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No. 8

THE REPUBLIC OF BOLIVIA

FEASIBILITY STUDY REPORT

ON

THE NATIONAL TELECOMMUNICATION

NETWORK PROJECT

MAY 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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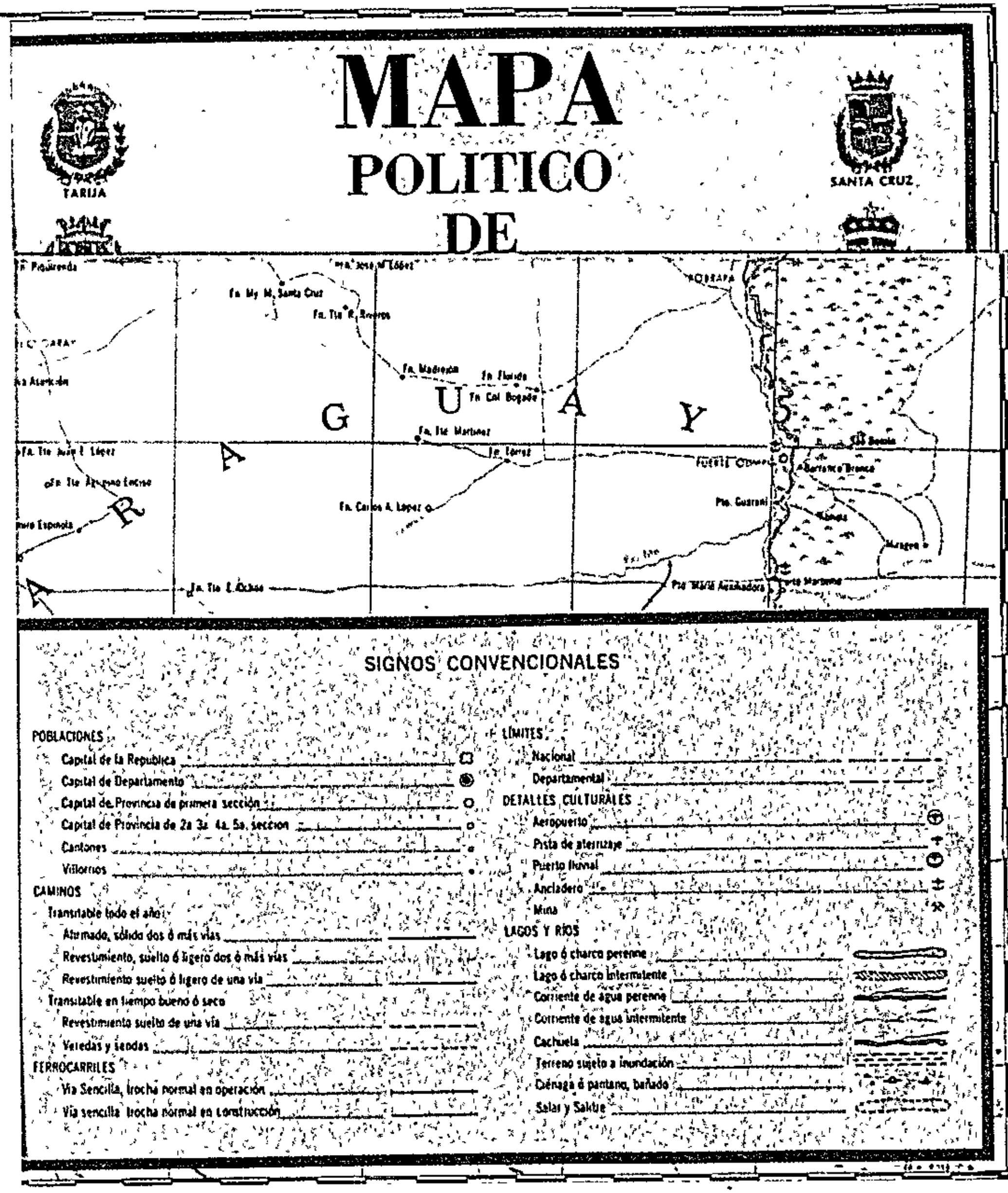
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Capital de Departamento
Capital de Provincia de primera sección
Capital de Provincia de 2a 3a 4a 5a sección
Cantones
Villorrios
CAMINOS
Transitable todo el año
Afirmado, sólido dos ó más vias
Revestimiento, suelto ó ligero dos ó más vias
Revestimiento suelto ó ligero de una via
Transitable en tiempo bueno ó seco
Revestimiento suelto de una via
Veredas y sendas
FERROCARRILES
Via Sencilla, trocha normal en operación
Via sencilla trocha normal en construcción
LIMITES
Nacional
Departamental
DETALLES CULTURALES
Aeropuerto
Pista de aterrizaje
Puerto fluvial
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Mina
LAGOS Y RIOS
Lago ó charco perenne
Lago ó charco intermitente
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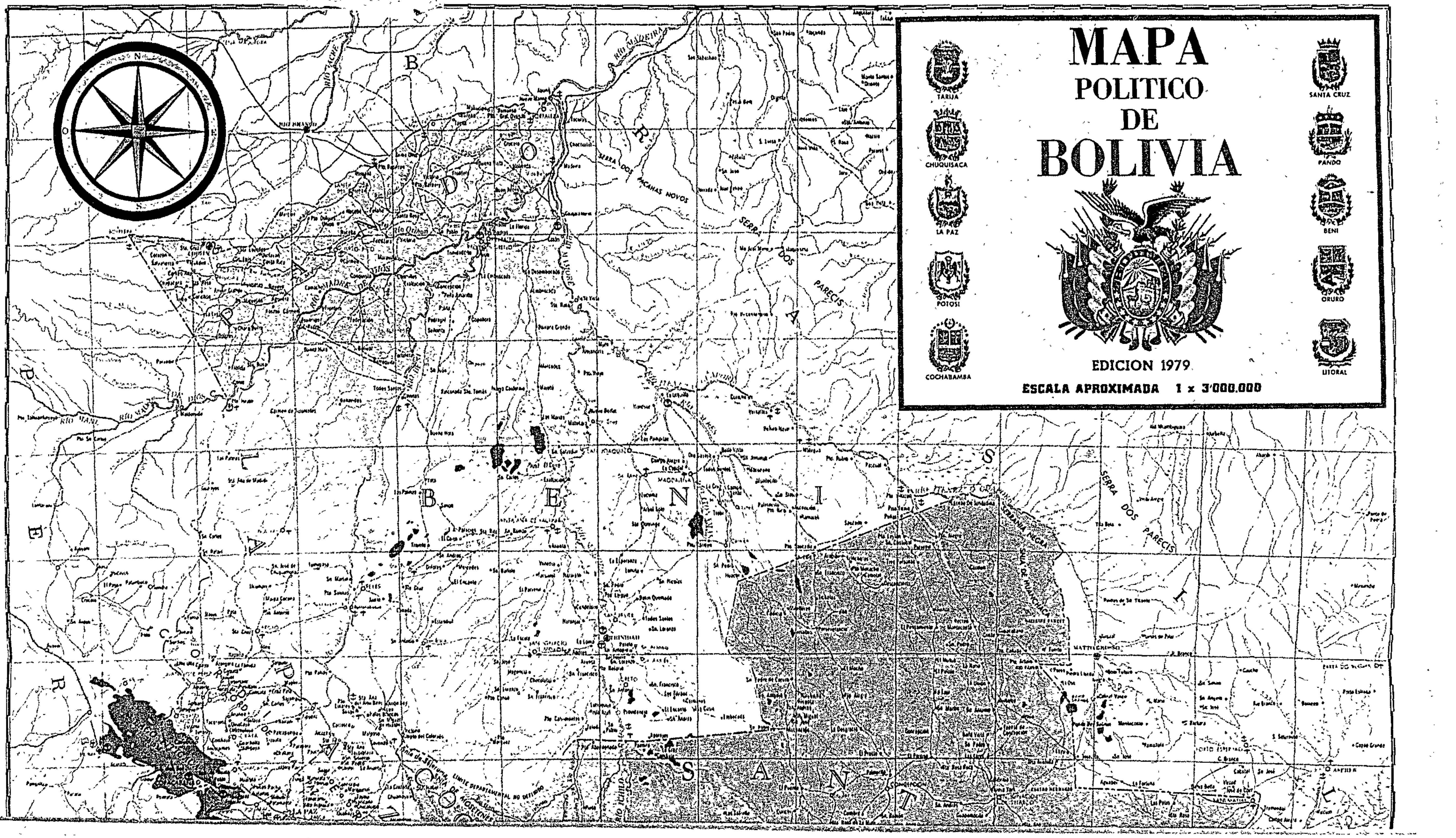
Cachuela
Terreno sujeto a inundación
Ciénaga ó pantano, bañado
Salar y Salitre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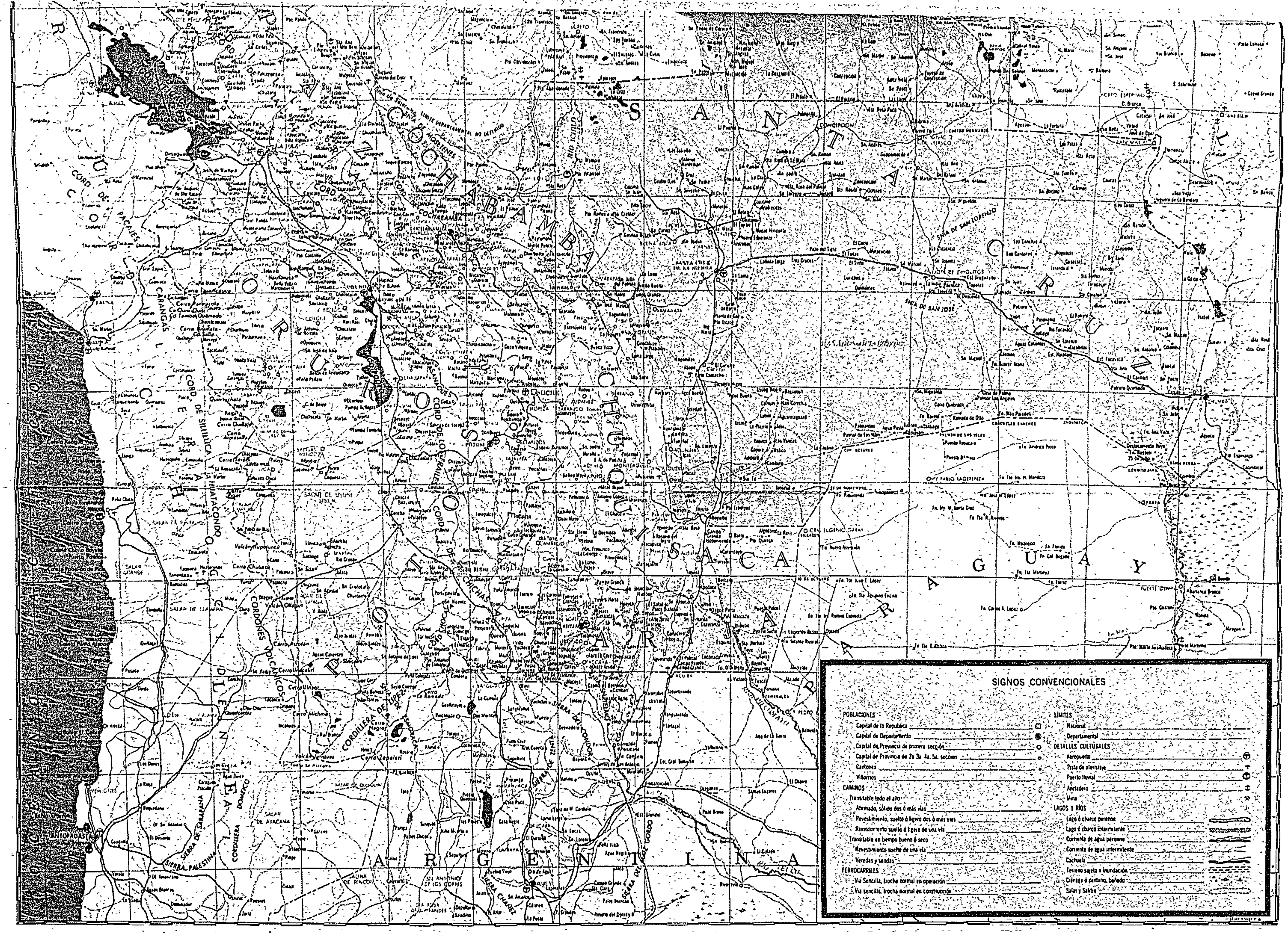

SANTA CRUZ
COCHABAMBA
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TARIJA
PARAGUAY
ARGENTINA
PERU
CHILE
ANTOFAGASTA
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PREFACE

In response to the request of the Government of the Republic of Bolivia, the Government of Japan decided to conduct a feasibility study on the National Telecommunecation Network Project and entrusted the survey to the Japan International Cooperation Agency (JICA).

The JICA sent to Bolivia a survey team headed by Mr. Ryoji Sasaki, Special Advisor for International Cooperation, International Cooperation Division, Minister's Secretariat, Ministry of Posts and Telecommunications, from October 1 to December 9, 1981.

The team had a series of discussions with the officials concerned of the Government of Bolivia and conducted a field survey.

After the team returned to Japan, further studies were made and the present report has been prepared.

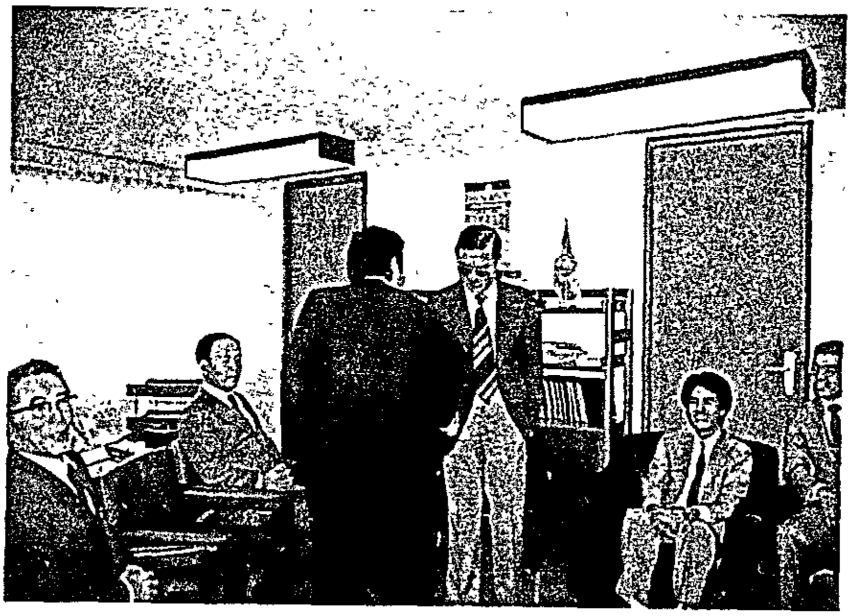
I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

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

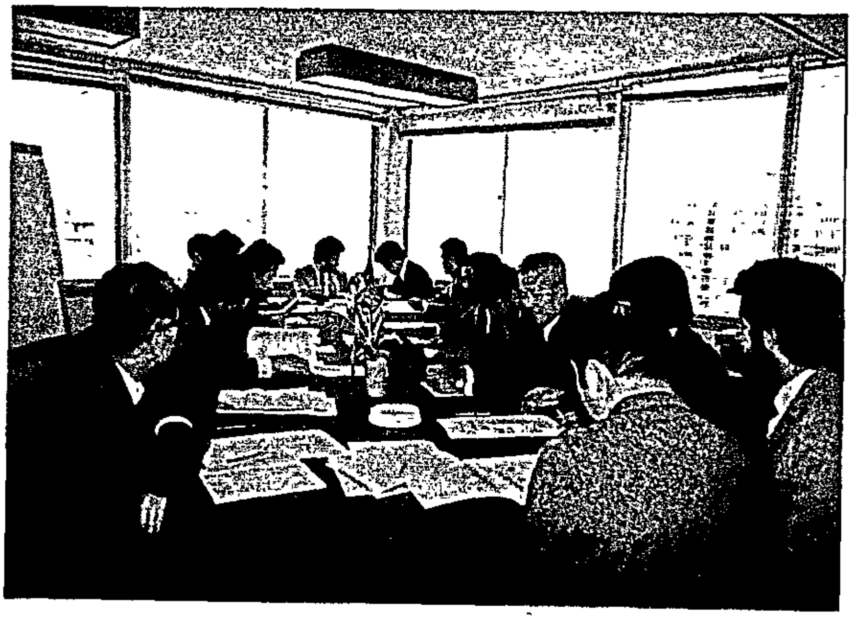
May 1982

Keisuke Arita
President
Japan International Cooperation Agency

Courtesy call on Director of DGT



Courtesy call on Director of ENTEL



Meeting with ENTEL and CEPITEL

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SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

1. Background

The Government of the Republic of Bolivia requested the Japanese cooperation with a view to implementation of the telecommunications network improvement and expansion program of that country. In response to the request, Japanese Government dispatched a preliminary investigation team for a period from June 22 through July 9, 1981.

The team exchanged views with the competent government agencies of Bolivia and obtained first-hand information concerning the working details of the program. By means of field surveys for part of the projected system route, the team collected necessary data and, at the same time, agreed with the Bolivian Government in regard to the Scope of Work of the feasibility study.

Then, for a period of 70 days from October 1 through December 9, 1981, Japanese Government dispatched the "Feasibility Study Team for the Telecommunications Network Improvement and Expansion Program of the Republic of Bolivia."

The feasibility study team performed its duty in accordance with the Scope of Work formulated by mutual agreement in the preliminary investigation. The team carried out field surveys to gather information relationg to the route plan, demand and traffic forecasts, system design, and economic evaluation of the project. All the collected information and data were analyzed for in-depth study, and, about the study results, a full coordination of views was made with the project related organizations of Bolivia.

This report, prepared by the feasibility study team after its return to Japan, is based on all such information and data duly coordinated and adjusted as aforementioned.

2. Summary

This study was carried out for the purpose of telecommunications network improvement and expansion in medium and small cities mainly in the southwestern region of Bolivia.
The outline of the telecommunications network improvement and expansion plan is as follows:

1) Construction of Local Telephone Offices and Outside Plants in 12 Medium and Small Cities

The total number of line units to be established in all 12 projected local telephone offices will be 8,100 line units in the initial stage and 13,900 line units in the ultimate stage.

For the outside plants, a total of 201 Km long subscriber cable system will be constructed.

2) Establishment of Toll Public Telephone Facilities in Remote Areas

Toll public telephone facilities utilizing the MAS system will be established in a total of 59 remote areas.

3) Construction of Toll Transmission Routes

In order to interface the above-mentioned local telephone offices and the toll public telephone facilities in remote areas with the existing transmission system, the microwave system will be newly constructed in 21 sections, the UHF system in 19 sections, and the VHF system in 69 sections.

4) Equipment Types

In the formulation of the implementation program for this Project, a full coordination of views with ENTEL was accomplished. As a result, decision was made to adopt the digital equipment for the switching system and the analog equipment for the transmission system. The latter is to facilitate the interface with the existing transmission system.

5) Work Period and Cost

This Project will be completed about 2.5 years after the signing of contract with the Contractor. The Project implementation cost is estimated at ¥7,841,310,000 for the Japanese yen portion and $b381,140,000 for the local currency portion.

6) Economic Evaluation

The economic evaluation of the Project implementation shows that the economic internal rate of return (IRR) is 9.87%. The financial IRR is 7.65% and, if a subsidy from the Bolovian National Treasury is available, is 8.51%.

7) Projects Merits

By the implementation of this Project, the subscriber trunk dialling system will become available for mutual connections among the seven major cities of Bolivia and among 12 medium and small local cities in the southwestern region of the country. At the same time, the telecommunications network in remote areas in the southwestern region will be remarkably improved.

3. Conclusions

Presently, in major seven cities of Bolivia, the telecommunications network is in good shape. However, the effective communication media to interrelate the mining, agricultural and livestock farming centers as the backbone of economic development of Bolivia has not yet been established in the desired state.

The promotion of agriculture and livestock farming, in particular, assumes utmost importance. The construction of roads to and from those lical centres is being hastened.

Mining is a staple industry of the country. Nevertheless, the communication media presently available to the mining offices are the mere leased lines by short wave and open wire provided by the Mining Corporation (COMIBOL).

From the viewpoint of industrial development, as well as regional administration, in Bolivia, it is desirable and even imperative that the telecommunications network improvement and expansion project be implemented at the earliest possible opportunity.

The three-fold economic evaluation of the project, i.e., from 1) the investment effect analysis from the angle of national economy, 2) financial returns, and 3) the business management capability of ENTEL as the project implementation entity, arrives at a conclusion that the project implementation is feasible.

In further details:

(1) The economic internal rate of return, 9.87%, of the project that includes the development of rural areas attests to the implementation feasibility when the opportunity cost of capital is considered.

(2) The utilization of subsidy grant from the national treasury makes the project implementation financially feasible also. That is to say, the financial internal rate of return is:

Without subsidy grant	7.65%
With subsidy grant	8.51%

(3) From the profit ratio of net worth, 13.51%, ENTEL's own fund management for project implementation is considered to stable from the long range viewpoint.

4. Recommendations

(1) Local telephone exchanges in various areas are presently operated by private companies. ENTEL should place all those local exchanges under its control and operate them more effectively and at higher efficiency from the viewpoint of single command management of telecommunications services.

