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THE MASTER PLAN STUDY ON MODERNIZATION AND REHABILITATION OF THE NATIONAL RAILWAYS IN THE REPUBLIC OF BOLIVIA

FINAL REPORT (SUMMARY)

NOVEMBER, 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

(JICA)

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PREFACE

In response to a request from the Government of the Republic of Bolivia, the Government of Japan decided to conduct a Master Plan Study on Modernization and Rehabilitation of the National Railways in the Republic of Bolivia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Bolivia a study team headed by Mr. Sadaaki KURODA, Japan Railway Technical Service (JARTS), 3 times between March 1990 and November 1991.

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

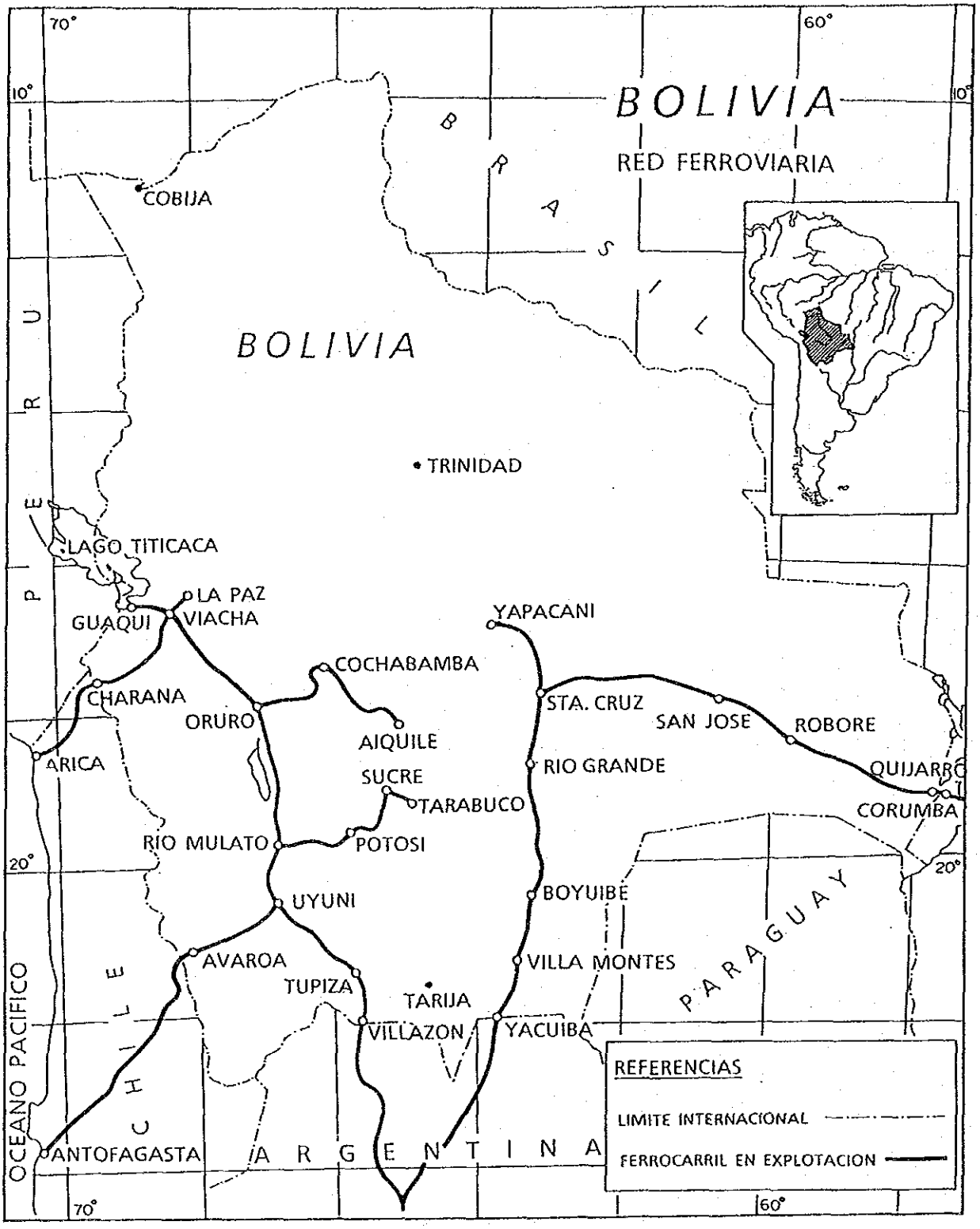
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

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

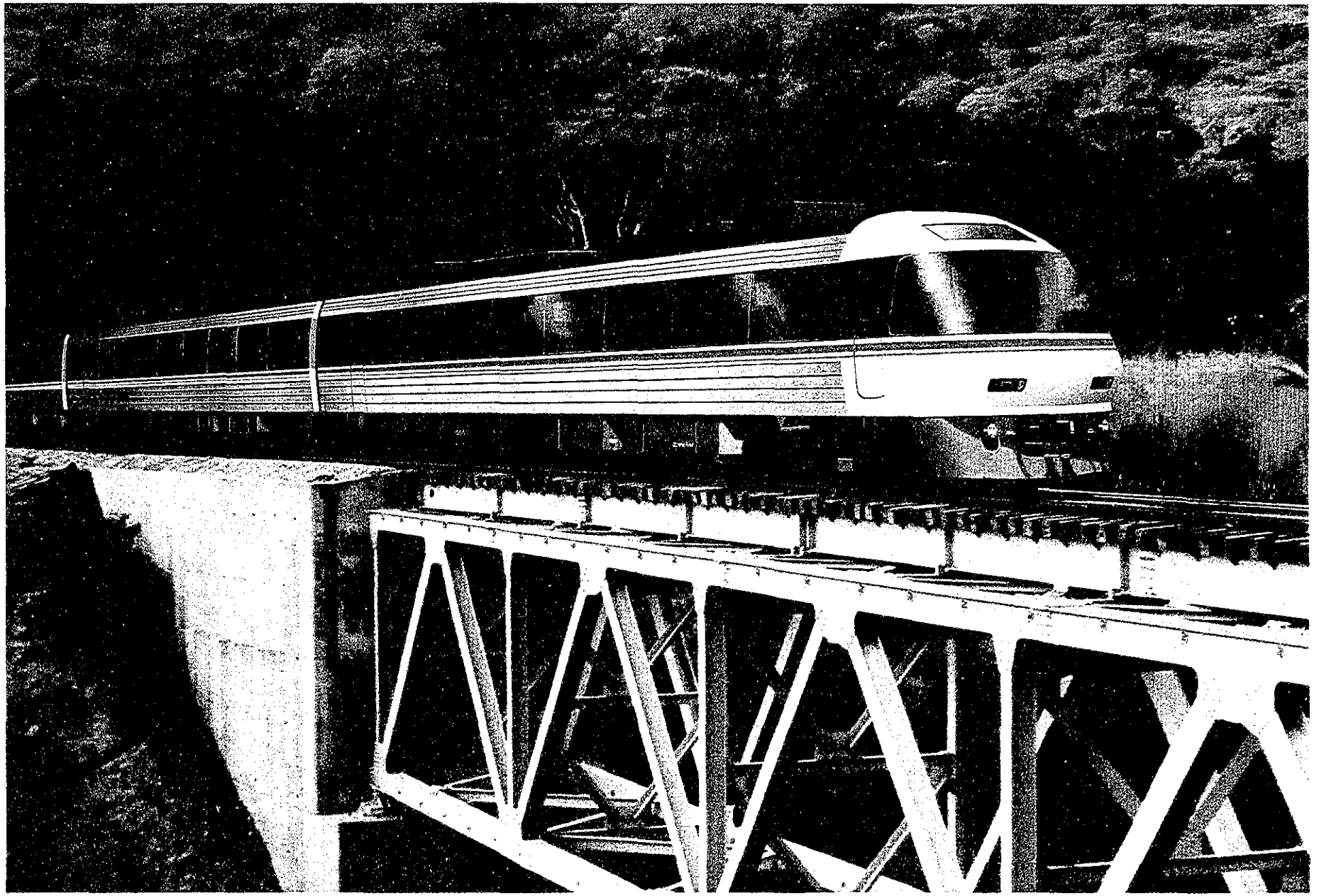
November 1991

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency



Survey Locations



Contents

(Summary)

1. Introduction

Empresa Nacional de Ferrocarriles (ENFE) operates routes totalling about 3,650 km in length (2,276 km in the Western Region and 1,373 km in the Eastern Region, without any physical connection between the two regions). The railway transports most of the imports and exports of Bolivia, and plays a major social and economic role as the main artery of the nation. Owing to a shortage of funds, however, no progress has been made in track improvement, modernization of signalling and telecommunication facilities, introduction of new rolling stock, etc. As the result, the railway is not fully functioning due to such factors as the extensive superannuation of facilities, decrease in the working ratio of rolling stock, and further due to natural disasters.

To cope with this situation, ENFE has specific projects for constructing links and improving tracks for the lines of the Eastern and Western Regions. There is also a need for rehabilitation and modernization of existing facilities and rolling stock a well as management improvement. However, there are no basic principles for deciding investment priorities when implementing plans. Given these circumstances, it has become urgent to draw up a master plan to establish a railway network and set up long-, medium-, and short-term railway construction plans.

With this background, the Bolivian Government requested the Japanese Government to carry out a study on railway network construction in Bolivia. Based on the Scope of Work concluded on October 5, 1989 between the Bolivian Government and the Preliminary-study Team of the Japan International Cooperation Agency (JICA), the Japanese Government dispatched a study team to Bolivia to conduct a study on drawing up a master plan for rehabilitation/modernization of a railway network.

This study covers all regions served by ENFE. It aims to draw up a master plan for setting up a modernized and rehabilitated railway network in Bolivia and for establishing stage-by-stage railway modernization/rehabilitation plans that are based on the master plan and take into account investment priorities. At the same time, the transfer of Japanese railway technologies to ENFE engineers in the course of the study is planned.

In this study, the basic principles in drawing up a master plan are as follows. Sufficient consultations with the Bolivian side have been made in selecting an optimum railway master plan and establishing modernization/rehabilitation plans by stage.

(1) Draw up the plan that can be easily implemented with a reasonable amount of investment, taking into consideration the economy of Bolivia and financial situation of ENFE.

(2) Draw up the plan for improving the railway so that the railway can greatly contribute to the social and economic growth and land development of Bolivia.

(3) Establish the plan that will ensure safe, stable, and reliable domestic transport and will also enable the railway to serve as a means of international transport.

