JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

VIETNAM RAILWAYS (VR)

STUDY FOR THE FORMULATION OF HIGH SPEED RAILWAY PROJECTS ON HANOI – VINH AND HO CHI MINH – NHA TRANG SECTION

FINAL REPORT

VOLUME I

DEVELOPMENT OF NORTH-SOUTH RAILWAYS

June 2013

ALMEC CORPORATION
JAPAN INTERNATIONAL CONSULTANTS FOR TRANSPORTATION CO., LTD.
ORIENTAL CONSULTANTS CO., LTD.
NIPPON KOEI CO., LTD.
JAPAN TRANSPORTATION CONSULTANTS, INC.

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USD 1 = JPY 78 = VND 21,000

(Based on rate on November 2011)

PREFACE

In response to the request from the Government of the Socialist Republic of Vietnam, the Government of Japan decided to conduct the Study for the Formulation of High Speed Railway Projects on Hanoi – Vinh and Ho Chi Minh – Nha Trang Section and entrusted the program to the Japan International cooperation Agency (JICA).

JICA dispatched a team to Vietnam between April 2011 and June 2013, which was headed by Mr. IWATA Shizuo of ALMEC Corporation and consisted of ALMEC Corporation, Japan International Consultants for Transportation Co., Ltd., Oriental Consultants Co., Ltd., Nippon Koei Co., Ltd. and Japan Transportation Consultants, Inc.

In the cooperation with the Vietnamese Counterpart Team including the Ministry of Transport and Vietnam Railways, the JICA Study Team conducted the study which includes traffic demand analysis, natural and socio-economic conditions, alignment planning, consideration of various options including the upgrading of existing railway, technical standards for high speed railway, implementation schedule and institutions, and human resource development. It also held a series of discussions with the relevant officials of the Government of Vietnam. Upon returning to Japan, the Team duly finalized the study and delivered this report in June 2013.

Reflecting on the history of railway development in Japan, it is noted that Japan has indeed a great deal of experience in the planning, construction, operation, etc., and it is deemed that such experiences will greatly contribute to the railway development in Vietnam. JICA is willing to provide further cooperation to Vietnam to achieve sustainable development of railway sector and to enhance friendly relationship between the two countries.

It is hoped that this report will contribute to the sustainable development of transport system in Vietnam and to the enhancement of friendly relations between the two countries.

Finally, I wish to express my sincere appreciation to the officials of the Government of Vietnam for their close cooperation.

June 2013

Kazuki Miura
Director, Economic Infrastructure Department
Japan International Cooperation Agency

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ABBREVIATIONS

ABS	Ausbaustecke
AC	Alternating Current
AC-DC	Alternating Current – Direct Current
ADB	Asian Development Bank
ADF	Asian Development Fund
AFA	Agriculture-Forestry-Aquaculture
AFC	Automatic Fare Collection
AGR	Average Growth Rate
AGV	Automotrice A Grande Vitesse
ARC	Automatic Route Control
AT	Auto Transformer
ATACS	Advanced Train Administration and Communications System
ATC	Automatic Train Control system
ATOS	Autonomous decentralized Transport Operation control System
ATP	Automatic Train Protection
ATPs	Automatic Transformer Posts
ATS	Automatic Train Stop
ATWL	Agility Trans West Line Limited
AVE	Alta Velocidad Española
BMRCL	Bangalore Metro Rail Corporation Limited
BOT	Build-Operate-Transfer
BT	Booster Transformer
CAI	Computer-Aided Instruction
CBTC	Communication Based Train Control
CCTV	Closed Circuit Television
CFEZ	Central Focal Economic Zone
CMS	Centralized Monitoring System
COMTRAC	Computer Aided Traffic Controlling System
COSMOS	Computerized Safety, Maintenance and Operation Systems of Shinkansen
CS	Copper Steel
CSR	Compensation, Support and Resettlement
CTC	Centralized Train Control
CTC	Centralized Traffic Controlling System
DB	Deutsche Bahn (Germany)
DF/R	Draft Final Report
DL	Diesel Locomotives
DMU	Diesel Multiple Unit
DoLISA	Department of Labor, Invalids and Social Affairs
DONRE	Department of Natural Resources and Environment
DS-ATC	High-speed railway signal system in Japan
DS-PC	Regulation of VNR (implementation criteria of companies)
EIA	Environmental Impact Assessment
EIRR	Economic Internal Rate of Return
EMU	Electric Multiple Units
EPIC	Etablissement Public à Caractère Industriel et Commercial
EPZ	Export Processing Zone
ERRI	European Railway Research Institute
ERTMS	European Railway Traffic Management System
ETCS	European Train Control System
ETR	Elettro Treno Rapido
EU	European Union
EVN	Vietnam Electricity
EZ	Economic Zone

F/R	Final Report
F/S	Feasibility Study
FDI	Foreign Direct Investment
FIRR	Financial Internal Rate of Return
GDP	Gross Domestic Product
GMS	Greater Mekong Subregion
GOV	Government Of Vietnam
GPS	Global Positioning System
GRDP	Gross Regional Domestic Product
GRIPS	National Graduate Institute For Policy Studies
GSM-R	Global System For Mobile Communications - Railway
GSO	General Statistics Office
HCMC	Ho Chi Minh City
HPMU	HSR Project Management Unit
HQ	Headquarters
HSR	High Speed Railway
IC	Integrated Circuit
ICAO	International Civil Aviation Organization
ICD	Inland Container Depot
IC/R	Inception Report
ICE	Inter City Express
IFC	International Financial Corporation
IMO	Infrastructure Maintenance
IP	Industrial Park
IP/PBX	Internet Protocol-Private Branch Exchange
IRR	Internal Rate of Return
IT	Information Technology
ITS	Intelligent Transport System
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JPY	Japanese Yen
JR East	East Japan Railway Company
JNR	Japan National Railroad
JNR	Japanese National Railways
JORSA	Japan Overseas Rolling Stock Association
JRTT	Japan Railway Construction Transport and Technology
Km	Kilometer
KOICA	Korean International Cooperation Agency
Korail	Korea Railroad Corporation
KR	Korea Rail Network Authority
KTX	Korean Train Express
KVA	Kilovolt Ampere
KV	Kilovolt
kW	Kilo watt
L	Length
LAN	Local Area Network
LCC	Low Cost Carriers
LCX	Leaky Coaxial Cable
LGV	Ligneagandevitesse
LLC	Limited-liability Company
LTE	Long Term Evolution
LVWC	Lyonnaise Vietnam Water Supply Company
LZB	Continuous train detection system in German high-speed train ICE
MAC	Middle Airports Corporation
MARD	Ministry of Agriculture And Rural Development
MLIT	Ministry of Land, Infrastructure, Transport And Tourism
MOC	Ministry of Construction

MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources And Environment
MOST	Ministry of Science and Technology
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment
MPPA	Million Passenger Per Year
MRD	Mekong River Delta
MRT	Mass Rapid Transit
MTT	Multiple-head Tie Tampers
MVA	Megavolt Ampere
NAC	Northern Airports Corporation
NATM	New Austrian Tunneling Method
NBS	Neubausterecke
NFEZ	Northern Focal Economic Zone
NH1	National Highway 1
NIURP	National Institute for Urban and Rural Planning
NSHSR	North – South High Speed Railway
NS Line	North-South Line
NTSC	National Transportation Safety Committee
NTV	Nuovo Transporto Viaggiatori
O & M	Operation And Maintenance
OCC	Operation Control Center
OD	Origin-Destination
ODA	Official Development Assistance
OJT	On-the-Job Training
P/R	Progress Report
PAPs	Project Affected Peoples
PC	People's Committee
Pc box	Pre-stressed Concrete box
PCI	Provincial Competitive Index
PCM	Pulse Code Modulation
PCU	Passenger Car Unit
PHC	Precipitation Hardened Copper alloy
PIC	Parcel Inter City
PMU	Project Management Units
PPP	Public – Private Partnership
PRC	Programmed Route Control System for Station
RAP	Resettlement Action Plan
RC	Reinforced Concrete
RFF	Réseau Ferré de France
RR	Ring Road
RRPF	Resettlement and Rehabilitation Policy Framework
RTRI	Railway Technical Research Institute
SAC	Southern Airports Corporation
SACEM	*Système d'aide à la conduite, à l'exploitation et à la maintenance* - Assisted driving, Control and Maintenance system
SCADA	Supervisory Control and Data Acquisition System
SDH	Synchronous Digital Hierarchy
SEDP	Socio-Economic Development Plan
SEDS	Socio-Economic Development Strategy
SFEZ	Southern Focal Economic Zone
SIA	Social Impact Assessment
SNCF	Société Nationale des Chemins de fer Français (France)
SOE	State Owned Enterprise
SP	Sectioning Post
SPW	Sound protection wall
SS	Substation

SSP	Sub-sectioning Post
TAC	Track Access Charge
TCN	Standard of Ministry
TCP/IP	Transmission Control Protocol/Internet Protocol
TCVN	Standard of Vietnam Government
TDS	Transport Development Strategy
TDSI	Transport Development Strategy Institute
TEU	Twenty foot Equivalent Units
TGV	Train A Grande Vitesse – high speed train
THSRC	Taiwan High Speed Rail Corporation
TID	Train Information Display
TRICC	Transport Investment And Construction Consultant Joint Stock Company
TVM	Transmission Voice-Machine
TWG	Technical Working Group
UIC	International Union Of Railways
UK	United Kingdom
UMRT	Urban Mass Rapid Transit
UNDP	United Nations Development Project
UPS	Uninterrupted Power Source
USD	United States Dollar
UVSA	Union Of Vietnam Science Associations
VASCO	Vietnam Air Services Company
VANSCORP	Vietnam Air Navigation Services Corporation
VHSRS	Vietnam High Speed Rolling Stock
VIAP	Vietnam Institute of Architecture and Urban and Rural Planning
VITRANSS2	The Comprehensive Study On The Sustainable Development Of Transport System In Vietnam
VJC	Vietnam-Japan Consultancy Joint Venture
VND	Vietnamese Dong
VNRA	Vietnam Railway Administration
VR	Vietnam Railways
VVVF	Variable Voltage Variable Frequency
WAN	Wide Area Network
WTO	World Trade Organization

1 INTRODUCTION

1.1 Background and Objectives of the Study

1) Background

1.1 Vietnam has achieved remarkable economic growth since the commencement of the policy of *Doi Moi*. In Vietnam, the North–South High-speed Railway (HSR) Project is expected to become a promoter of the country's further economic development as well to serve as a symbol of its successful growth. The Government of Vietnam (GOV) intends to implement this mega project with the support of Japan since the "Japan–Vietnam Joint Statement on the Comprehensive Development of Strategic Partnership for Peace and Prosperity in Asia" was made in 2006. During the period of 2007–2010, the Japanese government provided technical assistance through the Japan International Cooperation Agency (JICA) to conduct "The Comprehensive Study on the Sustainable Development of Transport System in Vietnam" (VITRANSS2) upon the request of the Vietnamese government. In VITRANSS2, a substudy on the HSR projects was carried out and a preliminary development strategy was formulated. During the same period, a pre-feasibility study of the HSR was also conducted by the Vietnam–Japan Consultancy Joint Venture (VJC), consisting of the Transport Investment and Construction Consultant Joint Stock Company (TRICC) and Japanese consultants, under Vietnam Railways (VR). The basic data for forecasting traffic demand and analyzing economic feasibility was shared between the two studies. In both studies, Hanoi–Vinh and Ho Chi Minh–Nha Trang sections were selected as the priority sections for initial investments.

1.2 Although a need for development of modern and efficient mass-transit for the most important north-south corridor of the country is observed, it was considered necessary to study more in detail on the aspects related to the development of HSR including socio-economic and environmental impacts as well as funding, operation and management, etc. For the HSR projects to be approved by the Assembly, a detailed analysis supported by scientific and objective grounds has to be conducted on the issues raised in previous sessions.

1.3 Given these circumstances and upon the request of the Vietnamese government, Japan has again provided technical assistance through JICA, this time to carry out the "Study for the Formulation of High Speed Railway Projects on the Hanoi–Vinh and Ho Chi Minh–Nha Trang Sections."

2) Objectives

1.4 The study aims to conduct a study on HSR development, analyze development alternatives, propose the optimal plan, develop a project implementation plan for the selected sections (namely, the Hanoi–Vinh and Ho Chi Minh–Nha Trang sections), and promote a better understanding of the HSR projects among various stakeholders. Specifically, the study's objectives are as follows:

(i) To formulate a basic development plan for the HSR (to include development scenarios that consider the existing railway as well, alternative alignments, and main infrastructure);

(ii) To formulate preliminary designs, system plans, cost estimates, construction plans, economic and financial evaluations, as well as financing plans;

(iii) To prepare the documents needed for the environmental and social studies;

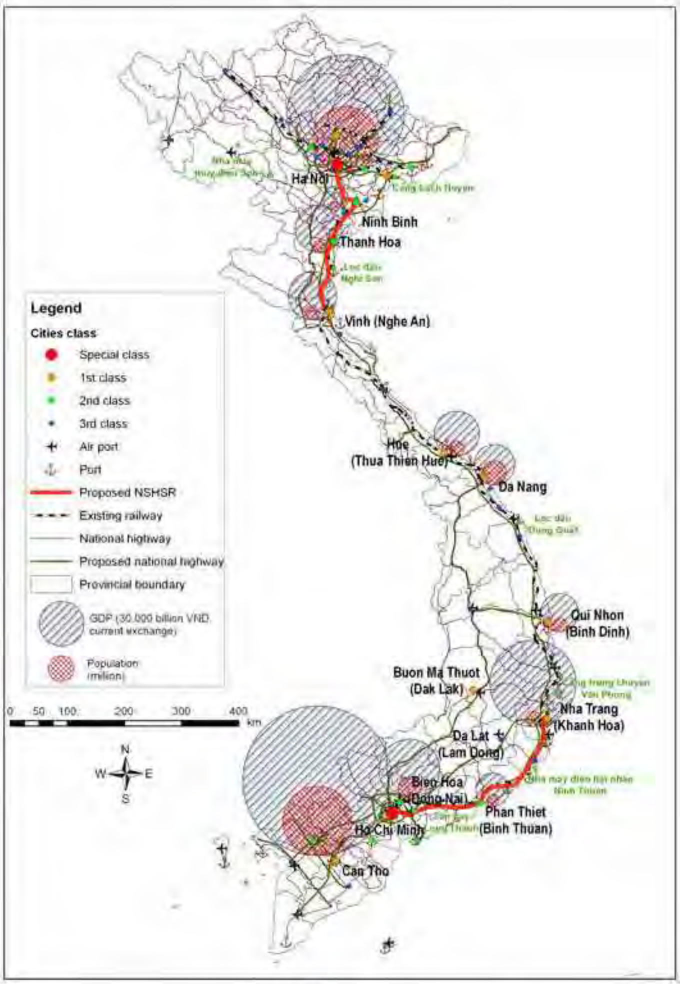
(iv) To formulate preliminary technical standards for high-speed railway; and

(v) To formulate a preliminary capacity development plan for high-speed railway construction, operation and maintenance.

1.5 On the basis of a series of discussions held between the Steering Committee and the Study Team as well as in the Stakeholder Meeting wherein there is a shared understanding to study the existing railway more in detail to identify its constraints and opportunities before introduction of the High Speed Railway.

3) Coverage of the Study

1.6 The main study area covers the priority sections of North-South High Speed Railway: namely, Hanoi-Vinh and HCMC-Nha Trang sections (see Figure 1.1.1). On the other hand, the comparative analysis of north – south railway development policies, through which most recommendable policy direction is proposed and the justifiability of HSR development is examined, is also included in the scope of the study. Thus, the whole north-south corridor connecting the biggest cities in Vietnam, Hanoi and HCMC, is also considered as a study area in general.



Source: JICA Study Team
Note: The GDP data covers centrally governed cities and provinces shown in parentheses.

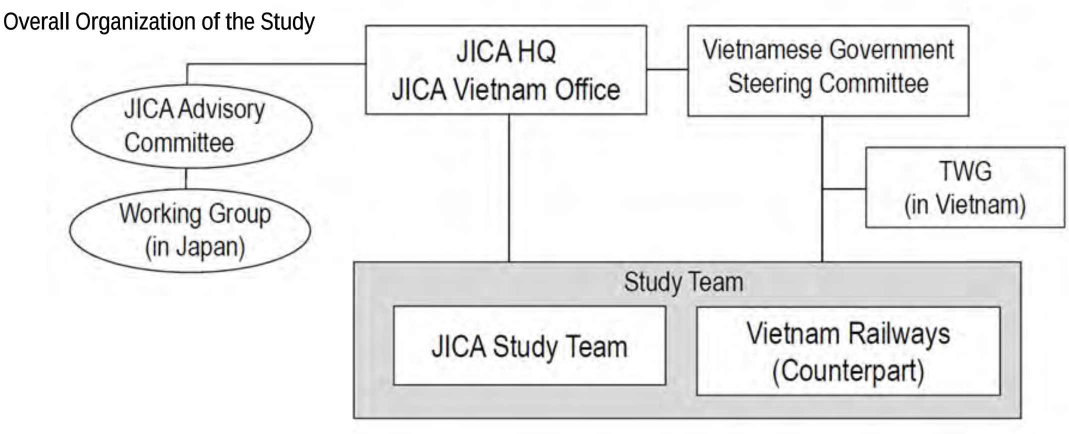
Figure 1.1.1 Location of the HSR Project Sections and Neighboring Cities

1.2 Study Implementation

1) Study Organization

1.7 For the smooth implementation of the study, close coordination system between Vietnamese and Japanese side has been established. Vietnamese Steering Committee is organized by members of Ministry of Transport (MOT), Vietnam Railways (VR) and other related agencies and technical working group members consist of Vietnamese experts and officers engaged in railway business.

1.8 On Japan side, besides JICA Headquarter and Vietnam Office, the JICA Advisory Committee and Working Group are organized to support the task of the JICA Study Team. JICA Advisory Committee and Working Group members consist of those from academia, Ministry of Land, Infrastructure, Transport and Tourism (MLIT), railway company and agency and give advices to the JICA Study Team based upon the knowledge and experiences of the development and operation of Shinkansen in Japan.

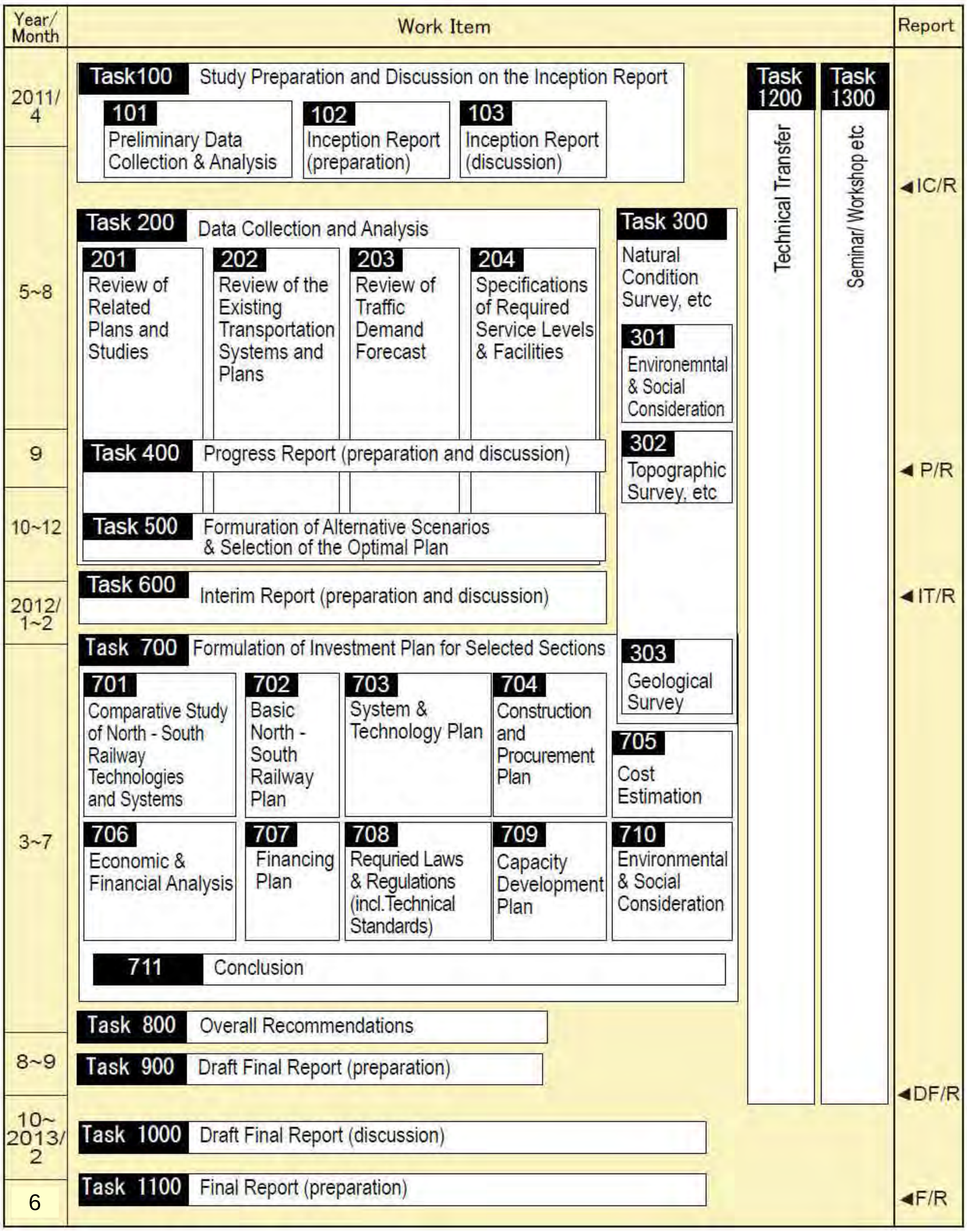


Source: JICA Study Team
Note: HQ = Headquarters, TWG = Technical Working Group

Figure 1.2.1 Study Organization

2) Study Framework

1.9 The study is composed of several tasks which can be grouped into two stages. In the first stage, from the beginning of the study to the Interim Report, the role of North-South railway including High Speed Railway (HSR) in Vietnam has been studied while the base data and information for developing the investment plan of HSR has been prepared and preliminary analysis is conducted. In the next stage, the investment plan will be prepared based on the optimal development scenario of North-South railway. Besides, through the whole study, the study will take steps to promote mutual understanding between the Vietnamese and Japanese stake holders of the projects through discussions and coordination. Figure 1.2.2 shows the overall work flow of the study.



Source: JICA Study Team

Figure 1.2.2 Overall Work Flow of the Study

3) Meetings and Consultation

1.10 Since May, 2011, several meetings have been conducted for the study, which includes the steering board meeting, counterpart working group meeting, meeting with Vice Prime Minister, Vice Minister of MOT, other related agencies in Hanoi and people's committee and stakeholders of provinces. The main meetings are listed as shown in Table 1.2.1.

Table 1.2.1 Main Meetings held

	Day	Meeting
Steering Committee Meeting and Counterpart Meeting	18 May, 2011	1st Steering Board Meeting (at MOT)
	19 May, 2011	Inception Report Meeting (VR)
	23 May 2011	1st Counterpart Working Group Meeting (VR)
	7 June 2011	2nd Counterpart Working Group Meeting (VR)
	24 August 2011	Sub Counterpart Working Group Meeting (discussion for IEE Study) (VR)
	27 September 2011	3rd Counterpart Working Group Meeting (discussion for Progress Report) (VR)
	28 September 2011	2nd Steering Board Meeting (at VR)
	23 February 2012	4th Counterpart Working Group Meeting (VR)
	24 February 2012	3rd Steering Board Meeting (at MOT)
	6 June 2012	1st Technical Workshop (VR) (discussion for ITR, alignments & stations, system)
	3 August 2012	2nd Technical Workshop (VR) (discussion for system)
	14 August 2012	4th Steering Board Meeting (at MOT)
	14-15 August 2012	Meeting with VR
	23 November 2013	5th Steering Board Meeting (at MOT)
Other Meetings	19 May 2011	Meeting with Vietnam Academy of Social Sciences
	20 May 2011	Meeting with Ministry of Planning and Investment
	20 May 2011	1st Explanation to Deputy Prime Minister Hoang Trung Hai
	29 September 2011	Meeting with Vietnam Academy of Social Sciences
	29 September 2011	Meeting with Ministry of Planning and Investment
	7 December 2011	Explanation to Vice Minister of MOT (Mr. Duc)
	8 December 2011	1st Stakeholder Meeting
	22 February 2012	2nd Explanation to Deputy Prime Minister Hoang Trung Hai
	July-September 2012	2nd Stakeholder Meeting (11 cities and provinces)
	23 November 2013	3rd Explanation to Deputy Prime Minister Hoang Trung Hai
	15 March 2013	4th Explanation to Deputy Prime Minister Hoang Trung Hai

Source: JICA Study Team

1.11 Besides the ones on the list, there are several small meetings for data and information collection conducted by study members. The contents of meetings are briefed as follows;

From the beginning of the Study to 2nd Steering Board Meeting (September 2011)

(i) **1st Steering Committee Meeting:** The explanation of Inception Report and discussion on it has been conducted with the attendance of Vice Minister Duc.

(ii) **Meeting with Vietnam Railways:** After the inception report meeting, two counterpart working group meetings and sub-meeting have been conducted. The main discussions with Vietnam railways are (i) the establishment of working group of Vietnam railways and the cooperation system between Vietnam Railways and JICA Study Team, (ii) the arrangement of site survey, (iii) the result of the review of existing railway facilities, (iv), development scenarios for existing railway and (v) methodology of socio and environmental consideration studies.

(iii) **Meeting with Deputy Prime Minister and other related agencies:** The Inception Report was explained at the meetings and mainly, objectives and directions were discussed.

(iv) **Meeting with Local Provinces:** The main purpose of meeting with local provinces at this stage is to explain the study outline and request the assistance of local provinces for the study. In addition, the data of the plans of provinces and the data and information for social and environmental consideration were requested. Generally, the provinces have intention to know the study and HSR project in depth and assist JICA Study Team.

(v) **2nd Steering Board Meeting:** The 2nd Steering Committee Meeting was held in Vietnam Railways to explain the progress report with attendance of Chairman of Vietnam Railways, Dr Bang. The main contents are (i) progress of the Study, (ii) Q&A: comments and responses, (iii) review of related plans and studies, and (iv) alternative scenarios and preliminary analysis, and (v) next steps.

(vi) **Meeting with related Agencies:** The contents of progress report were explained to Ministry of Planning and Investment and Vietnam Academy of Social Science and the North-South railway development scenarios and study requirements were mainly discussed.

After the 2nd Steering Board Meeting

(i) **Meeting with Vice Minister Duc of MOT (December 2012):** In the meeting, the study progress was explained to Vice Minister and the study direction was discussed.

(ii) **1st Stakeholder Meeting:** As a part of environmental and social considerations of the study, the 1st stakeholder meeting was conducted inviting related agencies in Hanoi and provinces. The outline of the study and the contents of environmental and social considerations were explained and discussed.

Table 1.2.2 List of Organizations Attended Stakeholder Meeting

Organizations and Agencies		Departments
State Agencies and Organizations	National Assembly	National Assembly Office
	National Transportation Safety Committee (NTSC)	
	Union of Vietnam Science Associations (UVSA)	
	University of Transport and Communications	Centre for International Research & Education Cooperation
	Ministry of Transport (MOT)	Department of Environment
		Department of Science & Technology
		Department of Planning & Investment
		Department of Transport Infrastructure
		Department of International Cooperation
		Vietnam Railway Administration (VRA)
		Transport development strategy institute (TDSI)
	Ministry of Construction (MOC)	Department of Architecture Planning
	Ministry of Natural Resources and Environment (MONRE)	Department of Land Planning
		Department of Land Administration General
	Ministry of Agriculture and Rural Development (MARD)	Department of Technology & Science
	Vietnam Railways	Department of Infrastructure
		Department of Preparation & Investment
		Department of Science & Technology
		Department of Transportation Business
		Department of Urban & Construction

Organizations and Agencies		Departments
		Management
		Department of Finance & Accounting
		Department of Rolling stocks
		Department of International Cooperation
		Department of Personnel Organization
	Transport Investment & Construction Consultant (TRICC)	
	The Mass Media	The People's Newspaper
		Labor Newspaper
		Youth's Newspaper
		Vietnamnet
		Vietnam Railway Newspaper
		Transport Newspaper
		Investment Newspaper
		Ban Duong Newspaper
		Electronic Newspaper
Provinces	Ha Nam	Department of Transport
	Nam Dinh	Department of Transport, Appraisal Division
	Ninh Binh	Department of Transport ,Infrastructure Division
	Thanh Hoa	Department of Transport, Planning Division
	Nghe An	Department of Transport
	Ninh Thuan	Department of Transport, Traffic Division
	Binh Thuan	Department of Transport
	Dong Nai	Department of Transport
	Thanh Hoa	People's Committee
	Thanh Hoa	Department of Construction
	Nghe An	Department of Natural Resources and Environment

Source: JICA Study Team

(iii) **Meeting with Deputy Prime Minister, Counterpart working group meeting and, 3rd Steering Board Meeting:** In the meetings, the followings are discussed; (i) the future transport demand along the North-South Corridor, (ii) bottlenecks in existing railways and limitation of numbers of trains by existing single track, (iii) difficultly of upgrading existing railway for high speed service, (vi) necessity of candidate initial sections (test tracks) and human resource development and (vi) importance of decision makers standing points and considerable options for infrastructures upgrading is explained. Though the discussions, the orientation of the study has been confirmed.

(iv) **Technical Workshops with Vietnam Railways:** To discuss about technical issues, two technical workshops have been held with VR. The main contents of the first workshop are (i) outline of the Interim Report, (ii) alternative alignments and station locations for Priority Sections (Hanoi-Vinh and HCMC-Nha Trang) and (iii) main characteristics and construction standards of HSR. The second stakeholder meeting focuses on the technical issues on construction specifications and HSR system; in detail, (i) construction specifications, (ii) electrification system, (iii) signalling, telecommunication and Automatic Fare Collection system, (iv) rolling stock, and (v) Operation Control Centre.

(v) **2nd Stakeholder Meetings:** The second stakeholder meetings have been held in 11 cities and provinces for discussing the HSR projects itself and the alignment and the locations of HSR stations; for the northern city and provinces (Hanoi, Ha Nam, Ha Nam, Nam Dinh, Ninh Binh, Thanh Hoa and Nghe An), the 2nd round of the 2nd stakeholder meetings have been held since the further modification of the alignment and station locations and the explanation to the city and provinces considered necessary. After the meetings for each city or province, the plenary meetings for each of northern and southern sections have been held in Hanoi and HCMC respectively.

(vi) **4th Steering Board Meeting and Meetings with Vietnam Railways:** In the 4th Steering Board Meeting, with the attendance of MOT Vice Minister Dong and the advisor Mr. Duc (previous Vice Minister of MOT), the following issues were mainly discussed; (i) traffic demand, (ii) North-south Railway Development directions and the schedule of HSR development, (iii) candidate initial sections (test tracks), and (iv) financing scheme.

(vii) **5th Steering Board Meeting:** In the 5th Steering Board Meeting, with the attendance of MOT Minister Dinh La Thang, the outcome of the whole study was discussed, with emphasis on the comparison of maximum speed of 200km/h and over 300km/h new line, candidate initial sections (test tracks) and proposed roadmap for HSR development, among others.

(viii) **6th Steering Board Meeting:** In the 6th Steering Board Meeting, with the attendance of MOT Minister Dinh La Thang, the results of a study on 5 initial sections (Ngoc Hoi – Phu Ly, Thu Thiem – Long Thanh, Gia Lam – Hai Phong, Thu Thiem – Vung Tau, Ngoc Hoi – Noi Bai) were discussed, along with comments on the outcomes of the whole study.

4) Counterpart Study Tour

1.12 As a part of the study, counterpart study tour was conducted to promote the better understanding of the study and Shinkansen among related agencies. The members from the departments of following agencies attended the tour held in Japan, including Central Party Office, Government Office, Committee of Science & Technology, National Assembly Office, Ministry of Finance, Ministry of Planning and Investment, Ministry of Transport, Ministry of Construction, Vietnam Railway Administration, Vietnam Academy of Social Sciences, and Vietnam Railways.

1.13 The program included the site visits to Shinkansen construction site, rolling stock centre, training centre, factory for rolling stocks and presentations by Ministry of Land, Infrastructure, Transport and Tourism (MLIT), Japan Railway Construction, Transport and Technology Agency (JRTT) and Professor Morichi at National Graduate Institute for Policy Studies. (see Table 1.2.3)

Table 1.2.3 Activities of Counterpart Study Tour

Date	Activities
7th Nov. (Mon)	• Departure from Hanoi to Narita
8th Nov. (Tues)	• Courtesy call to JICA Headquarter
9th Nov. (Wed)	• Presentation at Ministry of Land, Infrastructure, Transport and Tourism (i) Shinkansen-History and Characteristics (ii) Japan Railway Construction, Transport and Technology Agency and Construction of Shinkansen
10th Nov. (Thur)	• Site Visit: Shinkansen Construction site (Shin Aomori – Oku Tsugaru section) (in Aomori)
11th Nov. (Fri)	• Site Visit: Shinkansen Rolling Stock Center (Rifu) • Site Visit JR East Training Center (Shin-Shirakawa)
14th Nov. (Mon)	• Site Visit: Tokyu Car Cooperation (Yokohama) • Presentation at National Graduate Institute for Policy Studies (GRIPS) by Professor Morichi (Chair of JICA Advisory Committee)

Date	Activities
	(History and Characteristics of Shinkansen)
15th Nov. (Tues)	• Site Visit: Shinkansen Operation Control Center
	• Review of the Tour at JICA headquater
16th Nov. (Web)	• Leaving from Tokyo to Hanoi

Source: JICA Study Team

1.3 Structure of the Final Report

1.14 This Final Report is composed of the following:

(a) Summary

(b) Main Text

Volume I Development of North-South Railways

Volume II Part A Detailed Study on Hanoi – Vinh Section of HSR

Part B Detailed Study on HCMC – Nha Trang Section of HSR

Volume III Environmental and Social Considerations

(c) Technical Report

TR1 Assessment of Existing Railway and Improvement Options

TR2 Demand Forecast and Transportation Cost

TR3 Baseline Survey for Environmental and Social Considerations

TR4 Environmental Sensitivity Map

TR5 Geological Survey and Preparation of Topographic Map

TR6 Questions and Answers to Comments

2 REVIEW OF CURRENT SITUATION AND FUTURE TRANSPORTATION DEVELOPMENT DIRECTION FOR NORTH – SOUTH CORRIDOR

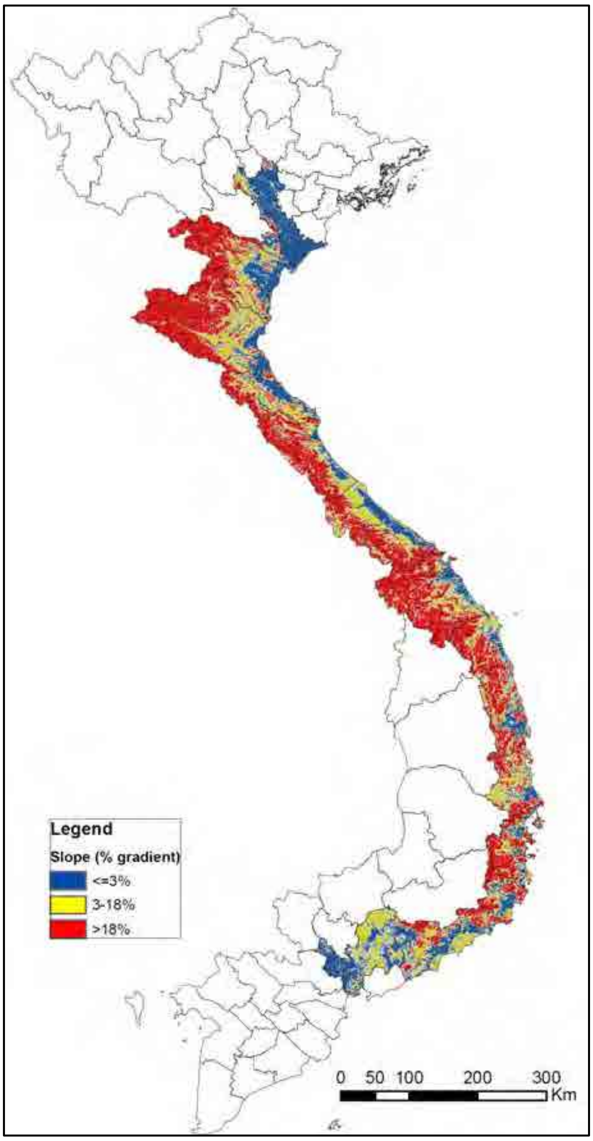
2.1 Natural Conditions

1) Geography

2.1 Vietnam is located on the east coast of the Indochina Peninsula. The total land is approximately 330,000km^2. The north-south length is approximately 1,650km, east-west length is approximately 600km, and the narrowest width is approximately 50km only. There are two large delta regions in the north and south, the Red River Delta and Mekong River Delta, of which 70% of the total national population reside in. The Truong Son Mountains range from north to south, and the middle coastal plains is located at its foot.

2.2 Major rivers are Hong River in the northern region, Ba River in the central region, and Dong Nai River in the southern region. The highest peak is Mt. Phang Xi Pang (3,143m), and the highest peak in Truong Son Mountains is Mt. Ngok Linh (2,598m).

2.3 The North – South Corridor is an S-shaped land covering 110,353km^2 of land, equal to 33.6% of the national total. The coastal areas are also low and flat, which has enabled smooth traffic and efficient transportation development. The upland areas are high in elevation and have relatively steep slopes of more than 10% gradient. (see Figure 2.1.1)



Source: MONRE, 2000.

Figure 2.1.1 Topographic Conditions of the North – South Corridor

2) Geology

2.4 The geology of Vietnam is divided around latitude 15°30" north, near Quang Nam Province. The geology of the northern and central region is mainly composed of Paleozoic and Mesozoic sediments. The Sichuan earthquake and Yunnan earthquake in China has caused a strong lineament along the Red River stretching from northeast to southwest direction from China. This region is subdivided into five areas based on the petrology. The geology of the southern region is characterized by Precambrian (Archean and Poterozoic) sediments and intrusive widely distributed from latitude 15°30" north to 14° north and forming "Kontun Massif". Mesozoic sediments and intrusive rocks are predominated in the southern part of this area. Plateau Basalt of Tertiary Period and Quaternary Period are distributed at the border of Cambodia. This region is subdivided into two areas based on the petrology. The two large deltas, the Red River Delta and Mekong River Delta are formed by fluvial deposits. The depths of soft grounds reach even 40m.

3) Climate

2.5 The climate zones in Vietnam can be divided generally into two areas by Hai Van Pass stretching between Hue and Danang, with one transitional area.

Table 2.1.1 Characteristics of Climate Zones in Vietnam

Area	Seasons
Northern region (North mountain/Midland and the Red River Delta)	North-easterly winds (October–March) bring dry and cold weather while south westerly winds (April to September) cause both high humidity and temperature. During the latter period, storms typically occur as these coincide with the rainy season (Aug to Nov).
Northern central region (North Central Coast from Thanh Hoa to Thua Thien Hue)	Transitional as this region is located between the northern and southern climatic zones which are segregated by the Hai Van pass. The rainy season coincides with the north easterly (September-December) winds and the dry season (November to April) with south westerly winds.
Southern region (Southeast Area and the Mekong River Delta)	Two obvious seasons: rainy season (May to October), dry season (November to April).

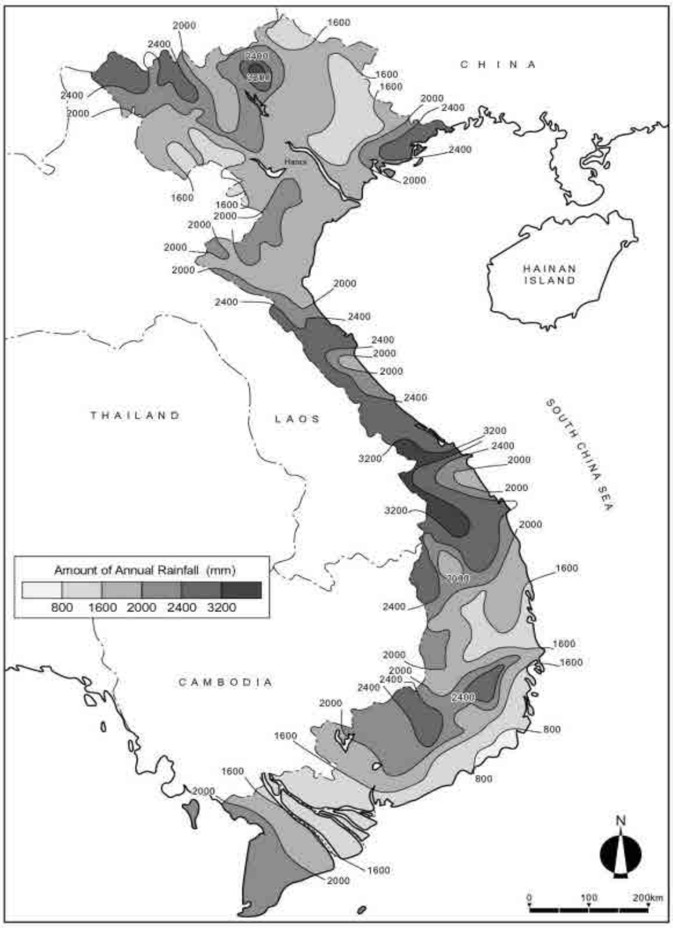
Source: JICA Study Team, 2012

2.6 As the country is located in a tropical monsoon area, annual rainfall is nearly 2,000mm. In some areas, annual rainfall can reach 4,000mm to 5,000mm, even up to 8,000mm on Bach Ma Mountain (Thua Thien Hue Province). On the contrary, it could be as low as 600mm to 800mm, in Binh Thuan Province. (see Figure 2.1.2)

2.7 Rainfall has been compared by a unit of 3 months. The maps in Figure 2.1.4 were formulated by using fixed point observation data provided by the General Statistics Office, and interpolating this to the whole region and taking the average monthly rainfall. While all areas experience April to September heavy rain, regional characteristics can be seen in other seasons. For example, during January to March, while the Central Region has much rain (over 80 mm per month), the Northern and Southern Regions have relatively light rain. During October to December, rain is light for the Northern Region only. The intensity of rainfall is a crucial issue for railway development, especially high speed operation since heavy rain and storms could lead to operation termination.

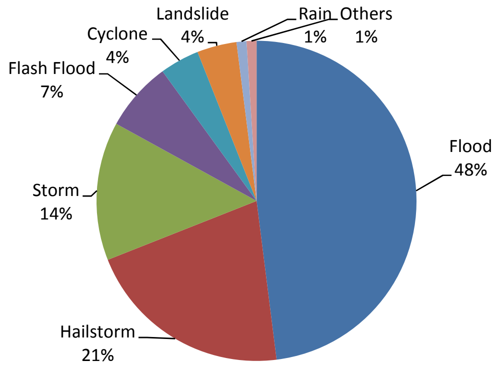
2.8 Variation of rainfall during the year affects the rainfall regime and is the main cause of droughts in the dry seasons and floods in the rainy season. While flood occurs in most areas along the coastal region, drought is rather limited to certain places in upland areas.

2.9 Every year, Vietnam suffers directly from 6 – 10 storms and tropical depressions causing heavy rain and flood. During a period of twenty years from 1989 to 2010, flood is the most reported with 48% of total disaster events. (see Figure 2.1.3) Storms and tropical depressions often occur from June to November but mainly in September and October. It often occurs in northern and central regions, occasionally in the southern region as well.



Source: NWRC, 2001.

Figure 2.1.1 Annual Rainfall Distribution in Vietnam



Source: "A Preliminary Analysis of Flood and Storm Disaster Data in Vietnam", UNDP, 2011.

Figure 2.1.2 Proportion of Reported Natural Disasters in Vietnam (1989 – 2010)

4) Landuse

2.10 Land uses along the corridor are diverse. The western mountainous area has a rich mix of natural forests, mangrove forests, melaleuca forests, planted forests, and industrial trees. However, this forestland is dramatically shrinking due mostly to logging and conversion to agricultural land. The lowlands are suitable for agriculture and are large producers of rice and other industrial crops. Residential area is mostly distributed in cities along the coast. While the Central Region sees recent developments in industry to utilize the vast unused land, industrial production is larger and more commercial in the southern areas.

5) Environmentally Sensitive Areas

2.11 **Protected Areas:** Vietnam is tropical country having high biological diversity and is one of emergence countries of the world in term of biological diversity conservation. Forest resource of Vietnam is still very rich in the number of plant and wildlife species with various forest types: coastal mangrove forest, forest on fresh water marsh, broad-leaved evergreen forest, semi-deciduous forest on low land, limestone mountain forest, alpine evergreen forest and mixed pine forest. Up to now according to statistics Vietnam has over 7,000 high vascular tree species. As predicted by botanists in Vietnam there are at least 12,000 plant species of which about 2,300 species are already used by the people as food, , medicine, animal feed, timber, essential oil and others.

2.12 There are 128 protected areas in Vietnam, in which: 30 are national parks; 48 are protected areas; 11 are species and habitat reservation areas; 39 are landscape protection areas. The percentage of protected forest area accounts for 9.1% of the total area in Vietnam. (see Figure 2.1.5) Besides these protected areas, there are 7 world heritage sites. National parks are protected areas that provide immense value to nature conservation, research, cultural heritage, and tourism. They should be located within a strictly protected area where all activities are prohibited. Within this protected area, there is a rehabilitation zone for regenerating forest plants and animals under threat of extinction and a recreational zone for showcasing to visitors the park's beautiful landscapes and inhabitants. National parks should be surrounded by buffer zones where production activities are restricted and monitored by the park management board.

2.13 Nature reserves are protected areas meant to conserve plant and animal species. Here, research is acceptable while tourism and recreation are not encouraged. Culturally and environmentally protected areas contain historical and cultural monuments and items with aesthetic or environmental value and tourism and recreation potential.

2.14 **Disaster prone areas:** In northern Vietnam, there are many faults that run from NNW (north-northwest) to SSW (south-southwest). The major rivers (including Red River) here flow down to the Gulf of Bac Bo along these faults. On account of these faults, there are many large landslides in the northern mountainous areas during heavy rainfall.

2.15 In central and southern Vietnam almost all the main rivers also flow down to the sea along faults, but the activities of faults are weak and the scale of landslides is small. In the mountainous areas in central Vietnam, however, the land has become unstable; a most conducive situation for landslide.

2.16 With these geological characteristics, transport accidents, especially landslides affecting railway and road, concentrically occur in northern Vietnam. Flashfloods and floods break out in the delta areas as Red River and Mekong River overflow.

2.17 Landslide-prone areas account for 6.8%, and flood-prone areas account for 29.7% of the total area in Vietnam. (see Figure 2.1.5) The national railway passes through three dangerous regions affected by flood and landslide brought by storms, typhoons and tropical heavy rain (the former two are within the target sections in this study). These areas are:

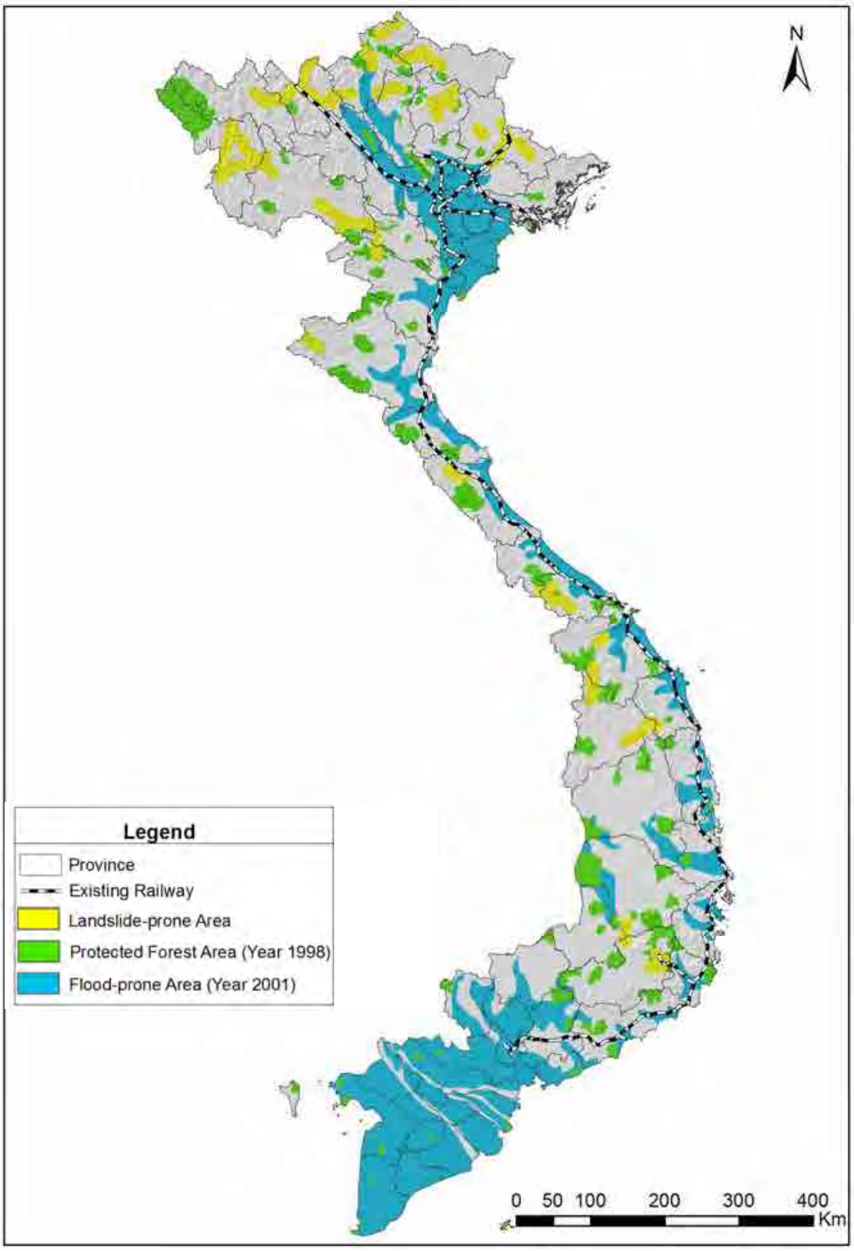
(i) Vinh–Thu Loc (319 - 498km): Flashflood and flood

(ii) Haoson–Ca Pass area (1,220 - 1,269 km) in Khanh Hoa Province: Falling stones and landslides in rainy season

(iii) Yen Bai–Lao Cai (155 - 293 km): 15 dangerous sites of flashfloods, floods and landslides in rainy season.

2.18 There were 58 bridges and 125 culverts destroyed and 430,678 m^2 of road surface subsided and peeled off due to the flood in year 2005. National roads have many sections where flashfloods, floods and landslides regularly occur due to storms, typhoons and tropical heavy rain. The northern and the central mountainous areas are regularly damaged by flashfloods and landslides (43.4% of landslide volume in the north and 55.2% of this in the central). National highway No 32, 37 in Yen Bai Province had a biggest landslide volume accounting for 37% in 2005.

2.19 Floods caused 24,208,650 m^3 of landslide of local roads (equivalent to 484 billion VND in loss) in 33 provinces in the whole country. Nghe An Province had a biggest landslide volume of local roads accounting for 19% in 2005.



Source: JICA Study Team, 2012

Figure 2.1.3 Distribution of Environmentally Sensitive Areas

2.2 Socio-economic Conditions

1) Population

2.20 The total population in the North – South Corridor is 40.0 million as of 2011, equal to 45% of the national total. Due to the introduction of the family planning policy since the 1960s and given the change of lifestyles, birth rates have dropped over the years and population growth in Vietnam is low. The average population growth rate in the region is 1.3%.

2.21 The proportion of people living in urban areas seems to have changed quickly throughout the years. Population is concentrated in urban centers, 6.8 million in Hanoi, 1.0 million in Danang, and 7.5 million in HCMC. The population density is highest in city centers in HCMC. However in general population density is low.

2.22 The economic boom has fueled a rapidly growing urbanization ratio, and urbanization is occurring rapidly, mainly in coastal cities. While the national average for urbanization rate is at 30%, urbanization rates are high in the southeast centering HCMC. Future population estimation figures show that urban population in the nation is expected to grow further in the future, reaching 44% in 2030.

Table 2.2.1 Historical Demographic Change in Vietnam

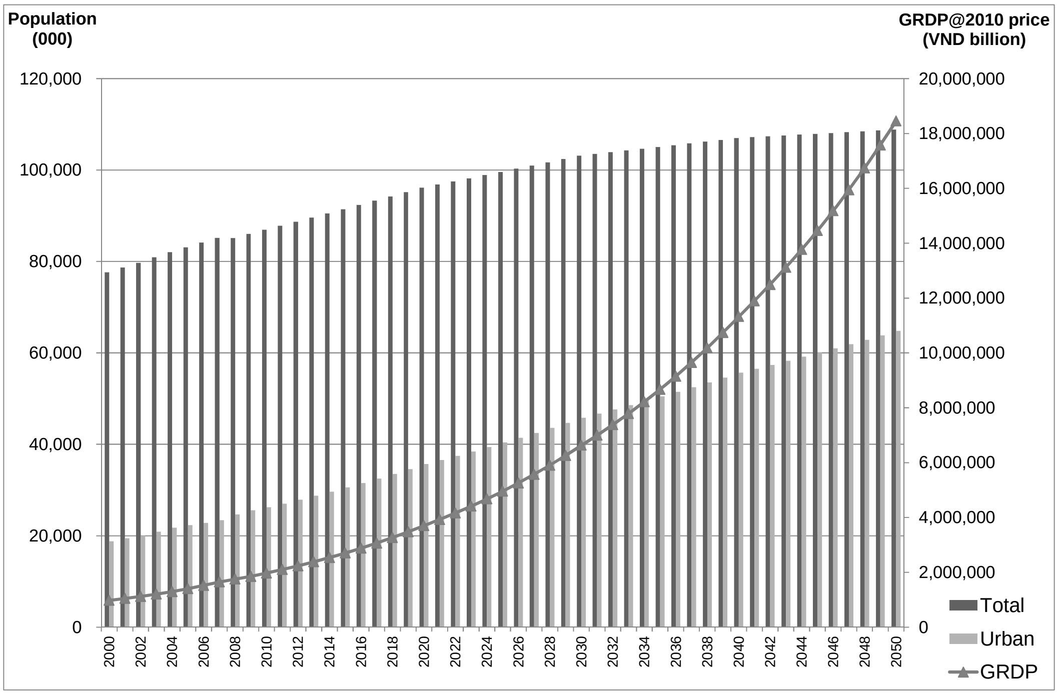
Year	Population (000)	AGR (%)	By Area		
			Urban	Rural	% of Urban
1990	66,233	2.25	13,281	52,952	20.1
1995	71,996	1.65	14,938	57,057	20.7
2000	77,635	1.36	18,772	58,864	24.2
2005	83,106	1.31	22,337	60,770	26.9
2007	85,155	1.21	23,370	61,785	27.4
2010	86,928	1.05	26,224	60,703	30.2
2020[1)]	96,159	1.00	35,675	60,484	37.1
2030[1)]	103,155	0.70	45,801	57,354	44.4

Sources: World Bank, "Vietnam Rising to the challenge", and Statistical Yearbook 2007
1) Estimated by General Statistics Office, MPI.

Table 2.2.2 Historical Demographic Change in Vietnam

			2000	2010	2020	2030	2040[3)]	2050[3)]
Population[1)]: 000			77,635	86,928	96,159	103,155	107,004	108,876
Urban Population[1)]	000		18,772	26,224	35,670	45,818	55,674	64,836
	%		24.2	30.2	37.1	44.4	52.0	59.6
GRDP [2)] @2010 price	VND billion		978,996	1,973,291	3,704,139	6,633,549	11,331,060	18,457,103
	(USD million)		(69,928)	(101,194)	(189,956)	(340,182)	(581,080)	(946,518)
	Per capita	VND billion	12.6	22.7	38.5	64.3	105.9	169.5
		(USD)	(900.7)	(1,164.1)	(1,975.4)	(3,297.8)	(5,430.5)	(8,693.5)

Source: MPI and GSO.
1) Estimated based on "Population Projection for Vietnam, 2009-2049 (February 2011).
2) Estimated based on revision made after the Communist Party National Congress XI (August 2008) to the latest "National Socio-Economic Development Plan, 2010-2011", i.e. '10-'15: 6.5-7.0%. 1 USD = 14,000 VND for 2000 (average exchange rate for 2000), 1 USD = 19,500 VND for 2010 and after (average exchange rate for 2010).
3) For population, estimated based on "Population Projection for Vietnam, 2009-2049 (February 2011). For GRDP, estimated based on growth rate at '00-'10: 7.3%, '10-'20: 6.5%, '20-'30: 6.0%, '30-'40: 5.5%, '40-'50: 5.0%.



Source: MPI and GSO.

Figure 2.2.1 Change in Population, Urbanization and GRDP

2) Economic Development

2.23 **GDP growth:** The North – South corridor region is leading the country's transition toward a modern and open market economy, and has seen high economic growth over the years. The average GDP growth in this corridor is high at 8.2%/ year (2000-2010). It is especially high for Hanoi, Ninh Binh, Quang Ngai and Dong Nai. The common characteristic for these provinces is that all these provinces all have been undergoing rapid industrialization. The per capita GDP in this region is highest for Hanoi and HCMC at 37.6 VND million/ capita and 56.0 VND million/ capita (in 2010, current price). Danang, Dong Nai and Khanh Hoa follow at 31.2 VND/ million, 29.5 VND million/ capita, and 29.4 VND million/ capita, respectively.

2.24 **Sector share:** The development of industry through investment to industrial zones/ clusters has long been one of the prime policies in Vietnam. Led by this policy, the North – South corridor is one of the main locations for this development, and many are developed along the NH01. Most of the IPs and EPZs are located in key economic zones of Vietnam, including NFEZ, CFEZ, and SFEZ, which occupy 60 percent of the natural land for IPs and EPZs. Dong Nai Province tops the list of biggest IP and EPZ owners, followed by Binh Duong Province and Ho Chi Minh City. However, most of other areas (especially rural areas) are still largely dependent on AFA sector, such as rice production.

2.25 **Investment:** Vietnam was accepted into the WTO membership on 11 July 2006. At present, Vietnam is included in the world's top 10 countries for FDI (based on classification list of AT Kearney World Consultant). Vietnam is also a part of the Greater Mekong Subregion (GMS) Economic Cooperation Program initiated by the Asian Development Bank.

2.26 Given these situations, investments in the North – South corridor are active as well. FDI projects are concentrated in Hanoi and HCMC, and a high-portion of foreign-invested enterprises are located in the SFEZ. Danang has been ranked first place for the Provincial Competitiveness Index (PCI) for three consecutive years since 2008 and is currently enjoying abundant investment, mainly for urban development and tourism industry. Although the biggest investors are pertaining to Asia, such as Taiwan, Japan, Korea, Singapore, Hong Kong SAR (China), foreign investment into IPs, EPZs and EZs keeps increasing with the interest of European and Latin American countries into Vietnam.

2.27 **Employment:** Agricultural labor force is decreasing very quickly, and growth of employment in this sector is modest. Labor in industry is significant, and is growing especially in recent years. Labor in services have been growing strongly and recently decreasing its speed in growth.

2.28 **Income and Poverty:** Average income and poverty rates differ greatly by province. While the three major cities of Hanoi, Danang, and HCMC have an average income of 1 – 2 VND million/ month, some provinces are as low as 0.6 VND million/ month. Poverty is serious in Ha Tinh and Quang Tri provinces, with more than 30% of the population under DoLISA standards. Inequality among different income quintiles is greatest in Hanoi, i.e. the average income of the highest income quintile is 7.1 times that of the lowest. The provinces in the central region seem to have more equal situations.

3) Summary of Current Socio-economic Situation

2.29 The total population in this corridor is 40.0 million as of 2011, equal to 45% of the national total. Urbanization is occurring rapidly, especially in coastal cities. The corridor has seen high economic growth over the years, and the average GDP growth in this region is high at 8.2%/ year. This is especially high in Hanoi, Ninh Binh, Quang Ngai and Dong Nai, which are expected to become economic engines to lead regional growth in the future after Hanoi and HCMC. This corridor also is home to many industrial zones, of which many are located along NH1. Investment is active, especially in the SFEZ. On the other hand, poverty is still an issue in many areas where the poor reside, and while some provinces have rather equally low per capita income levels, income inequality is large in major cities such as Hanoi.

4) Urbanization and Growth of Cities along North-South Corridor

2.30 Future national population estimation figures show that urban population in the nation is expected to grow further in the future, reaching 46% in 2030, and the North – South corridor region is expected to accommodate much of this population.

2.31 Although it is clear that Hanoi and HCMC will be the two main poles of development each expected to grow to a population of nearly of exceeding 10 million, cities such as Vinh, Thua Thien Hue, Danang, Quy Nhon, and Nha Trang, the medium-sized cities of today, will grow further in the future to become the regional catalyst of development. Danang especially will become the engine for development of the central region, expecting to reach a population of 3 million in 2030. Contrary to the development up to today in Vietnam based on industry, this city's development will be mainly based on the tertiary sector, especially tourism and new industries (IT, medical, eco-industry, etc.), attracting workers from neighboring areas as well. Thua Thien Hue and Quy Nhon, belonging to the CFEZ, will be integrated and grow in line with Danang. Vinh and Nha Trang, each located at the end of the priority sections of this study will grow even further to become regional growth centers. Although still a Class 2 City, Bien Hoa, leading the economic development of the southern region together with HCMC, has high potential to grow further in the future as well. The city currently is home to a population nearly the same as Danang, and in terms of economy, the GRDP level of Dong Nai Province is high, currently 3 times that of Danang.

Table 2.2.3 Development Indicators for Provinces along North – South Corridor

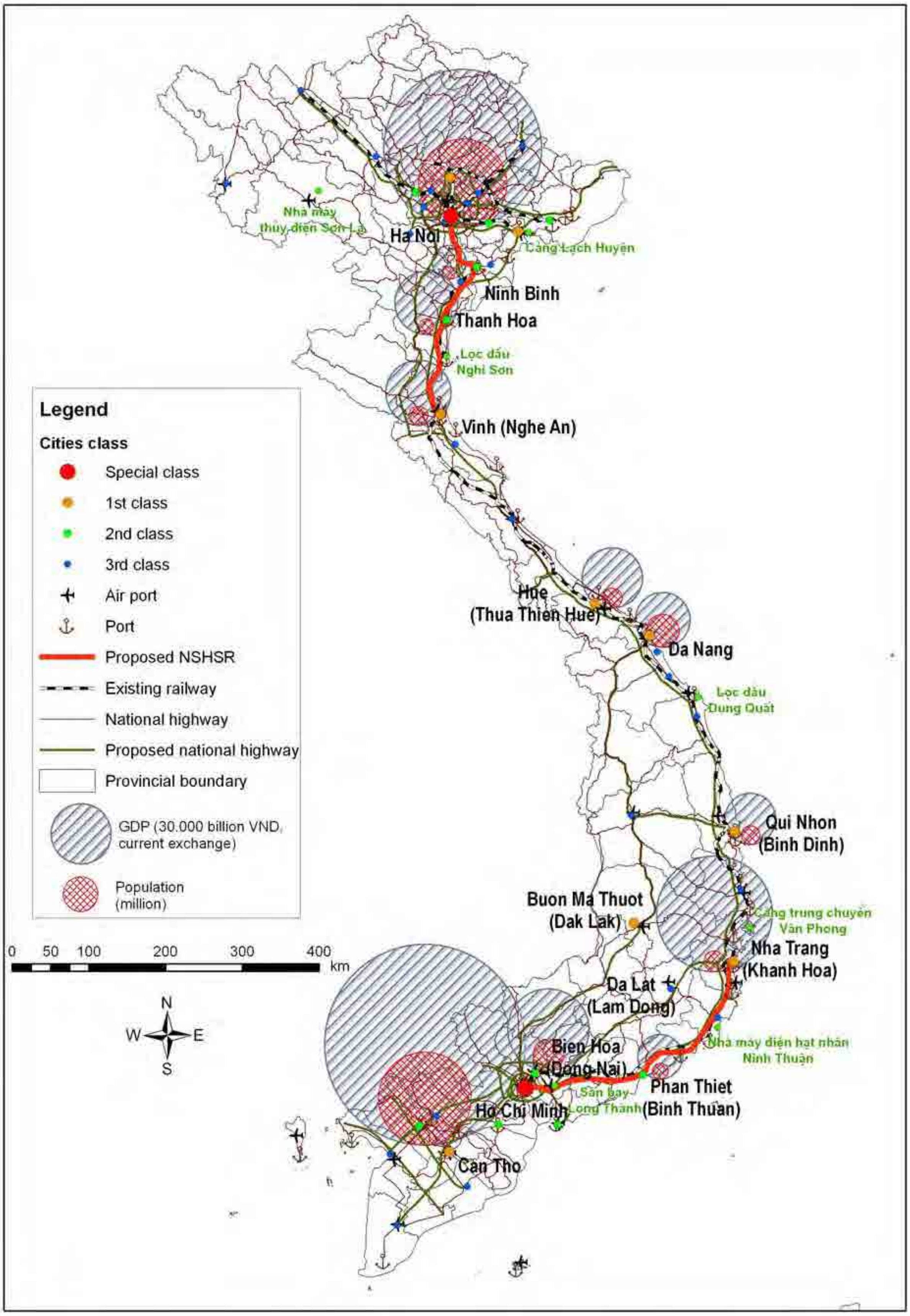
	Area (2011, km²)	Population (000)			Urbanization Rate (2011, %)t	GRDP[1/]			Per capita GRDP (2010, VND mil.)	Poverty Rate (2008, %)	FDI (88-09, USD mil.)
		2005	2011	AGR (05-11, %)		2005	2010	AGR (05-10, %)			
Hanoi	3,328.9	5,910	6,779	2.3	42.5	36,801	50,091	6.4	7.6	2.4	22,307
Ha Nam	860.5	790	787	-0.1	10.5	2,286	3,559	9.3	4.5	11.6	217
Nam Dinh	1,652.2	1,851	1,834	-0.2	18.0	5,109	6,927	6.3	3.8	10.6	120
Ninh Binh	1,376.7	893	908	0.3	19.0	2,692	4,655	11.6	5.2	13.0	578
Thanh Hoa	11,131.9	3,436	3,413	-0.1	11.1	9,460	13,511	7.4	4.0	24.9	7,040
Nghe An	16,490.3	2,896	2,943	0.3	13.3	8,136	10,798	5.8	3.7	22.5	371
Ha Tinh	5,997.2	1,248	1,229	-0.2	16.0	3,194	4,479	7.0	3.6	26.5	8,068
Quang Binh	8,065.3	830	853	0.5	15.2	1,776	2,435	6.5	2.9	21.9	42
Quang Tri	4,739.8	590	605	0.4	28.8	1,431	1,987	6.8	3.3	25.9	83
T. T. Hue	5,033.2	1,073	1,103	0.5	51.7	2,863	4,144	7.7	3.8	13.7	1,990
Danang	1,285.4	806	952	2.8	87.1	5,249	7,052	6.1	7.6	3.5	3,431
Quang Nam	10,438.4	1,407	1,435	0.3	19.3	3,895	6,079	9.3	4.3	19.6	5,190
Quang Ngai	5,153.0	1,210	1,222	0.2	14.6	2,921	5,804	14.7	4.8	19.5	4,828
Binh Dinh	6,050.6	1,478	1,497	0.2	27.7	4,380	6,138	7.0	4.1	14.2	316
Phu Yen	5,060.6	838	872	0.7	23.2	2,091	3,105	8.2	3.6	16.3	8,061
Khanh Hoa	5,217.6	1,115	1,174	0.9	44.5	6,105	8,306	6.4	7.1	9.1	1,345
Ninh Thuan	3,358.0	548	569	0.6	36.1	1,443	1,950	6.2	3.4	19.3	10,056
Binh Thuan	7,813.0	1,133	1,180	0.7	39.3	2,972	5,105	11.4	4.3	9.2	914
Dong Nai	5,907.2	2,264	2,665	2.8	33.7	15,518	24,182	9.3	9.4	4.3	17,838
HCMC	2,095.0	6,291	7,521	3.0	83.1	76,357	103,583	6.3	14.0	0.3	30,981
Total	111,055	36,608	39,540	1.3	39.3	194,679	273,890	6.4	7.0	11.0	123,777

Source: General Statistics Office.
1/ In 1994 price.

Table 2.2.4 Future Growth of Provinces

Province	Population (000)[1/]			Pop. AGR (%)		GRDP (VND bil., 1994 price)[2/]			GRDP AGR (%)	
	2010	2020	2030	10-20	20-30	2010	2020	2030	10-20	20-30
Hanoi	6,562	7,569	8,200	1.4	0.8	50,091	98,163	186,595	7.0	6.6
Ha Nam	786	813	837	0.3	0.3	3,559	6,769	12,488	6.6	6.3
Nam Dinh	1,830	1,933	2,013	0.5	0.4	6,927	10,687	15,991	4.4	4.1
Ninh Binh	901	936	962	0.4	0.3	4,655	10,004	20,852	8.0	7.6
Thanh Hoa	3,407	3,521	3,647	0.3	0.4	13,511	23,336	39,097	5.6	5.3
Nghe An	2,917	3,181	3,389	0.9	0.6	10,798	18,425	30,496	5.5	5.2
Khanh Hoa	1,168	1,284	1,378	1.0	0.7	8,306	16,277	30,941	7.0	6.6
Ninh Thuan	570	619	669	0.8	0.8	1,950	3,322	5,491	5.5	5.2
Binh Thuan	1,177	1,277	1,372	0.8	0.7	5,105	10,971	19,001	8.0	5.6
Dong Nai	2,569	3,018	3,356	1.6	1.1	24,182	47,390	90,081	7.0	6.6
HCMC	7,397	8,818	9,723	1.8	1.0	103,583	184,959	305,694	6.0	5.2
Total for 11 Provinces	29,284	32,969	35,546	1.2	0.8	232,667	430,303	756,727	6.3	5.8

Source: MPI and GSO.
1/ Estimated based on "Population Projection for Vietnam, 2009-2049 (February 2011).
2/ Estimated based on the national GRDP growth scenario, reflecting the revision made after the Communist Party National Congress XI (August 2008) to the latest "National Socio-Economic Development Plan, 2010-2011".



Source: JICA Study Team, 2012
Note: The GDP data covers centrally governed cities and provinces shown in parentheses.

Figure 2.2.2 Distribution of Main Cities along North-South Corridor

Table 2.2.5 Future Growth of Cities

City Name	City Class[2/ 3/]	Population (000)[1/]			Pop. AGR (%)		Urbanization Rate (%)		
		2010	2020	2030	10-20	20-30	2010	2020	2030
Hanoi	Special class	6,562	7,569	8,200	1.4	0.8	41.3	55.5	61.6
Nam Dinh	Class 2	243	375	578	4.4	4.4	79.7	81.6	90.9
Ninh Binh	Class 3	111	177	283	4.8	4.8	83.3	88.1	93.6
Thanh Hoa	Class 2	208	500	610	9.2	2.0	71.0	75.0	80.6
Vinh	Class 1	304	450	667	4.0	4.0	71.0	68.4	74.6
Nha Trang	Class 1	392	445	505	1.3	1.3	74.6	87.4	100.0
Thap Cham	Class 3	162	172	180	0.6	0.5	94.5	100.0	100.0
Phan Thiet	Class 2	216	285	429	2.8	4.2	87.7	89.8	97.9
Bien Hoa	Class 2	701	830	982	1.7	1.7	93.1	100.0	100.0
HCMC	Special class	7,397	8,818	9,723	1.8	1.0	83.3	84.0	85.7

Source: General Statistics Office, Provincial SEDPs.

1/ The future provincial population and urban population was estimated based on "Population Projection for Vietnam, 2009-2049 (February 2011). The ratio of population and urban population that each city accounts for in the corresponding provinces was based on SEDP targets adjusted in light of past trends.

2/ Class I cities are cities which have a population of more than 1 million and population density in inner city areas higher than 12,000 persons/km^2 for cities under the management of the Central Government, and more than 0.5 million and 10,000 persons/km^2 respectively for cities under the provincial management. Ratio of non-agriculture employment in inner-city area reaches at least 85% of total employment.

3/ Class II cities are cities which have a population of more than 0.8 million and population density in inner city areas higher than 10,000 persons/km^2 for cities under the management of the Central Government, and more than 0.3 million and 8,000 persons/km^2 respectively for cities under the provincial management. Ratio of non-agriculture employment in inner-city area reaches at least 80% of total employment.

2.3 Current Transportation Network and Services along North-South Corridor

2.32 **Transport Infrastructure:** North-south corridor possesses all the four transport modes available in Vietnam. The national highway (NH1) runs the full stretch of the corridor in parallel with the north - south railway. These two transport routes are akin to large logistical pipelines that collect and distribute the country's tradable goods through the many seaports and airports located along the routes. Table 2.3.1 shows the present situation of transportation infrastructures along the corridor and Figure 2.3.1 shows the national transportation network.

Table 2.3.1 Transport Infrastructure of North-South Corridor

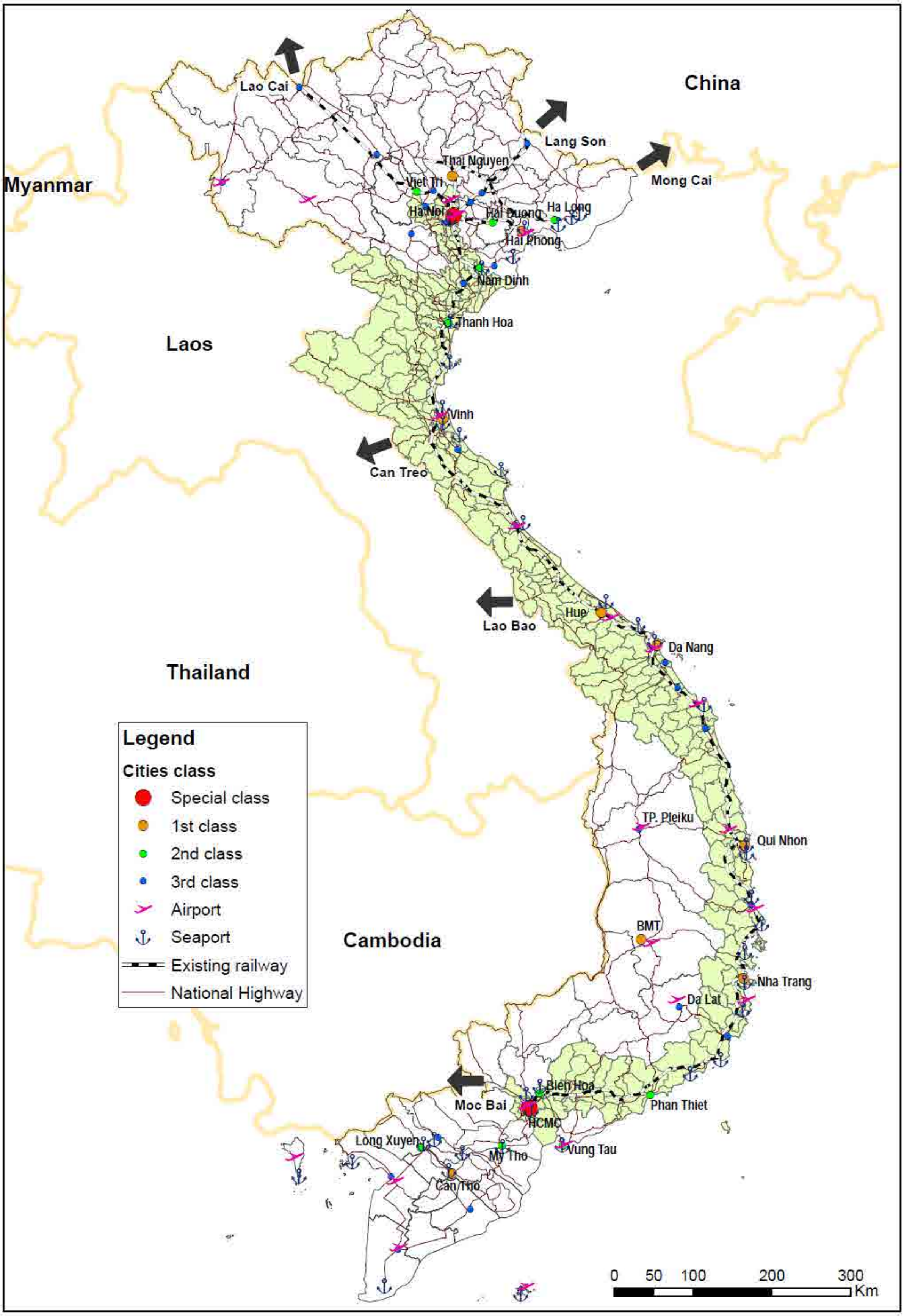
Road	Segment		Hanoi – Vinh (NH1, 365km)	Vinh - DaNang (NH1, 650km)	DaNang – Nha Trang (NH1, 510km)	Nha Trang - HCMC (NH1, 350km)
Road	Width		4 Lane:15% 2 Lane: 85%	4 Lane:12% 2 Lane: 88%	4 Lane:5% 2 Lane: 95%	4 Lane:20% 2 Lane: 80%
Road	Surface Condition		Good: 50% Fair: 18% Bad: 32%	Good: 37% Fair: 63%	Good: 85% Fair: 8% Bad: 7%	Good: 14% Fair: 68% Bad: 18%
Road	Bridges	No	56	175	264	94
Road	Bridges	Length (m)	3,810	10,135	18,585	3,407
Rail	Track		Meter gauge (Single Track)			
Rail	Location		Hanoi - Vinh	Vinh – DaNang	DaNang – Nha Trang	Nha Trang - HCMC
Rail	Crossings (no)		294	272	269	238
Rail	Bridges	No	127	270	487	267
Rail	Bridges	Length (m)	3,390	11,298	14,588	5,667

Airport	Location		Hanoi (Noi Bai)	Vinh (Nghe An)	Quang Binh (Dong Hoi)	Hue (Phu Bai)	DaNang (DaNang)	Quang Nam (Chu Lai)	Binh Dinh (Phu Cat)	Phu Yen (Dong Tac)	Khanh Hoa (Cam Ranh)	HCMC (Tan Son Nhat)
Airport	Service		Int'l/ Domst	Domst	Domst	Domst	Int'l/ Domst	Domst	Domst	Domst	Domst	Int'l/ Domst
Airport	Runway (m)		3,800	2,400	2,400	2,700	3,048	3,658	3,048	2,743	3,048	3,800
Airport	Capacity	Pax (000/yr)	6,000	100	300	582	1,000	291	291	20	243	15,000
Airport	Capacity	Cargo (ton/yr)	150,000	-	-		-	-	-	-	-	150,000

Port	Location		Quang Ngai	Hai Phong	Thanh Hoa	Nghe An	Ha Tinh	TT Hue	Da Nang	Quang Ngai	Binh Dinh	Khanh Hoa	BR-VT	Dong Nai	HCMC
Port	Class 1 Seaport		Cam Pha, Hon Gai	Hai Phong	Nghi Son	Cua Lo	Vung Ang	Chan May	Da Nang	Dung Quat	Quy Nhon	Nha Trang, Ba Ngoi	Vung Tau	Dong Nai	Ho Chi Minh
Port	Service		Int'l/ Domst	Int'l/ Domst	Int'l	Int'l/ Domst	Int'l/ Domst	Int'l/ Domst	Int'l/ Domst	Int'l/ Domst	Int'l/ Domst	Int'l/ Domst	Int'l/ Domst	Int'l/ Domst	Int'l/ Domst
Port	Berth	No.	12	51	6	9	4	7	20	3	8	6	34	22	82
Port	Berth	Length (m)	2240	5513	2292	836	304	780	2249	170	1120	749	5348	2791	9068
Port	Depth (m)		-12	-8.7	-10	-7.5	-10.8	-12.5	-12	-9.5	-12	-11.8	-12	-9.5	-13
Port	Capacity (000 ton/yr)		5,115	9,712	0	786	501	287	2,044	29	1,669	2,572	1,623	790	12,422

Source: JICA Study Team, 2012

2.33 The main bottlenecks for the road (NH1) are bridges. Although many bridges have been upgraded in recent years, there remain some bridges in bad condition. The pavement conditions are good in general; however, they have not been designed to accommodate the increasingly large volumes of heavy vehicles. Railway could attract a larger share of the corridor traffic, except for the fact that it is constrained by its single-track speed limitations at several sections. Slow operation at 30 - 60 km/h is required on 32 bridges, and in 7 tunnels at 15 – 50 km/h, both without mentioning to speed restrictions occasioned by short radii of curvatures.



Source: MONRE, General Statistics Office, other sources.

Figure 2.3.1 Spatial Structure and Transportation along the North – South Corridor

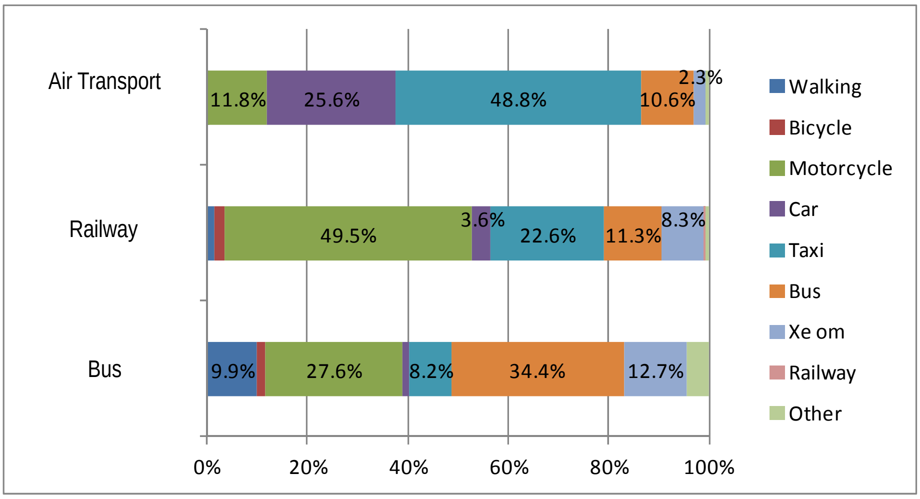
2.34 **Transport Service:** The service of each passenger transport mode is briefly summarized as follows;

(i) **Road Transport:** The road has limited capacity (mostly 2 lanes along NH1) and is occupied mainly by trucks. Therefore, average travel speed on roads is limited at present. Bus service along the corridor is quite developed and offered with high frequency (in Hanoi around 3,000 inter-city buses are operated for a day at four bus terminals while, in HCMC, also around 3,000 inter-city buses operated at two bus terminals.). Long distance buses from Hanoi to Ho Chi Minh (34 hours of travel) are offered for around 650,000 VND for seat and 920,000 VND for sleeper.

(ii) Railway: The single track North-south railway is connecting main cities along the corridor. The service frequency is around 14-22 trains/day for passenger and 10-12 trains/day for freight. The fastest train connects Hanoi and Ho Chi Minh in 30.0 hours costing around 600,000 VND for hard seat (no air conditioner) and around 1,600,000 VND for soft sleeper (level 1 with air conditioner).

(iii) Air Transport: Compared with bus and railway, the growth of air transport industry is remarkable. As of 2011, 438 flights/week are operated in Noi Bai Airport (among them, 424 flights/week are for the south direction) and 708 flights/week in Tan Son Nhat Airport (577 flights are for the north direction) for domestic travel. Besides the flag carrier, Vietnam Airlines, low cost carriers (LCC) also carry around 20% of air passengers. Noi Bai Airport and Tan Son Nhat Airport is connected by about 1 hour 50 minutes (time during on-board only). Accessibility from city center to airport differs in each location. In case of Hanoi, from Hoan Kiem District to Noi Bai airport, it takes 40-50 minutes while in Ho Chi Minh, from District 1 to Tan Son Nhat, it takes 20-40 minutes depending on traffic condition. The flight of Vietnam Airlines traveling between Hanoi and HCMC costs about 2,200,000 VND while LCC (Jet Star) offers the flights for the same route for about 1,300,000 VND.

2.35 **Access to terminal:** As a part of traffic survey, the access conditions of passenger transport along North South Corridor were interviewed with passengers. Figure 2.3.2 shows access modes to transport terminal. Public transport is not well-developed for access to terminals. In terms of railway, most of passengers access to railway station by motorcycle or taxi.



Source: JICA Study Team, 2012
Note: No. of samples: 1,914 bus passengers; 1,563 railway passengers; 984 air passengers

Figure 2.3.2 Access Mode to Transportation Terminals

2.36 Regarding the fare to access the terminals, the bus is the cheapest while railway is almost twice as much as the bus (see Table 2.3.2). The cost of air transport is much higher than the two other modes.

Table 2.3.2 Average Fare to Terminals

	Bus Passenger	Railway Passenger	Air Passenger
Average Fare (VND)	15,353	29,163	127,737

Source: JICA Study Team, 2012

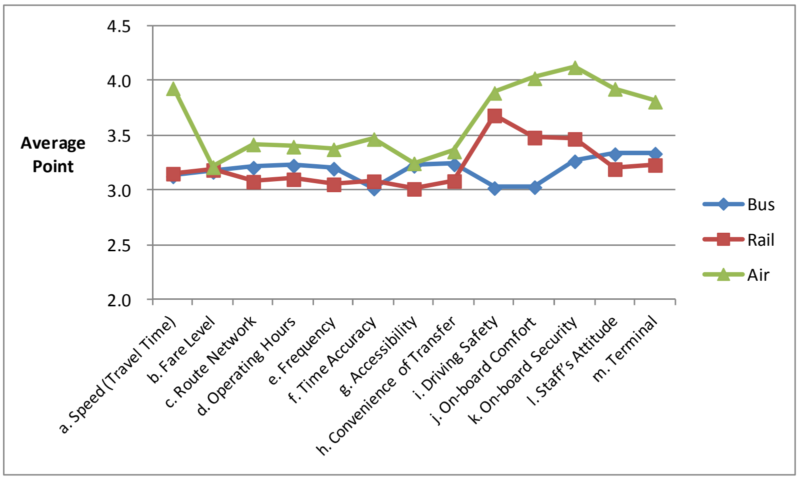
2.37 Table 2.3.3 shows the average access time to the terminals. Average access times for the bus, railway and air transport passengers are 27 minutes, 32 minutes and 50 minutes, respectively. For railway passengers, though, their average access time from one railway terminal to another is 266 minutes (which actually skews the overall figures to a higher average time).

Table 2.3.3 Average Access Time to Terminal (minutes)

Access Mode	Bus Passenger	Railway Passenger	Air Passenger	All
Walking	10.7	9.0	7.5	10.5
Bicycle	19.1	25.3	-	22.2
Motorcycle	18.0	26.8	33.5	24.0
Car	21.8	29.9	58.1	50.5
Taxi	23.1	26.8	46.8	35.9
Bus	41.2	68.2	58.8	48.3
Xe om	18.5	21.7	60.9	22.0
Railway	-	265.7	-	265.7
Other	43.3	62.5	73.6	47.4
All	26.9	32.2	49.8	33.8

Source: JICA Study Team, 2012

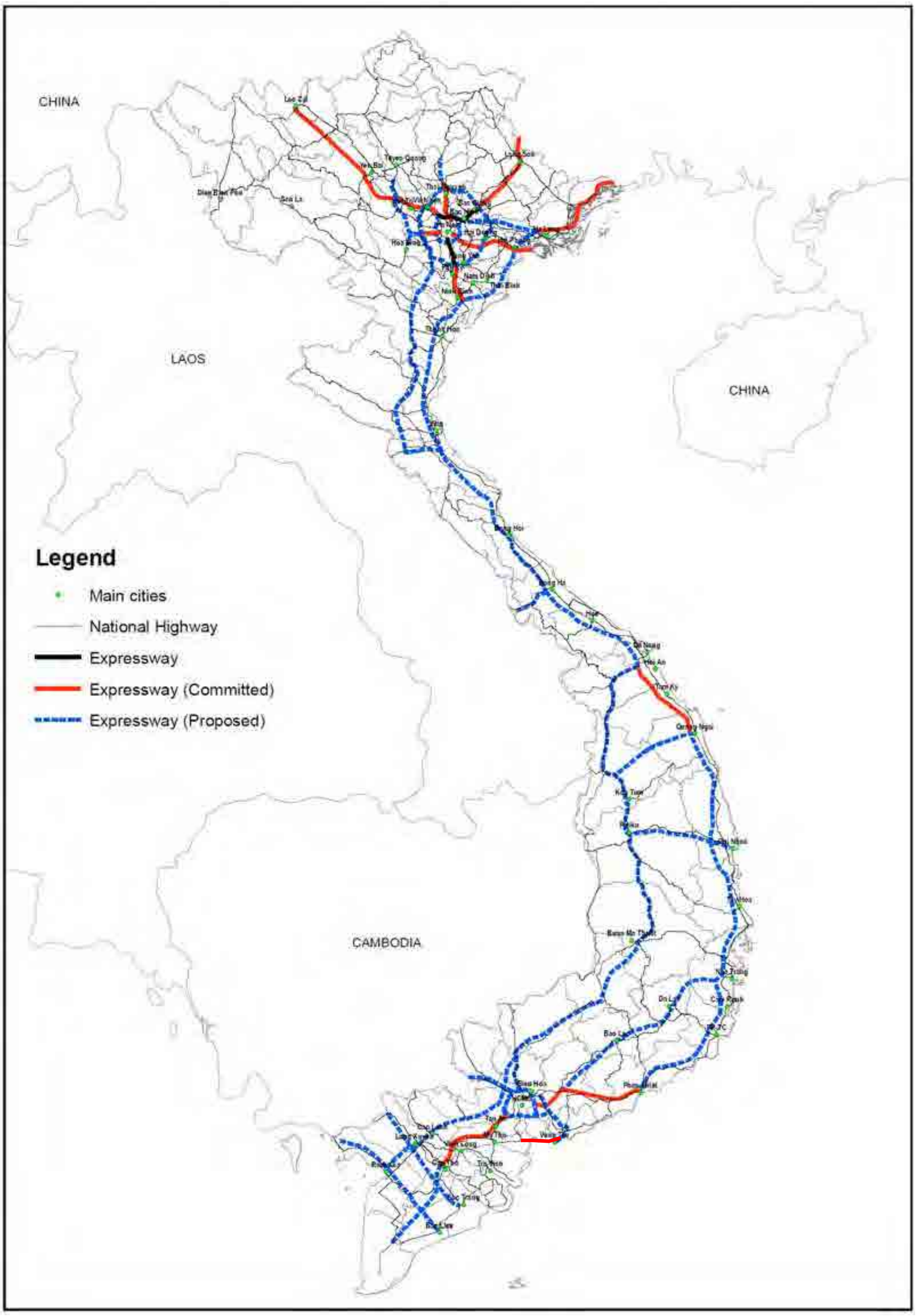
2.38 **Service Evaluation from passengers Perspective:** Figure 2.3.3 shows the evaluation of transport modes by uses. Besides travel time, the difference of evaluations is most obvious on driving safety, on-board comfort and on-board security. Generally speaking, railway transport is considered much safer than bus and this fact is one of the main reason that railway is chosen as travel mode.



Source: JICA Study Team, 2012
Note: Average point is calculated by converting evaluations as follows: Very Bad = 1 point, Bad =2 points, So-so = 3 points, Good = 4 points, Very good = 5 points.

Figure 2.3.3 Comparative Evaluation of All Travel Modes

2.39 **Perspective Projects:** Projects for the expressway and airway up to 2030 identified in VITRANSS2 gives an overall picture of the development of other modes in the future (See Figure 2.3.4 for MOT's master plan and Figure 2.3.5 which updated the network and investment costs). By this period, the north-south corridor will be connected by not only the existing NH1 but also this expressway. Many airports including Noi Bai and Tan Son Nhat Airport will be upgraded, and Long Thanh Airport will be newly constructed to accommodate the increasing demand (Figure 2.3.5).



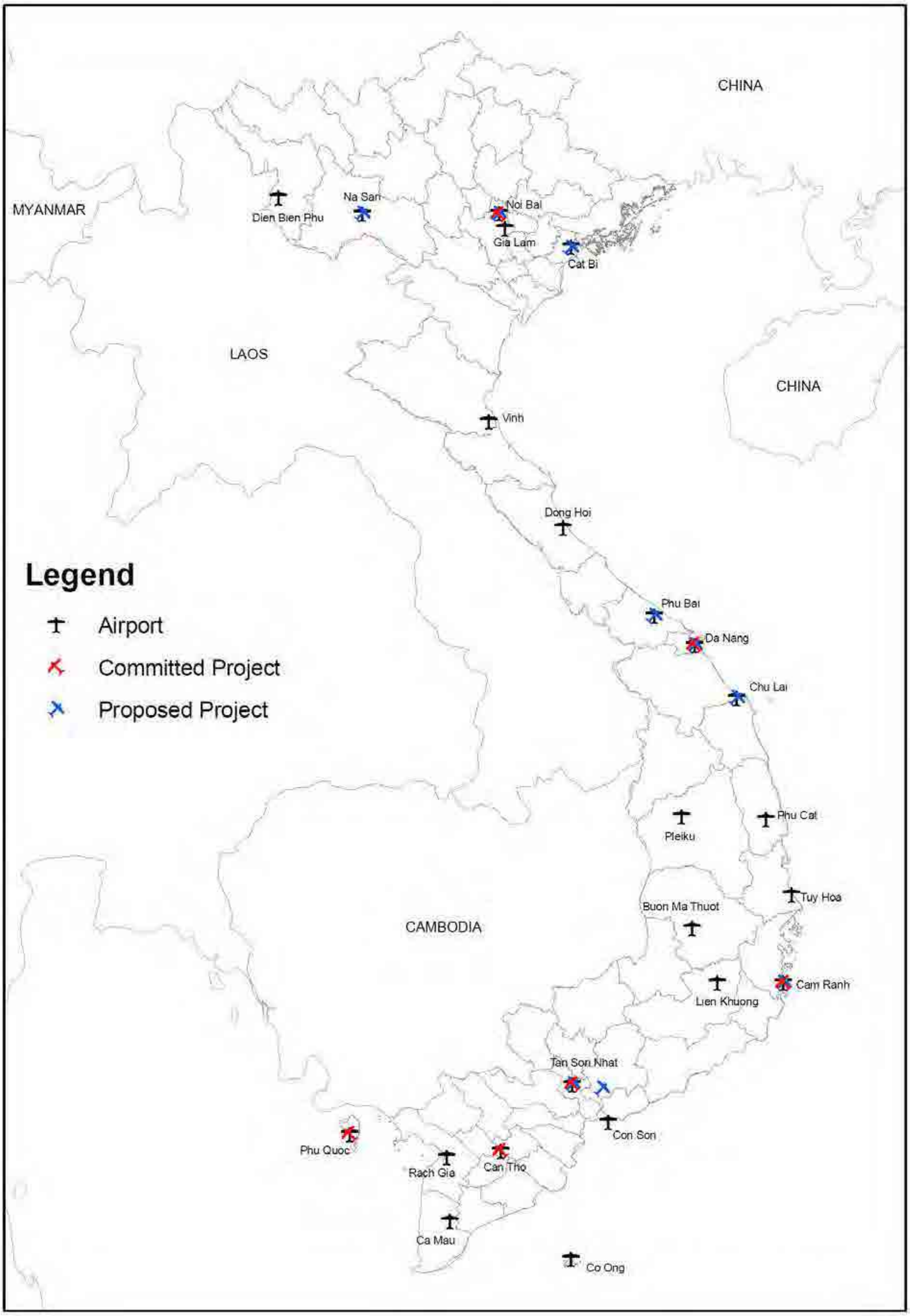
Source: VITRANSS2 (JICA, 2010)

Figure 2.3.4 Identified Road and Road Transportation Projects up to 2030 (Expressway)

Table 2.3.4 List of Expressway Projects in the MOT Master Plan

No.		Section	Length (km)	No. of Lanes	Cost (VND bil.)
North–South Expressway in the East	1	Cau Gie–Ninh Binh	50	6	9,300
	2	Ninh Binh–Thanh Hoa	75	6	12,380
	3	Thanh Hoa–Vinh	140	6	22,120
	4	Vinh–Ha Tinh	20	4-6	2,580
	5	Ha Tinh–Quang Tri	277	4	21,610
	6	Quang Tri–Da Nang	178	4	18,160
	7	Da Nang–Quang Ngai	131	4	17,820
	8	Quang Ngai–Quy Nhon	150	4	23,700
	9	Quy Nhon–Nha Trang	240	4	24,960
	10	Nha Trang–Dau Giay	378	4-6	55,940
	11	HCMC–Long Thanh–Dau Giay	55	6-8	18,880
	12	Long Thanh–Nhon Trach–Ben Luc	45	6-8	12,340
	13	HCMC–Trung Luong	40	8	13,200
	14	Trung Luong–My Thuan–Can Tho	92	6	26,250
N–S Expressway in the West	15	Doan Hung–Hoa Lac–Pho Chau	457	4-6	53,930
	16	Ngoc Hoi–Chon Thanh–Rach Gia	864	4-6	96,770
Northern Vietnam	17	Lang Son–Bac Giang–Bac Ninh	130	4-6	12,220
	18	Hanoi–Hai Phong	105	4-6	16,800
	19	Hanoi–Lao Cai	264	4-6	15,580
	20	Hanoi – Thai Nguyen	62	4-6	4,220
	21	Thai Nguyen–Cho Moi	28	4-6	2,940
	22	Lang–Hoa Lac	30	6	7,650
	23	Hoa Lac–Hoa Binh	26	4-6	2,550
	24	Bac Ninh–Ha Long	136	6	19,040
	25	Ha Long–Mong Cai	128	4-6	13,820
	26	Ninh Binh–Hai Phong–Quang Ninh	160	4	13,760
Central Vietnam	27	Hong Linh–Huong Son	34	4	2,450
	28	Cam Lo–Lao Bao	70	4	4,900
	29	Quy Nhon–Pleiku	160	4	12,000
Southern VIetnam	30	Dau Giay–Da Lat	189	4	19,280
	31	Bien Hoa–Vung Tau	76	6	12,160
	32	HCMC–Thu Dau Mot–Chon Thanh	69	6-8	20,010
	33	Can Tho–Ca Mau	150	4	24,750
	34	HCMC–Moc Bai	55	4-6	7,480
	35	Soc Trang–Can Tho–Chau Doc	200	4	24,200
	36	Ha Tien–Rach Gia–Bac Lieu	225	4	27,230
Ring Road System in Hanoi	37	Ring road No 3	56	4-6	17,990
	38	Ring road No 4	125	6-8	34,500
RR System in HCMC	39	Ring road No 3	83	6-8	20,750
Total			5,753		766,220

Source: MOT Master Plan (No.7056/TTr-BGTVT dated 5 November 2007).
Note: This table does not include the following: Bac Ninh–Phap Van section (40km), Phap Van–Cau Gie section (30km), Noi Bai–Bac Ninh section (30 km), and Lien Khuong–Da Lat section (20km).



Source: VITRANSS2 (2010, JICA)

Figure 2.3.5 Identified Air Transportation Projects up to 2030

Table 2.3.5 Committed/On-going Projects of Aviation Sector

Project	Description	Cost (mill. US$)	Implementing Agency	Fund Source (US$)
Construction of new airport				
Phu Quoc Island Airport	To construct a new airport with the capacity of 2 mppa and 15 thousands tonnes of cargo per annum.	56.0	SAC	State Budget (56)
Capacity Expansion of existing airport				
Terminal Construction at Danang International Airport	To construct a new terminal building with floor area of 36,000 sq.m. and the capacitty is 4 mppa. Expansion of apron, road and car parks are included.	84.0	MAC	State Budgest (83)
T2 Terminal Construction at Noi Bai International Airport	To construct a new terminal building with its capacity of 10 mppa. Expansion of apron, road and car parks are included.	800.0	NAC	State Budgest
Cargo Terminal Expansion at Noi Bai International Airport	To expand the cargo terminal to 260,000 tonnes per year and floor area of 15,000 sq.m	20.0	NAC	State Budget
Runway upgrading and terminal Construction at Can Tho Airport	Upgrading of runway to 2,400 m and construction of new terminal builindg with the capacity of 400 thousand domestic passengers per annum.	23.0	SAC	State Budget (23)
Runway Extension and Apron Expansion at Danang International Airport	To extend a runway to 3,500m and expand the apron	75.0	MAC	State, MAC, Private
Passenger Terminal Expansion at Danang Internaitional Airport	To expand passenger terminal building with the capacity of 6 mppa	100.0	MAC	State, MAC, Private
Cargo Terminal Constrcution at Tan Son Nhat International Airport	To handle 400,000 tons of cargo	50.0	SAC	State, MAC, Private
Improvement of navigation facility				
Control Tower Construction at Noi Bai International Airport	To construct a new control tower with the height of 87 m.	100.0	VANSCORP	State Budgest
Terminal Building and Control Tower Construction at Cam Ranh Airport	To consturct a new terminal building with the capacity of 1.4 mppa and total floor area of 14,000 sq.m.	12.5	MAC	State Budget (12.5)

Source: VITRANSS2
Note: Vietnam Air Navigation Services Corporation (VANSCORP); Middle Airports Corporation (MAC); Southern Airport Corporation (SAC); Northern Airports Corporation (NAC)

Table 2.3.6 Proposed Projects of Aviation Sector

Project	Description	Cost (mill. US$)	Original Schedule	Implementing Agency	Source
Construction on new airport					
Long Thanh Airport	To construct a new international airport with the capacity of 8 to 10 mppa.	6000.0	2010-2015	SAC	PM Decision No. 703/2005/QD-TTg
Capacity Expansion of existing airport					
T1&T2 Terminal Expansion at Noi Bai International Airport	To expand T1 & T2 to be able to handle 20 mppa	900.0	2015-2020	NAC	PM Decision No. 590/QD-TTg
T3 Terminal Construction at Noi Bai International Airport	To construct a new passenger terminal building of T3 with capacity of 15 mppa	1200.0	2010-2015	NAC	PM Decision No. 590/QD-TTg
Runway Construction at Noi Bai International Airport	To construct a new runway at southern side of the airport	500.0	2020-2030	NAC	PM Decision No. 590/QD-TTg
Cat Bi Airport Upgrading	To develop Cat Bi Airport to international airport with the capacity of 2 mppa and 3,200 m length runway.	300.0	2010-2015	NAC	PM Decision No. 1290/QD-TTg
Phu Bai Airport Upgrading	-	400.0	2008-2013	MAC	Aviation Master Plan

Project	Description	Cost (mill. US$)	Original Schedule	Implementing Agency	Source
Chu Lai Airport Upgrading for Cargo Transport (Stage1: original schedule: 2009-2015)	To construct cargo hub airport with capacity of 1.5 million tonnes of cargo per annum.	300.0	2009-2015	MAC	PM Decision No. 543/QD-TTg
Chu Lai Airport Upgrading for Cargo Transport (Stage2: original schedule: 2015-2025)	To construct cargo hub airport with capacity of 5.0 million tonnes of cargo per annum.	400.0	2015-2025	MAC	PM Decision No. 543/QD-TTg
Cam Ranh Airport Expansion	To develop the capacity to 2.65 mppa by 2015	100.0	2008-2010	MAC	PM Decision No. 1290/QD-TTg
Runway Upgrading at Na San Airport	To upgrade runway to be capable to opeate A320 and A321 aircraft with the capacity of 300 thousands passengers per annum and 2,000 tonnes of freight per annum.	60.0	-2010	NAC	Aviation Master Plan
Runway Improvement at Danang international Airport	Shifting of taxiway E6 to widen clearance from 75 m to 150m	-			
Taixway Construction at Danang international Airport	Building of a dual parallel taxiway to	-			
Expansion of Tan Son Nhat International Airport	To expand capacity of Tan Son Nhat International Airport to handle 25 mppa	200.0	2009-2015	SAC	
Other Tertiary Airport Improvement	Minor improvements of several regional airports that provide access to remote areas (Na San, Dien Bien Phu, Ca Mau, Pleiku, etc)	50.0			
Improvement of navigation facility					
Control tower Construction at Tan Son Nhat International Airport	To construct a new control tower	50.0	2009-2011	VANSCORP	Aviation Master Plan
Air Navigation System	Modernization of the air traffic management system	100.0			

Source: VITRANSS 2 Study(2010)

2.40 **Perspective Railway Projects:** The following railway projects are ongoing or committed. These projects are categorized as “A1” and explained in detail in Technical Report No. 1.

(i) Railway replace or improvement:

- Vinh – Nha Trang track structure (superstructure) replacement project
- Hanoi – Vinh and Nha Trang – HCMC sections track structure (superstructure) strengthening project

(ii) Upgrading/ replacing the existing bridges:

- Hanoi - Ho Chi Minh City Railway Bridges Safety Improvement Project (44 bridges)
- Hanoi - Ho Chi Minh City Weak Bridges Improvement Project (132 bridges)
- Hanoi – Ho Chi Minh City railway bridges safety improvement project (566 bridges)
- Hanoi – Ho Chi Minh City railway weak tunnels consolidation project

(iii) Signaling – Telecommunication System:

- Hanoi – Vinh Signaling – Telecommunication System Project, phase II
- Vinh – Sai Gon Signaling – Telecommunication Modernization Project, Phase I
- Operation Control Center Modernization Project
- Signal protection device for level crossing project on Hanoi - Ho Chi Minh City
- Amendment for level crossing project on Hanoi - Ho Chi Minh City

2.4 Overall Traffic Demand and Characteristics

1) Demand Analysis based on Traffic Survey and Traffic Demand Forecast

2.41 Based on the traffic survey result, the present OD data was updated from 2008 (VITRANSS2 traffic data) to 2010 . The summary of inter-provincial transport demand of both passenger and freight in 2010 and 2030 is shown in Table 2.4.1. Main characteristics are as follows;

(i) Total passenger travel demand in terms of number will increase from 0.9 million to about 2.9 million a day between 2010 and 2030 by 3.0 times, while the demand in terms of passenger-kms will increase from 170 million to 662 million a day between the same period by 3.9 times because people will travel in longer distance along with economic growth.

(ii) Increase in freight transport demand is also notable. 1.4 million tons transported daily in 2010 will increase to 3.7 million tons in 2030 or by 2.7 times. Ton-kms will also increase due to longer haulage of various cargos.

(iii) Transport demand will increase both at inter-regional level and within the region.

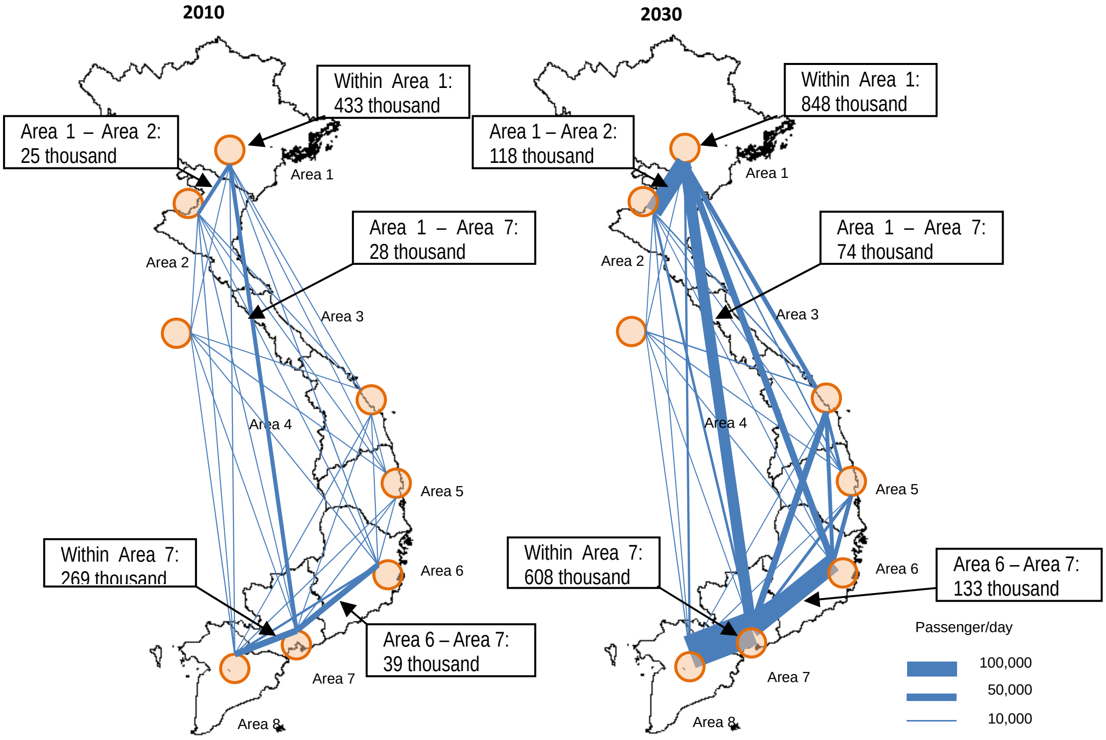
(iv) The heaviest traffic demand is observed between Mekong River Delta and South-east in 2010, though inter-regional transport demand is expected to increase for other pairs of regions.

(v) North-south transport demand is expected to increase faster than national average. All inter-regional passenger transport demand related to the north-south corridor is expected to increase by 4.5 to 5.5 times between 2010 and 2030. Freight traffic along the north-south corridor is also expected to increase faster than the national average.

Table 2.4.1 Forecast Increase in Passenger and Freight Traffic

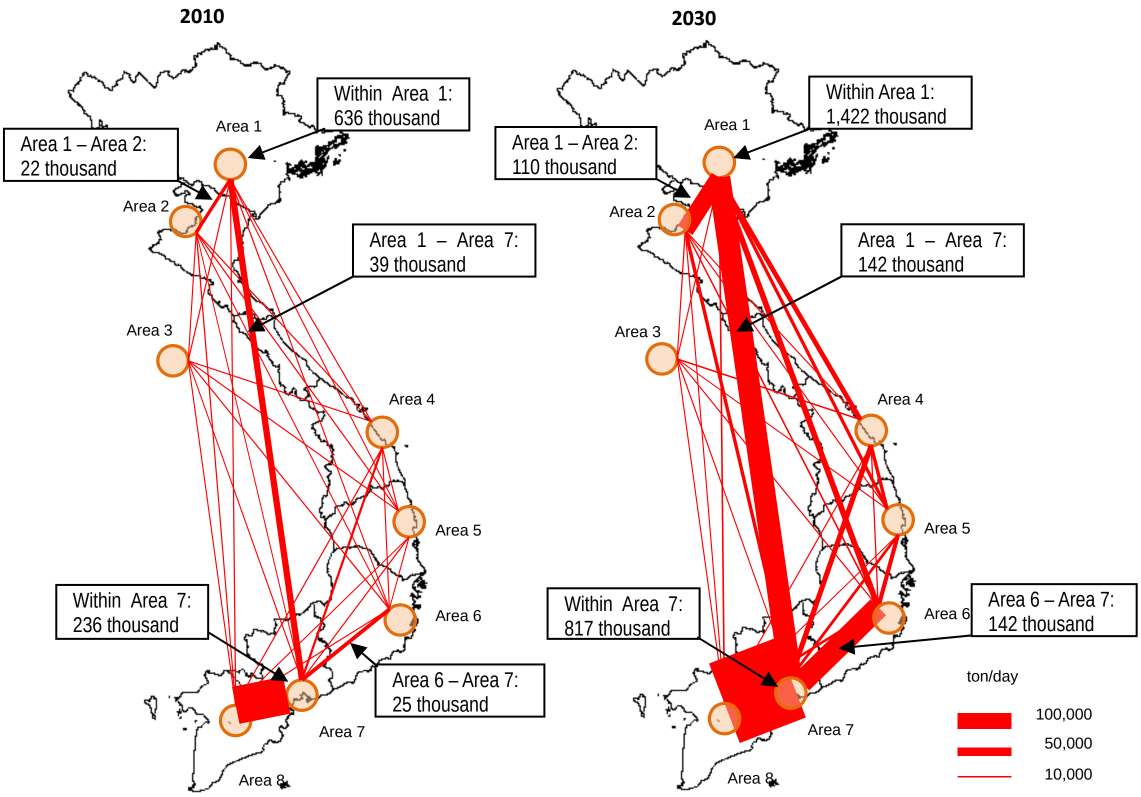
Item		2010	2030	Growth	
				2030/10	%/Yr
Passenger (per Day)	Number (000)	991	2,978	3.0	5.7
	Passenger-km (000)	170	662	3.9	7.0
	Average Trip Length (km)	172	222	1.3	-
Freight (per Day)	Tons (000)	1,377	3,732	2.7	5.1
	Ton-km (000)	260	810	3.1	5.8
	Average trip length (km)	189	217	1.1	-

Source: VITRANSS 2 (JICA, 2010) and JICA Study Team, 2012
Note: Assumption: Annual GDP growth ratio: 6.5% for 2010-2020 an d 6.0 for 2020-2030; annual population growth ratio: 1.0% for 2009-2020, and 0.7% for 2020-2030; annual urban population growth ratio: 3.0% for 2010-2020, and 2.5% for 2020-2030.



