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REPORT
OF
THE STUDY
ON
THE TRACK, TELECOMMUNICATION AND SIGNALLING IMPROVEMENT PROJECT
IN
THE SOCIALIST REPUBLIC OF THE UNION OF BURMA

SUMMARY

FEBRUARY 1987

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

RESTRICTED

LONG-TERM MODERNIZATION PROGRAMME

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LONG-TERM MODERNIZATION PROGRAMME

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SUMMARY

1. SCOPE OF THE STUDY

(1) Objective

The study objectives are to establish the long-term (1986-2005) modernization programme for track on the Mandalay line and for telecommunication and signalling on the Mandalay, Martaban, Prome and Myitkyina lines, and to select line(s) or section(s) for a feasibility study on the short-term improvement project.

Location of the lines is shown in Fig. 1.1.

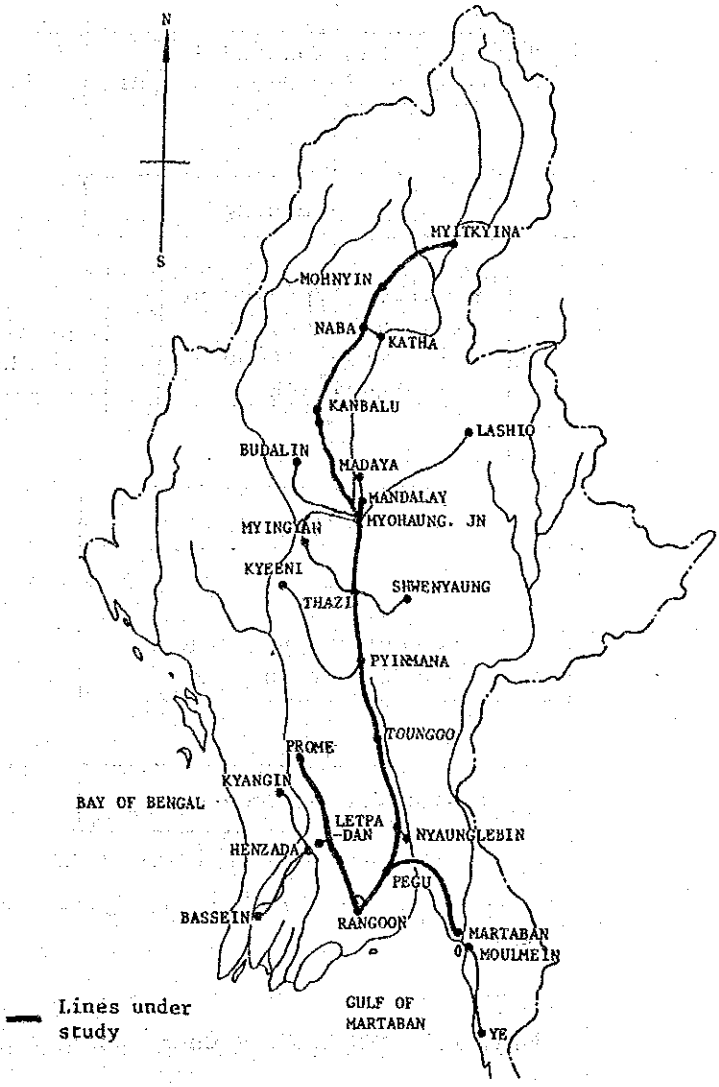

Fig. 1.1 Key Map of Burma Railways

(2) Method

The study was conducted in the following manner. Each work element will be explained in later chapters.

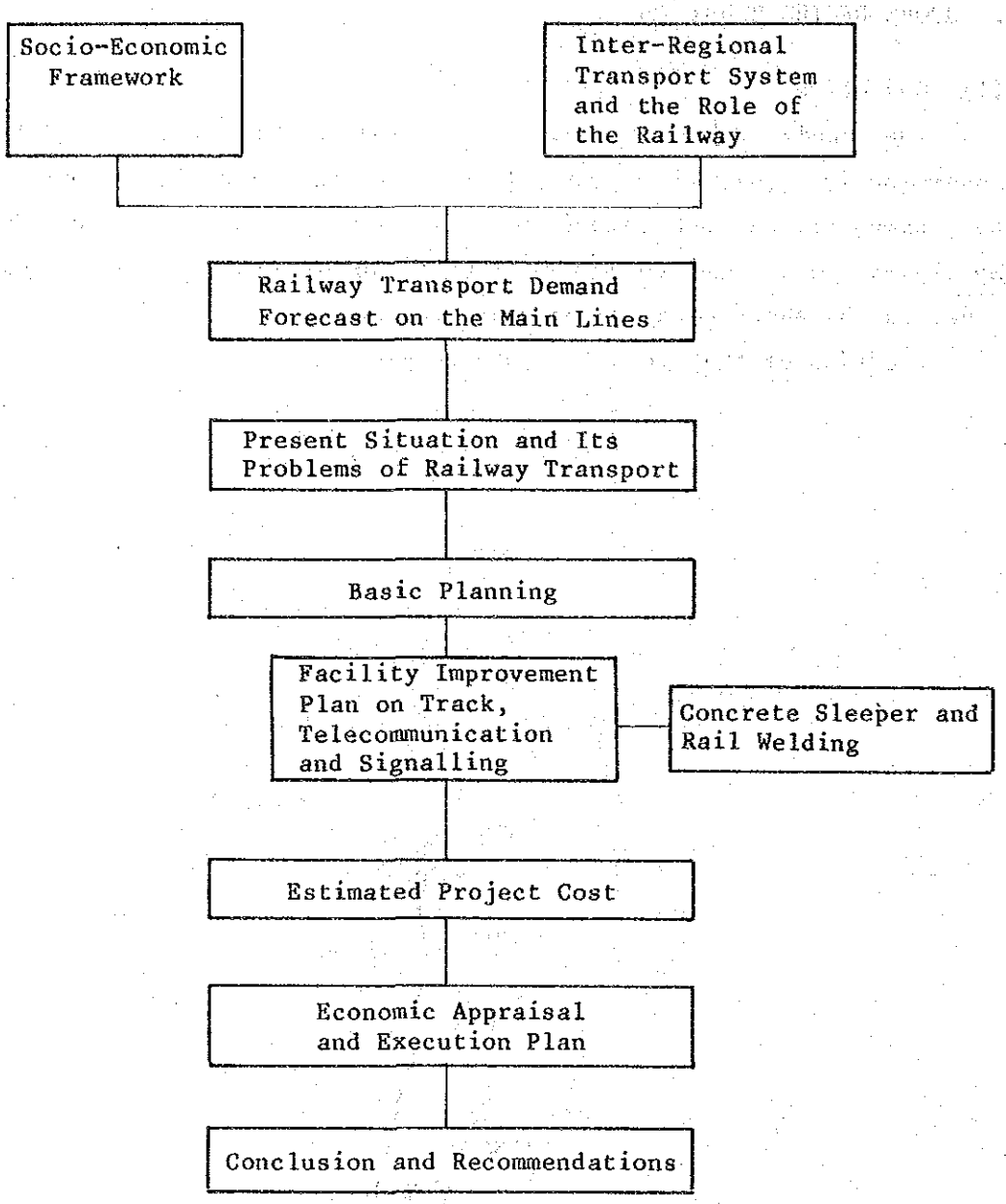

Fig. 1.2 Study Flow Chart

2. SOCIO-ECONOMIC FRAMEWORK

(1) Performance and present situation of the national economy

Burma has been implementing a series of Four-Year Plans within the framework of the long-term 20-Year Plan, aimed at doubling the standard of living of all the people in the Union and changing the economic structure from an agricultural one to an agriculture-based industrial one by 1993/94, which is the final year of the Plan.

The annual growth rates in real terms increased to 6.5 percent for the 3rd Four Year Plan period (1978/79 to 1981/82), as compared with 4.7 percent for the 2nd Four Year Plan period. The annual growth rates in the 4th Four Year Plan period (1982/83 to 1985/86) were 5.5 percent, despite the unfavourable international economic environment.

The strained balance of payments is one of the main characteristics of the national economy, the deficit in net exports being 2.9 percent of GDP in 1985/86. Another one is a relatively low investment ratio of 16.9 percent of GDP at current prices in 1985/86.

Agriculture is the major economic activity. Its percentage is 38.9 percent of GDP as compared with 9.9 percent for processing and manufacturing in 1985/86.

In 1985/86, Burma had a population of 37,115,000, and a GDP and per capita GDP estimated at Kyat 57,733 millions and Kyat 1,555.5 respectively.

(2) Present situation of regional economy

Burma is divided into four regions: lower Burma, middle and upper Burma, the Rangoon division, and the surrounding areas.

In the first and second regions (except the state of Mon), agriculture is the major economic activity accounting for more than 45 percent of gross regional product (GRP). There is some difference in agricultural structure arising from the main crops sown. Paddy field cultivation is not so dominant in middle and upper Burma as it is in lower Burma.

The Rangoon division's economic structure is basically centered around the trade and service sectors, although the primary and secondary industries are also active.

The surrounding areas are relatively underdeveloped in the various economic fields as compared with the first three regions.

As to the GRP differential for 1985/86, the Rangoon division has the highest, 50 percent above; lower Burma (except the state of Mon) is about 10 percent above; middle and upper Burma about average; and the surrounding areas one quarter to one third below the average.

(3) Forecasting on the national economy

GDP is forecasted to grow at 4.4 to 4.7 percent per annum through all the periods forecasted.

This is due to the continuing strain in the balance of payments in all the periods forecasted up to 2005/06, despite increasing exports on a quantum basis. The strain in the balance of payments will restrict import ability, which will influence investment, affecting economic growth. Therefore, the economic growth rates are forecasted to be confined within a limited extent.

(4) Forecasting on the regional economy

Middle and upper Burma will record relatively high economic growth rate in the period up to 1997/98. In the period of 1998/99 to 2005/06, growth rates of lower Burma and the Rangoon division will recover due to diversification in crops sown and other factors. The surrounding regions will have relatively low economic growth rates through all the periods forecasted (refer to Table 2.1).

The economic structure by region will change only in a very limited extent. Also, there will be slight reductions in GRP differentials.

Table 2.1 Forecasting of Economic Growth Rates and per Capita GRP Differential by State/Division

Forecasting of Economic Growth Rates by State/Division at 1985/86 Constant Prices, 1986/87 through 2005/06 (%)				Per Capita GRP Differential by State/Division, 1985/86
	1986/87 - 1993/94	1994/95 - 1997/98	1998/99 - 2005/06	(Whole Country = 100)
Rangoon	4.5	4.4	4.8	156
Pegu	4.2	4.0	4.4	111
Mandalay	5.0	4.7	4.9	101
Irrawaddy	4.4	4.3	4.5	106
Magwe	4.9	4.6	4.8	103
Sagaing	5.0	4.7	4.9	102
Kachine	4.1	4.0	4.3	72
Shan	4.4	4.2	4.5	71
Karen	4.2	3.3	4.1	59
Mon	3.9	3.8	4.6	79
Whole Country	4.5	4.4	4.7	100

Source: Study Team

3. INTER-REGIONAL TRANSPORT SYSTEMS AND THE ROLE OF THE RAILWAY

In Burma four kinds of transportation modes serve as inter-regional transport; the railway, road, water, and air transport operated by the government, co-operative and private organizations. Each means of transport functions in accordance with its characteristics, and the features of the railway are summarized as follows:

1) Although the total internal freight demand has been increasing at the rate of 6.4 percent per annum, the railway share among all modes decreased from 3.5 percent in 1977/78 to 2.5 percent in 1984/85, in spite of the stable demand.
2) The railway mainly plays a role in the long-haul transport (75 miles and above), and the share in this category were 14.6 percent and 11.4 percent in 1974/75 and 1984/85 respectively.

3) The railway is faced with difficult competition from other modes of transport, especially road transport.
4) The railway share within the government transport organizations (BRC, RTC, IWTC and BAC) is about 45 percent for freight (ton-mile) and 63 percent for passenger (passenger-mile) in 1985/86.
5) As for the network configuration, the railway is the only mode of transport with a nationwide network, going from north to south with some exceptions concerning frontier states.
6) Since the railway had about 1.5 to 2.0 times the amount of present freight transport in the 1960's, the existing transport capacity will be able to recover by some adequate means of maintenance and improvement.

