7. Facilities and Equipment Plan

7-1 Improvement of Existing Lines

The plan aims to improve facilities to implement safe and stable transportation. The target values of the improvement are given below.

- Train speed: Passenger train 95 km/h, freight train 75 km/h
- Rail: At least 75 Lb/yard, at least 85 Lb/yard in case of replacement
- sleeper: Wooden sleeper 1,600 sleepers/km in ordinary sections
  1,660 sleepers/km in curved sections
- Ballast: Crushed stone, at least 200 mm under sleepers
- Turnout: 8#, 10#, 12# (ordinary turnout)
- Construction line width: 6.00 m (single track),
  10.20 m (double track)

(1) Improvement Work

1) Tracks

- Rail replacement: Rails below 75 Lb/yard should be replaced by rails of 85 LB/yard.
- Ballast: Soil ballast should be changed to crushed stone ballast. Defective sleepers should be replaced.
- Turnout: A half of the turnouts of the main lines should be replaced.

Table 7-1 shows the quantities of the track improvement work.

2) Crossing

The crossings should have a structure which allow automobiles etc. to pass without any trouble. Fences should be constructed to show the location of each crossing clearly. (Refer to Figure 11-1 in the main report.) Table 7-2 shows the quantities of the crossing improvement work.

3) Station

- Improvement of station yard:
  Fences for prohibiting entry should be constructed around stations in densely populated areas. Crosscuts should be constructed where necessary to ensure safety for both trains and people. (Refer to Figure 11-2 in the main report.)
- Construction of new platforms:
  At present, a platform exists only front of the station building. Since the up main line and the down main line are used separately in station yard, a new platform should be constructed at every passenger station. (Refer to Figure 11-3 in the main report.)
- Track layout change:
  In some sections, freight trains must be divided or merged in order to secure enough transport capacity where the tractive constant is insufficient due to an alignment. Since facilities for division and merger are to be installed at the stations before and after such a section, the track layout at the stations should be changed. (Refer to Figure 11-4 in the main report.)

Table 7-1 Quantities of Rail and Turnout Replacement in Each Line Section

Line name	Rail (track extension km)	Turnout (set)	Ballast (track extension km)	Remark
Red Andina				
Villazon	689.0	50	544.8	
Guaqui	—	8	—	
Charaña	209.3	11	209.3	
Avaroa	0.3	10	127.4	
Cochabamba	191.7	36	204.8	
Sucre	345.0	25	348.2	
Total	1,435.3	140	1,434.5	
Red Oriental				
Quijarro	569.0	31	213.2	
Yacuiba	—	34	538.5	
Yapacani	—	11	—	
Total	569.0	76	751.7	
ENFE TOTAL	2,004.3	216	2,186.2	

Table 7-2 List of Crossing Requiring Improvement in Each Line Section

Line name	Number of locations to be improved	Line name	Number of locations to be improved	Line name	Number of locations to be improved
Red Andina				Red Oriental	
Villazon	120	Avaroa	25	Quijarro	100
Guaqui	10	Cochabamba	60	Yacuiba	135
Charaña	30	Sucre	60	Yapacani	30
		Total	305	Total	265
ENFE TOTAL	570				

- Construction and improvement of signal stations:
  In order to obtain enough transport capacity, a pass-by station should be be newly constructed in the middle of a section where the distance between stations is long. Or else, the current branch line should be improved and a signal station should be newly constructed. (Refer to Figure 11-5 in the main report.)

- Construction of intermodal facilities:
  Facilities which enable efficient transshipment from freight cars to trucks and from trucks to freight cars should be newly constructed. (Refer to Figure 11-6 in the main report.)

Table 7-3 shows the quantities of the construction and improvement work of station related facilities.

4) Bridge

Temporary abutments and piers, such as sleeper saddles, on which trains pass should be changed to permanent structures. The foundation of scoured abutments and piers should be reinforced.

Table 7-4 shows the number of locations requiring bridge improvement work in each line section.

5) Protection facilities

Banks and cut slopes which can cause large damages by a collapse should be protected by sheathing work or slope protection work. Fences which disable entry to tracks should be constructed where animals can go into tracks and obstruct train operation.

Table 7-5 shows the quantities of protection facilities in each line section.

6) On disaster section between Oruro and Cochabamba

The section between the 100 km 250 m point and the 137 km 500 m point (37 km 250 m in extension) where earth and rock avalanches bring about damages every year should be improved. Avalanches bury tracks and bridges. The track level is lowered by the rise of the river bed. A feasibility study must be made in future for detailed planning.

The two methods which were proposed by JICA experts and ENFE staff were studied. (Figure 7-1, 7-2) Table 7-6 compares the two proposals in terms of the quantities of work and the cost.

The two proposals are compared hereinafter.

(a) Cost of work

The proposal I requires 133.2 million US dollars, while the proposal II requires 24.6 million US dollars. Obviously, the proposal II is better because its cost is 1/5 compared with I.

(b) Workability

The tunnel construction of the proposal I will require large expenses for both the tunnel itself and other facilities required for tunnel construction. Since there is no access road to this section, either the railway line or the river in the dry season must be used. Therefore, great difficulties for transporting machines and materials are anticipated.

In the case of the proposal II, large construction machines can be carried by railway. Cutting and banking work can be carried out sequentially from the current line. The total construction period can be shortened by organizing two or more construction groups.

Table 7-3 List of Station Facilities Construction and Improvement Work

Line names	Station premises improvement	Platform construction	Layout change	Signal station construction and improvement	Intermodal facilities
Red Andina					
Villazon	7 stations	33 stations	8 stations Viacha, San Pedro, Oruro, Rio Murato, Uyuni, Atocha, Tupiza, Villazon	4 locations 8 km, 29 km Chocaya, El Chorro	1 location Tupiza
Guaqui	2 stations	3 stations	—	—	—
Charaña	1 station	8 stations	2 stations General Pando, Charaña	—	—
Avaroa	—	2 stations	1 station Avaroa	1 location Cantera	—
Cochabamba	5 stations	26 stations	1 station Cochabamba	2 locations 65 km, Ventilla	1 location Cochabamba
Sucre	4 stations	11 stations	2 stations Potosi, Sucre	9 locations C. Machicao, 36.5 km, 50.4 km, 123.9 km, Cebadillas, A. Dulce, Q. Quivi, N. Mriaca, Higeras	—
Total	19 stations	83 stations	14 stations	16 locations	2 locations
Red Oriental					
Quijarro	6 stations	20 stations	2 stations Guaracachi, Quijarro	—	2 locations Santa Cruz, Motacucito
Yacuiba	6 stations	23 stations	1 station Yacuiba	—	1 location Villamontes
Yapacani	—	—	—	—	—
Total	12 stations	43 stations	3 stations	—	3 locations
ENFE Total	31 stations	126 stations	17 stations	16 locations	5 locations

Table 7-4 List of Bridge Improvements in Each Line Section

Line names	Restoration of temporary bridge (location)	Abutment/pier reinforcement (location)	Remark
Red Andina			
Villazon	69	40	
Guaqui	–	2	
Charaña	10	7	
Avaroa	–	10	
Cochabamba	7	17	Excluding the disaster section
Sucre	–	3	
Total	86	79	
Red Oriental			
Quijarro	21	8	
Yacuiba	31	3	
Yapacani	–	–	
Total	52	11	
ENFE TOTAL	138	90	

Table 7-5 Quantities of Protection Facilities in Each Line Section

Line names	Slope protection work, etc. (Extension m)	Fences, etc. (Extension m)	Line names	Slope protection work, etc. (Extension m)	Fences, etc. (Extension m)
Red Andina			Red Oriental		
Villazon	8,470	42.3	Quijarro	650	247.2
Guaqui	—	3.3	Yacuiba	540	144.0
Charaña	2,930	10.4	Yapacani	—	—
Avaroa	—	8.6	Total	1,190	391.2
Cochabamba	3,580	20.9			
Sucre	4,270	21.3			
Total	19,250	106.8	ENFE TOTAL	20,440	498.0

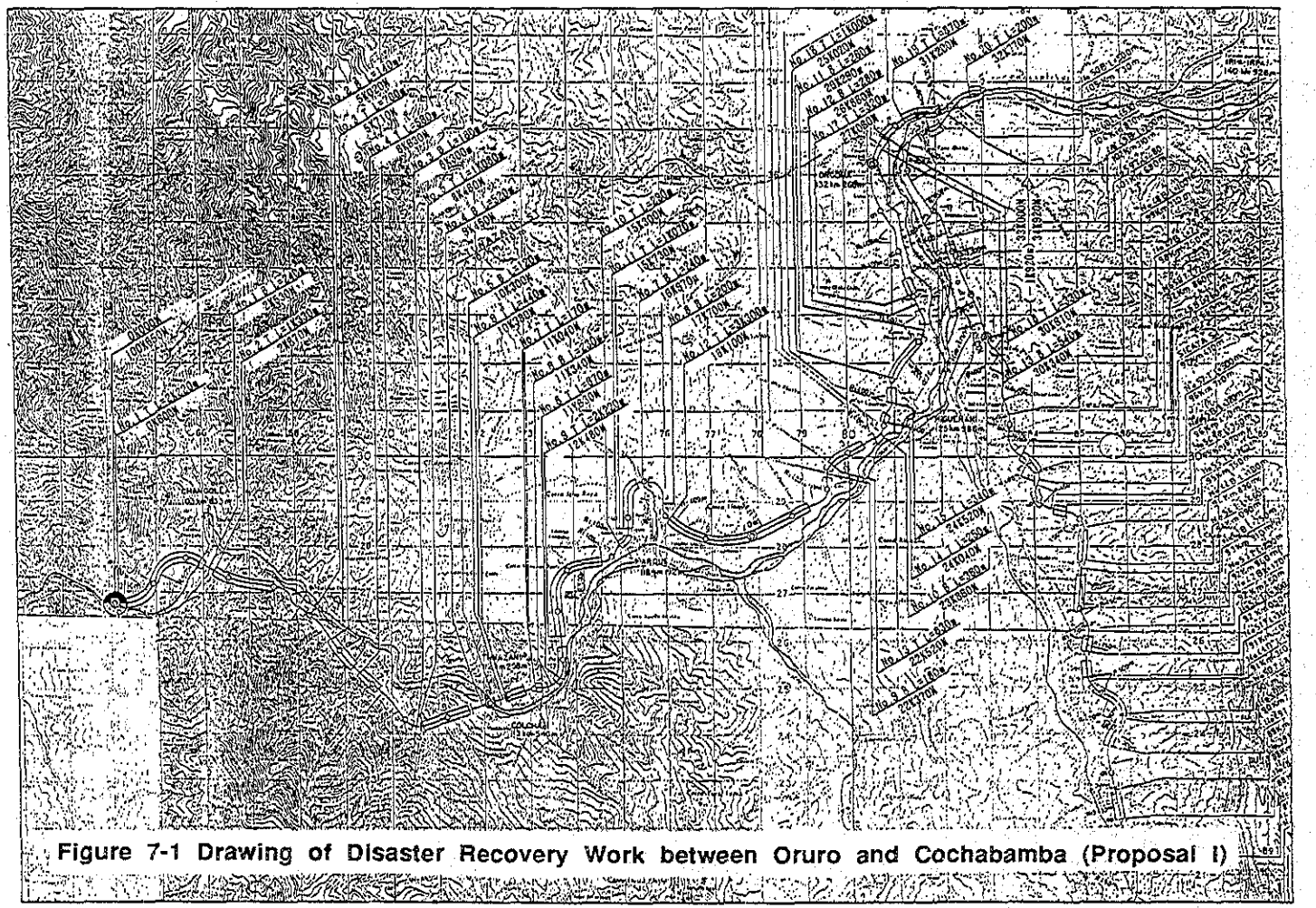

Figure 7-1 Drawing of Disaster Recovery Work between Oruro and Cochabamba (Proposal I)

