SOLOMON ISLANDS
FEASIBILITY STUDY REPORT
ON
THE TELECOMMUNICATION TRUNK NETWORK CONSTRUCTION PROJECT

MARCH 1980

JAPAN INTERNATIONAL COOPERATION AGENCY

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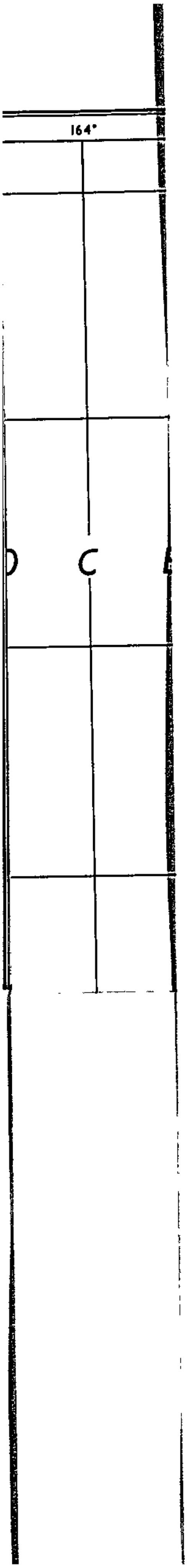
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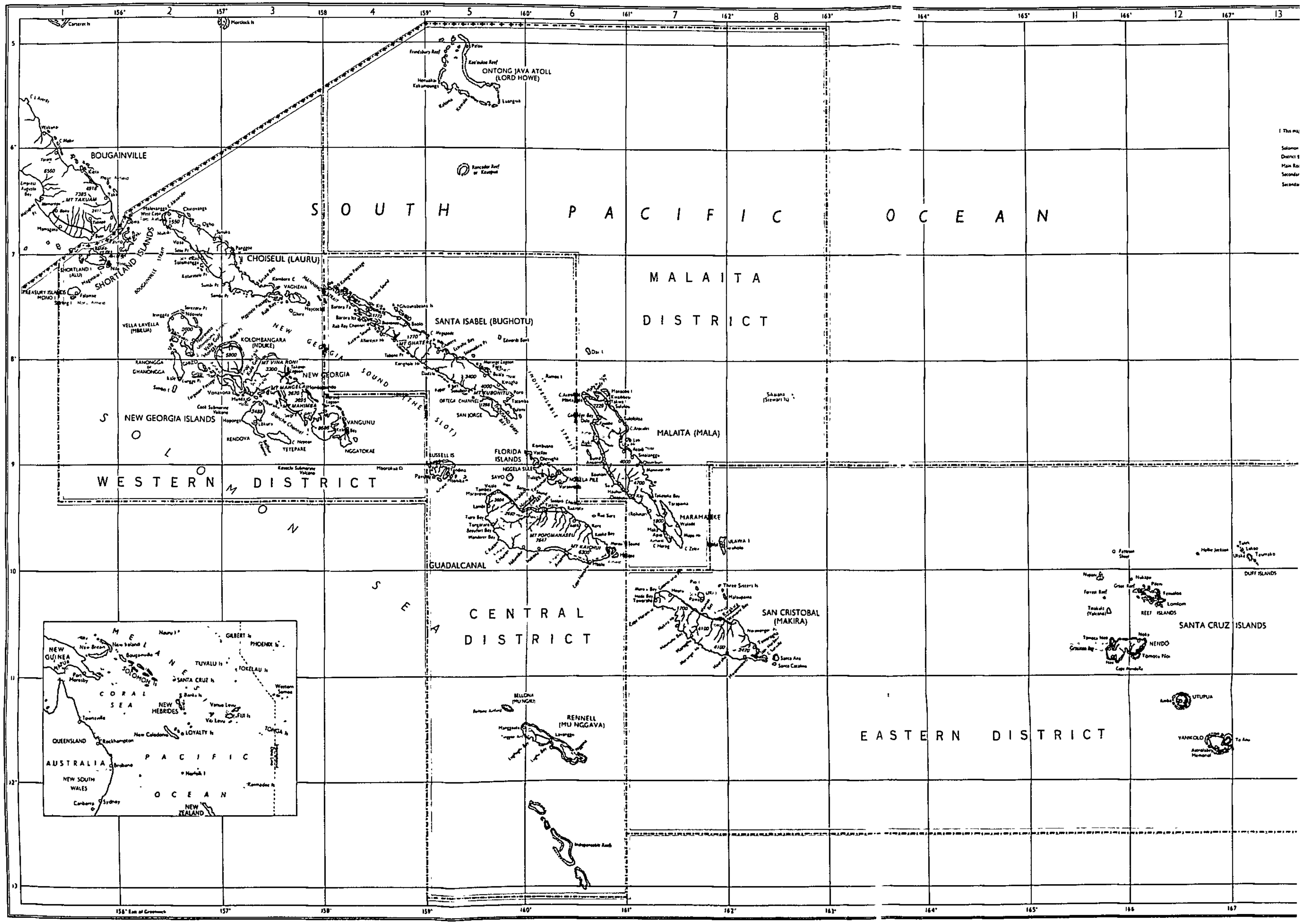

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RENNELL (MU NGGAVA)
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SANTA CRUZ ISLANDS
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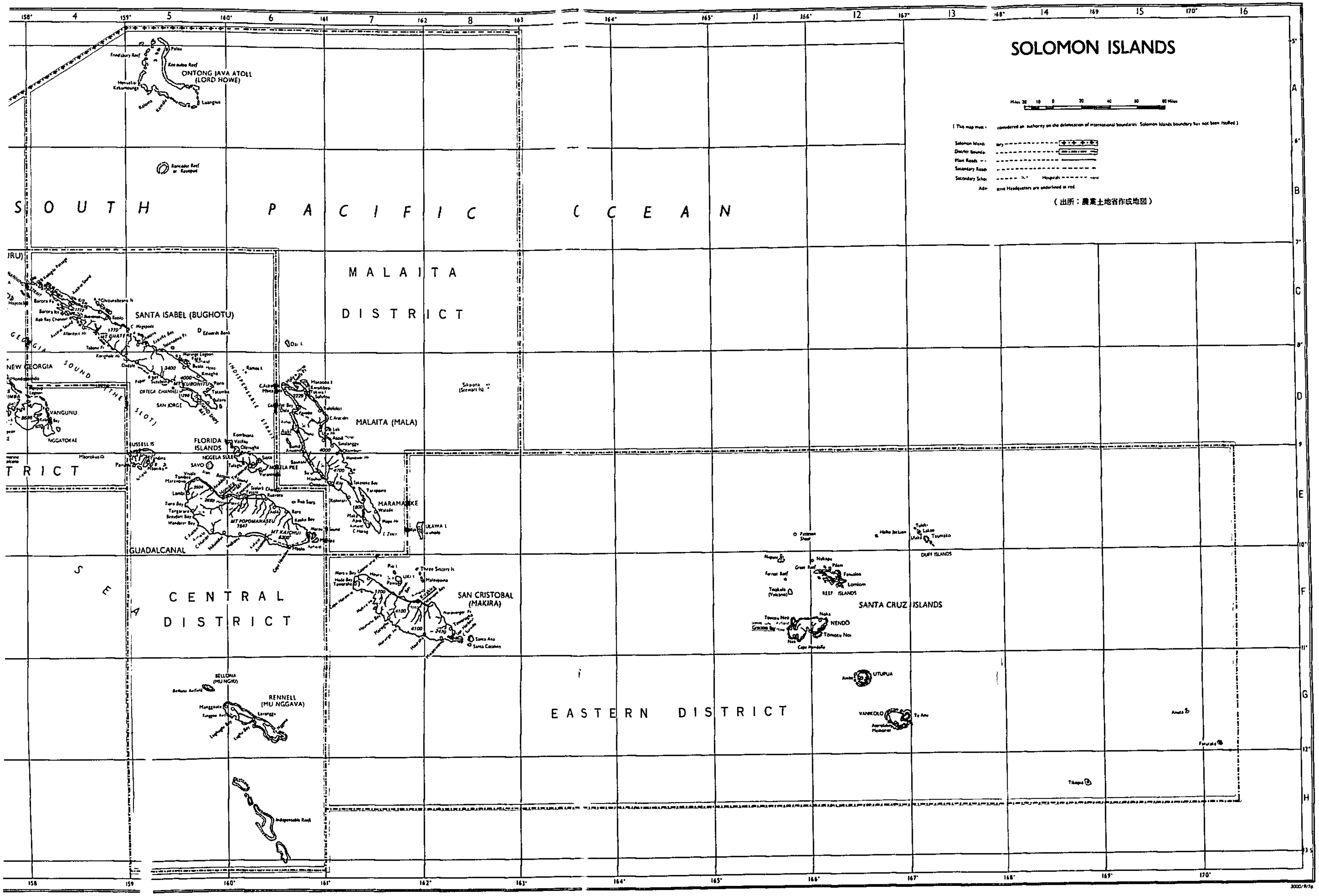

SOLOMON ISLANDS
（出所：農業土地省作成地図）
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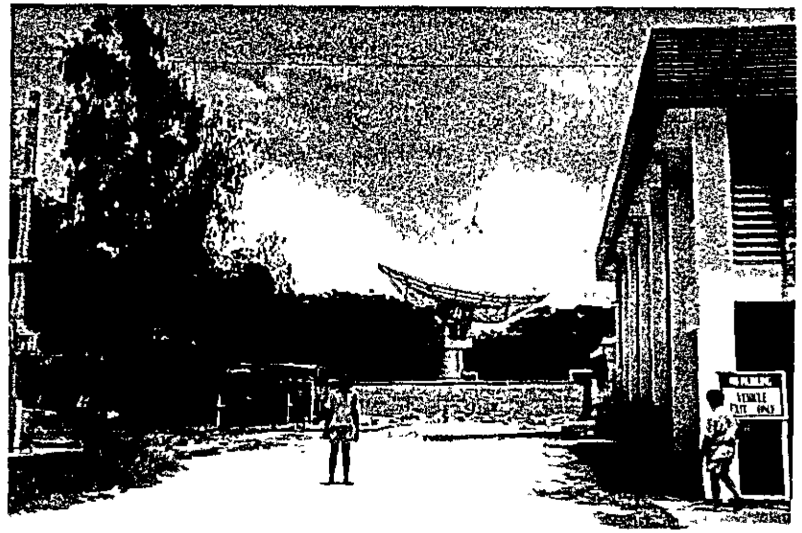
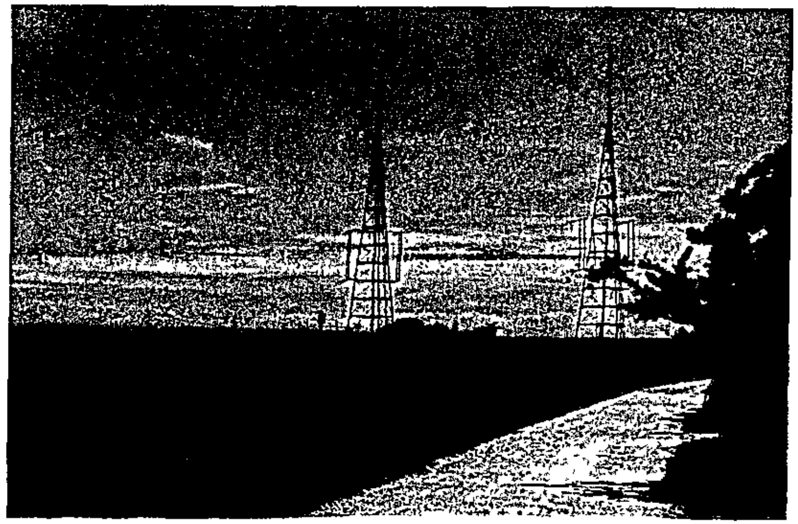
Consultation with Solomon P & T for implementation of field survey. At a meeting room of P & T.



Honiara Earth Station for Satellite Communications.

Propagation Test over the Radio Path between Auki and Sulufou. At the Sulufou site.



Existing Radio Station in Honiara VHF and HF antennas.

PREFACE

In response to the request of the Government of the Solomon Islands, the Government of Japan has decided to carry out a feasibility study on the telecommunication trunk network construction project, and the Japan International Cooperation Agency (JICA) conducted the survey.

JICA dispatched a survey team headed by Mr. Hiroshi Furukawa, Special Assistant to Director General, Radio Regulatory Bureau, Ministry of Posts and Telecommunications to the Solomon Islands to carry out a field survey for a period of 50 days from January 23rd to March 13th, 1979.

The team analyzed and examined information and data obtained during the field survey. After full consultations with the authorities concerned of the Government of Solomon Islands, the team compiled the present report for submission to the Government of the Solomon Islands.

I hope this report will be found to be useful for the development of telecommunications in the Solomon Islands, and contribute to the promotion of friendly relations between our two countries.

I would like to express my deep appreciation to the Government and the people concerned of the Solomon Islands for their close cooperation and assistance extended to the survey team.

February 1980

Keisuke Arita

Keisuke Arita,
President,
Japan International Cooperation Agency

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A SUMMARY AND RECOMMENDATIONS

The telecommunications trunk network Construction Programme in Solomon Islands is intended to provide a high quality wide band telecommunication circuit connecting major districts of the islands, which constitutes a trunk network of the future telecommunications system in the country.

Solomon Islands is a new country which became independent from the British protectrate on July 7, 1978. The government of Solomon Islands has laid down various development programmes for the development of the country and the promotion of national unification and has been promoting the improvement of the telecommunication network Construction Programme as part of such national programmes. The present project among the said national programmes is regarded as one of the highest priority project of the country.

Upon request of the government of Solomon Islands for a feasibility study for the project, the government of Japan sent a preliminary survey team to Solomon Islands in August 1978. The survey team, after holding consultation with the Solomon government and conducting field surveys in main districts, determined the project scale and established the policies for the feasibility study. The Japanese government then sent a feasibility study team for the "Telecommunication Trunk Network Construction Programme in Solomon Islands" to that country for a period of 50 days from January 23rd to March 13th, 1979.

The team conducted surveys for a route plan, telephone demand forecast, transmission system and economic evaluation on the basis of the scope of work determined by the preliminary survey carried out previously.

The following is a summary of the result of the feasibility study for the project.

1. Basic Plan for Telecommunication Network

The number of telephone subscribers in Solomon Islands is 1,350 at present but the demand for telephone in the region is so great that the number of applicants for telephone service is expected to reach 15,000 to 20,000 in the next 20 to 25 years.

To meet this increasing demand, the Solomon Government is now promoting the introduction of automatic switching system under the current local telephone network expansion project and plans to increase the number of exchanges in the six zones from the present seven to about 15 by the year 2006. The toll traffic generating from the 26 zones, where the Solomon Government desires to establish radio terminal stations, as well as from those automatic exchanges, is expected to reach 30 Erlangs in the initial stage and approximately 100 Erlangs in the ultimate stage.

As a telephone network to provide the above mentioned service, it is considered appropriate to construct a two rank system network centering around Honiara in the initial stage and to shift to 3 rank system network as the number of automatic exchanges increases in the future.

Under the plan, the direct distance dialing system will be used for all toll calls, and the toll rate system is scheduled to be changed from the present flat rate system applied to the nation-wide network to the time zone meter system.

The subscriber's number will be of the five digits closed numbering system and special code will consist of three digits of 1 X Y.

2. Transmission System

For transmission system, both the Trans-horizon system and the Line-of-sight system will be used for economy of construction work and rationalization of operation in view of special geographical conditions of Solomon Islands, and the diversity system will be employed for the Trans-horizon section to ensure circuit stability.

The frequency band will be UHF band and the modulation system will be FDM.

3. Transmission Route

Proposed transmission routes are shown in Fig. 1. Section of the site for radio stations was made with consideration given to radio propagation characteristics, relative difficulty of construction of access roads and the convenience of transportation of maintenance equipment and materials.

4. Power Supply System

The floating system using a standby engine generator will be employed for stations which can purchase commercial power and the floating system using a dual diesel engine generator will be employed for stations whose DC load is 500W or over and which cannot purchase commercial power. For stations with DC load of less than 500W, the parallel operation system with a thermo electric generator will be employed.

5. Radio Frequency Channel Arrangement

The frequency band to be used in the Trans-horizon section will be 2 GHz band and that for the Line-of-sight section having a transmission capacity of 60 CH or more will be 900 MHz band. For other stations with a relatively small transmission capacity, 400 MHz band will be used.

6. Maintenance and Operation

For maintenance of trunk networks, Honiara station will play the role of a master maintenance center and will be equipped with a remote centralized supervisory and control system for operation, supervision and control of the whole system. In addition to the master maintenance center, three stations of Auki, Gizo and Kirakira will be designated as maintenance centers and will be equipped with remote supervisory and control functions for centralization and laborsaving of maintenance work. Moreover, a maintenance crew will be assigned to each of these stations for periodic patrolling inspections of unttended stations located in their respective maintenance zones.

7. Construction Cost and Implementation Plan

Construction work will be carried out in stages and the whole project will be completed in two phases.

In the first phase, a trunk system connecting six zones of Honiara, Auki, Gizo, Kirakira, Tulagi and Tenakaro will be constructed at a cost of 2,328 million yen (2,253 million yen in foreign currency portion and 75 million yen in local currency portion).

In the second phase, branch systems will be constructed in 20 zones at a cost of 2,085 million yen (2,025 million yen in foreign currency portion and 60 million yen in local currency portion; 1979). Estimation of construction cost is shown in table 1 and table 2.

The project will cover a period of three years. The first year will be allocated to the preparation of detailed design and specifications, the second year for ordering and manufacture of equipment and the third year for installation, adjustment, receiving inspections and finalization of the project.

The start of the second phase construction will be timed with the implementation of the telephone exchange expansion programme.

8. Economic Evaluation

The financial and economic analyses of the project for all the 26 zones put the profit ratio of gross capital at 0.9% and the internal rate of return at 4.3% and these figures jump to 4.7% and 7.5%, respectively, if the object area of analysis is limited to the six main zones (Honiara, Auki, Gizo, Kirakira, Tulagi and Tenakaro). Yet, these figures are not considered high enough.

However, in consideration of the special gecgraphical conditions of

Solomon Islands comprising groups of solitary island, the necessity of the project can be fully recognized when the improvement of people's life as a result of economic and industrial development, substantiation of administrative functions and advancement of culture, all of which may be brought about by the completion of the telecommunication system under the project, is considered synthetically.

Table 1 Project Cost of Proposed System (Phase-I)

Item	Foreign Currency Protion		Local Currency Portion
	Thousand Japanese Yen	Equivalent US Dollars	Equivalent Solomon Dollars
1. Equipment Work Portion			
A. Communication equipment	576,128	2,618,764	-
B. Power plants	174,746	794,300	-
C. Cables	16,690	75,864	-
D. Antenna supporting structures	141,855	644,795	-
E. Maintenance facilities	97,420	442,818	-
F. Installation materials	34,778	158,082	-
G. Equipment shelters	166,647	757,486	-
H. Sub-total (F.O.B.)	1,208,264	5,492,109	-
I. Ocean freight & Marine Insurance	48,331	219,686	-
J. Sub-total (H+I)	1,256,595	5,711,795	-
K. Installation & the associated test	579,028	2,631,945	-
L. Training	25,000	113,636	-
M. One year maintenance	25,900	117,727	-
N. Customs clearance & domestic freight	-	-	49,532
O. Sub-total (J+K+L+M+N)	1,866,523	8,575,103	49,532
2. Civil Work Portion			
P. Land procurement & site formation	-	-	201,860
Q. Access-road construction	-	-	23,856
R. Sub-total (P+O)	-	-	225,716
3. Consulting Engineering Services	179,000	813,636	-
4. Basic Project Cost	2,065,523	9,388,739	275,248
5. Contingency	188,000	854,545	28,000
6. Total Project Cost	2,253,523	10,243,284	303,248

Exchange Rate: US$ 1 = 220 Japanese yen
Solomon $1 = 250 Japanese yen

Table 2 Project Cost of Proposed System (Phase-II)

Item	Foreign Currency Portion		Local Currency Portion
	Thousand Japanese Yen	Equivalent US Dollars	Equivalent Solomon Dollars
1. Equipment Work Portion			
A. Communication equipment	493,299	2,242,268	-
B. Power plants	266,503	1,211,377	-
C. Cables	5,902	26,827	-
D. Antenna supporting structures	187,103	850,468	-
E. Maintenance facilities	40,326	183,300	-
F. Installation materials	27,688	125,855	-
G. Equipment shelters	76,830	349,227	-
H. Sub-total (F.O.B.)	1,097,651	4,989,322	-
I. Ocean freight & Marine Insurance	43,906	199,573	-
J. Sub-total (H+I)	1,141,557	5,188,895	-
K. Installation & the associated test	549,787	2,499,032	-
L. Training	-	-	-
M. One year maintenance	-	-	-
N. Customs clearance & domestic freight	-	-	42,708
O. Sub-total (J+K+L+M+N)	1,691,344	7,687,927	42,708
2. Civil Work Portion			
P. Land procurement & site formation	-	-	153,392
Q. Access-road construction	-	-	23,856
R. Sub-total (P+O)	-	-	177,248
3. Consulting Engineering Services	165,000	750,000	-
4. Basic Project Cost	1,856,344	8,437,927	219,956
5. Contingency	169,000	768,182	22,000
6. Total Project Cost	2,025,344	9,206,109	241,956