4. RAILWAY TRANSPORT DEMAND FORECAST ON THE MAIN LINES

The traffic demands both in passenger and freight on the four main lines were forecasted, based on the estimated existing demands by line, taking into consideration the economic growth of the areas along each line expected in the future.

The target years are 1993/94, 1997/98 and 2005/06 in accordance with the planning stages of the modernization programme. The demand of the 'without project' case, as a basic case, is forecasted on the assumption that the existing railway condition among the other transport modes will remain stable even in the future. The 'with project' case is also estimated after due consideration of the probable traffic diverted from other transport means to the railway by the implementation of the modernization programme.

The summary of the results is tabulated as follows:

The Mandalay line will continue to play a major role in terms of traffic volume in accordance with the high economic growth in the Mandalay and Rangoon divisions, and a certain amount of diverted demand is expected because of the travel time reduction due to the project. For the Myitkyina line, next in importance to the Mandalay line, a large traffic demand is also expected from the forecasted economic growth in the Sagaing division.

As for freight traffic, the effect of the project in speeding it up is very slight except on the Mandalay line. The diverted demand for the other three lines, therefore, seems negligible.

Table 4.1 Forecast Passenger Demand

(1000 pass.)

Year	Mandalay line		Martaban line		Prome line		Myitkyina line	
	without	with	without	with	without	with	without	with
1984/85	6,252		3,026		3,208		5,351	
1993/94	7,709	8,790	3,970	4,085	4,283	4,408	7,352	7,481
1997/98	9,015	10,891	4,572	4,814	4,895	5,178	8,567	8,888
2005/06	12,623	17,099	6,306	6,951	6,599	7,308	11,815	12,639
Average Annual Growth Rate (%) 1984/85-2005/06	3.4	4.9	3.5	4.0	3.5	4.0	3.8	4.2

Source: Study Team

Table 4.2 Forecast Freight Demand

(1000 tons)

Year	Mandalay line		Martaban line	Prome line	Myitkyina line
	without	with	without/with	without/with	without/with
1984/85	926		112	195	301
1993/94	1,244	1,318	152	270	431
1997/98	1,421	1,565	176	314	510
2005/06	1,901	2,259	250	437	725
Average Annual Growth Rate (%) 1984/85-2005/06	3.5	4.3	3.9	3.9	4.1

Source: Study Team

5. PRESENT SITUATION AND ITS PROBLEMS OF RAILWAY TRANSPORT

(1) General profile and its problems

A preliminary study was carried out mainly on the present condition of train operation, and the actual situation of railway facilities on the four lines under study.

The study revealed that BRC has not made full use of such inherent advantages of a railway transport system as high speed, safety, riding comfort, and mass transport capacity due to the troubles of train operation and the ground facilities because of the following problems:

1) Train operation
   - Train speed reduction
   - Train operation delays
   - Train accidents
   - Engine troubles
   - Decline of train control system

2) Ground facilities and their maintenance control
   - Deterioration of facilities on track, telecommunication, and signalling due to aging, and decline of their operability.
   - Shortage of spare parts and materials for repair and maintenance work.

3) Others
   - Poor condition of power supply
   - Free access to railway facilities.

(2) Transport

The number of trains, the maximum speed, the scheduled speed and time of the typical passenger trains of the four lines are shown in Table 5.1.

Table 5.1 Current Number of Trains and Operation of Typical Passenger Train

Section	Number of trains		Express passenger train		
	Passenger	Freight	Maximum speed (km/h)	Scheduled Speed (km/h)	Scheduled Time
Rangoon -Mandalay line	18	10	64	45	13°45'
Rangoon -Martaban line	8	4	48	37	7°35'
Rangoon - Prome line	6	4	48	37	7°00'
Mandalay - Myitkyina line	6	10	48	23	24°00'

Source: BRC

(3) Train operation control

Control offices are equipped with communications facilities to issue and receive information to and from stations, rolling stock sheds, and other control offices. But, frequent telephone troubles occur due to the deterioration of equipment or maintenance problems, disturbing train operation.

(4) Track

The working distance between Rangoon and Mandalay is 620.4 km, in which the length of double tracks is 366.8 km (about 60%). This section is generally flat and less curved.

The weight of a rail is 75 lb (37 kg) and the standard length is 11.887 m (39 ft).

While most of sleepers are wooden ones, approximately 9,000 PC sleepers have been employed on a trial basis.

The deterioration of rails, turnouts, and wooden sleepers is serious.

Furthermore, the quantity of ballast is insufficient for whole sections, therefore, track irregularities are considerable. As a result, the speed of trains is restricted to 48 km/h (30 mph) at some sections.

The track between Rangoon and Mandalay is maintained by 10 maintenance depots. Each depot has some maintenance gangs. Maintenance work is mainly done manually.

(5) Telecommunication

The BRC telecommunication system consists mainly of bare wire block lines, telegram lines and control lines all leased from PTC, and about 150 wireless sets owned by BRC. Almost all of these facilities are not in good condition for efficient train operations.

Portions of the bare wires are sometimes stolen; resistance at connection points increases because of insufficient maintenance; and insulators are broken, decreasing insulation resistance in the wet season. The wireless sets of medium and high frequency types with vacuum tubes, are deteriorated due to a shortage of their spare parts supply. Magneto telephone exchanges installed in large yards are also deteriorated.

(6) Signalling

Signalling facilities are deteriorated. Especially, the mechanical interlocking devices are worn-out. The adjustment of tongue rails via pipes is difficult for the maintenance staff. The worn-out facing points at most stations must use the key bolt locking, resulting in train speed restriction.

Conditions of other signalling facilities are listed below.

1) Most of signals are of semaphore-type without any illumination at night, which also limits train speed there.

2) Token block system is frequently inoperable because of troubles of telecommunication lines in many sections. So, many block sections now are using paper line-clear ticket system, with communication by telephone, telegram or wireless.

3) Many stations have no power supply. The power supply at other stations is unstable with frequent power failures.

4) Few level crossing alarms are installed.

5) Some of troubled facilities are not repaired because of a shortage of spare parts.

6) A long time is necessary for the maintenance staff to arrive at the site of an equipment failure.

(7) PC Sleeper Manufacturing and Rail Welding

1) PC sleepers are produced in the BRC Bridge Girder Depot in Mahlwagon.

This PC sleeper manufacturing system uses the pretension method and the production capacity is 400 sleepers per week.

This Depot is scheduled to increase its production capacity to 800 per week.

2) The thermit welding method is used experimentally, with the length of welded rails being 11,89 m (99') x 3 or 11.89 (39') x 6.

Since mixture of the thermit welding has to be imported, BRC has a plan to introduce Gas Pressure Welding in order to use oxygen.

(8) Related railway projects

The following six projects related to the study are being implemented or planned, five by BRC and one by PTC.

- Track improvement plan
- Rolling stock modernization plan
- Circular line electrification project
- Doubling plan of track from Pyinmana to Mandalay
- Expansion programme of PC sleeper manufacturing
- PTC microwave network project

6. BASIC PLANNING

(1) Policy on establishing the long-term modernization programme

1) Basic policy

The long-term modernization programme will be established by line based on the concept that railway transport moves passengers and goods from place to place by rail, and that track, telecommunication, and signalling are closely interlinked for facility improvement, to improve the present ground facilities, and also to build up a foundation for reliable railway transport on a long-term basis.

2) Prioritizing the lines

The Mandalay line is considered to be the line to be improved in the immediate future for safe and effective train operation, and the other three lines will be improved in the medium to long term, taking into consideration the importance of the line in the BRC railway network, the actual transport volume, and the deterioration of its ground facilities.

A final decision on the priority of lines will be made after an overall evaluation.

3) Staging and targets

a) Staging

The long-term modernization programme will consist of three stages:

1st stage: 1986/87 - 1993/94, 8 years
2nd stage: 1994/95 - 1997/98, 4 years
3rd stage: 1998/99 - 2005/06, 8 years

b) The targets and goals

- Improvement of train speed and scheduled time on the Mandalay line

	Max. speed	Scheduled time
Passenger train	50 mph (80 km/h)	10 hours (1st stage)
	55 mph (88 km/h)	9 hours (2nd stage in plan A)
Freight train	35 mph (56 km/h)	25 hours

- Enhancement of train operation safety
- Improvement of punctuality of train operation

4) Facility improvement plan

The two alternative plans A and B of the facility improvement for the long-term modernization programme are prepared based on following principles: to meet the traffic demand of the next 20 years; and to improve the deteriorated ground facilities of track, telecommunication, and signalling for the modernized railway transport system.

Plan A has the target for the scheduled time of nine hours on the Mandalay line at the second stage; also, train radios, a CTC system, etc., will be installed in accordance with this plan.

While plan B will achieve the target of 10 hours, requiring smaller investment on the Mandalay and the other three lines.

The outline of plans A and B are shown respectively in Tables 6.1 and 6.2.

(2) Transport plan

The following transport plan is established, based on the traffic demand forecast.

1) Type of trains

Passenger train: Express train
Ordinary train
Local train
Freight train: Ordinary train

Table 6.1 Facility Improvement Plan A

Note: _____ is not included in or different from plan B

Line \ Staging / Targets	1st stage 1986/87 - 1993/94 (8 yrs) Scheduled time on the Mandalay line: 10 hours	2nd stage 1994/95 - 1997/98 (4 yrs) Scheduled time: 9 hours	3rd stage 1998/99 - 2005/06 (8 yrs)
Mandalay	- Track improvement . Replacement of rails, sleepers, and turnouts . Increase in ballast . Improvement of drains - Telecommunication improvement . Installation of UHF microwave network, telephone exchanges, and control telephones - Signalling improvement . Installation of colour light signals, interlocking devices (relay or electronic type) at three stations, electric lock devices for point, and level crossing alarm devices . Improvement of block system (token, tokenless or electronic type)	- Track . Replacement of rails, sleepers, and turnouts . Increase in ballast . Improvement of curve sections and drains - Telecommunication . Installation of train radio system - Signalling . Installation of interlocking devices (relay or electronic type) at the remaining stations	- Telecommunication . Installation of wagon data processor system, facsimile equipment, and passenger information equipment - Signalling . Installation of CTC
Martaban		- Telecommunication . Installation of cable and carrier system, telephone exchanges, and control telephones - Signalling . Installation of colour light signals (distant, outer, start), electric lock devices for points, and level crossing alarm devices . Improvement of block system (token)	- Telecommunication . Installation of facsimile equipment - Signalling . Installation of relay interlocking devices at major stations
Prome		- Telecommunication . Same as the Martaban line - Signalling . Same as the Martaban line	- Telecommunication . Same as the Martaban line - Signalling . Same as the Martaban line
Myitkyina			- Telecommunication . Same as the Martaban line at the 2nd and 3rd stages - Signalling . Same as the Martaban line at the 2nd and 3rd stages

Table 6.2 Facility Improvement Plan B

Note: _____ different from plan A

Staging / Targets / Line	1st stage 1986/87 - 1993/94 (8 yrs)	2nd stage 1994/95 - 1997/98 (4 yrs)	3rd stage 1998/99 - 2005/06 (8 yrs)
	Scheduled time on the Mandalay line: 10 hours		
Mandalay	- Track improvement . Replacement of rails, sleepers and turnouts . Increase in ballast . Improvement of drains - Telecommunication improvement . Installation of UHF microwave network, telephone exchanges, and control telephones - Signalling improvement . Installation of colour light signals, interlocking devices (relay or electronic type) at three stations, electric lock devices for points, and level crossing alarm devices . Improvement of block system (token, tokenless or electronic type)	- Track . Replacement of rails, sleepers . Increase in ballast . Improvement of drains	
Martaban		- Telecommunication . Installation of bare-wire and carrier system, telephone exchanges, and control telephones - Signalling . Installation of colour light signals (distant, outer), electric lock devices for point, and level crossing alarm devices . Improvement of block system (token)	
Prome		- Telecommunication . Same as the Martaban line - Signalling . Same as the Martaban line	
Myitkyina			- Telecommunication . Same as the Martaban line at the 2nd stage - Signalling . Same as the Martaban line at the 2nd stage

2) Maximum speed

Mandalay line: See Section 6 (1).
Martaban,
Prome, and
Myitkyina lines: Passenger train 30 mph (48 km/h, same as the present)
Freight train 20 mph (32 km/h, same as the present)

3) Scheduled time and speed

Table 6.3 shows the scheduled time and speed of typical express passenger trains for each line (ordinary passenger train for the Myitkyina line).