(4) Establish short-term (year 2000) and medium-term (year 2010) railway modernization/rehabilitation plans, setting the final target under the master plan at 2020. In deciding priorities of projects, give comprehensive consideration to such factors as: safety in transport; effects of investments; urgency; importance of the line concerned; and investment costs. In planning rehabilitation and modernization, take sufficient care to realize profitable and efficient railway operation, as well as to ensure safe, stable, and reliable transport.

(5) Establish necessary service levels, fully taking into consideration such factors as the present situation, characteristics, importance, and investment costs of the line concerned, in order to provide safe and stable transport.

(6) Harmonize the railway plans with various projects of nation and state levels, as well as projects of ENFE, World Bank, etc. that are going to start.

(7) Conduct studies on railway reinforcement, putting emphasis on rehabilitation and modernization of existing lines and facilities, to enhance their effective utilization. As for the plans of constructing new lines connecting with conventional lines, pay special attention to setting up sufficient links between the new railway lines and road and water transport, to realize an efficient intermodal transport.

At the same time, give sufficient consideration to an intermodal system that utilizes the conventional road and water transport without entailing railway construction.

(8) In deciding the plan of the optimum master plan in 2020 and short- and medium-term railway reinforcement plans, make comprehensive judgement based on quantitative evaluations of the economy and finance, taking into consideration qualitative evaluations of principles and policies of the national government and ENFE as well as social and technical aspects.

The report (summary) is a synopsis of the railway network reinforcement master plan for year 2020 and the short-term (2000), medium-term (2010), and long-term (2020) railway reinforcement plans.

2. Present Situation of ENFE

ENFE, established in 1964, is a public corporation under the control of the Ministry of Transport and Communications. It operates commercial routes totalling about 3,650 km and has about 7,000 employees.

ENFE routes consist of Western Region lines (2,276 km with the La Paz~ Oruro section as the core) leading to Chile and Argentina and Eastern Region lines (1,373 km with lines radiating from Santa Cruz) leading to Brazil and Argentina. Both regions are not connected within Bolivia. An outline of these routes is shown in Table 1. (Refer to Figure 2-1)

Freight accounts for the main portion of ENFE traffic, and main commodities carried are soybeans, mineral products, timber, and wheat. Especially, imports and exports account for about 80% of the total traffic and are carried on railway lines via neighboring countries. The railway is thus playing large economic and social roles as the main artery of the country. Passenger traffic of ENFE in 1988 was about one million persons and 370 million passenger-km. Freight traffic in the same year was about 800,000 tons and about 420 million ton-km. The traffic volume of ENFE has been declining since the peak in 1983 for passengers and in 1980 for freight. The main reasons for the decrease in traffic are considered to be the protracted suspension of train operation due to natural disasters, in addition to such factors as the superannuation of facilities and decrease in the working ratio of rolling stock. (Refer to Figure 2-2)

The commercial trains in operation at present are classified into rail buses (Ferrobus), passenger express trains (Expreso), passenger trains (Pasajero), mix trains (Mixto), and freight trains (Carga). These trains are operated on specific days of the week since the traffic volume is small. In 1988, about 9,000 trains were operated, and the delay of trains was about 21 hr. 50 min. per train (including trains on time) and about 4 hr. 50 min. per delayed train. The train operation system entirely depends on "handling by the personnel in charge", and mechanized facilities for operational safety are few. ENFE owns 53 locomotives for main tracks, 10 shunting locomotives, 22 diesel railcars, 181 passenger cars, and 2,032 freight cars.

As for the financial result of ENFE operation, revenues and expenses for 1988 were about 100 million bolivianos (about 5,000 million yen) and about 97 million bolivianos, respectively. It seems that

balance is being maintained for the present, thanks to such measures as shouldering of long-term liabilities by the government (in 1986) and restraint of new investment.

However, the improvement of railway facilities has been delayed due to a shortage of inherently-needed investment, resulting in the progress of extensive superannuation and insufficient maintenance. Delays are also seen in establishing appropriate systems for train operation and accident prevention. This is frequently causing accidents such as derailment. Furthermore, natural disasters are of annual occurrence, inflicting damages on the railway. In addition, owing to the superannuation of rolling stock and insufficient procurement of parts, the working ratio of rolling stock is decreasing.

Under these circumstances, ENFE is not sufficiently performing the inherent functions of the railway, and it is difficult at present to ensure safe, stable, and efficient transport. Accordingly, ENFE is planning to put emphasis for the time being on the reinforcement of the transport routes for the imports and exports (Santa Cruz~ Quijarro, Viacha~ Charana) by utilizing loans from the World Bank. At the same time, efforts are being mode to improve systems for business administration.

What is important to ENFE in the future is to display strong points of the railway, such as long-distance and large-volume transport, as well as to ensure safe and stable transport. For that purpose, it is necessary to: establish appropriate organizations and systems for railway operation based on a long-range prospect; promote introduction and improvement of ground facilities and rolling stock by adequate investment; and push forward such measures as pertinent control of train operation and efficient maintenance of ground facilities and rolling stock by personnel training. At the same time, efforts should be made to prevent railway accidents (accidents caused by natural disasters; accidents at crossings, etc.), with cooperation of the organizations concerned and residents along the routes.

Table 2-1 Main Features of ENFE

Items	Figures, etc.		Items	Figures, etc.
Track system	Single track, unelectrified		Stations	136 places
Gauge	1,000 mm		Signal stations	66 places
Minimum curve radius	Western Region	72 m	Bridges	954 places
	Eastern Region	250 m	Tunnels	26 places
Maximum grade	Western Region	38.5%	Level crossing	570 places
	Eastern Region	33.3%	Soil ballast	about 80%

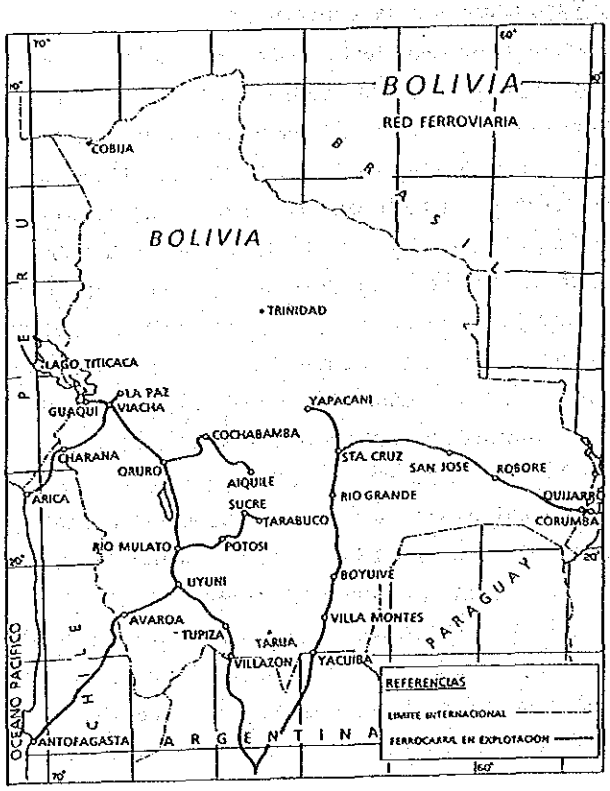


Figure 2-1 Rough Route Map of ENFE

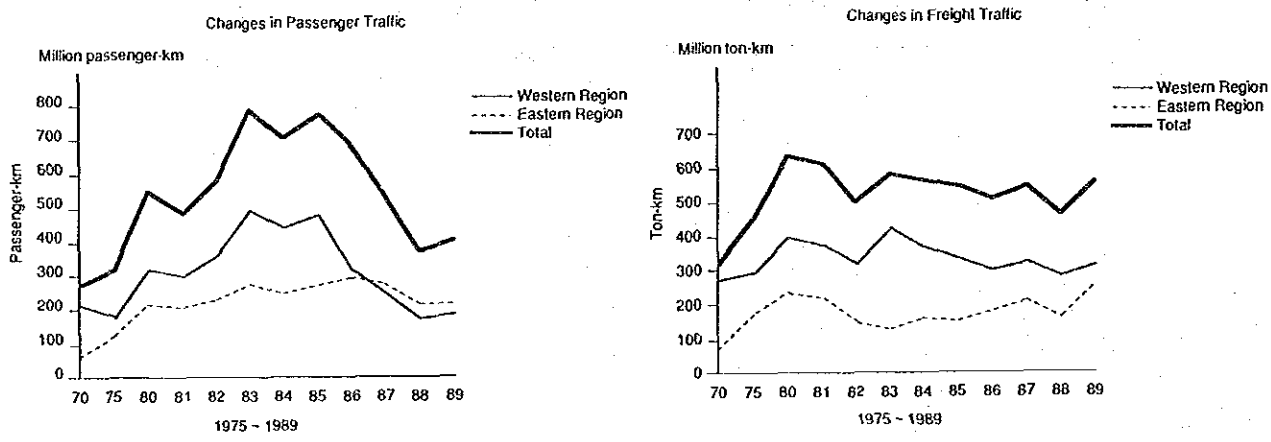


Figure 2-2 Changes in Passenger and Freight Traffic

3. Optimum Railway Network in 2020 and Phased Improvement Plan

3-1 Selecting Optimum Railway Network

The following procedure was employed for selecting the optimum railway network and for outlining the corresponding modernization plan (master plan) and the phased improvement plan on sufficient deliberation with Bolivia.

(1) Eight possible railway network plans for 2020 were proposed. (Table 3-1)

(2) Four typical plans were selected from the above eight plans mainly on the basis of qualitative overall evaluation.

(3) The optimum railway network was selected from the above four proposed plans.

Among the four proposed plans, Plan II was selected as the optimum railway network on the basis of the comparison table shown in Table 3-2 and in consideration on Bolivia's investment scale in the transport sector, the promotion of regional development along the route and the contribution to the international railway network, etc.

Table 3-2 Comparison of Proposed Plans

Plan	I	II	III	IV
Economic evaluation (EIRR)	(4) 5.33	(2) 7.65	(3) 6.79	(1) 8.84
Financial evaluation (Income and expenditure ratio)	(2) 0.974	(1) 1.060	(4) 0.837	(3) 0.969
Investment scale (100 million US dollars)	(1) 14.6	(2) 16.1	(3) 25.1	(4) 26.8

Notes: 1. The figures in ( ) indicate the sequence in terms of advantage.

2. Unit of EIRR: %

3. Income and expenditure ratio: Operating income/(Operating expenditure + Interest on loans)

4. The amount of investment reevaluated by ENFE was used as the railway construction cost between Aiquile and Santa Cruz.