(2) The 12 local exchanges to be newly established by this project are the first in Bolivia to operate with the digital switching equipment. Fully organized training is necessary for maintenance and operation personnel to take care of those 12 exchanges.

Subscriber cable maintenance is a brandnew maintenance category for ENTEL. Hence, for maintenance personnel in this division also, as much organized training as for switching equipment maintenance staff is required.

(3) As regards the exchange building and access road construction, ENTEL holds sufficient experience. Furthermore, this construction work can be financed by the local currency budget. Hence, ENTEL should carry out this construction work at its responsibility.

(4) The tariff system should be reviewed and revised, so as to maintain the newly invested capital effectively.

(5) The local currency portion be procured from domestic sources in Bolivia, including ENTEL's fund on hand.

(6) Stable fund procurement for the project implementation should be realized, including the subsidy grant from the national treassury. This is important for the wholesome management of the telecommunications network and facilities.

(7) This project is an integral long-distance toll transmission system project comprising the installation of switching facilities and subscriber cable facilities and the construction of microwave system and UHF/VHF system. In order to have the whole project completed without trouble within the prescribed work period, the best means is to employ the qualified Consultant.

CHAPTER I
INTRODUCTION

CHAPTER 1 INTRODUCTION

This report is to make sure of the viability of the Telecommunications Network Improvement and Expansion Program of the Republic of Bolivia, the main objectives of which are to expand the long distance direct dialling telephone network, to establish remote subscriber telephone facilities in rural areas, and to construct new telephone exchanges in middle- and small-sized cities.

For the backbone toll transmission system in Bolivia, the microwave transmission system that interconnects the principal cities, i.e., La Paz, Cochabamba, Santa Cruz, Oruro, Sucre, Potosi and Tarija, is already in operation. However, for

1) Remote cities of Villazon, Bermejo and Yacuiba in the southern border area adjoining Argentina,
2) Camiri, a city that now propospers as an oil-producing center,
3) Mining cities centering around Atocha, and
4) Caranavi and Punata, the growth cities as agricultural and livestock farming centres,

the toll transmission routes have not yet been established, posing a bottleneck to the industrial development.

This Project is to provide the toll transmission system to interconnect those cities in rural areas, to install switching and subscriber cable facilities in 12 medium and small cities, and to construct remote subscriber telephones in 59 areas.

This report describes the telephone demand and traffic forecast results, as well as the proposed network configuration and system architecture, for the whole field survey areas based on the Scope of Work agreed upon between the survey team and the Government of Bolivia. The survey areas comprise La Paz, Oruro, Cochabamba, Potosi, Chuquisaca and Tarija Provinces. The economic evaluation of the Project is also contained in this report.

For the line-up of study team members and the field survey itinerary, see Annex VII and Annex VIII.

The system envisaged by this Project mainly covers the telecommunications facilities for medium and small cities and remote communities. Since no much operating revenue can be expected from the system after its service-in, the system construction cost is controlled to the economically justifiable level.

CHAPTER 2
OUTLINE OF THE PROJECT

CHAPTER 2 OUTLINE OF THE PROJECT

2-1 Keynote of Implementation

Presently, in Bolivia, telecommunication services are extremely insufficient except in such big cities as La Paz and Santa Cruz. In rural areas, services are provided by magneto telephones and/or short wave communication. Therefore, as the integral development of rural areas makes progress, the importance of telecommunication system improvement and expansion continues to increase.

This background is reflected in the keynote of project implementation. It consists of these three points:

1. To expand the long-distance automatic trunk dialling network;

2. To provide remote subscriber telephones in rural areas;

3. To establish telephone exchange stations in medium-sized cities.

2-2 Selection of Local Communities

Local communities where to extend this Project have been selected, based on the Preliminary National Telecommunication Plan made by CEPITEL, as well as the information obtained by field surveys. Local communities selected as being eligible for coverage by this Project are listed in Table 2-1.

Some of local communities are of relatively small importance to the development of local societies so that the construction of telecommunication systems costs too much for the return on investment. Those local communities are excluded from the investment list this time.

2-3 Expansion of Long-Distance Automatic Trunk Dialling Network

The long-distance automatic trunk dialling network to be newly established is shown in Figure 2-1. The transmission route will be composed of the microwave, UHF and VHF systems. The existing transmission routes are of analog type so that, to facilitate the interconnection, the new transmission route will also be the analog type.

As regards the existing automatic switching equipment at Tupiza and Villazon Exchanges, the direct connection to the projected new long-distance automatic trunk dialling network is technically difficult. Therefore, the manual toll board will be installed at those two exchanges for the purpose of operator trunk dialling.

2-4 Remote Subscriber Telephones

Public telephone services in remote areas, which are now provided by magneto telephones and/or by short wave communication, will be changed to the automatic system by means of VHF system to be newly established.

The person in charge of tariff collection and call monitoring will be assigned to duty at each local community to be equipped with remote subscriber telephone facilities. This is the same as at present.

Local communities where remote subscriber telephones will be installed are as per Table 2-1. The average two telephones will be installed at each such local community.

2-5 Establishment of Exchanges in medium-Sized Cities

Digital type electronic switching equipment will be installed in the telephone exchanges to be newly established in medium-sized cities. The switching equipment will be the stationary type that allows capacity expansion up to 4,000 line switches at the final stage.

For the subscriber cable network, the aerial system will be adopted as far as possible.

The scheduled new exchange locations appear in Table 2-1.

Table 2-1(1/2) Outline of the Project

CR	CG	CL	REMOTE TELEPHONE
La Paz	La Paz	*La Paz	Corocoro Patacamaya Sicasica Achacachi
		*Viacha	
		Copacabana	Mina-Matilde Guaqui Desaguadero Huarina Huatajata
		*Cobija	
	Caranavi	Coroico	
		Caranavi	Guanay Tipuani
		Chulumani	Irupana Coripata Chojlla
	Oruro	*Oruro	Caracollo Antequera Colquiri Morococala Santa-Fe Challapata Eucaliptos
		Llallagua (Siglo XX, Uncia Catavi)	Chayanta
		Huanuni	
Cochabamba	Cochabamba	*Cochabamba	Villa-Tunari Colomi Pto. Villarroel Mizque Totora Irupa-Irupa Aiquile Capinota

Note: * means the existing exchange

Table 2-1(2/2) Outline of the Project

CR	CG	CL	REMOTE TELEPHONE
Cochabamba	Cochabamba	Punata	Tiraque Arani Ucureña Cliza Tarata
Potosi	Potosi	*Potosi	Betanzos
		Uyuni	
		Atocha (Telamayu)	Animas Santa-Barbara Tazna Tatasi Vetilla Siete-Suyos Pulacayo Santa-Ana Quechisla
	Tupiza	*Tupiza	
		*Villazon	
	Sucre	*Sucre	Tarabuco Yamparez
	Tarija	*Tarija	San-Lorenzo Culpina Concepcion Padcaya Cotagaita
		Camargo	Las-Carreras Villa-Abecia
		*Villamontes	
		Camiri	Boyuibe Charagua
		Monteagudo	
		*Yacuiba	Sanandita El-Palmar Carapari
		*Bermejo	

Note: * means the existing exchange

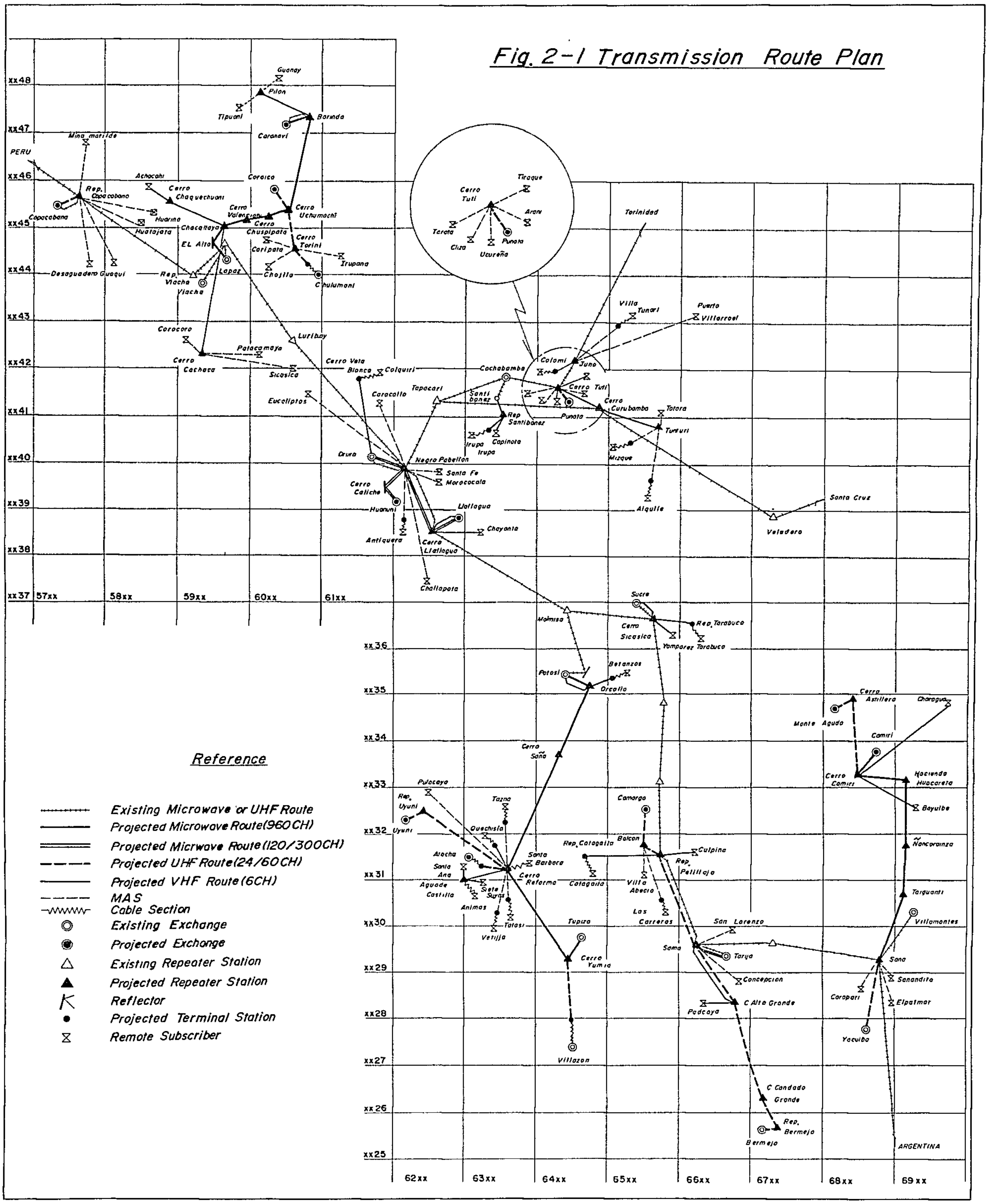


Fig. 2-1 Transmission Route Plan

CHAPTER 3
TELEPHONE DEMAND FORECAST

CHAPTER 3 TELEPHONE DEMAND FORECAST

3-1 General Remarks

In Bolivia, the telecommunications business is managed by the Direccion General De Telecommunicaciones (DGT) which is a Government organization, the Empresa Nacional De Telecommunicaciones (ENTEL) and private telecommunications companies. Services are planned separately by each organization.

For the country as a whole, telephone services are far from being satisfactory. Many areas are without telephones. Even in the areas where toll calls are possible, the service is provided in not a few cases by the poorly equipped short wave system or even by open wires.

This Project is to improve the telephone services in general, eliminating the no-telephone areas, initiating automatic trunking of toll calls, and readjusting the telephone network. The scope of project will be determined, based on the result of feasibility study by means of economic evaluation.

The areas to be covered by this Project are six provinces comprising La Paz, Cochabamba, Oruro, Potosi, Chuquisaca and Tarija.

The telephone demand forecast covering those six provinces is an estimate from the past records and the status quo. Generally, in a long period, unpredictable social and economic changes are apt to take place. Therefore, as stated in CCITT Manual, "National Telephone Networks for the Automtic Service," constant care and attention are necessary to review the plan and correct it where required so that it may not be isolated from the realities.

For demand forecast, various approaches are available. The methods of demand forecast for telecommunication services include the following:

(1) Historical extrapolation method

(2) Regression from causal relations method

(3) Intuitive forecast method

(4) Normative forecast method

The telephone development stages comprise the initiatory stage, expansion stage, popularizing stage and popularized stage, as shown in Table 3-1 and Figure 3-1. The demand forecast method fit for each development stage must be considered. The fact that even in the same country the development stages differ according to areas must be taken into consideration in the telephone demand forecast.

In this Project, the telephone demand forecast is made, based on Comisions Especial Del Plan Integral De Telecommunicaciones (CEPITEL) proposed "Plan de la Red Nacional de Telefonía," in principle. For the macroscopic demand forecast, the forecast model formula as shown in Paragraph 3-2 is worked out from the data collected in the survey, and the forecasted value by such formula is compared with the corresponding value obtained by the CEPITEL plan in order to make sure of the appropriateness of the former.

For the local communities (especially the communities where the telephone exchanges will be newly established), a careful study will be made about the existing economic sphere, inter-city relationships for cultural interflow, and city configurations and development prospects, based on the collected data and information. Findings in this study will be used in the review of forecasted demand.

Table 3-1 Telephone Development Stages

Initiatory Stage	In this stage, telephones are installed in military establishments, police and government agencies for purposes of communication and liaison mainly of military and political nature. Telephone demand forecast using a model formula is almost useless in this stage. Counting of the number of agencies requiring telephone service or determining the number of telephone lines from the political point of view is more practical.
Expansion Stage (First Half)	In this stage, the usefulness of business telephones begins to be recognized. However, the necessity for residential telephones is not yet broadly recognized. The telephone demand density is still extremely low. The convenience of telephones comes to be recognized in proportion to the increase of the number of telephones installed. Therefore, when considered by time series, the number of telephone subscribers often shows a tendency of increasing in geometrical progression.
Expansion Stage (Later Half)	In this stage, the convenience of residential telephones is widely recognized so that the demand for residential telephones increases rapidly. This stage covers the period from when the demand for residential telephones begins to come close to the demand for business telephones to when the majority of residences are provided with telephones. By time series, the generation of demand will most possibly be at the rate exceeding the geometrical progression. In this stage, it is desirable to make separate demand forecasts for business telephones and residential telephones.

Popularizing Stage	In this stage, business telephones are diffused sufficiently and most of additional installations are for residential telephones. The generation of stable demand can be expected until the majority of residences are provided with telephones.
Popularized Stage	In this stage, both business and residential telephones are diffused sufficiently. Even in this stage, the telephone demand for new business establishments and residences can be expected. However, sales promotion efforts on the part of telephone enterprises, including innovation attempts to make telephones more convenient to use, as well as the introduction of new types of services, whereby to explore further demand potentials, are indispensable for the growth of the telephone business.

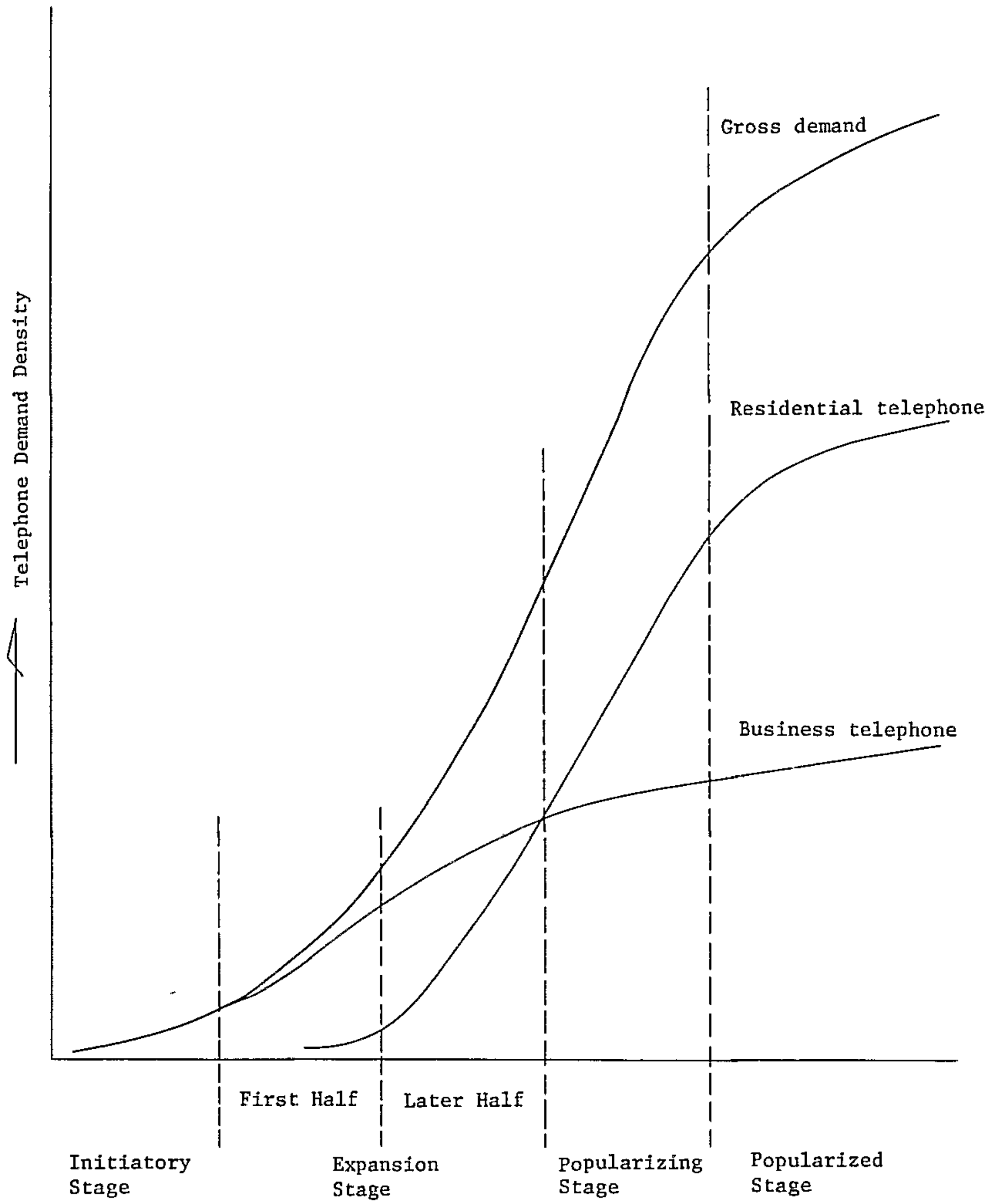


Fig. 3-1 Telephone Development Stages

3-2 Model Formula for Macroscopic Telephone Demand Forecast

In Bolivia, there are many areas where telephones are not available or telephone services are not sufficient, as previously stated. In principal cities, the automatic telephone system is established and the network expansion and improvement by private telephone companies are being carried out step by step. Thus, for the whole country, the telephone development is considered to be in the expansion stage.

For the demand forecast methods to be used for such stage, CCITT's GAS-5 Manual recommends three methods: (1) the historical extrapolation methods; (2) the regression methods by GNP which is a regression from causal relations with economic indices; and (3) the regression method by G-P ratio (GDP - Price).

For Bolivia, the demand forecast will be made from the relationship between GNP and the telephone demand density, based on the judgment of the past records. This method of demand forecast is commonly used in other countries whose situation resembles that in Bolivia.

As regards the correlation formula for GNP per capita (in U.S. dollars) and the telephone demand density (number of telephones installed) per 100 persons, the following has been obtained for use in this Project from the study of data any other countries: (Refer to ANNEX II.)

$$\log q = -3.2329 + 1.341 \log X$$

where

- q: Telephone demand density (number of telephones installed) per 100 persons
- X: GNP per capita (in U.S. dollars)

3-3 Estimation of GNP

The telecommunication network constitutes one of the basic requirements for national economy, so that the network keeping in balance with the national development is desirable. In this connection, an attempt is made here to estimate the development possibility of telecommunications in their relationship to the economic indices.

For such attempt, the estimate to some extent about the future size of national economy is necessary. When the government announcement as to the growth prospects of national economy is available, such announcement should of course be the guideline to follow. This time, however, GNP is estimated from the undermentioned data. And this estimate is strictly for the planning of telecommunication network, so that in the event of government announcement of a long-term economic plan, the estimate should be reviewed and corrected according to the government plan.

Past data concerning GNP in Bolivia are few as seen in ANNEX II-1. Therefore, the estimation of GNP in the future is difficult. This time, the estimate is made from "Banco Central de Bolivia Memoria Anual Gestion 1980" data.

GNP and GDP different economic indices. However, both are mutually related as indices to hint at future economic growth of the country. Thus, by referring to the growth rate of GDP, the estimate is made for the growth rate of GNP.

Assuming that the growth rate of GNP per capita is in the range of 2% to 4% per annum, the estimated GNPs per capita in the future at the growth rates of 2%, 3% and 4% per annum are shown in Table 3-3 and Figure 3-2. From Table 3-2, the average annual growth rate of GDP in the past five years (1975 - 1979) can be known to be 3.2%, so that the estimated growth rate of GNP to be used for telephone demand forecast in this Project is assumed to be 3%.

