan decided to dispatch a JICA Study Team (hereinafter referred to as "Study Team") for the execution of the Feasibility Study.

1.2 Objective of the Study

The objective of the Study is to conduct a feasibility study on rural telecommunications network for priority-given rural exchange areas for determining the technical and economic feasibility of the project.

1.3 Study Areas

At the beginning of the feasibility study, the following 6 Study Areas were selected from among 51 "Rural Exchange Areas" categorized by PTC in the country based on the guidelines formulated for the selection, for which the Zimbabwean authorities concerned and JICA Study Team agreed.

Beatrice (Mashonaland), Kezi (Matabeleland), Murambinda (Manicaland), Nkayi (Midlands), Gutu and Chatsworth (Masvingo).

Exchange location of Kezi exchange area is to be moved from the existing Kezi exchange to Maphisa under the exchange relocation plan of PTC.

The Study areas are illustrated in Figure 1.1.

1.4 Method of Approach and Schedule of the Study

The Study is made, based on the major findings during the field study in Zimbabwe and the mutual agreement reached through discussion between PTC and JICA Study Team during the study period.
The Flow Chart covering the whole study is shown in Figure 1.2.

The main subjects of the study are as follows:

- To formulate rural telecommunication development plan, i.e., telecommunications network plan, telecommunication network expansion plan for the Study areas, etc., based on the strategy and target set for the development
- To prepare implementation plan for the rural telecommunication development plan
- To estimate project cost
- To clarify financial and socio-economic feasibility of the rural telecommunication development plan for the Study areas

- To perform technology transfer to PTC staff through the feasibility study

1.5 Study Team Organization

1.5.1 Japanese Team

(1) JICA Study Team

Mr. Takashi YAMAMOTO	: Team Leader (Switching)
Mr. Ryoji SASAKI	: Co-leader (Network Planning)
Mr. Masayuki OIKAWA	: Demand/Traffic, Operation & Maintenance
Mr. Akira IWAMI	: Transmission
Mr. Mitozo NAKAZAWA	: External Plant
Mr. Tomiyuki KURODA	: Economic/Financial Analysis

(2) JICA Advisory Committee

Mr. Toru KIZUKA	: Chairman/Transmission System Ministry of Posts and Telecommunications
Mr. Yoshihiko HINOUE	: Network Planning Ministry of Posts and Telecommunications
Mr. Eiichi SAITO	: Switching System Japan International Cooperation Agency

1.5.2 PTC Members

Some members of Posts and Telecommunications Corporation have acted as the counterpart to the JICA Study Team and also as the coordinating body to the relevant organizations for the execution of the study.

The persons who closely concerned with the Study are as shown below:

Mr. Joshua CHIDEME	: Deputy Postmaster General
Mr. Philip MDIMU	: Assistant Chief Engineer Switching
Mr. Graham WOOD	: Manager Rural Exchange Planning
Mr. Simon NGOMA	: Section Manager Rural Exchange Planning
Mr. Abdullah MAHOMED	: Engineer Rural Exchange Planning
Mr. Musiyiwa ZANA	: Engineer Urban Exchange Planning
Mr. Lovemore NHUNZUI	: Senior Executive Officer Commercial
Mr. Samuel MABIKA	: Assistant Chief Engineer Local Network Development Transmission
Mr. Ken MAKUNURA	: Manager Rural Networks Transmission
Mr. Samuel KAMURIWO	: Engineer Rural Networks Transmission

The counterpart officials above greatly contributed to the satisfactory completion of the field survey and study work. Some valuable suggestions and useful data were also provided by members from other PTC directorates and other organizations outside the PTC that were not necessarily directly related to the study.

Two counterparts of PTC were dispatched to Japan to receive a training course conducted by JICA as the technology transfer for the study.

The names of counterparts and periods of training were as follows:

Name of Counterparts	Period
Mr. Musiyiwa ZANA	24 Mar. - 17 May, 1992
Mr. Abdullah MAHOMED	3 Jul. - 17 Aug. 1992

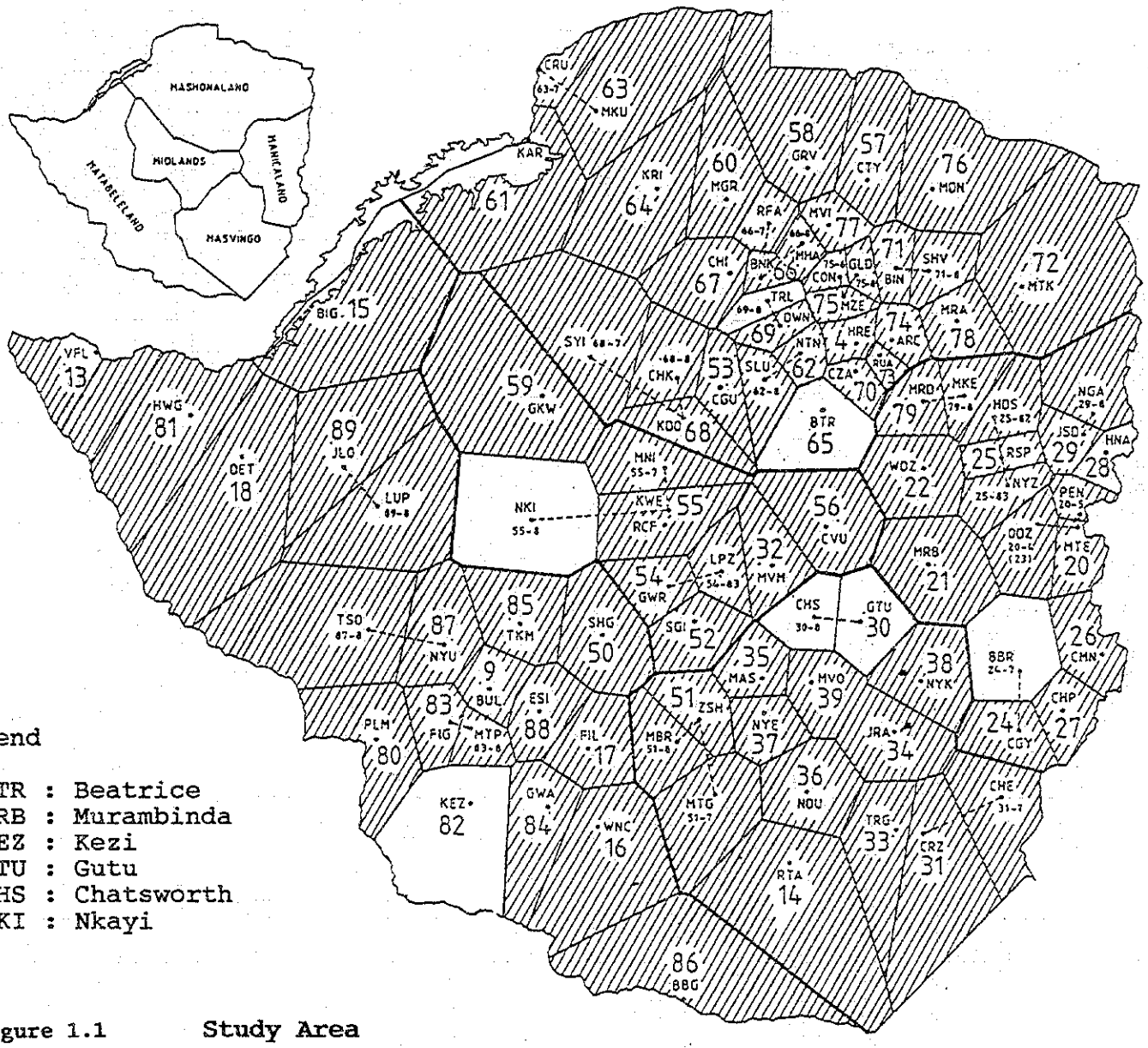
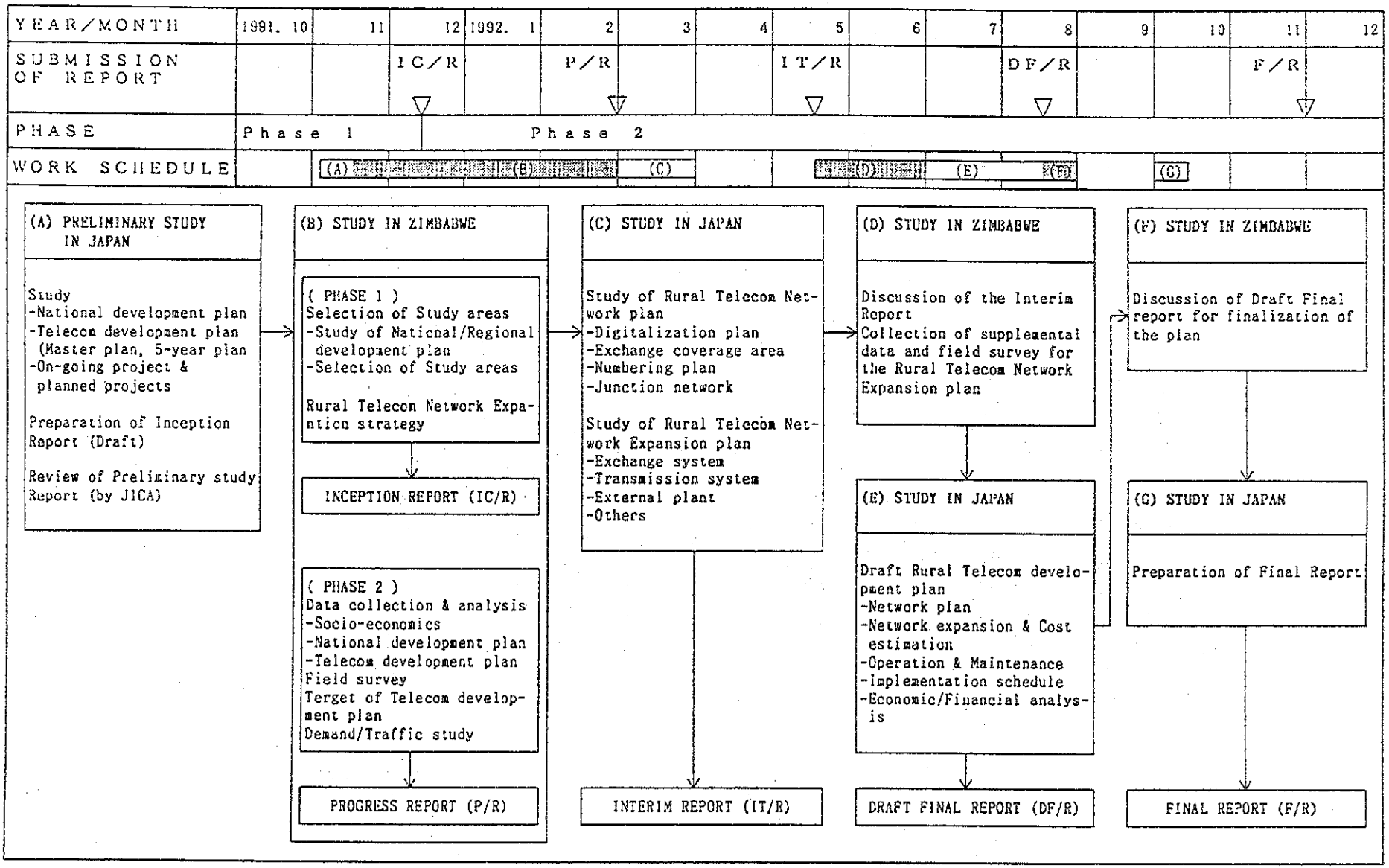


Figure 1.1 **Study Area**

Figure 1.2 FLOW CHART OF THE STUDY



2. ECONOMIC ASPECT

Since Independence in 1980, Economic growth in Zimbabwe, as well as income growth per capita has shown a fluctuating pattern, depending primarily upon the crop of agriculture.

Real change rate in Gross Domestic Product (GDP) during the 1980-1990 period lagged behind population growth and GDP per capita has been on the decline.
Droughts in 1983 and 1987 caused much damage to the economic growth, because most of communal farmers depend heavily on extensive water conservation. A drought in 1991 also severely affected agriculture.

2.1 Gross Domestic Product (GDP)

GDP gives a useful index to be applied to the structural pattern of production in economy besides helping to measure the rate of growth. It is available both at current and constant prices which indicate a measure of the real change. The productive system of Zimbabwe in the last decade can be seen from the Table 2.1.

In general, 1980-1984 indicated a real GDP change of over 2.3% which can be explained in the 1983 contraction in GDP of 4.0%, Agriculture was hit by drought, Mining by falling world prices and the relative strength of the Zimbabwe dollar.

1985-1989 indicated a real GDP change of just over 3.3%, a rate maintained in the second half of the decade in which, apart from the 1987 drought year, growth was steadier.
Fortunately, GDP real change in 1988 and 1989 has been higher, due to favourable weather conditions in 1988 and a considerable expansion of the Manufacturing sector related to enhanced availability of imports in 1989.

The newly published official estimate for GDP growth in 1991 was 4.3% (A Framework for Economic Reform (1991-1995)). However, the 1986-1990 Five Year Development Plan had, as major economic objectives, an average annual GDP rate of growth of 5.1%.

Table 2.1 GROSS DOMESTIC PRODUCT AT FACTOR COST

ITEM	1980	1981	1982	1983	1984	1985	1986	1897	1988	1989
AT CONSTANT PRICES (1980)										
AGRICULTURE & FORESTRY	451	515	478	403	496	614	576	472	592	587
MINING AND QUARRYING	285	278	284	280	291	288	293	300	295	307
MANUFACTURING	802	881	877	852	809	902	933	949	996	1055
ELECTRICITY & WATER	70	70	63	68	70	79	94	123	127	150
CONSTRUCTION	91	105	101	93	86	64	67	62	69	61
FINANCE AND INSURANCE	159	174	208	203	189	187	181	200	211	231
REAL ESTATE	43	43	43	44	44	44	45	45	46	47
DISTRIBUTIONS, HOTELS & RESTAURANTS	451	456	451	392	366	386	418	428	449	481
TRANSPORT & COMMUNICATIONS	211	221	226	224	226	237	244	234	248	254
PUBLIC ADMINISTRATION	291	339	333	338	364	372	370	386	409	423
EDUCATION	169	236	284	310	335	358	375	386	390	412
HEALTH	71	76	88	89	93	97	100	103	107	110
DOMESTIC SERVICES	65	63	61	60	59	60	60	61	61	62
OTHER SERVICES N.E.S	173	186	204	215	217	235	247	245	272	283
LESS IMPORTED BANKING SERVICE CHARGES	-108	-106	-112	-110	-105	-120	-122	-133	-128	-131
GDP AT FACTOR COST	3224	3537	3589	3461	3540	3803	3881	3861	4144	4332
NET INDIRECT TAXES	217	336	385	576	420	432	466	441	556	628
GDP AT MARKET PRICE	3441	3873	3974	4037	3960	4235	4347	4302	4700	4960
REAL CHANGE AT FACTOR COST (%)	10.68	10.00	1.00	-4.00	2.28	7.43	2.05	-0.52	7.33	4.54

2.2 Population

The population of Zimbabwe as of August 1982, was reported to be 7,608,432 in the 1982 census. The annual growth rate of the total population has declined from 3.3% per year during the period 1962-1969 to 3.0% in 1969-1982.