Source: JICA Study Team, 2012

Figure 2.4.1 Passenger Traffic Demand Distribution, 2010 and 2030



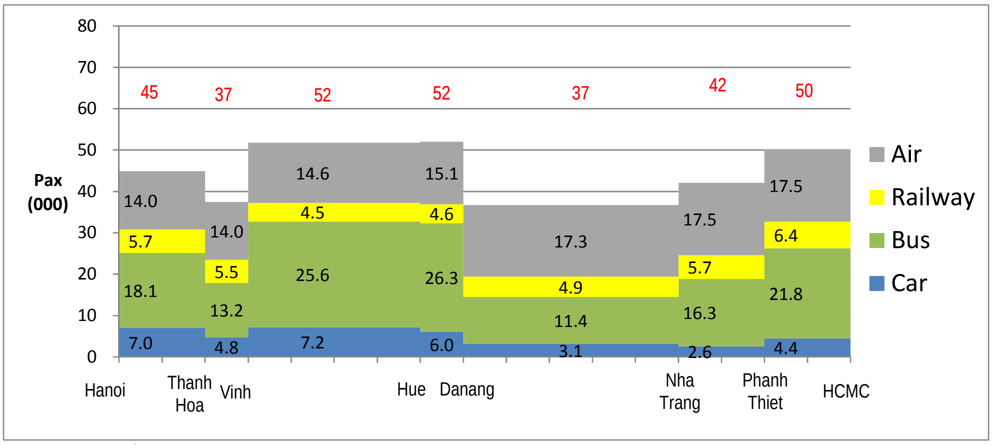
Source: JICA Study Team, 2012

Figure 2.4.2 Freight Traffic Demand Distribution, 2010 and 2030

2.42 **Modal Split of Transport Demand**: The model share of passenger traffic demand along the north-south coastal corridor, which is directly related to the objective of the Study. is analyzed based on updated OD data (Figure 2.4.3). Main characteristics are as follows;

(i) Cross sectional passenger traffic is roughly between 37 to 50 thousand passengers a day, wherein the highest traffic volume is observed for Hue – Danang and Vinh – Hue section (52,000 passengers/day)

(ii) Bus shares the highest percentage in all sections. The share of railway is small but higher than the one of car for all the section excluding Vinh-Danang.



Source: JICA Study Team, 2012

Figure 2.4.3 Passenger Traffic Demand by Mode along North-South Coastal Corridor, 2010

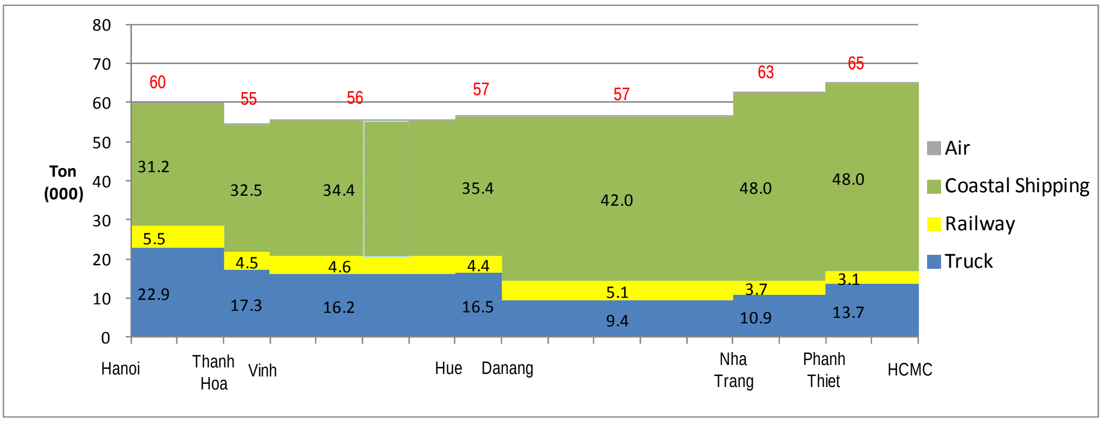
2.43 The same analysis was made on cargo traffic demand along the north-south coastal corridor. (see Figure 2.4.4) Main characteristics are as follows;

(i) There are cargo traffic demand of 55 to 65 thousand tons a day along the corridor.

(ii) Coastal shipping is the major mode of cargo transportation along the north-south followed by truck.

(iii) Along the coastal corridor, overall situation is the same as the entire north-south corridor. The coastal shipping shares almost 50 to 80% of the traffic.

(iv) Railway transportation 3,100 to 5,500 tons/day or 4.8% to 9.2% of the total cross section cargo traffic along the coastal corridor. The traffic is heavier for Hanoi – Vinh section than Nha Trang – HCMC section.



Source: JICA Study Team , 2012

Figure 2.4.4 Freight Traffic Demand by Mode along North-South Coastal Corridor, 2010

2) Baseline Analysis

2.44 In Baseline analysis, it is assumed existing transport network including committed projects will remain in 2030. The results of traffic demand analysis are presented by transport mode and by section of the north-south corridor (see Table 2.4.2 and Figure 2.4.5). Main findings are as follows;

(i) Passenger transport capacities of all modes including national roads, existing rail and air will be insufficient (the future growth of traffic demand will overwhelm the capacities of transport infrastructures).

(ii) Road transport demand on the coastal corridor overflows to inland routes; it occurs more explicitly in the north than in the south.

(iii) Air transport shares relatively high percentage of about 40% of cross sectional traffic.

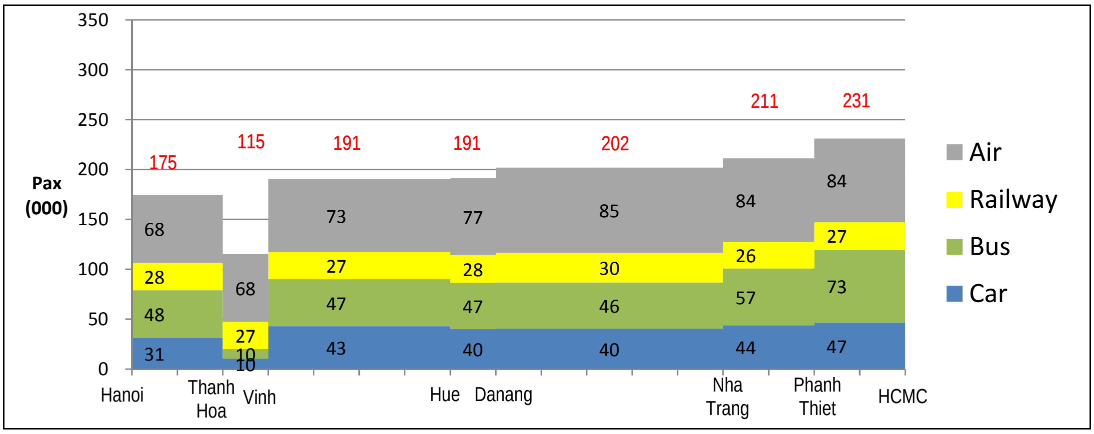
Table 2.4.2 Estimated Traffic Demand along North South Corridor (Baseline Scenario) 2030

			North		Central			South	
			N1. Hanoi – Thanh Hoa	N2. Thanh Hoa - Vinh	C1. Vinh - Hue	C2. Hue - Danang	C3. Danang – Nha Trang	S1. Nha Trang – Phan thiet	S2. Phan Thiet – HCMC
Passenger (no/day)	National Road	Car	31,395	10444.8	42,874	39,939	40,490	43,885	46,611
		Bus	47,529	9,671	47,029	46,635	46,299	56,962	73,239
	Existing	Rail	27,727	27,215	27,442	27,539	29,883	26,401	27,266
	Air		68,047	68,047	73,461	77,369	85,320	83,931	83,931
	Total		174,698	115,378	190,805	191,482	201,992	211,179	231,048
Transport Requirement (/day)	Road (pcu)	Passenger (pcu)	15,610	4,444	19,136	18,171	18,302	20,664	23,502
		Freight (pcu)	90,769	75,314	80,358	83,964	82,608	92,541	92,514
	Existing Rail	Passenger (no. of train)	28	28	28	28	30	27	28
		Freight (no. of train)	56	54	53	51	45	26	27
	Air	Passenger (no. of flight)	369	369	399	420	463	454	454
Capacity[1)]	Road (pcu)	Total (passenger and freight)	54,800	27,400	27,400	54,800	27,400	27,400	27,400
		For passenger	-35,969	-47,914	-52,958	-29,164	-55,208	-65,141	-65,114
	Existing Rail (no. of train)	Total (passenger and freight)	32	32	32	32	32	32	32
		For passenger	0	0	0	0	0	6	5
	Air	(No. of flight)	366-492						

Source: JICA Study Team, 2012

1)Capacities are estimated for total and that available for passenger transport after capacity required for cargo traffic demand is deducted from the total capacity

2) Airport capacity is assumed to be about 3 times of the present considering existing plans of airport development.



Source: JICA Study Team, 2012

1/ In the sections where there are alternative roads on inland, traffic on coastal side (North South Corridor) overflows to such roads as the demand outnumbers the capacity.

Figure 2.4.5 Estimated Traffic Demand along North South Corridor (Baseline Scenario) 2030

2.45 **Railway:** Total railway passenger traffic has been rather stagnant during the last three years. The number of daily passengers was 48,600, 48,147 and 46,733 in 2008, 2009 and 2010, respectively (see Table 2.4.3). Main characteristics are as follows:

(i) Traffic demand of Hanoi-Saigon Line had a 34% share in 2009 which increased to 37% in 2010, having carried 16,487 and 17,173 passengers per day in respective years.

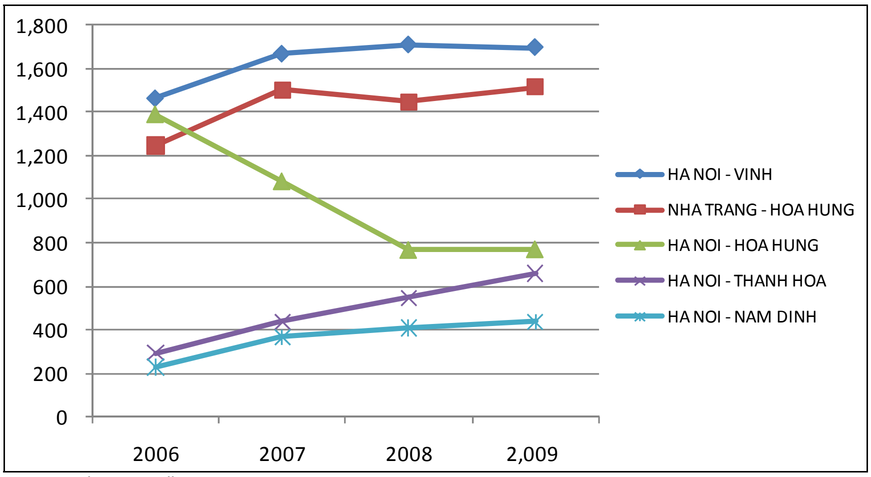
(ii) Other main lines for passenger transport include Hanoi–Haiphong, Gia Lam–Dong Dang, Yen Bien–Quang Trieu and Dong Anh–Lao Cai

Table 2.4.3 Railway Traffic Demand by Line

Line	2008	2009	2010
	no./day (%)	no./day (%)	no./day (%)
Hanoi–Saigon	16,487 (33.9)	16,108 (33.5)	17,173 (36.7)
Hanoi–Haiphong	8,805 (18.1)	8,771 (18.2)	8,461 (18.1)
Gia Lam–Dong Dang	7,338 (15.1)	7,228 (15.0)	6,621 (14.2)
Yen Bien–Quang Trieu	6,488 (13.3)	6,513 (13.5)	5,988 (12.8)
Dong Anh–Lao Cai	9,274 (19.1)	9,275 (19.3)	8,399 (18.0)
Pho Trang–Ha Long	268 (0.5)	252 (0.5)	91 (0.2)
Total	48,660 (100.0)	48,147 (100.0)	46,733 (100.0)

Source: Vietnam Railways

2.46 Regarding Hanoi–Saigon line, main pairs of demand include Hanoi–Vinh, Nha Trang– Hoa Hung (HCMC), and Hanoi– Hoa Hung (HCMC), which carried 1,696, 1,514 and 772 passengers per day, respectively, in 2010. Of the main OD pairs, the demand of Hanoi–HCMC has been decreasing, while that of Hanoi–Thanh Hoa/Nam Dinh has been increasing (see Figure 2.4.6). The sudden decrease of passenger trip between Hanoi – HCMC in recent years would be attributable to the low service quality of railway transport making the mode less competitive to air transport (the share of air traffic demand is increasing rapidly as shown in Table 2.4.9.)



Source: Vietnam Railways

Figure 2.4.6 Trend of Top 5 Major Pasenger OD Pairs (Hanoi–Saigon Line)

Table 2.4.4 Major OD Pairs of Railway Passenger Traffic (Hanoi–Saigon Line)

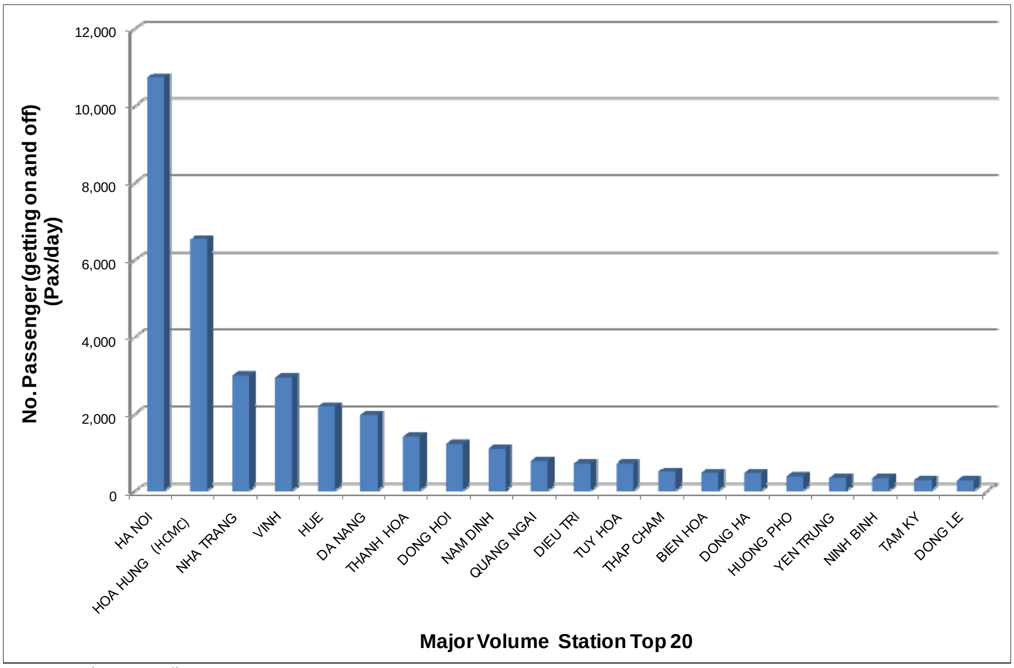
Order	OD Pair			Daily Pax in 2010
1	Ha Noi	–	Vinh	1,696
2	Nha Trang	–	Hoa Hung	1,514
3	Ha Noi	–	Hoa Hung	772
4	Ha Noi	–	Thanh Hoa	658
5	Ha Noi	–	Nam Dinh	437
6	Ha Noi	–	Da Nang	433
7	Ha Noi	–	Hue	366
8	Hue	–	Hoa Hung	362
9	Quang Ngai	–	Hoa Hung	331
10	Da Nang	–	Hoa Hung	330
11	Thanh Hoa	–	Hoa Hung	316
12	Nam Dinh	–	Hoa Hung	308
13	Dieu Tri	–	Hoa Hung	300
14	Ha Noi	–	Dong Hoi	274
15	Vinh	–	Hoa Hung	264
16	Thap Cham	–	Hoa Hung	245
17	Hue	–	Da Nang	241
18	Ha Noi	–	Nha Trang	224
19	Tuy Hoa	–	Nha Trang	224
20	Tuy Hoa	–	Hoa Hung	214
21	Da Nang	–	Nha Trang	185
22	Dong Hoi	–	Hue	183
23	Vinh	–	Huong Pho	152
24	Da Nang	–	Quang Ngai	140
25	Ninh Binh	–	Hoa Hung	123
26	Tam Ky	–	Hoa Hung	112
27	Dong Hoi	–	Da Nang	110
28	Dong Hoi	–	Hoa Hung	106
29	Minh Le	–	Dong Hoi	103
30	Dong Ha	–	Hue	95

Source: VR

2.47 Hanoi station is the most used railway station which accommodates more than 10,000 passengers per day, followed by Hoa Hung (HCMC) with about 6,200 passengers per day, then Nha Trang, Vinh, Hue, Da Nang and so on.

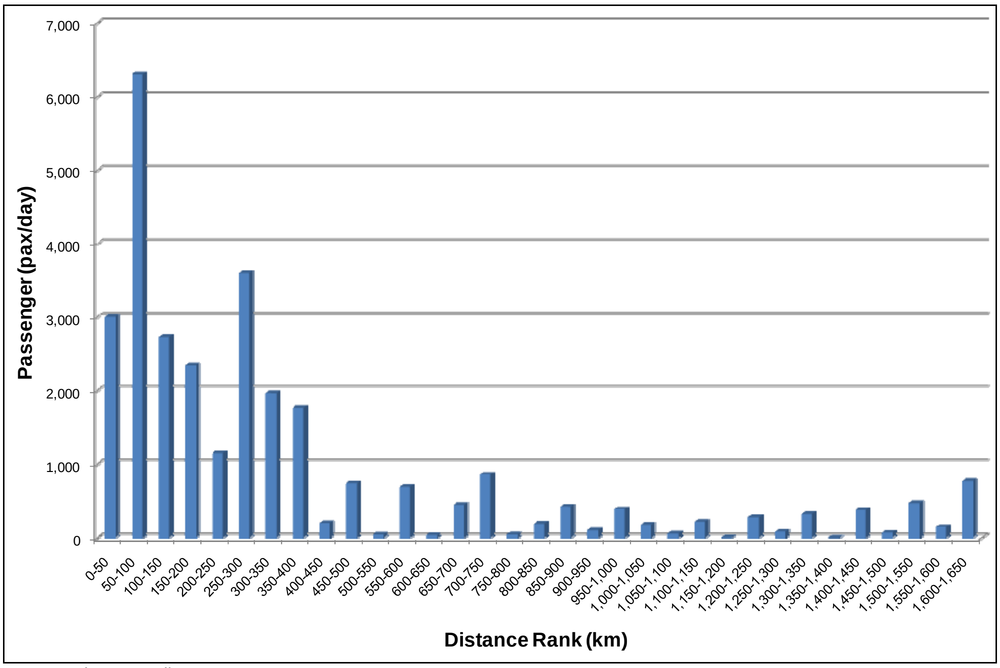
2.48 Average trip length of passengers using Hanoi – Saigon line is 365 km, while the most significant range of travel distance is 50-100 km and 250–300 km. This implies that the railway is mostly used for middle distance trips (see Figure 2.4.8).

2.49 A cross-section passenger traffic of the Hanoi–Saigon Line is between 4,858 and 6,945 passengers/day for both directions in 2010. The cross section traffic is more or less at the same level among subsections of the Hanoi–Saigon Line (see Table 2.4.5).



Source: Vietnam Railways

Figure 2.4.7 No. of Passengers by Railway Station on Hanoi–Saigon Line, 2010



Source: Vietnam Railways

Figure 2.4.8 Distribution of Passenger Trip Length on Hanoi – Saigon Line in 2010

Table 2.4.5 Cross Section Passenger Traffic Volume of Hanoi–Saigon Line

(no. of passengers/day)

Rail Section	Distance (km)2)	2008	2009	2010
		Cross Section	Cross Section	Cross Section
Ha Noi–Thanh Hoa	175.6	5,518–6,059	5,335–5,795	5,651–6,152
Thanh Hoa–Vinh	143.8	6,147–6,211	5,704–5,779	6,022–6,086
Vinh–Da Nang	462.2	5,061–5,636	4,493–5,122	4,858–5,475
Da Nang–Nha Trang	514.3	5,193–6,329	4,587–5,685	4,958–6,065
Nha Trang–Muong Man	235.6	6,596–6,662	5,891–5,955	6,298–6,337
Muong Man–Sai Gon	159.3	6,905–7,248	6,161–6,501	6,529–6,945
Total	1,690.8	5,061–7,248	4,493–6,501	4,858–6,945

Source: VR
Note:
1. Original VR data is annual volume is divided by 365 days.
2. Section length is by VITRANSS 2 GIS data.

2.50 Total freight traffic carried by the railway was 42,091, 40,083 and 30,269 tons/day in 2008, 2009 and 2010, respectively. The downward trend is recorded across all lines (see Table 2.4.6). The most utilized line of Dong Anh–Lao Cai had a share of about 23.5% of the total traffic in 2010, followed by Hanoi–Saigon (19.7%) and Gia Lam–Dong Dang (17.5%).

Table 2.4.6 Freight Traffic Demand by Line

Line	2008	2009	2010
	ton/day	ton/day	ton/day
Hanoi–Saigon	8,941	8,237	5,947
Hanoi–Haiphong	5,506	5,073	3,701
Gia Lam–Dong Dang	8,934	8,892	5,292
Yen Bien–Quang Trieu	4,974	4,899	4,703
Dong Anh–Lao Cai	9,475	8,435	7,124
Pho Trang–Ha Long	2,431	2.499	1,502
Van Dien–Bac Hong	2,280	2,048	2,000

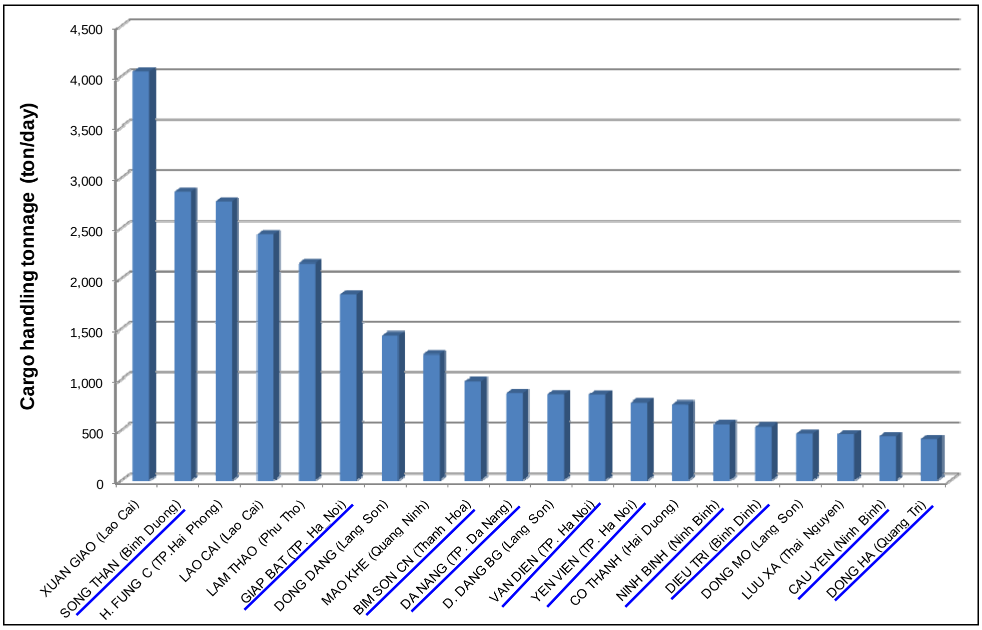
Source: Vietnam Railways

2.51 Main types of railway cargo are: (i) ore (26.6% of the total handling volume), (ii) coal (14.1%), (iii) construction material (10.3%), (iv) fertilizer (10.1%) and (v) non-processed food stuff (6.2%). They have a collective share of 67.3% of the total freight handling volume.

2.52 The stations which handle between 1500 - 4000 tons/day are Xuan Giao (Lao Cai), Song Thanh (Binh Duong), Lao Cai (Lao Cai), Lam Thao (Phu Tho) and Giap Bat (Hanoi) (see Figure 2.4.9).

2.53 The top 3 OD pairs of railway cargo traffic are Lam Thao (Phu Tho)–Xuan Giao (Lao Cai), H.Fung C. (Haiphong)–Xuan Giao (Lao Cai) and Giap Bat (Hanoi)–Song Than (Binh Duong) (see Table 2.4.7).

2.54 Average haulage of railway cargo is 466 km, while the most significant range of transport distance is 150–200 km, less than 50 km and 300–400 km (see Figure 2.4.10).



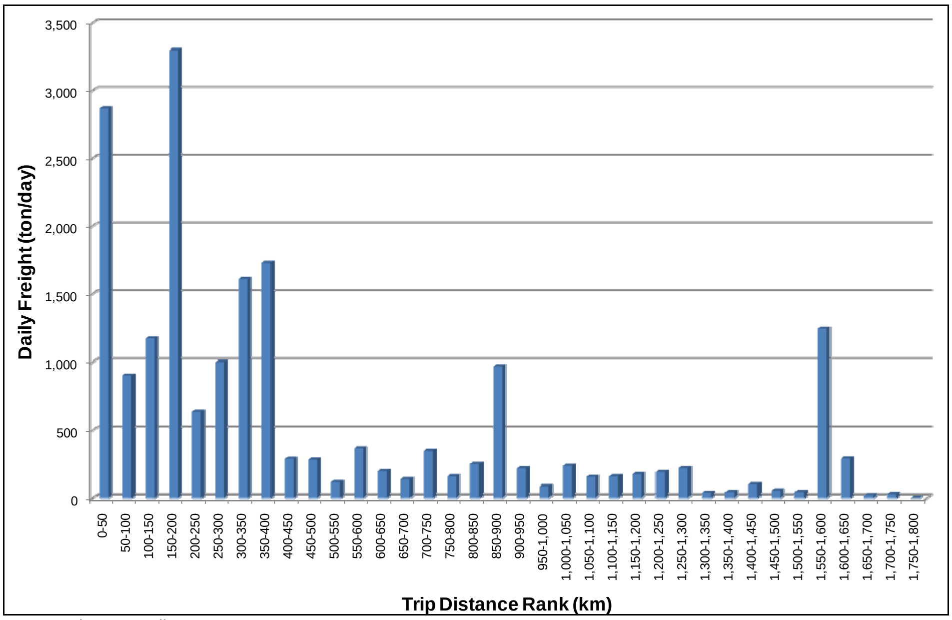
Source: Vietnam Railways

Figure 2.4.9 Railway Cargo Handling Tonnage by Station, 2010

Table 2.4.7 Major OD Pairs of Railway Cargo Traffic

Order	OD Pair			Daily Freight in 2010 (ton/day)
1	Lam Thao (Phu Tho)	–	Xuan Giao (Lao Cai)	1,559
2	H. Fung C (TP. Haiphong)	–	Xuan Giao (Lao Cai)	1,248
3	Giap Bat (TP.Hanoi)	–	Song Than (Binh Duong)	1,193
4	H. Fung C (Tp.Hai Phong)	–	Lao Cai (Lao Cai)	826
5	Mao Khe (Quang Ninh)	–	Co Thanh (Hai Duong)	752
6	Dong Dang (Lang Son)	–	D. Dang Bg (Lang Son)	591
7	Da Nang (TP. Da Nang)	–	Song Than (Binh Duong)	590
8	Ninh Binh (Ninh Binh)	–	Bim Son Cn (Thanh Hoa)	436
9	Van Dien (TP. Ha Noi)	–	Xuan Giao (Lao Cai)	428
10	Cau Yen (Ninh Binh)	–	Xuan Giao (Lao Cai)	380
11	H. Fung C (TP. Hai Phong)	–	Van Phu (Yen Bai)	314
12	Thuong Ly (TP. Hai Phong)	–	Lao Cai (Lao Cai)	295
13	Viet Tri (Phu Tho)	–	Xuan Giao (Lao Cai)	285
14	Yen Vien N (TP. Ha Noi)	–	D. Dang BG (Lang Son)	260
15	Dong Ha (Quang Tri)	–	Bim Son Cn (Thanh Hoa)	230
16	Gia Lam (TP. Ha Noi)	–	Phu Duc (Phu Tho)	224
17	Dong Mo (Lang Son)	–	Dong Dang (Lang Son)	212
18	Kim Lien (TP. Da Nang)	–	Song Than (Binh Duong)	201
19	Dieu Tri (Binh Dinh)	–	Song Than (Binh Duong)	198
20	Van Dien (TP. Ha Noi)	–	Yen Thai (Thanh Hoa)	193
21	Dong Dang (Lang Son)	–	Na Duong (Lang Son)	183
22	Song Than (Binh Duong)	–	Yen Vien N (TP. Ha Noi)	181
23	Thinh Chau (Thanh Hoa)	–	Phu Thuy (TP. Ha Noi)	180
24	Co Loa (TP. Ha Noi)	–	Mao Khe (Quang Ninh)	174
25	Giap Bat (TP. Ha Noi)	–	Lao Cai (Lao Cai)	150
26	Vinh (Nghe An)	–	Song Than (Binh Duong)	123
27	Lao Cai (Lao Cai)	–	B. Gioi LC (Lao Cai)	123
28	Hai Phong (TP Hai Phong)	–	Luu Xa (Thai Nguyen)	118
29	Giap Bat (TP. Ha Noi)	–	Da Nang (TP. Da Nang)	116
30	Dong Kinh (Lang Son)	–	Mao Khe (Quang Ninh)	114

Source: Vietnam Railways



Source: Vietnam Railways

Figure 2.4.10 Distribution of Railway Cargo Haulage (all Lines), 2010

2.55 A cross-section traffic of railway cargo on the Hanoi–Saigon Line varies by section. Traffic density in the North is higher than in the South. It is 4000–5000 tons/day in the north, 3000–4000 tons/day in the central and 3000 tons/day in the South (see Table 2.4.8).

Table 2.4.8 Cross Sectional Cargo Traffic Volume of Hanoi–Saigon Line

(tons/day)

Rail Section	Distance (km)	2008	2009	2010
		Cross Section	Cross Section	Cross Section
Ha Noi–Thanh Hoa	175.6	1,996–6,356	1,940–6,167	1,957–5,947
Thanh Hoa–Vinh	143.8	5,131–5,308	4,598–4,845	4,486–4,733
Vinh–Da Nang	462.2	4,868–5,366	4,250–4,999	4,221–4,789
Da Nang–Nha Trang	514.3	4,028–5,174	3,849–4,992	3,825–4,904
Nha Trang–Muong Man	235.6	3,741–3,979	3,397–3,731	3,253–3,675
Muong Man–Sai Gon	159.3	56–3,661	61–3,327	91–3,147
Total	1,690.8	56–6,356	61–6,167	91–5,947

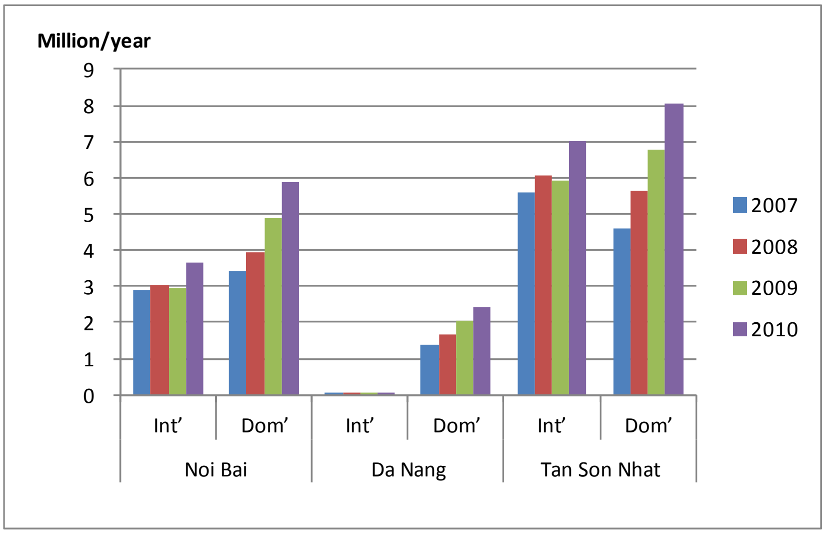
Source: Vietnam Railways
Note: 1. Original VR data is annual volume divided by 365 days.
2. Section length is by VITRANSS 2 GIS data.
3. Most of cargo traffic terminates at Song Thanh station (Binh Duong) at HCMC side.

2.56 **Air Transport**: Data on air traffic volume at the major airports in Vietnam over the last four years are shown in Table 2.4.9 and Figure 2.4.11. Domestic air traffic demand increased significantly, with an annual growth rate of 20.1%, from 9.4 million passengers in 2007 to 16.3 million in 2010. This growth would be attributable to the rapid increase of income levels of people, which promotes more travel, and more frequent transport services (i.e., increase in the number of flights).

Table 2.4.9 Traffic Volume at Major Airports in Vietnam

		No. of Passengers (000/year)				2010/2007	Annual Growth Rate ('07-'10)
		2007	2008	2009	2010		
Noi Bai	International	2,900	3,040	2,951	3,659	1.26	8.1
	Domestic	3,405	3,947	4,880	5,858	1.72	19.8
Da Nang	International	27	37	17	46	1.70	19.3
	Domestic	1,408	1,680	2,068	2,438	1.73	20.1
Tan Son Nhat	International	5,599	6,061	5,939	7,021	1.25	7.8
	Domestic	4,604	5,658	6,787	8,028	1.74	20.4
Total	International	8,525	9,138	8,907	10,726	1.26	8.0
	Domestic	9,416	11,285	13,734	16,325	1.73	20.1

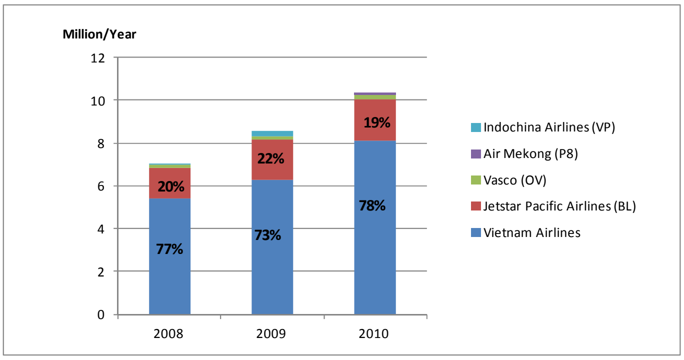
Source: Civil Aviation Administration of Vietnam



Source: Civil Aviation Administration of Vietnam

Figure 2.4.11 Traffic Volume at Major Airports in Vietnam

2.57 The number of annual domestic air passenger by operating company is shown in Figure 2.4.12 below. Both Vietnam Airlines and LLCs (i.e., Jet Star Pacific, VASCO, Air Mekong, Indochina Airlines) have been increasing their passenger volumes over the last three years.



Source: Civil Aviation Administration of Vietnam

Figure 2.4.12 No. of Annual Domestic Air Passenger by Operating Company

2.58 As of December 2010,130 flights/week are operated by Vietnam Airlines and 94 flights/week by LCC (Jet Star Pacific and Air Mekong) for Hanoi-HCMC (one-way). (For Hanoi-Vinh and HCMC-Nha Trang, 14 flights/week/way and 28 flights/week/way are respectively operated by Vietnam Airlines (no LCC services). Consider the frequency for Hanoi – HCMC route was 84 fights/week/way, the service frequency has increased significantly, by 2.7 times for 4 years.

2.59 **Coastal Shipping:** Data on cargo handling volume at the ports was also collected. Table 2.4.10 shows the changes in traffic demand from 2007 to 2010. While absolute total volume has been fluctuating very sharply during this period (especially between 2009 and 2010), domestic container cargo traffic has been increasing quite steadily by 5.4% yearly in all regions.

Table 2.4.10 Summary of the Cargo Throughput of Ports in Vietnam (2007-2010)

Region	Item		2007	2008	2009	2010	2010/2007	Annual Growth Rate 2007-2010
Northern Region	Cargo throughput (x 1,000 million tons)	Import	11,827	14,195	17,127	16,611	1.40	8.9
		Export	23,483	20,831	29,129	24,330	1.04	0.9
		Domestic	11,567	21,327	17,497	14,806	1.28	6.4
		Total	46,877	56,353	63,753	55,747	1.19	4.4
	Container (TEU)		1,075,658	1,380,202	1,762,627	1,936,826	1.80	15.8
Central Region	Cargo throughput (x 1,000 million tons)	Import	1,540	1,649	1,184	1,681	1.09	2.2
		Export	6,037	5,993	6,677	7,938	1.31	7.1
		Domestic	7,522	7,393	7,472	7,141	0.95	-1.3
		Total	15,099	15,035	15,333	16,760	1.11	2.6
	Container (TEU)		128,954	154,594	132,229	202,983	1.57	12.0
Southern Region	Cargo throughput (x 1,000 million tons)	Import	36,662	34,372	28,826	40,012	1.09	2.2
		Export	22,581	29,024	45,286	21,095	0.93	-1.7
		Domestic	12,770	12,388	19,301	17,392	1.36	8.0
		Total	72,013	75,784	93,413	78,500	1.09	2.2
	Container (TEU)		3,082,728	3,429,270	3,494,246	4,290,088	1.39	8.6
TOTAL	Cargo throughput (x 1,000 million tons)	Import	50,029	50,216	47,137	58,304	1.17	3.9
		Export	52,101	55,848	81,092	53,364	1.02	0.6
		Domestic	31,859	41,108	44,270	39,339	1.23	5.4
		Total	133,989	147,172	172,499	151,007	1.13	3.0
	Container (TEU)		4,287,340	4,964,066	5,389,102	6,429,897	1.50	10.7

Source: http://www.vpa.org.vn/vn/information/info_static2010.htm
Note: TEU – twenty-foot equivalent units.

2.60 **Summary of Recent Situation**: Recent trend of traffic demand shows that air transport and coastal shipping are increasing their importance in domestic transport market (as well as international one) compared with road and railway transport. As for passenger transport, it means the needs of long-distance transport (especially for travel between Hanoi and Ho Chi Minh) is keenly increasing and, on the other hand, faster and higher quality transport service is more and more preferred to cheaper but low quality service. It is also indicated that the capacity and performance of road and railway transport need to be improved to be remain and/or foster their functions for short and middle distance trip and the competitiveness to air transport for long distance trip. Regarding to freight transport, it is obvious that railway doesn't success to cater to the needs compared to other modes, and, again, the improvement of service quality of railway is necessary.

2.5 Current Government Policy and Plan

1) Introduction

2.61 The development of HSR is considered as a national project having huge impact on the social and economic development of North-South coastal corridor and the economy of the whole nation. On the other hand, it requires high investment cost, which is estimated as 55.8 billion USD for a whole section based on the estimation of prefeasibility study. Needless to say, such mega scale project should be consistent with the development orientations on national level, master plans in transport sector and other plans as it is not possible to be considered as a separate transport infrastructure among other transport systems and urban and rural development configurations.

2.62 Hereunder, the national socio-economic development plan and master plans of transport sector were reviewed and, thus, the necessity and expected roles of HSR in the context of policy and plans were re-identified.

2) National SEDS and SEDP

2.63 Socio-economic development strategy (SEDS) and socio-economic development plan (SEDP), which to be formulated based on SEDS, are the highest level development strategy and plan. As of March, 2012, the SEDS for 2011-2020 and SEPD for 2012 and the 5 year period 2011-2015 have been drafted.

(1) SEDS for 2011-2020

2.64 In the SEDS for 2011-2020, the main viewpoint of “sustainable development” is presented to pursue a new internal perception which reflects the close link between fast development and sustainable development and considers sustainable development is a requirement that run-through the Strategy.

2.65 The general goals of the strategy is as follows;

- Strive such that by 2020, Vietnam will basically become a modernized industrialized country with stable socio-politics, democracy, order, and consensus;
- The material and spiritual lives of the people will be markedly improved;
- Independence, sovereignty, unity and territorial integrity will be protected;
- The status of Vietnam on the international arena will continue to rise; and
  Creating solid preemption for higher development in the next phase.

2.66 To achieve the general goals above, 3 breakthroughs to be made are listed as follows;

- To complete the socialism-oriented market economy institution, with the focus on creating a fair environment for competition and administrative reform;
- To rapidly develop human resources, especially high quality human resources, focus on fundamental and comprehensive changes of national education; closely linking human resource development with the application of science and technology; and
- Establish a comprehensive system of infrastructure, with several modern constructions, focus on transportation systems and the infrastructure of major cities.

2.67 Thus, the achievements on economic restructuring, human resource development and infrastructure system development are mainly focused on SEDS.

(2) SEDP for 2012 and the 5 year period 2011-2015

2.68 SEDP for 2012 and the 5 years period of 2011-2015 has been formulated based on the review of the implementation of 5 year plan for 2006-2010 and the consideration of socio-economic context of Vietnam and the world. The followings are the general goals of the five-year socio-economic development plan for 2011-2015.

- Promote rapid economic development and sustainable innovation associated with the improvement of growth model and economic restructure towards higher quality, efficiency and competitiveness.
- Ensure social welfare and social security
- Improve spiritual and material life of the people
- Enhance external affairs, and improve the efficiency of international integration
- Protect the independence, sovereignty, unity, territorial integrity and social order and safety
- Create the foundation for our country, by 2020, to become an industrialized and modernized country.

2.69 To achieve these goals, seven main tasks are clarified including (i) concentrating on inflation control, macro-economic stability, ensured major balance of the economy (ii) prioritizing resources for implementation three breakthrough strategies (mentioned in SEDS) and economy restructuring, growth model renovation toward efficiency and competitiveness improvement (iii) solving difficulties and creating conditions for enterprises to develop production, business and market expansion, (iv) continuing improving social security and welfare and focusing on solving urgent social issues, (v) promoting development of science and technology and enhancing environment protection and improvement, (vi) improving effectiveness and efficiency of state management and strengthen anti-corruption and (vii) strengthening national defense and security and improve the efficiency of foreign affairs

2.70 In detail description of above-mentioned seven tasks, following issues are mentioned, which considered relevant with and important for the HSR project planning.

- The shifts of the growth model are highlighted, which are “the changes from scale development to quality development” and “from investment capital increase and intensive natural resources and labor use to enhancing efficiency, productivity, quality and competitiveness of the economy based on application of achievements in science, technology, high quality human resources and modern management skills”. In short, “qualitative” development is further emphasized rather than quantitative one.
- “The adjustment of investment structure in the direction of decreasing the public investment ratio and improving investment efficiency” is mentioned. More in concrete, it is noted that “the newly development projects shall be tightly controlled with proper funding sources, ensuring sufficient efficiency and investment procedures”. Thus, the efficiency is emphasized as one of prime factors to be considered for the public investment.
- Public-private partnership (PPP) model is raised as a promoted way to mobilize resources in developing large-scale infrastructure facilities.

(3) HSR Project in the Context of SEDS and SEDP

2.71 HSR is expected to have huge social and economic impact in Vietnam providing high standards transport service and also requiring and promoting sound railway industry and human resources with high technological capabilities for its sustainable operation. In this sense, the development of HSR is in line with the direction to be a modern industrialized country.

2.72 On the other hand, since the development of HSR requires huge amount of investment, it will possibly be a burden on national account, entailing investment risk which is not negligible. Therefore, the development plan of HSR should be studied and considered deliberately.

2.73 The promotion of railway and coastal shipping as alternative of road transport is clearly mentioned in SEDP for 2005-2010. For the sustainable transport system development, the railway system including existing railway and high speed railway is expected to take more significant role than before.

3) National Transport Master Plans

2.74 On the lower level of SEDS and SEDP, there is Transport Development Strategy (TDS) and master plan for each transport sector. Hereunder, the main contents of these strategies and plans including ones for railway sector are summarized,

(1) Transport Development Strategy (TDS)

2.75 The latest TDS is approved by Prime Minister Decision No.35/2009/QD-TTG, “Approving adjustment to the Transport Development Strategy up to 2020 with a Vision toward”, on March, 3rd, 2009. The development orientations up to 2020 for major five subsectors and railway industry are shown in Table 2.5.1. These orientations are quite comprehensive and aim for the high level of infrastructure development. As for railway sector, the development of north-south express railway of 350 km/h is indicated for prioritization while the upgrading of existing railways with a speed of 120 km/h and urban railway development are, also, mentioned.

2.76 The following two items are defined as the vision to 2030 for railway sector.

- Complete the system of the north-south express railway
- Vietnam’s railway system will meet the technical standards and integrate with the trans-Asian railway

2.77 In TDS, it is defined that the main role of railways is cater for long-distance and medium-distance mass passenger and cargo traffic while there is also the role of mass transit for trips within big cities. The specific objectives of railway transport industry up to 2020 are also defined including; (i) to develop rail-borne vehicles toward high specialization and a rational structure, (ii) to renew the pulling and loading powers towards modernization and expense and cost reduction, attaching importance to the development of high-speed train, (iii) to apply advanced technologies in transportation and manufacture of vehicles with a view to increasing the speed of trains, and (iii) to have around 1 100- 1,200 locomotives and 50,000-53,000 carriages of all kinds, including 4,000-5,000 passenger carriages by 2020.

Table 2.5.1 Transport Development Orientation up to 2020

Sector	Development Orientation up to 2020
Road:	● To upgrade national highways and provincial roads to reach prescribed technical standards ● To expand and build national highways with great transportation demands ● To build a system of expressways ● To upgrade external roads to reach technical standards of regional roads ● To set up a road maintenance fund for allocating capital for the maintenance of road infrastructure facilities.
Railway:	● To complete the renovation and upgrading of existing railways up to national- and regional-railway technical standards with a speed of 120 km/h ● To build new express railways and high-speed railways ● To prioritize the building of the north - south express railway with a speed of 350 km/h ● To rapidly develop iron-wheel transport in urban centers and railways in cities and suburbs as a core mass transit, firstly in Hanoi capital and Ho Minh City
Seaways:	● To develop a national system of ports, including an international transit port in Van Phong, international gateway ports and deepwater harbors in 3 key economic regions of accommodating new-generation container ships, general ports, special-purpose, ports passenger ports to meet socio-economic development and international integration ● To invest in developing seaport infrastructure in a coordinated manner including harbors, port access fairways, port access traffic and port logistic services.
Inland waterways:	● To complete the upgrading of main inland waterway routes up to prescribed technical standards ● To renovate and improve important sections and fairways ● To increase the length of river sections and fairways under management and operation ● To make intensive investment in upgrading and building major ports and cargo and passenger wharves, especially in the Red River and Mekong River deltas.
Airways:	● To complete the upgrading and expansion of existing airports and build new ones up to international standards ● To concentrate investment in international airports in the Hanoi capital region and Ho Chi Minh City ● To study and invest in new international airports with sizes and service quality on a par with major international airports in the region ● To increase the operation capacity of airports by 3-3.5 times by 2020
Railway industry:	● To build modern and comfortable passenger and cargo carriages which are diversified in types for domestic use and export ● To manufacture parts and accessories for and assemble modern locomotives.

Source: JICA Study Team based on Prime Minister Decision No.35/2009/QD-TTG, "Approving adjustment to the Transport Development Strategy up to 2020 with a Vision toward", on March, 3rd, 2009

2.78 In TDS, the development objects for North-south axis is also clarified as listed below. These objects include the development of several transport modes; namely road (national highway and expressway), railway (existing railway and high speed railway) and coastal shipping.

- To complete the upgrading and expansion of national highway 1A from Huu Nghi Quan to Nam Can
- To connect and upgrade the entire Ho Chi Minh road from Cao Bang to Dat Mui
- To build a North-South expressway and coastal roads
- To complete the upgrading of Thong Nhat railways up to national and regional technical standards
- To build the North-South express railway
- To develop the North-South passenger transportation route at sea.

2.79 While the necessity of multi-modal arrangement for the axis is identified, since the north-south axis has the length of more than 1,700 km, the infrastructure development projects for the axis tends be huge and costly. Therefore, the perspective for the long-term is crucial for the development of the axis.

(2) Railway Transport Master Plan and Strategy

(a) Railway Transport Development Strategy

2.80 The Strategy for Development of Vietnamese Railway Transport Up to 2020 with a Vision toward 2050 was formulated by VR, revised by MOT and approved by Prime Minister by Decision No. 1686/QD-TTg ,dated November 20, 2008. The strategy defined the specific key targets which are: at least 13% and 14% share of passenger and cargo traffic respectively with 37% share of passenger traffic on such main corridor as North-South corridor, 40% and over 45% share of passenger and cargo traffic respectively on the East-West corridor, and 20% share of urban passenger traffic. To achieve such targets, construction and upgrade projects are clarified including North-South High Speed Railway with the speed of 350 km/h giving priority to the early completion of Hanoi-Hue or Hanoi – Danang section and HCMC – Nha Trang section.

(a) Revised Railway Transport Master Plan

2.81 The latest comprehensive railway plan is “The Revise Master Plan on Railway Transport Development of Vietnam Up to 2020 with a Vision to 2030” formulated in consistent with the mentioned transport development strategy and railway transport strategy and approved by Prime Minister by Decision No. 1436/QD-TTg. It specifies the specific objectives and development plans for each aspect of railway transport, infrastructure, railway industry and traffic safety. To achieve the target of the increase of the share, the master plan contains the expansion of the network with accesses to major cargo origins/destinations and reinforcement of existing railway corridors. Furthermore, the master plan also includes the improvement of traffic safety covering the improvement of crossings system and the construction of cross-over.

Table 2.5.2 Summary of Railway Transport Master Plan

	Specific Objectives	Development Plan
Railway Transport	Up to 2020 • 13% share of passenger traffic • 14% share of freight traffic • 20% share in Hanoi and HCMC	• Passenger service: setting the target at long-distance transport service (300-500km) and urban railway service, commuter railway service and inter-provincial railway service • Freight service: development of heavy transport service from mining zone, ICD, factories, etc • Improvement of the competitiveness of transport service • Expansion of incorporation with regional and international transport and neighbouring countries
	Up to 2030 • 20% share of passenger and freight traffic • 25% share in Hanoi and HCMC	
Infrastructure	Up to 2020 • Improvement and upgrading of existing railway system (Class1) with connections to seaports, factories, etc • Completion of new railway lines • Railway transport growth in big cities • Prioritization of HSR sections • Conversion from single track to double tracks with electrification • Widespread of urban railway network	Up to 2020 • Improvement and upgrading of existing lines • Several HSR sections (development) • Yen Vien-Pha Lai-Ha Long-Cai Lan railway line (development) • Lao Cai-Hanoi-Hai Phong line (development) • Dong Dang-Hanoi line (development) • Dak Nong-Binh Thuan line (development) • Di An – Loc Ninh line (development) • Vung Ang – Mu Gai line (development) • Thap Cham – Da Lat Line (rehabilitation) • Dong Ha- Lao Bao line (study) • Access lines to ports, industrial zones, economic zones and mining zones (development) • Railway hubs (Hanoi, HCMC, Hai Phong, Danang, Dieu Tri (development) • Urban railway lines in Hanoi and HCMC (development)
	Up to 2030 • Urban railway network in Hanoi, HCMC and other cities • Realization of HSR • Construction of Highland central’s railway • Construction of railway on coastal	Up to 2030 • Highland central’s railway network (development) • Remaining sections of HSR (development) • Urban railway network in Hanoi and HCMC (development) • Coastal railway corridor (development) • Other lines (development)

	Specific Objectives	Development Plan
	provinces in North Delta • Construction of railway in Mekong River Delta	
Railway Industry	Up to 2020 • Striving for self-manufacture locomotives, materials, equipments, spare parts	Up to 2020 • Locomotive: manufacturing diesel locomotives with capacity of 2,000-2,500 KV for existing lines and new locomotives with capacity of 5,000 KW for new electrified railway lines, developing EMU trains for commuter service, and striving for 1,100-1,200 locomotives • Car: Development of car-building industry for domestic market and for exportation to regional countries, achieving 50,000 to 53,000 cars by all types • Railway spare parts and materials: satisfaction of local demand
	Up to 2030 • Satisfaction of the demand for locomotive, materials, equipment, spare parts of new railway projects and urban railway projects	Up to 2030 • Development of manufacture of railway spare parts and materials to meet domestic needs for new railway constructions and demand for exportation
Traffic Safety	• Minimizing railway accidents on three criteria (numbers of accidents, injuries, and causalities	Up to 2020 • Infrastructure: removing all local crossings, building up a crossing system with defence, collector road, barrier and fencing along the line, and flyovers at railroad crossings and establishing railway safety corridor in the overall network • Institutions and human resource development: comprehending legal documents and management apparatus of railway traffic safety, intensifying dissemination, education and popularization of law, etc • Rescue: accomplishment of the investment program in equipment for emergency rescue
		Up to 2030 • Completion of construction of separation works • Completion of the construction of railroad crossing

Source: JICA Study Team based on Prime Minister Decision No.1436/QD-TTG, “Approving the Revised Master Plan on Railway Transport Development of Vietnam Up to 2020 with a Vision to 2030”, on September, 2009

(3) Other Plans

2.82 **Railway Hubs in HCMC area:** As of December 2011, there is an ongoing study, which name is “HCMC Area’s Railway Hubs Detailed Planning”, conducted by Vietnam Railway Administration (VRA), targeting the development of railway hubs in HCMC area (within 50 km’s radius from Sai Gon station). In the plan, Hoa Hung (Saigon) station, Binh Treiu station and Tan Kien Station are considered as key stations for passenger, and An Binh station and Trang Nom transition station for freight. The investment phase proposed in the study is as follows;

(i) **Period 2010-2020:** To complete and operate the following alignments:
- Trang Bom – Hoa Hung (Double-track, electrified, and 1,435mm gauge);
- HCMC – Vung Tau (Double-track, electrified, and 1,435mm gauge);
- HCMC – My Tho-Can Tho (Double-track, electrified, and 1,435mm gauge);
- HCMC – Loc Ninht;
- Belt railway at the west of HCMC city (An Binh-Tan Kien section) (Double-track, electrified, and 1,435mm gauge);
- North South high-speed railway with the expected speed of 350km/h (HCMC - Nha Trang section) (Double-track, electrified, and 1,435mm gauge);
- Tan Thoi Hiep – Trang Bang (Double-track, electrified, and 1,435mm gauge);
- Thu Thiem – Long Thanh International Airport (Double-track, electrified, and 1,435mm gauge);

(ii) **Period 2020 – 2030:** To complete and operate the following alignments:
- The entire alignment of North – South railway;
- Can Tho – Ca Mau alignment.

(iii) **Period 2030 - 2050**
- To meet sufficiently all of railway criterions of a developed industry country and have a modern network of national railways and urban railways.

3 CONSTRAINTS AND OPPORTUNITIES OF THE EXISTING NORTH-SOUTH RAILWAY LINE

3.1 Existing Conditions of the North-South Railway

1) General

3.1 The Hanoi-HCMC Railway Line (NS Line) was constructed a long time ago, with low technical specifications and speed on 1000 mm gauge. The non-electrified single-tracked railway has mostly old and deteriorated structures, preventing train operation from serving fast, frequent and comfortable trips which then results in the gradual decrease in its transportation market share (see Table 3.1.1).

Table 3.1.1 Profile of Existing Line

Section			North		Central			South		Total (average)
			Hanoi-ThanhHoa	ThanhHoa - Vinh	Vinh-Hue	Hue-Danang	Danang-NhaTrang	NhaTrang-PhanThiet	PhanThiet -HCMC	
Distance(km)	kilometerage		175.2	319.0	688.3	791.4	1,314.9	1,551.1	1,726.2	-
	Sectional Distance		175.2	143.8	369.3	103.1	523.5	236.2	175.1	1726.2
No. of Stations			23	13	40	11	45	17	18	167
Crossing	No. by type	Class1	14	3	3	3	11	2	13	49
		Class2	18	11	14	10	18	7	18	96
		Class 3	182	69	184	49	237	108	73	902
	Average distance between crossings (km)		0.81	1.73	1.84	1.66	1.97	2.02	1.68	(1.6)
Curvature	R≦300m	No.	9	5	76	147	7	13	10	267
		Length(km)	1.6	1.5	12.5	14.8	2.1	3.2	3.1	38.8
	300m≦R ＜800m	No.	123	55	153	37	308	60	105	841
		Length(km)	25.3	12.8	39.0	9.0	85.8	18.1	24.7	214.7
	800 m≦R <1200m	No.	45	33	92	5	123	75	48	421
		Length(km)	5.2	7.1	25.9	1.4	34.1	22.2	14.4	110.3
	1200m≦R	No.	107	29	40	13	28	7	8	232
		Length(km)	9.6	5.9	9.3	0.9	4.6	0.5	0.4	31.2
	Straight line (km)		133.2	120.4	277.3	78.3	397.5	192	132.4	1331.1
Tunnel	No.		0	0	5	9	13	0	0	27
	Length (km)		0	0	0.7	3.2	4.4	0	0	8.3
Bridge	Steel	No.	15	13	41	14	42	24	8	157
		Length(m)	1166	823	4770	1139	7129	1303	916	17246
	Concrete	No.	43	56	284	99	588	190	48	1308
		Length(m)	632	836	3919	1744	9766	2606	743	20246
	Total length(m)		1798	1659	8689	2883	16895	3908	1659	37491
	Average bridge length (m)		31	24	27	26	27	18	30	(26)
Mountain pass					• HoaDuyet-ThanhLuyen (357 to 369 km, maxgradient= 6 ‰) • Khe Net pass (415 to 420 km, max gradient= 17‰)	• Hai Van pass (755 to 765 km, max gradient= 17‰)				
Velocity (km/h)	Maximum		80	100	80	80	90	80	80	-
	Minimum		30	70	25	30	50	60	40	
	Scheduled		53.9	57.9	51.2	40.2	52.6	58.1	51.5	-
Travel Time (h)			3.3	2.5	7.2	2.6	10.0	4.1	3.4	-

Source: JICA Study Team

Notes: 1) The level crossings are classified according to the grade of the crossing roads. The first class intersects with the class 3 trunk-road or higher road, class 2 intersects with class 4 road and class 5 or miner road, and class 3 means the other level crossings not listed class 1 and class 2 above. The total number of level crossing is 2,439 including the 1,047 authorized level-crossings and the other 1,392 non-approved level-crossings.

3.2 The current maximum speed of the NS Line is 90 km/h for passenger trains and 60 km/h for freight trains. Vietnam Railways delivers only five pairs of through passenger trains between the capital city of Hanoi in the north and the biggest economic center in the south, Ho Chi Minh City carrying 15 hundreds passengers travelling between the two cities a day. The fastest train takes 30.0 hours across this route while airlines provide two-hour trips with much higher frequency of 21 flights selling 96 hundreds seats a day for the same distance.

2) Alignment

3.3 The railway runs along the slope of Trung Son Range and passes many rivers and streams. It has 1,545 large and small bridges and many types of sewers along its route. However, many of the railway sections are usually flooded during stormy season due to the phenomena of forest destruction and irregular weather caused by climate change. This is especially true in the areas of Ha Tinh, Quang Binh, Thu Thien Hue, Da Nang and Quang Nam.

3.4 Since it passes three high mountainous areas, the railway execution is based on topography with tunnels, with small curve radius Rmin = 100m, and large slope in Khe Net, Hai Van and Hoa Duyet-Thang Luyen.

3.5 The railway geology is quite sustainable, except for some sections with falling rocks in passes and embankment area where the non-standard materials used have caused deformation, mud pumping, and rock pocket.

3.6 The railway runs across some flooded section, especially in stormy season, such as Km810 – Km826 in Quang Nam, Km921 – Km923 and Km932 – Km937 in Quang Ngai, Km1364 – Km1365 in Khanh Hoa, and Km1178 – Km1188 in Phu Yen.

3) Structures

3.7 **Assessment point for structures:** Many railway infrastructures are still not improved and upgraded. With rapid economic growth, demand for transportation and railway connecting neighboring countries is getting larger, therefore making railway capacity improvement is an urgent necessity.

3.8 **Cutting and embankment:** Some local points, accounting for 5% of the total length of the line, have narrow formation width and scatter in some sections of difficult terrain. In some narrow-formation sections, the ballast retaining walls were constructed of quarry-stones.

3.9 With regard to geology and hydrology of track formation, many formation sections on the existing railway are of weak geology that causes track formation to be unstable (e.g., falling rocks, stones concentrated on the pass area). This weak track foundation leads to subsidence.

3.10 **Bridge:** In the anti-French and the anti-American resistance wars, the railway line was substantially destroyed, making it non-operational for some period. After the wars, the line was rehabilitated or repaired, but only to resume train operation. It has not been adequately maintained or repaired, including many weak bridges that remain unimproved.

3.11 The entire Hanoi–Ho Chi Minh City Railway Line includes 1,454 bridges with a total length of 36,332m. In the years before 2008, projects for improving, upgrading and rehabilitating existing and building new bridges were carried out and have improved 756 bridges. The remaining 698 bridges, however, have not been funded.

3.12 These unimproved bridges contributed to the current speed restrictions and problems of safety along the railway line. Therefore, the bridge improvement projects should be continued from now.

3.13 **Tunnel:** There are 27 tunnels along the railway line. They are old and deteriorated and most have insufficient clearance based on current clearance limitation standards for railways. Because of this, all trains passing through these tunnels have to restrict their speed.

3.14 In recent years, four tunnels in the railway line have been reinforced and gradually upgraded. Rehabilitation of the other tunnels have not been adequately funded so train speed passing through them continues to be restricted. Therefore, to ensure the safe operation of the existing and planned new railways, investment for strengthening the remaining weak tunnels is very necessary.

4) Tracks

3.15 **Rail:** In general, the rails have been used for a long time and are of low quality. Rail surface is scaled, pock-marked, defective and worn out, especially in curve with small radius. Most of the existing rails P43 are L=12.5 m in length.

3.16 **Sleeper:** The existing sleepers are only stable when the trains operate with a velocity less than 80 km/h. The sleepers were made by distributed traditional method with out-of-date manufacturing equipment, so the product quality is low and inconsistent.

3.17 Almost all the concrete twin-block sleeper bars have rusty bracings. In case the train derails, the bracings can be destroyed and sleepers can be damaged.

3.18 **Ballast:** The dimension and the thickness of the track bed are quite sufficient based on recent regulations but the ballasts are still dirty and of the wrong dimension and specifications. This makes the elasticity of the track bed weak and slows down train operation speed.

3.19 Some ballast sections are dirty because of mud-pumping foundation or because they were not overhauled and cleaned for a long time. Because its strength is inadequate and is too thin in some sections, the ballast breaks and the edge becomes rounded.

3.20 **Turnouts on the Mainline:** The main line which goes through the stations includes 707 sets of turnouts of different kinds. Excluding the sets of turnout Tg1/9 P50 which are still good, the remaining turnouts (about 640 sets) are old and worn out, of inadequate standards, the points are nicked, and the fasteners are dirty and loose.

3.21 **Level crossing:** Almost the whole length of the Hanoi-Ho Chi Minh Railway Line runs along with the existing National Highway 1 (NH1). Thus, many roads crossing NH1 intersect with the railway as well. In addition, the rapid development of the road system leads to the rapid increase in the axis of provincial roads, district roads and inter-communal and inter-village roads until 2009. There are 2,439 level crossing points on the railway alignment, of which 1,047 points are licensed and the remaining points are illegal and need fencing or collecting together.

3.22 There are many illegal roads on the railway line which are opened by local residents and do not follow any technical standards. These crossings are often made of several concrete slabs or made of ballast or aggregate. There are neither checkrails nor level crossing boards at many areas.

5) Layout Density of Stations

3.23 The layout density of stations in the line section is not uniform, which means that the distance between stations and train operation time per section is also not uniform. Sections with non-uniform distances cause the differences in train operation time, difficulty in route establishment, and limited capacity of train operation because the time for stopping, waiting, avoiding and passing of the train is increased. Sections with 12-14 km distance and especially those with > 14 km need a long period of time for train operation. It is necessary to review the symmetric capacity to respond to the required capacity of these sections.

(i) In the Hanoi-Vinh-Dong Hoi-Da Nang Sections, the number of sections ≤ 6 km ranges from 14.3% to 17.4% and the number of sections > 14 km ranges from 4.4% to 10.7%. The average distance between stations is from 8.82 km to 9.63 km.

(ii) In the Da Nang-Dieu Tri Section, there is no section ≤ 6 km; the number of sections 6-8 km long is 8.0%, while sections of 12-14 km are 19.2%, and sections of more than 14 km are also 19.2%. The average distance between stations is 11.26 km.

(iii) In the Dieu Tri-Nha Trang-Sai Gon Section, the number of sections ≤ 6 km only ranges from 5.6% to 8.6% and the number of sections > 14 km ranges from 31.4% to 33.3%. The average distance between stations is from 11.75 km to 12.19 km.

6) Signaling and Communication Systems

3.24 **Signaling system:** The signaling system is critically important for ensuring safety in railway operations. A trivial human error may cause a fatal accident on a single track railway or in station premises without an adequate safety system. The current signaling system of the Hanoi-HCMC Railway Line is found to be inadequate to back up human errors. The following systems should be installed as soon as possible:

(i) Electronic interlocking system with micro-processing devices;

(ii) Automatic block system which detects trains by a track circuit, especially in station premises;

(iii) Automatic train stop system to back up driver’s failure; and

(iv) Automatic level crossing to reduce collisions with cars and motorcycles.

3.25 **Communication system:** With regard to the communication system, the existing system is enough to operate the single track railway system. On-going and planned projects should be implemented on schedule and customer-oriented systems such as a ticket booking system should be reinforced.

7) Rolling Stock and Maintenance Facilities

3.26 **Rolling stock:** Railways in Vietnam are not electrified, so all train formations consist of locomotives with diesel engines and some cars, passenger coaches and freight wagons. Almost all these rolling stocks are the old and heavy types, made up of thick steel and have a solid skeleton structure.

3.27 There are great differences between the technology of old trains and that of the recent EMUs. The old train type’s body material is heavy steel while the EMU’s is light stainless steel or aluminium alloy. The bogie’s spring is coils for the old type and air suspensions for the EMU. Old motors are direct current while the new types are AC induction motors. It is necessary to acquire these new technologies for the operation of a modern high speed railway. The on-going projects for urban railways in Hanoi and Ho Chi Minh are good opportunities for acquiring such technologies.

3.28 **Maintenance facilities:** The maintenance facilities of the existing railway are also backward and investment for this purpose is inadequate. Employees work in narrow spaces and under dangerous circumstances. Improvement of maintenance facilities is vital for the improvement of rolling stock.

8) Railway Operation

3.29 The North-South line earns more than 50 % of entire Vietnam Railways annual revenue making overall financial figure of the organization in surplus. Vietnam Railways currently operates in total 32 trains a day, 20 for passengers 12 for freights. Out of the 20 passenger trains 10 express trains run all through the North South line between Hanoi and Saigon. The other 10 are locally operated connecting major cities along the line. 10 freight trains run across the entire North-South line with two local ones between Bim Son and Dung Ha in the north. The train operation diagram is restricted by the line capacity between stations because the North-South Line is single-track. The lowest capacity is in the Hai Van Pass and the Khe Net Pass sections. Those sections require a long running time because of the steep gradient and the tunnels with speed restriction.

Hanoi station

Vinh station

Boarding and Alighting Passengers

Figure 3.1.1 Examples of Current Situation of Existing Railway

Railway sections in Hanoi Urban Area

Railway crossing controlled by security staff with slide gate and alarm system

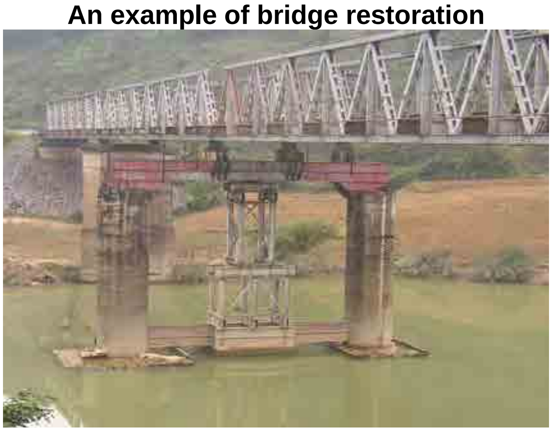
Railway crossing controlled by security staff with cross gate and alarm system

Railway crossing controlled by security staff with crossing gate

Railway Crossing with only sign of caution

Railway crossing (likely illegal)

An example of bridge restoration



Typical tunnel condition

Source: JICA Study Team

3.2 Main Bottlenecks in Existing Railway

1) General Assessment and Main Bottlenecks

3.30 The result of general assessment of existing railway revealed that it involves; various problems regarding alignment, structure, track, station, squalling and telecommunication, rolling stock and maintenance facilities, railway operation, among others (see Table 3.2.1)

Table 3.2.1 Identified Main Problems of Existing Railways

Item	Main Problems
(A) Alignment	(i) Flood during storm season, especially in Ha Tinh, Quang Binh, Thua Thien Hue, Danang and Quang Nam (ii) Steep slopes in Khe Net, Hai Van and Duyet-Thang Luyen (iii) Some sections of falling rocks and embankment area with non-standard materials (Non-standardized materials refers to the use of falling rocks for embankment which do not meet technical and safety standards (possible air spaces, etc.) and also silty clay used mainly in southern sections.)
(B) Structures	(i) Old structures in need for replacement (bridges, tunnels, etc.) (ii) Weak geology causing unstable track formation
(C) Track	(i) Degraded rail surface especially in curve with small radius (ii) Old structures in need for replacement (sleepers, ballast, etc.) (iii) 707 sets of turnouts, many in need of upgrading (iv) 1,047 points of authorized level crossings and 2,439 points of illegal level crossings in need for fencing etc.
(D) Station	(i) Non-uniform layout density of stations, causing differences in train operation time, difficulty in route establishment, (ii) Capacity limitation of train operation (stopping and waiting for train to pass)
(E) Signaling& telecommunication	(i) Existing system inadequate to back up human errors, which threatens safety (ii) No electric interlocking system with micro-processing devices, automatic block system, automatic train stop system, automatic level crossing, etc
(F) Rolling stock & maintenance facilities	(i) Old and heavy weight rolling stocks (ii) Need for new technologies such as lightweight electric multiple units (EMU)
(G) Railway operation	(i) Train operation diagram restricted by line capacity between stations due to single-track (lowest capacity in Hai Van and Khe Net Pass sections) (ii) Difficulty on increasing line capacity drastically unless adopting double-track

Source: JICA Study Team

2) Main Bottlenecks

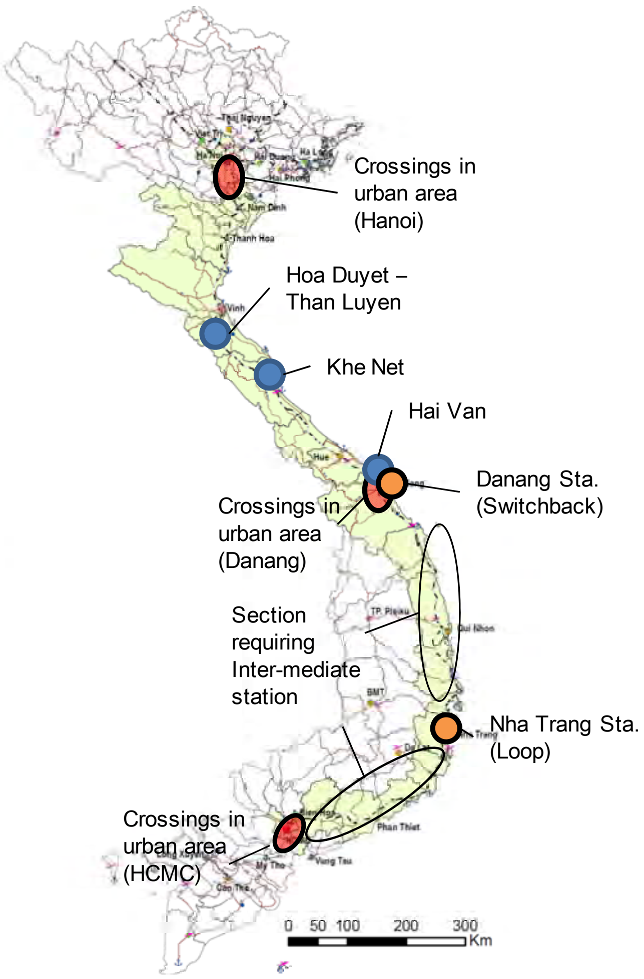
3.31 Main Bottlenecks facing existing railway which limit proper performance include following (see Figure 3.2.1);

(i) Critical bottleneck sections including Hai Van Pass, Khe Net Pass and Hoa Duyet–Thanh Luyen section which are provided with very poor alignment and structures.

(ii) Degraded structures including bridges, tunnels, road beds, and tracks and level crossings without safety measures causing the reduction of train speed

(iii) Switch back at Danang station and loop at Nha Trang station causing the extra travel time

(iv) The long distance between stations on single track (especially, in the south) limiting the train frequencies and causing the delays of trains (More interchange stations/facilities are necessary.).



Source: JICA Study Team

Figure 3.2.1 Locations of Bottlenecks

3) Most Critical Bottlenecks

3.32 The most critical bottlenecks are Hai Van Pass, Khe Net Pass and Hoa Duyet–Thanh Luyet section for which preliminary studies were made as follows;

(a) Hai Van Pass

3.33 Hai Van Pass section is located from km 750+356.80 (Near Lang Co station) to km 776+880 (Kim Lien station) in Thua Thien Hue and Danang. This section includes quite a bad alignment; there are 175 curves where minimum curves of less than R=400 m are found as shown in Figure 3.2.2 and Figure 3.2.3. In addition, this section requires auxiliary machine due to steep grade. Therefore, the operation speed in the section is significantly restricted.

3.34 Recommended measures include the following;

(i) Construction of new An Cu station in front of the northern tunnel; improve existing Kim Lien station by increasing the height to suit with new railway and by upgrading signaling system and passenger platforms

(ii) Construction of a tunnel which is 8,450m single tunnel for 1,000mm gauge. There are two reverse curves with R=1,000m at two tunnel portals.[1]

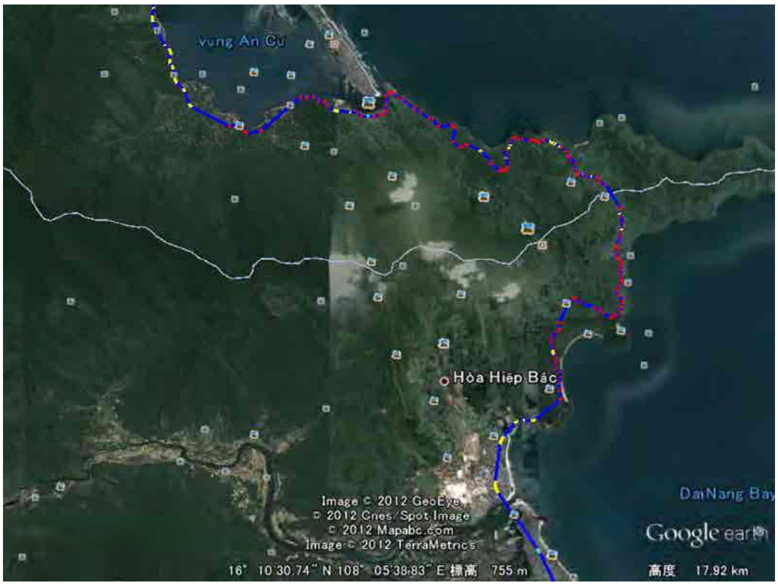
(iii) Construction of bridges including Hoi Mit bridge (L=71m), Hoi Can bridge (L=71m), and Hoi Dua bridge (L=30m) in the northern front of the tunnel and bridges in Km762+467 (L=50m) and Km763+171 (L=71m), and a flyover in Km763+355 (L=42m) in front of the southern tunnel.

3.35 Roughly, the estimated construction cost for these measures is US$ 185 million.

3.36 With this, maximum design speed will increase to 100 km/h and operation time in this section will be shorter by approximately 60 minutes. The auxiliary machine will be unnecessary, train safety will be ensured and capacity of the section will increase. The improvement of this section will well connect the two major cities in the Central Region, Danang City (population of 950,000) and Hue City (population of 350,000) and is expected to accelerate the overall development of the Central Region, especially for the tourism sector in both Danang City and Hue City.

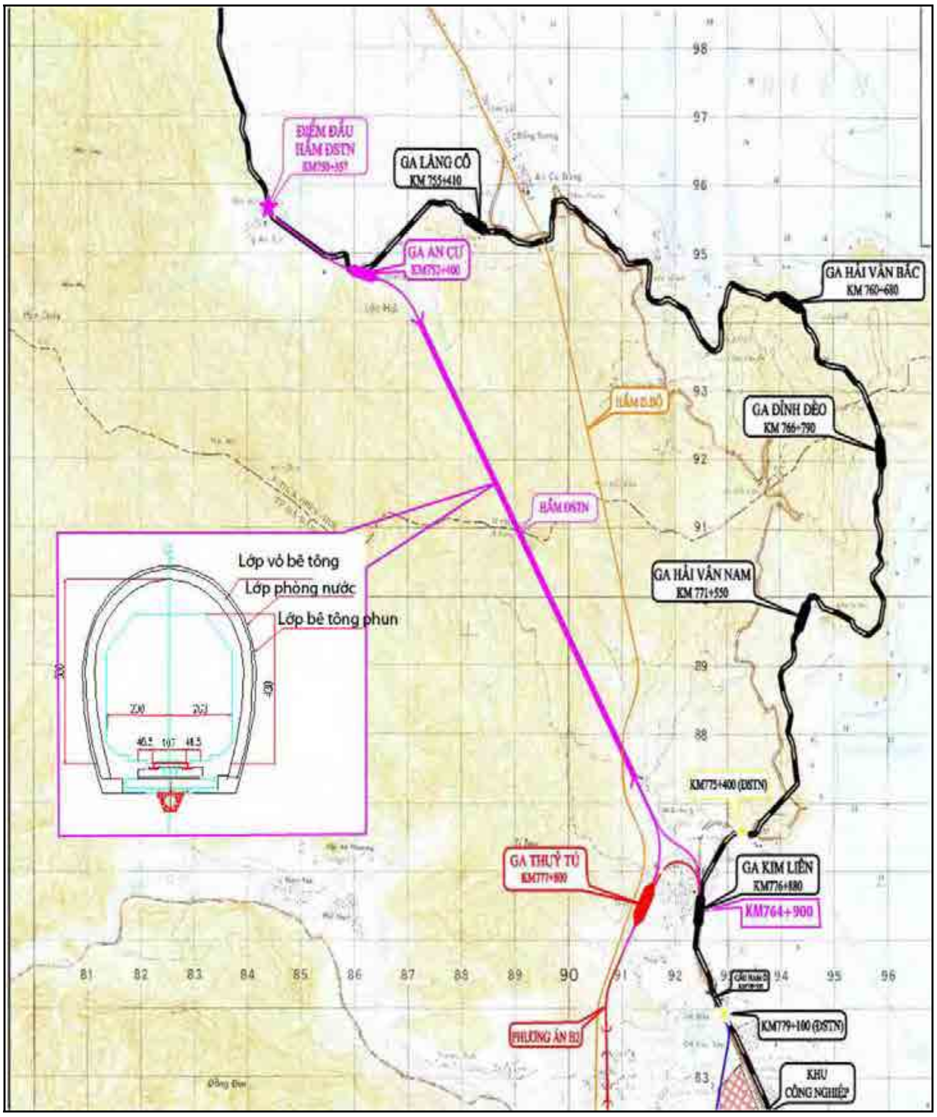
3.37 In planning and design for improvement for this section of the existing railway is desirable to consider the future introduction of the HSR.

1 Although the mentioned construction is for the improvement of existing railway, the construction of a tunnel with the specification of High Speed Railway is also possible option for better investment efficiency in case that this section serves as candidate initial section (test track).



Source: Mapped on Google Earth.

Figure 3.2.2 Realignment Plan Map of Hai Van Pass



Source: TRICC

Figure 3.2.3 Realignment Sketch Plan of Hai Van Pass

(b) Khe Net Pass Section

3.38 Khe Net Pass section is located from km 414+000 to km 423+000 in Quang Binh. This section includes quite a bad alignment with 30 curves where minimum curvature of less than R =400 m are found as shown in Figure 3.2.4. Thus, the operation speed in this section is restricted.

3.39 Recommended measures include the following;

(i) Construction of new railway tunnel for gauge 1,000mm

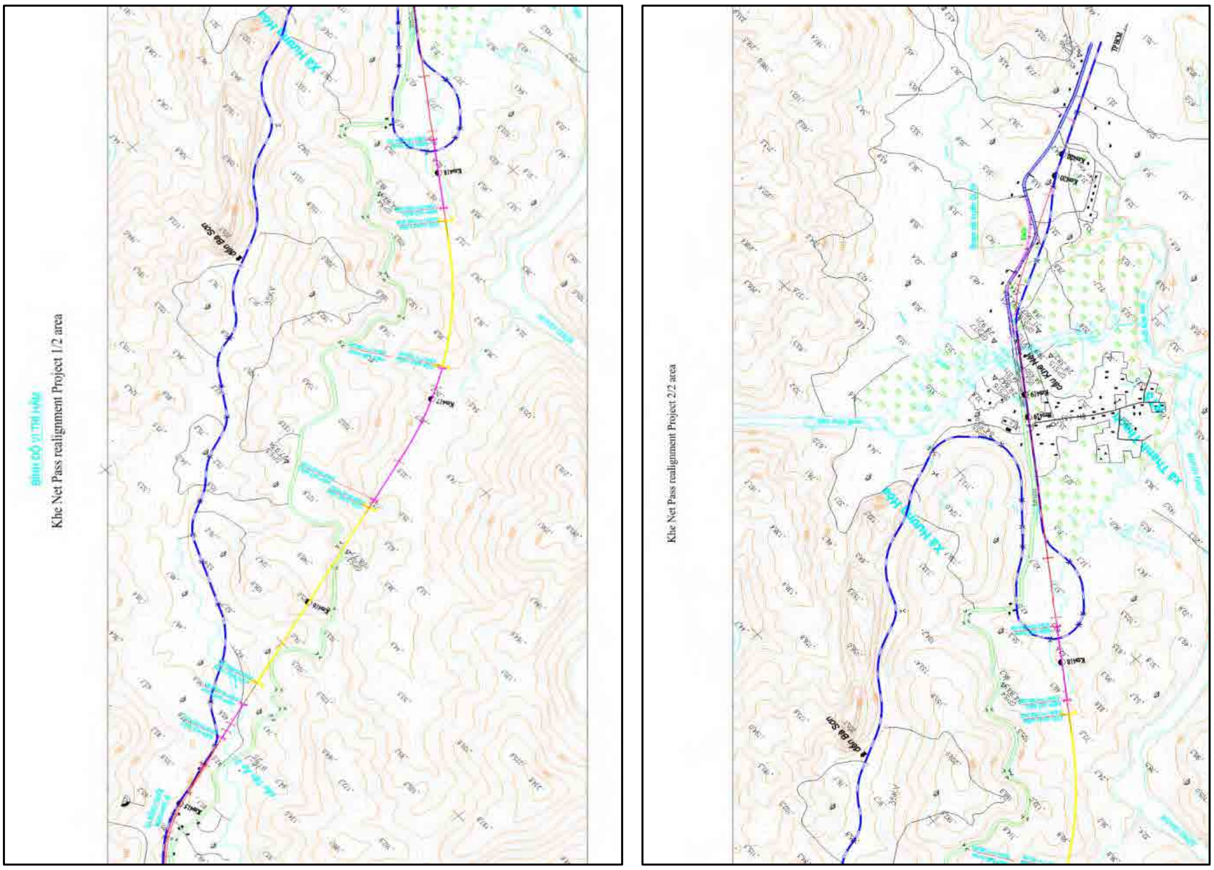
- Tunnel No.1 is 870.0 m and tunnel No.2 is 638.2m in length;
- The bridge approaching to the tunnel in the North side is 5 girders of 33m, the bridge between two tunnels is 19 girders of 33m, and the bridge approaching to the southern tunnel is 9 girders of 33m.

(ii) Improvement of one railway station

(iii) Construction of new track, level crossing and some bridges and culverts

3.40 The expected construction cost is US$ 49 million.

3.41 Maximum design speed will increase to 100km/h and operation time in this section will be shortened by approximately 8 minutes. Furthermore, train safety and increase in capacity will be ensured.



Source: TRICC

Figure 3.2.4 Realignment Plan of Khe Net Pass

(c) Hoa Duyet–Thanh Luyen Section

3.42 Hoa Duyet–Thanh Luyen section is located from km357＋000 to km370＋000 in Ha Tinh. This section includes a bad alignment; there are 18 curves where the minimum curvature of less than R=400m can be found as shown in Figure 3.2.5. Thus, the operation speed in the section is restricted.

3.43 Recommended measures include the following:

(i) Upgrading and improvement of track (4.719 km) and realignment of track (4.790 km)

(ii) Upgrading, improvement and construction of 3 bridges with total of 326 m track length

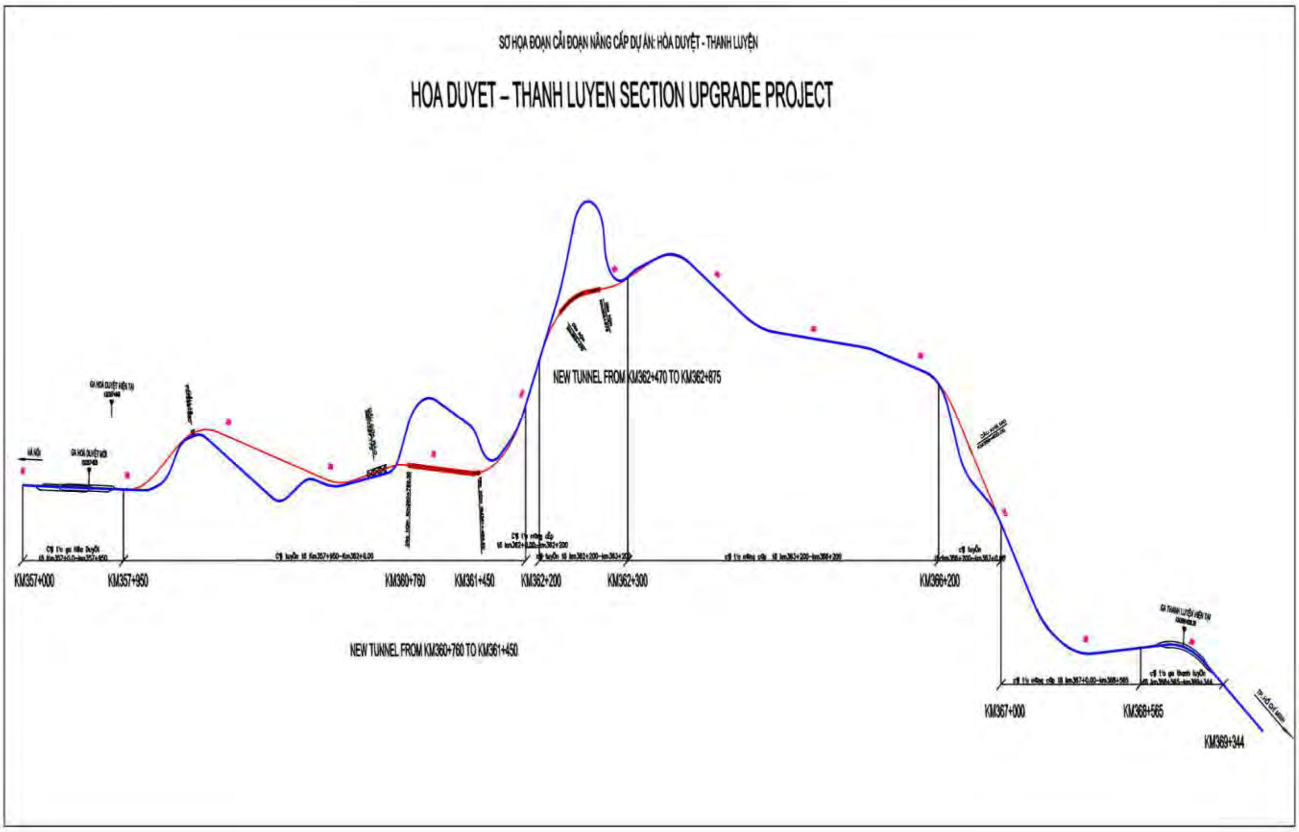
(iii) Construction of new tunnel for gauge 1,000 mm (1,070 m in length)

(iv) Construction and connection of 29 culverts

(v) Upgrading, improvement and construction of new optical cable system with digital electric exchange, semi-automatic block signal and centralized control turnout

3.44 The estimated construction cost is US$ 64 million.

3.45 Maximum design speed will increase to 100km/h and operation time in this section will be shortened by approximately 4 minutes. Furthermore, train safety and increase in capacity in the section will be ensured.



Source: TRICC

Figure 3.2.5 Hoa Duyet – Thanh Luyen Section Upgrade Project

4) Other Bottlenecks

3.46 While average distance between stations is about 10km, there are sections with long station spacing. Of the total of 24 sections with more than 15km between stations, 9 of them are located in Danang – Nha Trang section and 7 in Nha Trang – Phan Thiet section. (see Table 3.2.2)

3.47 Sections with small curvature also limit operating speed of trains. Of the total length of 1,726km, the sections with less than 800m radius total 251km or 14.5% of the total. Those with less than 400m radius account for 75km or 4.3% of the total. (see Table 3.2.2)

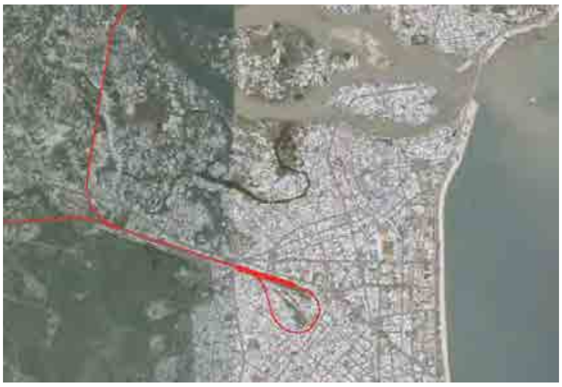
3.48 Switch back sections in Danang and Nha Trang also cause longer travel time (See Figure 3.2.6)

Table 3.2.2 Distance between Stations and Characteristics of Curvature

Section		North			Central		South		Total
		Hanoi-Thanh Hoa	Thanh Hoa-Vinh	Vinh-Hue	Hue-Danang	Danang-Nha Trang	Nha Trang-PhanThiet	Phan Thiet -HCMC	
Route Length (km)		175.2	143.8	369.3	103.1	523.5	236.2	175.1	1726.2
No. of Stations		23	13	40	11	45	17	18	167
No. of Sections by distance between stations	5 km less	z2	0	2	2	1	0	4	11
	5.0 less	14	2	19	3	12	2	6	58
	10.0-14.9	5	8	18	5	21	8	6	71
	15.0-20,0	1	2	1	1	9	7	3	24
Average Distance between Stations (km)		8.0	11.1	9.2	9.4	11.6	13.9	9.7	10.3
Curvature: km (no.)	R<100m	0(0)	0(0)	0(0)	0.8(7)	0(0)	0(0)	0(0)	0.8(7)
	100≤R<200	0.6(2)	0.1(1)	5.7(41)	11.7(124)	0(0)	0.7(3)	0(0)	18.8(171)
	200≤R<300	1.1(7)	1.4(4)	6.8(35)	2.2(16)	2.1(7)	2.5(10)	3.1(10)	19.1(89)
	300≤R<400	7.9(37)	2.9(12)	8.1(42)	2.2(10)	6.7(26)	4.1(16)	4.3(21)	36.3(164)
	400≤R<800	15.7(74)	9.3(40)	30.9(111)	7.3(29)	78.6(280)	13.9(41)	20.4(84)	176.1(659)
	800≤R<1200	4.3(40)	6.9(32)	25.4(90)	1.4(5)	33.3(120)	23.3(76)	14.4(48)	109.0(411)
	1200≤R	10.5(111)	5.4(28)	9.2(39)	0.8(13)	4.5(26)	0.5(7)	0.4(6)	31.3(230)
	Straight	143.0	117.8	291.3	76.7	398.3	191.3	139.3	1357.6

Source: JICA Study Team

Danang Station



NhaTrang Station

Source: JICA Study Team

Figure 3.2.6 Switchback Sections in Danang and Nha Trang

3.3 Opportunities and Constraints to Improvement of Existing Line

1) Overview

3.49 While existing railway involves a number of bottlenecks, various improvement measures are on-going and planned by the Government. It is also expected that the existing railway can be upgraded to provide much higher level of services than the current level, such as increase in operating speed to 200 km/h both for passenger and freight services through double and widening existing tracks. Dual gauge operation is also mentioned.

3.50 If these measures can be justified, it will become a competitive alternative to development of new high-speed line. Therefore, it is considered necessary and important to analyze the possibility and constraint of upgrading the existing railway up to the most appropriate level. The following three basic points, which were also raised and discussed in the National Assembly, are analyzed in the study;

(i) Converting to dual gauge for entire section of existing railway;
(ii) Upgrading of existing railway to accommodate train operation at maximum speed of 200 km/h; and
(iii) Mixed operation of passenger and freight trains at maximum speed of 200 km/h.

2) Analysis of Conversion of Existing Railway to Dual Gauge

3.51 The installation of dual gauge for the entire section, which is one of the alternatives for North South railway development discussed in Vietnam, is analyzed and the result is as follows:

(a) Application Practices of Dual Gauge

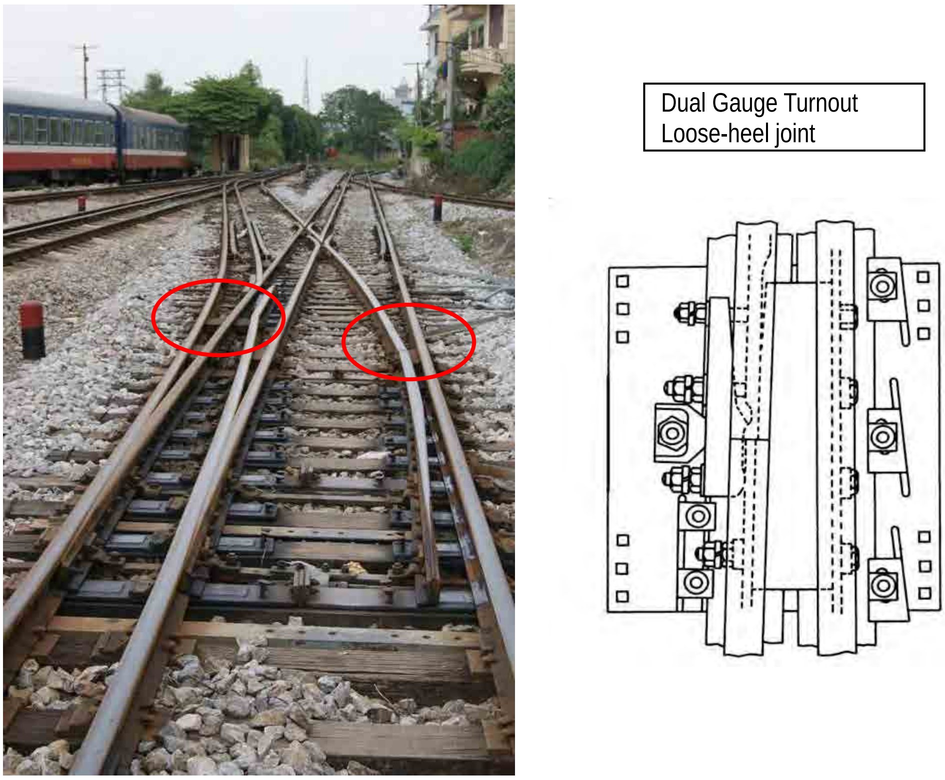
3.52 In Europe and Japan, generally dual gauge is applied at points where tracks with different gauges meet and there are few cases dual gauge is applied for the entire route. Dual gauge is used only for part of a section because of the restrictions posed on track layout and train speed on the standard-gauge line (also in Vietnam, dual gauge is applied for two lines connecting to China with total length of 220 km).

(b) Restriction of Speed Limit

3.53 While the purpose of dual gauge is to facilitate combined operation of high speed passenger train on standard gauge and freight train operation on narrow gauge, under the condition of mixed operation, high speed operation is not achievable (for example, in Akita Shinkansen line, where dual gauge is applied, average speed is only 85 km/h though maximum speed is 130 km/h).

3.54 In addition, the limit in speed is apparent on turnouts because of the following reasons (only limited improvement of operation speed is achievable by introducing dual gauge; the improvement of alignment is necessary for realizing faster speed):

- Turnouts have complicated structures. Non-availability of scissors, diamond crossing and special turnouts restricts the track layout.
- Combinations of standard- and narrow-gauge tracks on the main line side and those on the branch side necessitate 28 different turnouts, which require design numbers for turnouts to be limited.
- The speed on the straight side of the turnout in Figure 3.3.1 is limited to 80-90 km/h while seven turnouts out of 28 can be used for 120 km/h.

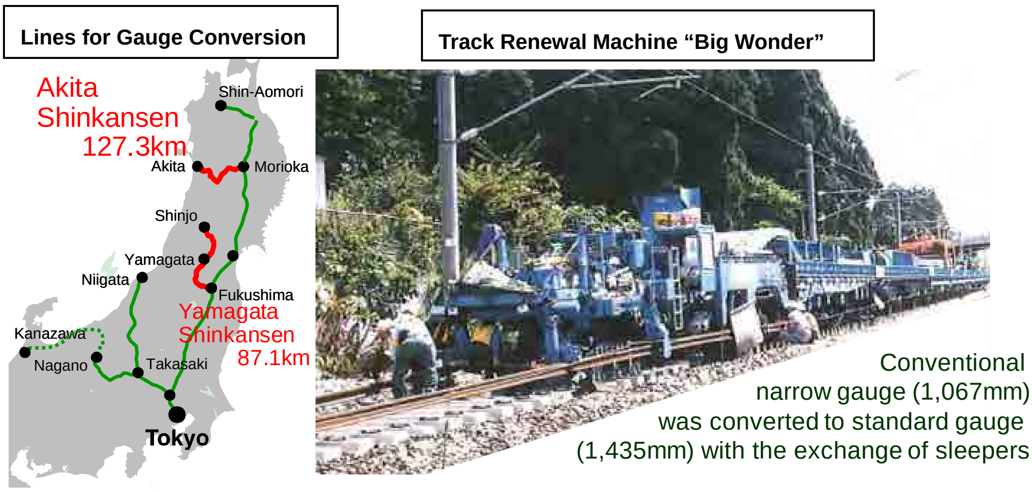


Source: JICA Study Team

Figure 3.3.1 Dual Gauge (Photo)

(c) Operational Suspension

3.55 The construction work is expected to be long and the train operation will be suspended during this period. Therefore, direct operation between Hanoi and HCMC will be suspended for a long period. Figure 3.3.2 shows the lines and a machine utilized for converting narrow gauge to standard gauge in Japan. In case of Akita Shinkansen line in Japan (127.3 km comprising of 75.6 km single track and 51.7 km double track), the conversion work took 5 years to finish.



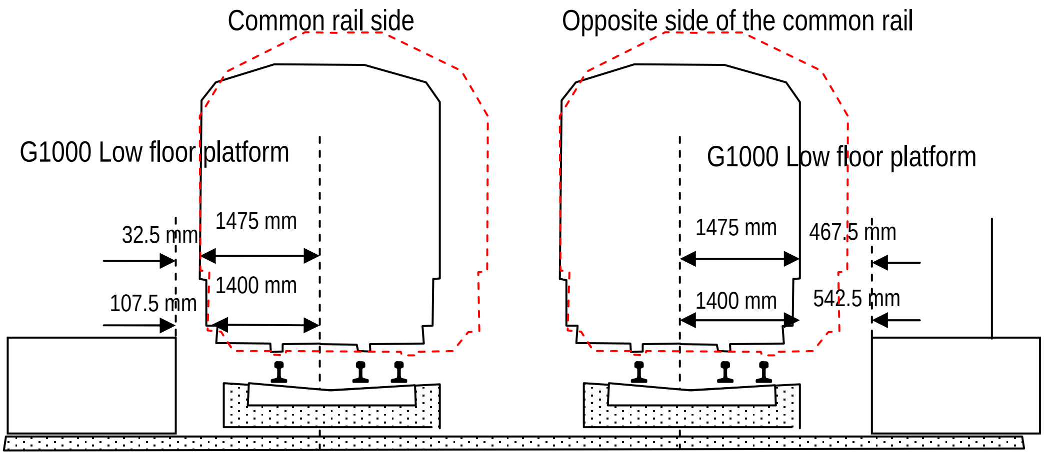
Source: JICA Study Team

Figure 3.3.2 Japanese Experiences of Gauge Conversion

(d) Construction Works

3.56 Most bridges of existing railway should be reconstructed due to the shift of load center.

3.57 Many station spatial layouts have to be remodeled since the distance between the platform and the track is different between the common rail side and the opposite side, restricting the track layout (See Figure 3.3.3).



Source: JICA Study Team

Figure 3.3.3 Track Layout of Dual Gauge

3.58 In addition, construction works along the line under operation is costly. Thus, the installation of dual gauge supposed to be more costly than the construction of a new standard gauge tracks by roughly five percent.

(e) Operation and Maintenance

3.59 Dual gauge for the entire route will involve difficulties on operation and maintenance and increase cost. The use of dual gauge requires the control of train operation on both the narrow- and standard-gauge tracks, which makes facilities and, operation and maintenance complicated.

(f) International Practices

3.60 There are several cases in the world which has mixed operation of passenger and freight railway transport. However, in all cases, in order to prevent accidents upon trains pass one another, decline of overall transport capacity and speed, various measures are taken, summarized as follows (see Table 3.3.1 for details):

(a) Segregation of operating time: Operation of passenger trains in the daytime, operation of freight trains in the nighttime.

(b) Segregation of operating line: Operation of passenger trains on the new line, operation of freight trains on the existing railway.

(c) Other measures: Limitation of maximum speed upon operation, or upgrading of rolling stocks for freight transport upon operation on new lines for high-speed transport.

Table 3.3.1 International Practices of Mixed Operation of Passenger and Freight Transport

Country	Current Situation	Past Experiences	Safety Measures
Germany	Segregation of operation time	• Maximum speed of high-speed railway (NBS): 250-300km/h • Maximum speed of existing railway for passenger transport (ABS): 180-250km/h • Maximum speed of existing railway for freight transport: 160km/h • In order to avoid accidents, the train diagram is arranged so that passenger and freight trains do not pass each other at over 200km/h. This is prohibited for tunnels and bridges at all speed levels. • Since the capacity of existing railway is lacking, there is a plan to operate freight transport on less crowded NGS sections.	• For NBS and ABS sections, freight trains operate only in the nighttime, segregating operation time with passenger trains. • Detecting of trains, control of trains through signal system, indication of warnings and stoppage at commanding stations are adopted. Relying on humans' attention only is strictly prohibited by law.
France	Segregation of operating line	• Maximum speed of high-speed railway (LGV): 300-320km/h • Maximum speed of existing railway for freight transport: 160km/h • Only TGVs and mail transport trains which have the same speed and rolling stock structure as TGVs are allowed to operate on LGV lines. • Upon the case that high-speed passenger transport and low-speed freight transport is operated on the same line, it will cause hindrances to the train diagram resulting low overall transport capacity and speed. • In order for freight trains to operate on LGVs, axle load should be under 17 tons, which is unfeasible. • Operating freight transport during nighttime is dangerous since track maintenance etc. is also conducted during nighttime.	• The construction of a high-speed railway line exclusive for freight transport is under plan.
Italy	Segregation of operation time for north-south railway, and segregation of operating line for east-west railway	• Maximum speed of high-speed railway (AV/AC): 300km/h • Maximum speed of existing railway for freight transport: 160km/h • On north-south railway (Verona, Rome, Napoli), high-speed passenger trains operate in the daytime, whereas low-speed passenger trains and freight trains operate in the nighttime. • On east-west railway (Torino, Milan, Venice), passenger trains operate on AV/AC lines, and freight trains operate on the existing railway line.	• Operation of freight trains on AV/AC is under plan, with conditions that needed safety measures will be taken. They are as follows: - Establishment of RICAD system on crossing sections of the existing line and AV/AC lines. Appropriate signaling on this point will prevent the ingress of overloaded trains. - To prevent collapse of load and sudden fall-outs due to unintended opening of doors of freight trains, load should be managed and eye-checked carefully at the origin station. Load balancing sensors and fire accident sensors should be set up inside tunnels. - To prevent overheating of bearings, temperature sensors should be set up for bearings and breaks, both on the train and on the ground.
Japan	Segregation of operation time	• Maximum speed of high-speed railway: 300km/h • High-speed passenger trains operate on Shinkansen lines, and freight trains operate on existing railway (narrow gauge). • There is a plan to operate high-speed passenger trains and freight trains as an exception in Seikan Tunnel section.	• For the Seikan Tunnel section, the maximum speed of operation will be limited at 140km/h.

Source: Summarized by JICA Study Team.

(g) Conclusion

3.61 Keeping in mind the above considerations, given that the total distance between Hanoi and HCMC is 1,600km and an existing line with narrow gauge already exists, it is strongly recommended that high-speed passenger transport be operated on a new line, separate from the existing line. The plan to change the tracks studded with dual gauge to a standard gauge railway is difficult and costly to implement. Dual gauge can be introduced, however, at particular and limited locations. Further considerations shall be made after the opening of HSR lines, reflecting the conditions of railway freight transport at that time in the future.

3) Analysis on Upgrading Existing Railway for Train Operation at Maximum Speed of 200 km/h

3.62 The issues to be considered for upgrading of existing railway for 200 km/h are mentioned in the following paragraphs

(a) Construction Cost

3.63 Operation at 200 km/h requires the track gauge of 1,435 mm (standard gauge), electrification, infrastructures without crossing with roads and improvement of curves, which subsequently leads to elevated stations and grade-separated crossings. Roughly estimated, curved sections need to be upgraded to those with 2,000 meter radius in more than 1,500 locations and, in more than 2,000 location, level crossings at roads need to be grade separated. The cost of electrification shall also be added to the construction cost.

3.64 The 1,435 mm gauge track to be added to the existing single track sections shall be constructed first, on which operation of single-track shall be implemented while the existing 1 m gauge lines shall be demolished. After removing the existing 1 m gauge track, other construction works required for the 1,435 mm gauge shall be implemented. To smoothly transfer operation from the 1m gauge to 1,435 mm gauge, therefore, facilities for these two different gauges shall be maintained for rolling stocks at depots and stations. This shall increase the construction cost.

3.65 The total cost will amount to approximately 40 billion US dollars (estimated based on the cost for Option B2 additionally taking the increase of alignments improved, rolling stocks, electrical equipments, deports and other infrastructures compared to Option B2 into account), roughly equal to the cost to construct a high-speed railway for 200 km/h operation.

(b) Construction Period

3.66 The period of construction work would become around14-23years, given the conditions stated in above, long route length and budgetary ability of work execution.

- Survey, designing and order placing: 2 to 3 years
- Construction of additional track: 5 to 8 years
- Preparation for 1,435 mm gauge single track operation: 1 to 2 years
- Construction work at the existing line: 5 to 8 years
- Preparation for double-track operation: 1 to 2 years
- Total 14 to 23 years

3.67 As the construction work is executed while the line is in service, trains cannot run at regular operating speed in some sections where train speed in limited.

(c) Possibility for Further Upgrading up to 300 km/h

3.68 If the plan of upgrading the exiting railways to 200 km/h is adopted, it is not conceivable to remodel railway again to 300 km/h railway system because of high construction cost and long construction period.

3.69 The increase in the speed of passenger trains is not possible either if the both of passenger and freight trains are operated on the same track.

4) Analysis on Mixed Operation of Passenger and Freight Trains at Maximum Speed of 200 km/h

3.70 The possibility of the mixed operation of passenger and freight train at 200 km/h is analyzed and the result is shown in the following paragraphs.

(a) Difficulty of 200 km/h Operation of Freight Trains

3.71 The current maximum speed of freight trains in the world is 120 km/h. On the other hand, in Germany, for example, freight trains were once operated at140 to 160 km/h although it has been dropped to 120 km/h because of the problems of profitability and security. For the following reasons, it is not the case in Europe that freight trains be operated mixed with high speed passenger trains in the same sections and time zones.

3.72 Although the possibility of 120 km/h operation of freight trains is not necessarily be denied in view of the technical development in the future, the obstacles for that purpose are too high to adopt the 200 km/h operation of freight trains in Vietnam.

(b) Experiences in European Countries

3.73 Freight trains are operated mixed with high-speed passenger trains at some places in Europe under several conditions.

- **Germany:** Freight trains were once operated at 140 to 160 km/h in the Bremen-Stuttgart section (710 km) and the Hamburg-Munich section (779 km) from 1991, which was reduced to 120 km/h in 1995 due to low profitability.
- **France:** Freight trains are operated at a maximum speed of 270 km/h eight times a day to transport mails, parcels and newspapers with remodeled TGV cars on the TGV Southeastern line. However, France does not have an idea to operate freight trains excluding aforementioned TGV remodeled cars on the same lines with high-speed passenger trains, as there are problems related to train operation diagrams and the time zone required for maintenance work. Rather, France has an idea to construct new lines for high-speed freight trains.

(c) Problems related to the security and the train operation diagrams in the mixed operation of 200km/h passenger trains and 120 km/h freight trains

3.74 The realistic maximum speed of the freight trains in Vietnam is considered to be 120 km/h. However, in such condition, the mixed operation of 200 km/h passenger trains and 120 km/h freight trains has the following problems from the viewpoint of safety and train operation diagrams, suggesting the difficulty of its implementation.

- **Passenger train operation at 200 km/h**

  When the impact at train collisions and the forward visibility distance for train drivers are considered, it is recommendable for Vietnam to introduce the same security system as that of Shinkansen in Japan which has no level-crossings and the ATC system installed in.

  In case of Japan, the forward visibility distance for drivers is specified as 600 m or over. For the Akita and Yamagata Shinkansen railways having road crossings, therefore, the operational speed is limited to 130 km/h or less, to ensure that trains can stop within the visibility distance when the emergency brake is applied. The Shinkansen trains run approximately 2 km after the emergency brake is applied at 200 km/h. It is of no use for drivers, therefore, to apply the emergency brake after noticing an abnormality ahead. This means that the ATC system is essential.