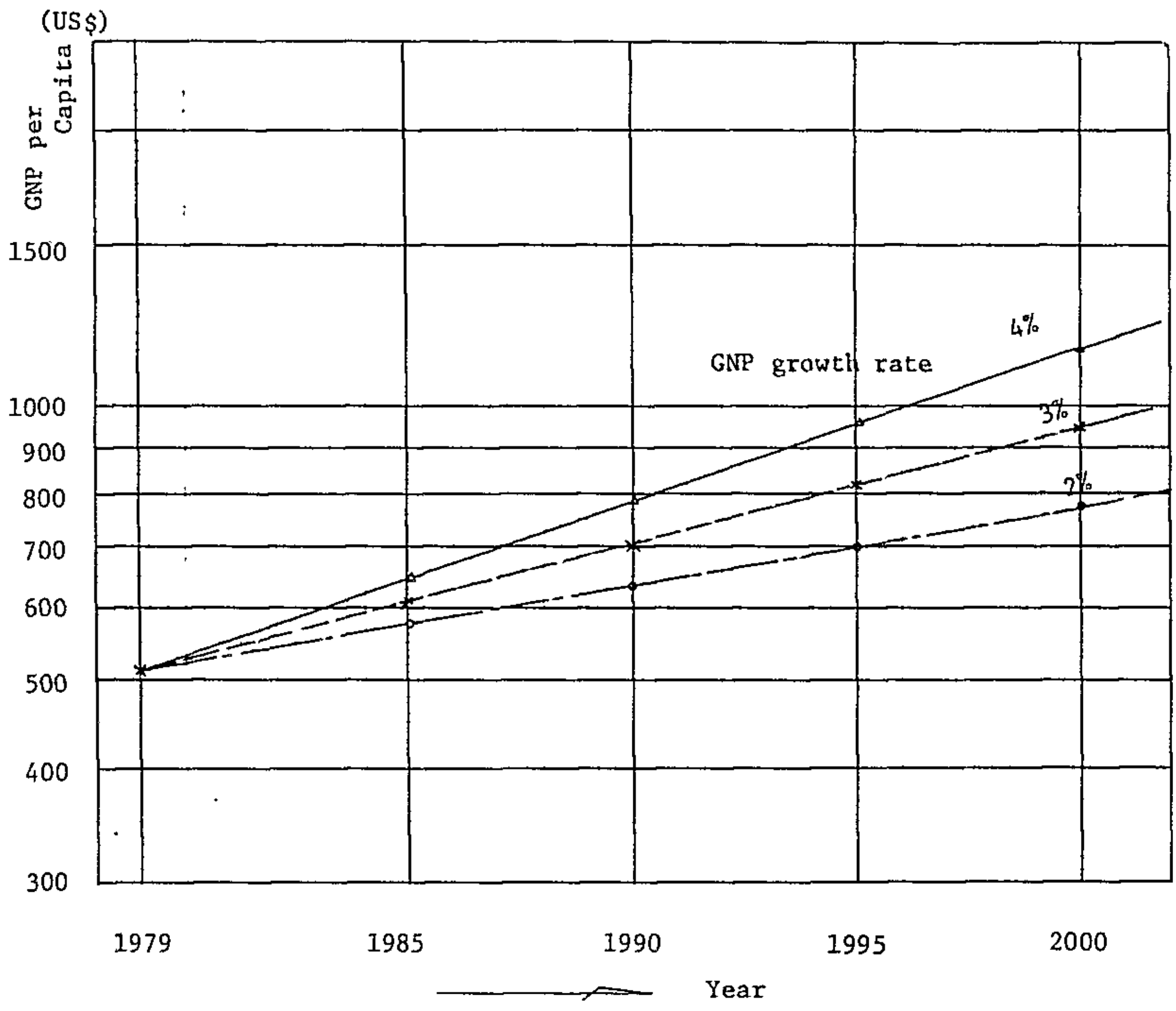


Fig. 3-2 Estimated GNP per Capita

Table 3-2 GDP in 1970 - 1979 (1970: Constant Price)

	1970	1971	1972	1973	1974	1975
GDP (in million Peso Boliviano)	12,374	12,985	13,732	14,668	15,563	16,353
	1976	1977	1978	1979		
GDP (in million Peso Boliviano)	17,468	18,064	18,628	19,007		

Table 3-3 Estimated GNP per Capita (in US dollars)

Growth Rate \ Year	1979	1985	1990	1995	2000
2%	510	575	635	700	775
3%	510	610	700	820	950
4%	510	650	790	960	1,160

3-4 Population Forecast

The total population of Bolivia is forecasted as in Table 3-9 by the logistic curve based on the population in 1975 - 1979 (Table 3-8) given in "Bolivia en Cifras 1980". The province by province population trends are forecasted by studying the collected data in the field surveys (see the data list marked with * appearing below) and in consideration of the following factors:

(1) Natural increase of population

(2) Inter-province population migration

(3) Existing economic sphere and interflow cities

(4) Future development plans

* Reference Data

a) Bolivia en Cifras

b) "Analisis de Problemas y Potenciales en Desaprollo Regional de Cochabamba" published by CORDECO

c) "Plan Regional de Desaprollo Economico y Social," Tomo I & II, published by CODETAR

d) "Proyecto de Factibilidad" published by COTAP

After studying the population forecast in Table 3-5 in the way mentioned below, judgment is made to the effect that the forecast can be used in this Project. (Refer to the reference data listed previously.)

1) To compare the Cochabamba Province population forecasted by the Corporacion Regional De Desarrollo De Cochabamba (CORDECO) and the corresponding population estimate by this Project. (Refer to Table 3-4.)

Table 3-4 Comparison of Cochabamba Province Population Estimates

	1985	1990
(A) Forecast by CORDECO	890,907	997,287
(B) Estimate by this Project	927,000	1,006,900
$\frac{(B) - (A)}{(B)} \times 100$	3.9%	1.0%

2) To compare the Tarija Province population forecasted by the Corporacion Regional De Desarrollo De Tarija (CODETAR) and the corresponding population estimate by this Project. (Refer to Table 3-5.)

Table 3-5 Comparison of Tarija Province Population Estimates

	1985	1990	1995	2000
(A) Forecast by CODETAR	229,875	257,653	288,787	323,683
(B) Estimate by this Project	251,600	273,300	303,000	327,400
$\frac{(B) - (A)}{(B)} \times 100$	8.6%	5.7%	4.7%	1.1%

3) Data concerning population in other provinces could not be obtained.

3-5 Macroscopic Telephone Demand Forecast

The macroscopic telephone demand is forecasted as in Table 3-10 and Figure 3-3, based on GNP per capita and population forecast. The demand forecast by CEPITEL as of 1990 is 250,000. The study of telephone demands in local communities in terms of telephone demand density in 1995 and 2000 leads to the judgment that those telephone demand densities specified in Table 3-10 can be used in this Project.

3-6 Telephone Demand Forecast in Project Areas

The telephone demand forecast in the areas to be covered by this Project is based on data and information collected in the field surveys, as well as the study of economic sphere, inter-city relationships for cultural interflow, city configurations and development prospects. By this forecast, the forecast by CEPITEL has been checked and corrected.

As shown in Figure 3-3, the telephone development in Bolivia is in the first half of the expansion stage. The most part of the areas to be covered by this Project are the areas without telephone or the areas where the toll call service is provided by the poorly equipped short wave system or open wires, though in few local communities, the local subscriber telephone service is maintained by PABX. Thus, after the completion of this Project, the diffusion of telephones is expected to become rapid and extensive.

The corrected telephone demand forecast in the areas of this Project is based on the telephone demand density compatible with the local community configurations and growth prospects. (Refer to Table 3-6 and Table 3-7.) The demand forecast details appear in Table 3-11. Demand forecast re-study items and local communities for which the demand forecast has been corrected are as follows:

(1) In the mining towns where mining company employees only inhabit, telephones are almost exclusively for communication among COMIBOL (Mining Corporation) offices. As of the present, the demand for telephones is small, but is expected to increase after the diffusion of residential telephones.

Table 3-6 Corrected Telephone Demand Density

Town	1985	1990	1995	2000
Corocoro	1.3	1.9	4.7	5.8
Chojlla	1.3	1.9	4.7	5.8
Colquiri	1.3	1.9	4.7	5.8

(2) In such local communities where agriculture is the main industry and where social activities center upon small markets for agricultural products and daily necessaries stores, the demand for telephones can be expected from public offices and marketplaces only. (Public offices include town offices, police stations, schools, post offices, ENTEL offices and railway stations.) The demand increase will be after the diffusion of residential telephones.

Table 3-7 Corrected Telephone Demand Density

Town	1985	1990	1995	2000
Achacachi	1.3	1.9	4.7	5.8
Irupana	1.3	1.9	4.7	5.8
Aiquile	1.3	1.9	4.7	5.8
Challapata	1.3	1.9	4.7	5.8

(3) For the telephone demand forecast in the Santivanez area, the CEPITEL plan is used temporarily. The reason is that the implementation time schedule for the factory construction plan remains undecided. Hence, the plan to establish the exchange station in the area by this Project is postponed until later. After all details of the factory construction plan have become clear, the demand forecast is to be considered anew.

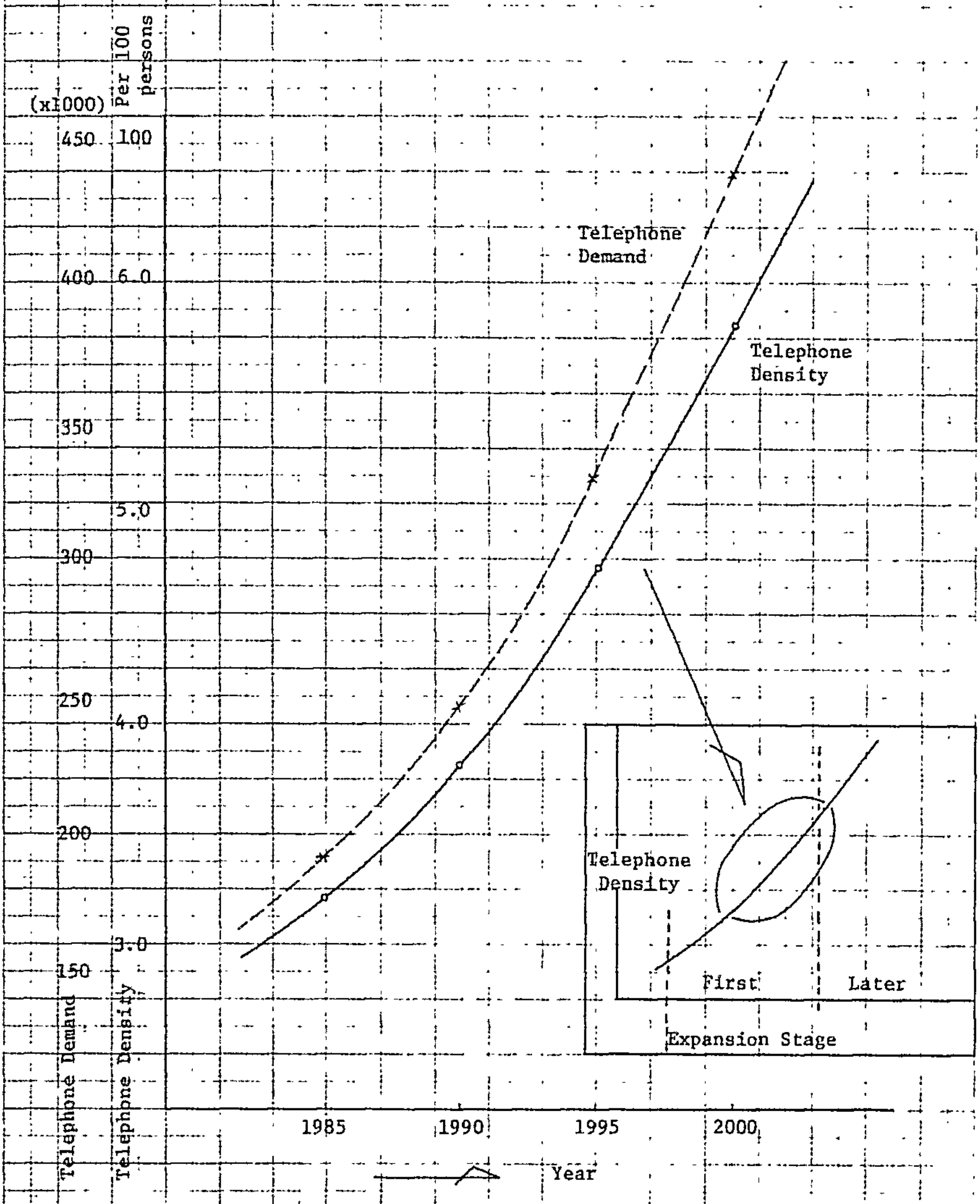


Fig. 3-3 Macroscopic Telephone Demand and Telephone Demand Density

Table 3-8 Total Population of Bolivia

Year	1975	1976	1977	1978	1979
Population	4,894,403	5,026,918	5,163,269	5,303,832	5,449,250

Table 3-9 Pupulation Forecast

Year	1985	1990	1995	2000	Remarks
Population	5,949,900	6,463,000	7,002,900	7,568,000	

Table 3-10 Macroscopic Telephone Demand Forecast

Year	1985	1990	1995	2000	Remarks
Telephone Demand	190,500	246,000	329,400	430,100	
Telephone Density per 100 persons	3.2	3.8	4.7	5.8	

Table 3-11 (1/6) Telephone Demand Forecast

Province: LA PAZ

Local Community	Telephone Demand				Remarks
	1985	1990	1995	2000	
LA PAZ	---	---	---	---	Existing
VIACHA	400	600	800	1,200	Existing
COROCORO	90	130	330	420	
CHOJLLA	80	125	340	470	
ACHACACHI	60	95	240	310	
IRUPANA	70	100	290	400	
CARANAVI	225	310	400	560	Proposed
COPACABANA	70	90	120	170	Proposed
GUAQUI	80	110	155	210	
PATACAMAYA	70	105	150	210	
CHULUMANI	130	170	225	270	Proposed
MINA MATILDE	65	90	125	160	
COROICO	105	140	185	270	Proposed
GUANAY	50	70	105	150	
CORIPATA	100	140	180	250	
DESAGUADERO	70	90	120	150	
HUATAJATA	50	70	90	140	
HUARINA	70	90	120	150	
SICA SICA	60	90	120	140	
TIPUANI	30	50	70	110	

Notes: 1) Existing: Existing exchange

2) Proposed: Proposed exchange

Table 3-11 (2/6) Telephone Demand Forecast

Province: COCHABAMBA

Local Community	Telephone Demand				Remarks
	1985	1990	1995	2000	
COCHABAMBA	---	---	---	---	Existing
QUILLACOLLO	1,245	1,685	2,325	3,140	Existing
PUNATA	305	430	610	850	Proposed
SACABA	180	265	385	550	*
CLIZA	110	145	195	260	
TIRAQUE	90	125	135	240	
ARANI	85	120	170	240	
TARATA	75	95	125	170	
CAPINOTA	75	95	130	170	
COLOMI	75	105	155	220	
UCUREÑA	60	80	110	150	
TOTORA	60	85	120	175	
SANTIVANEZ	20	25	35	45	
VILLA TUNARI	60	80	100	130	
PTO VILLARROEL	50	70	90	130	
MIZQUE	80	95	150	220	
IRUPA IRUPA	20	30	50	80	
AIQUILE	80	130	340	490	

Notes: 1) Existing: Existing exchange

2) Proposed: Proposed exchange

3) * : Distribution from Cochabamba Completed

Table 3-11 (3/6) Telephone Demand Forecast

Province: ORURO

Local Community	Telephone Demand				Remarks
	1985	1990	1995	2000	
ORURO	---	---	---	---	Existing
HUANUNI	985	1,320	1,790	2,210	Proposed
CHALLAPATA	60	90	220	290	
EUCALIPTOS	60	85	120	180	
ANTEQUERA	65	85	115	170	
MOROCOCALA	50	75	175	260	
CARACOLLO	60	90	120	150	
SANTA FE	45	65	140	170	
COLQUIRI	60	95	250	340	

Notes: 1) Existing: Existing exchange
2) Proposed: Proposed exchange

Table 3-11 (4/6) Telephone Demand Forecast

Province: CHUQUISACA

Local Community	Telephone Demand				Remarks
	1985	1990	1995	2000	
SUCRE	---	---	---	---	Existing
MONTEAGUDO	215	290	395	470	Proposed
CAMARGO	155	190	235	260	Proposed
TARABUCO	70	100	140	200	
CULPINA	20	30	50	80	
VILLA ABECIA	80	95	140	210	
YAMPARES	40	50	60	80	

Notes: 1) Existing: Existing exchange
2) Proposed: Proposed exchange

Table 3-11 (5/6) Telephone Demand Forcast

Province: POTOSI

Local Community	Telephone Demand				Remarks
	1985	1990	1995	2000	
POTOSI	---	---	---	---	Existing
LLALLAGUA	700	1,500	1,800	2,200	Proposed
VILLAZON	615	755	945	1,270	Existing
TUPIZA	525	645	805	1,080	Existing
UYUNI	230	305	410	530	Proposed
ATOCHA TELAMAYU	205	285	400	550	Proposed
TAZNA	85	110	145	190	
CHAYANTA	80	150	170	250	
ANIMAS	80	150	170	250	
SANTA BARBARA	75	110	130	150	
SIETE SUYOS	75	105	145	230	
PULACAYO	65	85	115	150	
TATASI	70	100	135	220	
BETANZOS	60	90	100	150	
QUECHISLA	25	30	40	50	
COTAGAITA	70	95	150	230	
SANTA ANA	75	90	140	220	
SIGLO-XX	650	690	875	1,010	**
CATAVI	450	565	720	810	**
UNCIA	375	475	600	700	**

Notes: 1) Existing: Existing exchange
2) Proposed: Proposed exchange
3) **: Distribution from Llallagua

Table 3-11 (6/6) Telephone Demand Forcast

Province: TARIJA

Local Community	Telephone Demand				Remarks
	1985	1990	1995	2000	
TARIJA	---	---	---	---	Existing
BERMEJO	835	1,195	1,735	2,000	Existing
YACUIBA	715	985	1,385	1,900	Existing
VILLAMONTES	390	525	720	900	Existing
SAN LORENZO	60	75	90	150	
CONCEPCION	40	50	70	90	
PADCAYA	65	80	100	150	
SANANDITA	30	40	50	70	
EL PARMAR	30	40	50	70	
LAS CARRERAS	30	40	60	80	
CARAPARI	50	70	100	150	
CAMIRI	1,210	1,595	2,145	2,830	Proposed
CHARAGUA	65	95	140	200	
BOYUIBE	50	70	105	155	

Notes: 1) Existing: Existing exchange
2) Proposed: Proposed exchange

CHAPTER 4
TELEPHONE TRAFFIC FORECAST

CHAPTER 4 TELEPHONE TRAFFIC FORECAST

4-1 Forecast of Subscriber Calling Rate

With the completion of this Project, the long-distance automatic trunk dialling service of a nationwide scale will be realized. Thus, to obtain the basic figure whereby to forecast the traffic between toll areas, the subscriber calling rate forecast is essential.

Subscribers are classified into two groups. One is the local telephone subscriber group, i.e., the subscribers in communities where the exchange stations will be established. The other is the remote subscriber telephone user group, i.e., the public telephone terminals in remote communities where the exchange stations will not be established.

The calling rate forecast will be made, based on the existing service data collected from the existing telephone booths during the field surveys. However, such collected data are incomplete data due to the poorly equipped existing facilities. Therefore, the following two elements are specifically considered in the traffic forecast after the service-in of long-distance automatic trunk dialling:

(1) Traffic increment resulting from reliability improvement of the facilities

(2) Traffic increment pursuant to the coming into effect of automatic trunk dialling

Item (1) above is given as the call loss rate in the existing data. The call loss rate means the percentage of unsuccessful call attempts due to the poor performance of facilities.

Item (2) is the commonly recognized trend. This signifies the rate of traffic increment resulting from the ease of communication, i.e., the coming into service of automatic trunk dialling.

4-1-1 Existing Traffic Records

The existing traffic records collected in the field surveys are compiled in Table Annex III-1 and III-2. Data of remote subscriber telephone service appear in Table Annex III-1. Presented in Table Annex III-2 are the local telephone subscriber data.

Table Annex III-3 shows the average duration of toll calls. According to this data, the average call duration is presumed to be 270 seconds (4.5 minutes). The assumption is made that this figure will remain unchanged even after the improvement of facilities and the initiation of automatic service.

Table Annex III-4 presents the lost call ratio due to the poor facilities performance. Traffic increment after the improvement of facilities is estimated to be in the neighborhood of 35%.

From Table Annex III-1, the following facts can be known:

(1) The monthly average number of calls by remote subscriber telephones consists of 152 originating calls and 124 terminating calls. These figures include telegraph services and message services besides telephone services. In the case of terminating calls, telephone service calls are about one-third of the total. Therefore, between the originating call rate and the terminating call rate of public telephones, no big difference is found. (Terminating calls are about 82% of originating calls.)

(2) For the local telephone subscriber call rates in Camiri and Santa Cruz, the local call rate is higher than the toll call rate.

4-1-2 Preconditions in Traffic Forecast

Figures specified below are used as preconditions in the traffic forecast.

(1) Traffic increment pursuant to the initiation of automatic trunk dialling

The general trend is that after the initiation of automatic trunk dialling, the traffic increases by 200% to 300%. (In Japan: 203%.) In this forecast, 250% is used.