3-2 Outlining Phased Reinforcement Plan (Year 2000, 2010, 2020)

The reinforcement plans in the intermediate stages were outlined on deliberation with Bolivia in consideration of the investment efficiency, the importance and special characteristics of line sections and other factors. Ten years were regarded as one unit. Accordingly, the total period of the master plan was divided into the phase up to the year 2000, the phase up to 2010 and the phase up to 2020.

The improvement project consists of the reinforcement and improvement of 9 line sections, the construction of 1 new line and the modernization of 5 items. The phased reinforcement plan is shown in Table 3-3.

Table 3-1 Proposed Railway Network Plans

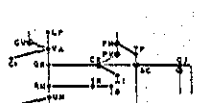
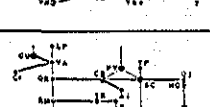
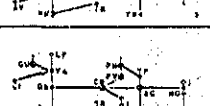
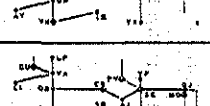
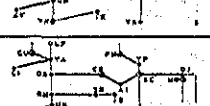
Proposed railway network plans (Year 2020)					Qualitative evaluation								
No.	Rough route	Rehabilitation and improvement of existing lines	Intermodal facilities	New line construction	Investment scale	Domestic railway transport network	Development effect	Profitability	Vehicle operation	International railway transport network		Characteristics	Plan No. (2020)
1		Required	1 Guaqui 2 Cochabamba 3 Santa Cruz 4 Puerto Villarroel 5 Villazon *6 Quijarro (River)* 7 Quijarro (Road)	None	◎	△	△	△	△	△	△	• Small-scale investment • *Improvement on current railway network only*	I
2		Required	1 Guaqui 2 Cochabamba 3 Santa Cruz 4 Puerto Villarroel 5 Villazon 6 Quijarro (River) 7 Quijarro (Road) 8 Puerto Mamorecillo	(2) Yapacani ~ Puerto Mamorecillo	○	△	△	△	△	△	△	• Improved railway network in northern region	
3		Required	1 Guaqui 2 Cochabamba 3 Santa Cruz 4 Puerto Villarroel *5 Villazon* 6 Puerto Busch	(3) Motacucito ~ Puerto Busch	○	△	○	△	△	○	○	• Improved railway network in eastern region • Linkage with international river	II
4		Required	1 Guaqui 2 Cochabamba 3 Santa Cruz 4 Puerto Villarroel 5 Villazon 6 Puerto Mamorecillo 7 Puerto Busch	(2) Yapacani ~Puerto Mamorecillo (3) Motacucito~ Puerto Busch	○	△	○	△	△	○	○	• Improved railway network in eastern and norther regions • Linkage with international river	
5		Required	1 Guaqui 2 Santa Cruz 3 Puerto Villarroel 4 Villazon 5 Quijarro (River) 6 Quijarro (Road)	(1) Aiquile~Santa Cruz	○	○	○	○	○	○	○	• Medium-scale investment • Railway network in which east and west trunk line systems are established	III
6		Required	1 Guaqui 2 Villazon 3 Quijarro (River) 4 Quijarro (Road) 5 Puerto Mamorecillo	(1) Aiquile~Santa Cruz (2) Yapacani~ Puerto Mamorecillo	△	○	○	○	○	○	○	• Phased railway network for plan 8	
7		Required	1 Guaqui 2 Santa Cruz 3 Puerto Villarroel 4 Villazon 5 Puerto Busch	(1) Aiquile~Santa Cruz (3) Motacucito~ Puerto Busch	△	○	○	○	○	◎	◎	• Phased railway network for plan 8	
8		Required	1 Guaqui 2 Villazon 3 Puerto Mamorecillo 4 Puerto Busch	(1) Aiquile~Santa Cruz (2) Yapacani~Puerto Mamorecillo *(3) Motacucito~Puerto Busch*	△	◎	◎	◎	○	◎	◎	• Large-scale investment • Complete railway netowrk	IV

Table 3-3 Proposed Phase Reinforcement Plan

Project name	Route extension (km)	Investment efficiency	Importance of line section: Trunk line	Importance of line section: Cross-continental	Special condition	Overall priority sequence (Rank)	Reinforcement plan schedule: 1991 2000 2010 2020	Remark
1. Line section improvement								
Red Andina								
Villazon L.	847.2	①	○	Partly ○		A		1991~2000, Lp.~Or., R.Mur.~Uyu. 2001~2010 The rest
Guaqui L.	65.8	③			• Being improved at present (Small urgency)	C		
Charaña L.	209.3	①		○	• Construction of parallel road (2000) • Large urgency for business strategy	A		
Avaroa L.	172.4	①			• Relatively good transport function (Small urgency)	C		
Cochabamba L.	204.8	②		○	• Large social importance • Disaster line section	A		
Sucre L.	348.2	②				C		
Red Oriental								
Quijarro L.	650.4	①	○	○	• Construction of parallel road (2020) • Large urgency for business strategy	A		
Yacuiba L.	539.0	③	○		• Construction of parallel road (2010) • Large urgency for business strategy • Large social importance	B		
Yapacani L.	209.2	②				C		
2. New line construction								
Pto. Buch L.	132.7	①			• Coordination with progress of mine development	B		
3. Modernization								
Rolling stock								Increase in rolling stock according to demand
Plant								1991~2000 Viacha, Guaracachi plants
Communication network								*UHF, switching system, etc.*
Computer								
Training school								1991~2000 Improvement of existing training school 2011~2020 Comprehensive training school

Note: Details of line section improvement
- Track improvement – Rail, turnout, ballast, maintenance machinery
- Crossing improvement
- Station improvement – Track layout change, signal station, intermodal facilities
- Bridge improvement – Replacement of temporary bridge, abutment and pier reinforcement
- Protection facilities – Slope protection, protection fence for track
- Improvement of disaster section (ORURO – COCHABAMBA)
- Construction of new signal facilities
- Improvement of some communication equipment

4. Demand Forecast

4-1 Forecasting Method

(1) Flow of Forecasting Procedure

The demand was forecasted by a 4-stage estimation method as shown in Figure 4-1.

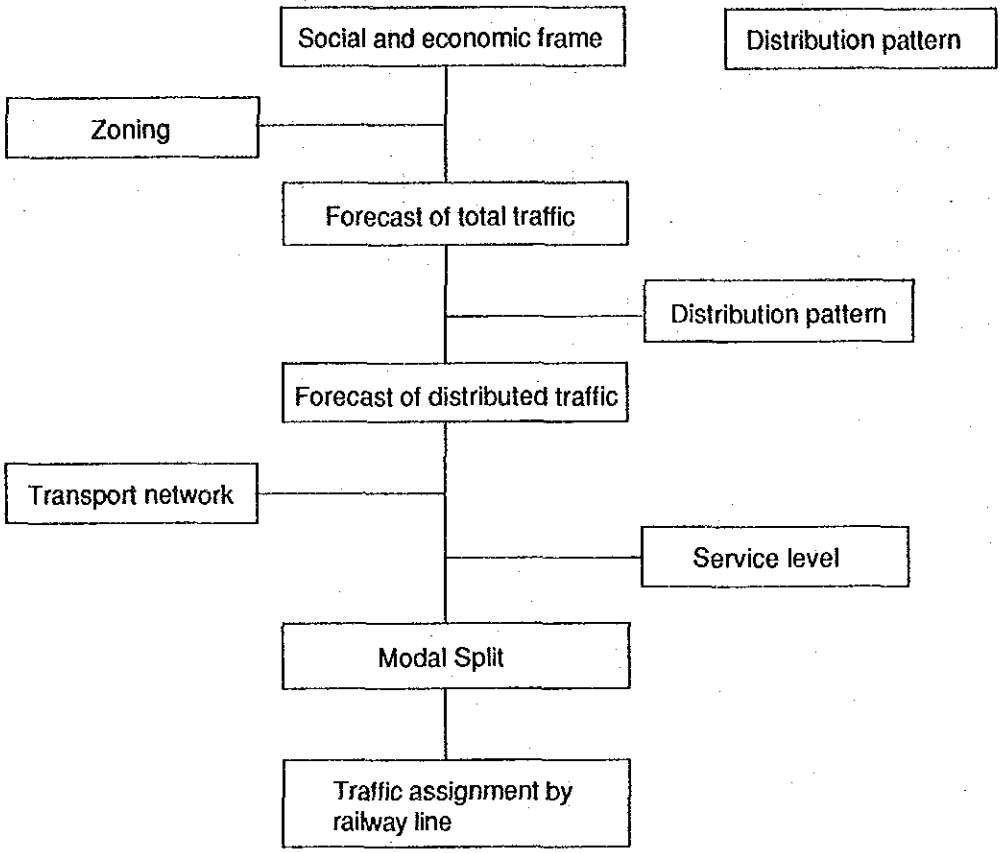


Figure 4-1 Flow of Traffic Demand Forecast

(2) Years of Forecast

2000, 2010, 2020

(3) Means of Transport

Passenger: Railway, road (bus), air

Freight: Railway, road (truck)

Note: Air service was excluded from the forecast of freight traffic because it accounted for only 1.2% of the total freight traffic in 1988.

(4) Forecast of Total Traffic

Concerning passengers, it was found that the growth rate of the total passenger traffic is related with the growth rate of the per capita GDP, and the correlation coefficient is 0.9894. Therefore, the total passenger traffic was estimated in proportion to the per capita GDP. Concerning

freight, data on road transport which accounts for 52% of the total freight traffic could not be obtained. Therefore, the difference between the production and consumption of the 12 major products was regarded as generated/attracted traffic. The generated/attracted traffic was estimated from the growth rate of GDP in each sector.

(5) Forecast of Distributed Traffic
The distributed traffic was calculated from the generated/attracted traffic and distance of each zone using the gravity model. Then, the accuracy was raised by applying T.J. Frator's method.

(6) Modal Split
The traffic by transport mode was estimated by the logit model using the schedule speed and the fares of each means of transport as resistance values.

(7) Traffic Assignment by Railway Line
The traffic between main stations was obtained by totalling the OD traffic between zones in the OD table obtained in (6) for each section.

4-2 Social and Economic Frame

Table 4-1 shows the gross domestic product (GDP), its year-on-year growth rate, the share between each sector, the total population and its year-on-year growth rate from 1978 through 1987.

The GDP began to decrease in 1980 due to the low international prices of primary products. The decrease was as large as –6.5% in 1983. However, it made a gradual recovery and attained a growth of 2.2% in 1987.