- **Structure and performance of freight trains**

  For high speed operation of freight train at 120 km/h, ATC system, which is a security system applied for Shinkansen, is need to be applied; the security devices and a high-reliability brake system for precise deceleration should be installed not only on locomotives but also on whole train-sets. On the other hand, container freight liner train system is also should be introduced for avoiding unexpected opens of door during operation and fall of cargo as well as breaks of cargo car’s axle caused by excessive heat. Thus, the current VN freight transport system should be totally changed; new rolling stock should be procured for freight liner system and base yards should be constructed.

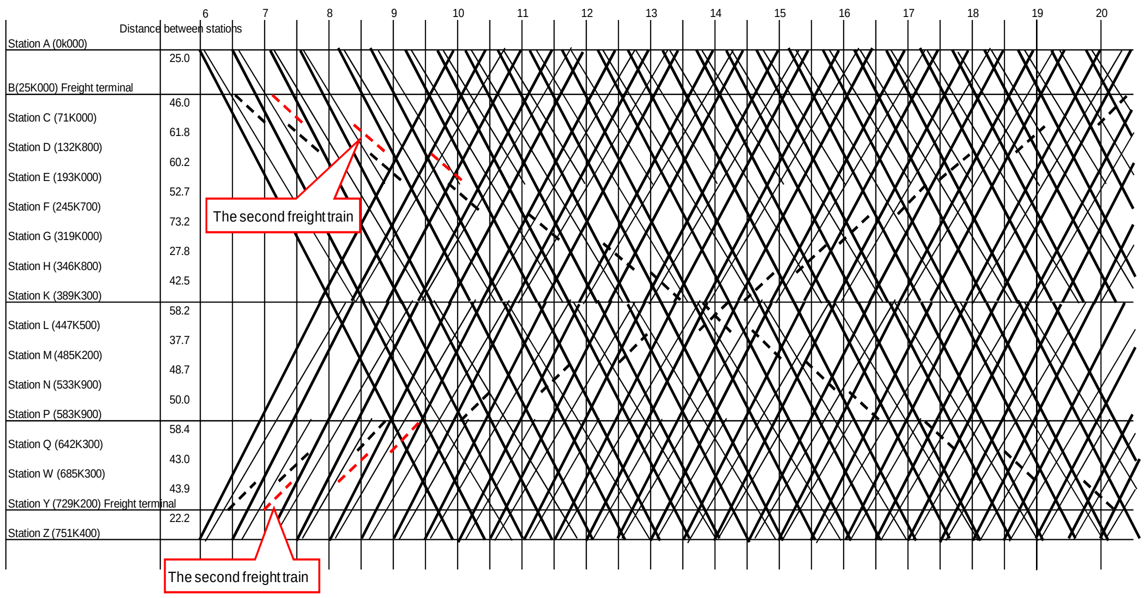
- **Train operation diagrams**

  When trains at different speeds are operated on the same line, the larger the speed difference is, the greater the influence is on the train operation diagrams. Although this is not desirable, it does not mean the mixed operation is impossible.

  At their presentation at UIC (International Union of Railways), those concerned with railways in Germany stated that the time zones for the operation of high-speed trains and freight trains should be separated, presumably by operating freight trains at night, which, although, would conflict with the night time maintenance work for 200 km/h operation of passenger trains.

  To extend the Shinkansen line to Hokkaido, three-rail tracks are laid through the Seikan tunnel in Japan. The initial train operation diagrams planned to run freight trains at night not to interfere with the Shinkansen trains. Under the current plan, however, freight trains are operated mixed with passenger trains with the speed of Shinkansen trains reduced to 140 km/h.

Considering these problems, the Study Team drew train operation diagrams to run 120 km/h freight trains mixed with 200 km/h passenger trains between Hanoi and Ho Chi Minh as shown in Figure 3.3.4. The operation diagrams are impractical as there is a great influence on passenger and freight trains.



Preconditions
1) Train speed Shinkansen train E2 composition 200 km/h operation
Freight train EF81 locomotive 120 km/h operation
2) Operation time DS-ATC assumed
3) Distance between stations The distance between stations set arbitrarily
4) Passenger train operation diagram
Hourly frequency of passenger train operation
Non-stop: 2, accommodation：1, accommodation in urban areas: 1

Freight train operation diagram
The second freight train cannot be set as the time intervals between passenger trains are too short.

Legends
Non-stop Shinkansen train
Accommodation Shinkansen train
Freight train

Source: JICA Study Team

Figure 3.3.4 Passenger and Freight Train Operation Diagram

3.4 Alternative Improvements for the North-South Railway Line

1) Preparation of Alternatives for Improvement

3.75 It is essential for the existing railway line to be modernized to meet the growing demands of passenger and freight volume in the course of a fast expanding Vietnamese economic growth(as for future traffic demand, see chapter 4.2). It is also crucial for the 1,726km railway line to be upgraded in order to survive fierce competition in the transportation market among various modes of transportation, i.e., rail, air, bus, car, truck and shipping.

3.76 There are multifold approaches to improve or upgrade existing non-electrified single track railway. Targets of improvement, therefore, have to be figured out first. The JICA Study Team has set up four possible upgrading or improvement alternatives: namely A1, A2, B1 and B2.The targets of each alternative are as follows:[1/]

(i) A1: Baseline, minimal improvement to ensure safe operation (ongoing and committed projects);

(ii) A2: Maximization of existing single track transportation capacity;

(iii) B1: Strengthening of transportation capacity through double tracking and increase in maximum operating speed to 120 km/h; and

(iv) B2: Double tracking with 1435 mm track gaugeand electrification with maximum operating speed of 150 km/h or more (semi high speed). All the intersections of railway and road are grade-separated.

3.77 Combining the outcomes of the four basic options with that of HSR plans, it will be easy to assess any possible scenarios suggested by various sectors in Vietnam including the National Assembly.

3.78 Although, in the following paragraphs, these options are discussed for the entire North-south railway, practically, the most appropriate option (target improvement level) should be selected from them by section and phase. Note that these options are not meant to be implemented step-by-step in order, but each options rather express the ultimate target improvement level of the existing railway (however, A1 is a baseline plan).

2) Features of Alternative A1

3.79 **Objectives of A1:** A1 is a baseline plan that consists of implementing ongoing and already committed improvement projects for the North-South Railway Line and other measures of minimum requirements to maintain safety levels of the structures as well as the current maximum operating speed of 90 km/h. This ongoing/committed option will reduce the schedule time between Hanoi and HCMC from the current 30.0 hours to 29.1 hours by the fastest train. This speed-up comes from the removal of speed-restricted sections currently imposed on the weak structures, such as old bridges, deteriorated tracks and pumping embankments.

3.80 **Scope of A1:** A1 will consist of the following railway improvement projects and activities:

(a) Station improvement: New waiting lines are added at seven stations, effective track lengths are expanded at seventeen stations and tracks are renewed at sixty eight stations.

1) Detail process and result of these alternatives are shown in Technical Report No. 1 Assessment of Existing Railway and Improvement Options.

(b) Renewal of old track components: This includes (i) Replacement ofold sleepers made of wood, steel and twin-block concrete, coming to durability limitwith mono-block pre-stressed concrete sleepers, (ii) Worn out T40 rails of 15 km long track are replaced with new 50K rails, dirty ballasts of 95 km long track are renewed, and 152 old switches with new ones, and (iii) Retrofitting pumping sections in a total of 74 km of embankments.

(c) Improvement of weak bridges and old tunnels: This includes (i) Replacement of over 100-year old bridges still in use on the North-South railway line and coming to their durability limits with new ones. The approach sections of the new bridges have improved alignments and track structures, and (ii) Replacement of 44 steel bridges and retrofitting 132 reinforced concrete bridges, replacement retrofitting of other 566 bridges, and repair of linings of 22 tunnels.

(d) Renewal and installment of telecommunication systems: Optical fiber cable system and dedicated digital telecommunication system are installed. Thunderbolt prevention system, grounding wires and stand-by equipment are also installed.

(e) Renewal and installment of signaling system: Micro-processing interlocking equipment and axle counter-based blocking equipment are installed for 34 stations. Semi-automatic block equipment in combination with axel counters are built for 72 stations. Devices of centralized control station to control relay interlocking in combination with axle counter are installed for 316 turnouts of the stations from Da Nang to HCMC.

(f) Modernization of Operation Control Center (OCC): Work stations for dispatchers are installed at the OCC at the head office, in Hanoi and in HCMC. Equipment for Global Positioning System (GPS) and other related devices are mounted on 350 locomotives.

(g) Improvement of Crossings: A total of 111 level crossings are improved. Of them, 21 are protected with side board, 31 with automatic warning signal, 33 with barrier, 22 with trolley barrier and 4 are replaced with underpass.

3.81 Since A1 is already on-going, this cost is already taken into consideration in official plans of Vietnam.

Source: JICA Study Team.

Figure 3.4.1 Image of Option A1

3) Features of Alternative A2

3.82 **Objectives of Alternative A2:** The target of A2 is to maximize the transportation capacity of the existing single track non-electrified North-South Railway Line while maintaining its current operational speed. Two major improvement measures are considered effective to significantly raise the transportation capacity of the railway line. One is realigning the three major bottleneck sections, including Hai Van Pass and Khe Net Pass that are forcing trains to run at quite a low speed due to continuous sharp curves and steep gradients. The other improvement measure is building a new siding station in each of the 18 sections between the two overly distant stations. Option A2 improvements will enable the operation of 25 pairs of trains a day over the entire line of the NS railway reducing the schedule time between Hanoi and HCMC to 25.4 hours by the fastest train

3.83 **Scope of Alternative A2:** A2 will consist of the following projects and activities:

(a) Realignment of Hai Van and Khe Net Passes: These two major bottleneck sections are realigned, constructing new shortcut lines with two medium tunnels, 870m and 638m for Khe Net Pass and a long one, 8,450m for Hai Van Pass. Tracks and signal systems in the two newly constructed sections are upgraded. The alignment between Hoa Duyet and Thanh Luyen is also improved, accompanied by track renewal and signal system upgrading.

(b) Building new siding stations: Long sections lengthen train operation time resulting in low passing capacity. To increase traffic capacity, new siding stations are built in the middle of 18 long sections ranging from 11.9 km to 18.9 km. The third tracks are added at the three existing stations to avoid the two adjacent stations having two advantageous tracks in train operation work.

(c) Signaling and telecommunication systems

- Semi-automatic block system and electric interlocking devices with axle counters as well as local equipment for Centralized Train Control (CTC)system are introduced into the new 18 stations. Train dispatching, monitoring and control systems are modernized using the CTC system.

(d) Level crossings: The level crossings at the intersection of the railway line and the highway are grade-separated. All the other remaining official level crossings are improved to automated level crossings with alarm warning and automatic barriers.

(e) Rolling stock: In proportion to the maximization of transportation capacity of the railway line, an increased number of rolling stock is needed. Around 67 new locomotives of D19E class and 1,043 new passenger cars are procured.

3.84 **Investment cost of Alternative A2:** The improvement projects under Alternative A2 are estimated to require a total investment of US$1.8 billion. (see Table 3.4.1 for breakdown).

Table 3.4.1 Estimated Investment Cost of Alternative A2

No.	Items	Million US$
1	Khe Net Pass improvement	48
2	Hai Van Pass improvement	181
3	HoaDuyet-Than Luyen section	63
4	New interchange stations	54
5	Signal and telecommunication	608
6	Crossing modernization	0
7	Depot	230
8	Rolling stock	341
	(A) Sub-total cost	1,524
9	Land acquisition	13
10	Construction services 2% of (1+2+3+4+5+6+7+8)	30
	(B)Sub-total cost	1,567
11	Contingency 5% of (B)	78
12	Tax and import tax, etc. 10% of (A)	152
	Total Project Cost	1,797

Source: JICA Study Team based on TRICC data.

Table 3.4.2 Cost Breakdown of Alternative A2

Item	Unit	Volume	Unit Price (USD)	Cost (USD mil.)	Remark
Khe Net Pass improvement	ea	1	48,000,000	48	9km
Hai Van Pass improvement	ea	1	181,000,000	181	26.5km
Hoa Duyet - Thanh Luyen section	ea	1	63,000,000	63	13km
New interchange stations	no.	18	3,000,000	54	
Signal & Telecommunications	km	1726	352,000	608	
Depot					
Tang Hoa	ea	1	162,500,000	163	Depot & Workshop
Muong Man	ea	1	38,750,000	39	Depot
Sai Gon	ea	1	3,750,000	4	Depot
Building Up of Existing Depots	ea	1	25,000,000	25	
Subtotal of Depot				230	
Rolling Stock					
Locomotive	no.	67	1,000,000	67	
Passenger car	no.	1043	262,000	273	
Subtotal of Rolling Stock				340	
Land Acquisition	ha	36	360,000	13	
Total				1,537	

Source: JICA Study Team based on TRICC data.

Source: JICA Study Team.

Figure 3.4.2 Image of Option A2

4) Features of Alternative B1

3.85 **Objectives of Alternative B1:** The target of Option B1 is to upgrade the existing non-electrified single tracked NS Railway Line to a non-electrified double tracked line, allowing faster train operation than at present. Double tracking is done by adding a new track next to the existing single track. Current maximum speeds of 90 km/h for passenger trains and 60 km/h for freight trains are raised up to 120 km/h for passenger trains and 70 km/h for freight trains through improving sharp curves.

3.86 **Scope of B1:** Alternative B1 will consist of the following projects and activities:

(a) Alignment: Sharp curves are improved all over the railway line with minimum radius of 800m, except for ones that will be very difficult to alter being near a station or urban area.

(b) Earthwork: Embankments are widened by adding earthworks to the existing ones, while cutting sections are broadened by excavating the slopes. New embankments and existing pumping sections are provided with reinforced roadbeds. Slope protections are mounted onto the embankment slopes.

(c) Bridge: New single tracked bridges are constructed parallel to the 888 already refurbished or rehabilitated bridges. The remaining 566 weak bridges built 70-100 years ago are reconstructed into double tracked bridges or added a single tracked bridge next to the existing ones.

(d) Tunnel: Three major bottleneck sections in the alignment, Hai Van Pass, Khe Net Pass are removed by constructing double tracked shortcut lines with medium or long tunnels. The other tunnels are replaced with double tracked tunnels driven parallel to the existing ones.

(e) Station: Station layouts are modified and expanded according to the increased volume of passengers and freight.

(f) Track: Old components of the track are replaced with P50 long welded rails, mono-block pre-stressed sleepers, 39 pieces per 25m. Ballasts are thickened to 30-35 cm with 20 cm thick sub-ballast beneath. Existing switches on the main line are replaced with #12 high speed switches which are laid on the newly added single line.

(g) Depot: The existing depots are expanded according to the increased numbers of locomotives and passenger and freight coaches. Two new freight car depots and workshops are developed in Da Nang and HCMC.

(h) Signal and Telecommunication: Electric interlocking devices and multiple block systems are introduced to upgrade the safety and maintainability of the line. Automatic train protection system (ATP) with speed checking function is also introduced to prevent the drivers from making train operating mistakes. Centralized traffic control system is installed to arrange the train operations effectively on the whole line. Synchronous Digital Hierarchy (SDH) system is installed as a back-bone network.

(i) Crossing: All the level crossings are upgraded to automated level crossings with alarm warning and automatic barrier function.

(j) Rolling Stock: In addition to the existing rolling stocks adaptable to 120km/h, 64 diesel locomotives for passenger trains, 83 diesel locomotives for freight trains, 840 passenger cars, and 3,900 freight cars all with operational performance of 120km/h are newly purchased.

3.87 **Investment Cost of B1:** The total investment cost of B1 is estimated at US$14.5 billion. (see Table 3.4.2 for breakdown)

Table 3.4.3 Estimated Investment Cost of Alternative B1

No.	Items	Million US$
1	Civil works	2,060
	Cutting	*66*
	Embankment	*874*
	Bridge	*718*
	Tunnel	*403*
2	Track work	1,308
3	Crossing	48
4	Electricity	4,790
	Signaling System	*3,066*
	Telecommunication System	*1,724*
5	Depot and others	723
6	Feeder line	33
7	Rolling stock	1,453
	(A) Sub-total cost	11,408
8	Land acquisition	1,086
9	Construction services 2% of (1+2+3+4+5+6+7)	199
	(B)Sub-total cost	12,693
10	Contingency 5% of (B)	635
11	Tax and import tax, etc. 10% of (A)	1,141
	Total Project Cost	14,468

Source: JICA Study Team

Table 3.4.4 Cost Breakdown of Alternative B1

Item	Unit	Volume	Unit Price (USD)	Cost (USD mil.)	Remark
Cut					
Cut	m^3	2,200,000	12	26	127km
Reinforced road bed	M	127,000	265	34	12m wide
Barrier	M	34,800	50	2	
Slope protection	M	46,100	100	5	
Subtotal of Cut				66	
Embankment					
Fill	m^3	19,200,000	15	288	1412km
Reinforced road bed	M	1,412,000	265	374	12m wide
Slope protection	M	705,800	100	71	
Barrier	M	2,824,000	50	141	
Subtotal of Embankment				874	
Bridge					
5<L<14	M	6,133	10,600	65	single track
15<L,30	M	5,527	11,900	66	single track
30<L<67.5	M	9,815	14,200	139	single track
67.5<L	M	19,470	21,400	417	single track
Culvert	M	19,550	1,600	31	
Subtotal of Bridge				718	
Tunnel	M	21,100	19,100	403	Double Track
Track					
Ballast track	M	1,717,000	725	1,245	P50 rail
Turn-out	no.	435	145,000	63	#12

Item	Unit	Volume	Unit Price (USD)	Cost (USD mil.)	Remark
Subtotal of Track				1,308	
Station	m^2	483,000	2,060	995	163 stations
Crossing	no.	2,439	19,500	48	automated
Signal & Telecommunications	km	1,726	2,775,000	4,790	ATS
Depot					
Hanoi	no.	1		109	Depot
Vinh	no.	1		141	Depot & Workshop
Da Nang	no.	1		209	Depot & Workshop
Nha Trang	no.	1		141	Depot & Workshop
Sai Gon	no.	1		123	Depot
Subtotal of Depot				723	
Feeder line	km	1,125	29,300	33	
Rolling Stock					
Passenger locomotive	no.	64	5,000,000	320	
Freight locomotive	no.	83	1,000,000	83	
Passenger car	no.	840	375,000	315	
Freight car	no.	3,915	187,700	735	
Subtotal of Rolling Stock				1,453	
Land acquisition	ha	1,063	1,022,000	1,086	
Total				12,496	

Source: JICA Study Team

Source: JICA Study Team.

Figure 3.4.3 Image of Option B1

5) Features of Alternative B2

3.88 **Objectives of Alternative B2:** The target of Alternative B2 is to upgrade the existing non-electrified single tracked NS line to an electrified double tracked line, raising maximum speeds of passenger trains from 90 km/h to 150 km/h, of freight trains from 60 km/h to 80 km/h, and of container trains to 120 km/h. Double tracking is done by adding a new track next to the existing single track.

3.89 **Scope of Alternative B2:** B2 will consist of the following projects and activities:

(a) Alignment: Sharp curves are improved with minimum radius 1,200m, except for the ones that are very difficult to alter being in the neighborhood of a station or urban areas.

(b) Crossing: All the level crossings are removed by elevating the railway line or building flyover or underpass roads.

(c) Earthwork: Embankments are widened by adding earthworks to the existing ones, while cutting sections are broadened by excavating the slopes. New embankments and existing pumping sections are provided with reinforced roadbeds. Slope protections are mounted onto embankment slopes.

(d) Bridge: New double tracked bridges are constructed parallel to the existing river bridges. Other bridges are reconstructed as double tracked bridges or added a single tracked bridge.

(e) Tunnel: Three major bottleneck sections in alignment—Hai Van Pass, Khe Net Pass and Hoa Vinh—are removed by constructing double tracked shortcut lines with medium and long tunnels. The other tunnels are replaced with double tracked tunnels driven parallel to the existing ones.

(f) Station: Layouts of elevated stations are remodeled according to the increased number of passengers. Freight-related facilities are moved to new freight stations constructed nearby. Remaining ground level stations are expanded according to the increased volume of passengers and freight.

(g) Track: Old components are replaced with 60K long welded rails, pre-stressed sleepers, 43 pieces per 25m, and high-speed #12 switches with movable nose crossings on the main line. Track ballasts are thickened to 30-35 cm with sub-ballast of 20 cm thick beneath.

(h) Depot and Workshop: The existing depots and workshops are expanded and remodeled to accommodate 146 electric locomotives, 280 EMUs, 2,090 container cars and 1,785 ordinary freight cars. A depot for EMUs, locomotives and freight cars is each located in Hanoi, Da Nang and HCMC. A depot for EMUs is in Vinh. Workshops are located in Vinh, Da Nang and Nha Trang.

(i) Signal and Telecommunication: This includes followings; (i) An average of three block sections are installed between stations. The distance of a block section will be approximately 3.5km long, on average. Train location will be detected using divided-multiple frequency track circuits for electrification of the railways. An automatic train protection system with speed checking function is adopted. (ii)Electric interlocking devices are installed. Train locations in the station areas are detected using continuous AF track circuits. Electrical switch machines are employed to turn switches in the stations. (iii) Operation Control Centers are built in Hanoi and HCMC to monitor and control train operations over the 1,726km railway line. The OCCs are equipped with central equipment of CTC and the stations with local equipment of CTC.

(j) Electrification: The line is electrified with a system of 25 KV AC, 50 Hz. A total of 36 sub-power stations with average distance of 50 km are built between Hanoi and HCMC. An AT feeding system is applied. A newly developed overhead system of CS simple catenary cable is applied.

(k) Rolling Stock: New rolling stock consisting of 146 electric locomotives with 2,550 kW capacity, 14 EMUs for Express, 27 EMUs for Local, 2,090 container cars, and 1,785 ordinary freight cars with performance of high speed operation, are purchased.

3.90 **Investment cost of Alternative B2:** Implementation of B2 will require a total investment cost of about US$27.7 billion. (see Table 3.4.3 for breakdown)

Table 3.4.5 Estimated Investment Cost of Alternative B2

No.	Items	Million US$
1	Civil works	3,684
	Cutting	175
	Embankment	2,024
	Bridge	1,015
	Tunnel	470
2	Track work	2,338
3	Station	2,240
4	Electricity	10,450
	Electric power	5,551
	Signal andTelecom	4,899
5	Depot and others	839
6	Rolling stock	2,869
	(A) Sub-total cost	22,419
7	Land acquisition	1,431
8	Construction services 2% of (1+2+3+4+5)	391
	(B) Sub-total cost	24,241
9	Contingency 5% of (B)	1,212
10	Tax and import tax, etc. 10% of (A)	2,242
	Total Project Cost	27,695

Source: JICA Study Team

Table 3.4.6 Cost Breakdown of Alternative B2

Item	Unit	Volume	Unit Price (USD)	Cost (USD mil.)	Remark
Cut					
Cut	m^3	6,500,000	12	78	
Reinforced road bed	M	130,000	285	37	12m wide
Barrier	M	68,000	75	5	
Slope protection	M	551,000	100	55	
Subtotal of Cut				175	
Embankment					
Fill	m^3	81,600,000	15	1,224	
Reinforced road bed	M	1,390,000	285	396	12m wide
Slope protection	M	1,950,000	100	195	
Barrier	M	2,780,000	75	209	
Subtotal of Embankment				2,024	
Bridge					
L<20	M	10,230	18,500	189	double track
20<L<50	M	14,590	21,500	314	double track
50<L	M	20,500	25,000	513	double track
Subtotal of Bridge				1,015	

Item	Unit	Volume	Unit Price (USD)	Cost (USD mil.)	Remark
Tunnel	M	21,850	21,500	470	Double Track
Track					
Ballast track	M	1,717,000	800	1,374	60K rail
Gauge widening	M	1,717,000	525	901	
Turn-out	no.	435	145,000	63	#12
Subtotal of Tunnel				2,338	
Station	m^2	1,018,000	2,200	2,240	163 stations
Electric Power					
Sub-power station	no.	36	68,750,000	2,475	
SCADA	no.	2	12,500,000	25	
Overhead catenary	km	1,714	1,000,000	1,714	
Feeder line	km	1,714	625,000	1,071	
Major station	no.	7	2,500,000	18	
Normal station	no.	159	1,250,000	199	
Depot	no.	4	12,500,000	50	
Subtotal of Electric Power				5,551	
Signal & Telecommunications	km	1,722	2,845,000	4,899	ATS
Depot					
Hanoi	no.	1		166	Depot
Vinh	no.	1		133	Depot & Workshop
Da Nang	no.	1		241	Depot & Workshop
Nha Trang	no.	1		133	Depot & Workshop
Sai Gon	no.	1		166	Depot
Subtotal of Depot				839	
Rolling Stock					
EMU for express	no.	228	3,125,000	713	
EMU for local	no.	280	2,500,000	700	
Locomotives	no.	146	5,000,000	730	
Freight car	no.	3,875	187,500	727	
Subtotal of Rolling Stock				2,869	
Land Acquisition	ha	1,400	1,022,000	1,431	
Total				23,850	

Source: JICA Study Team

Source: JICA Study Team.

Figure 3.4.4 Image of Option B2

6) Summary of Alternative Options

3.91 A technical overview of the four alternatives (A1, A2, B1 and B2) is shown in Table 3.4.5. A1 and A2 are single track while B1 and B2 are double track.

3.92 The breakdown of cost for each plan by section is shown in Table 3.4.6. The scale of Improvement is significantly different among plans (1,797.5 million USD for A2, 14,467.8 million USD for B1 (8.0 times of A2) and 27,694.0 million USD for B2 (1.9 times of A2). As for A2, the sections in the central, where the improvements on passes in mountainous area are required, are costly than other sections.

Table 3.4.7 Summary of Four Alternatives (A1, A2, B1 and B2)

		A1 (Committed)	A2	B1	B2
Railroad track	Track	Single	Single	Double	Double
	Electrification	Non-electrified	Non-electrified	Non-electrified	Electrified
	Gauge	1,000 mm	1,000 mm	1,000 mm	1,435 mm
	Minimum radius of curvature	100m (existing)	100m (existing)	800m	1,200m
	Withstand load	14 ton (existing)	14 ton (existing)	14 ton (existing)	22 ton
Maximum train speed	Passenger train	90 km/h (existing)	90 km/h (existing)	120 km/h	150 km/h
	Freight train	60 km/h (existing)	60 km/h (existing)	70 km/h	Container: 120 km/h Bulk: 80 km/h
Travel Time (Hanoi - Saigon)		29.1 h	25.4 h	15.6 h	12.7h
Facilities	Alignment improvement	• Same as existing	• 3 bottlenecks, Hai Van Pass, Khe Net Pass, HoaDuyet to Thon Luyen	• Substandard curvatures • 3 bottlenecks	• Substandard curvatures • 3 bottlenecks
	Effective length for station	Minimum 350m (existing)	Minimum 350 m (existing)	450 m	450 m
	Crossing	Level crossings (existing)	Automated level crossings	Automated level crossings	Grade separation
	Signaling	• Automatic interlocking system / semi-automatic block system in some stations (existing)	• Automatic interlocking system in all stations • Semi-automatic block system	• ATS • Automatic interlocking system in all stations • Automatic block system	• ATS • Automatic interlocking system in all stations • Automatic block system
Rolling stock		Diesel – electric locomotive	Diesel – electric locomotive	Diesel – electric locomotive	Electric train (passenger) Electric locomotive (freight)
Train Frequency (up + down)		• 32 trains/ day (existing)	• 50 trains/ day1/	• 116 trains/ day2)	• 122 trains/ day2)
Estimated Investment (approximately)		-	• 1,800 Million US$	• 14,500 Million US$	• 27,700 Million US$

Source: JICA Study Team
1/ Maximum frequency based on the improvement of 18 new intermediate stations.,
2/ Based on the traffic demand analysis on 2030 year.

Table 3.4.8 Investment Cost of Improvement Plans of Existing Railway

(Unit: Million US$)

			North		Central			South		
			Hanoi-Thanh Hoa	Thanh Hoa-Vinh	Vinh-Hue	Hue-Danang	Danang-Nha Trang	Nha Trang-Phan Thiet	Phan Thiet-HCMC	Total
Length (current, km)			175.2	143.8	369.3	103.1	523.5	236.2	175.1	1726.2
Existing Railway	A2	1.Khe Net Pass realignment Project	-	-	47.5	-	-	-	-	47.5
		2.Hai Van Pass realignment Project	-	-	-	181.2	-	-	-	181.2
		3.HoaDuyet-ThanhLuyen section upgrade project	-	-	62.5	-	-	-	-	62.5
		4.Construction pass-by new stations	-	2.7	5.4	2.7	13.5	18.8	10.8	53.8
		5. Signaling and Telecommunication facilities for new stations and for whole line	59.1	46.7	109.7	37.7	172.2	102.0	80.0	607.5
		6. Signal protection device for level crossing on Hanoi-Ho Chi Minh City	Included in item 5							
		7.Vehicle workshops and facilities for the increased transportation capacity	43.8	123.8	5.0	5.0	5.0	43.8	3.8	230.0
		8. Vehicle purchase for the increased transportation capacity2)	170.7	-	-	-	-	-	170.7	341.3
		7.Land Acquisition	1.0	1.3	2.7	2.5	1.1	2.7	1.2	12.5
		8.Construction Services	5.5	3.5	4.6	4.5	3.8	3.3	5.3	30.5
		9.Contingency	14.0	8.9	11.9	11.7	9.8	8.5	13.6	78.3
		10. Tax and import tax etc	27.4	17.3	23.0	22.7	19.1	16.5	26.5	152.4
		Total2/	321.4 (140.7)	204.2	272.2	268.0	224.5	195.6	311.7 (141.0)	1,797.5
	B1	1. Civil Work	136.3	138.6	490.1	299.4	818.9	202.6	54.5	2,140.4
		2. Track work	133.7	109.7	280.2	70.7	399.4	180.2	133.6	1,307.5
		3. Station	151.0	103.0	212.0	75.0	244.0	94.0	116.0	995.0
		4. Electricity	489.7	401.8	1,026.5	258.9	1,463.0	660.0	489.2	4,789.1
		5. Depot & others	108.8	50.0	91.3	145.0	113.8	91.3	122.5	722.5
		6. Rolling Stock2)	726.3	-	-	-	-	-	726.3	1,452.5
		7. Land Acquisition	158.4	120.3	147.7	45.7	330.7	140.7	143.0	1,086.4
		8. Construction Services	20.4	16.1	42.0	17.0	60.8	24.6	18.3	199.1
		9. Contingency	96.2	47.0	114.5	45.6	171.5	69.7	90.2	634.6
		10.Tax and import tax etc	174.6	80.3	210.0	84.9	303.9	122.8	164.2	1,140.7
		Total I2/	2,195.3 (1,469.0)	1,066.8	2,614.2	1,042.2	3,906.1	1,585.7	2,057.6 (1,331.3)	14,467.8
	B2	1. Civil Work	315.0	251.3	753.6	414.3	1,223.8	435.4	290.4	3,683.8
		2. Track work	239.0	196.1	501.0	126.4	714.1	322.1	238.8	2,337.5
		3. Station	490.9	147.5	497.8	167.3	478.5	189.5	268.4	2,239.8
		4. Electric city	1,068.4	876.7	2,239.5	564.9	3,192.1	1,439.9	1,067.3	10,448.8
		5. Depot & others	166.3	0.0	132.5	47.5	193.8	132.5	166.3	839.0
		6.Rolling Stock2)	1,434.5	-	-	-	-	-	1,434.5	2,869.1
		7.Land Acquisition	250.7	148.6	189.4	54.3	453.7	195.2	139.5	1,431.3
		8.Construction Services	45.6	29.4	82.5	26.4	116.0	50.4	40.6	391.0
		9.Contingency	200.5	82.5	219.8	70.0	318.6	138.3	182.3	1,212.0
		10.Tax and import tax etc.	371.4	147.2	412.4	132.0	580.2	251.9	346.6	2,241.8
		Total I2/	4,582.3 (3,147.8)	1,879.4	5,028.5	1,603.1	7,270.7	3,155.2	4,174.7 (2,740.2)	27,694.0

Source: TRICC and JICA Study Team, 2012

1/ The breakdown of A1 (on-going and committed) is not included in the table.

2/ Cost for rolling stock is included in the sections where terminal stations are located. Figures in the parenthesis show the cost excluding rolling stocks.

3.93 Brief evaluation of each alternative excluding A1 (consisting of committed and ongoing projects) is as follows:

(1) Alternative A2

3.94 The significant time savings is expected to be brought mainly by realignment of Hai Van Pass section (about 1 hour) and construction of 18 siding stations (about 2 and a half hours) as well as the operating cost savings resulting from the mode transfer. It is, therefore, highly recommendable to realize Hai Van Pass improvement and 18 new siding stations as soon as possible. The two projects along with the ongoing bridge improvement project of A1 and other improvement projects involved in A2 will enable to increase the operational capacity of the NS line from at present 32 up and down trains a day up to maximum 50 trains a day. There will be 13 pairs of through express train instead of current 5 pairs when A2 completed. This will upturn at present losing market share both in passenger and freight transportation.

(2) Alternative B1

3.95 The amount of investment for B1 is too enormous to implement for the entire 1,726 km at once. Stage implementation, therefore, has to be considered. Priority should be given to those sections whose traffic densities are coming close to their maximum operational capacities. Another important factor to be taken into account is that double tracking requires huge amount of land acquisition and relocation of numerous households. According to the calculations done by TRICC and the Study Team, roughly 10 km^2 of land acquisition will be needed while over 10,000 households have to be resettled. It is crucial to secure understanding and cooperation of the citizens before starting the project. Environmental Impact Assessment, therefore, is an essential part of the process. In the course of EIA, the problem of illegally occupied areas within each 15 m wide Right of Way range will inevitably arise. A definite decision making on how to resolve the problem would be necessary before implementation.

3.96 Alternative B1 will shorten the travel time between Hanoi andHCMC from current 29.5 hours by SE3 to 15.5 hours by the fastest trains when B1 is completed. Frequencies of both passenger train and freight train are also improved. Current 7 ~13 pairs of passenger train increase up to 10 ~ 20 pairs while from current 5 ~ 6 pairs to 31 ~ 38 pairs for freight train.

3.97 Alternative B2, The biggest advantage B2 brings is that all the level crossings are removed and level separated all along the NS line. Structures in urban areas are elevated high from the ground level which means far less railway accidents than at present. Of the 466 railway accidents that took place along the North South line in 2010, 451 were objective accidents. It is expected most of those accidents will disappear when B2 is completed. Alleviating effects on road traffic accidents brought by modal transfer from road to railway should also be taken into account. Evaluation of these effects would require further studies to figure out the method of measurement.

3.98 As for social considerations, land acquisition of over 20 km^2 will be needed while nearly 20,000 households have to be resettled.

3.99 The shortest travel time from Hanoi to HCMC is 12.7hours by the fastest express train when Option B2 completed. Frequencies increase to 10-21 pairs of passenger train, to 31-40 pairs of freight train.

Box 3.4.1 Improvement of Danang – Hue Section through the Future Introduction of HSR

This section (79.5km) aims to improve the Hai Van Pass bottleneck between Hanoi and HCMC where train speed is substantially low for the existing railway. It is also expected to accelerate the overall development of the Central Region, especially for the tourism sector in both Hue and Danang.

The route will be the same as described in the report of the preliminary feasibility study. A double-track railway will be constructed, with one track for the existing railway and the other for the high-speed railway. Hence high-speed railway performs two-way operation on a single-track. In order to guarantee the safety of train operation, necessary measures will be taken to prevent trains of existing railway from passing by those of high-speed railway when the latter are in high-speed operation. The structures include embankments (12.5km), cuts (15.6km), viaducts (19.8km), bridges (5.8km), and 2 tunnels (22.5km).

Test runs will be performed with a train set of 6-car composition. Train operation diagrams can be drawn to run a train per hour for test runs or for revenue service operation. Two train sets of 6-car composition will be prepared to enable 320 km/h operation. This enables drivers to experience and to test the maximum speed of 320 km/h and perform sufficient training operation and various tests for the purpose of cultivating human resources.

Rolling stock depots and workshops will be constructed at appropriate scales. Training houses, equipment/facilities for practical exercise and machines/materials for education will be provided, along with measuring instruments and test apparatus for tracks, trolley wires and other equipment.

Two tracks will be used both for the existing and high-speed railways separately in the double-track tunnel after the Hai Van tunnel has been constructed. However, as operating speeds of HSR and existing railway are quite different, they will not run in the tunnel section at the same time, to ensure safety of train operation. The approximate construction cost is 2,438 USD million.

Regarding its demand, in 2010, the passenger demand between Hue and Danang is 4,800/ day and is expected to increase to 13,700/ day in 2030. When the section is in place, it is also expected that the passenger demand between Danang and Quang Tri via Hue, and that between hue and Quang Nam via Danang will use this section. While there sufficient information is lacking for this section, the integration of Hue and Danang will generate significant impact on the movement of the people and tourists in this area.

Table 3.4.9 Passenger Demand related to Hue – Danang Section

Mode		Car	Bus	Existing Railway	HSR	Total
2010	Hue – Danang	972	3,597	241	-	4,810
	Hue – Quang Nam	142	1,930	47	-	2,119
	Danang – Quang Tri	35	398	45	-	478
2030	Hue – Danang	2,741	4,110	6,850		13,701
	Hue – Quang Nam	1,022	3,473	0	(1,906)	6,401
	Danang – Quang Tri	542	806	246	(525)	2,119

Source: JICA Study Team.

4 ALTERNATIVE SCENARIO FOR NORTH-SOUTH RAILWAY DEVELOPMENT

4.1 Review of Alternative Scenarios discussed in National Assembly

1) Comments and Opinions on Development of High-Speed Railway Collected and Reviewed so Far

4.1 During the discussion on the development of North-South High Speed Railway held in National Assembly (June 2010) and across the society during the time, the most fundamental issue was that the necessity and implementation of the HSR must be assessed and clarified in conjunction with development of all available transportation modes along the north-south corridor in general and existing railway in particular. The comments and opinions from various organizations and experts were so extensive that the government was required to respond to them adequately before farther discussion in the National Assembly. The comments and opinions were collected and reviewed initially, studied and discussed in this report by the Study Team (See Appendix A).

2) Review and Reorganization of Alternative Scenario

4.2 Initial set of alternative scenario on the development of the North-South railway development discussed in National Assembly in 2010 were reviewed and reorganized for more comprehensive study to provide a rational basis to formulate optimum strategy on the North-South railway development. The approach to this work is composed of three steps (See Table 4.1.1);

Step 1: Review of initial alternative Scenario

Step 2: Identification of opportunities and constraints to upgrading existing railway

Step 3: Identification of options for improvement of existing railway and development of new railway

Step1: Review of Initial Alternative Scenario

4.3 Initially there are six scenarios on the North-South railway development discussed in the National Assembly in 2010. They are in combination of existing railway and HSR (refer to Table 4.1.1). Main concerning points of the scenarios are related to;

(i) Possibility of improvement/upgrading of existing railway

(ii) Combination of improved existing railway and construction of new high-speed railway

(iii) Technical matters such as dual gauge (meter or 1,435 mm), track, maximum train speed (current to 200km/h), passenger and freight services, etc

Table 4.1.1 Steps for Review and Reorganization of Alternative Scenario

Step 1 Initial Alternative Scenario

Alternative	Existing Line	New Line
Scenario 1	• Upgrading to double track with dual gauge (meter + standard) • Current maximum speed for passenger and freight services	None
Scenario 2	• Upgrading to double track (standard gauge) • Maximum operating speed of 200 km/h for both passenger and freight services • Electrification	None
Scenario 3	• Improvement for local passenger and freight transport services • Single track	• Construction of new high-speed line (double track with standard gauge) • Maximum operating speed of 200 km/h for passenger and freight service
Scenario 4	• Improvement for local passenger and freight transport services • Single track	• Construction of new high-speed line (double track with standard gauge) • Maximum operating speed of 300 km/h for passenger service only
Scenario 5	• Improvement for local passenger and freight transport services • Double track	• Construction of new high-speed line (double track with standard gauge) • Maximum operating speed of 200 km/h for passenger and freight service
Scenario 6	• Improvement for local passenger and freight transport services • Double track	• Construction of new high-speed line (double track with standard gauge) • Maximum operating speed of 300 km/h for passenger service only

Step 2 Possibility of Upgrading of Existing Railway

- Possibility of converting to dual gauge for entire section of existing railway (1,700 km)
- Possibility of upgrading of existing railway infrastructure to accommodate train operation at maximum speed of 200 km/h.
- Possibility of mixed operation of passenger and freight trains at maximum speed of 200 km/h

Step 3 Options for Improvement of Existing Railway Options for New HSR

	Options for Improvement of Existing Railway
A1	• Minimal improvement to ensure safe operation (ongoing and committed projects) • Maximum Operating Speed: 60 km/h (Travel Time: 29.1 h (Hanoi-HCMC) • Capacity: 32 trains/day/both-direction
A2	• Maximization of existing single track transportation capacity • Maximum Operating Speed: 70 km/h (Travel Time: 25.4h (Hanoi-HCMC) • Capacity: 50 trains/day/both-direction
B1	• Double tracking with meter gauge • Maximum Operating Speed: 110 km/h (Travel Time: 15.6 h (Hanoi-HCMC) • Capacity: 170 trains/day/both-direction
B2	• Double tracking with standard gauge • Maximum Operating Speed: 135 km/h (Travel Time: 12.7 h (Hanoi-HCMC) • Capacity: 170 trains/day/both-direction

New Line
• Maximum Design Speed: 280 km/h (Maximum Operating Speed: 320 km/h)

4.4 The scenarios are briefly as follows;

Scenario 1: To upgrade the existing railway line with single track and 1000 mm gauge to dual gauge line (meter gauge + standard gauge) by expansion of the track foundation and sleeper replacement and to develop a parallel 1,435 mm gauge line with current maximum speed for passenger and freight transport

Scenario 2: To upgrade the existing railway line to electrified double track line with 1,435 mm gauge and maximum operating speed of 200 km/h for both passenger and freight transport

Scenario 3: To upgrade existing railway line for local passenger and freight transport service with single track and to develop a electrified double track line with 1,435 mm gauge both for passenger and freight transport with maximum operating speed of 200 km/h

Scenario 4: To upgrade existing railway line for local passenger and freight transport service with single track and to develop a new high speed railway line only for passenger transport with maximum operating speed of 300 km/h

Scenario 5: To upgrade existing railway line for local passenger and freight transport service with double track and to develop a electrified double track line with 1,435 mm gauge both for passenger and freight transport with maximum operating speed of 200 km/h

Scenario 6: To upgrade existing railway line for local passenger and freight transport service with double track and to develop a new high speed railway line only for passenger transport with maximum operating speed of 300 km/h

Step 2: Analysis on the Constraints of Upgrading Existing Railway

4.5 Of the initial alternative scenarios, there are three areas involving technical difficulties as explained in Chapter 3;

(i) Construction of dual gauge along 1,700 km long existing railway

(ii) Upgrading of existing railway infrastructure to meet 200 km/h operation

(iiI) Combined operation of passenger and freight trains at the speed of 200 km/h

4.6 As they involve technical difficulties and require excessive costs it is not practical to consider as a component of alternative scenario.

Step 3: Options for Improvement of Existing Railway and Development of New Railway

4.7 On the basis of the results of Step 2, the initial alternatives have been reorganized as follows;

Four options on improvement of existing railway including;

(i) A1: Baseline, minimal Improvement to ensure safe operation (on-going and committed projects);

(ii) A2: Maximization of existing single track transportation capacity;

(iii) B1: Strengthening of transportation capacity through double tracking and increase in maximum operating speed to 120 km/h;

(iv) B2: Double tracking with 1435 mm track gauge and electrification with maximum operating speed of 150 km/h or more (semi high speed). All the intersections of railway and road are grade-separated;

Construction of new high-speed railway as follows:

(i) New line at scheduled speed of 280 km/h (maximum operating speed: 320 km/h)

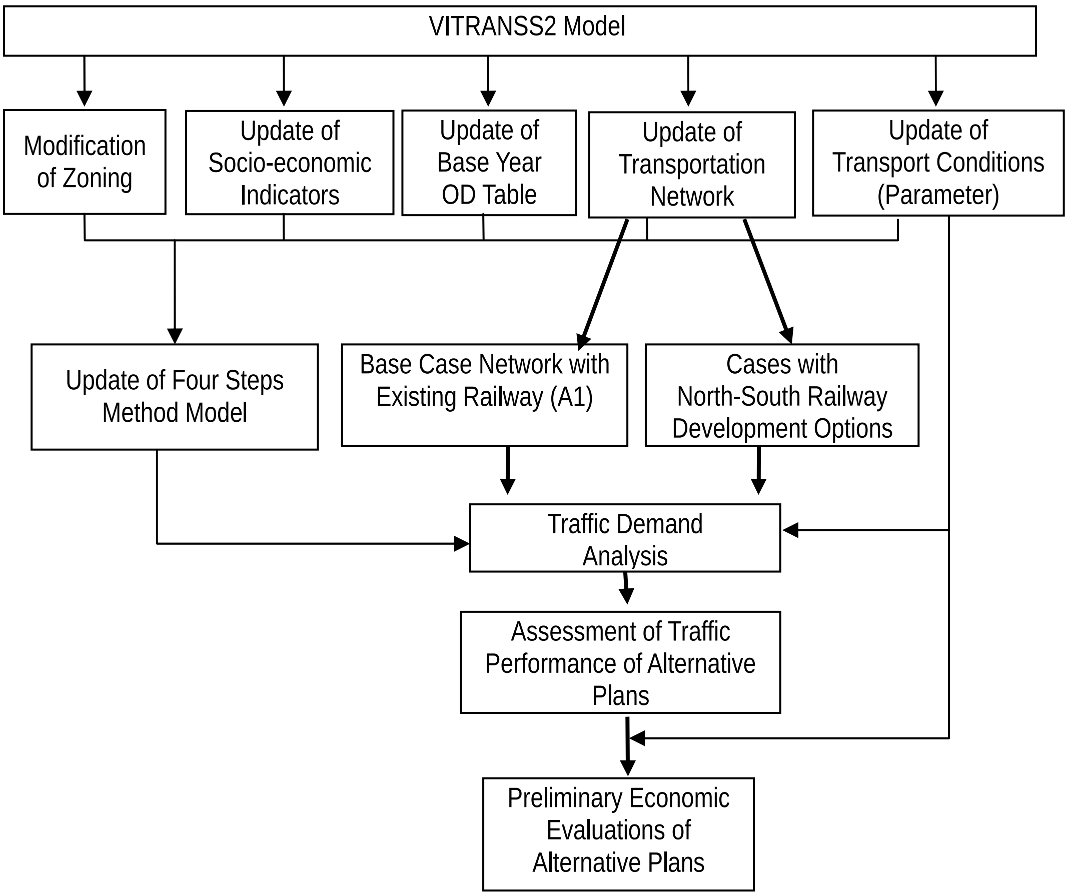
4.2 Traffic Demand Analysis

1) Methodology

(a) Outline

4.8 For the purpose of traffic demand analysis of the North-South Railway development options including upgrade of existing railways and construction of HSR, the model developed in VITRANSS2 was modified based on the latest traffic data and information available. The basic update was conducted on 1) Modification of Zoning, 2) Update of Socio-economic Indicators, 3) Update of Base Year OD Table, 4) Update of Transportation Network, 5) Update of transport Conditions (parameters such as fare/cost, access time and travel speed) and 6) Update of Four Steps Method Model. The traffic demand forecast for the improvement Option A1 was applied as a based case for the assessment of several alternatives. Figure 4.2.1 shows the entire flow for traffic demand analysis for existing railways.

4.9 In this study, the passenger traffic demand is updated while for freight traffic, the output from VITRANSS2 is utilised. Main Steps of traffic demand analysis are explained in the following;



Source: JICA Study Team

Figure 4.2.1 Flow of Traffic Demand Analysis (Passenger)

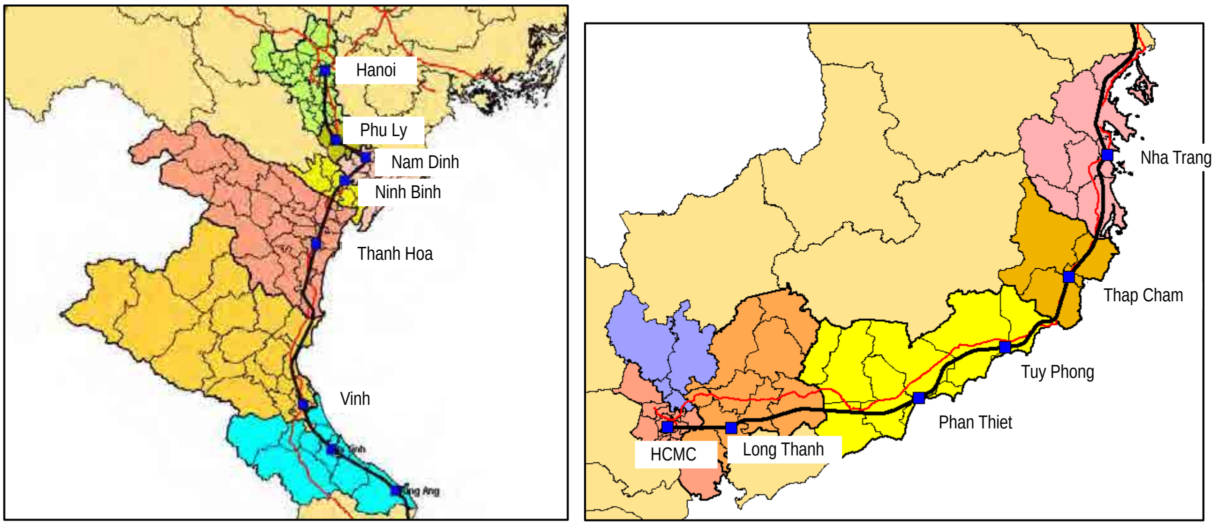
(b) VITRANSS2 Model

4.10 In VITRANSS2, the demand forecast model targeting domestic inter-provincial traffic demand in the whole Vietnam was developed for passenger and freight transport. In VITRANSS2 analysis, the four step method was applied for both of passenger and freight traffic demand forecast and the model was calibrated by the result of traffic surveys. In this study, the passenger traffic model was updated from VITRANSS2 using the latest available data while freight traffic demand was utilized from the outputs of VITRANSS2. The detail explanation of the model is provided in Technical Report No. 2 Demand Forecast and Transportation Cost.

(c) Update of Demand Forecast Model

4.11 Passenger traffic demand model was newly updated for the analysis on the priority sections of HSR in Vietnam. The main characteristics of the updates are as follows;

(i) Modification of Zoning: The zone unites were updated for conducting the analysis more in detail. Provincial boundaries applied for VITRANSS2 model were too large to analyse the traffic between stations and access traffic to railway stations. Therefore, in this study, district boundaries were applied in the provinces along North-South railway line (from Hanoi to Ha Tinh in the north and from HCMC to Nha Trang in the south).



Source: JICA Study Team

Figure 4.2.2 New Zones for Target Area

(ii) Socio-economic Indicators: Socio-economic Indicators, which are basic input of the demand forecast, were updated based on the latest data and socio-economic plans of national and local governments in Vietnam.

(iii) Base year OD Data: Base year inter-provincial traffic data was updated based on the traffic survey conducted in October 2011 and traffic data obtained from related agencies.

(iiv) Network and Parameters: The network and parameters were also updated based on the latest available data including transport passengers interview data conducted in October 2011.

(iv) Future OD Forecast Model: While the same model with VITRANSS2 was applied for the analysis, coefficients of traffic demand forecast model was re-estimated based on the latest socio-economic indicators and traffic data. For modal split model[1], the distinct model was developed for each of three types of OD pairs, namely within North area, within South area and the other OD pairs utilizing the stated preferences of modal choice obtained by interview survey.

(d) Update of Transportation Network and Assumed 2030 Overall Network

4.12 Transportation network was updated to be applicable to district level network analysis. More in detail;

(i) The existing railway network was reviewed and updated by applying the actual locations of railway stations precisely to be useful for district level analysis;

(ii) Expressway network was also reviewed and updated. The alignment and the locations of interchanges were updated based on the alignment study in VITRANSS2. Thus, the network data became applicable to the district level analysis; and

(iii) Provincial road network connecting districts to districts was newly developed in the network data.

4.13 The two types of transport network were developed as follows:

(i) "Do Committed" Network: This network includes financially committed or under construction projects. As for expressway projects, the following sections are included in addition to existing sections; (i) Cau Gie–Ninh Binh, (ii) Da Nang–Quang Ngai, (iii) HCMC–Long Thanh–Dau Giay, (iv) Long Thanh–Nhon Trach–Ben Luc, (v) Ha Noi–Hai Phong, (vi) Ha Noi–Lao Cai, (vii) Ha Noi–Thai Nguyen and (viii) Ha Long–Mong Cai.

(ii) "Do Something" Network: In Do Something Network, the following upgrades of network are considered in addition to Do Committed Network; (i) the national expressway network is assumed to be developed excluding sections along Ho Chi Minh Route, namely: Dong Hung – Hoa Lac – Pho Chau, Hong Ling – Huong Son, and Ngoc Hoi – Chon Thanh – Rach Gia; (ii) National Highway No.1 is assumed to be upgraded to 4-6 lanes in between Hanoi and HCMC; and (iii) Since airports in Hanoi and HCMC are considered to be bottlenecks for air traffic in the future, the capacity expansion is considered based on the future plans (new Long Thanh International Airport and the expansion of Noi Bai Airport).

(e) Update of Transport Conditions

4.14 The following parameters are updated for this study.

(i) **Load Factor:** Because of the difficulty of estimating the future occupancy rate of vehicles, the data obtained by traffic survey conducted in November 2011 was utilized for the future traffic demand.

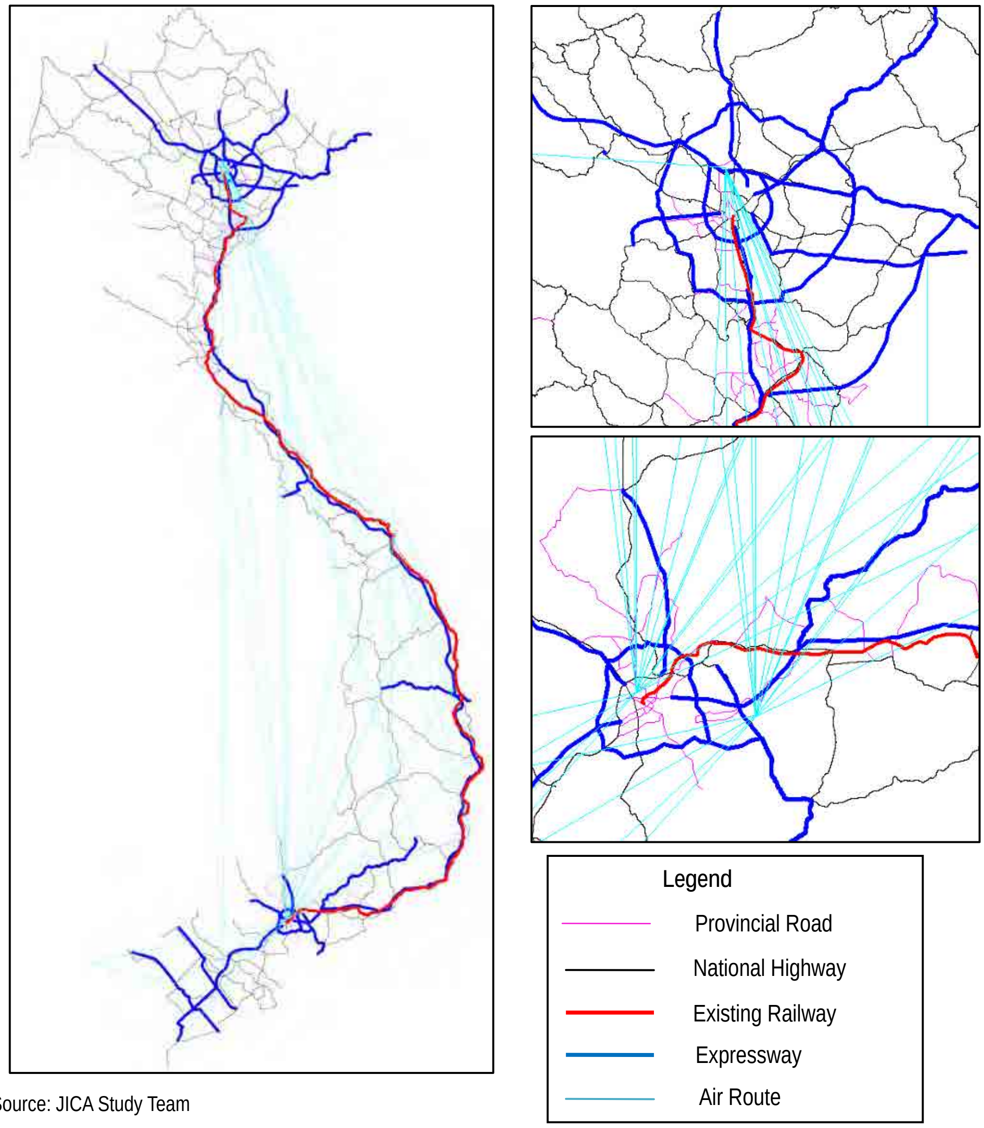
[1] In this modal split model, as the usage of motorcycle transport for inter-provincial transport is limited even as of now, reflecting on the future changes such as increase of car use and improvement of bus services for inter-provincial transport, the use of motorcycles as a means for inter-provincial transport were considered negligible. (Accessing to terminals by motorcycles is considered in the whole traffic demand analysis process.)

Table 4.2.1 Load Factor of Car and Bus

	Car	Bus
Average Occupancy (pax/veh)	3.20	20.49
No. of Samples	1,033	1,568

Source: JICA Study Team (Traffic Survey in November 2011)

(ii) Transport Fare and Cost: For selecting travel mode, transportation fare and cost is one of the major factors considered. The fares and costs for car, bus, railway and air transport are set as follows;



Source: JICA Study Team

Figure 4.2.3 "Do Something" Network

(1) Car: Gasoline price per passenger-km is calculated as shown in Table 4.2.2. Besides, the cost for vehicle itself is not taken into account because passengers select travel mode based on perceptible cost in general.

Table 4.2.2 Assumed Gasoline Price for Car

Gasoline Price ($/litter)[1/]	Drive Distance (km/litter)[2/]	Gasoline Price per passenger-distance	
		($/km/pax)	(VND/km/pax)
1.06	15.3 (for road; 40 km/h)	0.022	456
	13.2 (for expressway; 80 km/h)	0.025	527

Source: JICA Study Team

1/ Price as of June, 2011.
2/ Refer Appendix Calculation of Operation cost and Tariff

(2) Bus, Railway and Air: For public transportation, the actual fares are investigated and utilized for the input for demand forecast. The fare level is summarized in Table 4.2.3.

Table 4.2.3 Assumed Fare for Public Transporation

Mode	Fare (VND/km/pax)	Note
Bus	525	Based on the fare between Hanoi – HCMC (as of Oct 2011)
Railway	584	Based on fare for air conditioner/soft sheet for Hanoi - Saigon (as of Oct 2011)
Air	1,745	Based on the air fare for regular ticket between Hanoi-HCMC (Vietnam Airline, as of Oct 2011)

Source: JICA Study Team

(3) Cost for Expressway Use: As the fare levels for expressway network in Vietnam, 5 US Cent per km (for bus, 12.5 US Cent per km) is assumed considering international practices as shown in the following table.

Table 4.2.4 Expressway Toll (per Passenger-distance)

	Expressway Fare	
	(VND/km/veh)	(VND/km/pax)
Car	1,050	328
Bus	2,625	128

Source: JICA Study Team

(iii) Operation Speed: Average operation speeds for cars and buses are roughly assumed to be 40 km/h and 32 km/h respectively based on the interviews with drivers. As for expressway, the speeds are assumed to be improved to be twice as fast as on national and provincial roads. On the other hand, the actual operation speeds of railway and air transport for travel between Hanoi – HCMC were obtained and utilized for the analysis (60 km/h and 600 km/h respectively). The operating speeds of upgraded existing railway (A2, B1 and B2) were calculated in detail on the process of developing plans. (70 km/h (A2), 110 km/h (B1) and 135 km/h (B2)).

(iv) Access Time: The accessibility is also key factor to be considered model choice. In this study, the access time is calculated from the developed network data while, for waiting time, the obtained data from traffic survey (November 2011) was taken into consideration. Table 4.2.5 shows the result of the survey.

Table 4.2.5 Waiting Time Obtained from Traffic Survey

	Bus Passenger	Railway Passenger	Air Passenger
Waiting Time (min)	19.7	46.9	51.9
No. of Samples[1/]	806	514	334

Source: JICA Study Team (Traffic Survey in November, 2011)

1/ Interviewers who are leaving transport terminals only because the data of waiting passengers has bias to some extent

Considering the survey result, time at terminal for each travel mode in the future is assumed as shown in the following Table. As for railway, it is assumed that the increase of service frequency and operational accuracy will decrease waiting time while regarding to air transport, it is assumed that passengers will arrive airport 60 minute before departure time. As for HSR, the same waiting time with railway is assumed. (See Table 4.2.6)

Table 4.2.6 Assumed Time at Terminal

	Mode			
	Bus	Rail	HSR	Air Transport
Waiting Time (min)	20	20	20	60

Source: JICA Study Team

(v) Summary: Table 4.2.7 summaries the parameters applied to analysis. The occupancy of railway and air transport is considered in other sections.

Table 4.2.7 Assumed Operating Condition by Mode

Mode			PCU/Veh Ratio	Average Occupancy [1/]	Fare/Cost (VND/Pax-km	Travel Speed (km/h)	Time at terminal (waiting time) (min)
Road	Road	Car	1	3.2	527	40	0
		Bus	2.5	20.5	525	32	20
	Expressway	Car	1	3.2	855	80	0
		Bus	2.5	20.5	653	64	20
Railway	Existing Railway		-	-	584	60/70/110 /135 [2/]	20
	High Speed Railway [3/]		-	-	873	280	20
Air Transport			-	-	1,745	600	60

Source: JICA Study Team

1/ Based on traffic survey (2011) (The same condition is assumed for the future).
2/ Depending on the level of improvement of existing railway (A1, A2, B1, B2).
3/ For base case (various assumption shall be tested in the following study.).

(f) Assessment of Traffic Performance (Demand Supply Gap) of Alternative Plans:

4.15 Traffic performances of alternative plans are examined by comparing the potential and affordable traffic demand (demand gap analysis). For the diagnosis, the capacities of transport infrastructures are estimated. As for air transport, the number of flights is estimated to be three times compared to the present as airport facilities will be upgraded and constructed. The estimated capacities of cross sections of North-South coastal corridor are summarized in Table 4.2.9.

Table 4.2.8 Estimated Capacities of Transport Infrastructures

		Capacity	Unit	Note	Passenger Capacity (pax/day)	Note
National Highway	2 lanes	27,400	PCU/day	Based on Relevant Highway Capacity Manual		
	4 lanes	54,800	PCU/day	Based on Relevant Highway Capacity Manual		
	6 lanes	82,200	PCU/day	Based on Relevant Highway Capacity Manual		
Expressway	4 lanes	81,100	PCU/day	Based on Relevant Highway Capacity Manual		
	6 lanes	121,700	PCU/day	Based on Relevant Highway Capacity Manual		
Existing Railway	Single Track (A1)	32	Train/day (Both direction)	Current maximum operation frequency including 10 train/day freight train)	22,000	Assuming the capacity of a train is 1,000 passengers (a train consists of 15 cars) and the frequency of freight train is 10 trains/day
	Single Track (A2)	50	Train/day (Both direction)	Based on the analysis of A2	37,000	Assuming the capacity of a train is 1,000 passengers (a train consists of 15 cars) and the frequency of freight train is 13 trains/day
	Double Track (B1,B2)	170	Train/day (Both direction)	Based on the example of Tokaido-line in Japan (double track, 210 train/day). 20 % less operational efficiency is assumed compared to this case.	110,000	Assuming the capacity of a train is 1,000 passengers (a train consists of 15 cars) and the frequency of freight train is 60 trains/day
High Speed Railway		170	Train/day (Both direction)	Based on the example of Tokaido-line in Japan (double track, 210 train/day).	170,000	Assuming it is dedicative to passenger traffic and a train consists of 12 cars and can afford 1,000 passengers
Air Transport		366 (Hanoi side)-492 (HCMC side)	Flight/day (both direction)	Assuming the increase of operational frequency to 3 times of the current level (As of 2011, Hanoi to the south: 61 fights/day/direction and HCMC to the north: 82 flights/day/direction)	67,600-90,900	Assuming load factor is 0.7 and 50% of flights have 310 seats, 30% have 250 seats and 20% had 170 seat

Source: JICA Study Team

Note: 1) As for Noi Bai Airport, in addition to current T1 (6MPPA), T2 (10MPPA) is under construction and there are plans of the expansion of T1&T2(up to 20 MPPA) and the construction of T3 (15 MPPA)

2) As for airports in HCMC, in additional to the current Tan Son Nhat Airport (T1&T2: 15 MPPA), there is a plan to construct Long Thanh International Airport (Phase 1: 25 MPPA and Ultimate Phase: 52 MPPA)

Table 4.2.9 Estimated Capacities on North-South Corridor

Capacity for Each Mode				Hanoi - Thanh Hoa	Thanh Hoa - Vinh	Vinh - Hue	Hue - Danang	Danang - Nha Trang	Nha Trang - Phanh Tiet	Phan Tiet - HCMC
Road	Do Committed	No. Lanes	NH	4-6	2	2	4	2	2	2~4
			Exp	0-4 (0)	0	0	0	0-4 (0)	0	0-6 (0)
		Capacity (PCU/day)		54,800 - 82,200	27,400	27,400	54,800	27,400	27,400	27,400-54,800
	Do Something	No. Lanes	NH	4-6	4	4	4	4	4	4-6
			Exp	4-6	4	4	4	4	4	4-6
		Capacity (PCU/day)		135,900-203,900	135,900	135,900	135,900	135,900	135,900	135,900-203,900
Existing Railway	Option A1	Capacity (Pax/day)		22,000						
	Option A2	Capacity (Pax/day)		37,000						
	Option B1-B2	Capacity (Pax/day)		111,000						
HSR		Capacity (Pax/day)		170,000						
Air		Capacity (Pax/day)		67,600 (Hanoi side)-90,900 (HCMC side)						

Source: JICA Study Team

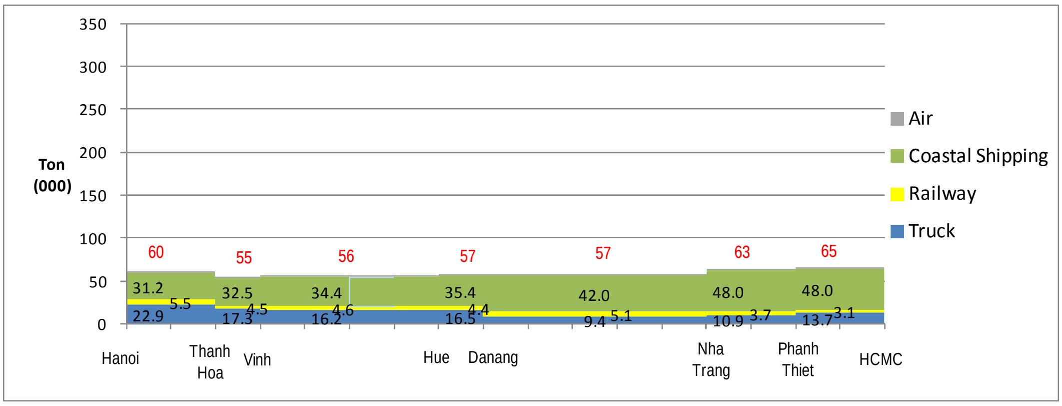
Table 4.2.10 Modal Shares of Freight Transportation, 2008 and 2030

		Road	Rail	Inland Waterway	Coastal Shipping	Air	Total
Volume transported (000 ton/day)	2008	604.9	25.5	643.0	58.1	0.3	1,351.8
	2030	2,132.7	155.1	1,317.0	125.8	1.0	3,731.6
Modal share (% in tonnage)	2008	45.4	1.9	48.3	4.4	0.0	100.0
	2030	57.2	4.2	35.3	3.4	0.0	100.0
Modal share (% in ton-km)	2008	36.6	4.3	30.5	28.5	0.1	100.0
	2030	53.0	9.7	19.9	17.2	0.2	100.0

Source: VITRANSS 2 (2010, JICA)

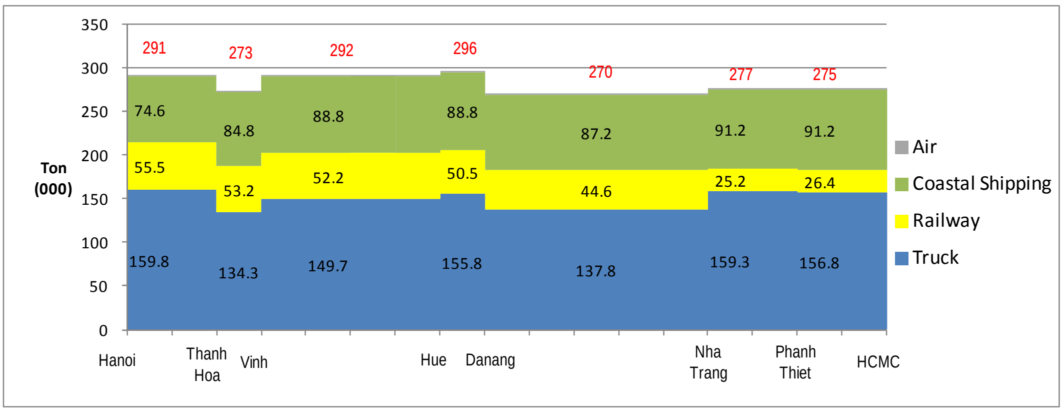
4.16 Figure 4.2.4 shows the updated current freight traffic demand (2010) on North South Coastal Corridor. As clearly indicated in the figure, the corridor highly depends on coastal shipping for freight transport in terms of volume while railway plays very limited role at present.

4.17 Figure 4.2.5 and Table 4.2.11 shows the cross sectional traffic demand on the same corridor in 2030 (estimated in VITRANSS2). In the future, truck traffic is expected to increase significantly as the scale of economic is growing and the service level of roads is being improved. As the demand on land-side increases, railway also have potential role to cater for such increase of demand. The freight train demand was estimated to reach to more than 50 trains for the north and central area, slightly over the capacity of alternative A2 plan.



Source: JICA Study Team

Figure 4.2.4 Cross Sectional Freight Demand on North South Corridor (2010)



Source: JICA Study Team based on VITRANSS2 (2010, JICA)

Figure 4.2.5 Cross Sectional Freight Demand on North South Corridor (2030)

Table 4.2.11 Cross Sectional Freight Traffic Demand in 2030

	North		Central			South	
	N1. Hanoi – Thanh Hoa	N2. Thanh Hoa - Vinh	C1. Vinh - Hue	C2. Hue - Danang	C3. Danang – Nha Trang	S1. Nha Trang – Phan thiet	S2. Phan Thiet – HCMC
Truck	159,840	134,272	149,678	155,841	137,791	159,254	156,843
Railway	55,528	53,200	52,197	50,451	44,561	25,210	26,425
Coastal Shipping	74,648	84,832	88,768	88,768	87,204	91,219	91,219
Air	910	910	910	921	902	837	837
Total	290,926	273,214	291,553	295,981	270,458	276,520	275,324
No. of Train Required (both direction)	56	54	53	51	45	26	27

Source: JICA Study Team based on VITRANSS2 (2010, JICA)
Note: Assumed capacity of a freight train is 1,000 ton.

2) Estimate of Passenger Traffic Demand and Analysis on Demand Supply Gap of Transportation Modes along the North South Corridor

(a) Analysis cases and assumptions

4.18 Traffic demand was estimated by evaluating the impact of different plans for improving existing railway system (A2, B1 and B2) based on Do Something Network for other transport modes (See Table 4.2.12).

Table 4.2.12 Scenarios for Analysis

Level of Improvement	Base Network
A-1: Baseline, minimal improvement to ensure safe operation	Do Something Network
A-2: Maximization of existing single track transportation capacity	Do Something Network
B-1: Strengthening of transportation capacity through double tracking and increase in maximum operating speed to 120 km/h	Do Something Network
B-2: Double tracking and increase of maximum operating speed to 150 km/h or more (semi high speed)	Do Something Network

Source: JICA Study Team

4.19 Main purpose of this analysis is to analyze following:

(i) To estimate total passenger traffic demand along the North South Corridor

(ii) To estimate how the total demand is shared among available transportation modes when they are operated under Do Something transport network and different service level of existing railway.

(iii) To estimate an impact of different service level of existing railway on its ridership.

4.20 As it is found impractical that air transport capacities can be provided unlimitedly, this section intends to estimate the demand by mode and analyze demand supply gap of related transportation modes along the North South Corridor based on the assumption that air transport capacity will be limited to three times compared to that of current situation.

(b) Analysis of A1 and A2

4.21 In these cases, it is assumed that roads and air transport will be developed as planned (Do Something Case) while existing railway will be improved to A1 and A2 levels. Main findings of the analysis are as follows (See Table 4.2.13 and Figure 4.2.6);

(i) Capacities of roads including national roads and expressways will be sufficient both in A1 and A2 cases.

(ii) Capacities of air transport will be in short in most of the sections.

(iii) It is estimated that existing railway in A1 case will carry daily about 26,000 to 27,000 passengers in the north, 26,000 to 28,000 passengers in the central and 25,000 to 26,000 passengers in the south. Considering the total capacities of existing railway (32 trains/day including passenger and freight), capacities will be in short in all sections due to the requirement for freight transport services.

(iv) In the case of A2 plan, modal share will be basically the same as in the case of A1. However, existing railway is able to attract passenger demand by 1,000 – 2,000 passengers more due to increase in travel speed. Capacities will also increase from 32 trains to 50 trains per day. In spite of this increase, capacities of existing railway are insufficient.

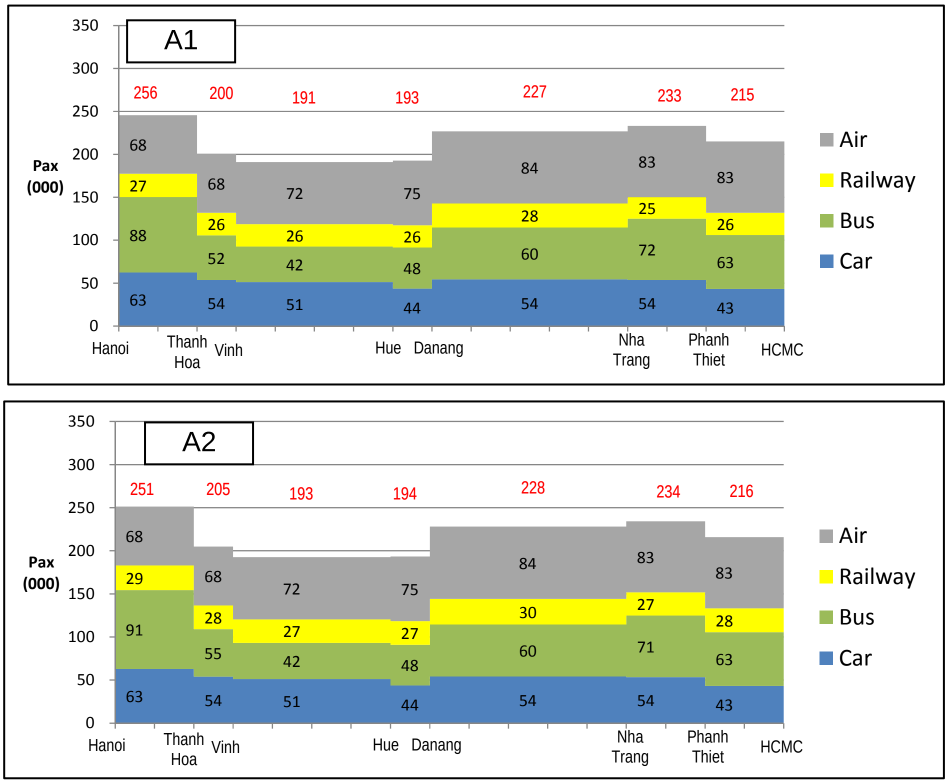
Table 4.2.13 Estimated Traffic Demand along North South Corridor (A1, A2), 2030

					North		Central			South	
					N1. Hanoi – Thanh Hoa	N2. Thanh Hoa - Vinh	C1. Vinh - Hue	C2. Hue - Danang	C3. Danang – Nha Trang	S1. Nha Trang – Phan thiet	S2. Phan Thiet – HCMC
A1	Passenger (no/day)	Road	National Highway	Car	1,296	2998.4	2,886	3,264	12,723	12,602	7,597
				Bus	19,892	5,434	29,063	14,917	25,121	40,029	21,744
			Expressway	Car	61,270	50,685	48,227	40,470	41,654	41,104	35,654
				Bus	67,814	46,529	12,540	32,759	35,300	31,530	41,185
		Existing	Rail		27,073	26,384	26,051	25,887	27,824	24,955	25,839
		Air			68,340	68,340	72,219	75,451	84,187	83,028	83,028
		Total			245,685	200,370	190,986	192,749	226,810	233,248	215,047
	Transport Requirement (/day)	Road (pcu)	Passenger		30,253	23,116	21,049	19,484	24,365	25,514	21,194
			Freight		90,769	75,314	80,358	83,964	82,608	92,541	92,514
		Existing Rail (no. of train)	Passenger		28	27	27	26	28	25	26
			Freight		56	54	53	51	45	26	27
		Air	(No. of flight)1/		370	370	391	409	456	450	450
	Capacity (/day)	Road (pcu)	Total		135,900	135,900	135,900	135,900	135,900	135,900	135,900
		Existing Rail (no. of train)	Total		32	32	32	32	32	32	32
		Air	(No. of flight)			366	(Hanoi)	- 492	(HCMC)		
	Demand Supply Gap (/day)	Road (pcu)	Volume/Capacity Ratio		0.89	0.72	0.75	0.76	0.79	0.87	0.84
			Capacity-Volume		14,878	37,470	34,493	32,452	28,927	17,845	22,192
		Existing Rail (no. of train)	(Capacity-Volume)		-52	-49	-48	-45	-41	-19	-21
		Air (no. of flights)2/	(Capacity-Volume)		-4	-4	-25	-43	36	42	42
A2	Passenger (no/day)	Road	National Highway	Car	1,459	3008	2,896	3,274	12,678	12,560	7,581
				Bus	21,408	5,450	29,538	14,900	25,416	39,980	21,596
			Expressway	Car	61,597	50,963	48,307	40,330	41,437	40,944	35,491
				Bus	69,846	49,627	12,433	32,604	34,972	31,317	40,906
		Existing	Rail		28,773	27,665	27,315	27,172	29,790	26,828	27,707
		Air			68,305	68,305	72,172	75,292	83,820	82,668	82,668
		Total			251,388	205,018	192,662	193,571	228,113	234,297	215,950
	Transport Requirement (/day)	Road (pcu)	Passenger		30,839	23,586	21,122	19,422	24,279	25,419	21,086
			Freight		90,769	75,314	80,358	83,964	82,608	92,541	92,514
		Existing Rail (no. of train)	Passenger		29	28	28	28	30	27	28
			Freight		56	54	53	51	45	26	27
		Air	(No. of flight)1/		370	370	391	409	454	449	449
	Capacity (/day)	Road (pcu)	Total		135,900	135,900	135,900	135,900	135,900	135,900	135,900
		Existing Rail (no. of train)	Total		50	50	50	50	50	50	50
		Air	(No. of flight)			366	(Hanoi)	- 492	(HCMC)		
	Demand Supply Gap (/day)	Road (pcu)	Volume/Capacity Ratio		0.89	0.73	0.75	0.76	0.79	0.87	0.84
			Capacity-Volume		14,292	37,000	34,420	32,514	29,013	17,940	22,300
		Existing Rail (no. of train)	(Capacity-Volume)		-35	-32	-31	-29	-25	-3	-5
		Air (no. of flights)2/	(Capacity-Volume)		-4	-4	-25	-43	38	43	43

Source: JICA Study Team

1/ Air traffic demand is under constraints of airport capacity, where in both of Hanoi and HCMC air traffic demand reaches to the capacities (since, in actual situation, the capacity has some fluctuation, small excess of traffic demand to the capacity in HCMC is considered possible to be handled).

2/ The capacity in Hanoi is applied for Hanoi – Danang section and the one in HCMC for HCMC – Danamg for calculating Capacity – Volume.



Source: JICA Study Team

Figure 4.2.6 Estimated Traffic Demand along North South Corridor (A1, A2), 2030

(c) Analysis of B1 and B2

4.22 As in the cases of A1 and A2, Do Something Scenario for roads and air transport services is assumed. Main findings of the analysis are as follows (See Table 4.2.14 and Figure 4.2.7)

(i) Capacities of roads including national roads and expressways will be sufficient both in B1 and B2 cases.

(ii) Capacities of air transport will be in short in most of the sections.

(iii) When the existing railway is double tracked and speed increase to 110 km/hr (scheduled speed) in B1 and farther to 135 km/h (scheduled speed) in B2, traffic demand will increase considerably. In B1 case, the northern sections will carry about 36,000 to 39,000 passengers/day, the central sections 36,000 to 40,000 passengers/day, and the southern sections 37,000 to 40,000 passengers/day. The demand in B2 will farther increase to 42,000 to 44,000, 41,000 to 46,000, and 43,000 to 45,000 passengers/day in the north, the central and the south sections, respectively.

(iv) While the passenger demand for existing railway increases, the capacities of double track railway are large enough to accommodate the increase.

(v) Although the demand for higher speed services along the north-south corridor is obviously seen, the increase of traffic demand from B1 to B2 is not so significant compared with the one of investment cost (from approximately 14,500 million US$ to 27,700 million US$). In addition, if competitive HSR is constructed, the demand will dramatically drop. Thus, the upgrade of existing railway to B2 level is not recommendable.

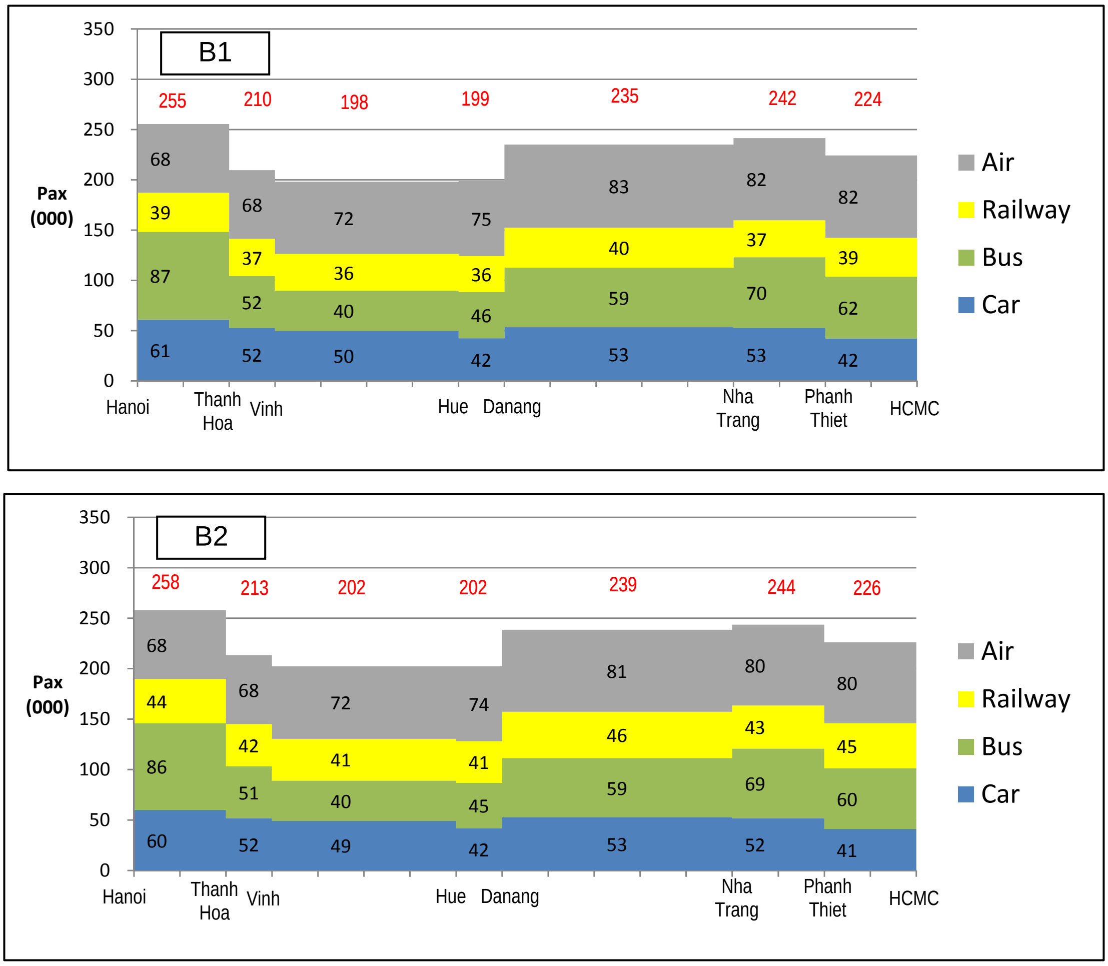
Table 4.2.14 Estimated Traffic Demand along North South Corridor (B1, B2), 2030

					North		Central			South	
					N1. Hanoi – Thanh Hoa	N2. Thanh Hoa - Vinh	C1. Vinh - Hue	C2. Hue - Danang	C3. Danang – Nha Trang	S1. Nha Trang – Phan thiet	S2. Phan Thiet – HCMC
B1	Passenger (no/day)	Road	National Highway	Car	1,251	2905.6	2,787	3,171	12,435	1,075	7,488
				Bus	18,228	5,155	27,948	10,761	25,047	39,628	21,375
			Expressway	Car	59,789	49,523	46,960	39,242	40,870	51,552	34,656
				Bus	69,141	46,873	12,056	35,079	34,431	30,661	40,234
		Existing	Rail		38,724	36,834	36,292	35,929	39,572	36,858	38,578
		Air			68,269	68,269	71,949	74,745	82,831	81,781	81,781
		Total			255,402	209,560	197,993	198,927	235,187	241,555	224,112
	Transport Requirement	Road (pcu)	Passenger		29,735	22,732	20,427	18,847	23,915	25,022	20,687
			Freight		90,769	75,314	80,358	83,964	82,608	92,541	92,514
		Existing Rail (no. of train)	Passenger		39	37	37	36	40	37	39
			Freight		56	54	53	51	45	26	27
		Air	(No. of flight)1/		370	370	390	406	449	443	443
	Capacity	Road (pcu)	Total		135,900	135,900	135,900	135,900	135,900	135,900	135,900
		Existing Rail (no. of train)	Total		170	170	170	170	170	170	170
		Air	(No. of flight)			366	(Hanoi)	- 492	(HCMC)		
	Demand Supply Gap	Road (pcu)	Volume/Capacity	Ratio	0.89	0.72	0.74	0.76	0.78	0.87	0.83
			Capacity-Volume		15,396	37,854	35,115	33,089	29,377	18,337	22,699
		Existing Rail (no. of train)	(Capacity-Volume)		75	79	80	83	85	107	104
		Air (no. of flights)2/	(Capacity-Volume)		-4	-4	-24	-40	43	49	49
B2	Passenger (no/day)	Road	National Highway	Car	1,178	2886.4	2,755	3,139	11,818	11,862	7,318
				Bus	17,556	4,918	27,530	14,712	24,662	39,136	20,744
			Expressway	Car	58,874	48,899	46,410	38,704	40,998	39,958	33,891
				Bus	68,330	46,537	12,417	30,243	33,981	29,907	39,267
		Existing	Rail		43,849	41,919	41,458	41,322	45,771	42,507	44,699
		Air			68,229	68,229	71,828	74,282	81,302	80,226	80,226
		Total			258,015	213,388	202,398	202,402	238,531	243,597	226,146
	Transport Requirement	Road (pcu)	Passenger		29,245	22,461	20,238	18,561	23,660	24,618	20,200
			Freight		90,769	75,314	80,358	83,964	82,608	92,541	92,514
		Existing Rail (no. of train)	Passenger		44	42	42	42	46	43	45
			Freight		56	54	53	51	45	26	27
		Air	(No. of flight)1/		370	370	390	403	440	434	434
	Capacity	Road (pcu)	Total		135,900	135,900	135,900	135,900	135,900	135,900	135,900
		Road (pcu)	Total		170	170	170	170	170	170	170
		Air	(No. of flight)			366	(Hanoi)	- 492	(HCMC)		
	Demand Supply Gap	Road (pcu)	Volume/Capacity	Ratio	0.88	0.72	0.74	0.75	0.78	0.86	0.83
			Capacity-Volume		15,886	38,125	35,304	33,375	29,632	18,741	23,186
		Existing Rail (no. of train)	(Capacity-Volume)		70	74	75	77	79	101	98
		Air (no. of flights)2/	(Capacity-Volume)		-4	-4	-24	-37	52	58	58

Source: JICA Study Team

1/ Air traffic demand is under constraints of airport capacity, where in both of Hanoi and HCMC air traffic demand reaches to the capacities (since, in actual situation, the capacity has some fluctuation, small excess of traffic demand to the capacity in HCMC is considered possible to be handled).

2/ The capacity in Hanoi is applied for Hanoi – Danang section and the one in HCMC for HCMC – Danang for calculating Capacity – Volume.



Source: JICA Study Team

Figure 4.2.7 Estimated Traffic Demand along North South Corridor (B1, B2), 2030

(d) Analysis of alternative plans based on estimated no. of trains

4.23 Traffic demand estimated for passenger and freight has been converted to no. of trains as follows;

(i) Passenger demand: The capacity of passenger trains is assumed 1,000 passengers/train. In this assumption, 1 set of train consists of one locomotive and 15 cars.

(ii) Freight demand: The capacity of freight trains is assumed 1,000 ton/train.

4.24 The main findings of the analysis are as follows (See Table 4.2.15);

(i) In the north, freight traffic demand is higher than the south, while passenger traffic demand is almost same in the north and the south. The total traffic demand on existing railway is higher in the north because of the difference on freight traffic demand. In 2020, the cross-sectional demand of North-south railway is 32-49 trains/day/both directions, which is less than the capacity of Option A2 (50 trains/day/both directions).

(ii) The traffic demand in 2030 varies depending on the service level of existing railway. In case of A2, the cross-sectional demand will be 53-85 trains and it exceeds the capacity of A2. If the existing railway will not upgraded to double track, proper share between and restrictions on freight and passenger trains should be alternatively considered.

(iii) In case B1 will be implemented for the whole line, the expected demand in 2030 is as much as 63-95 trains/day, which is much less than the capacity of double track (170 trains/day).

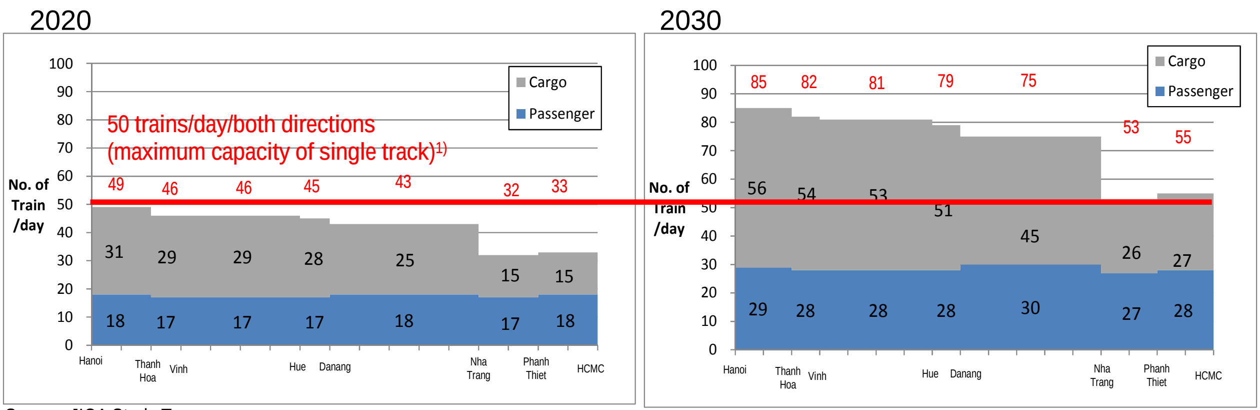
4.25 In case HSR will not be developed, Option A2 is necessary to be implemented around 2020-2025 while upgrade to double track (Option B1) will not be required at least by 2030. Since there is much difference on the capacities of A2 and B1, partial upgrade of some key sections (such as sections connecting to big cities) to double track is considerable as an intermediate development measure since double track for the whole section would be over investment.

Table 4.2.15 Estimated Traffic Demand of Existing Railways

Year	Service Level of Existing Railway		North		Central			South	
			N1. Hanoi – Thanh Hoa	N2. Thanh Hoa - Vinh	C1. Vinh - Hue	C2. Hue - Danang	C3. Danang – Nha Trang	S1. Nha Trang – Phan thiet	S2. Phan Thiet – HCMC
2020	A2 (70km/h) (No. of Train/day/both directions)	Passenger	18	17	17	17	18	17	18
		Freight	31	29	29	28	25	15	15
		Total	49	46	46	45	43	32	33
2030	A2 (70km/h)/ (No. of Train/day/both directions)	Passenger	29	28	28	28	30	27	28
		Freight	56	54	53	51	45	26	27
		Total	85	82	81	79	75	53	55
	B1 (110 km/h)/ (No. of Train/day/both directions)	Passenger	39	37	37	36	40	37	39
		Freight	56	54	53	51	45	26	27
		Total	95	91	90	87	85	63	66
Need for Improvement & Upgrading of Existing Railway		2015	A1	A1	A1	A1	A1	A1	A1
		2020	A2	A2	A2	A2	A2	A2	A2
		2030	(B1)	(B1)	(B1)	(B1)	(B1)	(B1)	(B1)

Source: JICA Study Team
Notes: 1) Demand in case HSR will not be developed is shown, 2) Scheduled speed is assumed for the service level of railways, 3) A1 (Committed and On-going projects) are assumed to be completed by 2015, and 4) B 2 is excluded because of its implemental difficulties.

4.26 Figure 4.2.8 visualizes demand supply gap of existing railway (A2 case) in 2020 and 2030. The traffic demand of railway is expected to exceed the maximum capacity of single track by 2030 although single track can cater to the demand in 2020.



Source: JICA Study Team
Note: 1) Under about 10 km between stations (A2). It is possible to increase the capacity of the line by shortening distance between stations although it requires considerable amount of construction works.

Figure 4.2.8 Demand Supply Gap of Existing Railway (no. of trains/day/both directions): Passenger and Freight (Service Level of Existing Railway is A2)

3) Basic Analysis on the Impact of HSR on Passenger Traffic Demand in North-South Corridor

4.27 While potential role of existing railway is studied and made clear and a need for higher speed transportation services are demanded in the north-south corridor, this section intends firstly to analyze the impact of HSR on future traffic demand pattern in the corridor. In order further to analyze the impact of HSR on existing railways, A-2 (maximization of single track capacity) and B-1 (double tracking) plans are assumed to be in place.

Table 4.2.16 Alternative Cases for Analysis

<table>
<tr><th>Case</th><th>Alternative Improvement Plans of Existing Railway</th><th>High Speed Rail (HSR)</th><th>Other Transport Modes</th></tr>
<tr><td>H-A2</td><td>A-2: Maximization of existing single track transportation capacity (Maximum operating speed: 70 km/h)</td><td rowspan="2">• 1,435 mm
• Double track
• Electrified
• Maximum design speed: 320 km/h
• Maximum operating Speed: 280km/h</td><td rowspan="2">• National roads are improved
• Expressways are developed
• Air transportation capacities increased</td></tr>
<tr><td>H-B1</td><td>B-1: Strengthening of transportation capacity through double tracking and increase in maximum design speed to 120 km/h (Maximum operating speed 110 km/h)</td></tr>
</table>

Source: JICA Study Team

(a) Traffic Demand in H-A2 Case

4.28 For the situation where HSR and existing railway with A2 plan (single track with scheduled speed of 70 km/h) are in operation, traffic demand is estimated by mode and section of the north-south corridor (see Table 4.2.17 and Figure 4.2.9). Main findings are as follows:

(i) HSR will absorb about 40 % of the cross sectional traffic or 85,000 to 110,000 passengers/day along the north-south corridor. HSR will attract passenger traffic both from air and roads.

(ii) There will be no capacity constraints in available transport modes except existing railway, especially its northern sections lack capacities due to requirement of freight transport services. Requirements for capacities of existing railway vary by north and south. Freight demand is large in the north, while passenger demand is almost the same in the north and the south.

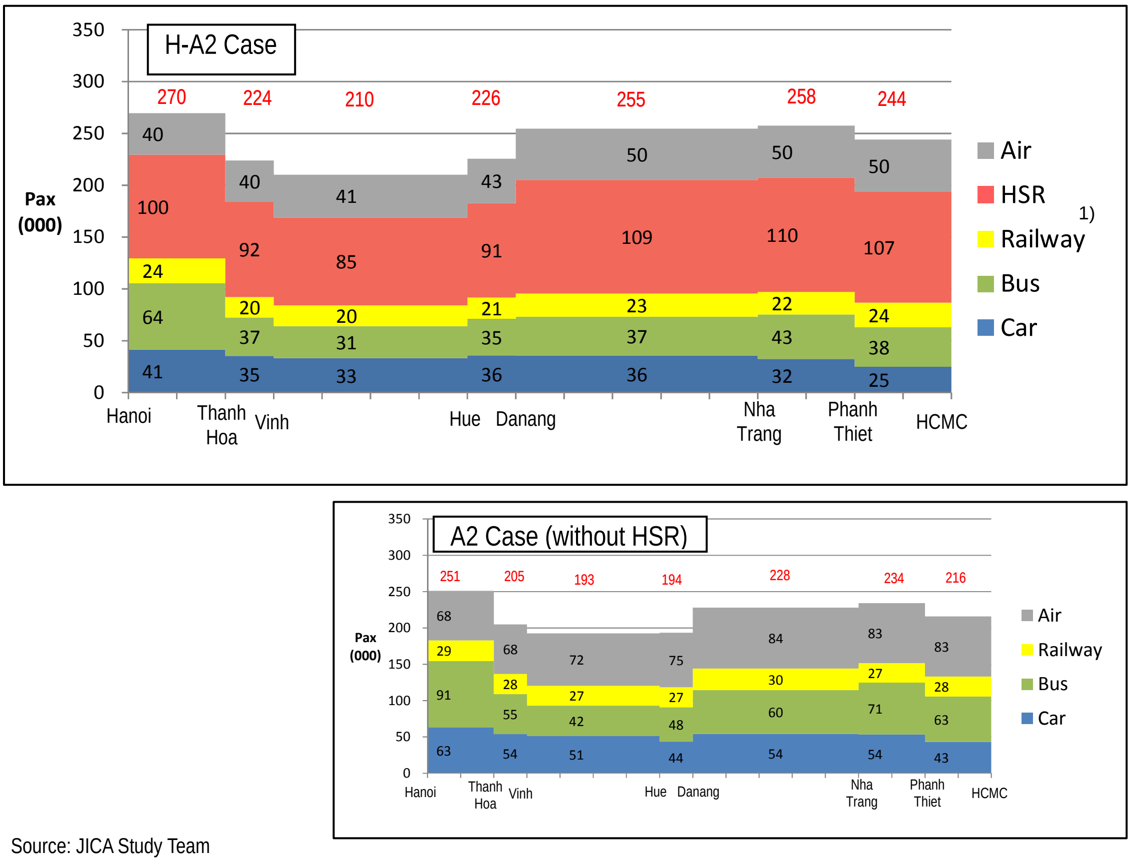
(iii) Impact of HSR on air transport demand is significant, though the results depend on assumed conditions such as fare, access time to/from respective modes, and perceived value of time.

Table 4.2.17 Impact of HSR on Traffic Demand by Mode along North-South Corridor (A2 Case), 2030

	Mode			North		Central			South	
				N1. Hanoi – Thanh Hoa	N2. Thanh Hoa - Vinh	C1. Vinh - Hue	C2. Hue - Danang	C3. Danang – Nha Trang	S1. Nha Trang – Phan thiet	S2. Phan Thiet – HCMC
Passenger Demand (no. of Pax/day)	Road	National Highway	Car	803	1836.8	1753.6	2,032	438	509	4,134
			Bus	20,629	4,975	21,457	11,360	7,024	27,850	11,499
		Expressway	Car	40,550	33,434	31,485	33,843	35,290	31,840	20,746
			Bus	43,668	32,325	9,409	23,990	30,350	15,105	26,571
	Railway	Existing	Railway	23,888	19,722	20,076	20,561	22,572	21,714	23,989
		High Speed	Railway	100,057	91,621	84,720	90,928	109,439	110,266	107,010
	Air			39,923	39,923	41,488	42,859	49,615	50,232	50,232
	Total			269,519	223,836	210,389	225,573	254,728	257,516	244,181
Transport Requirement (day)	Road (pcu)		Passenger	20,768	15,573	14,153	15,524	15,725	15,350	12,420
			Freight	90,769	75,314	80,358	83,964	82,608	92,541	92,514
	Rail (no. of train)	Existing Railway	Passenger	24	20	21	21	23	22	24
			Freight	56	54	53	51	45	26	27
		HSR		101	92	85	91	110	111	108
	Air	(no. of fights)		217	217	226	233	269	273	273
Capacity (day)	Road	(PCU)	Total	135,900	135,900	135,900	135,900	135,900	135,900	135,900
	Rail(no. of train)	Existing Railway	Total	50	50	50	50	50	50	50
		HSR		170						
	Air	(no. of fights)		366-492						
Demand Supply Gap (day)	Road (pcu)		Volume/Capacity Ratio	0.82	0.67	0.70	0.73	0.72	0.79	0.77
			Capacity-Volume	24,363	45,013	41,389	36,412	37,567	28,009	30,966
	Rail (no. of train)	Existing Railway	Capacity-Volume	-30	-24	-24	-22	-18	2	-1
		HSR	Capacity-Volume	69	78	85	79	60	59	62
	Air (no. of flights)[1)]	(Capacity-	Volume)	149	149	140	133	223	219	219

Source: JICA Study Team

1) The capacity in Hanoi is applied for Hanoi – Danang section and the one in HCMC for HCMC – Danamg for calculating Capacity – Volume



Source: JICA Study Team

Note: 1)"Railway" here indicates "Existing Railway " only

Figure 4.2.9 Impact of HSR on Traffic Demand by Mode along North-South Corridor (A2 Case), 2030

(b) Traffic Demand in H-B1 Case

4.29 When existing railway is double tracked and its speed increases, the demand for existing railway will increase by attracting the traffic mainly from roads. However, the level of passenger traffic demand of existing railway will not be significant, requiring no. of trains of 25 to 30/day/both directions which is far below available capacities of 170 trains/day/both directions including 26 to 56 freight trains/day/both directions (see Table 4.2.18 and Figure 4.2.10). Other main findings are as follows:

(i) When existing railway is further improved to B1 level (double tracking with 110 km/h speed), demand for existing railway increases for all sections though the increase varies by section (4,000 – 6,000 passengers/day). On the other hand, the demand for HSR will decrease by 3,000 to 4,000 passengers/day, which means the improvement at B1 level will absorb the passenger demand mainly from HSR.

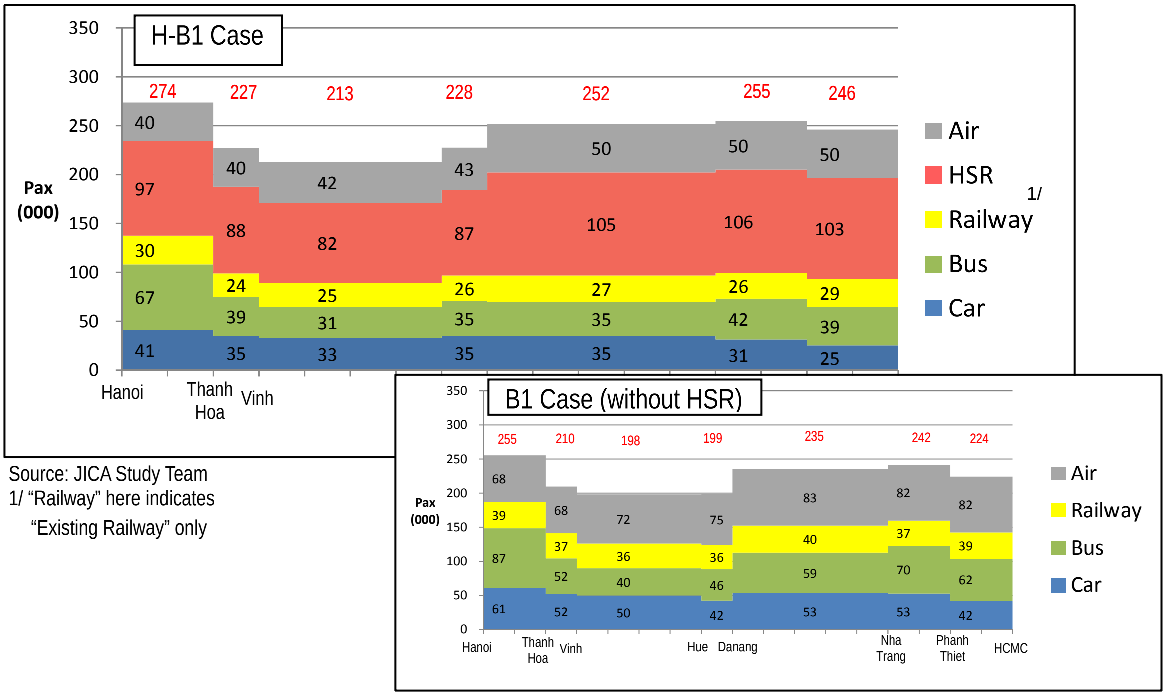
(ii) As railway improvement promotes the increase of passenger on the north-south corridor, the demand on roads (both national roads and expressways) does not change from H-A2 Case, although it works for mitigating traffic making a detour to inland roads.

Table 4.2.18 Impact of HSR on Traffic Demand by Mode along North-South Corridor (B1 Case), 2030

	Mode			North: N1. Hanoi – Thanh Hoa	North: N2. Thanh Hoa - Vinh	Central: C1. Vinh - Hue	Central: C2. Hue - Danang	Central: C3. Danang – Nha Trang	South: S1. Nha Trang – Phan thiet	South: S2. Phan Thiet – HCMC
Passenger Demand (no. of Pax/day)	Road	National Highway	Car	710	1827.2	1708.8	1,974	435.2	502.4	4,086
			Bus	15,622	4,672	22,424	12,220	6,868	25,424	11,376
		Expressway	Car	40,534	33,376	31,155	33,146	34,448	30,931	21,187
			Bus	51,102	34,759	9,024	23,203	28,071	16,408	27,670
	Railway	Existing	Railway	29,625	24,490	24,905	26,289	26,971	25,901	29,202
		High Speed	Railway	96,511	88,395	81,684	87,385	105,398	105,959	102,816
	Air			39,542	39,542	41,996	43,335	49,769	49,894	49,894
	Total			273,646	227,061	212,897	227,552	251,961	255,020	246,231
Transport Requirement (day)	Road (pcu)		Passenger	21,030	15,812	14,107	15,297	15,164	14,927	12,662
			Freight	90,769	75,314	80,358	83,964	82,608	92,541	92,514
	Rail (no. of train)	Existing Railway	Passenger	30	25	25	27	27	26	30
			Freight	56	54	53	51	45	26	27
		HSR		97	89	82	88	106	106	103
	Air	(no. of fights)		214	214	229	236	270	270	270
Capacity (day)	Road	(PCU)	Total	135900	108500	108500	135900	108500	135900	135900
	Rail(no. of train)	Existing Railway	Total	170	170	170	170	170	170	170
		HSR		170						
	Air	(no. of fights)		366-492						
Demand Supply Gap (day)	Road (pcu)		Volume/Capacity Ratio	0.82	0.84	0.87	0.73	0.90	0.79	0.77
			Capacity-Volume	24,101	17,374	14,035	36,639	10,728	28,432	30,724
	Rail (no. of train)	Existing Railway	(Capacity-Volume)	84	91	92	92	98	118	113
		HSR	(Capacity-Volume)	73	81	88	82	64	64	67
	Air (no. of flights)[1/]	(Capacity-	Volume)	152	152	137	130	222	222	222

Source: JICA Study Team

1/ The capacity in Hanoi is applied for Hanoi – Vinh section and the one in HCMC for Vinh – Nha Trang for calculating Capacity – Volume.



Source: JICA Study Team
1/ "Railway" here indicates "Existing Railway" only

Figure 4.2.10 Impact of HSR on Traffic Demand by Mode along North-South Corridor (B1 Case), 2030

4) Further Analysis on the Railway Passenger Demand and services of North-South Railway

4.30 The demand of the railway along the North-South corridor was farther analyzed from the viewpoints of train operation by converting railway demand to the number of train frequencies to facilitate comparison of the demand with railway capacities.

4.31 The railway traffic demand in terms of number of train frequencies was estimated by section of the corridor for existing railway comprising passenger train and freight train, and HSR (see Table 4.2.19). Main characteristics are as follows:

(i) Comparing with and without HSR cases, the demand of existing railway will shift to HSR in with HSR case.

(ii) Even in case existing railway is improved from A2 to B1, the total demand of existing railway and HSR is almost constant.

(iii) The demand of existing railway exceeds A2 capacities mainly due to that of freight traffic in almost all sections, but the demand is only 30-50% of B1 capacity.

(iv) The demand of HSR is 85 to 111 train frequencies in the case of A2, while it is 82-106 in the case of B1.

(v) The passenger traffic demand of existing railway is limited to about 30% of HSR, which implies that the role of existing railway is rather for local transport and freight transport.

Table 4.2.19 Estimated Railway Traffic Demand along the North-South Corridor, 2030

Case	Hanoi – HCMC Travel time (hr)		North		Central			South	
			N1. Hanoi – Thanh Hoa	N2. Thanh Hoa - Vinh	C1. Vinh – Hue	C2. Hue - Danang	C3. Danang – Nha Trang	S1. Nha Trang – Phan Thiet	S2. Phan Thiet – HCMC
A2 + HSR (whole section)	Existing Rail: 25.4 HSR: 5.7	Existing Rail	80(24)	74(20)	74(21)	72(21)	68(23)	48(22)	51(24)
		HSR	101	92	85	91	110	111	108
		Total	181	166	159	163	178	159	159
B1 + HSR (whole section)	Existing Rail: 15.6 HSR: 5.7	Existing Rail	86(30)	79(25)	78(25)	78(27)	72(27)	52(26)	57(30)
		HSR	97	89	82	88	106	106	103
		Total	183	168	160	166	178	158	160

Source: JICA Study Team
Note: Number in parenthesis refer to no. of passenger trains

5) Expected Role of Railways along North-South Corridor

4.32 From the demand analysis made in the previous sections, it is concluded that the railways along the north-south corridor are expected to play following roles;

(i) HSR can meet the demand for higher speed transport services which will increase further as income level of the people increase. A reason why HSR demand is high in the analysis is partly due to relatively low level of fare (1/2 of air fare) and easier access to the stations/terminals than air (generally speaking, access to airport takes longer time than other modes; based on a survey in 2011, average access times to Noi Bai Airport and Tan Son Nhat Airport are 60 minutes and 40 minutes, respectively; furthermore, domestic flight requests passengers to check-in 60 minutes before departure).