Table 6.3 Future Operation of Typical Passenger Trains

Section	After completion of stage	Scheduled time	Reduction in time	Scheduled speed (km/h)
Rangoon-	1st	10°00'	3°45'	62
	2nd	10°00 (9°00')	0'(1°00')	62 (69)
Mandalay	3rd		- ditto -	
Rangoon-	1st	7°05'	30'	39
	2nd	6°35'	30'	42
Martaban	3rd		- ditto -	
Rangoon-	1st	7°00'	0'	37
	2nd	6°20'	40'	41
Prome	3rd		- ditto -	
Mandalay-	1st	24°00'	0'	23
	2nd		- ditto -	
Myitkyina	3rd	23°00'	60'	24

Note: Figures in ( ) indicate those of plan A.

Source: Study Team

4) Train operation plan

The number of scheduled trains is estimated as shown in Table 6.4, based on the present train make-up and the traffic volume forecasted.

Table 6.4 Number of Trains per Day on the Four Railway Lines

Railway Line	Type of train	1993/94	1997/98	2005/06
Mandalay	Passenger	26	32	50
	Freight	17	21	30
Martaban	Passenger	11	13	19
	Freight	8	10	14
Prome	Passenger	8	10	14
	Freight	6	7	9
Myitkyina	Passenger	9	10	15
	Freight	16	19	26

Source: Study Team

(3) Basic design guides and policies

1) Design conditions on facility improvement are as follows:

- Train operation conditions in the future such as maximum train speed, number of trains, passing tonage.
- Climate conditions such as temperature, amount of rainfall.

2) Design policies

In drawing the facility improvement plan of track, telecommunication, and signalling, the following items should be taken into account fully in consideration of the situation in Burma and BRC.

- Establishment of adequate facility standards
- Coordination of standardization concepts and new technology on the improved facilities
- Coordination with related projects
- Required conditions for the ground facilities to be recommended
- Comparative evaluation with alternatives
- Drawing up an effective execution plan

(4) Technology transfer

Technology transfer of the railway modernization should be carried out essentially through study, detailed design, implementation, and commissioning stages.

During the study stage, the following items on long-welded rails and PC sleepers will be provided.

- Guidance or recomendations
- Design of standards
- Essentials of specifications
- Training curriculum

7. FACILITY IMPROVEMENT PLAN

(1) Track

1) The following items will be laid or improved.
   - Long welded rail
   - PC sleeper
   - Ballast
   - Turnout
   - Curve (plan A only)
   - Drain

2) Facility plan

a) Existing rails will be replaced by long-welded rails as much as possible.

b) Wooden sleepers will be replaced by PC sleepers except in sharply curved sections.

c) Ballast will be increased at long-welded rail sections and at other sections with insufficient ballast.

d) Worn-out or loosened turnouts will be replaced by new ones or replaced partially. Replacement of turnouts will be done in approximately 40 percent of turnouts in plan B.

e) Curves with radius of 699m (2 1/2°) or less will be improved where possible, and for curves with insufficient cant, the cant will be improved and transition curves extended (plan A only).

f) Rail bed drains in poor condition will be improved.

(2) Train operation control

The new control system consists of two tiers, i.e., central control office and divisional control offices.

In the new control system, system improvement and modernization are to be achieved by various communication facilities to ensure an efficient operation control system.

(3) Telecommunication

1) The lines required for improved telecommunication facilities are as follows:

- Block line
- Station-to-station line
- Control telephone line
- Exchange, tie, and subscriber line
- Wayside telephone line
- Train radio (plan A only)
- Facsimile transmission line (plan A only)

2) The facility plan is as follows:

a) A UHF micro wave network and underground cables will be installed on the Mandalay line (plans A, B), and on the other three lines a cable and carrier system (plan A) and a bare wire and carrier system by improving the existing PTC lines (plan B) installed.

b) Telephone exchanges will be of an automatic-type on the Manadalay line, and of a magneto-type on the three lines.

c) Control telephone equipment will be of a frequency selection calling type.

d) Train radio system will be installed on the Mandalay line (plan A only).

e) Wayside telephone lines will be provided by installing underground cables on the Mandalay line (plans A, B) and on the three lines (plan A only).

f) Wagon data processor system will be provided at the central control office and each divisional office on the Mandalay line (Plan A only).

g) Facsimile equipment will be set at major stations on the four lines (Plan A only).

h) Passenger information equipment will be provided on the Mandalay line (Plan A only).

i) The power supply will use the EPC source and engine generators to be equipped under the signalling facility plan.

(4) Signalling

1) The following items will be installed or improved.

- Interlocking device
- Block device
- Colour light signal
- Level crossing alarm
- CTC (Plan A only)

2) The facility is as follows:

a) Relay or electronic interlocking devices will be installed at large stations.

b) Electric lock devices will be installed at small stations.

c) For trains passing stations, isolation points will be set on the loop lines to increase the permisible speed through facing points.

d) As a block system, tokenless or electronic token system will be used.

e) Some of the mechanical signals will be replaced by colour light signals.

f) Level-crossing alarm will be installed on main roads on the four lines.

g) Relay or electronic interlocking devices will be installed at small stations on the Mandalay line, and at major stations on the other three lines (Plan A only).

h) A CTC system will be introduced in the future to the Mandalay line (Plan A only).

i) Overhead power lines will be installed from nearby power substations for the stations without power supply.

8. CONCRETE SLEEPER, RAIL WELDING AND BALLAST

(1) PC Sleeper manufacturing

In general, PC sleeper is manufactured by the following two methods;

- Pretension Method
- Post-tension method

Pretension method is recommended for the following reasons.

1) Although the manufacturing cost for this method is about the same as that for the post-tension method, the foreign currency portion of this cost is smaller.

2) The manufacturing system of this method has already been operated by BRC. The training for new staff is easier based on the existing facilities and basic technology.

(2) Rail welding

There are four methods of welding.

- Flash-butt welding
- Gas pressure welding
- Thermit welding
- Enclosed arc welding

BRC has used the Thermit welding method in a small section. In this report, the Gas-pressure welding methods is recommended because of high quality, easiness of performance and acquisition of materials.

(3) Technology transfer

The items of technology transfer are as follows:

1) Manufacturing of PC sleeper (pretension method)

- Design of new type sleeper
- Planning of PC sleeper factory

- Manufacturing program of PC sleeper
- Preparation of regulations and standards on design and manufacturing of PC sleeper

2) Rail welding (gas pressure welding method)
- Plan of welding facilities
- Technique for welding
- Preparation of regulations and standards on welding
- Rail replacement programme
- Other related items

(4) Railway ballast

The quantity of ballast required to strengthen the track between Rangoon and Mandalay was estimated approximate 630,000 m^3 (22,200,000 ft^3).

Based on the plan, to meet the estimated volume of ballast, two locations of quarry site with production capacity of 300 m^3 (≒10,000 ft^3) per day should be developed along the Martaban line and near Mandalay.

9. ESTIMATED PROJECT COST

As for the project cost, the following shows the estimated costs in 1986 prices for both foreign and local currency components:

Table 9.1 Project Cost for Plan A

Unit: million Kyats

Line	Foreign currency portion	Local currency portion	Total
Mandalay	851.46	489.16	1,340.62
Martaban	109.37	48.07	157.44
Prome	112.99	51.43	164.42
Myitkyina	239.88	108.39	348.27
Total	1,313.70	697.05	2,010.75

Note: including taxes

Source: Study Team

Table 9.2 Project Cost for Plan B

Line	Foreign currency portion	Local currency portion	Total
Mandalay	661.47	404.08	1,065.55
Martaban	48.53	14.60	63.13
Prome	49.38	27.61	76.99
Myitkyina	93.08	50.81	143.89
Total	852.46	497.10	1,349.56

Source: Study Team

10. ECONOMIC APPRAISAL AND EXECUTION PLAN

The economic appraisal is based on the results of the demand forecast and investment plans A and B. The object is not to evaluate the feasibility of each investment plan, but to prioritise each of these plans and four lines from a national economic point of view. The appraisal was conducted to compare the with project and without project.

(1) Major Premises

1) Benefits

The benefits, as a result of the project, are as follows.

- Decremental Investment in Rolling Stock
- Decremental Investment in Other Means of Transport
- Timesaving
- Maintenance Cost Reduction
- Operating Cost Reduction
- Decrease in Traffic Accident

The composition structure of benefits by lines and plans are shown in Table 10.1. As an example the case of Mandalay Line Plan B is shown in Fig. 10.1.

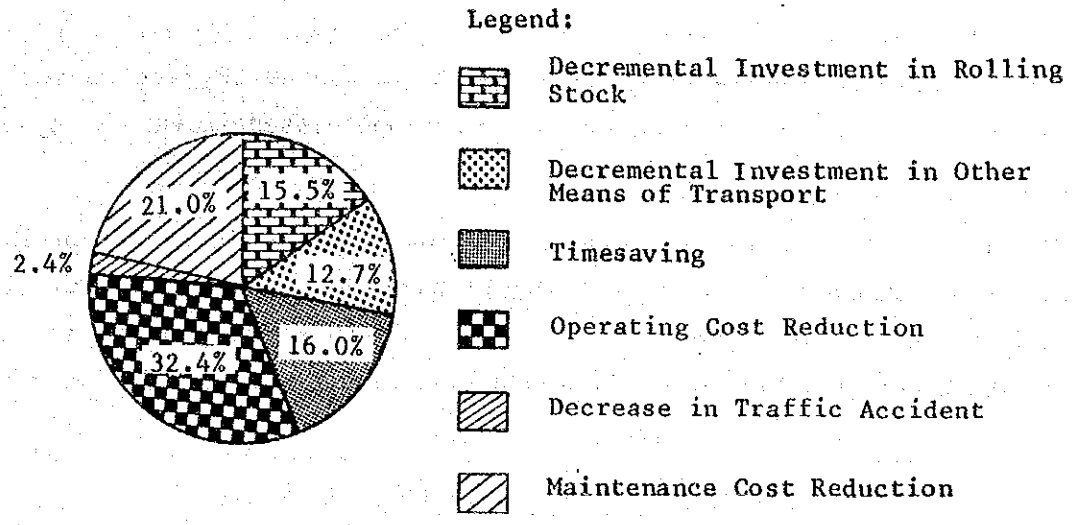

Fig. 10.1 Mandalay Line (Plan B)

Table 10.1 Benefit Composition

(Ks in Thousand)

	Plan A				Plan B			
	Mandalay	Martaban	Prome	Myitkyina	Mandalay	Martaban	Prome	Myitkyina
1. Dec. investment in rolling stock	50881	-155	-1573	-5889	49783	4934	5878	13457
2. Dec.investment in other means	40854	1345	878	6051	40854	1345	878	6051
3. Time saving	57813	3674	3241	7972	51331	3592	3134	7647
4. Maintenance cost reduction	62691	-4163	-4779	-11900	67486	342	2643	-1546
5. Operating cost reduction	103944	5562	3592	6482	103944	5562	3592	6482
6. Decrease in traffic accidents	8699	2076	2260	10126	7576	1839	2006	9007
7. Total	324882	8339	3619	12842	320974	17614	18131	41098

Note: All these benefits were discounted at a 10 percent annual rate.

Source: Study Team

2) Price

Prices of cost and benefit in this study are at the beginning of 1986. The official exchange rate is adopted while unskilled labour costs and oil price are adjusted. Transfer items such as tax and customs duties are excluded.

3) Investment

To compare the facility improvement plan of each line on an equal base, major investment are planned to be implemented in the first stage.

(2) Project Priorities

The results of the analysis are shown in Table 10.2. According to the table, Mandalay Line Plan B should have the highest priority with a total amount of investment larger than the other three lines together. Then Mandalay Line Plan A and Martaban Line Plan B are next in importance.