Population by Province, 1982 Census

ITEMS		Population	%
Zimbabwe		7,608,432	100.0
Manicaland		1,103,837	14.6
Mashonaland	Central	560,847	7.5
	East	1,496,500	19.8
	West	854,098	11.4
Matabeleland	North	962,064	11.7
	South	515,298	6.7
Midlands		1,086,284	14.5
Masvingo		1,029,504	13.7

(Source : District Population Data Sheet 1987)

According to the 1982 census, the greater portion of the population of Zimbabwe, 74.3%, lived in rural areas. Only 25.7% lived in urban areas. The two largest cities, HARARE and BULAWAYO, recorded more than half the population in the urban areas.

2.3 Unemployment

The total number of unemployed persons was 234,000 in 1987 and this represented a national unemployment rate of about 7% including communal farmers (peasant farmers).

It should be noted that the prevalence of a hidden unemployment rate might be drastically higher due to the jobless situation of communal farmers in the dry season. Most of the communal farmers become unemployed persons in the dry season, because it is impossible to get farm products during the dry season, and rural communities have quite limited formal employment opportunities.

2.4 Drought

In recent years, Zimbabwe suffered droughts cyclically. This is a serious problem that the government has had to deal with. In the last decade, there were terrible droughts in 1983 and 1987 that severely affected agriculture, resulting in decline in export. A drought in 1991 also severely damaged agriculture.

3. CURRENT STATUS OF TELECOMMUNICATION SERVICES

The current telecommunication services provided in the Study areas are as follows:

- Telephone service
- Non-voice services such as Telex, data communication service

Telephone service is mainly being provided with automatic exchange installed in the Study areas, except Nkayi where subscriber cable and trunk transmission systems are not constructed yet, and non-voice service, i.e., telex and data communication services, is provided to a few subscribers like bank, agriculture development organization, using leased circuit.
Present conditions of services mentioned above is shown in Table 3.1.

Regarding the telephone services, the telephone penetration ratio per 100 inhabitants in the Study areas is ranging from 0.08 to 0.17 (as of 1991), which is quite low compared with 13.2 for the major cities in the country.

Subscribers' line distribution in the rural areas is limited, and most of telephone connections are still being provided extensively by means of open-wire for distant subscribers outside BRA (Basic Rental Area which is an area with a radius of 5 km from the exchange).
Therefore, telephone availability is extremely low in communal lands where the majority of people are habitated.
For distribution of telephone subscriber lines, there are two types, one is with DEL (Direct Exchange Line) which is applied for subscribers inside BRA, and the other one is with Party-Line which is applied extensively for subscribers outside BRA.

Table 3.1 The Status of the Existing Telecommunications Facilities in the Study Areas

Exchange Name / Description	Beatrice	Murambinda	Kezi	Gutu	Chatsworth	Nkayi
Type of Switching Eq.	Strowger	Strowger	Strowger	Strowger	Strowger	Strowger
Capacity of Switching Eq.	200	200	200	400	200	200
Number of Subscribers						
DEL(Business)	48	53	39	114	25	0
DEL(Residential)	61	50	17	134	11	0
Total DEL Subs.	109	103	56	248	36	0
Public Call Offices	4	5	2	2	1	0
P/L Circuits	EPL 33	0	MPL 9	MPL 12	MPL 8	0
P/L Subs.(Business)	34	0	29	68	35	0
P/L Subs.(Residential)	184	0	21	67	34	0
Tatal P/L Subs.	218	0	50	135	69	0
*(Other Subscribers)	*17	*78	*15	* 1	*15	*66
Manual Switch Board	---	---	For Level 7	For Level 7	For Level 7	---
Commercial Power Supply	220V	220V	220V	220V	220V	220V
Standby Engine Generator	9kVA,SS,3P	7.5kVA,SS,3P	9kVA,SS,3P	9kVA,SS,3P	7.5kVA,SS,3P	9kVA,SS,3P
Subscriber Lines:						
- Local Cable						
Type of Cable	CCP/SD/OW	CCP/OW	CCP/OW	CCP/OW	CCP/OW	OW
No. of Pairs Terminated	250	400	200	400	200	0
Distribution System	Direct	Direct	Direct	Cabinet	Direct	Direct
Installation Method	Brd/Arl	Cdt/Brd/Arl	Brd/Arl	Cdt/Brd/Arl	Brd/Arl	Arl
- Radio System	UHF (4ch)	UHF (1ch)	-	-	-	-
Trunk Cable:						
Section	HRE-BTR	MTE-MRB	BUL-KZE	MVO-GTU	GTU-CHS	KWE-NKI
Circuit Length (km)	56	69(MTE-NYZ) 67(NYZ-MRB)	107	66(MVO-CHS) 35(CHS-GTU)	35	100 Not Exist
System	OW Carrier	OW Carrier	OW Carrier	OW Carrier	OW Carrier	Not Exist
No. of Channels	24	24	24	24	15	0
(No. of Leased Circuits)	-	-	-	3	-	-
No. of Telex Terminals	0	1	1	3	0	0
Maintenance/Operation						
No. of Staff	9	3	3	6	2	0
No. of Vehicles	2	1	1	0	1	0

Remarks:
EPL : Electronic Party Line
MPL : Manual Party Line
SS,3P : Single Standby, 3-Phase
Cdt/Brd/Arl : Conduit/Buried/Aerial
CCP : Colour Coded Polyethylene Insulated and Polyethylene Sheathed Cable
SD : Self-Supporting Distribution Wire
OW : Open Wire

Note: Figure with * mark denotes number of subscribers who are being served from adjacent exchange areas.

4. DEMAND AND TRAFFIC FORECAST

4.1 Demand Forecast

Telephone demand forecasts for the 6 study areas were carried out using microscopic method at 5-year interval in the 20 year period (up to 2011). Demand for non-voice services was also forecasted.
For the purpose of verifying the demand estimated based on the microscopic method, the forecast was also conducted using macroscopic method.

Forecast results obtained using microscopic forecast method are listed below.

Exchange	Forecasted year				
	1991	1996	2001	2006	2011
BEATRICE	333	416	559	667	955
KEZI	230	280	357	569	684
MURAMBINDA	181	261	487	626	826
CHATSWORTH	160	217	339	442	593
GUTU	368	485	892	1039	1240
NKAYI	161	223	396	456	550
TOTAL	1,433	1,882	3,030	3,799	4,848

Microscopic demand forecast for respective study areas has been made by using the collected statistical data and results of questionnaires which were obtained during the field survey, while, nationwide macroscopic demand has been estimated with the same methods applied in the Telecommunication Development Plan (1986-2005) by applying the latest data; GDP, population and telephone density in other countries.

4.2 Traffic Forecast

For the Study areas, traffic forecast was carried out based on the results of the demand forecast and an average calling rate of 0.07 Erlang and called rate of 0.06 Erlang per subscriber in the rural exchange areas. To estimate trunk circuit requirements, trunk call traffic to/from the exchange areas concerned was also estimated by applying the traffic distribution data given in PTC Technical Standards.

5. RURAL TELECOMMUNICATION DEVELOPMENT PLAN

5.1 Strategy for Rural Telecommunication Development Plan

The following strategies were established in accordance with the concepts of the National Development Plan. Consequently, it can be expected to support the socio-economic activities and rural development program, as well as to decrease a gap in telephone services between the major cities and the rural areas by adopting those strategies.

- To expand telecommunication services to "Growth Points/District Service Centres" and "Rural Service Centres" which were designated by the Ministry of Local Government for development of rural area based on National Development Plan,

- To reduce waiting applicants and number of subscribers sharing the same party-line, and

- To provide more public telephones in the rural areas to increase accessibility for the people without telephone.

5.2 Demand Fulfillment Program

To realize the target mentioned above, the following strategies are to be applied for telephone supply and network development.

5.2.1 Telephone Supply Strategy

- Distribution of subscriber lines shall be made on a DEL connection basis for the new subscribers, and no more additional P/L with Electronic Party-Line (EPL) shall be considered for providing telephone lines.

- Provision of DEL is made gradually for those party-line subscribers who do not get DEL at the initial stage and such provision would be completed within 10 years, i.e., by the year 2006.

- Public Call Offices (PCOs) shall be provided at the initial stage in the premises of post office, hospital and clinic based on PTC's plan for opening public telephones. The plan was made taking into consideration

accessibility to such telephones at any time and vandalism risks (mischief, thefts, etc).

5.2.2 Provisioning Period

Initial provision of telecommunications facilities shall be made to meet the demand 5 years ahead demand of the expected commissioning, i.e., the demand in 2001. Such an arrangement might be inevitable to expand the telecommunication services smoothly in the rural areas without heavy financial constraints.

Provisioning for further expansion would be appropriate if implemented every 5 years so as to avoid frequent expansion which may increase total costs for expansion work over a long period as labour costs may increase for completing such expansion.

5.3 Telecommunication Network Planning

5.3.1 Network Digitalization Plan

The rural telecommunication network shall be digitalized as much as possible to provide the foundation for the development of nationwide IDN and subsequent ISDN.

5.3.2 Numbering Plan

The following numbering scheme is to be used for subscribers in the Study areas when exchanges are replaced by digital switching equipment, in accordance with the numbering plan stated in the Master Plan for Telecommunication Development, which consists of 2 digits for the office code and 5 digits for the subscriber number.

Beatrice	:	65 CXXXX
Kezi (Maphisa)	:	82 CXXXX
Murambinda	:	21 CXXXX
Gutu	:	30 CXXXX
Chatsworth	:	30 8XXXX
Nkayi	:	55 8XXXX

5.3.3 Routing Plan

The traffic routing plan is to be kept as it is for each exchange, as no necessity to change is foreseen in the present routing plan, even though changing of homing arrangement was suggested in the Master Plan for Nkayi and Kezi in the future - for Nkayi the homing office is to be Bulawayo instead of Kwekwe, and for Kezi the homing office should be Figtree instead of Bulawayo.

5.3.4 Grade of Service

The following grades of services are to be applied for dimensioning the equipment as guidelines, which is considered as a standard by PTC for national network planning.

(1) Loss Probability

The internal point-to-point design blocking probability from any inlet to a selected free outlet is 0.002 for internal and 0.005 for both incoming and outgoing calls.

The grade of service on trunk circuits is to be better than 1 lost call in 100.

(2) Probability of Delay

Dial tone delay of less than 3 seconds for 97 % of the call attempts is prescribed under over loaded condition.

5.3.5 Transmission Plan

To ensure that subscribers in any part of the country are able to communicate with each other with adequate quality, the following design objectives which are specified in Network Planning Instructions, NP/005/X: "Transmission Plan - Loss Allocations", are applied for the study.

Overall Loudness Rating (OLR) for a national connection: 25 dB(Max)
SLR : 17 dB (Max) and 7.5 dB (Min), RLR : 8 dB (Max)

Transmission loss on Digital Loop	:	7 dB
Subscribers' line loss	:	8 dB(*)
Physical junctions loss		
for trunk or tandem junctions	:	5 dB
for direct junctions between local exchanges	:	10 dB

Loop resistance is to be less than 1000 Ohms for subscriber line.

(*): When a subscriber multiplexing system is introduced in the subscriber network, 5 dB loss at 800 Hz reference frequency can be allocated for 2-wire subscriber physical line connecting multiplex terminal equipment and subscriber, taking into account 3 dB of minimum transmission loss for 4-wire transmission section to eliminate the singing phenomenon.

The limits for the other impairments are to be in accordance with the Network Planning Instruction, NP/008/X; "Planning Performance of a Digital Transmission Network".

However, Bit Error Ratio (BER) performance objectives suggested in CCIR Rep. 380-3 are to be referred to as objectives in cases where digital Multi-Access Radio System (MARS) are introduced, to avoid excessive construction costs, namely the error performance for the local 64 kBit/s digital path with circuit lengths of less than 500 km shall not be exceeded.

a) 1×10^{-3} for more than 0.05 % for any month
(with integration time of 1 sec),

b) 1×10^{-6} for more than 1.5 % of any month
(with integration time of 1 min),

c) 1×10^{-8} (residual bit error ratio).

5.3.6 Signalling

Signalling system to be employed for the exchanges is R2 system, which is a channel associated signalling system, for the terminal exchanges in rural areas, as it may not require a large number of trunk circuits and to transfer a large volume and variety of signals.

5.3.7 Charging Method

In consideration of unification of the charging method in the whole country, an optimum charging method to be introduced to the exchanges in the Study areas is as follows:

- The charge determination and charge recording for all types of calls (Local, Trunk and International) are performed in each terminal exchange.
- A bulk method is applied to charge local calls.
- A detailed charging method is applied to trunk and international calls.
- The magnetic tapes with recorded charging data at the exchanges are processed by the PTC's Computer Bureau.

5.3.8 Synchronization of Digital Network

Network synchronization is to be considered for rural network towards future ISDN, where digital exchanges and digital transmission lines are to be introduced, based on the standards in "The National Synchronization Plan for the Zimbabwe Network" which employs Master-Slave method, as the establishment of IDN at secondary and primary center levels of switching hierarchy is being implemented with a target year of 2000.

5.4 Telecommunication Network Expansion Plan

Provision of facilities will be made along with the increasing demand. Taking demand/traffic forecast results into account, systems to be introduced for each study area have been studied, namely for exchange system, transmission system (cable and radio), external plant, and other supporting facilities.