Exchange Rate: US$ 1 = 220 Japanese yen
Solomon $ 1 = 250 Japanese yen

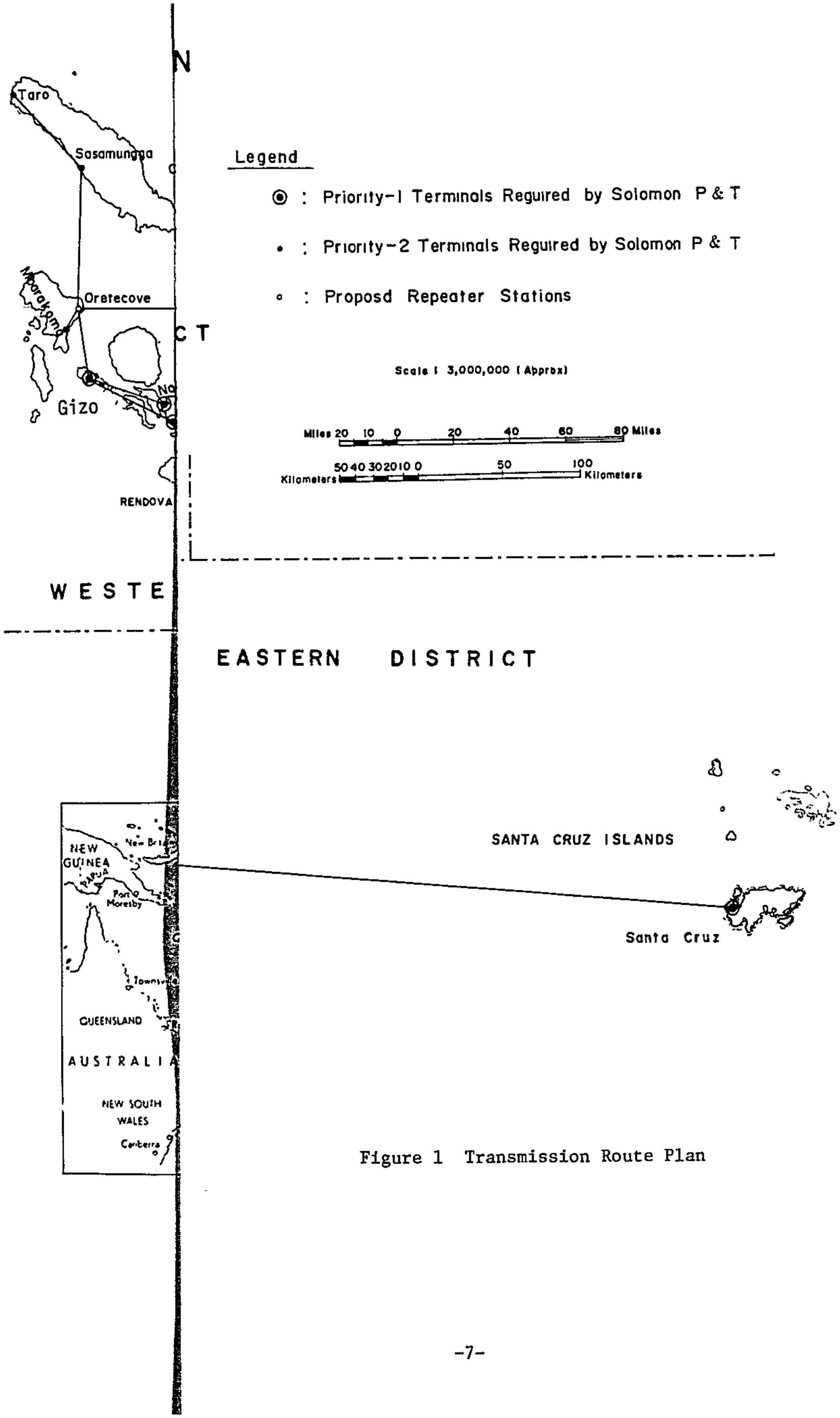


Figure 1 Transmission Route Plan

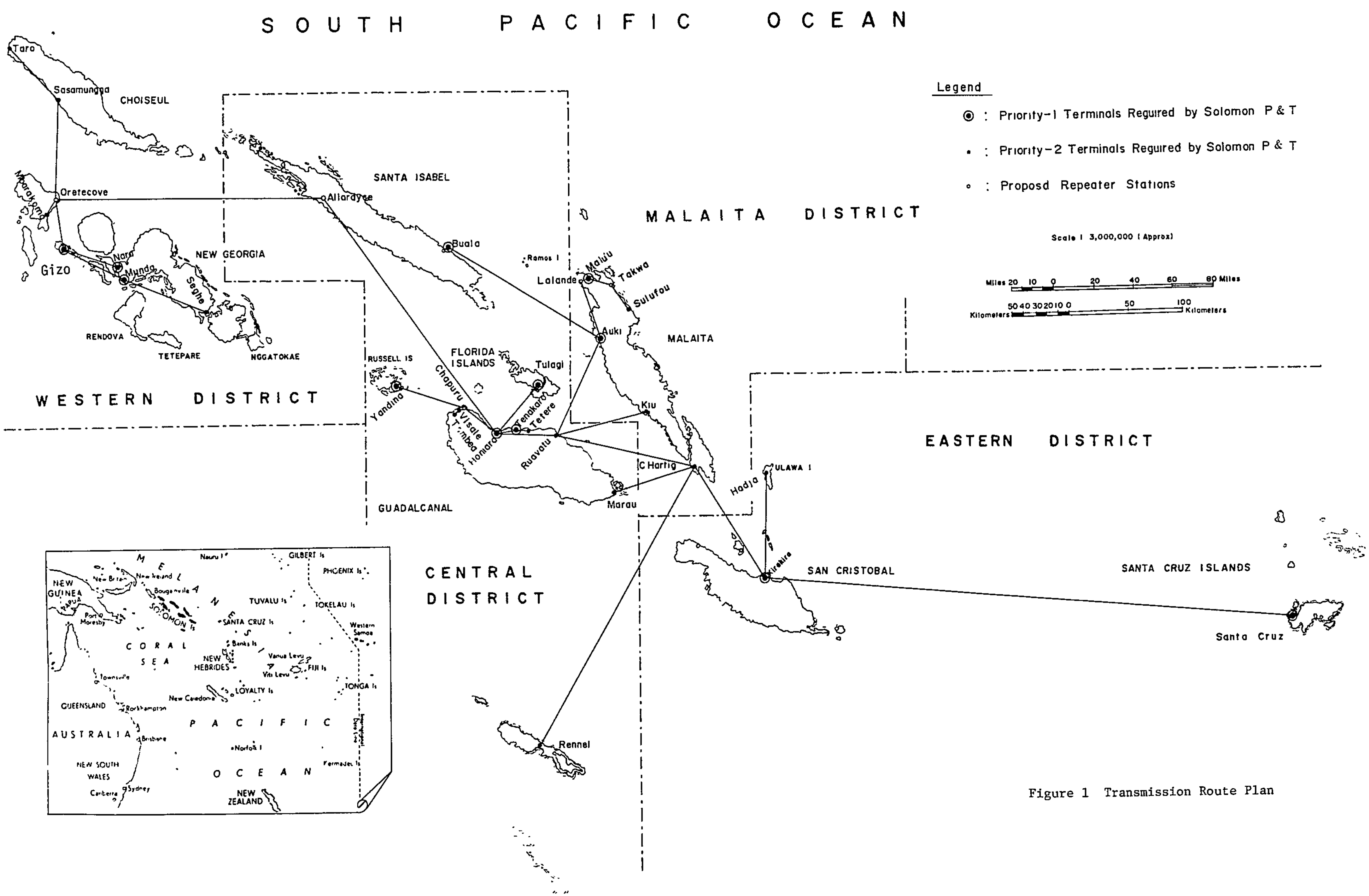


Figure 1 Transmission Route Plan

CHAPTER 1

INTRODUCTION

Chapter 1 Introduction

1-1 Background, Purpose and Direction of Survey

The domestic public telecommunication system now in use in Solomon Islands include a local automatic telephone system introduced to three districts of Honiara, Auki and Gizo, toll radio telephone circuits of VHF (Honiara-Auki) and HF connecting the above three districts and VHF teleprinter (Haniara-Auki) and HF telegraph circuits connecting post offices and telegraph offices handling domestic telegraphs. Each of these systems, however, is not satisfactory in terms of circuit performance and cannot meet adequately the future circuit demand.

Such a lag in the improvement of telecommunication network is a stumbling block to the future development of Solomon Islands comprising many islands scattered over a wide area of the ocean.

Under the circumstances, the Solomon government took up the improvement of domestic telecommunication trunk network as part of the Comprehensive National Development Project and worked out a telephone network expansion program to meet the future telephone demand and determined to expand telephone services to areas which were not covered by the existing telephone netowrk. In this connection, the Solomon government made a request to the economic cooperation study mission from the Japanese government, which visited Solomon Islands in February 1978, for assistance in the implementation of the project for construction of a trunk network which form the basis for the aforementioned program.

In reponse to this request, the Japanese government stated in reply that it was ready to conduct a feasibility study for the project and on the basis of the agreement between agencies concerned on the basic matters relative to the implementation of the survey, sent a six member preliminary survey team headed by Mr. Hirotsugu Fukui, Deputy Director of the Frequency Division, Radio Regulatory Bureau, Ministry of Posts and Telecommunications, to Solomon Islands for a period of 27 days from August 22 to September 17, 1978.

The team defined the scope of work (S/W) relative to the project size and the extent of survey, collected data necessary for the feasibility study and made surveys on the conditions of existing telecommunication systems and local communities.

With such a background, a 12 member team headed by Mr. Hiroshi Furukawa, Special Assistant to Director General, Radio Regulatory Bureau, Ministry of Posts and Telecommunications was sent to Solomon Islands for a feasibility study for a period of 50 days from January 23 through March 13, 1979 with the primary objective of formulating basic plans for the implementation of the domestic telecommunication trunk network in Solomon Islands, including selection of optimum transmission route and system, and collecting data necessary for a feasibility study of the project from technical and economic points of view on the basis of the result of preliminary survey.

To attain the above objective, the study team carried out site surveys, including land surveying and radiowave propagation tests and collected data and materials relative to the basic design of the project according to the scope of work. At the same time, the team held consultations with the Solomon government as a basic policy for extending cooperation for the implementation of the project.

The composition of the study team is as follows.

Mr. Hiroshi Furukawa (Leader of the Team)
Special Assistant to the Director General Radio Regulatory Bureau, Ministry of Posts and Telecommunications

Mr. Kengo Ono
Senior Engineer, Land Division Radio Communication Department, Radio Regulatory Bureau, Ministry of Posts and Telecommunications

Mr. Minoru Hirukawa
Assistant to Director General of Communications, Ministry of Posts and Telecommunications

Mr. Sigeaki Takashima
Engineer, Engineering Division, Monitoring Department, Radio Regulatory Bureau, Ministry of Posts and Telecommunications

Mr. Motonori Ando
Senior Engineer, International Affairs Bureau, Nippon Telegraph and Telephone Public Corporation

Mr. Kunio Miyagawa
Senior Engineer, International Affairs Bureau, Nippon Telegraph and Telephone Public Corporation

Mr. Toshihiro Higuchi
Senior Engineer, International Affairs Bureau, Nippon Telegraph and Telephone Public Corporation

Mr. Hiroshi Ohno
Senior Engineer, The Nippon Telecommunications Consulting Co., Ltd.

Mr. Shoji Aoki
Senior Engineer,
The Nippon Telecommunications Consulting Co., Ltd.

Mr. Michinori Maehiro
Engineer,
The Nippon Telecommunications Consulting Co., Ltd.

Mr. Yoshio Moritomo
Engineer,
The Nippon Telecommunications Consulting Co., Ltd.

Mr. Eiji Sakihara (Coordinator)
Special Assistant to Head, 2nd Division , Social Development Cooperation Department, Japan International Cooperation Agency

The itinerary for study team is shown in data sheet No. 1.

1-2 Object and Scope of Survey

The basic matters relative to the implementation of the project is shown in the scope of work, Data sheet No.2, which was agreed upon between the Government of Solomon Islands and Japan International Cooperation Agency (JICA).

The plan worked out by the Government of Solomon Islands calls for the introduction of telephone services to 23 main districts excluding the three districts of Honiara, Auki and Gizo, which are already covered by existing telephone network, and construction of a broad-band trunk network for connection of telephone networks in these districts through the telephone exchange center at Honiara.

According to the scope of work, construction of terminal stations of transmission network is divided into three stages. The following 12 locations are listed in the first priority group as important terminals which form the basis for the project.

*<u>Auki</u>	*<u>Kirakira</u>	<u>Santa-Cruz</u>
<u>Buala</u>	Malu'u	*Tenakaro (Tenavatu)
*<u>Gizo</u>	Munda	*<u>Tulagi</u>
*<u>Honiara</u>	Noro	Yandina

Of the above locations, the six areas with an asterisk are being considered as sites for construction of automatic exchanges in the initial stage and the seven districts underlined are administrative and economic centers of provinces.

The 14 locations on the second priority list are terminal areas, inclusion of which in the trunk telephone network is considered desirable unless special technical means are required for construction of terminal stations. Locations on the third priority list are those areas which are considered essential as relay stations or the like facilities.

As transmission systems to link all of these terminal stations to form a network, the line-of-sight system and the trans-horizon system, the satellite communication system and the cable communication system are available. As to the selection of the optimum system, it is necessary to prepare several alternative transmission route and make a comparative study from a broad point of view with consideration given to the following points.

(1) Possibility of meeting the long-term circuit demand.
(2) Possibility of securing the required circuit performance.
(3) Relative difficulty of construction work.
(4) Relative difficulty of operation and maintenance of the system.
(5) Economy of construction and maintenance of the system.

A site survey was made during the field reconnaissance at 41 locations, including the 26 proposed terminal station sites, listed as the first and second priority sites, from which the technically and economically feasible sites were selected as proposed sites from the standpoint of the size of available land and the relative difficulty in the acquisition of land.

Though the introduction of switchboard is limited to the previously mentioned 6 areas in the initial stage, measures will be taken to include the subscribers in those areas which have not been provided with a switchboard under the proposed network to make the operation of the entire system more organic. The circuit capacity, an important factor for selection of transmission system, will be determined on the basis of the forecast of toll traffics generating from subscribers in each area.

For the long-term forecast of circuit demand, the estimated number of terminals in the initial and ultimate stages shown in the telephone network expansion plan formulated by the government of Solomon Islands may be used as a reference. In the field survey, however, adequate studies were made on the present state of population and economic activities of the proposed sites and also on the possibility of expansion to adjacent areas and then the circuit demand was forecast for each area for the next 20 years or so following the inauguration of telephone services with consideration given to the growth rate of the Gross Domestic Product (G.D.P) of Solomon

Islands and the composition of circuit and exchange networks.

Since there is a plan for constructing a new radio station in Kirakira and Santa-Cruz in addition to the existing station in Gizo to eliminate blanket areas of radio broadcasting and to improve the quality of broadcasting, the radio program transmission circuits were included in the circuits from Honiara to these districts.

Besides, each item included in the attached scope of work was analyzed on the basis of the result of field survey and in particular, the following items were agreed upon between the survey team and the government of Solomon Islands.

The agreement is shown in Data Sheet No.3.

(1) Estimated traffic
(2) Allocation of transmission loss (draft)
(3) Interface
(4) Radio station building
(5) Power supply system
(6) Transmission performance
(7) Technical standards to be adopted
(8) Land use

1-3 Significance of the Project in Solomon Islands

Solomon Islands include many islands scattered over a wide sea area extending approximately 1,600 km from the east end to the west end, of which the six main islands are separated from each other in a distance of 80 to 100 km. Telephone is used in some districts but the rate of coverage is extremely low, which is approximately 9 per 1,000 of population and the communication network linking each island is very unsatisfactory, which is a stumbling block to the economic development of Solomon Islands.

The government of Solomon Islands regards this project as the first priority project in the Comprehensive National Development Program because the government expects that the completion of the project will contribute greatly to the development of politics, economy and culture in the country.

The study mission made a comparative study of various factors from technical and economic points of view to making the project match the actual situations in Solomon Islands and the desire of the inhabitant.

The project, when completed, is expected to play a major role in the stability of people's livelihood and the promotion of social and economic development in Solomon Islands, a new country which became independence from the British protectorate on July 7, 1978.

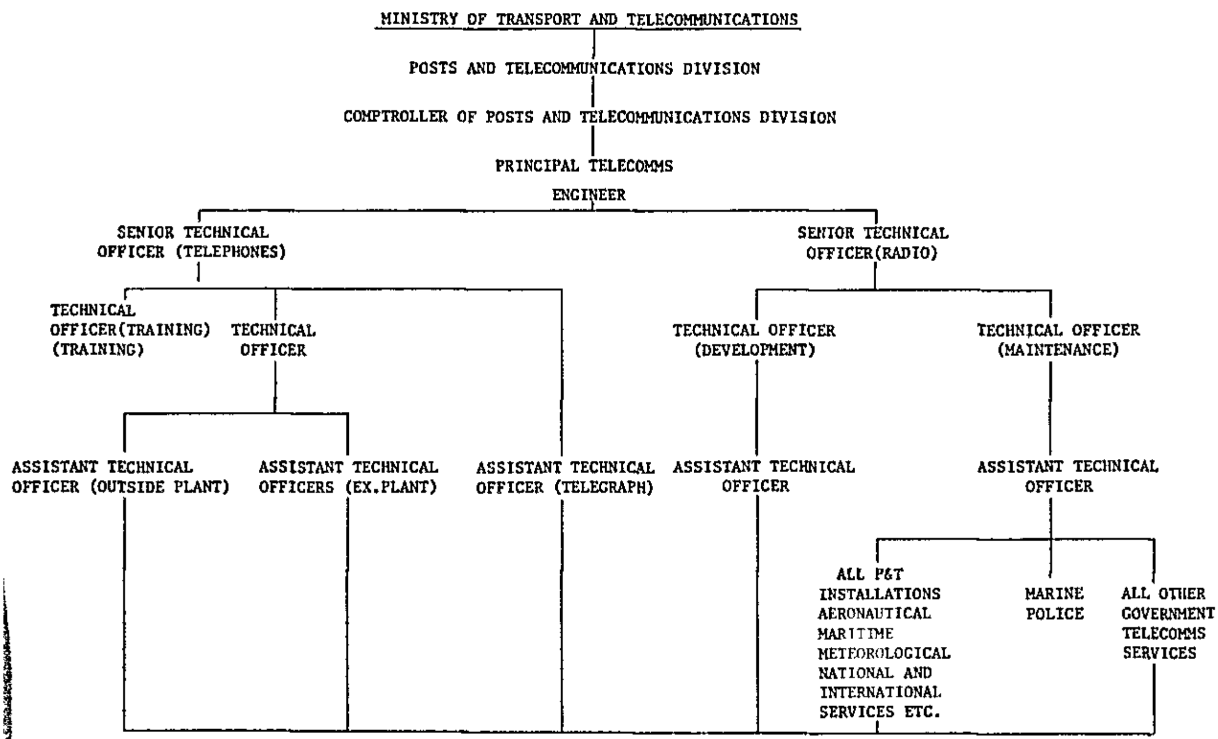
CHAPTER 2

OUTLINE OF EXISTING TELECOMMUNICATIONS SYSTEMS AND FUTURE PLANS

Chapter 2. Outline of Existing Telecommunications Systems and Future Plans

2-1 Management Structure of Telecommunication System

Telecommunication services in Solomon Islands are under the management of the Posts and Telecommunications Division of the Ministry of Transport and Communications. The management of various telecommunication systems is divided according to the following distribution of responsibility. The organization of the Posts and Telecommunications Division is shown in Fig. 2-1.



TECHNICAL STAFF

Figure 2-1 Organization of Poststand Telecommunications Division

(1) Management of domestic public communications (including communications with private radio stations) for telephone and telegraph, and aeronautical, maritime and meteorological communications and the responsibility for guidance, construction and maintenance of communication facilities and communication services for local governments, police and ocean-going ships are under the responsibility of the Posts and Telecommunications Division.

(2) Management of international public communications (telephone and telegraph) is under SOLTEL.

(3) Broadcasting (radio) is under the management of Solomon Islands Broadcasting Corporation (SIBC).

2-2 Domestic Telecommunication Services

2-2-1 Telephone Subscriber

In Solomon Islands, subscriber's telephone service is provided only in three cities of Honiara, Auki and Gizo. Each city is served by automatic exchanges of the step-by-step system. In Honiara, the number of subscribers is 800 and the number of telephone terminals is 1,200. In Auki and Gizo, the number of subscribers is 67 and 82, respectively.

2-2-2 Telephone Facilities Expansion Plan

In each area, the existing telephone facilities are not capable of meeting a new subscriber's demand. The growth of demand is especially remarkable in Honiara and the Posts and Telecommunication Division estimates the number of subscribers in 1980 at 1,800 or 1.5 times the present number. In order to cope with a new demand in the existing area and to introduce subscribers telephone service into areas which are not covered by telephone network at present, the Telephone Facilities Expansion Plan shown in Table 2-1 has been mapped out by the government.

Table 2-1 CONSTRUCTION PLAN FOR TELEPHONE FACILITIES IN SOLOMON ISLANDS

Name of place	Initial Stage		Ultimate Stage	Remarks
	Number of terminals	Number of circuits	Number of terminals	
Honiara	2,500	3,000	10,000	Replacement of an electronic switching system
(King George VI)	(400)	(500)	(500)	New satellite station of Honiara
Tenakaro	100	150	500	
Tulagi	100	150	500	
Gizo	150	200	500	Replacement
Auki	150	200	500	Replacement
Kira Kira	100	150	500	

2-2-3 Telephone Charging System

For telephone charge, the flat charging system is applied to local calls (the rate for business telephone in Honiara is 108 SI$ per annum, for example) and the rate for toll calls(between islands) is 90¢ for the first 3 minutes and 30¢ for each additional minute.

2-2-4 Radio communications

In Solomon Islands comprising many islands scattered over a wide sea area, radio communications are only means of communication between islands. Radio communications also play a very important role in communications within an island. In most areas except some sections like the Honiara-Auki section, telephone circuits of the SSB system using short waves only are in use at present. Accordingly, both the number of circuits and circuit performance are far from the satisfaction to users.

The composition of radio communications in Solomon Islands is based on the district communication system, by which the country is divided into four districts. As shown in Fig. 2-2, the country is divided into the central district around Honiara, the Malaita district around Auki, the western district around Gizo and the eastern district around Kirakira. Public telecommunications between islands are handled through the central station located in each of these districts. Within a district, small scale radio stations located in public facilities and radio stations provided by private enterprises are also in operation. The common frequency

(5,826 KHz) is operated on the time Sharing basis according to the schedule shown in Table 2-2. Transmitter power for radio equipment used by local government agencies and private enterprises are mainly 10W in capacity. Some of the post offices have a radio equipment provided with a hand operated generator. Prior to the operation of this type of radio equipment, the generator must be operated by hand to charge storage batteries. The local radio stations are not in a standby state and are operated only according to the schedule or when the need arises. It is difficult, therefore, to respond to the call from the other party all the time. Since this radio telephone uses shortwaves, the press-to-talk communication system, which uses one radiowave for transmission and receiving, is applied. Connection of the radio telephone with subscriber's station is done by Honiara operator who monitors speech and operates changeover switch to the sending speech and receiving speech on the radio telephone side.

Table 2-2 SCHEDULES FOR 5826 KHZ CIRCUIT RADIOTELEPHONE
HONIARA CONTROL ALL TIMES LOCAL

Hours	Station
07:30-07:45	VWR
07:45-08:15	Central District Station Including Roco and Tulagi
08:15-08:30	Buala/Gela Island
08:30-08:45	Yandina
08:45-09:00	Munda
09:00-09:30	Gizo/Tulagi/Sasape
09:30-10:00	Kira Kira
10:00-10:30	Santa Cruz
10:30-11:00	Yandina
11:00-11:15	Gizo/Tulagi/Sasape
11:15-11:30	Munda
11:30-11:45	Roviana, Roco and Liapari
11:45-13:00	Ringi Cove
13:00-13:30	Kira Kira
13:30-13:45	Yandina
13:45-14:00	Ringi Cove
14:00-14:30	Gizo/ Tulagi/Sasape
14:30-15:00	Santa Cruz
15:00-15:30	Munda
15:30-16:00	Buala/Gela Island
16:00-17:00	Ringi Cove
17:00-17:15	Roviana, Roco and Liapari
17:15-07:30	Honiara 5826 kHz Maintain Listening Watch (24 Hrs.)

R/T: Radio Telephone
W/T: Wireless Telegraph

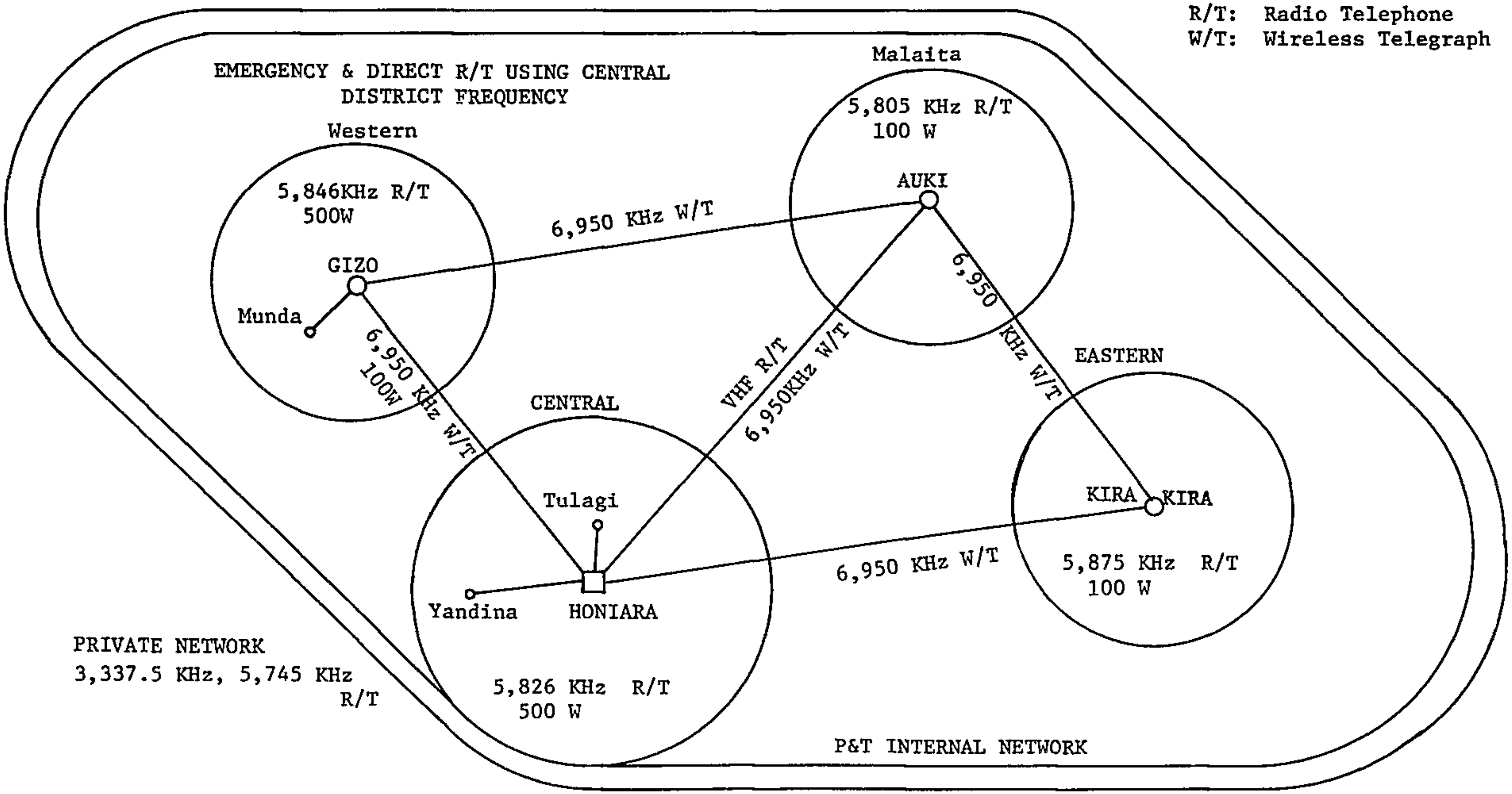


Figure 2-2 Internal Telecommunications Network in Solomon Islands

2-3 International Telecommunication Service

In the past, all international communications were processed by two-circuit direct trunk of shortwave established between Solomon Islands and Sydney (Australia). Lincompex was used for telephone circuit and an error correction device of ARQ was used for telegraph circuit to improve circuit performance. However, the system was not satisfactory for circuit performance, number of circuits and operating hours. At present, SOLTEL, a joint venture of government of Solomon Islands and C&W, provides international telephone, telegraph and telex services via an INTELSAT satellite over the Pacific Ocean. The earth station for satellite communications is located adjacent to the Ministry of Transport and Communications in Honiara and maintains facilities consisting of five telephone circuits of SCPC system and one telegraph and telex circuit. The service was inaugurated in December 1978 for telephone and in January for telegraph and telex.

2-4 Broadcasting Service

The Broadcasting service in Solomon Islands is managed by SIBC, and radio programs are broadcast from a transmitting station located near the Henderson International Airport in Guadalcanal by 10 KW medium wave transmitter and 10 KW shortwave transmitter. Radio broadcasting is also made in Gizo by 5 KW medium wave transmitter. Radio broadcasting is provided for 17 hours a day, starting at 5:30 A.M. and ending at 10:30 P.M. Programs include news programs of both foreign and home news, entertainment programs consisting mainly of music and educational programs. The home news is broadcast both in English and Pidgin English. Besides, personal message service is provided. The charge for personal message service is 3 SI$ per 30 words and the income from this service accounts for approximately 50 percent of the total income of SIBC. Since the service area is limited to the central district and the western district, a plan for construction of additional transmitting stations is being worked out as shown in Table 2-3.