(ii) Existing railway has relatively high potential demand for freight transport services. The estimated freight traffic volume is unable to be met by single track railway. If the freight traffic demand to be attended fully, there are no more capacities left for passenger traffic. Double tracking increases the capacities by 3 to 4 times of the existing railway (from 50 trains/day to 170 trains/day) which is excessive compared to estimated demand.

(iii) While traffic demand analysis in this study is made for up to 2030, farther increase in along the north-south corridor beyond 2030 is highly likely considering potential growth of socio-economy and urbanization trend. Under these circumstances the requirement for rail transport services will become noteworthy because construction of additional expressways will be much more difficult and expensive than the railway.

4.33 Potential roles of railway development along the north-south corridor are obviously seen and summarized as follows:

(i) Increasing demand for higher speed and quality services along the north-south corridor can be met by HSR in the most appropriate manner. Capacities of air transport services are limited and still expensive for public and expressways are unable to compete with HSR for medium and long distances.

(ii) Existing railway has two main roles. One is to meet freight transport demand which is estimated to be about 50 to 60 trains/day in 2030. Another is to meet various types of passenger demand including those of medium distance travel and feeder to HSR. Local transport demand around main cities located in the north-south corridor may also be a market for existing railway though the analysis is not made in the study.

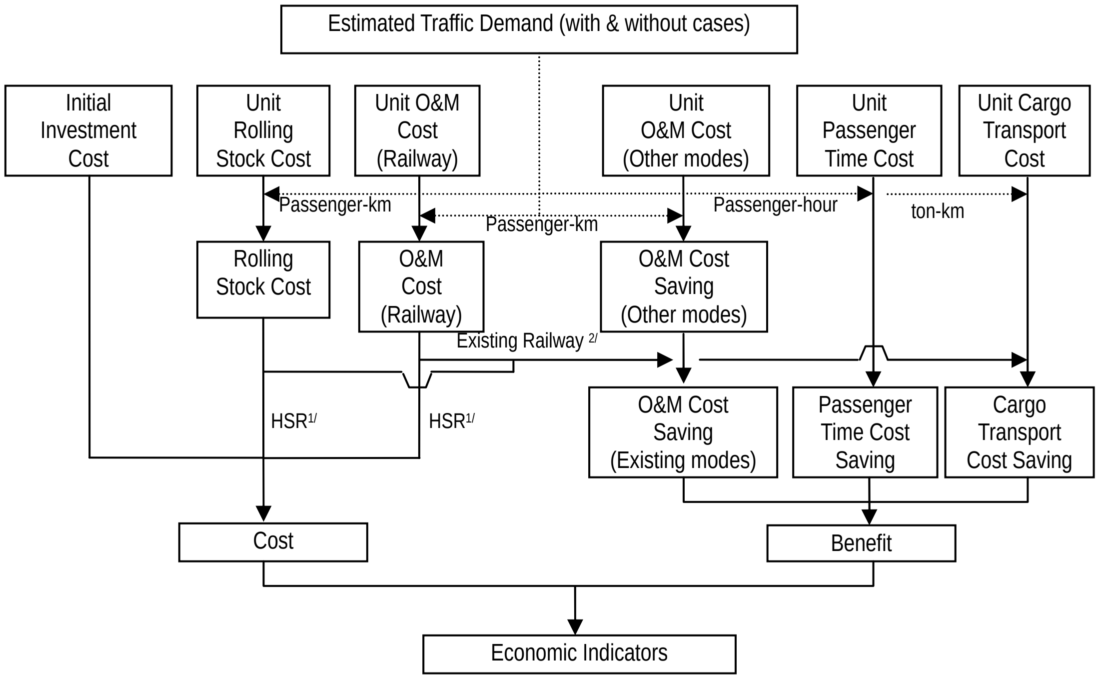
(iii) As the land to spare for transport infrastructure is limited along the north-south corridor, provision of high quality mass-transit transport is considered important for sustainable growth and development of the corridor beyond 2030.

4.3 Preliminary Economic Evaluation of North-South Railway Development

1) Methodology

(a) Overall Framework

4.34 Economic indicators are essential to assess viability of projects and to determine or prioritize project investments. The analysis for the upgrade of existing railway (A2, B1 and B2) and HSR was conducted (A1 is considered as a base case or “do-nothing” case since the projects in A1 are already committed).The framework of evaluation is shown in Figure 4.3.1 and the basic conditions and assumptions applied for economic and financial analysis for the study are explained in succeeding sections.



Source: JICA Study Team
1/ In case of HSR projects (new mode),
2/ Rolling stock cost and O&M cost are considered at benefit side

Figure 4.3.1 Basic Framework of Economic Evaluation

(b) Initial Investment

4.35 The initial investment cost for upgrading existing railway (A1, A2, B1 and B2) was estimated by TRICC and JICA Study Team. Besides, the cost estimation made by TRICC for Pre-F/S was utilized for HSR at this stage. The summary of the project costs for railway projects is shown in Table 4.3.1.

(c) Rolling Stock

4.36 For taking into account the required amount of rolling stocks depending on fluctuate traffic volume, the cost for rolling stocks are estimated by a simple way using the unit rolling stock cost per passenger distance. The applied unit cost is shown in Table 4.3.2.

Table 4.3.1 Project Cost for Upgrading Existing Railway (for whole section)1/

	Upgrade of Existing Railway/HSR Development (US$ million)			
	A2	B1	B2	HSR
Construction	345	4,443	8,261	22,430
Depot	230	723	839	732
Electric Facilities	-	-	5,551	7,008
Signal /Telecom	608	4,790	4,899	5,352
Engineering Service	30	199	391	711
Land Acquisition	13	1,086	1,431	1,791
Total	1,225	11,240	21,372	38,024

Source: TRICC and JICA Study Team
1/ Excludig rolling stocks, taxes and duties

Table 4.3.2 Assumed Cost for Rolling Stock

			Existing Railway			HSR
			A2[3/]	B1	B2	
Passenger Train	Assumed Cost	mil. USD/ train	4.9	10.9	38.5	64.0
	Capacity	pax/train	1,000	1,000	1,000	1,000
	Travel Distance	km/day	-[4/]	1,200	1,360	2,000
	Cost per Passenger Distance[1/]	USD/pax-km	-[4/]	17.7	55.1	48.1
Freight Train	Assumed Cost	mil. USD/train	1.0[3/]	7.8	10.2	-
	Capacity	ton/train	1,000	1,000	1,000	-
	Travel Distance	km/day	-[4/]	860	860	-
	Cost per Passenger Distance[2/]	USD/ton-km	-[4/]	11.1	18.8	-

Source: TRICC and JICA Study Team
1/ Assuming load factor of 65% and maintenance and standby period of 14%. Cost for maintance cars is also included (assumed 9% of total).
2/ Assuming load factor of 90% and mainetnance and standby period of 10% for B1 and load factor of 75% and mainenance and standby period of 10% for B2. Cost for maintance cars is also included (assumed 9% of total).
3/ Locomotive cost only (VR owns enough number of freight cars).
4/ Cost of rolling stocks of A2 are estimated based on operational plan (Therefore, travel distance is not assumed.)

(d) O&M Cost

4.37 Two types of O&M for railway, one is based on the current operation system of Vietnam Railways and the other is based on electrified railway operations in Japan, are estimated (See Technical Report No. 3 Demand Forecast Methodology and Transportation Cost, Chapter 4). Applied O&M costs are summarized in Table 4.3.3. (For economic analysis, the improvement of O&M cost of existing railway is considered in calculation of operation cost saving.)

Table 4.3.3 Applied O&M Costs

	Alternative	Cost	Note
Passenger Car Operation	A1, A2, B1	26.6 USD per 1000 pass-km	Diesel Locomotive
	B2, HSR	Calculated using formulation explained in Technical Report No.3 "Demand Forecast Methodology and Transportation Cost" Chapter 4.	Electrified
Freight Car Operation	All	19.4 USD per 1000 ton-km	Diesel Locomotive

Source: JICA Study Team

(e) Economic Benefit Considered

4.38 For the economic analysis of the projects, the following three types of benefit are taken as economic benefit including passenger time saving, passenger O&M cost saving (including O&M cost of existing railway) and cargo transport cost saving. Although other benefits can be considered, such as growth in industrial outputs and environmental influences, those were excluded from the economic analysis, since those are largely dependent on the social conditions and political will.

(i) **Passenger Time Cost Saving:** Passenger time cost saving was calculated by the following formula:

Passenger Time Cost (without projects) – Passenger Time Cost (with projects)

4.39 Since the unit passenger time cost differs by mode and by year, passenger-hours should be calculated by mode for the entire transport network. Table 4.3.4 shows the passenger time costs by mode assumed in this study.

Table 4.3.4 Assumed Passenger Time Costs

	Mode	2011[1/]	2030
Average Income[2/] (USD/month)	Car/Air	314	1056
	Bus/Rail/IWaterTransport	150	528
Passenger Time Cost (USD/hour)	Car/Air	1.96	6.60
	Bus/Rail/IWaterTransport	0.94	3.30

Source: JICA Study Team
1/ Based on the result of traffic interview survey,
2/ 160 working hours per month and income growth in proportion to per capita GDP.

(ii) **O&M Cost Saving (Passenger Transport excluding Railway:** Transportation projects give influences on transportation volume of other modes. By traffic assignment on demand forecast conducted for the study, passenger-km figures can be obtained by mode by link. For calculating O&M cost for road transport, the data in Table 4.3.5 is applied. Besides, for air transport, the figures in Table 4.3.6, which is roughly assumed from world average published by ICAO, are applied. (See Technical Report No. 3 Demand Forecast Methodology and Transportation Cost, Chapter 4 for details).

(iii) **Cargo Transport Cost Saving:** Cargo transport cost saving was calculated based on the tariff of actual cargo transport services (Table 4.3.7).

4.40 In case of A1 and A2, where potential traffic demand exceeds the capacity of railway transport already in 2030 (the share of capacities for passenger and freight is assumed same as the ratio of potential demand for them in 2030), it is assumed that such excess will be distributed to road transport (40%) and coastal shipping (60%)

4.41 As for B1 and B2, potential railway traffic demand doesn't exceed rail capacity in 2030. In case the demand increases to the capacity in far future, it is assumed that passenger traffic will be prioritized while freight traffic will be ensured to be carried at the level of 2030 at least.

Table 4.3.5 Vehicle Operating Cost (US$/1000 km)

	Speed (km/hr)	Car	Minibus	Standard Bus	Small Truck	Big Truck	Container Truck
Financial Cost	5	1081.7	994.2	1840.4	1836.8	1677.8	1426.0
	10	557.4	559.3	980.0	1089.0	997.2	795.3
	20	293.8	335.2	543.2	708.3	650.3	477.1
	30	202.7	258.8	395.3	537.4	543.3	362.6
	40	161.0	220.0	320.3	454.0	479.3	313.9
	50	135.4	197.2	276.3	416.0	484.5	287.0
	60	120.3	191.6	255.9	396.4	525.2	275.9
	70	110.9	191.9	245.6	394.4	585.8	270.2
	80	105.1	196.2	241.5	405.6	655.2	277.2
	90	102.5	205.2	243.5	437.6	714.9	290.8
Economic Cost	5	1065.3	561.9	1570.0	1668.3	1522.5	1340.8
	10	547.0	323.4	825.5	983.0	899.5	742.5
	20	286.7	200.3	449.5	634.2	582.2	440.8
	30	197.1	158.4	322.9	479.7	483.6	332.9
	40	155.6	137.2	259.0	404.1	425.2	286.3
	50	130.2	125.8	222.1	369.3	428.1	260.5
	60	115.0	124.1	203.1	351.3	462.2	249.2
	70	105.3	125.9	192.5	348.8	513.9	243.1
	80	99.2	130.6	187.5	358.1	573.6	248.4
	90	96.0	138.6	187.6	385.5	625.2	259.6

Source: JICA Study Team

Table 4.3.6 Operating Cost by Air Transport

Economic Cost (USD/ 000 passenger-km)	Financial Cost (USD/ 000 passenger-km)
64.7	74.4

Source: JICA Study Team

Table 4.3.7 Operating Cost by Transportation Mode (Economic Cost)

	Haulage (000VND/ton-km)				Loading/Unloading and Other Charges (000VND/ton)			
	Truck	Inland	Coastal	Air	Truck	Inland	Coastal	Air
1.paddy and food crop	1.79	0.29	0.14	11.9	25.0	23.5	45.0	200.0
2.sugar/sugarcane	0.89	0.29	0.14	11.9	25.0	23.5	45.0	200.0
3.wood/forestry	4.28	0.29	0.19	11.9	25.0	23.5	45.0	200.0
4.steel	1.06	0.29	0.19	11.9	25.0	23.5	45.0	200.0
5.construction material	1.12	0.29	0.19	11.9	25.0	23.5	45.0	200.0
6.cement	0.84	0.29	0.21	11.9	25.0	23.5	45.0	200.0
7.fertilizer	1.13	0.29	0.14	11.9	25.0	23.5	45.0	200.0
8.coal	1.31	0.29	0.19	11.9	25.0	23.5	45.0	200.0
9.petroleum product	1.19	0.29	0.21	11.9	25.0	23.5	45.0	200.0
10.industrial crop	1.56	0.29	0.14	11.9	25.0	23.5	45.0	200.0
11.manufactured goods	1.76	0.29	0.32	11.9	25.0	23.5	45.0	173.9
12.fishery product	2.98	0.29	0.32	11.9	25.0	23.5	45.0	182.6
13.animal meat	2.05	0.29	0.32	11.9	25.0	23.5	45.0	182.6
Average	1.69	0.29	0.21	11.90	25.0	23.5	45.0	195.3

Source: JICA Study Team based on several source
Note: 15% of VAT and other taxes are assumed in the calculation of economic costs.

(f) Basic Assumption

4.42 The basic assumptions made in the economic analysis of the projects include the following:

(i) Opening year is 2030 and 2040;

(ii) Period for analysis is 30 years;

(iii) The purchase of rolling stocks is conducted every five years for the demand of next five years;

(iv) Investment period is assumed as shown in Table 4.3.8.

Table 4.3.8 Assumed Investment Schedule for Railway Projects

Year before Opening	-10	-9	-8	-7	-6	-5	-4	-3	-2	-1	Total
	Cost allocation by year (%)										
Construction						10%	15%	25%	25%	25%	100%
Depot								30%	35%	35%	100%
Electric Facilities							10%	10%	30%	50%	100%
Signal /Telecom							10%	15%	25%	50%	100%
Engineering Service			50%	50%							100%
Land Acquisition						33%	33%	34%			100%

Source: JICA Study Team

(v) Residual cost is estimated under the assumption of durable time as follows: construction and depot: 60 years, electric facilities: 40 years, and signal/telecom: 30 years;

(vi) The fare level of existing railway is same as current level; and

(vii) The increase of overall traffic demand is assumed to be 4.9% per year (which is estimated traffic growth rate between 2020-2030) and the one of passenger time to be 4.3 % per year (which is estimated per-capita GDP growth rate between 2020-2030).

2) Preliminary Analysis

(a) Selected Cases for Analysis

4.43 Cases for economic analysis were selected to assess different options for north south railway development. Development options included improvement levels of existing railway at A2, B1 and B2 levels and development of HSR were analyzed individually based on the assumption that the entire section is improved/ developed at the same level and opened for operation in 2030 and 2040.

(b) Results of the Analysis

4.44 Main findings of the first step of economic analysis are as follows:

(i) With regard to improvement level of existing railway (whole section), A2 shows the highest economic viability, EIRR of 14%, under the assumption that the line is opened in 2030. On the other hand, B1 and B2 show 11% and 7%, respectively. This indicates that existing railway can be upgraded to A2 before 2030.

(ii) With regard to development of HSR, EIRR is estimated to be 11% and 18% under the assumption that the whole section is opened in 2030 and 2040, respectively. Opening of HSR is viable in 2040 case. This indicates that adequate timing of opening of HSR is sometime middle of 2030s.

5 ANALYSIS AND SELECTION OF HSR SYSTEM AND TECHNOLOGY

5.1 Review of High-Speed Railway Technologies in the World

1) Definition of High Speed-Rail

5.1 According to International Union of Railways (UIC), the high-speed rail system combines various elements using highly sophisticated technology. Thus there is no single standard definition of high-speed rail. Confining the definition of 'High speed', there are various levels from 160 km/h to 300 km/h as to each country and region. In general, high-speed rail is defined as follows:

5.2 High-Speed Lines shall comprise;

(i) Specially built new lines equipped to accommodate maximum speeds generally equal to or greater than 250 km/h

(ii) Specially upgraded lines equipped to accommodate maximum speeds in the order of 200 km/h

5.3 Based on the latest UIC data (updated as of May 21, 2012), there have been 15 countries in the world operating the high-speed railways as listed in Table 5.1.1. The combined total length of high-speed lines is 14,965 km. (See Table 5.1.1)

5.4 In this report, the technologies will be reviewed on the basis of the former definition, special built lines for equal to or greater than 250 km/h, in view of the situation of Vietnam's railway.

Table 5.1.1 High-Speed Railways in the World

Region	Country	Kilometers	
		In Operation	Under Construction
Europe	Belgium	209	0
	France	1,896	210
	Germany	1,285	378
	Italy	923	0
	Netherlands	120	0
	Spain	2,056	1,767
	Switzerland	35	72
	United Kingdom	113	0
	Sub-total	6,637	2,427
Asia	China	4,576	5,757
	Taiwan	355	0
	Japan	2,388	378
	South Korea	412	0
	Turkey	235	510
	Sub-total	7,966	6,645
Other Countries	Morocco	0	200
	USA	362	0
	Sub-total	362	200
Total World		14,965	9,272

Source: International Union of Railways (UIC), 2012

2) Japan

(1) Overview

5.5 The commercial operation of the Tokaido Shinkansen Line began on October 1, 1964 and the 48th anniversary will be marked in October, 2012. In March 2011, the entire route of the Kyushu Shinkansen Line (Kagoshima Route) was opened and the total extension of Shinkansen Lines reached 2,387.7 km. During all these years, there are no Shinkansen passenger fatalities and Shinkansen boasts the best safety record in the world. Also, punctuality is stable with average delay per one train of one minute or less.

5.6 Shinkansen uses the high-standard new line system which is independent from the existing lines as a rule to operate high-speed trains only and to allow a significant increase in the transportation capacity. Furthermore, the construction of "Dedicated high-speed passenger lines" eliminating crossings and the introduction of disaster prevention measures and highly-reliable protection system namely, the ATC (Automatic Train Control system), ensures a safety concept for thoroughly eliminating collision accidents, which is the foundation and the characteristics of Shinkansen. Also, the rolling stock weight has been reduced by controlling the rolling stock collision strength and introducing the "Electric Multiple-Unit (EMU)". The electric multiple unit realized the compact-size infrastructure due to light axel load and ensured a greater carrying capacity due to the adoption of wider car body width.

5.7 Furthermore, separating of operation and maintenance, adoption of single-directional operation, unifying of operating train performance (without mixed operation with locomotive train, etc.), development and application of the original concept for fire protection measures, the Centralized Train Control (CTC) and other latest technologies were implemented to restructure the railway system to establish the first high-speed railway system in the world.

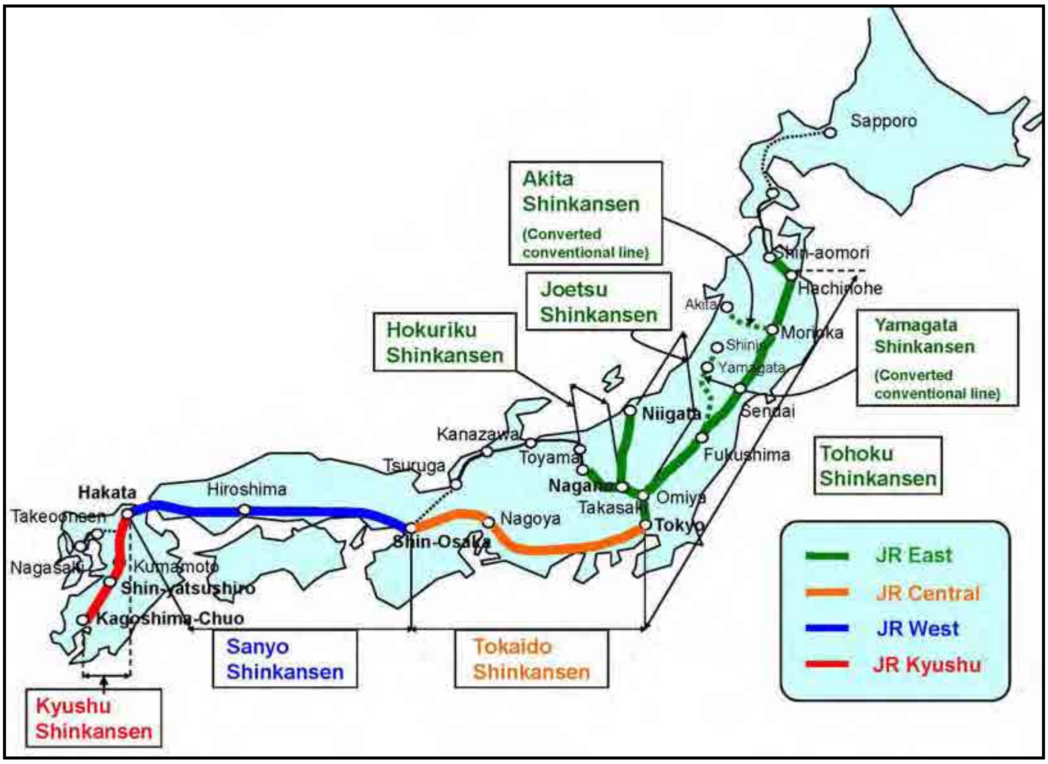
5.8 As a result, safety, which is unprecedented in the world, stability, efficient high-speed transportation with a large capacity and high density, reduction in the construction cost due to compact-size infrastructure, reduction in the operation cost due to highly energy-efficient transportation have been realized.

5.9 European countries, which began high-speed railway operation after Japan, originally adopted the existing line utilization system and locomotive train system, however, with the improvement in operation speed and increase in the high-speed railway users, they constructed the high-speed passenger dedicated lines and the Electric Multiple Unit system has become the main system in Europe. Also in Asian countries which operate a new high-speed railway, this system is mainly used.

5.10 It was natural for Japan's Shinkansen with high transportation density and a number of sections of soft ground to adopt the Electric-Multiple Unit system that ensures reduction in the maximum axle weight, increase in the capacity, and better overall brake performance. With the technological development after the adoption, some of the disadvantages for the initial Electric-Multiple Unit system such as inclusion of many parts and high costs for manufacturing of new train and maintenance, were eliminated to achieve further reduction in weight, train oscillation control, reduction in the micro air pressure wave in tunnels, further elimination of mechanical braking, and other technological development. It is considered that these technological developments allow lighter axel weight of rolling stocks, shorter track center intervals, and smaller tunnel cross section even for the higher-speed system.

(2) Description of New Lines

5.11 Japan has a total of 2,387.7 km of high-speed railway network with six lines including Tokaido, Sanyo, Kyushu, Tohoku, Joetsu and Hokuriku (see Figure 5.1.1 and Table 5.1.2)



Source: JICA Study Team

Figure 5.1.1 Network of Japan's Shinkansen

Table 5.1.2 Japan's Shinkansen (High-Speed New Lines)

Line name	Section	Opened	Maximum Operating Speed (km/h)	Total Length (km) (Actual Kilometers)
Tokaido Shinkansen	Tokyo–Nagoya–Shin–Osaka	Oct. 1964	270	515.4
Sanyo Shinkansen	Shin-Osaka - Okayama–Hakata	Mar. 1972 - Mar. 1975	300	553.7
Kyushu Shinkansen (Kagoshima Route)	Hakata– Shin–Yatsushiro–Kagoshima Chuo	Mar. 2004 - Mar. 2011	260	256.8
Tohoku Shinkansen	Tokyo–Ueno–Omiya–Morioka–Hachinohe-Shin–Aomori	June 1982 - Dec. 2010	300 320 (*1)	674.9
Joetsu Shinkansen	Omiya–Niigata	Nov. 1982	240	269.5
Hokuriku Shinkansen (Nagano Shinkansen)	Takasaki–Nagano	Oct. 1997	260	117.4
Total 2,387.7				

Source: JICA Study Team
*1: Operation at 320 km/h starts in March 2013.

(a) **Tokaido Shinkansen:** The Shinkansen Line was started service between Tokyo and Shin-Osaka as the first high-speed railway in Japan in 1964. As the transportation demand was extremely high in the Tokaido region and it was estimates that the existing Tokaido Main Line would reach the limit of transportation capacity, the Tokaido Shinkansen was planned and the plan was reviewed to increase lines. After examining some proposals including the gauge setting, it was determined that separate line with standard gauge should be constructed to make an innovative high-speed railway than the existing narrow-gauge railway. While existing train tracks for existing lines were available in the urban areas in European countries as the same gauge was used, it was necessary to separate Shinkansen lines and stations from the existing narrow-gauge lines in urban areas in Japan.

5.12 The Tokaido Shinkansen (515.4 km) connecting Tokyo and Shin-Osaka in 3 hours and 10 minutes made the distance available for one-day trip zone, while it took six hours and a half to travel for the same by the existing limited express trains. The Tokaido Shinkansen, the first high-speed railway system in the world, marked the start of a new era for high-speed railway system and triggered the development of high-speed railway network in European countries, etc.

(b) **Beginning of the Sanyo Shinkansen Line Operation:** After the success of Tokaido Shinkansen, the Sanyo Shinkansen was planned as the expansion for the existing lines under the 3rd long-term plan of the Japan National Railways. The construction for the section between Shin-Osaka and Okayama (160.9 km) started in 1967 and the operation began in March 1972. After that, the construction for the section between Okayama and Hakata started in 1970 and the operation began in March 1975. Approximately a half of total length (553.7 km) of Sanyo Shinkansen consists of tunnels and the Shin-Kanmon Tunnel, an undersea tunnel connecting Honshu and Kyushu, was completed as it was scheduled by adopting the grouting method and pipe roof method.

5.13 In addition to the reduction in the life cycle cost due to maintenance-free tracks, slab tracks without ballasts and sleepers were adopted for the Sanyo Shinkansen and the following Lines to ensure solid track structure.

(c) **The Act for Construction of Shinkansen Railway across the Country and Start of Operation of Tohoku and Joetsu Shinkansen:** The Act for Construction of Shinkansen Railway across the Country was promulgated in May 1970. After this, Shinkansen lines, that were considered as the measure for solving the lack of transportation capability of existing lines of the Japan National Railways, were planned and constructed under the national development strategy for “achieving the well-balanced land development and regional revitalization thorough the creation of high-speed network”.

5.14 The construction plan for Tohoku Shinkansen (Tokyo–Morioka: 496.5 km) and Joetsu Shinkansen (Omiya–Niigata: 269.5 km) was approved in October 1971, and the construction work for Tohoku Shinkansen by the Japan National Railways and for Joetsu Shinkansen by the Japan Railway Construction Public Corporation (hereinafter referred to as the “Railway Public Corporation”) (later becoming the Japan Railway Construction, Transport and

Technology Agency (Railway/Transport Agency) by merging with the Corporation for Advanced Transport and Technology in October 2003) was started, led by these implementing bodies.

5.15 The Tohoku Shinkansen (Omiya–Morioka) started operation in June 1982 and the Joetsu Shinkansen (Omiya–Niigata) started in November 1982. As the start of construction for the areas south of Omiya was delayed by the citizens' campaign affected by the rapidly heightened public awareness about the environmental conservation, the operation for the section between Omiya and Ueno began in March 1985.

5.16 The construction for the section between Tokyo and Ueno was implemented by the JR East after the JNR privatization reforms and the operation began in June 1991.

(d) **Shinkansen Lines Developed and Started under the New Scheme after the JNR Privatization Reforms:** The routes developed and started under the new scheme after the JNR privatization reforms include Hokuriku Shinkansen (Takasaki–Nagano: 117.4 km), Tohoku Shinkansen (Morioka–Shin-Aomori: 178.4 km), Kyushu Shinkansen (Hakata–Kagoshima: 256.8 km) and reaches a total of 552.6 km.

5.17 The Hokuriku Shinkansen has the total length of approximately 700 km, stretching from Tokyo to Osaka City via Nagano City, Toyama City, and Kanazawa City. As this Line shares the existing Joetsu Shinkansen between Tokyo and Takasaki, the newly constructed zone is between Takasaki and Osaka. The operation for the section between Takasaki and Nagano was started in October 1997 prior to the Nagano Winter Olympics. The big challenges for the Hokuriku Shinkansen were the reduction in costs and construction period. The particular challenge lied in the going through the Usui Pass with a difference of elevation of 660 m and a new rolling stock was developed to adopt a 30-per-mil steep for Shinkansen for the first time. In addition, ground station system was adopted, high-speed branch unit was developed, and high-speed simple catenary was introduced. Also, slab tracks, whose existing use had been limited to tunnels and elevated bridges, were used on the soil roadbeds.

5.18 The operation of Tohoku Shinkansen (Morioka–Shin–Aomori) began for the section between Morioka and Hachinohe in December 2002 and for the section between Hachinohe and Shin-Aomori in December 2010. As the total length of tunnels accounted for approximately 70% of the total length to be constructed, reduction in costs was achieved by using large machineries and taking other appropriate measures. Also, ground platform structure was used for the Ninohe and Hachinohe stations to reduce costs.

5.19 Kyushu Shinkansen Kagoshima Route has the total length of 256.8 km between Sanyo Shinkansen Hakata Station and Kagoshima-Chuo Station along Fukuoka, Kumamoto, and Kagoshima prefectures. The operation for the section between Shin-Yatsushiro and Kagoshima-Chuo began in March 2004 and the operation for the section between Hakata and Shin-Yatsushiro began in March 2011. The Shin-Yatsushiro Station adopts the "Platform-to-Platform System" to allow users to change existing line and Shinkansen line on the same platform, thus significantly contributing to the improved convenience of users and reduced time. A new technology for the foundation unique to the pyroclastic plateau was developed to ensure economic efficiency. In the construction work, a design utilizing the characteristics of the region was adopted and the "hybrid structure" which combined the civil structure and the architectural structure was introduced to reduce costs.

(3) Rolling Stock

(a) **0 Series Shinkansen:** This is the first Shinkansen rolling stocks built to run on Japan's new Tokaido Shinkansen which opened in 1964. The following Shinkansen rolling stocks are based on the 0 series Shinkansen. The initial maximum operating speed was 210 km/h and it reached 220 km/h in 1986 onwards. 0 Series Shinkansen consists of 16 rolling stocks, with the trainset length of 400.3 m and the capacity of approximately 1400 passengers, powered by the AC 25,000 V electricity at 60 Hz. For 23 years between 1964 and 1986 and up to the 38th type, a total of 3,216 trains were manufactured with many improvements. The regular service was terminated on November 30, 2008.

(b) **N 700 Series Shinkansen:** The new rolling stocks were jointly developed by the JR Central and JR West and the operation began in the autumn of 2007. Although the existing rolling stocks were not able to run at the speed of 255 km/h due to the horizontal force on the 60 sections with a 2,500-meter-radius curve on the Tokaido Shinkansen Line and the 270 km/h operation was available only for one third of total length of existing line, N 700 Series Shinkansen can run at the speed of 270 km/h for the section as much as two thirds of the total operation length by adopting the train tilting system. Furthermore, the travel time between Tokyo and Osaka was shortened by 5 minutes by increasing the start-up speed to 2.6 km/h/s. On the other hand, High-speed operation at 300 km/h is available for the Sanyo Shinkansen. N 700 Series Shinkansen is also operated for the Kyushu Shinkansen.N 700 Series Shinkansen consists of 16 rolling stocks with the train set length of 404.7 m and the capacity of 1,323 passengers.

(c) **E5 Series Shinkansen:** E5 Series Shinkansen is scheduled to run at the maximum operating speed of 320 km/h in March 2013. In order to reduce the micro-pressure wave in tunnels, the shape of the front car looks like a long nose. E5 Series Shinkansen is equipped with a system capable of 1.5-degree tilting so that it can run at a high speed in some sections with a 4,000-memter-radius curve on the Tohoku Shinkansen Line. E5 Series Shinkansen consists of 10 rolling stocks (8M2T) with the capacity of 731 passengers and the total train set length of 253 m.

3) France

(1) Overview

5.20 France realized a high-speed railway; Train a Grande Vitesse, (TGV), the first one of its kind in Europe. In September, 1981, the Paris-Lyon section started revenue service operation. As it attained success in high-speed operation, the high-speed railway network was extended toward the north, south, east and west, with its length reaching 1,896 km within the country. The network has been expanded to surrounding counties, as the TGV network to Switzerland, Thalys Network to Belgium and Germany and Eurostar Network to the UK.

5.21 As a feature of TGV, high-speed trains are running on a special line called LGV; Ligneagandevitesse, and also on existing tracks at city centers and in local areas. In this way, France was able to cut the costs to construct new lines, thereby improving the services for high-speed railway users and raising the demands there for.

5.22 At the beginning, the lines where trains run at a maximum speed of 200 km/h or over were defined as TGV. The maximum operating speed of TGV has been raised to 320 km/h. LGV was constructed by avoiding sharp curves. Initially, its maximum radius of curve was 4,000 m. As train speed increases, however, the maximum radius of curve has been increased up to 6,000 m or over. To ensure the safety of high-speed operation, fences to avoid trans-passers are constructed along the whole line, with level crossings totally eliminated. The track structure is constructed with ballasted tracks in principle using continuous welded rails.

5.23 The lines where TGV trains are operated are double-tracked under the left side operation system in principle. However, bi-direction operation on single tracks is also adopted.

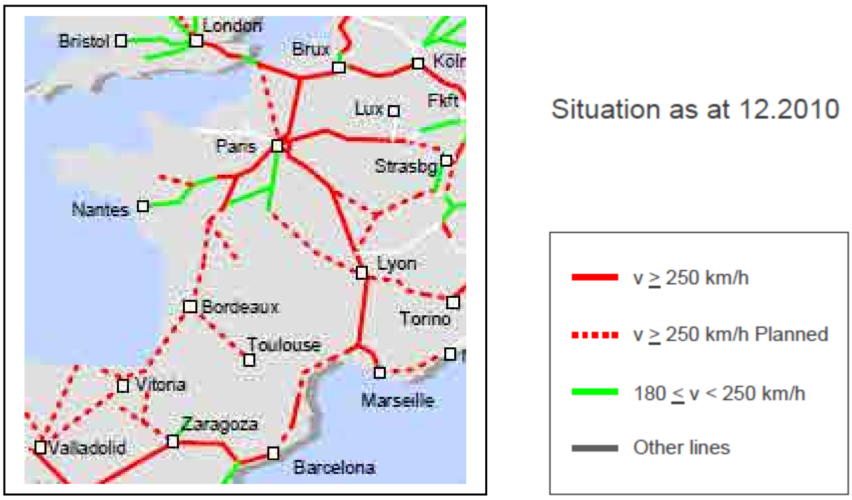
5.24 Passenger trains are running on the lines dedicated to high-speed operation, with freight trains or low-speed passenger trains excluded in principle, with some sections designed to exceptionally allow mixed train operation.

5.25 The voltage of power supply system is AC 25 kV. The signaling system is a cab signal system specific to the country. Transmission Voice-Machine (TVM) is in use. Some sections are installed with the European Train Control System (ETCS)-level 2.

5.26 France has a tradition to use the articulated bogie system for rolling stock and operate trains hauled by high-output locomotives. As the next-generation high-speed trains, France has developed trains called AGV that are composed of articulated electric multiple units (EMUs).

(2) Description of Main Lines

5.27 France has a total of 1,768 km of high-speed railway network with six lines operating (see Figure 5.1.2. and Table 5.1.3).



Source: UIC

Figure 5.1.2 High-Speed Railway Network in France

Table 5.1.3 Main Characteristics of TGV

Line	LGV-SudEst	LGV-Atlantique	LGV-Contournement Lyon	LGV-Nord	LGV-Med	LGV-Est
Year opened	1981/1983	1989/1990	1992/1994	1994/1996	2001	2010
Length	419 km	291 km	121 km	346 km	259 km	332 km
Usage	Dedicated	Dedicate	Dedicated	Dedicate	Dedicated	Dedicated
Track gauge	1,435mm	1,435 mm	1,435 mm	1,435 mm	1,435 mm	1435
Max. Axle Load	17tf	17 tf	17 tf	17 tf	17tf	17 tf
Max. design Speed	300 km/h	330 km/h	300 km/h	350 km/h	350 km/h	350 km/h
Max. operation Speed	270 km/h	300 km/h	300 km/h	300k m/h	300 km/h	320 km/h
Max. gradient	35/1000	25/1000	35/1000	25/1000	35/ 1000	25/1000
Min. vertical curve radius	16,000 m	25,000 m	25,000 m	25,000 m	25,000 m	25,00 m
Min. curve radius	4,000 m	4,545 m	5,000 m	6,000 m	6,250 m	6,000 m
Distance between Track centers	4.2 m	4.2 m	4.2 m	4.5 m	4.8 m	4.5 m
Formation width	13.0 m	13.6 m	13.6	13.9 m	14.2 m	13.9
Tunnel cross section	Nothing	71.0 m^2 or 2 x 46 m^2	100 m^2	100 m^2	100 m^2 63 m^2（230 km/h）	100 m^2
Width of Rolling stock	2,904 mm	2,904 mm	2,904 mm	2,904 mm	2,90 4mm	2904 mm

Source: JICA Study Team from various data

(a) **LGV Paris SudEst:** The LGV SudEst, the first high-speed railway line in France, connects Paris and Lyon. The first section was inaugurated in 1981 to draw up a curtain for the high-speed railway age in France, which had constructed a basic system of the French high-speed railway l lines thereafter.

5.28 In the city areas at the ends of the line, the trains depart from and arrive at the existing stations by using the existing lines. The line is dedicated to passenger trains with a maximum axle load of 17 tons. The dimensions of the line are: the distance between track centers 4.2 m; the maximum gradient 35%; the minimum curve radius 4,000 m. There are no tunnels along the line. The train operation started at a maximum speed of 260 km/h, which has been raised to 300 km/h, with the signal system TMV300 replaced with TVM420.

(b) **LGV Atlantique:** This is a high-speed railway line running from Paris to the western part of the country. It was opened up to Le mans and Tours, in 1989 and in 1990, respectively. The TGV Atlantique started 300 km/h operation first in the world. The line is designed to a maximum gradient of 15‰. Some tunnels exist along the line. The TGV car body is not sufficiently airtight. To avoid the effect of uncomfortable air pressure change, the train speed is reduced in tunnels. The trains directly run into the existing DC sections.

(c) **LGV Contounrnement Lyon:** This is a southward extension of LGV Paris SudEst, running to LGV Mediterranee from the Valence TGV station to constitute an axial line of the French territory.

(d) **LGV Nord-Europe:** This line was opened in 1993 to connect Paris to the border with Belgium and the France-UK Channel Tunnel. It has the role of an international trunk line. Its dimensions are: design maximum speed 350 km/h, distance between track centers 4.5 m and maximum gradient 25‰. To allow trains run into surrounding countries, various train types are used, such as TGV-SudEst, TGV-Atlantique, TGV-Duplex, Eurostar and Thalys trains, etc.

(e) **LGV Mediterranee:** This line was opened in 2001 to connect Valence and Marseilles. It connects the northern France and the Mediterranean district zone via LGV Contounnment Lyon. Dimensions: distance between tracks 4.8m and the maximum train speed 300 km/h (partly 320 km/h).

(f) **LGV-Est:** This line connects Paris to Baudrecourt in the eastern France and to the southern Germany, Luxemburg and Switzerland through existing lines. The maximum train speed has been raised to 320 km/h. The line is designed to higher specifications to allow 320 km/h operation. Track dimensions: the distance between track centers 4.5 m and the maximum gradient 25‰. The German ICE trains run into this line. Therefore, the signaling system uses the European standard ETCS in addition to the TGV standard TVM.

(g) **Perpigan–Figeres (Spain):** This line was opened in 2010 to cross the France-Spain border for mixed traffic services to run passenger and freight trains, which is a unique train operation style rarely seen in other high-speed railways. Extension to Barcelona is planned in the future.

(3) Rolling Stock

5.29 The basic TGV train formation is to place two power cars, one each at head and tail, to sandwich passenger cars having articulated bogies in-between, although some variations are seen on different lines.

(a) **TGV-Paris SudEst:** The cars used on this line belong to the first high-speed rolling stock in France to make a basis of all TGV trains. A 200 m-long 10-car train set has two locomotives, one each at head and tail, to compose a formation of 2L8T (two locomotives and eight trailers). The passenger cars in the train set have the articulated bogie system. Two train sets can be coupled into one when necessary. To cope with through-operation into existing tracks, a duel-voltage (AC25 kV + DC1,500 V) power system is adopted. The maximums speed originally set at 260 km/h has been raised to 300 km/h.

(b) **TGV-Atlantique:** The cars used on this line were introduced at the inauguration of LGV-Atlantique. The maximum speed of 300 km/h on LGV was the world highest in those days. The trains run at 220 km/h on existing tracks as well. Trains are mounted with inverter-controlled synchronous motors. A train set is composed of 12 cars as a 2L10T formation to a total length of 237 m.

(c) **TGV- Reseau:** The cars running on this line were developed to correspond to the Belgian international trains, etc. The trains run at a maximum speed of 320 km/h, with some corresponding to the DC3, 000 V power source. The train formation is 2L8T.

(d) **TGV-Eurostar:** The Eurostar connects Paris to London in the UK via Channel Tunnel and also London to Brussels. For this purpose, the trains correspond to DC3, 000 V and the AC750 third-rail system in Belgium and the UK, respectively. A train-set is composed of 20cars (2L18T) to a length of 394 m.

(e) **TGV-Duplex:** The trains composed of all double-decker type cars were developed to cope with the increasing demands for passenger transport at the inauguration of the Mediterranean line (LGV Mediterranee). The passenger capacity of a 200 m-long train set is 516 persons, a substantial increase from the approximately 350 persons of TGV- SudEst. To limit the axle load within the standard, an aluminum alloy car body is adopted. The maximum train speed in 320 km/h.

(f) **Thalys:** To guarantee the interoperability of European railways, the rolling stock for Thalys was developed on the basis of TGV to connect France to Belgium, the Netherlands and Germany. The Driver cab is installed at the center in the lateral direction to correspond to both the right- and left-side traffic systems and equipment corresponds to the four different power supply systems of these countries, seven signaling systems. The maximum train speed is 300 km/h. The train formation is 2L8T. Two train sets can be coupled into one.

(g) **TGV-POS:** The rolling stock for TGV- POS was developed for the international trains to run from Paris to Switzerland, Luxemburg and Germany, etc. via LGV-Est. The trains run at a maximum speed of 320 km/h and correspond to three power source systems or DC1,500 V, AC25 kV and AC15 kV at 16-2/3 Hz. The train formation is the TGV standard of 2L8T.

(h) **Next-Generation Rolling Stock AGV:** Aiming at establishing further high-speed railway networks, France is now developing the next-generation trains called Automotrice a Grande Vitesse (AGV) for 350 km/h operation. Although the series production cars of this type succeed the use of articulated truck system, they are composed of aluminum alloy car body and the train formation has shifted to the EMU system for the first time from the traditional locomotive haulage system of TGV. The rolling stock of this type has already been introduced into Italy to implement 300 km/h operation.

Table 5.1.4 Main Characteristics of TGV Rolling Stock

Series	TGV-SE	TGV-Reseau	TGV-Eurostar	TGV-Duplex	Thalys	TGV-POS
Year in Service	1978	1993	1993	1996	1996	2006
Train Formula	2L8T	2L8T	2L18T	2L8T	2L8T	2L8T
Feature (1)	C,A	C,A	C,A	C,A,D	C,A	C,A
Max. design speed (km/H)	300	320	300	320	320	320
Max. operation speed(km/h)	300	320	300	320	300	320
Train length (m)	200	200	394	200	200	200
Train width (mm)	2904	2904	2814	2896	2904	2904
Seat capacity	350	375	750	512	377	357
Train weight (t)	385	383	752	380	385	383
Max. Axle Load (t)	17	17	17	17	17	17
Power (kW)	6400	8800	12200	8800	8800	9280
Voltage	1.5kV 25kV-50Hz	1.5kV 3kV 25kV-50Hz	0.75kV 3kV 25kV-50Hz	1.5kV 25kV-50Hz	1.5kV 3kV 15kv16.7Hz 25kV-50Hz	1.5kV 15kv16.7Hz 25kV-50Hz
Gauge (mm)	1435	1435	1435	1435	1435	1435

Source: JICA Study Team editing UIC data, 2012
Note (1): C; Concentrated power, A; Articulated, T; Tilting, D; Double Decker

4) Germany

(1) Overview

5.30 The development of high-speed railways in Germany is now under way by two methods: upgraded existing lines, Ausbaustecke (ABS), and the construction of new lines for high-speed operation, Neubausterecke (NBS). On these lines, high-speed trains called Inter City Express (ICE) are running at a maximum speed of 200 km/or over. High-speed trains started running in 1991, far later than the inauguration of the TGV SudEst line (1981).

5.31 The year of 1991 started with the 250 km/h operation by ICE1 on the ICE line 6 including the new high-speed railway between Mannheim and Stuttgart. After the success of 250 km/h operation, Germany expanded the network in the country and is now expanding the international network to such places as Zurich in 1992, Wien in 1998, Amsterdam in 2000 with ICE3, Brussels in 2002 and Paris/Copenhagen in 2007. The total service route covered by German high-speed trains is as long as 1,285 km as of March 2011.

5.32 The following features are specific to German high-speed railways:

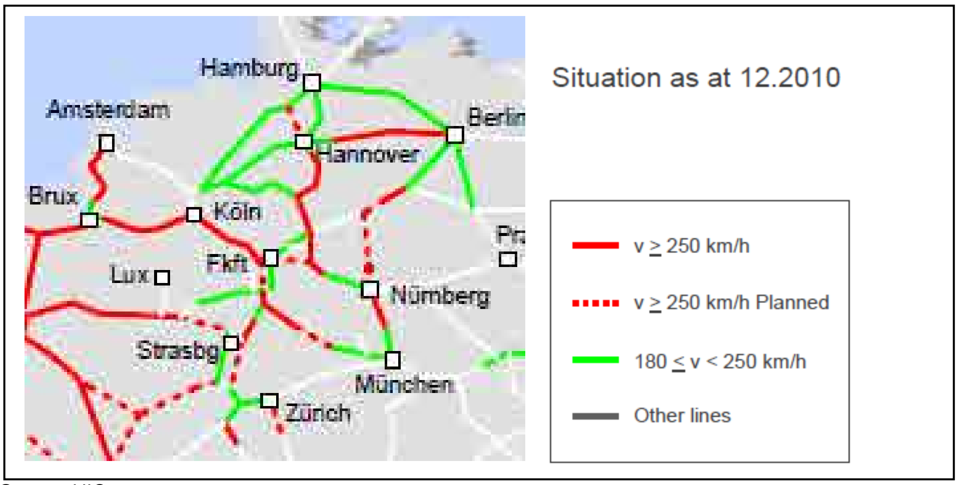
(i) Development is under way by both ABS and NBS schemes.

(ii) NBS is not necessarily dedicated to the lines for high-speed trains, but mixed traffic railways are also constructed under this scheme to deal with freight transport.

(iii) The power supply system uses the power of AC 15kV at 16-2/3 Hz, which is normally supplied to existing railways. This is rarely seen with other high-speed railways in the world.

5.33 Furthermore, the high-speed trains are equipped with the Linienzugbeeinflussung (LZB), a signal system specific to Germany. The single-track bi-directional operation is possible even in double-track sections.

(2) Description of Main Lines



Source: UIC

Figure 5.1.3 High-Speed Railway Network in Germany

Table 5.1.5 Main Characteristics of High-Speed Lines in Germany

Line	Hannover - Wurzburg	Mannheim -Stuttgart	Hannover - Berlin	Colonge -Frankfurt
Year opened	1988/1991/1994	1985/1991	1998	2002/2004
Length	338 km	109 km	189 km	197 km
Usage	Mixed	MIxed	Mixed	Dedicated
Track gauge	1,435 mm	1,435 mm	1,435 mm	1,435 mm
Max. Axle Load	20 tf	20 tf	20tf	16 tf
Max. design Speed	300 km/h	300 km/h	300 km/h	300 km/h
Max. operationSpeed	280 km/h	280 km/h	300 km/h	300 km/h
Max. gradient	12.5/1000	12.5/1000	12.5/1000	40/1000
Min. verticalcurve radius	30,000 m	30,000 m	30,000 m	11,500 m
Min. curve radius	7,000 m	7,000 m	7,000 m	4,000 m
Distance between Track centers	4.7 m	4.7 m	4.7	4.5
Formation width	13.7 m	13.7 m	13.7 m	12.1 m
Tunnel cross section	100 m^2	100 m^2	Nothing	92 m^2
Width of Rolling stock	3,020 mm	3,020 mm	3020 mm	3020 mm

Source: JICA Study Team from various data

(a) **Mannheim–Stuttgart and Hannover–Wurzburg:** These sections belong to the first phase new high-speed railway (NBS), designed in consideration of axle load (19.5t) and gradient (12.5%), while assuming common use for freight transport or mixed traffic operation. High-speed freight container trains were operated at 160 km/h for some time. The operation of freight trains is restricted due to the limited axle load and the maintenance costs for tracks and rolling stock, except the operation of Parcel Intercity (PIC).

(b) **Hannover–Berlin:** This is part of a high-speed railway inaugurated in 1998 to connect Hannover and Berlin, the capital of the country, which was constructed by combining two schemes: improvement of existing railways (ABS) and construction of new lines (NBS). The maximum speed is 200 km/h in the ABS section and 250 km/h in the NBS section. Rheda track, which is a sort of rigid tracks, is adopted in part of the total route.

(c) **Cologne–Frankfurt:** This is part of a second-generation high-speed railway dedicated to passenger transport without following the preceding case where freight trains were operated, thereby cutting the construction costs by changing the maximum axle load to 16 tons and the maximum gradient to 40‰. Rhedatrack, a sort of rigid tracks, is used along the whole route.

(d) **Cologne–Aachen:** This section was completed up to Duen in 2003, as part of the high-speed railway network extending to Brussels and Paris. This is a existing railway improved for high-speed operation (ABS), on which IEC trains run at a maximum speed of 250 km/h. As the TGV Thalys coming from France is not equipped with German signaling system, the maximum speed thereof is as low as 140 km/h.

(e) **Hamburg–Berlin:** This is an ABS line completed in 2004 to connect the two post-unification largest cities in Germany by executing large-scale construction work to remove level crossings and reinforce tracks since 2001. Trains are running at a maximum speed of 230 km/h to substantially cut the travel time between the two cities.

(f) **Nuremburg–Munich:** The Nuremberg–Ingolstadt section was completed by an NBS scheme and the Ingolstadt–Munich section by an ABS scheme. The maximum train speed is 300 km/h in the NBS section and 200 km/h in the ABS section. In the NBS section, regional trains (maximum speed 140 km/h) are also operated. Trains are installed with the German signaling system (LBZ) and ETCS-level.2/GMS-R of the European common specifications.

(3) Rolling Stock

5.34 There are a variety of Intercity Express (IEC) trains in Germany that cope with different applications, as the country shall operate not only high-speed trains but also international trains and other trains on a number of diversified railway lines in the country. Power at AC15 V at 16-2/3 Hz is the basic medium of energy supply used for existing railways, together with a DC1.5 kV/ 3kV system and diesel engines in supplementary use. There are some cars equipped with a car body tilting system.

5.35 Trains were hauled by locomotives at the initial stage. However, the train haulage system is replaced gradually with the electric multiple unit (EMU) system. The major train types are as follows:

(a) **IEC1:** This is a locomotive push-pull type train that started operation in 1991. Its total length is 358 m. The train formation is 2L12T to run at a maximum speed of 250 km/h.

(b) **ICE2:** This is a version, shortening the formation to 8-car composition for easier handling. One of the two locomotives is replaced with a passenger car attached with a driving cab. The train formation is 1L1C6M (where C stands for control trailer). The maximum speed in revenue services is 250 km/h in pulling operation and 200 km/h in pushing operation.

(c) **ICE-T:** The train is equipped with a car body tilting system to run on sharp curves in mountainous areas. It has a car body made of aluminum alloy. The maximum speed is 230 km/h. There are 7-car and 5-car composition train sets.

(d) **ICE3:** This is the first electric multiple unit (EMU) ICE train that made its debut in 1998 to run at a maximum speed of 300 km/h. The train formation is 4M4T. An aluminum alloy car body is adopted to correspond to the axle load of 16 tons. In August, 2002, it performed 300 km/h operation in the Cologne -Frankfurt section. There are train sets of different versions, such as those installed with a center driving cab and those corresponding to a multiple power supply system at 25 kV-50 Hz/DC1.5 k V/DC3 kV. In the section under the DC supply system, trains run at a maximum speed of 220 km/h. To control running speed used in combination are the disk brake, regenerative brake and eddy current brake systems.

(e) **ICE TD:** A diesel type train for non-electrified sections, equipped with a car body tilting system to run at a maximum speed of 200 km/h.

(f) **ICE Velaro:** A train designed on the basis of IEC3 running at a maximum speed of 320 km/h to correspond to the latest international trains. It has advanced into the networks in other countries. The trains used for international trains from Germany are called VelaroD, those for Spain Velaro E, those for Russia Velaro RUS (Сапсан/Sapsan) and those for China Velaro CHR. The body width for Velaro CHR is extended to increase the passenger capacity.

Table 5.1.6 Main Characteristics of ICE Rolling Stock

Series	ICE-1	ICE-2	ICE-3	ICE-T	ICE-TD	ICE-Veralo
Year in Service	1991	1996	1999	2000	2001	2011
Train Formula	2L12T	2L10T	3M2T	4M4T	4M	4M4T
Feature (1)	C	C	T,EMU	EMU	T.DEM	EMU
Max. design speed (km/H)	280	280	230	330	200	320
Max. operation speed(km/h)	280	280	230	300	200	320
Train length (m)	358	205	132	200	106	200
Train width (mm)	3020	3020	2850	2950	2850	2935
Seat capacity	703	368	250	429	196	460
Train weight (t)	782	410	273	409	200	454
Max. Axle Load (t)	19.5	19.5	15	16	N.A	< 17
Power (kW)	9600	4800	3000	8000	2240	8000
Voltage	15kv16.7Hz	15kv16.7Hz	1.5kV 3kV 15kv16.7Hz 25kV-50Hz	15kv16.7Hz	Diesel	1.5kV 3kV 15kv16.7Hz 25kV-50Hz
Gauge (mm)	1435	1435	1435	1435	1435	1435

Source: JICA Study Team editing UIC data
Note (1): C; Concentrated power, A; Articulated, T; Tilting, D; Double Decker

5) Italy

(1) Overview

5.36 Italy is a pioneer of high-speed railways in Europe, in that it demonstrated revenue service operation in the Rome–Ancona section in 1976,a prototype of the later series production ETR450 trains. Thereafter, Italy promoted construction of high-speed railways to complete the current 923 km-long high-speed railway network.

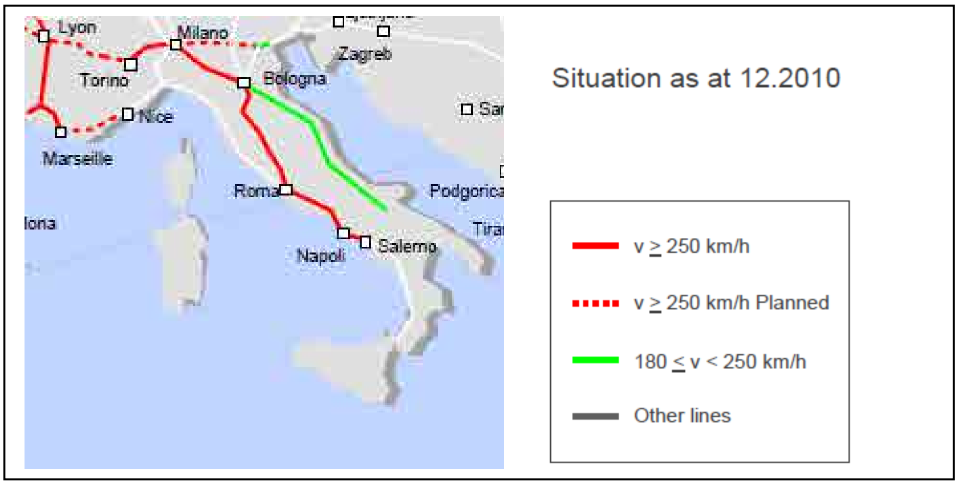
5.37 As a special feature of Italian railways, trains of the distributed traction type, such as diesel multiple unit (DMU) trains and electric multiple unit (EMU) trains have developed along with the car body tilting system from early stages. A high-speed railway model was established in the first high-speed railway constructing plan called Direttissima. Although the model eliminates level crossings and satisfies conditions for high-speed operation including those on gradients, it does not necessarily assume high-speed railway lines dedicated to passenger trains alone. In actuality, it also considers through-operation to/from existing railways, operation of freight trains. The standard distance between track centers is 5.0 m.

5.38 The power supply system supplies power at AC25 kV for the latest high-speed railways and at DC3, 000 V for the Rome-Florence section that was constructed earlier.

5.39 The 9-code type cab signal system (RS4Codici) was originally used for high-speed railways in Italy. In recent years, however, the European standard ETCS-level 2 is introduced into newly constructed high-speed railways.

5.40 Whereas Trinitarian monopolized train operation in the past, Nuovo Transporto Viaggiatori (NTV), a new entrant who participated in train operation, started 300 km/h operation in April 2012 on the Rome - Napoli line using the latest Automotrice a Grande Vitesse (AGV) trains (designed for 360 km/h operation).

(2) Description of Main Lines



Source: UIC

Figure 5.1.4 High-Speed Lines in Italy

Table 5.1.7 Main Characteristics of Dirrettisima in Italy

Line	Rome- Firenze	Rome- Naples	Firenze- Bologne	Bologne- Milano
Year opened	1981/1984/1992	2006	2009	2008
Length	248km	220km	77km	182km
Usage	Mixed	Mixed	Mixed	Mixed
Track gauge	1,435mm	1,435mm	1,435mm	1,435mm
Max. Axle Load	22.5tf	22.5tf	22.5tf	22.5tf
Max. design Speed	250km/h	300 km/h	300 km/h	300 km/h
Max. operation Speed	250km/h	300 km/h	300 km/h	300 km/h
Max. gradient	8.5/1000	18/1000	18/1000	18/1000
Min. vertical curve radius	20,000m	20,000 m	20,000/30,000 m	20,000/ 30,000 m
Min. curve radius	3,000 m	5,450 m	5,450 m	5,450 m
Distance between Track centers	4.2 m and 4.5 m	5.0 m	5.0 m	5.0 m
Formation width	13.0m	13.6 m	13.6 m	13.6 m
Tunnel cross section	54/60/68m^2	82 m^2	82 m^2	90 m^2
Width of Rolling stock	3150mm	3150mm	3150mm	3150mm

Source: JICA Study Team from various data

(a) **Rome–Florence:** This is the first high-speed railway called Direttissima in Italy. After construction work was started in 1976, the total route was inaugurated in 1992 to run trains at a maximum operating speed of 250 km/h. In the total route length of 254 km, the new high-speed section is 237 km long. The line is electrified at DC3 kV, the same voltage as that for existing lines. As this system cannot supply power sufficiently for 300 km/h operation, the voltage will be changed to AC25 kV.

(b) **Rome–Naples:** This is the second high-speed railway put into service in 2009 to run trains at a maximum speed of 300 km/h. This is the case where power at AC25 kV–50 Hz was introduced for the first time in Italian high speed-railways. The signal system of the European standard ETCS-level 2 is adopted.

(c) **Turin–Naples:** After partly opened in 2006 at the time of the Turin Olympic Games, this line was inaugurated up to Milan in 2009 to run trains at a maximum speed of 300 km/h.

(d) **Milan–Bologna:** This is an approximately 180 km-long railway opened in December 2008, where trains are running at a maximum speed of 300 km/h.

(e) **Florence–Bologna:** This railway crosses the Apennines. Most of the total length of 77 km is studded with tunnels including the longest one (length 18.7 km) in Italy. Train operation started in 2009 to cut the travel time to 30 minutes from about 60 minutes required in the past.

(3) Rolling Stock

5.41 There are two categories of typical high-speed rolling stock: one is the Pendolino type EMUs (ETR450/460/470/480/600) installed with a car boy tilting system (maximum speed 250 km/h) and the other the push-pull locomotive haulage type non-tilt ETR500 trains (maximum speed 300 km/h) .

(a) **ETR450/460/470:** These cars are tilting EMUs known as Pendolino, each having an aluminum alloy car body. The train formation is 8M1T. A train set is composed of nine cars all having first-class accommodations. ETR460 trains have some second class cars in the train composition. ETR470 trains accommodate AC15 kV-16-2/3 power supply for through-operation to/from Switzerland.

(b) **ETR480:** The basic performance is the same as that of ETR470, etc. The ETR480 trains can run on the Italian domestic high-speed railway lines at AC25 kV.

(c) **ETR500:** This is the high-speed rolling stock of the type of a concentrated traction system. A 12-car train set has two locomotives, one each at head and tail, to compose a 2L11T train formation. To run on the lines dedicated to high-speed operation alone, they are not equipped with the car body tilting system.

(d) **ETR600:** The ETR 600 trains are composed of the third-generation Pendolino cars to correspond to inter-operability. The train formation is 4M3T. They have aluminum double-skin car bodies of a shock absorber structure, to minimize the damage on passengers at collision.

(e) **AGV:** This is the up-to-date high-speed rolling stock developed by Alstom a TGV supplier in France. Unlike TGV, it adopts an EMU system. The AGV trains were operated in the Rome-Milan section in 2012 by NTV, a late entrant participated in high-speed operation, in advance of France. The cars designed for 350 km/h operation are now running at a maximum speed of 300 km/h.

Table 5.1.8 Main Characteristics of High-speed Train in Italy

Series	ETR450	ETR480	ETR500	ETR600	AGV
Year in Service	1988	1997	2000	2008	2012
Train Formula	8M1T	6M3T	2L12T	4M3T	6MB6TB
Feature (1)	T.EMU	T,EMU	C	T,EMU	A,EMU
Max. design speed (km/H)	250	250	300	250	300
Max. operation speed(km/h)	250	250	300	250	300
Train length (m)	234	237	354	187	200
Train width (mm)	2750	2800	2860	2830	2900
Seat capacity	390	480	671	432	446
Train weight (t)	435	422	640	443	384
Max. Axle Load (t)	12.5	13.5	17	17	17
Power (kW)	5000	5880	8800	5600	8640
Voltage	3kV	3kV 25kV-50Hz	3kV 25kV-50Hz	3kV 25kV-50Hz	3kV 25kV-50Hz
Gauge (mm)	1435	1435	1435	1435	1435

Source: JICA Study Team editing UIC data
Note (1): C; Concentrated power, A; Articulated, T; Tilting, D; Double Decker

6) Spain

(1) Overview

5.42 After operating the first high-speed trains in the Madrid - Seville section on the occasion of the Olympic Games in Barcelona and the International Exposition in Seville in 1992, Spain quickly expanded its high-speed railway network to establish the largest one of its kind in Europe featuring a total length of 2,000 km or over in 2011. Spain is a pioneer in the development of high speed railways, in that the country planned 350 km/h operation first in the world (between Madrid and Barcelona). After repeating partial inauguration of the Madrid–Barcelona section, Spain eventually started 300 km/h operation in that section in 2008.As various problems remain unsolved, however, the service speed is still 300 km/h. Thereafter, the Madrid–Valencia line was opened in 2010.

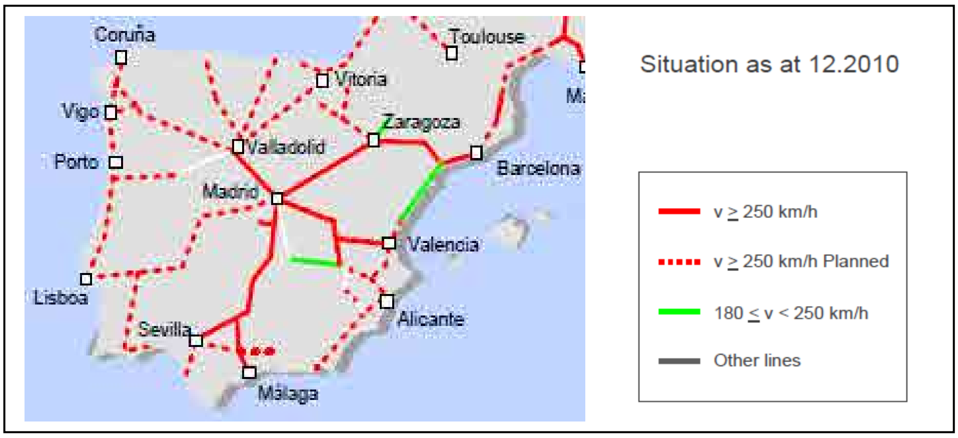
5.43 The railways in Spain feature that the existing lines are constructed to the broad- gauge (1688 mm) and pass sharp curves in mountainous areas. To perform through-operation to/from other countries, therefore, the country has been using cars equipped with a gauge-changing system and a car body tilting system.

5.44 Spain decided to adopt the standard gauge of 1,435 mm after repeating discussions in introducing high-speed railways. Therefore, Spain started high speed operation on a newly constructed standard-gauge section. High-speed railway trains are also running for through- operation to/from new lines/remodeled existing lines and non-remodeled existing lines. The technologically characteristic gauge- changing mechanism had already been developed by Talgo for through-operation between existing lines and the networks in other countries.

5.45 The high-speed railway operation in Spain started with the German signaling system, LZB system. Spain is positive in introducing ETCS, in that ETCS-level 1 has already been put in practical use on the Barcelona line, with the rolling stock equipment and ground facilities for ETCS-level 2 already installed and tested to suggest that revenue service operation is just around the corner.

5.46 The power supply system uses 25 kV overhead trolley wires and the track structures are of the ballasted type.

(2) Description of Main Lines



Source: UIC

Figure 5.1.5 High-Speed Railway Network in Spain

Table 5.1.9 Main Characteristics of High-Speed Lines in Spain

Line	Madrid- Sevilla	Madrid- Barcelona
Year opened	1992	2003/2006/2008
Length	471km	709km
Usage	Mixed	Mixed
Track gauge	1,435mm	1,435mm
Max. Axle Load	17.2/22.5tf	17.2/22.5tf
Max. design Speed	300km/h	350km/h
Max. operation Speed	250km/h	300km/h
Max. gradient	12.5/1000	20/1000
Min. vertical curve radius	24,000m	25,000m
Min. curve radius	3,900m	6,800m
Distance between Track centers	4.3m	4.7m
Formation width	13.3m	14.0
Tunnel cross section	75.0m^2	115m^2
Width of Rolling stock	2,904mm	2,904mm

Source: JICA Study Team from various data

(a) **Madrid–Seville:** This is the first high-speed railway line in Spain inaugurated on the occasion of the Seville International Exposition in 1992 to connect the capital city of Madrid and the Seville in the southern Spain. The structure to eliminate level crossings and utilization of AC25 V power supply system and ballasted tracks of this railway has established a standard for high-speed railways in Spain. Various standards are adopted to take into account the operation of freight trains, in that the maximum axle load is set at 22.5 tons, for example.

(b) **Madrid–Barcelona:** This is a line to connect the capital city of Madrid to Barcelona, the second largest city in Spain, on the coast of the Mediterranean Sea, inaugurated up to Barcelona in 2008, after repeating partial inaugurations in 2003 and 2006. The line is structured to allow 350 km/h operation, with the tunnel cross-section and the distance between track centers extended for that purpose. However, the current maximum train operation speed remains 300km/h.

(c) **Madrid–Valladolid:** This section was opened in 2007 as a hub of the high-speed railway network to the northern and northwestern Spain, having a 28 km-long tunnel on the route, the longest one in the country.

(d) **Madrid–Valencia:** This section was opened as part of the Levante line running along the Mediterranean Sea coast. Trains are now running at a maximum speed of 300 km/h on the line that is designed for 350 km/h operation.

(3) Rolling Stock

5.47 The high-speed trains are classified into three categories: AVE for long distance, Avant for medium distance and Alvia. For this reason, therefore, Spain has various types of rolling stock incorporating the technologies of different countries. What is specific to Spain is the gauge changing system equipped on the Alvia trains that run on standard gauge new lines and existing broad-gauge lines.

(a) **S-100/101:** The S-100 cars are of the TGV type concentrated traction system, introduced first into AVE, featuring a designed maximum train speed of 300 km/h. The S-101 trains, a version of the S-100 remodeled for broad gauge (1,668 mm) tracks, are designed to run at a maximum speed of 220 km/h. The train formation is 2L8T.

(b) **S-102/112:** These are the second generation AVE cars, or the Talgo type cars equipped with a single-axle articulated bogie system based on the traditional Spanish technologies. The design maximum speed is 330 km/h. The train formation is 2L12T. S112 is almost the same as S102. Only one difference in-between is that S112 has more passenger seats than S102.

(c) **S-103:** These are the third generation AVE cars, or the EMU type high-speed Velaro cars manufactured by Siemens and introduced into Spain. The train formation is 4M4T. The design maximum speed is 350 km/h.

(d) **S-104/114:** The S-104/114 cars have been developed for easy-to-handle medium-distance Avant trains adopting a short EMU system to run at a maximum speed of 250 km/h. The train formation is 4M.

(e) **S-120/130:** These are the dual-gauge type cars for through-operation to/from existing lines. The maximum train speed is 250 km/h. The train formation of the EMU type S120 cars is 4M and that of the Talgo type S-130 is 2L11T.

Table 5.1.10 Main Characteristics of AVE / Avant / Alvia Rolling Stock

Series	AVE S-100 (TGV)	AVE S-102 (Talgo)	AVE S-103 (Velaro-E)	Avant S-104	Alvia S-120	Alvia S-130 (Talgo)
Year in Service	1992	2005	2007	2005	2006	2007
Train Formula	2L8T	2L12T	4M4T	4M	4M	2L11T
Feature (1)	C,A	C,A,T	EMU	EMU	EMU	C,A,T
Max. design speed (km/H)	300	330	350	250	250	250
Max. operation speed(km/h)	300	300	300	250	250	250
Train length (m)	200	200	200	107	107	185
Train width (mm)	2904	2960	2950	2920	2920	2960
Seat capacity	329	319	404	236	196	298
Train weight (t)	392	324	439	222	238	N.A
Max. Axle Load (t)	17.2	17	< 17	17	16.2	18
Power (kW)	8800	8000	8800	4000	4000	4800
Voltage	3kV	25kV-50Hz	25kV-50Hz	25kV-50Hz	3kV 25kV-50Hz	3kV 25kV-50Hz
Gauge (mm)	1435	1435	1435	1435	1668/1435	1668/1435

Source: JICA Study Team editing UIC data
Note (1): C; Concentrated power, A; Articulated, T; Tilting, D; Double Decker

7) South Korea

(1) Overview

5.48 Korea Train eXpress (KTX) has introduced the technology based on the French TGV system and the maximum operating speed of KTX is 305 km/h. The project plan and routes were decided in 1990 and the construction started in June, 1992. After spending 12-year of time and project cost amounting to as much as 20% of national budget, the service was provisionally opened on April 1, 2004. On November 1 in 2010, the line between Seoul and Busan was fully opened. The fastest train connects the two cities in 2 hours and 18 minutes. With this railway, South Korea has become the Asian country which owns the second highest-speed railway system after Japan.

5.49 The Seoul-Busan Corridor, which connects soul and the international port city of Busan, has a series of big cities such as Daejeon and Daegu and the existing

Seoul-Busan line has been used for transportation. As the transportation capacity is close to its limit, the Seoul-Busan high-speed railway plan was formulated as the drastic measure for resolving the issue. As a result of the competition among Japan, France and Germany with advanced high-speed railway systems for international bidding for rolling stocks, signal and catenary system, it was decided to introduce the French TGV system in 1994.

5.50 As the same standard gauge (1435 mm) is used both for existing lines and for the high-speed new lines in Korea and the combined use of these two lines is available, it was decided to use the existing lines around Seoul and Busan and to construct a new high-speed line for other areas. Also, it was decided to open the new line in two stages and some of the routes were changed. The plan for direct operation from Daejeon to Mokpo and Gwangju was approved in 2000 after implementing the improvements in track structure for the existing Honam Line and the use of AC power for all lines.

(a) **The 1st Phase (Opened on April 1, 2004):** The high-speed new line was constructed only for the section between Seoul and East Daegu and the existing line was changed to AC power (25 kV60Hz) for the section near Daejeon and the section between East Daegu and Busan. Also, the direct service of high-speed new line and the existing line was established between Seoul and Busan and the operation thorough to the existing Honam Line was established after the electrification of this Line.

(b) **The 2nd Phase (Fully Opened on November 1, 2010):** The high-speed new line from East Daegu, Gyeongju, through to Busan was completed, making the full opening of high-speed new line between Seoul and Busan.

Source: "High Speed Trains of the World II" (Diamond, Inc.)

Figure 5.1.6 High-Speed Railway Network in South Korea

(2) Routes and Facility

5.51 The total length is 423.8 km. Major construction standard specifications are as shown in the Table 5.1.11.

Table 5.1.11 KTX Construction Specifications

Item	Description
Maximum design speed: 350 km/h	Maximum operating speed: 300 km/h (KTX-1) 305 km/h (KTX-2)
Gauge: 1,435 mm	Distance between track center: 5.0 m
Track: Ballast track Rail: UIC60 kg/m, long rail	Minimum curve radius: 6,250 m
Minimum curve radius: 7,000 m	Double track tunnel cross-section: 107 m^2

Source: JICA Study Team

5.52 The French TGV system has been introduced for the electric facility. The outline is as shown in the Table 5.1.12

Table 5.1.12 Outline of Electric Facility

Train control system	Automatic Train Control (ATC), capable of two way operation on single track Cab signal system: TVM (Transmission Voie Machine) 430
Power system	25 kV×2, 60 Hz, one-track AC, AT feeding system
Substation	10 stations: 2 for rolling stock base; 8 along the main line

Source: JICA Study Team

(3) Rolling Stock

5.53 The KTX-1, which started operation on April 1 in 2004, used the French TGV system and is characterized by its high-speed performance and a good combination of high-speed new line and existing line. In Korea, domestically manufactured high-speed trains for the maximum speed of 350 km/h were developed. KTX-2 was developed based on the results of test run with a prototype train. KTX-2 changed the unpopular fixed seat of KTX-1 into an expanding seat and consists of 10 rolling stocks to respond to a small number of passengers on the Honam Line for which the KTX-1 consists of as many as 20 cars. Basic specifications of KTX are as shown in the Table 5.1.13.

Table 5.1.13 Basic Specifications of KTX

Item	Rolling Stock Type	
	KTX-I	KTX- II
Maximum operating speed	300 km/h	305 km/h (maximum design speed: 350 km/h)
Power system	AC25 kV 60Hz	AC25 kV 60Hz
Train formation	2L2M16T (20 cars, total length of 388 m)	2L8T (8 cars, total length of 201.2 m)
Axle load	17 tons (maximum capacity)	
Weight	699 tons (empty) - 774 tons (full capacity)	403 tons (empty) - 434 tons (full capacity)
Rated output	13200 kW	8800 kW
Capacity	Special cabin (1st-class car: 2+1 seats):127 passengers Standard cabin (2nd-class car: 2+2 seats): 808 passengers Total: 935 passengers	Special cabin (1st-class car: 2+1seats): 30 passengers Standard cabin (2nd-class car: 2+2seats): 333 passengers Total: 363 passengers Including three wheel-chair accessible seats

Source: JICA Study Team

8) Taiwan

(1) Overview

5.54 Large-capacity and high-speed means of transportation had been strongly requested as a response to the concentrated population and economic activities in the western areas in Taiwan and to the increase in traffic demand accompanies by the economic growth in Taiwan since the late 1980's and the survey on high-speed railway was launched. Major events up to the conclusion of contract for electric and mechanical systems by a joint venture between several Japanese companies are as shown below:

(a) **June 1990:** Ministry of Transportation & Communications of Taiwan officially approved the construction of high-speed railway in the western part of Taiwan.

(b) **December 1994:** The BOT (Build-Operator-Transfer) Scheme Act was enacted.

(c) **October 1996:** Preliminary assessment for the eligibility of BOT operators was conducted.

(d) **March 1997:** Two groups passed the BOT operator assessment.

(e) **In the end of September 1997:** The Taiwan High Speed Rail Consortium proposing the German and French system was chosen as the preferred bidder.

(f) **April 1999:** The Taiwan High Speed Rail Corporation asked the Japanese group and the European group to submit a proposal on the system to be adopted.

(g) **December 28, 1999:** The Taiwan High Speed Rail Corporation chosen the Japanese group as the preferred bidder.

(h) **December 2000:** The Taiwan High Speed Rail Corporation concluded a contract on the electric and mechanical systems.

5.55 The scope of contract signed by the Japanese group mainly covered the provision of rolling stocks and entire electric facilities as well as the track work and basic design of depots.

5.56 In March 1999, the civil engineering work was started and the target speed of 315 km/h was achieved in the test construction zone on October 30, 2005. On January 5 in 2007, the operation for the section between Banqiao and Kaohsiung was started, and in the same year the delayed construction of underground section in Taipei City was finally completed. With this completion, the line between Taipei and Kaohsiung was fully opened on March 2, 2007.

5.57 As Japanese system was used for the new line, education and training on Shinkansen were provided in Japan to the employees of Taiwan High Speed Rail Corporation. The education and training covered approximately 170 employees in the fields like driver, operation control, operation planning, train conductor, electricity, signal and rolling stock and a total of more than 110,000 hours were spent.

Source: Japan Overseas Rolling Stock Association (JORSA), Newsletter 112, August 2009.

Figure 5.1.7 High-Speed Railway Network in Taiwan

(2) Outline of Route and Facility

5.58 The total length of line was 345 km between Taipei and Kaohsiung. The route planning data is as shown in the Table 5.1.14.

Table 5.1.14 Route Planning Data

Item	Description
Maximum design speed: 350 km/h	Maximum operating speed: 300 km/h
Gauge: 1,435 mm	Distance between track center: 4.5 m
Rail: 60 kg/m, long rail	Minimum curve radius: 6,250 m
Maximum gradient: 25‰ (some section tolerable of 35%)	Double track tunnel cross-section: approximately 90 m^2

Source: JICA Study Team

5.59 There were eight stations upon the start of operation between Taipei and Kaohsiung and another three stations will be added in the future. Only the four stations, Taipei, Banqiao, Taichung, and Kaohsiung stations, have the direct service to existing lines and most of the new stations are located far from the downtown.

5.60 Two rolling stock bases (Taichung and Kaohsiung) were established upon the start of operation and a new depot will be added in the Taipei district in the future. Also, the rolling stock workshop will be constructed in Kaohsiung district.

5.61 Approximately 72% (247 km) of the total structure consists of viaduct and bridges, approximately 19% (65 km including the underground section in Taipei) is made up of tunnels, and approximately 10% (33 km) consists of cutting and embankment.

5.62 The track structure for the underground section in Taipei and stations uses the German ladder track, ballast tracks are used around the Kaohsiung Station and

Japanese slab tracks are used for other areas. The turnout for the main line is in accordance with the European Specifications No. 33, 26, etc.

5.63 The outline of electric facility is as shown in the Table 5.1.15.

Table 5.1.15 Outline of Electric Facility

Item	Description
Train control system	Automatic Train Control (ATC), capable of two way operation on single track
Power system	25kV×2, 60Hz, one-track AC, AT feeding system
Substation	9 stations: 2 for rolling stock base; 7 along the main line
Catenary system	Main line: heavy compound system; other than main line: heavy simple system
Communication facility	Train radio system, PA (Passenger Address) system

Source: JICA Study team

(3) Rolling Stock

5.64 Rolling stocks are high-speed trains based on 700 Series Shinkansen used for Tokaido and Sanyo Shinkansen Lines at that time and they use a multiple-unit system driven by an AC motor designed for the use in Taiwan. Specifications of 700T are as shown in the Table 5.1.16. Currently, train frequencies per day are more than 70 round trips on Saturdays and Sundays. The line connects Taipei and Kaohsiung in 1 hour and 36 minutes to 2 hours.

Table 5.1.16 Basic Specifications of 700T

Item	Description
Maximum operating speed	300 km/h
Power system	AC25 kV 60Hz
Train formation	9M3T (12 cars, total length of 304m)
Weight	503 tons (empty)
Rated output	10260 kW
Capacity	Business car (1st-class car: 2+2 seats): one car for 66 passengers Standard car (2nd-class car: 2+3 seats): 11 cars for 923 passengers Wheel-chair accessible seats: 4 seats Total: 993 passengers

Source: JICA Study Team

9) China

(1) Overview

5.65 With the increase in the movement of goods and people in the vast land due to the economic growth, Chinese railways have been playing an important role. However, a drastic improvement was required in the railway system and the construction of new high-speed passenger dedicated lines was announced in the 10th five-year plan (2001-2005) to expand the cargo transportation on the existing lines. “The Medium-to Long-Term Plan for Railway Network” was established in the spring of 2004, stimulating the plan for the network to be constructed over the next 20 years and the railway construction schedule over the next five years. The implementation situation up to present for “The Medium-to Long-Term Plan for Railway Network” is as described below:

(i) The total length of line opened: approximately 7,500 km (200 km/hour or over)

(ii) The total length of line to be completed by 2020: approximately 13,200 km (200 km/hour or over)

5.66 The currently opened routes with the design speed of 350 km/hour are as shown in the Table 5.1.17.

Table 5.1.17 High-Speed Railways Opened in China

Route Name	Total Length (km)	Design Speed (km/h)	Start of Construction	Opened
Beijing–Tianjin	114	350	July, 2005	August 1, 2008
Wuhan–Guangzhou	1,069	350	June, 2005	December 26, 2009
Zhengzhou–Xian	505	350	September, 2005	February 6, 2010
Shanghai–Nanjin	301	350	July, 2008	July 1, 2010
Shanghai–Hangzhou	202	350	September, 2008	October 26, 2010
Beijing–Shanghai	1,318	350	April, 2008	June 30, 2011
Guangzhou–Shenzhen	116	350	August, 2008	December 26, 2011
Total	3,625			

Source: JICA Study Team

5.67 After examining high-speed railway design and technology in the world in details and introducing necessary technology, China established the design speed based on the situation in China. The design standards for each speed established are as shown in the Table 5.1.18.

Table 5.1.18 Design Standards for High-Speed Railways in China
(TB10621-2009, J971-2009)

Item	Unit	Maximum Design Speed		
		250 km/h	300 km/h	350 km/h
Gauge	mm	1,435		
Minimum curve radius	m	4,000	5,000	7,000
Minimum vertical curve radius	m	20,000	25,000	
Maximum cant	mm	180		
Tolerable cant shortage	mm	80		
Maximum gradient	‰	35		
Distance between track center	m	4.6	4.8	5.0
Maximum axle load	ton	20		
Track formation width :slab track	m	13.2	13.4	13.6
:ballast track	m	13.4	13.6	13.8
Tunnel cross-section (double tracks)	m^2	90	100	

Source: JICA Study Team

5.68 These design standard values such as distance between track center, maximum axle load, track formation width and tunnel cross-section are greater than those for Shinkansen and it is estimated that these values have an allowance to be on the safe side.

5.69 The Chinese Ministry of Railways reviewed the operation speed on June 13, 2011 prior to the start of operation of the Beijing–Shanghai High-Speed Railway and announced that the operation speed will be reduced from 350 km/h to 300 km/h from the start of operation. Furthermore, the operation speed for three routes including the route between Wuhan - Guangzhou that were opened and operated at the running speed of 350 km/h was reduced to 300 km/h according to the train schedule revised in July in the same year. On July 23 in the same year, a devastating high-speed train collision occurred in Wenzhou, which made people keenly aware of the importance and difficulty of ensuring safety during operation.

(2) Description of Main Lines

(a) **Beijing-Tianjin Intercity Railway:** The 114 km line started the operation with the maximum speed of 350 km/hour as the first high-speed railway in China on August 1 in 2008 which was one week before the opening of Beijing Olympics. After the start of construction in July 2005, the track construction work by using the Bougel of track of Germany was competed in December, 2007. Also, speed increasing test after the electric work and test operation according to the regular train schedule were implemented to get ready for the start of operation. Currently, four stations are opened and the line will be extended to the harbor area in Tianjin in the future. Note that this is a line different from the Beijing-Shanghai High-Speed Railway. The railway provides 94 train services per day in each direction, in addition to the 26 train services including direct services to the existing lines from Tianjin and high-speed (200-250 km/h) trains to Jinan, Tsingtao and other cities.

Source: JICA Study Team

Figure 5.1.8 High-Speed Railway Network in China

(b) **Wuhan-Guanzhou High-Speed Railway:** The line connecting Beijing and Guangzhou has one of the greatest amount of goods and passengers to be transported among Chinese railways and the carrying capacity of the line has reached a saturation point. Particularly, the overcrowding for the section between Wuhan and Guangzhou was high and early construction of the line was expected. The construction of the section between Wuhan and Guangzhou was started on June 23, 2005 and the operation was provisionally started for the section between Wuhan and Guangzhou North Station on December 26, 2009. The line extending to the Guangzhou South Station was opened on January 30, 2010, making the full opening of the line.

5.70 The minimum curve radius is 9,000 m for this section and the maximum gradient is 12‰. The number of stations was 14 upon the start of operation and the number of train services was 66 per day three month after the start of operation, with approximately 60% passengers of its capacity on average.

(c) **Beijing-Shanghai High-Speed Railway:** It is said that 0.3 billion people live along the Beijing-Shanghai railway line with a larger number of connected urban areas than that along the Tokaido Shinkansen Line in Japan. This line is highly expected to enjoy the increase in users due to economic growth. The groundbreaking ceremony for this line was conducted on April 18, 2008, attended by with the Chinese premier Wen Jiabao and the operation began on June 30, 2011. Although the construction period was practically three years, land issues have been almost solved for the entire line and civil engineering work has been ordered before the groundbreaking ceremony in most cases in China. It took only a little more than three years to complete civil engineering work, track work, electric work, test operation and other appropriate works for the 1,000 km line. Although the capability should be praised, there is a concern over ensuring of the structural quality, maintaining of safe and secure operation/maintenance system, and other issues.

5.71 A train set consists of 16 trains or 8 trains and the number of services is 63 per day (300 km/h) and 27 per day (250 km/h), which makes 90 services per day in total. The fastest train connects Beijing and Shanghai in 4 hours and 48 minutes.

(3) Rolling Stock

5.72 The Table 5.1.19 shows the typical rolling stock performance for the Chinese high-speed railways and the preceding section describes the background of development and the sections using each rolling stock type.

(a) **CRH2A:** CRH2A, developed after the Japanese E2 Series 1000, has been manufactured since 2006 and offered for the service since 2007. As the CRH2A has the specifications designed for warm region, it is mainly operated for the section between Shanghai and Nanjin, for the section between Shanghai and Hangzhou, and other lines starting from urban areas. The number of rolling stocks of this type has reached 100.

(b) **CRH308A:** CRH380A was developed for the Beijing-Shanghai High-Speed Railway and is used for this section at present. When the speed reached 486.1 km/h in the test run in December 2010, it became a hot topic.

(c) **CRH3C:** CRH3C was developed based on the Velaro high-speed train series of Siemens in Germany, aiming to the operation speed of 350 km/h from the beginning. The initial operation speed of 350 km/h mainly for the section between Wuhan and Guangzhou South was slowed to 300 km/h in August, 2011 onwards.

(d) **CRH380BL:** CRH380BL achieved the speed of 487.3 km/h in the test run in January 2011, marking the highest speed in the world among the rolling stocks for commercial operation. However, as failures frequently occurred after the start of operation between Beijing and Shanghai and serious defects were identified in the signal system, all the 54 rolling stocks in operation were recalled for improvement and repair.

Table 5.1.19 List of Rolling Stock Performance used for Chinese High-Speed Railways

Rolling Stock Name	CRH2A	CRH380A	CRH3C	CRH380BL
Maximum operating speed (km/h)	200 250 in terms of performance	300 380 in terms of performance	300 350 in terms of performance	300 380 in terms of performance
Electric system	AC25 kV 50Hz	AC25 kV 50Hz	AC25 kV 50Hz	AC25 kV 50Hz
Train formation	8 trains: 4M4T 201 m Capable of connecting 2 trains	8 trains: 6M2T 203 m	8 trains: 4M4T 200 m Capable of connecting 2 trains	16 trains: 8M8T
Rated output	4800 KW	9800 KW	8800 KW	19200 KW
Capacity	584-610 passengers	494 passengers	601 passengers	1005 passengers

Source: JICA Study Team

5.2 Comparison of High-Speed Railway Technologies and Subsystem

1) General

5.73 The main characteristics of existing high-speed railway technologies and subsystems in the world are explained below in a comparative manner. Main areas covered in the study include the following:

(i) Track gauge and construction gauge;
(ii) Construction specification;
(iii) Civil structure;
(iv) Tracks;
(v) Station and station facilities;
(vi) Automatic fare collection system;
(vii) Rolling stock;
(viii) Signal and telecommunication;
(ix) Electricity;
(x) Maintenance and depot; and
(xi) Operation planning.

2) Analysis of Typical HSR Technology and Subsystems

5.74 With regard to selecting appropriate technologies related to high-speed railway for Vietnam, the following are the main areas of concerns:

(i) New line or upgrading of existing line for high-speed rail;
(ii) Mixed traffic (passenger and freight) or dedicated use for passenger in high-speed train operation;
(iii) Single or bi-direction operation of trains;
(iv) Period of time for train operation in consideration of maintenance;
(v) Train formation in terms of traction distribution; dispersed or concentrated;
(vi) Fire protection policy; and
(vii) Maximum operating speed.

5.75 Discussions are held in the following:

(1) Two types of High-Speed Rail, New Line / Upgraded Existing Line

5.76 As the below indication, there are two types of high-speed railway (HSR) system in the world.

(i) High spec new line: Consists of the development of independent rail for HSR, which capably meets the risen passenger demands, resulting in a dramatic increase of the capacity.
(ii) Upgraded existing railway: Consists of the improvement of existing lines, so the high-speed operation is possible, resulting in the passenger volume transferring from other transport means due to the shorter travel time. However, the line capacity can’t be increased.

5.77 The Shinkansen system of Japan is typical one of high-spec new line system. In this system, the leap-frog technology could be applied regardless of the outdated existing-lines; hence, the highly safety level have been secured and the traffic capacity have been increased dramatically.

5.78 Countries in Europe (French, Germany, Italy, Spain, etc.) started HSR by upgrading the existing lines and constructing the new lines partly, because that could save the construction cost as well as shorten the development period.

5.79 In the second option, the condition of existing line must be similar to the one of HSR; especially, the rack gauge and the safety system. Moreover, it is impossible to increase traffic capacity, so the higher operation speed is realized; and, the more HSR traffic demand increases, the more new HSR lines are constructed in many countries. Nowadays, many countries are operating at high speed on new HSR line, while operating into a existing line at the lower speed regulated respectively.

(2) Mixed Traffic / Dedication for High-Speed Train

5.80 As above mention, there are two types of HSR in the world. In case of the upgraded line, the line has still played a role as existing railway continually, so it should be continuously operated to form as a mixed traffic.

5.81 On the other hand, most of high-spec new lines are dedicated to high-speed train in order to maintain high safety and efficient usage. Some new lines are constructed with the aim of mixed traffic, e.g. Hanover-Wurzburg NBA. In that case, it is necessary to adopt gentler gradient & heavier axel-load, so it results a higher construction cost and maintenance cost. Furthermore, operation periods of HSR must be constrained due to the low speed of freight & regional passenger trains and problems of cross passing freight train. Therefore, the mass of new HSR lines are distributed only to high-speed train.

5.82 Generally speaking, HSRs in countries which designed for dedicated line realize more traffic volume than those in countries which designed for mixed traffic.

Table 5.2.1 Traffic Volumes of High-Speed Rail

Country	Japan JR	France SNCF	Germany DBAG	Spain Renfe	Italy FS	Korea KORAIL	Taiwan THSRC
Length of HSR(km)	2387	1896	1285	2056	923	412	345
Passengers per day	791,000	313,000	202,000	29,100	91,400	103,000	88,600
Pass-km per day(Mil.pkm)	208	142	61.8	31.5	29.4	27.2	18.8
Passengers per km	87,000	75,000	48,000	15,000	32,000	66,000	54,000
Construction Type *1)	N	Mainly N	N + C	N + C	N + C	Mainly N	N
Operation	Dedicated	Dedicated	Dedicated / Mixed	Mixed (designed)	Mixed (designed)	Dedicated	Dedicated

Source: JICA Study Team
*1) N: High spec new line, C: Upgraded existing Line

(3) Single/ Bi-Direction Operation

5.83 All of HSRs in the world are double-track mode. European countries have adopted bi-direction double-track system to HSRs; the same as existing lines; and, countries, which developed HSR later (South Korea, Taiwan and China), have followed European system and adopted bi-direction system.

5.84 Main purpose of bi-direction system is to maintain the operation in case of accidents or troubles on one-track. Shinkansen has been distinctively adopted with the single-direction operation system on each line. Japan has formulate an unique policy as “Separation of maintenance& operation”. The policy prioritizes the safety and the reliability rather than the temporary operation. In this policy, extra crossovers and complicated power supply & signaling systems are unnecessary, resulting in lower construction cost.

5.85 Based on this policy, the reliability of Shinkansen has been enhanced, it is the world’s most safety (zero passenger fatalities in more than 47 years of operation) and reliable (average of less than 1 minute delay per train) HSR.

(4) Operation Period

5.86 Maintenance is one of most important subjects for safety of HSR. In the existing line, it has been carried out in the intervals of train operation. In HSR wind emanating from running train on the neighboring line is so strong, the measures performing maintenance safely are necessary. Many countries have divided time between operation and maintenance. Usually, the operation period is day time from 6 AM to midnight and maintenance period is the rest.

5.87 At present, the night high-speed trains are only operated on Beijing-Shanghai line in China, the distance is approximately 1300km. When the distance is longer, HSR is less competitive and necessity of night train might become more. In any case, maintenance method as well as the need of night trains should be considered.

(5) Train Formation in Terms of Traction Distribution

5.88 There are two types of train in terms of traction distribution: dispersed power and concentrated power. In Japan, the Shinkansen system, which was the pioneer of HSR, has adopted distributed power system: electric multiple unit (EMU) system. The introduction of EMU has provided a large capacity and been robust in the event of a failure; and, it is capable fast acceleration and deceleration. With the EMU’s light axel load, it also contributes to the reduction of infrastructure costs. Therefore, high-speed train in Japan has always been EMU.

5.89 On the other hand, European countries initially adopted the concentrated power system following to their existing train formation. As the operation speed is increasing higher, most of countries have switched to the EMU. The latest high-speed trains designed by major European suppliers are EMU. Now EMU is the mainstream of HSR.

(6) Maximum Operating Speed

5.90 Vietnam HSR connects about 1,600 km between big two cities of Hanoi and Ho chi minh, and its high speed becomes a very big element. That is, demand increases by being, and it contributes to an economic, social development of Vietnam if it is high-speed. Moreover, it is also important to acquire technology that enables construction and the operational management in the rapid-transit railway in which it reaches 1600㎞, and to attempt the promotion development of the rail industry and the relative industry in addition. It is thought that it is important to improve the ability to experience the high speed executed from an early stage in the world now to satisfy these, and to do the management.

5.91 It is the one to adopt 320 km/h that is the maximum operating speed at present based on such above-mentioned idea.

(7) Fire Protection Policy

5.92 In Europe, Passenger Refuge at Car Fire Accident and Safety Measure at Restoration is basically done by Two Single Line Tunnels etc due to Bi-directional Operation and Locomotive type System. On the other hand, in Japan, Fire Countermeasures given below are basically done by Double Line Tunnel, etc. due to Each Directional Operation and Electric Multiple Unit (EMU).

(i) Rolling Stock of Fireproof Materials and Door between Cars
(ii) Stop and Refuge at Station or Appointed place out of Tunnel
(iii) Non Stop in Tunnel and Escape out of Tunnel is Basic Idea.
(iv) Secure of Refuge Passage by Operation Stop of Other Line of Double Lines.
(v) In Underground and Tunnel, Secure of Refuge Measure by Ventilation and Exhaust

(8) Fire Protection Policy Especially of Tunnel

5.93 For Vietnam HSR, JICA Study Team proposes the measures of bi-directional operation, electric multiple unit (EMU) and separation between operation and maintenance for safety, and compact system. Therefore, the countermeasures mentioned below are proposed for tunnel fire protection besides double cross section about 64 ㎡ tunnel.

(i) Rolling Stock of Fireproof Materials and Door between Cars
(ii) Stop and Refuge at Station or Appointed place out of Tunnel
(iii) Non Stop in Tunnel and Escape out of Tunnel is Basic Idea.

Table 5.2.2 Comparison of Tunnel Fire Protection

Items	Japan	Europe
Tunnel Cross Section (Single or Double Line)	Double Line Cross Section	Single Line Cross Section over 5km (Two Single Tunnels)
Tunnel Cross Section	About $64m^2$	About $45m^2 \times 2 = 90m^2$
Fire Counter-measure	• Non Stop in Tunnel • Stop and Refuge at Station or Appointed place out of Tunnel	• Stop in Tunnel and Use of Refuge Passage
Operation at Fire	• Secure of Refuge Passage by Operation Stop of Other Line of Double Lines	• Bi-directional Operation of Other Line of Double Lines
Construction Cost	• Low Cost by Small Cross Section • Large Influence due to so many Tunnels	• High Cost of Two Single Tunnels
Difference of Rolling Stock	• Escape Possibility out of Tunnel due to Electric • Multiple Unit (EMU)	• Safety Measure and Operation at Fire on the Assumption of Stop in Tunnel due to Locomotive type

Source: JICA Study Team

3) Track Gauge and Construction Gauge

5.94 All countries to operate the high speed railway in the world adopts 1,435mm track gauge in a high-speed railway new line. There is track gauge that is bigger than this 1,435 mm in Spain (1668), Russia (1520) and India (1676), etc. if existing railways are improved and high speed is put out.

5.95 It is impossible to put out high speed by using of narrow gauge, because of stability in a curve section etc. Therefore, high speed railway needs big track gauge. In a maximum speed, high-speed railway new line of 300 km or more per hour, track gauge is 1,435 mm that is standard track gauge in the world.

4) Rolling Stock Gauge

5.96 A rolling stock gauge defines the maximum height and width of railway vehicles to ensure safe passage through bridges, tunnels and other structures. Classification systems vary between different countries and gauges may vary across a network, even if the track gauge remains constant.

5.97 In European countries the UIC gauge, which consists of three sub-types: A, B and C, is broadly applied to rolling stocks. The usual gauge used for new high-speed line is C: (3150 mm of width and 4650 mm of height). In Japan, the gauge for HSR is the special Shinkansen gauge (3400 mm of width and 4500 mm of height), which is 250 mm wider than the UIC gauge.

5.98 Wider gauges help increase the capacity of passenger transportation because the width enables 5 seat rows. Taller gauges such as Shinkansen gauge (4500 mm) and UIC-C (4650 mm) also increase the transportation capacity, since the no. of decks has been doubled. The larger rolling stock gauge may be considered as an option to maximize the transportation capacity and to improve the passengers' comfort, if the HS system is independent from the existing network.

5) Construction Gauge

5.99 The construction gauge is in the range of the lowest decrease of the space that gives the rolling stock gauge the room considerably, and the amount of room (space) is added to both sides and it is provided in the width of the vehicle limit. In the high-speed railway construction in Japan, 4,400 mm in the construction gauge width secured for both sides of the width of the vehicle limit by 500 mm is adopted by historical earnings etc.

5.100 In the UIC standard in Europe, there is no restriction to the construction gauge, and it is assumed to be a basis to provide the rolling stock gauge of the vehicle where it runs, and not to violate this rolling stock gauge in any case. Actually each country thinks the same room (space) of Japan both side of rolling stock gauge from the experiences of existing railways up to now.

5.101 The width of construction gauge in the high speed railway in China is provided clearly, and is 4,880 mm. It is considerably large compared with Japan, and is a numerical value on the safety side. The amount and the width of track formation are growing.

6) Construction Specification

5.102 The construction specification characteristics of high speed railway system in various countries are described below. (see Tables 5.2.3 and 5.2.4).

(1) Main Features of HSR Lines

(a) **Tokaido Shinkansen:** The Tokaido Shinkansen was the first high speed railway route planned for speeds over 200km/h. According to construction reports in 1965, the goal was to increase transport capacity by building a new double-tracked line for combined passenger and freight service parallel to the existing double-tracked line. It was suggested that night-time freight train operations be stopped once a week in order to secure maintenance time for the track at night. However dur to the considerable increase in passenger traffic, freight services were never implemented.

5.103 Two proposals for new track construction were examined: Proposal A would have added double-tracking to the existing narrow gauge line, while Proposal B would have seen the construction of a new, separate double-tracked line. Proposal A would have required the construction of grade separations in more than 1,000 locations with existing level crossings. This would have resulted in bad alignment, problems with land acquisition, and increased construction costs. It also became clear that there was little benefit in continuing operations on on the existing . Proposal B for the construction of a separate double-tracked line recommended adopting the 1,435mm gauge due to its better safety and higher transport capacity.

5.104 The construction specification adopted a curve radius of 2,500 m in accordance with a future design speed of 250 km/h and operating speed of 200 km/h. Currently, the operating speed has already reached 275 km/h thanks to improvements in vehicle performance and of cant values.

Table 5.2.3 Construction Specifications of TGV and Shinkansen

Item		Tokaido Shinkansen *1	Tohoku Shinkansen *2	Kyushu Shinkansen *3	TGV Sud-Est *4	TGV North Europe line *5
Line section		Tokyo -ShinOsaka	Tokyo -Shin -Aomori	Hakata ー Kagoshima-Chuo	Paris - Lyon	Paris -Calais
Opening year(s)		October 1964	June 1982 March 2011	March 2004 March 2011	September 1981 September 1983	September 1993
Use		Passenger	Passenger	Passenger	Passenger	Passenger
Gauge		1435 mm	1435 mm	1435 mm	1435 mm	1435mm
Maximum axle load Design axle load		11.4 tf 16 tf	13.1tf 17 tf	11.4 tf 16 tf	17 tf 25.5 tf	17 tf 25.5 tf
Design speed		250 km/h	260 km/h	260 km/h	300 km/h	350 km/h
Operating speed		275 km/h	300 km/h	260 km/h	300 km/h	300 km/h
Maximum gradient		15‰	15‰	35‰	35 ‰	25 ‰
Vertical curve radius		10,000 m	15,000 m (10,000 m)	25,000 (15,000)	25,000 m (16,000 m)	25,000 m (16,000 m)
Minimum horizontal curve radius		2,500 m	4000 m (3500 m)	4000 m (402 m)	4000 m (3200 m)	6000 m (4000 m)
Maximum cant		200 mm	180 mm	180 mm (200)	180 mm (200)	180 mm
Allowable cant deficiency		90 mm	90 mm	90mm(110)	85mm	85 mm
Track spacing		4.2 m	4.3 m	4.3 m	4.2 m	4.5 m
Width of formation level		10.7 m	11.3 m (11.6)	11.2 m	13.6 m	13.9 m
Inner cross section of tunnels		60.5 m^2	63.4 m^2	63.5 m^2	-	-
Car body width		3,380 mm	3,380 mm	3380 mm	2,904 mm	2,904 mm
Total length		515 km	672 km	257 km	410 km	333 km
Of which	Bridges	172 km	387 km	111 km	5 km	5 km
	Tunnels	69 km	234 km	125 km	0	5 km
	At-grades	274 km	51 km	21 km	405 km	323 km
Main track structures		Ballast track	Slab track	Slab track	Ballast track STEDEF	Ballast track
Turnout s		18#, 16#	18#, 16#	18#, 16#	65#, 46#	65#, 46#

Source: JICA Study Team

Table 5.2.4 Construction Specification of Taiwan HSR, Korea HSR, TGV Atlantique, and ICE, and Italy ETR

Item	Taiwan HSR *6	Korea KTX *7	TGV Atlantique line *8	ICE High speed line *9	Italy ETR *10
Line section	Taipei -Kaohsiung	Seoul -Busan	Paris- Le Mans Courtalan Saint Pellerin -Tours	Hannover - Wurzburg Mannheim - Stuttgart	Rome - Florence
Opening year(s)	January 2007	April 2004 November 2011	September 1989 September 1990	1988 June 1991	1992
Use	Passenger	Passenger	Passenger	Combined passenger and freight service	Combined passenger and freightservice
Gauge	1435 mm	1435mm	1435 mm	1435 mm	1435 mm
Maximum axle load Design axle load	11.3 tf 25.5 tf	17 tf 25.5 tf	17 tf 25.5 tf	16 tf 20 tf	16.5 tf 25 tf
Design speed	350 km/h	350 km/h	350 km/h	300k m/h	300 km/h
Operating speed	300 km/h	305 km/h	300 km/h	280 km/h	300 m/h
Maximum gradient	25‰ (35‰)	25‰	15‰ (25)	12.5‰	8.5‰ (18‰)
Vertical curve radius	-	-	25,000 m	22,000 m	20,000 m
Minimum horizontal curve radius	6,250 m	7,000 m	6250 m	4670 m	5,400 m
Maximum cant	180 mm	180 mm	180 mm	150 mm	160 mm
Allowable cant deficiency	-	-	60 mm	60 mm	-
Track spacing	4.5 m	5.0 m	4.2 m	4.7 m	5.0 m
Width of formation level	13 m	14 m	13.6 m	13.7 m	13 m
Inner cross section of tunnels	90 m^2	107 m^2	55-71 m^2 *	82-84 m^2	-
Car body width	3380 mm	2904 mm	2,904 mm	3,020 mm	2,904 mm
Total length	345 km	412 km	284 km	426 km	237 km
Bridges	247 km	112km	3.4 km	35 km	46 km
Tunnels	65 km	189 km	16 km	150 km	71 km
At grade	33 km	111 km	265 km	241 km	120 km
Main track structures	Slab track RHEDA2000	Ballast track RHEDA2000	Ballast track STEDEF	Ballast track	Ballast track
Turnouts	43.6#,33#,26#	24#	65#, 46#	24#	N/A

Source: JICA Study Team

5.105 Cut and embankment sections make up 275 km extension in 515km of route lengths. The poor soil should be likely intermediate in the earthwork section, therefore the ballast track was adopted because the ballast track was easy to be laid and also easy to be repair where any consolidation settlement might arise. The ballast track was adopted along almost entire section except some bridges. Ballast track was chosen because the soil quantity on quality on some some earthwork sections was porr, and since ballast track is both easy to install and later repair in case of consolidation settlement, Ballast track was used along the entire line except on some bridges.

(b) **Tohoku Shinkansen:** On sections of the Tohoku Shinkansen not requiring countermeasures against snow, the same roadway width of 11.6m as for the Sanyo Shinkansen was adopted. The original design speeds was 260 km/h, but this was increased to 300km/h on wherever possible.

5.106 The axle-load of the Tohoku Shinkansen was set to 17tf which consisted of the 16tf axle-load of the Sanyo Shinkansen with added weight for snow countermeasures. The track spacing between the up and down lines was set to 4.3m, and the inner cross section of tunnels was set to 63.4 m^2 which added the construction gauge to the 4.3m track spacing. The 4.3m track spacing and the 63.4 m^2 2 inner cross section of tunnels included in the construction specification were checked and determined to be safe for speeds up to 350 km/h in a report by the Railway Technical Research Institute in Japan.

(c) **Kyushu Shinkansen:** Both the design speed and the maximum operating speed of the Kyushu Shinkansen is 260 km/h. The total 257km route length includes an 8km connecting section from Hakata and consists of 111 km of bridges, 125 km of tunnels and 21 km of earth work structures.

5.107 The section around the Chikusi tunnel is located in mountainous terrain and has a maximum gradient of 35% influence of tunnel excavation work and minimize the earth cover of tunnel.

5.108 Due to restrictions on urban construction, some sections with a total length of 37.8km near Kurume and the Kumamoto station have sharp curves with a radius of 4,000m or less.

5.109 Most track structures consist of frame-shaped slab track. Ballast track only covers 10km or 4% of the total route length.

(d) **TGV Sud-Est:** Because the track gauge of regular lines in France is 1,435mm, the new high speed line has through operation with the regular line at main stations. The new high speed sections have an operating speed of 300 km/h, while the line sections have a speed limit of 160 km/h. Junctions between the new line and the regular line use No. 65 turnouts which have a 220 km/h through-speed. The main line uses No.46 crossover turnouts with a through-speed of 160 km/h in locations where single track operation is possible. Since the turnout numbers are so large, the secondary main line inside stations is between 800m to 1,300 m long.

5.110 The track structure consists of two-block RC sleepers with a ballast thickness between 300mm and 350 mm. The Sud-Est line has a 4.2m track spacing, 4,000 m (3,200 m) minimum horizontal curve radius, 25,000 m (16,000 m) vertical curve radius, and 180 mm (200 mm) maximum cant. A maximum gradient of 35% in order to avoid the use of tunnels. Most of the line consists of earthwork sections. The roadbed is 13.0m wide and its upper layer is reinforced.

(e) **TGV North Europe Line:** The design speed of the North Europe line has been increased to 350 km/h and the track spacing changed to 4.5 m.

(f) **Taiwan HSR:** The Taiwan HSR system uses a 25.5tf design axle load for civil structure, UIC 60kg rail, a 90m^2 inner cross-section for tunnels, and No. 44 turnouts at cross-overs in stations, all in accordance with French TGV specifications. No. 33 turnouts and No. 26 turnouts follow Germany specifications. The Japanese specifications are used for the vehicle system and slab track. Although the use of ballast track was at first planned on the northern part of the route, this was changed at the time of construction. As for the type of track structure, REDA2000 is used in station areas, frame-shaped slab track between stations, and ballast tracks near Taipei station and Zuoying station in Kaohsiung. Taiwan HSR has made a profit since 2011.

(g) **Korea KTX:** The Korea KTX was opened for service between Seoul and Taegu in April 2004 when some parts of the regular line were connected, and the whole 412 km long line was opened for traffic in November 2011. The new Gwangmyeong station (South Seoul station) was constructed in a suburb south of Soul. The line uses 30cm thick ballast track consisting of UIC 60 kg rail and PC sleepers or RHEDA2000 concrete roadbed track. Turnouts are German No.24 turnouts..

(h) **TGV Atalantic Line:** The Atlantic line is 280km long and consists of a 176 km route between Paris and Le Mans, as well as a second 104 km route beginning at the junction station Courtalan-Saint-Pellerin in the middle of the line and ending at Tours. Around 60% of the right- of-way used for the new line is either government-owned, road or railroad land. Open-cut tunnels were intentionally constructed and barrier walls erected in suburbs in order to reduce railway noise, and tunnels and open cut tunnels were also used in densely populated areas. , Both single-track and double-track tunnels are used.

5.111 The single-track tunnels were constructed using the shield method and have a 49 m^2 cross-sections area. The inner cross sections of three double track tunnels were changed to between $55m^2$ and $71m^2$in accordance with the velocity of passing trains in order to limit possible adverse effects caused by changes in air pressure.

5.112 Bridges are typically box girders and make up 3.4km of the total line length. Earthwork sections have a roadbed width of 13.6 m. The track structure consists of STEDEF ballast track with two-block RC sleepers and a ballast thickness between 300mm and 350mm.

5.113 The line uses both No. 65 and No. 46 turnouts, with No. 65 turnouts employed for junctions off the main line, and No. 46 turnouts for cross overs on sections with single track operation.

(i) **German ICE:** Since the ICE ha through service with regular lines and it also used for both passenger and freight traffic, it has a specified axle load of 20tf.