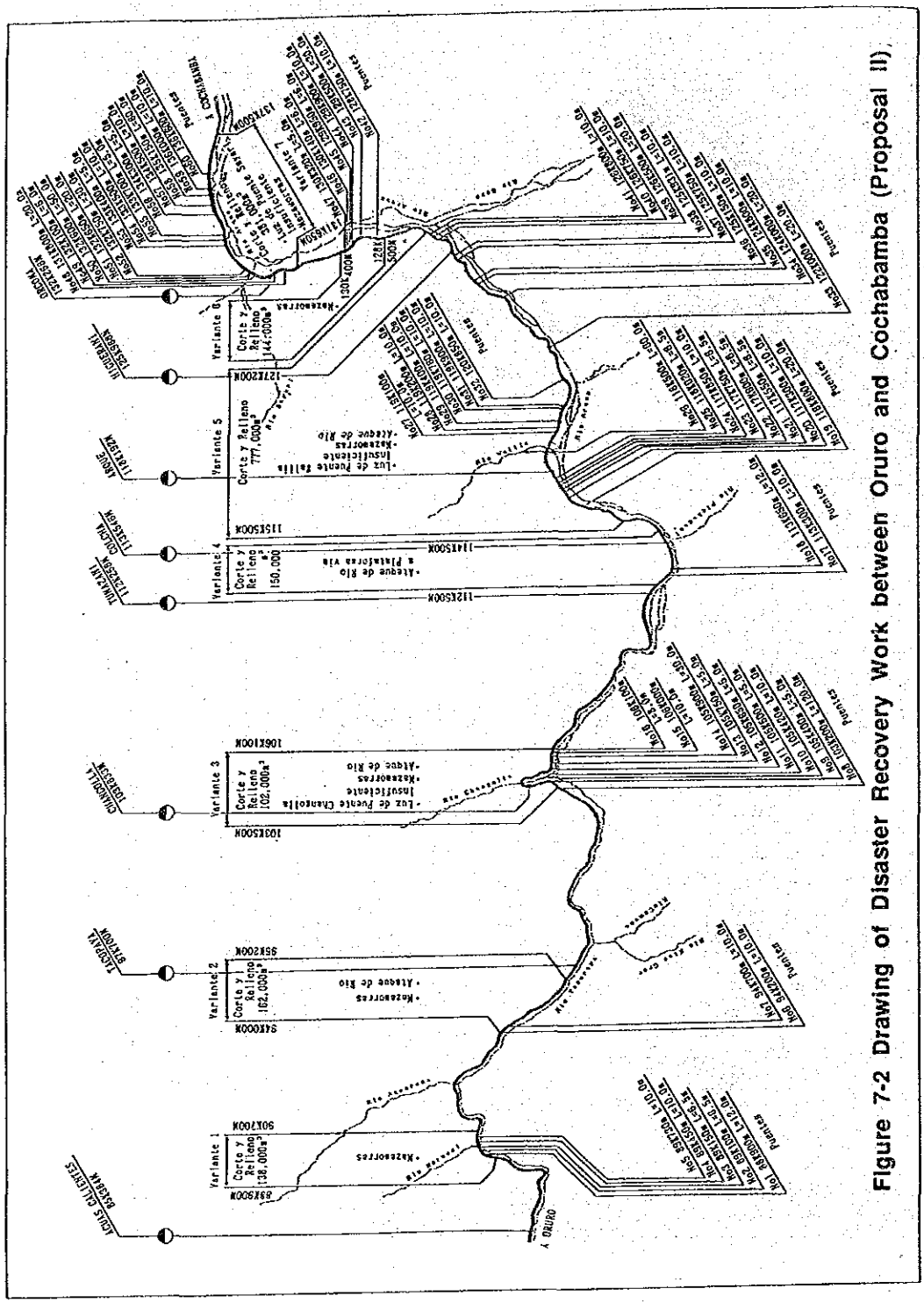

Figure 7-2 Drawing of Disaster Recovery Work between Oruro and Cochabamba (Proposal II)

Table 7-6 Quantities and Costs of Improvement Work between Oruro and Cochabamba

Work	Proposal I		Proposal II		Remark
	Quantity	Cost (10^3 US$)	Quantity	Cost (10^3 US$)	
Tunnel	18,230 m (20 locations)	92,791			
Bridge	4,300 m (13 locations)	27,413	889 m (60 locations)	6,919	
Banking	251,924 m	1,109	135,000 m	795	
Cutting	316,675 m	1,394	1,854,000 m	13,641	
Station building	600 m^2	533	600 m^2	935	5 stations
Signal facilities	1 set	—	1 set	—	Included in the reinforcement plan
Communication facilities	1 set	—	1 set	—	Included in the reinforcement plan
Track	33 km	1,637	30.9 km	851	Included in the reinforcement plan
Protection facilities	1 set	22	1 set	1,410	
Others	1 set	8,300			
Total		133,199		24,551	

(c) Effects

The proposal I will ensure safe and stable transport at considerably high probabilities. It cannot be said that the proposal II is sufficient. However, even if disasters occur, quick recovery will be possible. The waiting time for the resumption of train operation can be short. At present, train operation is suspended for about 1 month in case of a small disaster and 3 to 4 months in case of a large disaster.

For the above reason, the proposal II is adopted for the reinforcement plan in this report. A detailed study based on a feasibility study must be made for concrete planning. A rough procedure for a feasibility study and construction work is shown below.

1. Making a topographical map
2. Selecting a route accurately
3. Rough designing and study
4. Surveying the optimum route
5. Detailed designing and estimation of construction cost
6. Construction (including supervision)

The recovery work should be started in full scale by carrying out 1. – 3. immediately. High reliability in railway operation can be attained by implementing safe and stable transportation quickly.

(2) Maintenance System

1) Establishment of line inspection system

A track inspection and structure inspection system should be established. Data needed for their maintenance and management should be collected and the lines should be maintained on the basis of these data.

2) Improvement of standards and regulations

Those documents which are currently issued by the managers of the track section and the work section should be organized. Operation standards and procedures which are not currently provided should be added. It should be made sure that all the workers are given the information about these standards and regulations.

3) Provision of machines and instruments for maintenance work

- Machines and tools for rail replacement and ballast work
  Rail welder, multiple tie tamper, tie tamper, motor car, hopper vehicle, etc.
- Machinery for track management and correction
  Track inspection car, curve corrector, gauge, other apparatus
- Self-recording rain gauge for obtaining rain data

The 7-7 shows the machines and instruments required for maintenance work

Table 7-7 List of Machines and Instruments for Maintenance Work

Name	Unit	Western Region	Eastern Region	Total	Name	Unit	Western Region	Eastern Region	Total
Track maintenance						Set	7	5	12
M.T.T.	Car	1	1	2	Other machinery	Set	1	1	2
Hopper vehicle	Car	6	6	12	Measuring instruments				
Motor car	Car	1	1	2	Curve corrector	Unit	1	1	2
Rail carrying trolley	Car	3	3	6	Track inspection car	Car	1	1	2
Gas welder	Set	1	1	2	Level	Unit	8	6	14
Rail cutter	Set	7	5	12	Transit	Unit	8	6	14
Rail drill	Set	7	5	12	Train oscillation meter	Unit	1	1	2
Tie tamper	Set	31	13	44	Standard gauge	Unit	246	96	342
Rail loader	Set	2	2	4	Self-recording rain gauge	Set	123	48	171
Rail	Set	40	40	80	Square	Unit	122	47	169
Rail jack (10 tons)	Unit	488	188	676	Piece for measurement	Set	124	49	173
Rail jack (5 tons)	Unit	244	94	338	Other instruments	Set	1	1	2

(3) Phased Improvement Plan

The improvement plan related to facilities is summarized in Table 7-8.

Table 7-8 Facilities Related Phased improvement Plan (1)

Line name	Schedule				Item							Remark
	1991	2000	2010	2020	Rail replacement (km)	Turnout replacement (set)	Ballast work (km)	Crossing improvement (location)	Station premises improvement (station)	Platform construction (station)	Track layout change (station)	
Red Andina												
Villazon					304.3	21	116.7	50	5	10	2	
Villazon					384.7	29	429.1	70	3	23	5	
Guaqui					--	8	--	10	2	3	--	
Charaña					209.3	11	209.3	30	1	8	2	
Avaroa					0.3	10	127.4	25	--	2	1	
Cochabamba					191.7	36	204.8	60	5	26	1	
Sucre					345.0	25	348.2	60	4	11	2	
Total					1,435.3	140	1,434.5	305	19	83	13	
Red Oriental												
Quijarro					569.0	31	213.2	100	6	23	2	
Yacuiba					--	34	538.5	135	6	20	1	
Yapacani					--	11	--	30	1	--	--	
Total					569.0	76	751.7	265	13	43	3	
Grand total					2,489.7	216	2,186.2	570	32	126	16	

Table 7-8 Facilities Related Phased Improvement Plan (2)

Line name	Schedule (1991 2000 2010 2020)	Item: Signal station construction/ improvement (station)	Intermodal facilities (location)	Temporary bridge recovery (location)	Abutment, pier reinforcement (location)	Slope protection etc. (m)	Entry preventing work		Remark
Red Andina									
Villazon		2	--	29	17	3,560	17.8		
Villazon		2	1	40	23	4,910	24.5		
Guaqui		--	--	--	2	--	3.3		
Charaña		--	--	10	7	2,930	10.4		
Avaroa		1	--	--	10	--	8.6		
Cochabamba		2	1	7	17	3,580	20.9		
Sucre		9	--	--	3	4,270	21.3		
Total		21	2	86	79	19,250	106.8		
Red Oriental									
Quijarro		--	2	21	8	650	247.2		
Yacuiba		--	1	31	3	540	144.0		
Yapacani		--	--	--	--	--	--		
Total		--	3	52	11	1,190	391.2		
Grand total		21	5	138	90	20,440	498.0		

7-2 New Line Construction Plan

Under the concept of "Land Bridge", ENFE plans to construct new lines in various regions. It is their hope to link the currently separate railway networks of the Western Region and the Eastern Region, to establish a domestic railway network and to expand the international transport network.