Table 4-1 Transition of Gross Domestic Product (GDP) and Total Population (Million pesos, fixed price in 1980)

Sector		1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Production	Agriculture, stock-farming, fishery	21,490	22,262	22,563	22,354	23,900	19,981	24,552	26,789	25,534	25,489
	Mining	24,140	19,478	19,407	20,139	19,526	18,614	16,335	14,281	12,062	11,013
	Manufacturing	18,881	18,578	17,934	16,581	14,531	13,863	11,925	10,815	11,038	11,837
	Construction	6,681	6,479	4,521	4,058	3,698	3,639	3,555	3,168	2,918	3,080
	Subtotal	68,192	66,797	64,465	63,132	61,655	56,097	56,367	55,056	51,552	51,419
	*%	54.8	53.6	52.4	50.9	52.0	50.6	51.0	49.8	48.1	46.9
Basic service *		7,380	8,311	8,127	9,081	8,729	7,997	8,142	8,285	8,544	8,989
	*%	5.9	6.7	6.6	7.3	7.4	7.2	7.4	7.5	8.0	8.2
Other services		45,329	46,310	47,066	48,117	47,200	46,422	45,770	46,177	45,869	47,353
	*%	36.4	37.2	38.3	38.8	39.8	41.8	41.4	41.8	42.8	43.2
Indirect import tax		3,583	3,238	3,288	3,753	1,090	429	332	927	1,246	1,763
	*%	2.9	2.6	2.7	3.0	0.9	0.4	0.3	0.8	1.2	1.6
Total		124,490	124,656	122,946	124,083	118,674	110,943	110,611	110,445	107,211	109,524
Ratio to prior year	%	—	0.1	Δ0.4	0.9	Δ4.4	Δ6.5	Δ0.3	Δ0.2	Δ2.9	2.2
Population (1,000 persons)		—	—	5,600	5,755	5,916	6,050	6,211	6,321	6,559	6,748
Ratio to prior year	%	—	—	—	2.8	2.8	2.3	2.7	1.8	3.7	2.9

Note: * Mark indicates a share. However, the totals do not agree in some cases because of rounding.

Table 4-2 shows the social and economic data which were used for the traffic forecast. They are based on the GDP growth rate presented in "Economic and Social Development Strategy (1989 ~ 2000) (Ministry of Planning and Coordination)". The growth rates given in the Strategy were employed for 1989 ~ 2000. For 2001 ~ 2020, it was assumed that the growth rate is 1/2 compared with the preceding years in the production sector and is equal to the average value of the preceding years in the service sector. However, 80% of the value given in Table 4-2 was employed for mining because the estimate is too optimistic.

Table 4-2 Growth Rate of Population and GDP by Sector

Sector	1988 ~ 2000 (%)	2001 ~ 2020 (%)
Agriculture, stock-farming	3.8	1.9
Mining, metallurgy	12.4	6.2
Manufacturing	7.5	3.7
Oil	9.0	4.5
Power, gas, service water	13.8	7.0
Traffics, transport	4.4	2.2
Construction	3.6	1.8
Average of above sectors	4.9	2.4
Service	4.9	
Population	2.8	

4-3 Zoning and Transport Network

The transport network was divided into 22 zones, namely 18 domestic zones and 4 international zones (Brazil & overseas via Brazil; Chile & overseas via Chile; Argentine & Paraguay; Peru & overseas via Peru). The zoning is shown in Figure 4-2. The railway, road and air networks in 2020 are shown in Figure 4-3 through 4-5.

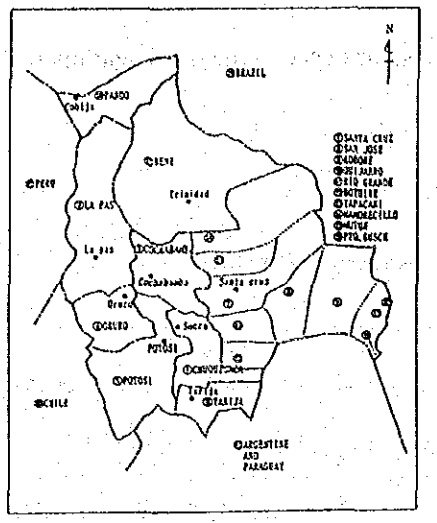


Figure 4-2 Zoning

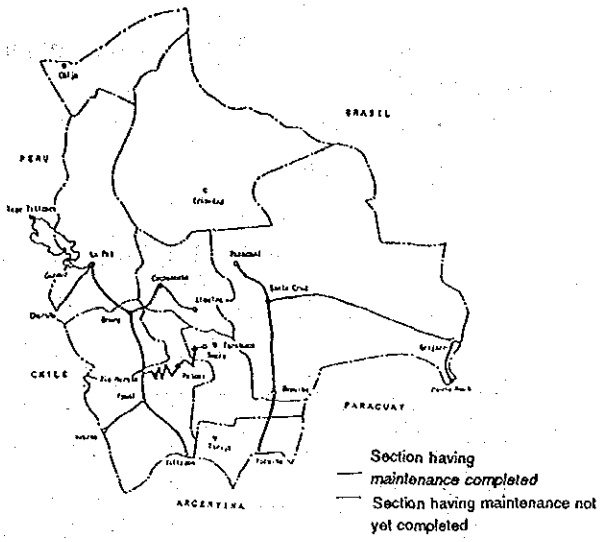


Figure 4-3 Railway Network

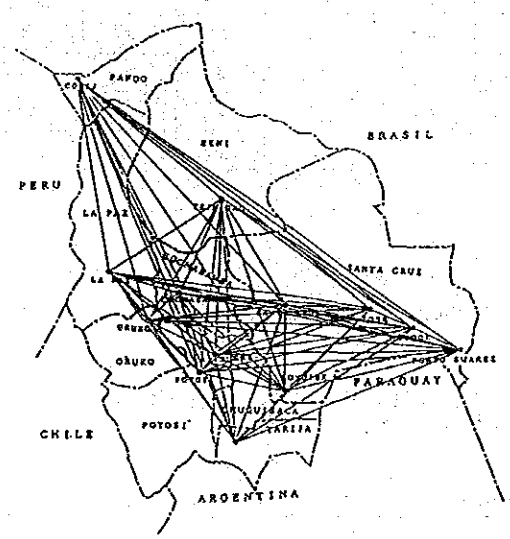


Figure 4-4 Air Network

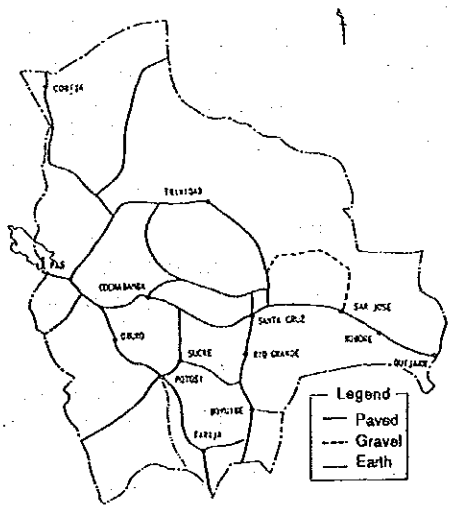


Figure 4-5 Road Network

4-4 Service Level

The service level (travel time and fare) of railway, road and air in each scheduled year up to 2020 is shown hereinafter.

(1) Travel Time

1) Railway

Table 4-3 Schedule Speed of Railway (km/h)

Section	Passenger				Freight			
	Current	2000	2010	2020	Current	2000	2010	2020
La Paz – Oruro	47	62	62	62	45	51	51	51
Oruro – Rio Murato	47	47	62	62	40	40	52	52
Rio Mulato – Uyuni	47	62	62	62	37	53	53	53
Uyuni – Tupiza	47	47	62	62	35	35	41	41
Tupiza – Villazon	47	47	62	62	33	33	40	40
La Paz – Guaqui	49	49	49	65	26	26	26	44
La Paz – Charana	58	52	52	52	36	41	41	41
Oruro – Cochabamba	46	40	40	40	25	30	30	30
Cochabamba – Aiquile	23	23	23	23	27	27	27	27
Rio Murato – Potosi	45	39	39	39	26	26	26	29
Potosi – Sucre	31	31	31	33	24	24	24	29
Uyuni – Avaroa	49	49	49	68	23	23	23	43
Santa Cruz – Quijarro	54	74	74	74	28	44	44	44
Santa Cruz – Yacuiba	58	58	74	74	28	28	38	38
Santa Cruz – Yapacani	—	—	—	—	22	22	22	22

2) Road

The schedule speed of each section was set on the basis of Table 4-4 and in consideration of Table 4-5 and 4-6. Table 4-6 was considered for intermodal transport.

Table 4-4 Average Running Speed by Topographical Condition and Road Surface Condition (km/h)

Topography	Road surface	Bus	Truck
High land	Paved	80	60
	Gravel	60	45
	Earth	40	30
Mountain district	Paved	45	40
	Gravel	35	30
	Earth	25	20
Low land	Paved	80	60
	Gravel	60	45
	Earth	40	30

Table 4-5 Resting Time of Road Transport

Passenger	15 min./1 hour of travel
Freight	10 min./1 hour of travel
	Additional 1 hour/4 hours of travel
	Additional 1 hour/8 hours of travel
	Additional 8 hour/12 hours of travel

Travel Time of Air Transport
Flight time: 0.00108*L + 0.293 hours
(L; Distance in km)
Access time: 1.0 hour
Waiting time: 1.5 hours

Table 4-6 Freight Transshipment Time (h)

Station name	2000	2010	2020
Santa Cruz	8	8	8
Cochabamba	8	8	8
Tupiza	36	36	8
Villa Monte	36	36	8

(2) Fares

The tariff of railway freight after the improvement were assumed as 90% of the road transport fares. All the other fares were assumed unchanged from the current fares.