Table 10.2 Results of Economic Analysis

Lines	Plan A			Plan B		
	EIRR	NPV (10%)	Total amount of investment (Economic Cost)	EIRR	NPV (10%)	Total amount of investment (Economic Cost)
	%	10^6 Ks	10^6 Ks	%	10^6 Ks	10^6 Ks
Mandalay line	7.2	-83	998 (900)	8.5	-44	795 (916)
Martaban line	(minus)	-42	119 (92)	6.4	-44	53 (71)
Prome line	(minus)	-51	122 (371)	4.1	-9	58 (349)
Myitkyina line	(minus)	-108	260 (803)	6.0	-10	110 (757)

Note: 1. Investments are implemented mainly in the 1st stage.
2. Total amount of investment doesn't include that for rolling stock, which are exibited in parentheses.

Source: Study Team

(3) Execution plan

An execution plan for the long-term modernization programme is established based on facility improvement plan B.

In establishing the execution paln, the facility improvement plans A and B were compared, from such viewpoints of various factors as total investment requirements, benefits and power supply situation to decide which plan is best.

A feasibility study on the Mandalay line in the long-term modernization programme will be conducted as the first step of a short-term improvement project. The execution plan is shown in Table 10.3.

Table 10.3 Execution Plan

Unit: million Kyats

Item	Stage	1st stage	2nd stage	3rd stage	Grand Total (Project Cost)		
	Year	86 93 / 87 94	94 97 / 95 98	98 05 / 99 06	Total	F/C	L/C
Mandalay line							
Track					1066	662	404
Telecommunication							
Signalling							
Martaban line							
Telecommunication					63	48	15
Signalling							
Prome line							
Telecommunication					77	49	28
Signalling							
Myitkyina line							
Telecommunication					144	93	51
Signalling							
Grand Total					1350	852	498

Note: F/C: Foreign Currency Component
L/C: Local Currency Component including Tax

Source: Study Team

11. CONCLUSION AND RECOMMENDATIONS

(1) Conclusion

The study on establishing the long-term modernization programme for track on the Mandalay line, and for telecommunication and signalling on the Mandalay, Martaban, Prome, and Myitkyina lines, has been carried out for achieving the following objectives: to prepare the execution plan of facility improvement to upgrade and modernize the deteriorated ground facilities; and to select line(s) or section(s) for a feasibility study from the viewpoints of an overall evaluation.

The following are the conclusions on the study.

1) BRC can be said not to be making full use of the advantages as a railway transport system, which has been caused mainly by the deterioration of the ground facilities due to aging.

Therefore, the facility improvement of the four lines should be done with an eye on the future role of railway transport because the present ground facilities will become worse and BRC might lose its competitive strength if the facilities are left as they are.

2) The Mandalay line ranks first as the line requiring facility improvement, since it has the heaviest transport volume, the highest growth in future traffic demand, badly deteriorated ground facilities, and the highest IRR value.

The facility improvement of the other three lines should be made, relying basically on the execution plan.

Based on the concept above, the Mandalay line should have top priority in being selected for a feasibility study, which will be conducted to further develop the short-term improvement project for carrying out a preliminary design and establishing a detailed execution plan together with an overall evalution.

(2) Recommendations

The following supporting measures are recommended to be taken to assure the smooth progress of the execution plan established and an effective train operation after commissioning.

1) Safety

- Further cultivation of discipline of employees concerned is desired to eliminate such human errors that might still cause train accidents.
- The countermeasures necessary for preventing free access of people to station yards and tracks are to be fully taken to ensure safety along with increase in train speed.

2) Maintenance control

The following items are recommended for maintaining the proper functions of the improved facilities.

- To establish a new maintenance system for the improved facilities
- To prepare standards, tolerances, and manuals
- To arrange a sort of Rail Gang Car for quick travel to the troubled areas
- To supply consistently necessary spare parts

3) Technology transfer

Modern engineering technology on tracks, telecommunications, and signalling is desired in general to be transferred through study, design and implementation stages.

4) Training

A new system is required to train maintenance staff about the new technology on the improved facilities.

5) Repair work on bridges

Repair work for some deteriorated bridges on the Mandalay line is required for increasing train speed.

6) Rolling stock

Further improvement in rolling stock availability is advised along with its modernization.

SHORT-TERM IMPROVEMENT PROJECT

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SHORT-TERM IMPROVEMENT PROJECT

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1. SCOPE OF THE STUDY

(1) Objective

The study objective is to establish a short-term improvement project for track, telecommunication and signalling on the Mandalay line, whose selection is based on the priority given in the long-term modernization programme.

(2) Method

This Report covers the following areas of the study as shown in the study flowchart. Each work element is explained in later chapters.

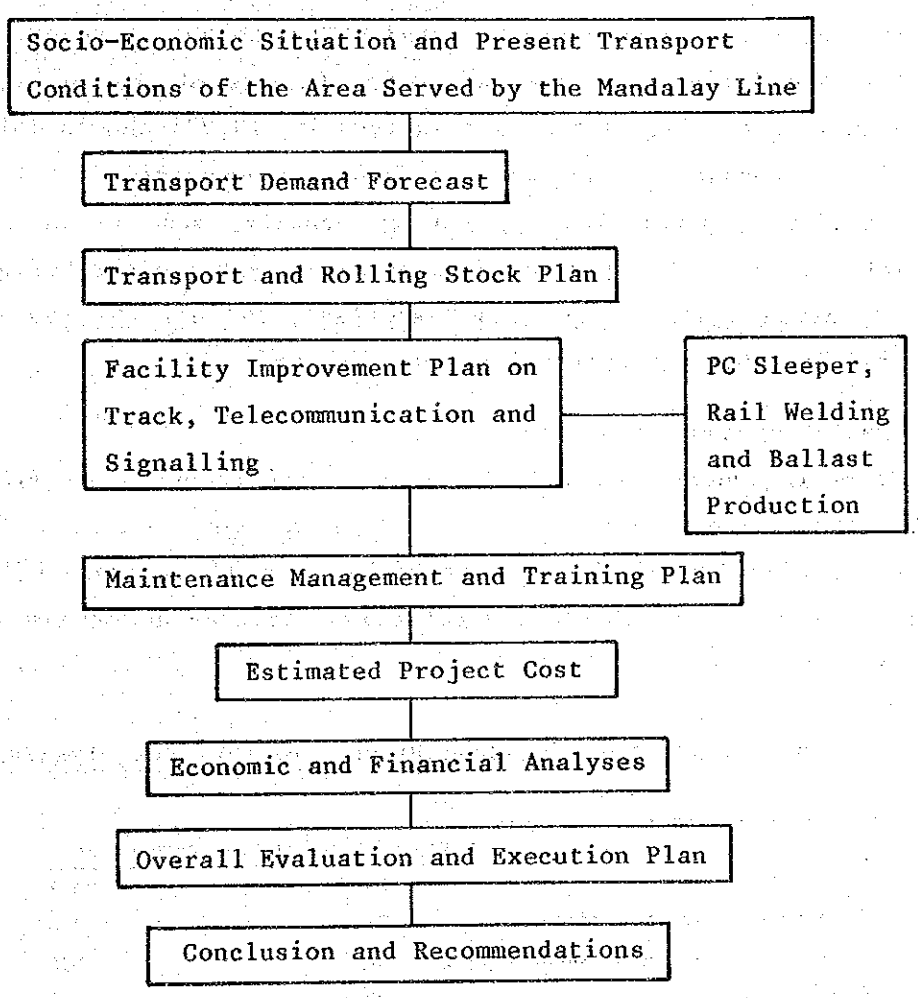


Fig. 1.1 Study Flowchart

2. SOCIO-ECONOMIC SITUATION AND PRESENT TRANSPORT CONDITIONS OF THE AREA SERVED BY THE MANDALAY LINE

(1) Socio-economic situation

The affected area is classified into two, namely, the directly affected area and indirectly affected area. The former consists of those areas being directly served by the Mandalay line: Rangoon, Pegu (East) and Mandalay (Main), while, the latter includes the areas indirectly served by branch lines which connect to the Mandalay line.

1) Population and land use

The directly affected area has a population of 10,278 thousand in 1985/86 according to an estimate based on two recent censuses.

The population of the area is forecasted by using various demographic data: 12,171 thousand in 1993/94, 13,233 thousand in 1997/98 and 15,606 thousand in 2005/06 at an annual growth rate of 2.1 percent.

Considering population, population density, and net area sown per population, the directly affected area may be aptly described as that it has two urban areas (Rangoon and Mandalay), and all the remaining ones are predominantly agricultural areas.

2) Present economic conditions

Gross regional product (GRP) of the area accounts to 34.8 percent of GDP in 1985/86.

Per capita GRP of the area is higher than the average of the whole country, and this is attributed to active services and trade activities in the area.

Table 2.1 Gross Regional Product of the Area, 1985/86

	Percentage to whole	Percentage by sector
Agriculture	25.7	28.7
Livestock, fishery & forestry	29.4	7.6
Mining, processing & manufacturing	34.7	11.0
Other goods	35.8	2.3
Transportation	38.7	3.8
Other services	41.3	13.3
Trade	47.7	33.3
Gross regional product	34.8	100.0

Per capita GRP (average of whole country = 100) : 126

3) Forecasting regional economy

GRP of the area is forecasted up to the year 2005/06 at the annual growth rates of 4.0 to 5.0 percent.

Table 2.2 Forecasted Gross Regional Product

	Rangoon	Pegu (East)	Mandalay (Main)
Annual growth rate (%)			
1986/87 - 1993/94	4.5	4.2	5.0
1994/95 - 1997/98	4.4	4.0	4.7
1998/99 - 2005/06	4.8	4.4	4.9
GRP at 1985/86 price (Kyat in million)			
1993/94	14,439	5,094	9,171
1996/97	17,173	5,966	11,012
2005/06	25,051	8,410	16,122

(2) Present railway transport

On the Mandalay line there are 18 passenger trains per day, which consist of 6 express, 4 mail/ordinary and 8 mixed/local trains. While, 10 scheduled freight trains and some special trains are daily operated for goods transport.

6,252 thousand passengers were carried by the Mandalay line in 1984/85, and this meant 22 percent to the whole main line. The major stations in terms of passenger volume are Rangoon, Mandalay, Pegu, Pyinmana and Thazi, with over one thousand boarding passengers per day.

The present passenger flow is estimated by using the data from BRC statistics and the interview survey carried out by Study Team in August, 1986.

The results are shown in the O-D table and the traffic volume by section.

Table 2.3 Present Passenger O-D, 1985/86

(in 1,000 passengers)

O \ D	1 MDY	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 RN	Total
1. MDY	244	122	110	48	18	53	530	1,126
2. TZI	141	340	134	39	14	44	247	959
3. PMA	87	86	585	72	17	30	137	1,014
4. TGO	40	36	80	77	37	34	106	410
5. NLB	18	24	33	55	160	56	82	428
6. PEGU	39	43	31	39	42	202	1,375	1,770
7. RN	579	265	178	110	79	1,315	258	2,785
Total	1,149	918	1,151	439	367	1,734	2,736	8,494

Note: 1. MDY : Mandalay to Myittha, and branch lines
2. TZI : Kume road to Nyaungyan, and branch lines
3. PMA : Shanywa to Myohla, and branch line
4. TGO : Thagaya to Pyu
5. NLB : Nyaugbintha to Kadok, and branch line
6. PEGU: Pyinbongyi to Kyauktan, and branch line
7. RN : Tongyi to Rangoon, and branch lines

Source: Study Team

Table 2.4 Passenger Traffic by Section, 1985/86

Section	Zone - Zone 1/ (Direction)	Distance (kms)	Passenger (1,000)
1) MDY-TZI	1 - 2	128	882
	2 - 1	128	905
	Both	128	1,787
2) TZI-PMA	2 - 3	130	1,238
	3 - 2	130	1,219
	Both	130	2,457
3) PMA-TGO	3 - 4	95	1,250
	4 - 3	95	1,368
	Both	95	2,618
4) TGO-NLB	4 - 5	118	1,269
	5 - 4	118	1,416
	Both	118	2,685
5) NLB-PEGU	5 - 6	75	1,321
	6 - 5	75	1,407
	Both	75	2,728
6) PEGU-RN	6 - 7	75	2,478
	7 - 8	75	2,528
	Both	75	5,006

1/ : Refer to Table 2.3 on the Zone Numbers.

Source: Study Team

The Mandalay line had 926 thousand tons of freight transport in 1984/85 and its demand had decreased from 1,001 thousand tons in 1982/83. Rice, sugar cane and forest products are major commodities.