5.4.1 Exchange System

(1) Type of Exchange system

Switching systems to be introduced for the exchanges except Chatsworth are of independent digital type. However, for Chatsworth exchange, a RLC (Remote Line Concentrator) with stand-alone function, which belongs to Gutu host exchange is employed.

(2) Exchange Capacity

The exchanges where to introduce facilities and installation capacities in the period from the year 1996 to 2011 are as follows:

Exchange	No. of Subscriber Line Units			
	1996	2001	2006	2011
BEATRICE	650	700	700	1000
KEZI	350	400	600	700
MURAMBINDA	300	500	650	850
NKAYI	250	400	500	600
GUTU	600	950	1050	1250
CHATSWORTH	300	400	450	600

5.4.2 Transmission System

(1) Transmission System Selection

As the result of study for the systems to be adopted for subscribers' line outside BRA and for trunk circuit connecting terminal exchange and its parent exchange, the following systems employing digital technique are selected.

(Subscribers' Line):

- Subscriber multiplexing system on PCM cable for the cluster with a relatively large demand and its distance from the exchange is 16 km or less

- MARS (Multi-Access Radio System), having 4 MBit/s transmission capacity and operating in 1.5 GHz band, for the area sparsely populated outside BRA and its distance from the exchange is more than 16 km

- Ordinary cable is utilized for subscriber line distribution inside BRA as well as outside BRA, and open-wire is also utilized alone or in combination with cable to keep line loss and loop resistance within the limits specified in the transmission plan.

(Trunk Circuit):

- A digital radio transmission system, having 34 MBit/s transmission capacity and operating in 2 GHz band. However, the radio frequency band for trunk transmission systems shall be reconsidered at the time of detailed system design taking into account PTC radio frequency assignment policies reflecting the resolutions made in WARC/92 (World Administrative Radio Conference held in 1992 at Malaga-Torremolinos), so as to avoid radio interference problem with future satellite communication system.

Outline of digital MARS currently available on the market is given below:

Radio frequency	:	1.5/2.4/2.6 GHz Band
Transmission capacity	:	2/4 MBit/s
Max. no. of subscribers	: -	270 with 2 MBit/s transmission capacity.
	-	540 with 4 MBit/s transmission capacity. In the case of loss probability of 0.01 and an average traffic of 0.07 Erl./sub.
Access system	:	DAMA (Demand Assigned Multiple Access)

Operating status of an entire MARS network can be monitored by the centralized supervisory system to be introduced at the base station.

(2) Transmission Route Selection

The transmission route plan selected based on the desk work using maps and in due consideration of the economic and maintenance aspects appears in Figure 5.1 (1/6-6/6) for rural exchange areas and in Figure 5.2 (1/2-2/2) for trunk routes, respectively.

Number of stations to be constructed is shown below.

Type of Station	No. of Stations						
	NKI	GTU	CHT	KEZ	BTR	MRB	Total
(MARS)							
Base Station	1	1	1	1	1	1	6
Terminal Station	13	8	7	10	12	14	64
Repeater with Sub. Unit	5	1	2	8	3	8	27
Repeater without Sub. Unit	1	1	1	-	-	-	3
(Cable PCM)							
Sub. Terminal Station	1	5	2	-	5	-	13
(Trunk Transmission System)							
Terminal Station	-	-	-	1	-	1	2
Repeater Station	-	-	-	2	-	3	5

(Note) Sub. : Subscriber

5.4.3 Cable and External Plant

(1) Structure of Cable Network

A new local cable network is to be constructed with direct buried cables, duct cables and aerial cables including open-wire. However, the existing open-wire network providing party-line services is to be maintained until all existing party-line subscribers are transferred to DEL which is planned to be completed within 10 years from the expected commissioning of the network, i.e., by 2006.

(2) Provisioning Period

In order to avoid repeated expansion work and heavy financial constraints, the initial provision of external plant facilities is made to meet the 10 years ahead demand after the expected commissioning year, i.e., the demand in 2006 which are listed below.

The Demand in 2006 for Study Area

Exchange	Total Demand	In BRA	Outside BRA
CHATSWORTH	442	136	306
GUTU	1,039	777	262
BEATRICE	667	226	441
KEZI	569	334	235
NKAYI	456	215	241
MURAMBINDA	626	259	367
TOTAL	3,799	1,947	1,852

(5) Proposed External Plant

a) Local Cable Network

Work volume (main items only) of proposed external plant in each Study area is as follow.

Exchange	Type of Cable			
	Duct	Buried	Aerial	Open-Wire
NKAYI	50m	4.0km	115km	54km
GUTU	400m	11.5km	100km	42km
CHATSWORTH	50m	1.7km	79km	33km
KEZI	50m	2.1km	113km	54km
BEATRICE	50m	6.0km	131km	60km
MURAMBINDA	50m	3.5km	151km	66km
Total	650m	28.8km	689km	309km

b) PCM Cable for Subscriber Multiplexing System

Work volume of PCM cable installation is estimated by the distance along the road from exchange to subscriber multiplexing terminal station.

Exchange	No.of Sections	Length(km)
NKAYI	1	13
GUTU	6	70 *
CHATSWORTH	3	45 *
KEZI	-	-
BEATRICE	5	80
MURAMBINDA	-	-
TOTAL	15	208

Note: Figure with * mark indicates total cable section length including one cable PCM section between exchange and repeater required for MARS.

5.4.4 Power Supply Systems

Power supply systems to be introduced for the rural telecommunications network are summarized below.

Power Supply Systems for Rural Telecommunications Network

Type of Station	Primary Power	Standby Power
Exchange/Base Stn.	Commercial Power	E/G+Battery
MARS Repeater	Solar Power	Battery
MARS Terminal	Solar Power	Battery
Terminal Stn. for Cable PCM	Solar Power	Battery
Radio Repeater on Trunk	Solar Power	Battery

(Note) E/G : Engine-Generator

Installation plan applied for power supply facilities are as under.

(1) For power supply facilities of exchange/base station, new power supply system, i.e., the battery full-floating system with engine-generator as a standby unit is to be provided under the current plan at Maphisa and Murambinda exchanges where commercial power is available.

The existing facilities or the facilities to be prepared by PTC are to be utilized at other exchanges/base stations. However, provision of rectifier and battery is to be made under the current plan for the rural telecommunication system at the 4 stations listed below:
- Beatrice, Nkayi, Gutu and Chatsworth terminal exchanges

(2) For the stations for subscriber multiplexing system (cable PCM and MARS) and trunk transmission system, solar power supply system is to be newly installed under the current plan.
7 days of autonomy is to be considered for the power supply system of MARS, and 10 days, for trunk transmission system.

(3) For the repeater stations of MARS at Chatsworth and Gutu where trunk transmission systems are installed, power supply system provided for trunk transmission system is to be used for MARS.
Power supply system to be introduced is summarized below.

Power Supply System	No. of Stations						
	NKI	GTU	CHT	KEZ	BTR	MRB	Total
(Solar Power System)							
MARS	19	9	10	17	15	21	91
Cable PCM Sys.	1	5	2	-	5	-	13
Trunk Transmission Sys.	-	-	-	2	-	3	5
(Full Floating System)							
Exchange/Base Station							
E/G, Rec. & Batt.	-	-	-	1	-	1	2
Rec. & Batt.	1	1	1	-	1	-	4

5.4.5 Antenna and Antenna Mast

(1) Antenna

For antenna to be adopted in MARS, omni-directional antenna and directional antenna, Yagi/horn/grid parabolic antenna are to be used at the base station and the subscriber terminal station, in principle. However, the grid type parabolic antenna is to be adopted for the section where high gain is required to meet the circuit requirement, while the grid type of antenna is to be used for trunk transmission circuit.

(2) Antenna Mast

A self-supporting tower is to be used for both MARS and trunk transmission system, in principle. However, in case antenna mast height is 25 m or less, steel pole is to be adopted for subscriber terminal station of MARS system, and a guyed type of antenna mast is to be considered for MARS repeater/terminal stations where considerably high mast is needed to give the necessary path clearance.

The antenna mast height and type for each exchange area are summarized below.

Antenna Mast		No. of Antenna Masts						
Type	Height	NKI	GTU	CHT	KEZ	BTR	MRB	Total
Pole	15m	6	3	5	1	4	9	28
Pole	20m	4	2	-	3	-	3	12
Pole	25m	1	1	1	3	5	1	12
Self	20m	-	1	-	-	-	1	2
Self	25m	-	-	1	2*	-	4	7
Self	30m	2	2	1	2	1	2*	10
Self	35m	4	-	-	4	2	2*	12
Self	40m	1	-	1	4	2	2	10
Self	45m	1	-	-	-	1	1	3

* : One antenna mast required for trunk transmission system is included in each figure.

Antenna mast constructed for trunk transmission system is to be used for MARS at Gutu and Chatsworth repeaters, where MARS and trunk transmission system are installed.

5.4.6 Building Facilities

Building facilities required in the current plan are as under.

(1) Building for the stations of subscriber multiplexing system (MARS and cable PCM) and new radio repeaters on the trunk route - prefabricated shelter/cabinet is to be provided to install transmission equipment as well as battery.
However, transmission equipment for both terminal and repeater stations is installed in the waterproof case.

(2) For terminal exchange and existing radio repeater stations on trunk route, existing buildings are to be utilized, except at Maphisa where new exchange building is to be constructed by PTC before commencement of construction work for the project.

(3) Shelter or cabinet to be newly constructed under the current plan is to be the prefabricated type that can be constructed easily and in a short period. Air-ventilation facilities are to be provided for these shelter or cabinet.

(4) Prefabricated type shelter/cabinet is to be as small as possible and be the kind that can be assembled at the field.
The shelter/cabinet necessary for the project are listed below.

Shelter/Cabinet Size	No. of Shelters/Cabinets						
	NKI	GTU	CHT	KEZ	BTR	MRB	Total
(MARS)							
Power (2x2m)	19	9	10	17	15	21	91
(Cable PCM)							
Transmission (2x2m)	1	5	2	-	5	-	13
Power (2x2m)	1	5	2	-	5	-	13
(Trunk Transmission Sys)							
Transmission (2x2m)	-	-	-	2	-	3	5
Power (2x2.5m)	-	-	-	2	-	3	5

5.4.7 Terminal Facilities

Subscriber apparatus, telephone sets for both public and ordinary subscriber, facsimile terminal and necessary facilities for subscriber line connection, such as poles, drop-wire (open wire), protector against surge current, are to be provided by PTC.
Based on the results of demand forecast, the number of subscriber apparatus to be provided at 1996, 2001 and 2006 are is follows.

EXCHANGE	1996	2001	2006
NKAYI	130	130	100
GUTU	330	260	200
CHATSWORTH	90	150	150
KEZI	130	240	120
BEATRICE	300	170	290
MURAMBINDA	200	230	200
TOTAL	1,180	1,180	1,060

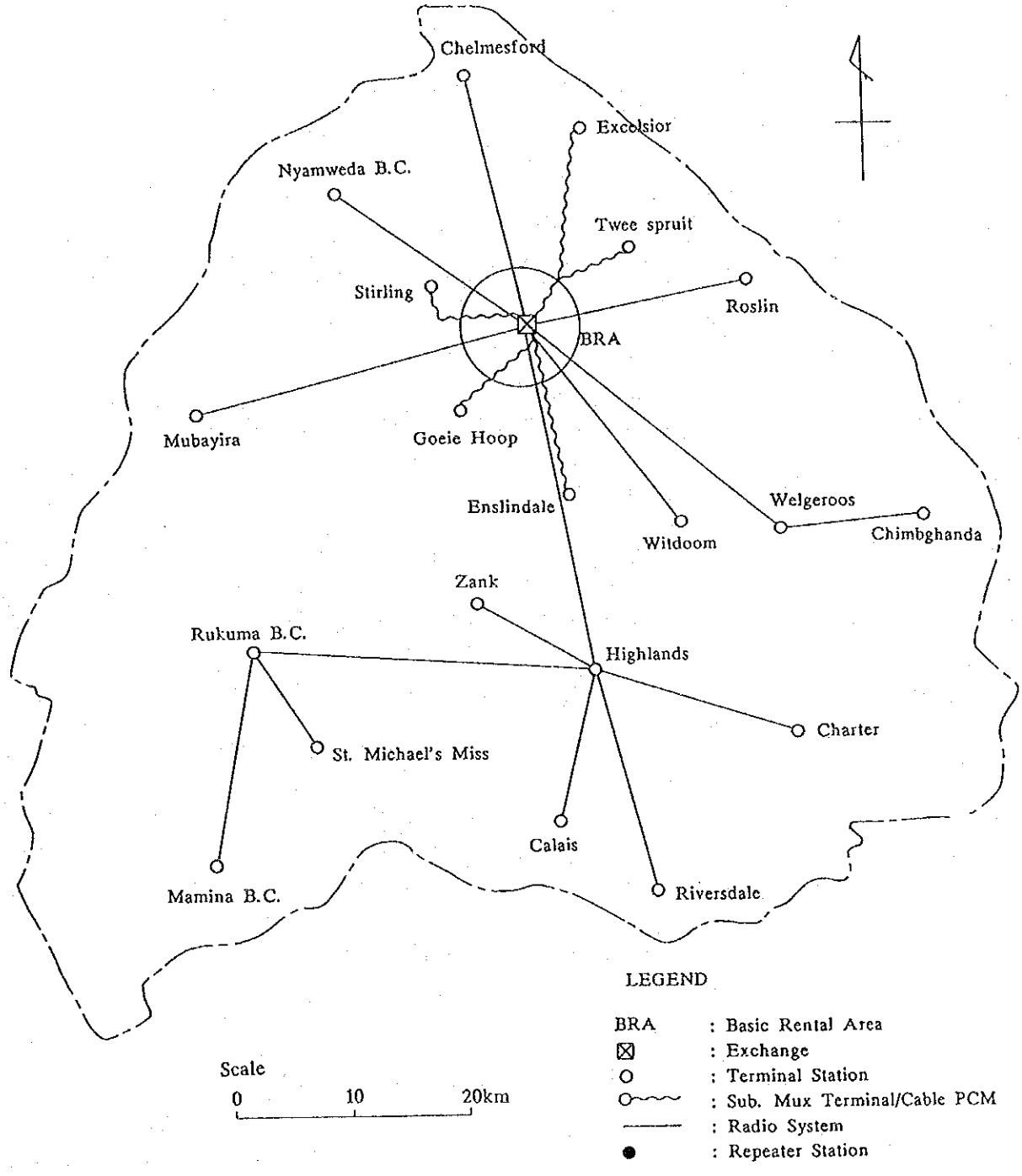


Figure 5.1 (1/6) Transmission Route Plan for Rural Exchange (Beatrice)

