No.

MINISTRY OF RAILWAYS,
GOVERNMENT OF INDIA

THE FEASIBILITY STUDY ON THE DEVELOPMENT OF DEDICATED FREIGHT CORRIDOR FOR DELHI-MUMBAI AND LUDHIANA-SONNAGAR IN INDIA

FINAL REPORT

Volume 1
EXECUTIVE SUMMARY

OCTOBER 2007

JAPAN INTERNATIONAL COOPERATION AGENCY

NIPPON KOEI CO., LTD.
JAPAN RAILWAY TECHNICAL SERVICE
PACIFIC CONSULTANTS INTERNATIONAL

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CONTENTS OF FINAL REPORT

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INR1.00 = JPY 2.77

PREFACE

At the Japan-India Summit Meeting in Delhi on the 29th of April 2005, eight-fold initiative for strengthening Japan-India Global Partnership was agreed by the Prime Ministers of both countries. Japan and Indian governments share the view that Japan's Special Terms for Economic Partnership (hereinafter referred to as "STEP") Scheme could be one of the effective means for carrying out large scale priority projects in infrastructure sector in India and confirmed their intention to examine the feasibility of the project, providing the inputs of Japanese technology and expertise.

In July 2005, The Government of India (hereinafter referred to as "GOI") officially requested the Government of Japan (hereinafter referred to as "GOJ") for Japan's technical cooperation to assist in the feasibility assessment of a high priority transport development initiative, the "Dedicated Multimodal High-axle Load Freight Corridors with Computerized Train Control System on Mumbai-Delhi and Delhi-Howrah" (hereafter referred to as the Project).

In response to the request from the GOI, Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched in October 2005 a contact mission to collect and analyze the necessary information for the above mentioned Project. JICA and the Ministry of Railways (hereinafter referred to as "MOR") agreed that the feasibility study of the Project would be executed jointly. Based on the result of the preliminary study, the GOJ decided in November 2005 to conduct the feasibility study on the development of a multimodal high axle load freight corridor with computerised control for Delhi-Mumbai and Delhi-Howrah (hereinafter referred to as "the Study").

In February 2006, JICA dispatched the preparatory study team, and the Scope of Work of the Study and the Minutes of Meeting were signed and exchanged between MOR and JICA.

In May 2006, JICA selected and dispatched the Study Team headed by Mr. Minoru Shibuya of Nippon Koei Co., Ltd., and consisting of Nippon Koei Company Limited, Japan Railway Technical Service, and Pacific Consultants International.

This report compiles the results of the Study that was carried out between May 2006 to the end of October 2007 and covers deliberation of various aspects of the Project such as the engineering feasibility, financial viability, and environmental and social consideration; all aspects being the key issues essential for the feasibility of the Project. Throughout the implementation of the Study, an Advisory Committee chaired by Mr. Katsuji Iwasa, Senior Advisor of Japan Freight Railway Company Limited, was organised to assist and to advise JICA and the Study Team for the execution of the study, as well as to coordinate and adjust the various stakeholders on the Japanese side. I would like to convey my appreciation to Mr. Iwasa and the members of the Advisory Committee for their continuous support to us.

Finally, it is my hope that this report will contribute to the realization of the Project and I wish to express my sincere appreciation to the officers of the Ministry of Railways of the Government of India who have devoted their time, provided information, and cooperating in good spirit with the Study Team for the completion of the Study.

October 2007

Eiji Hashimoto
Vice-President
Japan International Cooperation Agency

October 2007

Mr. Eiji Hashimoto

Vice-President

Japan International Cooperation Agency

Letter of Transmittal

Dear Sir,

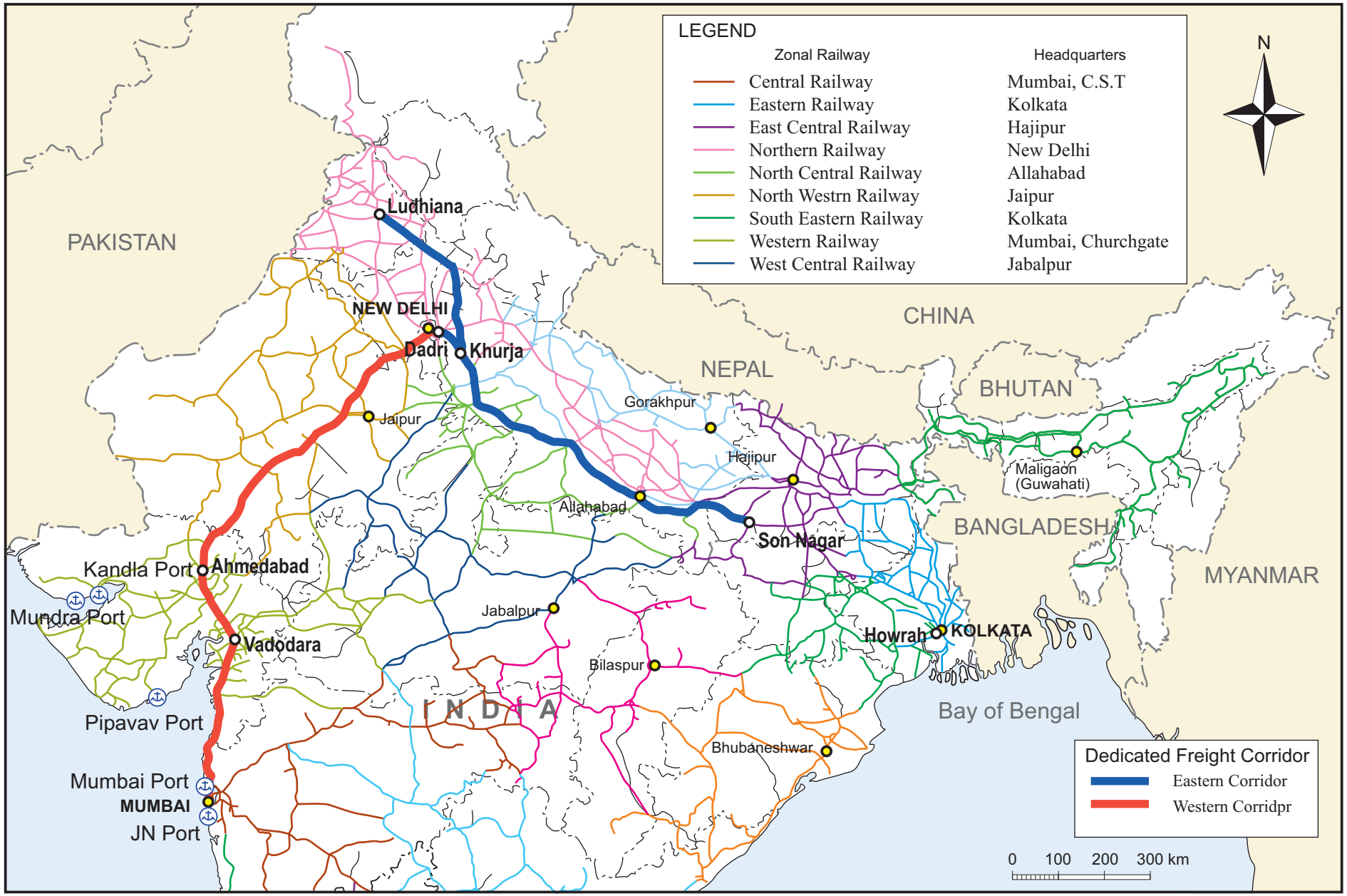
We have the pleasure of submitting herewith the Final Report on the "Feasibility Study on the Development of Dedicated Freight Corridor Delhi-Mumbai and Ludhiana-Sonnagar in India" (hereinafter referred to as the Study.).

The Study was undertaken from May 2006 to the end of October 2007 by the Study Team. The Study Team headed by Mr. Minoru Shibuya of Nippon Koei Co., Ltd., and is consisted of Nippon Koei Co., Ltd., Japan Railway Technical Service, and Pacific Consultants International.

We would like to express our sincere gratitude and appreciation to all the officials of your agency and the JICA Advisory Committee, the Ministry of Foreign Affairs, the Embassy of Japan in India, the Ministry of Railways as the counterpart agency, and to all of the counterpart personnel.

Yours faithfully,

Minoru Shibuya
Team Leader
Feasibility Study on the Development of
Dedicated Freight Corridor for Delhi-Mumbai and
Ludhiana-Sonnagar in India



LOCATION MAP

PROJECT AT A GLANCE

Project at a Glance (Entire Project)

No.	Description	Details	
		Western Corridor	**Eastern Corridor**
0	**Alignment**		
		JNPT - Vasai Rd – Vadodara – Ahmedabad – Ajmer – Rewari - Dadri	Sonnagar - Mughal Sarai – Kanpur – Khurja - Dadri, and Khurja – Kalanaur - Dhandari Kalan
1	**Route length**		
	Total Length	1,468 km	1,309 km
	- Double line	1,468 km	883 km
	- Single line	-	426 km
2	**Gradient**		
	- Ruling gradient	1 in 200 (5/1000)	
	- Steepest gradient in yards	1 in 1200 (0.83/1000) 1 in 400 (2.5/1000) exceptional case	
3	**Standards of construction**		
	- Gauge	1,676 mm	
	- Rails	60 kg/m UIC/90 UTS rail, HH rail	
	- Sleepers	PSC 1660 nos./km density for main line, 1540 nos./km density for loop line & sidings	
	- Points & crossings	60 kg rails, 1 in 12 with curved switches and CMS crossings on PSC fan shaped sleepers or FFU (Fibre reinforced Formed Urethane) sleepers Minor loop lines and non-running lines,1 in 8 1/2 turnout	
	- Ballast	300 mm cushion	
	- Maximum speed	100 km/hr	
	- Type of traffic and axle load	Double stack container movement on well type wagon and 5800 tonne train hauling with 25 tonne axle load	
4	**Formation (Detour Route)**		
	- Bank width for double line	12.5 m	
	- Slope of embankment	2H: 1V	
	- Cutting width for double line	14.9 m (11.9 m+1.5 m extra for each side for side drains)	
	- Slope of cutting	1:1	
	- Blanketing	0.60 m depth	

No.	Description	Details	
		Western Corridor	Eastern Corridor
5	**Curves**		
	- Maximum degree of curvature	2.5 degree curve (700 m radius)	
	- Curve compensation	At the rate of 0.04 % per degree of curvature	
6	**Moving dimensions**		
	- Vertical MMD	6.83 m for DSC	
7	**Vertical SOD**		
		7.76 m for DSC	
8	**Track centres**		
	Between two tracks of DFC	5.5 m	
	Between existing track and DFC	6.0 m	
9	**Bridges**		
	- Standard of loading	30 tonne axle load, 12 tonne/m trailing load	
	- Total linear water way of important bridges	12,810m (18 bridges)	2,660m (6 Bridges)
	- Total linear water way of major bridges	16,890 m	9,740m
10	**Road crossings**		
	- Total nos. of road under bridges (New on Detour)	133	79
	- Total nos. of Automatic Railway Crossing	505	368
	- Total nos. of road over bridges (Replacing)	27	8
	- Total nos. of road under bridges (Existing)	357	202
11	**Rail flyover**		
	- Total Nos of rail flyover	41	31
12	**Stations**		
	- Junction stations	9 stations	12 stations
	- Terminal stations	3 stations	2 station (Not Including Dadri)
	- Crossing stations Double line Single line	 32 stations -	 16 stations 36 stations

No.	Description	Details	
		Western Corridor	Eastern Corridor
13	**Tunnel**		
	- Number of tunnels	1	0
	- Total length of tunnel	4,000m	-
14	**Land required**		
	- Track	5,411 ha	2,832ha
	- ROBs	44 ha	12 ha
	Total	5,455 ha	2,844 ha
15	**Detour Route**		
	- Total length of Detour Route	474 km	275 km
16	**Signalling and Telecommunication System**		
	- Type of signalling	Automatic signalling using AF track circuit with advanced TPWS	
	- Section length on double line	1.5 km between stations 1 km nearby station	
	- Telecommunication System	GSM-R system	
17	**Train Traction System**		
	- Type of Train	Electric	Electric
	- Electrification system	25 kV AC	
	- Type of feeding system	AT feeding system (25kVx2)	
18	**Project Cost (mil. Rs)**		
	- Construction Cost	164,655	110,540
	- Consulting Service Cost	5,432	3,419
	- Physical Contingency	10,079	7,356
	- Price Escalation	18,838	13,749
	- Land Acquisition	26,640	25,495
	- Taxes	2,234	1,326
	- General Administration Cost	10,599	7,235
	- Interest during Construction	9,608	7,102
	- Procurement of locomotive	39,334	36,217
	Total Cost	**287,420**	**212,437**

No.	Description	Details	
		Western Corridor	Eastern Corridor
19	**Train operation**		
	- Operation Type	One manned operation without brake van	
	- Maximum speed	100 km/hr	
	- Traffic capacity Double line Single line	 140 nos. per day direction (4 hours maintenance block) 25 nos. per day direction(4 hours maintenance block)	
	- Train length	Corresponding to 686 m CSR	
20	**Economic and financial analysis**		
	- EIRR	14.09 %	15.26 %
	- FIRR	9.08 %	15.59 %
21	**Evaluation of induced impact**		
	- Induced impact on production	1,386 billion Rs.	
	- Induced impact on gross value added (GVA)	700 billion Rs.	
	- Induced impact on tax revenue	22 billion Rs.	
	- Induced impact on operating surplus	249 billion Rs.	
	- Induced impact on household income	372 billion Rs.	
	- Induced impact on employment	1.1 million people	

Project at a Glance (Phase I-a)

No.	Description	Details	
		Western Corridor	**Eastern Corridor**
0	**Alignment**		
		Vadodara – Ahmedabad – Ajmer - Rewari	Mughal Sarai - Kanpur - Khurja
1	**Route length**		
	- Total Length	918 km	710 km
2	**Gradient**		
	- Ruling gradient	1 in 200 (5/1000)	
	- Steepest gradient in yards	1 in 1200 (0.83/1000) 1 in 400 (2.5/1000) exceptional case	
3	**Standards of construction**		
	- Gauge	1,676 mm	
	- Rails	60 kg/m UIC/90 UTS rail, HH rail	
	- Sleepers	PSC 1660 nos./km density for main line, 1540 nos./km density for loop line & sidings	
	- Points & crossings	60 kg rails, 1 in 12 with curved switches and CMS crossings on PSC fan shaped sleepers or FFU (Fibre reinforced Formed Urethane) sleepers Minor loop lines and non-running lines, 1 in 8 1/2 turnout	
	- Ballast	300 mm cushion	
	- Maximum speed	100 km/h	
	- Type of traffic and axle load	Double stack container movement on well type wagon and 5800 tonne train hauling with 25 tonne axle load	
4	**Formation (Detour Route)**		
	- Bank width for double line	12.5 m	
	- Slope of embankment	2H: 1V	
	- Cutting width for double line	14.9 m (11.9 m+1.5 m extra for each side for side drains)	
	- Slope of cutting	1:1	
	- Blanketing	0.60 m depth	

No.	Description	Details	
		Western Corridor	Eastern Corridor
5	**Curves**		
	- Maximum degree of curvature	2.5 degree curve (700 m radius)	
	- Curve compensation	At the rate of 0.04 % per degree of curvature	
6	**Moving dimensions**		
	- Vertical MMD	6.83 m for DSC	
7	**Vertical SOD**		
		7.76 m for DSC	
8	**Track centres**		
	Between two tracks of DFC	5.5 m	
	Between existing track and DFC	6.0 m	
9	**Bridges**		
	- Standard of loading	30 tonne axle load, 12 tonne/m trailing load	
	- Total linear water way of important bridges	5,970m (4 bridges)	1,620m (2 Bridges)
	- Total linear water way of major bridges	7,960m	2,200m
10	**Road crossings**		
	- Total nos. of road under bridges (New)	87	48
	- Total nos. of Automatic Railway Crossing	317	212
	- Total nos. of road over bridges (rebuilt	1	2
	- Total nos. of road under bridges (extension)	207	110
11	**Rail flyover**		
	- Total Nos of rail flyover	29	18
12	**Stations**		
	- Crossing stations Double line	21 stations	14 stations
	- Junction stations	7 stations	8 stations
	- Terminal stations	0 stations	0 stations

No.	Description	Details	
		Western Corridor	Eastern Corridor
13	**Tunnel**		
	- Number of tunnels	0	0
14	**Land required**		
	- Track	3,329 ha	1,683ha
	- ROBs	2 ha	6 ha
	Total	3,331 ha	1,689 ha
15	**Detour Route**		
	- Total length of Detour Route	292 km	153 km
16	**Signalling System**		
	- Type of signalling	Automatic signalling using AF track circuit with advanced TPWS	
	- Section length on double line	1.5 km between stations 1 km nearby station	
	- Telecommunication System	GSM-R system	
17	**Train Traction System**		
	- Type of Train	Electric	Electric
	- Electrification system	25 kV AC	
	- Type of feeding system	AT feeding system (25kVx2)	
18	**Project Cost (mil. Rs)**		
	- Construction Cost	93,464	61,355
	- Consulting Service Cost	3,393	1,376
	- Physical Contingency	6,770	4,913
	-Price Escalation	12,653	9,182
	- Land Acquisition	16,339	15,143
	- Taxes	1,332	540
	- General Administration Cost	6,628	4,202
	- Interest during Construction	6,222	4,597
	- Procurement of locomotive	39,334	36,217
	Total Cost	**186,136**	**137,526**

No.	Description	Details	
		Western Corridor	Eastern Corridor
19	**Train operation**		
	- Operation Type	One manned operation without brake van	
	- Maximum speed	100 km/h	
	- Traffic capacity Double line Single line	 140 nos. per day direction (4 hours maintenance block) 25 nos. per day direction(4 hours maintenance block)	
	- Train length	Corresponding to 686 m CRS	

TABLE OF CONTENTS

THE FEASIBILITY STUDY ON THE DEVELOPMENT OF DEDICATED FREIGHT CORRIDOR FOR DELHI-MUMBAI AND LUDHIANA-SONNAGAR IN INDIA

FINAL REPORT

Volume 1

EXECUTIVE SUMMARY

CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS LIST

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

I. INTRODUCTION

0. In April 2005, Japan-India Summit Meeting was held in Delhi and it was agreed by prime ministers of both countries to share the view that Japan's Special Terms for Economic Partnership (STEP) Scheme could be one of the effective means for carrying out large-scale priority projects in infrastructure sector in India. The two sides confirmed their intention to examine the feasibility of Dedicated Multimodal High-axle Load Freight Corridors with Computerised Train Control System on Mumbai-Delhi and Delhi-Howrah routes (hereinafter referred to as "the Project") utilizing STEP Scheme and with the inputs of Japanese technology and expertise. In July 2005, Government of India (GOI) officially requested Government of Japan (GOJ) for the execution of Japan's technical cooperation to assess the feasibility of the Project, and the GOJ decided to conduct the feasibility study on the Project (hereinafter referred to as "the Study") in November 2005. In February 2006, JICA dispatched preparatory study team, and the S/W of the Study and the M/M were signed and exchanged between the Ministry of Railways (MOR) and JICA. The Study is to conduct: 1) Base-Line survey of the subject railway line and grasping the issues (Task 0); 2) Justification of the construction of the new freight corridor by comparison of alternatives (Task 1); 3) Feasibility Study on the Dedicated Freight Corridor Project (Task 2); and 4) to share Japanese experience in railway development and management. Task 1 was completed in March 2007 and whole study including Task 2 will be finished in October 2007. In order to smoothly implement the Study, the JICA Study Team (JST) was formulated by three groups of 1) Project management Unit, 2) Intermodal Research Unit, and 3) Engineering Unit.

In June 2006, JICA dispatched the Study Team to India for the Study for commencement of the site survey. Study area of the Study is as below, which is confirmed in S/W between the GOJ and GOI.

1) DFC Western Corridor: Jawaharlal Nehru Port Terminal (JNPT) - Dadri, Tughlakabad ICD including branch lines
2) DFC Eastern Corridor: Sonnagar – Dhandarikalan (Ludhiana), Khurja – Dadri including branch lines

The GOI decided to extend the DFC Eastern Corridor from Sonnagar to a planned deep seaport in Kolkata area. MOR and the Study Team had a series of discussion to include the extended section into the Study. However, the section was excluded from the Study, since location of the deep seaport in the Kolkata area was not decided within the Study period.

1. This report provides an overall summary of the findings of this study since its beginning to October 2007. Specifically, it covers all the survey content relating to Task 0, "Base-Line survey of the subject railway line and grasping the issues," Task 1, "Justification of the construction of the new freight corridor by comparison of alternatives," and Task 2, "Feasibility Study on the Dedicated Freight Corridor Project". Furthermore, this report was prepared based on the comments received on October 17th 2007 from the Ministry of Railways (MOR) on the Draft Final Report that was submitted to the MOR on September 18th 2007.