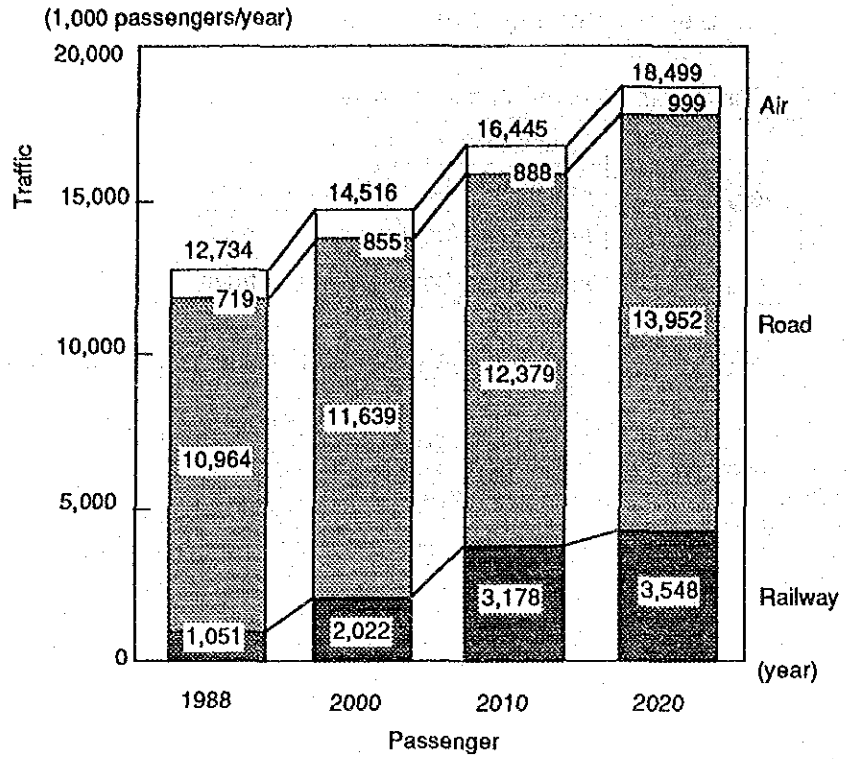
4-5 Results of Forecast

Table 4-7 and Figure 4-6 show the forecasted yearly traffic and share by transport mode. Figure 4-7 and Figure 4-8 show the forecasted yearly sectional railway traffic by line section.

Table 4-7 Forecasted Traffic and Share by Year and Ratio to 1988

Year	Passenger					Freight			
	Railway	Road	Air	All the means	W. OUT	Railway	Road	All the means	W. OUT
2000	2,022	11,639	855	14,516	892	1,814	2,962	4,776	1,502
	13.9	80.2	5.9	100.0	6.1	38.0	62.0	100.0	31.4
	1.92	1.06	1.19	1.16	0.85	2.08	3.24	2.67	1.72
2010	3,178	12,379	888	16,445	787	4,183	2,551	6,734	1,850
	19.3	75.3	5.4	100.0	4.8	62.1	37.9	100.0	27.5
	3.02	1.13	1.24	1.31	0.75	4.80	2.79	3.77	2.12
2020	3,548	13,952	999	18,490	850	6,229	3,509	9,738	2,479
	19.2	75.4	5.4	100.0	4.6	63.6	36.4	100.0	25.5
	3.38	1.27	1.39	1.48	0.81	7.14	3.84	5.45	2.84
1988	1,051	10,964	719	12,734	–	872	914	1,786	–
	8.3	86.1	5.6	100.0	–	48.8	51.2	100.0	–
	1.00	1.00	1.00	1.00	–	1.00	1.00	1.00	–

Note: Upper row: Traffic (Passenger in 1,000 passenger/year; freight 1,000 tons/year)
Middle row: Share (%), Lower row: Ratio to 1988 (time), W. OUT: WITHOUT of railway



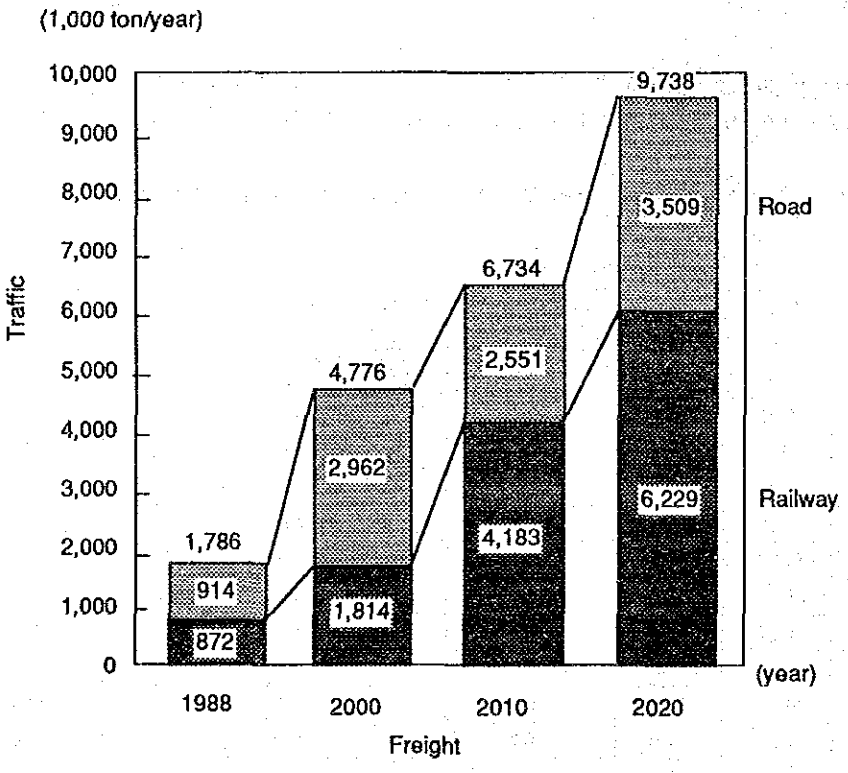


Figure 4-6 Forecasted Traffic by Year and Transport Mode

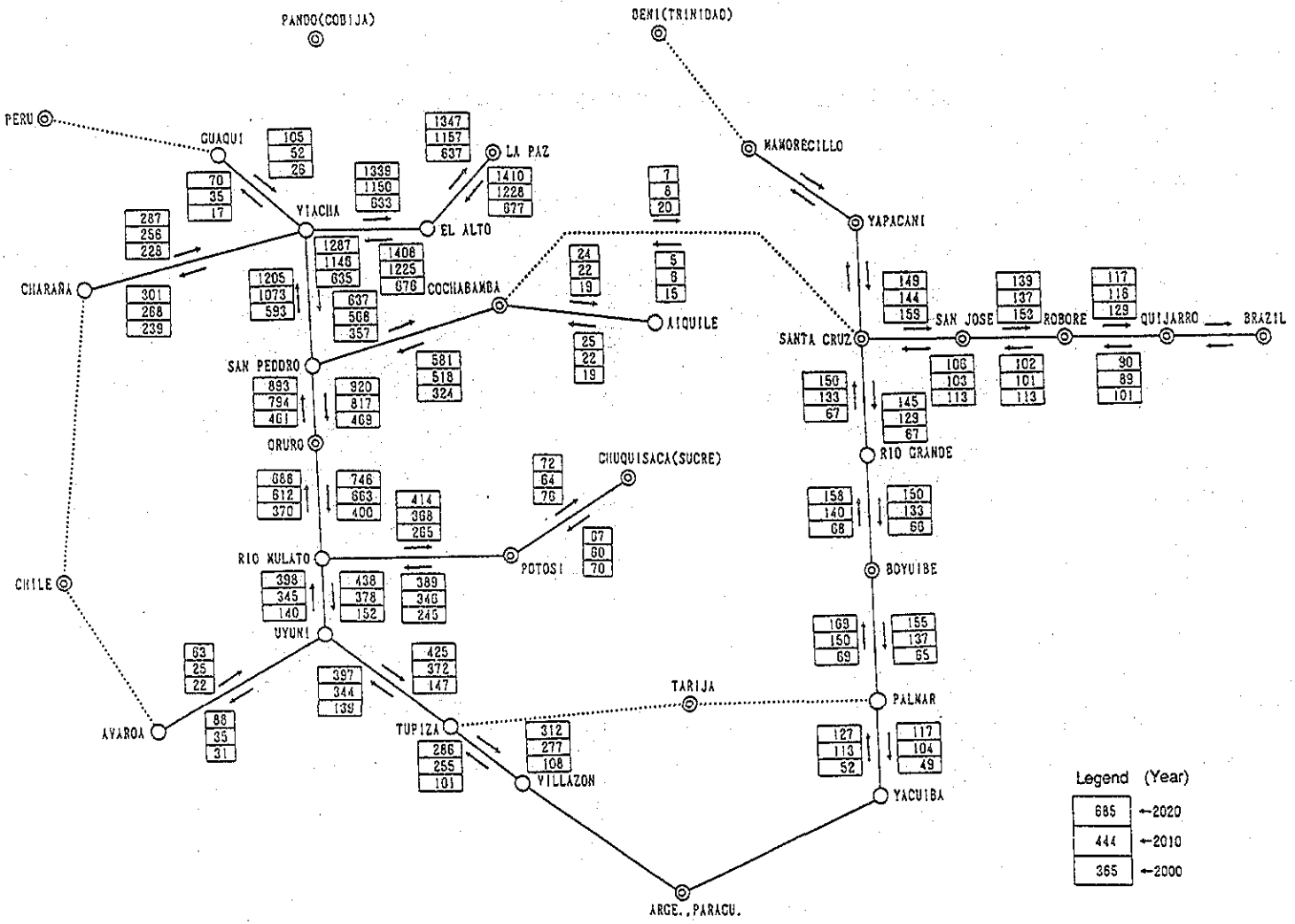


Figure 4-7 Sectional Railway Passenger Traffic (×1,000 passengers/year)