Table 2-3 EXPANSSION PLAN FOR THE RADIO BROADCASTING NETWORK IN SOLOMON ISLANDS

Name of place	Discription of planning
Kira Kira	Establishment of 5 kW MF transmitter
Gizo	Establishment of a small studio
Auki	Establishment of a small studio and a program transmission link from Auki to Honiara
Santa Cruz	Establishment of 2 kW MF transmitter

2-5 Aeronautical Telecommunications Service

As shown in Fig. 2-3, the aeronautical telecommunication system in Solomon Islands connects Honiara with other airfields by short wave radio telephone system. The operation facilities in Honiara area located in Henderson International Airport and are used for communication with other airfields and aircraft. The facilities in Honiara also handle maritime and meteorological communications. Operation and maintenance of these aeronautical communications system are under the responsibility of the Posts and Telecommunication Division.

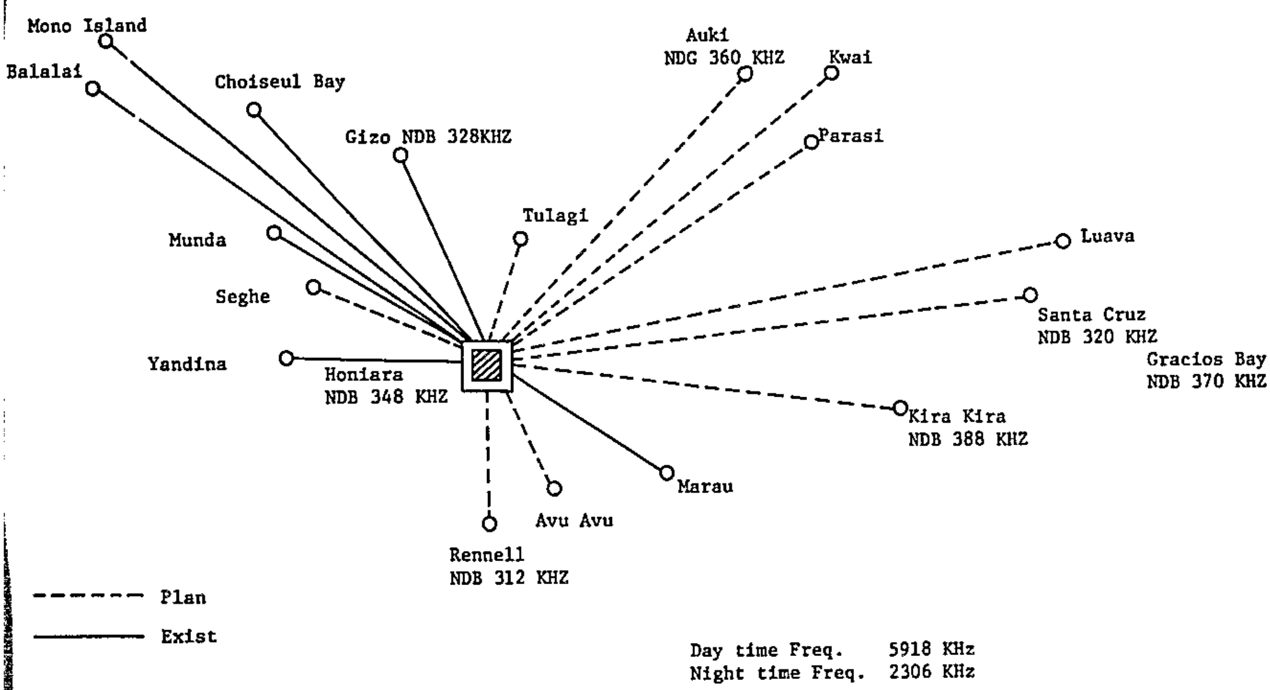


Figure 2-3 Aeronautical Telecommunications Network (Including NDB)

CHAPTER 3

BASIC PLAN FOR NATIONAL TELECOMMUNICATIONS NETWORK

Chapter 3 Basic Plan for National Telecommunications Netowrk

This chapter describes various technical standards and transmission capacities required for the study of the national telecommunications trunk network in Solomon Islands.

3-1 Composition of Telephone Network

3-1-1 Exchange office rank

For reasonable and systematic management of telecommunications of specified quality covering a vast service area like Solomon Islands, it is essential to define systematically the relationship between telephone exchanges. In Solomon Islands where the subscriber trunk dialing (STD) system is not applied to trunk calls and where the flat rate system is applied to trunk calls without regard to the distance, it is not absolutely necessary to clearly define exchange office ranks in this stage. However, when the automatic exchange is introduced for use on a nation-wide scale in the future, it will be necessary to clearly define exchange office ranks. In such a case, adoption of the three office rank system shown in Fig. 3-1 will be appropriate.

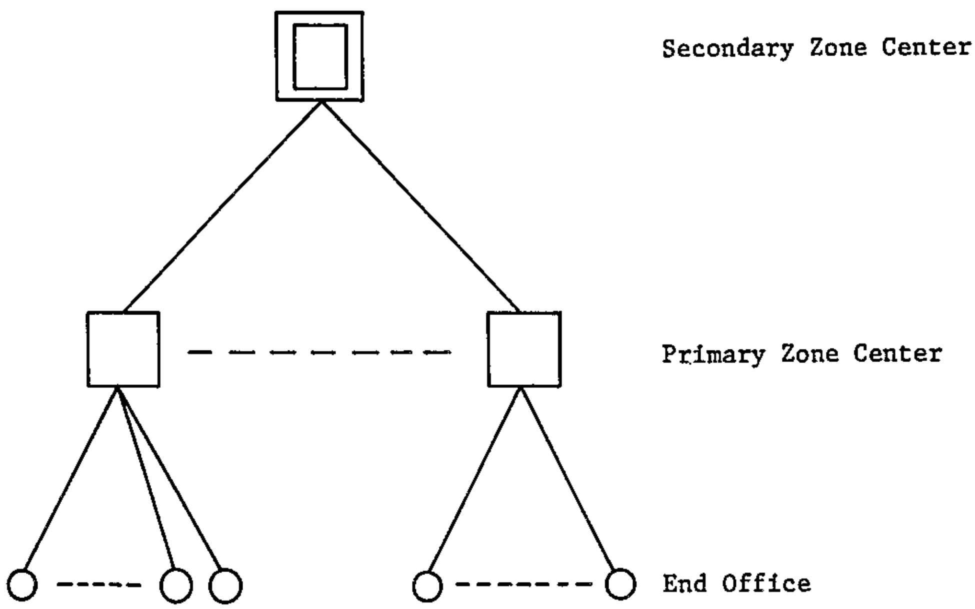


Figure 3-1 Exchange Office Rank

For the 26 areas where the government of Solomon Islands desires to provide telecommunications service, adoption of the office rank system shown in Table 3-1 will be appropriate.

Table 3-1 Office Ranks and Office Names

Secondary Zone Center	Primary Zone Center	End Office
Honiara	Honiara	Honiara
		Tenakaro
		Tulagi
		Buala
		Yandina
		Tetere
		Ruavatu
		Visale
		Tambea
		Marau
		Rennell
	Auki	Auki
		Malu'u
		Sulufou
		Kiu
		C.Hartig
	Gizo	Gizo
		Munda
		Noro
		Taro
		Sasamungga
		Mbarakoma
		Seghe
	Kirakira	Kirakira
		Santa Cruz
		Hadja

3-1-2 Composition of trunk circuit

The trunk circuit planned under the project is a multi-stage star shaped network centering around the capital city of Honiara as shown in Fig. 3-1. This is because most of trunk calls are assumed to concentrate in Honiara exchange or to be international calls.

3-1-3 Numbering plan

The national numbering plan of Solomon Islands is described below.

(1) Subscriber telephone number

According to the plan of P&T, the national universal numbering system will be adopted and all subscribers will be given five-digit numbers. Assignment of numbers to various districts is shown in Table 3-2.

Table 3-2 NATIONAL NUMBERS

(X is any digit 0 to 9)

	Number Group	No.of Numbers	Initial Exchanges	Possible Future Exchanges
Central District	2XXXX	10,000	Honiara Main	
	30XXX	1,000	Honiara Satellite	
	31XXX	1,000	Tenakaro	
	32XXX	1,000	Tulagi	
	33XXX	1,000		Rennell
	34XXX	1,000		Bellona
	35XXX	1,000		Buala
	36XXX	1,000		Kiu
	37XXX	1,000		Yandina
	38XXX	1,000		Marau
	39XXX			Unspecified
Malaita District	40XXX	1,000	Auki	
	41XXX	1,000		Malu'u
	42XXX	1,000		Maka
	43XXX			Unspecified (43XXX–49XXX)
	44XXX			
	45XXX			
	46XXX			
	47XXX			
	48XXX			
	49XXX			

	Number Group	No.of Numbers	Initial Exchanges	Possible Future Exchanges
Eastern District	50XXX	1,000	Kirakira	
	51XXX	1,000		Star Harbour
	52XXX	1,000		Hadja
	53XXX	1,000		Graciosa Bay
	54XXX			Unspecified
	55XXX			
	56XXX			
	57XXX			
	58XXX			
	59XXX			
Western District	60XXX	1,000	Gizo	
	61XXX	1,000		Noro
	62XXX	1,000		Munda
	63XXX	1,000		Simbe
	64XXX	1,000		Seghe
	65XXX	1,000		Mono
	66XXX	1,000		Nila
	67XXX	1,000		Taro
	68XXX	1,000		Sasamungga
	69XXX			Unspecified
Unallo-catted	7XXXX			
	8XXXX			
	9XXXX			

Though the number group assigned to each district does not necessarily correspond to telephone demand indicated, the district which is short in number groups will be given addition numbers of 7, 8, 9 in the unit of ten thousand.

Of the 26 areas where the government of Solomon Islands desires to cover by telephone network, rural areas have not yet been given any number group. It will be necessary to determine number groups for these areas by the time telephone service is inaugurated.

(2) Service codes

The service codes, application of which has already been determined, and the type of services to be provided are shown in Table 3-3. In the future, such services as time casting and weather forecast will be added.

Table 3-3 Service Codes Termination Plan

Code	Service	Exchange				
		Tenakaro	Tulagi	Auki	Kirakira	Gizo
100	Operator Assistance	Y	Y	Y	Y	Y
101	Operator Enquiries	Y	Y	Y	Y	Y
102	International Calls Via Operator (Booking)	Y	Y	Y	Y	Y
103	International Calls Via Operator (Demand)	Y	Y	Y	Y	Y
104	Fault Reporting	Y	X	X	X	X
105	Phonograms (National)	Y	Y	Y	Y	Y
106	Phonograms (International)	Y	Y	Y	Y	Y
108	Faultsmans Ring Back	X	X	X	X	X
109	Faultsmans Line	X	X	X	X	X
110	Radiotelephone Calls	Y	X	X	X	X
111	Emergency	Y	X	X	X	X

X = Terminated adjacent to local exchange

Y = Terminated in Honiara via trunk circuit

(3) Others

The prefix to be used at the time of inauguration of international subscriber dialing (ISD) will be "00". For abbreviated dialing of ISD, "OX" (X is any digit from 0 to 9) is being considered.

3-1-4 Charging system

The flat rate system is now applied to local calls in Solomon Islands. The trunk call charge is 30¢ per minute (minimum 90¢ per three minutes) regardless of the distance. This may be due to the fact that the existing exchange has no charging functions and that the trunk circuit in use now is a shortwave circuit.

However, the following plan is under study for adoption as a charging system in the future.

(1) Local call charge

For local calls, a rate of 6¢ per call is being considered but the inclusion of the time metering system is also being studied.

(2) Trunk call charge

For trunk calls, either the fixed time metering method or the periodical-pulse metering method is being considered. In any event, the zone charging system will be applied for calculation of telephone charges and service area is scheduled to be divided into the following 8 to 9 zones.

Central district	3 zones (or 4 zones)
Malaita district	1 zone
Eastern district	2 zones
Western district	2 zones

In the initial stage, however, this charging system will be applied only to four zones of Honiara, Auki, Gizo and Kirakira since automatic exchange service is restricted to 7 exchanges. For the initial stage, the trunk call charge plan shown in Table 3-4 is being considered.

Table 3-4 CHARGES FOR TRUNK CALLS

Between	Charge per Minute	No.of Seconds for 6¢ (Local Call Charge) if PPM is used
Zone 1* and Auki (zone)	18¢	20 secs
Zone 1* and Gizo (zone)	36¢	10 secs
Zone 1* and Kirakira (zone)	36¢	10 secs
Auki (zone) and Gizo (zone)	36¢	10 secs
Auki (zone) and Kirakira (zone)	36¢	10 secs
Gizo (zone) and Kirakira (zone)	48¢	7 1/2 secs
Within Zone 1* between:-		
Honiara/KG VI and Tenakaro	9¢	40 secs
Honiara/KG VI and Tulagi	12¢	30 secs
Tenakaro and Tulagi	12¢	30 secs

* Zone 1 comprises Honiara main exchange, King George VI satellite, and Tenakaro and Tulagi exchanges.

3-1-5 Telephone switching network plan

(1) Office ranks and switching functions

For the composition of a telephone switching network with office ranks as indicated in Fig. 3-1 (Section 3-1-1), the Primary Zone Center is required to have an exchange with toll outgoing and incoming call switching functions and the Secondary Zone Center is required to have an exchange with toll outgoing and incoming call switching functions and toll transit functions.

Shown in Fig. 3-1 is a configuration when a considerable number of local exchanges have been installed on a nation-wide scale. In Solomon Islands, three exchanges are presently equipped with automatic switches (local) and there is a plan to increase the number of automatic exchanges gradually to expand the coverage of telephone service. In the initial stage, therefore, the composition of telephone switching network is expected to be quite different from the one shown in Fig. 3-1.

(2) Exchange plan and switching network

According to the plan of the Solomon government, the number of automatic exchanges is scheduled to be increased from the Present 3 to 7 (one satellite office is included) by 1981 and to about 15 by the year 2006.

For this reason, construction of exchanges is not planned for many locations where the government of Solomon Islands desires to establish radio terminal stations under the "Telecommunications Trunk Network Plan", especially in the initial stage. Telephone services in areas where the construction of exchanges is not considered will be touched on at a later stage.

The following is a study of telephone switching network corresponding to the initial stage and the ultimate stage of the exchange construction plan.

(3) Telephone switching network in the initial stage

In the initial stage, seven exchanges are scheduled to be equipped with an automatic switch and the composition of telephone switching network with office ranks shown in Fig. 3-2 is considered.

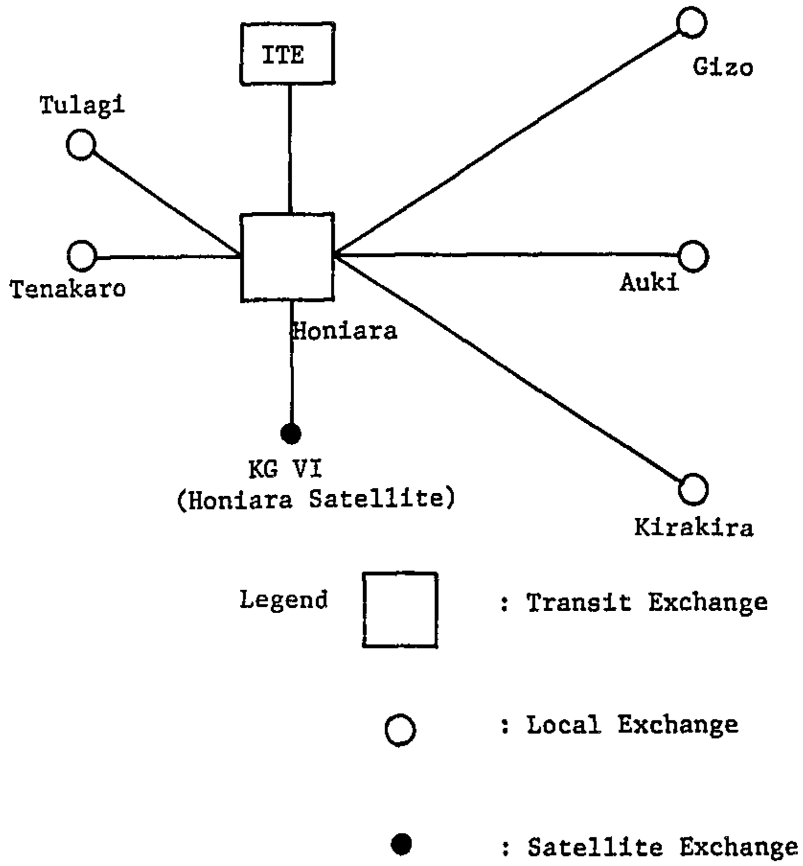


Figure 3-2 Trunk Network for the Initial Stage

Though the exchanges in Auki, Gizo and Kirakira are expected to play the role of a Zone Center in the future, they will be required to possess only the local exchange functions in this stage. All of the transit exchange functions will be possessed by the exchange in Honiara.

(4) Telephone switching network in the ultimate stage

With the increase of the number of automatic exchanges, the composition of trunk network is expected to shift to the 3 office rank network shown in Fig. 3-3. In this stage, all Zone Centers will be required to possess transit exchange functions.

P&T of the Solomon government has no plan to introduce 4W transit exchange for the time being. It will be necessary, therefore, for exchanges in Auki, Gizo and Kirakira to be equipped with transit exchange functions and to have circuits for international calls between them and ITE, separate from the circuits for national trunk calls as shown by wavy lines in Fig.

3-3, when the number of terminal stations in their respective zone centers has increased to more than two. This measure is required to satisfy CCITT's loss assignment standard (Recommendation G.121).

If a 4W transit exchange is intorudced to Honiara in the future, a combination of circuits for international calls and circuits for national trunk calls will be possible and in that event, the configuration of trunk network will be like the one shown in Fig. 3-3 without wavy lines.

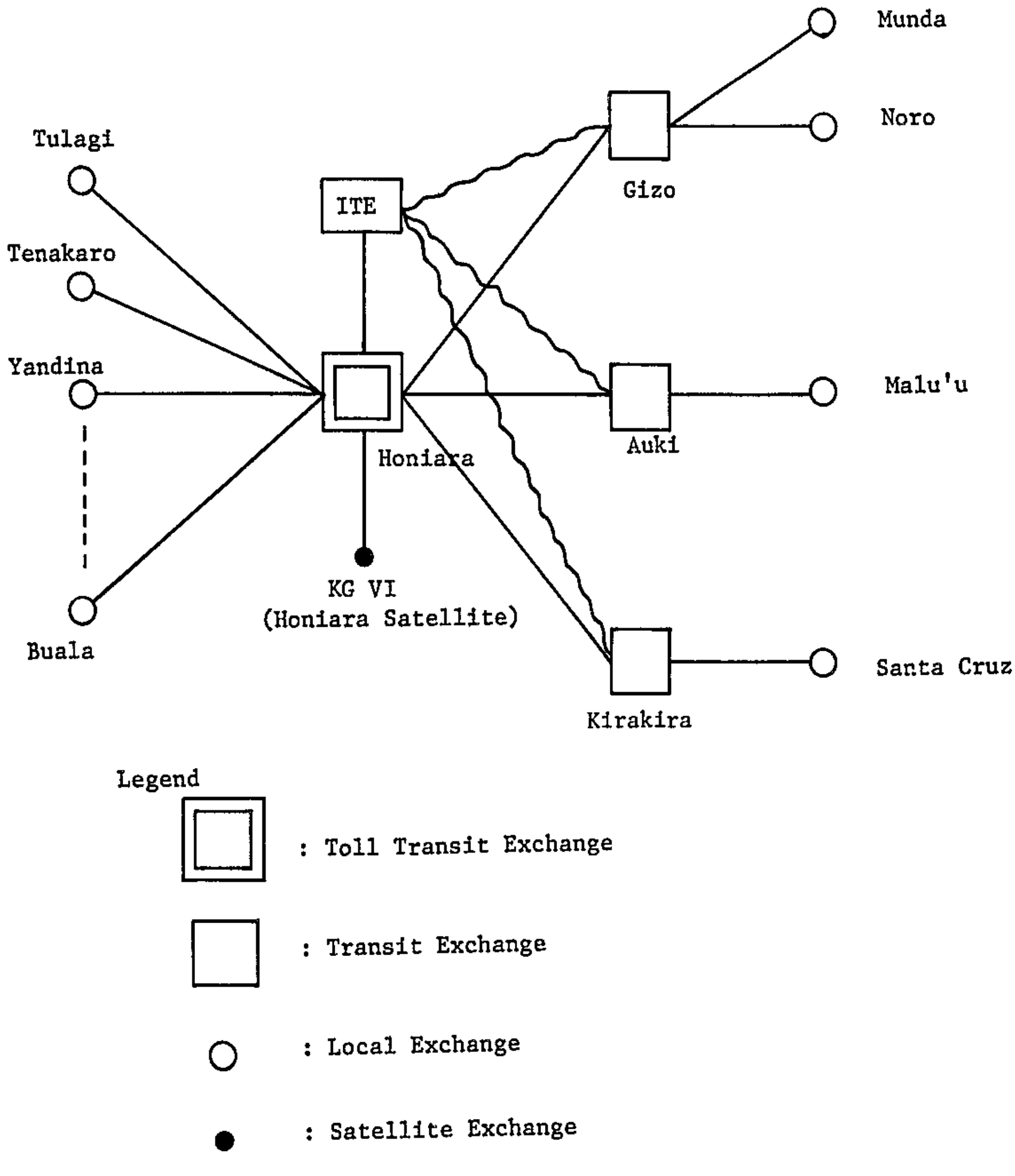


Figure 3-3 Trunk Network for the Ultimate Stage

3-1-6 Telephone service in rural area

The government of Solomon Islands desires to establish a telecommunications trunk network to cover all of the 26 areas of the country. However, many of these areas are not scheduled to be provided with a telephone exchange as mentioned previously. Limitati of telecommunications service in these areas to leased circuit servic may be expected, but the installation of ordinary telephone, which enables communications with many and unspecified persons, is more desirable as it increase the utility efficiency of the network.

Telephone service can be extended to these areas through accommodation of subscribers by nearby automatic exchanges or by automatic exchanges of high ranks in the toll zone as out-of-area subscribers. However, connection of subscriber lines with a remotely located exchange may pose such technical problems as transmission loss and signaling and also the cost increase because of the length of lines.

As a solution of such problems, a variety of rural areas telecommunications systems have been developed. In Solmon Islands, the important question is how to use effectively the trunk circuit of a limited capacity. To meet such requirement, the following systems, which are in wide use in many countries, may be considered.

<u>Concentrator</u>

This system is suitable to districts where telephone demand is more or less concentrated in specific areas.

In general, the number of subscribers which can be accommodated by this system is less than 100 (Fig. 3-4).

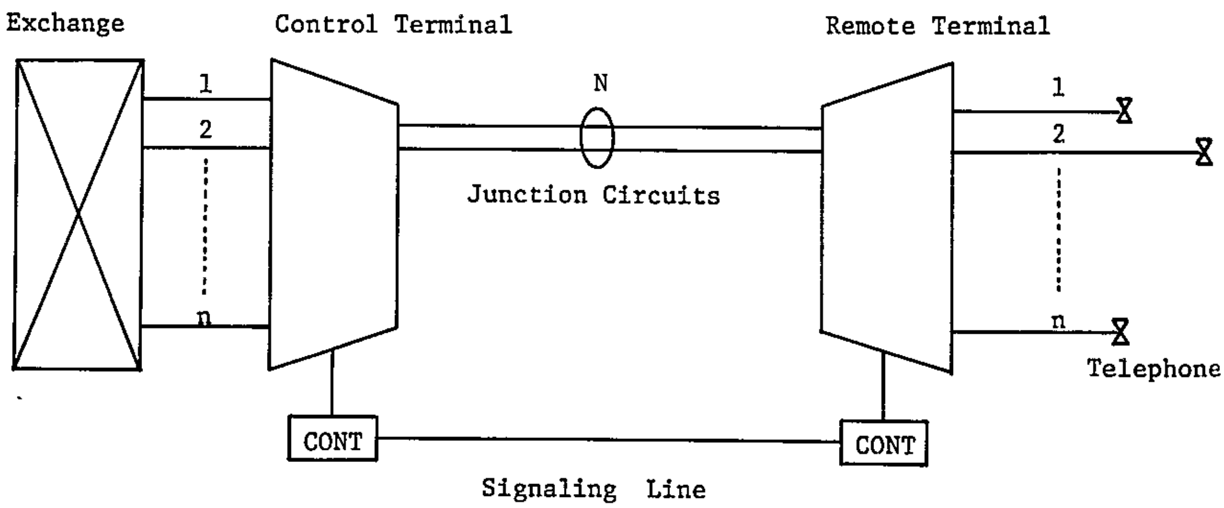


Figure 3-4 Typical Concentrator System

Rural Areas Radio Telephone System

This system is suitable to areas where telephone demand is distributed over a comparatively wide area and where construction of subscribers line is difficult because of lack of such facilities as roads or bridges. The number of subscribers which can be accommodated by this system is generally smaller than that by the concentrator (Fig. 3-5).