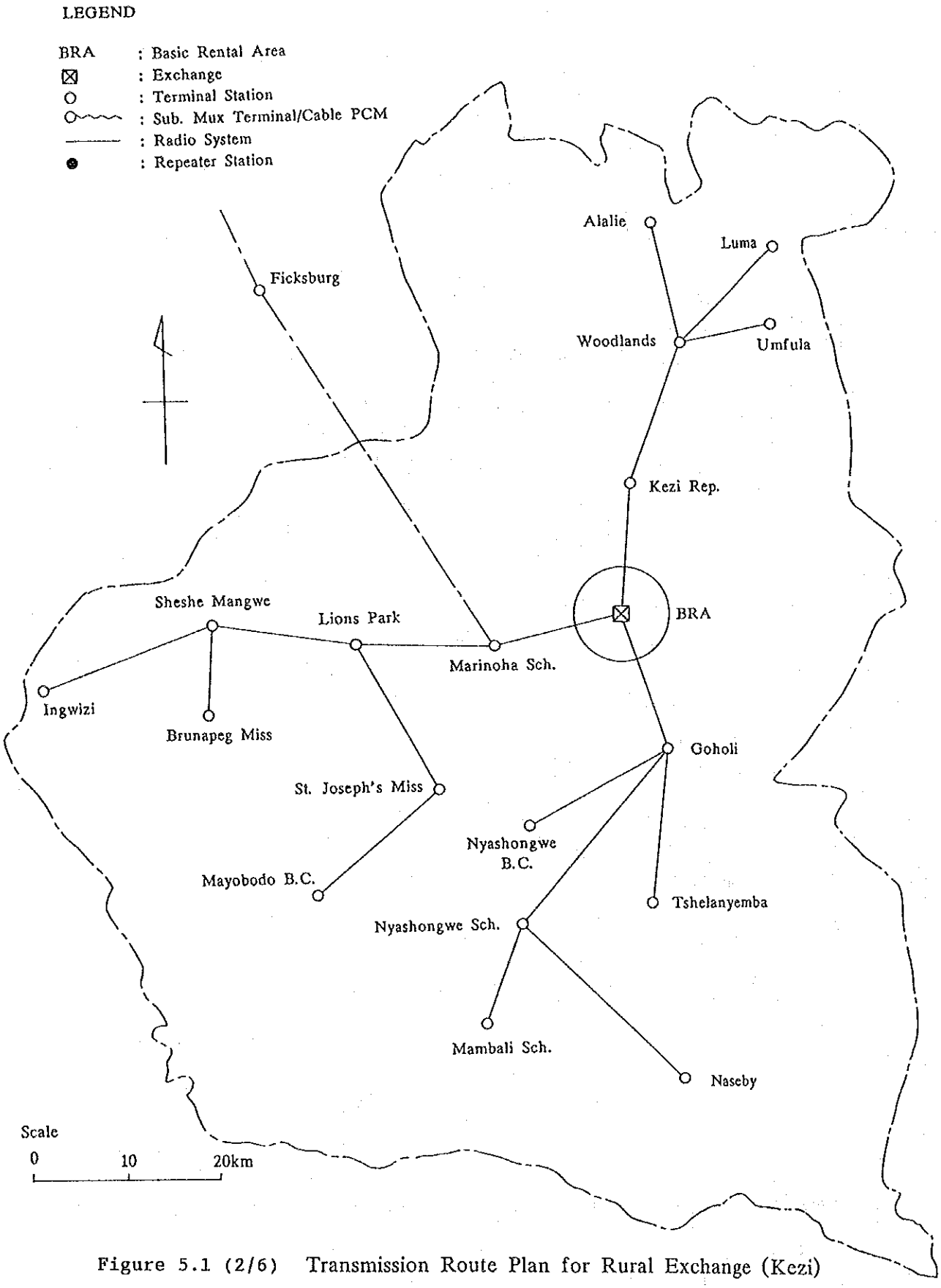


Figure 5.1 (2/6) Transmission Route Plan for Rural Exchange (Kezi)

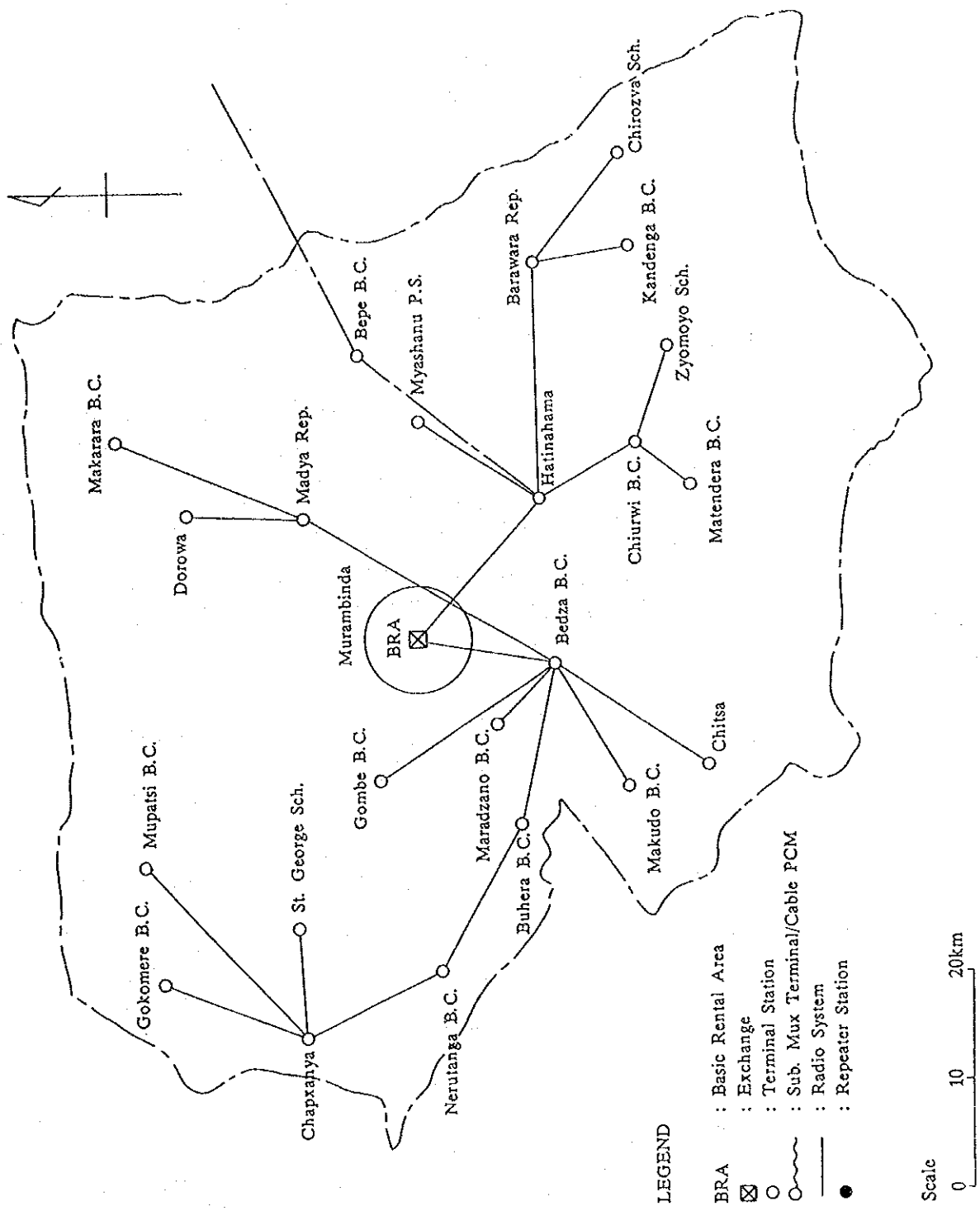


Figure 5.1 (3/6) Transmission Route Plan for Rural Exchange (Murambinda)

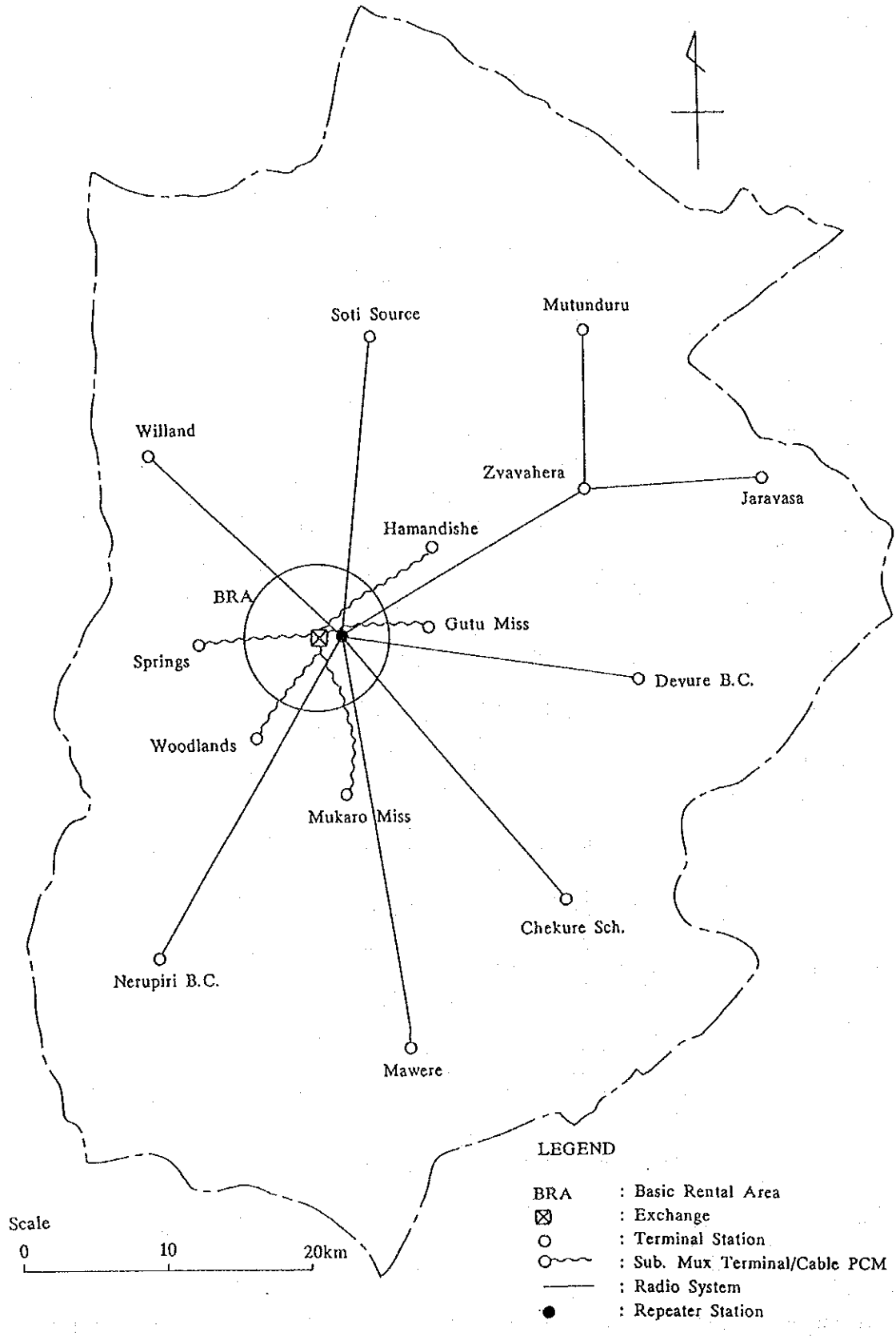


Figure 5.1 (4/6) Transmission Route Plan for Rural Exchange (Gutu)

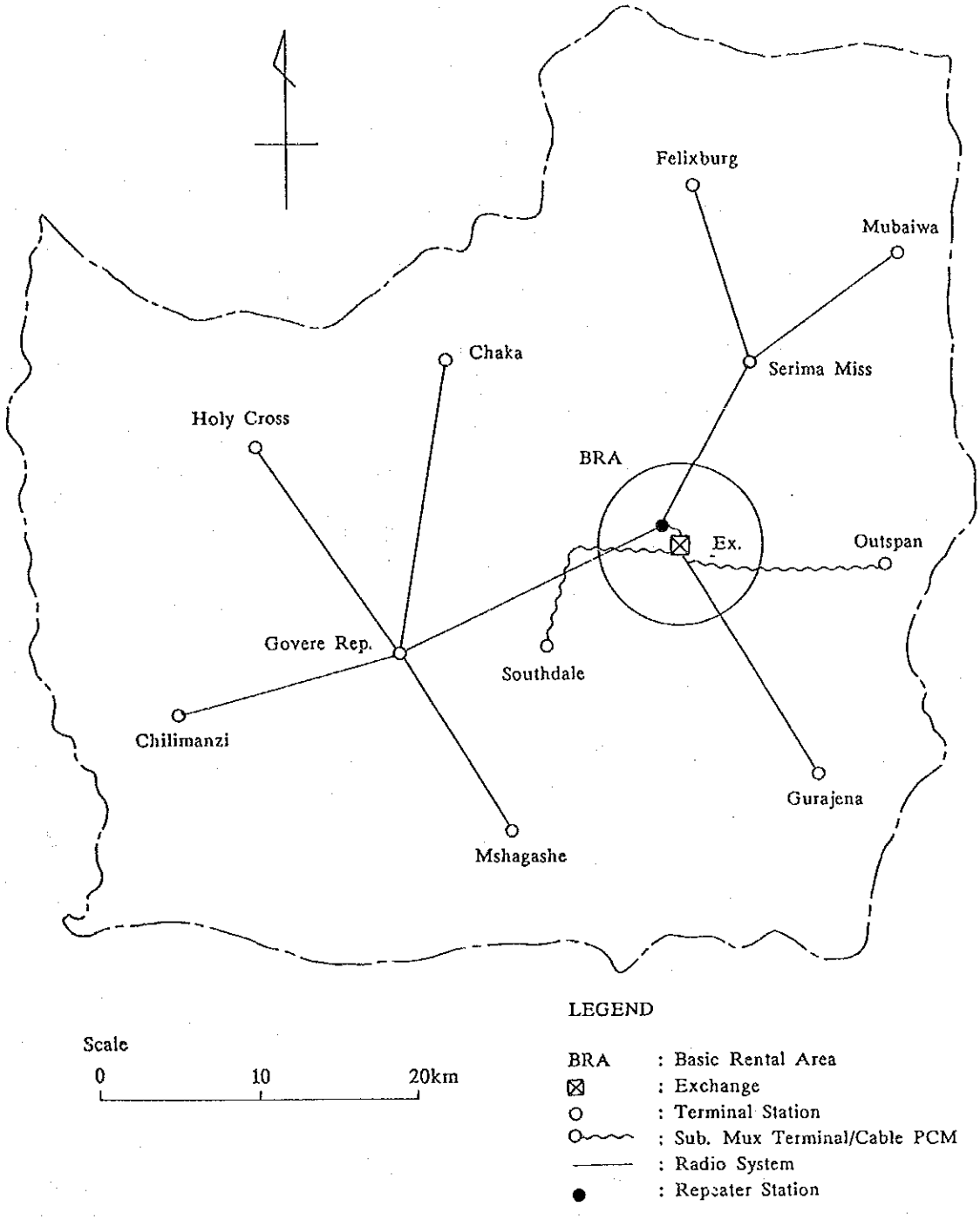


Figure 5.1 (5/6) Transmission Route Plan for Rural Exchange (Chatsworth)