5.114 The 4.7m track spacing was adopted to ensure safety when ICE passenger trains and freight trains pass each other. However, passenger trains and freight trains are operated at different times in order to avoid them having to pass each other. Freight trains are operated at night except on sections where it is possible to implement safety measures required by daytime operation.

5.115 The 4.7m track spacing requires tunnels to have a larger inner cross sectional area of between 82 m^2 and 84 m^2. Bridges use PC concrete girders and there are no steel bridges along the line. Labor saving tracks such as REDA2000 are used on some tunnel sections. With only a few exceptions, all earthwork sections use ballast track.

(j) **Italian ETR:** Since the ETR has through service with regular lines and is also used for both passenger and freight traffic, it has a specified axle load of 25tf. Newly constructed sections for the high speed railway account for 237km of the total 327 km route length between Rome and Florence. Some parts of the new high speed line are used to connect main cities such as Milan, Florence, Rome, and Naples.

5.116 There are many earthwork sections and the track structure consists of ballast track.

Table 5.2.5 Maximum Rolling Stock's Width in Typical HSR

Unit: mm

Country	Track Gauge	Max. Width of RS
France	1435	2904
Germany	1435	3020
Italy	1435	2900
Spain	1435	2960
United Kingdom	1435	2810
Russia	1520	3265
China	1435	3380
Taiwan-China	1435	3380
South Korea	1435	2970
Japan (HSR :Shinkansen)	1435	3380
Japan (Existing)	1067	3000

Source: JICA Study Team editing UIC data.

7) Civil Structures

5.117 The civil structures used for railways can broadly be divided into 3 major categories: earthworks, bridges & viaducts, and tunnels. The following Table 5.2.6 shows a comparison of the civil structures used for HSR systems around the world. Because economic efficiency is the top priority of European HSR systems, the civil structures are dominated by low embankment and cut sections, which account for 90% of the structures in France and Spain. In contrast, the dominance of bridge and viaduct structures is a characteristic of the HSR systems in Japan, Taiwan and China, and they comprise 72% and 87% of all civil structures in Taiwan and China, respectively. The HSR train route in Korea runs through mountainous areas and therefore has a remarkably large number of tunnels, which covered 46% of the total line length. (see Table 5.2.6)

Table 5.2.6 Comparison of HSR civil Structures

Country			Japan									
Line			Tokaido		Sanyo		Tohoku					
			Tokyo～Shin-Osaka		Shin-Osaka～Hakata		Tokyo～Morioka		Morioka～Hachinohe		Hachinohe～Shin-Aomori	
Length		km	515		563		496		95		81	
Construction period		yr	1959～1964		1965～1975		1971～1982		1989～2002		1998～2011	
Structure	Earthworks	km	274	53%	101	18%	27	5%	14	14%	12	15%
	Bridge & Viaduct	km	172	34%	194	34%	354	71%	12	13%	19	23%
	Tunnel	km	69	13%	268	48%	115	23%	69	73%	50	62%

Country			Japan								Korea	
Line			Joetsu		Hokuriku		Kyushu				KXT	
			Omiya～Niigata		Takasaki～Nagano		Shin-Yatsushiro～Kagoshima-Chuo		Hakata～Shin-Yatsushiro		Seoul-Busan	
Length		km	275		117		128		121		412	
Construction period		yr	1971～1982		1989～1997		1991～2004		1998～2011		1992～2010	
Structure	Earthworks	km	3	1%	16	14%	15	12%	6	5%	111	27%
	Bridge & Viaduct	km	165	60%	38	32%	25	19%	78	64%	112	27%
	Tunnel	km	107	39%	63	54%	88	69%	37	31%	189	46%

Country			Taiwan		China		France					
Line			THSR		CRH		Southeast		Atlantic		North Europe	
			Taipei～Kaohsiung		Beijing～Shanghai		Paris～Lyon		Paris～Le Mans / ～Tours		Paris～Calais	
Length		km	345		1318 (7118)		410		284		333	
Construction period		yr	1999～2006		2008～2011		1976～1983		1985～1990		1988～1993	
Structure	Earthworks	km	33	9%	162	12%	405	99%	265	93%	-	-
	Bridge & Viaduct	km	247	72%	1142	87%	5	1%	3	1%	-	-
	Tunnel	km	65	19%	16	1%	0	0%	16	6%	-	-

Note: The number in brackets for China is the total length on July 1st, 2011

Country			France		Germany						Italy	
Line			Mediterranean		ICE						Direttissima	
			Valence～Marseille		Mannheim～Stuttgart		Hannover～Wurzburg		Cologne～Frankfurt		Rome～Florence	
Length		km	250		99		327		177		237	
Construction period		yr	1995～2001		1976～1991		1979～1991		1995～2002		1970～1992	
Structure	Earthworks	km	220	88%	64	65%	177	54%	126	75%	120	50%
	Bridge & Viaduct	km	17	7%	5	5%	30	9%	6	3%	46	20%
	Tunnel	km	13	5%	30	30%	120	37%	47	22%	71	30%

Country			Spain		England	
Line			AVE		CTRL	
			Madrid - Seville		London～Folkestone	
Length		km	471		109	
Construction period		yr	1987～1992		1998～2007	
Structure	Earthworks	km	445	95%	66	60%
	Bridge & Viaduct	km	10	2%	17	16%
	Tunnel	km	16	3%	26	24%

Source: JICA Study Team

5.118 The civil structures of the HSR systems in each country are described in the following sections.

(1) Japan

5.119 More than 50% of the first Japanese HSR, the Tokaido Shinkansen consisted of earthwork sections to reduce the cost of civil work. The proportion of viaduct sections with slab track has since been increased to reduce the cost and time required by land acquisition, lower embankment repair costs after natural disasters such as typhoons and earthquakes, reduce maintenance costs of ballast track and increase the total economic efficiency of construction costs. The proportion of viaduct sections on the Tohoku Shinkansen (Tokyo–Morioka) and Joetsu Shinkansen (Takasaki–Niigata) are 71% and 60% respectively, and their respective earthwork sections account for only 5% and 1% of the total. Shinkansen lines have since then employed slab track installed on reinforced embankments and earthwork sections, which can be constructed on the same land width as viaducts. The number of earthwork sections has consequently increased slightly, but viaducts are now the typical structure used on open sections. In Japan, the use of beam slab rigid-frame viaducts has become common since the construction of the Tokaido Shinkansen, because the material cost is cheap compare with girder viaducts. Moreover, Japan is an island nation with many mountainous areas. The proportion of tunnels, which do not require land acquisition, is thus high and they account for about 1/3 of the total. Various countermeasures against noise (installation of soundproof walls and buffers, etc.) and snow (water sprinkler systems for melting snow and snow-storage facilities) have also been taken.

(2) Taiwan

5.120 There are many mountainous regions in Taiwan, but the densely populated areas as well as the HSR route are located on the western plains of the island. The island has a temperate to subtropical climate with an annual rainfall of more than 2,000 mm. Like in Japan, there are many earthquakes, and the weather and climate are also similar. Therefore, the civil structures of the Taiwan HSR are similar to those used in Japan where there are many natural disasters. This Taiwan HSR has many viaducts and bridges that account for 72% of the total route length. Girder viaducts with 30m PC box girder spans which fit in with the surrounding scenery are used as the typical structure.

5.121 Tunnels are constructed to German and French specifications and thus have large cross-sections. The cross-sectional area above rail level is 90 m^2 compared to 60 m^2 in Japan. Because the rolling stock is unable to copes with air tightness, tunnels are prepared as short as possible and have large cross-sectional areas.

(3) France

5.122 Most of the land area in France consists of undulating hills and diluvial plateaus with good soil quality, and 89% of the land can be used for agriculture. The amount of annual rainfall is small and ranges from 600mm– to 800mm and there are practically no earthquakes. The Southeast TGV line between Paris and Lyon was constructed without tunnels and the route selected so as to reduce construction costs and avoid problems with pressure waves which arise when trains run inside tunnels at high speeds. As a result, 99% of all structures are made up of either embankments or cuttings. Embankment slopes are generally 1:1.5, but slope consisting of low adhesion material are 1:2.0. Structures other than earthwork include bridges, viaducts, overpasses, box culverts, etc., but the total length of these section is only 5km. The typical viaduct structure is a PC box girder viaduct. Routes were constructed outside urban areas where land prices are cheaper in order to reduce the construction costs of civil structures.

5.123 Road sites were used for a 20km section of the TGV Atlantic line around Paris because a land widening plan could never be implemented. This part of the route consists of excavated sections covered by concrete, sections backfilled with soil, as well as mountain tunnels. The tunnel cross-sectional area varies between 55 m^2 and 71 m^2 depending on the speed of passing trains in order to reduce the effect of changes in atmospheric pressure. Railway land and state-owned land was used to avoid the development of forests and agricultural land. Crossing structures were also established so as not to inhibit the movement of wild animals. The help preserve the landscape, architectural departments and landscape engineers were involved in the work, and special consideration was given to the reduction of construction costs, environmental friendliness and the surrounding scenery.

8) Track Specification

(1) Characteristics of high speed railway track specifications

5.124 The track specifications of all high speed railways have the following characteristics in common.

(i) At design speeds between 300 km/h and 350 km/h, the minimum curve radius, vertical curve radius and maximum cant are all determined based on riding comfort, and the specifications used in each country are thus almost the same.

(ii) The track spacing used at a design speed of 350 km/h can be 4.2m, 4.3m, 4.5m or 5m and varies from country to country.

(iii) The wind pressure caused when trains pass each other is taken into consideration when setting the track spacing and some additional margin based on actual data is then added to this.

(iv) The roadbed width used at a 300 km/h design speed can be specified as 12.1m, 13.0m, 13.6m, 13.7m, 13.9m or 14.0m for earthwork sections and 11.3m for bridge and viaduct sections.

(v) The main track structures is ballast tracks.

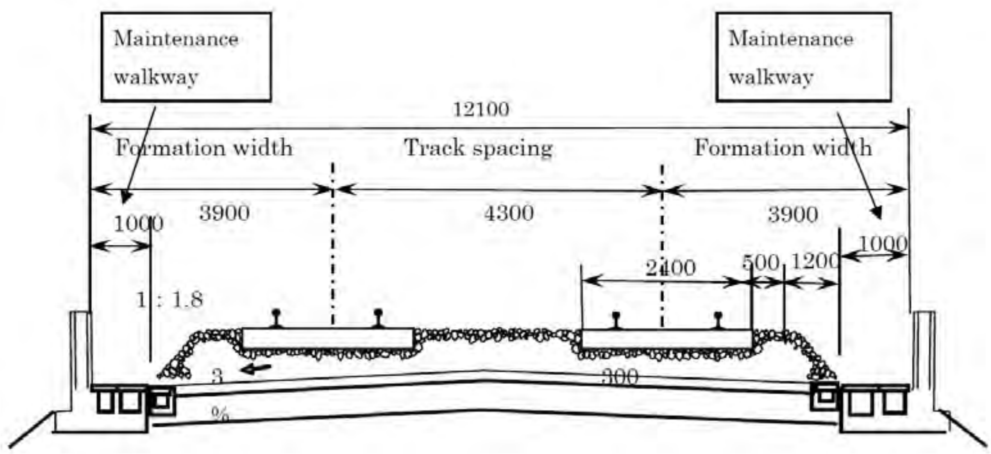
(vi) Track structures with concrete roadbeds usually consist of German RHEDA2000 or Japanese slab track.

5.125 The characteristics of track structures used for high speed railway in various countries are described below.

Table 5.2.7 Main Technical Characteristics of Tracks for High Speed Railway in the World

Line	Line Section	Opening Years	Main Track Type	Rail	Fastening >Main Type >Sub Type	Sleeper	Turnout
Tokaido Shikansen	Tokyo-Shin-Osaka	October 1964	Almost Ballast	JIS_60kg	Plate spring - 102	PC	18#, 16#
Tohoku Shinkansen	Tokyo-Shin-Aomon	June 1982; March 2011	Slab=87%; Ballast=8%	JIS_60kg	Plate spring -DF8 -DF4	PC	18#, 16#
Kyushu Shinkansen	Hakata Kagoshima-chuo	March 2004; March 2011	Slab=90%; Ballast=7%	JIS_60kg	Plate spring -DF8 -DF4	PC	18#, 16#
TGV Sud-Est	Paris-Lyon	September 1981; September 1983	STEDEF; Mostly Ballast	UIC_60kg	Plate spring - Nabia -	2block	65#, 46#
TGV North Europe	Paris-Calais	September 1993	STEDEF; Mostly Ballast	UIC_60kg	Plate spring - Nabia -	2block	65#, 46#
Taiwan HSR	Taipei-Gaoxiong	January 2007	RHEDA 2000; Slab Panel	UIC_60kg JIS 60kg	Plate spring -DF8 -Rheda2000	PC	43.6#,33#, 26#
Korea KTX	Seoul-Busan	April 2004; November 2011	Ballast; RHEDA 2000	UIC_60kg	Wire spring - Pandrol - Rheda2000	PC	24#
TGV Atlantique	Paris-Le Mans Courtalan Saint Pellerin-Tours	September 1989; September 1990	Almost Ballast	UIC_60kg	Plate spring - Nabia -	2block	65#, 46#
ICE High-speed	Hannover-Wursburg Manheim-Stuttgart	1988- June 1991	Almost Ballast	UIC_60kg	Wire spring - bossioh	PC	24#
Italy ETR	Roma-Firenza	1992	Almost Ballast	UIC_60kg	-	PC	-

Source: JICA Study Team



Source: JICA Study Team

Figure 5.2.1 Earthwork Section and Ballast Track in Japan

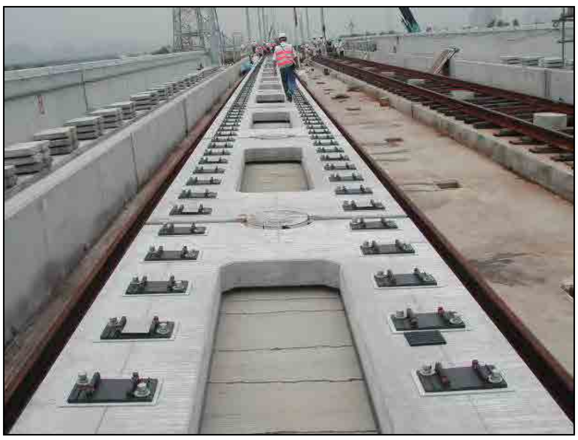
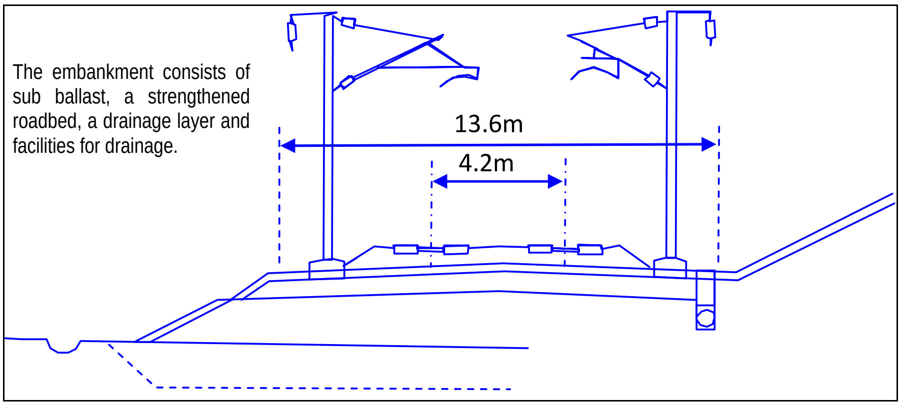


Figure 5.2.2 Slab Track in Viaduct Section of Taiwan High Speed Railway

Source: JICA Study Team

Source: Paris Sud-Est line with original TGV vehicle from Wikipedia livery 1987.jpg

Figure 5.2.3 Earthwork Section and Ballast Track in TGV Sud-Est Line



Source: JICA Study Team

Figure 5.2.4 Typical Cross Section of Earthwork Section of TGV

Source: website (www.open.ou.nl/hon/hslafl31.htm), 2012

Figure 5.2.5 RHEDA2000

(2) Main Characteristics of Selected Lines

(a) **Tokaido Shinkansen Characteristics:** The Tokaido Shinkansen has many embankment sections and uses almost entirely ballast track, although some bridge sections also employ non-ballast track. Since labor costs were low in Japan at the time of construction, ballast roadbed track was adopted because it could easily be constructed and replaced.

5.126 In those days, there were no concrete track structures that could be used for high speed railways. Labor costs for track maintenance gradually increased in Japan, and accordingly the life cycle cost of slab track became cheaper with respect to maintenance expenses.

5.127 18# turnouts are used for the main line, and 18# or 16# turnouts for main line crossovers. The 18# turnouts have a skeleton with a curve radius that allows arriving and departing trains to pass through at 75 km/h. In locations where it is required, turnouts on the main line side have a structure suitable for speeds of 200km/h or higher. The depot line uses 12#, 10# and 9# turnouts.

(b) **Tohoku Shinkansen Characteristics:** Since labor costs were high in Japan, slab track was adopted as the main track structure because of its life cycle cost advantages. Embankment sections employ slab track on earthwork with a supporting concrete slab and reinforced roadbed. Vibration reducing slab track is used on sections that require environmental countermeasures. Ballast track is used in locations with soft soil and for the vehicle depot and maintenance depot lines

(c) **Kyushu Shinkansen Characteristics:** Frame-shaped slab track is used as the main track structure for the Kyushu Shinkansen because it is more cost-effective compared to ordinary slab track.

(d) **TGV Sud-EST Characteristics:** The TGV Sud-Est has many earthwork sections with STEDEF ballast track using two-block RC sleepers. At main stations, the high speed line is equipped with facilities enabling through service with local lines.

5.128 The turnouts have been arranged to enable single track operation so that the other track of the double-tracked line can be repaired. To allow trains to pass through at high speed on the turnout side, 65# turnouts are used for the main line and 46# turnouts for crossovers on the main line.

(e) **TGV North Europe Line and TGV Atlantic Line Characteristics:** The track characteristics of these lines are the same as those of TGV Sud-Est.

(f) **Taiwan High-Speed Railway Characteristics:** Although there were first plans to use ballast track along the northern part of the route, this was changed to slab track at the time of construction. On earthwork sections, Japanese frame-shaped slab track is used between stations and German RHEDA2000 with concrete roadbed is used inside stations. Ballast track is used near Taipei station and the Zuoying station in Kaohsiung.

5.129 Both French 44# turnouts and German 33#/26# turnouts are used on the line. Considering the safety requirements of a planned future design speed of 350 km/h and the space needed to carry out maintenance work, the track spacing was set to 4.5m.

(g) **Korea KTX Characteristics:** Ballast track is used both on the earthwork and viaduct sections between Gwangmyeong and Taegu, while RHEDA2000 concrete roadbed track is used on tunnel sections. German RHEDA2000 concrete roadbed is also used for the section between Taegu and Busan. The Korea KTX uses German No. 24 turnouts.

(h) **Germany ICE High-Speed Line Characteristics:** The track structure of the German ICE consists of ballast track with PC sleepers. Since the ICE has through service with regular lines and is also used for both passenger and freight traffic, it has a specified axle load of 20tf.

(i) **Italy ETA Characteristics:** The Italy ETA uses ballast track with PC sleepers. Since the Italy ETA has through service with regular lines and is also used for both passenger and freight traffic, it has a specified axle load of 25tf.

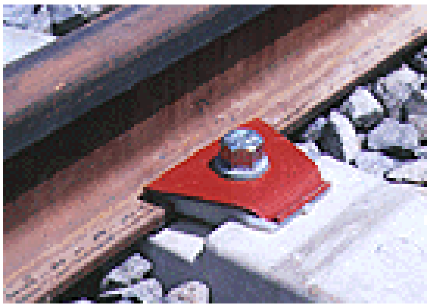
5.130 Fasteners being used as plate spring include the following: Japanese-DF4 type of a rail seat type fastener, Japanese-DF8 type with a tie-plate fastener for slab tracks and French-Nabla type fastener. On the other hand, fasteners being used a wire spring include the following: Germany-Vossloh type Fastener and British-Pandrol clip fastener (see Figure 5.2.6)

DF4 Type Fastening of a Rail Seat Type

Tie-Plate Fastening Called DF8 Type

Vossloh of Germany

NABLA of France



A Pandrol Used in Japan

Source: Compilation by JICA Study Team

Figure 5.2.6 Photos on Rail Fastenings

9) Station and Station Facilities

(1) Review of Latest Station Conditions

5.131 Table 5.2.8. shows new stations with the current status of HSR infrastructure by country. "Starting HSR" is when HSR operation started. "Operated line" is the length of HSR routes currently operating with the share in the world. "Latest Operating Line" is newly developed route till November 2011.

Table 5.2.8 New Stations in Top 5 Countries of HSR Infrastructure

Country	Starting HSR (year)	Operated Line with share	Latest Operating Line (km/year)	New and/or Renovated Stations in Latest Operating Line
China	2003	6,299km (36.7%)	Beijing ↔ Shanghai (1,318km / 2011)	Beijing South, Tianjin West, Jinan West, Nanjing South, Shanghai Hongqiao and other 19 stations
Japan	1964	2,664km (15.5%)	Kyushu Shinkansen: Hakata ↔ Shin Yatsuhiro (130km / 2011)	Shin Tosu, Chikugo funagoya, Shin Omuta, Shin Tamana, Kumamoto
Spain	1992	2,056km (12.0%)	Madrid ↔ Valencia / Albacete (432km / 2010)	Fernando Zabel, Requena-Utiel, Valencia Joaquin Sorolla, Albacete
France	1981	1,896km (11.0%)	LGV Est: Paris East ↔ Strasbourg (332km / 2007)	Champagne-Ardenne, Meuse, Lorraine, Strasbourg (Renovated)
Germany	1988	1,285km (7.5%)	Nurenberg ↔ Ingolstadt (89km / 2006)	Allersberg (Rothsee), Kinding (Altmühltal), Ingolstadt Nord
Above Countries Total		142,000 (82.7%)	The length of HSR route currently operating in the world is at 17,166km	

Source: UIC High Speed Department, November 2011

(a) China

5.132 In just the last few years, China has embarked on an unprecedented effort to invest in and build a vast HSR network. With almost 6,300 km of HSR lines in operation (most brought online just in the last 6 years), it now exceeds even Japan, the previous HSR infrastructure leader, by over 35%.

5.133 Beijin–Shanghai HSR line, 1,318km of length, has 24 stations including Beijing South, Tianjin West, Jinan West, Nanjing South and Shanghai Hongqiao. The line opened to the public for commercial service on July 30, 2011. The average daily ridership in its initial two weeks of operation was 165,000 passengers daily.

5.134 Those 5 stations are terminal stations with large platform area and huge space for waiting area similar with an airport terminal. Shanghai Hogqiao Station is the largest railway station in Asia and it achieved a zero-distance transfer with Terminal 2 of Shanghai Hongqiao International terminal. The train station waiting hall area is more than 10,000 m^2 and is capable of handling 10,000 passengers at the same time. Other 4 stations also have large waiting area in the station as shown on Figure 5.2.7.

Station Name / Station Area /Tracks (Platforms)	
Beijing South / 320,000 m^2 / 24 Tracks (13) 	Tianjin West / 200,000 m^2 / 24 Tracks (13) 
Jinan West / 100,000 m^2 / 15 Tracks (8) 	Nanjing South / 387,000 m^2 / 28 Tracks (15) 
Shanghai Hongqiao / 1,300,000 m^2 / 30 Tracks (16) 	

Source: Compilation by JICA Study Team

Figure 5.2.7 New Stations on Bejing-Shanghai HSR, China

(b) Japan

5.135 Japan has the oldest commercial HSR (Shinkansen) network in the world, with the first trains in operation in 1964. While not the largest, Japan has what is most likely the most comprehensive and integrated HSR system of any country in the world, with 2,664 km of HSR routes.

5.136 Kyushu Shinkansen including station and station facilities has been matured with high technology of Japanese HSR. New 6 stations on Kyushu Shinkansen have functional facilities in minimum space of station and Station building also has been designed at limited property area that located inside urban area and/or to be renovated existing station for connecting with local railway. Those stations are shown in the following Figure 5.2.8.

Station Name / Station Area /Tracks (Platforms)

Shin Tosu / 11,260 m² / 4 Tracks (2)

Kurume / 5,840 m² / 2 Tracks (2)

Chikugo Funagoya / 10,290 m² /3 Tracks (2)

Shin Tamana / 7,650 m² / 2 Tracks (2)

Shin Omuta / 8,230 m2 / 2 Tracks (2)

Kumamoto / 13,420 m² / 4 Tracks (2)

Source: Compilation by JICA Study Team

Figure 5.2.8 New Stations on Kyushu Shinkansen, Japan

(c) Spain

5.137 Spain has one of the largest HSR networks in the world, at over 2,000 km and 12 HSR lines, linking most of the country, behind only China and Japan, all of which have significantly larger land areas and populations.

5.138 Latest line, Madrid-Valencia/Albacete, was inaugurated on December, 2010 with newly opened stations such as, Fernando Zabel, Requena-Utiel, Valencia Joaquin Sorolla and Albacete. Valencia Joaquin Sorolla station and Albacete station were built in traditional area. Other 2 stations were built in outside city. 5 new stations are shown on Figure 5.2.9.

Station Name / Station Area /Tracks (Platforms)	
Fernando Zabel / 3,950 m^2 / 6 Tracks (2) 	Requen-Utiel / 600 m^2 / 4 Tracks (2) 
Joaquin Sorolla / 53,650 m^2 / 12 Tracks (6) 	
Albacete / 23,000 m^2 / 7 Tracks (4) 	

Source: Compilation by JICA Study Team

Figure 5.2.9 New Stations on Madrid–Valencia/Albacete, Spain

(d) France

5.139 France has among the largest HSR systems in the world, particularly compared to its land mass. With almost 1,900 km of HSR lines, France comes behind only China, Japan and Spain in existing infrastructure.

5.140

5.141 The latest route, LGV Est that a TGV high-speed rail line from Paris to Strasbourg, have 5 stations include existing 2 terminals, Paris East station and Strasbourg station. HSR train is nonstop operating between Paris East and Strasbourg. Other 3 stations that ground stations opened by newly construction, mainly operate as local transportation.

5.142 Those new stations are not interchanging stations with other line. Minimum facilities on platform in new stations, such as, passenger lift, stairs and shade had been placed. All of those stations are far from city center and almost passenger use private car, bus and taxi to access the station. Distance from city center to station is shown in Figure 5.2.10.

<table>
<tr><th colspan="2">Station Name / Location of Station / Distance from Urban City</th></tr>
<tr><td>Champagne-Ardenne / Bezannes /
Reims (5km)
</td><td>Lorraine / Louvigny /
Metz (18km), Nancy (30km)
</td></tr>
<tr><td colspan="2">Meuse / Les Trois Domaines /
Verdun (20km), Bar-le-Duc (24km)
 </td></tr>
</table>

Source: Compilation by JICA Study Team

Figure 5.2.10 New Stations on the LGV Est, France

(e) Germany

5.143 In terms of network size, Germany's HSR system currently ranks fifth in the world, with about 1,300 km of lines in operation, behind China, Japan, France and Spain.

5.144 Stations for Route Nurenberg-Ingolstadt are basically reused of existing station and platform. Allersberg (Rothsee) station and Kinding (Altmühltal) station are few of operation due to low passenger numbers and only the most basic equipment needed is present at the station. Ingolstadt Nord is newly opened station with minimum facility such as, platform shelf, lift, pedestrian underpass. Those stations are shown in Figure 5.2.11.

Station Name	
Allersberg (Rothsee)	Kinging (Altmuhltal)
	
Ignolstadt Nord	
	

Source: Compilation by JICA Study Team

Figure 5.2.11 New Stations on Nurenberg-Ingolstadt, German

(2) Comparison and Analysis on Stations and Station Facilities

(a) Volume of Passenger Traffic

5.145 Station volumes are quite different by country. China has a huge number of passengers and is required to have huge volume of station with integrated train network connecting to the regional railway. Due to the large volume of passengers, stations adopted the ability to control the passengers using boarding gates, in the same way as in the airport to railway station.

5.146 In Spain, France and Germany, high-speed rail is an improvement system for the railway network and new HSR station is not much difference with regional railway station with minimum facilities, such as ground railway, roof and lift for platform and waiting room in station building.

5.147 In Japan, HSR stations are larger than previously built stations because of improvement on safety control (installation of safety fence, lift for disable persons, etc), passenger demand for universal design and others. However, station volume is still average compared with other countries by minimum usage plan.

(b) Connectivity with Other Regional Railway

5.148 In Spain, France and Germany, almost all of the new HSR stations are far from existing urban area and the passenger have to access the stations by private car, taxi and bus. For developing new station, ride and park has been designed with large parking space. This is because the train station is an important method for city plan development. However today, local residents are now provided with other options of access (i.e., go to the destination by car or by air plane) and station usage has become less.

5.149 In Japan Initially, from the point of view of urban development, there have been several cases where single stations at the outskirts of the city were built. Because the results did not come out efficient, connectivity with regional railway are made much of today. Currently, 88% of the HSR station, including future stations, in Japan, connected with the regional railway. Please refer to the Table 5.2.9.

Table 5.2.9 Interchange HSR Station in Japan

Name of HSR Route in Japan	Total Number of Station	Interchange station	Percentage of interchange station
Hokkaido Shinkansen	9	8	89.9
Tohoku Shinkansen	22	18	81.8
Tokaido Shinkansen	17	16	94.1
Hokuriku Shinkansen	20	18	90.0
Sanyo Shinkansen	19	17	89.5
Kyushu Shinkansen	12	10	83.3
Total	99	87	87.9

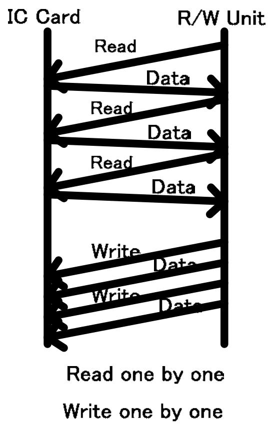
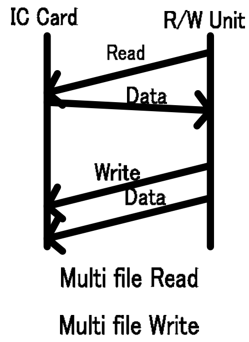
Source: JICA Study Team

10) Automatic Fare Collection System

5.150 To ensure the convenience of users and the income from passenger services, a number of railways have introduced automatic fare collection systems, which are composed of fare media, AFC equipment (read/write units), servers and clearing house servers when broadly classified, with non-contact IC cards, tokens and magnetic tickets (with magnetic records on the back) used in place of existing non-magnetic tickets.

5.151 There are three versions of non-contact IC cards depending on the gap between reader and writer: the “semi-contact type” (gap 2 mm or less), the “proximity type” (10 mm or less) and the “distant type” (70 mm or less). Those used for automatic passenger gates, a principal AFC component, are the proximity type non-contact IC cards, which are further classified into three types A, B and Felica. The type A cards developed by the Netherlands’ Phillips are popular mainly in Europe and other countries; Type B developed by Motorola mainly in the US and Type Felica developed by SONY in Japan and other Asian countries. See Table 5.2.8 for principal differences between these different types of cards. The type Felica cards have merits of high-speed reading and writing to make passengers smoothly pass automatic passenger gates, even during rush hours crowed with passengers, and being used as electronic money cards.

Table 5.2.10 A Comparison between Different Types of Cards

<table>
<tr><th></th><th>Type A</th><th>Type B</th><th>Felica Type</th></tr>
<tr><td>Standard</td><td colspan="2">ISO/IEC 14443</td><td>ISO/IEC 18092
212kpbs Passive mode</td></tr>
<tr><td>Card Size</td><td colspan="2">Credit card only</td><td>Form factor free</td></tr>
<tr><td>Radio Frequency (Carrier)</td><td colspan="2">13.56 MHz
Sub-carrier 847kHz</td><td>13.56 MHz
No Sub-carrier</td></tr>
<tr><td>Command Speed</td><td colspan="2">106 kbps</td><td>212 kbps</td></tr>
<tr><td rowspan="2">Performance</td><td colspan="2">Time Consuming</td><td>Fast</td></tr>
<tr><td colspan="2">
</td><td>
</td></tr>
</table>

Source: JICA Study Team

11) Rolling Stock

(1) Existing High Speed Rolling Stock

5.152 Since Tokaido Shinkansen which is the world's first high speed railway had started operation in 1964, the high speed rolling stock technology has been developed mainly in Japan, France, and Germany. In this section, the present typical high speed trains which are developed in three countries are described.

(a) Rolling Stock in Japan

5.153 When the Shinkansen started its operation in 1964, the maximum operating speed was 210 km/h. After that, the maximum operating speed has improved gradually. In 1997, the maximum speed reached to 300km/h on Sanyo Shinkansen line. Tohoku Shinkansen also started 300 km/h operation in 2011, and will start 320km/h operation in spring of 2013.

5.154 Power distributed system is one of the characteristics of Shinkansen rolling stock from the beginning. By adoption of this system, it became possible to reduce the loading capacity of roadbed and bridge.

5.155 Series E5: JR East series E5 was developed in order to raise the maximum operation speed of Tohoku Shinkansen to 320 km/h and it started operation at 300 km/h in March 2011. The operation at 320 km/h will be started in spring of 2013. New technologies of this train for high speed more than 300km/h are delivered from the experimental train, FASTECH 360. Not only having the traction and braking performance required for 320 km/h operation, but also having the environmental performance and riding comfortability.

5.156 In order to raise the environmental performance, the long nose shape is adopted to reduce the noise caused by micro pressure wave at the tunnel. Full bogie cover, low-noise pantograph, and smooth cover between cars are also adopted for noise reduction. For riding comfortability, the full active suspension system and the car body tilting system are equipped.

Source: JICA Study Team

Figure 5.2.12 Series E5

(i) **Series N700:** Series N700 was jointly developed by JR Central and JR West to pursue high speed performance, riding comfortability, and energy saving. It started operation in 2007 and it is operating on Tokaido Shinkansen, Sanyo Shinkansen, and Kyushu Shinkansen now. Maximum operating speed is 300 km on Sanyo Shinkansen. But it is restricted to 270 km on Tokaido Shinkansen and 260 km on Kyushu Shinkansen because of the alignments or designs of these lines.

5.157 Series N700 equips the car body tilting system which is adopted for the first time to the Shinkansen. The acceleration performance is improved to 2.6km/h/s, the same performance as commuter EMU train. These system and performance are contributing to reduce the travel time especially on Tokaido Shinkansen section which has many small radius curves. The travel time reduced for 5 minutes by introduction of this series although the maximum speed was not changed from 270 km/h.

5.158 Moreover, the environmental performance and riding comfortability are improved. The electric power consumption is reduced by reduction of car weight and air resistance. The semi-active suspension system contributes to improve riding comfort and smooth cover between cars contributes to outside and inside noise reduction.

Source: JICA Study Team

Figure 5.2.13 Series N700

(b) Rolling Stock in France

5.159 TGV, French high speed train, started operation between Paris and Lyon in 1981, after 17 years the Shinkansen had started in 1964. Its maximum speed, 260km/h, was faster than Shinkansen at that time. Push-Pull power concentrated system and articulated bogie system are distinctive of TGV unlike Shinkansen.

5.160 The rolling stock based on TGV is used for the trains like Eurostar and Thalys which connect France and neiglboring countries and also used for the trains of foreign countries like KTX of South Korea, AVE of Spain, Acela Express in the US, etc.

(i) **TGV-POS:** TGV-POS was ordered for the LGV Est (East European Line) and started operation in 2007. The maximum speed is 320km/h. This train is also adopted Push-Pull power concentrated system and articulated bogie system like other TGV trains. In April, 2007 the new world high speed record, 574.8km/h, had made by the special trainset based on TGV-POS.

Source: Naoto Yanase, JR East

Figure 5.2.14 TGV-POS

(ii) **AGV:** AGV is the new high speed rolling stock developed as a next-generation high speed train by Alstom, a manufacturer in France. NTV, an operator of Italian railway, introduced this trains first and started operation in April, 2012.

5.161 This train is also inherited articulated bogie system of TGV trains. But unlike TGV, power distributed system is adopted like Shinkansen and ICE3. The maximum operating speed is 300 km/h now.

Source: Naoto Yanase, JR East

Figure 5.2.15 AGV

(c) Rolling Stock in Germany

5.162 ICE, German high speed train, started operation between Hamburg and Munich in 1991. Its maximum speed was 250 km/h at that time. ICE1, the first generation of ICE, is adopted Push-Pull power concentrated system like TGV. The second series ICE2 is also power concentrated system but have only one locomotive in the end of the trainset and passenger car with driver cab in the other end. When the passenger car with cab runs at the head, the maximum speed is restricted to 200 km/h.

(i) **ICE3:** ICE3 is introduced in 2000 for German railway (DB). This train is adopted the power distributed system unlike ICE1 and ICE2. It was the reason for the adoption of power distributed system that the newly built high speed line had steep gradient of 40‰ for cost reduction and the distances between stations on the new line were relatively short. The present maximum operating speed is 320 km/h.

5.163 The high speed rolling stock series “Velaro”, based on ICE3, is operating in Spain, Russia, and China.

Source: Naoto Yanase, JR East

Figure 5.2.16 ICE3

(ii) **CRH3C:** CRH3C is one of the Velaro series operating in China. But the body width is expanded from 2950 mm to 3260 mm for increasing train capacity. It has 5 seats per 1 row in the economy class like the Shinkansen. The maximum operating speed of this train was 350 km/h, but the speed is restricted under 300km/h for the safety reason now.

Source: Naoto Yanase, JR East

Figure 5.2.17 CRH3C

(2) Merits and Demerits of Articulated Bogie System

5.164 Articulated bogie system is adopted to TGV and its series as high speed rolling stock. Merits of articulated bogie system are mainly improvement of riding comfort and reduction of trainset weight. As for the trainset weight, Shinkansen rolling stock which adopts the non-articulated bogie system is lighter than AGV with articulated bogie system. As for the riding comfort, there is not so much difference between articulated bogie system and non-articulated bogie system because of the development of the anti-vibration technologies like active suspension. Taking other merits and demerits into consideration, there is not so strong reason that the articulated bogie system must be adopted. (See Table 5.2.11 and Figure 5.2.18.)

Table 5.2.11 Merits and Demerits of Articulated Bogie System

Merits	• Lateral vibration is decreased because one bogie connects two cars directly with no coupling. • Body mount position on the bogie can be set higher position to improve riding comfort. • Since there are few bogies than other systems, total weight of a trainset decreases.
Demerits	• Since a trainset cannot be decoupled by each car, more maintenance works are needed. • Since few bogies share the car weight, the axle load increases. Therefore, car length will be shortened to reduce the axle load.

Source: JICA Study Team

Source: Naoto Yanase, JR East

.Figure 5.2.18 Articulated Bogie of TGV

(3) Merits and Demerits of Power Concentrated System and Power Distributed System

5.165 The power concentrated system is one of the high speed train traction system generally used in Europe. This system is adopted to TGV series, ICE1, ICE2, etc. Meanwhile, the power distributed system is the other major system. This system is mainly used by commuter trains but the Shinkansen adopted this system for the first time as high speed train. ICE3 also adopted this system in spite of ICE1 and ICE2 had adopted the power concentrated system. In addition, AGV recently adopts this system. It can be said that the power distributed system is the mainstream of the high speed rolling stock now.

5.166 The merits and demerits of power concentrated system and power distributed system are shown in Table 5.2.12. Comparing the two systems, the power distributed system has more merits for high speed train than the power concentrated system. Induction motor and VVVF system contribute to reduce the demerits of power distributed system related to the maintenance.

Table 5.2.12 Merits and Demerits of Power Concentrated System and Power Distributed System

	Power Concentrated System	Power Distributed System
Trains	TGV and its series ICE1, ICE2	Shinkansen AGV ICE3, Velaro series CRH
Merits	• Since power units (noise source) and coaches are separated, coaches are less noisy. • Since power units are few and concentrated, maintenance works are somewhat less.	• Since equipments are dispersed, axle load is light. • More traction axles contribute to higher acceleration and deceleration with electric brake. • Train can run with higher speed on up gradient section. • If some units have trouble, the train can keep running. (Redundancy)
Demerits	• Axle load of power unit is too heavy. • Since coaches cannot use electric brake, brake linings are exhausted early. • Since passenger cannot ride on power units, train capacity decreases.	• Since equipments are dispersed, maintenance works are somewhat more. • Coaches on traction system are little noisier.

Source: JICA Study Team

(4) Comparison of World High Speed Rolling Stock

5.167 About the train configuration, Japanese rolling stock has higher ratio of motor cars than other power distributed rolling stock. Though high motor car ratio seems to increase the cost and the maintenance works, the power and the size of each motor will be reduced and the maintenance work of induction motor is originally very little. Therefore high motor car ratio is not related to increase the cost and the maintenance directly. Meanwhile, this contributes the high acceleration and low axle load. Also regenerative electric brake of motor car can reduce the energy consumption and exhaustion of brake lining. Other characteristics are as follows:

(i) Maximum axle load, Series N700, 11.4t is the lightest and Series E5 is the second. Other trains are heavier than those 2 trains significantly. Lighter axle load contributes to reduce the wear of track and the load of structures.

(ii) Seats per train length (200 m), Series N700, Series E5 and CRH3C are more than the others. These 3 trains have wide body and 5seats per row in economy class cars. This figure contributes to increase the transport capacity and efficiency.

(iii) Weight per seat, Series N700, 0.48t is the lightest and Series E5 is the next. Lighter weight per seat means that the energy consumption per passenger is less. This is one of the important figures of high speed trains.

Table 5.2.13 Comparison of World High Speed Rolling Stock

Series	E5 (Japan)	N700 (Japan)	TGV-POS (France)	AGV (Italy)	ICE3 MF (German)	CRH3C (China)
Max. Op. Speed [km/h]	320	300	320	300	320	300
Configuration	8M2T	14M2T	2L8T	EMU-11 (6MB6TB)	4M4T	4M4T
Features	Distributed powered	Distributed powered	Concentrated powered Articulated	Distributed powered Articulated	Distributed powered	Distributed powered
Train length [m]	253	404.7	200	202	200	200
Body Width[mm]	3350	3360	2904	3000	2950	3260
Seats	731	1323	357	450	413	556
Max. axle load [t]	13.1	11.4	17	16.5	16	17
Train weight [t]	452	635 (Estimated)	383	374	435	425
Power [kw]	9600	17080	9280	7500	8000	8800
Power/Weight [kw/t]	21.2	26.9	21.9	20.1	18.4	20.7
Power/seat [kw]	13.1	12.9	26.0	16.7	19.4	15.8
Seats/100 m	288.9	327.9	178.5	222.8	206.5	278.0
Weight/seat [t]	0.62	0.48	1.07	0.83	1.05	0.76

Source: JICA Study Team based on the UIC Web Site World High Speed Rolling Stock

12) Signal and Telecommunication

(1) Overview

5.168 Trains are operated at 200 km/h or over in Japan, France, Germany, Italy, Spain, Korea, Taiwan, China, Austria, Sweden, Switzerland, the UK and some other countries. The high-speed railway system in Europe represented by the TGV in France and the ICE in Germany was established as an independent network making the Shinkansen system in Japan a reference and realized operation to/from existing existing railways and those in adjacent countries. Starting the construction of a high-speed railway by introducing technologies of Japan and Europe, China has claimed that it has established its own independent system.

5.169 The train detecting signal system in high-speed railways mostly uses track circuits, except part of the German system using axle counters instead of track circuits in conjunction with the Linienzugbeeinflussung (LZB) train detecting system (continuous train detecting system). The radio train control system ETCS is now at the stage of level 2, with the level 3 ETCS for high-speed railways without using track circuits being still under development (not commercialized yet).

5.170 The leaky coaxial cable (LCX) type train radio system is used in Japan where plenty of tunnel sections exist while the space-wave radio system in Europe and Taiwan. See Table 5.2.14 for the present high-speed railway signal telecommunication systems in major countries.

Table 5.2.14 Signal Systems of Major High-Speed Railways in the World

		Japan		France	Germany	Italy	Spain	South Korea	Taiwan	China	
Route length (km)		2,388		1,896	1,285	923	2,056	412	345	4,079 (8,000)	
Year of inauguration		1964	1982	1981	1991	1981	1992	2010	2006	1998	
Maximum speed (km/h)		300	300 (320)	320	320 (300)	300	300 (350)	300	300	300 (350)	300
Minimum headway (minutes)		4	4	3*	3	5	3	-	-	-	-
Signal	Signal system	Cab signal	Cab signal	Cab signal	Cab signal	Cab signal Wayside signal	Cab signal	Cab signal	Cab signal	Cab signal	Cab signal
	Train control	DS-ATC one-stage continuous control pattern	DS-ATC* one-stage continuous control pattern	TVM/ETCS2 one-stage continuous control pattern	LZB/ETCS2 one-stage continuous control pattern	SCMT/ETCS one-stage continuous control pattern	ASFA/ETCS one-stage continuous control pattern	TVM430 one-stage continuous control pattern	ATC one-stage continuous control pattern	CTCS3* one-stage continuous control pattern	CTCS3* one-stage continuous control pattern
	Train detection	Insulated track circuit	Insulated track circuit, Non-insulated track circuit	Non-insulated track circuit	Non-insulated track circuit Axle counter *	Insulated track circuit	Non-insulated track circuit	Non-insulated track circuit	Non-insulated track circuit	Non-insulated track circuit	Non-insulated track circuit
	Backward operation	Not adopted	Not adopted	Adopted	Adopted	Adopted	Adopted	Adopted	Adopted	Adopted	Adopted
	Operation to/from existing lines	Not adopted	Not adopted	Not adopted	Adopted	Adopted	Adopted	Not Adopted	Not Adopted	Adopted	Adopted
Telecom-munication	Train radio	LCX*	LCX	Space wave type	Space wave type	Space wave type	Space wave type	-	Space wave type	-	-
Remarks		* Leaky coaxial cable	*Interlocking-cum-ATC type	*Practically 15 trains per hour	*Applied to part of high speed railway lines	-	-	-	-	*Equivalent to ETCS 2	*Equivalent to ETCS 2

Source
1: "JREA Vol. 54 No. 5, 2011" for Japan, France, Germany, Italy, Spain and China, Maximum speed for China from the JICA study team
2: "JREA Vol. 48 No. 11, 2005" for Korea and Taiwan
3: The minimum headway from JICA study team for Japan and from "European Railway Signaling, 1995" for others
4: Backward operation and operation from/to existing lines from "JREA Vol. 48 No. 11, 2005"
5: Telecommunication and remarks from the JICA study team

(2) High-Speed Railway Signal System (DS-ATC) in Japan

5.171 The Shinkansen in Japan, which used a multi-stage brake control type ATC signal system at the initial stage, now uses the one-stage brake control type ATC system featuring the following.

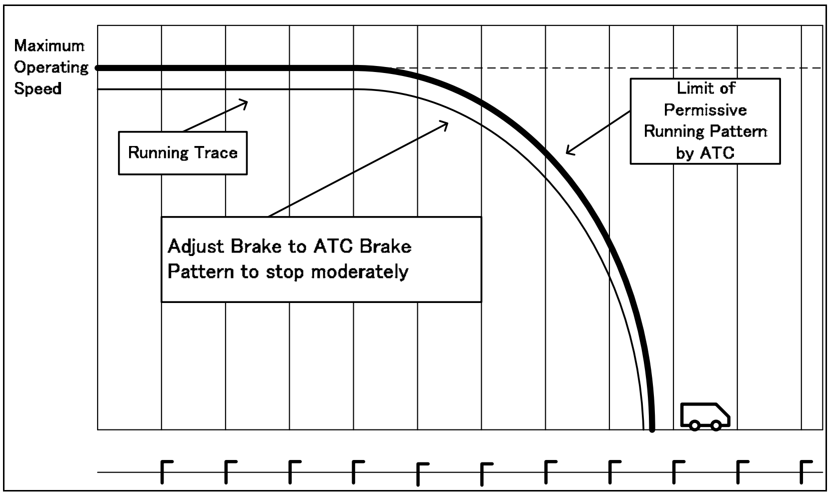
(i) The operation time is cut for trains arriving at stations.

(ii) Smooth brake control significantly improves ride comfort.

(iii) The most appropriate brake control is automatically selected for different car categories.

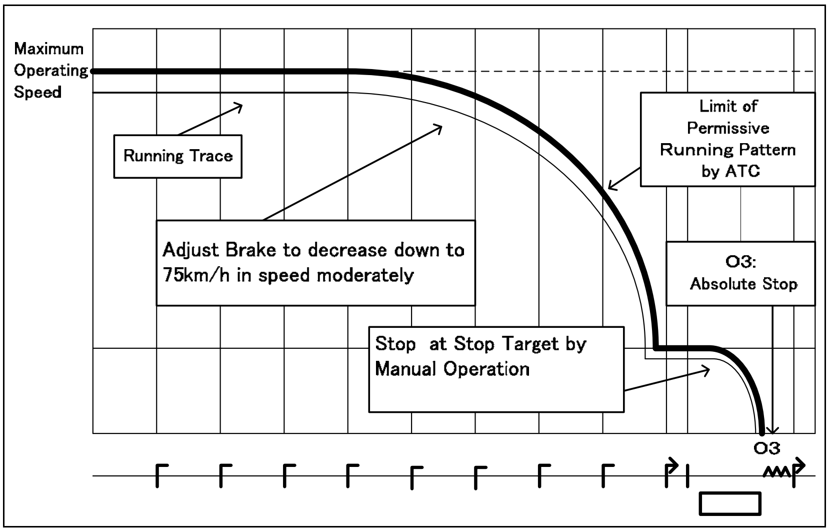
(iv) The car-mounted equipment relying system (storing track data on the car) automatically corrects errors in the train position based on the information sent from the transponder coils on the ground.

5.172 See Figure 5.2.19 and Figure 5.2.20 for the control method by the one-stage brake control type ATC system



Source: JICA Study Team

Figure 5.2.19 Train Control by DS-ATC (An Example of Midway Stopping)



Source: JICA Study Team

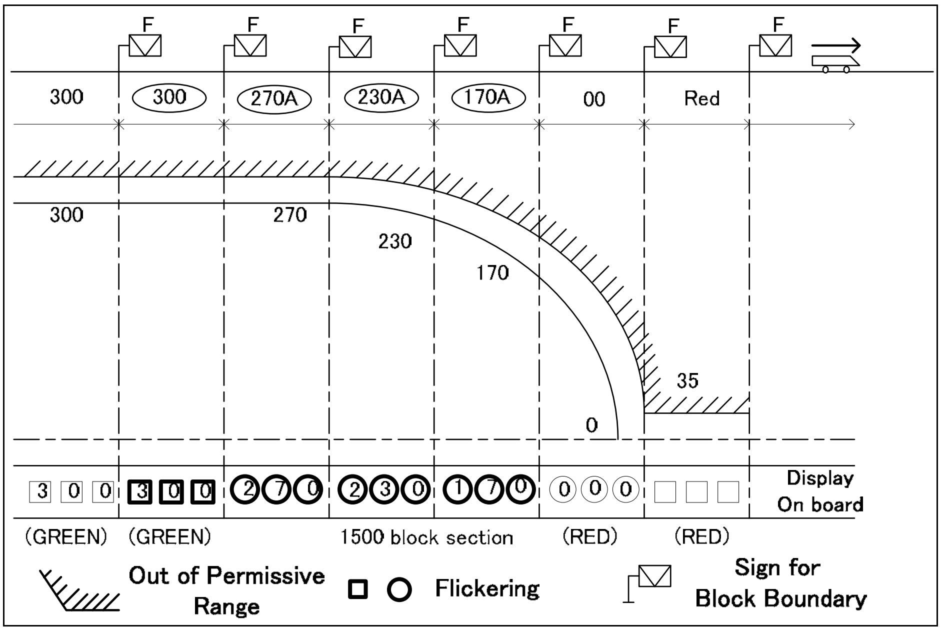
Figure 5.2.20 Train Control by DS-ATC (An Example of Stopping at a Station)

(3) French High-Speed Railway Signal System TVM430

5.173 The TVM300 multi-stage control type signal system, which was initially used by the French high-speed railways, was replaced with the one-stage brake control type TVM430 system, a continuous ground-cab information transmission system using track circuits through rails as a transmission medium. This system was specially developed to make both the ground and cab computers safely process signal information. The computers on the ground are installed in a 2 out of 3 composition approximately at 14 km intervals.

5.174 The safety of the ground to cab information transmission is attained with the high-level SACEM type (Paris subway) code scheme, with the accuracy of codes checked approximately several times per second with independent devices. French high-speed railways actually set 15 trains per hour although the TVM430 signal system theoretically allows 3-minute headway train operation.

5.175 The information to start/ stop the protection by the TVM signal system is automatically given to trains at the entrance/exit to/from high-speed sections through the loop coils installed on the track. See Figure 5.2.21 for the French TGV signal system (TVM430).



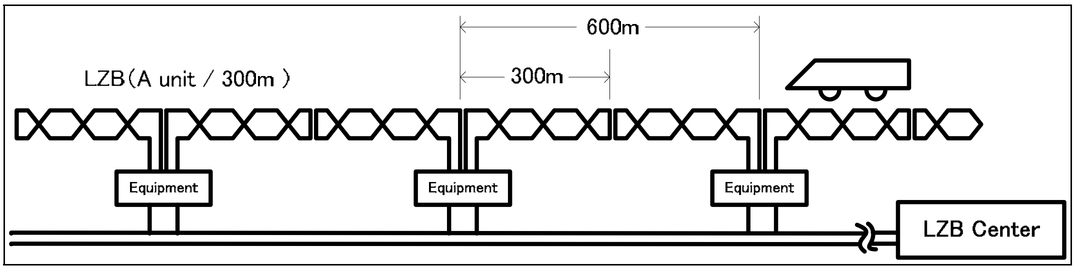
Source: JICA Study Team

Figure 5.2.21 TGV Signal System (TVM430)

(4) German High-Speed Railway Signal System LZB

5.176 German high-speed trains ICE use the LZB signal system (continuous train detection system). This signal system has two signal aspects “go” and “stop” with signals installed at 1 km intervals. To control the trains running at 200 km/h or over, induction coils are laid between rails, through which data is transmitted and the train position is detected. After introduced around 1977 first, the system was remodeled into LZB to incorporate micro-computers in 1991.

5.177 To detect the train position, the LZB System uses the induction cables that cross at 100 m intervals. More concretely, the system notices the train position as the information transmission breaks when the train is at a crossing point, where induction noise is also suppressed. Each of the 100 m sections is allocated with a specific position No., based on which train is traced both in the cab and on the ground. A car – installed device not only detects the crossing points but also calculates the running distance based on the information from the tachometer-generator. See Figure 5.2.22 for the composition of German signal system (LZB).



Source: JICA Study Team

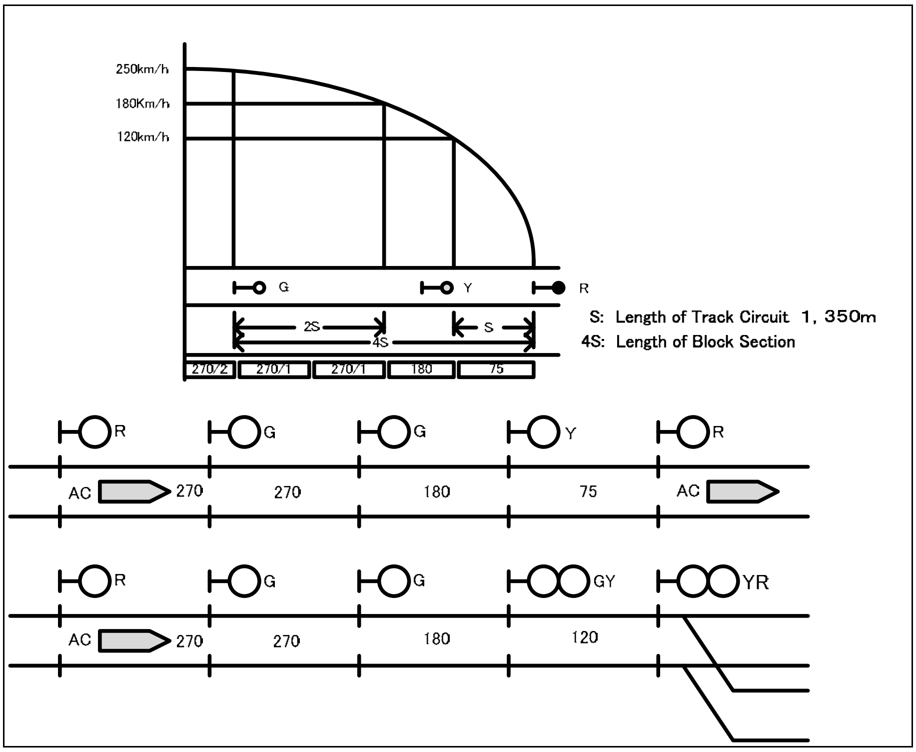
Figure 5.2.22 German ICE Signal System (LZB)

5.178 The interlocking system centralized at an LZB center controls track circuits and points as well as train operation in an area of dozens of kilometers. The LZB center collects information from up to 11 stations to enable operation of up and down. Each of the transmitters/receivers on the ground covers a 300 m-long section, with machine cubicles set at 600 m intervals.

5.179 In the case of new lines, only absolute signals are installed without block signals for trains that are not protected by the LZB signal system (non-high-speed trains). For blocking reasons, even red signals may allow entry of LZB trains. In this case, the red aspect of ground signals is designed to turn off.

(5) Italian High-Speed Railway Signal System

5.180 The signal system of the new high-speed railway between Rome and Florence is composed of averagely 5.5 km-long block sections, each separated into four track circuits further, which is virtually a two- aspect system having “go” and “stop” aspects alone. This means that trains running at the maximum speed shall be able to stop within a 5.5 km distance. For the trains that are going to stop at a station, 180 km/h and 75 km/h signals are given during the speed reducing process, with corresponding signals planted on the ground to give an advance notice. As it is the information to limit speed, however, speed codes of 120 and others are used. See Figure 5.2.23 for the signal system for the Italian high-speed railways.



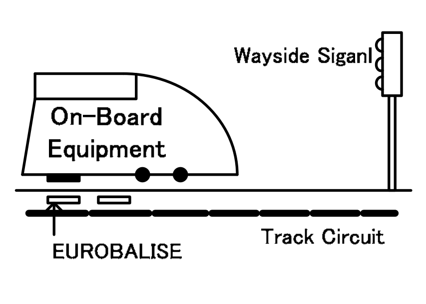
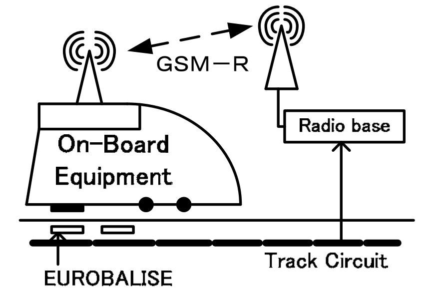
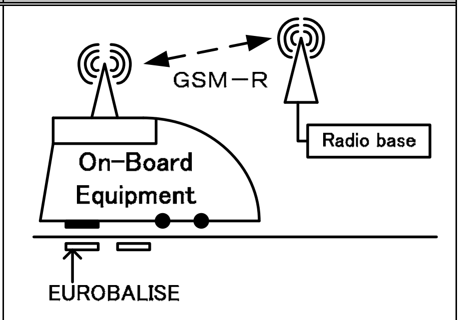
Source: JICA Study Team

Figure 5.2.23 The Signal System for the Italian High-Speed Railways

(6) The Signal System ETCS/ERTMS to use Radio Transmission

5.181 ETCS/ERTMS is a train control system now under development to realize inter-operability after the integration of European countries. The development of ETCS has been promoted by the European Railway Research Institute (ERRI) for more than 20 years. As the necessity arose to develop the ETCS system integrated with the traffic control function (ERTMS), however, it is now a practice to combine the two functions ETCS and ERTMS as a single term of ETCS/ERTMS.

5.182 There are three phases in the development aiming at Levels 1, 2 and 3, with the system function designed to improve as the phase proceeds in this order. The Level 1 aims at the so-called function of ATP (Automatic Train protection) with signals and track circuits remaining intact. The Level 2 intends to adopt cab-signals indispensable for high-speed operation, with a radio information transmission system adopted, though track circuits remain. The Level 3 is to establish an ultimate system for train detection in the cab without using track circuits. Figure 5.2.24 compares the Levels 1, 2 and 3 of ETCS.

Level 1	Level 2	Level 3
		
• Ground signals +Track circuits, equivalent to the ATP in Japan • Combined use with existing signals possible at lower costs than those of high-level systems	• Equivalent to the ATC in Japan while assessing the track-occupancy status of the route with track circuits and performing train control with GSM-R • The mainstream level at present and in the near future	• Equivalent to the ATACS in Japan to realize a moving block system while eliminating track circuits • Still under development • Not realized, not proven • for high-speed railways use

Source: JICA Study Team

Figure 5.2.24 A Comparison of the Levels 1, 2 and 3 of ETCS

5.183 Levels 1, 2 and 3 systems all use in combination wayside transponders called EUROBALISE featuring voluminous information and a railway-dedicated digital radio system called GSM-R.

5.184 High-speed railways that require inter-operability cope with up to the Level 2 system with track circuits remaining, though radio transmission is used. This means that the system is not so up-to-date.

5.185 As to the Level 3, the system was reportedly put into operation in February, 2012, on a 134 km-long low-density local freight line in Sweden with an “ERTMS Regional” pilot system introduced. Although ERTMS Regional is designed for moving block, the trains operate actually on virtual fixed block. It may be possible for the Level 3 to be used for railways at extremely low operation density with superannuated facilities such as those in local areas for the purposes of modernization. However, at the moment, it has not been realized for high-speed railway use. It has seldom been discussed for high-speed railways use. Therefore, the Level 3 system of ETCS for high speed railways is not evaluated from a viewpoint of safety/reliability, actual transport efficiency and cost.

(7) The Signal System CBTC to use Radio Transmission

5.186 CBTC (Communication Based Train Control) is used as a word meaning a various kind of train control systems using wireless telecommunication between ground and on-board equipment. ETCS (European Train Control System) is listed up as an example. Furthermore, CBTC has been mainly introduced to urban railways such as New York Subway, the Senseki line of JR East Co. (ATACS), monorails and other urban railways. It has been proven for CBTC to be used to aim at cutting headways for urban railways featuring a uniform operation style. However, the systems have not been realized for high-speed railways use.

(a) Train Radio System

5.187 As the proven train radio systems used for high-speed railways, there are the leaky coaxial cable (LCX) system in Japan and those to use space waves in Europe and Taiwan. Table 5.2.15 compares these systems. Although it introduced the space wave radio system first, the Shinkansen in Japan is using the LCX system in recent years, as trains shall pass tunnel sections frequently.

5.188 Space wave systems are used in Europe and Taiwan. TETRA allows use of four channels at 25 Hz per wave to claim higher wave using efficiency than GSM-R that allows eight channels at 200 kHz per wave.

Table 5.2.15 Train Radio Systems

	LCX	GSM	TETRA
Radio transmission medium	Leaky coaxial cable	Space wave	Space wave
Starting year	1982~	1991~	1998~
Frequency band (MHz)	400 (reception) 450 (transmission)	935-960 890-915	380-470 806-866
Number of channels	CH/ 2 waves Voice 22 Data 12	CH/ 1 wave 8 (→16)	CH/ 1 wave 4
Inter-channel width	25Hz	200Hz	25Hz
Multiplex communication method	TDMA	TDMA	TDMA
Technological standard	LCX Standard	GSM Standard	TETRA Standard
Service area	Japan	Europe	Europe, Taiwan, Singapore and Russia
Remarks	Adopted by Shinkansen in Japan studded with tunnel sections	Developed for public cellular phones. Has been determined to adopt GSM-R for railway use as an ETCS radio transmission system.	Developed for the police, railways and other official purposes and adopted for Taiwan Shinkansen.

Source: LCX: from “Records on electrical construction of Tohoku Shinkansen between Hachinohi and Shin-Aomori, 4, 2012, Japan Railway Construction, transport and Technology Agency”; GSM, TETRA: from “Learning from overseas railway electrical engineering, 5, 2007, Japan Railway Electrical Engineering Association”

13) Electricity

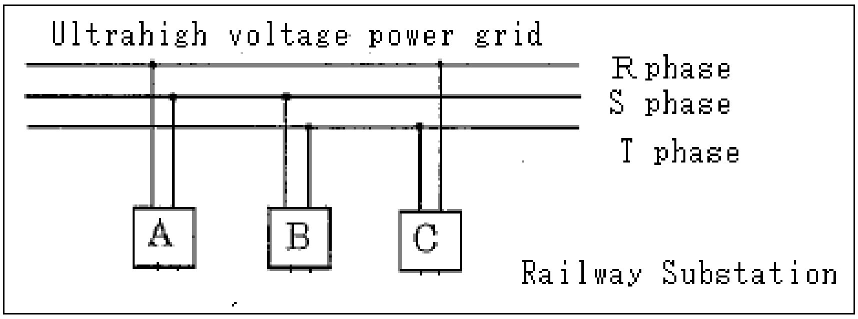
(1) Electric Power Receiving System

5.189 When broadly classified, there are two power receiving systems in terms of the number of phases for electric railway substations that receive power sent from the electric power company through its ultra-high voltage power grid. One is the single-phase type and the other the three-phase type power receiving system.

(a) Single-Phase Power Receiving System

5.190 As the loads of AC electric railways are in single-phase, this system uses simple single-phase transformers under a concept to mitigate the effects of the changes, such as unbalances and fluctuations in voltage, in the loads of electric railways on the power source system (on the side of power supply company) over the entire system.

5.191 In other words, when plural substations receive power from a power supply grid, different phases are selected in turn by different substations. This is called a cyclic single-phase power receiving system, which is widely adopted in Europe. This system has demerits, however, to affect other customers (such as enterprises) who are receiving power from the same source and give inductive interferences to the transmission system in the wayside areas. In this context, it is prescribed in Section 9.2 Electromagnetic Compatibility, Leaflet 660, International Union of Railways (UIC), that high-speed railways shall be designed and constructed electromagnetically coordinated with official and private equipment and devices existing in the surroundings. Therefore, the demerits mentioned above will become a serious and demanding issue in the future. However, a merit of this system is that it can be constructed at low costs. See Figure 5.2.25 for a conceptual drawing of the system.



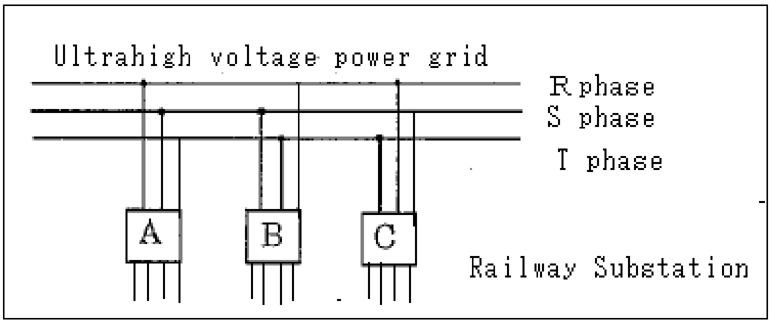
Source: Japan Railway Electrical Engineering Association, Study of overseas electric railway technology

Figure 5.2.25 Cyclic Single-Phase Power Receiving System

(b) Three-Phase Power Receiving System

5.192 This system receives power as it is at substations from the ultra-high voltage power grid of the electric power company, converts it into two sets of single-phase power (spaced by 90 degrees in phase from each other) and supplies them to contact wires to supply power to trains.

5.193 This system is based on a concept to mitigate the effects of unbalances and fluctuations in voltage through feeding transformers and features a merit that there are virtually no effects on the power source (on the side of the electric power company) nor inductive interferences on the wayside transmission system. However, the system has a demerit to entail high construction costs. This system is also widely used all over the world. See Figure 5.2.26 for a conceptual drawing of the system.



Source: JIC (Japan International Consultants for Transportation Co.)

Figure 5.2.26 Three Phase Power Receiving System

(2) Feeding System

5.194 When broadly classified, there are three high-speed railway feeding systems: the direct feeding system, the booster transformer (BT) feeding system and the auto transformer (AT) feeding system.

(a) Direct Feeding System

5.195 This is the simplest feeding system, with feeding circuits composed of trolley wires and rails alone. The current supplied to trains returns to the substation through the rails. Most of the return current leaks to the ground, however, to make it impossible to cancel the induction by the contact wire current, thereby propagating high inductive voltage to the surroundings. The experience in the past indicates that the leakage current amounts to about half the rail current in case no countermeasures are taken. This system is used in some countries in Europe.

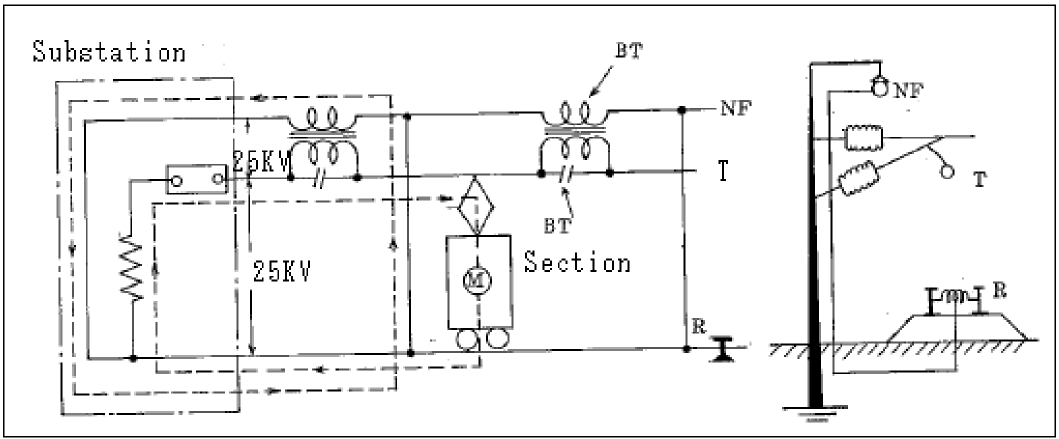
(b) BT Feeding System

5.196 To eliminate the weak points of the direct feeding system, a negative feeder is laid in parallel with the rails, through which the return current flows toward the substation. Booster transformers having a turn ratio of 1 to 1 that induce a negative current in the opposite direction are inserted between the contact wire and the negative feeder to spontaneously draw the return current from the rails.

5.197 When a current flows in the overhead contact wire, a current of almost the same quantity flows in the opposite direction in the negative feeder that is electromagnetically connected thereto by transformer action. As a result, the current leaked to the ground is drawn up into the rails and concentrates in the negative feeder. This substantially decreases the leakage current.

5.198 In the negative feeder, a current of almost the same quantity flows in the opposite direction to the overhead contact wire. When the negative feeder is installed close to the overhead contact wire in parallel, therefore, the electromagnetic interference by the current in the overhead contact wire cancels that by the current in the feeding wire to significantly reduce the electromagnetically induced voltage in the surroundings as a result.

5.199 This system is now widely used in the world. As a matter of fact, it was used for the Tokaido Shinkansen just after its inauguration and also as a standard system for AC-electrification in Japan until around the 1970s. See Figure 5.2.27 for a conceptual drawing of the system.



Source: Japan Railway Electrical Engineering Association, Introduction to electric railway (Substation)
NF: Negative feeder T: Contact wire (Trolley wire) R: Rail

Figure 5.2.27 Booster Transformer Feeding System

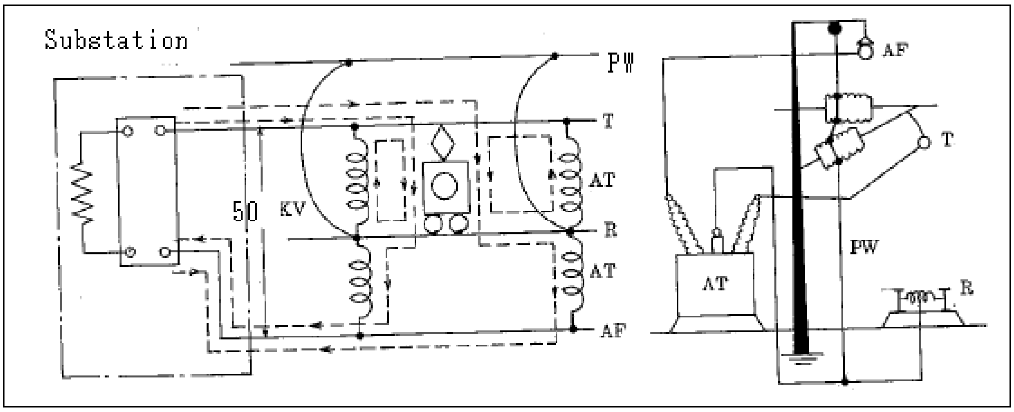
(c) AT Feeding System

5.200 The AT feeding system uses a feeder laid along the track to have the same voltage as that of the overhead contact wire and is polarized opposite to. Auto transformers (Ats) are installed at certain intervals along the track. The rail current of the train that has entered a section sandwiched with two adjacent auto transformers is drawn up with these transformers and returned to the substation through the feeder. The neutral point of each auto transformer is connected to the feeder and rails.

5.201 As a result, the current flowing in the feeder runs in the opposite direction to that in the overhead contact wire. This electromagnetically cancels the inductive interferences caused by the two wires.

5.202 As the voltage of the current going out of the substation is twice as high as that of the feeding voltage, longer intervals are allowed between adjacent substations while supplying a large quantity of power in a stabilized form. No arcs are generated as there are no sections, either.

5.203 This system has been in use as a standard for AC electrification since the 1970s. In particular, the AT feeding system at the commercial frequency that started in Japan is adopted globally as a standard system thereafter. See Figure 5.2.28.



Source: Japan Railway Electrical Engineering Association, Introduction to electric railway (Substation).

Figure 5.2.28 Auto Transformer Feeding System

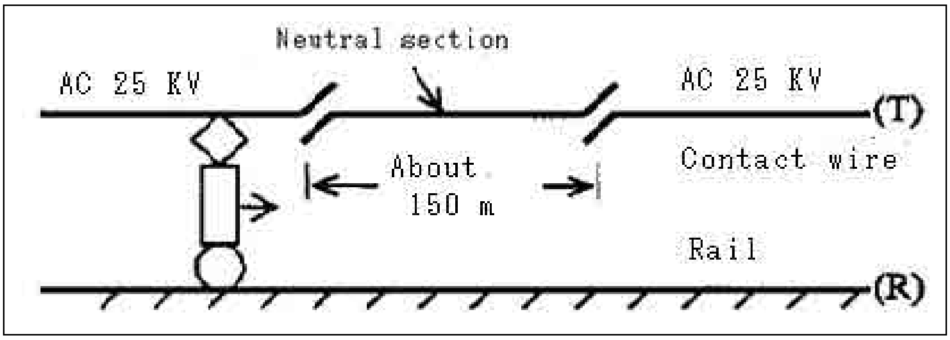
5.204 In jointing two different power sources such as adjacent substations, it is normally the case that a dead section is placed to prevent short circuits at the jointing point. When broadly classified, there are two methods for this purpose. One is to place a no-voltage dead section and the other to install an automatic changeover section.

(d) System to Use No-Voltage Dead Sections

5.205 This is a system to place a no-voltage dead section to a certain length (determined by the speed, length and number of pantographs of trains, where trains are supposed to run without powering in the notch-off state.

5.206 A demerit of this system is that train drivers shall place the handle of master controller at the notch-off position to reduce train speed before every dead section and run the section without powering. This hinders high-speed operation.

5.207 For the French TGV trains equipped with one pantograph each to run at a maximum speed of 300 km/h, 150 m-long no-voltage sections were installed to require coasting in the past. In recent years, however, this system has been replaced with the automatic changeover system with train detection coils installed on the ground to automatically cut the main power circuit on trains for coasting operation. (See Figure. 5.2.29.)



Source: Japan Railway Electrical Engineering Association, Study of overseas electric railway technology.

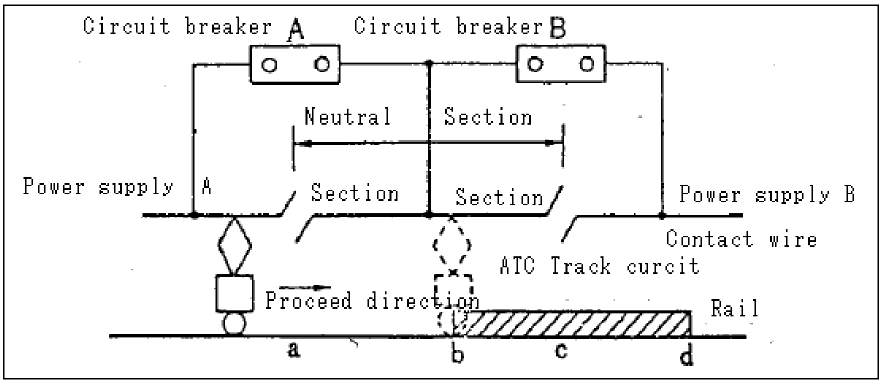
Figure 5.2.29 Dead section in France TGV

(e) System to Use Automatic Changeover Sections

5.208 This is a system to enable trains to run changeover sections in the state of notch-in (driving), with opposite power sources automatically switched by the changeover switches at high-speed at jointing points. This system is composed of two sets of air sections and changeover switches combined with ATC track circuits (see Figure 5.2.30). Below explained is the principle of the action of automatic changeover section.

- The switches A and B are turned on and off, respectively, until the train reaches the point a, with the neutral section a-c energized with the power source on the side A. When the train has entered the ATC track circuit at the point b, the switch A is automatically turned off and the switch B turned on. As a result, the neutral section is switched to the power source on the side B after an approximately 300 ± 50 mms no-voltage time has elapsed. Thus, the train can continue driving without any hindrance.

- When the train has passed the point d, the changeover switches B and A are turned off and turned on, respectively, to wait for the passage of a next train. The switches compose a duplicated system, with one used in the normal state and the other prepared as a standby unit.
- This system is adopted for the entire network of Shinkansen in Japan and for the railways in some countries (including Taiwan). A demerit of the system is the extremely high construction costs (one billion yen or so required for a changeover section). See Figure 5.2.30 for a conceptual drawing of the system.



Source: Japan Railway Electrical Engineering Association, Study of overseas electric railway technology.

Figure 5.2.30 Configuration of Changeover Section

(3) Structure of Catenary System

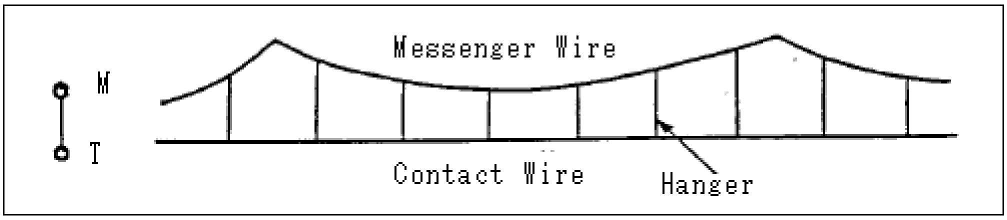
5.209 In recent years, most of the counties in the world including Japan use the simple catenary system for their high-speed railways. China has recently introduced a modified stitched simple catenary system into its 1,318 km-long high-speed section between Beijing and Shanghai opened on July 30, 2011 for 350 km/h operation. The Germany trolley wire system also uses a modified stitched simple catenary system.

5.210 The TGV southeastern railway in France was originally constructed under a modified stitched simple catenary system. The TGV northern railway was constructed, however, to use a simple catenary system instead, as the system introduced into the southeastern railway requires much manpower for maintenance.

(a) Simple Catenary System

5.211 This system, a basic and typical trolley wire (contact wire) hanging system widely used all over the world, is composed of messenger wires and trolley wires with the latter hung by hangers from the former to keep parallelism with the track surface.

5.212 This system, which was used for medium-speed railways in the past, has come to be introduced into high-speed railways as well, as a result of the research and development on the quality of trolley wire. See Figure 5.2.31 for a conceptual drawing of the system.

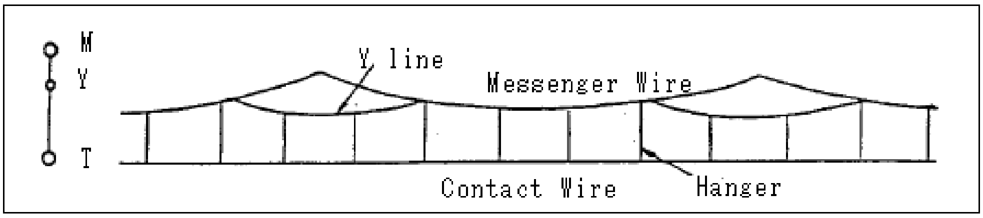


Source: Japan Railway Electrical Engineering Association, Introduction to catenary system.

Figure 5.2.31 Simple Catenary System

(b) Modified Stitched Simple Catenary System

5.213 To improve the speed performance of the simple catenary system, this system installs about 15 m-long wires (called Y-lines) in parallel with the messenger wire at the supporting points of the simple catenary system. This is to increase the uplift of the trolley wire around the supporting points with the Y-lines, reduce the hard points at the adjacent supporting points when a pantograph passes and decrease the difference in the uplift between the span center and the supporting points, thereby improving the speed performance of the system. See Figure 5.2.32 for a conceptual drawing of the system.



Source: Japan Railway Electrical Engineering Association, Introduction to catenary system.

Figure 5.2.32 Stitched Simple Catenary System

14) Maintenance and Depot

(1) Rolling Stock Maintenance

(a) Maintenance Method

5.214 There are corrective maintenance and preventive maintenance in maintenance method. Corrective maintenance is to repair or replace the equipments when it failed and preventive maintenance is to replace or repair the equipments before the life time or failure of the equipment for maintaining the equipments in satisfactory operating condition. Corrective maintenance can be reduce the maintenance cost because equipments will be used until the failure but it will cause passengers problem and it has risk of big accident. Therefore preventive maintenance is applied for rolling stock maintenance and systematic inspection is required for preventive maintenance.

(b) Maintenance Interval

5.215 Interval is specified for preventive maintenance. Interval is specified in time, in mileage or combined with time and mileage. Highest level of maintenance is overhaul and several levels of maintenances are specified between overhaul. Table 5.2.16 indicates the level and interval of inspection of High Speed Rail rolling stock of Germany, France and Japan.

5.216 Detail of maintenance method is not open and it is difficult to compare the method of high speed railway rolling stock in world wide.

(2) Line Maintenance

(a) **Maintenance Method:** Periodic maintenance was generally applied but trend is shifting to condition-based maintenance

(b) **Working Window:** In existing railway maintenance is performed during the time when train is operated however in high speed railway maintenance work is performed during night time and lines are isolated.

Table 5.2.16 Level and Interval of Inspection of Rolling Stock in Germany (ICE), France (TGV) and Japan

Country	Type	Interval	Items
Germany	L	2,000km	Brake check (1 hour) Cleaning of interior Water supply for toilet
	N	12,000km	L + visual inspection (1 hour)
	F1	60,000km	Inspection of measure equipments (24 hours)
	F2	240,000km	F1 + inspection of air condition (24 hours)
	REV	1,200,000km	(15 hours)
France	ES	5,000km	Check in service
	ESS	8 days	General level check
	ECC	22 days	Comfort checks
	EMN/ECF	37 days	Mechanical checks
	ATS1	52 days	Another systematic works
	ATS2	168 days	Another systematic works
	VL	450,000km or 10 months	Limited level checks
	VG	900,000km or 18 months	General level checks
	GVG	1,800,000km or 36 months	Complete level checks
Japan	Daily inspection	daily	Replacing expendable parts Checking the function for running, braking, doors, electric parts.
	Regular inspection	30 days or 30,000km	Checking the condition and function of pantograph, electric circuit, bogie, running gear, brake equipments, body, gauge, interior and other devices. Isolation test of electric circuit
	Bogie inspection	One and half year or 600,000km	Detaching of bogies and braking down to wheel, traction motor, suspension devices, bogie frame, gear box, and brake equipments to inspection and restoration
	Overhaul	3 years or 1,200,000km	Disassemble all the major parts to inspect and restoration.

Sources: Rolling Stock Technology 1993 Japan Association of Rolling Stock Industries; Maintenance and Operation of High-Speed Rolling Stock APTA UIC.

(c) **Sweep Train:** In the high speed railway of many countries sweep train is operated for confirmation that the line is clear and no obstacles after maintenance work. First train of the day will is operated as “sweep train” with slow down the maximum speed to 170 km/h to 200 km/h. In Japanese high speed railway designated “confirmation car” is operated after maintenance work during working window. Confirmation car has lighting device and CCTV to identify the obstacles and it is operated 70 km/h to 110 km/h.

5.217 Table 5.2.17 indicates the maintenance way of high speed railway in the world.

Table 5.2.17 Maintenance of High Speed Rail Line in the World

	Italy	Spain	France	Belgium	Taiwan	Korea	Japan
Length of Line (km)	640	N/A	389	210	345	212	714
Maximum speed (km/h)							
Design	300	300-350	260-320	260-320	350		300
Operation	300	300	300-320	260-300	300	300	300
Daily service (trains/day)	290	N/A	N/A	N/A	123	N/A	176
Structure (%)							
Bridged and viaducts	41.7	N/A	7	20.4	72.5	7	60
Tunnels	24.9		3	4.5	18.3	3	35
Earthwork	33.4		90	75.1	9.2	90	5
Track type (%)							
Ballast track	100	95	100	100	1.2	100	8
Slab track	0	5		0	98.5	0	86
Embedded rail	0			0	0.3	0	6
Maintenance bases							
Number	14	9	7	3	5	3	17
Average coverage(km)	46	158	78	71	69	70	42
Maintenance approach	①	②	③	④	⑤	⑥	⑦
Sweep train (Y/N)	No	Yes	N/A	Yes	Yes	Yes	N/A
Operation speed (km/h)		200			170		
Daily possession time						N/A	
During day	-	-		40min-1h			
Overnight							
1 track	-	-		6h	4.5h		
2 tracks	5.5h	4h	5.5h	4h			6h
Number of staffs/km single track (person/km)			N/A			N/A	
Management	0.031			0.025	0.26		0.118
Track and civil works	0.076	0.072		0.011	0.116/0.223		0.266
Energy and OCS	0.13	0.33		0.072	0.243/0.171		0.270
Control command	0.094	0.046		0.052			
Others				0.02			

Source "Maintenance of High Speed Lines 2010 UIC"

① moving from time-based maintenance to condition-based maintenance in terms of defect detection by mobile diagnostic means
② time-base and condition-base
③ actual: time-based future: condition-based
time-based maintenance: according to O&M manual – performance of PM works
Condition-based maintenance: currently being examined in each subsyste,
④ time-based inspection / condition-based maintenance
⑤ time-based maintenance: according to O&M manual – performance of PM works
Condition-based maintenance: currently being examined in each subsyste,
⑥ time-based / condition-based
⑦ time-based / condition-based

15) Train Operation

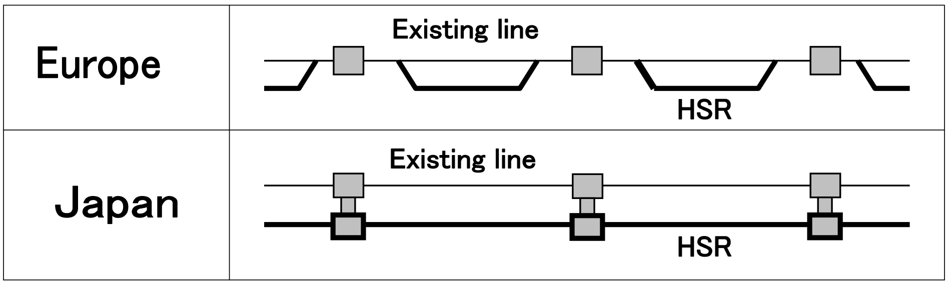
(1) Terminal Station

5.218 The high-speed railways in Europe perform through-operation to/from existing railways. To cut the construction costs, existing stations are used, with tracks and stations constructed only in suburban sections.

5.219 The starting and terminal stations, Paris Lyon and Lyon, of the South- East high-speed railway, the first high-speed railway inaugurated in France, are those of existing railways. Similarly, stations on existing railways are used by the high-speed railways inaugurated thereafter, such as the Atlantic, Mediterranean, Northern European and East European lines, with tracks and stations constructed only in suburban sections.

5.220 In Germany, lines for high-speed operation are set in the route to shortcut major stations, with existing terminal stations used. The starting and terminal stations of the Mannheim and Stuttgart section where high-speed trains were run for the first time in Germany are also those of existing lines.

5.221 In contrast, Shinkansen railways in Japan are completely separated from existing lines. This enables trains to run to the terminal station from suburbs without reducing operation speed and allows high-speed operation immediately after departing the starting station. When compared with the high-speed railways in Europe, this system minimizes the loss in the operation time when trains arrive at and depart from terminal stations. Terminal stations of Shinkansen are connected to those of existing railways.



Source: JICA Study Team

Figure 5.2.33 1 Track Layout on the Lines for High-Speed Operation

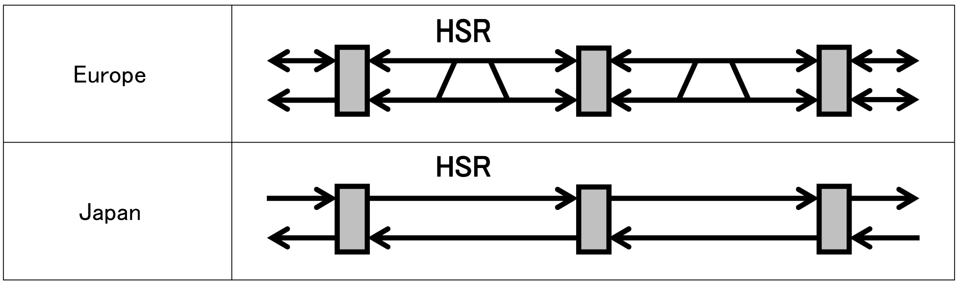
(2) Lines

5.222 The high-speed railways in France and Germany are based on a system of parallel single-track operation, with crossovers laid between stations to connect the up- and down-tracks, to allow trains run in two directions on a single track, in case the other track has failed.

5.223 In contrast, the Shinkansen railways in Japan operate up- and down-trains separately on the track dedicated to a particular direction. In case one track has failed, both tracks in the section that includes the failed point are completely closed, with train operation resumed in principle after the section has been restored.

5.224 More than 300 trains are operated everyday on the Tokaido or Tohoku Shinkansen railway. Therefore, only two or three trains can be operated on a track under the single -track operation system, in case the other track has become inoperative.

5.225 If feeding were stopped only for the defective track for the purpose of recovery work, it will compromise the life of workers due to mistaken electric shock. For this reason, power supply is stopped for the whole section, with priority placed on the recovery work.



Source: JICA Study Team

Figure 5.2.34 2 Lines

(3) Operation of Freight Trains

5.226 In Europe, it is a rule for high-speed trains not to cross freight trains, as it involves problems of security, or such mishaps as freight collapsing or casual opening of the doors of freight cars.

5.227 In the Mannheim–Stuttgart and Hannover–Berlin sections where high-speed trains are running in Germany, these trains of different categories are completely separated, in that only the time zone from 30 minutes after the end of high-speed train operation to 30 minutes before the start thereof is appropriated to the operation of freight trains

5.228 In France, the high-speed railways are dedicated to passenger transport to cut the initial construction costs. The freight cars running at 120 km/h do not rival high-speed passenger trains in terms of speed. This makes it impossible to draw ideal train operation diagrams when they are operated simultaneously on the same lines. Therefore, freight trains are operated on existing lines separately from high-speed passenger trains.

5.229 In this way, it is prohibited for freight trains to run in the sections for high speed operation or limited to enter such sections.

(4) Maintenance Work

5.230 To safely and precisely control the train operation of Shinkansen, it is important to implement maintenance work, such as exchanging rails, rewiring and inspection of trolley wires, inspection of point machines and ballast adjustment and other miscellaneous services, after revenue service operation has been completed.

5.231 In Japan, maintenance work is performed from 0:00 to 6:00 after the completion of revenue service operation. In France where the time zone for revenue service operation is 6:00 to 24:00 like in Japan, maintenance work is possible after the end of revenue service operation. In Germany, as freight trains are operated at night, the time zone for maintenance work shall be coordinated with freight train operation.

16) Operation Controlling System

(1) Overview

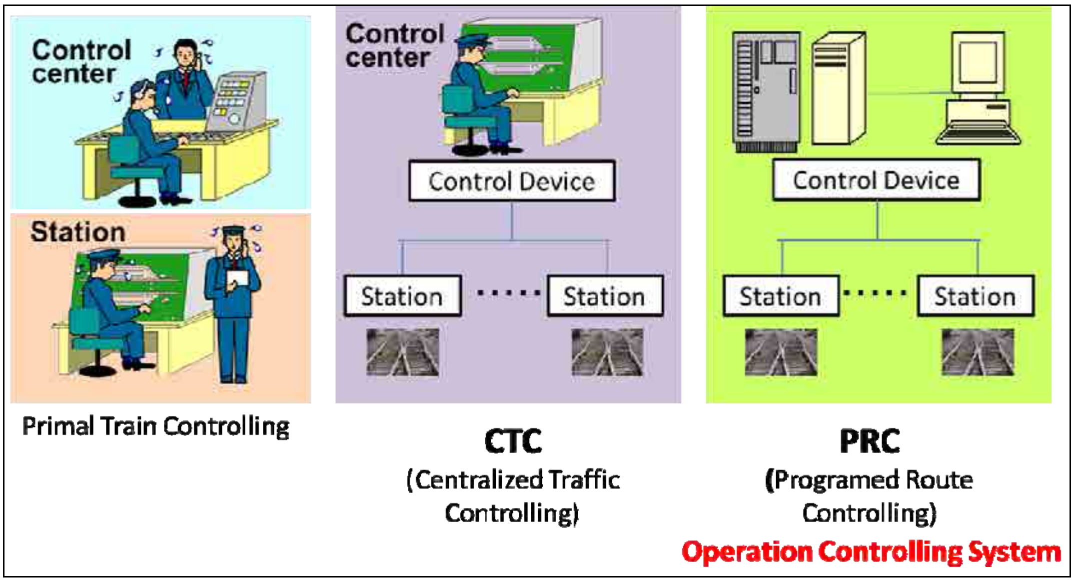
5.232 Requirements of Operation Controlling System are available to get the line situation, for example train location, delay time etc., and to be available to change the train schedule in real time, if necessary. Because railway operator’s first priority is to provide safety, punctual and sustainable train operation for customers. Development history of the Operation Controlling System is briefly given as follows:

(i) The first step of a Train Operation method is the leading by stations. In this method, dispatchers have no information about traffic situation, such that train location, delay time and so on. All information depends on station. So they have to confirm to each station staff and decide the operation schedule. Station staffs follow the instructions by dispatchers and control the train route. Therefore, this method is not suitable for high density and high speed train operation.

(ii) The second step is the Centralized Traffics Controlling system (CTC). It was developed in United States of America (USA) in 1927 to provide efficient train operation. Dispatchers' 'controlled the train passing rout from central controlling center, instead of station staffs. The device was composed of relay logic circuit.

(iii) And then the train Operation Controlling System has developed, which is able to control the train route automatically by computer. This is the Programed Route Controlling (PRC). But when the traffic incident occurred, it was impossible to change the train schedule. So that the man and machine interface device, which were able to change the train schedule, were added.

5.233 In this way, Operation Controlling System has been developed and applied for not only high speed railway but also the city railway. It has been the symbol of the modern railway operation.



Source: JICA Study Team

Figure 5.2.35 Progress of Train Operation Methods

(2) Operation Controlling System of Shinkansen

5.234 When Japanese National Railroad (JNR) revealed the Tokaido Sinkansen line in 1964, CTC was applied to the High Speed Railway and trunk line. It was the first success in the world. This system is composed solid-state transistor devices. At this period, traffic dispatchers were controlling the train passing rout by manual.

5.235 In 1970s, the Tokaido Shinkanasen was extended for the west part of Japan. According to the increasing number of trains and complicated train stopping patterns with line extension, JNR developed Automatic Rout Controlling devise (ARC). This system was installed middle stations and each terminal Station was controlled by dispatchers. Patterning of the train schedule is necessary for introduction of the ARC.

Therefore JNR produced the train diagram which operated 2 types train, “Hikari” of the express type and “Kodama” of the ordinary type.

5.236 In 1972, when the Sanyo Shinkansen, which was extended from the Tokaido Shinkansenfor west, was started on services, in this opportunity NR adapted the PRC, named COMTRAC(Computer aided Traffic Controlling system) . This system was automatically controlling the train rout by computer with the inputted scheduling data beforehand.

Table 5.2.18 Trend of Train Number in the Tokaido-Sanyo Shinkansen

Train Timetable Revision	Number of Train			Diagram Patern	Rout km (Station)	Note
	Express	Ordinaly	Totall			
01-Oct-64	28	32	60	1:1	515.4 (14)	Started Tokyo-ShinOsaka
01-Oct-65	40	46	86	2:2		Controllining by CTC
01-Nov-65	52	58	110			
01-Oct-66	56	65	121			
01-Oct-67	64	79	143	3:3		
01-Oct-68	72	106	178			
25-Apr-69	76	114	190			
01-Oct-69	78	124	202	3:6		Osaka Exposition
15-Mar-72	92	128	220	4:4	576.3 (19)	Expanded for OKAYAMA
02-Oct-72	92	132	224			Controllining by COMTRAC※
01-Mar-73	96	135	231			
01-Oct-73	100	135	235			
01-Mar-75	120	138	258	5:5	1069.1 (37)	Expanded for HAKATA
01-Jul-76	132	143	275	5:4		
01-Oct-80	138	117	255	5:5		
14-Mar-85	149	116	265	6:4		
10-Oct-86	163	147	310			

Source:“Shinkansen”Sankaido
*COMTRAC: Computer Aided Traffic Control System

(3) Modern System Configuration

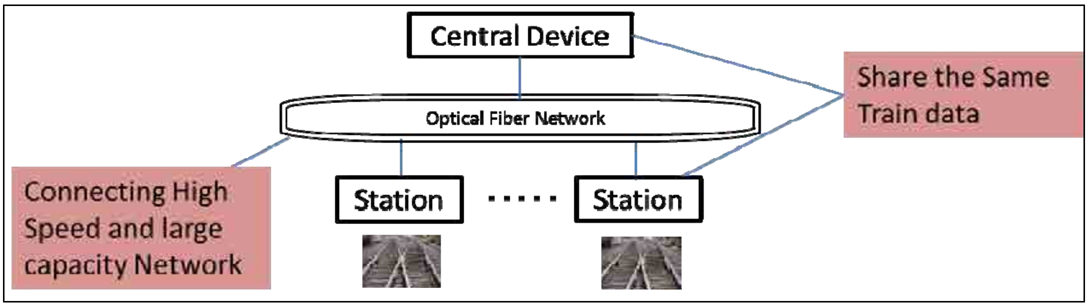
5.237 At the first of beginning, CTC and PRC were tree type system, which were composed central computer and station devises. After then system have been progressed accompany with the progress of information technologies.

5.238 In recent technology, the autonomous and decentralized system, which consisted central computer and station computers connected high speed and large capacity network cable, is current. The feature of this system is sharing the same diagram between central computer and station ones. (See Figure 5.2.36.) The advantage of this method is as follows:

(i) If central computer is failed but no problem each station system, it is possible to continue the train operation.

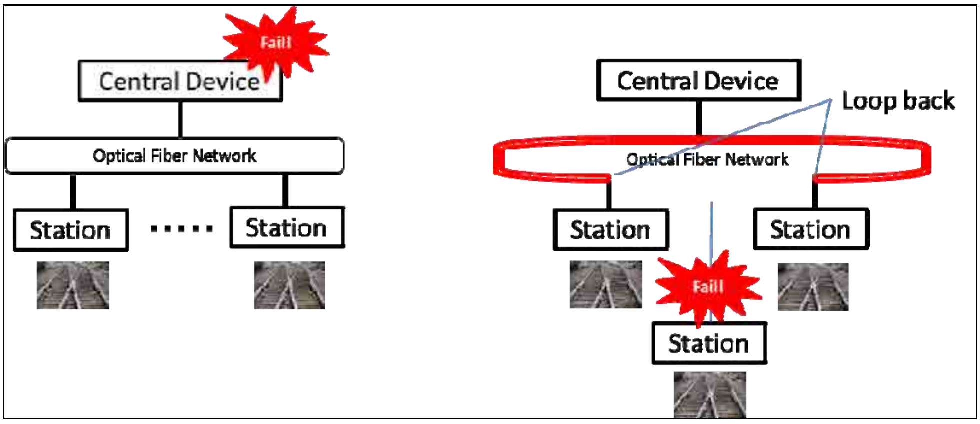
(ii) If some station system is failed, it is possible to continue the train operation by network loopback function.

(iii) It is possible to set up station by station. So that construction and installation work is simple and easy. (see Figure 5.2.37.)



Source: JICA Study Team

Figure 5.2.36 Autonomous and Decentralized System



Source: JICA Study Team

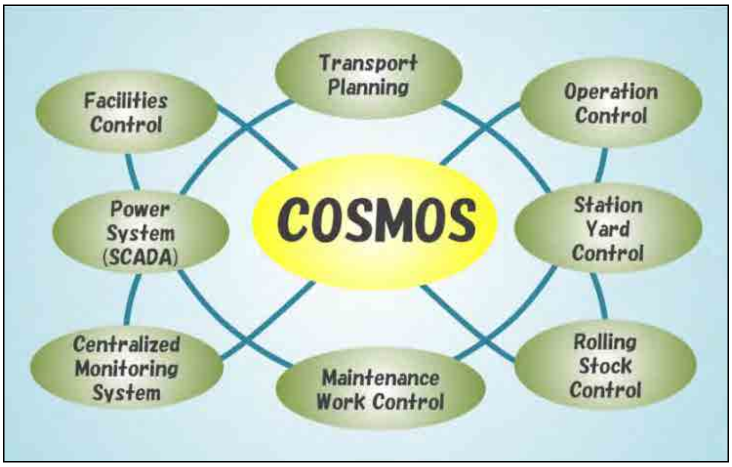
Figure 5.2.37 Advantage of Autonomous and Decentralized System

(4) COSMOS (Computerized Safety, Maintenance and Operation Systems of Shinkansen)

5.239 The East Japan Railway Company (JR East) developed new two types of Operation Controlling System by using of the autonomous decentralized system. One is COSMOS for Japanese High Speed Rail, Tohoku and Joetsu Shinkansen and another is ATOS (Autonomous decentralized Transport Operation control System) for existing commuter lines in greater Tokyo area in the late of 1990s. COSMOS is consisted in 8 sub-systems. (See Figure 5.2.38.)

(a) **Transport Planning:** This system provides the basic and temporary train schedule, rolling stock distributions, driving crew assignment plans. It also provides rolling stock inspection plans. These plans for the following two days are sent to the Operation Control System

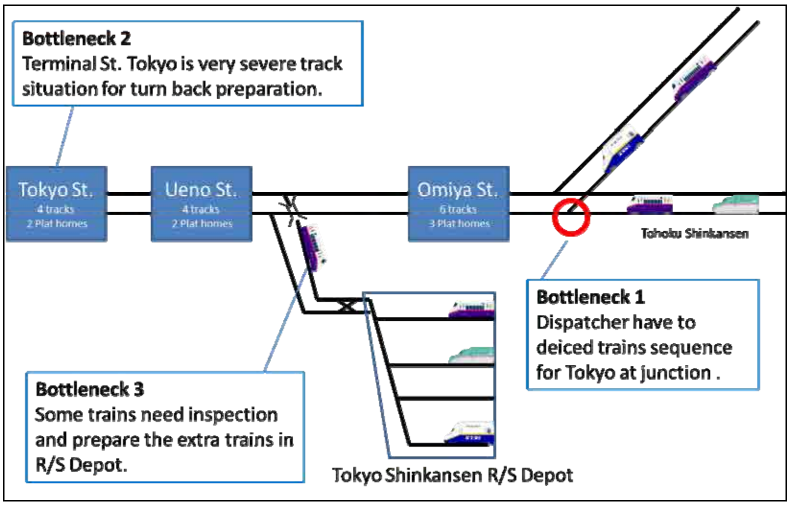
(b) **Operation Control:** This system displays the forecast operation schedule for future train running, and allows the operation schedule to be revised by entering changes directly into the line-type diagram. Routes can be displayed and operated on the same screen. Also, operation schedules are stored in the station PRC, allowing automatic route controlling. Passenger information and announcements are provided on the basis of the tracking information in the station system. This system also lets maintenance workers request maintenance car routes during work periods from work terminals.



Source: JICA Study Team

Figure 5.2.38 8 Sub-Systems of COSMOS

5.240 COSMOS is controlling two high speed lines from Tokyo terminal to Omiya junction. So this section is crowded, trains headway is 4 minutes and for the 2 different directions. And more there are only 2 platform 4tracks in Tokyo terminal. And some train may need daily inspection in the Rolling stocks depot. That is why dispatchers have to decide train sequence at Omiya junction and the COSMOS provide train arrival forecast. (See Figure 5.2.39.)



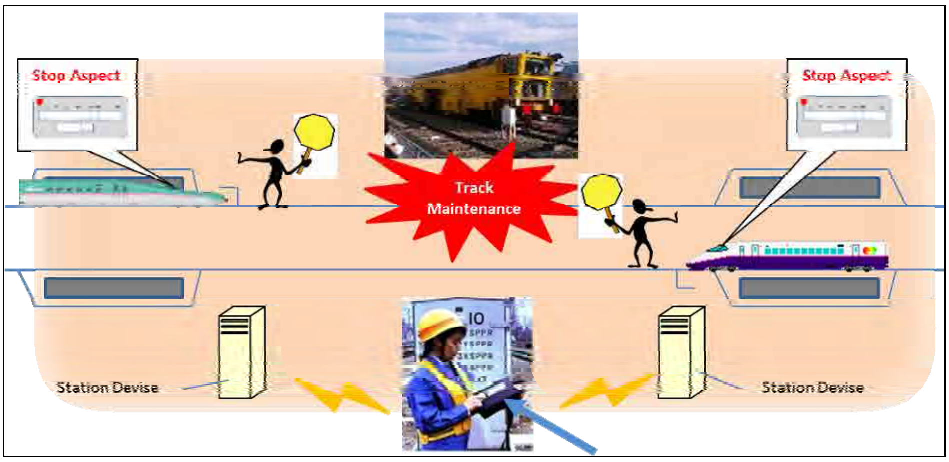
Source: JICA Study Team

Figure 5.2.39 The Reason Why COCMOS Adapted Forecast Operation Schedule for the Train Controlling

(c) **Rolling Stocks Control:** This system manages the rolling stock life cycle and records data that shows various equipment conditions and reliability. Malfunction information is input in real time at the work site and controlled as history information. This system also controls rolling stock inspections.

(d) **Facility Control:** This system analyzes, statistically processes, search and transmits inspection train data. It facilitates the retrieval of data required for maintenance work, and supports the preparation of maintenance work plans.

(e) **Maintenance Work Control:** When maintenance work is necessary some location, train operation must be stopped between station and station. Before systematized, Maintenance staffs have to inform to both stations. They can start the maintenance work with approve of both station. After work, maintenance staffs inform to both stations, too. After systematized, track maintenance staff plans and submits the work schedule to W/S; maintenance staff requests "Track Closing" for both Stations by the handy terminal; station devices close the tracks by signal automatically and after working, the maintenance staff informs the handy terminal. This system is developed for the existing line, which has many maintenance works in short maintenance hours. Due to safety improvement, JR East installed this for COSMOS. (See Figure 5.2.40.)



Source: JICA Study Team

Figure 5.2.40 Maintenance Work Control System

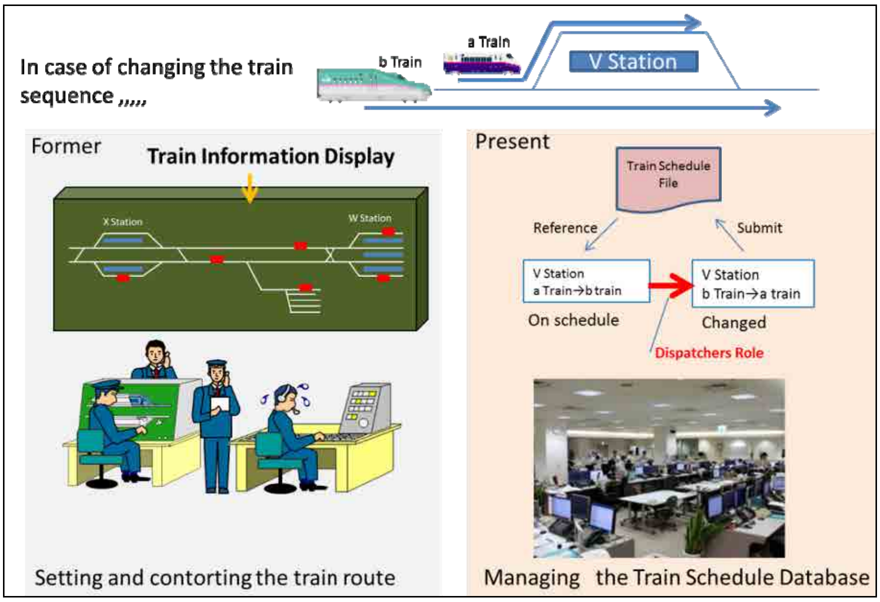
(f) **Station Yard Control:** This system supports the preparation of yard work plans and yard shunting schedules on the basis of planned and final operation schedules, and makes it possible to track rolling stock locations and control routes within the yard.

(g) **Centralized Monitoring:** This system monitors the conditions of the Shinkansen way-side facility and "machine room facility" equipment, and issues an alarm or otherwise alerts the controllers when a malfunction occurs. It also centrally controls the wind, snow, rain and rail temperature information gathered from the various measurement devices.

(h) **Power System (SCADA):** This system controls and monitors electric power supply system, and monitors the substation, catenary switchboard and other equipment conditions.

(5) Train Information Display (TID)

5.241 This display which was shown the traffic information, such that track layout, train location, delay time and so on, was the symbol of the train controlling center. However, COSMOS and ATOS system expelled it from the controlling center. That is why these systems have changed dispatchers' role. In case of change the train sequence at some station, dispatchers in the former CTC decided and setting the train rout by switches. But dispatchers in new system, COSMOS and ATOS, arranged the train schedule diagram database without contradiction. Therefore, COSMOS and ATOS bring epoch-making milestone for the Operation Controlling. (See Figure 5.2.41.)