(2) Busy Hour Call Concentration Rate

1) Remote Subscriber Telephone

Almost all calls are of the nature that must be served most urgently, so that the rate of call concentration at a certain hour is considered to be low. Hence, the busy hour call concentration rate is set at 1/9.

2) Local Subscriber Telephone

The busy hour is assumed to be 10 a.m. to 11 a.m. The call concentration rate in this busy hour is set at 1/6.

(3) Operating Days per Month

For the convenience of calculation, the number of operating days in one month is set at 24 days.

4-1-3 Calling Rate Forecast

The calling rates by subscriber categories, calculated from the previously described data and preconditions, are as follows:

Subscriber Category	Calling Rate per Subscriber (Erl)			Toll Call Ratio (%)
	Originating	Terminating	Total	
Local	0.03	0.027	0.057	15
Remote	0.20	0.16	0.36	100

For the local subscriber telephone calling rate, the percentage occupied by the general household telephone subscribers is expected to increase in accordance with the growth in the number of subscribers, and then decrease gradually.

4-2 Traffic Forecast in Toll Section

Here, to calculate the required transmission system capacity of each toll section, the traffic forecast for each toll section is made, using the earlier estimated subscriber calling rates.

4-2-1 Forecast Preconditions

The traffic forecast preconditions are as follows:

(1) The telephone network formation is star-shaped not only between the toll center (CG) and the local exchange station (CL) but between the regional center (CR) and the toll center also.

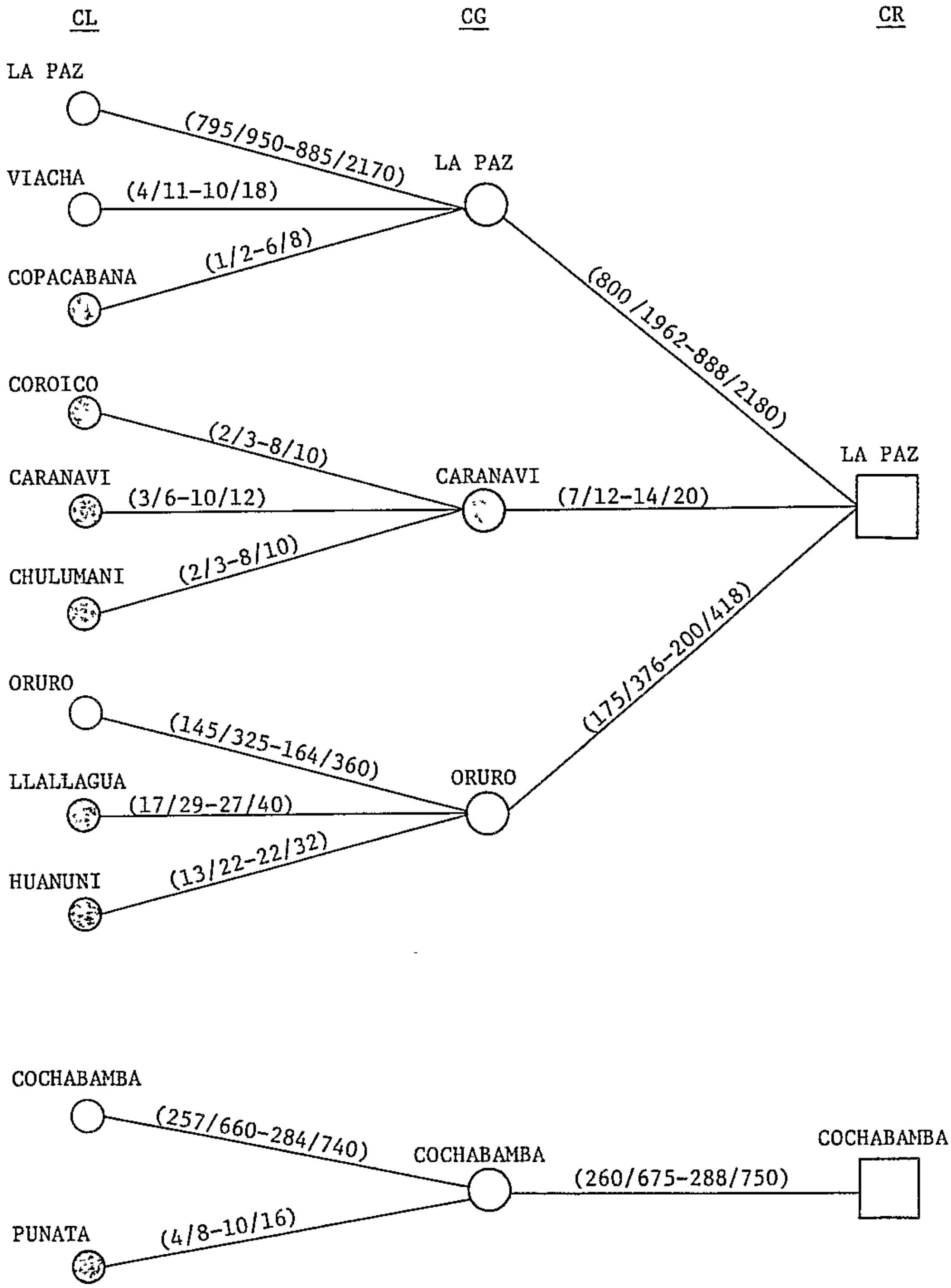
(2) It is so assumed that the originating traffic from each CL, proceeding through CG to which the CL belongs, wholly terminates at the CR concerned, or, more precisely, the traffic that is digested in the CG section is negligibly small.

(3) It is so assumed that the toll traffic from remote subscriber telephones is included in the toll calls from local telephone offices.

(4) The coverage years of forecast be 1990 and 2000.

4-2-2 Forecasted Traffic and Required Number of Circuits

The forecasted traffic and the required number of circuits by years are presented in Figure 4-1 (1/2) and (2/2), respectively. In the calculation of the required number of circuits, the lost call ratio in each section is set at 1/100. In the transmission system design, 20% overload is considered. Furthermore, the system is designed with surplus capacity so that it can serve the leased circuits and provide telex and telegraph services in addition to telephone service.



(a/b - x/y) : "a" Traffic in 1990, "b" Traffic in 2,000
"x" Circuit in 1990, "y" Circuit in 2,000

◌ : New Exchange Provision

○ : Existing Exchange

Fig. 4-1 (1/2) Traffic Estimate and Circuits Requirement

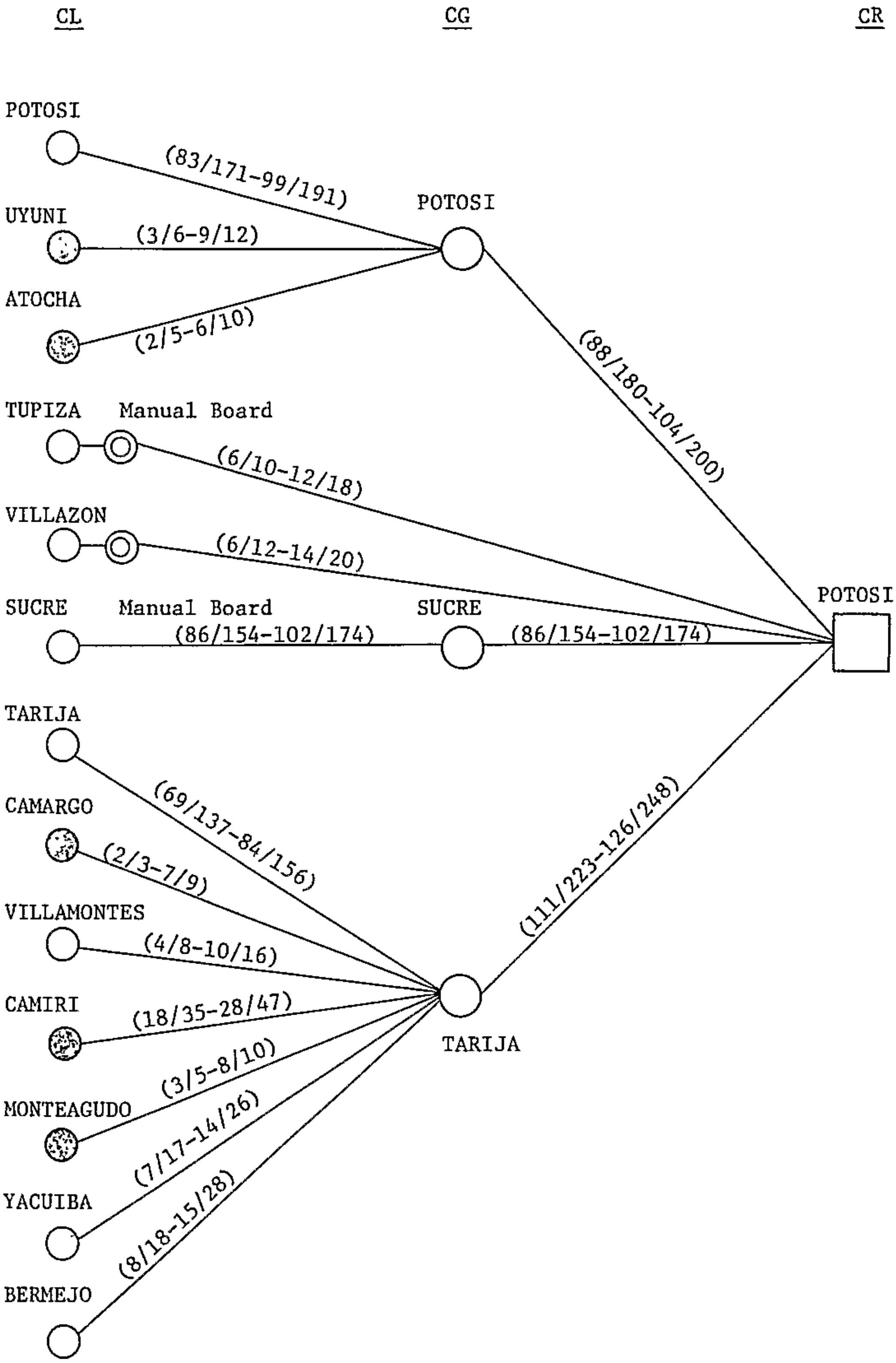


Fig. 4-1 (2/2) Traffic Estimate and Circuits Requirement

CHAPTER 5
ASSUMED PREMISES TO NETWORK PLANNING

CHAPTER 5 ASSUMED PREMISES TO NETWORK PLANNING

Premises to the telephone network planning are assumed as follows:

5-1 Work Schedule and Design Objective

5-1-1 Schematic Timetable

1982: Completion of project loan application to foreign government

1983: Exchange of loan agreements

1983: Formulation of detailed design for project implementation and preparation of tender documents

1984: Work contract and commencement of equipment manufacturing

1985-86: Execution of work and Testing

1987: System service-in

Full particulars of work schedules for and after 1983 are described in Chapter 9.

5-1-2 Design Objective

The design is to meet the forecasted demand as of 1990 and 2000.

5-1-3 System Life

The system life is to be 15 years after the completion of installation/construction work.

5-2 Basic Philosophy of Design

5-2-1 Guideline

The guideline of design is to observe basically the Preliminary Telecommunication Network Plan of Bolivia formulated by CEPITEL. Then, by the collected information and data, the CEPITEL plan will be reviewed and corrected where necessary.

5-2-2 Priority of Project Implementation

This Project primarily aims at the expansion and improvement of the domestic transmission network in Bolivia. Therefore, the network expansion to the areas of relatively small importance and the network construction in remote areas wherein the work cost will be extremely high in spite of limited service revenue are placed out of the scope of this Project. In the area by area importance evaluation, comments by ENTEL are duly considered.

5-2-3 Transfer from Analog to Digital Network

In view of the worldwide trends, the communication network of Bolivia is also bound to transfer from the existing analog network to a new digital network. (For details, refer to Annex I.) This Project is to take care of the first stage of the stage by stage network digitalization, so that in this Project the digital switching equipment will be introduced in the network. For the radio transmission system, in which case the interface with the existing system is of vital importance, the network expansion using the analog equipment will be carried out for the time being.

5-3 Network Operation/Management

Presently, in Bolivia, ENTEL operates and manages the toll network, whereas the local telephone exchanges are managed and operated by private companies. In this connection, CEPITEL desires and proposes that all networks be placed under the operation/management by a single responsible organization. Therefore, it is so arranged that the toll network to be newly constructed by this Project will certainly be operated and managed by ENTEL and the projected new local telephone exchanges will also be operated and managed by ENTEL.

CHAPTER 6
TECHNICAL CRITERIA/STANDARDS

CHAPTER 6 TECHNICAL CRITERIA/STANDARDS

For the technical criteria and standards to be employed in the implementation of this Project, the criteria and standards presently adopted in Bolivia will be used, in principle. Details of such technical criteria and standards are described below.

6-1 Network Plan

6-1-1 Office Hierarchy

The domestic exchange office hierarchy consists of three classes: regional center (CR), toll center (CG) and local exchange (CL).

Regional centers (CR) are La Paz, Santa Cruz, Potosi and Cochabamba.

6-1-2 Network Formation

The network formation between CRs is of mesh form. The network formation between CR and CG and between CG and CL is star-shaped. Depending upon the traffic volume in the future, the mesh-form and star-shaped compound network formation will be adopted between CR and CG.

6-1-3 Network Classification

(1) Transmission Network

The analog transmission network will be adopted. This is for convenience of interface with the existing transmission network. For transfer to the digital transmission network in the future, refer to Annex I.

(2) Switching Network

The switching equipment will be of the digital type. The existing analog switching equipment will be replaced with the digital type equipment on occasions, in preparation for the transfer to the digital network in the future.

6-1-4 Overall Grade of Service

National connection: 10% or less

Local connection : 4% or less

6-2 Numbering Plan

6-2-1 Code Numbers

"0" : Toll call discriminating prefix

"00" : International call discriminating prefix

6-2-2 Telephone Numbers

(Toll office code) - (Local office code) - (Subscriber number)

Total digits: Up to seven digits

Special number: 1XY

6-2-3 Toll Area Code

"2" : La Paz City

"3" : Santa Cruz City

"4" : Most part of Cochabamba and Beni Provinces and eastern part of Pando Province

"5X" : Oruro and Potosi Provinces

"6X" : Chuquisaca and Tarija Provinces

"7" : Spare

"8X" : Western part of La paz and Pando Provinces and part of Beni Province

"9X" : Santa Cruz Province

Where X = 2 - 9

6-3 Transmission Plan

6-3-1 Reference Equivalents on Domestic Network

National connection: 29 dB or less

Local connection : 22 dB or less

6-3-2 Transmission Loss Distribution on Trunk Circuit

CR - CR : 0 dB

CR - CG : 3.5 dB

CG - CL : 5 dB

6-3-3 Transmission Loss Distribution on Subscriber Line

7 dB

6-3-4 Noise Distribution on Trunk Circuit

CR - CR : Transmission system recommended by CCITT (10,000 pWOp/2,500 km)

CR - CG : 2,000 pWOp or less

CG - CL : 2,000 pWOp or less

6-4 Signalling System

6-4-1 Selective Signal

DP (existing network only) and R2-MFC (Ericsson) signalling

6-4-2 Supervisory Signal

Loop and E&M signalling

6-5 Charging System

6-5-1 Toll Call Charging

Call inside CG area:	Charging by Carlson system, in principle
Calls outside CG area:	Detail charging by CAMA equipment installed in CR to which the calling station belongs

6-5-2 Local Call Charging

Charging by fixed rate, in principle, regardless of the number of calls

6-5-3 Toll Tariff

By call duration and crow-flight distance between two CGs

6-5-4 Charging for Remote Subscriber

Automatic charging, in principle. In some cases, charging by public telephone consignee.

6-6 Network Engineering

For the eventual complete transfer of the telephone network to the digital system, the digital technology and equipment will be introduced gradually. As regards the transmission systems, the transmission network expansion by analog equipment will be continued for the time being in consideration of the interface with the existing analog equipment. For the switching equipment, the digital type equipment will be introduced positively.

Detailed plans and recommendations for the purpose of stage by stage transfer to the digital network appear in Annex I.

CHAPTER 7
BASIC FACILITIES PLAN

CHAPTER 7 BASIC FACILITIES PLAN

7-1 Telephone Switching Facilities

7-1-1 Construction of Local Exchange Offices

The digital electronic switching equipment to be introduced by this Project will be installed at medium or small capacity exchange offices.

The transportable (van type) switching equipment does not need the exchange office to be newly constructed; furthermore, the installation work for this switching equipment is easy. Therefore, this equipment is useful at the exchange office where the radio and transmission equipments are not co-used. However, the exchange offices to be newly constructed by this Project are to have both the radio and transmission equipments installed so that the exchange offices are required to be the composite buildings. Hence, in this Project, the transportable switching equipment will not be adopted.

The initial stage and ultimate stage capacities of the switching equipment should meet the telephone demand as of 1990 and 2000, respectively. In other words, the capacity expansion at reasonable cost should be possible up to 200 line terminals at the minimum and 4,000 line terminals at the maximum.

Table 7-1 presents a list of local exchange offices to be newly constructed by this project. The number of initial stage line terminals is set at the estimated demand level as of 1990.

7-1-2 Construction of Toll Telephone Offices

This Project does not envisage the construction of telephone offices that provide toll service only. Caranavi CG, however, will be constructed as TLS (Toll and Local Switch) by means of provision of toll switching function to the Caranavi local switching equipment to be newly established.

Provision of automatic distant direct dialling (DDD) function to the existing switching equipment at Tupiza and Villazon stations is technically difficult, so that at each of these two stations, one manual toll board will be installed whereby to handle toll calls by operator trunk dialling.

7-1-3 Remote Subscriber Telephone Facilities Plan

For the number of remote subscriber telephones to be established, the following standard can apply, in principle, regardless of the number of demand in each local community concerned:

General public telephone:	One per local community
Local community office telephone:	One "
Business-use telephone (for COMIBOL, etc.):	One " (for PABX)

As the result of individual field surveys, an average of two remote subscriber telephones will be established in each local community. This is based on the survey finding that in some local communities there is no need for separating local community office telephones from general public telephones so that general public telephones only can serve the purpose, whereas in some other cases three telephones are required in one local comminity.

As for the establishment of additional remote subscriber telephones to meet the increase of demand in the future, the additional installation is possible, where MAS (Multi Access Subscriber) system is utilized, by means of increasing terminal equipment within the limits of system capacity.

Table 2-1 summarizes the remote subscriber telephone facilities plan.

7-1-4 Power Supply Equipment

For source power, the commercial power supply will be used, in principle. Where the commercial power supply is not available or the supply hours are restricted or the supply is unstable, dual diesel engine generators will be installed.

A summary of power supply equipment plan appears in Table 7-2.

7-1-5 Telephone Office Building

For the telephone offices where the existing exchange buildings cannot be used to realize such ultimate stage capacity, the construction of exchange buildings will be considered.

7-2 Outside Plant Facilities

7-2-1 Subscriber Cable Network

(1) Work Area

Ideally, the subscriber cable facilities should be established in the way to cater for all telephone demand in the whole service area. However, in many cases, the service area is restricted mainly for economic reasons.

Table 7-1 Telephone Office Facilities

Office	Province	1990/2000
UYUNI	Potosi	400/600
ATOCHA	"	300/600
CAMARGO	Chuquisaca	200/300
CAMIRI	Santa Cruz	2000/4000
MONTEAGUDO	Chuquisaca	300/500
COPACABANA	La Paz	100/200
COROICO	"	200/300
CARANAVI	" (TLS)	400/600
LLALLAGUA	Potosi	2000/3000
HUANUNI	Oruro	1500/2500
PUNATA	Cochabamba	500/1000
CHULUMANI	La Paz	200/300
TOTAL		8100/13900

Table 7 - 2 Outline of Power Supply Facilities

Office	Exsisting Condition	Proposed Equipment
UYUNI	24^{H}	DEG
ATOCHA	6^{PM} - 11^{PM}	2DEG
CAMARGO	24^{H}	DEG
CAMIRI	24^{H}	"
MONTEAGUDO	6^{PM} - 12^{PM}	2DEG
COPACABANA	24^{H}	DEG
COROICO	24^{H}	"
CARANAVI	6^{PM} - 10^{PM}	2DEG
LLALLAGUA	24^{H}	DEG
HUANUNI	24^{H}	"
PUNATA	24^{H}	"
CHULUMANI	24^{H}	"

Note:

DEG: Diesel Engine, Rectifier and Battery

2DEG: Dual Diesel Engine, Rectifier and Battery

The work area, this time, i.e., the area wherein to establish the subscriber cable facilities, will be the area to have the local switching equipment installed and that the urban district in such area for the most part.

(2) Design Period

The design period of subscriber cable network plan is to be obtained, using as functions the cost of fundamental section required for the construction, cost per cable circuit, annual demand increase, interest on construction fund by loan, and so froth. The design period for subscriber cable network plan in this Project is based on the assumption that the primary cable capacity be equivalent to the demand five years ahead (1990) and the secondary cable capacity to the demand 15 years hence (2000).

(3) Structure of Subscriber Cable Network

Various structures of subscriber cable network are available, and each has its merits and demerits. Which structure to adopt depends upon whether the procurement of work materials is easy or difficult, as well as the fitness for natural environment and the maintenance feasibility.

Presently, in Bolivia, the following structures of subscriber cable network are mainly used:

1) Direct service system

2) Cabinet system

(The cabinet system uses the cross-connecting cabinet on the cable line and makes jumper connection of primary and secondary cables in the cabinet.)