The freight flow is also estimated both in the forms of O-D table and traffic volume by section as follows:

Table 2.5 Present Freight O-D, 1985/86

(in 100 ton)

O \ D	1 MOH	2 TZI	3 PMA	4 TGO	5 NLB	6 PEGU	7 MLG	Total
1. MOH	28	63	16	14	67	46	864	1,097
2. TZI	35	42	-	-	33	83	503	697
3. PMA	160	14	1,252	500	7	136	1,307	3,375
4. TGO	299	108	97	810	12	64	189	1,580
5. NLB	236	260	73	76	-	187	700	1,532
6. PEGU	140	79	76	6	-	-	438	740
7. MLG	595	468	106	104	20	727	11	2,030
Total	1,495	1,033	1,620	1,510	140	1,243	4,012	11,053

Note: 1. MOH : Mandalay to Myittha, and branch lines
2. TZI : Kume road to Nyaungyan, and branch lines
3. PMA : Shanywa to Myohla, and branch line
4. TGO : Thagaya to Pyu
5. NLB : Nyaungbintha to Kadok, and branch line
6. PEGU: Pyinbongyi to Kyauktan, and branch line
7. MLG : Tongyi to Rangoon, and branch lines

Source: Study Team

Table 2.6 Freight Traffic by Section, 1985/86

Section	Zone - Zone 1/ (Direction)	Distance (kms)	Freight (100 ton)
1) MOH-TZI	1 - 2	124	1,069
	2 - 1	124	1,466
	Both	124	2,535
2) TZI-PMA	2 - 3	130	1,626
	3 - 2	130	2,359
	Both	130	3,986
3) PMA-TGO	3 - 4	95	3,560
	4 - 3	95	2,538
	Both	95	6,098
4) TGO-NLB	4 - 5	118	3,312
	5 - 4	118	2,220
	Both	118	5,532
5) NLB-PEGU	5 - 6	75	4,079
	6 - 5	75	1,594
	Both	75	5,673
6) PEGU-MLG	6 - 7	71	4,001
	7 - 6	71	2,020
	Both	71	6,021

1/ : Refer to Table 2.5 on the Zone Numbers.

Source: Study Team

3. TRANSPORT DEMAND FORECAST

The traffic demands both in passenger and freight along the Mandalay line are forecasted, based on the estimated traffic in 1985/86, taking into consideration the economic growth of the area expected in the future.

The target years are 1993/94, 1996/97, 2005/06 and 2016/17 in accordance with the planning stages of the proposed project implementation.

The demand of the 'without project' case, as a basic case, is forecasted on the assumption that the existing railway condition among the other transport modes will remain unchanged even in the future. The 'with project' case is estimated after due consideration of the probable demands diverted from other transport means and induced by the implementation of the project.

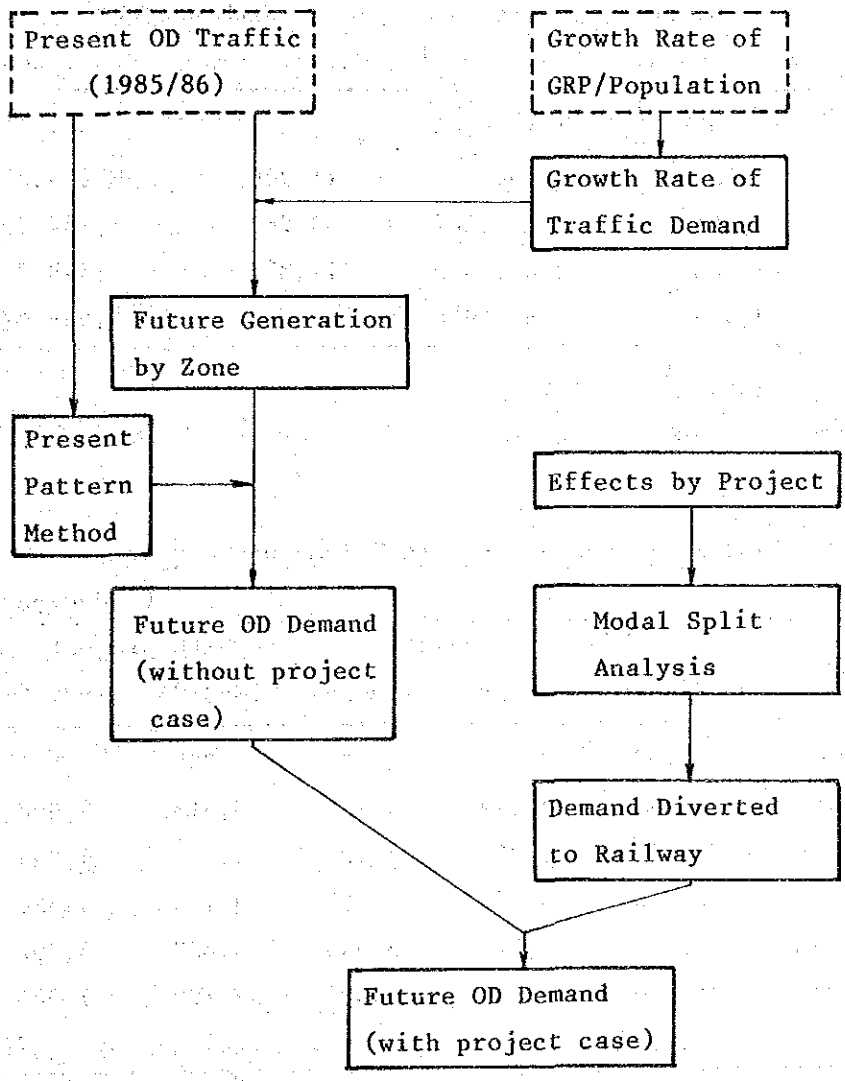


Fig. 3.1 Outline of Demand Forecasting

The summary results of the forecasted demand are shown in the following tables:

In 'without' case, 14,442 thousand passenger (1.7 times against in 1985/86) and 2,026 thousand tons of freight demand (1.8 times) are estimated in 2005/06.

On the other hand, 19,388 thousand passengers (2.3 times) and 2,674 thousand tons (2.4 times) are estimated in the case of 'with project', adding the diverted and induced demands in 2005/06.

Table 3.1 Total Passenger Demand

(1,000)

Year	Without project		With project	
	No. of Pass.	Pass.-kms 1/	No. of Pass.	Pass.-kms 1/
1985/86	8,494	1,693,725	-	-
1993/94	10,523	2,104,052	11,906	2,346,812
1996/97	11,341	2,273,267	13,783	2,733,255
2005/06	14,442	2,891,010	19,388	3,848,215
2016/17	19,313	3,870,928	29,353	5,839,473

1/: Excluding intra-zonal trips

Source: Study Team

Table 3.2 Passenger Traffic Volume by Section

(1,000 pass.)

Section	Without project			With project	
	1985/86	1993/94	1996/97	1993/94	1996/97
1) MDY-TZI	1,787	2,252	2,437	2,395	2,902
2) TZI-PMA	2,457	3,079	3,332	3,313	3,998
3) PMA-TGO	2,618	3,260	3,525	3,579	4,234
4) TGO-NLB	2,685	3,330	3,598	3,754	4,336
5) NLB-PEGU	2,728	3,376	3,648	3,822	4,392
6) PEGU-RN 1/	5,006	6,130	6,603	7,199	7,983
	(2,689)	(3,303)	(3,562)	(3,764)	(4,287)

1/: Figures in parentheses indicate the demand excluding the Martaban line.

Table 3.3 Total Freight Demand

(1,000)

Year	Without project		With project	
	Ton	Ton-kms 1/	Ton	Ton-kms 1/
1985/86	1,105	291,751	-	-
1993/94	1,408	374,412	1,522	405,835
1996/97	1,536	409,583	1,802	482,586
2005/06	2,026	541,850	2,674	761,767
2016/17	2,826	755,573	4,274	1,150,857

1/: Excluding intra-zonal trips

Table 3.4 Freight Traffic Volume by Section

(1,000 ton)

Section	Without project			With project	
	1985/86	1993/94	1996/97	1993/94	1996/97
1) MOH-TZI	254	329	361	346	428
2) TZI-PMA	399	516	565	548	670
3) PMA-TGO	610	785	859	843	1,014
4) TGO-NLB	553	709	776	777	915
5) NLB-PEGU	567	723	790	799	925
6) PEGU-MLG 1/	602	763	832	847	969
	(492)	(623)	(680)	(688)	(795)

1/: Figures in parentheses indicate the demand excluding the Martaban line.

4. TRANSPORT AND ROLLING STOCK PLAN

(1) Transport improvement plan

The short-term improvement project on track, signalling, and telecommunication, will be set up to achieve the transport on the Mandalay line based on the following four targets.

(a) Increase in train speed

Maximum speed: Passenger train: 80 km/h (50 mph)
Freight train : 56 km/h (35 mph)

Maximum permissible speed through turnouts:
Straight side : 72 km/h (45 mph)
Turnout side : 32 km/h (20 mph)

(b) Improvement of punctuality

(c) Enhancemnet of safety

(d) Increase in track capacity

The short-term implementation will require nine years, which will be divided into two phases as shown in Fig. 4.1.

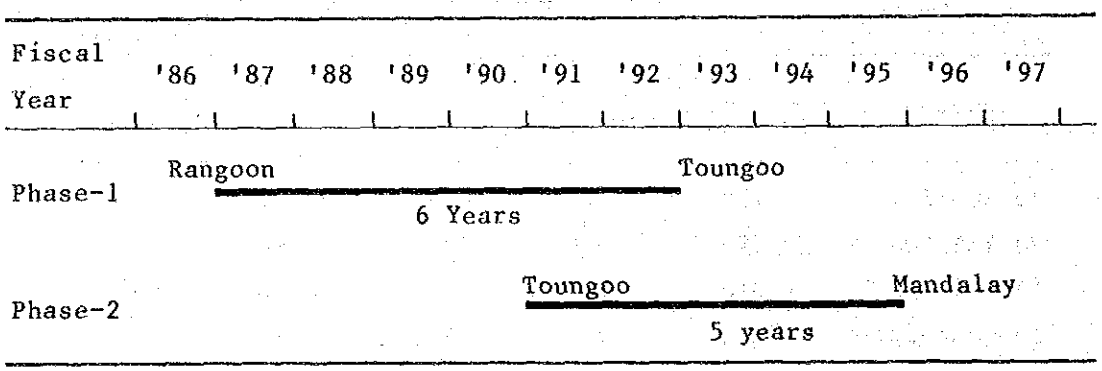


Fig. 4.1 Implementation Schedule

Source: Study Team

Timetable revision schedule will be carried out step by step, so that investment will quickly show the results.

(2) Effects from transport improvement

Completion of the project between Rangoon and Mandalay will give the following results of achievements:

(a) Increase in train speed. Scheduled time reduction by 27 to 33 percent, by increasing running speed. Express passenger trains will connect the two cities in 10 hours, ordinary passenger trains in 14 hours, and freight trains in 25 hours, respectively.

Improvement of utilization of rolling stock. 16 percent increase.

(b) Improvement of punctuality. Average 85 to 90 percent, by minimization of delays.

(c) Enhancement of safety. Average rate of decrease in accident: 60 to 75 percent.

(d) Increase in track capacity. Almost 1.6 times the present capacity by increasing the running speed of trains.

The rehabilitated line between Rangoon and Mandalay, along with the modernization of rolling stock now in progress, will be able to cope satisfactorily with the future transport demands.

(3) Transport plan

The transport plan shown in Table 4.1 will be set up, using the presumptions on future cross-sectional traffic volume, type of trains, train formations, etc. Along with the increased demand, the train-kilometers will be increased to 1.7 and 3.4 times the present, at the years of phase-2 completion and of 2016/17, respectively.

Table 4.1 Transport Plan

Year	Type of trains	Number of trains scheduled (both ways, per day)	(Total)	Train-kms (km/day)	(Total)
1985/86	Passenger trains	18	28	7,337	10,642
(present)	Freight trains	10		3,305	
1993/94	Passenger trains	18	26	10,398	14,538
(ph-1)	Freight trains	8		4,140	
1996/97	Passenger trains	24	34	13,608	18,464
(ph-2)	Freight trains	10		4,856	
2005/06	Passenger trains	30	44	16,601	23,397
	Freight trains	14		6,796	
2016/17	Passenger trains	46	68	25,282	36,218
	Freight trains	22		10,936	

Source: Study Team

(4) Rolling stock plan

Table 4.2 shows the number of rolling stock required. The number is estimated from standard car-kilometers and train-kilometers per day, based on the transport plan.