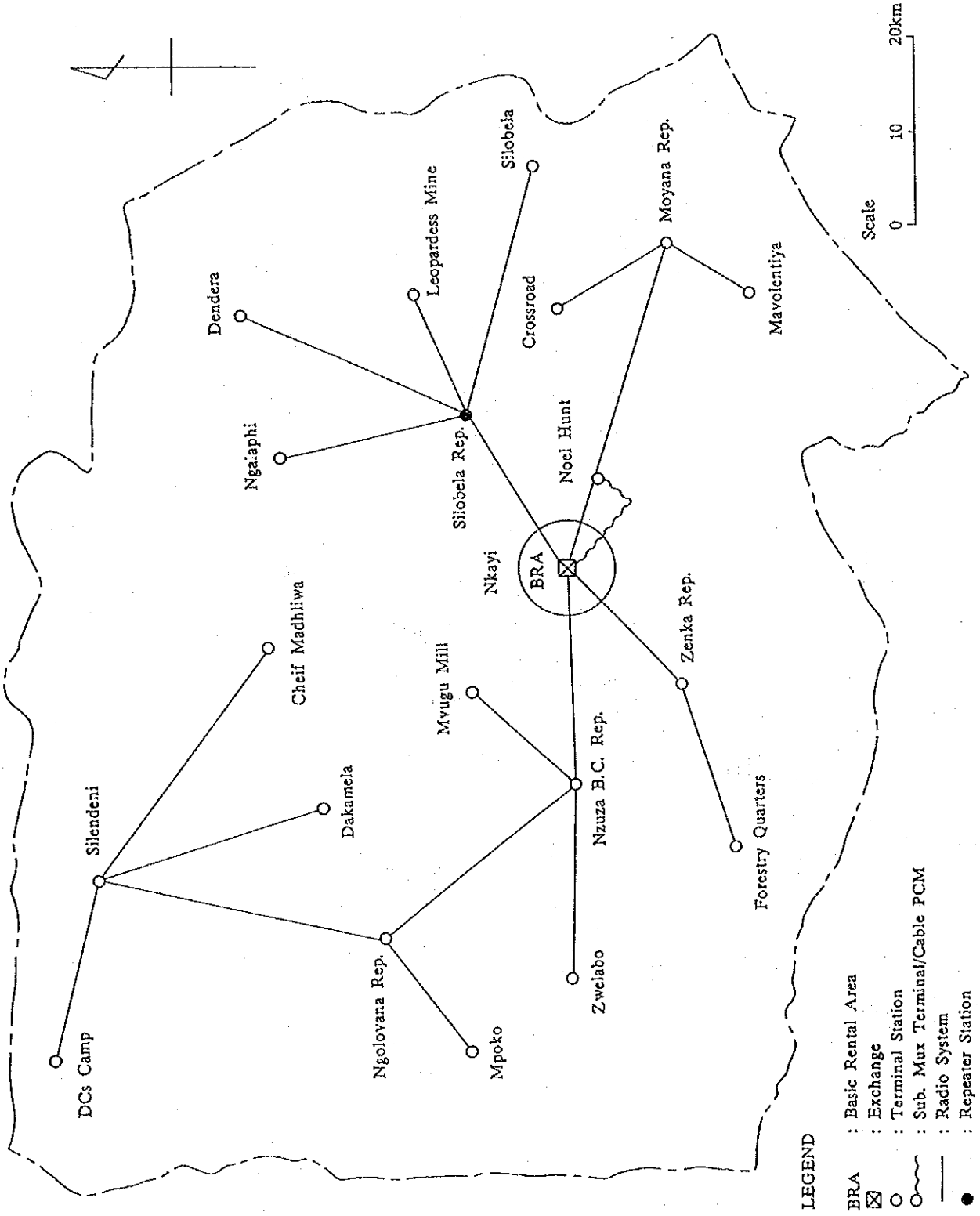


Figure 5.1 (6/6) Transmission Route Plan for Rural Exchange (Nkayi)

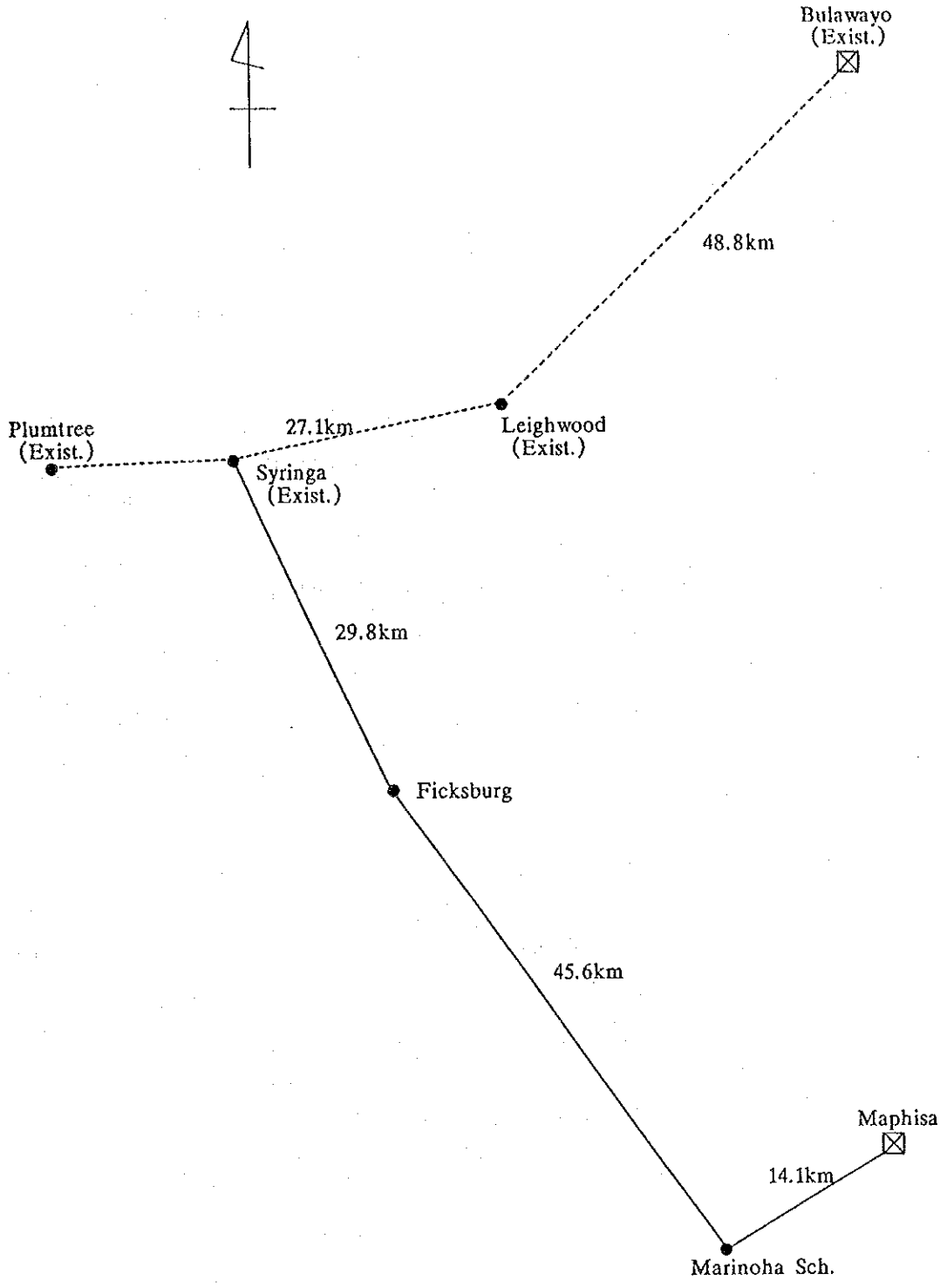


Figure 5.2 (1/2) Transmission Route Plan for Maphisa - Bulawayo Trunk Route

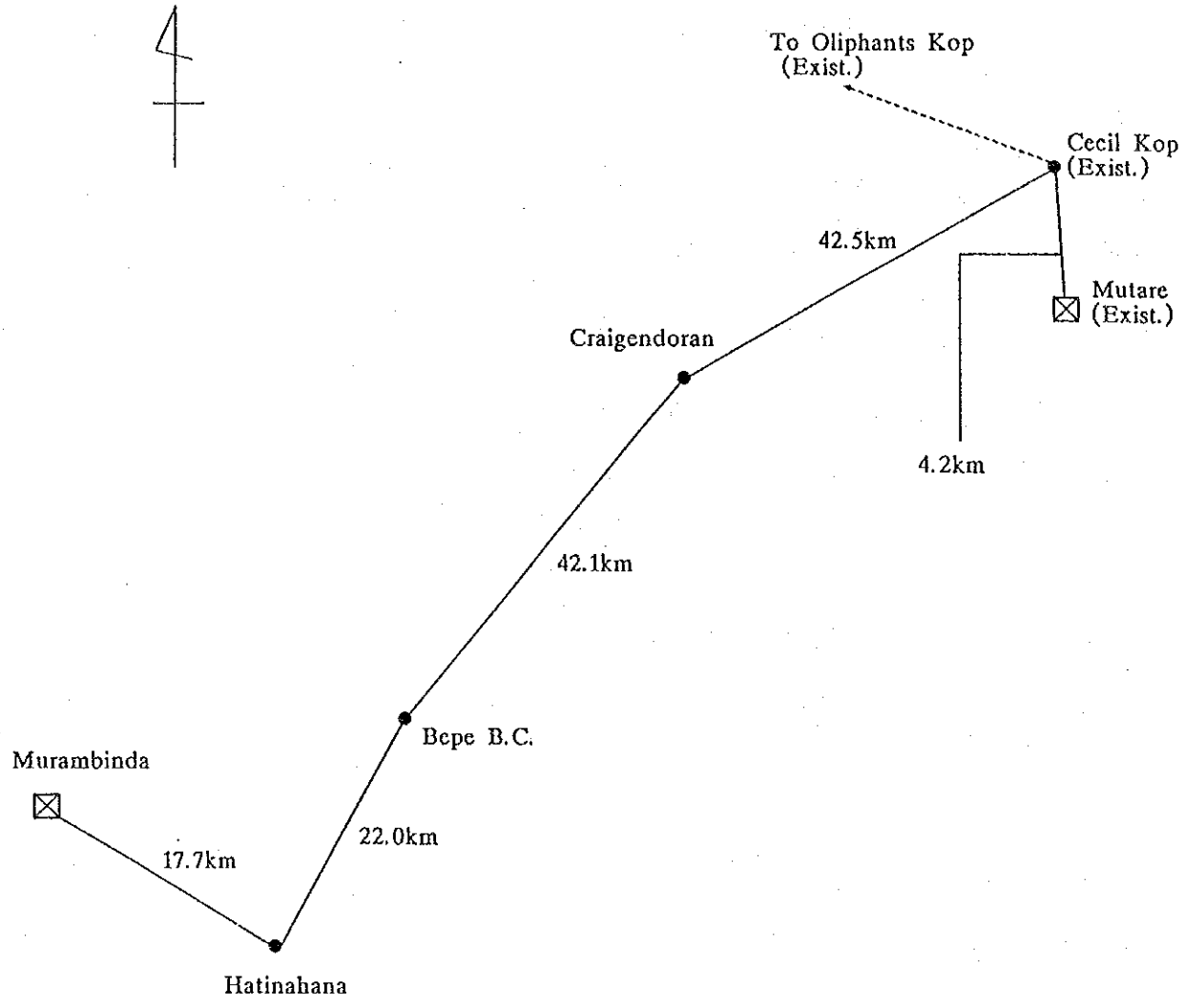


Figure 5.2 (2/2) Transmission Route Plan for Murambinda - Mutare Trunk Route

6. OPERATION AND MAINTENANCE

Operation and Maintenance for the existing telecommunications facilities in the Study areas is being performed by the regional centre for trunk transmission system and staff at the respective exchanges take the same functions for the switch and external plant network. And this constitution is considered to continue in future. By the introduction of supervisory system for switching system and transmission system, operation and maintenance work is considerably simplified. Hence, additional operation and maintenance staff are not required, except the staff for MARS which is constructed in the vast exchange area, when sufficient recruitment has been completed by PTC as per target staffing for the year 1995.

Proper type of vehicles shall be provided to this additional staff to maintain MARS, therefore, each study area should have the following establishment for the operation and maintenance staff after 1995.

Staff	Sub-System			
	Switching	Transmission	External	Total
TT TW GW	1 - 1	1 1 1	*a 2 -	2 3 2
TOTAL	2	3	2	7
VEHICLE	-	1	*b	1

TT: Telecoms Technician, TW: Telecoms Workers, GW: General Worker
*a: The duties of TT for External Sub-system will be undertaken by TT of Transmission Sub-system.
*b: Existing vehicle is to be used.

In addition to the above establishment, one vehicle for O/M staff for trunk transmission system as well as subscriber multiplexing systems should be provided at each parent exchange, i.e., five vehicles in total. The parent exchanges are listed below.