2. The Final Report consists of he following document:

Volume 1 Executive Summary (Task 0, Task 1, and Task 2)
Volume 2 Main Report (Task 0 and Task 1)
Volume 3 Main Report (Task 2)
Volume 4 Appendix 1 Technical Documents (Annex 1 Technical Working Papers)
Volume 5 Appendix 2 Preliminary Design Drawings (Annex 2)

<TASK 0 BASE-LINE SURVEY FOR RAILWAY TRANPORT CAPACITY DEVELOPMENT>

II. RAILWAY'S ROLE IN TRANSPORT SYSTEM OF INDIA

3. The Indian Government sanctioned the 11th Five-Year Plan (2007 - 2012) and issued last December. The Working Group Paper for the railway sector indicates enhancing of the transport capacity by construction of the DFC, and plan to reinforce the rolling stock fleet by procurement of locomotives amounting to 1,800 units within a five year period. The development of logistic centres and management of freight terminal operation by public-private-partnership (PPP) is also recommended as areas of development in the freight transport business.

4. The railway traffic volume continues to increase year by year. While its share in transport of passenger and freight transport is decreasing. This is due to the improvements of the road network, and the growth in vehicle ownership, and the fact that the railway traffic volume is now approaching the capacity limit of rail network facilities. The railway transport capabilities need to be reinforced to increase its share within the transport sector. The enhancement of customer oriented transport services is also required for the railway sector to survive the competition with the road transport.

III. SOCIAL AND ECONOMIC SITUATIONS IN DFC TRAVERSING REGIONS

5. The proposed new east-west freight line runs between the east coast state of Maharashtra (capital Mumbai) to the east coast state of West Bengal (capital Kolkata), and passes through a total of 10 states. These 10 states which contain a total population of 620 million people. The west coast region, centred on the city of Mumbai (Maharashtra and Gujarat states) is served by several deep-sea ports, and is a thriving centre of industry and commerce. The region centred on the capital city of Delhi is densely populated, and is a developing centre of industry, commerce, and agriculture. The northern region includes the state of Punjab, blessed with fertile soils and known as the "bread basket" of India, and the district of Ludhiana, a fast industrializing hub of manufacturing and information technology. The east coast region (West Bengal State), centred on the city of Kolkata, has achieved remarkable economic growth over recent years. Adjoining West Bengal on its inland border is the state of Jharkhand, which is developing as a centre for heavy industries such as steel mills, which rely on the state's rich coal and iron ore resources.

IV. PRESENT ISSUES IN RAILWAY FREIGHT TRANSPORT

6. Except for block train transport for bulk freight, the transport service provided by railways alone cannot complete the whole transport service. The rail transport requires connectivity to ports, freight collection facilities, inland container depots (ICDs), and connection to road transport. The containerisation of freight transport is presumed to be a global trend, making it a large business target of the Project. The container transport is based on intermodal transport and it realises the smooth transfer of freight. However for realisation of the enhancement of railway transport services of the container transport, it is imperative that the freight handling facility and collaboration with other modes of transport are well established. It shall be noted that improvement of the intermodal system is to secure the competitiveness of the railways against road transport.

7. As for port facilities connected to subject railway lines, the western corridor is served by a number of sea ports having a depth greater than 10m, including the ports of Jawaharlal Nehru

(JN) Port (max. berth depth 15m) and Mumbai (10m) in the Mumbai district, and the ports of Pipavav (12.5m), Kandla (14.6m), and Mundra (17m) on the Gujarat peninsula. JN port is India's busiest container shipping port, handling 60% of all containers shipped by sea in and out of India. On the other hand, the eastern corridor is served by the ports of Kolkata (8m), and Haldia (8.5m) near Kolkata. However, since both of these are river ports of shallow depth they cannot be used by large container ships. A deep-sea port serving Kolkata district has been planned for Sagar port (planned depth 12.5m) at the mouth of the Ganges river, but the project has not yet progressed beyond its inception.

8. Container transport on India's national railway network is now opened to 15 companies under license, and until recently it was exclusively operated by the public enterprise CONCOR (Container Corporation of India). CONCOR owns and operates approximately 40 Inland Container Depots (ICDs) throughout India. There are two ICDs in the Delhi Area, Tughlakabad (TKD) and Dadri, each connected to the rail network. The TKD ICD is favourably located, just 17 km from New Delhi Railway Station, but the condition of the roads servicing the ICD is poor. Another problem is that there is little potential for further expansion due to urbanization in the surrounding area. The TKD ICD is reported to have planned handling capacity of 250,000 TEU/year, but in reality, it handles approximately 400,000 TEU/year, greatly exceeding its normal capacity. The Dadri ICD began its operations in 2004, and was designed to have a capacity of 1 million TEU/year. Now, a half of the planned facilities has been developed to handle approximately half of its planned capacity. The access roads to the Dadri ICD are relatively well maintained, but the depot only handled some 100,000 TEUs of volume in the 2005-06 fiscal year. One reason for this low handling volume is considered to be the ICD's location, 45 km from Delhi. Many freight owners prefer to use the TKD ICD, which is closer to the city. CONCOR is currently planning a new large-scale ICD facility in the Delhi area, called Logistic Park, to connect with the new freight line.

9. Many sections of the Indian Railways network deploy an Absolute Block System (ABS) which allows only a single train to operate between two consecutive stations. This is a major factor hindering the increase in number of trains that can operate on the network (line capacity). Transport capacities of the network need to be upgraded by introducing automatic signalling and railway traffic control systems. In addition, the operation of freight train services is not based on scheduled timetables. In order to improve the quality of freight train services, it is imperative to introduce a modernised train operation management system that would facilitate transport services by scheduled freight trains.

V INTERMODAL TRANSPORT STRATEGIES FOR RAILWAY

10. Despite the road transport in India has disadvantageous factors compared to railways such as, high fuel cost, cumbersome paperwork and tax payment upon inter-state border crossing, the share of railway transport is decreasing year by year. Although insufficiency of rail capacity is recognised by the authorities, improvements of railway system are slow. From interview of freight shippers, freight forwarders, and the freight railway transporters such as CONCOR, issues such as “poor coordination among relevant concerned organisations”, “arrival time of freight is unknown”, “existing railway services is not user friendly” was highlighted.

11. Comparing the freight fare and the journey time between the rail transport and road transport between Mumbai and Delhi for transport of 40 feet container, the fare of the rail transport, standing at 49,000 Rupees, is cheaper than that of road transport which stands at 53,000 Rupee. However, the journey time of road transport is substantially shorter than rail transport. Therefore, there is an urgent need to implement the aforementioned improvement plan of the railways, reducing the total journey time to six days in total, and setting the arrival time by introducing train operation system based on the scheduled time table, and train reservation system that would fix the arrival of the container freight train.

12. More than 60% of the 20ft containers that are transported via railways exceed 20 tons in it weight. The container transport via railway is utilised for transport of relatively heavy load freight, on the other hand, road transport carry light weight commodities that are able to bear the burden of a high tariff. The transport fare need to be amended to become attractive to draw freight having higher transport cost.

13. For the realisation of customer-oriented services, it is advised that DFCCIL and MOR should not entrust the freight handling operation in the ICD to private sector enterprises but take a proactive role in exploiting the opportunity to create business by initiating measures such as: "visualization of logistic by introduction of freight tracing system", "establishment of credit guarantee institutions that would allow ease the administration of after delivery payment", "proactive implementation of ICD development plan for the metropolitan area." These effort shall enable the railways to grasp the core portion of intermodal transport as well as reinstate the share of the railways.

VI. EVALUATION OF LINE CAPACITY

14. There are numerous elements defining the size of the line capacity. An effective method that would enhance the line capacity is the improvement of signalling system by introducing automatic signalling. The JST estimated the line capacity by charted train schedule method which bases on the assumption that automatic signalling system is provided and layout of station yards are improved to eliminate restriction on operational speed. The results concluded that 140 trains/day/direction was obtained as line capacity of electrified double track line which considers the daily maintenance time of 4-hours. This figure exceeds the current line capacity of 85 trains/day/direction (71 train considering maintenance block) shown in the Line Capacity Statement (2005-06) by more than 50%.

15. The reasons for this difference of the line capacity are considered to be as follows.

i) The line capacity of IR is based on the current condition of station yard which forces trains to run at lower than 15 km/h or 30km/h.
ii) Existence of route interference of trains due to trains operating from the opposite direction.
ii) Signalling distance is not arranged to maximize the line capacity.
iii) The train acceleration and deceleration performance may be relatively lower than that officially recognised.

16. Based on item 14 and 15 of above, the JST adopts the following values for the line capacity used in the study of alternatives.

1) Use 140 train/day/direction as the line capacity for the double tack section of DFC, since it is considered that new line can satisfy the above conditions.
   Line capacity of a single line section of DFC is 40 trains/day/direction assuming the scheduled speed of freight trains will be doubled on the new line.
2) Use 110 train/day/direction, which is the average of 140 train/day/direction of above, and 71 train/day/direction as the line capacity of double track section of the existing line after the improvement. The line capacity on single line section, is assumed to be 20 train/day/direction, same as that on the current single line, assuming limitation exists despite improvement works are made.

VII. SITUATION OF THE EXISTING FACILITIES AND ISSUES

17. [Transport] The maximum speed of the trains is determined by the maximum emergency brake distance of 1,200m or by the designated distance up to the next signal. The length of the freight trains including container trains are set at the maximum effective length, currently at 686m, designated by Indian Railways norms, and has no latitude of in extending the train length. As

indicated in Paragraph no.9, the augmentation of line capacity in sections having constraints due to ABS signalling system can be achieved by introduction of automatic signalling. For the alleviation of the constraints mentioned in paragraph no.15, replacement of turnout with lesser tangent, track layout improvement and modernisation of interlocking into electronic interlocking system can be considered. The modernisation of train operation control system, currently dependent on manual operations, also needs to be considered.

18. **[Stations]** There are three categories of stations: 1) Large scale stations having functions of passenger station, freight station, locomotive depot, passenger coach depot, and freight wagon depot; 2) Medium scale stations with passenger platforms, freight loading/unloading sidings, and passing loops; and 3) intermediate stations with passenger platforms and passing loops. As is mentioned in the previous paragraph, the alleviation of the hindrances to the efficiency on the train operation within station premises can be achieved by such measures as replacement to smoother tangent turnouts. Also improvement in track layout of the stations in response to the changes in the transport demand is recommended.

19. **[Track Structures]** The Indian Railways classify the design speed in their construction standard for their broad gauge lines into five levels, from A to E. The standard specifications of the track structure for trunk lines classified as group A are: 300mm thick ballast; pre-stressed concrete (PC) sleepers laid at 1,660 pieces per kilometre; 60kg/m welded long rail; for 1,676mm broad gauge; with Pandrol fastener. Track strengthening works are ongoing for those line sections having specifications lower than the above. Head-hardened rails are used on sharp curved sections of lines on which mineral resources are transported.

20. **[Structures]** The majority of the existing lines are embankment structures. Elevated structure was observed only at bridge sections. Standard track centre distance of adjacent lines is 5.3m. Some sections on flat terrain were embankment structures where the material of the embankment was excavated from the ground adjacent to the line, leaving a long drainage type strip. The existing track are approximately 2 meters higher than the surrounding ground level which are presumed to have taken into consideration of flood water level.

21. **[Bridges]** The Indian Railways classify bridges over 300m span as Important Bridges, where the majority of them are through-girder truss type bridges which are composite of 30m or 60m standard span bridges. The majority of the bridges were more than 100 years of age and were observed to be well maintained. Newly constructed important bridges, such as the Sone Bridge, adopt the concrete structure (PC box girder). Bridges classified as Major Bridges, which are longer than 30 meters and less than 300m, are mostly upper-through plate girder type structure. Recently replaced major bridges adopts concrete bridge structure.

22. **[Electrification System]** Twenty five percent of the total railway lines in India are electrified. The electrified traction hauls 48% of all passenger transport by passenger-kilometer basis, and 61% of all freight transport by ton-kilometer basis. The AC 25KV system is adopted on most lines, with some exceptional application of DC1500V system. The lines with DC system are planned to be converted into AC system within a 5 year timeframe. The Zonal Railways clarified that there were no incidental suspension of power supply due to lightning damages, and there were no particular apprehension regarding power supply from power companies. The long term capacity reinforcement of power generation planned by the Ministry of Energy underscored the optimistic view of the zonal railways regarding stable power supply in the future.

23. **[Telecommunication System]** Optical fibre communications (OFC) systems are being installed along major rail tracks under the optical fibre development plan of Indian Railways. As of March, 2005, 27,000 route kilometres out of the total 42,000 route kilometres had been installed by RailTel Corporation, which is a Special Purpose Vehicle (SPV), with Ministry of Railways (MOR) participation. In addition, RailTel Corporation has started earning revenue by marketing the excess bandwidth available in Indian Railways communications facilities, such as the OFC

network and other infrastructure. A 150MHz mobile radio link is provided on limited sections for communication between train crews and station staff. The utilisation of the system was difficult since the communication quality deteriorates due to radio interference (noise) and does not meet operational needs. Therefore, with the aim of ensuring stable communications between train crews and station operators, a Global System for Mobile Communication for railway applications (GSM-R) based mobile communication system is now being introduced on the 'A', 'B' and 'C' routes of Indian Railways, totalling 3,200 route kilometres.

24. [Signalling System] As was indicated in paragraph n.9, the signalling system in station needs improvement to uplift the efficiency of the operation. Introduction of electric point machines are in process. The prevailing system is the mechanical interlocking system, and in view of the aged relay interlocking system, the introduction of the electronic interlocking is required.

25. [Rolling Stock] The railway related manufacturing industries in India flourish under the Ministry of Railways and establishments such as manufacturer of electric and diesel locomotives, passenger coaches, and wheel axle; state-owned manufacturer of heavy electric machinery and appliances exists. Private freight wagon manufacturers also exist. In principle, the Indian Railways procure rolling stock from these domestic manufactures. The industry has achieved to manufacture the state-of-the-art electric locomotive (WAG-9), a 6 axle, 6,000 horsepower locomotive of asynchronous motor drive, and the diesel locomotive (WDG-4), and the most recent 6 axle, 4,000 horsepower locomotive of asynchronous motor drive. Most of the rolling stock manufacturing technology was introduced from Europe, the United States, and Japan, and has been modified to fit the requirement of India. It should be noted that rolling stock with higher performance compared to the existing fleet is required for the operation of high speed container train and heavy haul freight train that will run on the dedicated freight corridor.

VIII. IMPROVEMENT AND DEVELOPMENT PLAN OF THE RELEVANT FACILITIES

26. [Improvement Plan of the Railways] The Zonal Railways are strengthening the transport capacity of their network by the following measures. These measures are those not to accommodate long term increase of transport demand but to accommodate transport demand at the moment.:

- Strengthening of Track Structure: Replacement of 52kg/m rail – wooden sleeper structure into 60kg/m – PC sleeper structure.
- Bridge replacement works: Replacement of ageing bridges by 25ton axle load capacity bridges.
- Double tracking and gauge conversion works: Double tracking of single track sections on trunk routes, and conversion from metre-gauge into broad gauge.
- Introduction of Automatic Signals: Introduction of automatic signalling are ongoing on premises of metropolitan areas along the Eastern Corridor (Ghazibad-Kanpur).
- Others: South-Eastern Railway are carrying out improvement works on their coal transport routes to increase the allowable axle load to 25tons on earthwork sections and 30tons on new bridges.

27. The Ministry of Railways has compiled the Integrated Railway Modernisation Plan 2005-2010 (IRMP) in November 2004. The IRMP comprises of modernisation of passenger transport projects (budget of approximately 140 billion Yen), modernisation of freight transport projects (budget of approximately 130 billion Yen), and other modernisation (budget of approximately 320 billion Yen). As for passenger transport, aims are made for the increase of speed of train operation, beautification of station facility, and improvement to information service system. As for the freight transport, aims are made for the modernisation of freight station, reinforcement of customer information related services, introduction of corrosion resistant / light weight wagons,

improvement to brakes, speed up of freight transport to 100km/hr operation, and double stack container operation. Other railway modernisation efforts are made on common areas of passenger and freight transport which include reinforcement of tracks to 25tons axle load, introduction of monitoring and maintenance system of bridges, modernisation of signalling and telecommunication system, modernisation of electric/diesel locomotives (inverter control etc.) The above improvements are ordinary railway modernisation measures that are implemented to cope with current and short term transport demand and are not radical transport capacity enhancement measures.

28. **[Improvement Plan of the Roads]** The National Highways Authority of India (NHAI) of the Ministry of Shipping, Road Transport and Highways, is spearheading the road development initiatives, putting highest priority on the trunk roads connecting the four corners of the Golden Quadrilateral, as well as roads stretching across from West to East, and North to South under the framework of the National Highway Development Project (NHDP). NHAI has classified the road network of the entire Indian continent into eight grades, including port connections, and has devised a development plan, which is in progress. By the implementation of the development plan, 50,000km of road network will be improved to have dual carriage way per direction by December 2015. There are also plans to develop intercity toll expressway by BOT schemes, ring road serving the metropolitan area, bypasses, and grade separation of intersections.

29. **[Improvement Plan of Ports]** Improvement plan of major port in the western corridor has revealed as follows through site survey and interviews:

    i) Mumbai Port: In order to increase the container handling capacity, development of 3 off-shore berths, construction of a large scale container yard by reclamation of docks under Build-Operate-Transfer initiatives are ongoing. By implementing this the container handling capacity will be enhanced from the current 200,000 TEU per annum to 1,900,000 TEU per annum.
    ii) JN Port: Construction of berth no.4 is planned, in which the cargo handling capacity will be strengthened to 4,000,000 TEU. The container handling capacity will be enhanced from the current 3,600,000 TEU per annum to 9,000,000 TEU per annum.
    iii) Pipavav Port: In the long term plan, there is a plan to construct a artificially excavated multi-purpose port having a total berth length of 2,200m and a depth of 15m. The container handling capacity is expected to increase to 3,400,000 TEU per annum from the current 420,000 TEU per annum.
    iv) Kandla Port: There is a plan to expand the container handling capacity to 700,000 TEU per annum from the current 170,000 TEU per annum. There are plans to develop the port facilities such as wharfs, terminals, and carry out dredging of ship lanes, which would serve as a industrial port.
    v) Mundra Port: Development of one coal berth within 2 to 3 years, a LNG jetty within 2 to 3 years, a liquid cargo jetty within 2 years, and 13 container berths within 4 to 5 year time frame are scheduled. After all works are complete, there would be 17 container berths, 12 bulk berths, totalling 29 berths. The container handling capacity will be enhanced to 8,400,000 TEU per annum from the current 1,200,000 TEU per annum.
    vi) Rewas Port: The Rewas Port located near Karanja Port, 10km south of JN port has plans to construct 6 berths having 2,000 m (depth of 13 m), and in the long term expanded to 22 berths (depth of 13 to 18 m). The port is scheduled to handle container, iron ore, coal, and liquid bulk.

30. **[Development of ICDs]** In the National Capital Region, there are two large scale ICDs (TKD and Dadri), 5 small scale ICDs (Loni, Asaoti, Palwal, Kosi Kalan, and Rewari), and one under construction in Patli. The total cargo handling capacity is approximately 1,400,000 TEU. The Indian Railways has signed a concession agreement with 15 freight forwarders in January 2007 that is expected to revitalization of goods transport by introducing the best practice of the private sector, promotion of streamlining. These freight forwarders shall submit the future ICD plan to

Indian Railway appropriately in accordance with this agreement, but there is no record that IR have received the plan from operators as of August 2007. The JST has got information that future ICDs are planned at Bijwasan on the southside of International airport in Delhi, at Sonipat and Panipat on the north of Delhi NCR region, and at Patli on the south NCR Delhi region.

IX. TECHNICAL MATRIX

31. [Technical Matrix] In this Study, elements of technology applicable for the DFC Project were deliberated, extracted and tabulated in a Technical Matrix form. The technical element matrix includes technologies, but not limited to, signalling system, train operation control system, container management system, electric locomotives, head-hardened rail, etc., in which Japanese firms have technological advantage and expertise. The JST has conducted a detailed study of applicable technologies taking into consideration comments from the Indian side, and narrowed down the applicable Japanese technology and expertise.

<TASK 1 JUSTIFICATION OF THE CONSTRUCTION OF THE NEW FREIGHT CORRIDOR>

X. STUDY OF ALTERNATIVES

32. According to the S/W and M/M made between JICA preparatory study team and MOR, study of alternatives was conducted for the sake of justification of construction of the Dedicated Freight Corridor (DFC) by setting other alternatives、which are the Dedicated Passenger Corridor (DPC) option and the Existing Line Improvement (ELI) Option. As the base case for the project evaluation, Without-Project (Zero Option) is also studied. The study of alternative was carried out in a following process:

1) Setting of options	Identify functions and purposes of respective alternatives and define routes of respective alternatives.
2) Evaluation of merits and demerits of each alternative	In order to recognize the peculiarities of each alternative, merits and demerits of respective alternatives were evaluated qualitatively
3) Preliminary (first stage) evaluation by comparison of demand and capacity	The projected demand in 2021-22 and 2031-32 and the line capacity was compared and considered for a representative section, and was analysed whether or not the alternative can suffice the demand.
4) Second stage evaluation	The project cost was estimated and economic comparison of alternatives were made.