Table 4.2 Required Number of Rolling Stock

Year	Locomotive	Coach	Wagon *
1993/94 (ph-1)	60	211	3,538
1996/97 (ph-2)	68	254	3,729
2005/06	90	325	5,222
2016/17	137	466	8,408

Note: * means the number equivalent to bogie car.
Source: Study Team

5. FACILITIES IMPROVEMENT PLAN

(1) Train operation control

A new control system will be organized in two tiers: a central control office and divisional control offices for more efficient train control of the entire line.

The central control office will keep train operation both safe and smooth for the entire line, using overall judgement. The divisional control offices will carry out the duties in their respective section of the line, following the instructions from the central control office, in case of emergency. The control work will be divided into five groups of

control of train, passenger, freight, rolling stock, and facility, to achieve fine-tuned works.

Control facilities will be provided as shown in the table below, for controllers to carry out their works.

Control Facilities

Type of Control	Telecommunication Facility	
	Plan A	Plan B
Central control office		
Train control	Control telephone system Train radio system	Control telephone system
Passenger control	Control telephone system Train radio system	Control telephone system
Freight control	Control telephone system Wagon data processor system	Control telephone system
Rolling stock control	Control telephone system	Same as left
Divisional control office		
Train control	Control telephone system Trian radio system	Control telephone system
Passenger control	Control telephone system Train radio system	Control telephone system
Freight control	Control telephone system Wagon data processor system	Control telephone system
Rolling stock control	Control telephone system	Same as left
Facility control	Control telephone system	Same as left

Type of control	Signalling Facilities	
	Plan A	Plan B
Divisional control office		
Train control	Train operation display system	Same as left
Passenger control		
Freight control		
Rolling stock control		
Facility control	Train operation display system	

(2) Track

1) Outline

The following improvement for the track facilities will be made as shown below, to increase train speed, and enhance train operation safety.

- Replacement of rails (by long-welded and jointed rails)
- Replacement of sleepers (by prestressed concrete: hereinafter referred to as PC, wooden, and bridge sleepers)
- Increase in ballast
- Replacement of turnouts (total and partial)
- Improvement of cant and transition curves
- Improvement of drainage

2) Alternative plans for improvement

The following three alternative plans are prepared for the improvement, in consideration of the cost and effect of the investment and improvement work capability.

(a) Alternative Plan A

As many long-welded rails and PC sleepers as possible will be laid. PC sleepers will also be laid in the sections not subject to rail replacement.

(b) Alternative Plan B

Laying of long-welded rails will be about 80 percent of the total length specified in Alternative Plan A, and PC sleeper laying will be limited in the sections where rails are to be replaced.

(c) Alternative Plan C

Laying of long-welded rails will be about 70 percent of the total length specified in Alternative Plan A, and PC sleeper laying will be limited in the sections where long-welded rails are to be laid.

In the Rangoon - Pegu section, long-welded rails and PC sleepers will be laid to the maximum extent. This section will be treated in the same way in the three alternative plans.

The following table outlines the major improvement works in each plan.

Alternative Plans

Major improvement works	Unit	Alternative Plans			Condition	
		A	B	C	Replacement of rails	Type of sleeper
Long-welded rails	km	610	490	410	Yes	PC
Jointed rails	km	145	265	25	Yes	PC
Jointed rails	km	-	-	320	Yes	W
Jointed rails	km	45	45	45	Yes	W
Total	km	(800)	(800)	(800)		
-	km	177	27	27	No	PC
-	km	10	160	160	No	W
G. total	km	(987)	(987)	(987)		
PC sleepers	1,000 pcs.	1,410	1,180	700		
Ballast	1,000 cu.m.	630	590	530		

Source: Study Team

Standards will be set on the type of rail, the spacing of sleepers, the supporting methods of joints in the PC sleeper sections and the ballast cross-section.

(3) Telecommunications

1) Outline

The following improvement for the telecommunication facilities will be made as shown below, to establish stable telecommunication network, and achieve effective train operation.

- Installation of the trunk telecommunication network
- Improvement of the communication lines between the organizations concerned
- Improvement of block and control lines
- Introduction of train radio system
- Introduction of wagon data processor system
- Introduction of facsimile equipment
- Introduction of passenger information equipment

2) Improvement plan

The plan for improvement of the telecommunication facilities will cover the following items, with consideration of geographic condition, social environment, and utilization and maintainability of facilities.

a) UHF microwave relay stations will be placed at 23 locations, the standard distance being 30 km.

b) The present bare wire telecommunication lines will be replaced by underground cables.

Aluminum-sheathed steel tape armored cables will be used in the Rangoon - Pegu section, and beyond Pegu polyethylene-sheathed steel tape armored cables used.

c) Time division telephone exchanges will be installed in Toungoo and Mandalay, and cross-bar exchanges installed in Pegu, Pyuntaza, Pyinmama, Thazi, and Myitnge.

d) Control telephones will be replaced by those of frequency-selective calling type.

e) Train radio system will use a frequency of 400 MHz. A radio base station will be located at each railway station. Communication between engine drivers and controllers/stationmasters will be available, and also drivers' communication with head office staff, available through the key at the control office. (Plan A only)

f) A wagon data processor system will be introduced at the central control office and each divisional control office. The transmission of wagon information will be done by using telephone lines. (Plan A only)

g) Facsimile equipment will be provided at the control office and main stations to exchange freight information.

h) Passenger information equipment will be provided at platforms of main stations.

Standards and performance specifications for major facilities, such as the UHF radio system, the underground cable, the exchange system, the train radio system will be prepared.

3) Alternative plans for improvement

The following two alternative plans, A and B, are formed with the involved investments and utilization taken into account:

Plan A includes the installation of a train radio system, which requires much investment. This plan also includes the provision of wayside telephone boxes at long bridges and main level crossings.

Wagon data processor system, included in Plan A, will not be urgently required, because, judging from a relatively small amount of wagons to be handled, the wagon control of the Mandalay line will be properly handled without a computer system.

Plan B excludes the installation of the train radio system and wagon data processor system, and includes the provision of more wayside telephone boxes for transmitting information between stations, compared with Plan A.

Plan B is recommended to be adopted in the execution plan.

(4) Signalling

1) Outline

The following improvement for the signalling facilities will be made as shown below, to enhance train operation safety, and achieve smooth and stable train operation.

- Installation of the block system with automatic train separation check devices
- Installation of colour light signals at station yards
- Installation of interlocking devices at major stations
- Installation of lock devices at wayside stations
- Installation of alarm devices at railroad level crossings

2) Alternative plans for improvement

The following two alternative plans for the improvement, are prepared with consideration of the investment amount, maintainability, and construction methods. Alternative Plan A adopts cab signal system, while Plan B uses conventional wayside signal system. However, alternative plans A and B include identical improvements on switches and installation of level crossing alarm devices.

(a) Alternative Plan A

- Electronic token block equipment based on cab signal system will be installed at each station. Train separation will be checked by a tail check device. Train operation conditions will be displayed at divisional control offices.
- An electronic interlocking device will be installed at Pegu, Pyuntaza, and Myohung, as well as at Thingangyun which will be the pilot station.
- Cab signal system with Automatic Train Stop function will be adopted.
- Electric lock devices will be installed to improve point lock at each station. Point lever will be provided by BRC.
- Alarm devices will be installed at the 20 main railway level crossings.

(b) Alternative Plan B

a) Common facilities for Draft-1 and Draft-2.

- Relay interlocking devices will be installed at Pegu, Pyuntaza and Myohaung.
- Installation of electric lock devices and level crossing devices will be the same as Plan A.
- Start, outer, and distant signals with colour lights will be installed at each station yard.

b) Draft-1

- Tokenless system will be used for double-track sections, and token system for single-track sections. Train separation on double-track sections will be checked by a check-in/check-out system or tail check devices, and on single-track sections by a stationmaster.

- Train operation conditions will be displayed automatically (using data transmitting devices) or manually on the train operation display unit at divisional control offices.

c) Draft-2

- Electronic token system with wayside signals will be used. Train separation will be checked by a tail check device. Train operation conditions will be displayed on the train operation display unit at divisional control offices.

Draft-2 will be adopted as Plan B in consideration of considerably higher cost of the tokenless system as compared with the electronic token system.

Standards and performance specifications for major facilities, such as the electronic token block equipment, and the electronic and relay interlocking devices, will be prepared.

(5) Power source facilities

The power supply situation is bad between Rangoon and Mandalay, with 30 percent of all stations in this section having no power supply. Therefore, the following two plans are examined, for the power supply for the telecommunication and signalling facilities in each station. The overhead wire supply plan, which is advantageous to cost, will be adopted.

- Plan for the overhead wire to get power from nearby power substations.
- Plan for the use of solar cells.

(6) Preparation for facility improvement

1) Construction standards

Construction standards will be prepared for the laying of long-welded rails, and for the installation of electronic equipment for signalling and telecommunication to do efficient and safe construction work.

2) Construction team

A team for management, planning, designing, on-site supervision, and works, will be secured to promote the construction. The necessary technical training will be done.

3) Construction equipment

Track motor car, trolleys, machinery, and equipment for replacement of rails, and other equipment necessary for the facility improvement work, will be procured.

6. SLEEPERS, RAIL WELDING AND BALLAST PRODUCTION

PC sleeper manufacturing, rail welding, and ballast production and distribution are studied based on the three track alternatives.

(1) PC sleeper

The PC sleepers will be manufactured by the following methods:

- Pretension method
- Post-tension method

In comparison of costs of the two methods, although the direct manufacturing cost by the pretension method is less than that by post-tension, in total, considering such indirect costs as those of factory and facilities, the post-tension method will cost less than the pretension method.

Neverthless, the pretension method will be recommended for the following reasons:

- The prestressing materials for the PC sleepers will have to be imported into Burma. This cost will be less for the PC wires of the pretension method.
- PC sleepers are presently being manufactured in Burma by BRC by the pretension method and plant workers have acquired the know-how.

(2) Rail welding

Gas-pressure welding method is adopted for the welding of rails. Welding of the rails will be performed in the workshop and on-site.

1) Workshop welding

The standard of 39 feet rail will be welded at the workshop into semi-long length for easy transport to the site.

2) On-site welding

The semi-long-welded rails transported from the workshop to the site will be welded into the prescribed length of long rail.

(3) Ballast production and distribution

Since the ballast supplied from the quarries to BRC has been manufactured by manual labor, the supply volume is limited. Furthermore, it is impossible to transport required volume by the present transport system of BRC.

It will be necessary to mechanise production operations for rock crushing at the quarries to produce the large quantity of ballast required for this project. In addition, it will be necessary to use dedicated ballast trains.

7. MAINTENANCE MANAGEMENT AND TRAINING PLAN

(1) Maintenance management

The followings will be necessary to achieve heigher maintenance efficiency.

- Improvement of maintenance methods and procedures
- Preparation of maintenance standards
- Provision of maintenance vehicles
- Supply of spare parts and components

(2) Training plan

The well-organized technical training of maintenance and operation personnel will be provided, keeping pace with the introduction of new system and technology.

8. ESTIMATED PROJECT COST

The estimated project cost is based on the quantities obtained in the course of planning of the facility improvement and on the unit costs for each improvement work item.

The alternative plans on track and signalling as described in Chapter 5 are summarized as follows:

	Track plan	Signalling plan
Alternative-1	A	A
2	A	B
3	B	A
4	B	B
5	C	A
6	C	B

The summary of the results of calculation for alternatives is shown in Table 8.1.