The present study searched for the optimum network in Bolivia in 2020 on the basis of the demand forecast, operation plan, economic and financial assessment, etc. As a result, a decision was made to select the section of Motacucito – Puerto Busch from ENFE's line construction plans and to integrate it to the network.

This line is to start at Motacucito Station of Quijarro Line in the Eastern Region and passes Mutun, which is estimated to be the largest iron ore mine in Bolivia. It ends at Puerto Busch, which is a port town on the River Paraguai forming the national border with Paraguay. It is about 130 km in extension. Its objective is to transport iron ores from Mutun and export them to foreign countries by way of the River Paraguai.

According to ENFE's basic plan, the total construction cost is estimated to be about 92 million US dollars. Figure 7-3 shows a rough layout and route between Motacucito and Puerto Busch. Since the route is located in the plain region in the eastern part of Bolivia, it will have no problem in terms of the longitudinal grade and the curve radius. However, the layout and the content of pass-by facilities should be studied again in view of the future transport tonnage and operation plan.

The construction period is planned to be 10 years between 2000 and 2010. However, this should be studied sufficiently in consideration of the development state of Mutun Mine and the results of a feasibility study.

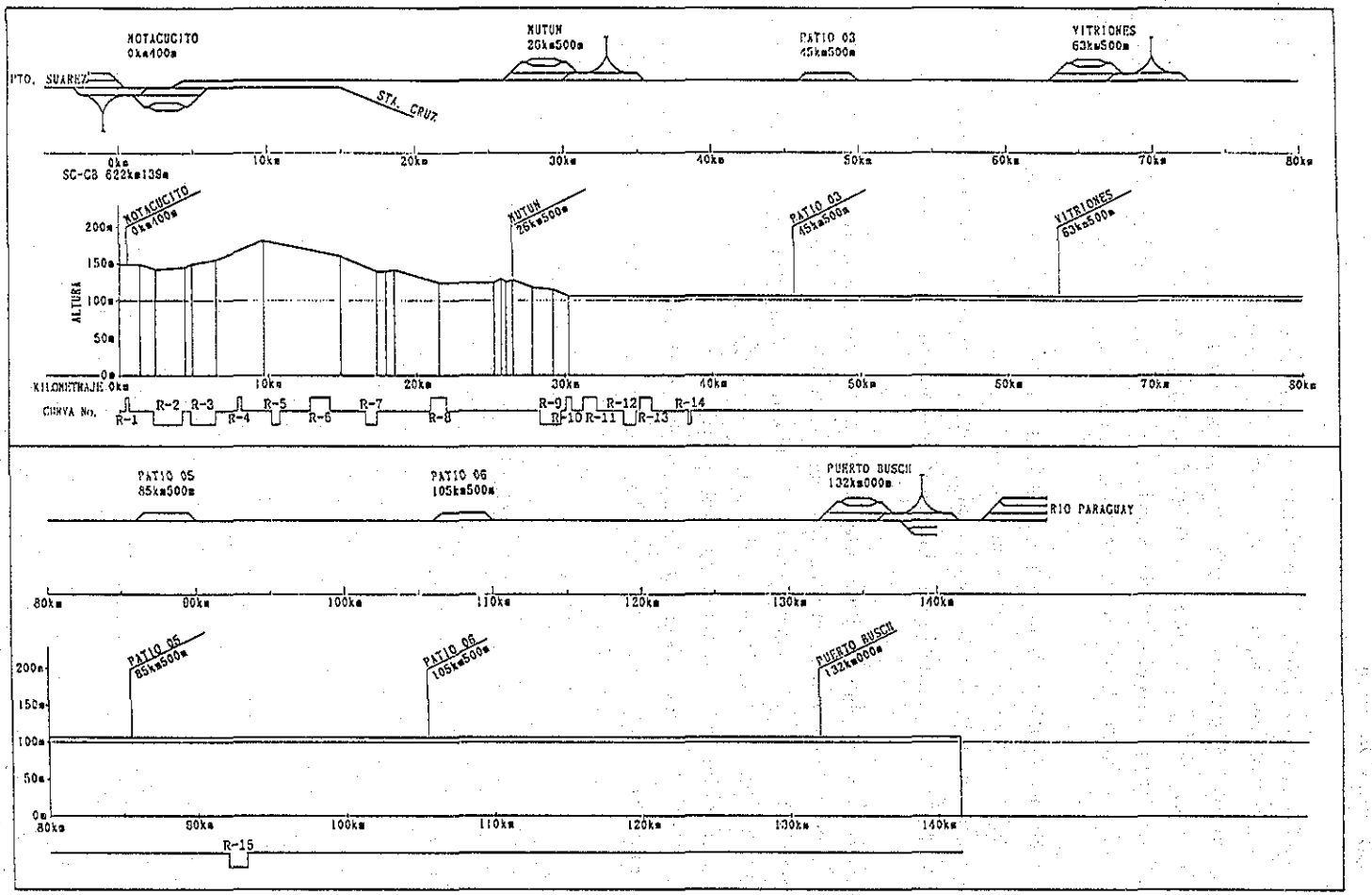

Figure 7-3 Rough Layout and Route between Motacucito and Puerto Busch

7-3 Signal and Communication Facilities Plan

(1) Signal Facilities Plan

The following signal facilities are to be newly installed.

1) Block device

"Tokenless block devices" are to installed between stations where trains can pass by.

2) Signal

"Starting signals" and "home signals" of the multiple color light type are to be installed at the above stations. "Distant signals" are also to be installed where necessary.

3) Interlocking device

Generally, "category 2 relay interlocking devices" are to be installed at the above stations. "Category 1 relay interlocking devices" which control turnouts and all the related devices are to be installed at the main stations.

4) Level crossing protection device

"Crossing alarms", "automatic barriers" or "crossing signposts" are to be installed at level crossings according to the traffic volume.

(2) Communication Facilities Plan

The current communication network consisting of open-wire lines and HF band radio telephones is to be improved and new facilities are to be installed.

1) Installation of VHF radio telephone system

- Block telephone line between adjacent stations: Used block operations and communications between
- Dispatch telephone line: Used for simultaneous and individual transmission of orders and communications between dispatch officers and station masters
- Telephone line for train radio: Used for communications between dispatch officers or station masters and train crew, for communications between station masters and maintenance workers, for emergency communications from other line section to stations

2) Improvement to UHF digital multiplex communication system

The current UHF analog communication line between La Paz and Oruro is to be digitalized and the digital multiplex communication network is to be expanded throughout the whole ENFE area.

This is based on the project which ENFE plans to complete by 1992. The coverage area was expanded.

3) Telephone switchboard

The telephone switchboards at the main stations are to be improved using UHF line. The telephone number of entire ENFE are to be improved and a TRK network is to be constructed.

(3) Phased Improvement Plan

The phased improvement plans shown in Tables 7-9 and 7-10 were made in consideration of the improvement plan of other facilities and the communication equipment improvement which is in progress at present under the World Bank's assistance.

Table 7-9 Phased Improvement Plan Related to Signals

Line name	Schedule 1991 2000 2010 2020	Signal facilities			Level crossing protection device	
		Class 1 relay interlocking (station)	Class 2 relay interlocking		With barriers (location)	Alarms only (location)
			Passing statio (station)	Pass-by station (station)		
Villazon 1		5	3	10	29	11
Villazon 2		5	5	21	12	5
Guaqui		1	0	2	10	8
Charana		1	1	8	4	6
Avaroa		1	1	4	2	1
Cochabamba		1	8	21	18	14
Sucre		1	3	17	18	9
Total of Western Region		15	21	83	93	54
Quijarro		4	8	19	10	20
Yacuiba		1	6	16	14	27
Total of Eastern Region		5	14	35	24	47
Total		20	35	118	117	101

Note: Villazon 1 ... Between La Paz and Oruro, between Rio Mulato and Uyuni
Villazon 2 ... Other sections

Table 7-10 Communication Network Improvement Plan

Item	Schedule 1991 2000 2010 2020	Content and quantity	
UHF		Radio equipment: 82 sets	Iron tower: 41 locations
		Antenna: 82 sets	Power unit: 49 sets
VHF fixed station		Radio equipment: 765 sets	Iron tower: 181 locations
		Antenna: 765 sets	*Power unit: 181 sets*
VHF fixed station Puerto Busch		Radio equipment: 40 sets	Iron tower: 8 locations
		Antenna: 40 sets	Power unit: 8 sets
VHF mobile station	176 sets / 28 sets	176 sets	
		(28 sets): PuertoBusch	
Switchboard		For 100 lines: 14 locations	
		For 300 lines: 3 locations	

7-4 Computer Equipment Plan

Computer related equipment is to be improved and reinforced step by step by 2010. Various management systems are to be modernized by constructing computer systems and their on-line network.

(1) Introduction of LAN (Local Area Network)

LAN is to be constructed by connecting C.P.D. (Centro de Procesamiento de Datos)'s office computes at La Paz, Oruro and Santa Cruz Stations with the work stations which will be installed at the main stations around them in on-line mode. Thus, the information management system is to be modernized.

C.P.D.'s office computers at these 3 stations are to be connected by on-line so that ENFE's head office can utilize various information of all the line sections from the system at La Paz.

Under this computer system, C.P.D. computers at the three stations will have the following functions and roles.

- C.P.D. at La Paz: Head office's comprehensive management, including business management, employee management, various statistical management, materials, income, etc.; Western Region's employee management, materials and accounting management
- C.P.D. at Oruro: Western Region's rolling stock management, passenger and freight sales management
- C.P.D. at S. Cruz: Eastern Region's rolling stock management, passenger and freight sales management

(2) Phased Improvement Plan

The improvement of computer equipment aims to raise the efficiency of management work by constructing an on-line network. The plan shown in Table 7-11 was made in consideration of the improvement of the communication line network.

Table 7-11 Computer Equipment Improvement Plan

Item	Schedule (1991 2000 2010 2020)	Quantity and location	Remark
Mini computer (C.P.D.)	••••	3 sets La Paz, Oruro, Santa Cruz	A network having a center at La Paz is to be constructed.
LAN	••••	3 sets La Paz, Oruro, Santa Cruz	The work stations at the three locations are to be connected.
Work station	••••	41 sets 26 sets in Western Region, 15 sets in Eastern Region	

8. Management Operation Plan

8-1 Organization

(1) Establishment of Head Office Function

At present, ENFE's head office and the Western Region are united. The Western Region is to be separated from this and become completely equal to the Eastern Region. The head office is to be organized above the Western and Eastern Regions. The head office is to perform management functions for entire ENFE.