33. [Definition of the DFC Option] The DFC Option was defined as the option to provide a new railway line for exclusive use of the long-distance freight transport. The existing lines are assumed to be utilised by all passenger trains and local freight trains. The route analysed was the route of the recommended in the RITES Feasibility Report. Since function of the DFC is transport of long distance freight, DFC has no necessity to pass through built-up area and is able to detour city areas by setting bypass routes. By this, the DFC can minimize cost of land acquisition and scale of resettlement in the built-up area. In addition DFC has advantage in reducing such negative impacts as traffic interference at level crossings, emission gas and noise harms toward local people living in built-up area by shifting freight trains to out skirts of the cities.

34. [Definition of the DPC Option] The Dedicated Passenger Corridor (DPC) Option is defined as the option to increase reserve capacity for freight transport on existing line by shifting long distance express passenger trains from the existing lines to the new passenger train line (DPC). Therefore it was assumed that all freight trains and local passenger trains remain on the existing lines. Since purpose of the DPC is passenger transport, DPC can not bypass the city area like DFC and should pass the built-up area along the existing lines to attract the passengers. Therefore DPC option needs additional land acquisition in the built-up area, which should drastically increase cost of the land acquisition and scale of the resettlement. In addition, since all trains should pass through the built-up area, DPC should have, in comparison with DFC option, larger negative impacts such as traffic interference at level crossings, emission of gas and noise/vibration harms toward local people living in city area. On the other hand, DPC has advantages to reduce construction cost of civil works including bridges due to adoption of axle load lower than those of DFC option.

35. [Definition of the ELI Option] The Existing Line Improvement (ELI) Option is defined as the option to increase line capacity of the existing line to accommodate future traffic demand of both passenger and freight. Major improvement works should be improvements of signalling system, track layout and train control of station area, and level crossings. In principle, ELI option require no land acquisition because it improvement1works are limited to those within present ROW. Several lines in the Indian railway network could be considered as ELI alternative. However the subject lines were selected as those which are currently used for the long distance freight transport which is the primary target of the Project. The ELI has advantages that it need no land acquisition nor resettlement, and can minimize initial investment, but has disadvantages that 1) its capacity enhancement is limited, 2) and it has larger negative impacts such as traffic interference at level crossings, emission of gas and noise/vibration harms on local environment, and 3) there is higher chance of interference to trains operating adjacent in the area subject to improvement.

36. [Definition of the ZERO Option] The Zero Option is defined as without project case, and used as the base case for evaluation of the project benefit. If the present passenger transport is to be sustained status quo, either of the following three options can be conceived: 1) Utilisation of alternative mode of transport (promotion of road development, and/or transport by trucks); 2) containment of traffic demand (re-examination of the thermal power development plan, promotion of industry development in the port region); 3) suppression of total demand (lowering the target of economic growth rate, and/or suppress power consumption or export/import). The answer to this could be no other than 1). Hence, the Zero option is defined as option where traffic exceeding the line capacity is borne by the road. In the zero option, the transport demand to be borne by the freight railways is assumed to be mainly borne by the road transport. The capacity of the existing lines are considered to be limited, thus treated as trivial. With regard to the railways, the zero option scenario considers the ongoing as well as the committed improvement works. With regard to the road transport, the zero option bases on the assumption that the highway network between Mumbai and Delhi, and Delhi and Kolkata are completed by 2021-2022, and that all national trunk roads are quadrupled as planned. On the other hand, it is a fact that the road development is not catching up with the demand due to sudden increase of road traffic volume. As for the railway network option, present on-going and committed improvement projects are included in this option. If the demand of DFC shift to road network additionally, traffic congestion of roads will become serious and lead to economic loss due to increase of vehicle running cost and journey time.

37. [Comparison of Traffic Demand and Traffic Capacity] Comparison of the line capacity in the projected demand was made between the Existing Line Improvement (ELI) option, the Dedicated Freight Corridor (DFC) option, and the Dedicated Passenger Corridor (DPC) option for the year 2016-17, 2021-22, and 2031-32. The result concluded that the line capacity of both corridors for the ELI option is not sufficient to accommodate the demand projected for 2016-17, hence the ELI option was ruled out.

The line capacity for DFC and DPC options, is sufficient until 2031-32, however the existing lines on the Western Corridor for DPC option can not accommodate the projected demand of 2020. The same goes for Eastern corridor in 2025. For the DFC option, demand projected for year 2026 exceeds the line capacity in partial section of the Western corridor, however there is sufficient capacity on the existing line on the Eastern corridor until 2030.

38. **[Economic Comparison of DFC and DPC]** The conclusions derived from the previous analysis indicate that the DPC option has no environmental superiority over the DFC option, and that there is unbalance of demand and capacity on existing and new lines. The advantage of the DPC may be the possibility of reducing the construction cost due to application of lower axle load. Hence, comparison of the estimated construction cost was made between both options indicated in paragraph 33, and 34. The result concluded that the total initial cost for DPC option was 50% and 40% higher, for the Western corridor and Eastern corridor, respectively. The reason was that the land acquisition cost and the civil works cost ended up higher since the station of the DPC option is located in urbanised areas. Hence it was concluded that the DPC option was ruled out since it has no superiority over the DFC option.

39. **[Evaluation of the Zero Option]** In the zero option, the transport of all freight demand - 21.8 million tons in 2013-14, 96.4 million tons in 2023-24, and 168.4 million tons in 2033-34, is assumed to be borne by railways. The transport of passenger demand in 2033-34 which is projected as 31.9 billion passenger-kilometre also is borne by the railways. In this case, the NH8 between Mumbai-Ahmedabad is projected to accommodate a daily traffic volume of 4,300 container truck, 1,300 ten ton capacity trucks, and 1,300 buses. On NH2, in addition to the above, a daily traffic volume of 3,600 ten ton capacity trucks, a maximum of 7,000 on some section, is projected. Hence construction of an additional four-lane road becomes inevitable to accommodate the future traffic volume. The JST observes that plans of 6-laning of the existing roads and construction of highway laid out in the National Road Development Plan alone will aggravate the traffic congestion, and result in stagnant logistic movement. Hence, the zero option is concluded to be an unrealistic option and that reinforcement of freight transport capacity of the railway was confirmed to be crucial.

<TASK 2 FEASIBILITY STUDY ON THE DEDICATED FREIGHT CORRIDOR PROJECT>

XI. REVIEW OF RITES REPORT (PETS-II)

40. **[Demand Forecast]** The projection is relatively moderate. Coal traffic is projected based on the committed plans of thermal power plant. On the other hand, the projected growth rate of international container traffic is slightly optimistic, however the traffic being projected up to 2021 and assumed becoming constant beyond 2021, it is considered not over estimated. The projection can not be used in economic and financial analysis because only the traffic demand on the DFC is forecasted.

41. **[Route Planning]** The route plan proposed in the PETS-II report recommends the reconstruction of ROB located at places parallel and adjacent to the existing line which is considered to be extremely difficult task, and detour routes penetrating through built-up areas. RITES is carrying out the Final Location Survey (FLS) to detail the alignment, however it is reported to be completed by end of December 2007, thus the information is not available to the JST within the study period. Hence, the JST deliberated on route taking into consideration the social and environmental aspects and made necessary amendments to what was presented in PETS-II.

42. [Geometrical Alignment Standard] Maximum gradient of 1 to 200; Minimum radius of curve of 700m; Distance of track centreline between DFC lines at 5.5m, and ditto at 6.0m between DFC and existing lines; Width of formation of 12.5m for embankment and 14.9m for cut section, are proposed. The geometrical alignment standard comply with the Indian Railway Standard, which the JICA Study will adopt, subject to no findings in particular engineering constraints.

43. [Track Structures] Applied standard specifications for track structures are as follows: axle load of 25 tons (30 tons in future); maximum train speed of 100 km/hr; clear standing room (CSR) of 750 m (1,500 m in future); maximum traction load of 5,800tons (15,000tons in future); rail: 60kg/m UIC of 90 kgf/mm2 UTS; adoption of HH (head hardened) rail at sharp curves. These requirements are IR standard, which the JST shall comply subject to no particular engineering constraints.

44. [Station Planning] The function of the DFC is providing direct freight transport by means of block trains, and freight stations load/unload goods are not planned on the DFC lines. For connection of the DFC lines with the existing lines and besides functions , junction stations (JS) are planned to be provided. Besides, for refuge of trains in occasions of accidents/trouble, or for waiting/stabling of maintenance machinery and, if necessary, for refuge of low speed trains, crossing stations (CS) are planned between junction stations.

45. [Grade Separation Structure of Level Crossings] The cost for constructing ROBs required for the grade separation at the level crossing is the heaviest item of the total cost estimated in the PETS-II report. The grade separation of the level crossing is a desirable project. However since the users and the beneficiaries of the ROB being the road transport, all the cost need not be borne by the DFC Project. Hence, the JST recommends that the grade separation project be separated from the DFC Project and implemented by annual budget. In addition, heigh tof the road surface of the ROB accommodating the double stack container (DSC) trains will be approximately 10m above the existing road. This will become a burden for non-motorised traffic such as pedestrian, bicycle, wheel cart, and cattle carriages. Such negative impact need to be considered for the grade separation structure of level crossings.

46. [Rolling Stock] The PETS-II estimated the required number of locomotives based on the performance of the existing locomotive fleet, and at the same time recommended the introduction of 9,500 and 12,000 horsepower locomotives. The rationale for the recommendation of the 12,000 horsepower locomotive is not clear. The JST studied the performance of locomotives required for the DFC and recommended 9,000 and 12,000 horsepower locomotives..

47. [Maintenance Depot] The PETS-II recommends the reinforcement of the existing maintenance depot and estimates the construction cost without providing concrete details. The JST conducted a rough analysis of the maintenance depot based on the projected number of locomotives calculated by the JST.

48. [New ICD Plan] The PETS-II concludes that at least of two large scale ICDs are required to be constructed in the National Capital Region to cope with the future increase of container traffic. However, the rationale for the site of the planned ICDs as well as the land acquisition, compensation, and the difficulty of implementation of the Project by means of environmental impact assessment study, etc. had not been deliberated.

49. [Preliminary Engineering Design of DFC] The PETS-II Report does not contain the drawings of the preliminary engineering design and final location survey (FLS). The route, alignment and preliminary engineering design of the junction station are being carried out and is reported to be completed by October 2007, at the earliest. Since the preliminary engineering design of RITES could not be completed within the JICA Study period, the JICA Study Team prepared the Guideline Design, and has provided it to RITES for them to complete the preliminary engineering design and FLS in line with its content.

XII. ESTABLISHMENT OF DEVELOPMENT SCENARIO FOR DFC

50. [The Objective for Establishing the Development Scenario] The Government of India has set a target to complete the implementation of the Project within 5 years, stating from 2008. However, from the results of the site investigation and the engineering analysis, there were sections having environmental and social constraints making it difficult for the early start of construction, as well as sections where construction need not start in the near future due to some margin in the line capacity. In order to judge that a part of the Project is feasible for implementation, the following conditions should be satisfied:

1) The traffic situation is so imperative that necessity of the implementation of the Project is justified.

2) The basic plan had been fixed based on sufficient engineering deliberation.

3) Environmental impact assessment is carried out based on the basic plan and issues regarding environmental and social aspect and its mitigation measures are identified.

4) The particular section can be formed as an independent Project generate project effects suffices to be established as a Project, and has project effect.

Each of the above conditions are issues which will be considered by JBIC and other international lending agencies for their project appraisal. Considering the above issues, the Project is divided into several sections and deliberated within each section of the aforementioned issues, and evaluate the feasibility of implementing each section, and establish a phased development scenario for the whole project as a precondition of analysis of the feasibility of the Project.

51. [Grasping the Conditions for the Feasibility of the Project] The following summarises the conditions for the feasibility of the Project.

1) The Situation of Traffic Demand and Line Capacity: Since the development of the DFC is approved by the Government, MOR has a policy not to implement projects to improve existing lines project that have conflict with the DFC Project. JST has evaluated the situation of the traffic demand and line capacity based on the line capacity of the existing lines and has confirmed that most of the existing lines will become saturated in the near future.

2) Maturity of Basic Plan: The major physical constraints for implementing this Project are the existing ROBs located in built-up areas that require reconstruction. There are several locations along both corridors, in parallel to the existing lines, where the reconstruction of the ROBs is considered extremely difficult, and re-examination of the route including the consideration of a detour route is necessary. It is also impossible for the early implementation for the section where a tunnel structure is proposed since a detailed engineering and environmental study, including a geological survey, is required to fix the basic plan.

3) Clearance of Environmental and Social Issues: The execution and approval of the environmental impact assessment (EIA) is an indispensable prerequisite for securing loans from JBIC and international lending agencies. The existing route proposed by RITES has routes which by a slight modification can substantially mitigate the impact on natural and social and environment. On the other hand sections were identified where significant number of squatters reside along the strip of land in parallel and adjacent to the existing line where DFC is proposed to be constructed, and locations within built-up areas where reconstruction of the ROBs shall have a serious negative impact on the social environment.

52. [Packaging of Project Components] Considering the conditions for the feasibility of the implementation of the Project, the Project area was divided into seven sections for the Western Corridor, and six sections for Eastern Corridor, as shown in figure 1-(1) and 1-(2). The condition for possibility of implementation each sections were examined.

53. [Establishment of the Phased Development Scenario and Sorting and Evaluation of the Feasibility Conditions of Each Sections] For the establishment of the phased development scenario, the characteristics of each section with regard to the conditions for the feasibility of the project was grasped, as well as the defining of the subject project for each development phase of the development scenario, and identification of the sections that need to be consolidated into each development phase. As indicated in the Final Report, the JST has separated the Project into three phases, and proposed the whole Project be implemented in fifteen years, on grounds that the existing lines be improved in advance of the DFC Project. In response to this proposition, MOR opined that 1) the DFC has been sanctioned to be implemented at the earliest and that a substantial extension cannot be permitted, and 2) the MOR has a policy in not carrying out the improvement works of the existing lines since the development of the DFC is prioritised. Considering the policy clarified by the MOR, the JST has established the policy for the phased development as follows:

Phase I-a Project: A Project composed of sections having commonality of stringent traffic situation in the short to mid-term future, and has non existence of engineering and environmental issues that would undermine the implementation of the works, and constitutes as a viable project that generate project effect independently, and considered to withstand the project appraisal by international lending agency.

Phase I-b Project: A Project composed of sections having commonality of stringent traffic situation in the short to mid-term future, however its implementation is judged to be impossible in the immediate future due to existence of serious difficulties from the engineering and environmental aspect, and likelihood of not being able to secure funds from international lending agency for its early implementation.

Phase II Project: A Project composed of sections having commonality of no serious traffic situation in the short to mid-term future, and it is judged that its implementation can be deferred until the traffic situation becomes stringent, as well as those sections that cannot immediately commence with the works due to necessity of review of its alignment.

The following table summarises the overall evaluation of the conditions of the feasibility of each section according to the aforementioned definitions:

Table 1 Western DFC - Phased Development Scenario

Item	Development Phase									
	Phase I-a				Phase I-b		Phase II			
Development Section	Rewari－Vadodara				Vadodara – Vasai Rd. and Vasai Rd. – JNPT		Dadri – Rewari			
Section Length	W-A2a 290km	W-A2b 368km	W-A3 124km	W-B1 136km	W-B2 344km	W-B3 89km	W-A1			
	918km				433km		117km			
Assumed Duration for Construction	6 years				8 years		6 years			
Commencement /Completion	2008-09* / 2013-14				2008-09 / 2015-16		2010-11 / 2015-16			
Reason for Selection of Section	No significant engineering and environmental constraint on alignment of sections parallel and adjacent to existing lines and detour sections. Basic plan is likely to be fixed this fiscal year.				Substantial numbers of ROB difficult to reconstruct. Requires reconsideration of alignment.		Subject section has a tunnel section and requires further study.			
Expected Benefit by Development	(1) Strengthening of the transport capacity of trunk line between Northern India including NCR and Gujarat where deep sea ports exist. (2) Improvement of the freight train operation to/from JNP/Mumbai Port by detouring the bottlenecked Ahmedabad to Vadodara sections.				(2) Improvement of transport capacity of section between Vadodara – Vasai Rd. where the traffic situation is most severely congested. Enhancement of freight transport capacity between JN Port, Mumbai and NCR. (2) Direct connection of Western DFC to JN Port.		(1) Improvement to the logistic network in NCR as the DFC is connected to the existing ICD of TKD and Dadri.			
Necessary Supplemental Projects and Conditions to be met for realisation of Project	**Supplemental Projects** (1) Construction of a new ICDs between Rewari and Delhi is required as the DFC is not directly connected to existing major ICD (TKD, Dadri) in Phase I-a. (ICD construction is included in scope of this study due to its importance) (2) Related to above (1), electrification between Rewari - Brar Square/ Patel Nagar is needed. (3) Shortcut Route between Delhi Cantt.-Brar Square to connect ICD (TDK, Dadri) via existing line. (4) Strengthening of transport capacity by improvement of signal and station yard between Vadodara-Vasai Rd. **Conditions to be met for realisation of Project** (1) Allocation of funds from Indian Government is required for land acquisition and construction works of the advanced initiated section.				**Conditions to be met for realisation of Project** (1) There exist a lot of existing ROBs in built-up areas where its reconstruction is considered to be difficult. Urgent review of engineering feasibility and reconstruction plan including the study on detour route is required. (2) Since W-B2 and W-B3 sections are the heavily urbanised areas, land acquisition is considered to be difficult. Prompt action is required for achieving consensus among residents and expediting land acquisition. (3) Route W-B3 requires further study based on the accurate topographic information since this section has steep undulations. Urgent topographic survey extending across the subject area and review of the alignment route is required. (4) This Project considers to		**Conditions to be met for realisation of Project** (1) The tunnel section is located in Eco-Sensitive area and expected to have significant environmental impact to agricultural land. Early start of environmental survey is required for approval of EIA since approval process is considered to take time. (2) Five ROBs exist along feeder line section to TKD where it is considered to be difficult for its reconstruction. Further study is required to minimise the number of reconstruction of ROBs, and consideration of plan to improve the existing lines.		

* 2008 – 2009 indicate Fiscal Year 2008

	(2) Decision to take up the works must be made before December 2007. (3) Discussion with road authorities regarding the reconstruction of the ROB is required urgently. (4) Decision by Government of India is required for the selection of technology proposed by JICA Study Team. (5) Urgent deliberation made and approval from of the GOI for the EIA along the alignment of the subject section is required. (6) Continuous effort for consensus building among residents residing along alignment is required. (7) Immediate establishment of policy for construction of ICD is required.	require sufficient funds and has engineering challenges which poses necessity of urgent consideration of securing funds from international lending agencies. (5) Assuming the involvement of international lending agencies, a timely execution and completion of an EIA study, that can bear the appraisal, is required.	

Table 2 Eastern DFC − Phased Development Scenario

Item	Development Phase					
	Phase I-a		Phase I-b			Phase II
Development Section	Mughal Sarai－Khurja		Khurja – Dadri and Khurja－Dhandori Kalan			Sonnagar – Mughal Sarai
Section Length	E-A1 322km	E-A2 388km	E-A3 46km	E-C1 242km	E-C2 184km	E-B
	710km		472km			127km
Assumed Duration for Construction	6 years		8 years			6 years
Commencement /Completion	2008-09 / 2013-14		2008-09 / 2015-16			2010-11 / 2015-16
Reason for Selection of Section	No significant engineering and environmental constraint on alignment of sections parallel and adjacent to existing lines and detour sections. Basic plan is likely to be fixed this fiscal year.		Substantial numbers of ROB considered as difficult to reconstruct exists along Khurja and D. Kalan which necessitate reconsideration of the alignment at some sections. The traffic between Khurja and Dadri is projected to become saturated in 2020, thus the implementation of the project of this section simultaneous with Rewari – Dadri section is considered to be reasonable.			The traffic between this section is projected to become saturated in 2025, thus the implementation of the project of this section is considered to be not urgent.
Expected Benefit by Development	Strengthening the transport capacity of entire eastern corridor by development of the sections of severe congestion.		(1) Strengthening of the logistic system between the eastern and western corridors by providing direct connection to both corridors. (2) To improve the congested traffic situation of NCR by providing a bypass route, and connection of the northern Indian region with the western/eastern areas by means of DFC.			(1) Connectivity to Sonnagar by completion of the development of eastern DFC.
Necessary Supplemental Projects and Conditions to be met for realisation of Project	**Supplemental Development Project** (1) Improvement of layout of Mughal Sarai Station to allow bypass of existing Mughal Sarai station. **Conditions to be met for realisation of Project** Conditions (1) to (7) indicated in Phase I-a Project of Western Corridor must be met.		**Conditions to be met for realisation of Project** (1) Conditions (1), (2), (4) and (5) indicated in Phase I-b Project of Western Corridor must be met.			**Conditions to be met for realisation of Project** (1) Finalisation of planning of the track layout of Mughal Sarai Junction station, and commencement of the land acquisition negotiation with the land owners of the region.

54. [Consideration of Applicability of Phased Development of Technical Options] The previous section established a spatial phased development scenario. The following summarises the considerations of the phased development of the several technical options to be adopted in the DFC project.

1) Container Transport System for the Eastern Corridor: In the short term, the container volume on the Eastern DFC is negligibly small, hence double stack container transport need not be introduced for the time being. Single stack container (SSC) transport and limiting the number of ROBs to be reconstructed as the precondition is recommended until the implementation of the deep sea port in

Kolkata region is realised, and the container traffic volume on the Eastern Corridor is sufficiently large.