Table 8.1 Summary of Project Cost in 1986 Prices

(Million Kyats)

Item	Currency \ Alternative	1	2	3	4	5	6
Track	F/C	385.874	385.874	356.045	356.045	281.425	281.425
	L/C	308.780	308.780	268.425	268.425	205.856	205.856
	Sub-total	694.654	694.654	624.470	624.470	487.281	487.281
Telecom-munication	F/C	226.366	226.366	226.366	226.366	226.366	226.366
	L/C	111.032	111.032	111.032	111.032	111.032	111.032
	Sub-total	337.398	337.398	337.398	337.398	337.398	337.398
Signalling	F/C	172.905	197.432	172.905	197.432	172.905	197.432
	L/C	77.069	87.990	77.069	87.990	77.069	87.990
	Sub-total	249.974	285.422	249.974	285.422	249.974	285.422
Total	F/C	785.145	809.672	755.316	779.843	680.696	705.223
	L/C	496.881	507.802	456.526	467.447	393.957	404.878
	Sub-total	1,282.026	1,317.474	1,211.842	1,247.290	1,074.653	1,110.101
Engineering service	F/C	44.480	44.480	44.480	44.480	44.480	44.480
	L/C	0.650	0.650	0.650	0.650	0.650	0.650
	Sub-total	45.130	45.130	45.130	45.130	45.130	45.130
Contingency (10% of the total)	F/C	78.514	80.967	75.532	77.984	68.070	70.522
	L/C	49.688	50.780	45.653	46.745	39.396	40.488
	Sub-total	128.202	131.747	121.185	124.729	107.466	111.010
Grand total	F/C	908.139	935.119	875.328	902.307	793.246	820.225
	L/C-total	547.219	559.232	502.829	514.842	434.003	446.016
	Sub-total	1,455.358	1,494.351	1,378.157	1,417.149	1,227.249	1,266.241

Note: F/C: Foreign Currency Component
L/C: Local Currency Component

9. ECONOMIC AND FINANCIAL ANALYSES

(1) General considerations

The economic and financial analyses were based on the results of the transport demand forecast and the facility improvement investment plan.

The criteria of the economic analysis were the Economic Internal Rate of Return (EIRR) and Net Present Value (NPV). For the financial analysis, the Financial Internal Rate of Return (FIRR) and NPV were adopted to determine profitability, with the Debt Service Cover Ratio (DSCR) used as a criterion of stability.

The general procedures of these analyses are shown in Fig. 9.1.

(2) Economic analysis

1) Major premises

The terms 'with project' and 'without project' are the same as those of the study on the long-term modernization programme (hereinafter referred to as the LTMP). As mentioned in the LTMP, for without project, the investment in rolling stock that would be necessary to meet transport demand was considered, which did not involve any kind of investment for the ground facilities.

The prices used in this report were set at the current prices as of the beginning of the feasibility study (August 1986). Therefore, the exchange rate is 7.1 Kyats per U.S. dollar (21.6 Yen per Kyats).

2) Results

The benefits studied in this report are as follows:

- Decremental investment in rolling stock
- Timesaving
- Maintenance cost reduction
- Operating cost reduction
- Decremental investment in other means of transport
- Decrease in traffic accidents
- Contribution to industrial development
- Improvement of passenger comfort

The compositions of the benefits were calculated as in Table 9.1. For example, the following figure illustrates such a composition for alternative-1.

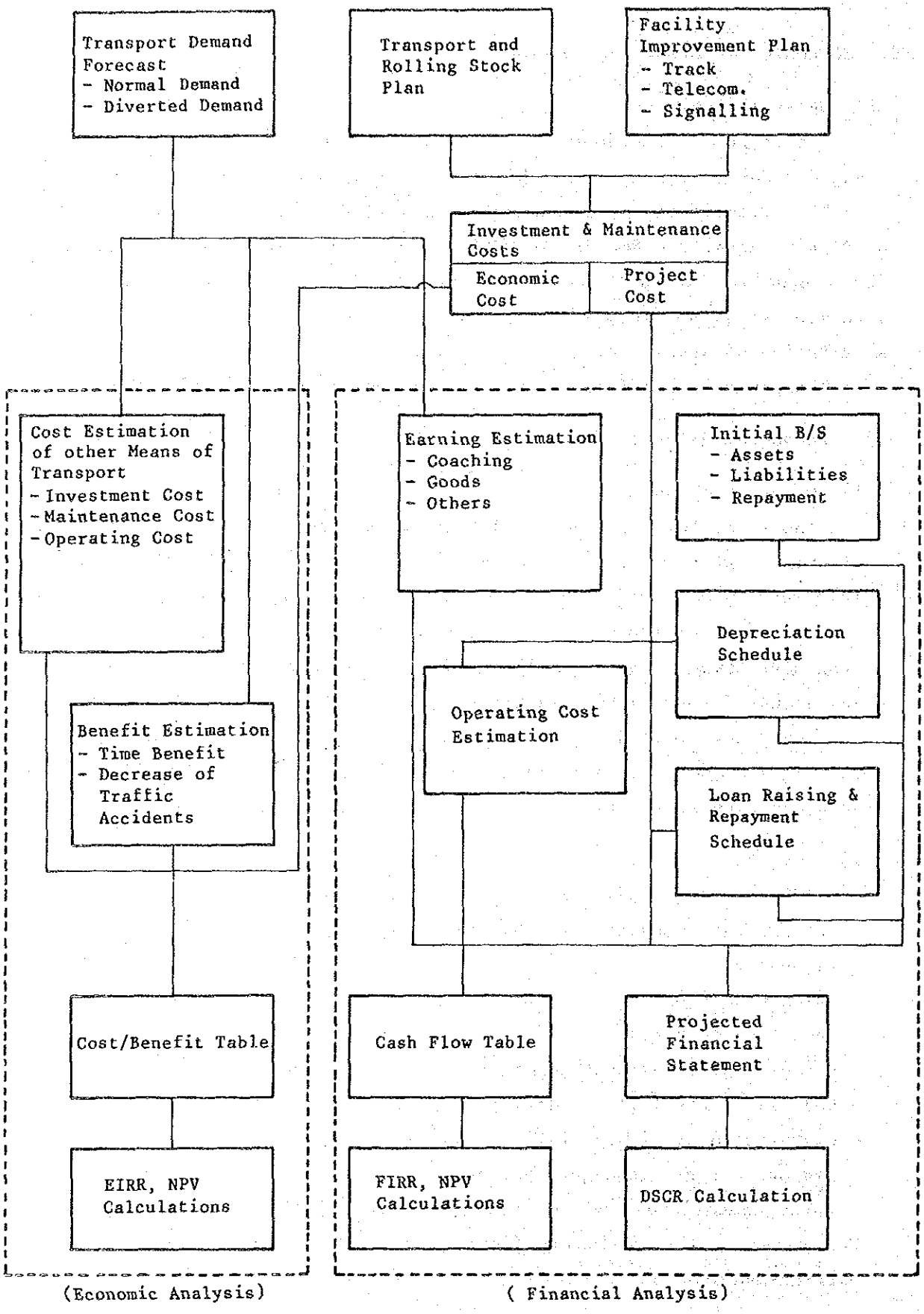


Fig. 9.1 Outline of Economic and Financial Analyses

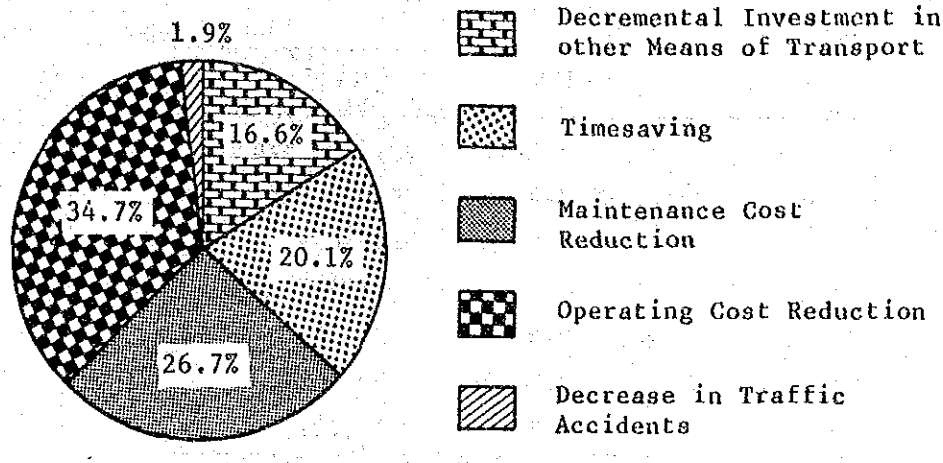


Fig. 9.2 Benefits (Alternative-1)

Source: Study Team

Table 9.1 Benefit Composition

(Million Kyats, %)

Particulars	Alternative 1	2	3	4	5	6
1. Decremental investment 1/ in rolling stock	-	-	-	-	-	-
2. Timesaving	104(20)	104(20)	104(21)	104(21)	104(22)	104(22)
3. Maintenanc cost reduction 2/	138(27)	137(27)	133(26)	132(27)	119(25)	118(25)
4. Operating cost reduction 2/	179(34)	179(35)	170(34)	170(34)	162(33)	162(34)
5. Decremental investment in other means of transport	86(17)	86(17)	86(17)	86(17)	86(18)	86(18)
6. Decrease in traffic accidents	10(2)	6(1)	10(2)	6(1)	10(2)	6(1)
Total	517(100)	512(100)	503(100)	498(100)	481(100)	476(100)

Note: 1/ The benefits that will be a result of the efficiency of the rolling stock are hidden due to the difference in the total amount of transport demand between the with and without projects.
2/ Benefits not only for railway but also for other means of transport are included.

Source: Study Team

The results of the EIRR and NPV for the six alternatives are shown in Table 9.2.

It is said that the EIRR guideline for developing countries ranges from 8 to 12 percent, meaning that all of these six alternatives are feasible.

Table 9.2 EIRR & NPV

	EIRR	NPV 1/
	(%)	(Thousand Ks)
Alternative-1	9.5	-28,348
2	9.2	-45,659
3	9.7	-16,240
4	9.3	-33,551
5	10.7	29,103
6	10.3	11,791

Note: 1/ discounted at a 10 percent annual rate

Source: Study Team

(3) Financial analysis

1) Profitability

(a) Major Premises

a) Earnings

Passenger fares by O-D pairs were computed as in the following tables.

(Ks/person)

RN	PEGU	NLB	TGO	PMA	TZI	MDY	
-	8.13	12.70	23.05	28.92	37.05	45.22	RN
	-	8.13	17.18	23.48	32.52	40.22	PEGU
		-	11.74	18.52	26.65	36.13	NLB
			-	9.48	18.52	28.00	TGO
				-	12.65	20.78	PMA
					-	12.65	TZI
						-	MDY

Fig. 9.3 Passenger Fare (Express)

Source: Study Team

(Ks/person)

RN	PEGU	NLB	TGO	PMA	TZI	MDY	
1.32	3.52	7.03	12.59	17.06	23.12	28.21	RN
	1.41	3.51	9.06	13.53	19.67	25.24	PEGU
		2.40	5.55	10.03	16.16	22.19	NLB
			2.55	4.47	10.61	16.63	TGO
				3.72	6.14	12.16	PMA
					1.79	6.02	TZI
						1.46	MDY

Fig. 9.4 Passenger Fare (Local)

Source: Study Team

Other passenger earnings such as parcel and luggage charges account for 22 percent as compared with pure passenger earnings.

Earnings from transporting goods were calculated based on the weighted mean of freight fares by O-D pairs, which is shown in the table below.

(Ks/Ton)

RN	PEGU	NLB	TGO	PMA	TZI	MDY	
3.9	17.4	19.1	28.1	16.3	42.1	41.5	RN
	6.6	4.9	15.1	31.4	31.9	36.6	PEGU
		10.3	13.2	26.7	30.8	29.4	NLB
			3.9	9.8	29.5	32.9	TGO
				5.5	17.6	31.1	PMA
					7.7	19.8	TZI
						9.8	MDY

Fig. 9.5 Tariff on Goods

Source: Study Team

In calculating these figures, the composition of commodity types and distance between each major station block were considered.

b) Expenses

- Administration cost

The Mandalay Line's administration cost of 13.8 million kyats was allocated in proportion to the track length.

- Fuel cost

The fuel cost estimation was based on the official fuel price (2.5 Kyats per gallon).

- Turnover tax

The turnover tax is eight percent of the pure passenger earnings.

(b) Results

The results of the FIRR and NPV are listed in Table 9.3. As compared to the average interest rate for investment (3.6 percent) and the interest charges against the total assets of the BRC (3.5 percent in 1984/85), alternative-5 barely meets feasibility requirements, and is followed by alternative-6.