(2) Outline of Head Office Organization

1) *Chief Engineer*

The Chief Engineer is a new post which is equal to the Vice President. This post has the final responsibility for engineering and accident prevention.

2) Audit Office, International Office and President's Office

The Audit Office, International Office and President's Office are to be organized by unifying the previous advisory organization (UNIDADES DE ASESORAMIENTO) and support section (UNIDADES DE APOYO) in addition to the current Planning & Coordination Office and Legal Affairs Office.

3) Finance Bureau, Transport Bureau and Facilities Bureau

Finance Bureau, Transport Bureau and Facilities Bureau are to be established in addition to the previous Investment Management Bureau and Construction Bureau. These 3 new bureaus are to control the executive organizations of the two branch offices and give guidance, coordination, assistance and advice.

(3) Organization of Branch Office

The Western Office and the Eastern Office are to be under the head office organization.
Figure 8-2 shows the organization (model) of a branch office.

1) Reorganization of general affairs and accounting sections

The General Affairs Division and Account Division are to be established by reorganizing the previous General Affairs Bureau and Personnel Bureau. Specially, the accounting/materials section should be independent and take responsibilities for materials management, etc.

2) Strengthening the marketing section

The current Transport Division of the Operation Bureau is to be reorganized. The marketing staff who belonged to the Transport Division and the station sections (stations, conductor) of the line sections are to be placed under the Marketing Division. Marketing activities are to be strengthened by this method.

3) Strengthening of operation and facilities section

The Operation Bureau is currently a gigantic organization accounting for 85% of the Region. It is to be reorganized and divided into the Operation Division, Rolling Stock Division and Facilities Division.

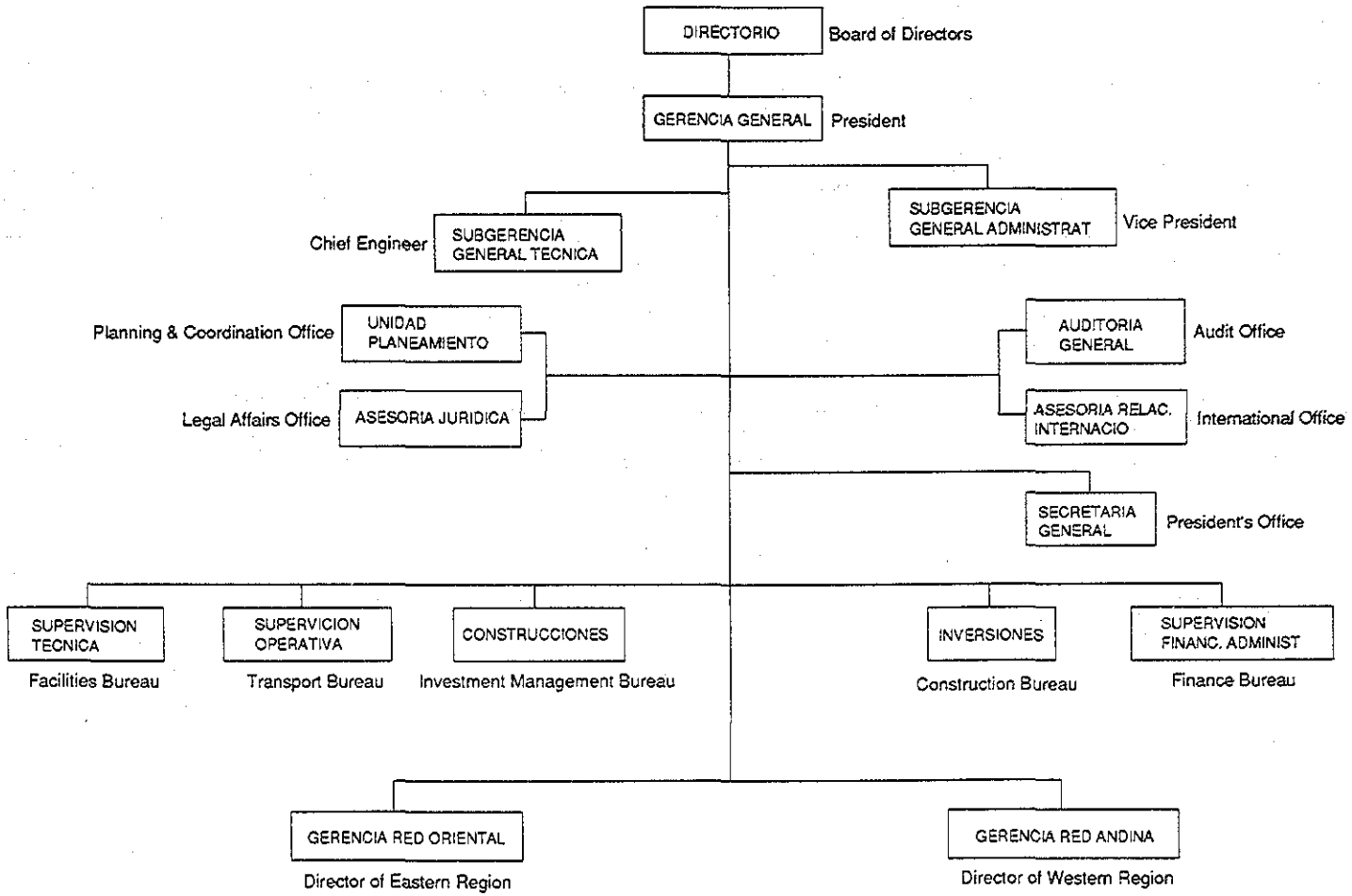

Figure 8-1 Organization Drawing of ENFE (Draft)

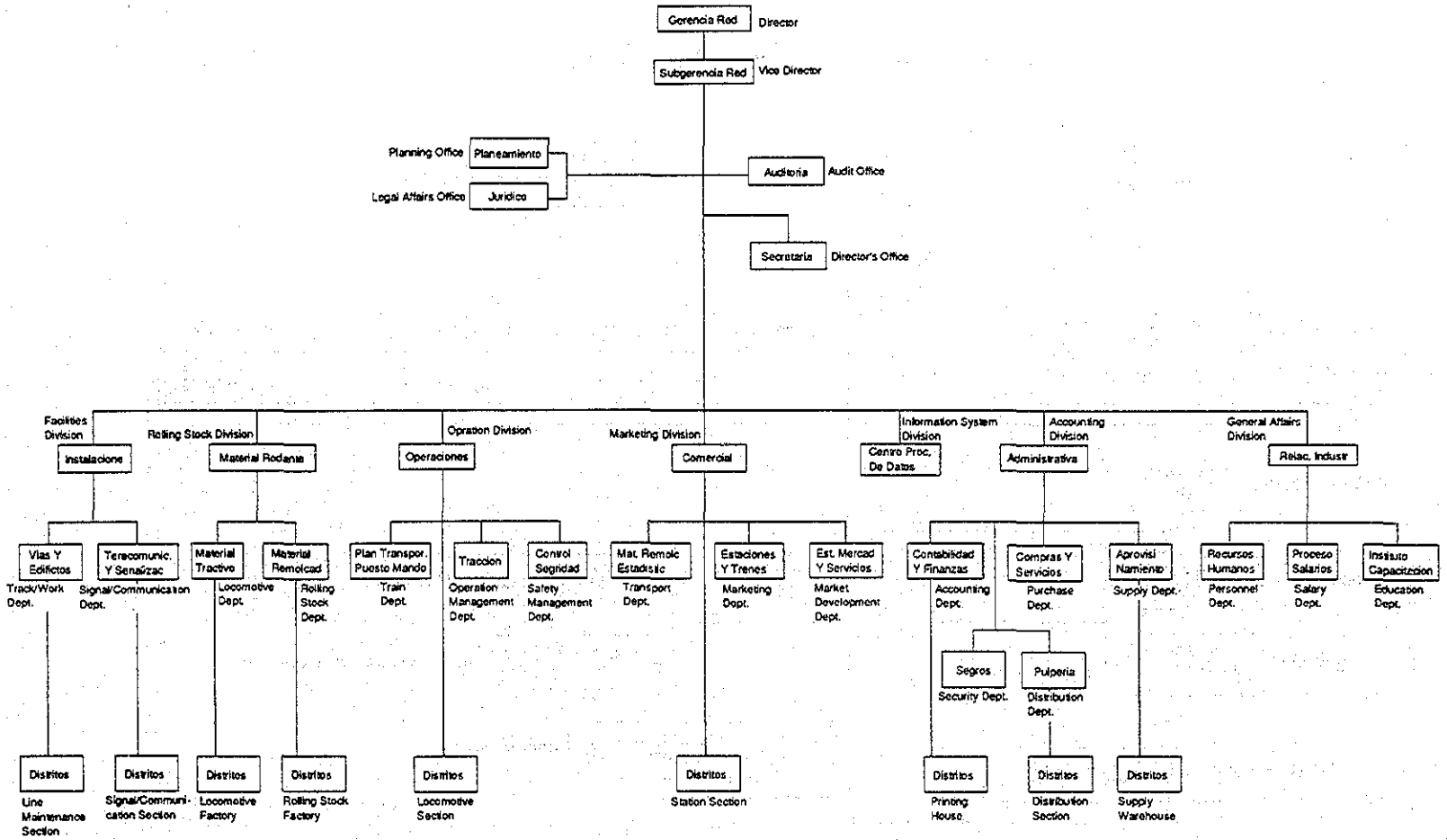

Figure 8-2 Organization Drawing of ENFE Branch Office

8-2 Personnel Assignment

(1) Personnel Optimization

ENFE employees' productivity has been declining yearly. Even if a personnel cut (reduction of 1,000 employees from the 1989 level) proposed in the plan agreement (1990) with the Ministry of Transport is executed in 1991, the transport volume per employee will be 150 thousand ton-km, which is about 73% compared with 1983 (205 thousand passenger/ton-km). Therefore, it will be necessary to execute this agreement completely and, at the same time, to search a way for personnel optimization.

According to the plan agreement of 1991, a reduction of 2,000 employees from the 1989 level is planned in future. Even if the transport volume increases gradually in future, the policy of not increasing employees should be maintained by means of labor reduction and rationalization.

(2) Improvement of Employment Management

A foundation for the future employment management must be established when the employment is new employees is suspended in future. Rational employment standards and employment tests for different job categories should be studied.

(3) Fair Assignment Management

Rational assignment standards should be set in order to prevent non-occupational factors from influencing personnel changes, promotion, etc. Scientific aptitude tests should be adopted for drivers and crew in order to prevent operation accidents.

8-3 Education and Training

(1) Policy for Improvement

The largest current problem is frequent operation accidents, such as derailments. Safety education and technical education are urgently necessary in the immediate future.