In this Project, these two structures of subscriber cable network will be used as follows:

1) Direct service system

In the exchange area where the local switching equipment capacity is less than 1,000 lines (equivalent to the demand 15 years ahead) and in the exchange area neighborhood.

2) Cabinet system

In the exchange area where the local switching equipment capacity is 1,000 lines or more (equivalent to the demand 15 years ahead) but excluding the exchange area neighborhood.

For the adoption of each structure of subscriber cable network, consideration must be made about the existing cable condition, demand distribution, etc., at the time the subscriber cable design is made.

(4) Cable Line Formation

The subscriber line consists of primary cable and secondary cable. For cable laying between MDF and distributing point is used duct-in cable, direct-buried cable, aerial cable or building cable.

1) Primary cable covers the subscriber line between MDF and cross-connecting cabinet and, in the area where the direct service system is used, between MDF and the first distributing point. In principle, primary cable is either duct-in cable or aerial cable.

2) Secondary cable covers the subscriber line between the cross-connecting cabinet and each distributing point and, in the area where the direct service system is used, between the first distributing point on the exchange side and each distributing point. In principle, secondary cable is either aerial cable or building cable.

(5) Subscriber Line Loss and D.C Resistance

The subscriber line loss value is determined as part of the transmission loss distribution value on the whole subscriber to subscriber speech path, as stated in Chapter 6.

CCITT stipulates that the standard transmission loss value between the exchange office MDF and subscriber be 11.5 dB on the transmitting side and 0.5 dB on the receiving side. Both these values include the loss value at the telephone set so that the loss value distribution on the subscriber line varies according to the telephone set characteristics.

The limit value of D.C resistance is to keep the attenuation of the signal current flow between the telephone set and the switching equipment within the fixed value in order that the telephone set and the switching equipment can operate normally.

Ordinarily, the D.C resistance limit value is more than 1,700 ohms when the exchange office switching equipment is the electronic equipment and 1,700 ohms when the switching equipment is the crossbar equipment.

Table 7-3 Amount of Main Construction Works

C.G. Area	Name of Exchange	Termination Cable Pair (Pair)	Cable Length (Km)	Remarks
LA PAZ	COPACABANA	400	3.0	
CARANAVI	CARANAVI	1,200	10.5	
	COROICO	600	5.0	
	CHULUMANI	600	15.5	
ORURO	LLALLAGUA	3,000	32.0	
	HUANUNI	3,000	26.0	
POTOSI	UYUNI	1,200	10.5	
	ATOCHA	1,200	14.0	
COCHABAMBA	PUNATA	1,500	26.5	
TARIJA	CAMARGO	600	18.0	
	CAMIRI	4,200	30.0	Removal of Existing Switches (800 lines)
	MONTEAGUDO	800	10.0	
Total		18,300	201.0	

(6) Main Construction Works

The main construction works are shown in Table 7-3.

7-2-2 Toll Cable Facilities

(1) The toll transmission system will be composed of radio links, in principle.

(2) The toll cable facilities are the wire transmission facilities to be established between the radio terminal office and the switching office in case these offices are far apart and the provision of radio transmission link between them is difficult because of topography and other environmental constraint.

(3) For the toll cable facilities, the aerial cable system will be used, in principle.

(4) For the toll cable facilities, the high quality cable for toll transmission, excellent in transmission performance, will be used.

7-3 Toll Transmission Line Facilities

7-3-1 Outline of Toll Transmission Line

The toll transmission line to be constructed by this Project will be composed of microwave system, UHF/VHF system and MAS system. The route map is in Figure 2-1.

The channel accommodation plan for the toll transmission line is formulated, based on the toll transmission channel plan described in Chapter 4. The number of channels to be provided at the initial stage is so arranged as to meet the estimated demand as of 1990. The system capacity is calculated to satisfy the telephone demand as of 2000, as well as the demand for leased lines, telex circuits, etc.

For the transmission lines in the section to constitute an integral part of the domestic backbone communication system in the future and in the section where the TV signal transmission is expected, the broad band microwave system (6 GHz upper band) will be constructed. The channel accommodation plan is in Figure 7-1.

The number of hops in the toll transmission route is in Table 7-4.

(1) Outline of Microwave Route

The microwave system to be constructed by this Project will use 6 GHz upper band (CCIR Rec. 384-2) and 7 GHz band.

Transmission capacity of 6 GHz upper band microwave system is for 960 telephone channels or one color TV channel.

In the case of 7 GHz band microwave system, 300-channel or 120-channel telephone transmission is possible. This system will be used for toll transmission between a big city and a medium sized city or between medium sized cities.

The number of systems to be constructed is one telephone system and one standby system. The operation changeover between the two systems in case of need is planned.

In the case of 6 GHz upper band microwave system, the IF relay system is used. At the through repeater station also, the telephone channel branching and insertion by the unit of 60 channels are possible up to the maximum 300 channels by means of IF leaking.

The IF leaking system has these advantages:

- Telephone channel branching at the through repeater station does not cause the transmission performance deterioration on the long-distance backbone circuit.

- The number of required modulator-demodulators can be reduced, and this leads to the reduction of equipment cost.

- Power consumption can be economized.

When the microwave system is of 7 GHz band, the relay system is of baseband relay, and the telephone channel branching and insertion at any station are easy. In view of this, the 7 GHz band system is scheduled to be used for the short-haul local circuit.

Most of microwave systems now in operation are of 2 GHz band. Hence no frequency interference.

Microwave stations scheduled to be constructed by this Project are listed in Table 7-5 and Table 7-6.

(2) Outline of UHF/VHF Route

Frequency bands to be used for UHF and VHF systems to be constructed by this Project are 900 MHz band and 160 MHz band.

1) 900 MHz Band System

The transmission capacity of this system is for 60 or 24 telephone channels. This system is planned as the transmission route to small cities.

Radio equipment cost remains the same for 60 channels transmission and 24 channels transmission. However, in the case of carrier terminal equipment, the cost for 24 channels transmission can be reduced considerably. Therefore, the 24 channels system will be adopted for small cities where a big demand growth is seldom expected.

The set standby system will be adopted from the viewpoints of effective frequency utilization and power consumption economy.

As the system is to be constructed as a local circuit, the construction cost saving assumes importance. Hence, for the tower, the panzer mast will be used and, for the antenna, the Yagi antenna will be adopted, in principle.

UHF stations to be constructed by this Project are listed in Table 7-7.

2) 160 MHz Band System

For the 160 MHz band system, the multiplex fixed system and MAS system are planned.

Sections where the multiplex fixed system will be established are:

a) Where the transmission capacity with MAS system is not sufficient;

b) Where a business organization, such as a mining company, wants to have its own leased line;

c) Where the transmission loss is large so that the intermediate repeating is necessary or the high gain antenna is required. (In the case of MAS system, the non-directional antenna is used, in principle, so that the high antenna gain cannot be expected.)

The section where MAS system will be adopted is where the remote subscribers from the base station number three or more, or where the number of remote subscribers is expected to increase in the near future.

The MAS system merit is that once the base station has been constructed, the subsequent increase of remote subscribers can be dealt with by a simple installation work and a low cost construction work. Contrarily, when the remote subscribers are few, MAS system is not an advantageous system to maintain from the economic point of view.

In view of the topographic features of Bolivia, remote toll subscribers will in many cases be located in the mountainous areas, especially the mountain valley communities. The radio propagation condition to those remote subscribers is generally poor and, in some areas, the propagation loss is considerably great. Means to reduce such propagation loss, including the establishment of repeater stations; require much cost. Cost per toll telephone channel sometimes becomes several times as much as in the ordinary case.

Hence, for the system to be established by this Project, the transmission performance deterioration will be permitted within the allowable limits, so as to reduce the necessary construction work cost.

In case where the mountain exists nearby, the radio equipment will be installed on the mountain-top and from there the lead-in telephone line will be established to the community concerned.

For this projected system, consideration is made to suspend the system operation during night. The reasons are:

a) Power supply cost must be reduced since this cost occupies no small percentage in the total system cost;

b) Communication traffic during night is presumed to be extremely small;

c) Toll call charge collectors will not be available during night.

Spare equipment will be stored at a specific maintenance station instead of at each telephone office.

Necessary radio frequencies to serve a plural number of remote subscribers when MAS system is adopted are shown in Table 7-10. This frequency assignment plan makes the effective frequency utilization possible.

The multiplex fixed system stations of the 160 MHz band system to be constructed by this Project, as well as MAS system base stations and expected remote subscribers, are shown in Table 7-8 and Table 7-9.

7-3-2 Outline of Field Survey Findings

Field surveys were carried out, based on the preliminary desk study results and the ENTEL plan.

In the preliminary desk study, maps of a 1:50,000 scale could be used for the most part of areas to be covered by this project.

For field surveys, the coverage areas were divided into two groups. For each group, the survey was made, participated in by the ENTEL Counterpart.

Field surveys, this time, placed emphasis on finding the degree of difficulty involved in the access road construction at each scheduled radio station site and the commercial power availability at each site. This was because, firstly, many of the coverage areas are located in the steep mountainous zone where the elevation above sea level is 4,000 m or thereabouts, and, secondly, even in the low land sector the roads are in the extremely poor condition so that a great difficulty is foreseen in the fuel supply to the projected radio stations.

The propragation performance study mainly consisted of the desk study. Propagation tests, including mirror tests, were not carried out. Therefore, the field study about propagation performance must be made prior to the Project implementation. This study comprises the mirror tests for the microwave system and the propagation tests for the UHF/VHF system.

Especially for the 160 MHz band system, the mountain diffraction propagation system will be adopted in many cases. And, in such cases, no small difference is usually found between the forecasted value by calculation and the actually measured value, so that the propagation tests must be carried out.

Particulars of each radio station site selected by field surveys, this time, i.e., latitude, longitude, elevation above sea level, radio section distance and azimuth angle, are compiled in Annex IV. Profile maps of hops are given in Annex V. These profile maps were made from geographical maps of a scale of 1:50,000. For the areas, of which the geographical maps could not be obtained, the profile maps were not produced.

Approximate lengths of access roads to be newly constructed to the projected radio stations and the commercial power availability at each site appear in Table 7-13.

7-3-3 Outline of system Design

(1) Propagation Path Study

Conditions whereby the antenna height at each radio station site was calculated are described below. Calculation results about the required antenna height at each site and the propagation loss in each radio section are given in each corresponding profile map.

1) 6 GHz Upper Band and 7 GHz Band

a) For antenna height, the first Fresnel zone is secured by K = 4/3.

b) For height of trees on the propagation path, the assumptions are as follows:

In the area with 4,000 m or more elevation above sea level:	0 m
In the area with 3,000 m - 4,000 m elevation above sea level :	10 m
In the area with less than 3,000 m elevation above sea level :	20 m

c) Antenna to be newly built at the existing radio terminal station in the urban area, such as La Paz and Oruro, is the roof-top antenna.

d) Space diversity system is to be adopted in the radio section where the system is required.

2) 900 MHz Band

a) For antenna height, the line of sight is secured by K = 4/3, in principle. Where this principle causes the antenna height to be excessively high, the antenna height is to be reduced within the allowable limits of propagation loss.

b) For height of trees on the propagation path, the aforementioned assumptions shall apply.

3) 160 MHz Band

a) Antenna height is to be 10 m, in principle. Mountain diffraction propagation is to be adopted in the radio section where it is required.

b) For height of trees on the propagation path, no assumption is established.

(3) Main Equipment Performance Parameters

Performance parameters of main equipment assumed in the system design are shown in Table 7-11 and Table 7-12.

The transmitting output power at the radio stations where the commercial power supply is not available is set at the possible minimum so as to economize the power consumption. In this case, the high gain antenna is used whereby to prevent the transmission performance deterioration.

(4) Remote Supervisory System

The remote supervisory system will be introduced on the 6 GHz upper band, 7 GHz band and 900 MHz band systems.

For the 160 MHz band and MAS systems, wherein the intermediate repeater station is seldom used, the remote supervisory system is not contemplated.

(5) Power Supply System

The selection of power supply system to radio facilities requires an especially careful study. This is because many of the areas to be covered by this Project are located in the mountainous zone where the elvation above sea level is 4,000 m or thereabouts or in the region where roads are so poorly built that the fuel supply, etc., to the radio stations is difficult. In the steep mountain area, consideration will be necessary for installing the engine generator at the foot of the mountain and transmitting the generated power to the mountain-top.

Power supply systems available include a) full-floating system, b) charge-discharge system, c) thermo-electric system, d) solar cell system and e) wind power plant system.

1) Full-floating System

When the commercial power supply is available, the full-floating system is most advantageous economically. Maintenance is also easy. This system keeps batteries fully charged at all times and ensures the long battery life. A typical system configuration appears in Figure 7-2.

For the stations not included in the microwave system route, consideration is made to do without standby engine generator. This is to reduce the power supply system and access road construction cost, as well as the maintenance cost. In this case, the required battery holding time is determined, taking into account the stable commercial power supply availability and the time requirement for maintenance personnel arrival at each such station from the maintenance center station.

2) Charge-discharge System

This system supplies the discharge current from the batteries charged for a fixed length of time and then charges the batteries again. The charge-discharge procedure is illustrated in Figure 7-3. It is performed through two pairs of rectifiers and batteries.

This system is suitable for the radio station where the commercial power supply is available during night only. One or two engine generators are used, depending upon the length of time for which the commercial power supply is available.

The merits of this system are, first, the fuel consumption saving as the result of short operating hours of the engine generator, and, second, the extension of the engine generator life. The demerit is the battery life reduction due to the repeated charge-discharge operations.

3) Thermo-electric System

This system uses the series connection of thermo-couples taking advantage of the Seebeck effect or metals, PbTe and SiGe or BiTe, and burns light oil or LPG gas to obtain the electromotive force of 6-7 volts at a temperature of about 450°C. The necessary DC voltage of 24 V or 48 V is supplied by means of boosting by the DC-DC converter.

The merit of this system lies in the high equipment reliability. This is because the equipment has no rotary section so that the mechanical wear and tear is limited. The ease of maintenance is another merit.

However, since gas or light oil is used as fuel, there is need for fuel supply which is a nuisance. As shown in Figure 7-7, the fuel consumption is even greater than in the case of charge-discharge system. Therefore, considering the necessity of fuel supply, the adoption of this system is not advisable. The system is shown in Figure 7-4.

4) Solar Cell System

This system has the merits in that the fuel supply is not necessary and that the life of solar cells is semi-permanent. Accordingly, the maintenance cost is extremely low.

No need for fuel supply by tank lorry leads to a broad reduction of access road construction cost. This is an especially important point in the steep mountainous area.

Therefore, when the commercial power supply is not available and the DC load is smaller than 100 watts, this system is useful a great deal even though the initial cost is somewhat high. (Refer to Figure 7-5)

The initial cost comparison between this system and other systems appears in Figure 7-6.

When adopting this system, it is desirable that the small capacity mobile engine generator be assigned to each main maintenance station so that it can be mobilized to cope with the solar cell capacity degradation due to bad weather and so forth.

5) Wind Power Plant System

The wind power plant system is not feasible to adopt as the power supply system in this Project. The reasons are:

a) The snow- and ice-coating of power plant due to freezing climate may, more often than not, degrade the power generating capacity.

b) Especially in the mountainous district, the wind direction and wind velocity vary greatly so that the constant power generation cannot be expected.

6) Station Building

Buildings of newly projected radio stations are to be constructed by ENTEL.

Remote subscriber equipment will be accommodated in the existing toll call offices, etc.

7) Access Road

The areas to be covered by this Project are in the mountainous zone, so that the access road construction in those areas costs a great deal. Hence, for the radio stations where there is need for fuel supply, the less costly access road construction without consideration of tank lorry passage must be designed.

Access roads to radio stations that serve remote subscribers will not be constructed, in principle. This is because the necessity of maintenance is slight.

Table 7-4 List of Projected Radio Stations

Radio Freq. Band	CH. Capacity	Number of Hops	Remarks
Microwave Band (6 GHz. Upper Band / 7 GHz Band)	960 CH	16	
	120 CH	3	
	300 CH	2	
	Sub Total	21	
UHF Band (900 MHz Band)	24 CH	8	
	60 CH	11	
	Sub Total	19	
VHF Band (160 MHz Band)	6 CH	28	
	MAS	41	
	Sub Total	69	
Total		109	

Table 7-5 List of Microwave Radio Stations
(6GHz Upper Band 960 CH)

1) LA PAZ - CARANAVI Route

LA PAZ	Terminal Station
EL ALTO	Reflector
CHACALTAYA	IF Leaking Station
C. VALENCIANI	Repeater Station
C. CHUSPIPATA	- ditto -
C. UCHUMACHI	IF Leaking Station
BORINDA	IF Repeater Station
CARANAVI	Terminal Station

2) POTOSI - TUPIZA Route

POTOSI	Terminal Station
ORCOLLO	Repeater Station
C. SAÑO	- ditto -
C. REFORMA	SG. Branching Station
C. YUMIA	IF Leaking Station
TUPIZA	Terminal Station

3) SANA - CAMIRI Route

SANA	SG. Branching Station
TAIGUANTI	Repeater Station
ÑANCORAINZA	- ditto -
HACIENDA HUACARETA	- ditto -
C. CAMIRI	SG. Branching Station
CAMIRI	Terminal Station

Table 7-6 List of Microwave Radio Stations
(7GHz Band 120/300 CH)

1. 120 CH System

1) NEGRO PABELLON - HUANUI Route

NEGRO PABELLON	IF Leaking Station
C. CALICHE	Passive Repeater Station
HUANUNI	Terminal Station

2) NEGRO PABELLON - C. LLALLAGUA Route

NEGRO PABELLON	IF Leaking Station
C. LLALLAGUA	Repeater Station
LLALLAGUA	Terminal Station

2. 300 CH System

1) ORURO - NEGRO PABELLON Route

ORURO	Terminal Station
NEGRO PABELLON	IF Leaking Station

2) TARIJA - SAMA Route

TARIJA	Terminal Station
SAMA	SC. Branching Station

Table 7-7(1/2) List of UHF Radio Stations

(900MHz Band 24/60 CH)

1. 24 CH System

1) C. UCHUMACHI - CHULUMANI Route

C. UCHUMACHI	IF Leaking Station
TORINI	CH. Branching Station
CHULUMANI	Terminal Station

2) Rep. COPACABANA - COPACABANA Route

Rep. COPACABANA	Terminal Station
COPACABANA	- ditto -

3) SAMA - CAMARGO Route

SAMA	SG. Branching Station
PELILLOJO	Base Band Leaking Station
BALCON	- ditto -
CAMARGO	Terminal Station

4) CAMIRI -MONTEAGUDO Route

CAMIRI	Terminal Station
C. ASTILLERO	Repeater Station
MONTEAGUDO	Terminal Station

Table 7-7(2/2) List of UHF Radio Stations

(900MHz Band 24/60 CH)

2. 60 CH System

1) C. UCHUMACHI - COROICO Route

C. UCHUMACHI	IF Leaking Station
COROICO	Terminal Station

2) C. TUTI - PUNATA Route

C. TUTI	SG. Branching Station
PUNATA	Terminal Station

3) REFORMA - ATOCHA Route

REFORMA	SG. Branching Station
ATOCHA	Terminal Station

4) REFORMA - UYUNI Route

REFORMA	SG. Branching Station
Rep. UYUNI	Repeater Station
UYUNI	Terminal Station

5) C. YUMIA - VILLAZON Route

C. YUMIA	IF Leaking Station
VILLAZON	Terminal Station

6) SAMA - BERMEJO Route

SAMA	SG. Branching Station
C. ALTO GRANDE	Repeater Station
C. CANDADO GRANDE	- ditto -
Rep. BERMEJO	- ditto -
BERMEJO	Terminal Station

7) SANA - YACUIBA Route

SANA	SG. Branching Station
YACUIBA	Terminal Station

Table 7-8(1/3) List of VHF Radio Stations
(160MHz Band 6 CH)

1) CHACALTAYA - ACHACACHI Route

CHACALTAYA	Terminal Station
C. CHAQUE CHUANI	Repeater Station
ACHACACHI	Terminal Station

2) CHACALTAYA - C. CACHACA Route

CHACALTAYA	Terminal Station
C. CACHACA	- ditto -

3) CARANAVI - PILON Route

CARANAVI	Terminal Station
BORINDA	Repeater Station
PILON	Terminal Station

4) ORURO - C. VETA BLANCA Route

ORURO	Terminal Station
C. VETA BLANCA	- ditto -

5) LLALLAGUA - CHAYANTA Route

LLALLAGUA	Terminal Station
C. LLALLAGUA	Repeater Station
CHAYANTA	Terminal Station

6) SUCRE - TARABUCO Route

SUCRE	Terminal Station
C. SICA SICA	Repeater Station
Rep. TARABUCO	Terminal Station

7) C. SICA SICA - YAMPAREZ Route

C. SICA SICA	Repeater Station
YAMPAREZ	Terminal Station

Table 7-8(2/3) List of VHF Radio Stations

(160MHz Band 6 CH)

8) SANTIBANEZ - CAPINOTA Route

SANTIBANEZ	Terminal Station
Rep. SANTIBANEZ	Repeater Station
CAPINOTA	Terminal Station