Source: JICA Study Team

Figure 5.2.41 Change of the Dispatchers' Roles

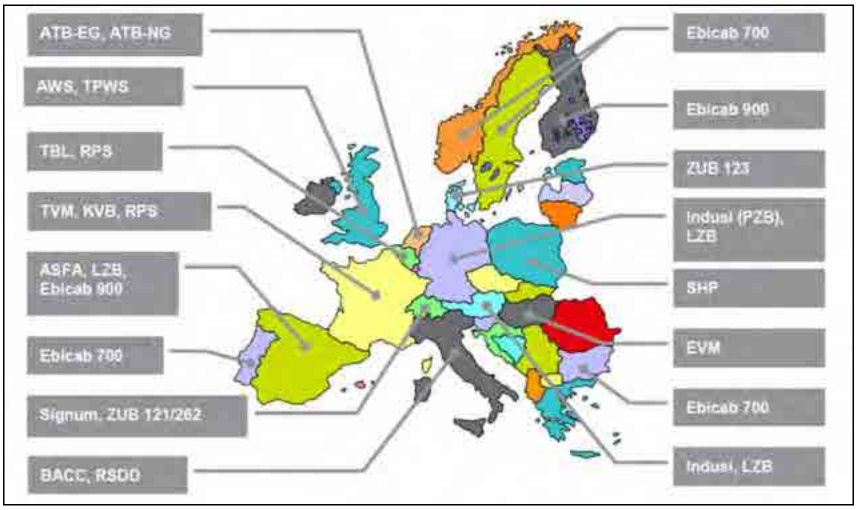
(6) Current European OCS

5.242 There are many kinds of Automatic Train Protection system (ATP) in Eurasian countries. (See Figure 5.2.42.) This situation is one of the obstructions for the cross border train operations between some countries. European Union (EU) initiated unified ATP and OCS systems since 1990s.Unified ATP is European Train Controlling System (ETCS) and OCS is European Railway Traffic Management System (ERTMS). (See Figure 5.2.43.) ERTMS is composed ETCS and GSM-R (Global System for Mobile communications - Railway)

5.243 Exactly ETCS/ERTMS project is important for not only European railway operators also manufactures and government sectors. Now ERTMS Level 2 is on service for the High Speed Rail in Italy and Spain. This function is limited for only train operation and other functions, for example the passenger information function, which is not complete yet. This project is delayed for the following reasons:

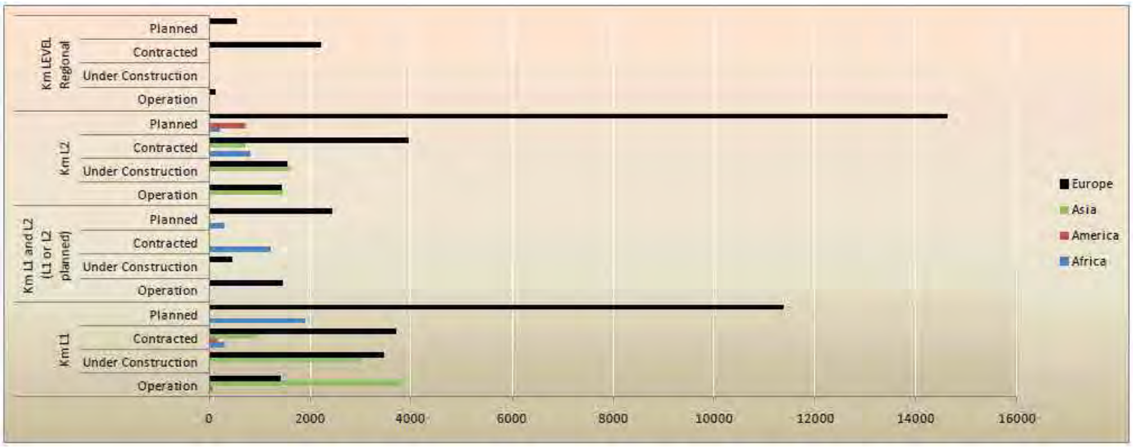
(i) Basic system is designed for huge traffic volume countries, for example France, Germany, so that there are many extra functions. It may be too huge system for small traffic volume countries.

(ii) GSM-R is one of the important components for ETCS. GSM is popularized many countries, however, there are many Special functions each countries. So it is difficult to specify unique.



Souse: http://www.ertms2012.eu/fileadmin/Content/Downloads/2011/pdf/InfoOnERTMS.pdf

Figure 5.2.42 ATP Methods in Europa



Source: UIC Benchmarking Final Report 2012

Figure 5.2.43 ERTMS Worldwide Situations

(7) Clarifications

5.244 Exactly European system, ERTMS, is the great system of unprecedented concept, because final target may be covered whole Europe and adapt the train controlling by wireless radio at Level 3 for furfures. However this system is so huge system that there are several technical and political barriers. For example technical specifications are revised many times and they have to issue more than 20 European languages. And due to long project term, technical matter progress day by day. ERTMS is adapted GSM-R (Global System for Mobile Communications for Railway) for the communication method, but up-date communication method is LTE (Long Term Evolution).First of beginning, the purpose of this system is available for the interoperability in European Railways, however, there are reports of only three places carrying it. Some countries have doubts about the effect of the introduction and complain about the delay of the construction progress.

5.245 Therefore, ERTMS is not suitable for any experiences and closed operators of the high speed rail operation. And more ERTMS has been developed for the dedicated route controlling function only so that passenger information service function is not yet practically used. This function will contribute to the punctuality of train operation. Finally if signal system adopts the Digital ATC, it must conform with all other functions. The JICA Study Team strongly insists that High-Speed Rail operation should be adopted with sufficient actual result system.

5.246 Required system for the High-Speed Rail in Vietnam should be as follows.

(i) Minimum and necessary function for the reasonable initial cost, and

(ii) Compatibility of DS-ATC and including the passenger information function

Table 5.2.19 Function Comparisons of the Operation Controlling System

	ERTMS	COSMOS	Recommended System for VHR
Function	Operation Controlling only	Whole system (Scheduling, Operation Controlling and other concerning six sub-systems)	Scheduling and Operation Controlling
Passenger information Service	Impossible	available	available
Compatibility of DS-ATC	Theoretically possible, but need inspection and confirmation	Possible	Possible
Cost *	Expensive (2039/ € 1.7 B)	Expensive	reasonable

Sources: ERTMS: http://www.rff.fr/IMG/RFF_RA%202009_GB_WEB.pdf; COSMOS: JR East not Public the amount Estimated million US$ order; and Recommended System by JICA Study Team.

5.3 Selection of Appropriate System Technologies for HSR in Vietnam

1) Role of HSR in Vietnam

5.247 Effects of high-speed railways on the economics and societies can be cited as conspicuous precedent brought about by the Tokaido and Sanyo Shinkansen railways in Japan and by the high-speed railways in Korea, China and Taiwan just after their inaugurations. These are the development of wayside areas, nationwide economic and social development, improvement of comprehensive technological power, up-growth of industrial structures and urban development in the surrounding areas of high-speed railway stations.

5.248 High-speed railways have made a great impact on such countries as Japan, Korea and Taiwan whose territories are not so large, in a sense that they strengthened the national power. The status to possess and manage high-speed railways significantly influences international circles, in that they lead to such events as the Olympic Games and International Expositions. This is also true with Vietnam. The construction of a high-speed railway in Vietnam will result in similar advantages.

5.249 Regarding the possibility of the future development of Vietnamese economics and societies from the viewpoints of the territorial area, population and geographical backgrounds, the transport demand is expected to increase and the traffic volume between the northern and southern areas, among others, will significantly augment, given the unique geographical conditions of the country, which is slender and long in the north to south direction. Besides the two largest cities, Hanoi and Ho Chi Minh, small- to medium-scale cities scatter in-between within a certain distance from the coastline.

5.250 Therefore, the realization of a high-speed railway to connect the two largest cities, with midway stations located in important cities, will effectively contribute to the economic and social development of Vietnam, cope with the increases in the transport demand and play an essential role in constructing a basic and important social infrastructure to attain economic and social development.

5.251 Furthermore, endowed with appropriate climates and lands and having a large number of farmers to account for 50% of the total population, Vietnam is a very important country that produces coffee, rice and other agricultural products. As economics develops in the future, however, it is thought that urbanization will quickly progress like in the present China. In such a situation, the small- to medium- scale cities between Hanoi and Ho Chi Minh will play a role of the recipient of the urbanization. As a feature of socialistic countries, plans of large-scale urban development will be promoted as a result, thereby accelerating development of wayside areas. What works as a driving and explosive power thereof is nothing but the high-speed railway.

5.252 The distance between Hanoi and Ho Chi Minh is longer than 1,500 km to make an unprecedentedly long railway route in the world. For reference, the distance between Beijing and Shanghai in China is approximately 1,300 km. It is thought that, as economics develop the traffic demand from other cities to the two cities will substantially increase along with the volume of direct traffic between these two cities.

5.253 Selection of transport means is governed by travel time and charge. The break-even point between airlines and railways is three hours in Japan and possibly a little longer in Vietnam due to the difference in the time value. Therefore, a long-distance travel in Vietnam implies the importance of high speed. The high-speed railway in Vietnam shall realize a maximum design speed of 350 km/h and a maximum operating speed of 320 km/h, in order to ensure the superiority to airlines as far as possible.

5.254 A high-speed railway is a fundamental transport means. Given its high-speed operation, it is obvious that an accident will entail large and serious damages. In recent years, it is often reported that train accidents have occurred in China and Korea. To ensure the safety of high-speed railways, the railway system shall be easy-to- observe and easy-to-understand. For this purpose as well, the Vietnamese high-speed railway shall have a role, simple and easy-to-manage, as a being to eventually enhance safety. In other words, the Vietnamese high-speed railway shall essentially adopt systems to separate the time zones for train operation and maintenance work and run trains in one direction using a single track.

5.255 Regarding the technological power of Vietnamese railways, railway industries and affiliated industries, Vietnam is not yet experienced much in railway technologies, partly because railways have been constructed by foreign countries. Electrification and construction of urban railways still belong to the tasks in the future. The country has not experienced railway technologies at all.

5.256 To construct, manage and maintain a 1,600 km-long high-speed railway, therefore, Vietnam shall acquire the technologies to make it viable and raise railway industries and those related thereto. We believe that this is another important role of the high-speed railway in Vietnam.

5.257 The summary of the above-mentioned roles of the high-speed railway in Vietnam is as follows.

(i) Guarantee the rapidity of travel by running trains at a maximum design speed of 350 km/h and a maximum operating speed of 320 km/h, currently world highest railway speed, to increase the transport demand, thereby accelerating the economic and social development of Vietnam.

(ii) Make a basis of economic and social development of the country and play a role of the driving and explosive power thereof, in conjunction with the development plans for wayside cities and regional areas and city planning schemes.

(iii) Accelerate the development of the small- to medium-scale cities between Hanoi and Ho Chi Minh, the exodus from agricultural farms to city areas and economic and social development of the country.

(iv) Establish reliability to enable transport at high-level safety and stability and aim at simple, clear-cut and easy-to-understand administrative management, and compact infrastructures.

(v) Acquire technologies to enable construction and administrative management of a 1,600 km-long high speed railway and raise/develop railway industries and those related thereto.

2) Key Aspects of HSR in Vietnam

(1) Dedicated or Mixed Traffic Use for Passenger and Freight Traffic

5.258 Improvement of existing railway cannot meet the increased demand and, upgrading of existing railway to meet high speed operation is technically difficult. Therefore, HSR must be constructed as a new high spec line of which track gauge and alignment are suitable for high speed operation. The new high spec line must be adopted standard gauge.

5.259 Considering the difference of track gauge and safety level between existing line and new line, the usage of this new high spec line should be dedicated to high-speed trains. Existing trains cannot be operated into the new line; and, high-speed trains cannot operate into existing line due to the difference, either.

5.260 Mixed use with freight train causes a high construction & maintenance cost, because heavy axel load requires strong infrastructure and damages more to infrastructure. Besides freight trains need to be able to operate on a standard gauge.

5.261 Mixed use with low speed passenger train causes low transport efficiency, because low speed train constrains frequency. Consequently, many countries uses high-speed line dedicated to high-speed trains with few exceptions of low frequency line. HSR should be recommended to be dedicated to high-speed train, either.

(2) Operation Period and Single / Bi-Direction Operation

5.262 Advantages and disadvantages of single/bi-direction operation have been considered in the previous section. HSR that connects 2 metropolitan cities, located more than 1600 km far from each other, is a huge project. Cost reduction in construction phase is vital for the success of this project. Single direction operation is recommended for HSR. Moreover, in the long run, the policy ‘Separation of operation & maintenance’ would contribute to high stability of train operation, because it prioritizes safety and reliability of operation.

5.263 Regarding operation period, day-time operation should be selected from 6 AM to 12 PM. It secures maintenance periods and contributes to ensure safety, reliability and stability of operation as a result.

5.264 The possibility of introducing night train should be examined in the future. The lengths of priority sections are shorter than 500 km, in that length of night trains are not required.

(3) Train Formation

5.265 HSR in Vietnam is a new construction line, so rolling stock gauge can be selected independently from the existing line. As prementioned, wider gauges help to increase the passenger transportation capacity. NSHRS is expected to have a strong demand in the future. High passenger transportation capacity will contribute to low energy consumption and operation cost, so 3.4m width which enables 5 seat rows should be selected as same as Shinkansen.

5.266 EMU System is the mainstream of HSR’s train formation in the world due to various advantages, high capacity, light weight, high acceleration &deceleration and so on. HSR also should apply EMU system. Japan has adopted EMU system from the advent of HSR and has got a variety of HS train series which are developed to meet circumstance of each high-speed lines. For reference, main types are shown in the Table 5.3.1. The optimum type should be selected in it.

Table 5.3.1 A Variety of Train Series of Shinkansen

Series	N700	E5	E4	E3	800
					
Train formation	14M2T	8M2T	4M4T	4M2T	6M
Feature	・High acceleration ・Longest train formation	Highest speed	・Double Decker ・High capacity	Operate into existing line	Operate on steep slope (35/1000)
Max. speed	300(km/h)	320	240	275	260
Starting Acceleration	2.6(km/h/s)	1.7	1.6	1.6	2.5
Train length	404.5 (m)	252.5	201	128	154.7
Car length	25 (m)	25	25	20.5	25
Body width	3360 (mm)	3350	3380	2945	3380
Capacity	1323(pax)	731	817	338	392
Motor power	17080 (kW)	9600	6720	4800	6600
Max. axle load	11.2 (t)	13.1	15.9	12.2	11.4

Source: JICA Study Team Note: T-Trailer, M-Motor

(4) Fire Protection Policy Especially of Tunnel

5.267 For Vietnam HSR, JICA Study Team proposes the measures of bi-directional operation, electric multiple unit (EMU) and separation between operation and maintenance for safety, and compact system. Therefore, the countermeasures mentioned below are proposed for tunnel fire protection besides double cross section about 64 m^2 tunnel.

(i) Rolling Stock of Fireproof Materials and Door between Cars

(ii) Stop and Refuge at Station or Appointed place out of Tunnel

(iii) Non Stop in Tunnel and Escape out of Tunnel is Basic Idea.

(5) Maximum Operating Speed

5.268 Vietnam HSR connects about 1,600 km between big two cities of Hanoi and Ho chi minh, and its high speed becomes a very big element. That is, demand increases by being, and it contributes to an economic, social development of Vietnam if it is high-speed. Moreover, it is also important to acquire technology that enables construction and the operational management in the rapid-transit railway in which it reaches 1600 km, and to attempt the promotion development of the rail industry and the relative industry in addition. It is thought that it is important to improve the ability to experience the high speed executed from an early stage in the world now to satisfy these, and to do the management.

5.269 It is the one to adopt 320 km/h that is the maximum operating speed at present based on such the above-mentioned idea.

(6) Fire Protection Policy

5.270 In Europe, Passenger Refuge at Car Fire Accident and Safety Measure at Restoration are basically done by Two Single Line Tunnels, etc. due to Bi-directional Operation and Locomotive Type System.

5.271 In Japan, Fire Countermeasures given below are basically done by Double Line Tunnel, etc. due to Each Directional Operation and Electric Multiple Unit (EMU).

- Rolling Stock of Fireproof Materials and Door between Cars
- Stop and Refuge at Station or Appointed place out of Tunnel
- Non Stop in Tunnel and Escape out of Tunnel is Basic Idea.
- Secure of Refuge Passage by Operation Stop of Other Line of Double Lines.
- In Underground and Tunnel, Secure of Refuge Measure by Ventilation and Exhaust

5.272 According to the basic ideas the above mentioned, the comparison of tunnel fire protection is shown by the Table 5.3.2.

Table 5.3.2 Comparison of Tunnel Fire Protection

Items	Japan	Europe
Tunnel Cross Section (Single or Double Line)	Double Line Cross Section	Single Line Cross Section over 5 ㎞ （Two Single Tunnels）
Tunnel Cross Section	About 64 ㎡	About 45 ㎡×2＝90 ㎡
Fire Counter-measure	• Non Stop in Tunnel Stop and Refuge at Station or Appointed place out of Tunnel	• Stop in Tunnel and Use of Refuge Passage
Operation at Fire	• Secure of Refuge Passage by Operation Stop of Other Line of Double Lines	• Bi-directional Operation of Other Line of Double Lines
Construction Cost	• Low Cost by Small Cross Section • Large Influence due to so many Tunnels	• High Cost of Two Single Tunnels
Difference of Rolling Stock	• Escape Possibility out of Tunnel due to Electric Multiple Unit(EMU)	• Safety Measure and Operation at Fire on the Assumption of Stop in Tunnel due to Locomotive type

Source: JICA Study Team

3) Technical Standards for Construction

5.273 In view of the basic roles of high-speed railway in Vietnam described in 5.3 (1), the following points were considered in the review for the preparation of draft specifications for construction standard:

(i) Required high-speed performance should be ensured.

(ii) Compact specifications that are the one of the advantages of Shinkansen should be basically used.

(iii) In consideration of the economic effects, the draft should aim to make the initial investment as small as possible.

(1) Speed

5.274 The maximum design speed was set to currently possible speed of 350 km/h as Hanoi is as far away as 1,600 km from Ho Chi Minh City and the high-speed operation is important. The initial target operating speed is set to 320 km/h which is the maximum operating speed in Japan (to be achieved in the spring of 2013 by the JR East).

(2) Curve Radius, Amount of Cant, etc.

5.275 In consideration of the stability when the rolling stocks run on a curve, track maintenance work, and other appropriate points, the minimum curve radius at the maximum design speed of 350 km/h is set to R = 6000 m which is suitable for the maximum cant of 180 mm.

5.276 It was confirmed that the amount of cant deficiency was approximately 60 mm and that the amount did not affect the passenger comfort at all. The radius set by KOICA is R = 5000 m and it can handle the speed of 350 km/h; however, the amount of cant deficiency is approximately 110 mm in this case and the passenger comfort and rolling stock stability will be significantly undermined by a great sideways pressure.

5.277 The maximum vertical curve radius is set to R = 25000 m that satisfies the vertical acceleration of 0.033 g or less which has been used after the Sanyo Shinkansen in view of the passenger comfort.

5.278 The maximum amount of cant was determined in consideration of the stability when the rolling stocks run on a curve, track maintenance work and other appropriate points.

5.279 The maximum gradient is set to 25 /1000 to avoid the speed limitation as much as possible in view of the actual results of the maximum gradient and rolling stock performance for Shinkansen Lines.

(3) Distance between Track Centers and Track Formation Width

5.280 As the actual results in Japan are 4.3 m at the speed of 320 km/hour, examination of the distance between track centers at the speed of 350 km/h was consigned to the Railway Technical Research Institute (public interest incorporated foundation).

5.281 The examination result shows that the track center interval of 4.3 m, when it is used for a long-nose rolling stocks (E5 Series, E954 Series Arrow Line), can be covered by the almost same range of peak pressures induced by the passing of existing rolling stocks. Therefore, the track center interval shall be set to 4.3 m.

5.282 As the distance between track centers is set to 4.3 m, the track formation width for Shinkansen (Kyushu Shinkansen) is adopted.

(4) Tunnel Cross-Section

5.283 As the outline of geological condition in Vietnam showed that the land includes hard rocks and the construction cost is proportionate to the size of tunnel cross-section, examination on the possibility of using the tunnel cross-section for Shinkansen was consigned to the Railway Technical Research Institute (public interest incorporated foundation). The result showed that the tunnel micro pressure wave of concern can be handled even at the speed as high as 350 km/hour (assuming the use of long-nose rolling stocks) by installing a buffer tunnel of a constant length according to the total length of tunnel at tunnel portals. Thus, the tunnel cross-section is set to 63.4 m^2.

(5) Axle Load

5.284 P16 is used for the axle load due to the following reasons:

(i) Although the load for currently scheduled rolling stocks is 12 tons or less, P16 is recommended when considering the possible introduction of double-deck rolling stocks in the future.

(ii) In consideration of the axle load for maintenance rolling stocks carrying rails, P16 is recommended.

(6) Track Structure

5.285 As roadbed structures such as embankment and cutting are used as the infrastructure architecture, ballast tracks shall be adopted due to the following reasons:

(i) Following after the roadbed structure is easier than the slab tracks.

(ii) Initial investment is smaller than that for slab tracks.

(iii) The geographic structure of Vietnam shows that ballasts of good quality can be easily obtained.

(iv) The ballast scattering problem, which frequently occur in Japan due to snow, never occurs in Vietnam. However, slab tracks shall be used inside tunnels for maintenance and also for bridges because the slab track is light in weight.

(7) Major Structures

5.286 Roadbed structure such as embankment and cutting shall be used as the major structures for this time due to the following reasons:

(i) Roadbed structure is extremely inexpensive in Vietnam, compared to the costs of bridges.

(ii) Embankment materials of good quality can be easily obtained along the new line in Vietnam.

Table 5.3.3 Specifications for the Construction Standard of Vietnam High-Speed Railway

	Item	Unit	JICA Study Team	Pre-FS	KOICA (for 350 km/h)
1	Gauge	mm	1,435	1,435	1,435
2	Number of tracks		Double tracks	Double tracks	Double tracks
3	Maximum design speed	Km/h	350	350	350
4	Maximum operating speed	Km/h	320	300	300
5	Minimum curve radius	m	6000	6000	5000
6	Maximum vertical curve radius	m	25,000	25,000	25,000
7	Maximum cant	mm	180	180	180
8	Maximum gradient	1/1000	25	25	25
9	Distance between track centers	m	4.3	4.5	5.0
10	Formation level width	m	11.3	11.6	13.2
11	Hollow cross-section area inside tunnels	m^2	63.4	80	Approximately 116
12	Axle load		P16	P16	UIC25
13	Track structure		Ballast track Slab track	Slab track	Ballast track
14	Major structures		Embankment, cutting, beam bridges	Beam bridges	Embankment, cutting

Source: JICA Study Team

4) Operation Planning

(1) Transport Demand

5.287 We calculated the transport demands in 2030, 2035 and 2040 in the Ngoc Hoi–Vinh and Nha Trang–Thu Thiem sections based on the number of boarding/alighting passengers at each station obtained through passenger flow surveys.

Table 5.3.4 Number of Boarding/Alighting Passengers at Different Stations in the Ngoc Hoi–Vinh Section

Year	2030		2035		2040	
	Boarding/day	Alighting/day	Boarding/day	Alighting/day	Boarding/day	Alighting/day
Ngoc Hoi	36,426	35,861	46,423	45,703	59,165	58,247
Phu Ly	4,162	3,925	5,304	5,002	6,760	6,375
Nam Dinh	10,702	10,683	13,639	13,615	17,383	17,352
Ninh Binh	5,552	5,526	7,076	7,043	9,018	8,976
Thanh Hoa	9,515	10,048	12,126	12,806	15,455	16,320
Vinh	14,257	14,571	18,170	18,570	2,3157	23,667

Source: JICA Study Team

Table 5.3.5 Number of Boarding/Alighting Passengers at Different Stations in the Nha Trang–Thu Thiem Section

Year	2030		2035		2040	
	Boarding/day	Alighting/day	Boarding/day	Alighting/day	Boarding/day	Alighting/day
NhaTrang	20,043	20,433	25,544	26,041	32,555	33,188
Thap Cham	8,220	8,159	10,476	10,398	13,351	13,252
Tuy Phong	501	493	639	628	814	801
Phan Thiet	2,611	2,595	3,328	3,307	4,241	4,215
Long Thanh	6,549	6,604	8,346	8,417	10,637	10,727
Thu Thiem	31,408	31,048	40,028	39,569	51,014	50,430

Source: JICA Study Team

(2) Setting of the Stoppage/Passage Patterns

5.288 The numbers of boarding/alighting passengers in the Ngoc Hoi–Vinh and Thu Thiem–Nha Trang sections are similar to those in fiscal year 2011 in the Utsunomiya–Sendai section, Tohoku Shinkansen, operated by the JR East.

5.289 The stoppage/passage patterns for the North-South High-Speed Railway are, therefore, set by referring to those said sections.

Table 5.3.6 Stoppage/Passage Patterns, Tohoku Shinkansen

	Stations						
	Utunomiya	Nasushiobara	Sin Sirakawa	Koriyama	Fukusima	SiroisiZaou	Sendai
No of Boarding Pax/day	34,023	4,586	2,504	15,904	14,380	781	64,498
Express type	–	–	–	–	–	–	●
Passage type	●	–	–	●	●	–	●
Stop type	●	●	●	●	●	●	●

Source: JICA Study Team

(a) Principle of Stoppage/Passage Patterns

5.290 We set the stoppage/passage patterns in drawing train operation diagrams based on the number of boarding/alighting passengers at each station based on the following principle:

(i) Express type trains run without stopping at midway stations

(ii) The passage type trains stop at the stations having 10,000 boarding/alighting passengers or over.

(iii) All stoppage type trains stop at the stations having 1,000 boarding/alighting passengers or over.

(iv) One passage type train stops per two hours at the stations having less than 1,000 boarding/alighting passengers.

Table 5.3.7 Principle of Stoppage/Passage Patterns

Type	No. of Boarding Pax/day	Pattern
Express type	-	Terminal passage
Passage type	more than 10,000	stop
Stop type A	more than 1,000	stop
Stop type B	not more than 1,000	2hour/1 train

Source: JICA Study Team

(b) Stoppage Type B

5.291 At the Shiraishi–Zao station, Tohoku Shinkansen, one stoppage type train stops per two hours to guarantee the least boarding chance for boarding passengers.

5.292 Eight stoppage type B trains (one train per two hours) provide a transport capacity of 6,072 passengers. This will be able to cope with the transport demand of 4,250 passengers at a load factor of 70%.

Table 5.3.8 Stoppage Type B

Type	No. of Boarding Pax/day	Pattern	Train Set	Transport Volume	Passenger Volume 70%
Stop Type B	not more than 1,000	1 train/2hour	8	6,072	4,250

Source: JICA Study Team

(c) Transport Capacity

5.293 We will plan the number of trains assuming the use of an E5 composition train set, or a 253.0 m-long 8M2T 10-car train set, comprising nine common cars and a green car (special accommodations car), with a passenger capacity of 759 persons.

Table 5.3.9 Composition of a Shinkansen Train Set[1/]

	T	M	◊ M	M	M	M	◊ M	M	M	T
Capacity	29	100	85	100	75	100	85	100	51	34
weight (t)	41.5	45.9	46.1	46.2	46.9	46.7	47	45.9	45.4	41.9

Source: JICA Study Team

1/Composition is 8M2T with train length of 26.5m for T-car and 25m for M-car. Weight of trains is 435.5 ton (empty train) and 499 ton (loaded to capacity)

(3) Calculation of the Minimum Train Running Time

5.294 We calculate the minimum train running time using an E5 composition train set running at 320 km/h.

(a) **Train Set:** The train set is a 4-unit (8M2T) type composition, equipped with traction circuits with VVVF inverter controlled three-phase induction motors.

(b) **Powering Performance:** Starting acceleration: 1.7 km/h/s and Balances speed: 360 km/h (open section, 3%)

(c) **Running Resistance:** We use the formulae for the running resistance in open and tunnel sections.

- Open section
  = 6.160000+0.0545004V+0.0010365999VV
- Tunnel section
  = 6.160000+-0.0398389V+0.0020918331VV

(d) **Brake Deceleration:** We apply the one-step deceleration by the deceleration by the digital ATC system.

Table 5.3.10 Brake Deceleration

Speed		(km/h)	(km/h/s)
320	→	300	1.37
300	→	275	1.41
275	→	240	1.46
240	→	210	1.53
210	→	160	1.60
160	→	110	1.74
110	→	75	1.92
75	→	0	2.16

Source: JICA Study Team

(e) **Minimum Train Running Time:** The minimum running time for the trains of passage/stoppage patterns in the Ngoc Hoi–Vinh and Nha Trang–Thu Thiem sections.

Table 5.3.11 Passage Patterns throughout the Ngoc Hoi–Vinh Section

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Ngoc Hoi	0.0			
Phu Ly	45.6	0:11:00	—	0:11:00
Nam Dinh	67.7	0:04:30	—	0:04:30
Ninh Binh	103.4	0:07:00	—	0:07:00
Thanh Hoa	154.0	0:09:30	—	0:09:30
(Hoang Mai)	230.0	0:14:30	—	0:14:30
Vinh	283.9	0:12:30	—	0:12:30
		0:59:00	—	0:59:00
		scheduled speed	289km/h	

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Vinh	283.9			
(Hoang Mai)	230.0	0:12:30	—	0:12:30
Thanh Hoa	154.0	0:14:30	—	0:14:30
Ninh Binh	103.4	0:09:30	—	0:09:30
Nam Dinh	67.7	0:07:00	—	0:07:00
Phu Ly	45.6	0:04:30	—	0:04:30
Ngoc Hoi	0.0	0:11:00	—	0:11:00
		0:59:00	—	0:59:00
		scheduled speed	289km/h	

Source: JICA Study Team

Table 5.3.12 Two-Station Stoppage Patterns in the Ngoc Hoi–Vinh Section

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Ngoc Hoi	0.0			
Phu Ly	45.6	0:11:00	—	0:11:00
Nam Dinh	67.7	0:06:30	0:01:30	0:08:00
Ninh Binh	103.4	0:09:00	—	0:09:00
Thanh Hoa	154.0	0:11:30	0:01:30	0:09:30
(Hoang Mai)	230.0	0:16:30	—	0:14:30
Vinh	283.9	0:12:30	—	0:12:30
		1:07:00	0:03:00	1:10:00
		scheduled speed	243km/h	

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Vinh	283.9			
(Hoang Mai)	230.0	0:12:30	—	0:12:30
Thanh Hoa	154.0	0:16:30	0:01:30	0:18:00
Ninh Binh	103.4	0:11:30	—	0:11:30
Nam Dinh	67.7	0:09:00	0:01:30	0:10:30
Phu Ly	45.6	0:06:30	—	0:06:30
Ngoc Hoi	0.0	0:11:00	—	0:11:00
		1:07:00	0:03:00	1:10:00
		scheduled speed	243km/h	

Source: JICA Study Team

Table 5.3.13 Four-Station Stoppage Patterns in the Ngoc Hoi–Vinh Section

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Ngoc Hoi	0.0			
Phu Ly	45.6	0:13:00	0:01:30	0:14:30
Nam Dinh	67.7	0:08:30	0:01:30	0:10:00
Ninh Binh	103.4	0:11:00	0:01:30	0:12:30
Thanh Hoa	154.0	0:14:00	0:01:30	0:15:30
(Hoang Mai)	230.0	0:16:30	—	0:16:30
Vinh	283.9	0:12:30	—	0:12:30
		1:15:30	0:06:00	1:21:30
		scheduled speed	210km/h	

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Vinh	283.9			
(Hoang Mai)	230.0	0:12:30	—	0:12:30
Thanh Hoa	154.0	0:16:30	0:01:30	0:18:00
Ninh Binh	103.4	0:14:00	0:01:30	0:15:30
Nam Dinh	67.7	0:11:00	0:01:30	0:12:30
Phu Ly	45.6	0:08:30	0:01:30	0:10:00
Ngoc Hoi	0.0	0:13:00	—	0:13:00
		1:15:30	0:06:00	1:21:30
		scheduled speed	210km/h	

Source: JICA Study Team

Table 5.3.14 Passage Patterns throughout the Nha Trang–Thu Thiem Section

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Thu Thiem	0.0			
Long Thanh	36.1	0:09:00	—	0:09:00
(Ham Tan)	103.0	0:13:00	—	0:22:00
Phan Thiet	153.2	0:09:30	—	0:31:30
Tuy Phong	220.5	0:13:00	—	0:44:30
Thap Cham	283.6	0:12:00	—	0:56:30
Nha Trang	362.1	0:17:00	—	1:13:30
		1:13:30	—	1:13:30
		scheduled speed	295km/h	

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Nha Trang	362.1			
Thap Cham	283.6	0:17:00	—	0:17:00
Tuy Phong	220.5	0:12:00	—	0:29:00
Phan Thiet	153.2	0:13:00	—	0:42:00
(Ham Tan)	103.0	0:09:30	—	0:51:30
Long Thanh	36.1	0:13:00	—	1:04:30
Thu Thiem	0.0	0:09:00	—	1:13:30
		1:13:30	—	1:13:30
		scheduled speed	295km/h	

Source: JICA Study Team

Table 5.3.15 One-station Stoppage Patterns in the Nha Trang–Thu Thiem Section

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Thu Thiem	0.0			
Long Thanh	36.1	0:09:00	—	0:09:00
(Ham Tan)	103.0	0:13:00	—	0:13:00
Phan Thiet	153.2	0:09:30	—	0:09:30
Tuy Phong	220.5	0:13:00	—	0:13:00
Thap Cham	283.6	0:14:00	0:01:30	0:15:30
Nha Trang	362.1	0:19:00	—	0:19:00
		1:17:30	0:01:30	1:19:00
		scheduled speed	274km/h	

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Nha Trang	362.1			
Thap Cham	283.6	0:19:00	0:01:30	0:20:30
Tuy Phong	220.5	0:14:00	—	0:14:00
Phan Thiet	153.2	0:13:00	—	0:13:00
(Ham Tan)	103.0	0:09:30	—	0:09:30
Long Thanh	36.1	0:13:00	—	0:13:00
Thu Thiem	0.0	0:09:00	—	0:09:00
		1:17:30	0:01:30	1:19:00
		scheduled speed	274km/h	

Source: JICA Study Team

Table 5.3.16 Two-station Stoppage Patterns in the Nha Trang–Thu Thiem Section

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Thu Thiem	0.0			
Long Thanh	36.1	0:11:00	0:01:30	0:12:30
(Ham Tan)	103.0	0:15:00	—	0:15:00
Phan Thiet	153.2	0:09:30	—	0:09:30
Tuy Phong	220.5	0:13:00	—	0:13:00
Thap Cham	283.6	0:14:00	0:01:30	0:15:30
Nha Trang	362.1	0:19:00	—	0:19:00
		1:21:30	0:01:30	1:24:30
		scheduled speed	257km/h	

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Nha Trang	362.1			
Thap Cham	283.6	0:19:00	0:01:30	0:20:30
Tuy Phong	220.5	0:14:00	—	0:14:00
Phan Thiet	153.2	0:13:00	—	0:13:00
(Ham Tan)	103.0	0:09:30	—	0:09:30
Long Thanh	36.1	0:14:30	0:01:30	0:16:00
Thu Thiem	0.0	0:11:30	—	0:11:30
		1:21:30	0:01:30	1:24:30
		scheduled speed	257km/h	

Source: JICA Study Team

Table 5.3.17 Three-station Stoppage Patterns in the Nha Trang–Thu Thiem Section

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Thu Thiem	0.0			
Long Thanh	36.1	0:11:00	0:01:30	0:12:30
(Ham Tan)	103.0	0:15:00	—	0:15:00
Phan Thiet	153.2	0:11:30	0:01:30	0:13:00
Tuy Phong	220.5	0:15:00	—	0:15:00
Thap Cham	283.6	0:14:00	0:01:30	0:15:30
Nha Trang	362.1	0:19:00	—	0:19:00
		1:25:30	0:04:30	1:30:00
		scheduled speed	241km/h	

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Nha Trang	362.1			
Thap Cham	283.6	0:19:00	0:01:30	0:20:30
Tuy Phong	220.5	0:14:00	—	0:14:00
Phan Thiet	153.2	0:15:00	0:01:30	0:16:30
(Ham Tan)	103.0	0:11:30	—	0:11:30
Long Thanh	36.1	0:14:30	0:01:30	0:16:00
Thu Thiem	0.0	0:11:30	—	0:11:30
		1:25:30	0:04:30	1:30:00
		scheduled speed	241km/h	

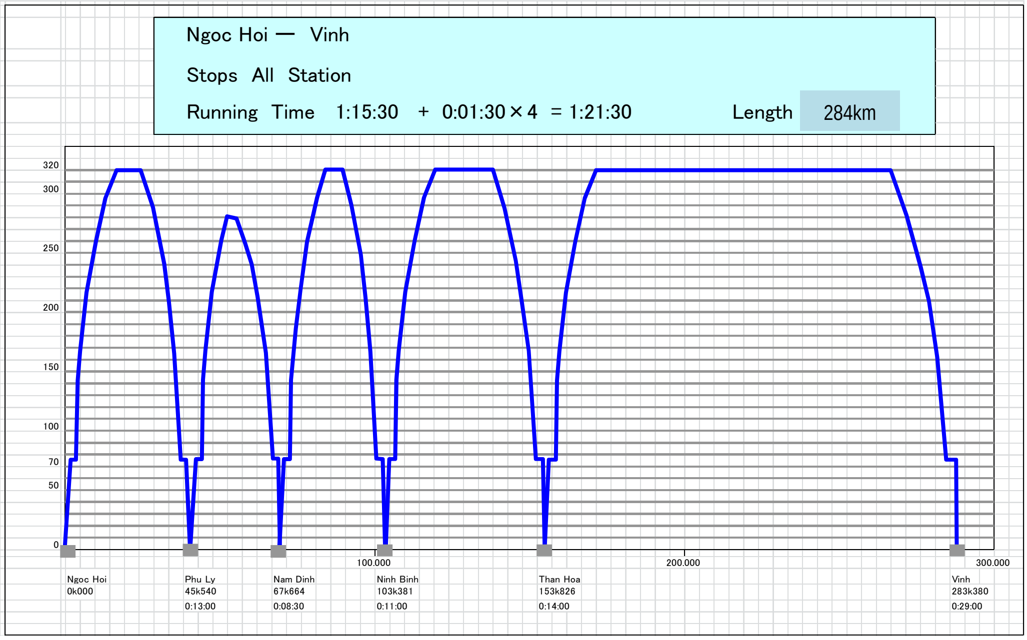
Source: JICA Study Team

Table 5.3.18 Four-station Stoppage Patterns in the Nha Trang–Thu Thiem Section

		320km/h		
	km	regular runningtime	stop time	regular runningtime
Thu Thiem	0.0			
Long Thanh	36.1	0:11:00	0:01:30	0:12:30
(Ham Tan)	103.0	0:15:00	—	0:15:00
Phan Thiet	153.2	0:11:30	0:01:30	0:13:00
Tuy Phong	220.5	0:17:00	0:01:30	0:18:30
Thap Cham	283.6	0:16:00	0:01:30	0:17:30
Nha Trang	362.1	0:19:00	—	0:19:00
		1:29:30	0:06:00	1:35:30
		scheduled speed	226km/h	

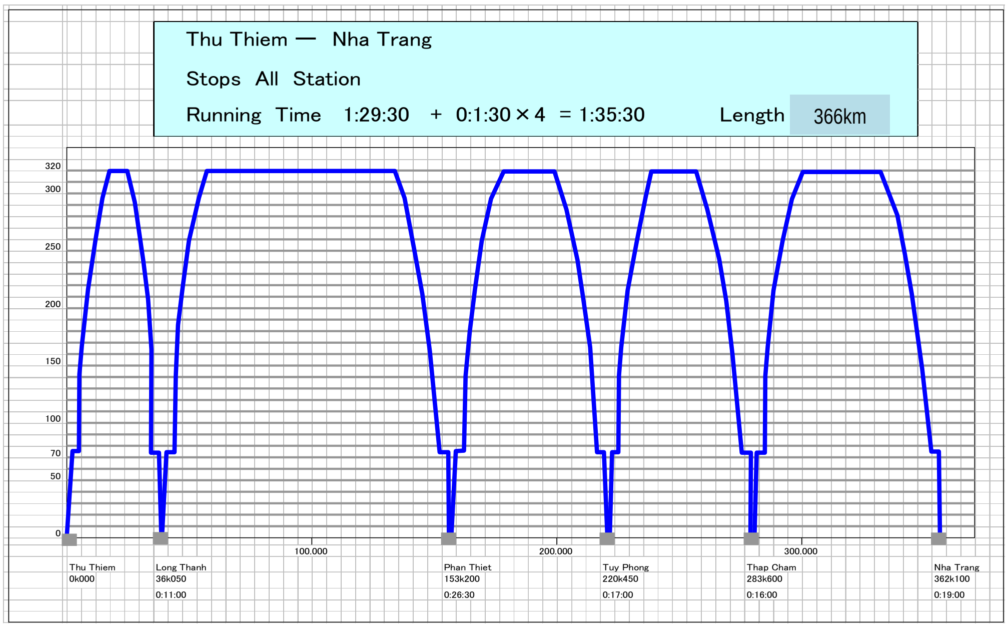
		320km/h		
	km	regular runningtime	stop time	regular runningtime
Nha Trang	362.1			
Thap Cham	283.6	0:19:00	0:01:30	0:20:30
Tuy Phong	220.5	0:16:00	0:01:30	0:17:30
Phan Thiet	153.2	0:17:00	0:01:30	0:18:30
(Ham Tan)	103.0	0:11:30	—	0:11:30
Long Thanh	36.1	0:14:30	0:01:30	0:16:00
Thu Thiem	0.0	0:11:30	—	0:11:30
		1:29:30	0:06:00	1:35:30
		scheduled speed	226km/h	

Source: JICA Study Team



Source: JICA Study Team

Figure 5.3.1 Train Performance Curve in the Ngoc Hoi–Vinh Section



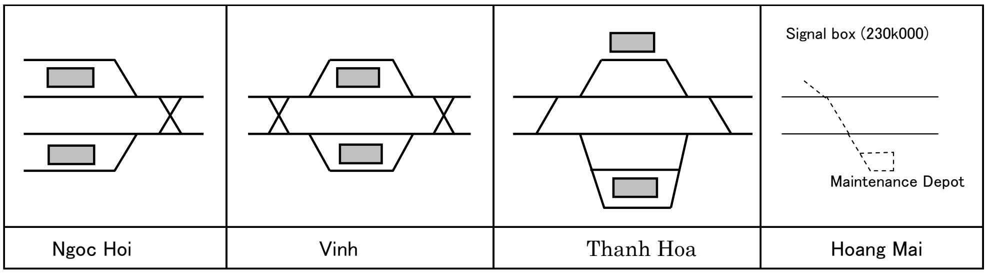
Source: JICA Study Team

Figure 5.3.2 Train Performance Curve in the Thu Thiem–Nha Trang Section

(4) Track Layouts in Different Station Yards

(a) Station yards between Ngoc Hoi and Vinh

5.295 Shuttle services will be performed for revenue service trains at the Ngoc Hoi and Vinh stations using island platforms. The conditions of the test run trains after the truck and general inspections will be checked on the up-track No.2 of the Thanh Hoa station. The Hoang Mai maintenance depot will be located at the center between Thanh Hoa and Vinh.

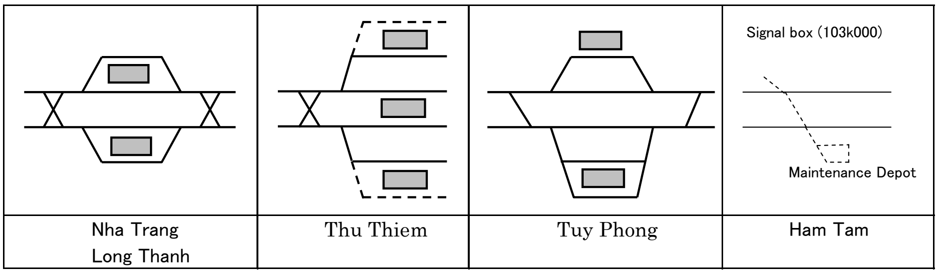


Source: JICA Study Team

Figure 5.3.3 Track Layouts in Different Station Yard

(b) Station Yards between Nha Trang and Thu Thiem

5.296 Shuttle services will be performed for revenue service trains at the Nha Trang and Thu Thiem stations using island platforms. The Thu Thiem station will be equipped with three platforms with six tracks in the future. The Long Thanh station, a junction after the inauguration of the airport, will be installed with island platforms for shuttle services to/from Thu Thiem. The Tuy Phong station will have an up-track No. 2 where the conditions of the test run trains after the truck and general inspections will be checked. The Ham Tam maintenance depot will be located at the center between Phan Thiet and Long Thanh.



Source: JICA Study Team

Figure 5.3.4 Track Layouts in Different Station Yard

(c) Schematic Drawings of Station Yards

5.297 Figures 5.3.3 and 5.3.4 illustrate the schematic drawings of the track layouts of the stations between Ngoc Hoi and Vinh and between Nha Trang and Thu Thiem, North-South High-Speed Railway.

5) Civil Structures

5.298 Basic conditions related to the civil structures include topographical, geological and soil, seismic, intersection and vicinity, construction, environmental, operation and maintenance conditions, as well as running and seismic safety conditions. In addition, economic efficiency, workability, construction time, operation and maintenance after commencement of operations shall be considered. In particular, economic efficiency will be well considered when selecting civil structures for the HSR system in Vietnam.

5.299 Civil HSR structures include earthworks such as embankments and cuttings, viaducts, bridges, station structures, box culverts and tunnels. In order to minimize construction cost, earth structures were basically selected in open sections. Viaducts were applied to the areas where population density is high to avoid hitting major buildings, roads, railways, or to the areas where soft alluvia of N values less than 5 are continuous for more than 20m deep thus the expected residual settlement of embankment is large. Attention should be paid on the following points in designing each structure. Recommendations for the selection of each type of structure are given below.

(1) Embankments and Cuttings

5.300 Many things such as collapsing caused by settlement and rainfall, mud-pumping and maintenance have to be considered when designing and constructing earth structures (embankments and cuttings).

5.301 In recent years in Japan, the development of layer thickness adjustment materials, reinforcement materials, drainage blankets, slope protection work and roadbed reinforcement as well as the adoption of performance-based design methods have made it possible to construct earthworks with the same durability, safety, usability and recoverability characteristics as concrete and steel structures.

5.302 In addition to being cheap and easy to construct, embankments and cuttings should be used as civil structures on open sections whenever possible because of the following reasons:

(a) Embankment construction costs are relatively low compared to viaducts.

(b) Relatively good-quality embankment material can easily be obtained in Vietnam. It is also possible to recycle material and use good quality tunnel muck and soil from cuttings for embankments.

(c) When the supporting ground is soft, pre-loading and vertical drains can be used as countermeasures against consolidation settlement of the ground under the embankment, while soil improvement and lightweight embankment construction methods are effective countermeasures against soft ground. If soil improvement is uneconomical due to the required depth, viaducts supported by foundation piles are recommended instead of embankment structures. Hence, areas where soft alluvia of N values less than 5 are continuous for more than 20m deep thus the expected residual settlement of embankment is large. Moreover, since many soil improvement methods are available, it is necessary to pay attention to economic efficiency as well as local soil and environmental conditions in order to select an appropriate method. Various soil improvement methods are described in the following sections.

(i) **Surface Treatment Method:** Shallow soft layers up to a depth of about 2-3m can be treated with the replacement, surface mixing or sand mat methods. In Vietnam, the replacement method is recommended due to its economic efficiency and workability.

(ii) **Accelerated Consolidation Method:** The accelerated consolidation method is used to compact cohesive soil by facilitating soil consolidation and drainage with loading and drain material. However, it is necessary to observe any adverse effects on nearby structures. If the construction period is long and there are few time constraints, the pre-loading method is more economic. The sand drain method is recommended if the location of the consolidation layer is shallow and rapid consolidation is required.

(iii) **Compaction and Tamping Method:** The compaction and tamping method includes the sand compaction pile and the vibro-flotation methods. These methods are used to press sand into the ground by vibration and impact loading. However, vibration and noise pollution are problems associated with this method.

(iv) **Soil Solidification Method:** Soil solidification methods include the deep mixing, the lime-pile and the chemical grouting methods. Soil solidification involves treating deep soil layers by hardening existing soil with solidifying materials. Vibration and noise are generally not problems with this method. If construction costs are high and the area to be treated large, the economy of this method shall be compared to viaduct construction with pile foundations.

(v) **Supporting Pile Method:** The supporting pile method includes the pile-net and column-net methods. If the depth of the soft layer is about 3-10m, the construction cost of this method is cheaper than that of the soil solidification method, but some vibration and noise occur during pile driving.

(d) The use of reinforcement materials is effective to improve the earthquake and rain resistance of embankments. Embankment reinforcement materials are different from thickness adjustment materials and are not used for auxiliary surface compaction, but to increase tensile strength and prevent rotational slip. Proper drainage of the embankment is also important, and placing drainage blankets under the toe of the slope is effective in preventing both an increase in pore water pressure inside the embankment and the collapse of the structure.

(e) The establishment of slope protection works is effective for the prevention of slope erosion of embankments and cuttings, rainwater infiltration, surface slip, and protection of the environment. The types and performance of main slope protection works used for embankments and cuttings are described in Table 5.3.19 and Table 5.3.20.

Table 5.3.19 Types and Performances of Slope-Protection Works for Embankments

Type	Performance				
	Seepage control	Prevention against surface layer erosion	Prevention against Surface Layer slip	Prevention of soil erosion caused by spring Water	Environmental Protection by greening
Concrete-block pitching	◎	◎	○	○	—
Anti-weed sheets	◎	◎	—	—	○
Lattice frame work	—	◎	◎	◎※1	◎※2
Rip rap masonry	—	◎	○	○	—
Planting work	—	○	—	—	◎

◎ Excellent performance ○ : Good performance — : No effect
※1: inside protected by cobble stones ※2: Inside protected by planting works

Table 5.3.20 Types and Performances of Slope-Protection Works for Cuttings

Type	Seepage control	Prevention against surface layer erosion	Prevention against weathering	Prevention against surface layer collapse and peeling	Prevention of soil erosion caused by spring water	Environmental Protection by greening
Concrete-block pitching	◎	◎	◎	—	○	—
Pre-cast concrete lattice framework	—	○	○	○	◎※1	◎※2
Cast-in-place concrete lattice framework	—	◎	○	◎	◎※1	◎※2
Spray framework	—	◎	○	◎	◎※1	◎※2
Concrete protection work	◎	◎	◎	◎	○	—
Waterproof anti-weed sheets	◎	◎	◎	—	—	○
Mortar spraying work	◎	◎	◎	○	○	—
Concrete spraying work	◎	◎	◎	○	○	—
Planting work	—	○	—	—	—	◎

◎ Excellent performance ○ : Good performance — : No effect
※1: Inside protected by cobble stones ※2: Inside protected by planting works

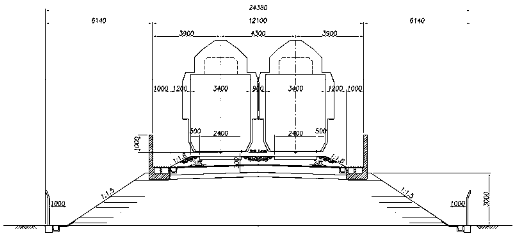
5.303 Roadbeds for ballast track on embankments and cuttings shall be strengthened by using mechanically stabilized crushed stone for the lower layer and asphalt for the upper layer of the roadbed, because this prevents rain water penetration and improves abrasion resistance. Thus, the stability and durability of the roadbed is improved and mud pumping caused by train loading can also be prevented.

5.304 The formation level of HSR embankments requires at least a 1m clearance on the outside of the wind pressure side for a maintenance walkway and to prevent the top of the slope from collapsing. About 1m shall also be provided for a maintenance walkway at the toe of the slope.

5.305 Depending on the soil quality, the slope gradient of embankments and cuttings shall in general be about 1:1.5 to 1.8 and 1:1.2 to 1.8, respectively. If necessary, a 1.5m wide berm shall be provided for high slopes. Berms effectively prevent slope erosion by reducing the flow speed and amount of surface water during rainfall, and they can also be used as walkways for slope maintenance.

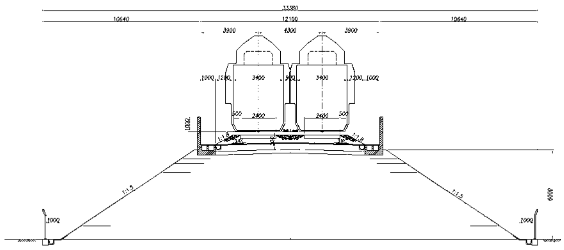
5.306 In Japan, embankments up to a height of about 20m have been constructed, but these are mainly limited to tunnel entrances in mountainous regions with good supporting soil. The construction of embankments that are too high creates problems for the surrounding environment because they ruin the landscape, impede airflow and require more land. Considering the above, the maximum embankment height recommended for Vietnam is about 9m on typical sections, and viaducts should be constructed if the height exceeds this.

5.307 Figure 5.3.5 to Figure 5.3.7 show typical embankments and Figure 5.3.8 to Figure 5.3.10 typical cuttings of different heights.



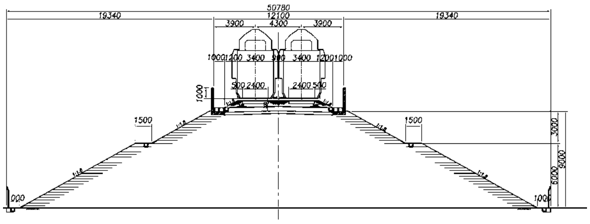
Source: JICA Study Team

Figure 5.3.5 Typical Embankment (H=3m)



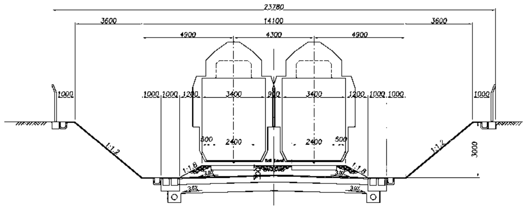
Source: JICA Study Team

Figure 5.3.6 Typical Embankment (H=6m)



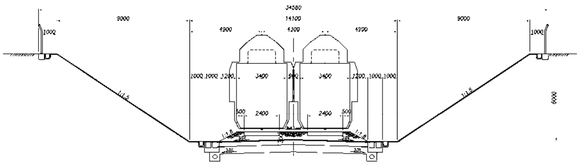
Source: JICA Study Team

Figure 5.3.7 Typical Embankment (H=9m)



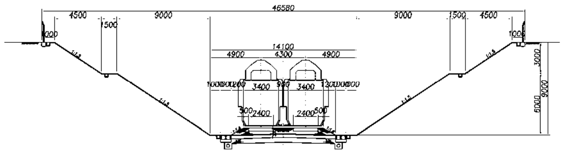
Source: JICA Study Team

Figure 5.3.8 Typical Cutting (H=3m)



Source: JICA Study Team

Figure 5.3.9 Typical Cutting (H=6m)



Source: JICA Study Team

Figure 5.3.10 Typical Cutting (H=9m)

(2) Viaduct and Bridge

5.308 In order to ensure the safety and stability of high speed train operations, all existing railway lines and roads require grade separated crossings. These shall be constructed as viaducts or bridges if embankments cannot be used due to excessive height or soft ground. In some locations, however, the independent grade separation of roads might have to be considered instead.

5.309 PC T-girders and PC box girders shall typically be used for viaducts, overbridges and pedestrian overpasses in urban areas for the following reasons.

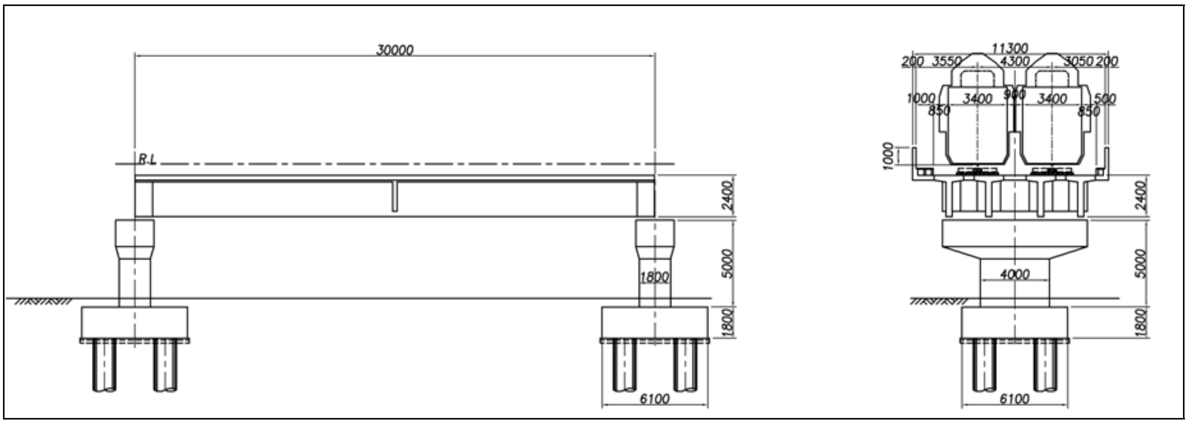
(i) Typical 6m high embankments require approximately three times more land than viaducts. Embankment structures divide urban areas and also increase the costs and time required for land acquisition which in turn can delay construction. Girder viaducts are therefore recommended under these circumstances.

(ii) Although Japanese style rigid-frame viaducts are economical and have the lowest material costs of all viaduct structures, their complicated bar arrangement can pose problems during construction supervision in Vietnam. On the other hand, PC girders are commonly used overseas and are fast to construct if identical continuous girders are employed. The shorter construction period enables considerable savings to be made during construction.

(iii) The construction cost of girder viaducts is determined by the length of the PC-girders in relation to the number of spans and piers. Generally, L=30m～35m PC T-girder viaducts are most economical. PC T-girders can be adopted for L=20m～45m and have been used for many Shinkansen bridges in Japan. The girders are usually fabricated at yards near the site and erected with cranes. For increased economic efficiency, the formwork can be moved and reused in other locations.

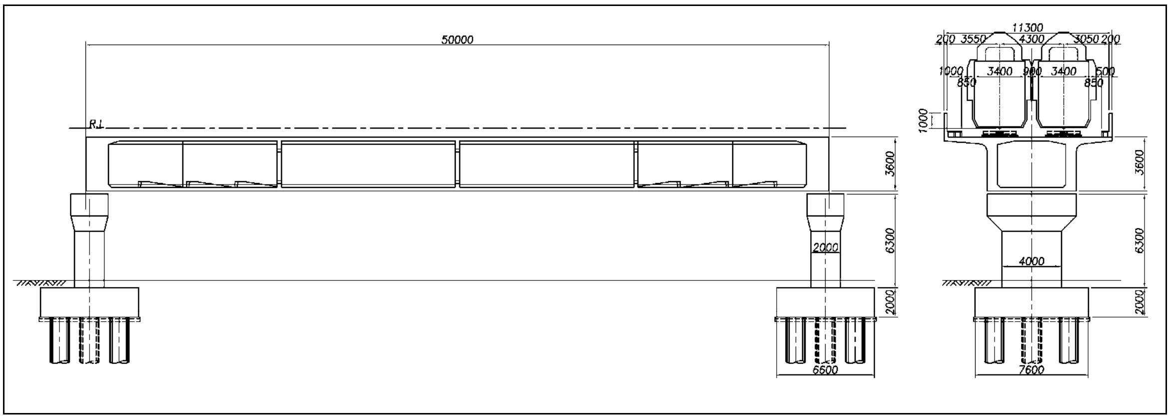
(iv) To increase economic efficiency and reduce maintenance costs, PC T-girders, PC box girders and continuous PC girders are adopted for overbridges, pedestrian overpasses and small rivers. PC box girders are adopted for bridges with L=30m～60m and are commonly used both overseas and for many Shinkansen bridges in Japan. Although scaffolding and girder falsework is generally used for construction, it is also possible to use the incremental launching and lateral transfer methods.

5.310 Typical drawings of girder viaducts are shown in Figure 5.3.11 and Figure 5.3.12.



Source: JICA Study Team

Figure 5.3.11 Typical Girder Type of Viaduct -1



Source: JICA Study Team

Figure 5.3.12 Typical Girder Type of Viaduct -2

5.311 Since running safety and riding comfort are very important for HSR rolling stock, strict limits have to be set for girder deflection, unevenness and angular rotation of the track surface, and differential displacement. These limits also have to be considered when selecting civil structures. The following tables describe each limit value used for HSR in Japan.

Table 5.3.21 Design Limit Values for Girder Deflection Based on Running Safety under Normal Conditions

Number of spans	Maximum speed (Km/h)	Girder or member span length Lb(m)									
		10	20	30	40	50	60	70	80	90	More than 100
Single	260	Lb/700									
	300	Lb/900									
	360	Lb/1100									
Multiple	260	Lb/1200						Lb/1400			
	300	Lb/1500						Lb/1700			
	360	Lb/1900						Lb/2000			

Source: JICA Study Team

Table 5.3.22 Design Limit Values of Vertical Unevenness of Track Surface Based on Running Safety under Normal Conditions

Maximum speed (Km/h)	Single span (mm)	Multiple span (mm)
260	2.0	3.0
300	1.5	2.5
360	1.0	2.0

Source: JICA Study Team

Table 5.3.23 Design Limit Values for Angular Rotation of Track Surface Based on Running Safety under Normal Conditions

Maximum Speed (Km/h)	Vertical Direction θ_L(・ 1/1000)		Horizontal Direction θ_L(・ 1/1000)	
	Parallel Displacement	Folding	Parallel Displacement	Folding
210	4.0	4.0	2.0	2.0
260	3.0	3.0	1.5	2.0
300	2.5	2.5	1.0	1.0
360	2.0	2.0	1.0	1.0

Source: JICA Study Team

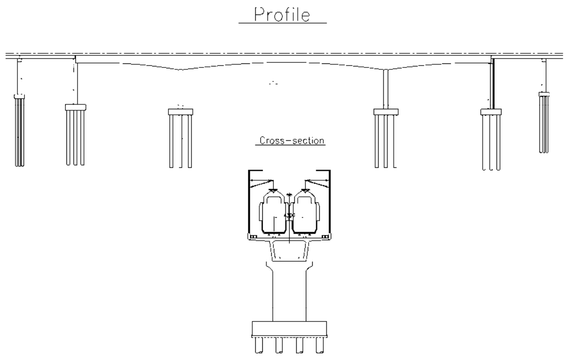
Table 5.3.24 Limit Values for Differential Displacement of Track Surface during Earthquake

Direction	Maximum Speed (Km/h)	Angular Rotationθ_l (・ 1/1000)			Unevenness (mm)
		Parallel Displacement		Folding	
		Lb=10m	Lb=30m		
Horizontal	210	5.5	3.5	4.0	10
	260	5.0	3.0	3.5	8
	300	4.5	2.5	3.0	7
	360	4.0	2.0	2.0	6

Source: JICA Study Team
Lb: Girder or member span length

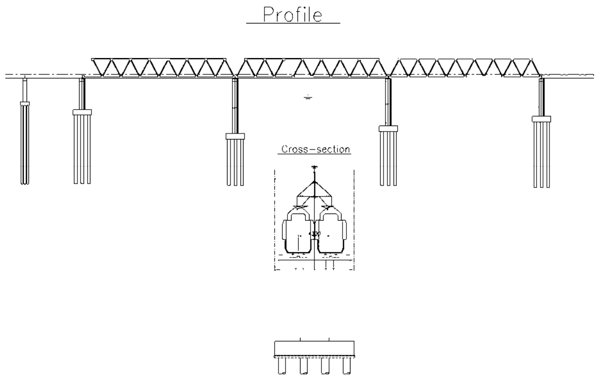
(3) Large Bridges

5.312 It is important to consider the economy and workability of large bridges that cross rivers, railways and highways. Especially when planning bridges that cross big rivers, it very important to select substructures that can be constructed during the flood season and superstructures that can be constructed in river basins. Continuous rigid-frame PC girders and steel-truss girders typical of large bridges are shown in Figure 5.3.13 and Figure 5.3.14.



Source: JICA Study Team

Figure 5.3.13 Continuous PC Girder



Source: JICA Study Team

Figure 5.3.14 Steel Truss Bridge

(4) Station Structures

5.313 Station structures can be further classified into terminal stations as well as large-scale, medium-scale and small-scale intermediate stations. Stations can be constructed directly above railways or roads, or the lower levels can be used for the concourse or commercial facilities. Stations can also be located at grade or underground.

5.314 Here, four types of stations are proposed: 3-layer structures, 2-layer structures, 1-layer structures and canal structures.

5.315 Stations with 2 or more layers basically employ girder viaduct structures with rigid-frame substructures. Hybrid structures, where the load of the station shed is not supported by the civil structure but by the building foundation, have recently become common in Japan because of their economy.

5.316 The selection of station structure is based on the following considerations:

(i) Although beam-slab rigid-frame viaducts are used for elevated stations in Japan, they require complicated bar arrangement which might cause problems during construction supervision in Vietnam. Therefore, the use of PC T-girders is recommended as for typical viaducts.

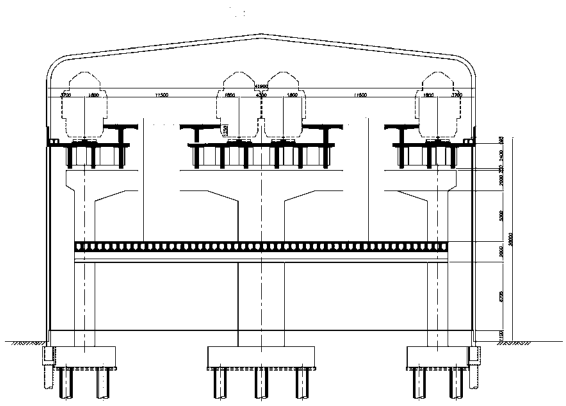
(ii) Since it is necessary to consider the space utilization under the viaduct, rigid-frame rather than wall-type substructures are recommended because they allow pier locations to be determined based on the concourse layout.

(iii) The span length of the middle slab of 3-layer elevated stations is approximately 25m. In order to ensure enough overhead clearance, a pre-tensioned PC box girder structure is recommended because of its low girder height. This reduces the construction cost since the overall height of the station as well as the height of surrounding structures can be reduced.

(iv) Considering passenger safety and convenience, elevated station buildings are recommended for ground level stations. Because they do not support the railway structure, elevated station buildings can be thought of as general building structures.

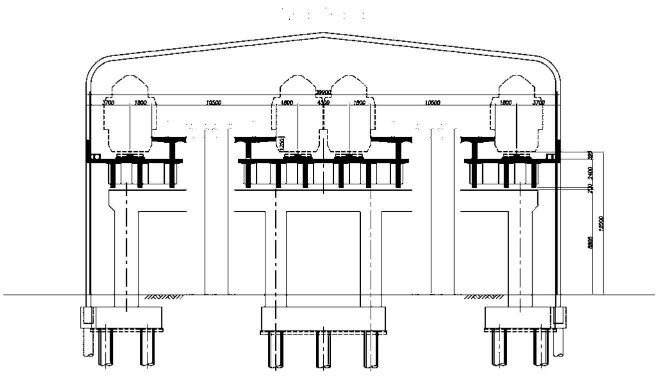
(v) Stations with canal structures are located one level lower than the ground level. In locations with groundwater, U-shaped retaining walls or underground box rigid-frame structures shall be employed, but earth retaining walls are more economical if no groundwater is present. The earthquake resistance of earth retaining walls can be improved by using reinforcement material. In this case, the station building is essentially an elevated structure and can therefore be treated as a general architectural structure.

5.317 Typical station structures are shown in Figure 5.3.15 to Figure 5.3.18.



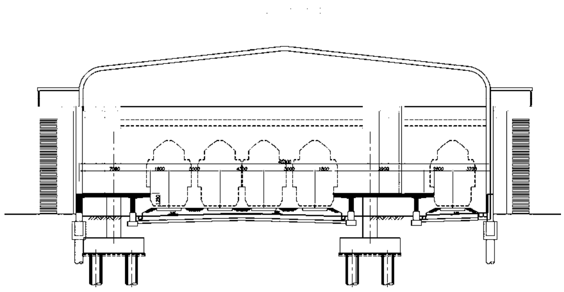
Source: JICA Study Team

Figure 5.3.15 3-Layer Structure



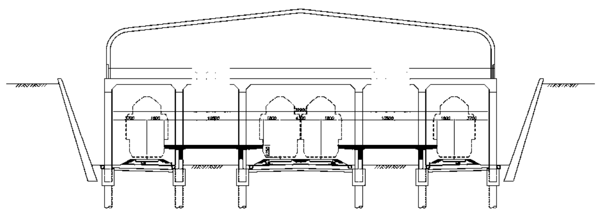
Source: JICA Study Team

Figure 5.3.16 2-Layer Structure



Source: JICA Study Team

Figure 5.3.17 1-Layer Structure (Elevated Station Building)



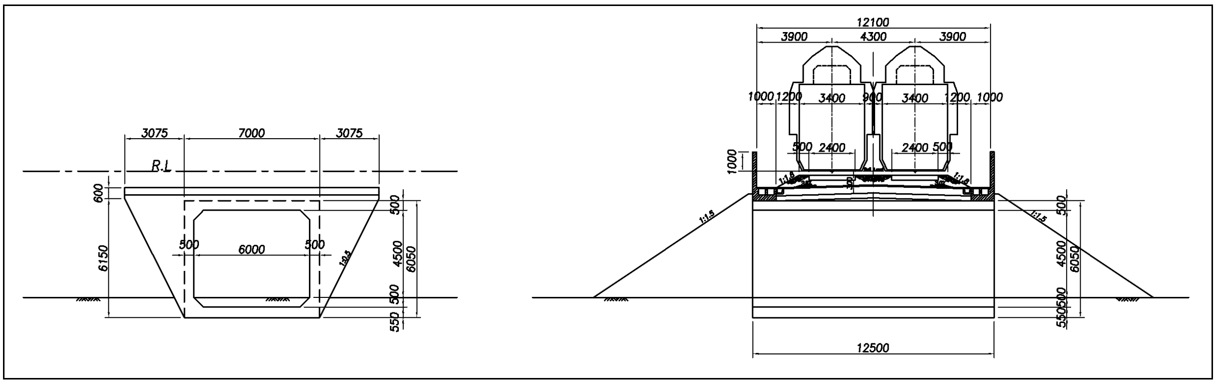
Source: JICA Study Team

Figure 5.3.18 Canal Structure (Elevated Station Building)

(5) Box Culverts

5.318 Embankment construction may cut off roads and waterways and cause water to dam up during rainfall. Medium and large roads that cross embankments generally require bridge abutments, but box-culverts are more economical for rural and narrow roads. For waterway crossings, it is also proposed to bury ducts inside or under the embankment.

5.319 A typical drawing of box culvert is shown in Figure 5.3.19.



Source: JICA Study Team

Figure 5.3.19 Typical Drawing of Box Culvert

(6) Tunnels

5.320 Tunnels shall generally be constructed with the NATM method and have the same 63.4m^2 cross-sectional area as the double-tracked Shinkansen lines in Japan.

5.321 Table 5.3.25 shows a comparison of the tunnel cross-sectional areas used in various countries.

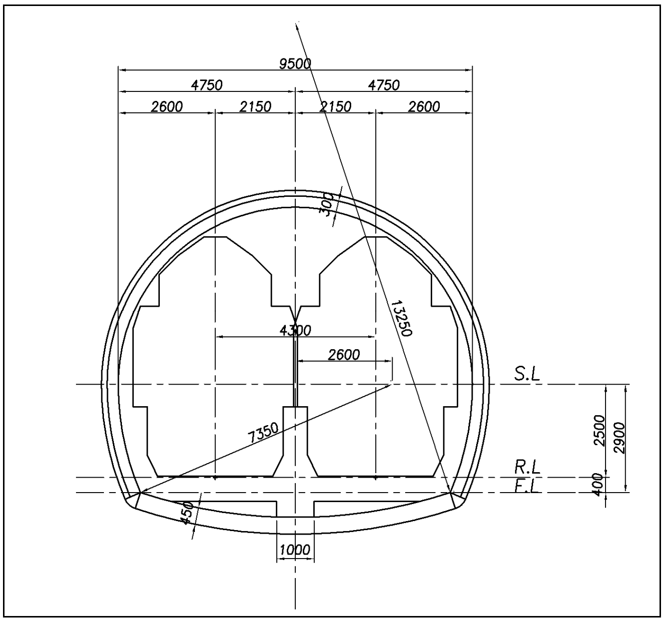
Table 5.3.25 Comparison of Tunnel Cross-Sectional Areas in Various Countries

	Japan	France	Germany	Taiwan	China
Cross-section (m^2)	64	55～71	82～84	74～90	90～100

Source: JICA Study Team

5.322 The tunnel cross-sectional area is affected by the different track spacing and rolling stock construction gauge used in each country and is mostly larger than in Japan. The cross-sectional area is usually varied according to train speed to reduce the effects of pressure changes that occur when trains pass through tunnels.

5.323 Because the airtightness of Japanese HSR rolling stock is excellent and tunnels have countermeasures against air-pressure waves, it is possible to use a smaller tunnel cross-sectional area and thus significantly reduce construction costs. A typical tunnel cross-section is shown in Figure 5.3.20.



Source: JICA Study Team

Figure 5.3.20 Typical Cross-Section of Tunnel

6) Tracks

(1) Selection of Track Structures

5.324 The track structures to be used for the Vietnam high speed railway are described below. The main track structures currently used for high speed railways can be divided into ballast and non-ballast track. Non-ballast track includes slab track and RHEDA 2000, etc.

5.325 An optimal track structure has to be chosen based on economic efficiency, conditions during construction, maintainability, ease of maintenance, environmental countermeasures, life cycle costs, as well as the possibility of future changes in track layout.

5.326 The present issue of the Vietnamese high speed railway projects is the high construction cost in relation to its economic scale. On the other hand, the labor required for maintenance work is still cheap which means the construction of ballast track is advantageous when it comes to reducing construction costs.

5.327 Future urban development might require changes to be made to the existing track layout in stations or the construction of entirely new stations. Such changes to the track layout are cheap when using ballast track.

5.328 Table 5.3.26 shows the characteristics of main track structures and their respective merits in Vietnam.

Table 5.3.26 Features of Main Track Structures and Life Cycle Cost in Vietnam

	Ballast Track	Slab Track	RHEDA2000[1)]
Structure	PC sleepers and ballast roadbed	Frame shaped-slab and cement asphalt mortar as adjustment material	PC sleepers and concrete roadbed
Initial investment	small	comparatively large	comparatively large
Maintenance costs	comparatively large	small	small
Noise and vibration	small	somewhat significant	somewhat significant
Life cycle costs	Advantageous	Disadvantageous under certain conditions	Disadvantageous under certain conditions

Source: JICA Study Team
1) A ballastless track system used for mainline tracks, especially on high-speed routes, developed by RAIL.ONE in Germany.

5.329 As shown in Table 5.3.27 and the Tokaido Shinkansen example illustrates, the disadvantages of ballast track can be appropriately managed. In the case of the Vietnam HSR, it is advisable to control construction costs since future revenue forecasts are yet to be confirmed.

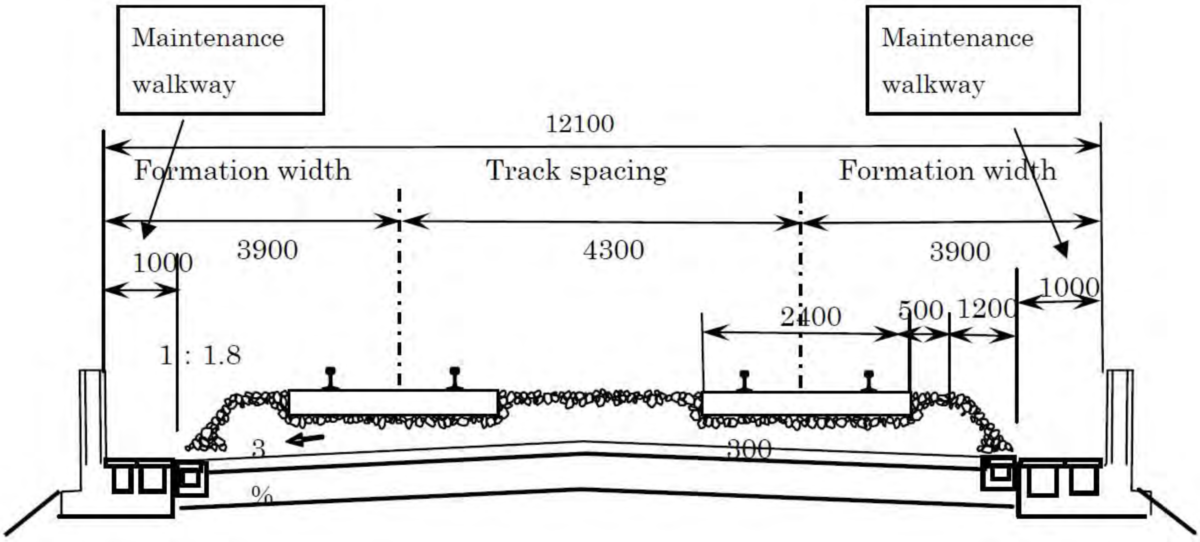
5.330 Because ballast track has many advantages and any disadvantages can be effectively managed, the use of ballast track is recommended as the main track structure for the Vietnam high speed railway.

Table 5.3.27 Management of Disadvantages of Ballast Track

Disadvantages of ballast track	Experience from Tokaido Shinkansen
1) Increase in passing tonnage may lead to higher maintenance costs.	This is not an issue if maintenance costs are 60 percent or less of revenue.*1
2) Lack of maintenance personnel.	This issue can be solved by increased mechanization and the use of IT.
3) Increase in material replacement work.	Can be managed by replacing materials both periodically and whenever required.
4) Up-front investments may be advantageous in the future despite results of LCC analysis	It is advisable to control construction costs when future revenue forecasts are yet to be confirmed.
5) At speeds exceeding 280 km/h, wind from passing trains may cause ballast particles to become detached from the ballast bed (ballast flight).	Polyurethane ballast stabilization can be used where required.

Source: JICA Study Team
Notes
1) In 1968, the income-expenditure ratio of the Tokaido Shinkansen was 0.60 according to the former JNR's profit-and-loss statement.
2) In 2007, the income-expenditure ratio of the Tokaido Shinkansen was 0.51 according to the April 10, 2010 issue of Toyo Keizai magazine.

5.331 When the life cycle costs (construction costs with added maintenance costs) of frame-shaped slab track and ballast track in Vietnam are examined, it becomes clear that the life cycle cost of each track type may not yet balance even 50 years later.



Source: JICA Study Team

Figure 5.3.21 Earthwork Section with Ballast Track

Box 5.3.1 Comparison of Life Cycle for Slab and Ballast Track Structure

Table 1 Life Cycle Cost (LCC) Comparison of Slab Track and Ballast Track (000 US$)

		Construction Costs / km	Annual Maintenance Cost per km	LCC (Present Value)	
Japan	Slab Track	2100	18.75	2271	10 year LCC
	Ballast Track	1550	81.25	2290	10 year LCC
Vietnam	Slab Track	1525	7.5	1595	50 year LCC
	Ballast Track	975	32.5	1277	50 year LCC

Source: JICA Study Team

Calculation conditions:

(1) The costs for Japan are based on available reference data.

(2) The costs for Vietnam are calculated based on Japanese costs using a ratio of 0.25 for labor costs, 0.40 for machine operation and 0.2 for tariffs on material imports.

(3) The maintenance costs of ballast track are assumed to be 4.3 times higher than for slab track.

(4) The discount rate is 4% per year in Japan and 12% per year in Vietnam.

Table 2 Calculation of Life Cycle Costs based on Japanese Unit Prices (000 US$)

Year	Discount Rate	Japan: 20 Million T / Year							
		Slab Track				Ballast Track			
		Construction Costs	Maintenance Costs	Maintenance Costs Present Value	Present Value Total	Construction Costs	Maintenance Costs	Maintenance Cost Present Value	Present Value Total
0	1	2100	18.75	18.75	2,118.8	1550	81.25	81.25	1,631.3
1	0.961538			18.03	2,136.8		18.75*4.3↑	78.13	1,709.4
2	0.924556			17.34	2,154.1			75.12	1,784.5
3	0.888996			16.67	2,170.8			72.23	1,856.7
4	0.854804			16.03	2,186.8			69.45	1,926.2
5	0.821927			15.41	2,202.2			66.78	1,993.0
6	0.790315			14.82	2,217.0			64.21	2,057.2
	0.759918			14.25	2,231.3			61.74	2,118.9
8	0.73069			13.70	2,245.0			59.37	2,178.3
9	0.702587			13.17	2,258.2			57.09	2,235.4
10	0.675564			12.67	2,270.8			54.89	2,290.3
11	0.675564			12.67	2,270.8			54.89	2,290.3
12	0.649581			12.18	2,283.			52.78	2,343.
	0.624597			11.71	2,294.			50.75	2,393.
			Sub total	170.8			Sub total	740.3	
			50 year LCC	2,270.8		50 year LCC	2290.3		

Table 2 Calculation of Life Cycle Costs based on Vietnamese Unit Prices (000 US$)

Year	Discount Rate	Japan: 20 Million T / Year							
		Slab Track				Ballast Track			
		Construction Costs	Maintenance Costs	Maintenance Costs Present Value	Present Value Total	Construction Costs	Maintenance Costs	Maintenance Costs Present Value	Present Value Total
0	1	1525	7.5	7.50	1,532.5	975	32.5	32.50	1,007.5
1	0.961538		18.75*0.4↑	6.70	1,539.2		81.25*0.4↑	29.02	1,036.5
2	0.924556			5.98	1,545.2			25.91	1,062.4
3	0.888996			5.34	1,550.5			23.13	1,085.6
4	0.854804			4.77	1,555.3			20.65	1,106.2
46	0.208289			0.04	1,594.7			0.18	1,276.9
47	0.208289			0.04	1,594.7			0.16	1,277.0
48	0.208289			0.03	1,594.7			0.14	1,277.2
49	0.208289			0.03	1,594.8			0.13	1,277.3
50	0.208289			0.03	1,594.8			0.11	1,277.4
			Sub total	69.8			Sub total	302.4	
			50 year LCC	1,594.8		50 year LCC	1277.4		

Source: JICA Study Team

Viaduct Section with Frame Shaped Slab Track

Source: Japanese railway civil engineering association magazine, February 2008 page-56

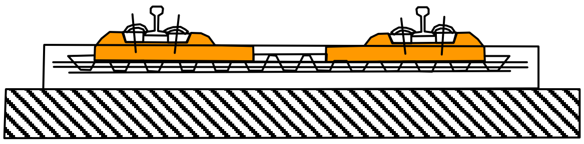
RHEDA 2000 (from Wikipedia article on slab-track)

Source: http://www.open.ou.nl//hon/HSLAFL35.htm

RHEDA 2000 track under Construction

Source: http://www.open.ou.nl//hon/HSLAFL35.htm

RHEDA2000 Cross Section



Composed with 2block sleeper and concrete roadbed

Source: JICA Study Team

Figure 5.3.22 Features of Slab Track

(2) Classification of the Track Structure according to the Type of Civil Structures

5.332 The proposed track structures for various types of civil structures are shown in Table 5.3.28. Ballast track should be used on cut and embankment sections, while viaduct sections require either ballast track or slab track.

5.333 Slab track should be used on sections where it is important to prevent ballast flight near stations, decrease the need for track maintenance, and reduce noise caused by night-time track maintenance.

5.334 Ballast track or slab track should be used on bridge and viaduct sections which intersect rivers, roads and railways. Slab track should be used on sections where the amount of track maintenance work needs to be reduced.

5.335 Ballast track, bridge sleeper track or directly fastened track may be used for steel bridges.

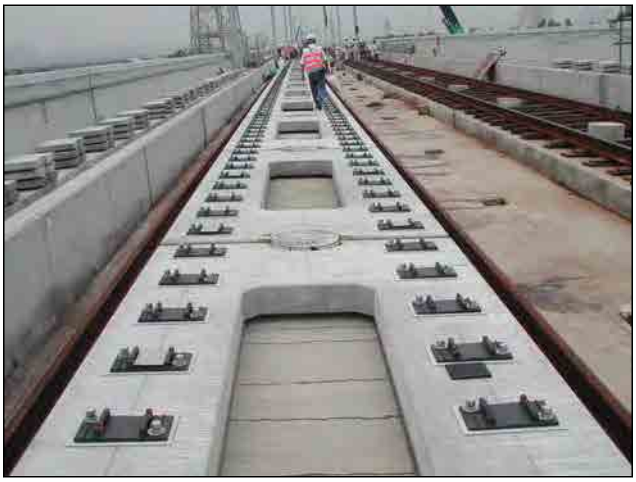
5.336 Since the construction costs of ballast track are comparatively low, it is advantageous in terms of cost performance. (See Box 5.3.1.)

5.337 There is less space to perform ballast renewal and track material replacement on tunnel sections, which increases their maintenance costs compared with open sections. Slab track may therefore be used on long tunnel sections.

Table 5.3.28 Proposed Track Structures for Various Type of Civil Structures

Type Of Civil Structures	Typical Track Structure
1) Cutting and embankments	Ballast track
2) Viaducts and bridges	Slab track: On sections longer than 500m and where less track maintenance is desired. Ballast track: On short sections.
3) Tunnels	Slab track Ballast track should be used on short sections.
4) Sections with particularly difficult topographical and geological conditions	Ballast track
5) Sections other than the above	Comparison and use of ballast track, slab track or non- ballast track.

Source: JICA Study Team



Source: JICA Study Team

Figure 5.3.23 Viaduct Section with Frame Type Slab Track in Taiwan High Speed Railway

Source: JREA April 2011 pages 15

Figure 5.3.24 Tunnel Section with Frame-Shaped Slab Track

Source: JICA Study Team

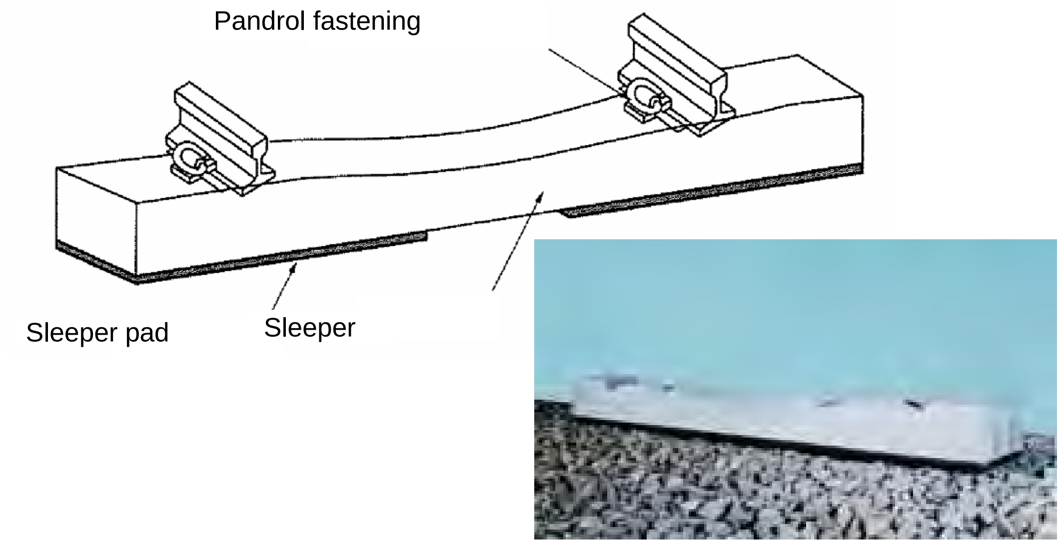
Figure 5.3.25 Bridge Sleeper Track between Hanoi and Ninh Binh

Source: JICA Study Team

Figure 5.3.26 Directly Fastened Track on Steel Girder at Kubo River Bridge in Saga prefecture, Japan

(3) The View of the Environmental Countermeasures in Ballast Track Structure

5.338 On all sections of the route, it is essential to consider the surrounding environment such as existing houses and hospitals and schools in order to determine which sections require countermeasures.



Source: Compiled by JICA Study Team

Figure 5.3.27 Elastic PC Sleeper for Ballast Track with Sleeper Pads

5.339 Compared to ballast track, slab track has a slightly higher noise level and an approximately 3 dB higher vibration level.

5.340 The track structure should employ appropriate countermeasures against vibration considering the housing density and the proximity of nearby hospitals and schools.

5.341 The use of ballast track with sleeper pads under PC sleeper surfaces is proposed in urban areas, residential districts and on other sections which require countermeasures against vibration.

(4) Slab track characteristics and sections of application

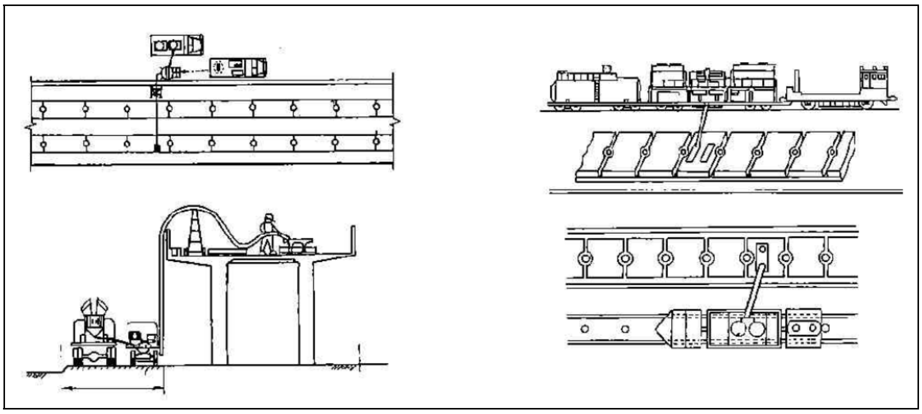
5.342 Slab track is normally used on continuous sections. The following three issues need to be considered when constructing slab track:

(i) Since the facilities required to construct slab track are large, the equipment costs can be reduced by sequential construction.

(ii) Embankments and cut sections require enough supporting strength.

(iii) Materials such as asphalt mortar and resin need to be controlled for quality during construction.

5.343 In order to take advantage of the characteristics of slab track for the Vietnam high speed railway, its use should be considered for viaduct, tunnel and bridge sections with a construction length over 500m where it is easy to ensure accuracy during construction.



Source: Compiled by JICA Study Team
1) Construction materials and plant are placed on a service road and track slabs are installed on the bridge or viaduct.
2) Construction materials and plant are placed on one track and track slabs are installed on the other track.

Figure 5.3.28 Construction of Slab Track

(5) Proposed Track Structure Specifications

5.344 The proposed track structure specifications are shown in Table 5.3.29. The track structures should be able to safely support the high speed train cars and have appropriate maintenance and environmental characteristics. The most economical structures should then be chosen among those that meet the required criteria.

Table 5.3.29 Proposed Track Structure and Material Specifications

Type	Standard Track	Usage classification
Ballast track	PC sleepers	Typical section: Number of sleepers : 43 sleepers / 25m for main line Ballast depth: 300mm for cut and embankment sections 250mm for tunnel sections 200mm for viaduct sections 200mm to 150mm for depot lines
Slab track	Frame-shaped slab track	Classification of frame-type slabs : tie plate fastening for concrete structure sections and curve sections rail seat type for tunnel sections
Rail	60 kg/ m	Rail length : continuously welded rail (CWR) for main line jointed rail for depot line
Turnouts		Ballast track type turnouts for viaduct and earthwork sections

Source: JICA Study Team

(6) Turnout Numbers

5.345 Large turnout numbers shall be used in the following cases:

(i) When the train speed on the turnout side is 220km/h on connecting lines with through service.

(ii) When facilities for single-track operation are installed and one track is used as both the up and down line to allow maintenance of the other track and its overhead wires, and the turnout through speed is set to 160km/h.

(iii) The Vietnam north-south high speed railway has no connection lines for through service and there are no plans for single-track operation.

(iv) Moreover, track maintenance work is scheduled to take place at night.

(v) No. 18, No.16 and No. 12 turnouts are used since trains will have speeds between 40 km/h and 75km/h when arriving at and departing from stations.

5.346 The turnouts proposed for the Vietnam high speed railway are shown in Table 5.3.30 which describes the characteristics of main turnouts and their application.

Table 5.3.30 Characteristics of Main Turnouts and Their Proposed Application in Vietnam HSR

Turnout number	Characteristic	Proposed Application in Vietnam
No. 65	220km/h through speed on turnout side	N/A
No. 46	160km/h through speed on turnout side	N/A
No. 24	100km/h through speed on turnout side	N/A
No. 18	75km/h - 80 km/h through speed in turnout side	Main track
No. 16	70km/h through speed on turnout side	Main track
No. 12	A 55km/h through speed on turnout side	Terminals and siding tracks
No. 9	40km/h through speed on turnout side	Depot

Source: JICA Study Team

7) Station and Station Facilities

(1) Volume of Station

5.347 Minimum facilities of station, such as ticket counter, waiting room, gate and others were applied in current station in Vietnam. Platform width is also smaller than 10m. In determining the size of the station, the number of ridership is the most important item. In view of universal design, convenience and safety items are also required of station users. In this case, initial construction cost will be higher than the common station in Vietnam. However, the value for safety is justified since casualties or injuries caused by accidents will cost much higher in terms of lives as well as cost for repairs and reconstructions.

5.348 Therefore, Japanese safety and convenience system which have depth in accumulated knowledge for HSR, shall be selected.

(2) Connectivity with Other Regional Railway

5.349 Gauge size of long distance railway in Vietnam is Meter Gauge (1,000) with single rail. HSR shall develop new route by individual railway in whole segments. As for the alignment of the HSR, placing this at the outskirt of the city will be easier and cheaper. According to HSR planning in the world, connectivity with the regional railway has been overhauled due to the failure of urban development around the stations with decreased number of passengers. HSR shall not make a similar failure even in Vietnam.

8) Automatic Fare Collection (AFC) System

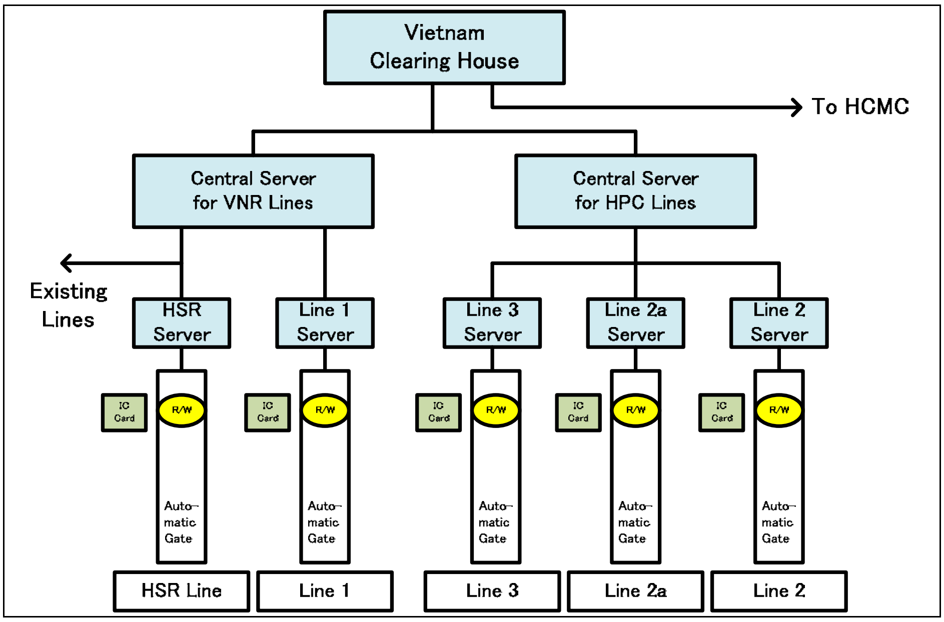
(1) Selection of AFC System

5.350 To ensure the convenience of users and the income from passenger services, the high-speed railways in Vietnam shall introduce an AFC system, which will be composed of fare media, AFC equipment (Read/write units), servers, clearing house servers and a WAN network when broadly classified, with non-contact IC cards, tokens and magnetic tickets (with magnetic records on the back) used in place of existing non-magnetic tickets. There are three types of non-contact IC cards A, B and Felica. The type A cards are popular mainly in Europe and other countries, and the Type B cards mainly in the US. The type Felica cards are used for traffic systems and as electronic money cards mainly in Japan and other Asian countries such as Hong Kong (all transport operators), China (Shenzhen), Taiwan (Kaohsiung), Thailand (Metro and Airport Line) and India (Delhi Metro).

5.351 The type Felica cards have merits of high-speed reading and writing to make passengers smoothly pass automatic passenger gates, even during rush hours crowed with passengers, and being used as electronic money , which are desired to be adopted in the Hanoi and Ho Chi Minh areas and as an integrated card system for transport facilities across the country.

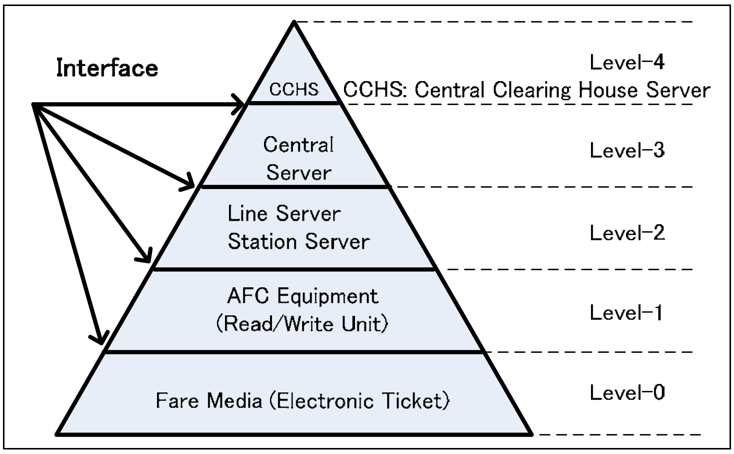
(2) Composition of AFC System

5.352 Figure 5.3.29 illustrates an example of the composition of interoperable AFC system when an automatic fare collection system is introduced into the Hanoi area and Figure 5.3.30 for the composition of AFC system as an information system. To improve the convenience of users, it is strongly desired to adopt such a hierarchical structure that enables system composition to allow common use with the Vietnam high-speed railways, Hanoi elevated railway line 1, existing railways, Hanoi urban railways and Ho Chi Minh City transport organizations.



Source: JICA Study Team

Figure 5.3.29 Example of Interoperable AFC System for Hanoi Area



Source: JICA Study Team

Figure 5.3.30 Example of Interoperable AFC System for Hanoi Area

5.353 The composition of the AFC System with their corresponding function are briefly explained as follows:

(a) Fare media (Electronic Tickets)

5.354 There are IC cards for stored fare cards, tokens and magnetic tickets for single journey tickets in fare media or electronic tickets. In high speed railways, magnetic tickets are used mainly for seat reservations and fare tickets while IC cards are used for high-speed railway commuter pass or fare tickets as well. In urban railways, IC cards are used mainly for commuter pass or fare tickets while magnetic tickets are used for seat reservations and fare tickets as well.

(b) AFC equipment (Read/Write Units)

5.355 Having read/write units, the AFC equipment is typically represented by automatic passenger gates. Other devices required for the AFC equipment include IC card issuing machines, ticket vending machines, money charging machines, automatic fare adjusting machines and ticket office machines.

(c) Station servers and line servers

5.356 Station servers having important functions to perform income control and ID control are connected with automatic passenger gates, ticket office machines, IC card issuing machines and money charging machines at each station through LAN.

5.357 The income control means the calculation and control of the charges for magnetic tickets, tokens and IC cards. It also means the control and storage of the information on the number of users who have passed automatic passenger gates, time of passage and boarding/alighting stations. The ID control is to prevent wrong usage of tickets, control black lists and re-issue lost cards. A set of station server is installed at each station, with the collected information summarized and controlled for each line by the line server.

(d) Central Servers

5.358 The information collected and controlled for each line is eventually collected and controlled by the central server of each organization.

(e) Clearing House Server

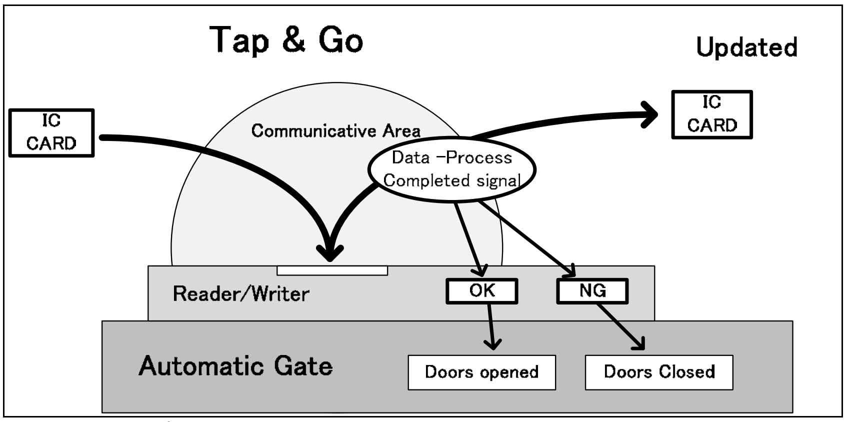
5.359 The clearing house server settles/liquidates the income/payment between different organizations and liquidates electronic money.

5.360 Figure 5.3.31 provides examples of automatic passenger gates and Figure 5.3.32 is the processing at a passenger gate when a user passes.

Example No. 1	Example No. 2

Source: JICA Study Team

Figure 5.3.31 Automatic Passenger Gate

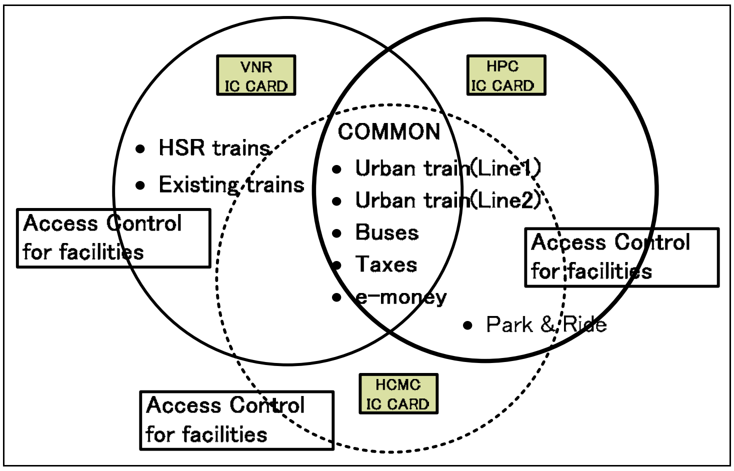


Source: JICA Study Team

Figure 5.3.32 Processing at an Automatic Passenger Gate when a User Passes

(3) Development of Interoperable AFC System for Vietnam Railways

5.361 IC cards are used for multiple purposes. They can be applied further not only to the high-speed railways, urban railways, existing railways, buses and taxis in Vietnam but also to purchases and sales of commodities as well. They will also be used for access control for offices and facilities for the purposes of security control. The interoperable AFC system is proposed for Vietnamese Railways to adopt. See Figure 5.3.33 for an image of such applications.



Source: JICA Study Team

Figure 5.3.33 Further Development of the Application of Interoperable AFC System

9) Rolling Stock

5.362 Basic Concepts, Requirements and Solutions conceivable for Vietnam High Speed Rolling Stock (VHSRS) are shown in Table 5.3.31.

5.363 We propose the rolling stock based on Japanese Series E5 for the Vietnam high speed rolling stock. Series E5 has enough performance to operate at 320 km/h and can satisfy all the requirements mentioned in Table 5.3.32.

Source: JR East

Figure 5.3.34 Series E5

Table 5.3.31 Basic Concepts, Requirements and Solutions of Vietnam High Speed Rolling Stock

Concepts	Requirements	Solutions
High Speed	VHSRS should have the traction, braking and aero dynamic performance that can operate at 320 km/h max.	• Power distributed system • Long nose shape
Mass Transport	VHSRS should have enough capacity equivalent to passenger demand efficiently.	• Wide body (5 seats/ row)
Safety	VHSRS should be equipped with signal system which controls the train smoothly and prevents the collision absolutely.	• Digital ATC system
Reliability	VHSRS should have redundancy to continue running when some power units have troubles.	• Power distributed system
Energy Saving	VHSRS should have the performance to be low energy consumption.	• Light weight body (Double skin aluminum extruded structure) • Light axle load
Environmental Friendliness	VHSRS should have the performance to be low noise.	• Long nose • Low noise pantograph • Smooth cover between cars • Full bogie cover
Riding Comfort	VHSRS should offer the riding comfort even at a maximum speed.	• Full-active suspension

Source: JICA Study Team

(1) Basic Specification

5.364 Basic Specification of Vietnam High Speed Rolling Stock is shown below.

Table 5.3.32 Basic Specification of Vietnam High Speed Rolling Stock

Item	Specification
Track gauge	1435 mm
Power supply	AC25kV 50Hz
Maximum operation speed	320 km/h
number of car	10 cars (8M2T)
Capacity	All seats can be reclined and can face different directions Total 759 (Executive Class 51 , Economy Class 708)
Weight	Approx. 460 t / Train (Unloaded)
Maximum Axle load	Approx. 13t (100% passenger volume)
Major dimensions	
Length (lead car)	26250 mm
Length (other cars)	25000 mm
Maximum width	Approx. 3350 mm
Maximum height	3650 mm
Distance (between bogies)	17500 mm
Body structure type	Aluminum alloy double-skin extruded structure (Airtight Structure body)
Bogie	
Bogie type	Bolster less type
Wheel dimension	Φ =860 mm
Wheel base	2500 mm
Traction System	
Control system	VVVF Inverter-Converter control System with IGBT 3 level PWM
Main motor	Induction Motor, power:300 kW / unit 32 units/train, 9,600 kW/ train
Pantograph	2 units/ train, single-arm pantograph (low-noise type)
Brake system	Electric command brake equipment with regenerative brake
Safety system	Digital ATC with onboard braking control
Train radio	Space wave & LCX (digital)

Source: JICA Study Team

(2) Technologies to be adopted for Vietnam High Speed Rolling Stock

5.365 Technologies which VHSRS should be adopted are the follows:

(a) **Traction System:** VHSRS should have the redundancy against troubles of traction system to keep transportation stability. Therefore, it should be adopted power distributed system. Power distributed system also contributes the reduction of maximum axle load and higher acceleration and deceleration. Induction motor and VVVF control system contribute to reduce the maintenance work. The rated power output of one induction motor should be over 300kw and the total rated power of trainset will be 9600kw. This will be enough power to operate at 320 km/h.

(b) **Wide Body for Mass Transport:** For increasing capacity of train efficiently, wide body should be adopted for VHSRS. Approx. 3350 mm wide body enables to set 5seats per row in the economy class cars. Enlarge the capacity of each car contributes to reduce the number of cars and the cost for rolling stock.

Source: JICA Study Team

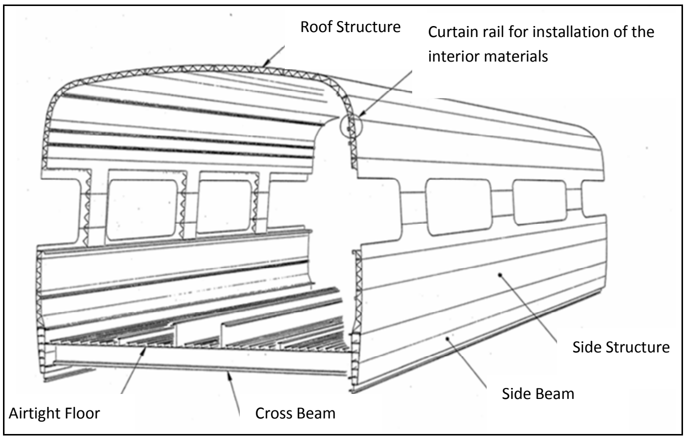
Figure 5.3.35 Economy Class Car of Series E5

Source: JICA Study Team

Figure 5.3.36 Executive Class Car of Series E5

(c) **Digital ATC:** VHSRS should be equipped with Digital ATC system for safety operation. Cab signal will be indicated with train speed on the monitor screen in front of the driver. The detail of this system will be mentioned in the "Signal & Communication" section.

(d) **Light Weight Body and Equipments:** Recently, most of the high speed rolling stock of the world adopts aluminum double skin extruded structure to reduce the body weight and axle load with securing the body strength. The weight of equipments has also been reduced up to now. JR East Series 200 is the aluminum alloy body train with framed structure introduced in 1982. Its weight is 583t for 10cars while the weight of series E5 is 452t. Therefore, weight of series E5 is 22% reduced from series 200.Light weight also contributes to reduce the energy consumption and operating cost.



Source: JR East

Figure 5.3.37 Aluminum Double Skin Extruded Structure

(e) **Environmental Performance:** Micro pressure wave at the tunnel is one of the most serious problems of high speed railway. To reduce the effect of micro pressure wave, VHSRS should minimize the cross sectional area of the body while keeping the passenger capacity. VHSRS should also have long nose shape. Series E5 has 15 m long and optimized nose shape to reduce the noise from micro pressure wave. This body shape contributes not only to reduce the noise but also to improve the aerodynamic performance like air resistance and effect to the train on the opposite track. On the technical specification of Vietnam High Speed Railway that the distance between track centers is 4.3m and the tunnel cross sectional area is 63.4 m^2, this long nose body shape is one of the necessary requirements to run over 300km/h.

Source: JR East

Figure 5.3.38 Long Nose Shape of Series E5

5.366 Pantograph is one of the big noise sources. VHSRS should be equipped with low noise pantographs and noise reduction plates. VHSRS will have two pantographs per trainset, but only one pantograph is used while running to reduce the noise.

Source: JR East

Figure 5.3.39 Low-noise Pantograph and Noise Reduction Plates

5.367 There are a lot of other measures to reduce the noise like smooth covers between cars, full bogie cover and sound-absorbing panels shown in figures below.

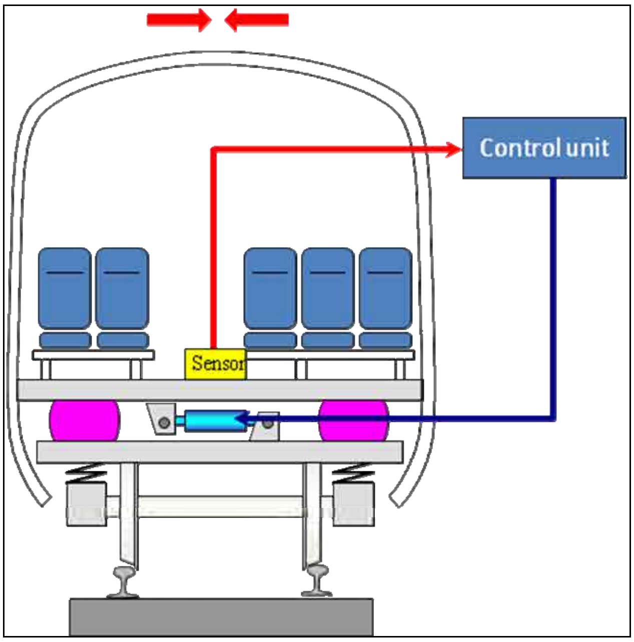
Source: JR East

Figure 5.3.40 Smooth Cover between Cars

Source: JR East

Figure 5.3.41 Full Bogie Cover and Sound-Absorbing Panels

(f) **Riding Comfort:** For passenger riding comfort at the maximum speed, VHSRS should be equipped with full-active suspension system for all cars. The control unit of this system detects the lateral vibration from the sensor unit and controls the actuator actively to reduce the vibration. This system of Series E5 can reduce the vibration at 320 km/h as the same level of Series E2, former main model of JR East Shinkansen, at 275 km/h.



Source: JICA Study Team

Figure 5.3.42 Full-Active Suspension System

5.368 Series E5 is also equipped with car body tilting system which enables to run at a curve 4000 m in radius at 320 km/h. But for Vietnam High Speed Rolling Stock, there is no need to be equipped with this system because almost all the curves are more than 6000 m in radius on planned VHSR alignment

(3) Maintenance system for Vietnam High Speed Rolling Stock

5.369 Proposed maintenance system of Vietnam High Speed Rolling Stock is shown in Table 5.3.33. This system is based on the Shinkansen maintenance system.