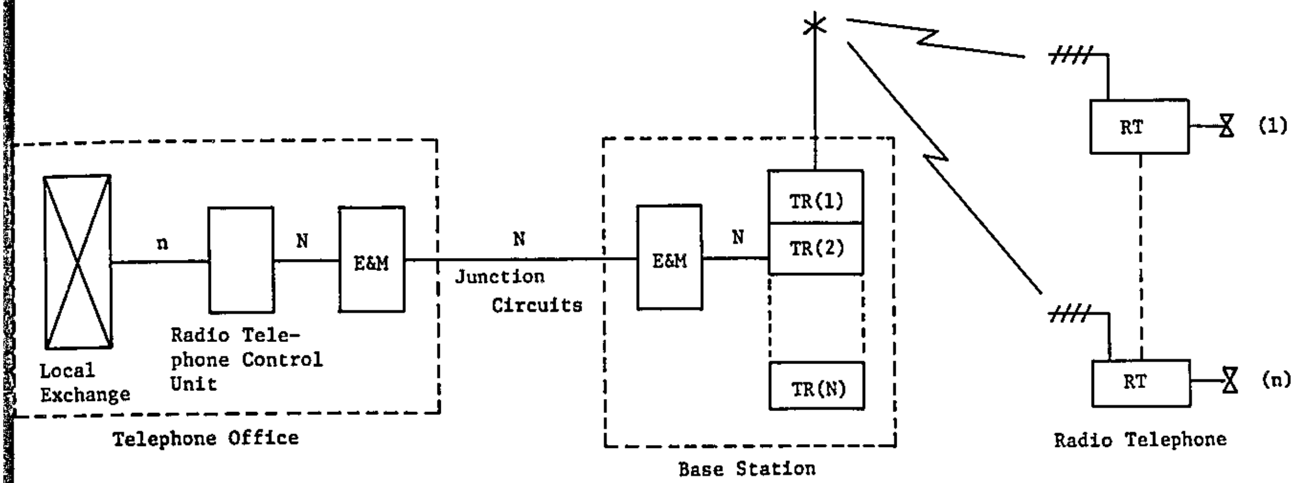


Figure 3-5 Typical Rural Radio Telephone System

In Solomon Islands where infrastructures are not adequately provided in many places and where a certain number of islands must be considered as one service area, application of the rural area radio telephone system may be advantageous in many cases.

A typical example of the effect of the system having these concentrating functions or the relationship between the number of subscribers and the number of junction circuits is shown in Fig.3-6. The effect is insignificant when the number of subscribers is very small but increases sharply from the point where the number of subscribers exceeds 5.

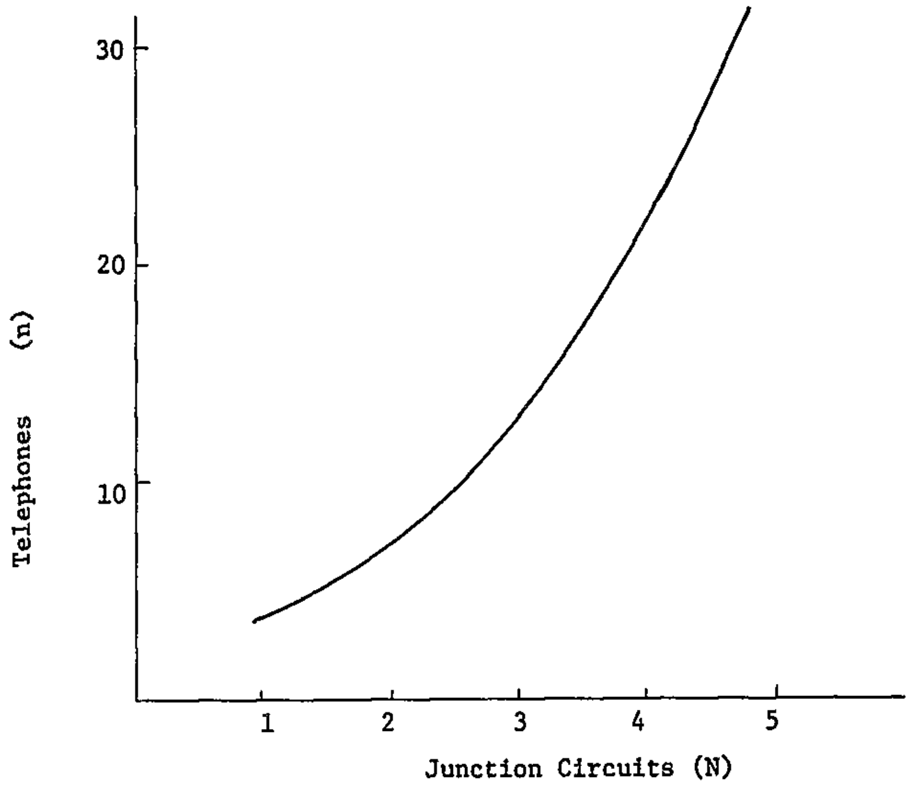


Figure 3-6 Junction Circuits versus Telephones

The composition of the trunk network when telephone service is expanded to 26 areas using the rural area radio telephone system and the concentrator corresponding to the initial stage and the ultimate stage of the telephone exchange plan is shown in Fig. 3-7 and Fig. 3-8, respectively.

In this study, however, the subscribers in rural areas are assumed to be accommodated by exchanges of higher ranks in the toll zone

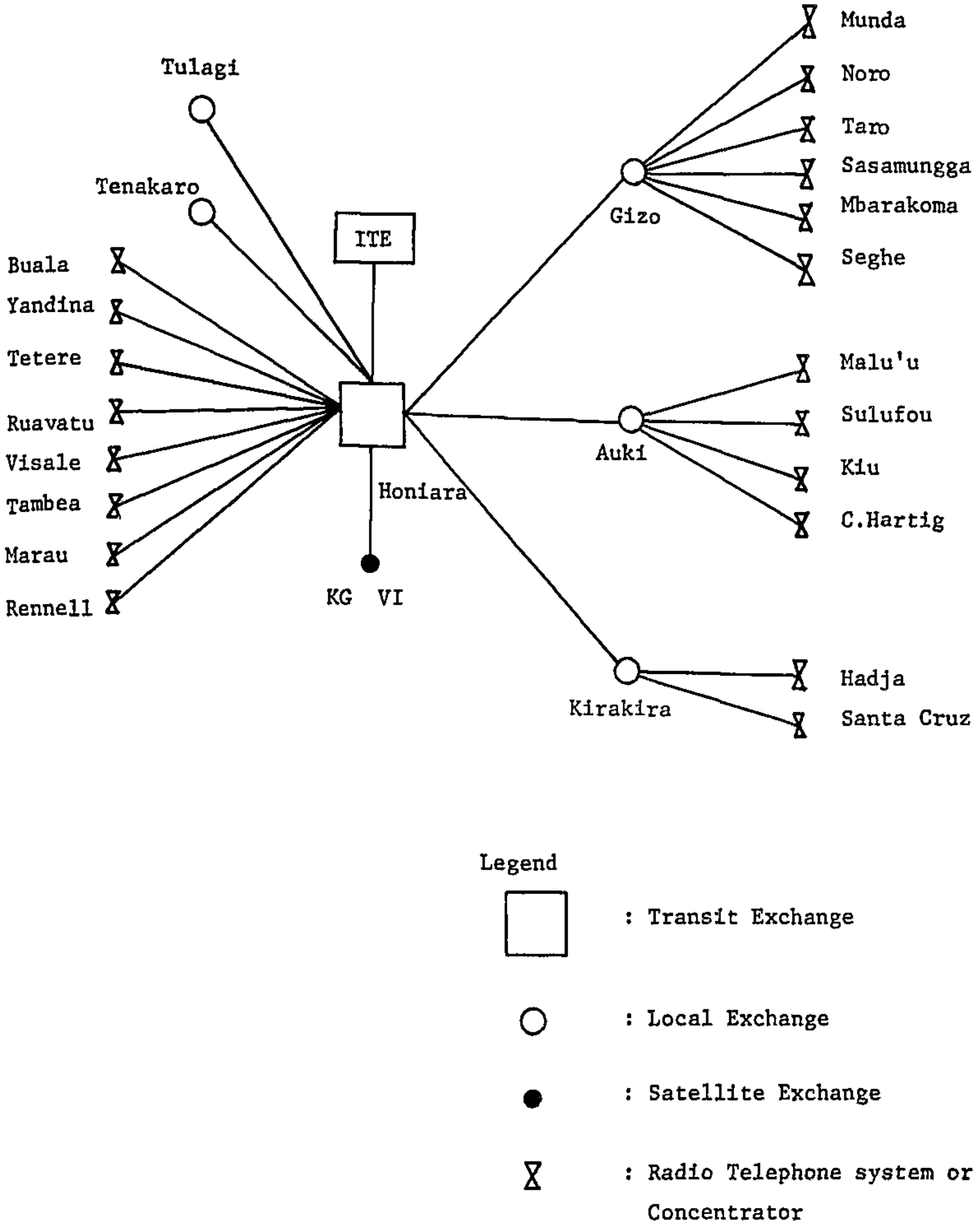


Figure 3-7 Telephone Network for the Initial Stage

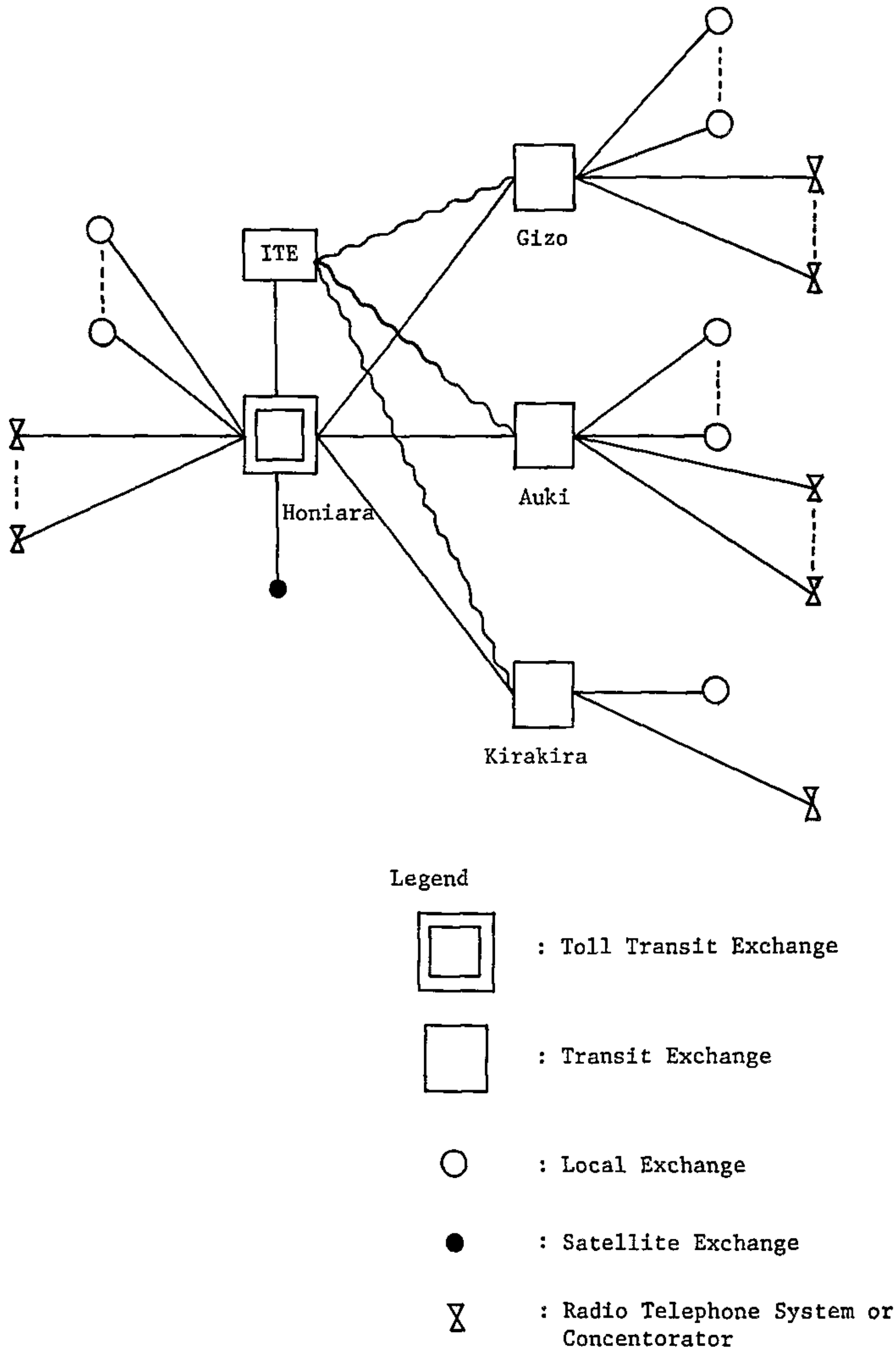


Figure 3-8 Telephone Network for the Ultimate Stage

3-1-7 Operator service

In Solomon Islands, all operator services are concentrated in Honiara. In other words, all operator assistance calls and operator enquiry calls are connected to the operator board in Honiara.

3-1-8 Request for international calls

All requests and enquiries for international calls are handled solely by the international operator position of SOLTEL in Honiara as in the case of operator service mentioned in the preceding seciton 3-1-7.

3-1-9 Handling of radio telephone

As a rule, connection of small scale radio stations at public institutions and private radio stations provided by industries with general telephone lines is provided through radio operators at each exchange.

3-1-10 Other services

All telegraphs are accepted by Honiara and acceptance of fault information and handling of other matters are the responsibility of each exchange as a rule.

3-2 Trunk Circuit Demand Forecast

In this section, an attempt will be made to estimate the number of trunk circuits to determine the transmission capacity, which is one of the most important factors for selection of the optimum transmission system.

Of course, estimation of the number of trunk circuits must be based on telephone demand forecast and traffic forecasting, both of which will also be discussed in this section to the extent necessary for demand forecast.

Time and duration of demand forecast must be determined according to the progress of the "Local Network Project" now under way and on the following condition.

(1) The scope of initial facilities must be determined according to the demand forecast for 1986.

(2) Demand forecast must be made up to the year 2006, the last year of the local network project, under the long term planning for use as a reference for selection of the optimum system. The following forecast is based on past experiences and present situations in Solomon Islands. In

general, unforeseen social and economic changes may not be available over a long period of time. It is important, therefore, to review the plan constantly and make necessary revisions and pay constant attention to the plan so that it will not depart from the reality as stated in CCITT manual "National Telephone Network for the Automatic Service".

3-2-1 Telephone demand forecast

Though a variety of methods are available for demand forecast, the following are generally used for demand forecast in the field of telecommunications.

(a) Historical extrapolation method
(b) Casual relation regression method
(c) Intuitive forecast method
(d) Normative forecast method

The telephone development stage may also be broken down into the initiating stage, expansion stage, popularization stage and popularized stage as shown in Table 3-5. It is important, therefore, to select a method for demand forecast matching the development stage.

Table 3-5 Telephone Development Stages

Initiating Stage	In this stage, telephone is provided in military establishments, police and government agencies for the purpose of communication and liaison mainly in military and political fields. Telephone demand forecase using a model formula is almost useless in this stage and counting of the number of agencies requiring telephone service or determination of the number of telephone lines from a political point of view is more practical.

Primary Expansion Stage	In general, the convenience of telephone in business sector is beginning to be recognized but the need for household telephone is not recognized so greatly. Telephone density is very low but the convenience of telephone is recognized gradually in proportion to the increase of telephone installed. By time series, the number of telephone subscribers often shows a tendency of increasing in geometical progression.
Latter Expansion Stage	The convenience of household telephone is widely recognized and demand for houshold telephone increases sharply. This stages covers a period from the time when the demand for household telephone comes close to the demand to the time when a majority of households are provided with telephone. By time series, there is a possibility of demand generation for exceeding the geometical progression. In this stage, it is desirable to make separate demand forecast for business telephone and household telephone.
Populariza-tion Stage	Business telephone has been diffused sufficiently and most of additional installations are for household telephone. Generation of stable demands is expected until a majority of housholds are provided with telephone.
Popularized Stage	Both business telephone and household telephone have been diffused sufficiently as a whole. Even in this stage, telephone demand for new business establishments or households can be expected. However, the sales effort on the part of telephone enterprise to develop a new demand, through introduction of new systems which make telephone more convenient to use and a new type of services, is indispensable for the growth of the business.

Demand forecast must also consider the fact that development stage differs from one district to another in the same country.

In the following, an attempt will be made for macroscopic demand forecast for the entire country and microscopic demand forecast by area.

(1) Macroscopic telephone demand forecast

1) Macroscopic demand model

In Solomon Islands, many areas are without telephone but major cities are provided with automatic telephone service which is scheduled to be expanded in the near future. It may be said, therefore, that the country as a whole is now in the expansion stage of telephone service.

As a methodology for macroscopic demand forecast for such a stage, CCITT, GAS/5 manual recommends three methods, namely, the historical extrapolation method, the regression method by GDP, which is a regression from casual relations with economic indicators, and the regression method by GP-Ratio.

For Solomon Islands where statistics data are very scarce an attempt will be made to forecast telephone demand from the correlation between GDP and telephone density, the method widely used for such a condition.

Shown in Fig.3-9 is the correlation between telephone density per 100 population and GDP (US$) per capita based on the data obtained from various countries. The correlation between the two can be determined using the method of least squares as follows.

$$\log q = -2.95 + 1.25 \log X$$

where q : Telephone density per 100 population

X : GDP (US$) per capita

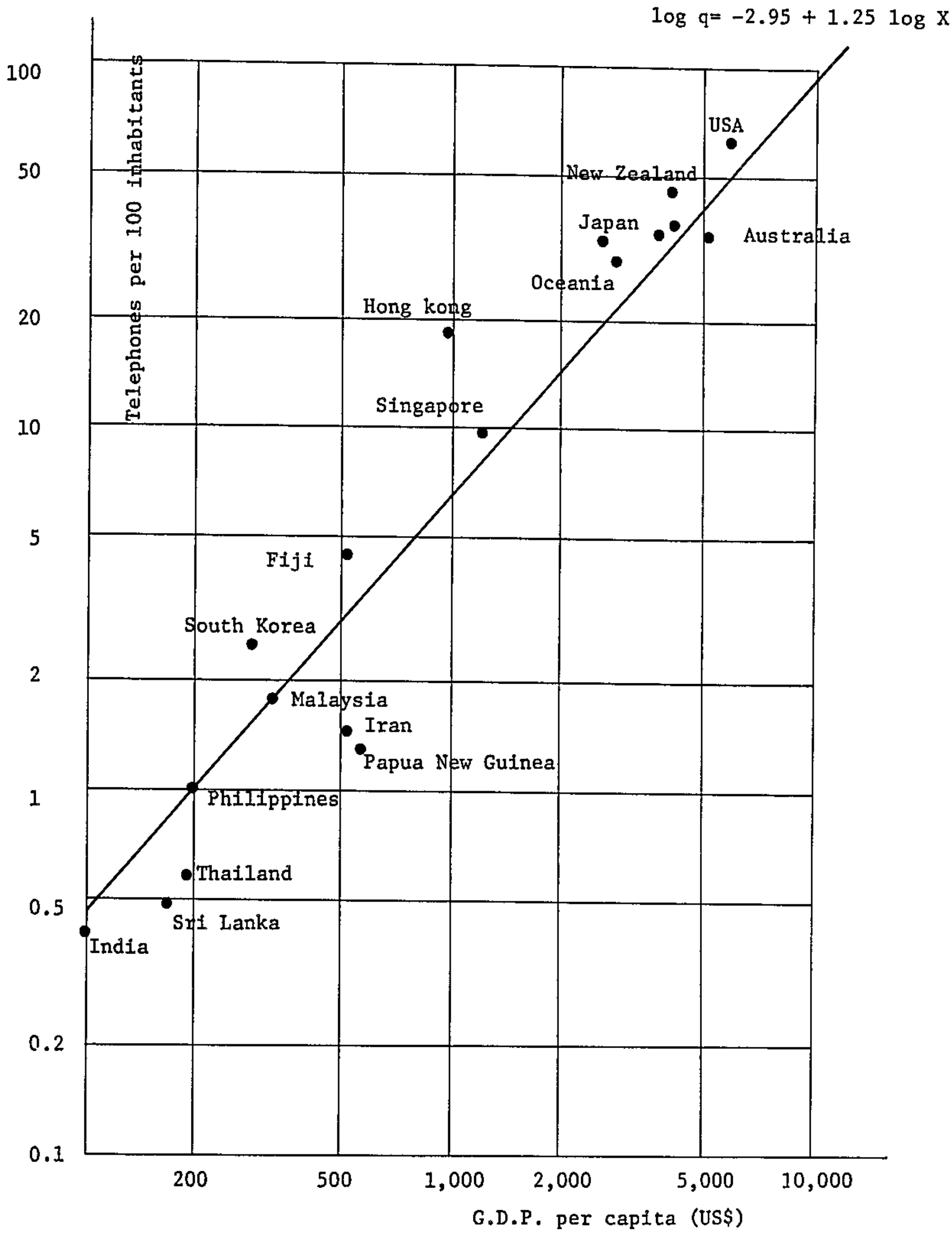


Figure 3-9 Correlation between Telephone Density and G.D.P. per capita, year 1973

2) Estimation of GDP

The telecommunications network is one of the foundations of national economy and its development in harmony with the development of national power is most desirable. In this sense, the report attemps to forecast the development of telecommunications in correlation with economic indicators. For this purpose, it is essential to estimate the future economic size of the country in some sectors. If the government has made public an economic outlook for 15 to 20 years ahead, it must be followed naturally but the estimate of GDP in this instance is based on the following. It must be pointed out, however, that the estimate is only for planning of the telecommunications network and that the plan should be reviewed for necessary revisions if and when a long-term economic plan is announced by the government.

As shown in Table 3-6, the GDP per capita in Solomon Island is SI$186 in 1973 and SI$210 in 1977 (at 1973 price) with an average annual growth of about 3 percent. The growth rate of GDP in other countries excluding oil producing countries is shown in Table 3-7, in which case the average annual growth rate is about 4 percent. Though the economy of Solomon Islands is expected to grow at a higher rate in the future with the improvement of infrastructures, the average annual growth of GDP per capita is estimated to be in a range of 3 to 5 percent because of a relatively high population increase rate of the country.

The estimated GDP per capita in the future under the assumption of growth rates of 3, 4 and 5 percent is shown in Fig. 3-10.

Table 3-6 Estimated Gross Domestic Product at Current Prices
1973 - 1977 (SI$000)

Category	1973	1974	1975	1976	1977
(a) Monetary Sector					
1. Wages & Salaries					
Expatriates	3290	4592	4813	5623	6000
Solomon Islanders	5746	6541	8054	10906	11700
Sub-Total	9036	11133	12867	16529	17700
2. Operating Surplus					
Business	2524	6611	3209	5212	7696
Government	146	152	133	547	746
Households	1108	3955	1516	1380	2770
Sub-Total	3778	10718	4858	7139	11212
Incomes (Monetary) at factor cost (1 + 2)	12814	21851	17725	23668	28912
3. Depreciation	3213	3996	4622	5216	6172
GDP (Monetary)at factor cost (1 + 2 + 3)	16027	25847	22347	28884	35084
4. Indirect Taxes less subsidies	2378	4121	3430	4000	5408
GDP (Monetary)at market prices (1 + 2 + 3 + 4)	18405	29968	25777	32884	40492
(b) Non Monetary Sector					
5. Gross subsistence product	17210	21100	23625	26078	29600
(c) All Sectors					
GDP at factor cost (1 + 2 + 3 + 5)	33237	46947	45972	54962	64684
GDP at market prices (1 to 5)	35615	51068	49402	58962	70092
GDP at factor cost ($ per head) (Current Prices)	186	254	242	275	308
GDP at factor cost ($ per head) 1973 constant prices	186	209	195	214	210

Table 3-7 Gross Domestic Product Growth by Country

Countries	Growth rate (1975/1970x100)
Israel	122
Indonesia	128
Korea	149
Sri Lanka	113
Thailand	119
Turkey	128
Burma	116
Argentina	112
Colombia	118
Norway	120
Hungary	134
Finland	119
Poland	153
Kenya	104
U.S.S.R.	126
U.S.A.	107
Average	123
Growth rate 1975/1970 pa (%)	4

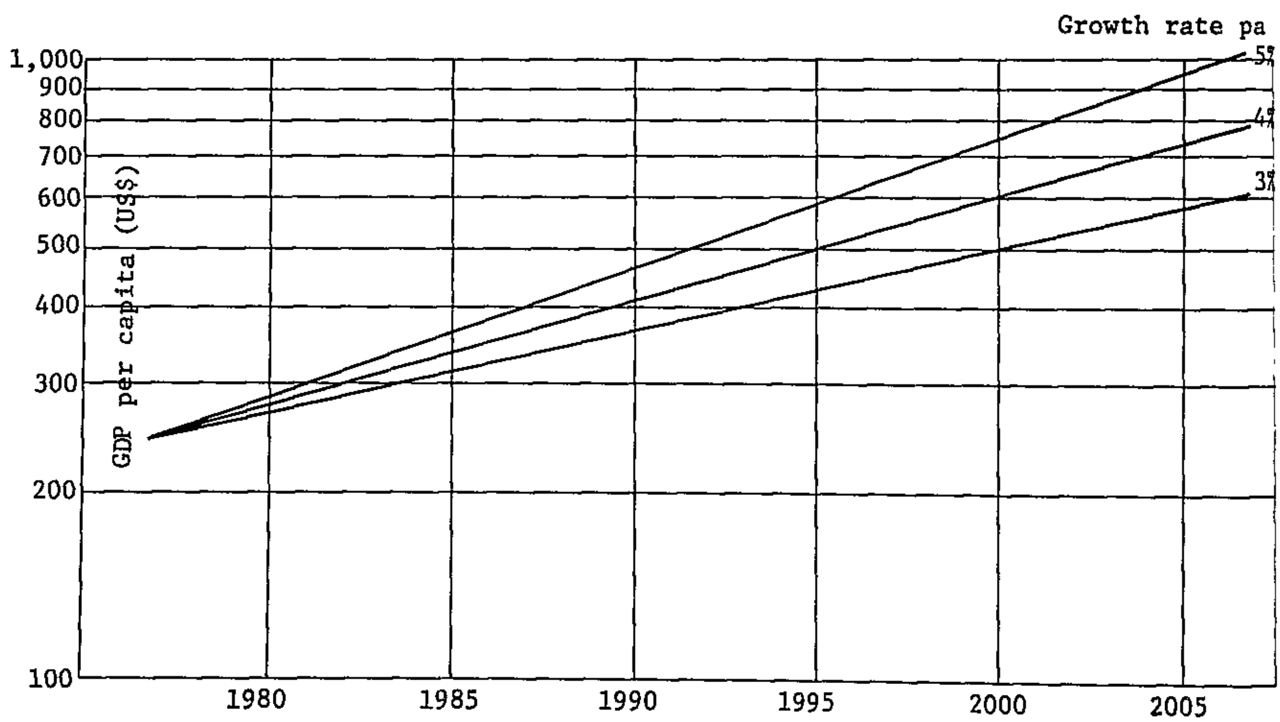


Figure 3-10 Forecast of Gross Domestic Product per capita (US$)

3) Population forecast

The population at the 1970 and 1976 censuses is shown in Table 3-8. The average annual population growth during the period between the two censuses is at a very high rate of 3.4 percent. This rate is extremely high as compared with the rate of other neighbouring countries (Table 3-9). The population by age group at the 1976 census is shown in Fig. 3-11. Since the census shows a sharp increase of younger generations of the age under 19, the tendency of comparatively high population growth is expected to continue for some time. In the meantime, the government of Solomon Islands is taking such measures as family planning to curb population increase for balanced economic development of the country. The target of the government for population growth is 3.1 percent and the population in 1997 forecast by the government is approximately 400,000.