Table 9.3 FIRR & NPV

	FIRR	NPV 1/
	(%)	(Million Kyats)
Alternative - 1	2.9	- 94
- 2	2.8	-120
- 3	3.1	- 68
- 4	2.9	- 94
- 5	3.4	- 16
- 6	3.2	- 42

Note: 1/ discounted at a 3.5 percent annual rate

Source: Study Team

2) Stability

(a) Major premises

In an aim to examine financial stability after the investment, the existing financial position was noted in the financial statement of the Mandalay Line, resulting in the existing fixed assets, current assets, deferred liabilities, current liabilities and government

equity being allocated in proportion to the track length, number of rolling stock and other indices.

The funding for the investments were decided to be wholly based on term loans. The foreign and local currency portions were raised by foreign loans and M.E.B. term loans respectively. The terms of each loan are shown in Table 9.4.

Table 9.4 Terms of Loans

Particulars	Grace Period	Repayment Period	Installment	Interest Rate
Foreign Loan	5 years	20 years	equal annual	2.75%
M.E.B				
Term Loan	5	5	- ditto -	5.0
Working Capital Loan	-	-	-	8.0

Source: M.E.B., Study Team

(b) Results

Fig. 9.6 shows the projected profit and loss from 1987/88 to 2016/17. According to the figure, profits will increase year by year from 1996/97, while the period up to 1995/96 will have low profitability.

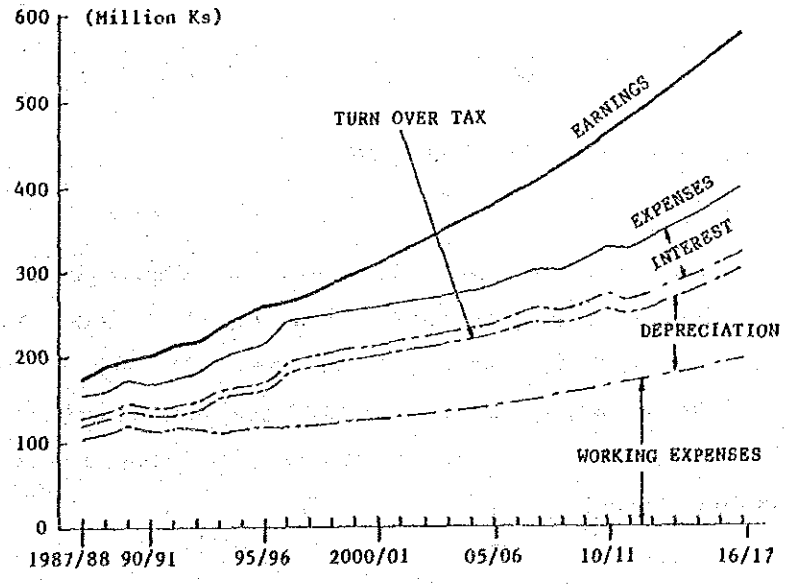


Fig. 9.6 Projected Profit and Loss

Source: Study Team

The results of the DSCR calculations are shown in Fig. 9.7. Generally, it is said that the annual DSCR should exceed 1.0 and cumulative DSCR during this entire project period is desired to be around 2.0.

The results of the annual DSCR are below the affore-mentioned criteria up until 1992/93, and furthermore, the results decline from 1995/96 to 1999/2000. On the other hand, the cumulative DSCR is 1.21 and the figure is relatively low compared with the criterion mentioned above.

Therefore, the Mandalay Line, which is improved, was estimated as barely stable.

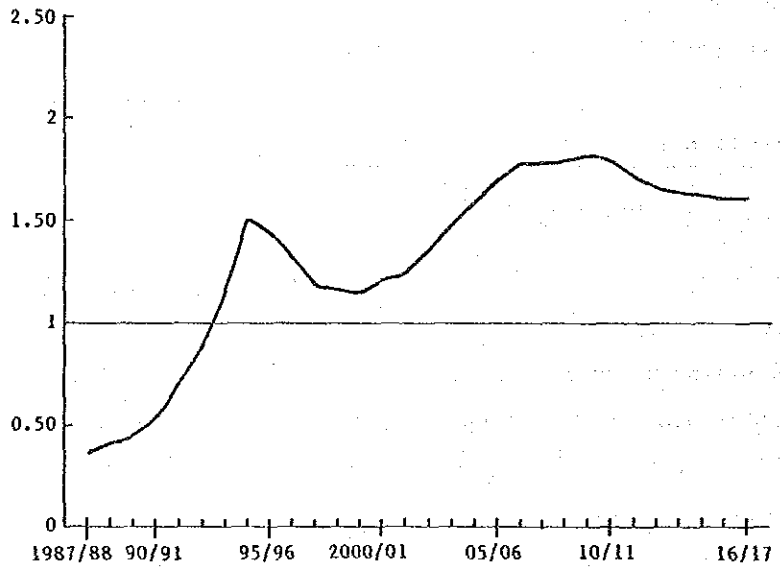


Fig. 9.7 Debt Service Cover Ratio

10. OVERALL EVALUATION AND EXECUTION PLAN

(1) Overall evaluation

From a national economic point of view, the improvement project is feasible even though any alternative among the six is adopted. Especially, alternative-5 is estimated as the best and is followed by alternative-6. Furthermore, according to the sensitivity tests, the alternatives-5 and -6 will be durable against the changes of investment costs and transport demand.

From a financial point of view, the project barely meets feasibility requirements in alternative-5, followed by alternative-6. Sensitivity tests shows that the results of FIRR will easily fail to keep the position even when the slight changes in investment costs and transport demand are made. The study revealed that the stability will not reach an adequate level, if any measure for improving the financial position will not be taken.

Economic and financial analyses were made for six alternatives with a combination of three track plans, one telecommunication plan and two signalling plans.

As for the three track plans, the goal of 10-hour scheduled time between Rangoon and Mandalay will be attained by any of the three, and there are little differences among them in the contribution to the four fundamental goals of the Project, that is the increase or improvement of train speed, operational punctuality, safety and track capacity. Plan C is recommended to be adopted in the execution plan based mainly on the result of the economic and financial analyses.

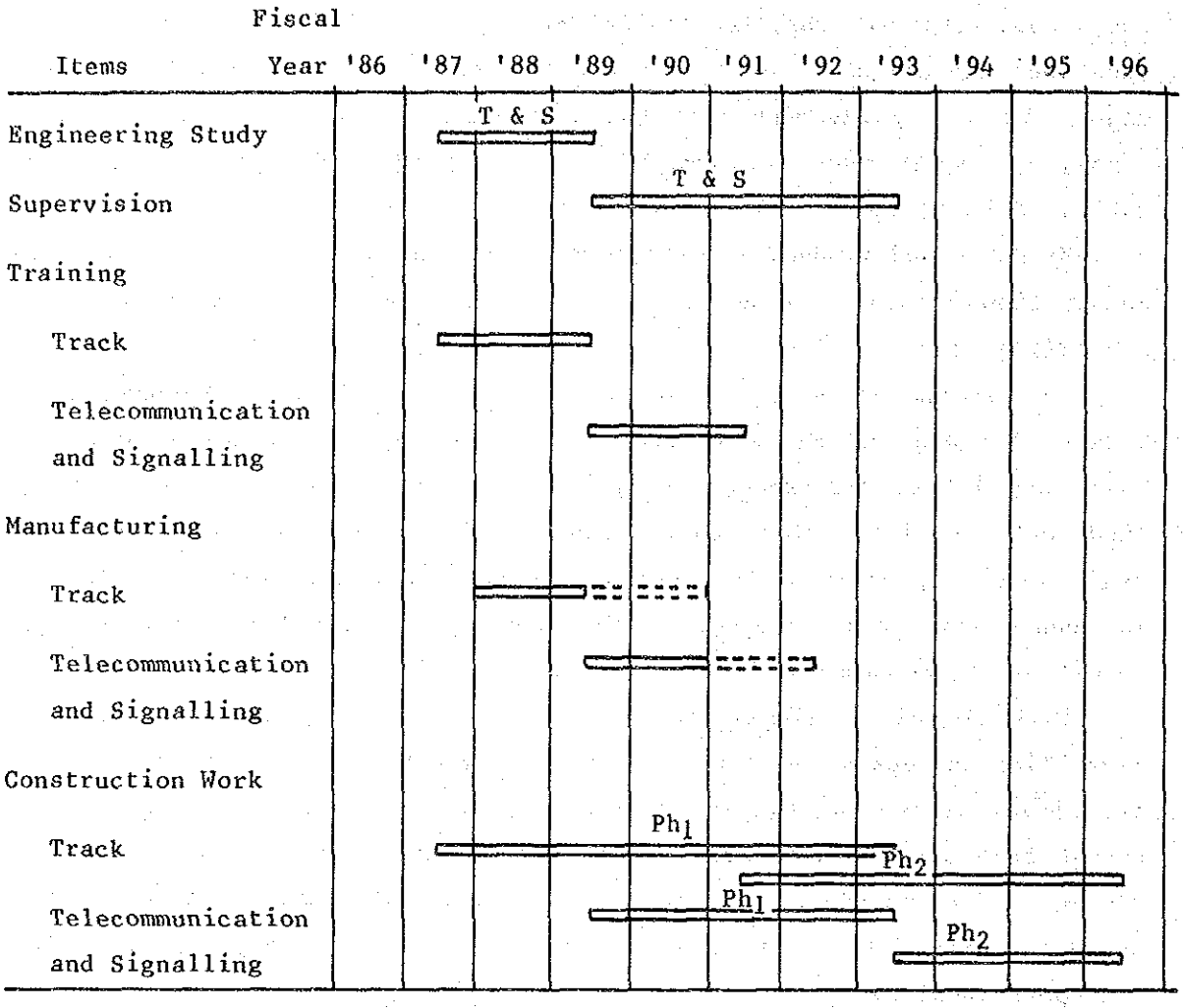
With regard to signalling, there is a characteristic difference in signalling and operational system between two alternatives. Plan A adopts cab signal system, while Plan B uses conventional wayside signal system, though both systems are based on the electronic token system. Plan B is recommended to be adopted in the execution plan, attaching importance to a characteristic difference in the adaptability to the current signalling and operational system.

In conclusion, the alternative-6 is recommended to be adopted as the execution plan, composed of Plan C of track, Plan B of telecommunication and Plan B of signalling.

(2) Execution plan

The project schedule and project cost are shown in Table 10.1 and Table 10.2, respectively.

Table 10.1 Project Schedule



Note: Ph1 and Ph2 indicate phases of the short-term improvent project.
T & S mean telecommunication and signalling.

Table 10.2 Project Cost

(Thousand Kyats)

Item	Foreign	Local	Total
Track	281,400	205,900	487,300
Telecommunication	226,400	111,000	337,400
Signalling	197,400	88,000	285,400
Sub total	705,200	404,900	1,110,100
Engineering service	44,500	600	45,100
Contingency (10% of the total)	70,500	40,500	111,000
Total	820,200	446,000	1,266,200

11. CONCLUSION AND RECOMMENDATIONS

(1) Conclusion

The economic and financial analyses show that the project would considerably contribute to the economic development of Burma, though it would not be surely expected to fetch a financial profit to BRC.

The implementation of the project is highly recommended from the viewpoint that these facility improvements are essential for the railway to restore its inherent advantages and to play an important role as the main transport means in Burma.

(2) Recommendation

Some recommendations are made in the following, to contribute to smooth implementation of this project and satisfactory operation thereafter.

1) Organization for the project

It is recommended to set up a project team which is responsible for promoting of the project from the planning to the execution, because it would be a necessity to control the development of the project by the integrated management.

2) Rolling stock

Rolling stock modernization is being carried out for the improvement of railway transport. This project on ground facility improvement will not bring about full effects without satisfactory progress of the rolling stock plan. So, it would be better to revise the present rolling stock plan coordinating it with the ground facility improvement.

Also, further improvement in rolling stock availability is advised along with its modernization.

3) Training

The training plan, outlined in this report, covers only the minimum requirements in objective, duration and number of trainees for acquisition of advanced technology and new operation and maintenance system. It is, therefore, recommended that the training plan be continued on an expanded and long-term basis under a continuing collaboration of experts abroad after the commissioning of the project.

4) Safety

To eliminate train accidents, further cultivation of discipline of employees concerned will be important, though fewer accidents are expected due to the facility improvements.

Countermeasures necessary to ensure safety along with increases in train speed are to be fully taken, especially measures for preventing the free access of people to station yard and tracks.