9) C. TUTI - TUNTURI Route

C. TUTI	Terminal Station
C. CURUBAMBA	Repeater Station
TUNTURI	Terminal Station

10) POTOSI - BETANZOS Route

POTOSI	Terminal Station
ORCOLLO	Repeater Station
BETANZOS	Terminal Station

11) C. REFORMA - SANTA ANA Route

C. REFORMA	Terminal Station
AGUA DE CASTILLA	Repeater Station
SANTA ANA	Terminal Station

12) C. REFORMA - SIETE SUYOS Route

C. REFORMA	Terminal Station
AGUADE CASTILLA	Repeater Station
SIETE SUYOS	Terminal Station

13) C. REFORMA - QUECHISLA Route

C. REFORMA	Terminal Station
QUECHISLA	- ditto -

14) Rep. PELILLOJO - Rep. COTAGAITA Route

Rep. PELILLOJO	Terminal Station
Rep. COTAGAITA	- ditto -

Table 7-8(3/3) List of VHF Radio Stations
(160MHz Band 6 CH)

15) Rep. PELILLOJO - CULPINA Route

Rep. PELILLOJO	Terminal Station
CULPINA	- ditto -

16) SAMA - PADCAYA Route

Rep. SAMA	Terminal Station
C. ALTO GRANDE	Repeater Station
PADCAYA	Terminal Station

17) C. CAMIRI - CHARAGUA Route

C. CAMIRI	Terminal Station
CHARAGUA	- ditto -

18) C. CAMIRI - BOYUIBE Route

C. CAMIRI	Terminal Station
BOYUIBE	- ditto -

Table 7-9(1/2) List of VHF Radio Stations
(MAS)

Base Station	Remote Subscriber
1) Rep. COPACABANA	MINA MATILDE
	HUARINA
	HUATAJATA
	GUAQUI
	DESAGUADERO
2) C. CACHACA	SICA SICA
	PATACAMAYA
	COROCORO
3) PILON	GUANAY
	TIPUANI
4) C. TORINI	IRUPANA
	CHOJLLA
	CORIPATA
5) NEGRO PABELLON	CARACOLLO
	SANTA FE
	MOROCO CALA
	EUCALIPTOS
	CHALLAPATA
	ANTIQUERA
6) C. TUTI	TARATA
	CLIZA
	UCUREÑA
	ARANI
	TIRAQUE

Table 7-9(2/2) List of VHF Radio Stations

(MAS)

Base Station	Remote Subscriber
7) JUNO	COLOMI
	VILLA TUNARI
	PUERTO VILLARROEL
8) TUNTURI	TOTORA
	AIQUILE
	MIZQUE
9) C. REFORMA	PULACAYO
	TAZNA
	TATASI
	VETILLA
10) BALCON	VILLA ABECIA
	LAS CARRERAS
11) SAMA	SAN LORENZO
	CONCEPCION
12) SANA	SANANDITA
	EL PALMAR
	CARAPARI

Table 7-10 MAS RF CH Design Conditions

Lost call ratio: En = 0.01

Calls: 0.36 erl./subscriber

(Originating & terminating calls combined)

Busy hour concentration rate: 0.143

No. of Sub's (N)	Total Calls (erl.)	No. of RF CH (n)	No. of Sub's (N)	Total Calls (erl.)	No. of RF CH (n)
2	0.102	2	22	1.122	5
3	0.153	2	23	1.173	5
4	0.204	3	24	1.224	5
5	0.255	3	25	1.275	5
6	0.306	3	26	1.326	5
7	0.357	3	27	1.377	6
8	0.408	3	28	1.428	6
9	0.459	4	29	1.479	6
10	0.510	4	30	1.530	6
11	0.561	4	31	1.581	6
12	0.612	4	32	1.632	6
13	0.663	4	33	1.683	6
14	0.714	4	34	1.734	6
15	0.765	4	35	1.785	6
16	0.816	4	36	1.836	6
17	0.867	4	37	1.887	6
18	0.918	5	38	1.938	7
19	0.969	5	39	1.989	7
20	1.020	5	40	2.040	7
21	1.071	5	41	2.091	7

Table 7-11 Typical Parameters of Transmitter/Receiver

ITEM	6GHz Upper Band	7GHz Band	900MHz Band	160MHz Band	MAS	Note
1) Transmitting Output Power	+27 dBm	+30 dBm +24 dBm +15 dBm	+37 dBm +30 dBm	+40 dBm +30 dBm	+40 dBm +30 dBm	
2) Branching Circuit Loss	4 dB (1 + 1 Sys.)	4.5 dB (1 + 1 Sys.)	8.1 dB	5.0 dB	3.0 dB	Per 1 Hop
3) Noise Figure of Receiver	6.5 dB	8 dB	6.5 dB	5.5 dB	8 dB	
4) Frequency Deviation	200KHz r.m.s	100KHz r.m.s (120 CH) 200KHz r.m.s (300 CH)	35KHz r.m.s (24 CH) 100KHz r.m.s (60 CH)	0.6 Radian (PM)	±5KHz	
5) Equipment Noise (Radio) (M + D)	24 pWpo 23 pWpo	41 pWpo (Includ. M+D)	190 pWpo (Includ. M+D)	20,000 pWpo (Includ. Mux)	20,000 pWpo	Per 1 Hop
6) Threshold Level	-84 dBm	-85 dBm	-92.5 dBm (60 CH) -95.5 dBm (24 CH)	-106 dBm	-116 dBm	
7) Nominal Rx Input Power	-34 dBm	-45 dBm	-57 dBm	-60 dBm	-73 dBm	

Table 7-12 Typical Parameters of Antenna System

	6GHz Upper Band	7GHz Band	900MHz Band	160MHz Band	Note
1) Parabolic Antenna Gain					
1.2 mø	35.9 dB	36.5 dB	-		
1.8 "	39.5 "	40.1 "	21.5 dB		
2.0 "	40.4 "	41.0 "	-		
2.4 "	42.0 "	42.6 "	24.0 "		
3.0 "	43.9 "	44.5 "	26.0 "		
3.3 "	44.3 "	45.0 "	-		
4.0 "	46.0 "	46.6 "	-		
4.2 "	-	-	29.0 "		
2) Yagi Antenna Gain					
3 Ele · 1 Stag			-	8.2 dB	
5 " · "			11.2 dB	11.2 "	
8 " · "			12.7 "	12.7 "	
12 " · "			14.2 "	14.2 "	
14 " · "			14.7 "	- "	
8 " · 2 Stags			15.2 "	15.2 "	
12 " · "			16.7 "	16.7 "	
14 " · "			17.2 "	-	
3) Feeder Loss	0.045 dB/m	0.046 dB/m	0.1 dB/m 0.07 dB/m	0.036 dB/m 0.023 dB/m	

Table 7-13(1/2) Constructing Lengths of Access Roads and Commercial Power Line

Radio Station	Commercial Power Line (km)	Access Road (km)			Remarks
		Roadway	Repair	Footpath	
CHACALTAYA	0.1		1.0		
C. VALENCIANI		4.0			
C. CHUSPIPRTA		5.0			
C. UCHUMACHI	5.0	6.0	5.0		
C. TORINI	4.0	2.5			
C. CACHACA				1.0	
C. CHAQUECHUANI				1.0	
C. BOLINDA		1.0			
C. VETA BLANCA	1.0			1.0	
Rep. ANTIQUIRA	1.0		0.5		
TUNTURI		3.0			
Rep. SANTIBANES	1.0	2.0			
Rep. AIOUILE				0.5	
Rep. COLOMI	1.0			2.5	
Rep. VILLA TUNARI			1.5	1.0	
Rep. ATOCHA				1.0	
ORCOLLO		1.0			
Rep. UYUNI	0.5	0.5			
Rep. VILLAZON	1.5	1.0			
AGUADE CASTILLA		2.0			
Rep. QUECHISLA	0.1			0.3	
Rep. TATASI	0.5			1.0	
Rep. VETIJJA				1.0	
Rep. BETANZOS				0.5	
Rep. TAZNA	0.2			0.2	
BALCON	0.5	1.0			

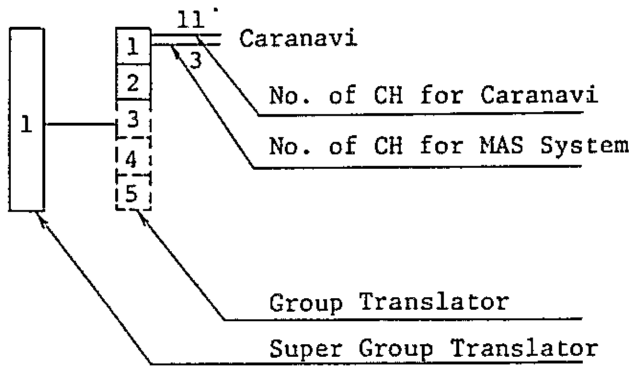
Note: Necessary construction work sites only.

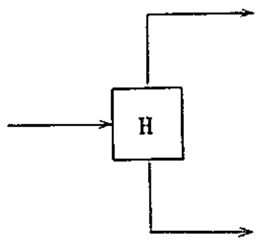
Table 7-13(2/2) Constructing Lengths of Access Roads and Commercial Power Line

Radio Station	Commercial Power Line (km)	Access Road (km)			Remarks
		Roadway	Repair	Footpath	
C. ALTO GRANDE		10.0			
C. CANDADO GRANDE		10.0			
Rep. COTAGAITA				5.0	
TAIGUANTI		3.0			
NANCORAINZA		0.5			
HACIENDA HUACARETA		0.5			
Rep. BERMEJO	2.0	3.0			
C. CAMIRI	1.0	0.1			
C. ASTILLERO		6.0			
Rep. TARABUCO	3.0			1.0	
PILON			2.0	0.1	
Total	22.4	62.1	10.0	17.1	

Note: Necessary construction work sites only.

<u>Abbreviation of Channel Accommodation Plan</u>





: Hybrid for IF/SG/G Leaking System

6 G - 960	: 6 GHz Upperband 960 CH System
7 G - 300	: 7 GHz Band 300 CH System
900 M - 60	: 900 MHz Band 60 CH System
160 M - 6	: 160 MHz Band 6 CH System
MAS	: MAS System

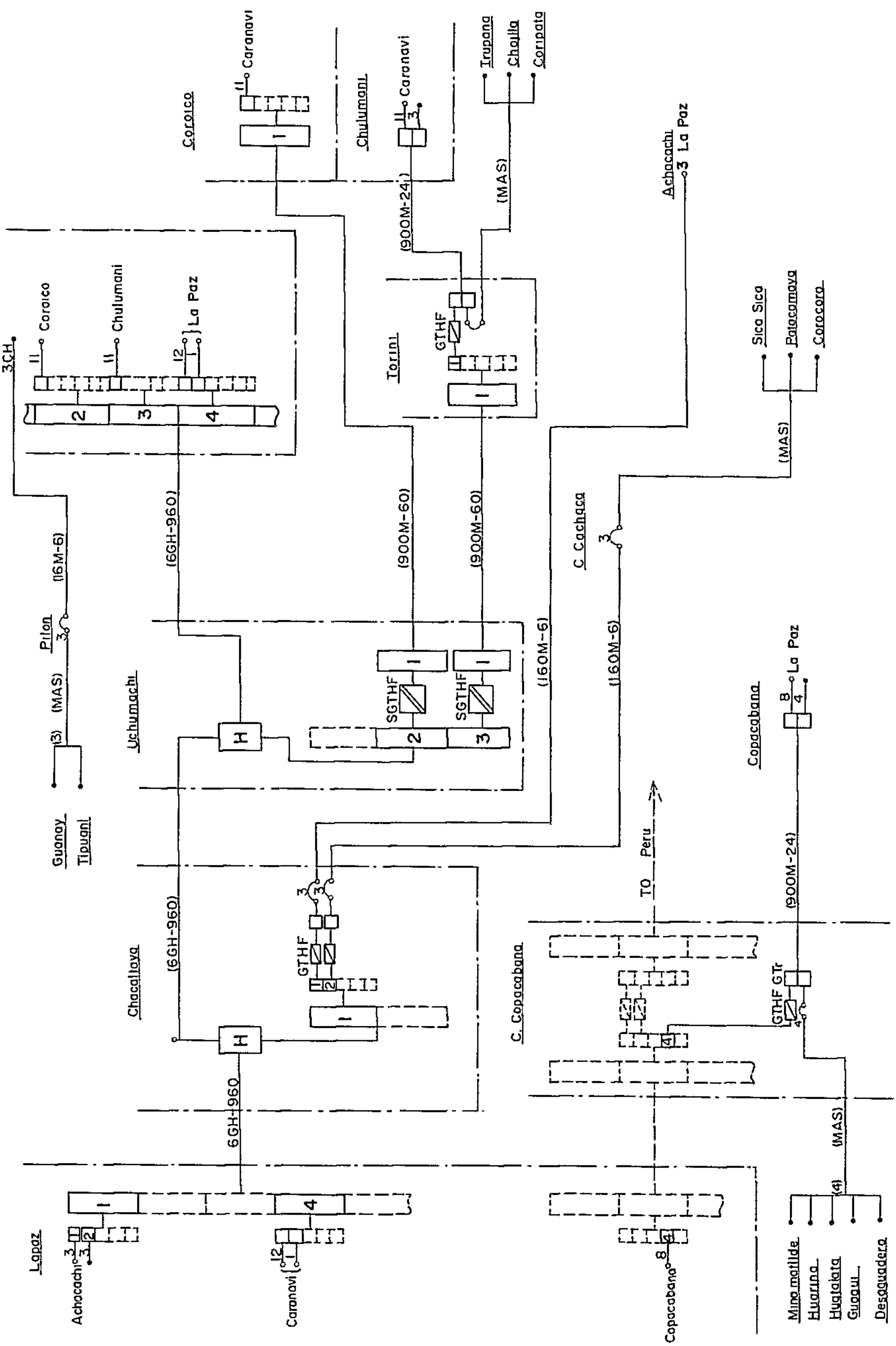
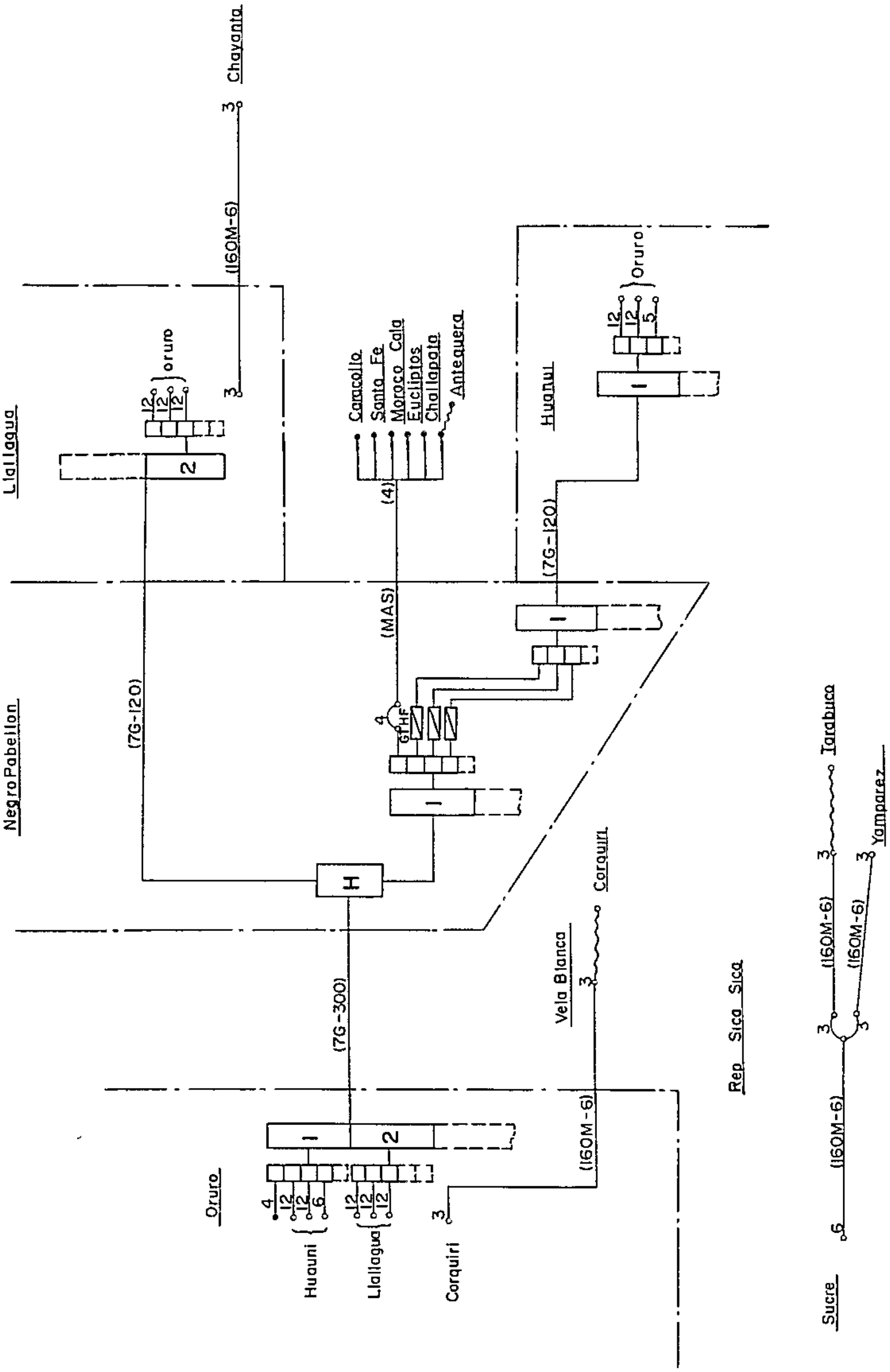