2) Station Yard Planning: The junction station should be planned to fit the requirements of the short term transport volume. The reduction of number of grade separated structures and simplification of the facility plan is recommended. Until the traffic situation becomes severe, the effective length of the sidings is recommended to be in accordance to the existing maximum effective length (= 750m).

3) Elimination of level crossings by construction of ROBs: In conjunction with the implementation of the DFC, the Ministry of Railways has a policy to eliminate all level crossing where DFC trains are planned to pass. However, due to the following three reasons the implementation of the grade separation works require special consideration: (1) Construction of ROBs in built-up areas are extremely difficult and has substantial negative impact on the area; (2) Improvement of local road network together with integation of adjacent level crossings need to be considered; (3) Sufficient coordination with road authorities regarding design and cost allocation is required. Hence, the ROB construction project is recommended to be separated from the Project and treated as a separate Project which the Government of India should implement. Where DFC trains operate, improvement of existing level crossings by automatic train detection system is recommended to be included in the Project.

4) Traction System of the Western Corridor: It was confirmed in the Minutes of Meeting of the Fourth Steering Committee, held in March 2007, that the electrification of the Western Corridor should be implemented once the double stack container (DSC) operation under electrified wire is confirmed proven, and that in the initial stage diesel traction be adopted. However, the JST has visited China to observe the DS container operation under wire and concluded that this indeed was a proven technology. The analysis carried out in the JICA Study concludes that from the aspect of economics and transport demand needs, double stack container operation adopting the well type wagon was verified to be superior. Even though it was found that flat type wagons are not proven of its stability, the JST recommends the electrification of Phase I-a Project of the Western Corridor with utilization of well type double stack wagons, after verifying that the well type double stack operation is superior in economical aspects as well as the consideration of necessity from transport demand.

XIII. DEMAND FORECAST

55. [Methodology] The future origin-destination (O/D) were computed from the present one by applying the future commodity-wise traffic growth rates among states, and then the future O/D tables were assigned to railway network for rail traffic projection. International container traffic was projected by multiplying rail share to the projection of international container throughput at ports, assuming that distribution pattern of container traffic would be the same as the present one. For coal transport, the methodology in PETS-II was so proper that the projection was applied in this Study. Traffic volumes of other commodities were projected from the results of regression analyses that applied population and GDP by sector as their explanatory variables, assuming GDP growth rate to be 7% per annum. Passenger traffic was computed by multiplying growth rates that were estimated from a regression analysis with population as its explanatory variable to the present number of passenger trains for each route.

56. [International Containers] International container throughput was projected to become 43 million TEUs in 25 years, which would be approximately eight times the present one. This traffic volume is as large as that of USA and is approximately half to that of China. The container traffic by rail in the Western Corridor would increase by approximately 14 times in the same period due to the increase of rail share by the opening of the DFC and reach approximately 10 million TEUs.

57. [ICD] As a result, container throughput at ICDs in and around Delhi was estimated to become 6 million TEUs in 2033-34. It is clear that the demand would exceed the present capacity of the ICDs. Since it is not realistic that such huge demand concentrates on Delhi area, it would be

necessary to decentralize new ICDs.

58. [Coal] There are 11 thermal power houses with the total power generation of 7,370 MW which relate to the Eastern Corridor, among the committed projects of thermal power houses in the 11th Five Year Plan. With the completion of these power houses, coal traffic would reach 6.5 million tonnes which would be about 2.4 times the present traffic at 2.71 million tonnes (2004-05), and the traffic was estimated to become 8.9 million tonnes finally. This is the estimation in PETS-II and this Study also applied the result.

59. [Traffic volume in terms of tonnage and TEU] It was projected that the Eastern DFC would carry 68.7 million tonnes in 2013-14, which would increase to 140.8 million after 10 years (more than two-folds), and reach 152.4 million after 20 years. On the other hand, the Western DFC would carry 37.7 million tonnes (including 1.5 million TEUs) in 2013-14, 96.2 million tonnes (including 5.5 million TEUs) after 10 years, and 140.4 million tonnes (including 8.8 million TEUs).

60. [Number of Trains on East DFC] It was projected that the number of trains would be 50 – 60 trains per direction per day in 2013-14, which would increase to 70 – 90 trains in 10 years and 80 – 100 trains in 20 years. Coal traffic accounts for 70% of the total traffic toward Delhi, and empty trains including those of coal trains account for 80% of the total traffic of the opposite direction. Traffic volume on the section of Khurja – Ludhiana would be only 20-30 trains per direction even after 20 years.

61. [Number of Trains on Western DFC] Since container trains from various ports of Gujarat State converge, the number of trains between Palanpur and Delhi is about twice that of Mumbai – Palanpur section. The number of container trains is projected to be 140 trains per direction 20 years after the opening of the DFC. The total traffic of Palanpur – Phulera was estimated to exceed the line capacity of the DFC with 180 trains per direction per day. The demand forecast assumes the single stack train operation.

62. [Risk Analysis] The future traffic was projected for scenarios with different GDP growth rate and rail share for container transport. While on the Eastern DFC the fluctuation would not be so large, the traffic volume in tonnage on the Western DFC would be 70% in 2023-24 and 60% in 2033-34, on assumption that the rail share is constant and the GDP growth rate is 5% per annum.

XIV. COMPARATIVE ANALYSIS OF TECHNICAL OPTIONS

63. [Container Transport System] The height of Maximum Moving Dimension (MMD) is 6.83 m for DSC on flat wagon and 6.23 m for DSC on well wagon.

Preliminary designs of infrastructures are based on the MMD for DSC on flat wagon.

PETS II has proposed diesel traction, double stack container (DSC) operation, using flat wagons. The projected traffic demand in 2031 can not be handled by single stack container (SSC) operation alone. Capacity of DSC on flat provides double of that of SSC. Capacity of DSC using well type wagons provides 1.5 times of SSC. Either the flat or the well type wagons can accommodate the traffic volume projected by JST.

A economic analysis was carried out comparing the combination of electric or diesel, and SSC, DSC on flat or well. The results conduct the DSC on well by electric traction to be most economical. The transport costs per one TEU for both DSC on flat and well are calculated as 74.3% and 75.9% respectively of the SSC.

The DSC on well type wagons is used for commercial operations in US, China and Australia.

Relatively short trials of the DSC on flat were done only in India. And the same cannot be stated for Flat wagon option that it is a proven technology. It may be applicable to introduce the DSC on flat option only at the stage that safety operation was confirmed after exhaustive and meticulous test running for different loading conditions over a sufficiently long period.

The Chinese Railway operates DSC on well trains under 25kV OHE. There are no safety problems by keeping clearances more than 270 mm.

Since the PETS-II recommends the application of DSC operation with well type wagons on electrified lines of the Eastern corridor, if the Western corridor also adopts the DCS with well type wagons, having a common maximum moving dimension (MMD), container trains would be able operate continuously on both corridors. Also DSC on well wagons will need lower costs for infrastructure improvements for the existing connected lines should that be required in future. Accordingly DSC on well wagon is recommended. However, the Eastern corridor does not require the DSC operation in the short term.

64. [Catenary and Pantograph] A study was made on the height of the rolling stock and the catenary wire based on the MMD mentioned above. The proposed clearance between the rail top and the bottom surface of the ROB was determined to be 7.76 m for DSC on flat wagons, and 7.16 m for DSC on well type wagons. Also a study was conducted to analyse the implication on the contact position of the pantograph and the catenary wire after the catenary is raised to 7.53m. It was concluded that there was no issues for catenary poles erected at 63 m interval. The length of transition of the catenary wires of DFC from 7.53 m to and the existing wires at 5.6 m height were also examined and recommendations were made.

65. [Traction System (Electrification/Diesel)] The electrified traction system is advantageous system, in terms of fewer impact on environmental and economic aspects, to cater for the particular level of traffic demand projected in the JICA Study. Despite the fact that the freight transport on the Western Corridor is a mixed traffic of container and bulk, and having a higher transport density, the PETS-II recommended the diesel traction. The electrification of the Eastern DFC was proposed in PETS-II.

In light to this, the JST carried out a comparative study of the traction system for the Western corridor in terms of energy consumption, CO_2 gas emmission, and economic cost. The comparsion of the former two were based on British Thermal Units (BTU). The conclusion was that, diesel freight trains consumes 3.0 times more energy, and emits 1.9 times more CO_2 gas per BTU than electric freight trains.

Compared with the diesel traction system, the electrification system requires a larger initial investment but the procurement cost of the locomotives, and operation and maintenance expense is lower. In this Study, the cost increase factors were taken into consideration and economic analysis was conducted for a 30 year period using the life-cycle-cost. The conclusion is that the life-cycle-cost of the electrification system saves Rs. 8,363.6 crore (Rs.959.8 crore in terms of net present value), and revealed to be economically advantageous. Recalculation was conducted in accordance to the suggestion, made in the 5th Meeting of the Steering Committee held in July 2007, to take the same service life of 36 years for electric and diesel locomotive, which did not change the conclusion.

66.【Double Coupled Train (loop length 1500m)】 The PETS-II report proposes the double coupled train (DCT) operation system to enhance the transport capacity. However, the JICA Study revealed that from result of the demand forecast for both Corridors, the introduction of the DCT operation would not be required even in 2033-34. For the operation of the DCT, the extended effective loop length accommodating the DCT will result in the reduction of the line capacity, since more time is required for other single trains to pass the across the loop, which is subject to speed restriction, turnout, and signals. JST calculated that if a single train is operated on the 1,500m loop, the number of the trains passing the loop will be reduced by 17%.

Remote locomotive control technologies for long trains are practiced in US, etc. by radio or wire. Therefore, the Double Coupled Train (DCT) is a proven technology. Radio system has problems in transmission in tunnels or covered area and does not synchronise wagons' braking. Otherwise, there are no problems on transmission in wired system.

With regard to the automatic air brake system used in India, long train causes longer stopping distance due to longer response time. Also long trains are susceptible to derailment risks due to increase of coupler forces. Electric command air brake (EP) and Electromagnetic automatic air brake (ARE) are developed to reduce response time to shorten stopping distance and increase reliability. In a case of ARE, cost of rolling stock will be raised about USD 10,000 per each.

Train composition with a light weight brake as an intermediate vehicle increases the risk of derailment and is not recommended.

The situation in which the rationality to introduce the DCT operation is realised, is when the line capacity of the railway infrastructure does not suffice the demand and requires the provision of new lines, and the DCT is introduced as an alternative to the construction of the new line. Since the DFC Project is taken as a precondition, and if the double stack container operation is not viewed as inevitable, the necessity of securing loop length having 1,500m is not justified.

67. [Comparative Analysis of Methods for Level Crossing Improvement] Since the DFC will have high traffic density in the future, the grade separation of the level crossing (LX) with heavy road traffic is desirable. The standard set by the Indian Railways stipulate that level crossing having over 100,000 TVU be furnished with a ROB, however this limit can be significantly relaxed by introduction of automatic train detection and alarm system along with motor operated gate barrier. JST estimated the economic loss due to closed LX on condition that the automatic system is introduced. The conclusion was that the construction of ROB is justified to be economically feasible for LX that exceeds 900,000 TVU of 2005-06 level.

XV. TRANSPORT PLAN OF DFC

68. [Establishment of Preconditions] Conditions that require to be met for realising operation of 140 trains per direction on DFC are established. Those conditions include: 1) organizing of operation rules; 2) arrangement of the roles and the establishment standard for stations; 3) required performance of locomotives; 4) standard for signalling installation; 5)Speed limit on turnouts.

69. [Assessment of Train Running Time] Calculation of train operation time was made by generating run-curve combining the information of vertical and horizontal information, speed limit, and locomotive performance. The conclusion was, theoretically, a train of 5,800 tonne bulk cargo hauled by 12,000 HP locomotive making 2 minute stop at every junction station, resulted in the scheduled speed of 90kmph for both corridors. This does not include spare time and can not be adopted directly for the actual travelling time.

70. [Preparation of the train diagram] The minimum headway is calculated by identifying the section with the maximum number of trains from the projected yearly traffic allocated on each section. The train diagram was prepared from the traffic demand data and the travelling time based on the data already calculated.

71. [Estimation of Number of Rolling Stock] The number of turn-rounds and the turn-round time was estimated by the tabulated annual number of trains by section, and the locomotive operation time and the number of rolling stock was calculated using the running train kilometre and average speed of the train. The requirement of the rolling stock for DFC in 2023 concluded as: 431 units of locomotives, 9,300 units of container wagon, and 13,000 units of bulk wagon.

72. [Introduction of Train Time Table] The time table is indispensable on DFC since the route control is conceived to be carried out by the computerised control system. The introduction of the time table is beneficial from the view point that it will enhance the quality of the inter-modal transport since the arrival time will become clear. IR has apprehension on the introduction of the time table for freight trains running on existing lines. However, they have already introduced the crack train system which has time table for internal use. JST proposes the step-wise introduction of the time table.

73. [Enhancement Measures of Line Capacity] Simultaneously with the introduction of the automatic signalling system IR has started to improve the track layout of stations to abolish the route conflict between up and down trains. Also, replacement of local stopping trains from the locomotive hauled coaches to EMU is also being carried out. Such measures to enhance line capacity are being carried out in the recent years. For the future, JST assess that IR can break the way of thinking of IR staff which think the line capacity at 85 trains/day/direction is the maximum limit for the double line with automatic signal, by enhancement of the quality of the facilities and rolling stock, along with the introduction of software measures.

74. [Through operation to/from existing lines and DFC] The junction station which links the DFC and the existing line could become a weak point due to time loss for change of locomotives, crew, and wait during approach operation of other trains. By analysing the work process, the changing time of the locomotives can be reduced from the current 20 minutes to 15 minutes, and the crew shifting time from the current 5 minutes to 2 minutes. Consolidation of operations by centralised traffic control at the operation centre, and introduction of time table for freight train can drastically reduce the time loss due to approaching operation. Brake-van will not be required on DFC due to the introduction of the one man operation, and the connection of the brake-van is recommended be abolished on the existing line. Such measures are recommended to be taken up by IR to overcome the weak point of the connecting point at junction station.

75. [Loading/unloading at intermediate stations] The JST assess that by the block train operation of IR, the container transport to stations for small volume cargo will dissipate. In order to resolve this, and in order to maintain the transport time without considerable extension, JST advises that it is effective to handle the containers at the arrival/departure loop of intermediate stations, and recommends the deliberation of its introduction. JST recommends IR to refer to the experience of JR Freight.

76. [Actual travel time of train] The travel time between major stations including the stations on feeder lines was calculated according to the phased development plan. A journey that took three days was reduced to a single day in the maximum reduction case. By average, a two days journey was reduced to a single day. However, the time reduction achieved was less than that was obtained at the connecting points of inter-modal transport. The JST recommends the improvement of connecting points of inter-modal transport.

XVI. PRELIMINARY ENGINEERING DESIGN OF FACILITIES AND EQUIPMENT

77. [Basic Policy] The task of the JICA Study is to carry out preliminary engineering design by reviewing the PETS-II feasibility study carried out by the Indian side. However the PETS-II outlines only the overall concept and does not provide concrete engineering design of structures and facilities. The alignment design and the preliminary engineering design are currently under execution by RITES concurrently with the Final Location Survey (FLS), which its submission is revealed to be in October this year at the earliest. In view of this situation, the JST prepared a guideline design (GLD), and based on this the JST will carry out the environmental and social consideration study, cost estimate, and implementation plan. The policy of JST is, after the

submission of the GLD to the Indian side, to establish mutual agreement that the Indian side finalise their preliminary engineering design complying to the GLD.

78. [Axle Load] JST applied 25 tonne axle load for design of track structures, and 30 tonne axle load for structures.

79. [Route Plan] The method adopted for reviewing the route plan of RITES was by plotting the route information on satellite photograph image with building and structures identifiable, and rerouted the alignment avoiding such objects to minimise the impact on the social environment. The vertical alignment planning was carried out using information obtained by JST by video footage, interlinked with GPS information, of the whole existing alignment. The following sections are proposed to be modified by the JST.

Eastern DFC : Allahabad Detour, Kanpur Detour, Etawah Detour, Aligarh Detour
Western DFC : Vadodara-Ahmedabad Detour, Palanpur Detour, Kishangarh Detour, Phulera Detour, Ringas Detour

80. [Location of Station and its Layout] The layout of the junction station proposed in the PETS-II was having a grade separated crossing of connecting lines between the existing lines and the DFC lines that intersects with the a large angle. The large intersection angle makes it necessary for the acquisition of large area of land to accommodate the grade separated structure. The plan needs to be reviewed in terms of land use and environmental and social consideration. The final layout is being prepared by RITES, and the Guideline Design was prepared by JST to facilitate planning of RITES considering the aspects of above. For example, for those connecting lines with few trains operating, at-grade crossing with a middle line were planned to minimise the number of railway flyovers. Also for lines with few trains at a particular direction, connection lines were not configured and planned as switchback operation.

As a provision for the future, RITES has planned the clear standing room (CSR) at 1,500m, which is an excessive facility to accommodate the demand within the time span of the Project life. The JST recommends the determination of the location and acquisition of the land for the provision of 1,500 m CSR in the future, however the CSR be constructed at 750m.

81. [Civil Structures] Earthworks: The review of the volume of earthwork can not be carried out with precision, due to the lack of availability of the full information in the PETS-II with regard to the alignment and basis for the calculation of earthwork volume. The JST calculated the earthwork volume by utilising the available relevant vertical alignment data attached to the PETS-I, namely the elevation information of ground level and planned formation level, and verified by satellite images and 1 to 50,000 scale topographic sheets, and estimated the earthwork volume by the method explained in paragraph 79.

ROB and RUB: ROB and RUB will interfere with the construction of the DFC. The availability of sufficient planar space and vertical clearance for the existing ROB over the DFC corridor that is planned in parallel and adjacent to the existing lines was examined to judge the necessity of reconstruction for each ROB. In this Study, site investigation was carried out and this information was used in devising countermeasures. The countermeasures need to be finalised after carrying out a detailed study.

Bridges: The JST has carried out a flood analysis of the rivers of the Western Corridor for the important bridges, and presented the required span of the bridges in the Guideline Design.

82. [Track Facility] The JST applied the 25 tonnes axle load for the study on DFC track structure. The 25 tonne axle load is applied on track improvement project of the existing lines which are currently at 22.9 tonnes. The application of 30 tonnes axle load requires further engineering examination and is its application can be considered when replacement of the track structures

becomes necessary in the future. There is trend to adopt stronger rail by railways of other countries having heavy haul railways, and some heavy axle load railways have replaced its rail to head hardened (HH) rails on all sections. The application of HH rails for DFC is can be examined.

Since the procurement of timber is difficult, the Indian Railways utilises pre-stressed concrete sleepers for their turnouts. In view of easiness of construction/maintenance work synthetic resin sleepers, which the technology was established in Japan and is the utilisation widely prevailing, can be used for turnouts as well as ballast-less steel girders.

83. [Traction Power Facility] The RITES report recommended the tapping of power for the DFC Eastern line from existing substations, however the JST deliberated on the new provision of an independent traction power facility for the DFC. The JST recommends the adoption of the AT feeding system since it has advantage of longer interval between substations, and requires no sectioning. The conceived distance between the substation is 50 km. Each substation should tap on 2 pair of three-phase branch line of a 220 kV commercial grid to ensure stability and reliability of power supply. Centralized control through installation of the SCADA system is recommended.

The analysis for the traction power facility on the Western corridor was not conducted by RITES as they assumed adoption of diesel traction system.

84. [Traffic Management System] For the traffic control of DFC, we JST propose a comprehensive computerised total traffic management system combined with signalling system, telecommunication system, centralised traffic control (CTC) system and traffic management system. This system will achieve punctual train operation, simplify the traffic management organisation, rationalise facility management, and provide efficient freight transport. By utilising this system, the railways can become competitive against road transport. The link between each system – traffic operation, signalling, automatic train protection, telecommunication, between the train and wayside equipment, is connected to the dispatcher/station by modernised mobile communication through optical fibre cable communication network. The link is expected to achieve seamless traffic management. It is desirable that train dispatchers and facility commanders managing the traffic operations of each corridor are consolidated at one location to realise integrated operation of the DFC.

85. [Telecommunication System]the Indian Railways have selected and is introducing the optical fibre communication system and Global System for Mobile Communication for Railway Applications (GSM-R) system on their business as their next generation fixed and mobile telecommunication system. Microwave communication and metallic cable communication system can be considered as the alternative of fixed communication system, however the JST recognises the advantage of optical fibre cable (OFC) communication systems compared to other fixed telecommunication systems, such as metallic cable and micro wave communication systems, from a technical point of view (capacity advantage, electromagnetic compatibility) and commends the OFC. As for the mobile telecommunication system, in addition to the prevailing mobile communication system, the Terrestrial Trunked Radio (TETRA) can be considered as alternative of mobile communication system. However, the GSM-R is commendable for applications on DFC, due to its expandability for train operation, in addition to the voice and data communication functions it provides.