Table 5.3.33 Maintenance System of Vietnam High Speed Rolling Stock

Type of Inspection	Inspection Points	Interval	Venue	Duration
Daily Inspection	Operation and function of pantographs, running gears, brakes, door operating system, etc. shall be inspected.	Less than 48 hours	Depot or Workshop	About one hour
Regular Inspection	What is required for normal function of a train, such as conditions and function of pantographs, main circuit system, control system, brake system, bogies, and insulation of electric parts, shall be inspected. Bogies shall be inspected for the shape of the wheel tread and flaws on axles	Less than 30 days or 30,000 km	Depot or Workshop	One day
Bogie Inspection	Main parts of bogies, *e.g.* wheel sets, wheels, driving device, brake system, main motors, shall be disassembled from bogies and inspected. Efficiency of the inspection shall be guaranteed with use of bogie replacement system, *i.e.* temporary replacement of the bogies to be inspected with back-up bogies.	Less than 18 months or 600,000 km	Workshop	About three days, temporary replacement of bogies
General Inspection	Detailed inspection shall be carried out on the main equipment disassembled from cars. Efficiency of the inspection shall be improved by replacing the equipment to be inspected with a back-up. At the same time, bodies shall be repaired and repainted and passenger cabin equipment shall be repaired.	Less than 36 months or 1,200,000 km	Workshop	About 3 weeks

Source: JICA Study Team

10) Signal and Telecommunication

(1) Selection of Signal System

5.370 As the train control system applicable to the high-speed railways in Vietnam, four versions of different origins are conceivable, namely: (i) DS-ATC from Japan, (ii) TVM from France, (iii) LZB from Germnay, and (iv) ETC3 now under development in Europe.

5.371 A comparison of systems shows that the DS-ATC system is recommendable. The following reasons are cited:

(i) The Level 3 system of ETCS for high-speed railway that uses radio transmission, which is still at a developmental stage, in not yet feasible for commercialization at the moment. Therefore, it is not proven from the viewpoint of safety, reliability, actual transport efficiency and cost. On the other hand, Level 2 is not different from the track circuit type and is rather complicated in the sense that it additionally uses radio transmission. Therefore, it is also not recommended.

(ii) The LZB system originated in Germany that lays induction coils on the track. It disturbs track maintenance works and is not recommended as well.

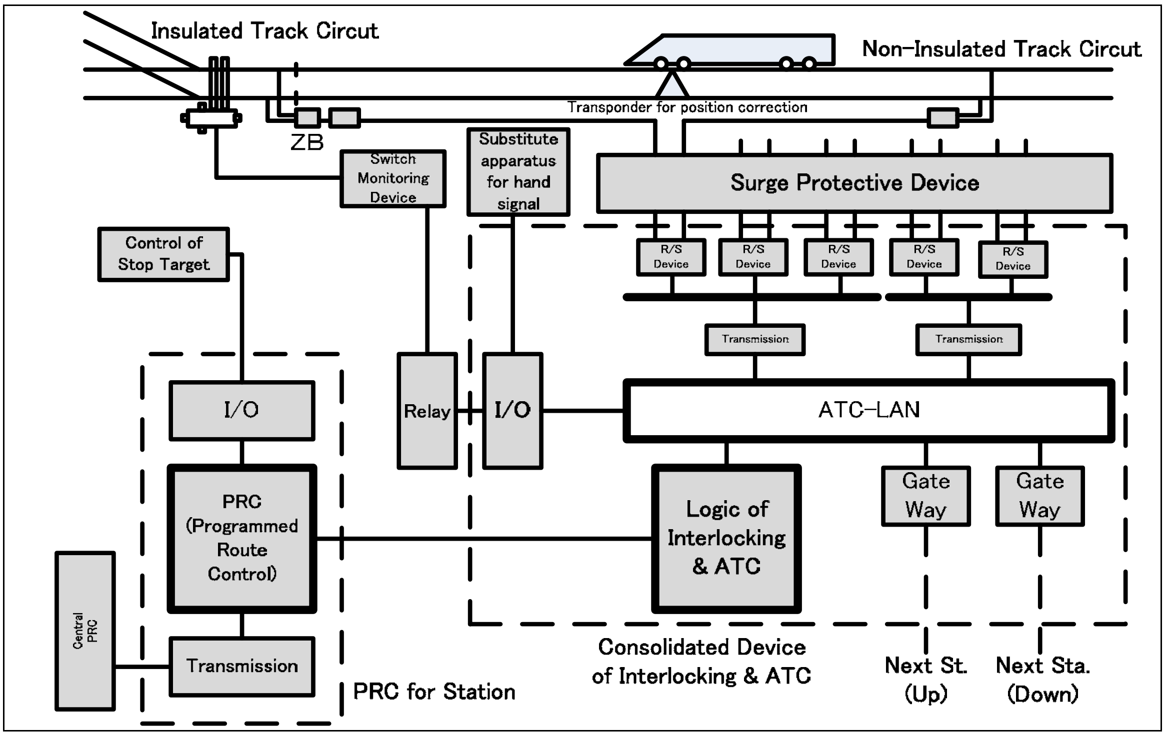
(iii) In terms of function, the French system is similar to the DS-ATC in Japan, which integrates the interlocking function and ATC to make the system simpler and high reliable at lower cost. For this reason, the JICA Study Team recommends the DS-ATC of Japan.

(2) Composition of Signal

5.372 The composition of the signal system that will be applied to the high-speed railway in Vietnam is briefly explained as follows:

(a) Interlocking-cum-ATC System

5.373 The stations in the Hanoi–Vinh and HCMC–Nha Trang sections will be equipped with interlocking-cum-ATC units to process the signals from the electronic interlocking system and ATC ground equipment with one logic unit. This composition has the following merits, namely: (1) Prevents duplicated logic processing and information transmission/reception to/from other units to make system costs lower, (2) Realizes the direct input of an interlocking tables and other control conditions to make designing and work execution simpler. Figure 5.3.43 shows the composition of the interlocking-cum-ATC system.



Source: JICA Study Team

Figure 5.3.43 Composition of the Interlocking-cum-ATC System

(b) Track Circuits

(i) **Non-insulated AF Track Circuits:** This will be adopted between stations to improve riding comfort and maintainability.

(ii) **Insulated AF Track Circuits:** This will be adopted in station yards as boundary discrepancies shall be avoided to ensure safety in turnout sections and at route starting/end points.

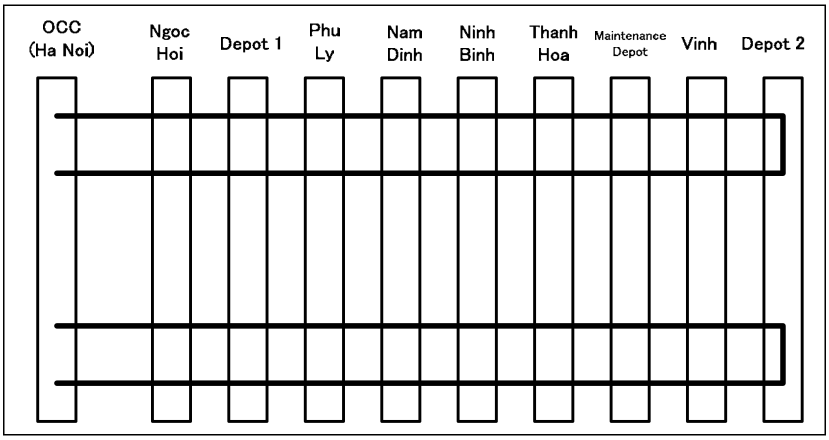
(iii) **Divided Multiple Frequency Track Circuits:** As the track circuits used to detect trains on the safety sidings installed between mainlines and maintenance depots, divided multiple frequency tract circuits (normally used for AC-electrified sections other than those for high-speed railways) will be adopted.

(iv) **Axle Counters on the Track Side:** In train operation under a substitute block system, axle counters on the track side will be used to detect the presence/non-presence of trains between stations, independently of the ATC ground coils. For this purpose, two groups of three –axle counters are set, with the space in between assumed to be a virtual track circuit. A ground of three-axle counters can judge even the direction of running trains.

(v) **Electric Point Machines:** Electric point machines for high-speed railways will be used for the main lines and for the approach to the deadhead operating section to rolling stock depots from the main lines, and those of the normal type in rolling stock depots and maintenance bases.

(vi) **Station Programmed Route Control System (Station PRC System):** Station PRC systems will be installed as a decentralized train control system at the stations and rolling stock depots. The system receives train operation diagrams from the central traffic control system through a network, based on which it implements train operation autonomously at each station. To ensure its high reliability, the network to connect the station and the central operation control system shall be structured as a duplicated loop composition. See Figure 5.3.44 for the network composition of the operation control system between Hanoi and Vinh. The basic functions of the station PRC system are as follows.

- Preserves the train operation diagrams for three days transmitted from the central and collates them with the train numbers received through ATC to autonomously control routes.
- Allows manual control of routes and temporary speed restrictions through the manipulation of terminals at the center and stations.
- Implements public address broadcasting and controls departure posts based on the station diagrams and the information on track occupancy status sent through track circuits.
- Establishes the routes for maintenance cars from handy terminals during the maintenance work time zones.



Source: JICA Study Team

Figure 5.3.44 Composition of the Network for Station PRC Control (Hanoi–Vinh)

(vii) **Center Traffic Control System:** See the section (1) Central traffic control system.

(viii) **Automatic Train Detection System for the Substitute Block System:** Each station will be installed with an automatic train detection system having the functions to judge the occupancy status of the routes to/from adjacent stations and count the number of trains, which is used for train operation under a substitute block system. The system uses axle detectors for train detection.

(ix) **Power Source Equipment:** As the power source for the signal system, (1) the dedicated power distribution source for railway use is appropriated in the normal state; (2) one with a backup generator is mobilized for emergency use and (3) the trolley power source is secured as a standby apparatus. To switch all the loads of signal equipment to the trolley power, a single-phase uninterrupted power source (UPS) unit will be prepared.

(x) **Signal Cables:** Categories of signal cables and applications of each cable will be specified in consideration of transmission characteristics, frequencies, environments for use, degree of importance and economy.

(xi) **Other Devices:** Other devices used for signal and security are changeover devices for sectioning posts, transponder ground coils to correct position errors, train protection devices, train approach alarming devices and forbidden movement indicators, of which changeover devices for sectioning posts and transponder ground coils to correct position errors are explained below.

- Changeover devices for sectioning posts: Sectioning control track circuit units will be placed as a special train detection device to automatically change the changeover sections to be installed at the places where different phases of substations (SSs) and sectioning posts (SPs) join to the same phase according to the train position. Discrepancies of train detection boundaries are prohibited for the non-insulated track circuits laid for ATC between stations. Therefore, virtually discrepancy-free voltage/current charging type non-insulated track circuits will be adopted.
- Transponder ground coils to correct position errors: Trains mounted with DS-ATC equipment are running while recognizing their position all the time based on the information obtained from the speed-generator. To determine the position when the system starts or compensate for the errors in the speed-generator data due to skids, slips or wheel diameter errors, transponder coils will be installed on the ground.

(3) Telecommunication System

5.374 The technological development of optical transmission, radio access and LAN in recent years has economically realized high-speed mass transmission of signal for long distances. Instead of the design in the past to raise the circuit accommodation efficiency, a simple network design will be adopted in consideration of maintainability. The composition of the signal system that will be applied to the high-speed railway in Vietnam is as follows:

(a) Telecommunication Cables

5.375 As the trunk transmission route/in the Hanoi-Vinh and HCMC- Nha Trang sections of the south-north high-speed railway in Vietnam, four optical fiber lines, two lines separately with 20-core cables, and another two separately with 80-core cables, will be laid. The 20-core type cables accommodate the circuits of optical PCM carrier system (10G) and those for the operation control system requiring long-distance transmission, while the 80-core type cables accommodate other circuits. In addition, spare circuits will be reserved to 20% of the total capacity to prepare for system expansion in the future. Table 5.3.34 gives the design conditions for optical carrier circuits.

Table 5.3.34 Design Conditions for Optical Carrier Circuits

Item \ Section	Inter-office connection (10G)	Inter-office connection (150M)
Optical fiber cable	DSM	SM
Optical transmission line speed	9953.28Mbps	155.52Mbps
Optical transmission format	Based on STM-6	Based on STM-1
Emitting/receiving wave length	1550 nm	1310 nm
Optical transmission level	7.0~9.5 dBm	-3.0~3.0 dBm
Optical receiving level	-26.0~-5.0 dBm	-35.0~-17.0 dBm
System margin	2 dB	6 dB
Allowable loss of transmission line	30.5 dB	20 dB
Approximate standard relaying distance	90 km	40 km

Source: JICA Study Team

5.376 To use for telecommunication purposes, 30-pair cables will be laid along the entire route. In AC-electrified sections, aluminum sheathed cables will be used with relaying coils inserted as the countermeasures against induction, as voltages are induced otherwise in the telecommunication cables. The telecommunication cables accommodate the circuits for wayside telephones, cable gas pressure monitors, pluviometers and tunnel lighting controllers for which a common power source shall be used.

(b) Trunk Transmission Route

5.377 As trunk transmission route, optical PCM carrier units (10G) and (150M) will be installed. The former will accommodate the circuits to control the operation control system, IP dispatching, IP exchange and equipment status monitoring, while the latter those to control the power control system, wayside telephones, optical cable monitoring and train radio approach.

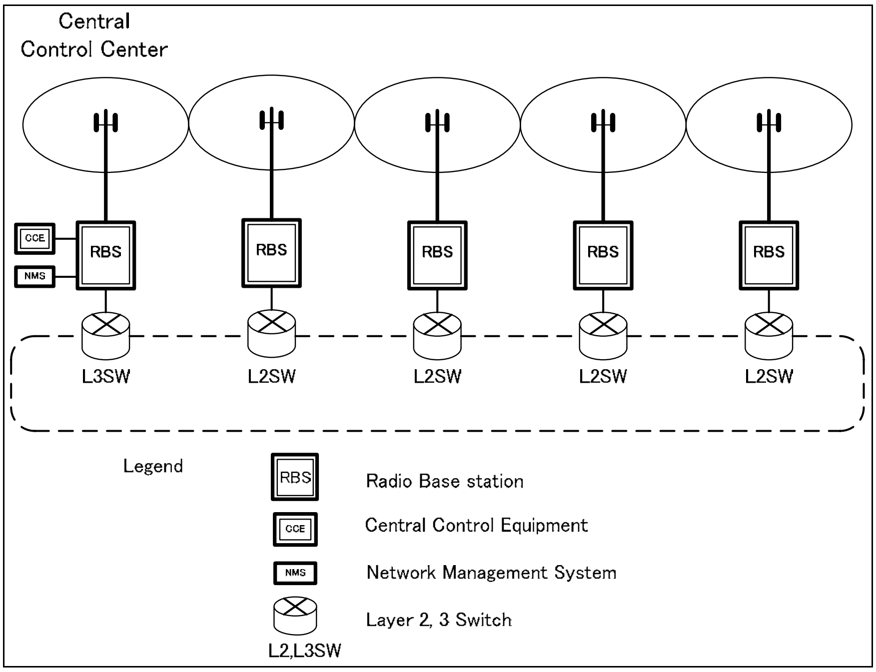
5.378 The system will be structured as a duplicated composition to improve reliability through its redundant features.

(c) Train Radio System

5.379 A train radio system will be used for data transmission between the ground and trains for operation and passenger dispatching services, official/public telephones and transmission of official data.

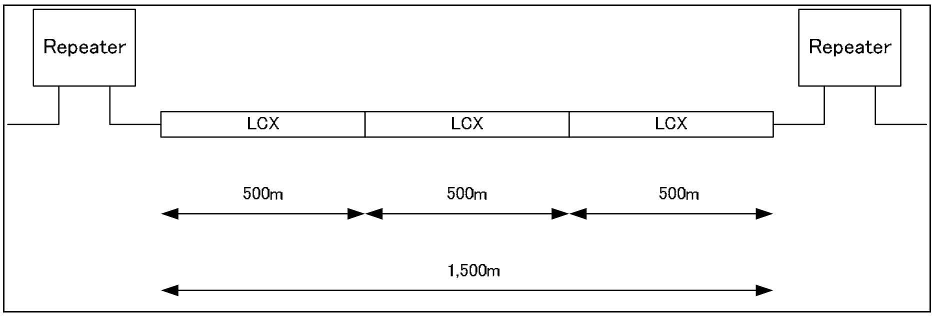
5.380 As the high-speed railway in Vietnam features short tunnel sections (approximately 20% of the route length in the northern section and 10% in the southern section), the study team proposes the space wave type mobile digital transmission system in the main, complemented with the leaky coaxial (LCX) cable system as a countermeasure against weak electromagnetic fields in tunnel sections.

5.381 As the mobile digital telecommunication system to be adopted for Vietnam, TETRA and GSM-R are conceivable. TETRA allows the use of four channels per wave at 25 kHz to claim a higher wave utility frequency than GSM-R that allows eight channels per wave at 200 kHz. In view of the possibility for railways to obtain permission for the use of waves (frequencies) in Vietnam, TETRA is thought to be appropriate for the railway (a plan exists to use frequencies for urban railways in Vietnam). See Figure 5.3.45 for an example of the composition train radio system.



Source: JICA Study Team

Figure 5.3.45 Composition of the Train Radio System



Source: The JICA Study Team

Figure 5.3.46 An Example of the Installation of LCX (tunnel sections)

(d) Centralized Monitoring System

5.382 To provide dispatchers with the information on the status of signal and telecommunication equipment and transmit correct information to maintenance depots, centralized monitoring system for equipment status monitoring will be installed. See Table 5.3.35 for the object equipment of this monitoring control system. The interface between the object equipment and the system will be LAN, serial or a contact method.

Table 5.3.35 Objects of the Centralized Monitoring System

Equipment	Components
Signal equipment	Interlocking-cum-ATC system
	Track circuits
	Electric point machine
	Station PRC system
	Automatic train detection system
	Power source units
	Others
Telecommunication equipment	Optical carrier system
	Telephone exchanges system
	Wayside information monitoring system
	Master clock
	Radio transmission system
	Power source equipment for wayside telephone
	Status of the machine room
	Cable gas pressure monitors
	CMS for mechanical equipment
	Others

Source: JICA Study Team

(e) Dispatching Telephone System

5.383 Whereas circuit frequency selection type dispatching telephones were used in quantities in the past, Vietnam shall adopt the dispatching telephones to utilize the TCP/IP technology, together with centralized dispatching telephones to concentrate the circuits for dispatching and telephone services into one telephone set.

(f) Automatic Telephone Exchanges

5.384 IP-PBX type automatic telephone exchanges will be adopted.

(g) Wayside Equipment

5.385 A wayside telephone system will be introduced for train operation dispatching and as the circuits for the maintenance of tracks, power supply, signaling and telecommunication equipment, with wayside telephone sets placed at 500 m intervals on the side of maintenance passage in open sections and in the machines/materials shafts in tunnel sections.

5.386 To control the safety of the high-speed railway in Vietnam, the information on the measurement by anemometers and pluviometers will be collected by the wayside information monitoring system and sent to dispatchers. The status of signal and telecommunication equipment at each station will be collected by the centralized monitoring system (CMS), while the information on the status of the equipment at substations and in the sections between stations is collected by the wayside information monitoring system as the volume of the information is comparatively small.

(h) Terminal Equipment

5.387 The terminal equipment to be installed are dispatching facsimiles, passenger guidance equipment, terminals of train operation control system, terminals for maintenance work control and station equipment (broad casting equipment, ITVs, fire alarms and electric clocks) .

(i) Power Source Equipment

5.388 The telecommunication machine rooms normally use the commercial power source, are equipped with spare generators for emergency use and receive duplicated three-phase 220V and single-phase 220V power supplies. Rectifiers, DC-AC inverters and storage batteries will also be installed.

11) Electricity

5.389 The study team proposes a draft plan on the most reliable system to have incorporated advanced technologies that are rapidly progressing in recent years out of the proven and highly reliable technologies adopted for the Shinkansen in Japan and other high-speed railways in the world as a whole, while taking into consideration the maintenance requirements after the inauguration of the high-speed railway in Vietnam.

(1) Electric Power Receiving System

5.390 The study team proposes a T-branch system to separate two transmission lines from the extra-high voltage transmission network of Vietnam Electricity (EVN), a state-owned electric power company, (branching the lines 1 and 2 from a point on the transmission network in a T-shaped configuration) and draw them separately into substations through two sets of transformers, with one used for normal services and the other as a standby unit, without using them in parallel, with the former automatically switched to the latter, in case it has failed.

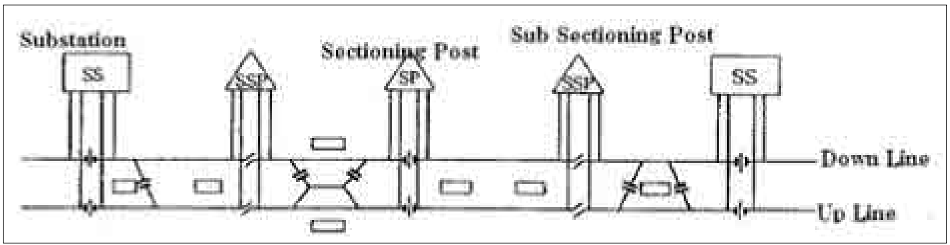
5.391 The position of T-branch and the receiving voltage are subject to the negotiation with EVN. It is desirable, however, to draw power from the 220 kV transmission network into substations as a high-speed railway requires a large quantity of power.

5.392 The study team proposes to install a substation separately for rolling stock depots. Since rolling stock depots don’t consume much power, power shall be received from the EVN’s 110 kV transmission network through two lines (normal service and spare lines) from a T-branch.

(2) Feeding Circuit System

5.393 In AC- electrified sections, a “sectioning post” is installed at the center between two adjacent substations to join the power sent from these substations (power sources) and a “sub-sectioning post” between substations and the adjacent sectioning post to limit the feeding distance where power supply has been interrupter at accidents or for maintenance purposes. More concretely, the purpose of sub-sectioning posts is to minimize the length of the section where power supply is interrupted by isolating the section electrically in case the trolley wire has failed, for example.

5.394 In contrast to the sectioning posts that are indispensable to joint different power sources, sub-sectioning posts are not necessarily required for high-speed railways. Nevertheless, the study team proposes their installation in consideration of accidents and maintenance work. See Figure 5.3.47 for a conceptual drawing of the arrangement of sectioning and sub-sectioning posts.



Source: Japan Railway Electrical Engineering Association, Introduction to electric railway (Substation)

Figure 5.3.47 Configuration of AC Feeding Circuit

(3) Feeding System

5.395 The study team proposes the AT feeding system that uses auto transformers (ATs), which is now a world standard for AC electric railways.

5.396 Whereas the direct feeding system and the BT feeding system do not suit high-speed operation, as the former has the problem of transmission interference and the latter that of arc generation when trains pass jointing sections, the AT feeding system features the following merits.

(i) Longer spaces are allowed between substations.

(ii) The effect of inductive interference on transmission lines can significantly be eliminated.

(iii) The supply voltage (feeding voltage) from substations can be twice as high as the voltage applied to contact wires.

(iv) It suits large-capacity loads

(4) System to use Change-Over Sections

5.397 To supply power to trolley wires from a substation, two sets of single-phase power sources, 90 degrees different in phase (phases A and B), are output at a point directly downstream of the substation from the secondary side of the transformer for the up- and down-tracks on the left side and on the right side of the substation. These two single-phase power sources are jointed at the point, while two different power sources from adjacent substations are at sectioning posts.

5.398 Change-over sections shall be installed to prevent short circuits between two power sources in different phases when a train passes. To enable high-speed trains to pass the jointing point while powering, the study team proposes to adopt the system to use automatic change-over sections. A demerit of this system is that it entails high construction costs or about 100 million yen at each place.

5.399 The system to use dead sections requires for trains to pass the neutral section between two sections in the notch-off state to drop speed momentarily.

5.400 Under the system to use automatic change-over sections, an air section is placed at each end of the about 1,000 m-long neutral section. When a train enters the train detecting circuit in the neural section or when it has passed the detection track circuit installed on the exit side, the power sources are switched with a change-over switch. The un-energized time is about 300 ± 50 mms.

5.401 To constitute a duplicated system two change-over switches are prepared, one for normal use and the other as a spare unit.

(5) Contact Wire System

(a) Voltage of Contact Wire

5.402 See Table 5.3.36 for the voltage of the proposed contact wire system.

Table 5.3.36 Voltage of the Overhead Contact Wire

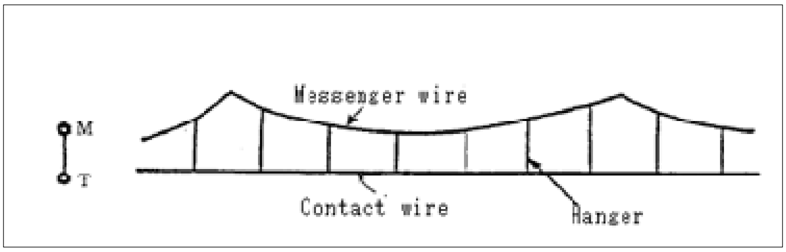
Category	Voltage
Highest voltage	30 KV
Standard voltage	25 KV
Lowest voltage	22.5 KV
Instantaneous minimum voltage	20 KV

Source: Records of the construction work of electric equipment / facilities,

(b) Structure of Catenary System

5.403 The study team proposes the simple catenary system as the most advantageous contact line system from the viewpoint of high-speed performance, construction costs and maintainability.

5.404 The study team doesn't recommend the modified stitched simple catenary system adopted by Germany and China, as it entails high construction costs and requires manpower to adjust the Y-line portion. See Figure 5.3.48 for a conceptual drawing of the system.



Source: Japan Railway Electrical Engineering Association, Introduction to electric railway (Catenary system)

Figure 5.3.48 Simple Catenary System

(6) Substation

5.405 All substations and related facilities shall be installed outdoors.

(i) Substations for feeding power shall be installed at 50 km- intervals as a standard.

(ii) Sectioning posts (each having a site area of 6,000 m^2) shall be positioned at the center between two adjacent substations as a standard.

(iii) To limit the sections under power shutdown at accidents and for maintenance work, a sub-sectioning post (each having a site area of 1,500 m^2) shall be placed at the center between adjacent substation and sectioning post as a standard.

(iv) Air sections shall be placed directly downstream of substations, sectioning posts and sub-sectioning posts as a standard.

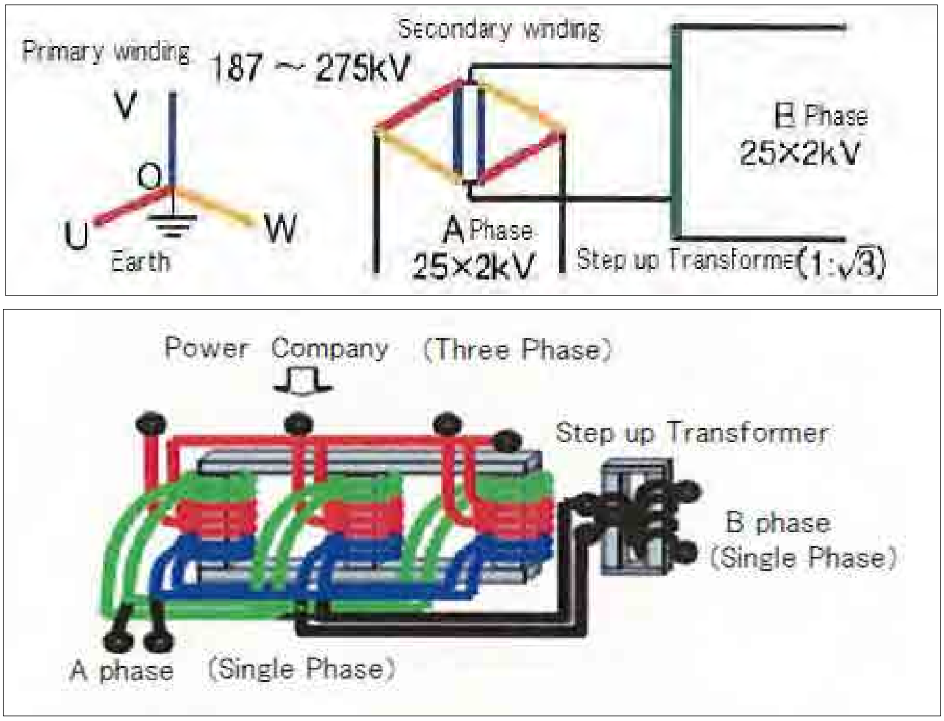
(v) To supply power to rolling stock depots, substations (each having a site area of about 7,500 m^2) shall be placed other than those for feeding. Each rolling stock depot shall have a substation for this purpose.

(7) Transformer for Feeding

5.406 The study team proposes the adoption of the most advanced roof-delta connected transformers for high-speed railways, which feature smaller sizes (eliminating set-up transformers), lightweights, smaller power losses and lower construction costs when compared with the modified wood-bridge connected transformers that were used for high-speed railways in the past.

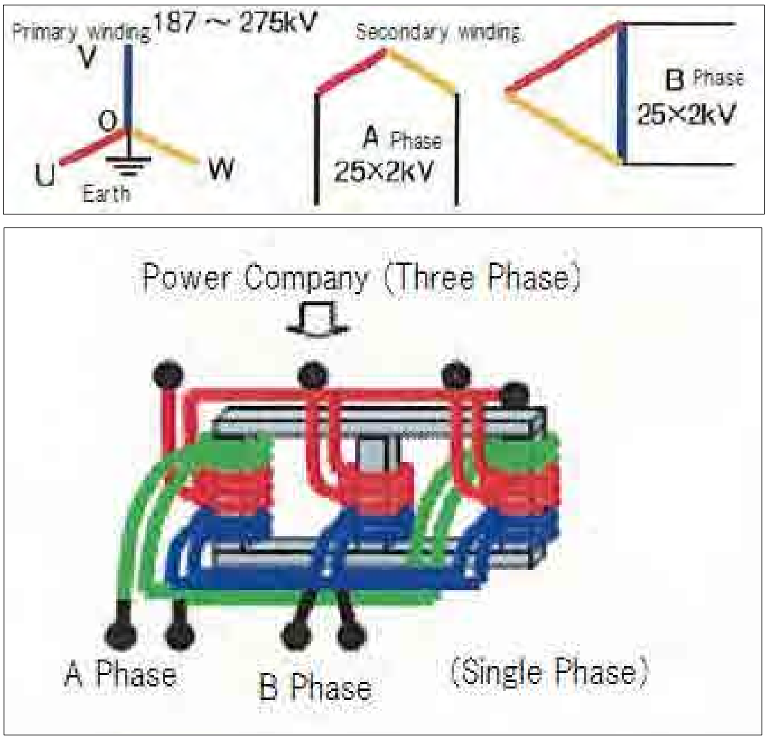
5.407 The standard capacity of the transformers for feeding shall be 50MVA.

5.408 See Figure 5.3.49 and Figure 5.3.50 for the conceptual drawings of modified wood-bridge connected and roof-delta connected transformers, respectively.



Source: RRR 2011.3, Power supply technology for high speed railway

Figure 5.3.49 Modified Wood-Bridge Connected Transformer



Source: RRR 2011.3, Power supply technology for high speed railway

Figure 5.3.50 Roof-Delta Connected Transformer

5.409 Table 5.3.37 shall be complied with in regard to the voltage unbalance ratio and voltage fluctuation.

Table 5.3.37 Unbalance Ratio and Fluctuation of Voltage

Voltage unbalance ratio	3% or less (averaged over 2 hours)
	5% instantaneous
Voltage fluctuation	3% or less (averaged over 2 hours)
	5% instantaneous

Source: Records of the construction work of electric equipment/facilities, Tohoku Shinkansen (Hachinohe-Shin-Aomori)

(8) Auto Transformer

5.410 Auto transformers shall be installed at substations, sectioning posts, sub-sectioning posts and auto-transformer posts (ATPs) as a standard.

5.411 The standard capacity of an auto transformer shall be 7.5 KVA.

(9) Transformer for Rolling Stock Depots

5.412 It is difficult to switch power sources between phases A and B inside rolling stock depots where trolley wires and other wirings are concentrated and complicated unlike on main lines. It is convenient, therefore, to deal with a rolling stock depot as an electrical load as a whole. For this reason, the power received in three phases at the substation installed for a rolling stock depot is converted into a set of single-phase power source. Scalene Scott connected transformers to have improved the inter-phase unbalance on the three phase side are normally used to supply single-phase power to such places as rolling stock depots.

5.413 Two transformers shall be used, with one for normal services and the other as a standby unit.

(10) Protective Devices at Substations and Related Facilities

5.414 Substations and related facilities shall be equipped with protective units in accordance with laws and technical standards.

(11) Monitoring and Control Systems

5.415 The operation control center (OCC) at the center monitors and controls the operation of the equipment and apparatus at substations, sectioning posts, sub-sectioning posts and power distributing stations through the power supervisory control and data acquisition (SCADA) system.

5.416 The power SCADA system is normally installed on the same floor as that of OCC for the above-mentioned purposes.

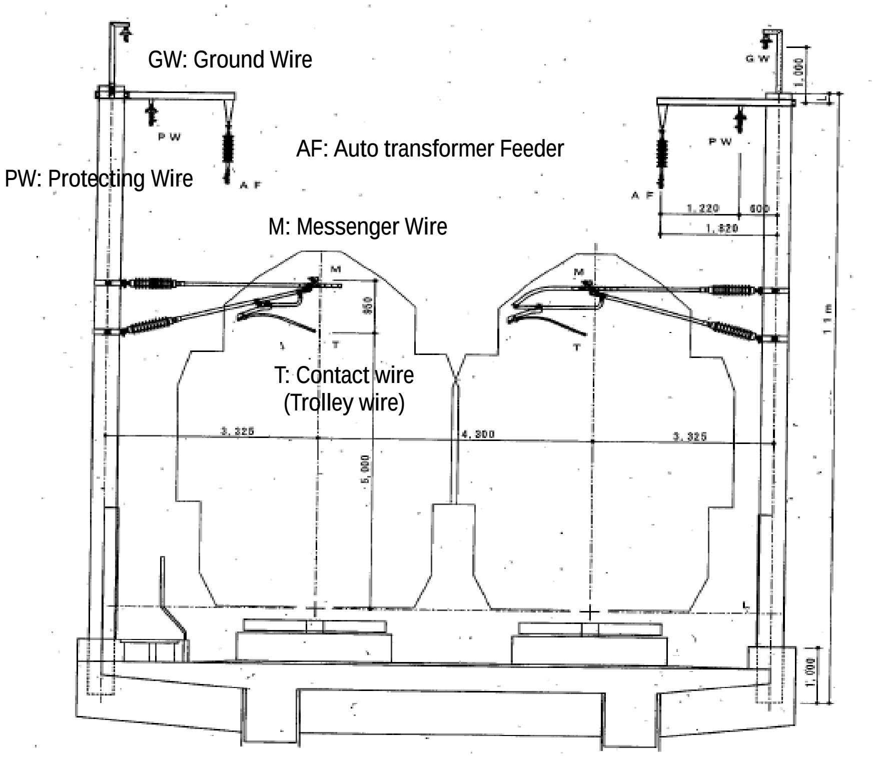
(12) Contact Wire System

(a) Messenger Wire And Contact Wire

5.417 The study team proposes to adopt the simple catenary trolley wire system for high-speed railways. The material used for contact wires is called the precipitation hardened copper alloy (PHC), which is superior to the copper steel (CS) used in the past for high-speed railways in terms of strength, conductivity and abrasion resistance anti-wear agent. As the PHC contact wires are made of a single alloy, it features environment-friendliness to allow a 100% recycle.

5.418 The standard height of simple catenary trolley wires is 9.950 mm both in open and tunnel sections.

5.419 See Figure 5.3.51 for the construction of the simple catenary contact wire feeding system.



Source: Records of the construction work of electric equipment/facilities, Tohoku Shinkansen (Hachinohe-Shin-Aomori)

Figure 5.3.51 Configuration of Catenary System

Table 5.3.38 Kind and Standard Tension of Messenger Wire and Contact Wire

Category	Wire type/sectional area (mm^2)	Standard tension (KN)
Messenger wire	Hard drawn copper stranded wire PH 150	19.6 KN
Contact wire	PHC (Precipitation Hardening Copper) 110	19.6 KN

Source: Records of the construction work of electric equipment/facilities, Tohoku Shinkansen (Hachinohe-Shin-Aomori)

(b) Feeder

5.420 Feeders are used to supply power from substations to contact wires 。 See Table 5.3.39 for the wire type and standard tension of feeders.

Table 5.3.39 Kind and Standard Tension of Feeder

Wire Type	Standard Tension (KN)
Hard drawn stranded wire HAL 300 mm^2	3.92 KN

Source: Records of the construction work of electric equipment/facilities, Tohoku Shinkansen (Hachinohe-Shin-Aomori)

(c) Support of Contact Wires

5.421 The span between the supports of overhead contact wires shall be as per Table 5.3.40 The standard difference in length between adjacent spans shall be 10 m or less, or 15 m or less when the length of 10 m or over is not applicable.

Table 5.3.40 Standard Spans

Section	Standard span
Open section	50 m
Tunnel section	45 m

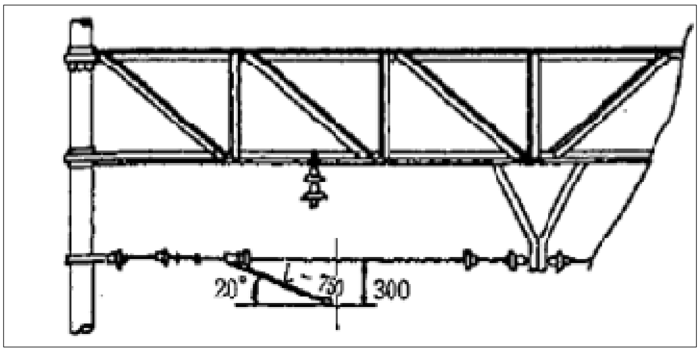
Source: Records of the construction work of electric equipment/facilities, Tohoku Shinkansen (Hachinohe-Shin-Aomori)

(d) Pole

5.422 The study team proposes the adoption of lightweight steel pipe poles applied with rust preventive melting galvanization (HDZ55) planted in concrete foundations as standard or bolt-shaped foundations on bridges or other structures to which a concrete foundation is not applicable.

(e) Beam

5.423 Fixed beams shall be used as a standard in rolling stock depots and station yards where contact wires are laid in quantities. See Figure 5.3.52 for a fixed beam.

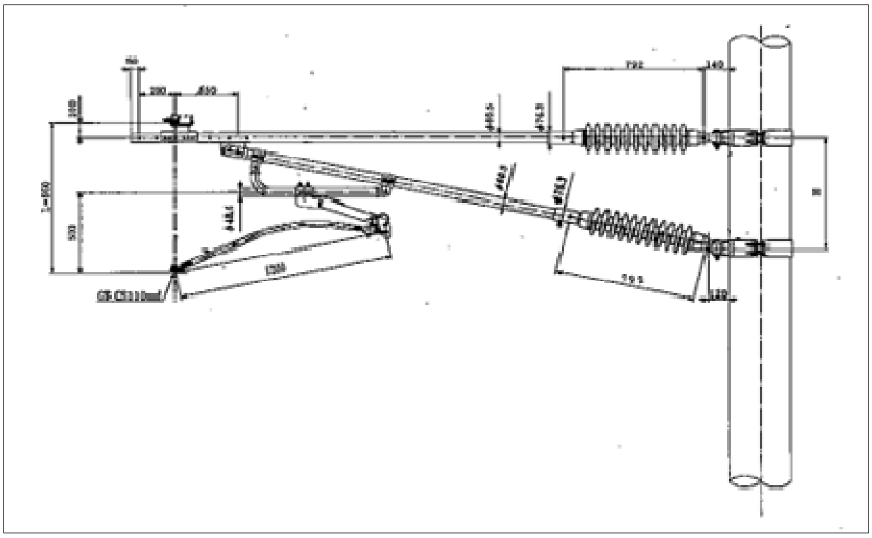


Source: Japan Railway Electrical Engineering Association, Introduction to electric railway (Catenary system)

Figure 5.3.52 Fixed Beam

(f) Free bracket

5.424 Free brackets shall be used to support contact wires as a standard. See Figure 5.3.53 for the composition of free bracket.

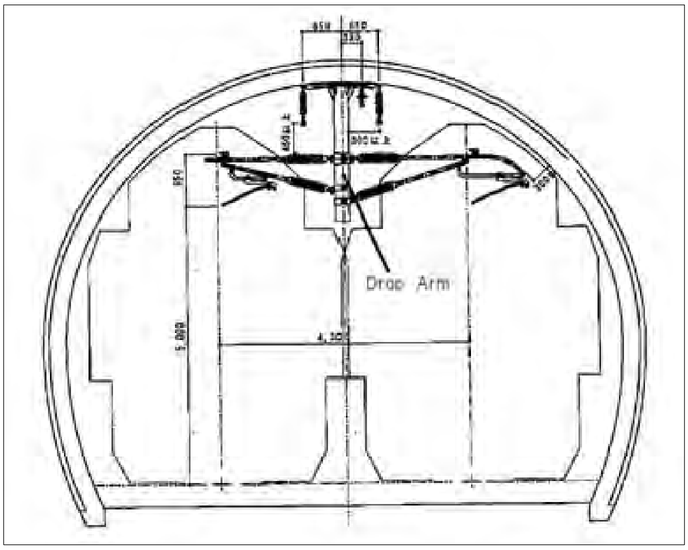


Source: Records of the construction work of electric equipment/facilities, Tohoku Shinkansen (Hachinohe-Shin-Aomori)

Figure 5.3.53 Free Bracket

(g) Drop Arm

5.425 Steel pipe drop arms shall be used to support contact wires in tunnels as a standard.



Source: Records of the construction work of electric equipment/facilities, Tohoku Shinkansen (Hachinohe-Shin-Aomori)

Figure 5.3.54 Drop Arm

(13) Components of the Contact Wire System to be Constructed Integrated with Civil Engineering Structures

5.426 The components of the contact wire system to be constructed integrated with civil engineering structures are the foundations of poles, beams and other supports, those in tunnels, earthing structures, track-crossing pipes and supports of cables/wires.

(14) Lighting and Power Distribution System

5.427 Lighting and power distribution system shall be planned to supply power other than that required to drive trains.

5.428 Principal loads include lighting at stations and in tunnels, air conditioning, escalators, machines to sell tickets and for other purposes, water supply and draining pumps, power-driven machines and equipment in rolling stock depots signal/telecommunication equipment rooms and receptacles for maintenance work. The power for this purpose shall be received through a high-voltage power receiving circuit from the electric power company (EVN). In case power supply is interrupted, an emergency spare generator (gas turbine type) shall be installed as a standard.

(a) Power Distribution Room

5.429 Power distribution room shall be installed at stations, rolling stock depots and signal/telecommunication equipment rooms. The power distribution room at passenger handling stations suffices for supplying power to the loads in the station yards.

5.430 At their high-voltage power distribution boards, the power distribution stations receive power from the electric power company through a high-voltage circuit (7 KV or less) or an extra-high voltage circuit (7 KV or over) in case a high-voltage circuit is not available, convert the voltage to the level required for loads and supply to station yards and other equipment/facilities.

5.431 In case power supply is interrupted by the electric power company, an emergency standby generator (gas turbine generator) shall be prepared, with a fuel tank having a standard capacity to store fuel to generate power for 10 hours..

5.432 As a power source under the power distribution room, each of the basic load points shall be equipped with an indoor electricity room to which power shall be supplied through two circuits (regular use and as a spare).

5.433 The power distributing room shall be installed with a remote monitor and control board for to remotely monitor and control the station through the power control - SCADA system.

(b) Power Distribution Line

5.434 A circuit of high-voltage power distribution lines for three-phase 7 KV (or cables for 7 KV or over in case 7 KV cables are not available) shall be laid along the track to supply power to the equipment/facilities between stations.

5.435 Power branched from the above circuit is supplied to rolling stock depots and signal/telecommunication equipment cubicles located along the track at about 30 km intervals between stations.

5.436 High-voltage transformer cubicles shall be installed at about 1 km intervals along the track to supply power to the receptacles for maintenance work and wayside information units (pluviometers, etc.).

5.437 Power cables for power distribution lines shall be laid in the cable duct constructed for civil engineering purposes in open sections and on the side walls in tunnel sections.

12) Maintenance and Depot

(1) Rolling Stock Maintenance

(a) Maintenance Level and Interval

5.438 Interval of maintenance is highly relied on design or rolling stock. Since recommended rolling stock is same as Japanese High Speed railway, maintenance level and interval is also recommended to be the same as Japanese High-speed train because Japanese High-Speed trains are operated successfully for 48 years.

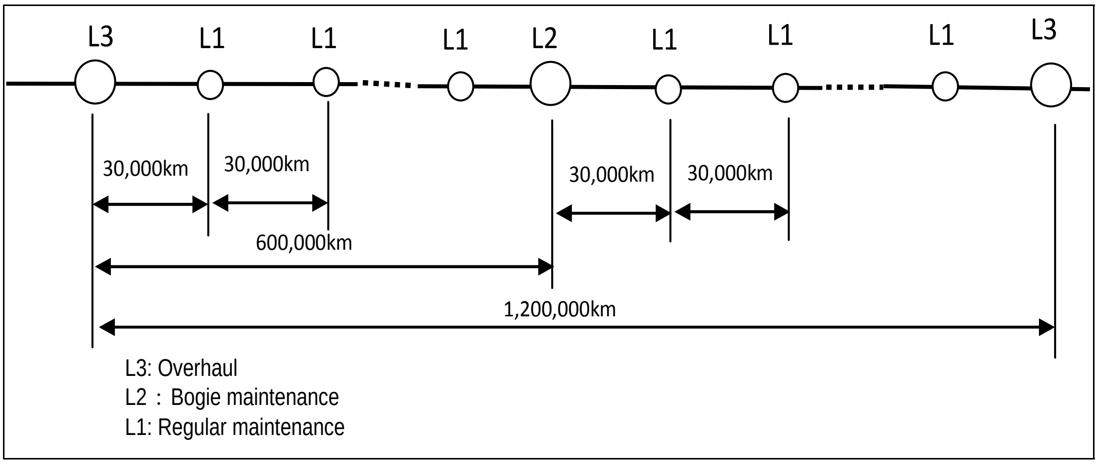
5.439 Recommended Inspection level and interval are classified as follows.

Table 5.3.41 Level and Interval of Rolling Stock Inspection

Type	Interval	
Daily inspection	daily	Replacing expendable parts Checking the function for running, braking, doors, electric parts.
Regular inspection	30 days or 30,000km	Checking the condition and function of pantograph, electric circuit, bogie, running gear, brake equipments, body, gauge, interior and other devices. Isolation test of electric circuit
Bogie inspection	One and half year or 600,000km	Detaching of bogies and braking down to wheel, traction motor, suspension devices, bogie frame, gear box, and brake equipments to inspection and restoration
Overhaul	3 years or 1,200,000km	Disassemble all the major parts to inspect and restoration.

Source: JICA Study Team

5.440 Higher level inspection includes lower level of inspection. Figure 5.3.55 shows the interval of inspection.



Source: JICA Study Team

Figure 5.3.55 Interval of Inspection

(b) Spare Parts Rotation

5.441 In the heavy maintenance major parts are dismounted and mounted after inspection and repair work. Duration for inspection and repair work of the parts are varied depending on the parts. When inspection and repair work of one part takes time, rolling stocks has to be suspended to wait for the completion of the part being repaired. When the parts are replaced with spare parts, it is not necessary to wait for the completion of the repair work, which increases the availability of the rolling stocks. Replaced parts after inspected and repaired will be stored as spare parts to be installed in the next rolling stock. Parts that require long time for inspection and repair shall be identified and shall be designated as spare parts for rotation.

5.442 Bogie is recommended for rotation and bogie inspection is to replace with spare bogie and it will take a day or two to complete the inspection.

(c) Depot Facilities

5.443 Daily Inspection and Regular Inspection will be conducted in depot and Bogie Inspection and Overhaul will be conducted in workshop.

5.444 Function of depot is to stable the trains in the night time. Trains are operated in day time but in the night time track should be clear for maintenance of way and wayside facilities. Trains should be stabled somewhere, and to minimize the running time from terminal to depot, it is preferable that depot is located near the terminal.

5.445 Following facilities are required for depot:

(i) Stabling tracks: equipped with steps for the drivers to enter the drivers' cab.

(ii) Inspection track: with inspection shed and pit for inspection of the bogie and under frame equipments and platform for inspection of roof top equipments.

(iii) Cut out switch of power line will be installed so that worker can go up the roof for inspection.

(iv) Train washing plant: to wash the outside of the train automatically while train passes the track

(v) Wheel turning machine: under floor lathing machine to shape the wheel tread without disassembling the bogie

(vi) Water supply system: for supplying the water for the train

(vii) Sanitary sewage disposal plant: for disposing the sanitary sewage from the train.

(d) Workshop

5.446 Bogie inspection and over haul will be conducted in the Workshop also ATC inspection and occasional repair works will be conducted in the workshop.

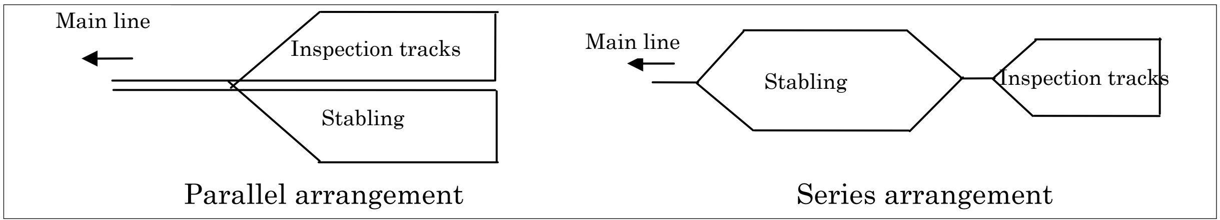
(i) **Location of Workshop:** Spare parts will be replaced in daily inspection and regular inspection. Therefore. the Workshop will be located at the same complex of the depot.

(ii) **Tracks for Workshop:** Workshop should have following tracks, (a) Testing Track: for function testing after heavy maintenance and repair works; and (b)Assembling and Disassembling Track: for dismantling/mantling the bogie and roof top equipments from body. Tracks shall be equipped with lifting jacks and overhead crane.

(iii) **Equipments for Workshop:** The following equipment are required for the workshop to conduct heavy maintenance; (a) Traverser table for transferring the vehicle from a track to other parallel tracks. It will be installed between assembling/disassembling track and body shop, (b) Lifting jack to lift up the body for dismantling the bogie from body, (c) Overhead crane to lift up the equipments from vehicle or carry the heavy equipments and set on the test bench, (d) Testing equipments for function and performance testing of several types of equipments such as traction control equipments, brake control equipments, air conditioning units, etc, (e) Wheel press machine to assemble and disassemble the wheels to axle, (f) Wheel lath to re-profile the wheel tread, (g) Ultra sonic flaw detector for detecting the flaw on the axle by ultra sonic, and (h) Washing plant for washing the equipments such as bogie, motors, etc.

(e) Track Layout of Depot

5.447 Main facilities of the depot are stabling tracks and inspection tracks. There are two way of arrangement for depot track layout one is parallel arrangement and the other is series arrangement.



Source: JICA Study Team

Figure 5.3.56 Track Arrangement of Depot

5.448 Normally after the inspection train will wait at the stabling track until its scheduled departure time. In parallel arrangement train has to switch back when going to stabling track from inspection track. Series arrangement is ideal for efficient train operation. Series arrangement will be applied when there is enough length of the land for depot.

(f) Criteria of Construction of Tracks of Depot

5.449 Following criteria will be applied for track layout of the depot:

(i) Minimum curve radius: depot and access track 200m

(ii) Switch type: 9#

(iii) Scissors crossing: 12#

(iv) Maximum gradient of access track: 25‰

(v) Minimum length of stabling track: 400 m + 80 m (for 16 car train)

(vi) Length of inspection track: 250 m (for 10 car train)

(2) Line Maintenance

(a) Working Window

5.450 Maintenance works of the line shall be done at night time while trains are not operated. Service time is planned from 6:00 to 24:00; therefore 0:00 to 6:00 will be the working window for line maintenance. Tracks shall be isolated from service trains for the safety of maintenance personnel.

(b) Maintenance Base

5.451 Speed of maintenance vehicle is about 50km/h. As window time for maintenance is 6 hours in maximum, transferring time from base to the site should be minimized. Distance from adjacent maintenance base should be 50km to 80km for efficient land use.

5.452 The following tracks and facilities shall be provided in maintenance base.

(i) Stabling tracks for maintenance vehicle

(ii) Inspection tracks and inspection shed

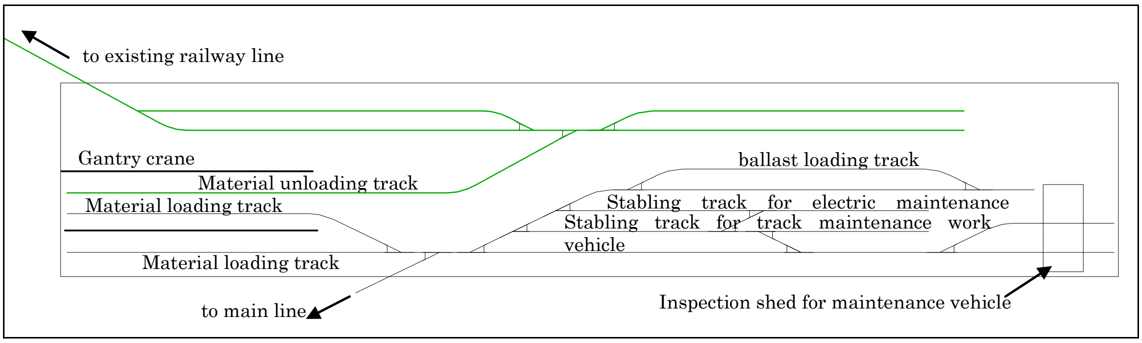
(iii) Material loading track: for loading the materials such as rail, sleeper, etc. gantry crane will be installed along the track.

(iv) Ballast lading track: for loading ballast to the wagon. Hopper with belt conveyer will be installed on the track.

(v) It is preferable to have access track with existing railway so that materials can be transported by existing freight train. If access of existing railway is not available materials are brought by road transportation.

(vi) At least one maintenance base should have connection with existing railway.

(vii) Typical track layout of maintenance base is indicated in Figure 5.3.57.



Source: JICA Study Team

Figure 5.3.57 Typical Track Layout of Maintenance Base

(c) Confirmation Work

5.453 In Japanese High Speed Rail confirmation Car is operated after maintenance work to confirm that line is clear and there are no obstacles on the track but in other countries "Sweep Train" is operated for confirmation work. First train of the day is assigned as sweep train and operated with maximum speed of 170 km/h to 200 km/h.

5.454 Confirmation car is operated in the window time of maintenance. Maintenance time has to be shortened to keep the time for operating confirmation car but confirmation works will be much assured by the devices equipped in confirmation car such as lighting device and CCTV.

5.455 When sweep train is operated traveling time of first train of the day is longer than ordinary trains.

5.456 To keep the service level of High Speed Railway and to secure the safety, it is recommended to provide confirmation car.

(d) Maintenance Vehicle

5.457 Following vehicles are recommended for maintenance work

(i) Motor car: for towing Tram

(ii) Confirmation car : for confirming after maintenance work

(iii) Locomotive : for towing Hopper wagon

(iv) Hopper wagon : for transporting new ballast to the site

(v) Tram : for caring materials

(vi) Tamping machine : for tamping the ballast

(vii) Lining machine : for fixing the alignment of the track

(viii) Ballast regulator : for regulating the ballast after tamping

(ix) Bolt Power Wrench: for tying and untying the bolt of the rail

(x) Catenary installation vehicle : for installing the overhead line

(xi) Catenary inspection vehicle : for inspection and repairing overhead line

(xii) Rail grinder :for grinding rail top

(xiii) Locomotive : for towing hopper wagon

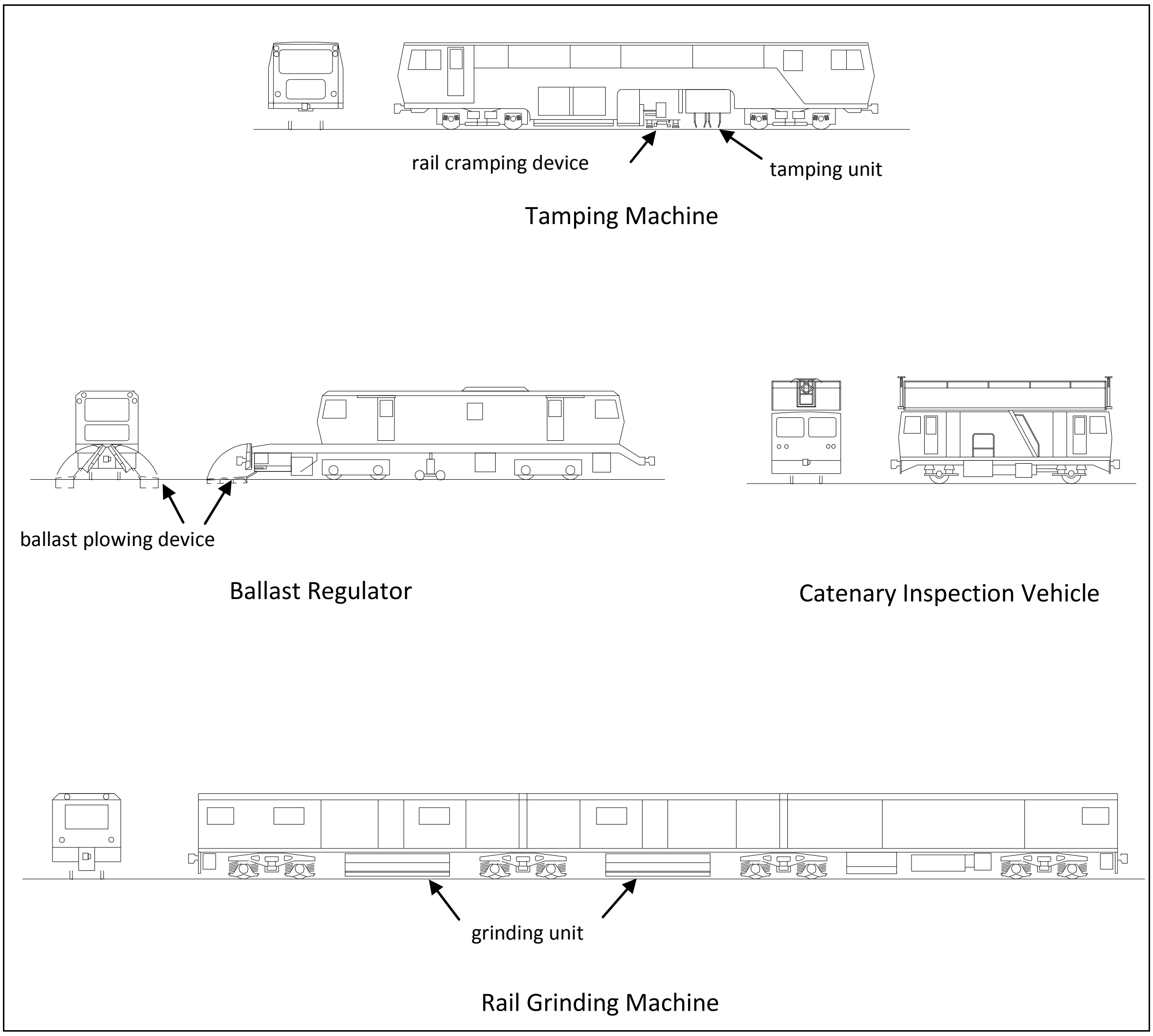
5.458 Figure 5. 3.58 gives the images of maintenance vehicles.

5.459 As these vehicles are operated without signaling system following devices are recommended to be installed in maintenance vehicles to prevent accidents:

(i) Proximity warning device: it will provide alarm when the vehicle become close to other vehicle to prevent collision.

(ii) Automatic Stopper at Turnout: to prevent the vehicle to enter the turnout from inappropriate direction.

(iii) Preventive device of uncontrolled moving: To prevent the moving without driver and applying emergency brake when driver is faint or sleeping.



Source: JICA Study Team

Figure 5.3.58 Images of Maintenance Vehicles

6 IMPLEMENTATION DIRECTIONS AND KEY AREAS FOR CONSIDERATIONS

6.1 Proposed Overall Roadmap for HSR Development

1) Main Factors Considered in Formulating Road Map

6.1 Based on the analysis made in previous chapters and sections, the basic development directions for the north–south railway are explained in summary as follows;

(i) **Demand along the north-south corridor:** Until 2030, basic passenger and freight transport demand along the north-south corridor can be met without the HSR by a combination of current plans including the expansion of national roads to 4-6 lanes, construction of 4- to 6-lane expressways, expansion of air transport by three times its existing capacity, and improvement of the existing railway to A2 level and B1 level for areas of high demand. However, this scenario is unable to satisfy future demand which require quality services, especially faster speed services. Demand for travel at higher speeds along the north-south corridor in the future is significant. Without the HSR, excessive demand for air transport will be generated, which is practically impossible to meet through the expansion of airports and related services. Based on a demand analysis made on the assumption that the HSR is in operation in 2030, it can attract a significant volume of passengers and relieve burden on air transport at lower fares (half of air fare) as well as road transport. Although the improvement of the existing railway can expand transport capacity and improve operating speeds, it cannot sufficiently meet the requirement for higher speeds the HSR can provide.

(ii) **Economic and Financial viability of HSR:** Although the demand for HSR is significant, economic viability is low because of heavy initial investment cost. It is estimated that the timing when EIRR exceeds 12% is around 2040. Priority sections can be economically justified around 2030. However the financial viability is very low. The fare revenue alone can never pay back the investment costs but at most operating expenses. It is also necessary to consider financial support of the Government necessary for HSR development for long time in the future.

(iii) **Integrated and coordinated Development of Existing Railway and HSR:** Assuming that the HSR starts operating between 2030 and 2040, the development direction of the existing railway can be as follows:

- Improvement to A2 level can be implemented at the earliest possible time;
- Improvement to B1 level must be limited to selected sections and should require a more detailed study in conjunction with the development of the HSR; and
- Improvement to B2 level cannot be justified.

The development of the HSR for the entire section between the north and south would be justifiable by 2040. As the investment costs of the HSR is so large, the development must be done in stages starting from priority sections.

(iv) **Need for sufficient lead time for preparatory work:** As the development of the HSR requires considerable amount of time and effort, it is important to have a good preparatory work and pre-investment activities at the early stage for formulating technical standards, developing human resources, and establishing institutions for operation besides construction work.

2) Roadmap for HSR Development

6.2 Although it has been recognized that full HSR operation is a long-term undertaking, it is necessary to formulate a practical roadmap for a step-wise implementation of this large-scale project to ensure effective development and efficient operation when completed. While a detailed plan will be formulated in the next step of project development, a preliminary plan is presented in this study (see Figure 6.1.1). The main points to note are as follows:

(i) Initial section will be completed by 2021. After it is used for test operation and training, it is opened for commercial operation.

(ii) Preparatory work, especially including human resource development and preparation of regulations, is so critical in this stage that an initial section is proposed to be developed[1]. Initial section will be completed by 2021. After it is used for test operation and training, it is opened for commercial operation.

(iii) South priority section (HCMC-Nha Trang) will be constructed ahead of north priority section and opened for commercial operation around 2030. The north priority section (Hanoi-Vinh) will be constructed around 2035.

(iv) Of the remaining sections, Danang-Hue section will be constructed by 2040, while Vinh-Hue and Danang-Nha Trang sections will be constructed during 2040s.

6.3 Based on the road map, impact of investment cost of HSR on the potential budget envelop for transport sector is analysed based on the assumption of the percentage to GDP. The result is that the investment cost of HSR to budget envelop of transport sector shares about 2.5 to 14.9% for each period of years of 2015-2020 and 2021-2025, respectively. (see Figure 6.1.1) This indicates that future transport sector budget will be able to accommodate the investment to HSR without crowding out other priority projects.

[1] Initial operation section is explained in detail in 6.2 of this chapter.

		12-15	16-20	21-25	26-30	31-35	36-40	41-50
Improvement of Existing Railway	A1 level							
	A2 level							
	B1 level (partial)							
Preparatory work	Updated Pre F/S, Approval by National Assembly	★						
	EIA, Basic Design for Priority Sections							
	Organization and Institutional Development							
Initial Section	Detailed Design							
	Land Acquisition / Construction		Construction					
	Human Resource Development							
	Test / Training and Initial commercial Operation			Test Operation	Commercial Operation			
North Priority Section	Detailed Design							
	Land Acquisition / Construction				Construction			
	Commercial Operation							
South Priority Section	Detailed Design							
	Land Acquisition / Construction			Construction				
	Commercial Operation							
Other Sections	Vinh - Hue							
	Hue - Danang					D/D	Construction	Operation
	Danang - Nha Trang							
Estimated Project Cost of (US$ mill)	HSR	-	943	3,717	10,226	5,284	2,482	30,897
Budget Envelop for Transport Sector (US$ mill)	3% of GDP	-	28,287	38,362	51,337	67,697	88,478	259,371
	4% of GDP	-	37,716	51,149	68,450	90,263	117,970	345,828
	5% of GDP	-	47,145	63,937	85,562	112,829	147,463	432,286
% of HSR Cost to Transport Sector Budget Envelop (4% of GDP case above)		-	2.5	7.3	14.9	5.9	2.1	8.9

Source: JICA Study Team.

1) Average construction cost for priority sections calculated by the JICA Study Team was used: 31.0 US$ million/ km (average of north and south priority sections). In 2011 price. 1 USD=21,000 VND. GRDP was estimated based on revision made after the Communist Party National Congress XI (August 2008) to the latest "National Socio-Economic Development Plan, 2010-2015", i.e. '10-'20: 6.5%, '20-'30: 6.0%, '30-'40: 5.5%, '40-'50: 5.0%.

Figure 6.1.1 Preliminary Roadmap for High-Speed Railway Development

6.2 HSR Initial Section

1) Rationale of Initial Sections (First Segment of HSR Priority Sections)

6.4 In order to develop HSR which is a significant and long-term national project in the most effective and appropriate manner, it is expected that an initial section (which refers to the first segment of HSR priority sections) is constructed and operated with following objectives:

- To provide an effective base for human resource development necessary for construction, operation and management of HSR based on actual system through the initial section.
- To commence actual high-speed operation at early stage not only for training but also commercial purpose for experiences of the people and promoting social consensus on the HSR.
- To provide inputs for preparation of necessary institutions such as regulations, technical norms/ standards and others related to effective development of HSR.

6.5 Conditions that must be met by the initial section include following;

(i) A section of which land can easily be acquired should be selected to guarantee an early start of construction work;

(ii) The requirements for straight sections, curves, tunnels, bridges, route profile, ground facilities, and other conditions should be satisfied to allow collection of data for high-speed operation;

(iii) A distance of at least 30km or more to enable running at the maximum speed and acceleration/deceleration should be guaranteed to test the conditions of rolling stock, tracks[2], contact wires, and electric facilities (the first- and second-phase sections can be separated where necessary);

(iv) Adjacent areas should be acquired to serve as workshop and for inspection/repair facilities to fabricate carried-in cars, implement running tests, and maintain facilities;

(v) Staff accommodation for long periods is necessary for various tests and training;

(vi) For deepening the understanding of the people through promotions, initial sections are expected to be located near a big city.

(vii) It would be appropriate for initial sections to become a part of the revenue service line once commercial operations commence.

(viii) The initial sections should be part of the North-South HSR line.

(ix) Project feasibility is high, such as high demand for commercial operation, easiness of land acquisition, etc.

(x) Possibilities to implement the projects are high. For example, the projects are incorporated to approved urban plans, land is available, coordination with other projects is ensured, etc.

6.6 In Japan, initial sections as test tracks had been utilized for around two years before the operation. However, since HSR technologies are far different from ones currently applied in Vietnam, it would take a longer period mainly for human resource development, preparation of maintenance manuals, and testing of the HSR system to allow appropriate introduction of the HSR to Vietnam (see Box 6.1).

[2] The selection of ballast and slab tracks shall be decided after the operation of initial sections.

Box 6.2.1 Test Tracks Constructed/ Used in Japan and Taiwan

Name	Reasons of location and the after-test status	Test contents and the after-test status	Miscellaneous
Tokaido Shinkansen (Kamonomiya Model Track) Length≒40km Period: 2 years (04/1962-04/1964)	• Lands had been acquired based on a plan to run bullet trains before the war, which facilitated the start of construction at an early stage. • Sufficient lengths of straight sections, curves, tunnels and bridges along with a proper route profile and ground facilities were available, which were appropriate for data collection. • The area was close to the Tokaido line so that test cars and materials could easily be carried into the test site. • The test site was also close to the Railway Technical Research Institute (RTRI) at Kunitachi to facilitate addressing problems promptly in case one has occurred. • The track is now appropriated for part of the revenue service line. • The space for the Kamonomiya base is now used as the site to store maintenance cars.	(i) Speed raising tests (ii) Track and STC -performance tests (iii) Noise and air tightness tests (iv) Current collecting performance tests (v) Training of train crew and maintenance staff (vi) Some prototype test cars are now remodeled and used as track/electric facilities inspection cars	Attracted a great number of news reporters and thousands of visitors/test riders.
Tohoku Shinkansen (Oyama test track) Length≒43km Period: 2 years (06/1978-06/1980)	• A length of about 40 km was required for the test runs of Shinkansen cars • Tests were implemented for a long period to discuss the maintenance conditions after the start of revenue service. • The Oyama area was appropriate in consideration of the progress of the construction of revenue service line then under way. • The test track is now used as part of the revenue service line.	(i) Speed raising tests (ii) Noise and vibration prevention tests (iii) Two-frequency combined ATC performance tests (iv) Current collecting system tests (v) Air conditioning and ventilation performance tests (vi) Driving system load tests (vii) Abnormal voltage measuring tests (viii) Short train-set track short-circuiting sensitivity tests	Used for ground facilities inspection and speed increasing tests with a newly input 921-1 type shinkansen track inspection car.
Taiwan Shinkansen Test Track Length≒60km Period: 2 years (01/2005-01/2007)	• The test track was constructed close to the Yanchao workshop where a base for maintenance facilities is also located (at a point of 40-minute drive from Kaohsiung) as a workshop and training facilities were thought to be necessary. • The required test track length was a sum of 25 km for acceleration, 20 km or over for running at the maximum speed, 6 to 7 km for deceleration and a margin to perform tests of rolling stock, tracks, contact wires and power supply facilities. • A hotel was necessary near the test track to accommodate a number of people who participated in long and diversified tests. • The test track is now used as part of the revenue service line.	(i) Speed raising tests (ii) Car carrying-in, fabrication and running tests (iii) Training of track and contact wire laying work at a tentative track installed within the rolling stock base.	The distance for acceleration is about 25 km (up to 315 km/h) and about 19 km (up to 300 km/h) with series 700 Taiwan Shinkansen cars. The distance for acceleration up to 300 km/h is about 15 km and that for deceleration from 300 km/h is about 5 km with series E5 “Hayabusa” cars.

Source: JICA Study Team.

2) Running Speed and Required Length of Initial Section

6.7 In order to achieve high-speed, it is necessary to construct sufficient length of initial section. For example, approximately 38km is necessary to operate a train to meet 320 km/h, while 51km is necessary to accommodate 350 km/h operation. (see Table 6.2.1)

Table 6.2.1 Length of Initial Section by Target Running Speed

Running speed	Section for acceleration		Section for constant speed operation		Section for deceleration/stop		Total length of section	
	Distance	Time	Distance	Time	Distance	Time	Distance	Time
160 km/h	2k500m	1'35''	10k000m	3'45''	2k500m	2'02''	15k000m	7'22''
200 km/h	4k100m	2'08''	10k000m	3'00''	3k800m	2'28''	17k900m	7'36''
300 km/h	14k300m	4'33''	10k000m	2'00''	8k500m	3'34''	32k800m	10'07''
320 km/h	18k600m	5'24''	10k000m	1'53''	9k650m	3'48''	38k250m	11'05''
350 km/h	28k900m	7'16''	10k000m	1'43''	11k700m	4'10''	50k600m	13'09''

Source: JICA Study Team.

3) Candidate Sections as Initial Sections

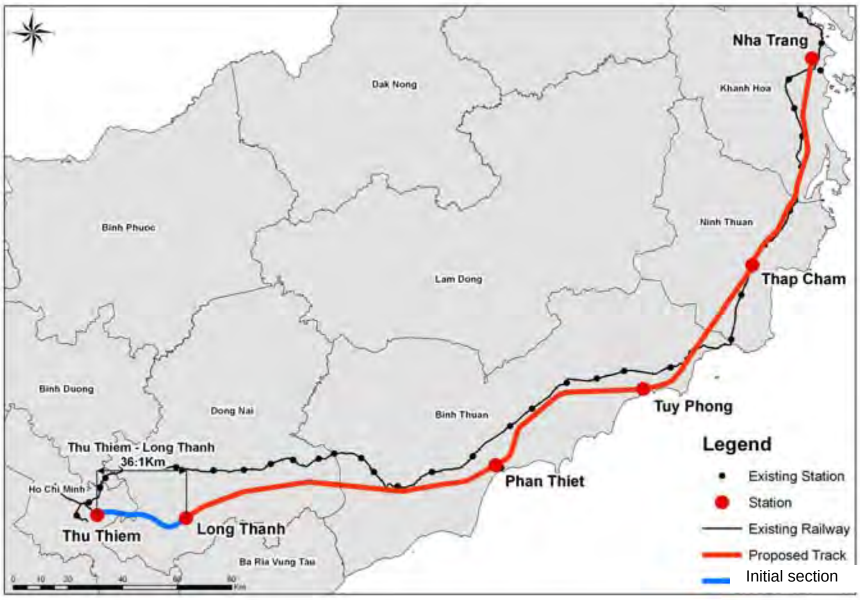
6.8 Two candidate sections which can mostly satisfy the above conditions are selected as follows: (see Figure 6.2.1 and Table 6.2.1)

(i) **Ngoc Hoi-Phu Ly (approximately 46km):** This section is a part of the north priority section and connects two cities of Hanoi and Phu Ly in Ha Nam Province. When the initial section is connected with on-going UMRT Line 1 at Ngoc Hoi, it can also serve as a suburban commuter line towards the south of Hanoi metropolitan area.

(ii) **Thu Thiem-Long Thanh International Airport (approximately 36km):** This section is a part of the south priority section and connects two new large-scale developments such as new urban center in Thu Thiem and new international airport at Long Thanh in Dong Nai Province. When Thu Thiem is connected with HCMC metro line, the initial section can provide a high-speed access to the airport.

Ngoc Hoi-Phu Ly Section

Thu Thiem-Long Thanh Section



Source: JICA Study Team.

Figure 6.2.1 Locations of Initial Sections

4) Technical Aspects on Candidate Initial Sections

(a) Ngoc Hoi – Phu Ly section (45.6 km)

6.9 The section, length 45.6 km, branches at a 12.2 km point from Ngoc Hoi (0 km) to a rolling stock depot. The structures include: embankments (11.8km), box culverts (0.2km), viaducts (32.2km), and bridges (0.9km).

6.10 Two train sets of 6-car composition will be prepared to enable 320 km/h operation. This enables drivers to experience and to test the maximum speed of 320 km/h and perform sufficient training operation for revenue services and various tests for the purpose of cultivating human resources.

6.11 Rolling stock depots and workshops at appropriate scales for the test period as well as full operation on the northern section will be designed and constructed. Training houses, equipment/facilities for practical exercise and machines/materials for education will be provided, along with measuring instruments and test apparatus for tracks, trolley wires and other equipment.

(b) Thu Thiem – Long Thanh section (36.1 km)

6.12 The section, length 36.1km, branches at a 9.6 km point from the Thu Thiem station to a rolling stock depot. The structures include embankments (5.6km), cuts (4.6km), box culverts (0.1km), viaducts (23.4km), and bridges (1.6km).

6.13 The rolling stock is the same as that described in the Ngoc Hoi – Phu Ly section. On this test section as well, drivers can experience and feel the maximum speed of 320 km/h. Descriptions of revenue service operation, rolling stock depots and workshops are completely the same as those in Ngoc Hoi – Phu Ly section.

(c) Summary of Candidate Initial Sections

6.14 The two candidate initial sections have been compared from various aspects and are summarized in Table 6.2.2.

Table 6.2.2 Outline of Candidate Initial Sections

		Ngoc Hoi – Phu Ly	Thu Thiem – Long Thanh
Length (km)		45.6 km	36.1 km
Profile		• Connects UMRT Line 1 terminal station in Hanoi City to Phu Ly City, the capital city of Ha Nam Province (population of 80,000).	• Connects the new town in HCMC and the new Long Thanh International Airport (LTIA). • Plan for the extension of Line 2 of UMRT. • The estimated users of LTIA (passengers, pick-up and send-off, airport staff, etc.) total to 176,700/day in 2020 of which half will be shared by LTIA, the other half by Tan Son Nhat Airport. This figure will increase to 270,800 in 2030 of which likewise half will be shared by LTIA.
Infrastructure & System	Structure	Embankment: 11.8km Box Culvert: 0.2km Viaduct: 32.2km Bridge: 0.9km	Embankment: 5.6km Cut: 4.6km Box Culvert: 0.1km Viaduct: 23.4km Bridge: 1.6km
	Depot	Land is available. Area is planned at 12.2km from Ngoc Hoi Station, around 38ha. Structures and facilities will be established in proportion to the number of trains.	Land is available. Area is planned at 9.6km from Thu Thiem Station, around 32ha. Structures and facilities will be established in proportion to the number of trains.
	System	HSR specification proposed in Volume I Chapter 5.3 (p.5-86 onwards).	HSR specification proposed in Volume I Chapter 5.3 (p.5-86 onwards).
Rolling Stock and Operation		320 km/h 6 cars, 1 train set 1 -2 trains/ hour (commercial operation is possible)	320 km/h 6 cars, 1 train set 1 -2 trains/ hour (commercial operation is possible)
Human Resource Development Center		Training facility and machines will be provided in depots.	Training facility and machines will be provided in depots.
Environmental / Social Aspects		• Detailed study of EIA is needed. • Land allocated for HSR in Phu Ly City.	• Detailed study of EIA is needed.

Source: JICA Study Team.
1/ Construction cost excludes land acquisition costs, contingency, tax, and others.

5) Estimated Construction Costs of Candidate Initial Sections

6.15 The approximate project cost for each candidate initial section is summarized in Table 6.2.3.

Table 6.2.3 Approximate Project Costs for Candidate Initial Sections (US$ million)

Item \ Section	Ngoc Hoi－Phu Ly (45.6 km)	Thu Thiem－Long Thanh (36.1 km)
Civil engineering construction work (civil engineering structures, viaducts, bridges)	651	508
Tracks (ballast tracks and slab tracks)	127	101
Stations (2 stations)	158	219
Power transmission (power transmission and substations, trolley wires, power)	363	352
Signal and telecommunication	173	150
Rolling stock depots and workshops	114	135
Costs of rolling stock	57	57
Education/training facilities and machines/materials for education	26	26
Total	1,669	1,548

Source: JICA Study Team.

6) Preliminary Analysis on Potential Demand

6.16 While it is difficult to estimate the demand for initial sections, an analysis is made based on available information to indicate possible sources of demand.

(i) **Ngoc Hoi – Phu Ly section:** In 2010, the passenger demand between Hanoi and Ha Nam is 7,343/ day which is expected to increase to 39,700/ day in 2030 due to rapid progress of urbanization in Hanoi metropolitan region. Estimated demand for HSR in the priority section shows that a total of about 10,000 passengers/ day will use HSR. This indicates that if initial section is properly provided with access service to/ from the south especially Nam Dinh and Ninh Binh, it can attract more passengers. It is to be noted that this level of ridership is only possible when UMRT Line 1 and HSR is connected effectively at Ngoc Hoi Terminal Station. (see Table 6.2.4)

Table 6.2.4 Passenger Demand between Hanoi and Ha Nam

Mode	2010			2030		
	Between Hanoi and			Between Hanoi and		
	Ha Nam	Nam Dinh	Ninh Binh	Ha Nam	Nam Dinh	Ninh Binh
Car	664	1,786	1,177	7,360	4,391	2,556
Bus	6,643	5,352	572	19,697	10,237	6,831
Existing Railway	36	440	62	2,555	4,883	780
HSR	-	-	-	10,091	(7,406)[1)]	(2,933)[1)]
TOTAL	7,343	7,578	1,811	39,703	26,917	13,100

Source: JICA Study Team.

1) It is assumed that Ngoc Hoi – Vinh Section is opened.

(ii) **Thu Thiem – Long Thanh section:** Although the passenger demand between HCMC and Dong Nai Province is very large as estimated in the study to be 69,500/day in 2010 and 159,600/day in 2030, the location of the initial section between Thu Thiem and Long Thanh has no relevance to the figure because both ends are located in green fields. Therefore the demand is largely dependent on the future development of Long Thanh International Airport. It is estimated in the Long Thanh International Master Plan Project that the total number of passenger demand in 2030 is 141,400/day[3]. It is also assumed in the study that about 25% of the passenger demand will use urban rail and HSR. This implies that approximately 35,000 passengers will use the initial section when it is in operation.

Table 6.2.5 Estimate of Long Thanh Airport Traffic Demand, 2030

Mode	Type of Passengers (no./day)			Total
	Air passenger	Airport worker	Well wishes	
Motorcycle	3,425	7,143	3,722	14,290
Car/ Taxi	17,123	3,571	13,023	33,722
Bus	47,945	25,000	20,472	93,417
TOTAL	68,493	35,714	37,222	141,429

Source: Long Thanh International Master Plan Project.

7) Assessment of Candidate Initial Sections

6.17 While two initial sections have different features, it is preliminarily discussed farther to assess priority for implementation. Main criteria for comparative assessment include the following:

(i) Satisfaction of technical requirements: This is to evaluate candidate initial sections can meet requirement for high-speed operation at the speed of 300-350 km/h.

(ii) Training environment: This is to evaluate if the environment on human resource development and training related to high-speed railway construction, maintenance, operation and management is adequately provided in the areas where the candidate initial sections are located.

(iii) Demand: Although the initial sections are not meant directly for commercial operation, it is important that they meet actual demand, because they will be opened for commercial operation after the initial training.

(iv) Publicity: While HSR is a significant project of national importance, for the Government and the people, it is also important to promote understanding of the society on the use and effects of high-speed railway.

[3] It is estimated that the number will increase to 565,700/ day when the airport is fully operational.

(v) Regional development impact: This refers to potential impact of initial sections on urban/ regional development along the route.

(vi) Construction cost: This refers to the magnitude of investment costs.

(vii) Availability of lands: It is critical to ensure availability of lands for construction of the initial sections including those for the tracks, depots and other related facilities.

(viii) Others: Other factors which are unique to candidate initial sections are also considered.

6.18 The two candidate initial sections were evaluated based on the proposed criteria (see Table 15.5). The characteristics are explained as follows:

(i) Both candidate sections satisfy technical requirements;

(ii) Training environment was evaluated equally since the candidate sections are in the vicinity of large urban areas;

(iii) Traffic demand is larger in the south, however the premise is that the operation of Long Thanh International Airport should be as scheduled and the access (urban railway) from HCMC inner city area to Thu Thiem area needs to be ensured;

(iv) Publicity is rated higher for the South;

(v) Regional development impact is rated higher for the North (in which many cities are located);

(vi) There is no great difference in construction cost;

(vii) For the north, preconditions for smooth implementation are made relatively clear. For Ngoc Hoi terminal, HPC provided a total of 170ha including UMRT Line 1, existing railway and HSR, and a detailed plan is being prepared. For Phu Ly Station, the City has incorporated the location of HSR alignment and station in its approved urban plan to control the development within the land for HSR development.

(viii) For the south, the initial section will be affected by three large-scale projects including (i) Thu Thiem urban development (ii) new Long Thanh International Airport and (iii) connecting urban rail line between Thu Thiem and City Center in HCMC. In order for the proposed initial section to function effectively, the three projects must be implemented in coordinated manner timely.

6.19 Based on the above analysis, it is preliminarily concluded that priorities for the initial sections are in the order of (1) Thu Thiem – Long Thanh and (2) Ngoc Hoi – Hanoi, though differences are insignificant.

6.20 While it is recommended to construct Thu Thiem – Long Thanh by the Japan side based on the objective assessment by the JICA Study Team, the decision will be apt to political matters as well. Hence, the final decision shall be made swiftly by the Vietnam side to ensure smooth development of the HSR in the future.

6.3 Operation and Management Organization

1) VR Organization

6.21 On 1 July 2010, VR changed into a one-member limited-liability company (LLC), based on Notification No. 973/QD-TTG (25/June/2010), as shown in Figure 5.4.2 (refer to Figure 5.4.2 for the pervious organizational chart).

6.22 In 2003, VNRA and VR were separated, with VR becoming a state-owned enterprise (SOE) based on the 2005 state-owned enterprise law (later, this law was supplanted by the integrated enterprise law which took effect on 1 July 2010). Then, the affiliate companies were reorganized as stock companies and the introduction of "one member LLC" was accelerated in 2008. On 1 July 2010, VR became an LLC by virtue of said SOE law.

6.23 Since 2003, VR has changed significantly and further organizational changes are expected. Actually, an affiliate freight company was expected to change into a stock company as a model case in January 2012. To prepare for the reorganization, the freight company is now transferring all stations to the passenger company and a rolling stock base to the "Traction Union."

6.24 The situation of the organization before and after 30 June 2010 is compared below.

(i) Under the headquarter organization, the "Construction Division" was changed into the "Construction and Investment Department," while the "Planning Division" and the "Statistics and Computer Division" were merged as the "Statistics and Planning Management Department."

(ii) Two "vocational colleges" were merged, while other colleges and training centers were reorganized and became affiliate organizations attached to the VR Vocational Colleges.

6.25 In this manner, large-scale reorganization was avoided, even though VR changed from being an SOE into a one-member LLC. However, the division of affiliate companies changed from business to accounting base, in that the following organizations were adopted:

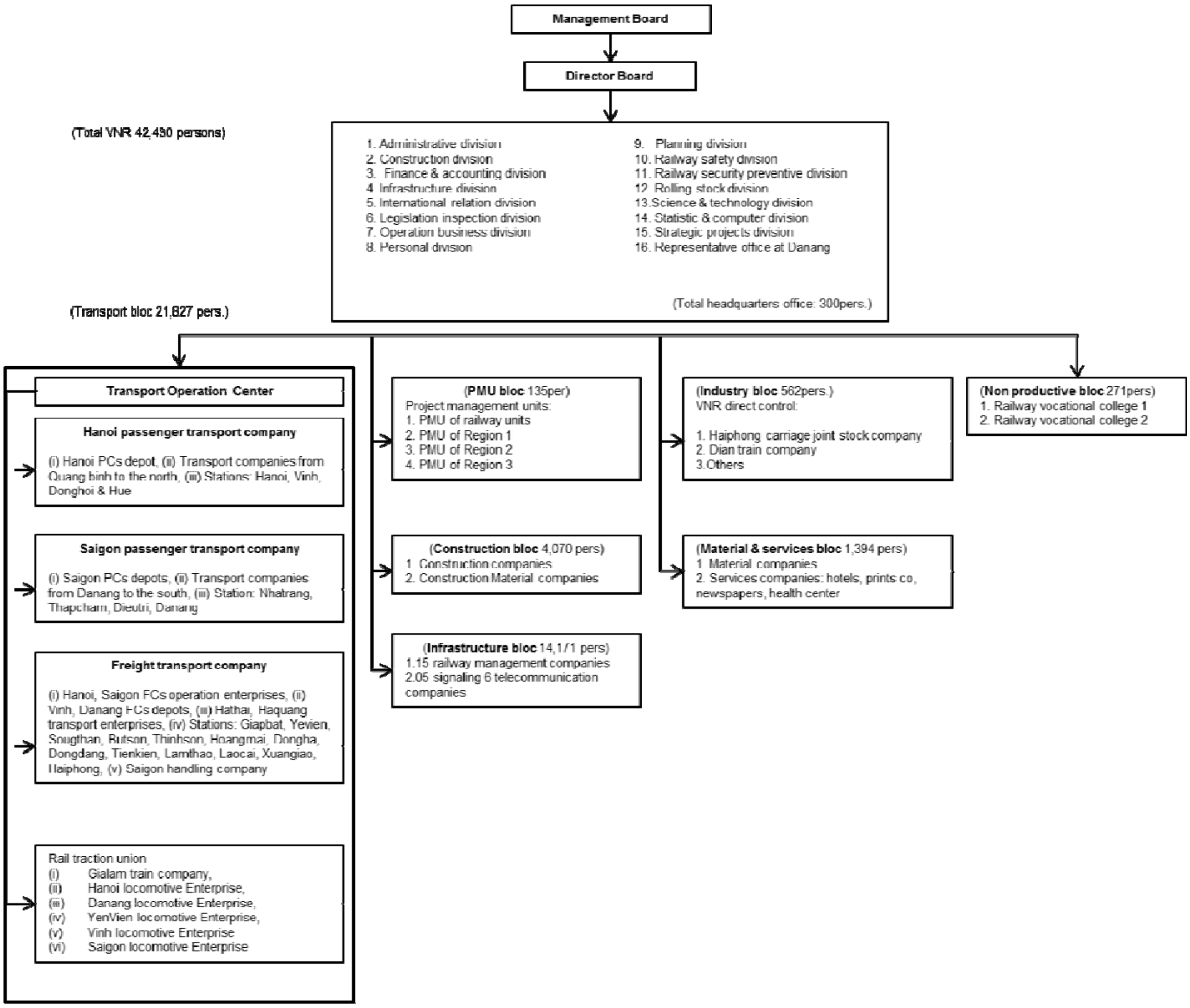
(i) Independent Accounting Units, which are independent accounting organizations;

(ii) Public Independent Accounting Units, which are independent accounting organizations receiving official subsidies;

(iii) Dependent Accounting Units or independent accounting organizations subordinate to VR;

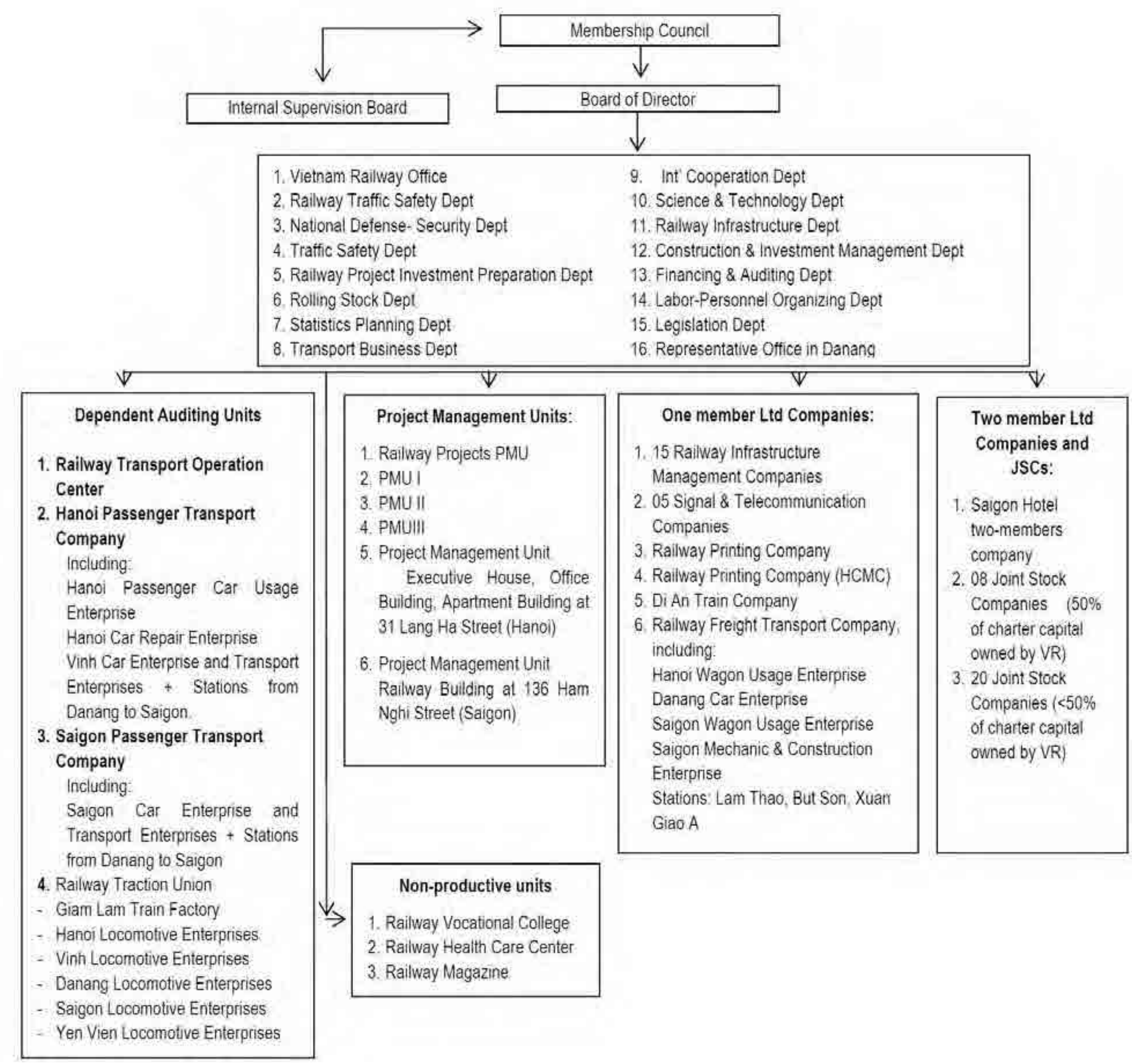
(iv) Management Units directly controlled by VR; and

(v) Joint stock companies."



Source: Vietnam Railways

Figure 6.3.1 VR's Old Organizational Chart



Source: Vietnam Railways

Note: On August 1 of this year, "Railway Traffic Safety Department" has been in charge of the safety of VR headquarters, and the name has been changed "The Center for Railway Natural Disasters, Incidents Responses & Rescue". This new organization will implement protection measures against natural disasters and fire, as well as rescue operations in times of disasters/fire. It is assumed that has been revised based on the concept of national disaster prevention.

Figure 6.3.2 VR's Current Organization Chart

2) VR's Organizational Issues

6.26 The organizational issues in VR, listed below, are based on the information acquired by the JST from interviews with the relevant departments of the head office, associated companies, and the work site.

(i) Raising management efficiency, and

(ii) Improving relations between divisions in the head office and affiliate companies.

6.27 On comparing VR with the present status of Japan's railway sector, it can be assumed that VR, which has a total operating route length of about 2,600 km, has quite a lot of employees, about 40,000. Based on Figure 6.3.3, the Japanese National Railway (JNR) once had more than 400,000 employees. However, in its reorganization and especially when JR was privatized, the types of works were rationalized, and business improved significantly. In the case of VR's workforce, there are no indications from the government on employment measures. VR can make its own decision on this issue if it wants to enhance its business efficiency.

6.28 VR's employees at work sites understand what they must do and what they want to do to solve pending problems. However, they unanimously complain that they do not have the budget to do so, which is their greatest problem. For this reason as well, VR's management efficiency must be improved to solve problems at work sites. There were some respondents, however, who attributed the overstaffing to the existence of single tracks, diesel locomotives (DLs), the semi-automatic signal system, frequent stations on routes, and other conditions of equipment/facilities, all of which are labor-intensive. The important point is VR's attitude toward addressing the issue of improving management efficiency.

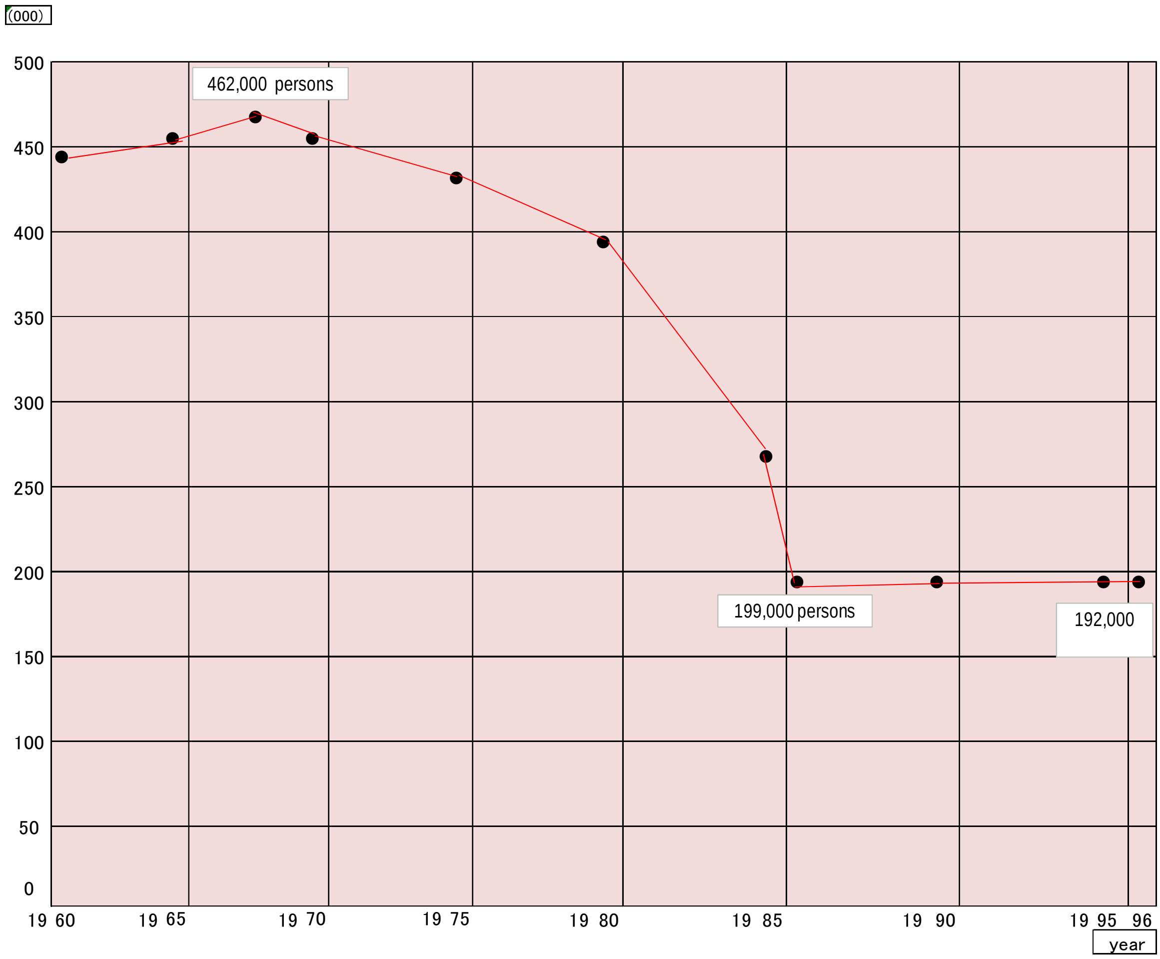
6.29 As already mentioned, track maintenance and signal/telecommunication companies are run with government funds. There is little incentive to increase management efficiency under a management structure which is closely tied to the government. The VR head office imposes various demands and requirements on passenger/freight and other transport-related companies. Nevertheless, the VR head office cannot cope with maintenance-related companies. At present, maintenance-related companies must obtain approval from the VR head office about: (i) the number of employees, (ii) target profit, and (iii) management plans. There is a rapid trend in recent years to reorganize VR's affiliated companies as joint-stock companies. This is in marked contrast to the very slow change in the number of employees. However, the workforce in some companies is gradually being reviewed, such as one passenger transport company where station services are now being reorganized.

6.30 There are a number of ways to cut the number of employees and increase management efficiency. Similar to those implemented in Japan by the JNR several decades ago, rationalization measures :include (i) reviewing the criteria for train crew services, (ii) remodeling crossings for unmanned operation, and (iii) reducing staff (cutting the number of employees including those engaged in shunting) to reflect the following (see Figure 6.3.3):

- Modernization of CTC and station interlocking system;
- Introduction of train radio systems; and
- Introduction of large track maintenance machines.

(a) Relations between Head Office Divisions and Affiliate Companies

6.31 According to the organization chart above, VR has split almost all services and entrusted them separately to affiliated companies. Therefore, the head office organization is rather simple compared with those of Japanese railways, which is an advantage. However, there are some functions that should not be outsourced and should remain with the head office, such as train operation control dispatch. Some affiliated companies complain that it takes a long time to obtain approval from the head office for their requests because the latter has too few staff. Some affiliated companies, such as those engaged in track maintenance or signal/telecommunication, struggle to retain employees due to low wages. On the other hand, there is a "railway construction company," which can autonomously set employee salaries at considerably higher levels than those in companies under the direct control of VR.



Source: MOT in Japan

Figure 6.3.3 Changes in No. of Personnel of Japan National Railway and JR 7 Companies

6.32 The issue of company split is also connected with safety enhancement; so, it's a must to re-examine the current VR organization from the viewpoints of ensuring safety and modernizing the existing railway in the future.

(b) Safety Management

6.33 In railway companies, promoting any safety measure first requires the company to clarify the basic policy for safety measures in detail and make its concerned employees put those measures into practice. In addition, there is a need to: (i) provide daily coaching to employees to prevent accidents, (ii) understand exactly the occurrence of accidents and implement precautionary measures, (iii) share relevant information to prevent accidents, and (iv) provide training to prevent the assumed causes of accidents, among others.

6.34 The JICA Study Team was infomed that safety management for the whole VR organization is controlled by a division in the head office through coordination and arrangement with the heads of different divisions. Interviews with affiliated companies and worksite offices revealed that safety management practices differ from those in Japan wherein the division in charge has firm responsibility over safety.

6.35 Safety measures are first implemented by associated companies. It's inevitable for each associated company to guarantee its own safety since the organization of VR has been split. To promote safety, the Safety Countermeasure Division in the VR's head office coaches associated companies.

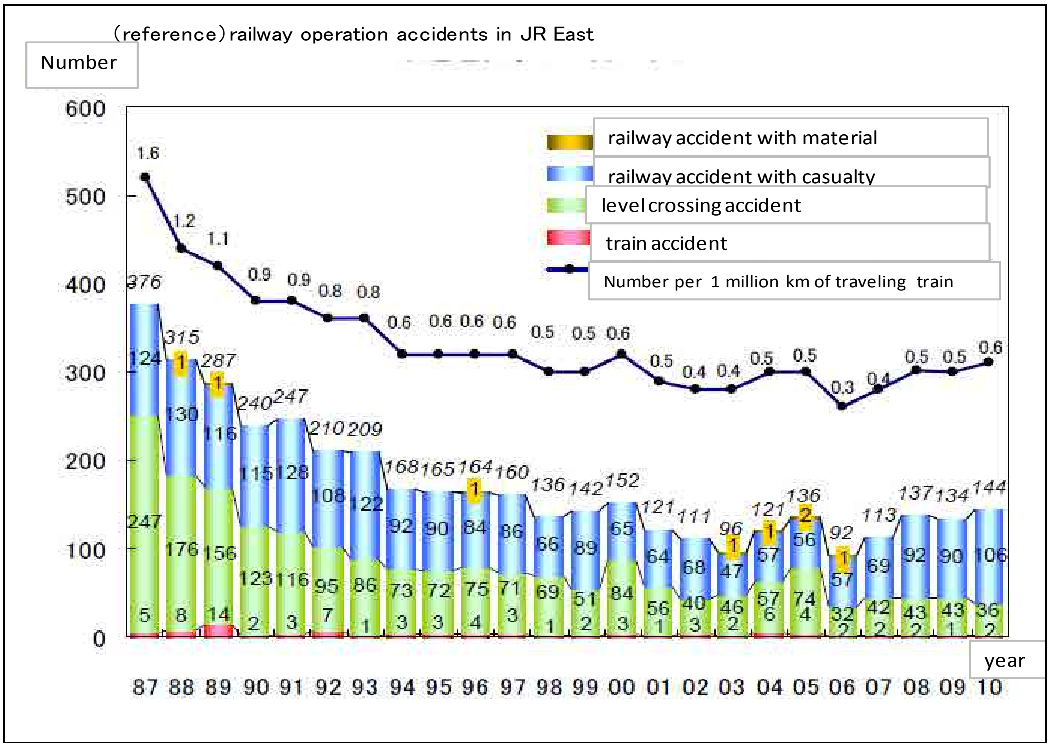
6.36 Appropriate guidance on technical matters may not be possible, unless the divisions in charge participate in safety management. This may be attributed to the fact that technological divisions in the head office are not sufficiently staffed. However, technical services can be performed provided the standards specified by MOT and VR are complied with, since there are few technical changes.

6.37 In order to ensure railway safety, employees have to first obtain the relevant knowledge related to the work. However, this is not the only way railway staff are making strenuous efforts to prevent accidents: Multiple trainings are required to keep employees motivated to prevent accidents.

6.38 Therefore, multifaceted approaches toward accident prevention should be implemented, which include the method of sharing information on accident causes and precautionary measures. However, VR will not be able to cope with rapid technological advances and upgrades in different fields in the future by its conventional methods. For example, with aid from France, an electronic interlocking system has been introduced in several station yards around Hanoi. Work sites are struggling to train employees on advanced technologies such as electronic interlocking system. The JICA Study Team heard that the advanced technology cannot be understood in a single training session, so there have been further training in cooperation with manufacturers. Still, only a few can sufficiently understand the system.

6.39 Thus, if new equipment/facilities are introduced in succession from now on, and if, besides the current training at VR Vocational College, no on-the-job (OJT) training is given, the staff will not be able to absorb new knowledge. VR should not only leave OJT training to the work site, but also establish a training system that tackles systematically as a company. Moreover, teaching the new technology should not be entrusted to foreign manufacturers because it will never become a Vietnamese technology. To this end, the company should establish an instruction system for new technologies.

6.40 In addition, even as VR is struggling with ageing track equipment and vehicles, crossing accidents and track interference are considered bigger problems. Especially regarding crossings, VR has many manually operated crossings and these have become one of the main causes of accidents. At a track maintenance company which has about 1,000 employees, there are about 500 guards attending to crossings. This even though trains do not run so frequently. Crossing accidents are an important aspect of railway safety management. JR East Japan succeeded in greatly reducing serious accidents (see Figure 6.3.4). Measures for crossings may be the first issue to be addressed when modernizing railways. Regarding the checks by the safety division in the head office, there are some notable safety practices implemented without giving prior notice. This is an effective method to understand the actual conditions of affiliated companies and work sites. Moreover, the “Locomotive Enterprises” to which drivers belong perform mini-tests and health checks (checks for alcohol, blood pressure, mental state, etc.) using personal computers before they start work, which is likewise notable.



Source: JICA Study Team

Figure 6.3.4 Railway Accidents in JR East

(c) Human Resources at VR

6.41 VR employees whose tasks relate to train operation are trained based on regulation No. 38/2010/TT-BGTVT (Training Facilities and Curriculums for Employees Directly Engaged in Train Operation) issued by the MOT. Regarding assignments and positions not specified in the above regulation, other laws such as the Vocational Training Law (No. 76/2006/QH) enacted by the government is applied.

6.42 In Vietnamese society, people work based on a qualification system. Grades 1 to 7 are linked with the salary system for regular employees. Those who have worked for three years or more at a certain grade are entitled to take an examination to be promoted to a higher grade. There is a rule that employees cannot be assigned to particular jobs, such as patrol inspectors at track maintenance depots, unless they have reached a certain grade. In contrast, there is a system whereby drivers, who enjoy higher salaries than employees in other job categories, are not promoted to higher grades. Employees are periodically required to pass one or two examinations in a year to maintain their current grades. This examination is important to assess the ability of employees. Because the workers of track and signal/telecommunication maintenance companies do not receive satisfactory wages, it is difficult for these companies to keep them. Thus, various problems must be solved before implementing technical education.

1) Organization to prepare for the modernization of existing railways in the future

6.43 Under the above circumstances, it is extremely difficult for VR to raise funds by itself to modernize the existing railways. Therefore, there is no alternative but for VR to seek and accept the help of other countries in modernizing its railways and introducing information technology.

6.44 As described above, when these new technologies are introduced, it is necessary to consider a company's organizational structure so that the approach to and coaching for OJT training can be made suitably. More specifically, there will be a need for an education and training organization under the direct control of the head office to strengthen OJT training. Organizational structures of company do not need to be rigid, but should be suitable for the needs of the times. If a new organization structure like this is not developed, the modernization of the VR in a short period of time would be impossible.

6.45 VR has introduced general-purpose IT, such as an accounting system, which is used by private companies. Nevertheless, the use of IT in specific fields of railway operation is extremely delayed. In fact, it has just implemented a ticket booking system.

6.46 To introduce HSR technology, IT is indispensable. These technologies will be incorporated extensively into the urban railways to be constructed in Hanoi and HCMC. It may be necessary to acquire the technologies being used for urban railways. Most railway companies in Japan have set up IT divisions independent of electricity divisions. This means that IT is important to new railways. As VR must eventually make its IT division independent, it should prepare to do so at the earliest possible time.

2) Approach to Discussions on Operational Organization of HSR in Vietnam

6.47 In Section 5.3, the present status of railway technologies in Vietnam is explained, modernization of existing railways expected in the future, and the necessity to acquire the technologies for urban railways including those of Shinkansen. To hold up such a lofty target as the construction of a high-speed railway in the country, it is required for Vietnamese people to recognize the status of Shinkansen technologies in Japan from an early stage in project planning. For this reason, therefore, there is a need for an initial section and a plan to develop diverse human resources for the long term through training programs in Japan as part of the overseas training scheme for Vietnamese staff. In this chapter, an ideal picture is described of the operational organization to manage the HSR in Vietnam.

6.48 It will be subject to discussions in the future on how to position the HSR operational organization in the country after its inauguration. Whatever shape it may take, however, the HSR operational organization should function self-sufficiently. From this viewpoint, what the ideal HSR operational organization should be and how this can be achieved is discussed.

6.49 In discussing the operational organization of the HSR managing enterprise, this report elaborates on the organization of the Tokaido Shinkansen, the first one of its kind in Japan, as well as the case of the Tohoku and Joetsu Shinkansen, whose organization combines that of the Shinkansen and the existing narrow-gauge railway. After that, the report cites the case of the Taiwan Shinkansen.

3) Operational Organizations in Japan and Taiwan

(a) Tokaido Shinkansen

6.50 After obtaining an approval from the Minister of Transport for "an Additional Tracks Construction Project between Tokyo and Osaka, Tokaido Main line," the Japanese National Railways (JNR) established the following offices for the purpose of constructing the Tokaido Shinkansen Railway:

(i) Trunk Line Construction Department at its head office (April 1959);

(ii) Tokyo Trunk Line Construction Office as a regional organization (April 1959); and

(iii) Shizuoka, Nagoya, and Osaka Trunk Line Construction Offices (December 1960)

6.51 To strengthen the authority to promote construction work, JNR reorganized the Trunk Line Department at the head office into the Shinkansen General Affairs Department in April 1960.

6.52 In parallel with the construction of a Shinkansen railway featuring high technologies to run trains at a maximum speed of 210 km/h, JNR constructed a test track called the Kamonomiya model track attached to a control depot in 1962, where drivers and other personnel were trained on operating new technologies required for the new Shinkansen railway.

6.53 The Tokaido Shinkansen Inauguration Preparatory Committee set up in 1960 determined that the Tokaido Shinkansen railway, after its inauguration, should be integrated with the JNR as a branch under an operational organization organized on the line.

6.54 On 1 October 1964 the Shinkansen railway, which had a length of about 515 km, was inaugurated under such an administrative arrangement and at a time when the Shinkansen General Affairs Department at the head office was abolished and the Trunk Line Construction Offices in Tokyo, Shizuoka, Nagoya and Osaka were reorganized as local organizations of the Tokaido Shinkansen Branch Office. Table 6.3.1 and Figure 6.3.5 show the personnel and organizational chart, respectively, of Tokaido Shinkansen at the time of its inauguration.