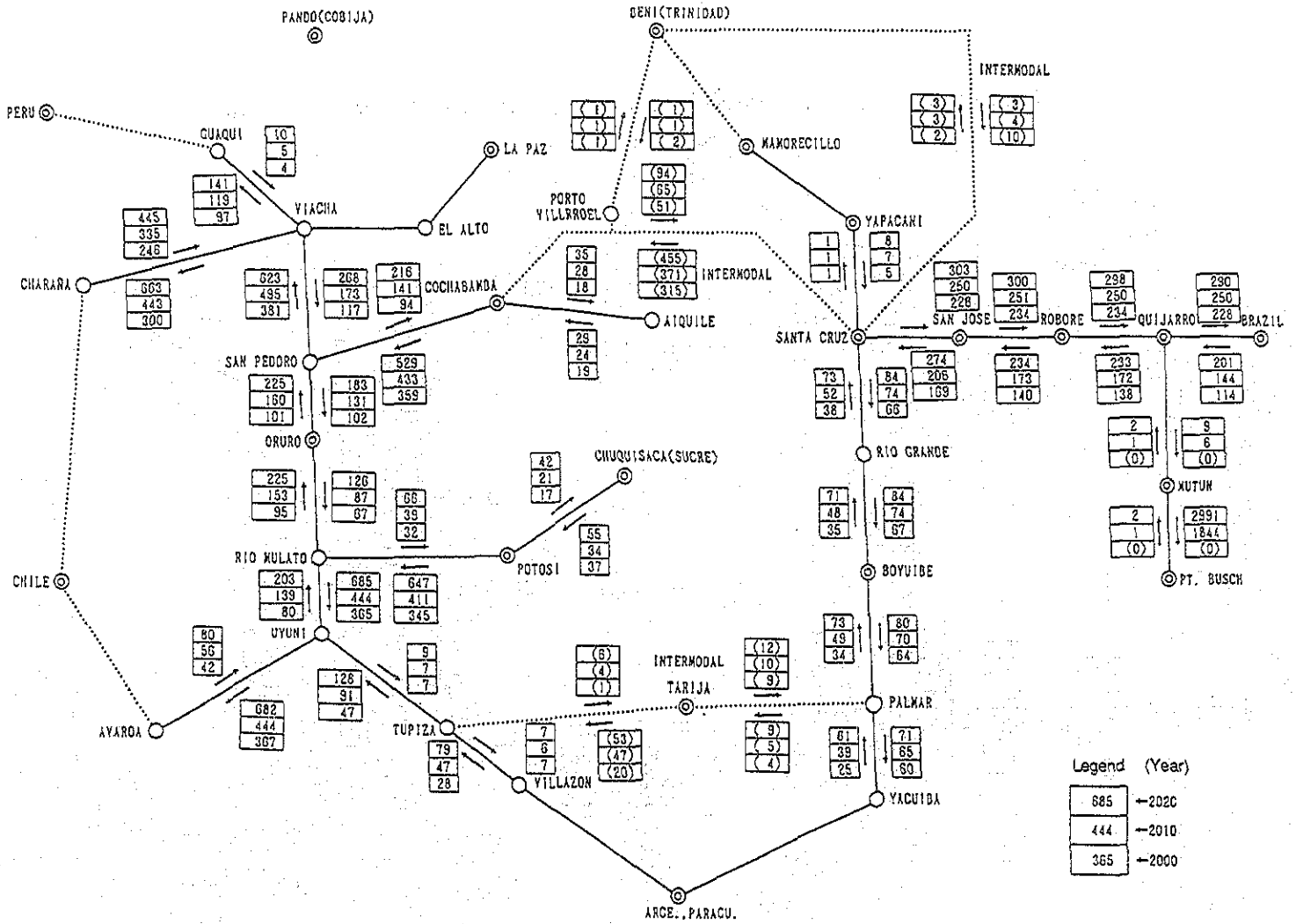


Figure 4-8 Sectional Railway Freight Traffic (×1,000 tons/year)

5. Business Improvement Plan

5-1 Basic Policy for Business Improvement

When the projects of this master plan are executed, it is expected that ENFE will establish a foundation for normal railway operation and gain trust from users and the Bolivian people by improving the lines and facilities, by raising the speed, safety and accuracy of train operation and optimizing the organization and the personnel. It will be become an attractive means of transport. The business improvement plan presents the improvement measures and the future direction which were proposed in consideration of the future traffic demand, the state of the road network and competitions with other means of transport. Therefore, it will be important to start with feasible measures and to deepen the degree of improvement gradually.

The following improvement policy is common to passenger and freight transport.

(1) Changing the Business Attitude
The business should be changed from a passive attitude to a positive attitude. Efforts must be made to develop the market by actively inviting passengers and freight.

(2) Establishing Business Administration System
The business organization should be unified so that ENFE's business activities as a whole can be grasped. Thus, an administration system must be established.

(3) Modernizing Business Information Management
The management of business information must be modernized along with the increase in traffic and the progress of the times. For example, an automatic seat reservation system and a freight information system utilizing the computer technology should be introduced.

5-2 Improvement Policy for Passenger Business

(1) Changing the Basic Business Attitude
ENFE must change from the railway-oriented attitude to the user-oriented attitude. Train schedule tables should be improved and publicly released and the station environment should be improved in order to settle an image of "Railway offering good service" and "ENFE loved by users".

(2) Improving the Passenger Business System

1) Improving the passenger train operation system
Express stations should be set, the seat reservation system and the passenger class system should be improved along with the improvement and increase of passenger transport capacity.

2) Improving the Passenger Fare System
Passenger tickets and express tickets should be separated to increase conveniences for users. The basic passenger fare system should be improved. For example, the distance proportional fare system should be promoted. The system of gradual fare reduction for long distance passengers should be adopted. Children's fares should be set. It should become possible to sell various passenger tickets and discount tickets.

(3) Improving the Infrastructure for Passenger Business

1) Sightseeing development and related business
Sightseeing spots should be developed and sightseeing trains which will invite tourists should be set. Other sightseeing resources should be utilized fully. Resorts, such as hot springs, should be developed through a tie-up with local enterprises.

2) Linking with private bus service
In consideration of convenience for users, bus service should be offered where it is useful for linkage with private bus service and where no railway service is available.

The above improvement plan is schematically shown in Figure 5-1.

5-3 Improvement Policy for Freight Business

(1) Developing Positive Business Efforts

1) Expanding commercial contracts
The freight business which accounts for 80% of the railway income will continue to play an important role as the trunk business field. Efforts should be made to increase the transport volume by expanding commercial contracts in which shipment conditions are set with each cargo owner.

2) Promoting the privately-owned freight car system
The system of privately-own freight cars should be utilized positively as a means to increase available freight cars. The increase in special-purpose freight cars, such as hopper cars and tank cars, should be promoted.

3) Promoting market survey and development
The market development section should be established in the marketing department at each branch office. This section should obtain information about cargo owners and freight distribution and establish an organization for market development.

(2) Modernizing the Method of Transport
An efficient transport method should be set for each field according to the state of future cargo flow. The transport method should be modernized. For example, an optimum method should be adopted for each type of commodities and container transport should be promoted.

1) International freight transport
Both general-purpose freight cars and special-purpose freight cars should be employed. They should leave major stations and go to the national border directly.

2) Domestic freight transport
The new container transport method should be employed as far as possible. Ordinary freight trains with container cars should be operated.

3) Iron ore transport
Piston trains consisting of special-purpose cars (for iron ore) should be operated.

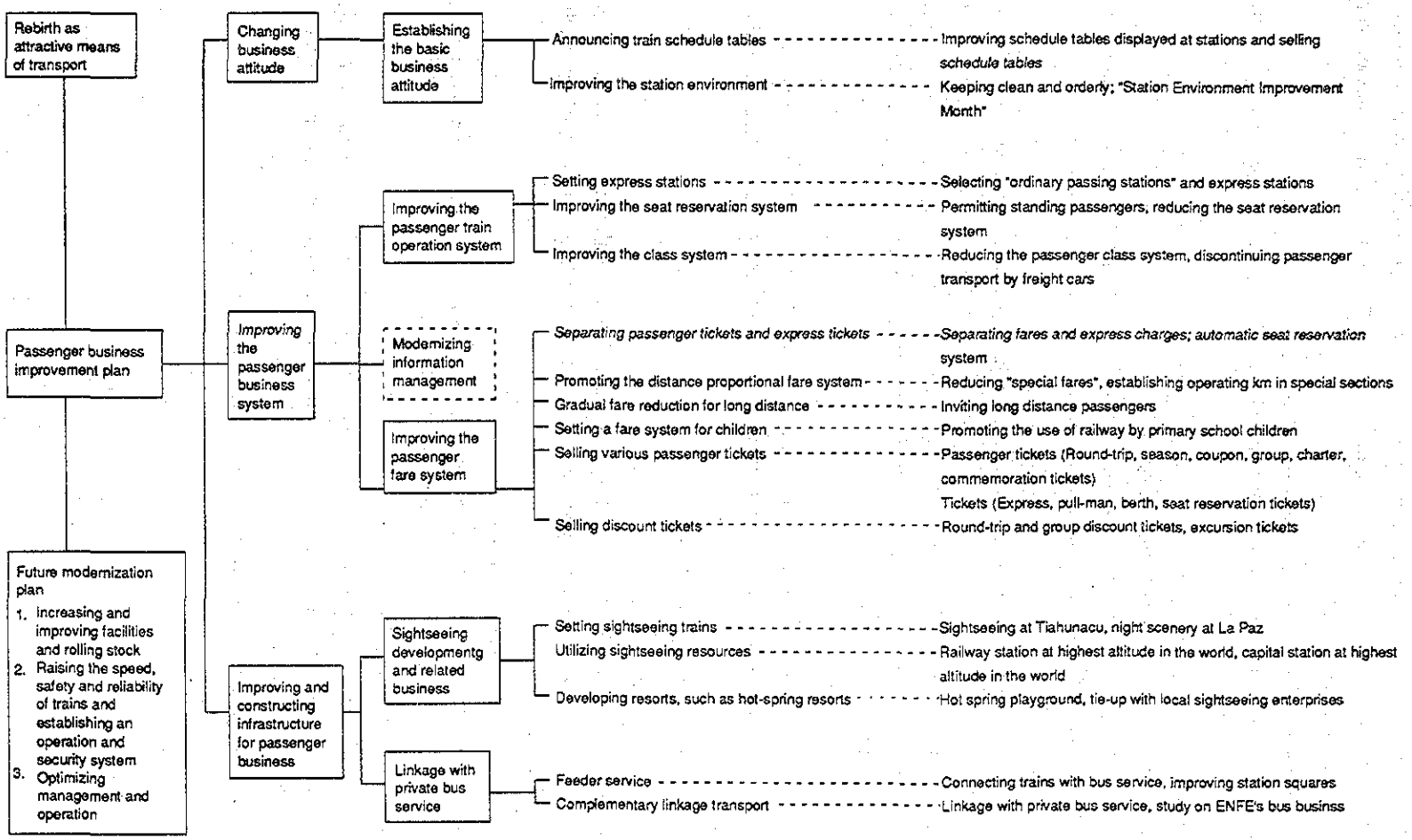


Figure 5-1 Passenger Business Improvement Plan

4) Intermodal transport
Pallets and fork lifts should be used for mechanizing cargo handling work required for transshipment between trucks and freight cars. For domestic transport, containers should be used for transshipment.

5) Raising the efficiency of freight car connection work
Freight car connection work should be simplified by operating trains directly to destination, for example.

(3) Raising the Efficiency of Transport

1) Raising the efficiency of customs inspection
The inspection hours at customs stations should be extended. The inspection time at customs stations should be shortened in future.