86. [Signalling System] For the train detection system, the JST recommends the Audio Frequency (AF) track circuit, where joint-less type are opted for between stations, and insulated rail joint type within stations. For the Automatic Train Protection System, the JST proposes the Advanced TPWS that carry out the speed checks at onboard devices, receiving the speed restriction information either from the transponder or track circuit. The cab signal is also recommended as an optional that would assist the driver during foggy situation,. The JST aims to realise the introduction of an advanced traffic control system for DFC which integrates the aforementioned telecommunication, signalling, CTC, and traffic management, systems mentioned in paragraph

no.84.

87. [Rolling Stock] Axle load: Two cases, specifically for 25 tonnes and 30 tonnes, were analysed on the impact of increase of axle load. For bulk freight wagons, the 25 tonne axle load accommodates 28% more payload than the existing 20.3 tonne axle load wagons, and similarly 58% more payload for 30 tonne case, which indicates that the transport efficiency increases in proportion to the increase of the axle load. However, in consideration of the implication on the cost of the infrastructure as well as the interoperability to and fro the feeder lines, the JST recommends the adoption of 25 tonne axle load in the initial stage and providing provision in the design for 30 tonne axle load to allow future conversion. Regarding the container wagons, the application of 25 tonne axle load will accommodate a payload consisting of two 20 ft containers plus one 40 ft container, or two 40 ft container - double stacked. The 25 tonne axle load is recommended over the 30 tonne axle load, since there will be constraints on the arrangement of the freight within the container which would attain only marginal increase of payload.

Performance of the locomotive: The analysis of the relation between the gradient, velocity, and the locomotive power concluded with the recommended specification for the electric locomotive as follows: For bulk transport - 8 axle 12,000 Hp; and for DFC container transport – 6 axle 9,000 Hp. The underlying assumption was that the axle load is 25 tonne, the traction load of 5,800 tonnes for bulk transport, 4,500 tonne for container transport, maximum speed of 100 km/hr on at-grade section, equilibrium speed of 75-80 km/hr. For diesel traction, the traction power for the driving wheel per axle being 750 Hp, three 6-axle locomotives for bulk haul, and two 6-axle locomotives will be required for container train.

Development and production: Since the electric locomotives will have a newly developed high-performance shaft (as referred in paragraph 46), a prototype needs to be developed, tested for its performance as well as the verification of its interface performance with telecommunication and signalling facilities, at least 2 years prior to the commissioning of the DFC. The requirement of the locomotives is 170 units by commissioning and 15 to 30 units every year after commissioning. In light of the locomotive manufacturing capability within India, either import, construction of a new factory or improvement of manufacturing capabilities may need to be considered for the procurement of these locomotives. New wagons that can accommodate 25 tonne axle need to be developed at the earliest. Particular attention is required for the protected design patent, held by the United States, of the well-type wagons.

88. [Rolling Stock Maintenance Plan] Since failure of rolling stock have significant implication on the transport capacity, the JST analysed the statistics of rolling stock failure and maintenance activities. The JST recommends the improvement of the assembly line for the brake devices, and the improvement of the working conditions.

89. [Maintenance Depot] Based on the estimated numbers of locomotives, the JST concludes that two additional maintenance depots for electric locomotives, and two additional wagon maintenance depot are required on the DFC corridors. Simultaneously, the strengthening of the existing maintenance depot is recommended. Since a new maintenance depot, for exclusive use for the maintenance of locos of the Eastern corridor is planned in Lucknow by the Indian Railways, the JST recommends the establishment of the facility in Rewari for maintenance of locos operating on the Western corridor. The JST recommends the establishment of a new ROH/POH in Dadri for the wagons of Eastern corridor, and the establishment of a new ROH in Rewari for the Western corridor. Basically land for the maintenance depot can be established in the land of existing facility. Even if additional land is required to locate the depot, unused land possessed by MOR is available.

XVII. ACTION PLAN FOR IMPROVEMENT OF INTERMODAL TRANSPORT

90. 【Importance of Development of Inter-modal Transport System】 The railway transport has an undisputable economical advantage over road transport, in which the fuel consumption per tonne

kilometre by railway transport is significantly less than that of road transport. On the other hand it is a fact that the railway transport can not complete the entire transport by itself, which can be termed as a disadvantage. Hence in case of railway transport, the connections to other modes of transport (generally with road transport) are required to complete the entire transport process. Accordingly, the number of connection process such as transhipment and storing of freight will increases. The more the connections, the more the transport cost and increase in transport time. Thus, it is imperative that the railway community fully is aware that the transport by railways needs to be entrusted to other mode of transport at the transport connection point. This fact is the utmost weak spot of railway transport. In order for the railways to become a competitive transport mode against road transport, the conquest of this weak spot is issue.

To meet the demand that increase each year prior to the completion of DFC, and full utilization of the transport capacity of the DFC after its commissioning, the development of inter-modal transport need be started immediately where possible.

91. **【Inter-modal strategy (Ports)】** The handling volume of freights via railways in future is calculated on the assumption that 35% of the handling volume of ports along the DFC will be borne by the railways. Concrete improvement plan of facilities for handling, transit and stabling of containers in the port is worked out based on the improvement plan at ports presented in Chapter 9 of Volume 2 (Task0&1). Renovation of railway yard within JNP, the largest container port in India, is planned in accordance to the increase in container handling volume. For the handling and transit of the container inside ports, data link between the train reservation system and container handling facilities in port, and the establishment of mutual subcontracting system for the mixed container train is proposed.

92. **【Inter-modal strategy (Feeder lines)】** The improvement of the freight handling capacity at the port and the line capacity on main line is likely to cause the feeder line between ports and the DFC to become a bottleneck. From the demand forecast, the JST has estimated the period required for the conversion of the existing non-electrified single track feeder lines into double track lines that connects the major ports of Mundra, Kandla, and Pipavav, located in Gujarat State. The result was that the feeder lines originating from Mundra port and Kandla port will be required to be doubled by 2023-24. But the feeder line for Pipavav port will not be required to be doubled until 2033-34.

93. **【Inter-modal strategy (Railway)】** In order to resolve the prevailing issue of uncertainty of train railway freight transport, the introduction of time table for freight trains is important. One of the reason for not being able to introduce the time table for freight trains, which is the lack of line capacity, will be resolved by the implementation of DFC. However, the issue of the departure of the freight train until full load is achieved, still remains. For the solution of this issue, the provision of a intermediate stations, equipped with a container loading/unloading system on the arrival/departure loop, along the DFC is proposed.

94. **【Inter-modal strategy (ICD of Delhi National Capital Region (NCR))】** Two ICDs are located in the Delhi NCR, i.e., TKD and Dadri. It is envisaged that the total handling volume at Delhi NCR in future will be substantial and that it shall exceed the handling capacity of these two ICDs. In Phase I-a, the DFC will not reach the existing ICD, so the provision of a new ICD between Rewari and Delhi will be a prerequisite for the Phase I-a Project. The implementation of the ICD in Delhi NCR by private operator is not yet determined. Hence the JST proposes that DFCCIL take up the construction of the ICD and include the scope in this Project.

95. **【Inter-modal strategy (alliance with trucks)】** Road transport is the archrival competitor , as well as a partner, of the rail transport. In the aggregate, trucking companies in India are small in scale and there are opinion from consigners that they find it difficult to locate a reliable trucking company. So it is proposed for the rail freight forwarders to establish alliance with trucking companies to establish an inter-modal container transport service, and recommending to consigners.

96. **【Improvement target for the transport time of Inter-modal transport】** The total transport time was calculated to clarify the improvement target for the proposed inter-modal transport. At present, it takes 168 hour via road from vessel at JNP to the consignees in Delhi for the transport time, and 317 hours at average via rail. The result of calculation suggests that this 317 hours can be reduced to 99 hours by adopting the inter-modal strategy. With this strategy, transport via rail has advantage in transport time over transport via road.

97. **【Effect of the inter-modal transport】** Economical evaluation with adoption of the inter-modal strategy is calculated. Stabling time at port is reduced by 5 days, and that at ICD is reduced by 2 days. Benefit is combined with the benefit from the reduction of the transport time of the freight, reduction of the charge for custody and the improvement of the access road. The total benefit for thirty five years without the time benefit to be derived from the implementation of DFC is Rs.203,430 million. The net present value after discounted by capital opportunity cost, i.e., 12% is 22,530 million Rs. Especially the benefit derived from reduction of stabling time at ICD and port is enormous.

98. **[Establishment of Taskforce for Improvement of Inter-modal Transport]** The JST recommends the establishment of a taskforce involving the railway relevant organization for the improvement of the overall railway container transport. The role of the taskforce is to identify the issues raised in the JST report as well as the bottlenecks, build consensus, provide feedback to each member of the taskforce, and formulate an action plan. The candidate member of the taskforce is recommended to be Ministry of Railways, Ministry of Shipping and Road, Ministry of Commerce and Industry, Planning Commission, DFCCIL, relevant port authorities, port operators, freight forwarders, relevant State Government, academic society, and representatives from the client. The DFCCIL is recommended chair the taskforce, since it is the enterprise that will manage the groundbreaking railway transport of DFC.

XVIII. OPERATION AND MAINTENANCE PLAN

99. **[The Organization]** The operation and maintenance organization of DFC requires being lean, however the staffing must be competent and ready to cope with unexpected emergency situations. The operation of the trains are required to be smooth over the whole stretch of the DFC. In this report, some recommendations are provided for the organization based on the experiences of from Japanese experiences, namely the integrated control by CTC operation of Shinkansen lines. Based on this, a conceptual relation between the dispatcher and the stations on the DFC is presented.

For the headquarters, the department-wise issues to be tackled there are discussed and the organization including the remote office is studied. The operation division (operation centre) is identified as one of the department of the headquarters. The most important issue for the operation centre is identified as the communication between the dispatchers for existing lines and that of DFC. The constitution of well communication system between them is proposed and the organization of the operation centre is also proposed. For the train operation system, the experience of Japanese railways on the introduction of one man operation and the abolishment of the brake-van is introduced because these systems can be introduced to Indian railways also.

For instruction and training system, the importance of the role of the engineers is increased on DFC according to the introduction of one man operation, introduction of CTC system which requires the direct communication between dispatchers and drivers and also the drivers who belong to IR have to operate the train according to the different General Rules of DFCCIL from IR. To provide well developed instruction and training system for drivers and dispatchers are important for safety operation of DFC.

For maintenance works, to reduce the occurrence of the failure or trouble of facilities or rolling

stock and the constitution of the quick response system at the occurrence of the trouble or accidents are important. DFC will be constructed with brand new high level technology to reduce the total life cycle cost. The standard of the allocation for the maintenance is proposed to maintain the facilities well and make quick response at emergency. As for the temporary treatment of the trouble, the allocation of the station staff that is instructed and trained for the acquisition of the skill is proposed.

100. [Operation and Maintenance Cost] The unit expense to be used to calculate the expenses for the DFC is split into personnel expenses and expenditures other than wages. The unit personnel number to be adopted in the calculation is based on the experience from the KONKAN Railways, which is considered to be a new standard in IR, where the staffing of personnel per operating kilometre is merely 24.1% of the average of the Indian Railways. And that of Japanese railways is also based on for the examination of staff number of DFC. The staffing of DFC is sought to be leaner than that of the Indian Railways as the number of stations per route km of DFC is fewer than that of IR. The unit expense for wages was 158,000 Rs. of the Indian Railway in average. The expense per unit is the actual achievements of the Indian Railways. The revenue is calculated based on the unit tariff of IR, namely Rs. per ton-km or Rs. per TEU-km, and demand forecast of DFC.

101. [Yearly revenue and expenditure] Using the figure shown in paragraph no.99, the yearly number of category-wise staff and the expenditure are calculated. In 2013-14, the number of staff for Eastern corridor is 5,110 and that for Western corridor is 6,565 (These figure includes the number of drivers and rolling maintenance staff who belong to IR). As for the balance, figure shows the soundness of DFC from the beginning though this figure is that before payment of interest and depreciation cost. The increase of the revenue and expenditure by the implementation of DFC project has same tendency though its volume is smaller than that of DFC.

XIX. ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

102. Environmental and social considerations for the DFC project should be conducted with initiative of Indian Government in principle. However, comprehensive examinations on environmental and social considerations for the railway development have not so far been carried out by the Indian Government from the planning stage of the development since there is no provision of the Environmental Impact Assessment (EIA) for railway development under the Indian laws and regulations.

Adequate environmental and social considerations are mandatory in the case where the DFC Project is applied for the fund of donors such as JBIC, ADB and the World Bank. Therefore, in addition to the environmental and social considerations under the JICA Environmental Guidelines[†], various examinations and recommendations, which are required to be conducted by the Indian side in implementation of the DFC project, were made in the Study from viewpoints of possibility of fund by international donors. Thereby Indian Government should understand the extent of environmental and social considerations necessary to carry out in accordance with requirements of international donors' funded project. Based on the recommendations in the Study, it is expected that the Indian side implement recommended actions for the DFC project as earlier as possible with well understanding institutional framework for implementation of adequate environmental and social considerations for the DFC project.

103. In the course of the JICA Study, Environmental and Social Considerations Study (ESCS) was conducted as initial environmental examination level study in the first year of the Study for whole route of the DFC project to examine preliminarily environmental and social impacts caused by the DFC project as well as to conduct alternative analysis and environmental scoping for Environment and Social Impact Mitigation Measures Study (ESIMMS). In the ESCS, video

[†] JICA Guidelines for Environmental Social Considerations, April 2004

recording of railway was undertaken from the train along the whole DFC route to record present environmental/social and railway facility/structural conditions. In addition, GIS mapping was conducted by using satellite image along the 1-km strip of the present railway. Then, the ESIMMS was conducted as quick environmental impact assessment study for the priority section of the DFC project in the second year of the Study to examine potential impacts, evaluation, mitigation measures and environmental management and monitoring plan as well as preparation of resettlement and rehabilitation plan framework[‡].

104. Relative high concerns on railway noise and vibration are seen for the residents along the existing railway track as an environmental issue caused by the railway development according to a questionnaire survey conducted during the Study. Since any study on railway noise and vibration has not been conducted in India so far, field measurements for the railway noise and vibration to obtain basic data for forecast of noise and vibration level caused by the DFC project was conducted as well as railway and environment noise and vibration measurements at sensitive receptors such as hospital, school, and temple to examine proportion of railway noise and vibration against the environmental levels, respectively. Based on results of the noise and vibration forecast and mitigation measures proposed in the Study, detailed examinations and adequate measure design should be conducted, especially in urban section, in the further stage of the project.

105. Relative high concerns on railway noise and vibration are seen for the residents along the existing railway track as an environmental issue caused by the railway development according to a questionnaire survey conducted during the Study. Since any study on railway noise and vibration has not been conducted in India so far, field measurements for the railway noise and vibration to obtain basic data for forecast of noise and vibration level caused by the DFC project was conducted as well as railway and environment noise and vibration measurements at sensitive receptors such as hospital, school, and temple to examine proportion of railway noise and vibration against the environmental levels, respectively. Based on results of the noise and vibration forecast and mitigation measures proposed in the Study, detailed examinations and adequate measure design should be conducted, especially in urban section, in the further stage of the project.

106. Railway route for the DFC project was basically designed with detouring urban area to avoid large-scale involuntary resettlement. On the other, since most of the detour routes pass through the existing farm area, acquisition of farm land and farmers' relocation will be occurred. In addition, relocation of illegal occupants or squatters who presently resides in and around the railway stations will also be subject to the relocation due to improvement of the station under the DFC project.

In a railway section between Vasai Road and Rewari, where is subject to the ESIMMS in the Western Corridor, while there are many and long detour sections passing though the farm area, some 1,300 structures are subject to the relocation with involuntary resettlement at both detour and parallel sections in total. On the other, in a railway section between Mughal Sarai and Dadri, where is subject to the ESIMMS in the Eastern Corridor, there are some sections where can not avoid to pass through urban area even in the detour route. As result, some 2,300 structures are subject to the relocation with involuntary resettlement at both detour and parallel sections in total. After finalization of the DFC routes, detailed resettlement and rehabilitation plans have to be prepared at district level with detailed inventory for the resettlers.

In the railway section subject to the ESIMMS in the Western Corridor, some 500 squatters who depend on railway station on their living and reside within impact range of construction for the DFC project, are seen along the DFC sections in total, especially in southern part of the Surat section. Appropriate support for the squatters will be one of crucial issues in the resettlement and

[‡] The ESCS and ESIMMS are equivalent to the Environmental and Social Considerations Study at IEE Level and the Environmental and Social Considerations Study at EIA Level under the JICA Environmental Guidelines, respectively.

rehabilitation plan. Likewise, over 200 squatters will be subject to the resettlement in the Eastern Corridor in total.

In addition, impact to livelihood for farmers caused by the farm land acquisition will be expected to occur in the detour sections in Haryana, South part of Gujarat, and Maharashtra in the Western Corridor, and Uttar Pradesh in the Eastern Corridor. Since some affected farmers may face difficulty to purchase alternative farm land near their farm land due to lack of available land, the DFC project should support for such farmers to find alternative farm land, not only provide farm land compensation at replacement cost in cash, from viewpoint of livelihood recovery for the affected people.

107. Although the National Rehabilitation Policy-2006 (NRP-2006) should be a basis for preparation of the framework of the resettlement and rehabilitation plan to avoid or minimize social impacts caused by the land acquisition and involuntary resettlement, some items to be concerned has gaps between the policy and requirements under international donors on social considerations, which are such as application of the replacement cost for the farm land acquisition mostly seen at the detour section and assistance for the squatters mostly seen at parallel sections. To fill such gaps, MOR and DFCCIL should initiate necessary preparations and actions on coordination with relevant agencies and establishment of implementation body to implement land acquisition and resettlement based on resettlement and rehabilitation framework with various measures proposed in the Study.

108. It is not preferable that standards and practices on resettlement and rehabilitation plan applied to be applied under the DFC project are different among the concerned states, since the DFC project is a national project. Instead, resettlement and rehabilitation plan should be well planned and practiced with same standards as a national project. For it, DFCCIL should have a special section in charge of resettlement and rehabilitation plan to implement land acquisition and resettlement in the field as prime responsible body and should conduct public consultation and negotiation with project-affected people, while MOR has asked concerned states for the land acquisition in the previous railway projects and the District Collectors had main responsibility for implementation of the land acquisition and compensation. At the same time, a mechanism should be established to monitor the status of implementation of actions proposed in the Study such as preparation of asset inventory, institutional set-up of DFCCIL, and policy of land acquisition and compensation.

109. An Environmental Working Group for the DFC project (EWG) was established under MOR for the Study, since there was no organization under MOR in charge of environmental and social considerations. EWG consists of MOR, MOEF, MORD, and academic advisors. Eight EWG meetings were held as of September 2007 to discuss about environmental and social considerations for the DFC project. In addition, field inspections by the academic advisors were conducted at several times.

110. Public Consultation meetings/Stakeholders Meetings (SHM) were held during the Study. First Stage SHM was conducted between January and February 2007 at ten states along the whole DFC project area. Second and Third Stage SHMs were held between June and July 2007 and between August and September 2007, respectively, at 37 districts along the priority DFC project area. In addition, village-level meetings were held between the Second and Third Stage SHMs. In the end of the JICA Study, a central level stakeholder/public consultation meeting was held on 28th September to disseminate the results of ESIMMS to the stakeholders and the public. In the initial stage of the SHMs, though MOR as project proponent did not participate in the SHMs, the DFCCIL personnel were participated in the several SHMs in the Third Stage SHM after regional officers of DFCCIL were appointed.

Some objections to the Project were raised by local peoples in the SHMs conducted in the Study. By taking this fact into consideration, MOR/DFCCIL should make their efforts to obtain consensus to the Project from the stakeholders including project-affected peoples. In addition, the

ESIMMS reports prepared in the Study should be opened to the public and obtain opinions from the public prior to the governmental approval of the reports.

111. In order to implement measures on environmental and social considerations adequately, environmental management has to be implemented in the pre-construction and construction phases based on the Environmental Management Plan (EMaP) proposed in the Study with implementing body and methods. In operation phase of the DFC project, effects of the measures including status of livelihood recovery of the project-affected people due to land acquisition and involuntary resettlement has to be monitored based on the Environmental Monitoring Plan (EMoP) proposed in the Study as well as establishing implementing body to implement necessary feedback actions based on the monitoring results.

XX. PROJECT COST ESTIMATE

112. [Defining the Scope of the Project] The Project cost estimate earmarked is total cost of the works of each phase that have development impact by its implementation. Cost items included in the project cost estimate are listed as follows:

1) Land acquisition, compensation; 2) Relocation of public utilities; 3) Reconstruction of the existing ROBs; 4) DFC Infrastructure construction; 5) ICD required to be built in Phase I-a; 6) Consultant fee (Survey, design, tender document preparation, tender assistance, construction supervision); 7) Procurement cost of locomotives; 8) Construction cost of depot; 9) Physical contingencies; 10) Price escalation; 11) Tax & duties; 12) Interest during construction.