1) The technological standards should be raised by basic technological education.
2) The education for preventing accidents should be improved in order to decrease accidents due to operational mistakes by employees.

(2) Improvement of Educational Facilities

1) Improvement in immediate future (2000)
   (a) Machacamaruca Railway Training Center of the Western Region should be improved.
   (b) Santa Cruz Training Center of the Eastern Region should be improved.
2) Construction of comprehensive education institution (2020)
   "Central Railway Training Center" concept must be adopted and a comprehensive and central educational institution should be constructed under a long-term plan.
3) Other improvement measures
   (a) Full-time lecturers
   All of the instructors are dispatched lecturers at present. At least the necessary full-time lecturers should be appointed.

(b) Improvement and editing of teaching materials
Textbooks should be edited and printed by collecting previously used teaching materials systematically. They should be distributed among employees at low prices.

8-4 Management and Administration Expenses

The items of management and administration expenses were determined on the basis of ENFE's account settlement in 1989. A basic unit was set for each item and totals were obtained.

The result is shown in Table 8-1.

Table 8-1 Estimate of Management and Administration Expenses

(Unit: 1,000 Bolivianos)

Year	2000	2010	2010
Personnel expense	74,646	80,301	85,956
Non-personnel expenses	79,633	112,624	143,950
Total	154,279	192,925	229,906
In US dollars (1,000 dollars)	48,212	60,289	71,846

9. Investment Scale and Phased Investment Plan

9-1 Assumptions for Estimation of Improvement and Construction Cost

(1) The labor cost, the materials cost (including the hire of machines) and the miscellaneous expenses of each work item are considered for estimating the improvement and construction cost.

(2) The prices as of September, 1990, are used as the basis for the improvement and construction cost.. The element of escalation is not considered.

(3) The improvement and construction cost is classified into the domestic currency and the foreign currency. All the expenses are calculated in US dollars.

(4) The exchange rate as of September, 1990, (1 US dollar = 140 yen = 3.2 Bs) is assumed as the exchange rate.

(5) CIF prices are used for imported materials and machines (including vehicles) which are to be paid in the foreign currency.

(6) Labor cost of every work item is paid in the domestic currency.

(7) The unit prices for labors and materials of each work type are based on ENFE's data. Concerning the work types which are not carried out by ENFE, the records in Japan are used as reference.

(8) In consideration of the unpredictability of works, 10% of the work cost is set as a reserve fund.

The result of ENFE's study was reviewed and used as the construction cost of a new line.

9-2 Investment Scale and Phased Investment Plan

Table 9-1 shows the amount of investment required for each item and in each phase.

The total amount is 1,455.9 million US dollars. The line reinforcement cost amounts to 441.5 million US dollars (30.4%), the Puerto Busch Line construction cost amounts to 92.3 million US dollars (6.3%) and the itematized improvement cost amounts to 922.1 million US dollars (63.3%). When the investment is classified by project, the rolling stock improvement cost amounts to 829.3 million US dollars, accounting for 57.0% of the total. It is far larger than the line reinforcement cost (441.5 million US dollars, 30.4%). When the line reinforcement cost is classified by region, the Western Region accounts for 69.6% and the Eastern Region accounts for 30.4%. The cost of the Western Region, which has a long line extension and poor alignment conditions, is more than twice as large as that of the Eastern Region. When the investment is classified by phase, the cost during the 1st phase (1991 ~ 2000) is 720.1 million US dollars (49.5%), the cost during the 2nd phase (2001 ~ 2010) is 484.9 million US dollars (33.3%) and the cost during the 3rd phase (2011 ~ 2020) is 250.9 million US dollars (17.2%). The projects of the 1st phase are urgent items. The fact that the urgent projects account for a half of the total investment indicates that investments for railway facilities have been relatively neglected.

Table 9-1 Table of Investment by Item and Phase

(Unit: million US dollars)

Project name / Investment phase		1991 ~ 2000	2001 ~ 2010	2011 ~ 2020	Total	Compared with each item	Compared with total cost
Line enforcement	Villazon line	50.3	72.5	0.0	122.8	30.6	9.3
	Guaqui line	0.0	0.0	1.8	1.8	0.5	0.1
	Charaña line	32.6	0.0	0.0	32.6	8.1	2.5
	Avaroa line	0.0	0.0	6.5	6.5	1.6	0.5
	Cochabamba line	63.1	0.0	0.0	63.1	15.7	4.8
	Sucre line	0.0	0.0	52.6	52.6	13.1	4.0
	Total of Western Region	146.0	72.5	60.9	279.4	69.6	21.2
	Total including reserve fund	160.6	79.8	67.0	307.4		
	Quijarro line	83.7	0.0	0.0	83.7	20.9	6.3
	Yacuiba line	0.0	37.2	0.0	37.2	9.3	2.8
	Yapacani line	0.0	0.0	1.0	1.0	0.2	0.1
	Total of Eastern Region	83.7	37.2	1.0	121.9	30.4	9.2
	Total including reserve fund	92.1	40.9	1.1	134.1		
	Total of line reinforcement cost	229.7	109.7	61.9	401.3	100.0	30.4
	Total including reserve fund	252.7	120.7	68.1	441.5		
New line (P. Busch) construction		0.0	83.7 92.3	0.0	83.7 92.3	100.0	6.3
Itematized improvement	*Rolling stock improvement*	360.8	232.3	160.8	753.9	89.9	57.0
	Factory improvement	35.4	12.5	0.0	47.9	5.7	3.6
	Communication network improvement	28.6	1.1	0.0	29.7	3.5	2.2
	Computer	0.0	1.2	0.0	1.2	0.2	0.1
	Education institution improvement	0.1	0.0	5.4	5.5	0.7	0.4
	Total of itematized improvement	424.9	247.1	166.2	838.2	100.0	63.3
	Total including reserve fund	467.4	271.9	182.8	922.1		
Total		654.6	440.5	228.1	1,323.2		
Grand total (including reserve fund) (%)		720.1 (49.5)	484.9 (33.3)	250.9 (17.2)	1,455.9 (100.0)		100.0

Table 9-2 shows the investment required for each project classified by item and domestic/foreign currency. Reserve funds are not included in these figures.

Table 9-2 Table of Investment by Item and Domestic/Foreign Currency (1)

(Unit: 1,000 US dollars)

Investment phase			1991 ~ 2000			2001 ~ 2010			2011 ~ 2020			Total		
Project name		Domestic/foreign currency	Domestic currency	Foreign currency	Total	Domestic currency	Foreign currency	Total	Domestic currency	Foreign currency	Total	Domestic currency	Foreign currency	Total
Line reinforcement	Western Region													
	Villazon line	Civil engineering cost	8,121.9	1,589.0	9,710.9	14,246.1	1,575.2	15,821.3	0.0	0.0	0.0	22,368.0	3,164.2	25,532.2
		Track cost	5,464.3	31,373.4	36,837.7	14,780.6	36,853.1	51,633.7	0.0	0.0	0.0	20,244.9	68,226.5	88,471.4
		Building cost	0.0	0.0	0.0	855.0	0.0	855.0	0.0	0.0	0.0	855.0	0.0	855.0
		Power cost	809.0	2,963.0	3,772.0	813.0	3,360.0	4,173.0	0.0	0.0	0.0	1,622.0	6,323.0	7,945.0
		Total	14,395.2	35,925.4	50,320.6	30,694.7	41,788.3	72,483.0	0.0	0.0	0.0	45,089.9	77,713.7	122,803.6
	Guaqui line	Civil engineering cost	0.0	0.0	0.0	0.0	0.0	0.0	256.8	9.2	266.0	256.8	9.2	266.0
		Track cost	0.0	0.0	0.0	0.0	0.0	0.0	95.7	433.9	529.6	95.7	433.9	529.6
		Building cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Power cost	0.0	0.0	0.0	0.0	0.0	0.0	234.0	754.0	988.0	234.0	754.0	988.0
		Total	0.0	0.0	0.0	0.0	0.0	0.0	586.5	1,197.1	1,783.6	586.5	1,197.1	1,783.6
	Charaña line	Civil engineering cost	4,101.5	544.6	4,646.1	0.0	0.0	0.0	0.0	0.0	0.0	4,101.5	544.6	4,646.1
		Track cost	7,010.3	19,564.8	26,575.1	0.0	0.0	0.0	0.0	0.0	0.0	7,010.3	19,564.8	26,575.1
		Building cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Power cost	274.0	1,068.0	1,342.0	0.0	0.0	0.0	0.0	0.0	0.0	274.0	1,068.0	1,342.0
		Total	11,385.8	21,177.4	32,563.2	0.0	0.0	0.0	0.0	0.0	0.0	11,385.8	21,177.4	32,563.2
	Avaroa line	Civil engineering cost	0.0	0.0	0.0	0.0	0.0	0.0	1,038.9	0.0	1,038.4	1,038.9	0.0	1,038.4
		Track cost	0.0	0.0	0.0	0.0	0.0	0.0	3,632.4	1,021.0	4,653.4	3,632.4	1,021.0	4,653.4
		Building cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Power cost	0.0	0.0	0.0	0.0	0.0	0.0	156.0	648.0	804.0	156.0	648.0	804.0
		Total	0.0	0.0	0.0	0.0	0.0	0.0	4,827.3	1,669.0	6,496.3	4,827.3	1,669.0	6,496.3
	Cochabamba line	Civil engineering cost	20,281.3	9,329.2	29,610.5	0.0	0.0	0.0	0.0	0.0	0.0	20,281.3	9,329.2	29,610.5
		Track cost	7,957.1	19,946.7	27,903.8	0.0	0.0	0.0	0.0	0.0	0.0	7,957.1	19,946.7	27,903.8
		Building cost	1,789.5	0.0	1,789.5	0.0	0.0	0.0	0.0	0.0	0.0	1,789.5	0.0	1,789.5
		Power cost	799.0	3,032.0	3,831.0	0.0	0.0	0.0	0.0	0.0	0.0	799.0	3,032.0	3,831.0
		Total	30,826.9	32,307.9	63,134.8	0.0	0.0	0.0	0.0	0.0	0.0	30,826.9	32,307.9	63,134.8
	Surce line	Civil engineering cost	0.0	0.0	0.0	0.0	0.0	0.0	3,739.1	18.4	3,757.5	3,739.1	18.4	3,757.5
		Track cost	0.0	0.0	0.0	0.0	0.0	0.0	11,900.3	34,041.5	45,941.8	11,900.3	34,041.5	45,941.8
		Building cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Power cost	0.0	0.0	0.0	0.0	0.0	0.0	599.0	2,262.0	2,861.0	599.0	2,262.0	2,861.0
		Total	0.0	0.0	0.0	0.0	0.0	0.0	16,238.4	36,321.0	52,560.3	16,238.4	36,321.0	52,560.3
	Total of Western Region		56,607.9	89,410.7	146,018.6	30,694.7	41,788.3	72,483.0	21,652.2	39,188.0	60,840.2	108,954.8	170,387.0	279,341.8