Fig. 7-1 (1/6) Channel Accommodation Plan



Fig・7-1 (2/6) Channel Accommodation Plan

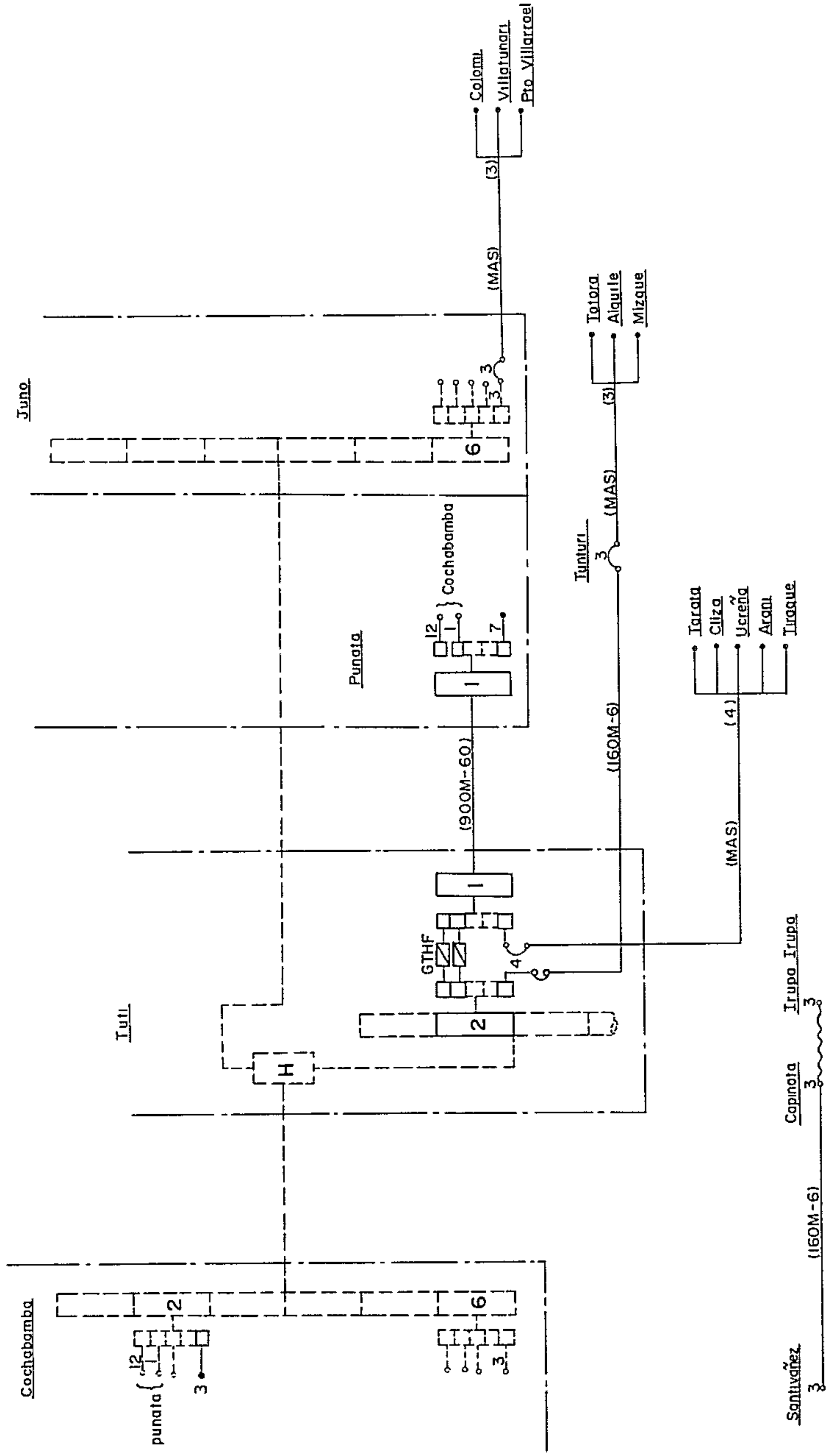


Fig. 7-1 (3/6) Channel Accommodation Plan

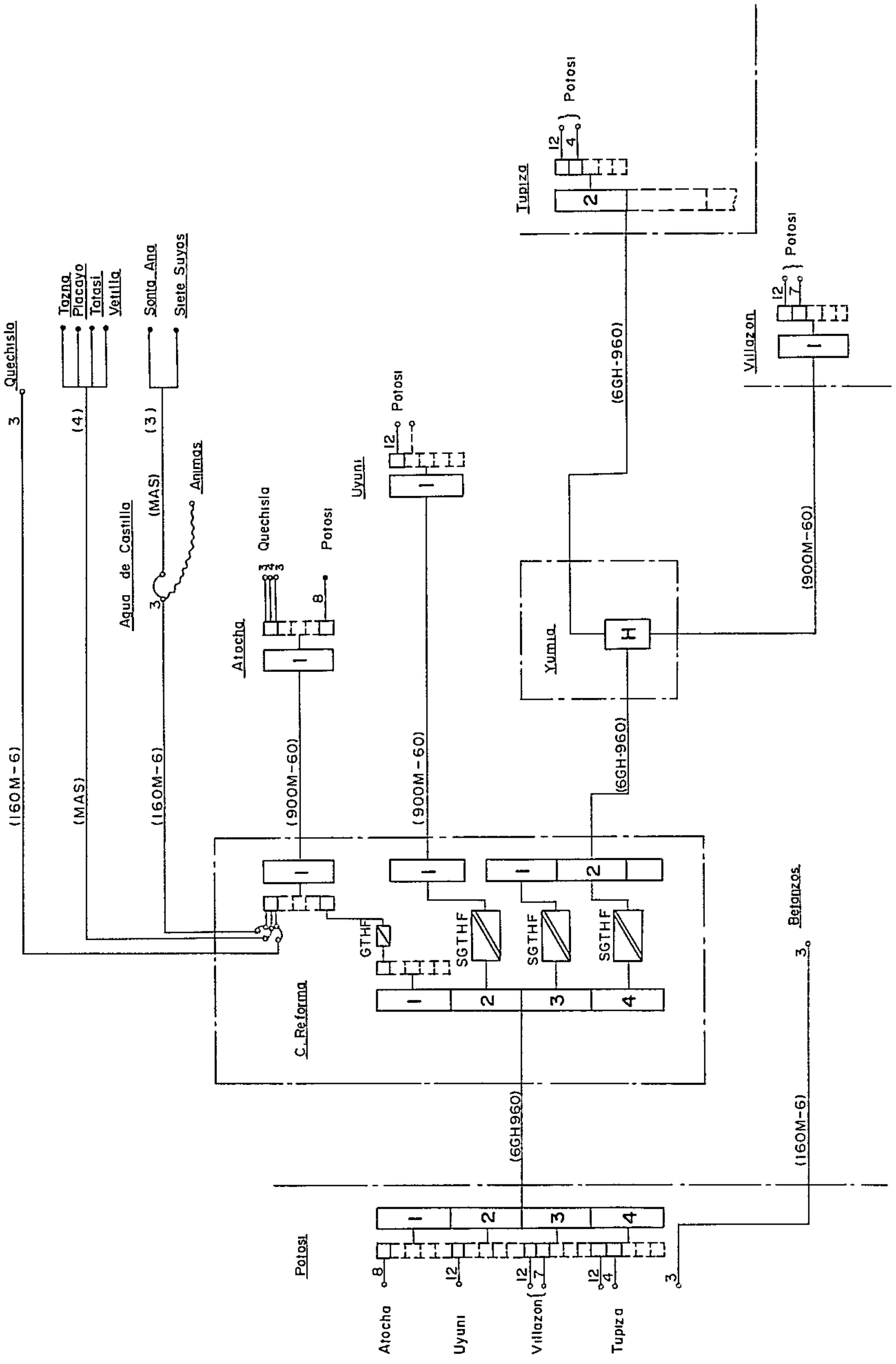


Fig 7-1 (4/6) Channel Accommodation Plan

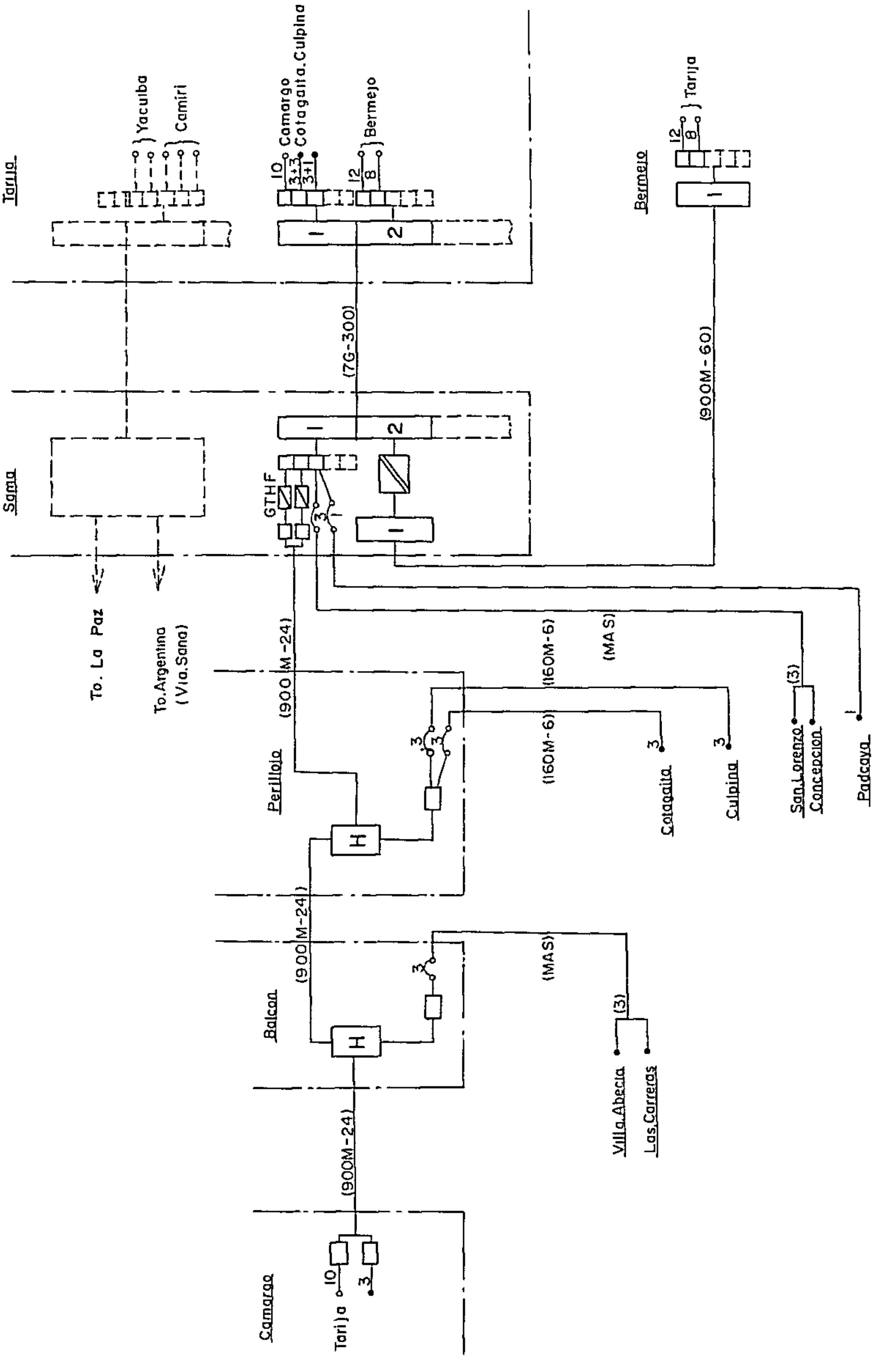
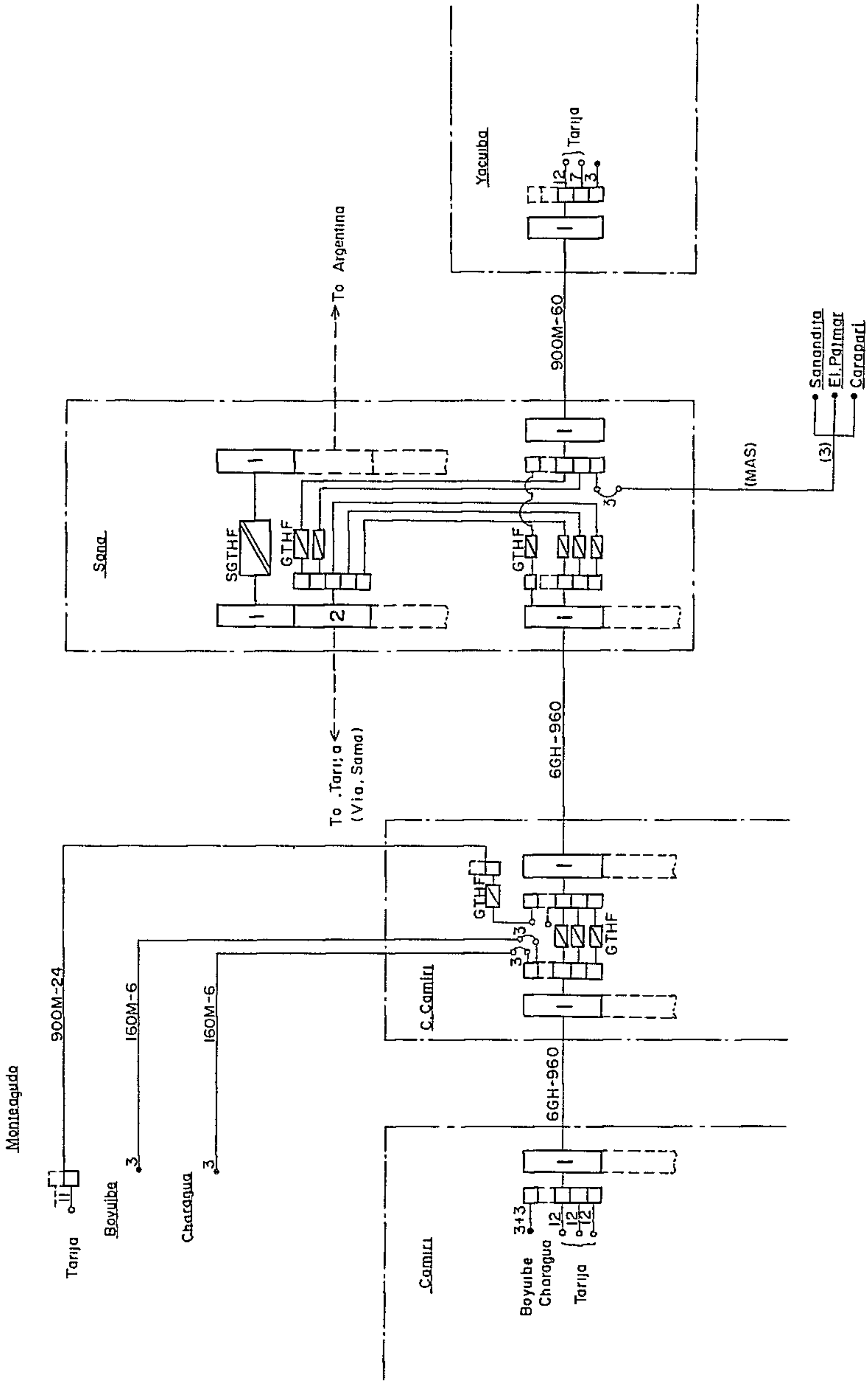


Fig · 7-1 (5/6) Channel Accommodation Plan



Fig· 7-1 (6/6) Channel Accommodation Plan

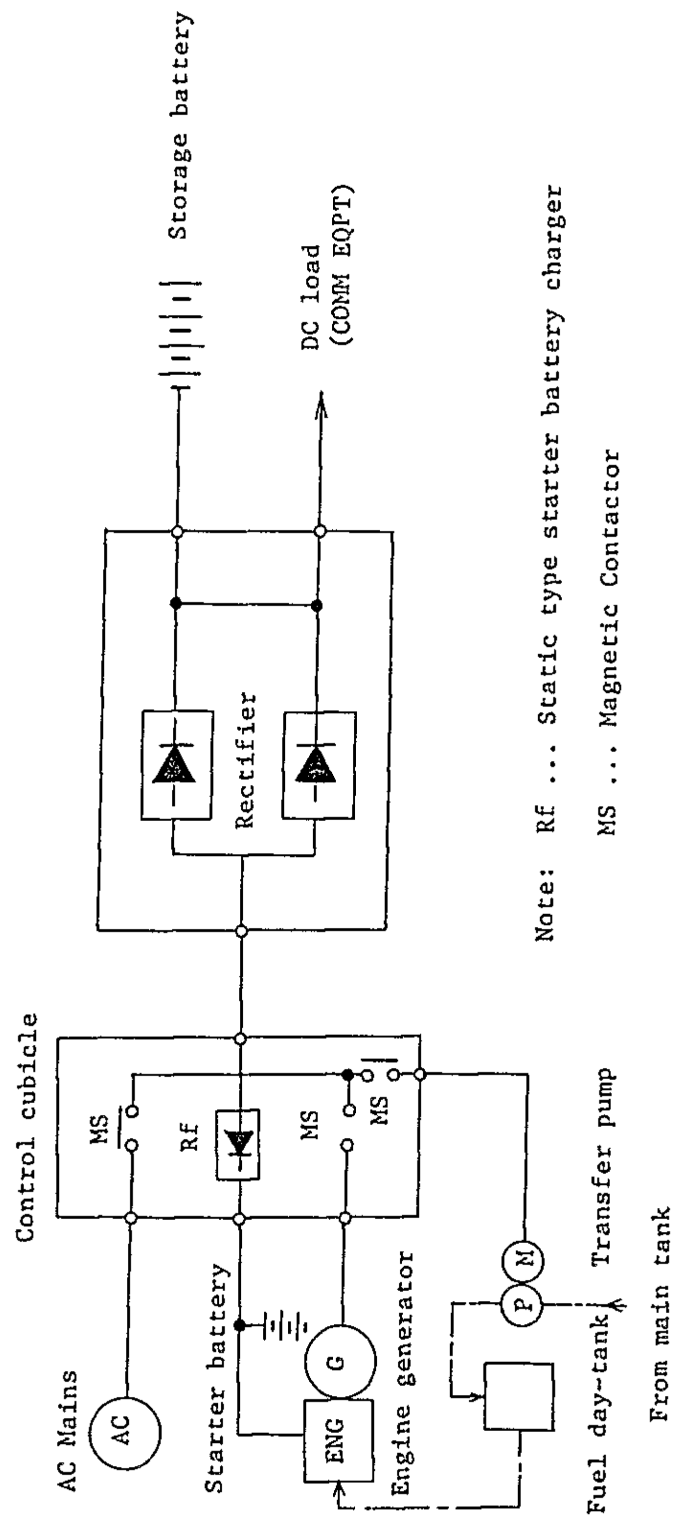


Fig. 7-2 Power Supply System using Standby Engine Generator on Full-Floating Basis at AC Mains Station

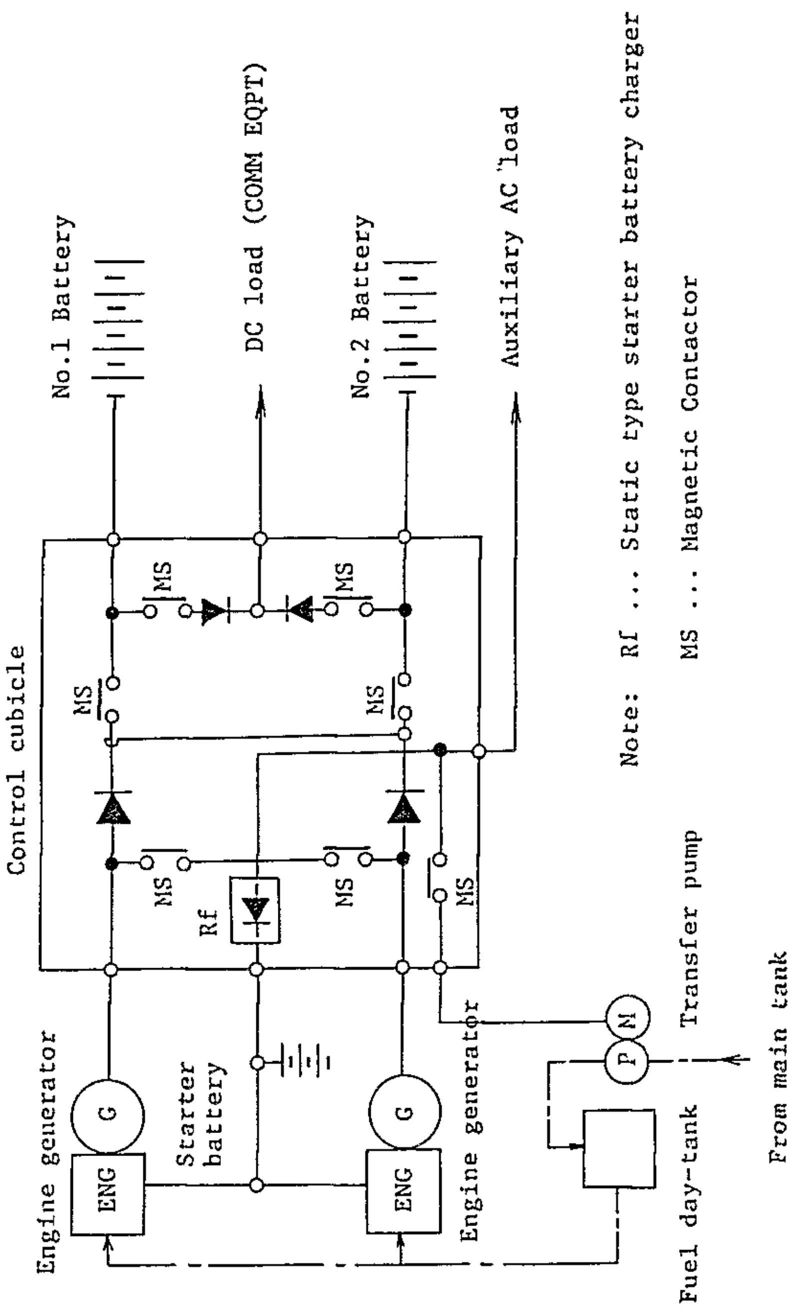


Fig. 7-3 Power Supply System using Dual Prime Engine Generator on Charge-Discharge Basis