Besides the above, wagons will be required, however its procurement cost were excluded from the Project cost since it is assumed to be procured by the railway freight forwarders. The cost for improvement of the existing lines was also excluded from the Project cost since this will benefit other lines than the DFC. The cost for the grade separation of the level crossings, which was included in the Project cost in PETS-II, was excluded from the Project cost as per the assessment made in paragraph no.54 3). Among the cost items excluded in the PETS-II, the cost items included in the JICA Study are items from 5) to 12). Among these, the Indian Railways (IR) is assumed to be the responsible executing agency for item 7) Procurement cost of locomotives and 8) Construction cost of depot. If Yen loan is the precondition, items 6) and, 7) to 12) need to be included in the Project cost.

113. [Project Cost Estimate] The cost estimate presented in PETS-II and Final Report were reviewed and recalculated as follows:

Table 3 Estimated Total Cost of the DFC Project

Description	Western Corridor (million Rs.)	Eastern Corridor (million Rs.)	Total (million Rs.)	Ratio
1) Construction Costs (DFCCIL portion)	163,938	110,540	274,477	54.9%
2) Construction Costs (IR portion)	717	0	717	0.1%
3) Rolling Stock Cost (EL by IR portion)	39,334	36,217	75,551	15.1%
4) Consulting Service Cost	5,432	3,419	8,851	1.8%
5) Physical Contingency	10,079	7,356	17,436	3.5%
6) Price escalation	18,838	13,749	32,587	6.5%
Sub-total	238,339	171,281	409,620	81.9%
7) Land Acquisition and Compensation	26,640	25,495	52,134	10.4%
8) Preliminary Expenses (Survey & Design)	742	491	1,232	0.2%
9) General Administration Cost	9,857	6,744	16,601	3.3%
10) Taxes	2,234	1,326	3,560	0.7%
11) Accrued Interest during Construction	9,608	7,102	16,710	3.3%
Total Project Cost:	287,420	212,437	499,857	100.0%

Description	Western Corridor (million Rs.)	Eastern Corridor (million Rs.)	Total (million Rs.)	Ratio
Items excluded from DFC Project Cost				
*Wagon & Depot Cost	20,999	16,004	37,003	
*New ROB Construction & Land Cost (PETS2)	30,605	21,962	52,566	

Note: * signify referential estimate.

The number of locomotives to be procured in Phase I-a are projected number sufficing the demand up to 2023. The Phase I-a Project cost is estimated as follows:

Table 4 Estimated Cost for DFC Phase I-a Development

Description	Western Corridor (million Rs.)	Eastern Corridor (million Rs.)	Total (million Rs.)	Ratio
1) Construction Costs (DFCCIL portion)	92,747	61,355	154,102	47.6%
2) Construction Costs (Depot – IR portion)	717	0	717	0.2%
3) Rolling Stock Cost (EL - IR portion)	39,334	36,217	75,551	23.3%
4) Consulting Service Cost	3,393	1,376	4,769	1.5%
5) Physical Contingency	6,770	4,913	11,683	3.6%
6) Price escalation	12,653	9,182	21,835	6.7%
Sub-total	155,615	113,043	268,658	82.9%
7) Land Acquisition and Compensation	16,339	15,143	31,482	9.7%
8) Preliminary Expenses (Survey & Design)	464	279	742	0.2%
9) General Administration Cost	6,164	3,923	10,087	3.1%
10) Taxes	1,332	540	1,872	0.6%
11) Accrued Interest during Construction	6,222	4,597	10,820	3.3%
Total Project Cost	186,136	137,526	323,662	100.0%

XXI. ECONOMIC AND FINANCIAL ANALYSIS

114. [Economic Analysis] According to the result of economic analysis, DFC construction with total investment cost of Rs.287,420 Million in Western DFC, and of Rs.212,437 Million in Eastern DFC, will generate benefits of 1.2 times in Western DFC and 1.4 times in Eastern DFC. There are many kinds of benefits. Measured benefits are; 1) time saving, 2) vehicle operating cost saving, 3) reduction of exhaust gas as is presented in paragraph 65 earlier. Direct benefits are to be generated by saving in operating cost of wagons, passenger cars, trucks, and buses. Cargoes and passengers, which would be affected by DFC, will also receive direct benefit of travel time saving. In terms of environmental effects, reduction of exhaust gas from trucks and buses are also measured. In this Study, 10 items of benefit were measured.

Total investment costs and maintenance and operation cost for 35 years were compared with total benefits during the same period at discounted present value of 2007. The Economic Internal Rate of Return is 14.09% for Western DFC, and 15.26% for Eastern DFC. When this index exceeds 12%, the investment is judged as being feasible. This high Economic Internal Rate of Return proves that the project generates large economic benefits for India, and that it is a very important national project.

115. [Financial Analysis] Total freight transport revenue was compared with necessary cost over 35-year project life period. Costs consist of construction cost, rolling stock cost, and of operation and maintenance cost. The costs were discounted to the present value of 2007. As the result, the Financial Internal Rate of Return was 9.08% for the Western DFC and 15.59% for the Eastern

DFC. Therefore, a long-term and stable low-interest financing is required to secure financial durability of the Project.

116. [Economic Impact (Multiplier) Analysis] Such huge projects, as the DFC give large impacts to socio-economies of India and the neighbouring countries. As soon as the project starts, various socio-economic activities would take place such as: (Investment) –> (Direct Demand) –> (Production) –> (Income) –> (Consumption) –> (Production). Through the process, employment, income, tax income and external trade (import and export) are to be affected and induced. Inter-Modal Research Unit measured the economic impacts or multiplier effects by using Input-Output Model or so-called the I/O model. In this study, the economic impacts were calculated and analyzed by using the model developed by the Inter-Modal Research Unit, as shown below:

Induced impact on production: 1,386 billion Rs.

Induced impact on gross value added (GVA): 700 billion Rs.

Induced impact on tax revenue: 22 billion Rs.

Induced impact on operating surplus: 249 billion Rs.

Induced impact on household income and employment: 372 billion Rs., 1.1 million people

Induced impact on international trade: export 50 billion Rs., import 67 billion Rs.

Among these induced impacts, the impact to household includes to the poor. According to the Planning Commission, number of the poor in India is estimated as approximately 190 million in 2004/05. These people are expected to receive the income increase and the employment expansion as well as the travel time saving benefit, which was measured in the economic evaluation.

117. [Regional Development Effects] The DFC Project is expected not only to vitalize national whole economy, but also to grow regional socioeconomic situation. Acceleration of regional development is considered a key from a viewpoint of the national development planning. Various effects, as shown below, can be foreseen by implementing the DFC project.

Acceleration of Nationwide Development

The DFC Project will shorten time distance of Delhi - Mumbai and Delhi – Sonnagar by approximately 1/3 (comparison of average travel speed). Industrial and social activities in related areas are expected to be vitalized by the reduced time distance. These new conditions will stimulate development of core cities along the corridors. These development will cause a proper wide-area regional development through job provision and reduction of income disparities.

Promotion of Industry

One of the most important impacts on regional development by the DFC Project is the location and relocation of manufacturing plants. Since the DFC Project will offer speedy and scheduled transport of raw materials and products, new factories and facilities of relevant businesses will be constructed.

The DFC is expected to be developed at an earliest stage, because the project is one of basic premises of the “Delhi-Mumbai Industrial Corridor (DMIC), for which concerned government agencies of India and Japan as well as private firms have been intensifying their activities in these days. The project will have an important role to promote industrial development along the area.

Promotion of Agriculture, Forestry and Fisheries

The DFC will provide faster and reliable transport between agricultural and forestry area and markets

as well as food and wood processing plants. Therefore, this will expand production areas as well as consumption areas in agriculture and forestry industries. In the same manner, seafood products market will be expanded because transport time is to be shortened between coastal area and inland area. In this way, the project will promote the agriculture, forestry and fishery industries on a large scale, which is one of the key policy issues of the country.

Improvement of Living Standard

The DFC will alleviate traffic congestion of passenger and freight transport both on roads and railways in India. Convenience and comfort of passengers would also be improved by the project. Accessibility to hospitals, schools and government offices will be improved indirectly. People will be able to use these facilities easier than before. As a result, living standard of the people along the DFC will become better and it will secure their livelihood in the same manner as the provision of job opportunities and household income increase.

XXII. CONSIDERATION OF THE EXECUTING AGENCY AND ITS BUSINESS PLAN

118. Through independent efforts made since 2001 of increasing business efficiency, and some assistance from ADB and World Bank, the Indian Railways managed to improve its productivity, generate more revenue, and increase its net revenue in 2006-07 to 148.7 billion Rs. (410 billion Yen), which is a spectacular increase of 6.3 folds compared to 2001-02. The source of this revenue is from freight transport, and MOR is confident in actively undertake the implementation of the DFC Project.

119. To recover the lost railway market share, which would increase the DFC business revenue, the following two measures are required: 1) Development of rail-side Warehouse & Logistic Park which is a connection point of integrated logistic system between long distance rail transport with road transport; 2) Establishment of mechanism that guarantees the arrival date of freight that would recuperate the credibility for safety and reliability. Also in line with the assumed structure of demand, an establishment of strategic fare by commodity and by transport distance is important. It is also important to sustain, in the DFC, the improved productivity in the railway utilisation, personnel productivity and wagon productivity, which are all realised in the past 5 years, and which resulted in the increase of the railway transport ton kilometre.

120. It is essential for IR to restore the past high market share in the trunk industrial corridors in order to support expected high GDP growth and industrialization. In this sense, DFC is most expected development project. Aiming at the target, DFC has to go through reforms to get out from the old regime. Two target figures are needed for monitoring the degree of the achievement as the minimum requirements.

1) Railway Container market share: Western Corridor 35%

This is an index which monitors the development, enhancement and prevalence of "Customer Oriented Business Development" in DFCCIL and IR.

2) Operating Ratio: DFC (35%), Western Corridor (30%)

This is an index which monitors achievement of high target of railway transport productivity in Canada and USA by DFC,

121. Recommendation is given for the following so that DFCCIL will be able to carry out its day-today management independently: 1) separating the accounting system from that of Indian Railways to secure the increased revenue from DFC; 2) giving function and autonomy for project planning, and operation & business development; 3) establishment of DFC Railways under the MOR, which is equivalent structure of Zonal Railways under MOR, that would collectively

manage and take on a role as a marketing front line for freight transport services.

122. The DFC Railway shall own locomotives, drivers and wagons, will provide transport services to the licensed 15 container and bulk transport companies according to the concession agreement and collect transport charges. The DFC Railway will also enter long-term contracts with major customers for transport services and receive transport charges from them. On the other hand, the DFCCIL will receive Track Access Charge (TAC) from DFC Railway and Zonal Railways for freight transport services taken on lines other than DFC, based on the concession agreement entered with them. The Zonal Railways will receive transport and haulage charge from customers as revenue, and this will be then dispersed to DFC Railway based on the revenue allocation system which have been used by the Zonal Railways.

123. Reviewing the forms of TAC of countries in the world (Europe, North America and Japan) we found concepts and rules are different from country to country. Therefore, the Study Team concluded that there is no best way both theoretically and practically. The Study Team recommends English business model, in other words, "Costs and returns model", because DFCCIL is a Public Sector Undertakings.

124. Necessary amount of the fund for the DFC is estimated as approximately 500 billion Rs. Construction work is planned in three phases. Based on an assumption that financial resources consist of self-finance (annual interest rate: 6.5%), Yen Loan (0.4%), other international lending agencies (6%) and commercial loans (12%), cash flow projections were conducted.

125. Risk analyses were conducted for the following four cases: 1)Project risk assuming the recuperation of railway market share has failed and annual GDP growth rate is 5%, which is lower than the assumed rate by 2%; 2)Organizational risk in which 20% of DFC revenue is sunk in the Zonal Railways; 3)Operating ratio risk in which the standard ratio is not achieved, 4)Interest rate risk of unavailability of fund from international lending agencies and replaced by commercial loans; 5)Implementation risk of cost overrun of 50% with 2-year completion delay, 6) Revenue risk in recovering middle and long distance transport market by the strategic tariff formation failure, 7)Composite risk in which business risks and implementation risks occur simultaneously. As a result, the analyses showed better performances than the minimum acceptable values of average DSCR (1.2) and ROE (6%) in any cases.

XXIII. PROJECT IMPLEMENTATION PLAN

126. [Project Implementation Schedule] The official request for Official Development Assistance from the Government of India was made to the Japanese Government in June 2007. The Project implementation plan was devised assuming that the Yen Loan will be extended. All projects implemented by the Yen Loan requires to comply with the procurement guidelines established by JBIC, which stipulates the tender process and preparation of tender document, for employing consultants as well as procuring contractors. The following assumptions were made for the time required for the tender process and preparation of tender documents:

1) Procurement of consultants under international competitive bidding	10 months
2) Procurement of material/preparation of tender document	6 months (for procurement of material), 12 months (for preparation of tender document)
3) Procurement of suppliers that procures the goods	4 months
4) Procurement of contractor under international competitive bidding	12 months

On the other hand, the following activities were considered as critical issues for the implementation of the Project:

i) Land acquisition / compensation: 18 months is required from the day the subject land is identified until the day of commencing with the works.

ii) Reconstruction of existing ROBs: Coordination with road authorities, time is required for land acquisition.

iii) Civil works: Works that need to take a head start among all works.

iv) Procurement of ballast and sleepers: Materials that require procurement in advance to the commencement of the works, due to constraint in production capacity.

v) Design and production of locomotives: Approximately six years from the award of contract to the supplier is required for the processes of detailed design, approval, production of prototype, and it's testing.

Considering the above issues, based on the phased development scenario, two options for the implementation of the Phase I-a Project were conceived.

Option-1: Assumes that all the works eligible for Yen Loan are covered by Yen Loan. In this case, the Government of India is to bear 17.4% of the total Project cost.

Option-2: Assumes that the cost for civil works - which are considered as critical activity, procurement of 30% of the ballast and sleepers required, preliminary engineering design of the locomotives, are borne by the Government of India. In this case, the Government of India is to bear 33.4% of the total Project cost.

The Phase I-b is assumed to commence in 2008 by Indian Government funds, and a minimum of two years lead time is required until the commencement of works funded by international lending agencies. Hence, the duration of the Phase I-b Project is assumed to take 8 years. Among the Phase II Project, the assumption was made that the section between Rewari and Dadri require an additional 2 (two) years for additional engineering survey, basic design, and EIA study. Also, from the demand situation, the JST judged that the commencement of works for the section between Sonnagar and Mughal Sarai can be deferred for two years.

As the result, the completion of the DFC project is estimated to be eight (8) years in 2015-2016 after concluding the loan agreement (L/A) for Phase I-a Project.

127. [Project Implementation Structure] The Phase I-a Project alone amounts to more than 1,600km of new railway line, and in order to complete within the scheduled timeframe, a firm implementation structure is required to be setup. DFCCIL is the executing agency responsible for the construction of infrastructure, in which the DFCCIL is contemplating of forming a lean management organisation, and outsource human resources for the implementation of the Project. If the Project is financed under Yen Loan (STEP), a project implementation system, which complies to JBIC Guidelines and differs from those adopted by the Indian Railways for the implementation of past railway projects becomes a mandatory procedure, which includes procurement of consultants, and employment of contractor(s) by international competitive bidding. Thus, for the implementation of the Project, an employment of an international consultant as the General Consultant (GC) will be required for overall project management. The GC will carry out the detailed design, preparation of the tender document, assist the tender, supervise the works, and carry out the training of the operation and maintenance.

In Phase I-a, a Core Team of the GC will be positioned in the centre for the overall management of the Project, and Zonal Management Teams (ZMT) will be positioned on each Corridor, and under the ZMT, Divisional Supervision Team (DST) will be positioned to supervise the works on site. The ZMT would coordinate with headquarters of the Zonal Railways in each region, and manage and monitor the activities of the respective DST, and report to Core Team. The DST shall liaise and coordinate with the District office under the Zonal Railways, carry out daily site supervision.

The proposed organisational structure is presented in the following Figure 3-(1) and Figure 3-(2).

XXIV. COMPREHENSIVE EVALUATION OF THE PROJECT

128. [Evaluation of Technical Feasibility] Phase I-a project and proposed technologies concerning the plan, which the Study Team proposed, were evaluated feasible. With regard to the Flat DSC transport system for the Western Corridor, which is proposed by the PETS2 report, was not proved in any commercial operations. The system was evaluated as not feasible, because of technical feasibility. The Study Team proposes the Well type DSC system, which has been proved already. The existing ROBs in urban areas, which need to be reconstructed included in Phase I-b project and Phase II project, are considered to give negative environmental impact to the near by residents very seriously as well as the reconstruction work is foreseen technically very difficult. Therefore, technical feasibility of the ROB reconstruction should be examined carefully from now on.

129. [Evaluation of Feasibility on Social and Environmental Considerations] With regard to the Phase I-a project, the Study Team judged that serious negative impacts to natural and social environment would be avoided and/or minimized, if the FLS is completed, and then the Environmental Management and Monitoring Plans and Framework of Resettlement and Rehabilitation Plan are adequately implemented by the Indian side according to the guideline design, which the Study Team has offered. A large scale relocation program, reconstruction of urban ROBs and construction of a new tunnel are schedule in Phase I-b project and Phase II project. Serious negative impact to social environment in the concerned areas could be occurred, if present DFC development implementation plan is executed as it is. The Study Team judged that careful and further examination of the plan should be carried out. On the other hand, modal shift from road transport to railway transport will be realized by the implementation of DFC, which would reduce energy consumption of India and also reduce the green house gas. It was confirmed, consequently, that DFC would improve the social and natural environment in the concerned region tremendously in this sense.

130. [Evaluation of Feasibility on Organizational Aspect] Infrastructure portion of DFC is to be constructed and maintained by the newly organized DFCCIL. The DFCCIL has been just established and its organization is being expanded towards DFC development. MOR changed its policy to enlarge responsibilities of DFCCIL and established a new section in DFCCIL, which tends to have a function of marketing. Many concerned personnel has a similar opinion that DFC would be equipped with a completely different new system from IR both in terms of hardware and software, and that they would make the success of the DFC project to be a trigger to rationalize/innovate the existing IR. This innovative willingness of the Indian side will certainly contribute to the realization of the DFC, although feasibility of the innovation in organizational/institutional aspects can not be evaluated at the moment.

131. [Evaluation of Feasibility on Economic/Financial Aspect] Economic analysis proved the feasibility of the DFC project for both the Western and Eastern Corridor. The Eastern Corridor was proved in financial feasibility as well. However, low interest loans are crucially necessary to secure the financial feasibility of the Western Corridor, because FIRR of the Western Corridor stays at around 9%.

The economic and financial analysis of the priority section of the Phase I-a Project concluded a figure slightly lower, but a close internal rate of return, than that of the overall Project. This confirms that the implementation of the Phase I-a Project alone is capable of generating sufficient impact, and the economic impact analyses carried out by the JST in this Study proved huge impacts such as inducing increase in production, increase of gross added value, increase of tax revenue, increase of household income, and increase of employment. Even if there is delay or suspension for the implementation of projects other than Phase I-a, the implementation of Phase I-a Project is independently viable.

132. [Evaluation of Feasibility on Definition of Project Scope] Project scope of the Study includes DFC railway infrastructure construction accompanied by reconstruction of the existing ROB

along the Corridors as a main portion, "construction of new ICD" which is to be developed by DFCCIL and "procurement of electric locomotive and construction of locomotive depot" which is to be done by IR as supplemental portions. This definition of the project scope is considered appropriate when Yen-Loan is prerequisite because the definition includes factors which are necessary to make the project to function as expected, and the project is characterized as highly public service oriented and factors which will be used almost exclusively for DFC. The PETS2 included the ROB construction works at all intersections with roads along DFC alignment. However, the construction of ROBs can not be justified in terms of feasibility of technical, economic and social/environmental considerations. In addition to this, ROB was not justified to include to the Project when considering about the exclusive use by DFC. Therefore, ROB construction works were excluded from the scope of the Study. The Study Team proposes that the MOR would construct the ROBs as an independent project according to an adequate construction schedule. It should be noted that land acquisition, compensation for relocation and necessary consultancy services are included in the Project scope.

As for the branch line section between Asaoti and Tuglakabad ICD of the Western Corridor, JST concludes that this section be excluded from the DFC project scope due to the envisaged difficulty of reconstruction of existing ROB on the section, limited capacity expansion of TKD ICD yard and the difficulty of land acquisition. The transport of containers on this section can be managed by strengthening the transport capacity by improvement of existing lines.

133. [Evaluation of Feasibility on Project Implementation] The Study Team proposes that Phase I-a project would start construction works in 2008/09 and that construction period would be 6 years. This proposal would be realistic in terms of construction period when Indian side finishes land acquisition as scheduled. Construction period of the Phase I-b project will be 8 years considering necessary time for the above mentioned technical issues. The Phase II project needs 2-year lead time to examine and solve the new tunnel construction issue. An effort by the Indian side to solve the above issues during the lead time critically affects successful DFC project implementation as planned in this Study.

XXV. RECOMMENDATION AND CONCLUSION

134. [Conclusion] The DFC Project is concluded to be a project with overall economical and financial high investment value.

Phased Development Scenario

The implementation of Phase I-a Project is judged to be reasonable in engineering terms, and in terms of environmental aspects as well - with appropriate measures proposed in the report are executed, the impact on the environment and society can be minimised. Also, the necessity of the Project is justified by the projected demand, hence urgent implementation of the Project is strongly recommended.