EXCHANGES	PARENT EXCHANGES
NKAYI	KWEKWE
GUTU, CHATSWORTH	MASVINGO
KEZI	BULAWAYO
BEATRICE	HARARE
MURAMBINDA	MUTARE

7. IMPLEMENTATION PLAN

The overall time schedule of project implementation is shown in Table 7.1 and construction schedule is shown in Table 7.2, respectively.

As shown in the time schedule, engineering services which includes detailed design and field survey is to be carried by consultant to prepare tender documents.

Taking the work volume and conditions of the project areas spreading in the wide area, the JICA Study Team proposes that the construction work be scheduled to be carried out by dividing into two groups, in principle.

Namely, based on the priority order given to respective exchange areas by PTC, implementation is to be taken in Nkayi, Gutu and Chatsworth exchange areas at first, and then in the other remaining 3 exchange areas; Kezi, Beatrice and Murambinda exchange areas.

With the above arrangements, service can be started from the area where network construction including subscriber line connection has been completed. The service-in at the first area is expected in mid 1996, and for the last area, by the beginning of 1997.

However, the services at the very beginning period in the first 3 exchange areas will start with limited number of subscribers to whom subscriber line connection is completed, as it may take time in completing subscriber connection to all applicants spread in vast outside BRA.

Table 7.1 Project Implementation Schedule

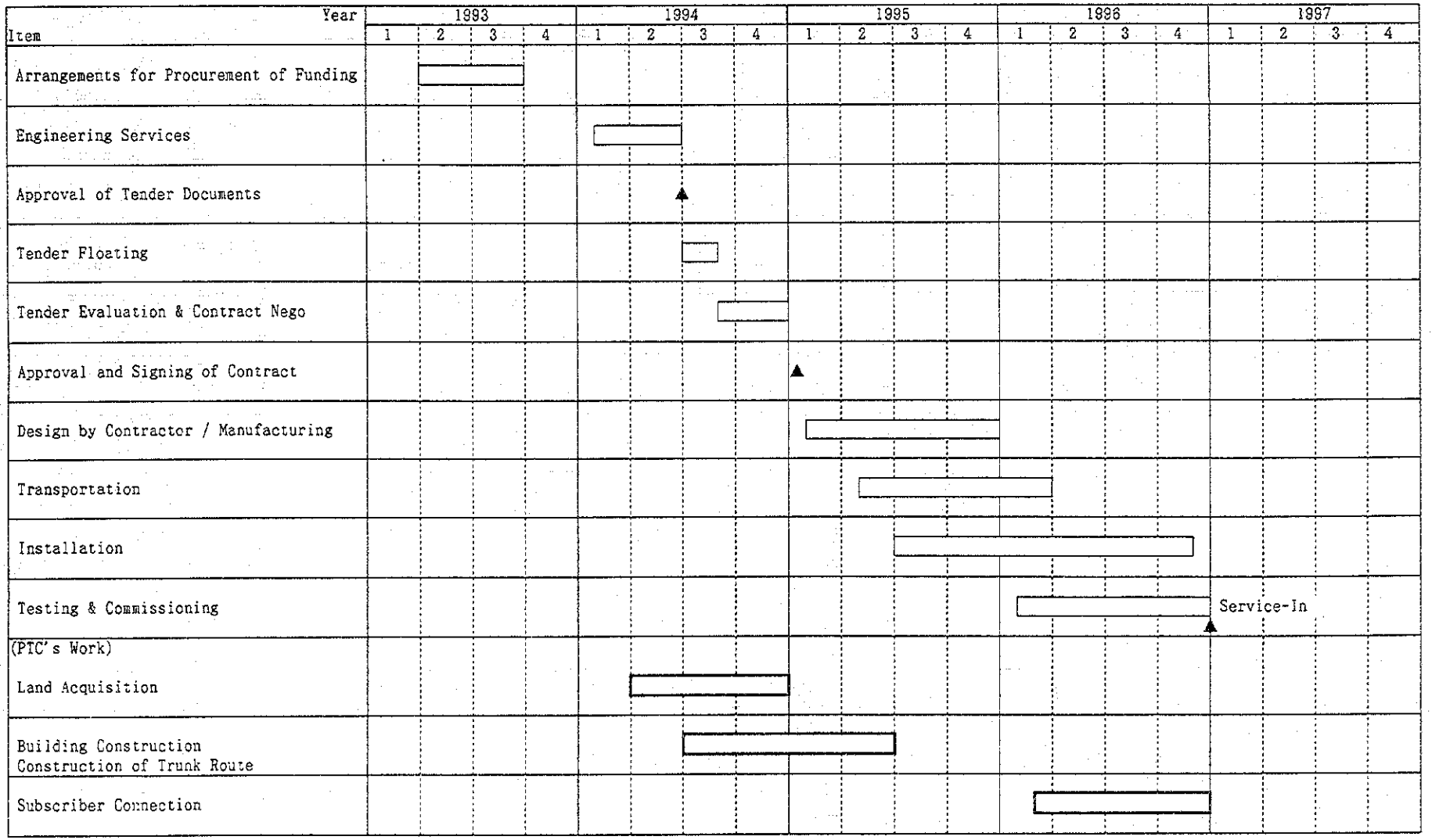


Table 7.2 Constraction Schedule

Year	1993				1994				1995				1996				1997			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
First Group (Nyayi, Gutu, Chatsworth)																				
-Tower & Shelter (Foundation/Erection)											▭	▭	▭							
-Transmission & Switch Sys.												▭	▭	▭						
-External Plant											▭	▭	▭	▭						
-Acceptance Test													********** Commissioning ▲							
(Subscriber Line Connection by PTC)													==========	==========	==========	==========				
Second Group (Rezi, Beatrice, Murambinda)																				
-Tower & Shelter (Foundation/Erection)												▭	▭	▭						
-Transmission & Switch Sys.													▭	▭	▭					
-External Plant													▭	▭	▭					
-Acceptance Test															********** Commissioning ▲					
(Subscriber Line Connection by PTC)														==========	==========	==========				

8. PROJECT COST ESTIMATE

8.1 Initial Investment

Project cost required at the initial stage for establishing rural telecommunications network is shown in Table 8.1, "Summary of Project Cost", and cost required by PTC for the work related to implementation of the project is shown in Table 8.2, "Expenditure Schedule", separately.

Preconditions to the above project cost estimates are as under.

a) Construction work in each exchange area, except subscriber line connection, is to be carried out by contractor on turn-key basis according to detail design and specifications (tender specifications and technical specifications) made by consultant.

The subscriber line connection work is to be carried out by PTC at its own cost.

b) Equipment and materials cost is to be estimated by Free On Board (FOB) price in Japan. Therefore, Insurance and Freight cost are to be estimated based on the assumption that transportation from Japan to Durban is by sea and from Durban to Harare by land. The cost is to be figured in US Dollar equivalent. In this case, the rate of exchange to apply is to be US$ 1 = Yen 130.

c) Local currency portion covering land procurement, building construction, materials locally procured, inland transportation cost for equipment and materials and wages of locally employed labourers is to be figured in US Dollar equivalent. In this case, the rate of exchange to apply is to be US$ 1 = Z$ 5.02.

d) Cost of spares is to be figured in the amount covering 3 years stock.

e) Trunk route for (Maphisa-Bulawayo) and (Murambinda-Mutare) sections are to be constructed under the current plan.
New digital trunk route to Maphisa exchange is to be constructed between Maphisa and Syringa which is the existing repeater station on Bulawayo-

Plumtree analog trunk route. And the trunk circuit is to be connected to the existing analog trunk circuit through analog-digital convertor to be provided at Syringa.

Meanwhile, 4 sections, i.e., new digital trunk route for 3 sections connecting rural exchanges and their respective parent exchanges, and circuits (*) connecting remote line concentrator and its host exchange, are to be constructed by PTC in time with the expected date of commissioning of the Rural Telecommunications Network.

(Beatrice-Harare), (Chatsworth-Gutu)*, (Gutu-Masvingo), (Nkayi-Kwekwe)

f) All costs are to be estimated at price level as of 1992, and no price escalation is considered.

g) The following are to be constructed by PTC at its own cost.

- Construction of new exchange building at Maphisa.

- Acquisition of new radio station sites for both rural telecommunications system and trunk transmission system, ground levelling and provision of fence for those sites
  However, cost for acquisition of new site spaces is not estimated in the estimated cost, since such may not apply in acquiring such land space in the rural area.

- Provision of subscriber apparatus (both public and ordinary telephone set and facsimile terminal) and subscriber line connection

- Constructing 4 transmission routes: (Beatrice-Harare), (Chatsworth-Gutu), (Gutu-Masvingo) and (Nkayi-Kwekwe)

- Construction of building, access road and antenna masts for Nkayi-Kwekwe trunk route, and construction of cable for the section between Harare-Beatrice.

8.2 Reinvestment

Cost necessary for expansion of facilities to meet with the increasing demand exceeding the initial provision is to be borne by PTC. Namely, provision of additional circuits for exchange system and subscriber multiplexing system as well as subscriber lines connection is to be made by PTC at its own cost. These cost are shown in Table 8.3, "Reinvestment Schedule".

8.3 Expenditure Schedule

For implementation of the project in accordance with the preceding arrangement, expenditure for each year is shown in Table 8.2 for the initial stage of the project, and in Table 8.3 for addition of subscriber circuits, respectively.

Expenditure in the initial stage is divided into two portions, one is expenditure required by PTC for preparatory works related to implementation of rural telecommunications network improvement project, such as construction of building, access road, tower for the trunk routes, subscriber line connection, and the other one is for construction of rural telecommunications network.

The latter one is further divided into two parts, i.e., foreign currency portion which requires for equipment/material procurement and for installation work by foreigner, and local currency portion which requires for procurement of local installation materials and labourers.

All those expenditures are shown in the above mentioned tables in equivalent US dollar.

8.4 Operating Cost

The operating cost consists of the direct and the indirect expenditure required for the operation and maintenance of the telecommunication systems as well as for administrative works related to rural telecommunication network operation.

And these expenditure are the personnel expense and general expense, such as running cost of equipment and vehicles, procurement of spare materials required for maintenance, etc.

Estimation of operating cost for each study area is stated in the Table 8.4 using a conversion rate of 1 US$ = 5.02 Z$ = 130 Yen.
In addition to the above expenditure, the costs of insurance for facilities to be constructed should be added and the costs have assumed approximately 0.1% of the book value of total Equipments & Facilities costs for the six study areas, based on the current PTC's insurance system.

Total expenditure costs to be increased after completing the project are stated in the Table 8.5 in each project year.

However, Nkayi (NKI) exchange is not put in-service at present. It is planned that the exchange will commence service before 1995.
Thus, the operating cost is estimated as if the exchange were operating just as other exchanges for the study purposes.

Table 8.1 Summary of Project Cost

Unit:Thousand US$

Exchange Name	SUMMARY			Nkayi			Gutu			Chatsworth			Kezi			Beatrice			Murambinda			Training Center		
Currency	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
Transmission Sys.	5,467	0	5,467	613	0	613	757	0	757	655	0	655	1,118	0	1,118	838	0	838	1,486	0	1,486	0	0	0
-MARS Sys.	2,851	0	2,851	538	0	538	267	0	267	352	0	352	585	0	585	441	0	441	668	0	668	0	0	0
-Trunk Sys.	1,351	0	1,351	0	0	0	0	0	0	0	0	0	533	0	533	0	0	0	818	0	818	0	0	0
-Cable PCM Sys.	1,265	0	1,265	75	0	75	490	0	490	303	0	303	0	0	0	397	0	397	0	0	0	0	0	0
Switching Sys.	1,965	0	1,965	342	0	342	447	0	447	162	0	162	291	0	291	402	0	402	321	0	321	0	0	0
External Plant	2,579	2,538	5,117	294	384	678	665	410	1,075	388	318	706	235	375	610	707	551	1,258	290	500	790	0	0	0
Power Plant	1,972	0	1,972	311	0	311	245	0	245	211	0	211	422	0	422	330	0	330	453	0	453	0	0	0
-Solar Sys.	1,742	0	1,742	288	0	288	222	0	222	188	0	188	353	0	353	307	0	307	384	0	384	0	0	0
-E/G, Rec. Battery	230	0	230	23	0	23	23	0	23	23	0	23	69	0	69	23	0	23	69	0	69	0	0	0
Ant. Mast	1,543	0	1,543	308	0	308	97	0	97	110	0	110	392	0	392	251	0	251	385	0	385	0	0	0
Eq. Shelter	1,194	0	1,194	139	0	139	240	0	240	130	0	130	176	0	176	272	0	272	237	0	237	0	0	0
Test Eq. & Spares	798	0	798	81	0	81	81	0	81	81	0	81	81	0	81	81	0	81	81	0	81	312	0	312
Maintenance Vehicles	209	0	209	38	0	38	38	0	38	19	0	19	38	0	38	38	0	38	38	0	38	0	0	0
SUB - TOTAL	15,727	2,538	18,265	2,126	384	2,510	2,570	410	2,980	1,756	318	2,074	2,753	375	3,128	2,919	551	3,470	3,291	500	3,791	312	0	312
Transportation/Inst. Cost	8,368	2,192	10,560	1,204	368	1,572	1,352	212	1,564	954	177	1,131	1,453	515	1,968	1,622	365	1,987	1,754	517	2,271	29	38	67
SUB - TOTAL	24,095	4,730	28,825	3,330	752	4,082	3,922	622	4,544	2,710	495	3,205	4,206	890	5,096	4,541	916	5,457	5,045	1,017	6,062	341	38	379
Engineering Services	2,624	-	2,624	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL	26,719	4,730	31,449	3,330	752	4,082	3,922	622	4,544	2,710	495	3,205	4,206	890	5,096	4,541	916	5,457	5,045	1,017	6,062	341	38	379