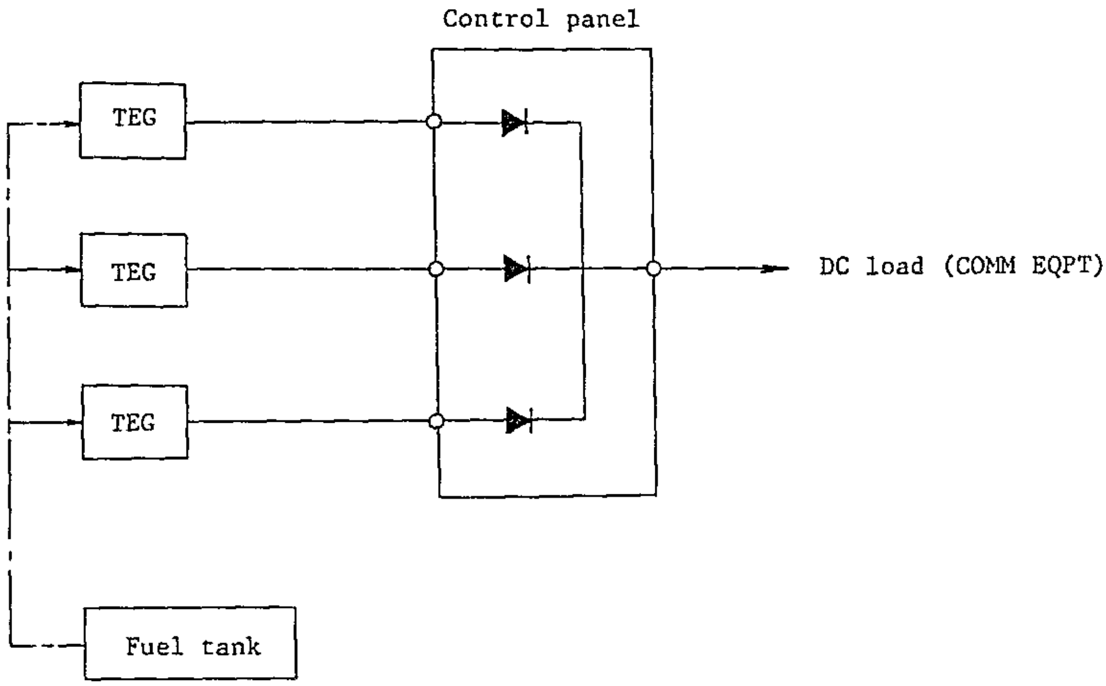


Fig. 7-4 Power Supply System using Thermoelectric Generator

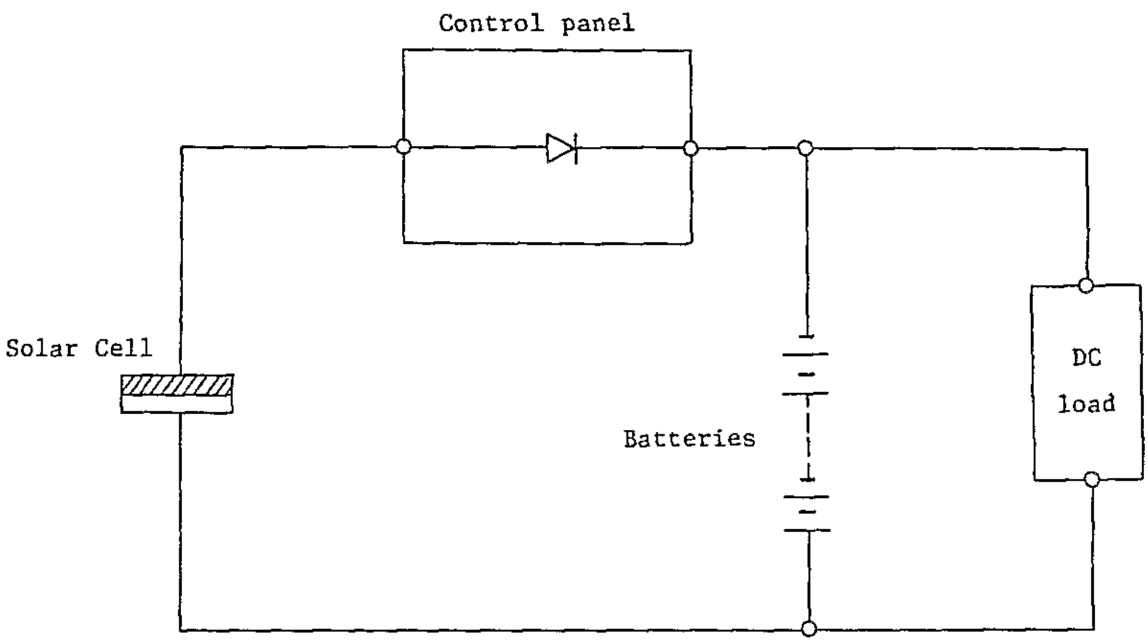


Fig. 7-5 Power Supply System using Solar Cells

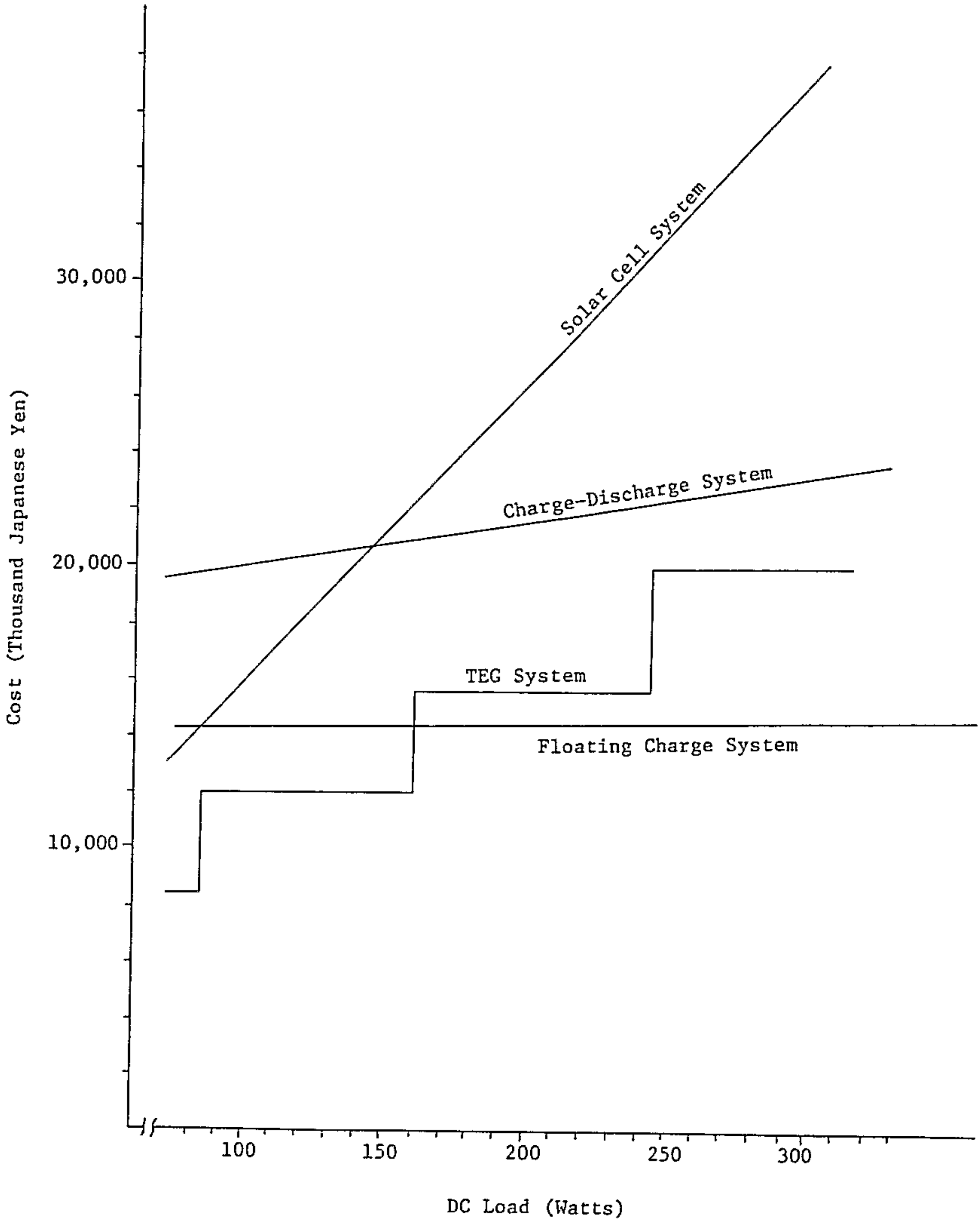


Fig. 7-6 Initial Cost of Various Kinds of Power Supply Systems, with DC Load of 100 - 300 Watts

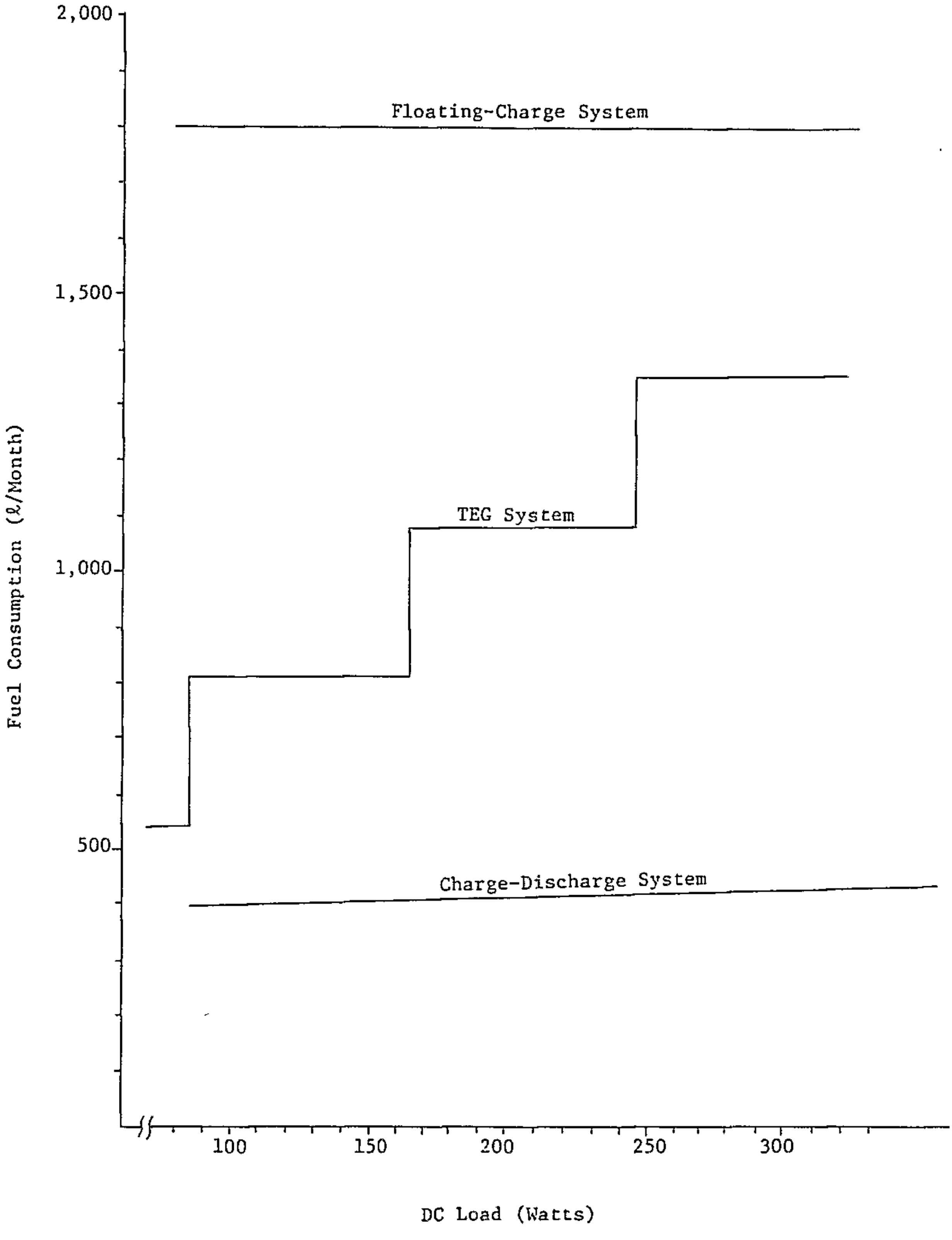


Fig. 7-7 Fuel Consumption of Various Kinds Power Supply Systems, with DC Load of 100 - 300 Watts

CHAPTER 8
MAINTENANCE AND OPERATION

CHAPTER 8 MAINTENANCE AND OPERATION

Although, in Bolivia, both the transmission and switching systems in the existing telecommunication network are the analogue type, the digital electronic switching system will be introduced by this Project. Also, in the local telephone network which at present is operated by private companies and other competent organizations, the telephone offices to be newly established by this Project will come under the operation and maintenance by ENTEL.

In due consideration of the foregoing situation, the maintenance and operation system and the training system for personnel in charge is to be studied.

8-1 Maintenance

8-1-1 Switching Equipment, Power Supply Equipment

Local telephone switching equipment and power supply equipment to be newly established by this Project will, in principle, be placed under centralized maintenance from the toll center (CG) or the regional center (CR). In case the telephone office concerned is located more than 100 km distant from CG or CR, the maintenance personnel will be stationed on permanent duty at the telephone office.

Spare parts and testing instruments necessary for the maintenance work will be put in custody at the centralized maintenance station or the telephone office where the maintenance staff is on duty.

The maintenance organization and staff details by stations are given in Table 8-1.

8-1-2 Remote Subscriber Telephone

At the telephone office where the maintenance staff in charge of the switching equipment is stationed, one technician will be assigned to the remote subscriber telephone maintenance. This one technician is included in the number of technicians on the maintenance staff of each telephone office identified in Table 8-1.

Besides the Table 8-1 arrangement, eight more technicians for eight more telephone offices are needed. Each of these eight technicians will take care of maintenance of the remote subscriber telephone to be accomodated in each of eight existing telephone offices.

8-1-3 Subscriber Cable Facility

For subscriber cable facilities, centralized maintenance will be carried out, in principle, from the maintenance center to be created in the toll center (CG) or the regional center (CR).

At the telephone office with the local switching equipment of 1,000 or more lines (based on the forecasted demand 15 years ahead) and at the telephone office more than 100 km distant from the CR, a separate maintenance center will be established and the maintenance staff on permanent duty will be stationed there. They will take care of trouble shooting, inspection itinerary and so forth.

Measuring equipment and spare parts in frequent need will be kept in store at each maintenance center and each telephone office. The less frequently needed stores and such items that cost much in small quantity will be stocked at the maintenance centers only.

The maintenance organization and staff details appear in Table 8-2.

8-1-4 Toll Transmission System

For the purpose of maintenance of the toll transmission system to be newly constructed, the personnel lineup shown in Table 8-3 is considered to be necessary.

In Bolivia, the backbone transmission system by a microwave system is already in operation. Hence, for the maintenance of the newly projected toll transmission system, the increase of personnel at the existing radio stations will be sufficient to meet the needs for the most part.

The maintenance personnel are distributed in due consideration of the road condition during the rainy season, as well as the special importance of the toll transmission system.

Spare panels required for maintenance purpose are to be collectively held in stock at La Paz.

8-2 Operation

8-2-1 Newly Installed Switching Equipment, Power Supply Equipment

The aforementioned maintenance staff will assume responsibility for operation of switching equipment and power supply equipment to be newly installed by this Project.

8-2-2 Newly Installed Toll Manual Board

At Tupiza and Villazon Exchanges, the introduction of DDD function is technically impossible. As an alternative, the toll manual board will be newly installed at each of these two exchanges, whereby to begin the operator trunk dialling service. Service hours will be from 6:00 a.m. to 10:00 p.m. Two operators will be assigned to duty at each exchange.

8-2-3 Remote Subscriber Telephone (Public Telephone) Consignee

Automatic public telephone system cannot be used for remote subscriber telephones to be accommodated in the existing local switching equipment, because the coin collecting signal is not uniform. The alternative is to employ the remote subscriber telephone consignee who will take care of call monitoring and coin collection.

For remote subscriber telephones to be accommodated in the switching equipment which will be newly installed by this Project, automatic public telephones can be used. However, the coin boxes in the telephones may become easily full, making it impossible to accept more coins and thus causing the call attempts to fail, or the telephones may be lost by stealth. In view of these possibilities, it is recommendable to employ the consignee in this case also.

The necessary number of such consignees is 59.

8-3 Training

So as to proceed ahead with the implementation of this Project without hitches and to realize the correct, prompt and efficient system operation and maintenance after the completion of the whole system, the top requirement is to obtain the capable management personnel and field workers. For this purpose, the training of such manpower is important.

8-3-1 Subjects of Training

The training must be administered on the following subjects:

(1) Management of work execution

(2) Knowhow on the proper use of new equipments and materials

(3) Maintenance and operation management

(4) Correct handling of measuring equipment and testing equipment

(5) Fault discovery/localization and fault statistics upkeep

8-3-2 Training Period and Number of Trainees

The training comprises three courses. They are held at different places and on different subjects.

(1) Training in the equipment manufacturer's country

This training category is mainly for engineers to assume maintenance and operation duty. Out of the engineers who have finished this training the instructors at the classroom training for technicians to be held in Bolivia will be chosen.

Besides, the training on telecommunication network management will be made for senior engineers.

The period required for the above training and the number of trainees to be accepted are:

- On telecommunication network management:

  2 months; 4 senior engineers

- On switching equipment and power supply equipment:

  Primary: 4 months; 10 engineers

  Secondary: 4 months; 8 engineers and 5 technicians

- On outside plant:

  2 months; 14 engineers

- On transmission and radio engineering:

  2 months; 6 engineers

(2) Classroom training in Bolivia

Instructors at this training category will, in principle, be the engineers in different fields of specialization who have finished the preceding category (1) training. The training texts are to be supplied in the appropriate number of copies by the equipment manufacturer(s).

This training is for technicians to be in charge of equipment maintenance and operation. Therefore, to obtain the required number of trained personnel, it is recommendable that this training be held several times per year periodically.

The period required for this training and the number of trainees to be accepted are:

- On switching equipment:

  Primary: 3 months; 20 technicians

  Secondary: 3 months; 20 technicians

- On power supply equipment:

  1 month; 10 technicians

- On outside plant:

  Primary: 2 months; 15 technicians

  Secondary: 2 months; 15 technicians

- On radio and transmission equipment:

  Primary: 2 months; 14 technicians

  Secondary: 2 months; 14 technicians

(3) On-the-job training (OJT)

During the implementation of this Project, the preceding categories (1) and (2) trainees will be sent to the work sites so that they can obtain the live knowledge of work execution and the work management methodology. This on-the-job training will be carried out, no matter whether the work is to be completed on the contractor's turn-key base or directly by ENTEL.

Table 8-1 Maintenance System of Switching Equipment and Power Supply Equipment

Telephone Office	Centralized Maintenance Office	Maintenance Personnel			Spare Parts
		Eng.(SW)	Tech.(SW)	Tech.(PW)	
UYUNI ATOCHA	UYUNI UYUNI	2	5	2	0
CAMARGO	CAMARGO	2	5	1	0
CAMIRI	CAMIRI	2	5	1	0
MONTEAGUDO	MONTEAGUDO	2	4	1	0
COPACABANA	COPACABANA	2	5	1	0
COROICO CARANAVI CHULUMANI	COROICO COROICO COROICO	3	7	2	0
LLALLAGUA HUANUNI	ORURO ORURO	2	5	2	0
PUNATA	COCHABAMBA	2	5	1	0
	TOTAL	17	*1 41 *2 (8)	11	0

Notes: 1) *1: Inclusive of remote Subscriber telephone (newly planned)

2) *2: Maintenance personnel for remote subscriber telephone to be accommodated in the existing office

3) Eng.: Engineer

4) Tech.: Technician

5) SW : Switching equipment

6) PW : Power supply equipment

Table 8-2 Maintenance System of Subscriber Cable Facilities

Centralized Maint. Office	Telephone Office	Maintenance Personnel			Remarks
		Eng.	Tech.	Total	
UYUNI	UYUNI ATOCHA	2	4	6	CG: POTOSI
CAMARGO	CAMARGO	1	2	3	CG: TARIJA
CAMIRI	CAMIRI	1	3	4	
MONTEAGUDO	MONTEAGUDO	1	2	3	
COPACABANA	COPACABANA	1	2	3	CG: LA PAZ
COROICO	COROICO CARANAVI CHULUMANI	3	6	9	CG: CARANAVI
LLALLAGUA	LLALLAGUA	1	3	4	CG: ORURO
HUANUNI	HUANUNI	1	3	4	
PUNATA	PUNATA	1	3	4	CG: COCHABAMBA
	TOTAL	12	28	40	

Table 8-3 Maintenance Arrangement for Toll Transmission System

Name of Station	Maintenance Staff	
	Eng.	Tech.
LA PAZ	1	2
COROICO	1	2
CARANAVI	-	2
ORURO	-	2
COCHABAMBA	1	2
POTOSI	-	2
ATOCHA	1	3
UYUNI	-	2
TUPIZA	-	2
CAMARGO	-	2
TARIJA	1	2
BERMEJO	-	2
YACUIBA	-	2
CAMIRI	1	2
Total	6	29

Note: Figures above indicate the number of required maintenance personnel for transmission routes to be newly established.

CHAPTER 9
PROJECT IMPLEMENTATION PLAN

CHAPTER 9 PROJECT IMPLEMENTATION PLAN

9-1 Equipment Procurement Methodology

The methods of procuring the necessary equipment for the implementation of this Project are twofold, i.e.:

(1) Procurement in Bolivia

(2) Procurement from a foreign country

Work items/expenses to be procured/financed by Category (1) above include the following:

1) Construction of telephone office and radio station buildings

2) Construction of access roads

3) Inland transportation expense

4) Warehousing expense

5) Equipment installation expense

Equipment items/expenses to be procured/financed by Category (2) above include the following:

1) Transmission and radio equipment including feeder cable, antenna and antenna tower

2) Telephone switching equipment

3) Telecommunication cable, subscriber cable equipment and telephone sets

4) Power supply equipment

5) Measuring equipment and spare parts

6) Consultant service fee

7) Transportation expense and insurance fee

8) Foreign currency portion out of equipment installation expense

9) Training expense

9-2 Project Implementation Schedule

The implementation schedule pertaining to this Project is compiled in Table 9-1. The implementation is to be carried out in four phases. They are:

First Phase: From the detail study for making tender documents to the work contract signing

Second Phase: Detail design of equipment and installation works

Third Phase: Manufacture of equipment and transportation of manufactured equipment to work sites

Fourth Phase: Equipment installation and adjustment, and acceptance tests

Out of the aforementioned implementation work series, the construction of buildings and access roads will be planned and executed irrespective of the implementation stages shown above, but should be completed not later than the equipment conveyance into the buildings in the third stage.

9-3 Work Execution Methodology

The installation of switching equipment, power supply equipment, and radio/transmission equipment is to be carried out by the contractor on the turn-key basis.

The outside plant installation is also to be carried out on the turn-key base inclusive of the local contract between the contractor and the local service company.

All these works have much in common with the building and access road construction by ENTEL. In the execution time schedules also, both work categories are mutually related. For this reason, the contractor should preferably be a single company.

9-4 Consultant

For the purpose of satisfactory progress of project implementation, employment of a qualified consultant is recommended.

The consultant is to participate in all four phases of project implementation and to assist ENTEL in the execution of all necessary works.

Consultant services at each phase of project implementation are as follows:

First Phase: To carry out detailed field surveys and, based on the findings, formulate tender documents.
To evaluate the bids submitted in the tender and assist ENTEL in contract negotiations and contract signing.

Second Phase: To examine detail design drawings submitted by the contractor.

Third Phase: To inspect the contractor's factory shipments, jointly with ENTEL.

Fourth Phase: To control the work progress in consideration of the relationships with other works (such as building construction and power lead-in work) and, at the final stage of the whole work series, carry out the acceptance tests.

The consultant should be chosen out of the third parties rich in experience and without any special relationship with the contractor. This is important because the consultant must fulfill his duty righteously and free from prejudice.

TABLE 9 − 1 IMPLEMENTATION SCHEDULE