Table 9-2 Table of Investment by Item and Domestic/Foreign Currency (2)

(Unit: 1,000 US dollars)

Investment phase			1991 ~ 2000			2001 ~ 2010			2011 ~ 2020			Total		
Project name	Domestic/foreign currency		Domestic currency	Foreign currency	Total	Domestic currency	Foreign currency	Total	Domestic currency	Foreign currency	Total	Domestic currency	Foreign currency	Total
Line reinforcement	EasternRegion													
	Quijarro line	Civil engineering cost	11,628.9	1,161.6	12,790.5	0.0	0.0	0.0	0.0	0.0	0.0	11,628.9	1,161.6	12,790.5
		Track cost	9,961.6	54,927.7	64,889.3	0.0	0.0	0.0	0.0	0.0	0.0	9,961.6	54,927.7	64,889.3
		Building cost	1,710.0	0.0	1,710.0	0.0	0.0	0.0	0.0	0.0	0.0	1,710.0	0.0	1,710.0
		Power cost	895.0	3,460.0	4,355.0	0.0	0.0	0.0	0.0	0.0	0.0	895.0	3,460.0	4,355.0
		Total	24,195.5	59,549.3	83,744.8	0.0	0.0	0.0	0.0	0.0	0.0	24,195.5	59,549.3	83,744.8
	Yaciba line	Civil engineering cost	0.0	0.0	0.0	12,681.7	1,701.6	14,383.3	0.0	0.0	0.0	12,681.7	1,701.6	14,383.3
		Track cost	0.0	0.0	0.0	15,239.5	3,334.9	18,574.4	0.0	0.0	0.0	15,239.5	3,334.9	18,574.4
		Building cost	0.0	0.0	0.0	855.0	0.0	855.0	0.0	0.0	0.0	855.0	0.0	855.0
		Power cost	0.0	0.0	0.0	752.0	2,658.0	3,408.0	0.0	0.0	0.0	752.0	2,656.0	3,408.0
		Total	0.0	0.0	0.0	29,528.2	7,692.5	37,220.7	0.0	0.0	0.0	29,528.2	7,692.5	37,220.7
	Yapacani line	Civil engineering cost	0.0	0.0	0.0	0.0	0.0	0.0	49.7	4.6	54.3	49.7	4.6	54.3
		Track cost	0.0	0.0	0.0	0.0	0.0	0.0	255.1	699.2	954.3	255.1	699.2	954.3
		Building cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Power cost	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		Total	0.0	0.0	0.0	0.0	0.0	0.0	304.8	703.8	1,008.6	304.8	703.8	1,008.6
	Total of Eastern Region		24,195.5	59,549.3	83,744.8	29,528.2	7,692.5	37,220.7	304.8	703.8	1,008.6	54,028.5	67,945.6	121,974.1
	Total of line reinforcement		80,803.4	148,960.0	229,763.4	60,222.9	49,480.8	109,703.7	21,957.0	39,891.8	61,848.8	162,983.3	238,332.6	401,315.9
New line construction	Puerto Busch line	Civil engineering cost	0.0	0.0	0.0	14,424.0	23,081.0	37,505.0	0.0	0.0	0.0	14,424.0	23,081.0	37,505.0
		Track cost	0.0	0.0	0.0	18,025.0	25,070.0	43,095.0	0.0	0.0	0.0	18,025.0	25,070.0	43,095.0
		Building cost	0.0	0.0	0.0	808.0	1,502.0	2,310.0	0.0	0.0	0.0	808.0	1,502.0	2,310.0
		Power cost	0.0	0.0	0.0	146.0	628.0	774.0	0.0	0.0	0.0	146.0	628.0	774.0
	Total of new line construction		0.0	0.0	0.0	33,403.0	50,281.0	83,684.0	0.0	0.0	0.0	33,403.0	50,281.0	83,684.0
Itematized improvement	Rolling stock improvement	Rolling stock cost	0.0	360,817.0	360,817.0	0.0	232,593.0	232,259.0	0.0	160,816.0	160,816.0	0.0	754,226.0	754,226.0
	Factory improvement	Building cost	11,062.0	0.0	11,062.0	198.0	0.0	198.0	0.0	0.0	0.0	11,260.0	0.0	11,260.0
		Machine cost	0.0	24,336.0	24,336.0	0.0	12,273.0	12,273.0	0.0	0.0	0.0	0.0	36,609.0	36,609.0
		Total	11,062.0	24,336.0	35,398.0	198.0	12,273.0	12,471.0	0.0	0.0	0.0	11,260.0	36,609.0	47,869.0
	Communi-cation network improvement	Power cost	3,384.0	25,232.0	28,616.0	120.0	1,016.0	1,136.0	0.0	0.0	0.0	3,504.0	26,248.0	29,752.0
	Computer	Power cost	0.0	0.0	0.0	12.0	1,204.0	1,216.0	0.0	0.0	0.0	12.0	1,204.4	1,216.0
	Education institution improvement	Civil engineering cost	0.0	0.0	0.0	0.0	0.0	0.0	401.8	217.5	619.3	401.8	217.5	619.3
		Track cost	0.0	0.0	0.0	0.0	0.0	0.0	22.2	66.5	88.7	22.2	66.5	88.7
		Building cost	54.7	6.2	60.9	0.0	0.0	0.0	1,243.0	466.5	1,709.5	1,297.7	472.7	1,770.4
		Power cost	0.0	0.0	0.0	0.0	0.0	0.0	20.0	3,000.0	3,020.0	20.0	3,000.0	3,020.0
		Total	54.7	6.2	60.9	0.0	0.0	0.0	1,687.0	3,750.5	5,437.5	1,741.0	3,756.7	5,498.4
	Total of itematized improvement		14,500.7	410,391.2	424,891.9	330.0	247,086	247,416.0	1,687.0	164,566.5	166,253.5	16,517.7	822,043.7	838,561.4
Grand total			95,304.1	559,351.2	654,655.3	93,955.9	346,847.8	470,803.7	23,644.0	204,458.3	228,102.3	212,904.0	1,110,657.3	1,323,561.3

10. Economic and Financial Analysis

10-1 Economic Analysis

(1) Evaluation Method

The objective of this economic analysis is to study whether or not the phased investment plan up to 2020 is feasible from the standpoint of the national economy. In order to make an economic analysis, the project life was assumed as 70 years, including 30-year construction period. EIRR (Economic Internal Rate of Return) was obtained from a discounted cost-benefit analysis. The economic viability of this plan was studied on the basis of EIRR.

Since this plan must be evaluated by an economic analysis from the standpoint of the national economy, not market prices, but accounting prices obtained by excluding transfer items such as customs and value added tax are used for obtaining EIRR.

(2) Investment Cost

Table 10-1 shows the total investment cost during the 30-year construction period. It was assumed that a reinvestment is necessary for rolling stock, signalling and telecommunication facilities after their service life. If this plan is not executed ("Without"), the rolling stock workshops will not be improved. Therefore, the service life of rolling stock was assumed shorter than the service life assumed by the execution of this plan ("With") by 5 years. Contingencies was estimated to be 10% of the construction cost.

Table 10-1 Total Amount of Investment

(Unit: 1,000 US dollars)

Item		1991 ~ 2000	2001 ~ 2010	2011 ~ 2020	Total
Rehabilitation Improvement cost	Domestic currency	70,983	53,325	20,595	144,903
	Foreign currency	118,667	37,256	34,267	190,190
New line construction	Domestic currency		30,234		30,234
	Foreign currency		42,560		42,560
Rolling stock	Foreign currency	360,817	232,593	160,816	754,226
Signalling & Telecommunications	Domestic currency	5,601	1,675	899	8,175
	Foreign currency	35,755	8,864	3,664	48,283
Workshop & Equipment	Domestic currency	10,056	180		10,236
	Foreign currency	24,336	12,273		36,609
Contingencies		62,622	41,896	22,024	126,542
Grand total		688,837	460,856	242,265	1,391,958

(3) Estimation of Benefits

The benefits which are expected by the execution of this plan are expressed as the reduction (saving) of economic costs attained by "With" compared with "Without". The following benefits were considered for this economic analysis.

1) Reduction of total operating cost by railways and roads

The reduction of the total operating cost is the most important benefit. It was estimated by obtaining the difference between "With" and "Without" in the total operating cost for the forecasted total passenger and freight traffic demand, including railways, roads and waterways.

2) Time benefit by increasing train speed and avoiding delay

The time benefit was determined by multiplying the estimated unit time value of a passenger and freight by the travel time reduction attained by increasing the train speed and avoiding train delay.

3) Reduction of road maintenance cost

It is anticipated that road traffic will be partly diverted to railway by improving exiting lines and constructing a new line. Road maintenance cost is saved by decreasing road traffic. The maintenance cost reduction was estimated by applying a formula between road maintenance cost and road traffic.

4) Avoidance of disaster restoration cost between Oruro and Cochabamba

Since disaster occurs every year between Oruro and Cochabamba in the Western Region, the improvement of this section was included in the phased investment plan. This eliminates the yearly cost of restoration work. The restoration cost which can be avoided was estimated on the basis of the disaster restoration expenses during the last 10 years.

5) Reduction of accident restoration cost by decreasing train accidents

It is expected that train accidents can be decreased greatly by the railway improvement work. The accident restoration cost can be decreased as a result. Like the disaster restoration cost, the reduction of accident restoration cost was estimated on the basis of the previous expenses.

Table 10-2 shows the yearly cost reduction attained by the above benefits.

Table 10-2 Yearly Benefits

(Unit: 1,000 US dollars)

Fiscal year	2000	2010	2020
Reduction of transport cost	40,393	91,340	106,726
Time benefit	2,886	5,771	8,657
Reduction of road maintenance cost	2,574	5,643	8,634
Avoidance of disaster restoration cost	435	435	435
Decrease of train accidents	115	230	345
Total	46,403	103,419	124,797

(4) Analysis Result and Sensitivity Analysis

The EIRR of the phased investment plan was calculated on the basis of the investment costs and the estimated benefits. The result was 11.0%. This is lower than Bolivia Central Bank's average interest rate on loans in 1989 ~ 1990, namely 14%. However, it is above 10%, which is said to be the World Bank's criterion for project selection.

This is a long-term project (30 years). Some of the subprojects have high economic profitability, while some have relatively low profitability. Therefore, the economic profitability of each subproject should be studied sufficiently before starting the subprojects of the phased plan.

On the other hand, it is suspected that the construction cost and the traffic demand give a large influence on the result of EIRR calculation. Therefore, a sensitivity analysis of these 2 factors was made. The result is shown in Table 10-3.