With regard to Phase I-b Project, its implementation is inevitable due to the serious traffic situation. However there are sections in which technical and environmental issues need to be solved which require maximum effort by the Government of India for its resolution prior to the start of construction.

With regard to the implementation of Phase II Project, the traffic situation of the relevant sections are not serious at current, but the plan of the tunnel section would require careful investigation and examination in the technical and environmental aspect which require continuous and maximum effort by the Government India.

Optimal Technical Option

After careful and detailed study of various options, the following technical options were judged as optimum for the DFC development: Electrification on both Western and Eastern Corridor

- The traction system shall be electrified on both western and eastern corridor.
- Container transport system for the Western Corridor shall be the Double Stack Container (DSC) with the "Well Type";
- Container transport system for the Eastern Corridor shall be the Single Stack Container (SSC);
- Access to the TKD shall be through an improved existing railway line, not through the DFC;
- Clear standing room (CSR) at stations shall be 750m (Land acquisition shall be 1,500m preparing for future traffic demand); and,
- Construction of Road Over Bridges (ROBs) along the existing railway lines was not included in the Project. This shall be developed by the Indian side.

Environmental and Social Consideration

Out of all the Project sections, some sections were deemed to have significant impact on social environment. In addition, some dissenting opinions against the Project were raised by the local residents at the Stakeholder meetings. Thus the JICA Study Team (JST) emphasises in the conclusion and recommendation of the Study that it is crucial for DFCCIL and MOR to make maximum effort to build consensus with the local residents for the implementation of the Project. It was also judged indispensable for the smooth implementation of the Project that appropriate land price is fixed for necessary land acquisition, earlier completion of the relocation plans and prompt procedures for the land acquisition and the relocation.

Railway Management Plan

It was confirmed that an institutional set up of a totally independent management is necessary for a rapid and an independent decision making. In addition to this, introduction of modernized railway technologies and system is a must for the sound railway operation. The Dedicated Freight Corridor Project is merely a part of the whole freight transport system. Throughout the course of the Study, it was confirmed that the relevant intermodal facilities and service of the system need to be developed in order for the Project investment to be effectively utilised and for the expected various effects of the Project. It was concluded that MOR/DFCCIL need to take initiative in approaching the relevant authorities for the realisation of the total transport system development.

135. [Actions Need to be Taken] The following actions need to be taken by the Government of India for the smooth implementation of the Project:

1) It is imperative that the fund raising for the Project is be arranged at favourable terms for the success of the whole Project. It is advised that the Government of India deliberate on the necessity of funds from international lending agencies such as ADB and World Bank in addition to the funds from Japan, for the implementation of the Project including the implementation of Phase I-a Project and start consultation with them.

2) Necessary funds to cover the cost for land acquisition and advanced implementation of work are arranged immediately by the Government of India.

3) The completion of the preliminary engineering design and Final Location Survey of the facilities covered in Phase I-a should be made by December 2007.

4) With regard to the existing ROBs, which are major obstacles of the Project, immediate execution of engineering survey and preliminary engineering design of the existing ROB subject to reconstruction should be made. Prior to the work, discussions with the road authorities should be commenced as soon as possible.

5) Immediate decision should be made by the MOR on the technical options proposed in the JICA Study Report.

6) With regard to the construction of the new ICD between Rewari - Delhi, which is necessary for the Western Corridor Phase I-a Project, immediate decision making should be done considering the proposal made in the JICA Study.

7) If the Government of India is contemplating to finance from international lending agencies, including he Yen Loan, after a thorough examination, the evaluation and approval of the environmental and social consideration study by the Government of India is a prerequisite. The above procedure need to be executed in a timely manner.

8) In view of dissenting opinion against the Project received in the Stakeholder Meetings, which originates from the experiences in past projects with inadequate compensation and assistance related to the land acquisition and resettlement, continuous effort for consensus building of the residents residing along alignment is required through public consultation meetings initiated by MOR/DFCCIL, by considering that some objections were raised by local peoples during the stakeholder/public consultation meetings of the Study based on the experiences in the previous public infrastructure projects with inadequate compensation and assistance in terms of the livelihood recovery

   The following are required to implement in preparation of detailed resettlement and rehabilitation plan.

· Market price survey on land should be conducted for land and assets of the project-affected peoples based on the results of the Final Location Survey.

· Compensation policy of the DFC Project should be finalized based on the Market Price Survey.

· The squatter or illegal occupants should be involved in the public consultation process of the project not to plunge them into the poverty due to the relocation under the project.

9) Implementation of the following are required in implementation of the resettlement and rehabilitation plan.

   Based on the result of FLS, a survey on market price for the land and assets to be acquired from the project –affected peoples,

   The compensation policy should be prepared based on the survey,

   The illegal occupants or squatters residing in Right of Way (ROW) should be involved in the consultation process to take adequate considerations and measures to avoid making poorer after the relocation,

   In implementations of the relocation, at the same time when DFCCIL employ the international consultant for the internal monitoring, other international consultants should be employed by the donor for the external monitoring.

10) Actions for improvement towards the intermodal transport is necessary regardless of the DFC Project. It is imperative that MOR/DFCCIL take initiative in making immediate actions in establishing the Intermodal Transport Improvement Taskforce as was proposed in the Report.

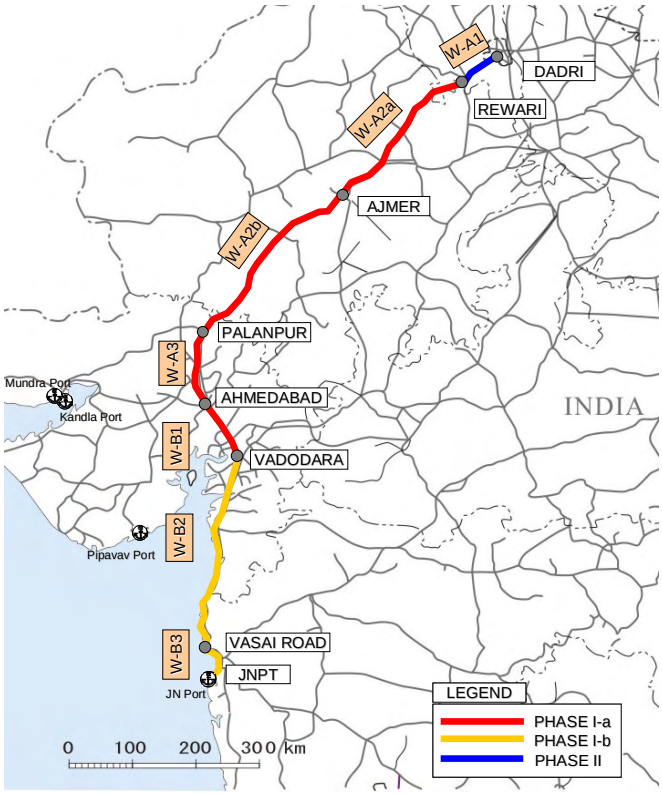


Figure 1 - (1) Phased Development Scenario of DFC Western Corridor

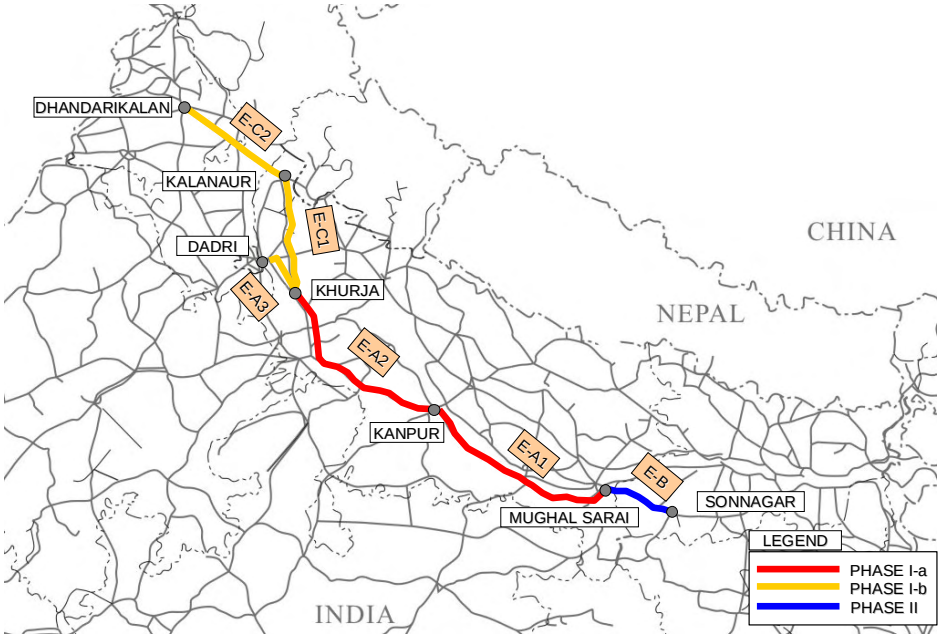


Figure 1 - (2) Phased Development Scenario of DFC Eastern Corridor

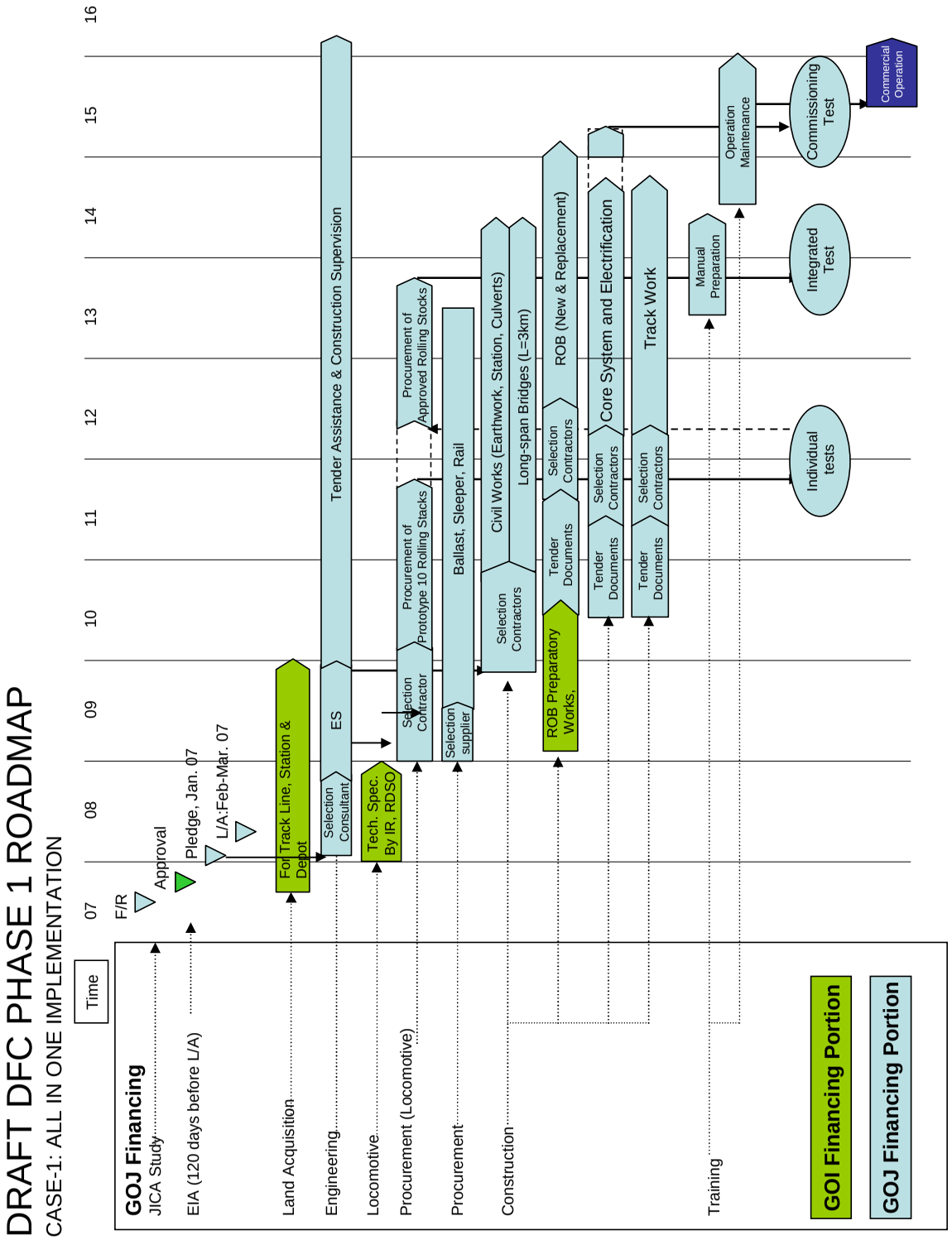


Figure 2 - (1) Project Implementation Schedule (Totally Financed by ODA)

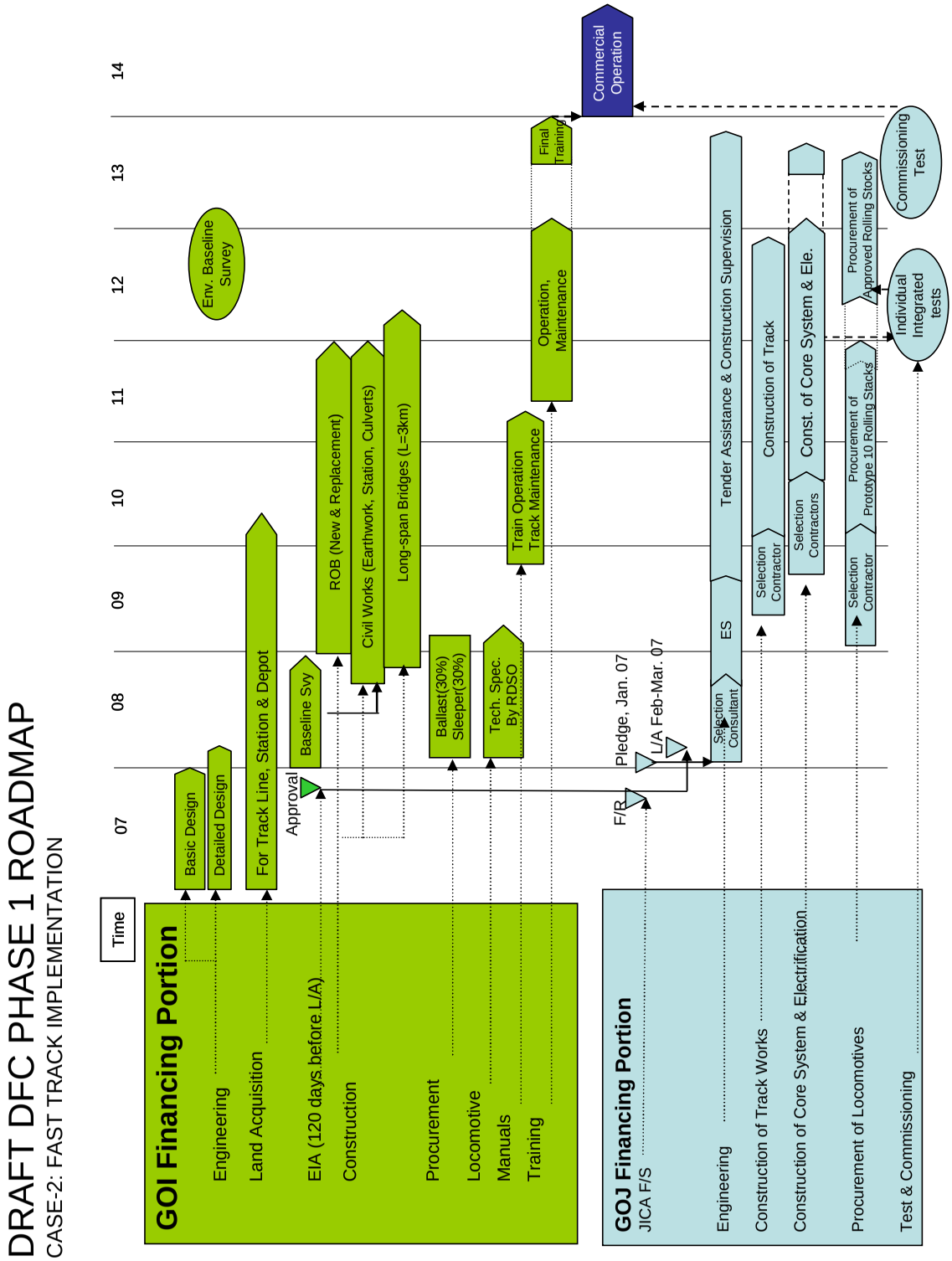


Figure 2 - (2) Project Implementation Schedule (Jointly Financed by GOI and ODA)