2) Optimizing import/export freight car management
The operation efficiency of freight cars should be raised in order to shorten the stay of export freight cars in foreign countries. For example, the current state information of export freight cars should be obtained accurately. The overseas organizations should be strengthened, the freight car operation system must be established and communication facilities should be improved.

3) Decreasing freight stations
Freight stations should be concentrated gradually. The layout of freight stations should be optimized by unifying and abolishing medium-sized and small freight stations and other methods.

(4) Modernizing Cargo Handling Facilities

1) Modernizing freight stations
The tracks, freight platforms and buildings, cargo loading/unloading yards and passages at freight stations should be improved. At least the necessary cargo handling machines should be installed.

2) Modernizing cargo handling method
The pallet system must be developed and containerization should be promoted in order to promote joint transport between railway and truck.

3) Modernizing freight information system
An on-line freight information management system using a computer should be introduced so that freight business information and freight car information can be utilized for routine business management.

The above improvement plan is schematically shown in Figure 5-2.

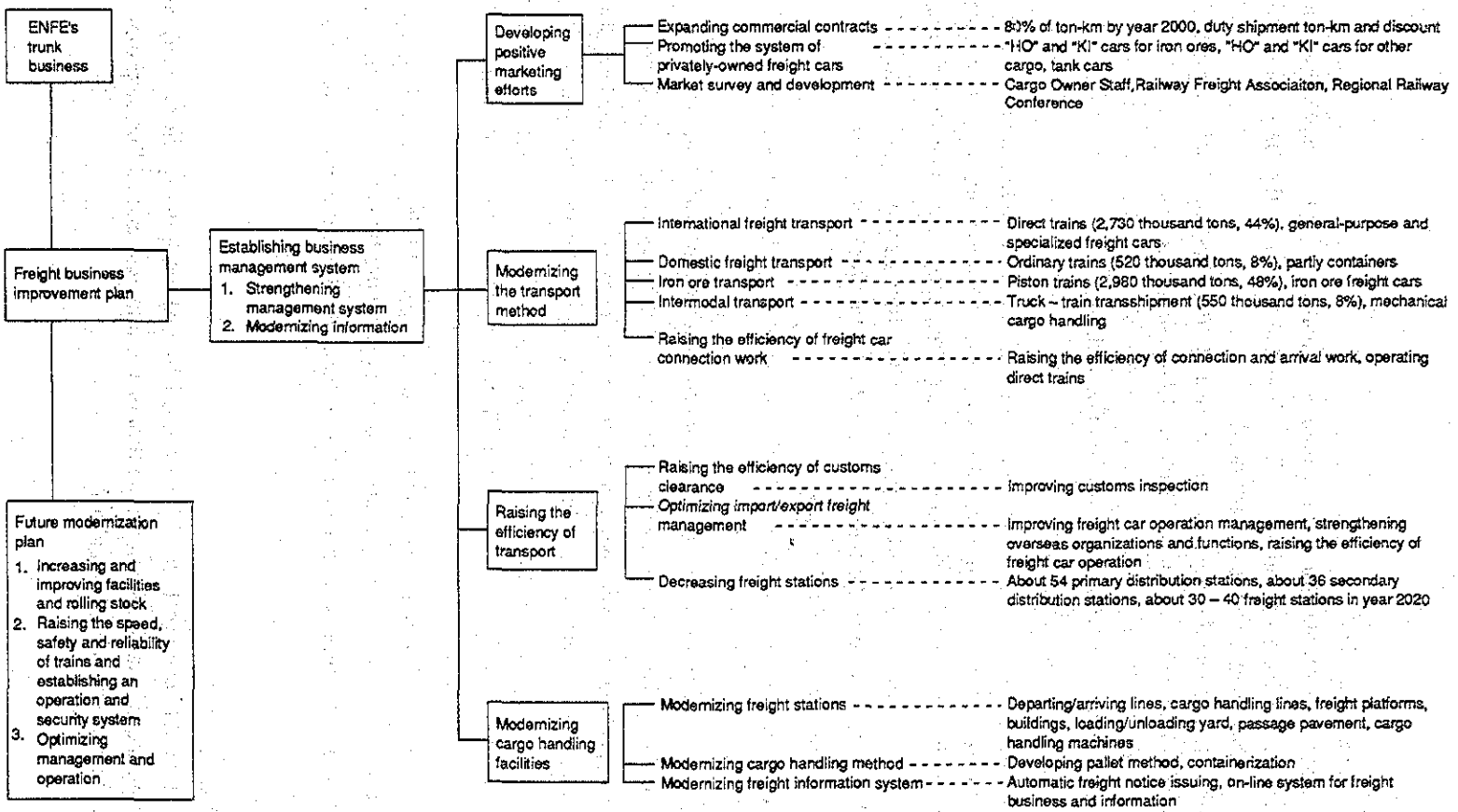


Figure 5-2 Freight Business Improvement Plan

6. Operation and Rolling Stock Plan

6-1 Operation Plan

(1) Basic Policy for Operation Plan

A rebirth and modernization plan for ENFE should be formulated by giving high priority to the safety and stability of train operations. ENFE should function as the base for Bolivia's economic development and meet the people's need.

For this reason, a fundamental study on the security and safety system should be made and a rebirth and modernization plan which is suitable for ENFE should be made.

In addition, the efficiency of overall transport management should be raised in view of the fact that ENFE is the center of an international transport network.

(2) Basic Conditions for Operation Planning

1) The route which is covered by this plan is about 3,550 km (including about 130 km of a newly constructed line) except some line sections. The maximum operation speed of passenger trains is to be 95 or 80 km/h and that of freight trains is to be 75 or 65 km/h.

2) The "tokenless block system" using multiple color light signals is to be adopted. The interlocking system is to be the class 1 or class 2 relay interlocking system.

Trains are to run on the right side track.

3) Electric operation is not to be adopted. Passenger trains are to be driven by DC and freight trains are to be hauled by DEL.

4) The rolling stock performances are to be as stated in 6-2 Rolling Stock Plan.

5) The traffic is to be based on the results of demand forecast presented in Chapter 4.

6) The passengers boarding efficiency is to be about 70% because medium and long distance trains account most of the trains. A dining car is to be connected to each train.

7) Loading efficiency of freight cars is to be 70% (28 tons) on the basis of the previous records. However, the loading efficiency of iron ore trains between Mutun and P. Busch is to be 93% (37 tons).

8) The recursion period of import/export freight cars is to be 15 days and that of domestic freight cars is to be 11 days. The recursion period of iron ore freight cars is to be 1 day.

9) The percentage of empty cars per freight train is about 35%. Iron ore trains are loaded only in one way.

(3) Operation Plan

1) *Commercial speed of trains*

The commercial speed of trains is determined by making a run (performance) curve, calculating the standard operation time (hours and minutes) and adding stop time. The results are shown in Table 6-1 and 6-2.

Table 6-1 Commercial Speeds of Passenger Trains

(km/h)

Section			Distance (km)	Current		After improvement	
				Hour: min.	Commercial speed	Hour: min.	Commercial speed
La Paz	→	Villaz.	845.6	18 h 05'	47	13 h 40'	62
La Paz	→	Guaqui	108.0	2 h 13'	49	1 h 40'	65
La Paz	→	Charana	248.5	4 h 16'	58	4 h 45'	52
Uyuni	→	Avaroa	170.6	3 h 31'	49	2 h 30'	68
La Paz	→	Cochab.	444.4	7 h 45'	57	8 h 35'	52
Cochab.	→	Oruro	210.7	4 h 33'	46	5 h 15'	40
Oruro	→	R. Mula.	208.7	3 h 02'	68	2 h 50'	74
R. Mula.	→	Potosi	174.3	3 h 51	45	4 h 30'	39
Potosi	→	Sucre	175.3	5 h 35'	31	5 h 20'	33
La Paz	→	Sucre	801.0	16 h ~	50	16 h 00'	50
S. Cruz	→	Quijar.	640.1	11 h 49'	54	8 h 40'	74
S. Cruz	→	Yacuib.	535.5	9 h 15'	58	7 h 15'	74

Table 6-2 Commercial Speeds of Freight Trains

(km/h)

Section			Distance (km)	Current		After improvement	
				Hour: min.	Commercial speed	Hour: min.	Commercial speed
Viacha	→	Villaz.	803.9	18 h 05'	47	13 h 40'	62
Viacha	→	Guaqui	65.3	2 h 13'	49	1 h 40'	65
Viacha	→	Charana	206.8	4 h 16'	58	4 h 45'	52
Uyuni	→	Avaroa	170.6	3 h 31'	49	2 h 30'	68
S. Pedro	→	Cochab.	210.7	7 h 45'	57	8 h 35'	52
R. Mula.	→	Potosi	174.3	4 h 33'	46	5 h 15'	40
Potosi	→	Sucre	175.3	3 h 02'	68	2 h 50'	74
Guaraca.	→	Quijar.	635.6	3 h 51'	45	4 h 30'	39
Guaraca	→	Yacuiba	535.5	5 h 35'	31	5 h 20'	33

2) Operation plan

Figure 6-1 and 6-2 show the numbers of passenger trains and freight trains in each target year.

Facility improvements, including the construction of new signal stations, are necessary in addition to modernization in the sections where the track capacity becomes insufficient as a result of increasing trains. Such improvements will be made in advance in some sections in order to cope with the increasing transport demand.