Table 10-3 Result of Sensitivity Analysis

Case	EIRR (%)
Basic case	11.00
10% increase in construction cost	10.05
10 decrease in traffic demand	9.96
10 increase in construction cost + 10 decrease in traffic demand	9.08

The result of the sensitivity analysis revealed that a 10% decrease in the traffic demand has a larger influence on the EIRR than a 10% increase in the construction cost.

Therefore, efforts should be made to pump up the traffic demand in executing the phased investment plan.

(5) Assessment

The EIRR of the phased investment plan is 11.0%. It is higher than the World Bank's criterion for project selection (10%). It can be said that this plan is sufficiently feasible from the standpoint of the national economy in view of its EIRR and in consideration of the effects of increasing employment opportunities during and after the construction period on Bolivia's economy and other indirect benefits, such as environmental merits obtained by partly diverting road transport to railway.

10-2 Financial Assessment

(1) Objective and Method of Analysis

The phased investment plan ending in 2020 was analyzed from the financial viewpoint. ENFE's possibility for sound operation as an enterprise after the plan was studied by forecasting the income and expenditure and the cash flow. FIRR (Financial Internal Rate of Return) was used as an indicator for the assessment. Most of assumptions made for the economic analysis were used for the financial assessment as well. However, some different conditions were set because of the nature of the financial assessment.

1) Investment cost

Unlike the economic analysis, market prices were used. Therefore, no tax adjustment was made. The amount of investments was divided into 3 phases (10 years per phase) and it was assumed that expenses are paid in lump sum in the middle of each phase (1995, 2005, 2015).

2) Fund acquisition

Concerning the foreign currency fund required for the initial investment, it was assumed that loans will be obtained from public organizations which are applicable to and most advantageous for Bolivia. The following two conditions were set on this assumption. It was assumed that the Government is to provide all of the domestic currency portion of the initial investment.

Fund procurement 1

Interest rate	:	2.7% p.a.
Period	:	30 years (including 10 years of grace)
Repayment method	:	Equal installments for 20 years paid every half a year

Fund procurement 2

Interest rate	:	0.75% p.a.
Period	:	40 years (including 10 years of grace)
Repayment method	:	Equal installment for 30 years paid every half a year

3) Fare rate (Freight rate)

The passenger fare was assumed as US$ 0.015/passenger-km and the freight rate was assumed as US$ 0.060/ton-km. These figures were obtained by calculating the income per passenger-km and ton-km on the basis of ENFE's records in 1989 and 1991 and converting the result to US dollar by the exchange rate in each year (US$1 = Bs. 2.7 in 1989, US$1 = Bs. 3.2 in 1990).

(2) Analysis Result and Sensitivity Analysis

The income and expenditure of the phased investment plan was forecasted on the basis of the above assumptions. The cash flow was drawn and the FIRR was calculated. Like the economic analysis, a sensitivity analysis was made in terms of two factors (construction cost and traffic demand) and the combination of the two. The result is shown in Table 10-4.

Table 10-4 FIRR (Including Result of Sensitivity Analysis)

Case	FIRR (%)
Basic case	2.17
10% increase in construction cost	1.64
10 decrease in traffic demand	0.82
10 increase in construction cost + 10 decrease in traffic demand	0.37

The result of the analysis is as follows. If the fund procurement 1 is adopted, the FIRR is below the interest rate on the loan (2.7%) even in the basic case. A considerable fund shortage will be accumulated around in 2011 ~ 2020 when both the repayment of the loan and the reinvestment for rolling stock begin. Since it is difficult to supplement this shortage by the open market loan, it is impossible to avoid an additional burden on the Government which must provide the domestic currency portion of the initial investment. If the fund procurement 2 is adopted, no special problem in terms of the cash flow arises. Therefore, it is necessary not only to obtain the governmental's financial assistance, but also to acquire a foreign currency fund under extremely advantageous conditions in order to execute the phased investment plan as a sound enterprise operation.

The sensitivity analysis revealed that a 10% decrease in the traffic demand has a larger influence on the FIRR than a 10% increase in the construction cost. In other words, the same result was obtained for the EIRR and FIRR.

However, the FIRR will be only 0.37% if a 10% increase in the construction cost and a 10% decrease in the traffic demand occur at the same time. In this case, the management will be difficult even if the fund procurement 2 is used.

(3) Study of Investment Scale

According to the Bolivian Government's "Economic and Social Development Strategy 1989 ~ 2000", the country plans to invest 122.3 million US dollars in the whole transport sector per year on average during the first 10 years of the phased investment plan. The investment in the railway subsector (the total of ENFE and COMIXTA) will amount to 13.2 million US dollars, accounting for 10.8% of the total investment in the transport sector. No investment plan after 2001 is presented. However, it was assumed that the amount of the investment will increase at the same rate as the growth rate forecast of the GDP (2.45% per year) which was used for the demand forecast. The yearly investment in the transport sector was estimated by this method. The funds required for executing the phased investment plan were compared with the investment plan and the estimated investment. The result is shown in Table 10-5.

Table 10-5 Ratio of Initial Investment to Planned Investment and Estimated Investment in Transport Sector

(Unit: million US dollars)

Period (year)	Initial investment (A)	Investment in transport (B)		A/B (%)
1991 ~ 2000	720	Plan	1,223	58.9
2001 ~ 2010	485	Estimate	1,829	26.5
2011 ~ 2020	251	Estimate	2,330	10.8
Total of 1991 ~ 2020	1,456		5,382	27.1

The investment in the railway subsector which is planned in "Economic and Social Development Strategy 1989 ~ 2000" is only 10.8% of the planned investment in the entire transport sector. However, the fund which is required for the phased investment plan will be 27.1% of the total investment in the transport sector. Specially, the amount of investment during the 1st phase (1991 ~ 2000) accounts for more than half of the total investment of the

transport sector. However, this plan is meaningful from the viewpoint of the national economy. If the highest priority can be given to the railway reinforcement for the country's economic development, it can be said that this plan is significant. It is important to conduct a feasibility study before starting each project and to study its urgency and profitability sufficiently in order to formulate a reasonable investment plan.

(4) Assessment

The FIRR of this phased investment plan is only 2.17% as discussed above. However, it can be operated by taking financial measures, such as the governmental investment for the domestic currency portion if a loan of extremely advantageous conditions can be obtained for the foreign currency portion.

11. Conclusion and Proposal

11-1 Conclusion

(1) Railway Network in 2020 in Master Plan

Bolivia's railway network reinforcement was planned on the basis of the existing lines and in consideration of the construction of new lines connecting to existing lines as well as intermodal transport utilizing existing roads and rivers.

First, eight possible railway networks were proposed. Four typical proposals were selected from the eight by comprehensively and qualitatively evaluating the investment scale, domestic railway transport network, development effects, ENFE's profitability, the efficiency of rolling stock operation, etc. Then, the selected four proposals were evaluated comprehensively in terms of the economic and financial assessment, investment scale, the promotion of regional development and the contribution to the international railway network,etc. The optimum railway network (2020) was selected on the basis of this evaluation.

The optimum railway network (2020) which was selected consists of the modernized existing lines, intermodal transport between Cochabamba and Santa Cruz by a road and a new railway line between Motacucito and Puerto Bush as shown in Figure 11-1. This railway network has the following characteristics. The Western Region and the Eastern Region can be linked by intermodal transport by a road. Import/export freight from/to foreign countries (the Atlantic Ocean side) can be carried without going through another country by providing a direct access to the River Paraguai Parana River, which is an international river.

(2) Railway Rehabilitation and Modernization in Master Plan

The railway rehabilitation and modernization were planned with an objective of securing safe and stable transportation and improving ENFE's management to sound financial state with the least possible investment.

The main rehabilitation and modernization plan is summarized below.

1) Establish a train operation system and install new safety facilities, such as signal facilities.
2) Set train service meeting the traffic demand. To secure enough line capacity, construct new signal stations and change the track layout in station premises, etc. and take other necessary measures.

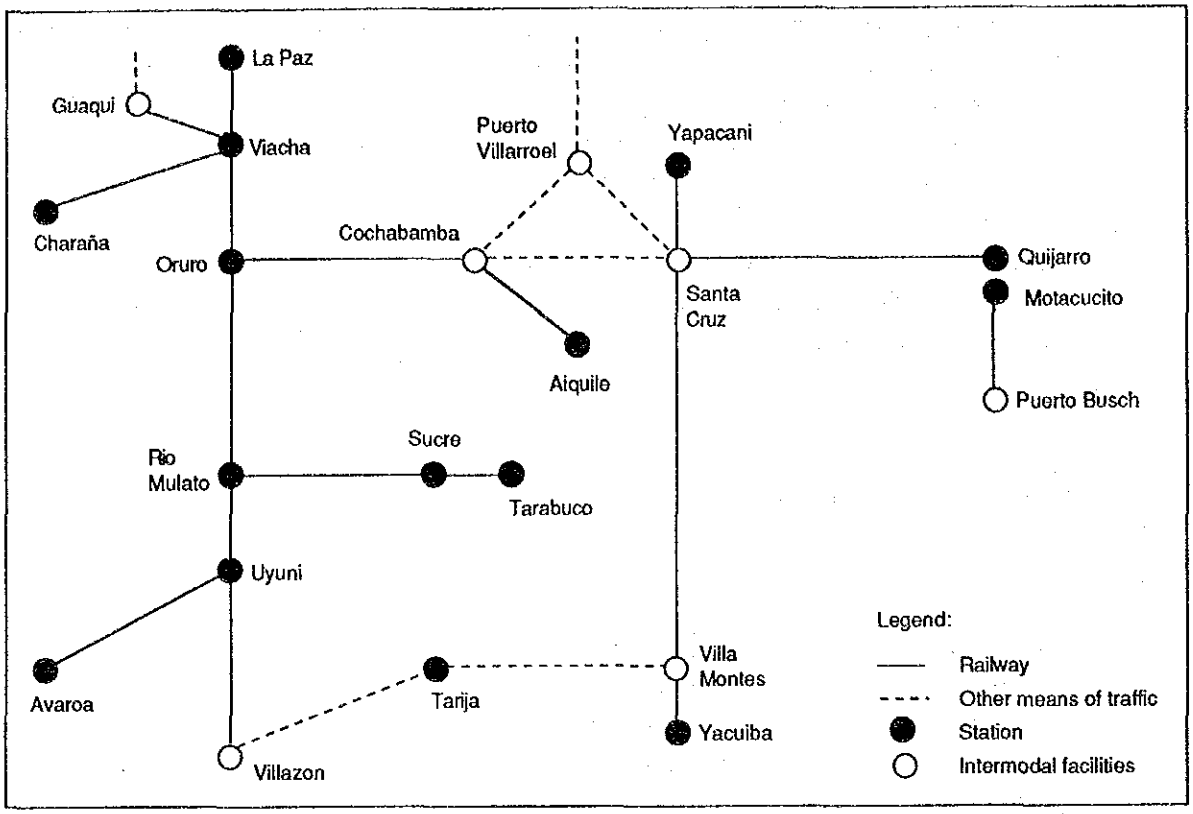

Figure 11-1 Rough Route of Railway Network

3) Increase and improve the rolling stock according to the traffic demand and the train operation plan. Improve the repairing facilities at the maintenance factories in order to raise the operating rate of the rolling stock.