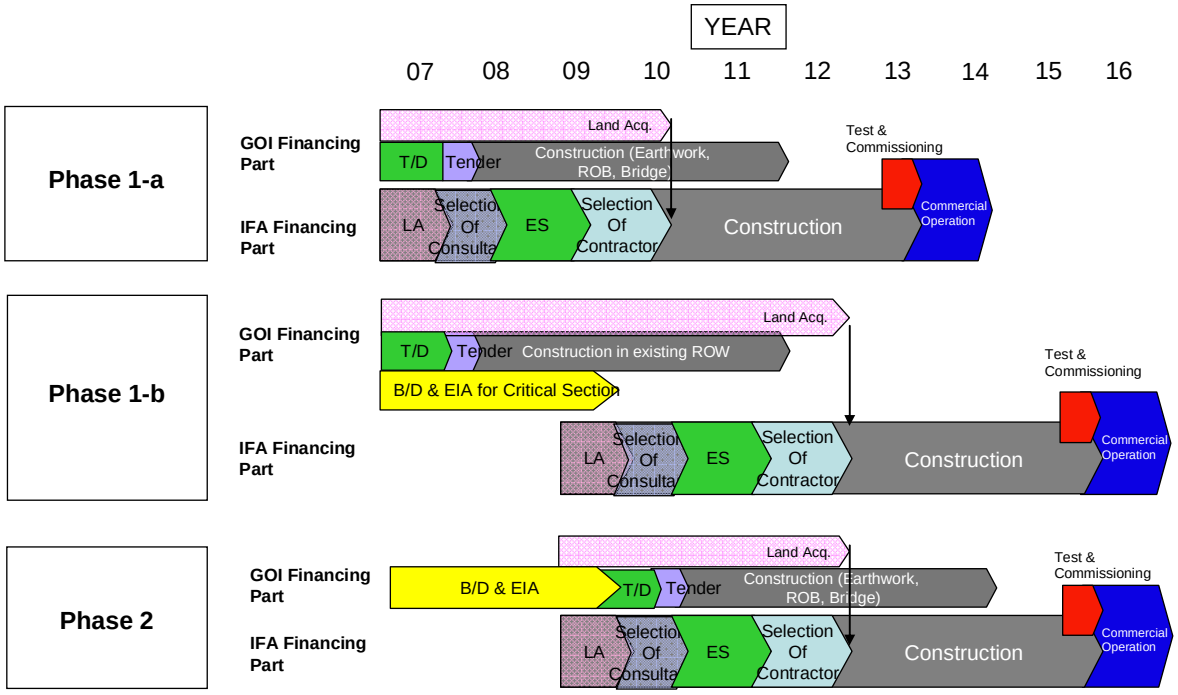


Figure 2 - (3) Overall implementation schedule

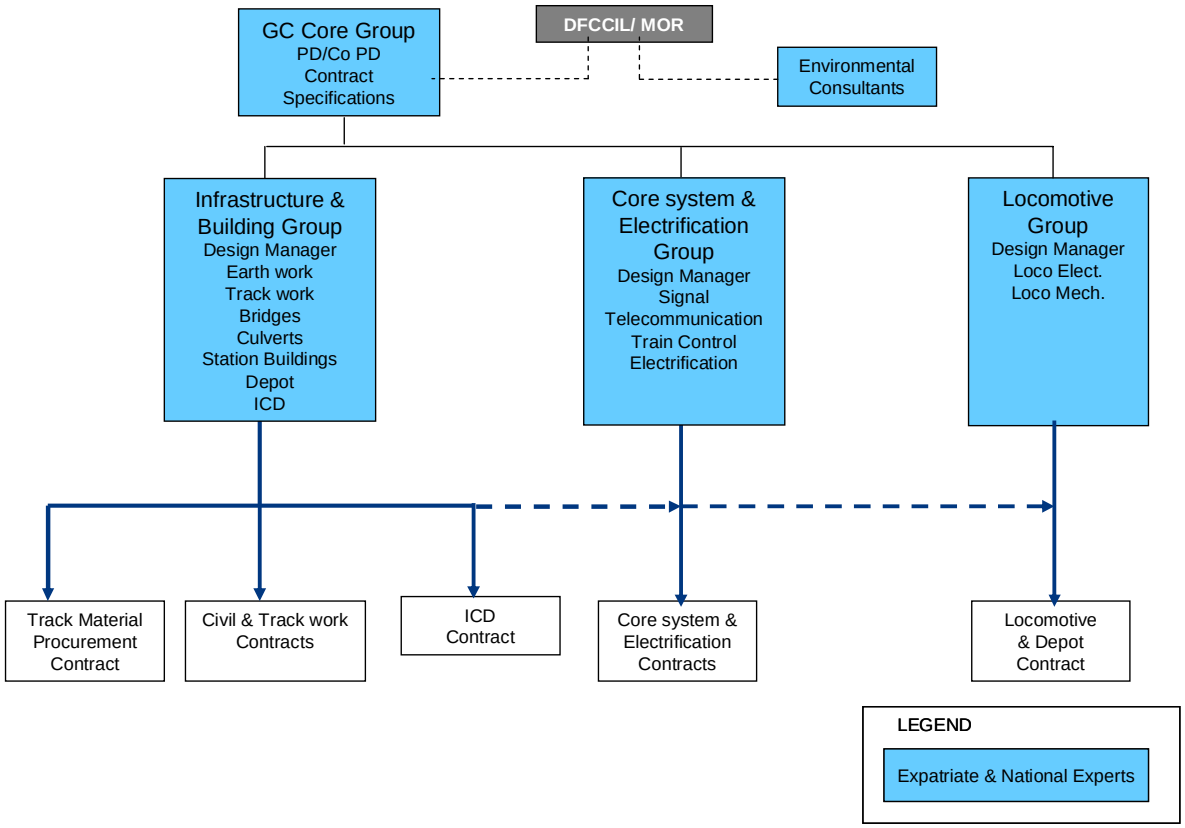


Figure 3 - (1) Organization Structure of Design and Tender Stage

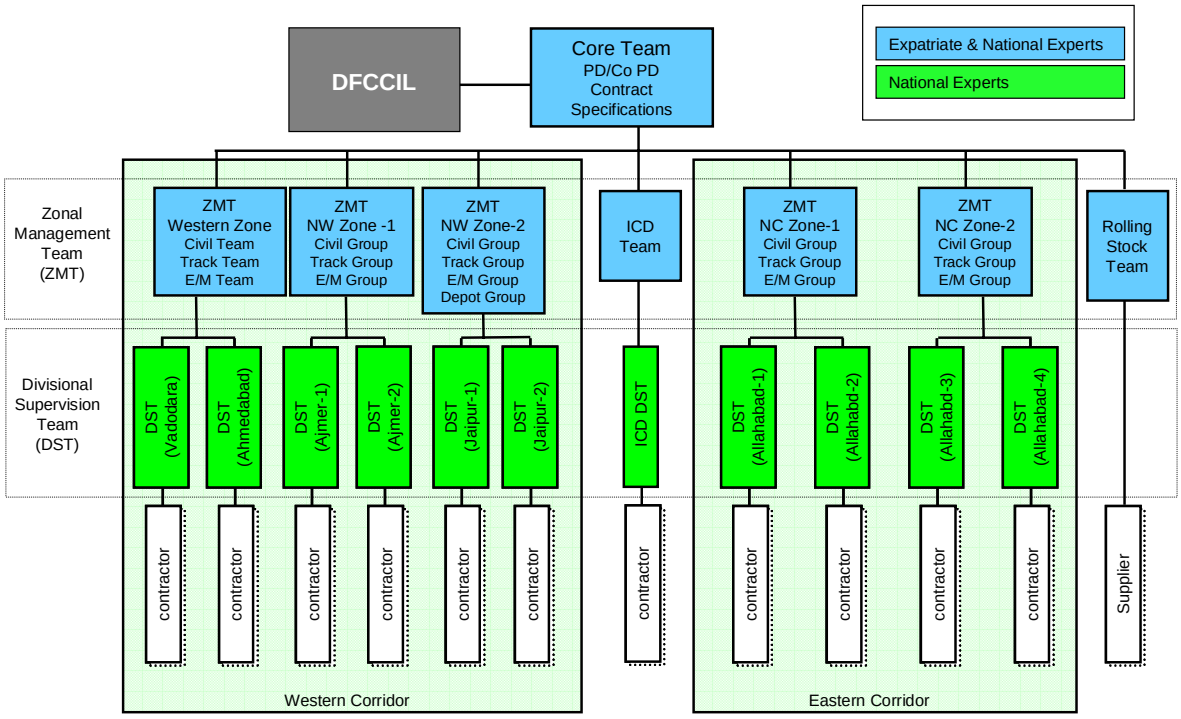


Figure 3 - (2) Organisation Structure of Construction Supervision Stage

ABBREVIATIONS LIST

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A	AAR	Association of American Rairoads
	ABB	Air Blast Breaker
	ABS	Absolute Blocking System
	AC	Super high voltage transmission
	ACD	Anti-Collision Device
	ADB	Asian Development Bank
	ADI	Ahmedabad Division
	ADV	Advisior
	AF	Audio Frequency
	AFTC	Audio Frequency Track Circuit
	AGA	Agra
	AGC	Agra Division
	AII	Ajimer Division
	ALD	Allahabad Division
	AM	Additional Member
	AOH	Additional Overhaul
	AP	Andhra Pradesh
	APSEB	Andhra Pradesh State Electricity Board
	ARE	Automatic Air Brake System
	ARTC	Australian Rail Track Corporation
	ASN	Asansol Division
	AT	Auto-transformer
	ATC	Automatic Train Control
	ATO	Automatic Train Operation
	ATP	Automatic Train Protection
	ATS	Automatic Train Stop
	ATSP	Automatic Train Stop Control with Speed Pattern Profile
	AUG	Aurangabad
	AWR	Alwar
	AxC	Adoption of Axle Counter
B	BCCL	Bharat Coking Coal Limited
	BCLA	Container Wagons with Automatic Couplers
	BCLB	Container Wagons with Fixed Coupler
	BESCOM	Bangalore Electric Supply Company
	BG	Broad Gauge
	BHEL	Bharat Heavy Electrical Limited
	BKI	Bandikui
	BMA	Bangalore Metropolitan Area
	BMP	Bangalore Mahangara Palika (Bangalore City Government)
	BMRTL	Bangalore Mass Rapid Transit Limited
	BNW	Bhiwani

	BPAC	Block Proving by Axle Counter
	BPK	Billion Passenger Km
	BRD	Baroda
	BRDA	Bangalore Regional Development Authority
	BSC	Base Station Controllers
	BSS	Base Station System
	BT	Booster Transformer, Boosting Transformer
	BTKM	Billion Tonne Km
	BTS	Base Transceiver Station
	BTU	British Thermal Unit
	BVH	Ballabgarh
	BWSSB	Bangalore Water Supply and Sewerage Board
C	CAD	Computer Aided Dispatch
	CAGR	Compound Annual Growth Rate
	CAPEX	Capital Expenditure
	CARG	Compound Annual Rate of Growth
	CAS	Collision Avoidance System
	CCEA	Cabinet Committee of Economic Affairs
	CCGT	Combined Cycle Gas Turbine
	CCH	Chinchwad
	CCI	Chamber of Commerce and Industry
	CCL	Central Coalfields Limited
	CDM	Clean Development Mechanism
	CDMA	Code Division Multiple Access
	CEA	Central Electric Authority
	CERC	Central Electricity Regulatory Commission
	CFA	Cash Flow Projection
	CFS	Container Freight Station
	CL	Curve Length
	CLS	Colour Light Signal
	CLW	Chittaranjan Locomotive Works
	CM	Construction Management
	CMA	Chennai Metropolitan Administration
	CMDA	Chennai Metropolitan Development Authority
	CMR	Construction Manager
	CMS	Cast Manganese Steel
	CMWSSB	Chennai Metropolitan Water Supply and Sewerage Board
	CNB	Kanpur
	CNG	Compressed Natural Gas
	CNOC	Consolidated National Operations Center
	CO2	Carbon Dioxide
	CONCOR	Container Corporation of India Ltd.
	CPT	Chennai Port Trust
	CR	Central Railway

	Cr.	Crore
	CRCS	Computerized Route Control System
	CRIS	Centre for Railway Information Systems
	CS	Crossing Station
	CSO	Central Statistics Organization
	CSR	Clear Standing Room
	CTC	Centralized Traffic Control System
	CTCC	Centralized Traffic Control Centre
	CWSS	Cauvery Water Supply Scheme
D	DB	Design & Build
	DBB/ DBD	Design-Bid-Build
	DBOM	Design-Build-Operate-Maintain
	DCT	Double Coupled Train
	DDR/ DER	Dadri
	DEC	Delhi Cantt
	DFC	Dedicated Freight Corridor
	DFCCIL	DFC Corporation of India Ltd.
	DGPS	Differential GPS
	DH	Diamond Harbor
	DHN	Dhanbad
	DL/ DLI	Delhi
	DLW	Diesel Locomotive Works
	DMRC	Delhi Metro Rail Corporation
	DMRTS	Delhi Mass Rapid Transport System
	DO	Dausa
	DPC	Dedicated Passenger Corridor
	DR	Detailed Railway Noise and Vibration Survey
	DRB	Detailed Railway Noise and Vibration Survey at Bridge
	DRP	Detailed Railway Noise and Vibration Survey at Plain Route
	DSC	Double-stack container
	DSS	Double Slip Switch
	DT	Double Track
	DTMF	Dual Tone Multi Frequency
	DUA	Distant Urban Area
E	ECL	Eastern Coalfields Limited
	ECR	East Central Railway
	EDI	Electric Data Interchange
	EGNOS	European Geostationary Navigation Overlay Service
	EIA	Environmental Impact System
	EIRENE	European Integrated Railway Radio Enhanced Network
	EIRR	Economic Internal Rate of Return
	EJR	East Japan Railway
	ELI	Existing Line Improvement
	ELL	Electric Leveling Luffing

	EMaP	Environmental Management Plan
	EMC	Electromagnetic Compatibility
	EMoP	Environmental Monitoring Plan
	ER	Eastern Railway
	ERTMS	European Rail Traffic Management System
	ES	Engineering Services
	ESA	European Space Agency
	ESCS	Environment and Social Consideration Study
	ESIMMS	Environmental and Social Impact Mitigation Measures Study
	ETCS	European Train Control System
	ETSI	European Telecommunication Standards Institute
	EU	European Union
	EUDL	Equivalent Uniformly Distributed Load
	EWG	Environmental Working Group
F	F/S	Feasibility Study
	FCL	Full Container Load
	FDI	Foreign Direct Investment
	FDMA	Frequency Division Multiple Access
	FIRR	Financial Internal Rate of Return
	FL	Formation Level
	FLP	Freight Logistic Park
	FLS	Final Location Survey
	FO	Freight Operations
	FOIS	Freight Operations Information System
	FS	Feasibility Study
	FSW	Friction Stir Welding
G	G.Noida	Greater Noida
	GADEROS	Galileo Demonstrator for Railway Operation System
	GAIL	Gas Authority of India Limited
	GAR	Guntur
	GBAS	Ground-based Augmentation System
	GC	General Consultants
	GDP	Gross Domestic Product
	GGC	Gangapur City
	GHz	Giga Harzs
	GIS	Geographic Information System
	GL	Ground Level
	GNSS	Global Navigation Satellite Systems
	GOI	Government of India
	GOJ	Government of Japan
	GOM	Government of Maharashtra
	GPRS	General Packet Radio Service
	GPS	Global Positioning System
	GQ	Golden Quadrilateral

	GSDP	Gross State Domestic Product
	GSDP	Gross State Domestic Product
	GSDPi(y)	GSDP of state in the year
	GSM	Global System for Mobile communication
	GSM-R	Global System for Mobile Communication for railway applications
	GT	Gas Turbine
	GTI	Gateway Terminal India
	GTO	Gate Turn Off Thrystor
	GU	Gujarat
	GZB	Ghaziabad
H	H.P.	Himachal Pradesh
	ha	Hectare
	HH	Head Hardened
	HLR	Home Location Register
	HO	Head Office
	Hp	Horse Power
	HPGCL	Haryana Power Generation Co. Ltd.
	HSR	Hisar
	HT	High Tension
	HWH	Howrah
	HYC	Hydrabad
	Hz/	Hertz
I	IA	Intersection Angle
	IBS	Intermediate Blocking System
	IC	Independent Consultant
	IC	Inspection C
	IC	Radio Frequency Identity
	ICCP	Information and Community Consultation Programme
	ICD	Inland Container Depot
	ID	Identification
	IE	Independent Engineer
	IEC	Ineternational Electrotechnical Commission
	IEE	Initial Environmental Examination
	IGBT	Insulated Gate Bipolar Transistor
	IGM	Import General Manifest
	IMO	Independent Monitoring Organization
	IOH	Intermediate Overhaul
	IP	Intersection Point
	IPCC	Intergovernmental Panel on Climate Change
	IPGCL	Indraprastha Power Generation Co. Ltd.
	IR	Indian Railways
	IRR	Internal Rate of Return
	IRR	Inner Ring Road
	ISO	International Organization for Standardization

	ISO	International Organization for Standardization
	IWT	Inland Water Transport
J	J Yen	Japanese Yen
	J&K	Jammu and Kashmir
	J.N. Port	Jawaharlal Nehru Port
	JAI	Jaipur
	JARTS	Japan Railway Technical Service
	JBIC	Japan Bank for International Cooperation
	JETRO	Japan External Trade Organisation
	JICA	Japan International Cooperation Agency
	JN	Junction
	JNPCT	Jawaharlal Nehru Port Container Terminal
	JNR	Japanese National Railways
	JOD	Jodhpur
	JR	Japan Railway
	JS	Junction Station
	JST	JICA Study Team
	JV	Joint Venture
K	KBI	Knorr-Bremse India
	KBPS	Kilo Bites Per Second
	KDS	Kolkata Dock System
	KEB	Karnataka Electricity Board
	KoPT	Kolkata Port Trust
	KPCL	Karnataka Power Corporation Limited
	KPR	Kanpur
	KPTCL	Karnataka Power Transmission Corporation Limited
	KRCL	Konkan Railway Corporation Ltd
	KUIDFC	Karnataka Urban Infrastructure Development & Finance Corporation
	KUWS&DB	Karnataka Urban Water Supply and Drainage Board
L	LCL	Less than Container Load
	LCX	Leaky Coaxial Cable
	Leq	Equivalent noise level
	LNG	Liquefied natural Gas
	lpcd	Litre per capita per day
	LT	Low Tension
	LUD	Ludhiana
	LWR	Long Welded Rail
M	M	Million
	M.P.	Madhya Pradesh
	MAL	Malanpur
	MARS	Multi Access Reservation System
	MCL	Mahanadi Coalfields Limited
	MDB	Moradabad
	MDP	Mandideep

	MEPZ	Madras Export Processing Zone
	MGD	Million Gallon per Day
	mld	million litre per day
	MLIT	Ministry of Land Infrastructure and Transport, Japan
	MM	Man Months
	MMD	Maximum Moving Dimensions
	MMRDA	Mumbai Metropolitan Regional Development Authority
	MMU	Mobile Maintenance Units
	MOEF	Ministry of Environment and Forest
	MOF	Ministry of Finance
	MOR	Ministry of Railways
	MOR road	Manali Oil Refinery Road (Chennai)
	MORD	Ministry of Rural Devevelopment
	MOU	Memorandum of Understanding
	MPs/MLAs	Member of Paliament/Member of Legislative Assembly
	MRTS	Mass Rapid Transit System
	MRVC	Mumbai Rail Vikas Corporation Ltd.
	MSC	Mobile Switching Center
	mtpa	Million tons per annum
	MTR	Mid-term Rehabilitation
	MTRC	Mobile Train Radio Communication
	MU	Million Unit (=1,000,000kWh)
	MUL	Mulund
	MUTP	Mumbai Urban Transport Project
	MUX	Multiplexer
N	NAG	Nagpur
	NATM	New Austrian Tunnelling Method
	NCL	Northern Coalfield Limited
	NCR	National Capital Region
	NDE	New Delhi
	NDP	Net Domestic Product
	NEEPCO	North Eastern Electric Power Corporation
	NER	North Eastern Region
	NESDP	National Economic and Social Development Plan
	NGO	Non-Governmental Organization
	NH	National Highway
	NHAI	National Highways Authority of India
	NHDP	National Highways Development Project
	NHPC	National Hydro Power Corporation Limited
	NMDP	National Maritime Development Programme
	NMPT	New Mangalore Port Trust
	NR	Northern Railway
	NRP	National Rehabilitation Plan
	NRVY	National Rail Vikas Yojana

	NRVY	National Rail Vikas Yojana
	NSDP	Net State Domestic Product
	NSICT	Nhava Sheva International Container Terminal
	NTKM	net tonne km
	NTPC	National Thermal Power Corporation
	NTPC	National Thermal Power Plant Co. Ltd.
	NWR	North Western Railway
O	OFC	Optical fiber cable
	ONGC	Oil and Natural Gas Corporation Ltd.
P	PAF	Project Affected Family
	PAP	Project Affected People
	PB	Performance Bond
	PCM	Pulse Code Modulation
	PESB	Public Enterprise Selecting Board
	PETS	Preliminary Engineering cum Traffic Study
	PIT	Pitampur
	pkm	Passenger Kilometer
	PLF	Power Load Factor
	POH	Periodical Overhaul
	POL	Petroleum-Oil-Liquid
	PPP	Public Private Partnership
	PPTA	Project Preparatory Technical Assistance
	PPTA	Project Preparatory Technical Assistance
	PSC	Prestressed Concrete
	PSEB	Punjab State Electricity Board
	PSU	Public Sector Undertaking
	PWD	Public Works Department
R	R&M	Renovation and Modernization
	RAP	Resettlement Action Plan
	RC	Reinforced Concrete
	RDSO	Research Designs and Standards Organization
	REW	Rewari
	RITES	Rail India Technical and Economic Services
	RL	Rail Level
	RLMS	Rural Load Management System
	RMG	Railed Mounted Gantry Crane
	ROB	Road Over Bridge
	ROBs	Road Over Bridges
	ROH	Routine Overhaul
	ROW	Right-of-Way
	RRD	Ravtha Road
	RRP	Framework of Resettlement and Rehabilitation Plan
	RRR	Reinforced Rail Road
	RS	Railway Station

	Rs.	Indian Rupees
	RTK	Real Time Kinematics
	RTRI	Railway Technical Research Institute
	RUB	Road Under Bridge
	RVNL	Rail Vikas Nigam Limited.
	RWF	Railway Wheel Factory
S	SBAS	Satellite-based Augmentation System
	SBI	Sanarmati
	SC	Schedule Castes
	SCADA	Supervisory Control And Data Acquisition
	SDH	Synchronous Digital Hierarchy
	SEBs	State Electricity Boards
	SECL	South East Central Coalfield Limited
	SERCs	States Electricity Regulatory Commission
	SEZ	Special Economic Zone
	SGC	State Grievance Committee
	SGSN	Serving GPRS Support Node
	SH	State Highways
	SIPCOT	State Industries Promotion Corporation of Tamil Nadu Ltd.
	SMTP	Sub-Manifest Transshipment Permit
	SOD	Schedule of Dimensions
	SP	Section Post
	SPAD	Signal Passed at Danger
	SPART	Self-propelled Accident Relief Trains
	SPCM/ID-PAF	Stakeholder/Public Consultation Meeting and Identification of PAFS
	SPURT	Self Propelled Ultrasonic Rail Testing
	SPV	Special Purpose Vehicle
	SR	Sensitive Receptor
	SRSF	Special Railway Safety Fund
	SRTUs	State Road Transport Undertakings
	SSC	Single Stacked Container
	SSI	Solid State Interlocking
	SSS	Single Slip Switch
	ST	Schedule Tribes
	sta.	Station
	STEP	Special Terms for Economic Partnership
	STM	Synchronous Transfer Mode
	Stn	Station
	SVN	Space Vehicle Number
T	TA	Technical Assistance
	TAC	Track Access Charge
	TCI	Transport Corporation of India
	TCL	Transitional Curve Length
	TERI	The Energy and Resources Institute

	TETRA	Terrestrial Trunked Radio
	TEU	Twenty feet equivalent unit
	TKD	Tughlakabad
	tkm	Track Kilometer
	TLD	Track Loading Density
	TMCP	Thermo-Mechanical Control Process
	TMG	Tire Mounted Gantry Crane
	TNEB	Tamil Nadu Electricity Board
	TNRDC	Tamil Nadu Road Development Corporation
	TOR	Terms of Reference
	tpa	Tons per annum
	TPP	Thiruvottiyur Ponneri Panchetti
	TPWS	Train Protection and Warning System
	TS	Terminal Station
	TSS	Traction Substation
	TU	Transport Units (tkm+pkm)
	TVU	Train Vehicle Unit
	TWS	Thick Web Switches
	TWS&DB	Tamil Nadu Water Supply and Drainage Board
U	U.P.	Uttar Pradesh
	UFW	Unaccounted for water
	UIC	Union Internationale Chemins de Fer
	ULBs	Urban Local Bodies
	UP	Unit Price
	UPRVUNL	Uttar Pradesh Rajya Vidyut Utpadan Nigam Ltd.
	UrEDAS	Urgent Earthquake Detection and Alarm System
	UTS	Ultimate Tensile Strength
V	VCB	Vacuum Circuit Breaker
	VCL	Vertical Curve Length
	VK	Vakkadu
	VRRC	Village Resettlement and Rehabilitation Committee
	V-SAT	Very Small Aperture Terminal
	VTMS	Vessel Traffic Management System
W	WB	World Bank
	WCL	Western Coalfield Limited
	WCR	West Central Railway
	WDM	Wave Division Muyltiplexing
	WLC	With line capacity
	WOL	without the maintenance interval
	WR	Western Railway