Table 8.2 Expenditure Schedule

UNIT IN US $

	1994						1995						1996						TOTAL
	MATERIAL		INSTALLATION				MATERIAL		INSTALLATION				MATERIAL		INSTALLATION				
	FOREIGN	LOCAL	FOREIGN	LOCAL			FOREIGN	LOCAL	FOREIGN	LOCAL			FOREIGN	LOCAL	FOREIGN	LOCAL			
				SKILL	UNSKILL	TOTAL				SKILL	UNSKILL	TOTAL				SKILL	UNSKILL	TOTAL	
1) PREOPERATION																			
NKAYI	0	3,833	0	5,667	0	9,500	0	3,333	0	4,500	0	7,833	0	0	0	12,667	0	12,667	30,000
GUTU	0	3,833	0	5,667	0	9,500	0	3,333	0	4,500	0	7,833	0	0	0	12,667	0	12,667	30,000
CHATSWORTH	0	3,833	0	5,667	0	9,500	0	3,333	0	4,500	0	7,833	0	0	0	12,667	0	12,667	30,000
KEZI	0	3,833	0	5,667	0	9,500	0	3,333	0	4,500	0	7,833	0	0	0	12,667	0	12,667	30,000
BEATRICE	0	3,833	0	5,667	0	9,500	0	3,333	0	4,500	0	7,833	0	0	0	12,667	0	12,667	30,000
MURAMBINDA	0	3,833	0	5,667	0	9,500	0	3,333	0	4,500	0	7,833	0	0	0	12,667	0	12,667	30,000
SUB.TOTAL 1)	0	23,000	0	34,000	0	57,000	0	20,000	0	27,000	0	47,000	0	0	0	76,000	0	76,000	180,000
2)PREPARATORY WORK																			
EX.BUILDING(Tr)																			
CHATSWORTH Rep.	0	0	0	0	0	0	0	30,600	0	8,200	12,300	51,100	0	0	0	0	0	0	51,100
Rep.NKY-KWEKWE	0	55,100	0	34,500	28,400	118,000	0	47,000	0	74,000	68,000	189,000	0	0	0	0	0	0	307,000
BEATRICE-HRR	0	0	0	0	0	0	0	50,000	0	180,000	270,000	500,000	0	0	0	0	0	0	500,000
MAPHISA EX.	0	0	0	0	0	0	0	44,000	0	15,500	16,400	75,900	0	0	0	0	0	0	75,900
SUB.CONNECTION	0	0	0	0	0	0	0	0	0	0	0	0	0	278,100	0	22,900	18,000	319,000	319,000
SUB.TOTAL 2)	0	55,100	0	34,500	28,400	118,000	0	171,600	0	277,700	366,700	816,000	0	278,100	0	22,900	18,000	319,000	1,253,000
3)INITIAL WORKING CAP.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	102,000	102,000
4)EQUITY TOTAL=1)+2)+3)	0	78,100	0	68,500	28,400	175,000	0	191,600	0	304,700	366,700	863,000	0	278,100	0	98,900	18,000	497,000	1,535,000
5)EQUIPMENTS&FACILITIES																			
NKAYI	0	0	0	0	0	0	881,000	177,000	415,000	25,000	39,000	1,537,000	1,355,000	344,000	715,000	53,000	74,000	2,541,000	4,078,000
GUTU	0	0	0	0	0	0	1,068,000	184,000	461,000	27,000	40,000	1,780,000	1,635,000	366,000	792,000	54,000	76,000	2,923,000	4,703,000
CHATSWORTH	0	0	0	0	0	0	724,000	144,000	330,000	20,000	30,000	1,248,000	1,119,000	291,000	572,000	42,000	59,000	2,083,000	3,331,000
KEZI	0	0	0	0	0	0	1,134,000	195,000	504,000	33,000	50,000	1,916,000	1,739,000	387,000	863,000	66,000	93,000	3,148,000	5,064,000
BEATRICE	0	0	0	0	0	0	1,211,000	243,000	557,000	34,000	52,000	2,097,000	1,855,000	475,000	952,000	67,000	95,000	3,444,000	5,541,000
MURAMBINDA	0	0	0	0	0	0	1,356,000	252,000	611,000	40,000	60,000	2,319,000	2,069,000	493,000	1,041,000	76,000	110,000	3,789,000	6,108,000
SUB TOTAL 5)	0	0	0	0	0	0	6,374,000	1,195,000	2,878,000	179,000	271,000	10,897,000	9,772,000	2,356,000	4,935,000	358,000	507,000	17,928,000	28,825,000
6) ENGINEERING SER.	0	0	1,570,000	0	0	1,570,000	0	0	370,000	0	0	370,000	0	0	684,000	0	0	684,000	2,624,000
7) TOTAL = 5)+6)	0	0	1,570,000	0	0	1,570,000	6,374,000	1,195,000	3,248,000	179,000	271,000	11,267,000	9,772,000	2,356,000	5,619,000	358,000	507,000	18,612,000	31,449,000
8) GRAND TOTAL = 4)+7)	0	78,100	1,570,000	68,500	28,400	1,745,000	6,374,000	1,386,600	3,248,000	483,700	637,700	12,130,000	9,772,000	2,634,100	5,619,000	456,900	525,000	19,109,000	32,984,000

Table 8.3 REINVESTMENT SCHEDULE

IN US $

YEAR	MATERIAL		TOTAL	WORK		TOTAL	GRAND TOTAL
	FOREIGN	LOCAL		SKILL	UNSKILL		
2000	443,000	18,000	461,000	8,000	7,000	15,000	476,000
2001	0	36,000	36,000	2,000	4,000	6,000	42,000
2002	0	36,000	36,000	2,000	4,000	6,000	42,000
2003	0	36,000	36,000	2,000	4,000	6,000	42,000
2004	0	36,000	36,000	2,000	4,000	6,000	42,000
2005	980,000	115,000	1,095,000	44,000	62,000	106,000	1,201,000
2006	0	194,000	194,000	2,000	4,000	6,000	200,000
2007	0	194,000	194,000	2,000	4,000	6,000	200,000
2008	0	194,000	194,000	2,000	4,000	6,000	200,000
2009	0	194,000	194,000	2,000	4,000	6,000	200,000
2010	0	194,000	194,000	2,000	4,000	6,000	200,000
2011	0	97,000	97,000	1,000	2,000	3,000	100,000
TOTAL	1,423,000	1,344,000	2,767,000	71,000	107,000	178,000	2,945,000

Table 8.4 Operation and Maintenance Costs

UNIT IN US$

	1991	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
EXCHANGE: BEATRICE																	
S/W CAP.	200	200	650	650	650	650	700	700	700	700	700	700	700	700	700	700	1000
PERSONNEL	18,800	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700
GENERAL	2,400	2,400	9,500	9,600	9,700	9,800	9,900	9,900	9,900	9,900	9,900	9,900	10,700	11,500	12,100	12,800	13,500
EXPENDITURE	21,200	23,100	30,200	30,300	30,400	30,500	30,600	30,600	30,600	30,600	30,600	30,600	31,400	32,200	32,800	33,500	34,200
EXCHANGE: MURAMBINDA																	
S/W CAP.	200	200	300	300	300	300	500	500	500	500	500	650	650	650	650	650	850
PERSONNEL	18,800	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700
GENERAL	2,400	2,400	5,700	6,200	6,600	7,000	7,600	7,900	8,300	8,500	9,000	9,400	9,800	10,400	10,800	11,200	11,700
EXPENDITURE	21,200	23,100	26,400	26,900	27,300	27,700	28,300	28,600	29,000	29,200	29,700	30,100	30,500	31,100	31,500	31,900	32,400
EXCHANGE: NKAYI																	
S/W CAP.	200	200	250	250	250	250	400	400	400	400	400	500	500	500	500	500	600
PERSONNEL	18,800	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700
GENERAL	2,400	2,400	5,000	5,300	5,700	6,000	6,400	6,600	6,900	7,100	7,300	7,600	7,800	8,200	8,300	8,500	8,800
EXPENDITURE	21,200	23,100	25,700	26,000	26,400	26,700	27,100	27,300	27,600	27,800	28,000	28,300	28,500	28,900	29,000	29,200	29,500
EXCHANGE: KEZI																	
S/W CAP.	200	200	350	350	350	350	400	400	400	400	400	600	600	600	600	600	700
PERSONNEL	18,800	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700
GENERAL	2,400	2,400	5,900	6,000	6,200	6,300	6,400	6,900	7,300	7,800	8,300	8,800	9,000	9,300	9,500	9,700	9,900
EXPENDITURE	21,200	23,100	26,600	26,700	26,900	27,000	27,100	27,600	28,000	28,500	29,000	29,500	29,700	30,000	30,200	30,400	30,600
EXCHANGE: CHATSWORTH																	
S/W CAP.	200	200	300	300	300	300	400	400	400	400	400	450	450	450	450	450	600
PERSONNEL	18,800	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700
GENERAL	2,400	2,400	5,400	5,700	5,900	6,200	6,400	6,500	6,600	6,700	6,900	7,000	7,400	7,900	8,000	8,400	8,800
EXPENDITURE	21,200	23,100	26,100	26,400	26,600	26,900	27,100	27,200	27,300	27,400	27,600	27,700	28,100	28,600	28,700	29,100	29,500
EXCHANGE: GUTU																	
S/W CAP.	400	400	600	600	600	600	950	950	950	950	950	1050	1050	1050	1050	1050	1250
PERSONNEL	18,800	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	20,700	24,100	24,100	24,100	24,100	24,100	29,300
GENERAL	4,700	4,700	9,700	10,500	11,300	12,000	13,000	13,200	13,500	13,700	14,000	14,200	14,700	15,200	15,600	16,000	16,600
EXPENDITURE	23,500	25,400	30,400	31,200	32,000	32,700	33,700	33,900	34,200	34,400	34,700	38,300	38,800	39,300	39,700	40,100	45,900
PERSONNEL	112,800	124,200	124,200	124,200	124,200	124,200	124,200	124,200	124,200	124,200	124,200	127,600	127,600	127,600	127,600	127,600	132,800
GENERAL	16,700	16,700	41,200	43,300	45,400	47,300	49,700	51,000	52,500	53,700	55,400	56,900	59,400	62,500	64,300	66,600	69,300
INSURANCE	0	0	31,000	29,000	27,000	25,000	23,000	21,000	19,000	17,000	16,000	14,000	12,000	10,000	9,000	7,000	5,000
TOTAL	129,500	140,900	196,400	196,500	196,600	196,500	196,900	196,200	195,700	194,900	195,600	198,500	199,000	200,100	200,900	201,200	207,100

Table 8.5 ADDITIONAL OPERATING COSTS

UNIT IN US$

	PERSONNEL	GENERAL	INSURANCE	TOTAL
1991				0
1996	11,000	0	0	11,000
1997	11,000	25,000	31,000	67,000
1998	11,000	27,000	29,000	67,000
1999	11,000	29,000	27,000	67,000
2000	11,000	30,000	26,000	67,000
2001	11,000	33,000	23,000	67,000
2002	11,000	35,000	21,000	67,000
2003	11,000	36,000	19,000	66,000
2004	11,000	37,000	17,000	65,000
2005	11,000	39,000	16,000	66,000
2006	15,000	40,000	14,000	69,000
2007	15,000	43,000	12,000	70,000
2008	15,000	46,000	10,000	71,000
2009	15,000	47,000	9,000	71,000
2010	15,000	50,000	7,000	72,000
2011	20,000	53,000	5,000	78,000

9. ASSESSMENT OF RESULT OF FINANCIAL ANALYSIS

The point at issue when discussing the project's financial state is the scale of sales revenue. Because the project targets developing areas, growth in demand is expected to be slight, coupled with low income growth.
This poses difficulties in carrying out a project requiring a large investment and is the most distinctive feature of rural projects. In other words, although a telecommunications network is needed in order to expedite economic growth, the funds required to provide and administer such a network are often in short supply.

The profitability of a project planned under these circumstances is very low, which makes it difficult to carry out this kind of project using conventional fund raising methods. Two cases were assessed, case 1 being the loan/equity method and case 2 the grant/equity method.

9.1 Case 1 (Loan/Equity)

The financial analysis of this case 1 was conducted with the following conditions: Interest rate -- 11.5% p.a.; repayment period -- 15 years including the grace of 5 years.

In this case, a loss of US$5,675,000 is recorded, with a total loss of US$58,298,000 for the 15 year period of the project. This puts pressure on the funds, resulting in a fund shortage for each operating year of the project. It will also lead to the government of Zimbabwe having to provide a subsidy, which will amount to US$45,750,000 (an annual average of US$3,050) -- twice the amount of initial investment.

A further study of the financial status, based on leading financial indicators and the results of sensitivity analysis indicates the following:

(1) The Debt Service Coverage Ratios show 0.09 to 0.67 throughout the repayment period, meaning that the funds raised through operations will not be able to cover the majority of the funds required for repayment throughout the period of the project.

This indicates, therefore, the necessity for the government of Zimbabwe to provide a large subsidy. Even if the rate of interest on borrowing is 0.0%, a government subsidy will still be needed to make up for the shortage of funds.

(2) The Cash Break-Even Point indicates that 3 to 15 times anticipated revenues will be required each year from the first year of operation until the completion of the project. This supports the above prediction of a fund shortage. Given these conditions, it is not possible to calculate the Financial Internal Rate of Return (FIRR). The scale of cash flow is so insignificant as to be not worth the reckoning if the project is to be based on borrowing.

(3) Even lower interest rates for the long-term borrowing, which constitute 70% of the total investment, will only slightly reduce the formidable fund shortage. For example, even if we lower the interest rate of 11.5% given in the base case is lowered by 8 % to 3.5%, it is still not possible to calculate the FIRR.
Furthermore, a case where the entire portion of the funds required are covered by equity capital with no long-term loans taken out will still only slightly alleviate the situation. Even in this case, it still remains impossible to calculate the FIRR.

(4) As the results of the sensitivity analysis indicate, cases where sales revenues can be increased while the total investment can be decreased do not even present a financial state of affairs which affirms the feasibility of the project.

The above points show that it is difficult to justify making the investment for the project. The project requires an investment too great for the small revenue anticipated, thus placing great pressure on funds.

9.2 Case 2 (Grant/Equity)

Case 2 introduces a grant in order to overcome the problem of the project's profitability. The cost for preparatory works -- such as the cost of installing transmission links -- needed to allow the facilities for the project to be brought in, Pre-operation costs and Initial

Working Capital are covered by the equity portion, on the understanding of the need for a grant.

The costs of Equipment and facilities constituting the telecommunications network are covered by the grant portion. This reduces the amount of funds which the Government of Zimbabwe need to supply, and guarantees profitability and enables operation.

There will be a fund surplus throughout the life of the project, except for those years in which a large amount of Reinvestment is required. There is thus no need for a government subsidy, which is necessary during periods where there is a fund shortage. No cash flow problems will arise.