4) Improve tracks (rails, turnouts, ballast, etc.), civil engineering structures (roadbed, bridge, etc). level crossing facilities (crossing structure, installation of level crossing protection devices, etc.) and protection facilities (slope protection, fences, etc.) in consideration of the train speed, load and frequency which are planned.

5) Construct a communication system consisting basically of VHF radio telephones and UHF multiplex communications.

6) Install computer terminals at main stations and connect them by the improved communication network in order to utilize ENFE's computer system effectively and by on-line basis.

7) As for the so-called disaster section between Cochabamba and Oruro where train operation is suspended yearly due to frequent disasters, establish necessary countermeasures so that safe and stable transport can be assured urgently to local residents and for intermodal transport between Cochabamba and Santa Cruz.

8) The freight business will continue to be ENFE's trunk business field. Raise the efficiency of freight transport by operating freight cars adequately, by unifying and organizing freight stations. Promote the modernization of cargo handling facilities and methods. In

the field of passenger business, improve the fare system and the related rules according to users' convenience and other needs along with the gradual improvement of the transport capacity.

9) Improve ENFE' organization by separating the head office function. Reorganize the Eastern and Western Regions and plan adequate personnel assignments in consideration of productivity improvement. As for the educational facilities, improve the current facilities of the both regions in the immediate future and improve the practical training. Construct a central and comprehensive educational institution in future.

10) In order to secure efficient intermodal transport between Cochabamba and Santa Cruz, improve the related intermodal facilities.

11) Construct a new line (about 133 km) between Motacucito and Puerto Busch for transporting iron ores from Mutun and for connecting railway transport to river transport by the River Paraguai Parana, which is an international river.

(3) Phased Railway Reinforcement

In order to implement the master plan of 2020, the priority ranking of the projects which constitute the master plan was studied. Accordingly, a phased railway reinforcement plan in 2000, 2010 and 2020 was outlined.

The 15 projects shown in Table 11-1 were set as the components of the master plan. Their investment priority ranking was studied. The line reinforcement and new line construction projects were raked in consideration of their investment effects, importance, social nature and other special conditions of each line section. The itematized projects were ranked in consideration of their importance and urgency. Each of the projects was ranked in terms of investment priority by a joint study between Bolivian Counterpart Team and JICA Study Team in consideration of Bolivia's policy and the coordination with the export route reinforcement project which is being executed by ENFE and the World Bank.

Table 11-1 shows the phased railway investment plan which was outlined in consideration of the investment priority ranking in every 10 years.

(4) Economic and Financial Assessment of Master Plan

If ENFE's master plan ending in 2020 is executed according to the above phased railway reinforcement plan, the EIRR (Economic Internal Rate of Return) will be 11%. This is above the criterion which is applied to project selection by international financing organizations, such as the World Bank and Asia Development Bank. In consideration of indirect national, economic and social benefits, such as the creation of employment opportunities and environmental protection, it can be judged that this master plan is feasible from the viewpoint of the national economy.

However, the foreign currency portion of the investment must be obtained from an international organization of a low interest rate or inter-governmental loans and the domestic currency portion must be contributed by the Bolivian Government in order to recover ENFE's financial condition to a sound state.

The Government may have to provide a subsidy for deficits during the initial period. If such a measure is taken, it will be possible to achieve cumulative profits at the end.

(5) Conclusion

The FIRR (Financial Internal Rate of Return), which evaluates ENFE's master plan ending in 2020 and the phased reinforcement plan from the standpoint of an enterprise's business, is 2.17%. Low interest rate loans and governmental assistance will be necessary for ENFE to achieve a sound financial state.

However, the EIRR (Economic Internal Rate of Return), which evaluates the plan from the standpoint of the national economy, is 11%. This is above the criterion of project selection adopted by international financing organizations, such as the World Bank and the Asia Bank. Therefore, it can be judged that the plan is significant in terms of the national economy.

When the trunk railways in various countries in the world are examined, it is found that self-supporting is difficult for most of them. However, these countries recognize the national and economic significance of trunk railways as an important infrastructure for their social and economic activities. They have the trunk railways play an adequate role by providing the necessary financial assistance.

In other words, the trunk railways in a country should not be judged only from the financial viewpoint. They should be evaluated from the viewpoint of the national economy.

It has a large significance to have an appropriate dependence on railway transport in view of the global problem of environmental destruction by automotive exhaust gas and for the efficient energy utilization. The content of the investment required for each project should be analyzed and studied in details before actually starting a project. Based on these analysis and studies, efforts, should be made to select inexpensive imported materials and machines, including rolling stock, as long as permissible from the quality standpoint, and to examine the possibility whether or not a part of investments can be delayed according to the improvement state of roads which are competitive with railways. By trying to decrease investments as far as possible by these efforts, it will be possible to improve the financial aspect of this master plan.

It can be judged that this master plan is significant for Bolivia's society and economy from the comprehensive viewpoint as discussed above. Therefore, the first step toward its implementation should be taken as soon as possible.

In order to implement this master plan effectively, both hardware investments (facilities, rolling stock, etc.) and software improvements (management, administration, marketing policy, maintenance, education, etc.) are essential.

Table 11-1 Phased Railway Reinforcement Plan

Project name	Line extension (km)	Reinforcement schedule 1991 2000 2010 2020	Remark
1. Line section reinforcement			
Western Region			
La Paz~Villazon	847.2	———	1991~2000 La Paz~Or., R.Mur.~Uy. 2001~2010 Remaining line sections
Voacja~Guaqui	65.8	———	
Viacha~Charaña	209.3	———	
Uyuni~Avaroa	172.4	———	
Oruro~Cochabamba	204.8	———	
Rio Mulato~Sucre	348.2	———	
Eastern Region			
Santa Cruz~Quijarro	650.4	———	
Santa Cruz~Yacuiba	539.0	———	
Santa Cruz~Yapacani	209.2	———	
2. New line construction			
Motacucito~Puerto Busch	132.7	———	
3. Itematized modernization			
Rolling stock		———	Increase rolling stock according to demand.
Factory		———	1991~2000 Viacha, Guara.Factory
Communication network		———	UHF, Switchboard etc.
Computer system		..... ———	
Educational facilities		——— ..... ———	1991~2000 Improvement of existing schools 2011~2020 Comprehensive institution

Note:
- Track improvement ... Rail, turnout, ballast, maintenance equipment
- Level crossing improvement
- Station improvement ... Layout change, signal station, intermodal facilities
- Bridge improvement ... Replacement of temporary bridge, abutment and pier reinforcement
- Protection facilities ... Slope protection, fence
- Improvement of disaster section between Oruro and Cochabamba
- Installation of new signal facilities
- Partial improvement of communication equipment

11-2 Proposal

In order to assure the implementation of this master plan, the following actions are proposed.

(1) In order to implement the urgent improvement projects of the 1st phase (1991 ~ 2000), efforts must be made to obtain the necessary funds.

Among these projects, the improvement of the section between Oruro and Cochabamba is specially important because it is the trunk line of the east and west transportation and frequent disasters cause the suspension of train operation. A feasibility study, including the production of topographical maps, should be carried out immediately and a low interest loan from an international organization or an inter-governmental loan should be obtained. The factory improvement project (Viacha and Guaracachi Factory) is also important for raising the operating rate of rolling stock and securing stable and efficient transportation. A feasibility study of this project should also be carried out immediately and a loan from an international organization or an inter-government loan should be obtained.

For the reinforcement projects of Santa Cruz – Quijarro, Viacha – Charana and other line sections, a loan from an international organization or an inter-governmental loan should be obtained on the basis of the study result of this report.

As discussed in "Conclusion", efforts should be made to select inexpensive imported materials and machines, including rolling stock, as long as permissible from the quality standpoint. A part of investments can be delayed according to the improvement state of roads which are competitive with railways. Attempts should be made to raise the profitability of the projects by trying to decrease investments as far as possible.

(2) In order to implement this master plan effectively, not only hardware investments (rolling stock, ground facilities, etc.), but also software improvements are essential as discussed before. For example, the management (including the organization) must be improved and a reliable operation system and measures for preventing accidents should be established. A track and structure maintenance system should be established. The marketing strategy and the education system should be improved. It will be effective to ask a railway-advanced country to dispatch experts for an adequate period in order to promote software improvements. The recommended actions for the 1st phase projects (1991 – 2000) discussed in (1) and (2) are summarized in Table 11-2.

(3) This master plan covers a long period (30 years). Social and economic changes within and outside Bolivia are quite probable during this period. Therefore, this master plan should be reviewed after an adequate period. Since the Bolivian Government reviews the long-term social and economic plans once every 5 years, it is one of the possibilities to review this master plan at about the same interval.

Such a review will be appropriate for the project of constructing a new line between Aiquile and Santa Cruz. Efforts should be made to establish intermodal system using road transportation for the time being. When the master plan is reviewed, the feasibility of the new line should be studied on the basis of Bolivia's economic ability and the international freight traffic demand using the land bridge.

Table 11-2 Concrete Actions for 1st Phase (1991 – 2000) Projects

Item	F/S	Loan, grant	Expert	Remark
1. Line section reinforcement				Track improvement, specially ballast supply, rail and sleeper replacement
La Paz ~ Villazon		O		L.P. ~ Or., R.Mur. ~ Uy.
Viacha ~ Charaña		O		Related to World Bank projects
Oruro ~ Cochabamba	O	O		Concrete improvements, investment scale and phased plan should be studied by F/S.
Santa Cruz ~ Quijarro		O	O	Related to World Bank projects
2. Itematized project				
Rolling stock increase and improvement		O		Rolling stock increase and improvement according to demand; related to World Bank projects
Plant improvement	O			Viacha, Guaracachi Plant
Communication network improvement		O		Related to Wolk Bank projects; priority to trunk system
Educational facilities		O	O	Improvement of existing facilities
3. Software improvement				
Organization, management and administration			O	Related to World Bank projects
Marketing policy			O	
Operation system			O	Including the prevention of operation accidents
Track maintenance			O	
Rolling stock maintenance			O	
Electric equipment maintenance			O	

Note: F/S; Feasibility study

Loan, grant: Railway rehabilitation projects, etc. should be carried out by obtaining machines and materials with loans and grants while making coordination with the World Bank's export corridor project.

Expert: Advice from experts of railway advanced countries should be obtained and those which are possible should be started first.