The population forecast by year on the basis of the above data is shown in Fig. 3-11.

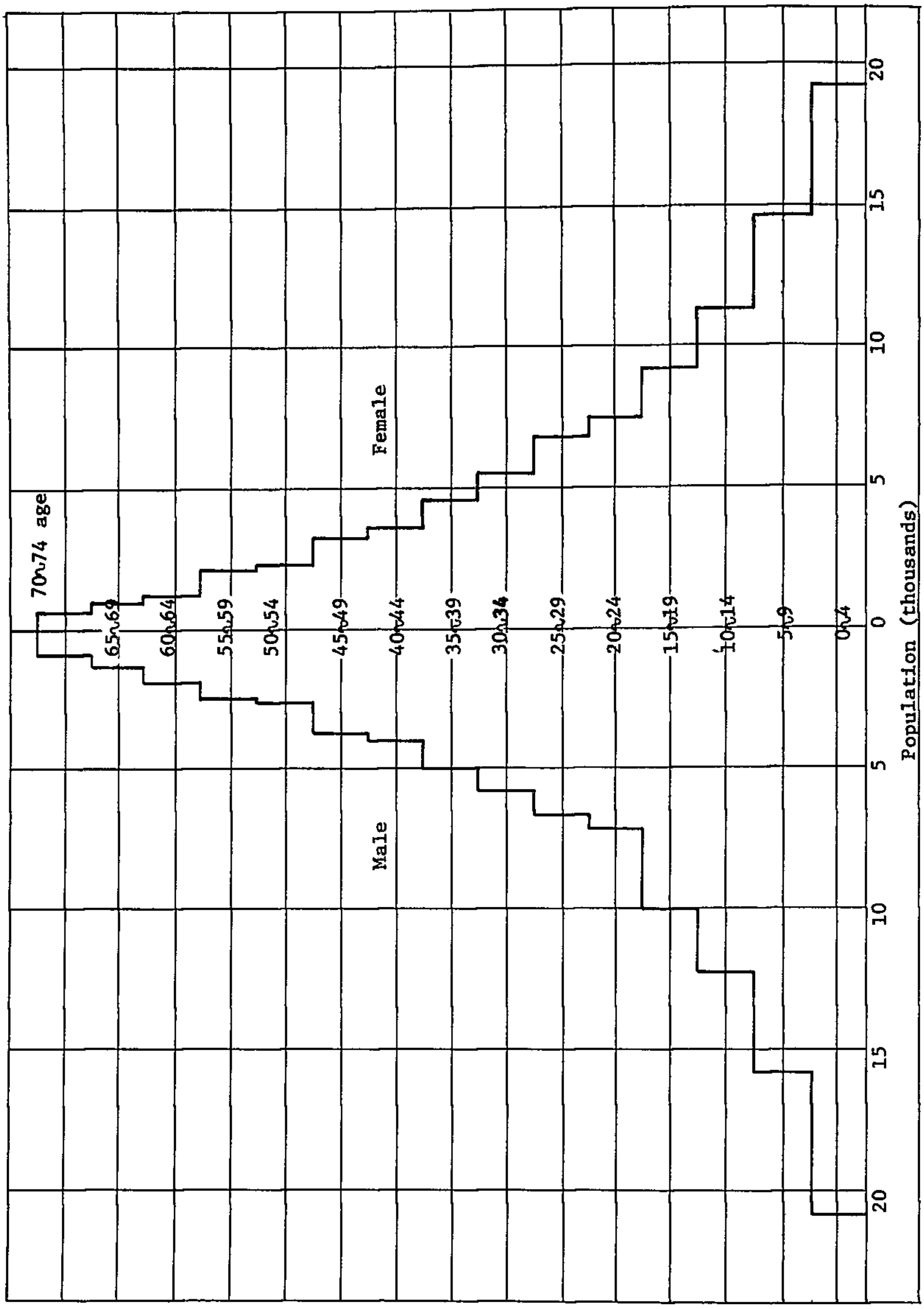
Table 3-8 POPULATION AT THE 1970-1976 CENSUS

Council Area	1970	1976
Western	32231	40329
Santa Isabel	8653	10420
Central Islands	10922	13576
Guadalcanal	23996	31677
Honiara	11191	14942
Malaita	51722	60043
Makira/Ulawa	12390	14891
Eastern Islands	9078	10945
Ships*	815	-
Total Solomon Is.	160998	196823
% Growth Rate 1976/1970 pa		3.4

* in the 1970 Census 815 persons were enumerated as on board ships

Table 3-9 Population Growth in Neighboring Countries 1973/1970 pa (%)

Australia	1.6
New Zealand	1.8
Fiji	1.9
Western Samoa	2.3
Tonga	2.8
Papua New Guinea	3.2
Indonesia	2.1
Philippines	2.9



70∼74 age
65∼69
60∼64
55∼59
50∼54
45∼49
40∼44
35∼39
30∼34
25∼29
20∼24
15∼19
10∼14
5∼9
0∼4
Female
Male
20
15
10
5
0
5
10
15
20
Population (thousands)

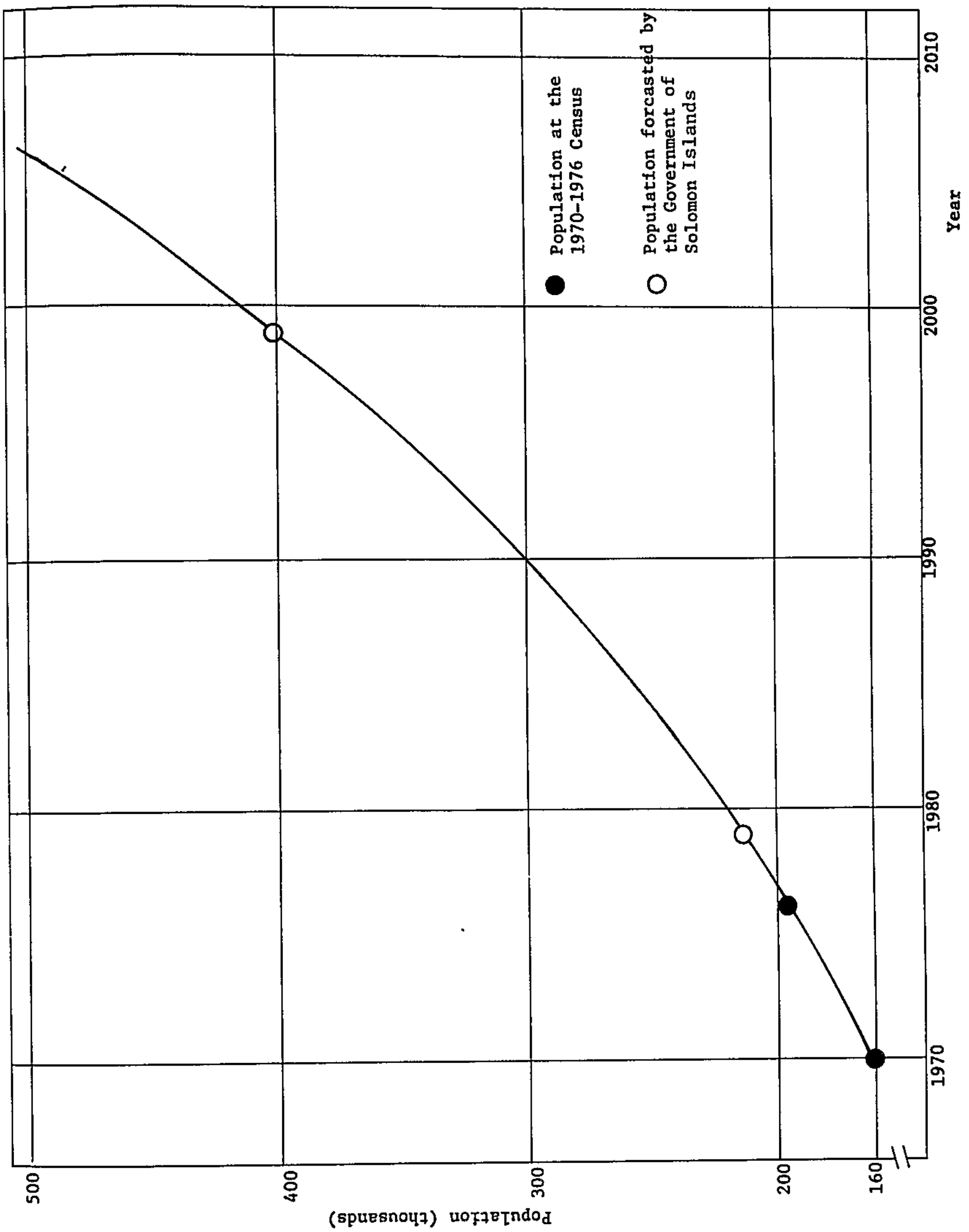


Figure 3-12 Forecast of Population

4) Telephone demand forecast

The telephone density shown in Fig. 3-13 can be estimated from a macroscopic demand model and GDP per capita. The telephone demand calculated from the population forecast is shown in Fig. 3-14.

From these forecast, the number of subscribers, now totaling one thousand and several hundred, is expected to increase to 15,000 to 20,000 in the next 20 to 25 years.

For local network, on the other hand, a project is already under way in accordance with Table 3-10. It may be said that two estimates almost coincide each other.

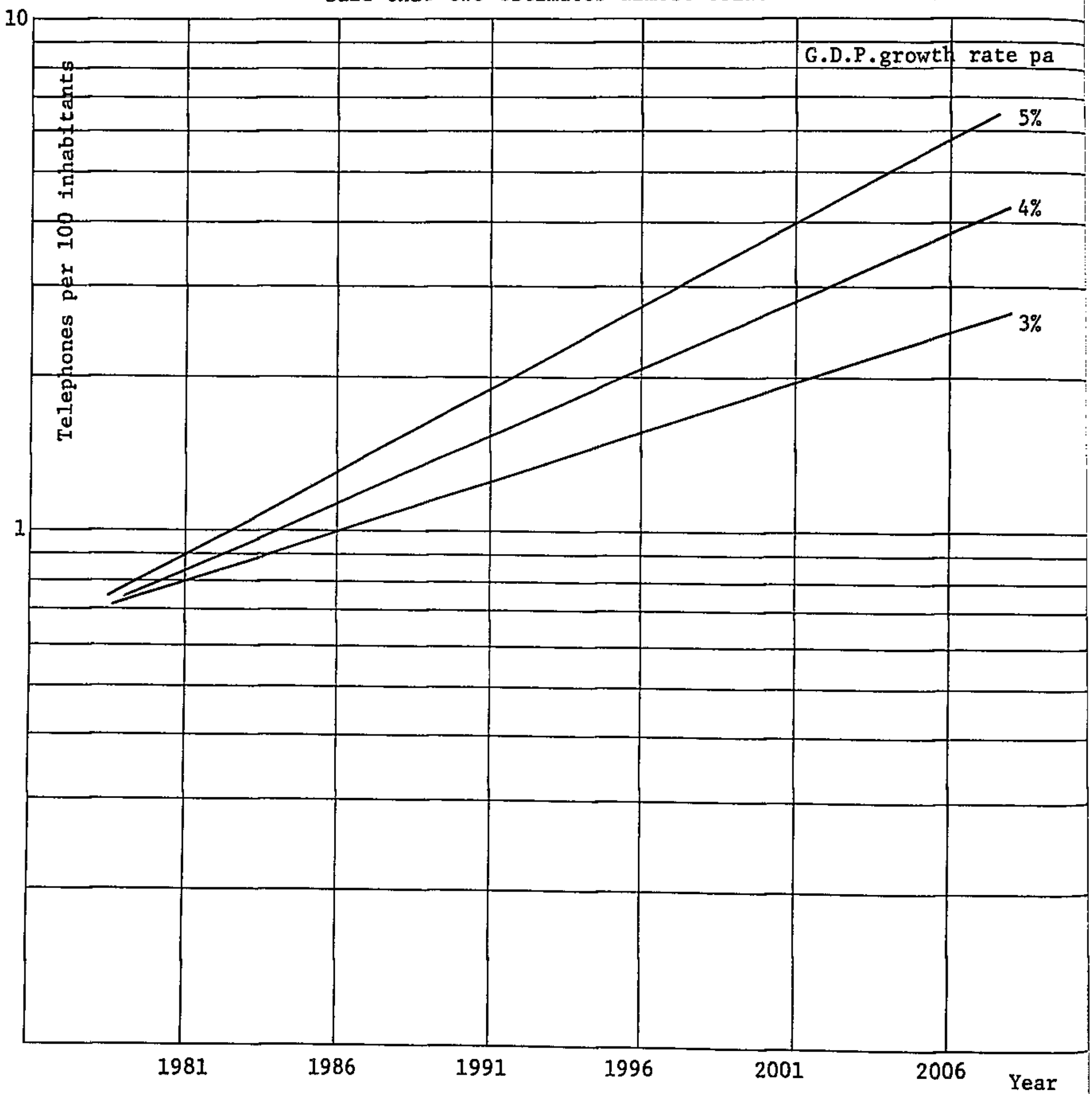


Figure 3-13 Telephone Density in Solomon Islands

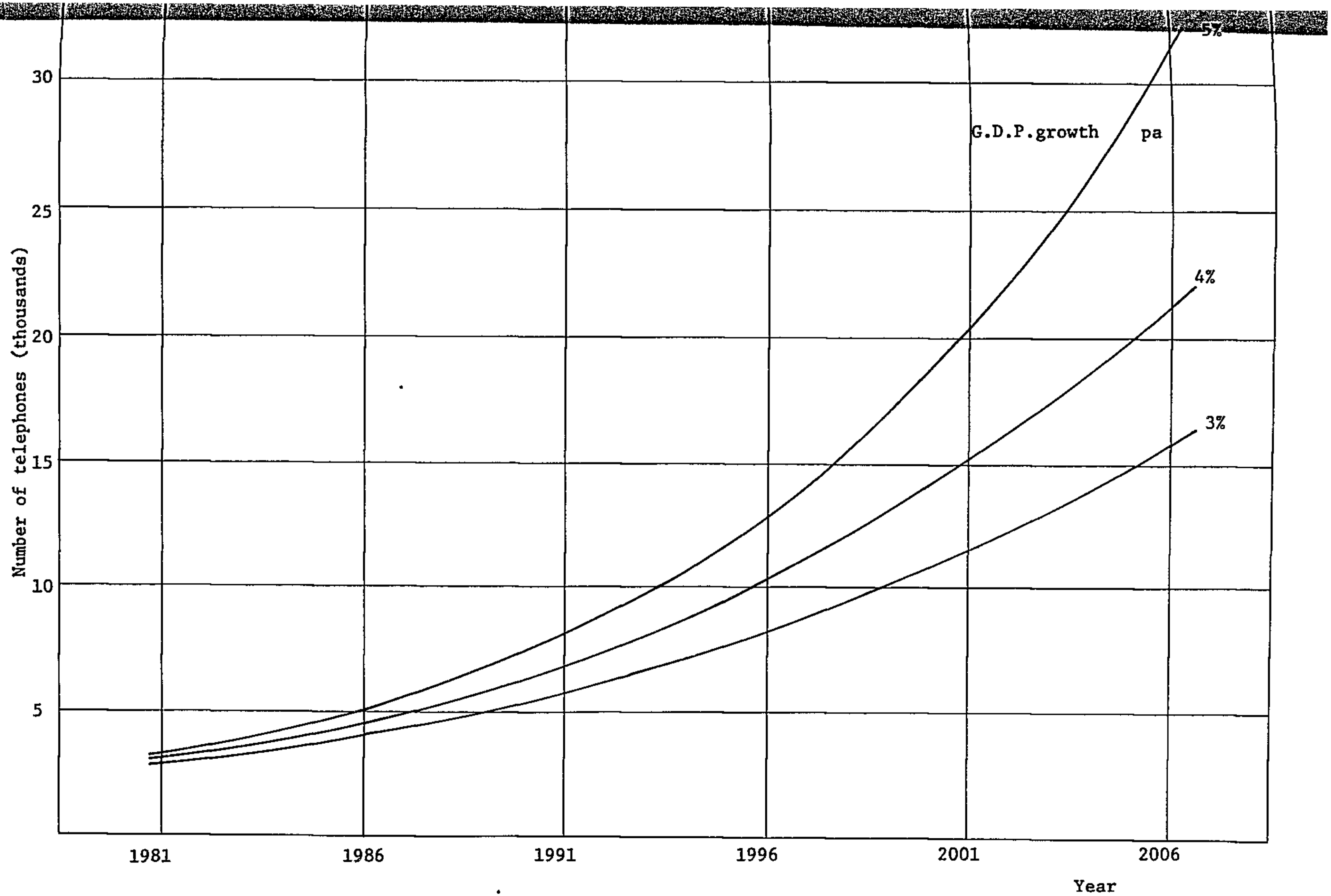


Figure 3-14 Foecast of Telephone Demand

Table 3-10 Summary of Forecasts of Exchange Lines and Stations and Exchange Capacities

MID-YEAR	HONIARA MAIN	HONIARA SATELLITE	AUKI	GIZO	KIRAKIRA	TULAGI	TENAKARO	OTHER	TOTAL
Working Lines in - 1981	1320	105	95	105	30	30	30		(7) 1715
1986	1900	170	150	165	50	50	40		(7) 2525
1991	2740	275	230	260	75	75	50	(2) 45	(9) 3750
1996	3930	440	340	380	110	110	65	(4) 105	(11) 5480
2001	5650	675	475	530	155	155	80	(6) 180	(13) 7900
2006	8150	1000	640	710	205	205	100	(8) 280	(15) 11290
Working Stations in - 1981	2520	190	140	155	45	45	45		(7) 3140
1986	3020	300	225	250	70	70	60		(7) 4595
1991	5200	475	350	390	110	110	75	(2) 70	(9) 6780
1996	7470	750	510	570	165	165	95	(4) 160	(11) 9885
2001	10750	1150	715	800	230	230	120	(6) 270	(13) 14265
2006	15500	1700	960	1070	310	310	150	(8) 420	(15) 20420
Nominal Exchange Capacities (in Lines) Required up to - 1986	2400	200	150/200	200	50	50	50		(7)3100/3150
1991	3000	300	250	300	100	100	50	2x50	(9) 4200
1996	4200	500	400	400	150	150	100	4x50	(11) 6100
2001	6000	800	500	600	200	200	100	6x50	(13) 8700
2006	10000	1200	1000	1000	250	250	150	8x50	(15) 14250

It is needless to say that the planning of trunk network must be based on the telephone development plan for local network. For districts where the project has already become definite under the local network plan now in progress, the trunk circuit should be planned on the basis of such a project.

5) Telephone demand forecast by area

For the seven exchanges in six areas where the project under the local network plan is already in progress, a telephone demand forecast has already been made by the government of Solomon Islands as shown in Table 3-10. For other areas, as

Table 3-11 Telephone Demand in Rural Area

	1986	2006	
Visale Tambea Ruavatu Marau Sulufou Kiu C.Hartig Mbarakoma Taro Sasamungga Seghe Hadja	Around 5 subscribers	Less than 20 subscribers	Local exchange will not be introduced until the year 2006
Buala Rennell Malu'u Santa Cruz	Around 10 subscribers	0∿50 subscribers	Local exchange will be introduced by the year 2006
Tetere Yandina Munda Noro	More than 10 subscribers	50∿100 subscribers	Local exchange will be introduced in comparatively early stages

shown in Table 3-11, many of which are not provided with telephone service and which are considered to be in the initiating stage of telephone development, a telephone demand forecast using a model formula is considered almost useless.

Accordingly, telephone demand in these areas in the initial stage was estimated from the number of government offices and private enterprises, which are assumed to be provided with telephone service and then the demand increase trend, which is similar to the macroscopic demand forecast, was assumed for the subsequent stage. This forecast, however, was made on the assumption that no major changes would take place in such main industries as agriculture and fisheries in any of these rural areas in the future. However, it is quite probable that these rural areas will undergo a major change in the future because of their potentialities for development of the tourism industry and other manufacturing industries. Such industrial developments have a major effect on the planning of telecommunications network. It is essential, therefor, to pay constant attention to the movement of industries and review the long-term planning for necessary revisions.

3-2-2 Forecast of toll traffic

The traffic between the seven exchanges in six areas, where the project under the local network plan is in progress, has already been forecast as shown in Table 3-12.

For rural areas, the traffic was estimated from the previously mentioned telephone demand forecast as shown in Table 3-13.