The payout period for the equity capital of US$1,535,000 required in the initial investment is 3 to 4 years. All of the additional funds needed for facility expansion can be paid out. A cash flow of US$8,850,000 is yielded throughout the operating period, with FIRR at 19.51%. The profit ratio reflects the soundness of financial state.

This FIRR is attained because the equity accounts for only 4% of Total Investment Costs and anticipated sales revenues are sufficient to maintain the stable operation. Note should be made of the fact that FIRR values are largely affected by changes in the percentage of equity in the total cost of investment.

A further study of the financial status based on major financial indicators and the results of a sensitivity analysis shows the following;

(1) The Profit Break Even Point for each year of the project is 50% or lower. The Cash Break Even Point is 20% or lower. These levels point to a sound situation in terms of profits and funds.

(2) The results of sensitivity analysis are as follows;

The results of sensitivity analysis are summarized in Figure 9.1.

a) Total Costs of Investment

If the Total Investment Costs varies by plus or minus 10% from the base value, the FIRR value also fluctuates by about 10%. Although the total costs of investment do affect the project's profitability to some extent, they do not have a life or death influence over the project.

b) Sales Revenue

Fluctuations of sales revenues affect the project's profitability to a relatively large extent.
If sales revenues vary from the estimates by plus or minus 20%, FIRR values fluctuate by about 30%. Because the areas targeted by the project largely comprise communal farming areas which are subject to natural misfortunes, there is a strong possibility that sales revenues may decline. But even where sales revenues drop 20%, the FIRR of 12.52% remains above 10%.
It therefore seems that the profitability of the project, as one which serves to meet basic human needs, is secure.

c) Grant Portion of Total Costs of Investment

With a small equity portion in the total costs of investment, the results of financial analysis point to preferable profitability. But it should be noted that a decrease in the grant portion attributing to an increased portion of equity in the Total Investment Cost affects the project viability greatly.
For example, as noted in the sensitivity analysis, should the grant portion set based on the equity portion decrease 10% and this decrease is covered using equity, the FIRR will experience a major fall from 19.51% to 2.52%.

Similarly, if the grant portion should fall 20%, the FIRR will decline to -2.92%. This would mean it would be impossible to secure funds, making it very difficult to complete the project. The above points indicate that the case which uses the grant/equity methods allows the project to operate with solid profitability, provided the assumed grant can be introduced.

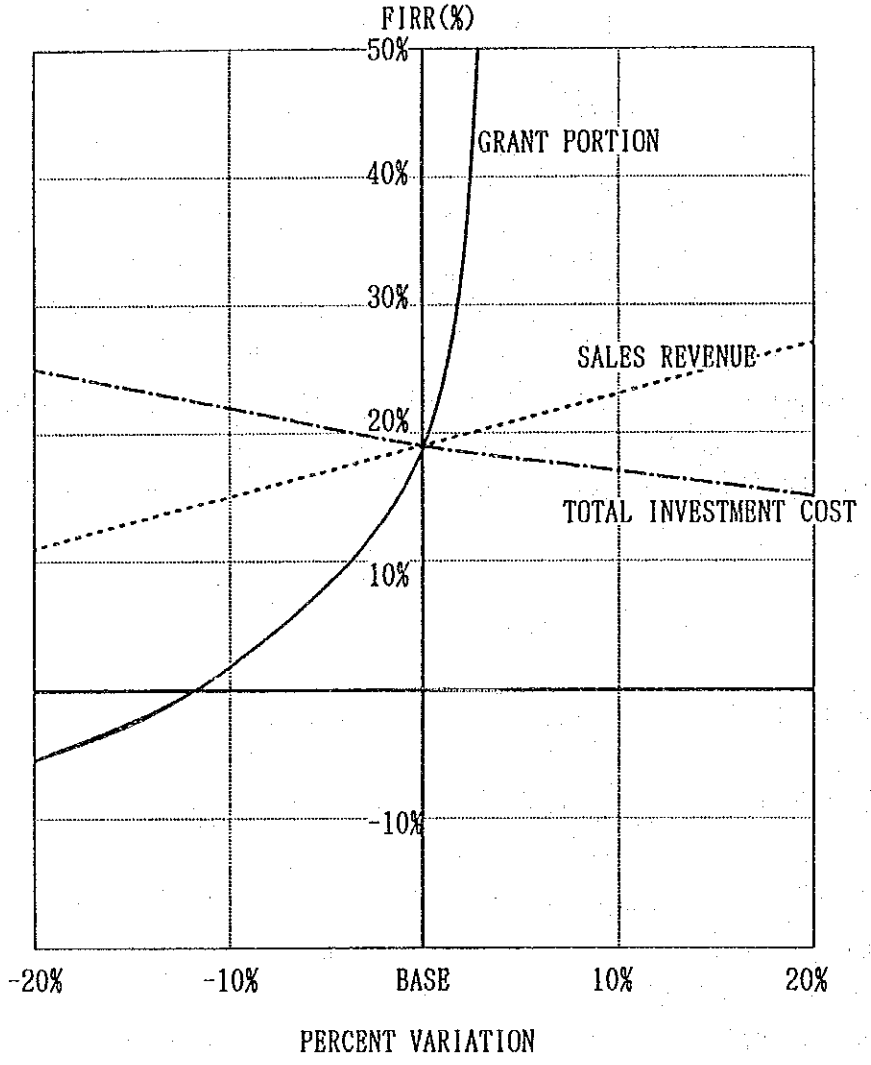


Figure 9.1 Summary of Sensitivity Analysis for Case 2
IRROE % to variation of Financial Parameter

10. ECONOMIC ANALYSIS

Referring to the two bases settled in the financial analysis the following two cases will be analyzed and Economic Internal Rate of Return (EIRR) on total investment (case 1) and EIRR on equity (case 2) will be calculated.

Case 1 : Corresponding to the case 1 (Loan/Equity case)
EIRR on total investment (100% Equity with elimination of loan borrowing)

Case 2 : Corresponding to the case 2 (Grant/Equity case)
EIRR on Equity any, in other words, on total investment paid by PTC

- Willingness To Pay

The direct benefit of this project is calculated by adding the value of Willingness To Pay of beneficiaries to the financial value of sales revenue.
In order to judge the value of Willingness To Pay (WTP), Interview survey was carried out for 120 households and commercial offices in various areas. The outcome is summarized as follows;

Table 10.1 Willingness To Pay

Items	Average Value	Maximum Value
Call Charge	+Z$ 1/call	+Z$ 5/call
Installation Fee	+Z$ 150/line	+Z$ 2000/line
Rental Fee	+Z$ 20/month	+Z$ 150/month

Note: The detailed result of Interview survey is shown in DATA FILE, "Result of Questionnaire".

- Economic Value of the Benefit

The above mentioned "Willing To Pay" is to be used as the base value of the economic benefit expected by the project.

The current telephone tariff system in Zimbabwe is based on the distance from an exchange to respective subscribers. Namely, a distant subscribers pays higher amount than subscribers located closer to the exchange.
For installation fee and basic rental fee, the farthest subscriber from the exchange has to pay more than 50 times, as compared to subscribers inside BRA. This means that subscribers outside a BRA have been paying the premium under the current system.

Considering the above characteristics, scale of economic benefit is estimated based on the following 3 cases.

Economic Benefit Case (E.B.1)

E.B.1 : The premium is calculated by outcome of interview survey.

Premium of Call charges/call : Z$ 1
Installation fee/line : Z$ 150
Rental fee/month : Z$ 20

Economic Benefit Case (E.B.2)

E.B.2 : The economic value of benefit assumed by the highest tariff payment of the furthest subscriber in each exchange area.

Table 10.2 Assumed premium for each exchanges

(Unit : Z$)

Items	NKI	GTU	CHS	KEZ	BTR	MRB
Call charge per call	5.0	5.0	5.0	5.0	5.0	5.0
Installation fee	4668.8	4668.8	4668.8	6760.4	5764.4	4668.8
Annual Rental fee	2337.6	2337.6	2337.6	5313.6	3825.6	2337.6

Economic Benefit Case (E.B.3)

E.B.3 : The economic value of benefit derived from the highest tariff payment in all exchange areas where the project covers telecommunications service.

Call charges/call : Z$ 5.0
Installation fee/line : Z$6,760.4
Rental fee/annum : Z$5,313.6

The result obtained in this Economic Analysis is discussed here, and summarized in Table 10.3 and in Figure 10.1.

(1) The result of Economic Analysis clearly states that EIRR (Economic Internal Rate of Return) is much higher than the FIRR (Financial Internal Rate of Return) in both base cases.
This implies that the economic benefit is very high due to the greatness of people's demand for telecommunication services even though the present tariff in market price is controlled under a relatively low charge.

(2) The EIRRs in Case 1 suggest that the project will stand to be economically feasible coupled with the high economic benefit assumed even though the project is wholly implemented on an equity basis. It can be also pointed out that the project can be operated without financial difficulty if the present tariff is increased by about 10 times.

(3) The EIRRs in Case 2 are very high. This is due to the very small investment on PTC side in the total investment cost of which major portions are supplied by a great grant aid.

Table 10.3 Summary of Economic Analysis
(EIRR for base case)

Economic Benefit Value	Premium to Financial Value	EIRR	
		Case 1	Case 2
E.B-1	2.9	-3.84 %	62.00 %
E.B-2	11.0	13.74 %	151.00 %
E.B-3	13.0	16.70 %	167.00 %
FIRR	(1.0)	N.A.	19.51 %

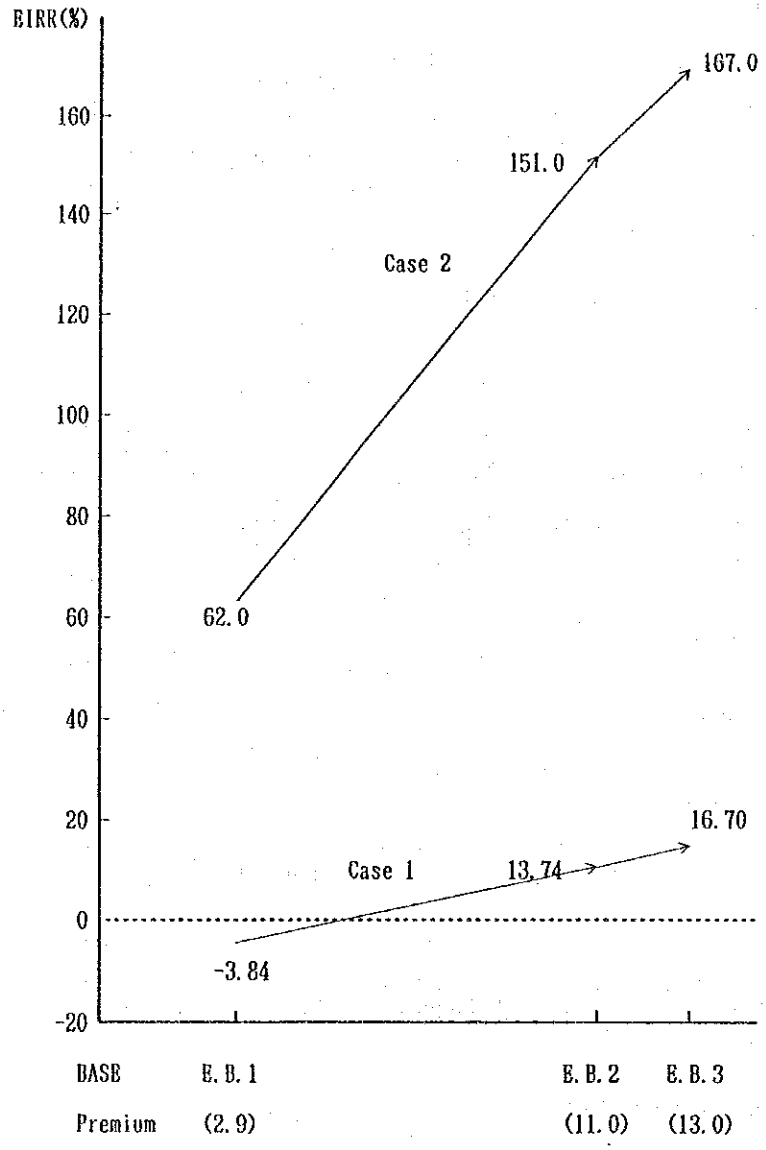


Figure 10.1 Result of Economic Analysis

(Sensitivity of EIRR to variation of Social Economic Benefit)

11. RECOMMENDATIONS

1. Location of Waiting Applicants

To confirm location of subscribers including waiting applicants in all exchange areas involved prior to the execution of detailed field survey to reduce the period required for system and network designing and to enable PTC to make preparatory arrangement for subscriber line connection.

2. Site Confirmation and Land Acquisition

To confirm by field survey the Maphisa new exchange site and new radio stations selected by the feasibility study, and this time to make necessary prior arrangements for building construction, land acquisition, ground levelling, and land formation. Also, to select substitute sites to be used in case the land acquisition and construction is difficult at the primarily selected sites or those sites prove to be disqualified.

The field survey of sites is indispensable for smooth progress of construction work and its completion without delay.

3. Construction of Building and Provision of Transmission System

To construct a new building at Maphisa (Kezi Area) and transmission system for the following 4 sections

- (Nkayi-Kwekwe), (Chatsworth-Gutu-Masvingo) and (Beatrice-Harare)

In addition to the above, provision of analog multiplexing equipment is to be made at Bulawayo and Syringa stations to interface with digital radio link established for (Syringa-Maphisa) section.

4. Launching of this project is considered promising, especially if the project is undertaken with the help of a grant aid. Implementation is likely to contribute to enhancement of economic development and improvement of social welfare of Zimbabwean people.

5. General Assessment

This project aims to set an example for projects of its type which are needed for economic development but which do not yield an immediate revenue. With such small sales revenues anticipated, a project requiring a large investment poses too great a burden. If the common financial scheme (Case 1) using the Loan/Equity method is employed, the distinctive feature of rural projects mentioned in Item 9, "ASSESSMENT OF RESULT OF FINANCIAL ANALYSIS" is evident, making it difficult to carry out the project from a financial perspective.

But if the bulk of the funds needed for the project can be covered by a grant provided through bilateral aid, financially sound operations are promised and the project is justified. The distinctive feature of these kinds of projects must be recognized and the benefits accruing from the project as shown in the economic analysis needs to be taken into account. In this case, undertaking the project with the help of a grant seems likely to contribute to the economic development and provision of infrastructure in Zimbabwe.