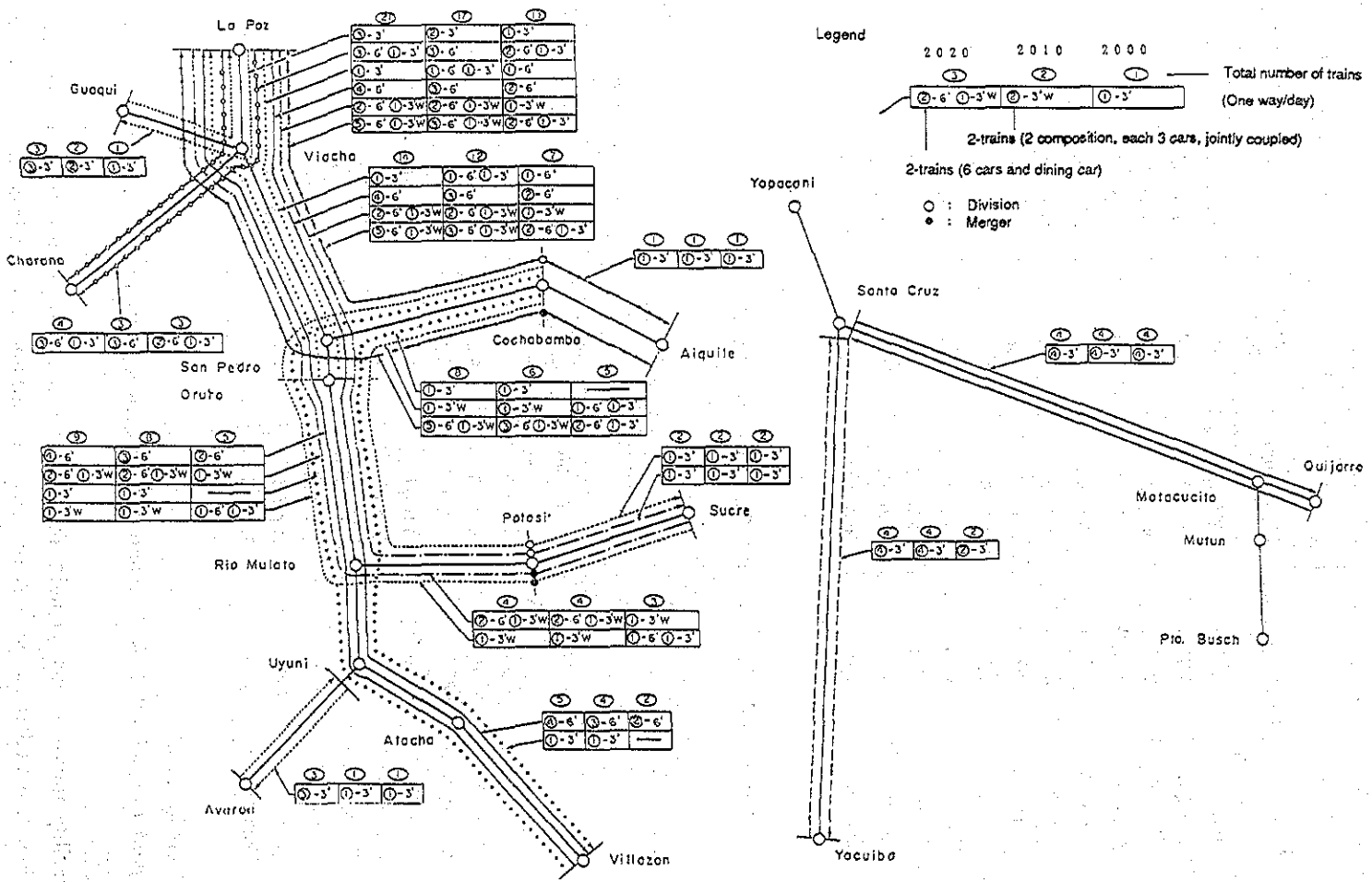


Figure 6-1 Passenger Train Operation Plan in Each Line Section

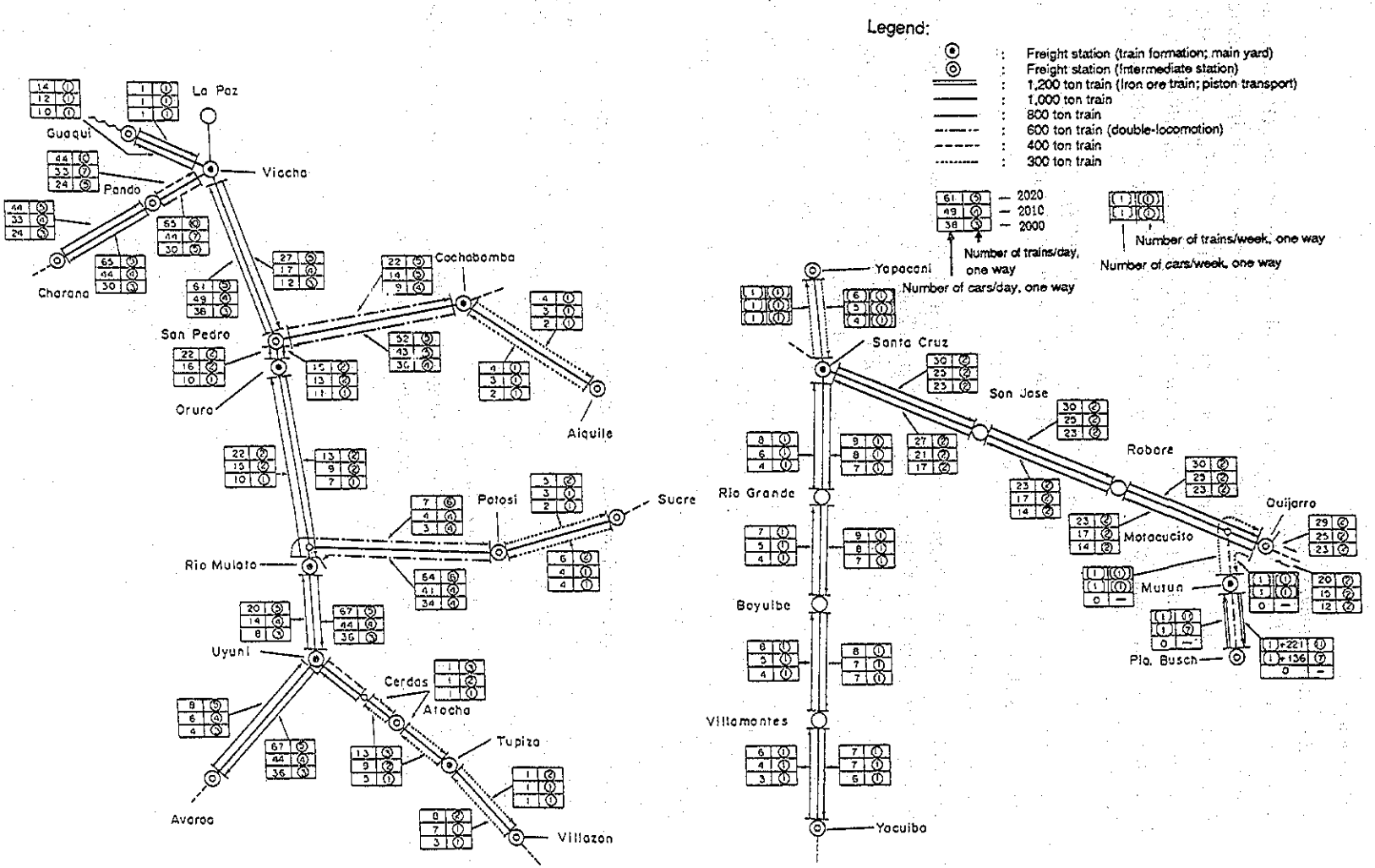


Figure 6-2 Freight Train Operation Plan in Each Line Section

6-2 Rolling Stock Plan

(1) Rolling Stock Plan

1) Rolling stock for passenger trains

Currently, rail-cars (Ferro Bus) and locomotive-hauled passenger trains (Pasajero) are used for passenger transport. However, they are old and obsolete and their operation efficiency is low. Therefore, all of them are to be replaced by rail-cars of a new type (DC). A passenger train is to consist of 3 cars or 6 cars. A dining car (a seat car with the dining room) is to be connected to every train. A car with a driver's cab is to be on the two ends of every train.

Passenger cars are to have cloth seats and have a storage and a toilet.

Every car is to have an engine because trains are operated in graded line sections. The acceleration at starting is to be 3.25 km/h/s.

2) Locomotive for freight cars

At present 1000 type and 900 type locomotives (DEL) are used for hauling passenger cars and freight cars. Since the 900 type locomotives are obsolete, only 1000 type locomotives are to be used. The current locomotives are to be gradually replaced by those of multiple-unit control in order to raise the transport efficiency in graded line sections.

1000 type locomotives (DEL) having the output of 1,140 kW and the pulling force of about 22,500 kg at starting are to be employed for graded line sections. Multiple operation should be possible in sharply graded line sections.

At present, 800 type and 500 type locomotives (DHL) are used for shunting, but only 800 type locomotives are to be used.

3) Freight cars

Freight cars can be classified into those for import/export and those for domestic cargo. An increase in freight cars should be planned according to the demand in consideration of the fact that about 1,200 cars among the 2,150 currently used cars can be operated in 2000 and privately-owned freight cars will increase.

(2) Necessary Number of Rolling Stock and Increasing Plan

Table 6-3 shows the necessary number of locomotives, passenger cars and freight cars estimated on the basis of the train-km and car-km of the operation plan.

Table 6-3 Necessary Number of Rolling Stock and Increasing Plan

Classi-fication	Region	2000 (year)		2010 (year)		2020 (year)		Total
		Necessary number	Number of increase	Necessary number	Number of increase	Necessary number	Number of increase	Number of increase
DC	Western Region	187	187	285	98	347	62	347
	Eastern Region	64	64	81	17	81	0	81
	Total	251	251	366	115	428	62	428
DEL for main line	Western Region	47	31	57	26	70	13	70
	Eastern Region	15	7	20	13	24	4	24
	Total	62	38	77	39	94	17	94
DHL for shunting	Western Region	3	3	3	0	7	4	7
	Eastern Region	2	2	2	0	2	0	2
	Total	5	5	5	0	9	4	9
FC	For import/ export cargo	1,890	690	2,430	540	3,400	970	2,200
	For domestic cargo	430	366	730	255	1,010	238	859
	Total	2,320	1,056	3,160	795	4,410	1,208	3,059

Note: The number of freight cars, excluding 1,200 cars for import/export and privately-own cars for domestic freight (accounting for 15% of freight cars for domestic freight), is given as the increase of FC.

(3) Rolling Stock Maintenance Plan

The rolling stock management system must be established and testing equipment, machines and facilities should be improved.

Table 6-4 shows the factories and maintenance centers which are planned by 2010.

Table 6-4 Rolling Stock Maintenance Factory Improvement Plan

Region	Name	Maintenance	2000	2010
Western Region	Viacha Factory	Inspection and repair of DC, DEL, DHL	O	
	Uyuni Factory	Inspection and repair of FC		O
	Oruro Maintenance Center	Inspection and repair of DC, DEL		O
	La Paz Maintenance Center	Inspection and repair of DC, DEL		O
	Cochabamba Supporting Factory	Small-scale inspection and repair of all kinds		O
	Sucre Supporting Factory	"		O
	Machacamarca Supporting Factory	"		O
	Tupiza Supporting Factory	"		O
Eastern Region	Guaracachi Factory	Inspection and repair of DC, DEL, DHL	O	
	Robore Factory	Inspection and repair of FC		O

Note: O mark indicates the improvement of inspection and repairing facilities.