Table 3-12 (1) Honiara Automatic Exchange Incoming Traffic (Erlangs)

	MID-YEAR TRAFFIC		
	1981	1986	2006
1. Honiara Subscribers	108.57	163.57	852.81
2. Honiara Satellite Exch (King George VI)	7.98	13.35	92.82
3. Other Exchanges:-			
3.1 Tenakaro	1.40	1.85	4.04
3.2 Auki	3.94	6.20	16.63
3.3 Tulagi	1.25	2.07	8.12
3.4 Gizo	3.86	5.91	15.46
3.5 Kirakira	1.25	2.07	8.12
3.6 Other (Unnamed)	-	-	11.52
4. HF Radio (from Radio Operator - included in 1 above)	(2.07)	(2.30)	(3.41)
5. VHF Radio (from Radio Operator - included in 1 above)	(0.49)	(0.86)	(6.83)
6. International (from SOLTEL)			
6.1 Manual to Auto	2.71	1.23	5.55
6.2 Auto to Auto	1.92	4.55	30.78
7. From Automanual Switchboard	1.48	2.23	11.20
Totals-Incoming switched traffic	134.36	203.03	1057.05

Table 3-12 (2) Honiara Automatic Exchange (continued)
Outgoing Traffic (Erlangs)

	MID-YEAR TRAFFIC		
	1981	1986	2006
1. Honiara Subscribers	118.92	174.50	896.91
2. Honiara Satellite Exch (King George VI)	5.32	8.90	61.88
3. Other Exchanges:-			
3.1 Tenakaro	0.70	0.92	2.02
3.2 Auki	1.97	3.10	8.31
3.3 Tulagi	0.62	1.04	4.06
3.4 Gizo	1.93	2.96	7.73
3.5 Kirakira	0.62	1.04	4.06
3.6 Other (Unnamed)	-	-	5.76
4. HF Radio (To Radio Operator - 110)	0.01	0.02	0.03
5. VHF Radio (To Radio Operator - 110)	0.25	0.43	3.41
6. International:-			
6.1 Auto to Manual (SOLTEL)-Booking (102)	0.96	0.32	1.12
6.2 Auto to Manual (SOLTEL)-Demand (103)	-	1.06	3.73
6.3 Auto to Auto (00 and OB)	-	4.07	35.77
6.4 Phonograms (106)	0.10	0.17	1.23
7. To Automanual Switchboard, etc.			
7.1 Operator Assistance (100) (A/M)	1.26	1.97	8.70
7.2 Operator Enquiries (101) (A/M)	0.32	0.46	2.09
7.3 Fault Reporting (104) (A/M)	0.06	0.09	0.42
7.4 Phonograms (105) (T/O)	0.10	0.15	0.40
7.5 Faultsmans Ring Back (108) (EQ)	0.10	0.14	0.62
7.6 Faultsmans Line (109) (T/D)	0.05	0.07	0.31
7.7 Emergency Services (111) (A/M)	0	0	0
Ineffective Traffic not terminated (0.8%)	1.07	1.62	8.49
Totals-Outgoing Switched Traffic	134.36	203.03	1057.05

Table 3-12 (3) Tenakaro Exchange

Incoming and Outgoing Traffic (Erlangs)

	TRAFFIC		
	1981	1986	2006
Incoming Traffic			
From Tenakaro Subscribers	1.56	2.05	6.73
From Honiara	0.70	0.92	2.02
Totals	2.26	2.97	8.75
Outgoing Traffic			
To Tenakaro Subscribers	0.83	1.09	4.64
To Honiara	1.40	1.85	4.04
To Phonograms To Faultsmans Ring Back To Faultsmans Line To Emergency Service	0.01	0.01	0.02
Ineffective Traffic not Terminated	0.02	0.02	0.05
Totals	2.26	2.97	8.75

Table 3-12 (4) Tulagi Exchange

Incoming and Outgoing Traffic (Erlangs)

	TRAFFIC		
	1981	1986	2006
Incoming Traffic			
From Tulagi Subscribers	1.56	2.59	13.53
From Honiara	0.62	1.04	4.06
Totals	2.18	3.63	17.59
Outgoing Traffic			
To Tulagi Subscribers	0.90	1.52	9.26
To Honiara	1.25	2.07	8.12
To Phonograms To Faultsmans Ring Back To Faultsmans Line To Emergency Service	0.01	0.01	0.04
Ineffective Traffic not Terminated	0.02	0.03	0.17
Totals	2.18	3.63	17.59

Table 3-12 (5) Auki Exchange

Incoming and Outgoing Traffic (Erlangs)

	TRAFFICE		
	1981	1986	2006
Incoming Traffic			
From Auki Subscribers	4.93	8.85	55.42
From Honiara	1.97	3.10	8.31
Totals	6.90	11.95	63.71
Outgoing Traffic			
To Auki Subscribers	2.88	5.62	46 47
To Honiara	3.94	6.20	16.63
To Phonograms To Faultsmans Ring Back To Faultsmans Line To Emergency Service	0.02	0.03	0.12
Ineffective Traffic not Terminated	0.06	0.10	0.51
Totals	6.90	11.95	63.73

Table 3-12 (6) Gizo Exchange

Incoming and Outgoing Traffic (Erlangs)

	TRAFFIC		
	1981	1986	2006
Incoming Traffic			
From Gizo Subscribers	5.51	9.85	61.86
From Honiara	1.93	2.96	7.73
Totals	7.44	12.81	69.59
Outgoing Traffic			
To Gizo Subscribers	3.50	6.77	53.44
To Honiara	3.86	5.91	15.46
To Phonograms To Faultsmans Ring Back To Faultsmans Line To Emergency Service	0.02	0.03	0.13
Ineffective Traffic not Terminated	0.06	0.10	0.56
Totals	7.44	12.81	69.59

Table 3-12 (7) Kirakira Exchange

Incoming and Outgoing Traffic (Erlangs)

	TRAFFIC		
	1981	1986	2006
Incoming Traffic			
From Kirakira Subscribers	1.56	2.59	13.53
From Honiara	0.62	1.04	4.06
Totals	2.18	3.63	17.59
Outgoing Traffic			
To Kirakira Subscribers	0.90	1.52	9.26
To Honiara	1.25	2.07	8.12
To Phonograms To Faultsmans Ring Back To Faultsmans Line To Emergency Service	0.01	0.01	0.04
Ineffective Traffic not Terminated	0.02	0.03	0.17
Totals	2.18	3.63	17.59

Table 3-13 Rural Areas Traffic (Erlangs)

	1986	2006
Honiara Exchange		
From Buala	0.27	1.33
To Buala	0.13	0.67
From Yandina	0.27	1.33
To Yandina	0.13	0.67
From Visale	0.13	0.53
To Visale	0.07	0.27
From Tambea	0.13	0.53
To Tambea	0.07	0.27
From Rennell	0.27	0.93
To Rennell	0.13	0.47
From Marau	0.13	0.53
To Marau	0.07	0.27
From Ruavatu	0.13	0.53
To Ruavatu	0.07	0.27
From Tetere	0.53	2.67
To Tetere	0.27	1.33
Auki Exchange		
From Sulufou	0.13	0.53
To Sulufou	0.07	0.27
From Malu'u	0.27	1.33
To Malu'u	0.13	0.67
From Kiu	0.13	0.53
To kiu	0.07	0.27
From C. Hartig	0.13	0.53
To C. Hartig	0.07	0.27

	1986	2006
Gizo Exchange		
From Mbarakoma	0.13	0.53
To Mbarakoma	0.07	0.27
From Taro	0.13	0.53
To Taro	0.07	0.27
From Sasamungga	0.13	0.53
To Sasamungga	0.07	0.27
From Noro	0.53	2.67
To Noro	0.27	1.33
From Munda	0.53	2.67
To Munda	0.27	1.33
From Seghe	0.13	0.53
To Seghe	0.07	0.27
Kirakira Exchange		
From Hadja	0.13	0.53
To Hadja	0.07	0.27
From Santa Cruz	0.27	1.33
To Santa Cruz	0.13	0.67

3-2-3 Estimation of the number of trunk circuits

(1) Trunk circuit

The number of trunk circuits required for trunk calls is estimated as follows on the basis of the switched traffic mentioned previously.

1) Conditions for estimation of the number of circuits required.

a) Outgoing circuits and incoming circuits will be provided separately between automatic exchanges.

b) In areas where automatic exchange are not provided, concentration of circuits will be attemped with the use of rural area telephone system and subscribers will be accommodated by automatic exchanges of higher office ranks in the toll zone with the use of bothway circuit.

c) The number of circuits required will be calculated using Erlang's B formula.

d) Service grade will be 0.01.

2) Estimated number of circuits

The number of trunk circuits calculated under the above conditions is shown in Table 3-14.

Table 3-14 Telephone Traffic and Circuits

	TRAFFIC (Erlangs)		CIRCUITS (CH)	
	1986	2006	1986	2006
<u>Honiara Exchange</u>				
From Auki	6.86	19.55	14	30
To Auki	3.44	9.79	9	18
From Gizo	7.49	22.92	15	34
To Gizo	3.78	11.47	9	20
From Kirakira	2.47	9.98	7	18
To Kirakira	1.27	5.00	5	11
From Tulagi	2.07	8.12	7	16
To Tulagi	1.04	4.06	5	10
From Tenakaro	1.85	4.04	6	10
To Tenakaro	0.92	2.02	5	7
From Buala	0.27	1.33	3	5
To Buala	0.13	0.67		4
From Yandina	0.27	1.33	3	5
To Yandina	0.13	0.67		4
From Visale	0.13	0.53	3	4
To Visale	0.07	0.27		
From Tambea	0.13	0.53	3	4
To Tambea	0.07	0.27		
From Rennell	0.27	0.93	3	5
To Rennell	0.13	0.47		3
From Marau	0.13	0.53	3	4
To Marau	0.07	0.27		
From Ruavatu	0.13	0.53	3	4
To Ruavatu	0.07	0.27		
From Tetere	0.53	2.67	4	8
To Tetere	0.27	1.33		5
<u>Auki Exchange</u>				
From Honiara	3.44	9.79	9	18
To Honiara	6.86	19.55	14	30
From Sulufou	0.13	0.53	3	4
To Sulufou	0.07	0.27		
From Malu'u	0.27	1.33	3	5
To Malu'u	0.13	0.67		4
From Kiu	0.13	0.53	3	4
To Kiu	0.07	0.27		
From C. Hartig	0.13	0.53	3	4
To C. Hartig	0.07	0.27		
<u>Gizo Exchange</u>				
From Honiara	3.78	11.47	9	23
To Honiara	7.49	22.92	15	34
From Mbarakoma	0.13	0.53	3	4
To Mbarakoma	0.07	0.27		
From Taro	0.13	0.53	3	4
To Taro	0.07	0.27		
From Sasamungga	0.13	0.53	3	4
To Sasamungga	0.07	0.27		
From Noro	0.53	2.67	4	8
To Noro	0.27	1.33		5
From Munda	0.53	2.67	4	8
To Munda	0.27	1.33		5

	TRAFFIC (Erlangs)		CIRCUITS (CH)	
	1986	2006	1986	2006
From Seghe	0.13	0.53	3	4
To Seghe	0.07	0.27		
<u>Kirakira Exchange</u>				
From Honiara	1.27	5.00	5	11
To Honiara	2.47	9.98	7	18
From Hadja	0.13	0.53	3	4
To Hadja	0.07	0.27		
From Santa Cruz	0.27	1.33	3	5
To Santa Cruz	0.13	0.67		4

(2) Long-distance leased circuit

1) Radio porgram circuit

The Solomon Islands Broadcasting Corporation (SIBC) is planning to expand its service area on a nation-wide scale through construction of a transmitting station in Gizo, Kirakira and Santa Cruz in addition to the existing station in Honiara. For this purpose, a radio program circuit (50Hz-10,000Hz, 3 telephone CH equivalent) connecting the studio in Honiara and transmitting stations must be provided.

For reliability of broadcasting, it may be necessary for SIBC to provide a standby circuit. In such a case, a separate route using a short wave circuit will be effective. Under the trunk network project, a 10 KHz broad band circuit (3 telephone CH equivalent) and one order-wire circuit will be provided between the studio in Honiara and each transmitting station. There is also a plan to establish a studio in Auki and transmit locally made programmes to Honiara. In such a case, the circuit will be similar to the circuit mentioned above.

2) Other leased circuits

In the future, a new demand for leased circuits is expected to generate for such purposes as telegraph relay, telex, data communications, facsimile, police, meteorological and aeronautical communications and industrial use.

In the relatively popularized stage of telephone development, the share of long-distance leased circuits is normally less than 10 percent of the number of trunk circuits. However, in areas where telephone density is localized, a relatively high share of long-distance leased circuits may be experienced. In Solomon Islands, it is difficult to determine this tendency as no statistics is available for analysis.

In this study, it is assumed to provide 1/2G (6 CH) of leased circuits in the initial stage and 1G (12 CH) in the ultimate stage which is equivalent to 10 percent or slightly over of the number of toll circuits, between Honiara and each zone center and one or two leased circuits for other terminal stations.

(3) Number of trunk circuits

The number of trunk circuits and long-distance leased circu required, calculated under the previously mentioned conditions (and (2) including some standby circuits, is shown in Table 3-15 in the unit of 1/2 G (6 CH).

Table 3-15 Trunk Circuits

(International Traffic via Honiara Exchange)

	CIRCUITS	
	1986	2006
Honiara - Auki	3.0	6.0
- Gizo	3.0	6.0
- Kirakira	2.0	4.0
- Tulagi	1.5	2.5
- Tenakaro	1.5	2.0
- Buala	0.5	1.0
- Yandina	0.5	1.0
- Visale	0.5	0.5
- Tambea	0.5	0.5
- Rennell	0.5	1.0
- Marau	0.5	0.5
- Ruavatu	0.5	0.5
- Tetere	0.5	1.5
Auki - Sulufou	0.5	0.5
- Malu'u	0.5	1.0
- Kiu	0.5	0.5
- C.Hartig	0.5	0.5
Gizo - Mbarakoma	0.5	0.5
- Taro	0.5	0.5
- Sasamungga	0.5	0.5
- Noro	0.5	1.5
- Munda	0.5	1.5
- Seghe	0.5	0.5
Kirakira- Hadja	0.5	0.5
- Santa Cruz	1.0	1.5

* G means 12 channels.

P&T of the Solomon government has no plan to introduce 4W transit exchanges for the time being. Zone centers other than Honiara, therefore, will be required to provide circuits for international calls separate from the circuits for national trunk calls when these centers have more than two local exchanges. The number of trunk circuits calculated under the above consideration is shown in Table 3-16.

Table 3-16 Trunk Circuits (International Traffic from Zone Center to ITE via Exclusive Circuits)

	CIRCUITS (G)*	
	1986	2006
Honiara - Auki	3.0	6.0
- Gizo	3.0	7.0
- Kirakira	2.0	5.0
- Tulagi	1.5	2.5
- Tenakaro	1.5	2.0
- Buala	0.5	1.0
- Yandina	0.5	1.0
- Visale	0.5	0.5
- Tambea	0.5	0.5
- Rennell	0.5	1.0
- Marau	0.5	0.5
- Ruavatu	0.5	0.5
- Tetere	0.5	1.5
Auki - Sulufou	0.5	0.5
- Malu'u	0.5	1.0
- Kiu	0.5	0.5
- C.Hartig	0.5	0.5
Gizo - Mbarakoma	0.5	0.5
- Taro	0.5	0.5
- Sasamungga	0.5	0.5
- Noro	0.5	1.5
- Munda	0.5	1.5
- Seghe	0.5	0.5
Kirakira - Hadja	0.5	0.5
- Santa Cruz	1.0	1.5

*G means 12 channels.

3-3 Technical Standards

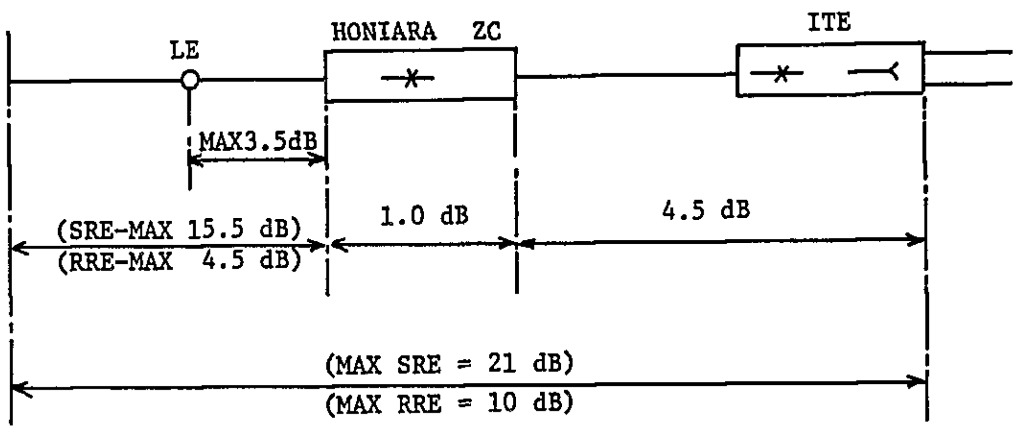
The following technical standards will be applied to the telecommunication trunk network project in Solomon Islands.

3-3-1 Transmission performance

(1) Transmission loss assignment

The transmission loss assignment plan for international calls shown in Fig. 3-15, formulated with a view to satisfy CCITT Recommendation G.121B, is suggested by P&T of the Solomon government.

INTERNATIONAL TRANSMISSION PLAN-INITIAL



INTERNATIONAL TRANSMISSION PLAN-ULTIMATE

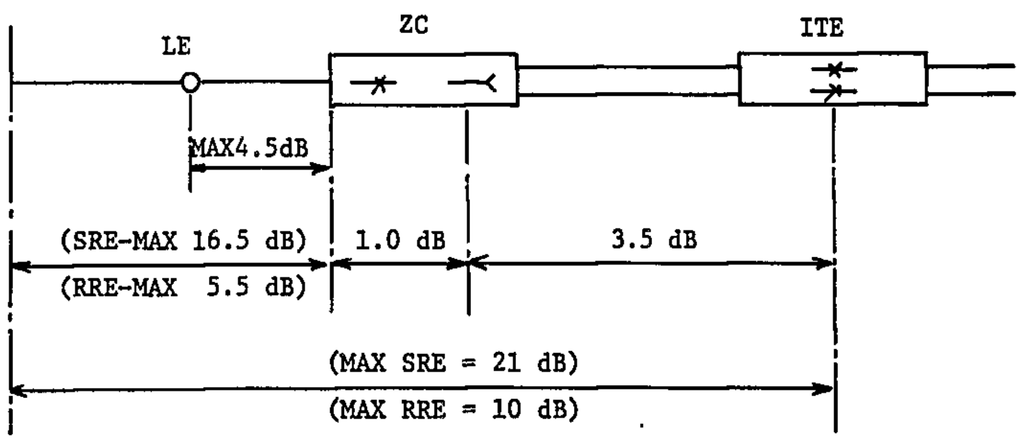


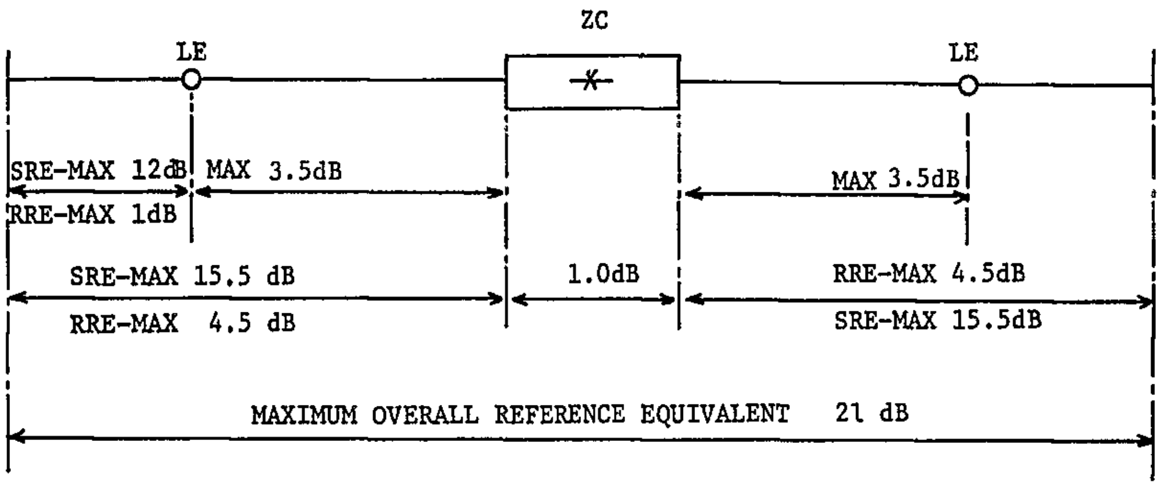
Figure 3-15 International Transmission Plan

The maximum reference equivalent between subscribers stations and international exchange is set at SRE = 21 dB and RRE = 10 dB, with reference equivalent necessary for securing stability of transmission assigned to trunk network and the remainder assigned to local network.

The government of Solomon Islands has determined not to introduce 4W transit exchanges for the time being for simplification of maintenance. To satisfy CCITT Recommendation G.121 in the future, it will be necessary for each of Auki, Gizo and Kirakira exchanges to provide a direct circuit for international calls between it and ITE when shifting from LE function to ZC function.

The transmission loss assignment plan for domestic calls is shown in Fig. 3-16. The maximum reference equivalent is set at 31dB which is sufficient for securing adequate speech quality.

NATIONAL TRANSMISSION PLAN-INITIAL



NATIONAL TRANSMISSION PLAN-ULTIMATE

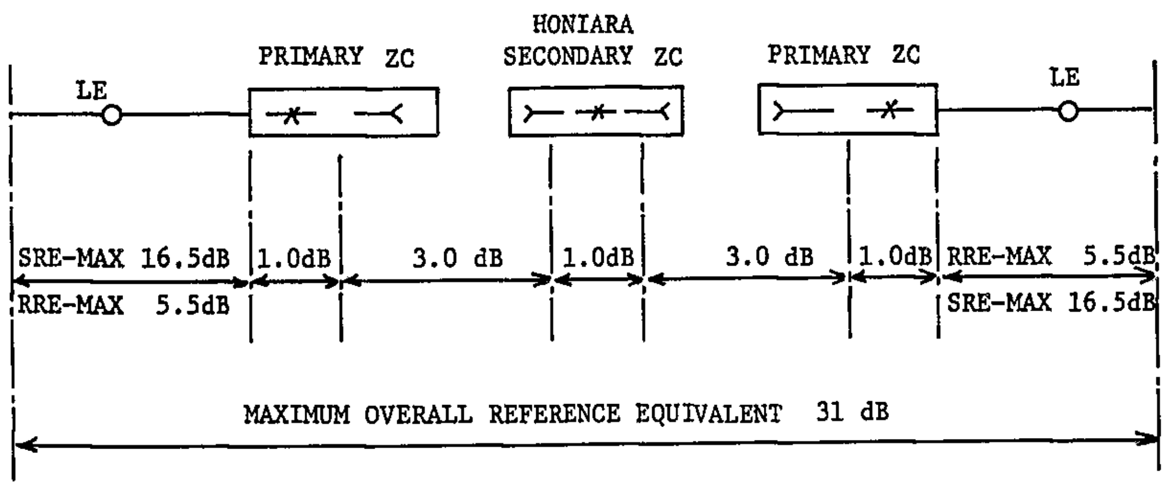


Figure 3-16 National Transmission Plan

(2) Noise standards

In principle, the noise power between local exchanges and th international exchange should be less than 10,000 PW in accordanc with CCITT Recommendation G. 123.

For islands, between which the establishment of a radio rela station is not possible, a study will be made separately from an economic point of view in Chapter 4.

3-3-2 Traffic engineering standard

For distribution of loss probability, the economic optimum distribution method, which distributes the loss probability according to the cost between sections, and the uniform distribution method, which distributes the loss probability uniformly among sections are available. It is know that the cost difference between the two methods is very small. Application of different loss probabilities to different sections is very troublesome from a management point of view. In this study, therefore, the uniform distribution method was applied.

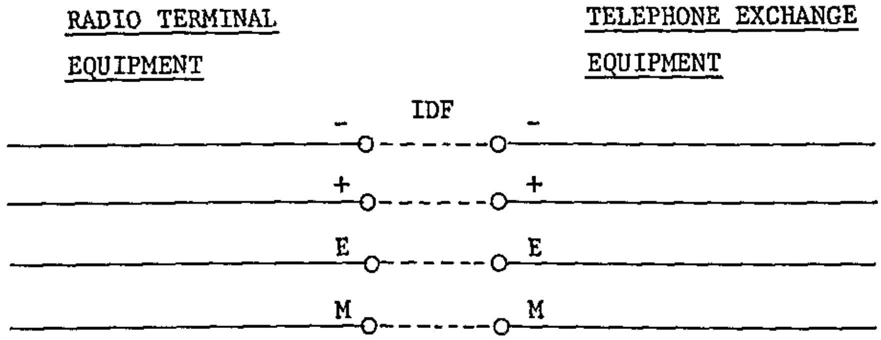
In many cases, loss probabilities of 1/100, 1/200 and 1/500 are normally applied. In the case of Solomon Islands where the number of transit stages is small, a loss probability of 1/100 will be applied.

3-3-3 Interface between telephone exchange and radio terminal equipment

P&T of the Solomon government has determined to use the following interface between the telephone exchange and the radio terminal equipment and is implementing the local network project accordingly.

(1) The hybrid for 2W/4W switching will be provided on the radio terminal equipment side. The impedance on the 2 wire side will be 600Ω balancing. The nominal impedance on the exchange equipment side will also be 600Ω.

(2) The interface between the telephone exchange equipment and the radio terminal equipment will be as shown below.



(3) For signalling system, the analogue version of CCITT signalling system, which satisfies such requirements of CCITT Recommendation Q400, Q411, Q412 and Q416, will be applied.

(4) The operating conditions of circuits for connection of sending exchange A with receiving exchange B via radio terminal equipment and the condition of E and M wire, according to the table of CCITT Recommendation Q411, are as follows.

Operating condition	Forward Signal (Note 1)	Backward Signal (Note 2)
1. Idle	Open	Open
2. Seized	Earth	Open
3. Answered	Earth	Earth
4. Clear-back	Earth	Open
5. Release	Open	Open or Earth
6. Blocked	Open	Earth

Notes:

1. The forward signals shown in the above table represent the condition on the M wire from exchange A to the radio terminal equipment at the A end of the circuit, and the condition on the E wire from the radio terminal equipment at the B end of the circuit to exchange B.
2. The backward signals shown in the table represent the condition on the M wire from exchange B to the radio terminal equipment at the B end of the circuit, and the condition on the E wire from the radio terminal equipment at the A end of the circuit to exchange A.

CHAPTER 4

TRANSMISSION ROUTE PLAN AND SYSTEM DESIGN

Chapter 4 Transmission Route Plan and System Design

4-1 Overview

In the long distance telecommunications trunk network planning, what is basically important is to determine the optimum communication system and transmission route. This means the selection of communication system best fitted for the given geographical conditions and technical requirements, as well as the transmission route which satisfies the technical terms and conditions required of such communication system and which is the best available in terms of system economy.

The Solomon Islands consist of a large number of islands scattered in the ocean. The domestic telecommunications trunk network in the Solomon Islands must be the technically and economically desirable system under such geographical conditions. In other words, the system must be such as will maintain the required performance and keep the initial cost, as well as the operation and maintenance cost, to the possible minimum.

When the radio system and the cable system are compared under the aforementioned terms and conditions, the former is found to be distinctly preferable to the latter in both technical and economical aspects.

The radio communication system now in practice comprises two major categories: the terrestrial radio communication system and the satellite communication system. The satellite communication system, though mainly used for international communications, is adopted in some countries for domestic communications also.

For communications among islands scattered in the extensive area, such as the Solomon Islands, it will be proper to use the satellite communication system. However, this system requires advanced techniques for operation and maintenance so that a large number of high level engineers must be assigned for operation and maintenance of the system. Furthermore, for establishing the telecommunications trunk network using a communication satellite, the earth station must be constructed in each of many (26) areas where required.

This fact makes the satellite communication system not exactly more advantageous than the terrestrial radio communication system insofar as the construction cost is concerned.

From the foregoing viewpoint, judgment has been made that the satellite communication system is not preferable as a system for the Solomon Islands domestic telecommunications trunk network. However, when a terrestrial radio system for the trunk network has been completed in the future and comes to perform an important role in the development and upkeep of the

Solomon Islands society and economy and, as the result, the greater reliability comes to be required of the trunk network system, it will be necessary to study the satellite communication system as a backup system for the terrestrial radio communication system.

For the reasons mentioned above, the system for the Solomon Islands domestic telecommunications trunk network is to be planned strictly in the forms of the terrestrial radio communication system. Accordingly, technical and economic studies for the selection of the optimum transmission system and route are made in this chapter.

Initial and annual maintenance/operation costs of the satellite communication system and terrestrial radio communication system are given in the supplementary data attached at the end of this report.

4-2 Selection of Transmission Route

For the transmission system to cater for the circuit demand estimate given in Chapter 3, both the line-of-sight system and the trans-horizon route are applicable technically. In case the line-of-sight system is adopted, radio stations must be constructed on the top or at a high place of mountains in order that all the propagation paths will be under the line-of-sight conditions. Furthermore, to ease the station access, the access roads must be built and the pier facilities must also be newly established. This entails a big civil work cost. Table 4-1 presents the civil work cost estimates for line-of-sight and trans-horizon system.

Table 4-1 Comparison of Civil Work Cost Estimates

Cost Item	Line-of-Sight system	Trans-Horizon system
Road Construction (including pier facilities)	¥1 billion approx. (US$4,545,000 approx.)	¥10 million approx. (US$45,000 approx.)
Ground Leveling, Land-Formation for station site	¥75 million approx. (US$341,000 approx.)	¥63 million approx. (US$286,000 approx.)

As seen Table 4-1, the line-of-sight system requires greater civil work cost and initial cost than the trans-horizon system. Besides, as the number of stations required increases, not only the initial cost but the operation and maintenance cost also increases. Thus, economically, the line-of-sight system involves a greater disadvantage than the trans-horizon system.

In view of the foregoing, it is recommended that the terrestrial radio communication system mainly composed of trans-horizon propagation paths be adopted in the projected Solomon Islands domestic telecommunications trunk network system.

Figure 4-1 is the transmission route plan based on the terrestrial radio communication system. In this transmission route plan the following basic requirements are taken into full consideration:

(1) To reduce the number of stations to the technically possible minimum;

(2) To avoid as far as possible the station sites where access roads are required;

(3) To select the geographically so qualified sites that the small scatter angle can be obtained especially for the troposcatter propagation path;

(4) To so arrange that the transmission route extends via the point where the branching to Priority-1 Terminals and Priority-2 Terminals as shown in Scope of Works [1] is technically easy.

4-3 Transmission System Study

The channelling plan for the initial and the ultimate stages based on the transmission route plan proposed in the preceding Paragraph and the circuit demand estimate prepared in the preceding Chapter appears in Figure 4-2. Figure 4-3 indicates the circuit assignment diagram based on the channelling plan mentioned above. In this diagram, the required transmission capacity of and the applicable system for each section are indicated. For further description, the system parameters required for each section are generally determined, based on the required transmission performance, transmission capacity, transmission route length, and so forth. The following Paragraph describes the study made to select the optimum transmission system and the outline of the selected system.

4-4 A Comparison of Various Transmission Systems and Selection of Optimum Transmission System

4-4-1 UHF System and SHF System

For the system to be adopted in the line-of-sight section where the 60-channel or more transmission capacity is required, SHF System (7 GHz band) and UHF System (900 MHz band) were taken up for comparative studies from technical and economic viewpoints. Table 4-2 presents the comparison of characteristics of SHF System and UHF System.

Table 4-2 Comparison Between SHF and UHF Systems

Item	SHF System	UHF System
1. Equipment/Material Cost (FOB basis)	Approx. ¥4,300 million (Approx. US$20 million)	Approx. ¥2,300 million (Approx. US$10 million)
2. Transmission Capacity	300ch	120ch
3. Operation, maintenance	Since CCIR-recommended performance is required, inspection items are many. Maintenance capability of higher level than for UHF system is required.	Maintenance method is simpler than for SHF system. Hence, operation/ maintenance is easy.
4. Maintenance cost	Quantities of spare panels and parts to be stored are large. Hence, maintenance cost is higher, compared with UHF System.	Required cost of system maintenance is lower, compared with SHF System.
5. Initial cost per channel	In case the required number of channels is up to 300, initial cost is higher than in the case of UHF system.	In case the system is of small capacity, initial cost is lower than in the case of SHF System.
6. Transmission performance	Fading is siverer than in the case of UHF system. Therefore, in order to maintain the required transmission performance, the application of diversity system is necessary.	Considering the propagation characteristic, the application of diversity system is not necessary. Composition of transmission system is simpler than that of SHF system.

As seen in the table above, UHF System predominates over SHF System in the cost of the system construction and maintenance, and ease of the Solomon Islands domestic telecommunications trunk network.

4-4-2 FDM System and PCM System

In the comparative studies of FDM System and PCM System, the 900 MHz band system was used as a reference system. In the technical aspect, no much distinction can be recognized, whichever system is adopted for the telecommunications trunk network. In terms of equipment cost, PCM System commands advantage because the cost of carrier terminal equipment required in the system is low. Given in Figure 4-4 is the comparison between FDM System and PCM System in the main equipment cost in accordance with the number of voice channels to be accommodated.

For establishing the Solomon Islands domestic telecommunications trunk network, a large number of trans-horizon troposcatter systems are to be applied to satisfy the system performance required under the given geographical conditions. At the present stage, the PCM System application for the troposcatter propagation path is still being developed. Especially, for the broad band system to accommodate 60 channels or more telephone circuits, there is room for further technical study and solution, so that, in the troposcatter section, FDM System has to be used. Therefore, if PCM System is used for the propagation path outside the troposcatter section, it follows that two modulation systems are used in one transmission system. This means that the unified system operation and maintenance become infeasible, and this certainly is not advisable. Furthermore, the carrier terminal equipemnt cost assumes no much importance, considering its percentage to the total installation cost. Hence, with a view to composing the trunk network by a single modulation system and thereby easing the operation and maintenance of the transmission system, the adoption of FDM System is recommended.

4-4-3 Study of Trans-Horizon System

The application feasibility of trans-horizon communication system is determined by means of comparison with other systems in terms of cost performance to be considered for the equipment and materials supply, and for the installation and the system performance and maintenance under the given geographical conditions.

The trans-horizon communication system is divided into the following systems by the propagation path characteristics:

(1) Mountain Diffraction System

This system will be applied in case where the propagation path length is relatively short and an obstacle, such as a mountain, that interrupts the line-of-sight path, and, even if the diffraction loss due to such and obstacle is considered, the required transmission performance can be obtained. Also, in case where an island or a mountain exists in the spherical earth diffraction propagation path and the ridge diffraction loss due to such an obstacle is small, compared with the spherical earth diffraction loss, and where the required transmission performance can be obtained economically as in the case mentioned above, the mountain diffraction system is used. Out of all propagation paths that constitute the transmission route, the sections where this system is to be adopted are Lalande-Malu'u Section, Munda-Seghe Section and Kirakira-Hadja Section.

(2) Spherical Earth Diffraction System

This system can be applied in the propagation path where the propagation path length is relatively long and where the extremely great antenna height is required in order to secure the line-of-sight radio propagation. In other words, this system is a system that economically sets the equipment parameters so that the required transmission performance can be obtained by the economical antenna height. For determining the economical antenna height, it is important to maintain the line-of-sight condition at the median value of K's variation distribusion in order that the propagation mode will be the diffraction mode during the hours exceeding 50% of each month. The sections where this system is to be adopted by considering the foregoing are Ruavatu-Kiu Section, C. Hartig-Marau Section and Oretecove-Sasamungga Section.

(3) Troposcatter System

This system is applied for the long distance propagation path that connects distant islands, where the propagation mode will be the scatter mode. By considering the geographical conditions of the transmission route and after the technical and economic studies, it was decided to use this system in the following sections: Ruavatu-C. Hartig, C. Hartig-Rennel, Kirakira-Santa Cruz, Honiara-Allardyce, Allardyce-Oretecove and Auki-Buala. As for Honiara-Gizo and Visale-Gizo troposcatter propagation paths, the result of study shows that both are technically and economically not feasible because of excessive basic transmission loss and intermodulation noise.

4-5 Outline of System Design

4-5-1 Site Selection

The final site selection will be made, based on the result of field survey for the purpose of detail design. This Report describes the general situation of each proposed site selected through the map study and field survey which were carried out for the purpose of feasibility evaluation. Items worth consideration in regard to the site selection are also pointed out.

Of the many items to be considered in the site selection, those of special importance are: (1) To select such sites where civil work cost can be kept to the possible minimum; (2) To select propagation paths with good characteristics in order that the required transmission performance can be obtained economically; and (3) To make sure that the technical and economic consideration is fully made so that the proper operation and maintenance of the system can be performed.

In view of the unique geography of the Solomon Islands, trans-horizon communication system is best suited for the required low cost system. More specifically, the proposed sites must be in such locations where the existing roads can be utilized to advantage so as to reduce the number of access roads to be newly built; where the required land space can be obtained with ease; and where the civil work cost for land formation can be minimized.

Table 4-3 presents the particulars of initially selected survey sites, based on the foregoing requirements. The further field survey will be carried out for determining the final locations of the proposed site. For details of initially selected proposed sites, refer to Annex 4-1.

Table 4-3 Proposed Station Site List (1/2)

Name	Altitude (m)	Coordinate Longitude (°.'.".)	Coordinate Latitude (°.'.".)	Next Site Name	Next Site Distance	Bearing to The Next Site from T. N. (°.'.".)	Remark
Honiara	70	E150.56.55	S9.25.58	Tenakaro	17.1	88.16.04	Existing station
				Tulagi	43.1	31.08.29	
				Ruavatu	48.2	89.46.50	
				Chapuru	32.2	308.32.33	
				Allardyce	232.0	322.19.59	
Tenakaro	10	E160.06.17	S9.25.41	Honiara	17.1	268.14.33	
				Tetere	11.8	99.45.28	
Tetere	5	E160.12.38	S9.26.46	Tenakaro	11.8	279.44.25	
Tulagi	40	E160.09.05	S9.05.57	Honiara	43.1	211.06.32	
Ruavatu	2	E160.23.18	S9.25.57	Honiara	48.2	269.42.33	
				Kiu	72.2	77.15.08	
				C.Hartig	118.4	102.15.11	
				Auki	82.5	25.01.39	
Kiu	2	E161.01.47	S9.17.10	Ruavatu	72.2	257.08.55	
C. Hartig	40	E161.26.37	S9.39.24	Ruavatu	118.4	282.04.45	
				Marau	71.0	253.08.10	
				Rennel	254.9	209.51.01	
				Kirakira	101.3	148.45.21	
Marau	20	E160.49.25	S9.50.33	C.Hartig	71.0	73.14.25	
Rennel	60	E160.16.45	S11.39.19	C.Hartig	254.9	30.03.51	
Kirakira	10	E161.55.26	S10.26.24	C.Hartig	101.3	328.40.21	
				Hadja	72.4	2.36.04	
				Santa Cruz	424.0	94.32.23	
Hadja	10	E161.57.14	S9.47.06	Kirakira	72.4	182.35.45	
Santa Cruz	40	E165.47.32	S10.43.13	Kirakira	424.0	273.50.02	
Auki	177	E160.42.21	S8.45.15	Ruavatu	82.5	204.58.40	
				Lalande	48.1	340.47.36	
				Buala	138.9	299.33.38	
Buala	10	E159.36.31	S8.07.57	Auki	138.9	119.43.14	
Lalande	2	E.160.33.43	S8.20.34	Auki	48.1	160.48.53	
				Malu'u	7.8	90.13.51	
Malu'u	30	E160.37.58	S8.20.35	Lalande	7.8	270.13.14	
				Takwa	15.7	98.46.29	
Takwa	20	E160.46.26	S8.21.53	Malu'u	15.7	278.45.15	
				Sulufou	12.8	140.17.02	
Sulufou	5	E.160.50.53	S8.27.13	Takwa	12.8	320.16.23	

Table 4-3 Proposed Station Site List (2/2)

Name	Altitude (m)	Coordinate		Next Site		Bearing to the Next Site from T. N. (°.'.".)	Remarks
		Longitude (°.'.".)	Latitude (°.'.".)	Name	Distance (km)		
Chapuru	5	E159.43.09	S9.15.04	Honiara	32.2	128.34.46	
				Yandina	58.4	290.02.11	
Yandina	5	E159.13.11	S9.04.11	Chapuru	58.4	110.06.55	
Allardyce	40	E158.39.43	S7.46.05	Honiara	232.0	142.31.28	
				Oretecove	206.3	270.26.12	
Oretecove	2	E156.47.21	S7.44.59	Allardyce	206.3	90.41.16	
				Sasamungga	78.8	357.51.37	
				Mbarakoma	21.0	203.50.19	
				Gizo	39.2	171.34.31	
Sasamungga	5	E156.45.45	S7.02.12	Oretecove	78.8	177.51.49	
				Taro	54.4	312.10.54	
Taro	5	E156.23.52	S6.42.22	Sasamungga	54.4	132.13.30	
Mbarakoma	35	E156.42.44	S7.55.24	Oretecove	21.0	23.50.56	
Gizo	70	E.156.50.29	S8.06.04	Oretecove	39.2	351.34.06	
				Noro	41.3	107.41.12	
				Munda	52.8	116.51.33	
Noro	17	E157.11.55	S8.12.52	Gizo	41.3	287.38.11	
Munda	80	E157.16.09	S8.19.00	Gizo	52.8	296.47.55	
				Seghe	72.3	112.35.55	
Seghe	4	E157.52.35	S8.34.04	Munda	72.3	292.30.37	

4-5-2 Outline of Propagation Paths

The outline of each propagation path appears in Table 4-4. The profile maps are prepared in Annex 4-2. Each profile map is produced from the topographical map drawn to a scale of 1:50,000.

Table 4-4 Outline of Propagation Path Conditions (1/3)

No.	Path	Path Length (km)	Path Conditions
1.	Honiara - Tenakaro	17.1	Path is over palm woods. Flat land near the reflection point. Height of palm trees: approx. 20 m.
2.	Honiara - Tulagi	43.1	Path is on the sea. No obstacle to cut off the reflected wave. Reflection point is on the sea.
3.	Honiara - Ruavatu	48.2	Path is over palm woods. Wilderness near the reflection point. Height of palm trees: approx. 20 m.
4.	Ruavatu - Kiu	72.2	Path is over the sea. Both sites are of low elevation. When antenna height is 80 m, line-of-sight propagation is available at K=4/3 and spherical earth diffraction loss appears at K=1.
5.	Ruavatu - C. Hartig	118.4	This is the troposcatter path. For the site selection, felling of palm and other trees is necessary to remove obstacles in the foreground.
6.	C. Hartig - Marau	71.0	This is the oversea path. Elevat on of both sites are low. When antenna height is 50 m, line-of-sight propagation is available at K=4/3 and spherical earth diffraction loss appears at K=1.
7.	C. Hartig - Rennel	254.9	This is the troposcatter path. Path condition near the Rennel site is especially problematical. Obstacle lies in the foreground. Reconsideration is required for the detailed system design.
8.	C. Hartig - Kirakira	101.3	Troposcatter path. To remove obstacles in the foreground of both sites, felling of trees is necessary.
9.	Kirakira - Hadja	72.4	Oversea path with obstacle in the near middle. As K approaches 1, diffraction loss appears.
10.	Kirakira - Santa Cruz	424.0	Troposcatter path. Since the distance is long, 19 mø or so antenna is required. At both sites, felling of trees is necessary to obtain visibility to the seashores in the foreground.

Table 4-4 Outline of Propagation Path Conditions (2/3)

No.	Path	Path Length (km)	Path Conditions
11.	Ruavatu - Auki	82.5	Oversea path with reflection point on the sea. In case of K=1, when low frequency is used, spherical earth diffraction loss appears.
12.	Auki - Buala	138.9	Troposcatter path. Buala site must be cleared of obstacle in the foreground.
13.	Lalande - Auki	48.1	Most part of path is over the sea. Reflection point is on the sea. Since obstacle exists in the foreground of Lalande, antenna height at Lalande is required to be 50 m or more.
14.	Lalande - Malu'u	7.8	Mountain diffraction path. Although the distance is short, approx. 250 m obstacle exists 3 km or so from Lalande.
15.	Malu'u - Takwa	15.7	Combined overland and oversea path. Reflection point is on the sea. There is a hill that serves to prevent reflected wave. Hence no problem.
16.	Takwa - Sulufou	12.2	This path consists of 5:1 overland and oversea combination. Reflection point is at the seashore. This seashore serves as a hill to prvent reflected wave. Hence no problem.
17.	Chapuru - Honiara	32.2	This path consists of 3:2 overland and oversea combination. Reflection point is on the land and its neighborhood is heavily wooded. Approx. 6 km in the foreground of Chapuru exists obstacle that stands 40 m or more high. Hence antenna height at Chapuru is required to be 50 m or more.
18.	Chapuru - Yandina	58.4	Oversea path. At both sites the elevation is low so that antenna height is required to be 50 m or more. At K=1, this path become spherical earth diffraction path.
19.	Honiara - Allardyce	232.0	Troposcatter path. Allardyce site must be located at a point without obstacle in the foreground.
20.	Oretecove - Allardyce	206.3	Troposcatter path. Both sites must be located at the points without obstacle in the foreground.

Table 4-4 Outline of Propagation Path Conditions (3/3)

No.	Path	Path Length (km)	Path Conditions
21.	Oretecove - Sasamungga	78.8	Oversea path. At less than K=4/3, spherical earth diffraction propagation is available.
22.	Sasamungga - Taro	54.4	Most part of path is over the sea. Nearly 20 km from Taro lies obstacle. This causes mountain diffraction loss
23.	Oretecove - Mbarakoma	21.0	Oversea path with reflection point on the sea. However, path lenth is short. Hence no problem.
24.	Gizo - Oretecove	39.2	Oversea path with reflection point on the sea.
25.	Gizo - Noro	41.3	Most part of path is over the sea. It is possible to have reflection point located overland. Hence no problem.
26.	Munda - Gizo	52.8	Combined oversea and overland path. Oversea and overland combination rate is nearly 50:50. Reflection point is on the land. Hence no problem.
27.	Munda - Seghe	72.3	This path consists of 2:1 oversea and overland combination. Approx. 4km in the foreground of Seghe exists 200m or more high obstacle. This causes mountain diffraction loss.
28.	Tenakaro - Tetere	11.8	Overland path.

4-5-3 Determination of Antenna Height

This Paragraph enumerates the items to be considered when determining the antenna height.

Propagation paths that constitute the transmission route can be divided into four categories, as previously stated. The following is the basic philosophy to determine the antenna height required for each propagation path:

(1) For the line-of-sight propagation path, the antenna height must be so determined as will be clear of radio propagation obstacle in the neighborhood of radio station and will also be clear of midway obstacle on the propagation path to obtain the free space propagation attenuation at the median value of K. The clearance factor in this case is approximately 0.6.

(2) For the mountain diffraction propagation path, the antenna height must be so determined that the allowable basic transmission loss in consideration of the required transmission performance can be obtained. In this case, the economical balance with other parameters (such as transmitter output power and antenna gain) must be considered.

(3) For the spherical earth diffraction propagation path, the antenna height must be so determined that at the median value of K the slight clearance can be kept between radio ray and the critical point on the spherical earth surface.

The foregoing antenna height determination criteria are the basic requirements for design not only to achieve the required transmission peformance but also in consideration of system economy.

(4) For the troposcatter propagation path, the antenna height must be so determined that the clearance of 3 m or more can be kept between the lower edge of parabolic antenna and the ground surface for avoiding the bad influence on the radio propagation.

4-5-4 Transmission Loss and Fading

Following is an outline of methods to estimate the basic transmission loss and the depth of fading on various types of propagation paths that constitute the transmission route:

(1) The basic transmission loss on the line-of-sight propagation path is given by the free space propagation attenuation

calculation [2] . The fading depth is estimated by the GAS-3 formula [3].

(2) The basic transmission loss on the mountain diffraction propagation path is equal to the free space propagation attenuation plus the ridge diffraction loss (K= median value). For the ridge diffraction loss estimation, various methods have so far been announced but, in this Report, the Bullington formula [4] is used. Fading in the mountain diffraction propagation path is, as in the case of line-of-sight propagation, the ineterferential fading due to the multi-path effects for the most part. Thus, for the estimation of the fading depth, the method of the same estimation on the line-of-sight propagation path is used.

(3) The basic transmission loss on the spherical earth diffraction propagation path is equal to the free space propagation attenuation plus the median value of the spherical earth diffraction loss. The spherical earth diffraction loss is estimated by the method stated in the CCITT Report [5] . In the case of spherical earth diffraction propagation, the variation of diffraction loss due to the variation of K, i.e., the so-called K type fading, exert the bad influence on the transmission performance. On the assumption that the 99.9% value in the variation distribution of K is 1 [6], the volume of variation of the diffraction loss in case where K has varied from its median value to 1 is used as the fading depth.

(4) On the troposcatter propagation path, the annual median value of the propagation loss is set as the basic transmission loss. The estimation method for this basic transmission loss is shown in the CCIR Report [7] . It is said that the scatter angle is one of factors which have strong influence on the determination of the basic transmission loss and, in the circuit design, the smaller the scatter angle, the better. In other words, it is the prime requisite for site selection to find such locations where the geographical condition permits the long line-of-sight path and reduces the scatter angle.

The troposcatter propagation loss variation depends upon the complicated correlations between the variation of meteorological elements and the propagation mechanisms. This loss variation directly affects the system reliability so that it assumes

Special importance in the system design.

Generally, fading that occurs in the troposcatter propagation path comprises two types. One is the long term variation with the small variation range and the other is the short term variation with the large variation range. In the former, the propagation characteristics vary in several minutes to one hour or so, and the variation range changes according to the season, propagation path length, topography, frequency and so forth. The latter is ordinarily the variation of not more than several minutes and is due to the interferential fading due to the multi-path effects. This varialtion displays Rayleigh distribution in the case of single reception and the Pearson's V type distribution in the case of diversity reception.

4-5-5 Outline of Terrestrial Radio System

(1) System Composition

Generally, the terrestrial radio system uses the standby system in order to improve the service reliability. The standby system includes the RF channel standby system and the equipment standby system. The former in adopted for the large capacity transmission system, such as the line-of-sight microwave system, and the latter for the small capacity line-of-sight or trans-horizon transmission system. Figure 4-5 presents the typical system block diagram of the equipment standby system. Shown in Figure 4-6 is the typical equipment block diagram of the troposcatter propagation system. The dual diversity system shown here is the composite base band system using two radio frequencies and is commonly called the frequency diversity system. The quadruple diversity system is composed of the combined space diversity system and frequency diversity system. Shown here is the system composed of the combined angular diversity system, which is a kind of space diversity system, and the frequency diversity system. The angular diversity system commonly uses one antenna for transmission and reception. Usually it requires a smaller land space than the space diversity system. The equipment cost also is lower.

(2) Outline of Main Equipment

The terrestrial radio system to be used in the Solomon Islands domestic telecommunications network is composed of the following main equipment:

UHF radio transmitting and receiving equipment
UHF antenna feeder
Remote supervisory and control system
Carrier multiplex terminal equipment and connecting cable
Power supply system

Design parameters for the above main equipment and performance required of such equipment are summarized below.

1) UHF Radio Transmitting and Receiving Equipment

Radio transmitting and receiving equipment parameters are determined, based on the required transmission performance and propagation path characteristics. Table 4-5 is a list of typical parameters for each equipment.

Table 4-5 Typical Parameters of Transmitter/Receiver

Item	2GHz Band		900 MHz Band		400 MHz Band		
1. Transmitting Capacity in Ch.	24	120	60	120	6	12	24
2. Transmitting Power in Watt	50	100	5	5	10	10	10
3. Noise Figure in dB	2.5	2.5	7	7	6	6	6
4. IF Bandwidth in MHz	0.71	1.1	6	6	0.4	1.3	1.3
5. Baseband Frequency in KHz	12 to 108		60 to 300	12 to 36	12 to 108		
		60 to 552	60 to 552		12 to 60		
6. Figure of Merit in dB	180	181	162	157	179	175	170
7. Threshold Level in dBm	-105	-102	-90.2	-90.2	-105	-97	-97
8. Equipment Thermal & Intermodulation Noise in pWOp	200	200	200	200	500	500	500
9. Frequency Deviation in KHz	35	200	100	100	35	35	35

2) UHF Antenna/Feeder

Antenna and feeders required are listed in Table 4-6 and Table 4-7 according to types and frequencies used.

Table 4-6 Type of Antenna to be Considered

Type	Isotropic Gain in dB			
	7GHz	2GHz	900MHz	400 MHz
1. Yagi Antenna				11.0
2. 1.2mϕ Parabolic Antenna				11.0
3. 2.0mϕ Parabolic Antenna	40.8		22.5	45.5
4. 3.0mϕ Paraboiic Antenna	44.3		26.0	19.0
5. 4.0mϕ Parabolic Antenna	46.6		28.5	21.5
6. 6.0mϕ Parabolic Antenna		39.8		
7. 10mϕ Parabolic Antenna		44.2		
8. 12mϕ Parabolic Antenna		45.8		
9. 19mϕ Parabolic Antenna		49.8		

Table 4-7 Type of Feeder to be Considered

Type	Attenuation in dB			
	400MHz	900MHz	2GHz	7GHz
1. Solid Dielectric Coaxial Cable	0.1	-	-	-
2. Foam Dielectric Coaxial Cable	0.04	0.03	0.05	-
3. Waveguide	-	-	-	0.06

Antenna must satisfy the electrical requirements and should preferably be the small-sized, light-weight type. Feeders should preferably be the standard coaxial cable type and, when the allowable transmission loss so requires, should be the low attenuation coaxial cable type.

3) Remote Supervisory and Control System

The remote supervisory and control system must be capable of economical and appropriate operation and maintenance of the communication system so that it can maintain the required performance. It is recommended that the radio repeater stations that constitute the communications system be unattended as far as possible and the system control be centralized at Honiara Maintenance Center. This mean that the Honiara radio terminal station be provided, in principle, with centralized supervisory and control function covering all radio stations in the system.

The remote supervisory and control system generally performs 1) remote supervision, 2) remote control and 3) order wire telephony. For these performances the high reliability is indispensable so that the supervisory and control signalling system to be used must have the function detect wrong signals. The outline of supervisory and control system required in the Solomon Islands domestic telecommunications trunk network is described below.

Figure 4-7 illustrates the system diagram of the supervisory and control system. In this illustration, 1) indicates the trunk network route composition and maintenance zone. Each maintenance zone should have the maintenance center where the centralized supervision of radio station in the zone is carried out. Honiara Station as the master control center carries out the centralized control of system operation and maintenance. 2) indicates the express order wire channel system that connects the maintenance centers and the omunibus order wire channel system that connects all radio stations. 3) indicates the remote supervisory system. It features that the maintenance center will recieve alarms from all supervised stations in its maintenance zone and Honiara Station will receive alarms from all stations in the system. 4) indicates the remote control system featuring the centralized control at Honiara Station. This control system is simplified for economic reasons. That is to say, at the remote station where the radio system with transmission capacity of less than 12 channels branches out the equipment is provided with automatic changeover function so that the station is not remote controlled from Honiara Regional Center.

Main remote control functions are:

a) Working unit-standby unit changeover in transmitting and receiving equipment
b) Engine generator start/stop

4) Carrier Multiplex Terminal Equipment and Connecting Cable

The composition of FDM terminal equipment to be installed in telephone terminal stations of the proposed telecommunications trunk network and the base band frequency arrangement are shown in Figure 4-8. The channel accommo dation plan is based on the circuit demand estimates for the initial stage (1986) and the ultimate stage (2006). Figure 4-9 through Figure 4-12 present the installation plans for each stage.

The cable system will be adopted for the sections where it is technically and economically more advantageous than the radio system. Resultes of comparative study of both systems are summarized below.

a) Entrance Cable

The required entrance cable length is less than 2 km in all the sections studied. The allowable transmission loss in cable sections is 8 dB (Honiara, Gizo, Kirakira and Auki) and 4.5 dB (Tulagi). In these cases, it is technically and economically advantageous to use the standard cable with the mutual capacitance of 50 nF/km applicable to junction cable in the non-loaded system. It is recommended to adopt jelly-filled cable that permits easy maintenance and installation in buried condit system.

b) Toll Cable

With respect to the transmission system for the Tenakaro-Tetere section, the comparative study was made for radio system and toll cable system. The finding is that the radio system is somewhat more advantageous in terms of initial cost but in maintenance cost the toll cable system holds greater advantage. In all-round judgement, there is little or no distinction between the two. However, since the Tetere Telephone Exchange construction plan has not yet been finally decided, the cable system poses difficulty in regard to cable accommodation. Hence the radio system is to be adopted for the Tenakaro-Tetere section.

c) Subscriber Cable

For the Visale and Tambea areas, the subscriber cable installation from the Chapuru radio repeater station can be considered. The allowable transmission loss in the subscriber cable section is 8 dB so that junction cable may be used. Jelly filled cable which is easy to maintain should be used and the direct buried cabling method should be adopted.

5) Power Supply System

In order to ensure high reliability of radio communication system, the selection of optimum power supply system assumes great importance. This selection requires the best consideration of system economy on one hand and easy system operation and maintenance on the other.

In the case of the Solomon Islands domestic telecommunications trunk network, the most part of radio stations that constitute the network will be located in the mountains or on the solitary islands. For this reason, the power supply system to be established in the network is required to be highly reliable and easy to maintain and is preferred to be unattended.

The power supply system which is adopted in the station where commercial power is available and the system for the station without access to commercial power differ. For the former is used the system that normally depends upon commercial power to feed the load but at the time of commercial power failure supplies power from the standby system. The system for the station where commercial power is not available operates always with the in-house generator to make the power supply.

Following is the summary description of the results of study of all power supply systems:

a) Different Types of Power Supply Systems

There are different types of power supply systems that can be applied to the terrestrial radio system. Each power supply system has its merit and demerit.

i) Diesel Engine Generator System

The station that receives the commercial power supply is usually equipped with the standby engine generator system. This standby system operates by the floating charge system and supplies the d.c. output to the load. At the station without access to commercial power, the floating charge system by the alternate operation of two engine generators is commonly adopted. This floating charge system keeps batteries fully charged at all times and ensures the long life of batteries. On the other hand, this system has such demerits as wear and tear of rotary section due to continuous engine operation, large fuel consumption, and frequent overhauls required so that, from the viewpoint of maintenance, it is not an economical system. Figure 4-14 and Figure 4-15 present the typical system diagrams of the two power supply systems mentioned above.

ii) Battery Charge-Discharge System

This system features that the batteries are charged for a fixed length of time and then the discharge current from the batteries is supplied to the load, and then the batteries are charged again. This charge-discharge operation is carried out by two sets of engine generators and storage batteries. A typical system diagram appears in Figure 4-16.

This system is characterized as follows:

a) Since the power supply to the load is by the storage battery discharge, the supplied current does not include the noise ripple.

b) The running time of engine is shorter than in the case of the floating charge system. Hence the small mechanical abrasion of engine. The maintenance period and the engine life can also be lengthened.

c) Fuel consumption is small so that the operation and maintenance cost can be reduced.

d) Apart from the above merits, the power supply capacity is problematical. That is to say, since the d.c. load of 500 to 700 watts forms the economical supply range, this system is advantageous for power supply to the small power consuming load but is not fit for feeding the large power load. Meanwhile, for the feeding system to the small capacity load of 80 to 200 watts, the thermoelectric generator (TEG) system introduced in the next Paragraph is preferred because it reduces the initial cost.

e) Because of the frequent storage battery charges and discharges, the battery life is short.

f) The rotary section contained in the system increases the types and quantities of consumables required, compared with the solar cell system and the TEG system. The indoor floor space required for system installation is also large.

iii) TEG System

This system holds the following characteristics:

a) There is no limit to the applicable ambient temperature.
b) Since no rotary section is used, the wear and tear of the system is limited to some extent.
c) Capacity increase is easy. Only the additional TEG unit installation serves the purpose. Hence the rational initial capacity can be planned.
d) The small size and light weight account for easy installation work. Since all components except the control panel can be installed out-of-doors, the indoor floor space required is relatively small.
e) The same fuel as of the diesel engine can be used.
f) The equipment reliability is high.
g) The TEG unit installation space is subject to restrictions to some extent. Hence the limit to power supply capacity.

Figure 4-17 presents the typical system diagram.

iv) Solar Cell System

Characteristics of this system are as follows:

a) The cell capacity is determined, based on the sunshine volume estimate. It can be safely assumed to be approximately 10 times the load capacity. The holding time of the cell had better be considered to be 0.5 month or so, allowing for no sunshine hours during night. Figure 4-18 is the typical system diagram.
b) Equipment cost is higher than in the case of other systems. The load of 50 watts or so forms the economical power supply limit. At the station of 80 watt capacity, for instance, the cell with approximately 1 kilowatt output power is required and this cell needs the installation floor space of ·pproximately 38m^2. Therefore, when the load is of

large capacity, the acquisition of proper sized land for cell installation is not always easy.

c) Fuel supply is not necessary so that the maintainability is extremely good.

d) Technical information on the solar cell system and the initial costs of various kinds of power supply systems with DC load of 100 - 300 watts are given in the supplementary data attached at the end of this report.

b) Economic Comparison of Different Systems

i) Initial cost

(1) In case of 500 watt load

Charge-discharge system:
¥28,717,000 (US$130,532)

Floating charge system:
¥15,717,000 (US$71,441)

TEG system:
¥31,274,000 (US$142,155)

(2) In case of 80 watt load

TEG system:
¥8,249,000 (US$37,495)

Solar cell system:
¥16,892,000 (US$76,782)

ii) Annual Running Cost

(1) In case of 500 watt load

Charge-discharge system:
¥896,000 (US$4,073)

Floating charge system (double engine system):
¥2,313,000 (US$10,514)

TEG system:
¥2,831,000 (US$12,868)

(2) In case of 80 watt load

TEG system:
¥708,000 (US$3,218)

Solar cell system:
¥7,000 (US$32)

c) Optimum System

Based on the result of the above study, the optimum power supply system for each type of station is recommended as follows:

i) AC mains station

The floating charge system by the standby engine generator is recommended.

ii) Self-powered station

(1) Station where d.c. load power is 500 watts or more.

The floating charge system by dual engine generators is recommended.

(2) Station where d.c. load power is 400 watts or less.

The TEG system is recommended. The reason is that this system excels the floating charge system in equipment reliability and ease of operation and maintenance, and suits the geographical condition of the Solomon Islands.

For station by station power consumption estimates, refer to Table 4-8.

Table 4-8 Estimation of Power Consumption at Stations

Station	Power Consumption		
	DC -24V(W)	AC 3ø(VA)	AC 1ø (VA)
1. Honiara	1,360	10,000	3,500
2. Tenakaro	290		2,500
3. Tetele	260		2,500
4. Tulagi	260		2,500
5. Ruavatu	2,275		2,500
6. Kiu	80		1,500
7. C. Hartig	6,295		3,500
8. Marau	80		1,500
9. Rennel	2,805		2,500
10. Kirakira	2,000	16,000	3,500
11. Hadja	80		1,500
12. Santa Cruz	225	16,000	3,500
13. Auki	860		2,500
14. Buala	915		2,500
15. Lalande	240		1,500
16. Malu'u	240		1,500
17. Takwa	360		1,500
18. Sulufou			
19. Yandina	140		1,500
20. Allardyce	685	20,000	3,500
21. Oretecove	835	10,000	3,500
22. Sasamungga	220		1,500
23. Taro	80		1,500
24. Mbarakoma	80		1,500
25. Gizo	540		2,500
26. Noro	180		1,500
27. Munda	260		1,500
28. Seghe	80		1,500

d) System Maintenance

Maintenance visit to each station is to be made once every six months, in principle. The station equipped with dual engine generators is to receive the maintenance visit once every two months because the limit to continuous running time of engines is set at approximately 720 hours. Maintenance periods and maintenance Personnel by systems are given in Table 4-9. Fuel tank capacity is so designed that the continuous engine running for the undermentioned time lengths is possible.

i) Station equipped with standby engine generator: 1 month

ii) Station equipped with dual engine generators
Allardyce Station: 3 months
Other stations: 2 months

iii) Station equipped with the TEG system: 6 months

Table 4-9 Maintenance Personnel & Period Required

System	Number of Maintenance Visits (per year)	Personnel & Days Required
Dual Prime DEG	6	2 persons x 3 days
C/D system	2	2 persons x 3 days
TEG System	2	1 person x 3 days
Solar cell system	2	1 person x 3 days
Standby DEG	2	2 persons x 2 days

(3) Tower and Antenna

The requirements that apply to the tower and antenna must be determined after full technical and economic studies. The tower strength is designed to endure the overland wind velocity of 45 m/sec. For antenna, consideration is made to use the light-weight antenna in order not to affect the tower strength adversely. Following is the outline of tower and antenna to be used:

1) Tower

The tower height is determined in consideration of the antenna height above ground which is required in the section concerned. In the troposcatter section the large aperture antenna is used and, since the required antenna height is relatively low, the self-supporting tower is adopted. Figure 4-19 is the typical layout of the self-supporting tower. The guyed mast is economical because, as the tower height increases, the work cost decreases, compared with the self-supporting tower. Figure 4-20 is the typical layout of the guyed mast.

2) Antenna

The requirements applicable to the antenna must be determined in consideration of such technical matters as radio propagation characteristics and radio interference. As already stated, the light-weight and low-cost antenna, compatible with the technical requirements for antenna, is used so as to reduce the tower cost. The undermentioned criteria by which to reduce the tower cost. The undermentioned criteria by which to use the antenna are specified in accordance with the abovementioned standard.

a) For the 2 GHz band (troposcatter section) large aperture antenna, the plate type parabolic antenna is to be used.
b) For the 900 MHz band antenna, the relatively light-weight grid parabolic antenna is to be used. The antenna size is to be determined according to the required antenna gain and directivity.
c) For the 400 MHz band antenna, the grid parabolic antenna and the Yagi antenna are to be used as specified below.

(1) Mountain diffraction or spherical earth diffraction section: Grid parabolic antenna.
(2) Line-of-sight section: Yagi antenna

Figure 4-21 is the reference diagram showing the tower and antenna types and antenna heights according to stations.

The final requirements for tower and antenna are determined at the time of detail design.

(4) Site and Building

The basic requirements applicable to the site selection have already been described in Paragraph 4-5-1. The site layout must be prepared, taking into consideration the proper arrangement of station building, tower, fuel tank, water tank, parking area and so forth. For station buildings, the equipment shelters are utilized except where the existing buildings can be used for station buildings. Typical examples of site layouts are given in Figure 4-22 and Figure 4-23.

(5) Radio Frequency Allocation Plan

The basic requirements pertinent to the radio frequency allocation plan are outlined below.

1) Radio Frequency Allocation

a) 900 MHz band is to be used in the line-of-sight section (transmission capacity: 60-channel or more) so as to reduce the equipment cost.

b) 2 GHz band is to be used in the troposcatter section. To use 2 GHz band after the comparison between 2 GHz band and other frequency bands in terms of basic transmission loss, fading depth and antenna gain on the troposcatter propagation path is technically and economically advantageous.

c) 400 MHz band is suitable for the section other than the above a) and b) sections, where the transmission capacity is relatively small. This frequency band is distributed to fixed and mobile communications by the International Telecommunications Treaty. Since this distributed band is broad, mutual frequency interference can be easily avoided.

2) Radio Frequency Arrangement

Figure 4-24 gives an example of radio frequency arrangement. This arrangement is based on the following basic requirements:

a) 2 GHz band: In compliance with CCIR Rec. 382.

b) Other frequency bands: Arranged by the following methods; (1) To comply with the frequency classification by service types as stipulated in the International Telecommunications treaty; (2) To make frequency allocation, based on the balanced frequency arrangement and in consideration of economical equipment design.

(6) Noise Performance Analysis

1) Noise Allocation

For noise allocation, consideration is made in order that the allowable noise level recommended by CCITT will be satisfied at Honiara, the international exchange station. More specifically, to the basic trunk (i.e., the circuit that connects the Primary Center and Local Exchange designed in the initial stage), the allowable noise level of 10,000 pWOp (S/N = 50 dBp)based on CCITT Rec. G-123 is applied. To the circuit that branches from the basic trunk and extends to the local radio station, another 10,000 pWOp is distributed, taking the system operation economy into consideration. This means that the noise power at the international exchange station increases to 20,000 pWOp in the worst case but, considering its S/N which stands at 47 dBp, such is not the noise performance that poses a problem in a practical sense. Table 4-10 is the table of noise distribution based on the above consideration. The noise power shown in this table shows the mean noise power. The allowable noise power applicable to the radio section is so established that the 99.9% service reliability can be secured. That is to say, the design parameters are so established that in 99.9% hours of each month the circuit interruption due to threshold will not take place.

Table 4-10 Noise Allocation for The Proposed Radio System

1. Noise Allocation for The Backbone System between Primary Centre and Local Exchange

- Total allowable Noise 10,000pWOp(50dBp)
  - Radio Link Noise 7,500pWOp(51.3dBp)
    - Thermal noise at Receiver input 4,500pWOp(53.5dBp)
    - Equipment thermal/intermodulation noise, 1,500pWOp(58.2dBp)
    - Interference noise, 1,000pWOp (60dBp)
    - Feeder echo and propagation distortion noise, 500pWOp(63dBp)
  - Multiplex equipment noise 2,500pWOp(56.0dBp)

2. Noise Allocation for the Spur Line branching from The Backbone System

- Total allowable noise
  - Radio link noise 8,500pWOp(50.7dBp)
    - Thermal noise at receiver input 6,000pWOp(52.2dBp)
    - Equipment thermal/intermodulation noise, 1,500(63dBp)
    - Interference noise, 500pWOp(58.2dBp)
    - Feeder echo and propagation distortion noise, 500pWOp(63dBp)
  - Multiplex equipment noise 1,500pWOp(58.2dBp)

2) Noise Calculation

In order to estimate the noise performance between circuit terminals of the terrestrial radio system to be adopted to constitute the Solomon Islands domestic telecommunications trunk network, the propagation calculations of all kinds were carried out for all radio sections. That is to say, the total circuit noise was calculated, using the parameters shown in Paragraph 4-5-5 (1). The results of calculations appear in Table 4-11. Table 4-12 through Table 4-15 carry the results of calculations made in the course of total circuit noise calculations. All these calculations were made with the small-sized program computer.

As is evident in Table 4-11, the mean noise at each circuit terminal satisfies the design objective. For the 99.9% value also, S/N is above 30 dBp in the worst section. This fact indicates that the practically reliable circuit formation is possible

Table 4-11 Estimation of Noise Power in Voice Circuits between Honiara Zone Centre and Local Exchanges

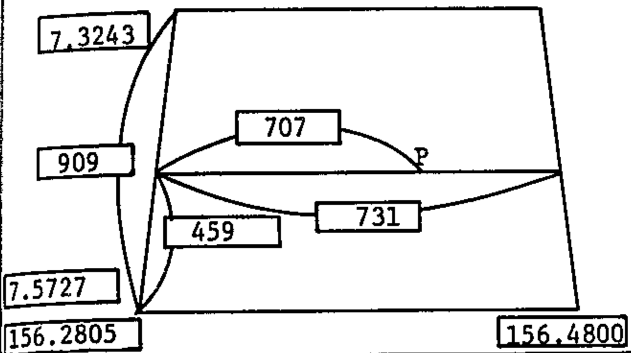
Circuit	Noise Power for 50% of Time (pWOp)	Signal-to-Noise Ratio for 99.9% of Time (dBp)
Honiara - Santa Cruz	3,596	30.9
Honiara - Rennel	3,519	31.7
Honiara - Buala	1,697	39.4
Honiara - Malu'u	4,206	53.1
Honiara - Tenakaro	502	60.0
Honiara - Tulagi	502	61.5
Honiara - Yandina	3,944	53.5
Honiara - Noro	4,155	31.7
Honiara - Munda	4,202	31.7

Note: For design objectives to the noise power refer to the previous paragraph, 1) Noise Allocation.

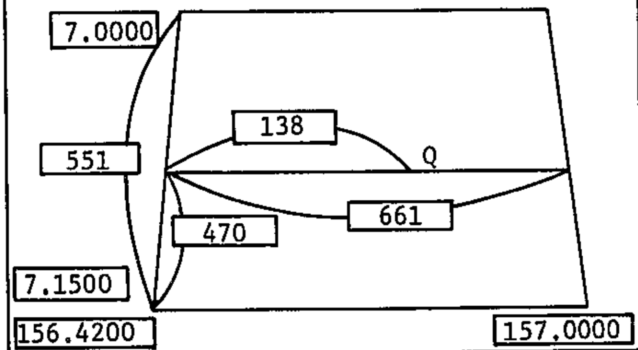
Table 4-12 PROPAGATION PATH DATA	Path No. 22

Site P	Oretecove	——	Site Q	Sasamungga

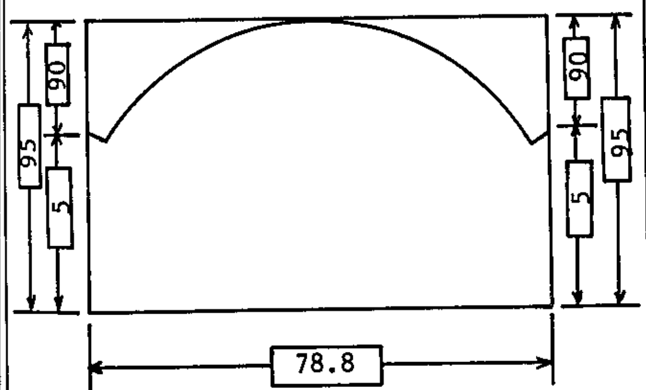
Map No. 7/156/11



Map No. 7/156/4



Long-1 (D.MS)	156.2805 ***	Long-1 (D.MS)	156.4200 ***
Long-2 (D.MS)	156.4800 ***	Long-2 (D.MS)	157.0000 ***
Lati-1 (D.MS)	7.5727 ***	Lati-1 (D.MS)	7.1500 ***
Lati-2 (D.MS)	7.3243 ***	Lati-2 (D.MS)	7.0000 ***
X 1-2 (mm)	731.0 ***	X 1-2 (mm)	661.0 ***
X 1-0 (mm)	707.0 ***	X 1-0 (mm)	138.0 ***
Y 1-2 (mm)	907.0 ***	Y 1-2 (mm)	551.0 ***
Y 1-0 (mm)	457.0 ***	Y 1-0 (mm)	470.0 ***
Long. (D.MS)	156.4721 ***	Long. (D.MS)	156.4545 ***
Lati. (D.MS)	7.4459 ***	Lati. (D.MS)	7.0212 ***
G. Elevation	5 (m)	G. Elevation	5 (m)
Profile No.	22	Type of Path	Spherical earth diffraction



Path Distance & Azimuth

Long-P (D.MS)	156.4721 ***
Lati-P (D.MS)	-7.4459 ***
Long-Q (D.MX)	156.4545 ***
Lati-Q (D.MS)	-7.0212 ***
d (Km)	78.8 ***
αP→Q (D.MS)	357.5137 ***
αQ→P (D.MS)	177.5149 ***

Estimated diffraction loss

F	400.0 ***
D	78.8 ***
H1	95.0 ***
H2	95.0 ***
X0	938.9 ***
X1	478.5 ***
X2	478.5 ***
G(X0)	23.0 ***
F(X1)	-5.0 ***
F(X2)	-5.0 ***
In case of K=4/3:	
A	12.5 ***
X0	1136.4 ***
X1	501.7 ***
X2	501.7 ***
G(X0)	35.0 ***
F(X1)	-3.0 ***
F(X2)	-3.0 ***
In case of K=1:	
A	20.5 ***

Table 4-13 Basic Transmission Loss in a Troposcatter Path

Item	Symbol Used	Unit	Honiara - Allardyce
Radio frequency	f	MHz	2000.0 ***
K-factor	K	-	1.50 ***
Path distance	D	km	232.8 ***
Elevation of Transmitting site	hto	m	70.0 ***
Transmitting antenna height	hat	m	14.5 ***
Average elevation of Tx site	ht	m	0.0 ***
Distance from Tx site to horiz.	dLt	km	40.2 ***
Horizon obstacle height	hLt	m	0.0 ***
Elevation of Receiving site	hro	m	40.0 ***
Receiving antenna height	har	m	14.5 ***
Average elevation of Rx site	hr	m	0.0 ***
Distance from Rx site to horiz.	dLr	km	32.3 ***
Horizon obstacle height	hLr	m	0.0 ***
Transmitter horizon angle	o	mr	6.59 ***
Receiver horizon angle	o	mr	9.32 ***
Scatter angle	θo	mr	15.91 ***
Path asymmetry	S	-	0.71 ***
Horizon intersect height	ho	m	895.5 ***
Product of D and θo	Dxθo	km.rad	3.7 ***
Effective distance	de	km	260.4 ***
Attenuation function	F(Dxθo)	dB	146.0 ***
Adjustment for Lsr	Vn(50,de)	db	0.0 ***
*Median basic loss	*Lsr	dB	197.7 ***
*Median basic loss	*Lsr	dB	197.7 ***
Transmitting antenna gain	Gt	dB	49.5 ***
Receiving antenna gain	Gr	dB	49.5 ***
Path antenna gain	Gp	dB	82.8 ***
Median basic loss	Lsr	dB	114.9 ***

Note; Tx - Transmitting
Rx - Receiving.

Table 4-14 Thermal Noise in Free Space

Item	Symbol Used	Unit	Honiara - Tenakaro fo=900MHz	Honiara - Tulagi fo=900MHz	Honiara - Ruavatu fo=900MHz
Radio frequency	f	MHz	900.0 ***	900.0 ***	900.0 ***
Transmitting power	Pt	dBm	37.0 ***	37.0 ***	37.0 ***
Receiver noise figure	NF	dB	7.0 ***	7.0 ***	7.0 ***
Branching filter loss	Lb	dB	2.6 ***	2.8 ***	2.8 ***
Baseband top frequency	fh	KHz	300.0 ***	300.0 ***	552.0 ***
Test tone deviation	So	KHz·rms	100.0 ***	100.0 ***	200.0 ***
Threshold level	Pth	dBm	-90.2 ***	-90.2 ***	-90.2 ***
Feeder loss per meter	Lf/m	dB/m	0.025 ***	0.029 ***	0.029 ***
Path length	D	Km	17.1 ***	43.1 ***	48.2 ***
Free space loss	Po	dB	116.2 ***	124.2 ***	125.2 ***
Transmitting ant. dia.	Dia.t	mϕ	2.0 ***	4.0 ***	4.0 ***
Transmitting ant.gain	Gt	dB	22.5 ***	28.5 ***	28.5 ***
Transmitting feeder length	Dft	m	30.0 ***	25.0 ***	60.0 ***
Transmitting feeder loss	Lft	dB	0.9 ***	0.7 ***	1.7 ***
Receiving ant.dia	Dia.r	mϕ	2.0 ***	4.0 ***	4.0 ***
Receiving ant.gain	Gr.	dB	22.5 ***	28.5 ***	28.5 ***
Receiving feeder length	Dfr	m	30.0 ***	25.0 ***	65.0 ***
Receiving feeder loss	Lfr	dB	0.9 ***	0.7 ***	1.9 ***
Total feeder loss	Lf	dB	1.7 ***	1.5 ***	3.6 ***
Receiving input level	Pr	dBm	-38.7 ***	-34.5 ***	-37.6 ***
Threshold margin	Mth	dB	51.5 ***	55.7 ***	52.6 ***
S/N in free space	S/No	dBp	90.3 ***	94.6 ***	92.2 ***
Thermal noise	No	pWp	0.9 ***	0.3 ***	0.6 ***
No/47500	-	%	0.00196 ***	0.00073 ***	0.00128 ***
No/10^6	-	%	0.00017 ***	0.00006 ***	0.00011 ***