Table 6.3.1 Tokaido Shinkansen Personnel at Its Inauguration

(October 1, 1964, about 515 km)

(unit : person)

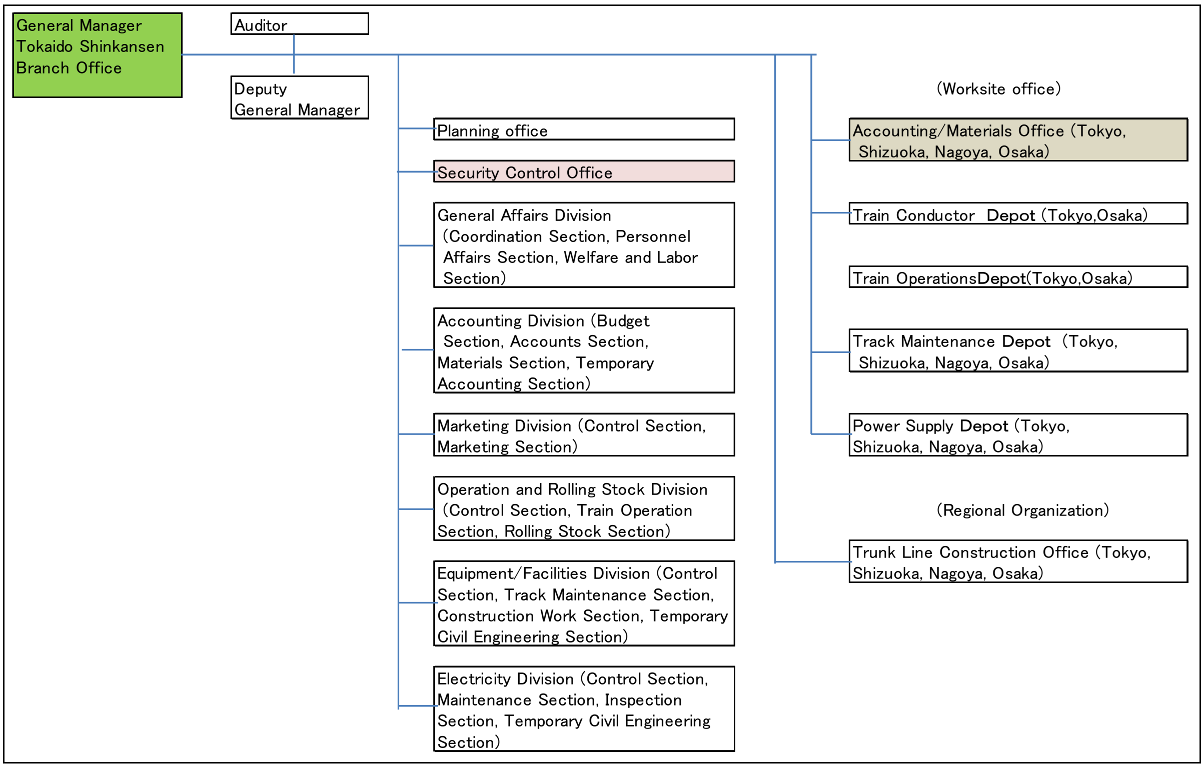
Stations and Sales	Train Operation	Track and Civil Maintenance	Electric Facilities Maintenance	Others	Total
326	943	1268	980	446	3963

Source: JICA Study Team

6.55 At the Tokaido Shinkansen Branch Office, one of the most important divisions is the Security Control Office which discusses new technologies studied and developed for the security and operation of high-speed railways and implements comprehensive measures to ensure safety.

6.56 As computerized information processing had become increasingly important to precisely and quickly implement operation control and maintenance services for the Shinkansen, a committee was set up to discuss computerization, with the Information Control Office being organized in 1970. The duties of the Information Control Office are currently borne by the System Control Office, Central Dispatching Office for the Tohoku and Joetsu Shinkansen railways.

6.57 At the start of the Tokaido Shinkansen railway, four accounting/materials offices were placed in Tokyo, Shizuoka, Nagoya, and Osaka as local organizations for worksite operations. These local accounting/materials offices were placed within a materials supplying system directly under the Shinkansen Branch Office to promptly supply a variety of materials to field sites. In the case of JNR, materials were supplied through the materials supply centers under the Accounting Department in the head office. It is important to establish an efficient materials supply system to avoid delay in materials procurement which can result in disturbances in Shinkansen train operation.



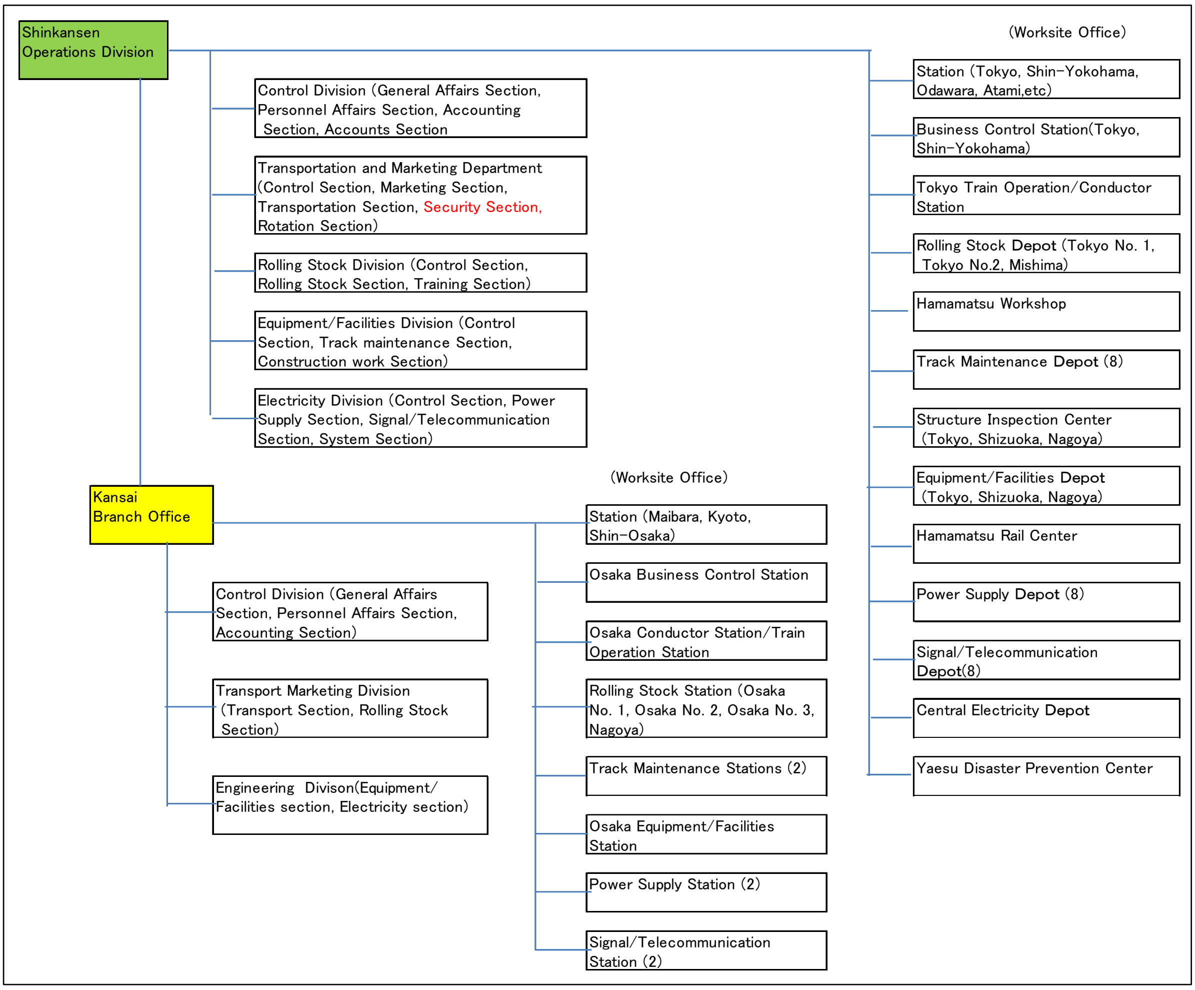
Source: JICA Study Team
[1] 1 October 1964

Figure 6.3.5 Organizational Chart of the Tokaido Shinkansen Branch Office at Its Inauguration[1]

6.58 A difference in the current administrative organization of the Tokaido Shinkansen (JR Central), as shown in Figure 6.3.6, from that in the past is that the Kansai Branch Office has been organized to manage the section west of Maibara, as problems may arise when remote sections are managed directly from the head office. However, the services at the Branch Office are limited primarily to the control of the field sites, with policy making for the Shinkansen still the responsibility of the Shinkansen Operations Division at the head office. (See Figure 6.3.6).

(b) Tohoku and Joetsu Shinkansen

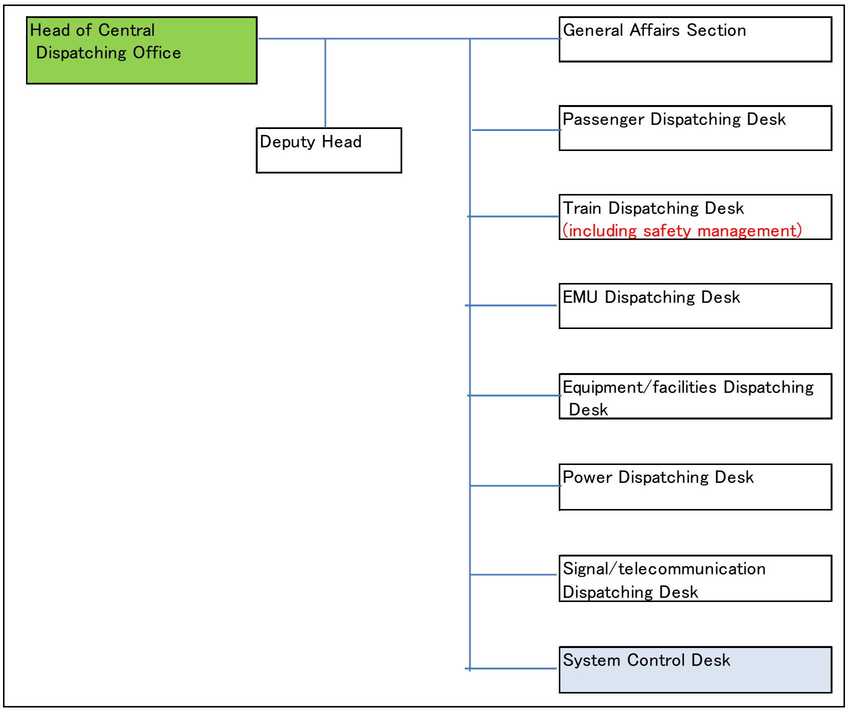
6.59 To prepare for the inauguration of the Tohoku and Joetsu Shinkansen, JNR set up preparatory offices in the regional administrative offices of Morioka, Sendai, Niigata, Takasaki, and Tokyo North in March 1973. Regarding the operational system of the Tohoku and Joetsu Shinkansen, the JNR Executive Committee decided in February 1980 to take advantage of the experience in the Tokaido/San-yo Shinkansen and to consider the local characteristics of the Tohoku and Joetsu areas.



Source: JICA Study Team

Figure 6.3.6 Current Organizational Chart of the Tokaido Shinkansen Operations Division, JR Central[1]

6.60 Because of the experience obtained during the 17 years or more after the inauguration of the Tokaido Shinkansen, maintenance services for the Shinkansen have stabilized, with most of the technologies specific to it simultaneously spreading into existing narrow-gauge railways. As a result, modern technologies are now prevalent over the entire area of responsibility of the JNR. In consideration of these circumstances, the Committee judged that the Regional Administrative Offices should take charge of the Shinkansen in addition to narrow-gauge railways. To carry out centralized train operation, however, a special organization called the "Tohoku/Joetsu Shinkansen Centralized Dispatching Office" was established to direct Regional Administrative Offices in regard to Shinkansen dispatching services (see Figure 5.4.9). It was determined to divide field organizations belonging to Regional Administrative Offices into two: one for Shinkansen and the other to take charge of both Shinkansen and narrow-gauge railways. This organizational structure should not be adopted for the HSR in Vietnam for two reasons, namely: (i) it assumes that virtually no differences exist between Shinkansen and narrow-gauge railway services, and (ii) the command center for train operation is extremely difficult to set up.



Source: JICA Study Team

Figure 6.3.7 Organizational Chart of the Central Dispatching Office for Tohoku/ Joetsu Shinkansen

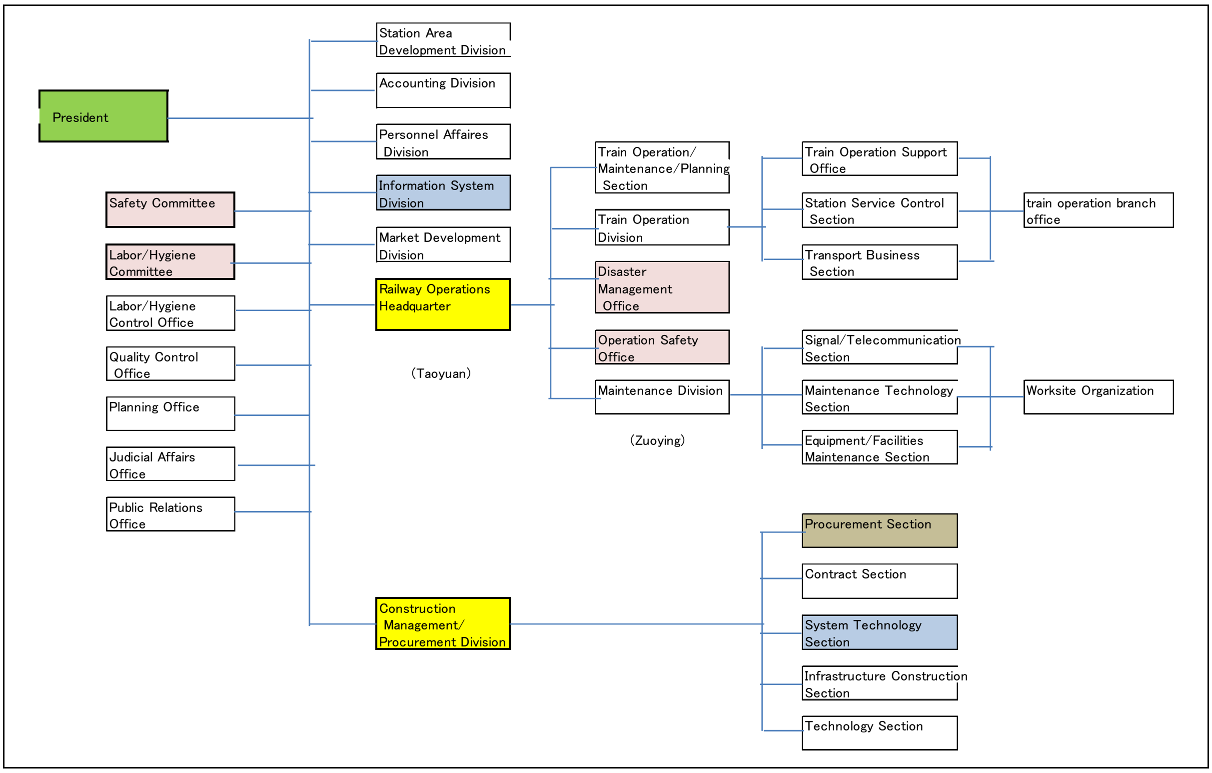
(c) Taiwan High-speed Railway

6.61 In the operational organization of the Taiwan High-speed Railway (see Figure 5.4.10), one of the noteworthy points is that the organization is highly oriented toward market development other than that for Shinkansen technologies: It has divisions to develop markets and surrounding areas of stations. In other words, the organization was constituted to deal with the tasks of increasing income from railway services. The organization is not much different from that of the Shinkansen in Japan in regard to other technologies. In the same way as the Tokaido Shinkansen was at during its initial stage, after inauguration, however, the Taiwan Shinkansen retained the Construction and Procurement Division within the organization to address related services.

6.62 Being conscious of the large-scale earthquake that took place during the construction period, the Taiwan Shinkansen has instituted the Emergency Management & Security Office besides the Operation Safety Office in the Railway Operations Headquarter.

6.63 In addition to the divisions/sections for regular duties, two committees, i.e., Safety Committee and Labor Safety Committee, were organized to ensure safe train operation and prevent labor problems. This organizational structure implies an extremely important stance of the Taiwan Shinkansen.

6.64 The Operation Safety Office in the Railway Operations Headquarter takes charge of safety in train operation. It is essential that issues related to safety be discussed within the committees including top management. Therefore, it is recommended that the Vietnamese HSR should have such an organization in some form or another.



Source: Compiled by JICA Study Team

Figure 6.3.8 Organizational Chart of Taiwan High-speed Railway

4) Discussions on the Operational Organization of Vietnam's HSR Managing Enterprise

6.65 In discussing the operational organization of the Vietnamese HSR, what should be consider first is how to ensure the safety of trains running at 300 km/h or more. The system for safety measures should be incorporated into the HSR from the construction stage. A typical exemple to prove this point is the Shinkansen in Japan, which was constructed with the concept of fail-safe as the basic safety ideal and which has not experienced serious accidents since its inauguration several decades ago.

6.66 However excellent the system may be, the possibility of the occurrence of accidents is not totally deniable, in case the system fails or unexpected mishaps occur, such as procedural mistakes in train operation, wrong maintenance services, natural disasters, and other acts of God. As railways constitute a system interlinking different technologies, it is required to construct an organization to realize interdisciplinary linkages beyond the boundaries in between. In the Shinkansen railways in Japan and Taiwan, the operational organization, including management divisions and field offices, shows a vertical link separating different technological disciplines. This is an excellent organization in the sense that those who belong to one discipline are in friendly rivalry with others to improve their technologies.

6.67 Such an organization has a demerit, however, in that too strong an egoistic insistence sometimes impedes organizational efficiency, while requiring much coordination between different fields. It is also required, therefore, to prevent such demerits in discussing the administrative organization of the Vietnamese HSR.

6.68 Furthermore, as the technologies of the Shinkansen differ much from those of the existing railways in Vietnam, managing these different types of railways as a mixture should be avoided. The administrative organization of the Vietnamese HSR will be the subject of future discussions including its relation with MOT and VR. At the very least, the organization should function within the HSR managing enterprise.

(a) Organizations under direct control including services at field offices

6.69 The current Vietnam Railway has simplified its head office organization and has entrusted actual operations to separate companies. However, as there are some problems of excessive company split-up or related employee’s education system and so on4 in this organization, it is not necessarily a satisfactory structure.

6.70 In the case of the HSR utilizing technologies that are totally different from those used in the past, the necessary services that are functional within the organizations of HSR management companies as mentioned above, including those of worksite organizations, will be under the direct control of the HSR, in view of the current railway technologies in Vietnam.

(b) Organizations related to safety

6.71 The Security Control Division which plans and implements comprehensive security measures reportedly played an important role at the start of the Tokaido Shinkansen. This fact is worth consideration. The divisions/sections that will take charge of security measures have been discussed repeatedly before and after the privatization of the JNR. Before privatization (JNR), the Security Section that was in charge of safety was under the Train Operation Division dealing with train operation. After privatization (JR Central), the Security Section was placed under the Transportation & Marketing Department, Shinkansen Operations Division. In the case of JR East, on the other hand, the entity in charge of safety was an independent organization called the Safety Measure Department which was separated from the Transport & Rolling Stock Department or a division related to maintenance. It is now called the Transport Safety Department.

6.72 In the operational organization of the Vietnamese HSR, the organization in charge of safety will be independent of other technological fields and be positioned close to the top in order to plan and implement comprehensive security measures and ensure smooth coordination between different fields, in the same way as was done in the Tokaido Shinkansen in Japan when it started passenger transport services.

6.73 It goes without saying that discussions shall be held on safety measures related to train operation of HSR, in addition to those on ensuring the safety of passengers and employees.

6.74 In the operational organization of HSR now under consideration, its own services are supposed to be implemented under its direct control. Nevertheless, there may be some services that shall be entrusted to outside organizations. Sometime after the inauguration of business operation, therefore, the issue to outsource part of its services will certainly come to fore. A point to consider at that juncture is that the safety organization should be established not only in the HRS managing enterprise but also in its subcontractors.

6.75 To promote concrete safety measures, railway companies shall distinctly specify their basic policies on safety and make them thoroughly understood among employees. For this purpose, railway companies shall:

- Establish a method to educate employees on workplace safety and plan training programs to utilize training facilities.
- Correctly assess accidents that have occurred and establish preventive measures.
- Share information to prevent repeat accidents.
- Perform regular training on emergency situations.
- Furthermore, it is also important to plan additional investment in safety facilities in consideration of the actual operation and to prepare a budget for them.

6.76 In determining safety measures, railways shall pay special attention to the accidents caused by compound factors encompassing multiple disciplinary fields. It is true that engineers in charge of safety in a particular field devote themselves in the safety measures in their own field. As railways are a system composed of various technologies, engineers in charge should keep an eye on these accidents, such as those caused by interactions between pantographs and contact wires and between wheel treads and rails. To solve these problems, it is required to institute a safety control organization independent of any disciplinary field.

6.77 In discussing railway accident preventive measures in Japan, it has frequently been said based on the experience in the past that small-scale accidents precede a large-scale accident without exception. In case a minor accident has occurred, therefore, it shall be discussed whether or not it will lead to a serious accident. For this purpose, a safety measures committee shall be organized within the enterprise, with top management included as committee members. This committee shall survey the accident that has occurred, investigate its cause and discuss the methods to establish preventive measures. This is a convention adopted by almost all railway companies in Japan and also in the Taiwan Shinkansen. To ensure the safety of railways, commitment is required in the organization for the top management and the rank and file as a whole to make concerted efforts to address the issue of safety. In this context, after the Fukuchiyama railway accident in Japan that claimed more than a hundred lives, the Ministry of Land, Infrastructure, Transport and Tourism adopted a new rule on the safety control system by railway business promoters. The rule emphasizes the importance of the safety control system in which top management is involved.

(c) Intelligent Transportation System

6.78 The management of high-speed railways will not hold without the aid of computers. In the Shinkansen railways in Japan, drawing of train operation diagrams, control of train operation and management of maintenance services are all computerized. This is important for high-speed railways having a mission to perform high-speed mass transport of passengers.

6.79 Therefore, one of the most important tasks for Vietnam Railway is to determine the extent it shall introduce technologies of computerization into its railway networks in the future. So far, Vietnam Railway has introduced computerized accounting systems and other general-purpose information technologies that are seen in other enterprises. However, the introduction into special fields such as those related to railway operations is totally delayed, in that the computerized ticket booking system has just started, for example.

6.80 As mentioned above, it was as late as in 1970 or six years after the inauguration that the Tokaido Shinkansen set up the Information Control Division in order to introduce a full-fledged ITS. To utilize a computer system for the purpose of implementing operation control for Shinkansen railways and maintenance services quickly and precisely, it is not enough to constitute the system alone. What is far more important than that are the improvement of the system after starting operation, trouble shooting, and training of system operators. In particular, the system in connection with train operation management has a problem which links directly to safety.

6.81 Therefore, after establishing the system, railway companies in Japan send personnel responsible for system operation to computer manufacturers to acquire skills required for their jobs. For this reason, Vietnamese HSR shall organize an "information control division" or a "system control division" as an independent organization so that the Vietnamese HSR will function in the same way as the Shinkansen in Japan did.

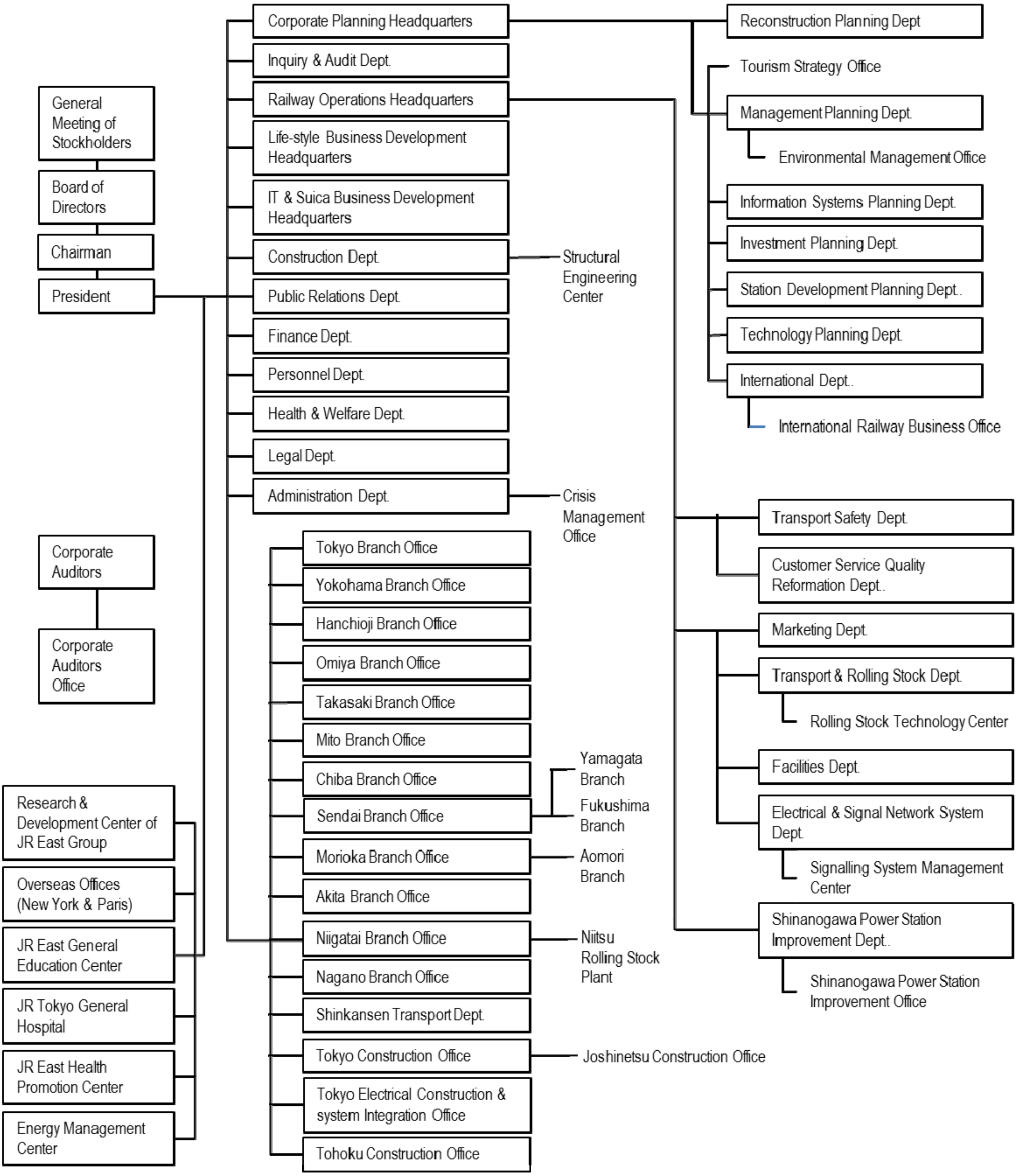
6.82 The importance of such an organization is suggested even by the fact that in the Taiwan Shinkansen case, an independent "information system division" is organized at the head office and a "system technology section" in the construction/ procurement division. As shown in Figure 6.3.9, JR East in Japan also has two organizations, the Information Systems Planning Department and the IT & SUICA Business Development Headquarter. It may not be possible for Vietnamese HSR to introduce a similar comprehensive control system like what the Shinkansen in Japan had at its inauguration but to establish such an organization in the future will be required for a safe and efficient HSR. As such, it is desired for Vietnam to prepare an organizational structure for that purpose.

(d) Materials Procurement Division

6.83 In its operational organization at the start of the Tokaido Shinkansen, JNR placed a materials center as one of the worksite offices under the Tokaido Shinkansen Branch Office. As a result, a mechanism was instituted to quickly supply materials to places in need of such.

6.84 In materials procurement, there are such issues as (i) quality, (ii) delivery time, and (iii) costs. In the case of Tokaido Shinkansen, as the stations for train operation, track maintenance, and power supply are located cheek by jowl with each other in an area, material supply services by these stations were concentrated into the accounting/materials offices to raise efficiency and for specialization. JNR also reduced deskwork for maintenance services at worksite offices as much as possible, aiming at establishing an organization in which they can devote themselves to their primary assignments.

6.85 The materials the HSR will use in the future will mostly be related to new technologies. To ensure the safety of high-speed HSR train operation, therefore, quality control of materials is essential. Furthermore, these materials are hardly available in the market and require long periods to manufacture. To avoid hindrances to train operation right after inauguration, it is essential to procure required materials in required quantities. As often seen in railways in Southeast Asian countries, in case a part of a car has failed, a corresponding part is frequently appropriated from other cars as replacement as it cannot be obtained just in time or cannot be procured for budgetary reasons. As a result, the number of active cars decreases, making it impossible to turn trains as scheduled. The Vietnamese HSR shall by all means avoid such a situation. For this reason as well, the Vietnamese HSR is required to establish an appropriate organization to procure materials without fail.



Source: JICA Study Team

Figure 6.3.9 Organizational Chart of JR East

(e) Measures to prevent disasters

6.86 In view of the meteorological conditions specific to the country, Vietnam shall prepare for fierce squalls and floods. The reason why the “Disaster Countermeasures Division” is instituted in the administrative organization of the Taiwan Shinkansen is reportedly the occurrence of earthquakes before its inauguration. The issue of disaster prevention measures is important for Vietnam as well. Although it may not be necessary to have an independent organization, the Vietnamese HSR is required to discuss at least the installation of a “safety and disaster countermeasures division” integrated with the safety measures division.

(f) Operation control center (OCC)

6.87 In daily train operation services, trains inevitably get delayed due to the failure of rolling stock and equipment or restrictions due to meteorological conditions. In case such a situation arises, the railway operator shall, after correctly assessing the situation, quickly issue appropriate instructions and make proper arrangements through coordination among those concerned. The operation control center (OCC) is organized exactly for this purpose.

6.88 OCCs are currently planned for the lines 1 and 2 in Hanoi and the line 1 in Ho Chi Minh City. The one planned for HSR is based on the same concept as that of the OCCs for urban railways. Computers will be utilized in the systems for train operation control and equipment monitoring in different fields in the same way as in urban railways. What is most conspicuously different from urban railways in regard to maintenance is the fact that the time zones for train operation and maintenance work are distinctly separated to guarantee the safety of Shinkansen train operation. Such services or train operation and maintenance work shall strictly be conducted through cooperation between train operation and maintenance work dispatchers. In this sense as well, communications and coordination between different desks within the OCC are more important than anything else. Therefore, desks and equipment shall be arranged in the OCC to enable dispatchers for different fields to coordination wth each other.

(g) Organization for Training

6.89 Refer to Chapter 5 for the present status of railway technologies in Vietnam. Given the fact that Vietnam doesn’t have the technologies of electrification or ITS for railway management, the country shall educate those related to railway technologies by all means, thereby raising their levels up to those of the countries who are already a member of the HSR club. The necessity of the above-mentioned training is not limited to the period prior to the inauguration of HSR alone, but shall consistently be maintained thereafter.

6.90 Acquisition of technologies before inauguration will essentially necessitate the transfer of construction technologies during the initial section construction period and acquisition of technologies based on actual tests on the initial section. In case the Vietnamese HSR implements partial inauguration using the initial section, it will be advantageous to perform training for the employees during this period to start revenue service operation in the whole of priority sections in the northern and southern areas.

6.91 Therefore, a training organization shall be reinforced at the inauguration of these priority sections in the northern and southern areas when the technology transfer for the concerned employees completes. For this reason, a training center shall be installed directly under the Head Office, separate from the Personnel Affairs Division, Head Office or the Personnel Affairs Section, Branch Office. The reason why this training center shall be an independent organization is that it will be in existence over 10 years from the incorporation of the managing company to the inauguration of the northern and southern priority sections and those approximately 5,000 employees shall be educated/trained in one way or another.

6.92 Beginning with the driving simulator of HSR, the training center shall be equipped with training facilities for each of the different fields, including those for recovery operation in case a contact wire has failed, in view of the fact that Vietnam lacks the technologies of electrification. Even in Japan, it is often the case that the contact wire system fails during revenue service time zone, requiring a long recovery time.

6.93 The training center shall bear the responsibility not only for technological education but also for OJT on non-technological issues and the promotion of small-group activities. The OJT, which is the most important learning method hitherto not implemented in Vietnam, shall be reinforced. What is required for Vietnam is not only training but also the promotion of small-group activities wherein trainees are required to think by themselves. The promotion of small-group activities is indispensable to the training system as seen in the case of JR East where it led to the vitalization of the company after its privatization.

(h) Organizational aspects in the HSR route separated into the northern and southern sections

6.94 In regard to the organization of the HSR, there are problems which arose from the separation of the HSR section into (i) the Ngoc Hoi–Vinh section (approximately 290 km) and (ii) the Thu Thiem–Nha Trang section (360 km).

6.95 Problems regarding the organization of branch offices: As the HSR section is divided into two, an administrative organization is required not only in the Hanoi area but also in the Ho Chi Minh area. To discuss this issue, the case of the current Kansai Branch Office under the Tokaido Shinkansen Railway Operations Headquarter in Japan can serve as an example. The Kansai Branch Office maintains an organization at a reduced scale by limiting its management services to worksite control alone. Based on this concept to minimize the scale, the organization of the Vietnamese HSR is discussed below.

6.96 **OCC:** Under the current HSR construction plan, the HSR route will be divided into two sections, namely, the northern section and the southern section, for each of which an OCC shall be installed for the time being. After the full Hanoi–Ho Chi Minh route has been completed in the future, however, the two OCCs set separately for the two sections shall possibly be integrated into one.

6.97 **Training Facilities:** The education on and training for HSR will be implemented primarily in the facilities belonging to the initial section before the inauguration of the HSR. Even after tests are completed on the initial section, however, these initial section facilities shall be used as a training center under the head office, because they will claim a rather large scale for training and accommodation purposes. The training center shall be used mainly for field training. The installation of an HSR train operation simulator before the inauguration of HSR will also be discussed.

6.98 When access time and distance of trainees are taken into account, however, the training center shall desirably be located close to revenue service lines in the same way as OCCs are. When only one training center belonging to the head office is established, trainees shall bear enormous amounts of cost and time to reach it from Ho Chi Minh or Hanoi. Therefore, it is desirable that each of these areas has training facilities in one form or another. This holds true with the training of urban railway employees as well. For the time being, urban railways may use the VR Vocational Colleges in the northern and southern areas. Classroom education may be a primary form of education about the HSR, but utilization of the VR Vocational Colleges in Ho Chi Minh and Hanoi areas shall also be considered.

5) Draft Organizational Chart of the Vietnamese HSR Managing Company

6.99 A draft organizational chart of the Vietnamese HSR managing company is drawn based on the above discussions. (see Figure 6.3.10)

(a) Organization of the Head Office

6.100 **Divisions under the Head Office:** The head office of the Vietnamese HSR managing company shall have the following business segments, divisions, and offices with their respective assignments (described in brackets)

(i) Management Planning Division (management policies and investment planning);

(ii) Safety and Disaster Management Office (company-wide safety and disaster countermeasures);

(iii) Education and Training Office (education planning for employees and work related to the training center);

(iv) General and Personnel Affairs Division (general affairs and personnel management);

(v) Financial Affairs and Materials Division (financial affairs and materials);

(vi) Railway Operations Headquarters (comprehensive coordination of railway management matters; some work of each division such as marketing, transportation, rolling stock, equipment/facilities, and electricity related to HSR operation); and

(vii) Information System Office (systems on train operation control and company-wide office IT).

6.101 In addition, each division/office has sections corresponding to its services, fulfills its duties, issues instructions to branch offices, and coordinates between branch offices.

6.102 As the HSR service route is separated into the northern and southern sections for the time being, the HSR shall set the Hanoi Branch Office and the Ho Chi Minh Branch Office to take charge of the northern and southern sections, respectively, in regard to train operation and maintenance of equipment/facilities. To implement train operation control, therefore, each of these branch offices shall be installed with an OCC.

6.103 The Management Planning Division will take up management policies and investment planning in general and will also be in charge of environmental and social issues. Although as to what extent the responsibilities regarding environmental and social issues should be under the HSR Managing Company is up to the policy, laws and institutions to be stipulated by Vietnam in the future[4], necessary tasks to be undertaken are explained as follows:

[4] In the case of Japan, issues regarding to social environment (land acquisition) is undertaken by another entity (Japan Railway Construction, Transport and Technology Agency (JRTT)) and this is one possible example of demarcation of responsibility for Vietnam as well.

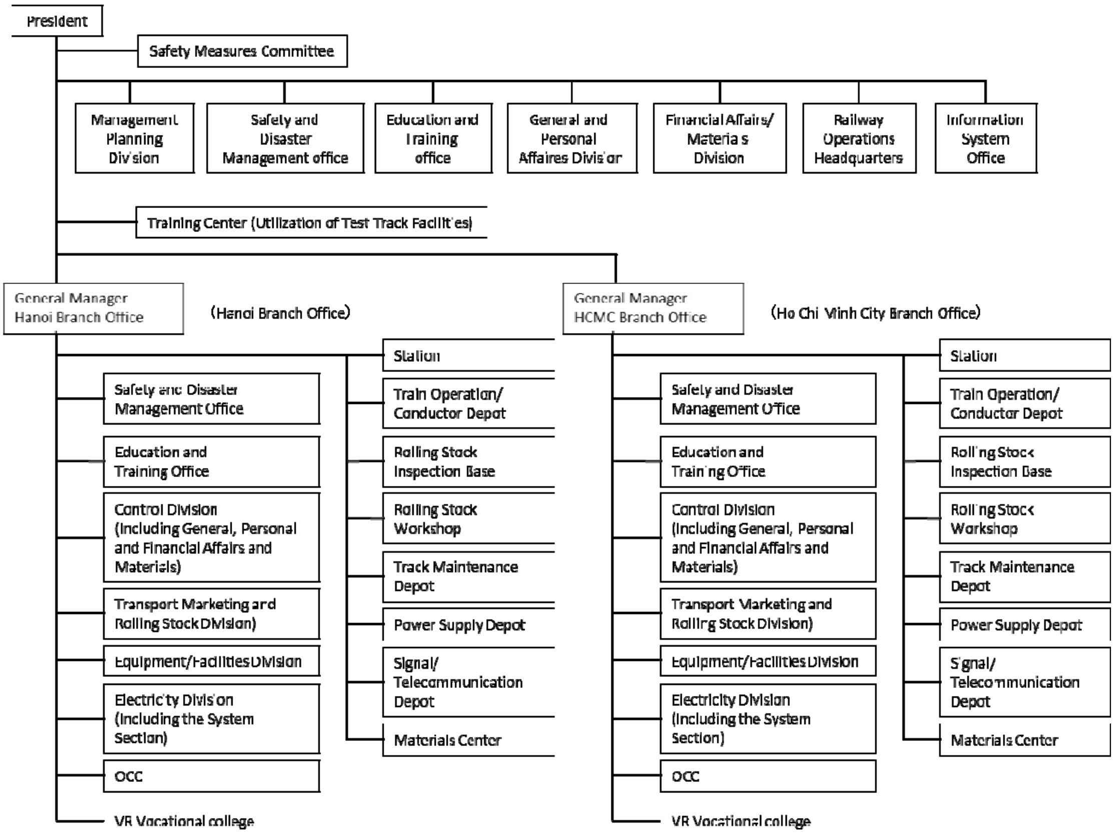
(i) Natural and Living Environment

- Environmental Impact Assessment for sections to be developed;
- Environmental monitoring (during construction and after commencement of operation), including reporting to funding agencies;
- Countermeasures for issues identified through environmental monitoring;
- Environmental management activities in general; and
- Response to grievance raised by residents.

(ii) Social Environment

- Resettlement and rehabilitation of residents[5] (formulation and implementation of Resettlement Action Plan);
- Livelihood monitoring of displaced residents, including reporting to funding agencies;
- Countermeasures for issues identified through livelihood monitoring; and
- Response to grievance raised by residents.

6.104 As mentioned in the discussion on the Vietnamese HSR organization, the Safety and Disaster Countermeasures Office under the head office is an organization independent of the Railway Business Segment. To ensure HSR safety, the Safety Countermeasure Committee shall be set up to discuss safety issues within the organization including the top management.



Source: JICA Study Team
(Note) The above figure omits the board of directors, vice presidents, auditors and other organizations that are thought to be necessary at the incorporation of the company.

Figure 6.3.10 Organizational Chart of the Vietnamese HSR Managing Company

5 The actual resettlement shall be undertaken by local governments.

6.105 The Education and Training Office shall educate 5,000 employees or more for approximately 10 years. Its assignments include the arrangement of curricula, lecturers, and teaching rooms; preparation of training center utilization plans; promotion of OJT and small-group activities; and other matters.

6.106 Train operation control, maintenance of equipment/facilities, and marketing shall basically be borne by each branch office, with the coordination in between implemented by the Railway Operations Headquarter at the head office. As described in the discussion on the Vietnamese HSR organization, it is more efficient for the Information System Division to be under the head office to collectively deal with the ITS for HSR train operation/maintenance and the office ITS for financial/personnel affairs. Regarding the training center, this was discussed on preceding pages.

6.107 Even after the integration of the northern and southern sections in the future, this head office organization will remain effective only if the scale is enlarged to cope with the expanded marketing areas. The organization of branch offices can cope with the situation as well based on the concept of expanding the area of responsibility accordingly with a boundary set between Vinh and Nha Trang.

6.108 **Number of Employees at the Head Office:** The head office will have approximately 170 employees. Refer to Volume II for the detailed number of employees at the head office.

(b) Organization of Branch Offices

6.109 **Divisions under the branch office:** The mission of branch offices is to implement services related to daily train operation control, maintenance of equipment/facilities, and marketing. However, branch offices cannot function by themselves. Therefore, the general services and those on personnel and financial affairs and materials control shall be provided by the Control Division.

6.110 The Safety and Disaster Management Office shall be an organization independent of the Transport, Marketing and Rolling Stock Division like the corresponding divisions in the head office. It shall promote measures to ensure safety in conjunction with the Safety and Disaster Management Office in the head office. The Education and Training Office shall promote the education of employees in coordination with its counterpart office in the head office; the same applies to the Safety and Disaster Management Office.

6.111 The Transport、Marketing and Rolling Stock Division shall control daily train operation, sell tickets, and provide other station services. The Equipment/Facilities Division and the Electricity Division are in charge of the maintenance of tracks/ structures and electric facilities, respectively.

6.112 The services related to the ITS shall be implemented by the head office, with daily trouble shooting and training of those assigned to the division in charge of systems organized in the Electricity Division.

6.113 Regarding the OCC, this as discussed on preceding pages. To implement the training of those related to HSR, the VR Vocational Colleges in Hanoi and Ho Chi Minh offices shall be used to complement the function of the training center belonging to the head office in consideration of geographical conditions.

6.114 **Number of Employees, Control Division, Branch Office:** Each of the Branch Offices in Hanoi and Ho Chi Minh City will have approximately 190 employees. Volume II discusses the detailed number of employees in branch offices.

(c) Concept of Worksite Organizations

6.115 As the worksite organizations, the following stations/bases/centers shall be placed in different sites:

(i) Passenger handling station;

(ii) Operation/conductor depot;

(iii) Rolling stock inspection depot ;

(iv) Rolling stock workshop;

(v) Truck maintenance depot;

(vi) Power supply depot;

(vii) Signal/ telecommunication depot; and

(viii) Materials center.

6.116 As described in the discussion on the Vietnamese HSR organization, the materials center is an organization that shall never be overlooked to ensure the safety of train operation. Therefore, two centers shall be set up in each branch office, or a total of four.

6.117 At the inauguration of the entire priority sections in the northern and southern areas in 2031–2035, the Hanoi Branch Office and the Ho Chi Minh City Branch Office will have approximately 2,200 and 2,500 worksite employees, respectively (see Volume II for the detailed number of worksite employees).

6) Operational Organization Before and During HSR Construction

6.118 The construction of the Vietnamese HSR is a project that will significantly influence the finance of the country. Whatever the organization of the Vietnamese HSR managing company may have and at whatever position it may be placed, the preparatory organization for HSR construction shall be instituted within the government. More concretely, it is appropriate to make it an internal organization of MOT. A reason for this is that as it consumes a long period of time from the preparatory stage to the completion of construction, it may be difficult to entrust the project to the HSR managing company from the preparatory stage. Another reason is that it will become necessary to obtain approval for urban development plans and establish HSR technical standards and other institutions during the period of preparation.

6.119 In addition, it will take a long period of time to implement training and technical transfer for those concerned in Vietnam. Therefore, it is essential that a initial section be constructed before the start of revenue services. This initial section has the tasks of transferring construction technologies during the construction period, operating trains for test purposes after completion, and providing training. Therefore, the above-mentioned preparatory arrangements shall also be undertaken by the government.

6.120 The concrete steps for the above purpose are as follows:

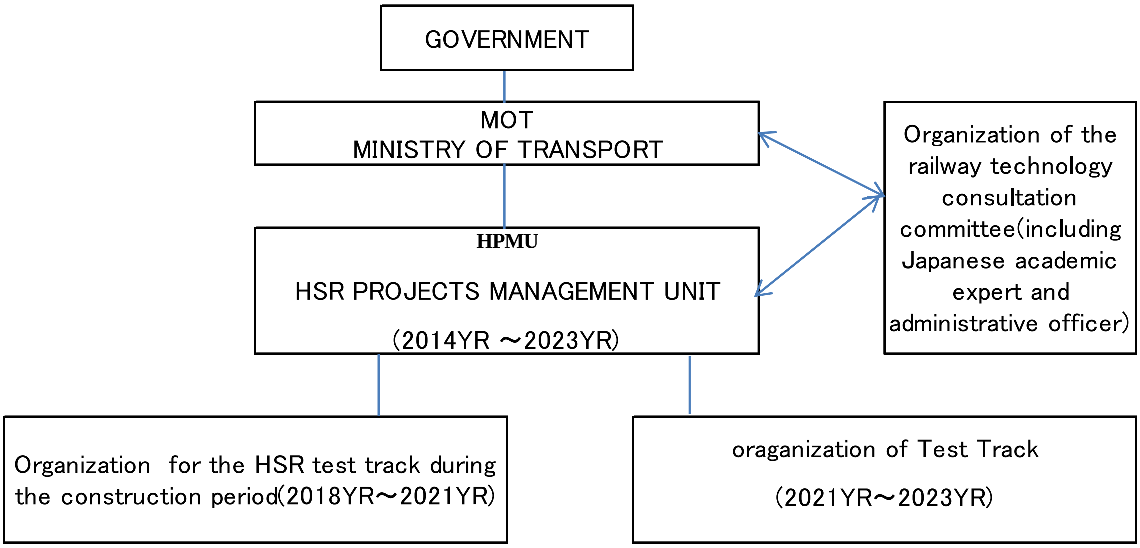
(a) Establishment of Organizations from Preparation to Operation of Initial section

6.121 After obtaining the approval of the National Diet for the project, it is thought that the HSR Project Management Unit (HPMU) shall be set up in the MOT as an HSR construction preparatory organization. This organization shall be in existence until the completion of the establishment of related institutions and the technological transfer using the initial section to Vietnamese HSR personnel or until the completion of tests for about nine years from 2014 to 2023.

6.122 To establish related institutions and technological standards during this period, an organization of the railway technology consultation committee shall be set up with MOT members, Vietnamese government officers, VR members, academic experts from Japan, and members of Japan's Ministry of Land, Infrastructure, Transport and Tourism, as a venue for opinion exchanges among high-ranking government officials.

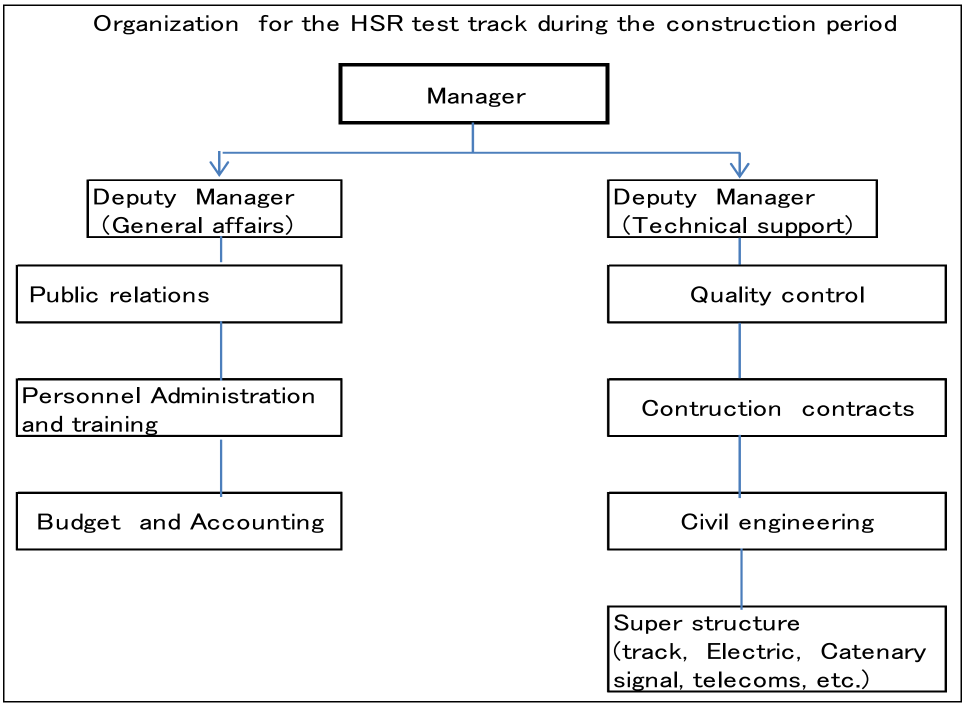
(b) Establishment of Organization during Construction of Initial section

6.123 During the construction period (2018 to 2021), a worksite organization for the HSR initial section shall be set up under the HSR Project Management Unit (HPMU) (2014 to 2023) in the MOT, to supervise construction and transfer construction technologies (see Figure 6.3.12).



Source: JICA Study Team

Figure 6.3.11 Interrelationship of HSR-related Organizations



Source: JICA Study Team

Figure 6.3.12 Organization for HSR Initial section during Construction

(c) Establishment of Organization during HSR Tests

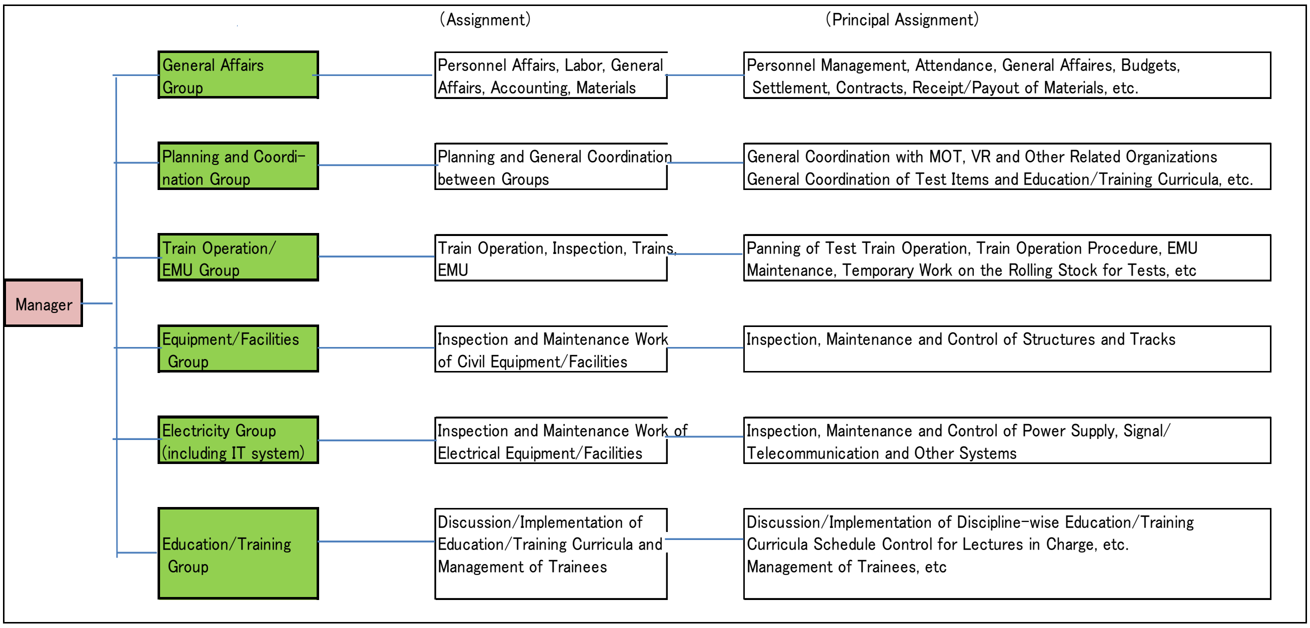
6.124 After the construction of the initial section, an organization (see Figure 6.3.13) shall be set up under the HSR Project Management Unit (HPMU) (2014 to 2023) in the MOT to carry out tests on the initial section and provide training (2022 to 2023). to employees required for the HSR's partial inauguration using the initial section .

(d) Incorporation of HSR Managing Company before Commercial Operations

6.125 **Organization for Partial Commercial Operations using Initial section:** If the Vietnamese HSR implements revenue service operation by using the initial section, it is thought that the HSR managing company shall be incorporated by 2020 at the latest or about four years before the start of revenue services in order to educate or train personnel in using the initial section and implement preparatory services for the inauguration of the HSR.

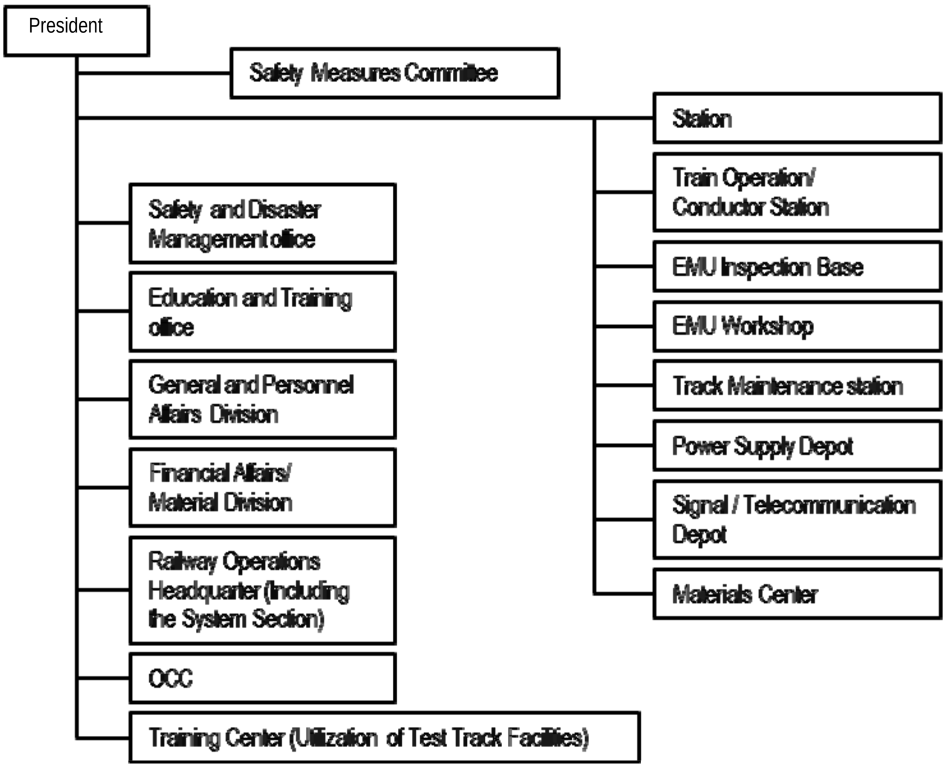
6.126 The operation line in this case should not exceed 50 km. Therefore, the company should only have personnel that meet the demands of the operation line. It is expected to be a small organization (see Figure 6.3.14) which is expected to be absorbed by the headquarters or branch offices when the entire northern and southern priority sections are inaugurated. However, the worksite organization shall be established according to the needs of each section, taking into account preparation for a full-scale opening in the future.

6.127 **Number of Employees during Partial Commercial Operations:** By the time the initial section will be used for partial commercial operations, the head office will have approximately 100 employees and worksite organizations with about 400 employees, or a total of approximately 500 (refer to Volume II for the detailed number of employees during the partial commercial operations of the initial section).



Source: JICA Study Team

Figure 6.3.13 Organizational Chart of Initial Section Control Office



Source: JICA Study Team

Figure 6.3.14 Organizational Chart for Partial Commercial Operations of Initial Section

6.4 Human Resource Development

1) Major HSR Technologies

(1) Overview

6.128 Railways are a huge system comprising tunnels, bridges, roadbeds and tracks, rolling stock, substation that supplies power, telecommunication and signal devices to operate trains, and operators/dispatchers and other people to control train operation. The railways system includes many subsystems, therefore:

(i) Subsystems to form the overall system should be highly reliable backed up by individual technologies;

(ii) Subsystems should be integrated to effectively and organically function to constitute a stable system; and

(iii) Efforts should be continuously made to develop human resources that support the subsystems, create organizations to ensure safety, prepare rules, and implement training.

6.129 What are the differences between existing railways and HSRs? One is the fact that train drivers can apply brakes when they notice an abnormality ahead in the case of existing railways, whereas HSR trains running at 300 km/h cannot stop until they have ran about 5 km after an emergency brake is activated. In other words, it is too late to take necessary actions after finding an abnormality or if the situation is totally beyond human perception. This is true not only for train drivers but also for those in charge of tracks and electric facilities. Based on this concept, HSR facilities should be installed and internal regulations enforced.

6.130 It goes without saying that one purpose of HSRs is to cater to the necessity of safe transport. Shinkansen trains in Japan have safely been running for many years without experiencing serious accidents because the system has incorporated the concept of “fail safe” (i.e., in the event of failure, devices/systems respond in ways that will cause no or minimum harm to other devices or danger to personnel) as its safety philosophy. In discussing organizational and human resource development for HSRs, it is extremely important to incorporate the safety philosophy of “fail safe” and make it thoroughly understood by concerned people.

6.131 In view of the above-mentioned huge systems structure, the component technologies of railways such as train operation, rolling stock, signals and power, and track maintenance, are so specialized that coordination between and among different divisions becomes extremely difficult. As a result, systematic discussions on railways as a whole tends to become insufficient. To strengthen their functions and realize high cost-performance railways, therefore, integrated judgment on the “system” beyond the boundaries of such disciplines is highly important. The HSR organization should be able to make such judgment.

6.132 In particular, high-speed railways are so strongly attuned to a systematic structure where different disciplines are interlinked with each other that an organization shall be constructed to ensure cooperation among multidisciplinary teams.

6.133 With this in mind, the JICA Study Team studied current (i) railway technology, (ii) organization, and (iii) training system in VR after which the Team examined the operational organization and human resource development needed for the HSR.

(2) Present Status of VR Railway Technologies

6.134 The present status of VR railway technologies are as follows:

(i) Single-track operation does not allow a sufficient number of trains to meet the demand;

(ii) Railways have not yet been electrified, so only diesel locomotives can be used to haul trains;

(iii) Security and signal systems, such as ATS or automatic signals, are not in use;

(iv) Interlocking systems at stations are of the relay and mechanical types, which are obsolete;

(v) Telecommunication facilities for dispatching are superannuated telephones;

(vi) The construction of the CTC system has not been completed;

(vii) Machines for track maintenance are few, large maintenance machines and inspection cars deployed are limited to several sets of multiple-head tie tampers (MTT) and rail-flaw detecting cars.

(viii) A ticket reservation system has just been introduced.

6.135 In addition, more serious issues are about bridges, tunnels and other infrastructures. It will be a demanding task, therefore, to start discussions from this state of affairs when introducing a high-speed railway system. While obtaining cooperation from foreign countries, VR is addressing the issue of modernization little by little. Even though the necessity of modernizing the existing railways has been recognized, VR will eventually be bothered with a funding problem.

(3) Introduction of New Railway Technology

6.136 In the future, various modernization projects of VR's existing lines will be carried out in accordance with the demand. However, the need to electrify existing lines is not so great at present. If so, VR cannot learn electrification technology from existing lines before HSR construction. Moreover, various types of ITS have been introduced for HSR operation.

6.137 Until HSR construction, electrification and ITS technology should be learned by all means. In Vietnam now, some urban railway projects in Hanoi and Ho Chi Minh City are ongoing. Prior to HSR construction, it will be very important to acquire the technology of these urban railways.

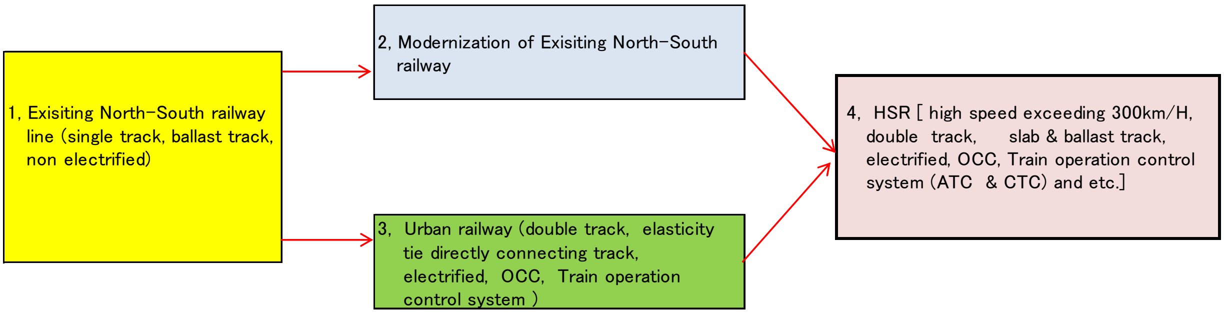
6.138 As a reference to the technology required for the HSR, each system used in the current Shinkansen and the needed expertise are shown in Table 6.4.1. Human resource development for HSR will be discussed in subsequent sections of this report.

6.139 Meanwhile, when considering the flow of new acquisitions to modernize existing lines and construct urban railway until HSR construction, the most suitable method is shown in Figure 6.4.1.

Table 6.4.1 Main Technology Introduced to the Shinkansen and Needed Expertise

Rolling stock, facilities and system	IV. Shinkansen	Qualification	Note
1. Rolling stock and speed	1. Shinkansen car (1) AC induction motor, electric multiple units (2) Shinkansen car inspection system a. Management of car vibration (bogie testing, measurement of wheel, rail contact forces) b. Axle flaw detect system, grinding machine for wheel c. ATC characteristic inspection 2. Speed - 300km/h (1) Rolling stock technology for higher speed than 300-km/h (E5 system) a. Full-active suspension, b. Car body tilting system, c. Brake systems for higher speed than 300-km/h, d. Pantagraphs for low noise, and so on. (2) Maintenance of above-mentioned technology	Shinkansen driver high speed train operation aptitude tests)	
2. Electric facilities	1. Facilities of electric power and substation (1) Substation inspection motor car (inspecting distribution board) 2. Facilities of overhead contact line (high tensile overhead contact line (1) Maintenance of overhead contact line (inspection, electric repair car, catenary installation vehicles) (2) Electric and track inspection car 3. High speed turnouts (related signaling) 4. Train radio and shunting yard radio 5. ATC maintenance 6. The measures against thunderbolt and leaky current 7. Maintenace standard of each Shinkansen electric facilities	1. Electric licensed engineer 2. Constructing qualification of electric facilities 3. Operating qualification of catenary installation vehicles	-
3. Track and civil infrastructure	1. Slab track and Shinkansen ballast track 2. Long rail and high speed turnots (turnout with movable nose crossing) 3. Shinkansen civil infrastructure 4. Electric and track inspection car 5. Slab track inspection tools (large-scaled track maintenance machine is not necessary 6. Maintenance standard of each track and civil infrastructure	1. Supervisor of track construction 2. Inspection engineer of civil infrastructure	
4. Tarin operation management and safety management system	1. ATC 2. CTC - including disaster detecting system (wind, rain and earthquake) 3. COSMOS (Shinkansen total management system) (1) Transport planning system, (2) Train operating management system, (3) Management system of work inside yard premise, (4) Car management system, (5) Management system of track maintenance, (6) Management system of electric power and substation, (7) Monitoring system of communication and information, (8) Equipment management system. 4. Separation of tarin operation time zone and maintenance work time zone – operation of confirmation car. 5. Means of tain protection: (1) Train protective switch, (2) Emergency ground switch, (3) Train protection radio, (4) Device for clearance disorder alarm 6. No level crossing (elevated structure or underground)	-	It is necessary to deploy train operation Manager and becomes possible to do simplification of procedures about designing locomotive and facilities by deploying design manager in Japan.
5. Business facilities	1. Automatic fare collecting system	-	-
6. Safety training	1. Train protection of neighbor track 2. Thorough fail safe (Shinkansen philosophy of safety)	-	-
7. Environmental protection	1. Measures against noise and vibration 2. Measures against tunnel sonic boom	-	-
8. Education and training facilities	1. Construction of Shinkansen test line and training facilities 2. Development of Shinkanse educational institution	-	-

Source: JICA Study Team



Source: JICA Study Team

Figure 6.4.1 Acquisition of Railway Technology for HSR Construction

2) Training in VR

(1) Present Status of Training in VR

6.140 About the current state of education and training in the VR, two issues of "on -the-job training" and "versatile-ized education" are taken up.

(a) OJT as Core of Training

6.141 Training in Japanese railways includes on-the-job training using actual equipment, facilities, and other educational media in the field. This does not mean that formal education is no longer necessary once an employee has acquired needed qualifications; repeat education is essential to maintain the motivation to prevent accidents and ensure the safety of railways. As mentioned above, people cannot work in railway services in the current VR unless they have an appropriate qualification. Regarding on-the-job-training, VR repeats similar practices several times a year but nothing more at the work site. Rather than detailed education and guidance such as those implemented in Japan, VR focuses on repeating qualification tests regularly every year. Employees are subject to penalties or are forced to change jobs if they do not pass the test.

6.142 VR places emphasis checking qualifications rather than education. In Japan, when train operation and related matters change, Japanese railway companies usually give on-site training about the changes. In contrast, in VR, employees are given training in changes in procedures at educational organizations and receive a certificate. For this reason, when complementary education is required for such changes, employees must be educated at VR's vocational college and receive certificates as proof. This is the case because it is not only VR, but also the country, which is firmly based on qualifications. This system may be adequate when technical changes are infrequent, but this cannot deal with fast-changing technology. Aside from qualification, it is also necessary to strengthen OJT for employees.

(b) Life-cycle-oriented Multiskill Education

6.143 The qualifications of VR employees are now finely regulated by law to create a hierarchical system whereby, for example, a driver remains a driver for life. Staying at a job category for life reduces work motivation. For this reason, urban railways in Japan adopt a life-long career system so that employees can experience different jobs/services and can be promoted from being a station staffer, conductor, or driver to a manager, for example. This enhances their work motivation and improves staff efficiency through multiskilling. In Japan, employees can improve their capabilities by experiencing various tasks, being assigned to different workplaces, and repeatedly moving between positions.

6.144 Due to legal and other restrictions, Vietnam cannot flexibly implement policies like those in Japan. Qualifications are specified for most job categories of railway employees as mentioned above. When an employee wants to change jobs, education acquired within the organization is not sufficient; he or she is normally required to obtain a qualification and certificate from an appropriate educational organization.

6.145 An employee assigned at a station remains there for life in Vietnam, except for some employees. Because a company housing policy like that in Japan has not been established in Vietnam, employees cannot be transferred to remote places in Vietnam. If an employee has been ordered to move to a remote workplace, for example, he/she often quits the company because of the attendant high cost of motorbike fuel to commute to the new workplace.

6.146 The Vietnamese government must establish a mechanism to entrust the training of railway employees to respective companies in the future. Otherwise, it will be difficult to promote a diverse training so that employees can do different jobs and VR can effectively improve its staff efficiency. In an interview with relevant divisions at the head office, the interviewees showed interest in the training system in Japan and thought that a diverse education is necessary to raise staff efficiency.

(2) Training to Modernize Existing Railways

(a) Matters to Consider in Training

6.147 VR cannot raise the funds to modernize the existing railways by itself. Nevertheless, VR's own efforts are also required. It must strive to increase the efficiency of its personnel, which it has already started.

6.148 As seen with some railway construction companies associated with VR, they are now introducing new technologies such as those for elevated railway construction. Some have already sent several employees to Japan for training and have expressed their intention to promote overseas training in the future. Such cases are rare, however, where companies which have sufficient profit can address the issue based on their own judgment. It is probably difficult to immediately ask for a life-cycle-oriented multidisciplinary education in the situation of the present VR. However, on-the-job training to correspond to the new technologies introduced from now on should be strengthened. On-the-job training should be examined including the organization

6.149 On the other hand, the VR vocational colleges in Hanoi and Ho Chi Minh City are large, with modern buildings and superb accommodation, presumably because of their relation with a qualification-oriented society. On the other hand, their training equipment/ facilities are old-fashioned and superannuated. However, Binh Duong College in Ho Chi Minh City is now introducing new equipment such as station interlocking and telecommunication systems. An operation simulator will soon be introduced.

6.150 If training facilities are improved in line with the construction of urban railways, it will help VR to shift to HRS technologies. Japan should discuss ways of assisting Vietnam to improve its educational facilities and materials related to electrification and ITS, in particular.

(b) Preparation of Training Tools/Materials and Fund Raising

6.151 As mentioned above, it is extremely difficult for Vietnam to prepare the tools/materials for training and to provide the funds required in the future by itself. To train engineers in urban railways that will be constructed, it is difficult for Vietnam to acquire the necessary technologies without the support of other countries. To establish a training system for transferring HSR technologies, a long time and large training facilities must be prepared in view of the present technological level of the country.

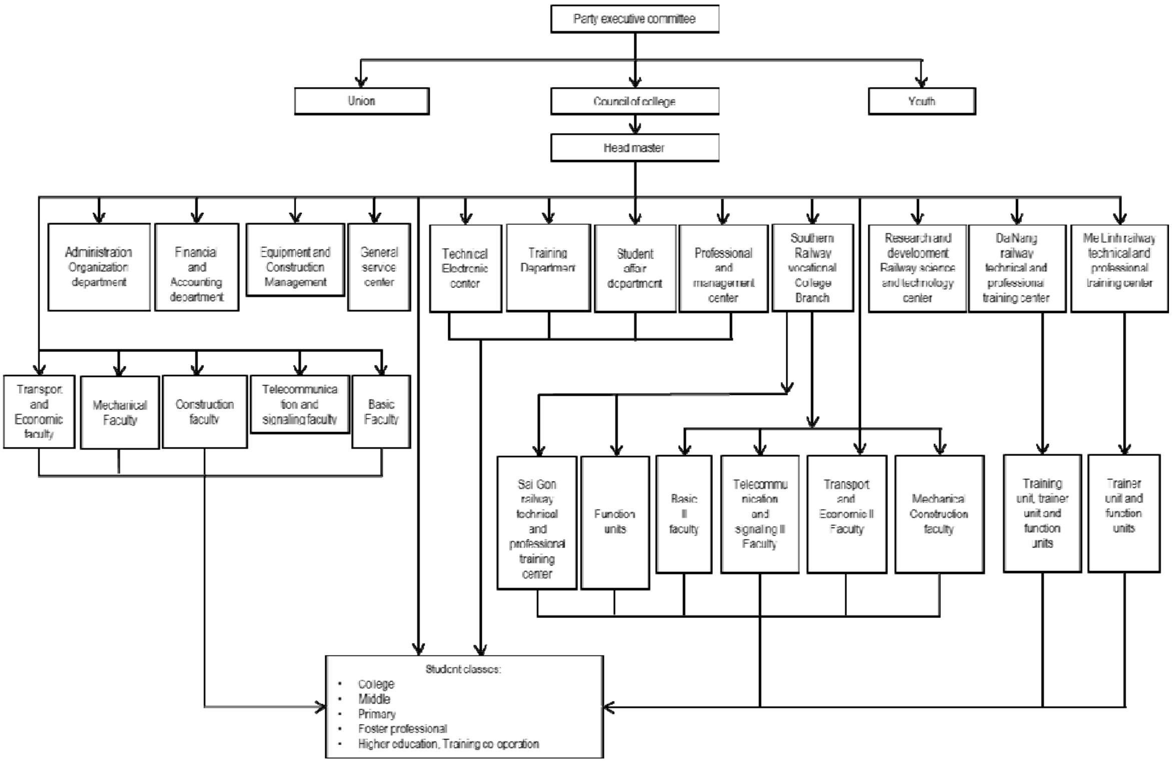
6.152 The training period normally required for railway construction is not sufficient for this purpose. To construct HSR without fail, an HSR initial section must be constructed before the preparatory training period for several years prior to starting revenue services. Training and other special measures can then be performed using the actual HSR.

(c) VR's Vocational College

(i) **Positioning of educational organizations:** As mentioned earlier, VR established two colleges before June 30, 2010, which were then merged into one, the Railway Vocational College, when the state-owned VR was reorganized as a one-member LLC. The Railway Vocational College has become the railway training center in the country, with the Me Linh Training Center, Southern Vocational College, and Saigon Training Center as branches (see Figure 6.4.2).

(ii) **Relationship between College and Related Ministries and Agencies:** Organizationally, the College belong to VR but guided by the Department of Vocation and Training, Ministry of Labor, with regard to vocational training, approval of new training programs, and formats of various certificates (see Figure 6.4.2).

(iii) **Educational and Practical Facilities of VR Vocational College:** Though the College has functional buildings, facilities are inadequate and need improvement. Only the train operation simulator and the ticket booking system are introduced as the latest technologies. Besides, facilities for teaching electrification technologies, ATC, CTC and other security systems are still lacking. Whereas, information technology related to train operation control will become increasingly important in the future.



Source: VR

Note: Department, Faculties, centers cooperate with others under the regulation.

Figure 6.4.2 Organizational Chart of Railway Vocational College

3) Human Resource Development

(1) Basic Concept

6.153 To discuss the training of future manpower, it requires assessment of the present status of VR railway technologies. Based on each problem, the need for and methods of training about essential technologies shall individually be discussed in concrete terms. As stated, current VR railway technologies are backward to start construction and operation of HSR system. Therefore, the basic concept for the development of human resources for HSR should also be from the level of the present VR workforce and planned with a long-term vision.

6.154 The first consideration should be reeducating the current railway administration and management workforce. Construction of urban railways and preparation for operation are already in progress in Hanoi and Ho Chi Minh. In this context, the issues of driver licensing and qualifications of lecturers have already been actualized.

6.155 These issues related to law can hardly be settled by those engaged in practical fieldwork. To become a train driver in urban railways equipped with security facilities, applicants are required to have experience as an assistant train driver for several months, which would be a huge loss for VR in terms of time and cost. However, job categories and qualifications of railway employees are prescribed in detail by national decrees. Even if railway operators want to implement a system that takes into consideration life cycles in order to enhance the motivation of employees, it is impossible to do so from the viewpoint of established conventions. Such issues will certainly come to fore in the future HSR. In addition, these are indispensable issues for Vietnam Railway in promoting modernization and improving management efficiency. To solve such problems that can hardly be settled by practitioners, appropriate authorities shall decide the course to follow.

6.156 For this purpose, a committee tentatively referred to as the "railway technology consulting committee" has to be organized within the Vietnamese government to initiate discussions among those concerned, .e.g, ministries, agencies, and VR, together with the learned and experienced. HSR experts are also required to participate in the committee to provide technical advice. Furthermore, study tours in Japan and seminars are recommended in order to deepen VR staff's understanding of railway projects.

6.157 To develop human resources for urban railways and the HSR initial section, it is expected that the existing railways shall be modernized and a number of urban railways will be constructed. Given the necessity to introduce rolling stock, tracks and electric equipment for that purpose, as well as maintenance technologies for such facilities, necessary technologies for HSR are shown below.

(i) Rolling Stock: Running gears, ATC technologies and rolling stock technologies for high-speed operation at 300 km/h or over (series E5 and others).

(ii) Electric Facilities: Technologies for power supply and substation, ATC and CTC, train radio system.

(iii) Tracks and Civil Structures: Slab tracks, long rails, high-speed turnouts, large maintenance machines, and Shinkansen civil structures.

(iv) Train Operation Control System: ATC and CTC,

(v) Shinkansen integrated control system (Transport planning system, Train operation control system, Yard work control system, Rolling stock control system, Maintenance work control system, Power supply control system, Telecommunication information control/monitor system and Facilities/equipment control system etc).

(vi) Learning of power-related technologies shall be implemented utilizing urban railways and HSR initial section before HSR construction, if not electrifying existing railway.

(2) Issues in Training in HSR

6.158 In developing countries, one of the problems in the developing railway engineers is the training of executive members. When graduates of very reputable universities enter railway companies, they become executives even without worksite experience. That means they will be assigned with the duties of executive members without acquiring the knowledge of worksite organizations supporting train operation. As this is also the case in Vietnam, efforts shall be made by all means to avoid such a situation. For this purpose, Vietnam shall adopt an executive development system that will allow graduates to gain worksite experience for a certain period of time in the same way as in Japan.

6.159 When parts or components such as those of rolling stock fail, railways often rely on their manufacturers for trouble shooting or repair of defective parts/components. Of course, it is important for railways to make an effort to acquire information on various technologies from manufacturers in order to improve their technological level. However, they shall not depend on manufacturers for everything. This is also the case of railways in southeastern Asian countries. With such an attitude, they will not become technologically self-reliant.

6.160 The most important components for rolling stock for high-speed operation are the running gears of trucks (see Table 6.4.3). To ensure safety, various checking systems including the axle flaw detecting system, are adopted. Furthermore, series E cars are equipped with (i) full-active suspensions, (ii) a car body tilting system, and (iii) brake systems for high-speed operation of 300 km/h or more.

6.161 Unlike existing railways, the time for HSR train operation must be distinct from the schedule for maintenance work to ensure passenger and staff safety, as well as short maintenance period for long sections. To do this, various inspection and maintenance machines need to be introduced.

6.162 The operation of high-speed railways is impossible without computer systems. Shinkansen utilizes computer systems to draw train operation diagrams and control train operation/maintenance work. Thus, computers function indispensably for high-speed mass transport systems. Under the circumstances, it is an important issue to what extent VR should introduce computer systems in the future. VR utilizes computer system for accounting systems and other general IT technologies enterprises apply in general. However, IT technologies related to railway operation of VR are far behind the newest technologies; the ticket booking system has just been introduced. However, when introducing the IT system, it should be noted that system users are human beings and the system itself is a tool. Therefore, it is necessary to educate users not to commit mistakes about the database and handling.

6.163 With regard to the organization and development of human resources in Vietnam, VR needs a roadmap for human resource development for HSR (see Figure 5.4.17), clarifying how and where to utilize IT technologies for education considering the schedule of modernizing existing railways, the construction of urban railways, and the construction of the HSR initial section.

6.164 In this context, it is important to utilize a number of staff who have working in urban railways and are capable of working for the HSR in the future. At the same time, it is also necessary to select young key staff in each specific field who can become the main HSR engineers in the future and educate them on urban railways in Vietnam and Shinkansen in Japan.

6.165 Having 40,000 employees, VR has a limited income, indicating that it is not efficient in comparison with railways in foreign countries. Due to lack of funds, VR fails to implement/introduce training programs and facilities. For workers in urban and high-speed railways which will be constructed in the future, it is suggested to utilize existing employees to acquire new technologies and funds from available sources and improve management efficiency. Accordingly, the personnel and funds for human resource development would be secured until the construction of the HSR network. Apart from overseas aids, VR must also raise necessary funds on its own.

(3) Menus for Human Resource Development

6.166 Considering financial and technological aspects, HSR construction would require a long-term perspective. The following should be considered in human resource development prior to the start of HSR operation:

(i) Study tours for a variety of stakeholders to deepen their understanding of HSR technology;

(ii) Training in Japan for each HSR technological section;

(iii) Training in the construction of HSR and urban railways;

(iv) Study on preparing regulations and manuals on operation and maintenance (utilizing urban railway projects and the HSR initial section); and

(v) Training on O&M techniques (utilizing urban railway projects and HSR initial section).

6.167 Study tours and trainings in Japan will promote an understanding of HSR technologies among stakeholders and railway experts. The training for construction is also necessary for engineers in Vietnam to be capable of engaging in HSR construction independently. The training at this stage is also beneficial for learning O&M technologies relevant to electrification and overhead-line and infrastructure and track (for a speed of 300 km/h), and operation through computer systems. Training on operation and maintenance is necessary from the construction stage to operation (utilizing urban railway projects and HSR initial section); since some urban railway projects are ongoing, training intended for urban railways should also be utilized for HSR operation. Acquisition and transfer of these technologies should be carried out for urban railway and the HSR test line to expect perfection.

4) Human Resource Development and Initial Section

(1) Overview

6.168 Human resource development for HSR utilizing both urban railways and the HSR initial section is a considerable option. To transfer the HSR system comprehensively to Vietnam, long-term training utilizing the HSR initial section is necessary. Thus, the initial section is desirable to be developed at an early stage.

6.169 While Vietnamese experts are capable of learning the technologies relevant to electrified railway through urban railway operation, the infrastructures and tracks for high speeds (more than 300 km/h), overhead lines, and rolling stock for HSR have differences with those of urban railway; therefore, unique training for HSR is required. In terms of construction accuracy (for 300 km/h operation), slab track, HSR turnout and high tension overhead line, certain technologies are required which are not available in Vietnam as of now. It is necessary to confirm the extent to which domestic human resources and technologies are applicable.

6.170 While some of the technical specifications of HSR have been provided in Vietnam, it is not comprehensive. Items such as width of formation level and cross-section area of tunnels influence construction costs while necessary safety measures peculiar to Vietnam should be confirmed. These items should be approved by responsible agencies through practices on the initial section.

6.171 Furthermore, Vietnam shall check whether there are no issues to be reinforced from the viewpoint of safety in consideration of the conditions specific to the country. Vietnam shall check how to cope with the meteorological conditions (high temperature in the dry season and fierce squalls in the rainy season, for example). In more concrete terms, Vietnam shall check how to implement operation control to meet different meteorological conditions and under what conditions pluviometers or monitoring cameras shall be installed. Those related to the Vietnamese HSR shall utilize the initial section and other facilities to verify and check these conditions and obtain approval thereof from the authorities of the country. It is also desirable to reflect the results as necessity arises to the construction of the revenue service railways.

6.172 People cannot acquire skills through learning from lectures alone. It is believed that the most important way to learn is to apply the learning and repeating it until one has gained the needed skills.

(2) Technology Transfer during Initial section Construction Period

6.173 In constructing an initial section, it is desirable to promote technology transfer on the equipment/facilities of high-speed railways. In Vietnam, the technologies to construct civil engineering structures are introduced during road construction work. In contrast, Vietnam hasn't experienced much in the technologies on tracks, signals or power supply. In constructing urban railways and designing/constructing a high-speed railway initial section, therefore, it is desirable for Vietnam to complete the initial section while promoting technological transfer among engineers who have been prepared as the future core staff to manage the high-speed railway. If they participate in the projects at the design and construction work stage, engineers will be useful not only in the construction work of the high-speed railway, but also in the control of equipment/facilities after construction.

6.174 During the construction period, HSR engineers mentioned above shall be transferred to a worksite organization under the HPMU in the MOT (see Figure 6.3.12).

(3) Training at the Initial Section and Installation of a Training Center

6.175 Chapter 6.3 has described the organization after the initial section is constructed. Although this organization will primarily implement tests on the track, the test promoter shall also take charge of the training of those related to the Vietnamese HSR. It is difficult, however, to execute this task by foreign experts alone even from the viewpoint of the required manpower. As the counterparts of the foreign experts who will execute the tests, therefore, Vietnamese engineers shall be assigned to educate/train HRS-related members in cooperation with foreign lecturers. Therefore, Vietnam is required to prepare not only facilities related to the initial section, but also those to train and accommodate trainees and related persons.

6.176 The trainees at the initial section are primarily the Control Division staff, leaders at worksite organizations, and personnel belonging to worksite organizations that will handle the partial commercial operations of the initial section (see Table 6.4.2 for the preliminary number of employees assigned with tests and training).

Table 6.4.2 Number of Employees for Tests and Training

Item	Foreign Expert	VN Personnel	Remarks
Manager	1	—	
Sub-manager	—	1	
General Affairs Section	2	6	Including materials service
Planning and Coordination Section	3	3	
Train Operation/Rolling Stock Section	4	12	
Equipment/Facilities Section	4	12	
Electricity Section	6	16	Including the IT system
Training Section	6 + (14)	10 + (14)	Figures within brackets indicate the number of employees in common with other groups.
Total	26 + (14)	60 + (14)	Same as above
Grand total	86 + (28)		Same as above

Source: JICA Study Team

(4) Training Center after the Completion of the Tests at the Initial Section

6.177 When the initial section is in use, facilities for tests and accommodation are installed to implement training of HSR-related personnel. After the completion of tests, however, these facilities shall be used as a training center directly under the Head Office of the HSR managing company. During the partial commercial operations of the initial section, facilities for revenue services will be restricted when a test is underway. It is required, therefore, to install an HSR operation simulator to enable training without using the commercial facilities; training facilities for different disciplines and a computer-aided instruction (CAI) system. Figures 6.4.3 and 6.4.4 show the equipment and facilities in the training center.

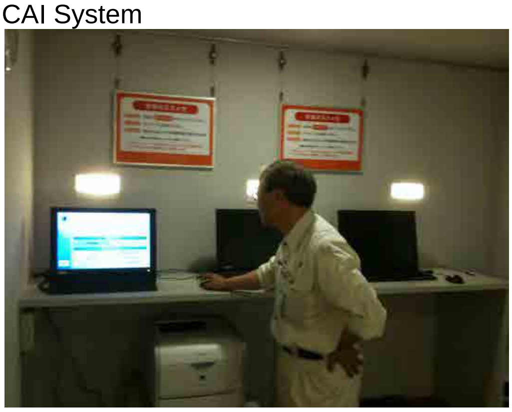
(1) Track Maintenance

(2) Turnout

(3) Contact Wires

(4) Construction and Rolling Stock Gauges

(5) CAI System



Source: Compiled by JICA Study Team

Figure 6.4.3 Equipment and Facilities in the Training Center

(1) Facilities for Outdoor Exercises

(2) Point

(3) Signal Room

(4) Telecommunications Room

(5) OA Classroom

Source: Compiled by JICA Study Team

Figure 6.4.4 Electrical Facilities and Equipment in the Training Center

(5) Training during Partial Commercial Operations of Initial section

6.178 The inauguration of the entire priority sections in north and south will take place approximately seven years after the start of the partial commercial operations of the initial section. This seven-year period shall be used, therefore, to educate and train the approximately 5,000 employees required for the inauguration of the priority sections. The trainees during this period are primarily the worksite personnel, Control Division staff, and leaders at worksite organizations who are not educated on or trained in the HSR.

5) Detailed Training of Vietnamese HSR Personnel

6.179 The necessity of developing HSR personnel has been explained. The detailed method and number of employees to be educated/ trained are described below and on succeeding pages.

(1) Concrete Method to Train Human Resources

6.180 **Preparation of instructors:** The Vietnamese HSR shall consider how to prepare instructors and determine what positions they are to be assigned to. The initial candidates are VR employees. It is thought that at least those who will become HSR core members shall be selected from the current VR employees and educated/trained while keeping pace with the HSR construction schedule. It may not be necessary, however, to select all other members totaling to about 5,000 from VR, in view of the significant technological differences between HSR and existing railways. However, it is an urgent task for VR to raise management efficiency, so that it can produce the employees required for the urban railway Hanoi line 1, for example.

6.181 Regarding HSR employees, VR shall discuss how to secure human resources by hiring new employees or by other means while taking account of the progress of improving management efficiency.

6.182 Before the incorporation of the HSR managing company, it may be appropriate to assign those who are under training to the HSR Project Management Unit or the Organization for the HSR initial section during the construction period.

6.183 **Method of Training:** Taiwan dispatched a number of railway employees to Japan for training at the JR East and JR West to prepare for the inauguration of its Shinkansen railway. In case the period from the preparation stage to inauguration is short, the Vietnamese HSR cannot help but follow suit. However, as the Vietnamese HSR can take a long period of time for training of employees including the period of testing on the initial section, VR can minimize the number of trainees to be sent to Japan, with the rest, approximately 5,000 in number, to be educated/trained in Vietnam although training are partly implemented in Japan. Thus VR will be able to cut the cost of training.

6.184 **Target Trainees for Human Resource Development:** To promote human resource development, VR shall first specify the target employees and the method of training.

6.185 For this purpose, the JICA Study Team adopted the following five levels, of which the level that claims the largest number of target trainees is the worksite personnel. For this level, VR shall train Control Division staff and leaders of worksite organizations to eventually become instructors.

- Executives (heads of divisions or higher levels);

- Managers (heads of sections and worksite organizations);
- Training center lecturers;
- Control Division staff and worksite organization leaders;
- Drivers, conductors, and OCC members; and
- Worksite personnel.

6.186 To make the executives (i) acquire the knowledge about the Shinkansen in Japan, they shall principally be entitled to overseas training in Japan. The managers shall be subject to overseas training and training programs for managers in Vietnam. Training center lecturers, who are the experts shall, together with Japanese experts, train the control division staff and worksite organization leaders and shall carry out exercises for half a year or more in Japan to experience UMRT Line 1 and shall thereafter become lecturers for the staff of the initial section and at the training center. The Control Division staff and worksite leaders shall play a pivotal role in developing HSR personnel. Employees required for the partial commercial operations of the initial section shall engage in exercises in Japan for a certain period of time and shall be educated thereafter using the initial section. After that, the employees for the entire priority sections in the north and south shall be educated and trained using the initial section. It is assumed that the leaders who would have already been trained prior to the commercial operations of the entire north and south HSR sections would approximately be 20% of the total required HSR workforce.

6.187 The drivers, conductors, and OCC members shall acquire expertise regarding their respective jobs. As it is often controversial in urban railways, the issue in what form drivers are to be licensed shall be discussed later in this report. This section simply estimates the number of employees and the period required for training; other matters will be tackled in other sections.

6.188 Worksite personnel shall be trained by the Control Division staff and worksite organization leaders as needed.

(a) **Acquisition of Technologies related to UMRT Line 1 and Construction Work:** Since VR is supposed to manage UMRT Line 1 as well, there may be some hurdle in educating/training HSR employees at a place having a different organization. In view of the fact that HSR is a national project, it is important to allow employees to acquire the technological skills to operate urban railway (UMRT Line 1) by overcoming such hurdle. Training center lecturers mentioned above will serve this purpose. To acquire the technological skills related to the construction of the HSR initial section, those who will become the Control Division staff and worksite organization leaders shall be selected.

(b) **Training of Worksite Personnel:** The training of worksite personnel shall be implemented by the Control Division staff and worksite organization leaders. As there are a great number of trainees and training shall be implemented in parallel for different discipline, therefore, it cannot be done all at the training center of the initial section. Therefore, part of the facilities of the VR Vocational College shall be used.

(2) Training Period and Number of Target Trainees

6.189 Tables 6.4.3 and 6.4.4 summarizes the status of training in Japan and for UMRT, while Tables 6.4.5 and 6.4.6 summarizes the training period and number of trainees based on the above-mentioned concept.

Table 6.4.3 Overseas Training Tours and Technological Training in Japan

Item	Target Trainee	Period	Frequency of Training and No. of Trainees per Training	Total No. of Trainees
Overseas training	(1) Executives	2 weeks	5 persons x 6 times	30
	(2) Managers	3 weeks	10 persons x 6 times	60
Practical exercises in Japan for the employees in different technological divisions	(1) Training center lecturers	6 months	10 persons x 6 times	60
	(2) Control Division staff and worksite organization leaders (employees for the partial operation using the initial section)	2 months	10 persons x 15 times	150
Total No. of Trainees				300

Source: JICA Study Team

Table 6.4.4 Acquisition of Urban Railway (UMRT Line 1) Technologies and Initial Section Construction

Item	Target Trainee	Period	Frequency of Training and No. of Trainees per Training	Total No. of Trainees
Acquisition of technologies at the urban railway URT line 1	Training center lecturers	2 years	30 persons x 2 times	60
Acquisition of the technologies at the initial section construction work	To be selected from the Control Division staff and worksite organization leaders	2 years	30 persons x 2 times	60
Total No. of Trainees				120

Source: JICA Study Team

Table 6.4.5 Training at the Initial Section Training Center

Target Trainee		Period	Frequency of Training and No. of Trainees per Training	Total No. of Trainees
1. Training of the training center lecturers assigned to the UMRT line 1		10 months	60 persons x 1 times	60
2. Employees for the partial inauguration using the initial section	(1) Control Division staff and worksite organization leaders	4 months	50 persons x 3 times	150
	(2) Worksite personnel	2 month	50 persons x 6 times	300
	(3) Drivers	8 months	20 persons x 1 time	20
	(4) Conductors	4 months	15 persons x 2 times	30
	(5) OCC members (required during the period of training operation for drivers)	6 months	28 persons x 1 time	28
Total No. of Trainees				588

Source: JICA Study Team

Table 6.4.6 Training after HSR Initial Section

Target Trainee	Venue of Training	Period	Frequency of Training and No. of Trainees per Training	Total No. of Trainees
(1) Control Division staff and worksite organization leaders	Training center and worksite organizations	4 months	50 persons x 20 times	1,000
(2) Worksite personnel	VR Vocational Colleges and worksite organizations	2 month	80 persons x 41 times	3,280
(3) Drivers	Training center	8 months	20 persons x 8 times	160
(4) Conductors	Training center	4 months	30 persons x 8 times	240
(5) OCC members (required during the period of training operation for drivers)	Training center and OCC	6 months	20 persons x 3 times	60
Total No. of Trainees				4,740

Source: JICA Study Team

(3) Contents of Training

6.190 **Training of Executives:** The problems in training executives in developing countries were already discussed. Therefore, the concrete training schedules will not be discussed anymore. However, it is necessary to prepare a venue for executives to experience worksite services in one way or another.

6.191 **Training in Safety Measures Common to Different Fields:** At the training center and other facilities, what will be common among different fields is the training in safety. To ensure safety, a system shall be established for the whole of the railway as explained above. In this context, a concept of "fail-safe system" exists as a factor for Shinkansen in Japan having been operated for a long period of time without experiencing accidents. In addition to this concept, there are more important missions for railway operators, in that they shall make their employees thoroughly understand the importance of preventing: (i) accidents in train operation and (ii) injuries to passengers and employees. At the HSR managing company, all members from the top to the rank-and-file personnel shall be deployed to promote organization-wide safety measures. For this purpose, it is extremely important for railway operators to address safety as a management policy. At the incorporation of the company, therefore, the Vietnamese HSR shall establish basic management policies, clearly stating their position on safety. These policies shall be disseminated to its employees for strict compliance.

6.192 **Preparation of Appropriate Rules and Manuals for Different Fields:** For the purpose of train O&M, the Shinkansen railways in Japan prepare a number of rules and manuals for each of the different fields. The rules to ensure the safety of Shinkansen train operation are not only set forth by Shinkansen railways but they are also closely linked to the laws and ministerial ordinances issued by the government.

6.193 To start the commercial operations of HSR, therefore, Vietnam shall prepare laws at the preparatory stage and set rules and manuals for different fields within the organization. To prepare the laws for HSR in particular, government officials related to HSR shall acquire the knowledge thereof and experience actual train operation on the initial section. To facilitate opinion exchanges between government officials in Vietnam on one hand and experts and government officials in Japan on the other, to prepare for the HSR construction, Japan will exert every effort to organize a railway technology consulting committee and extend full cooperation with Vietnam.

6.194 Appropriate rules and manuals referred to the above shall be finalized before the start of the tests on the initial section if possible, or before the completion of the tests at the latest.

6.195 Employees in different fields shall be instructed on these rules and manuals first, before receiving training in the structures of equipment/facilities or rolling stock and the methods of their handling/inspection, trouble shooting and maintenance. The curricula to be used for the above training shall also be discussed. In this training, teaching through one-way communication from the lecturers' side is not enough. Computer-aided instruction (CIA) shall be used to teach the trainees.

6.196 **Special Technological Factors in the Development of HSR Employees:** In the above discussions, the development of HSR employees is described from a macroscopic viewpoint. There may be some special technologies in different fields, however, that will require quite a long period of training. As the number of employees related to this problem seems to be limited, however, this matter will be tackled in future studies.

(a) Rolling stock: (1) Control of car body vibration (tests on a truck running a testing machine, control of truck running, measurement of wheel load /lateral force, etc.), (2) Axle flaw detection, (3) Wheel grinding, (4) Inspection of ATC characteristics, etc.

(b) Track and civil engineering: (1) Slab track inspecting device, (2) Maintenance of ballast-reinforced track beds, (3) Long rails and high-speed turnouts, (4) Handling of multiple tie tampers and maintenance cars, etc.

(c) Electric equipment/facilities: (1) Maintenance of substations, (2) Maintenance of high-tension trolley wire system, (2) Handling of contact wire spreading cars and electric equipment/facilities maintenance cars, etc., (2) Maintenance of ATC and CTC, (4) Maintenance of insulated and non-insulated track circuits, (5) Train radio and yard radio, (6) Disaster detecting system.

(d) General systems: (1) Train operation control system, (2) Power supply system control system (supervisory control and data acquisition system: SCADA), (2) Passenger information system, etc.

(4) Qualifications and Development of Human Resources

6.197 As already mentioned on the current status of railway technologies in Vietnam, the country is a society principally oriented toward qualifications. In Japanese railways as well, several qualifications are legally set, such as those of drivers, construction work execution controllers, and electric equipment/facilities chief engineers in regard to construction work. The qualifications of track construction controllers, civil engineering structure inspection engineers, and handlers of contact wire spreading cars are mostly effective only within railway companies. Regarding the development of human resources, in view of the Vietnamese qualification-oriented society, it might be appropriate that Vietnam discuss the introduction of a qualification system in one way or another to depart from the passive training system in which trainees are supposed to be taught by means of mere one-way communication.

Table 6.4.7 Formulation of Rules for Different Fields in the Shinkansen in Japan

Laws and ministerial ordinances, etc.	Internal		
	Internal control rules and implementation criteria	Procedure and criteria, etc.	Standards and main points (manuals), etc.
(1) Stations and Marketing			
1. Railway operations law (1) Ministerial ordinance to specify the criteria on railway technologies (2) Ministerial ordinance on the security of train operation	• Operation rules • Train operation handing/ implementation criteria • Norms on the safety of train operation	• Income from transport services and compiling/handling of relevant reports • Lost articles handling criteria • Rules on the discounts for physically handicapped persons and other charges • Procedure to control train operation at disaster • Procedure to deal with the accidents in train operation • Procedure on the railway meteorological notification • Procedure to inspect the appropriateness of railway-related services • Procedure to report and classify accidents in train operation	• Rules on the handling of IC card tickets

Laws and ministerial ordinances, etc.	Internal		
	Internal control rules and implementation criteria	Procedure and criteria, etc.	Standards and main points (manuals), etc.
(2) Rules on Train Crews			
1. Railway operations law (1) Ministerial ordinance to specify the criteria on railway technologies (2) Ministerial ordinance on the security of train operation (3) Ministerial ordinance on the license for power car drivers	• Train operation handing/ implementation criteria • Norms on the safety of train operation	• Procedure to control train operation at disaster • Procedure to deal with the accidents in train operation • Procedure on the railway meteorological notification • Procedure to inspect the appropriateness of railway-related services • Procedure to report and classify accidents in train operation • Standards on the training of power car drivers	• Main points in train operation • Standards for drivers •((1) Criteria of driver duties, (2) Standards on driver services, (3) Guideline to train operation/handling in emergency) • Standards for conductors • ((1) Criteria on conductor duties, (2) Standards on conductor services, (3) Guideline to train operation/handling in emergency)
(3) Rolling Stock			
1. Railway operation law (1) Ministerial ordinance to specify the criteria on railway technologies[1)] (2) Notice on the regular inspections for equipment/ facilities and rolling stock[2)] (3) Criteria on the interpretation of director directives[3)]	• Rules on the control of rolling stock • Criteria on the implementation of Shinkansen car services (Decretory specification of the criteria on service implementation) • Criteria on the implementation of the rolling stock structure (Prescription of the minimum specifications)	• Standards on the Shinkansen car services (Speculations) (Specification of the servicing system and standards on services) • Standards on the design of rolling stock structure and other structures (Prescription of design criteria, targeted numerical values and specifications)	• Standards of the detailed rules on the services for cars of different types
(4) Equipment/ Facilities			
1. Railway operation law (1) Ministerial ordinance to specify the criteria on railway technologies[1)] (2) Notice on the regular inspections for equipment/ facilities and rolling stock[2)]	• Rules to control implementation criteria • Shinkansen track equipment/ facilities implementation criteria	• Rules on the Shinkansen track structure implementation criteria • Criteria on the implementation of the maintenance of Shinkansen civil engineering structures • Procedure to use maintenance cars (Speculations) • Procedure to spread track ballast while running (Speculations) • Standards on the guarding against disasters on tracks, etc. (Speculations)	• Working rules on the procedure for Shinkansen train operation related to maintenance work • Specifications on the security of construction work close to revenue service lines • Standards on the inspection of welded parts of rails • Main points in the train operation control against rainfall, etc.

Laws and ministerial ordinances, etc.	Internal		
	Internal control rules and implementation criteria	Procedure and criteria, etc.	Standards and main points (manuals), etc.
(5) Electricity			
1. Railway operation law (1) Ministerial ordinance to specify the criteria on railway technologies1) (3) Notice on the regular inspections for equipment/ facilities and rolling stock2)	• Train operation handing/ • implementation criteria • Rules to control implementation criteria • Shinkansen track equipment/ • facilities implementation criteria • Criteria on the implementation of Shinkansen operation security equipment/facilities	• Procedure of trolley wire maintenance work under power shutdown (Speculations) • Procedure of maintenance work (Speculations) • Criteria on the control of the system of electric equipment/facilities (Speculations) • Criteria on the report of the statistics of electric telecommunication traffic (Speculations) • Criteria on the utilization of electric telecommunication (Speculations) • Criteria on the installation of wire electric telecommunication equipment/facilities (Speculations)	• Standards on the design of electric structures (Shinkansen substation equipment/facilities) • Standards on the design of electric structures (Shinkansen trolley wire system) • Standards on the Shinkansen signal/security equipment/facilities • Standards on the design and execution of the construction work of Shinkansen signal/security equipment/facilities
2. Railway operations law (1) Rules on the report of railway accidents, etc. (ministerial ordinance) (2) Rules on the report of railway operation, etc.		• Criteria on the report of electricity accidents (Speculations) • Design specifications • Criteria on the report and statistics of electric equipment/facilities, etc. (Speculations)	
3. Electricity enterprises law (1) Detailed rules on the implementation of electricity enterprises law (2) Technological criteria on electric equipment/facilities	• Rules on security	• Criteria on power supply and demand (Speculations)	• Main points in the report and statistics of power supply and demand

Source: JICA Study Team
1) Rolling stock servicing, inspection of trains, duties of regular inspections, requirements for rolling stock performance, etc.
2) Periodicals of regular inspections, exceptions thereof, etc.
3) Concretized representation of the interpretation of ministerial ordinances and notice

6.5 Funding Options

1) General

6.198 In other countries, HSR projects have been carried out mainly by governments or public entities. However, private sectors become involved recently in the operations and development of high-speed railways. The involvement of the private sector in HSR development is important to decrease the financial burden on governments and also to enhance the operational or managerial efficiency of high-speed railways. Such involvement does not necessarily mean that the private sector can or should take full risks of a high-speed railway projects. This section oversees the international examples of high speed railway developments, and then discusses funding options.

2) International Examples of HSR Operational Structures

6.199 This subsection describes international examples of high-speed railways. The table below depicts the division of responsibilities between private and public sectors.

Table 6.5.1 Responsibilities of Private and Public Sector in HSR Management

<table>
<tr><th colspan="2"></th><th>Japan</th><th>Japan (Lines opened before 1997)</th><th>Taiwan</th><th>Korea</th><th>Germany</th><th>France (Original)</th></tr>
<tr><td colspan="2">Operation</td><td rowspan="5">JR (Private)</td><td rowspan="7">JR (Private)</td><td rowspan="7">THSRC (established as private, but public share was increased)</td><td rowspan="5">Korail (Public)</td><td colspan="2" rowspan="2">Deutsche Bahn (Shares owned by public)
SNCF (Shares owned by public) and etc.</td></tr>
<tr><td>Rolling stock</td><td rowspan="3">Main tenance</td></tr>
<tr><td>Super Structure (Rail, station, signal)</td><td rowspan="2">DB Netz (100% subsidiary of DB)</td><td rowspan="2">RFF (Public) and / or Concessionaire (Private)</td></tr>
<tr><td>Sub-structure (Land, tunnel, bridges)</td></tr>
<tr><td>Rolling stock</td><td rowspan="3">Ownership</td><td>Deutsche Bahn (Shares owned by public)</td><td>SNCF (Shares owned by public)</td></tr>
<tr><td>Super Structure (Rail, station, signal)</td><td rowspan="2">JRTT (Public)</td><td rowspan="2">KR (Public)</td><td rowspan="2">DB Netz (100% subsidiary of DB)</td><td rowspan="2">RFF (Public)</td></tr>
<tr><td>Sub-structure (Land, tunnel, bridges)</td></tr>
</table>

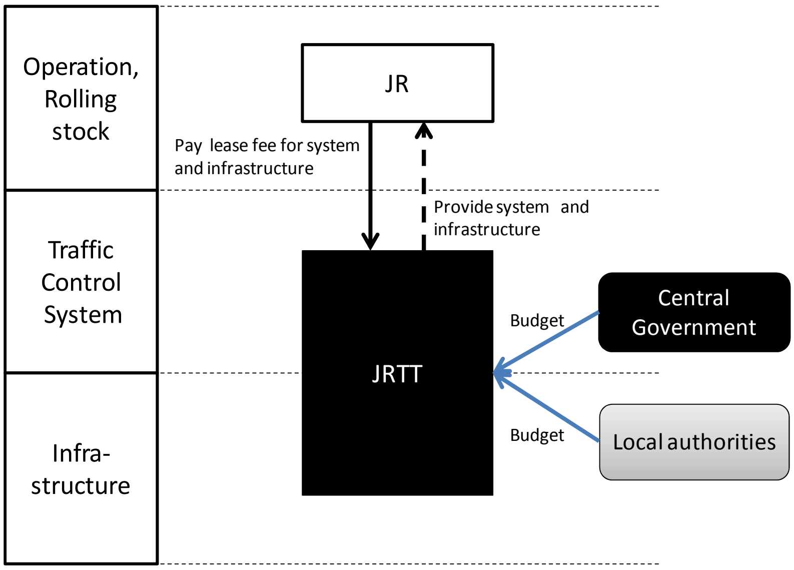
Source: JICA Study Team
* In France, a part of infrastructure is invested by private concessionaires.
** DB (Germany) is a private joint stock company and SNCF (France) is an industrial and commercial public institution (EPIC) both wholly owned by governments.

(1) Japan

6.200 In Japan, the first high-speed railway (Shinkansen) started operations in 1964 between Tokyo and Osaka (515 km). Other lines have been developed since then. In 1987, the public operator, Japan National Railways, was split and privatized as Japan Railways).

6.201 Currently, JR (private) and a public agency share the responsibilities in the development of new high-speed railway lines. The operations of high-speed railway are under the responsibility of JR, while the infrastructure is developed and owned by the public agency, Japan Railway Construction, Transport and Technology Agency (JRTT).

6.202 Besides the operations of high-speed railways, JR carries out the maintenance of infrastructure, which is owned by JRTT. JR pays JRTT a rental fee for the use of the infrastructure.

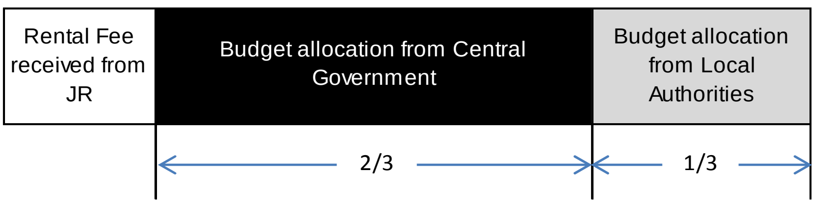


Source: JICA Study Team

Figure 6.5.1 Division of Responsibilities in Japanese HSR

6.203 The key feature of the Japanese high-speed railway is that the operation of high speed railway, maintenance of rolling stock, and maintenance of infrastructure are carried out consistently by the lead of the JR group. This consistency is said to be the key to the operational safety and efficiency of high speed railways.

6.204 Infrastructure developments are funded by several sources. The first source is the infrastructure rental fee paid by the operator, JR. The remaining amount comes from state budget. Two thirds of the state budget is from the central government and the remaining one third is from local authorities.



Source: JICA Study Team

Figure 6.5.2 Revenue Sources of JRTT

6.205 The infrastructure rental fees paid by JR to JRTT are not fixed; they are determined by revenues of the JR group on the respective lines. In other words, JRTT or the government covers a part of the operational or ridership risks, so that JR can be profitable.

(2) Taiwan

6.206 The high speed railway in Taiwan is a unique case, in which both the development and operation of infrastructure were carried out under a BOT scheme. Under the BOT scheme, Taiwan High Speed Rail Corporation (THSRC) made all the investment in rolling stock, traffic control system, and infrastructure, and it carries out the operation of high speed railway for 35 years, before transferring them to the government.

6.207 Originally, the government was involved in THSRC as a minority shareholder (11.9%), and most of the equity came from private investors. Debts were financed through private credit institutions with government guarantees.

6.208 However, since the commencement of commercial operations in 2008, THSRC had incurred losses due to several reasons, such as (i) overestimated ridership, (ii) cost overruns, and (iii) higher interest costs than planned. As THSRC faced problems in cash flows and repayment of debts, the government decided to step into the management, by increasing its shares and the number of board members in THSRC. The government also refinanced the debts of THSRC through state-owned banks, offering lower interest rates. The annual depreciation amounts were also reduced, so that THSRC can post profits. Eventually, THSRC started making profits from 2011. During the restructuring processes, the total government financial contributions were increased from 21% to 84%.

6.209 This case is indicating that the high-speed railway projects, in which private sector takes huge risks with high debt proportion, faces difficulties. Such projects can eventually lead to the increase in government cost burdens and responsibilities.

(3) Korea

6.210 In Korea, high-speed railways started commercial operations in 2004. Korail (Korea Railroad Corporation) is responsible for the operations, and KR (Korea Rail Network Authority) is for the ownership and development of infrastructure. Korail is a public company, which also operates local railways. KR is a public body, fully funded by the government. Korail pays rental fee for the infrastructures to KR.

6.211 High speed railways were initially planned to be developed with BOT scheme, but the government decided to implement the projects through public bodies (Korail and KR), due to the huge costs and project risks.

6.212 Korail receives financial support for ridership from the government. If the actual demand is smaller than the target, the government pays the predetermined compensations to Korail to cover part of the losses. Although Korail would make efforts to minimize the gap between the target and actual demands also to minimize losses from operations, it might face unlimited loses if the gap is too huge.

(4) Germany and France

6.213 In Europe, each country separates operators from infrastructure managers, according to “Council Directive of 29 July 1991 on the development of the Community's railways (91/440/EEC)”.

6.214 High speed railways are operated by DB (Deutsche Bahn) in Germany and SNCF (Société Nationale des Chemins de fer Français) in France. DB (Germany) is a private joint stock company and SNCF (France) is an industrial and commercial public institution (EPIC) both wholly owned by the government. Infrastructure is managed by DB Nez in Germany and RFF (Réseau Ferré de France) in France. These companies also carry out the maintenance of the infrastructure.

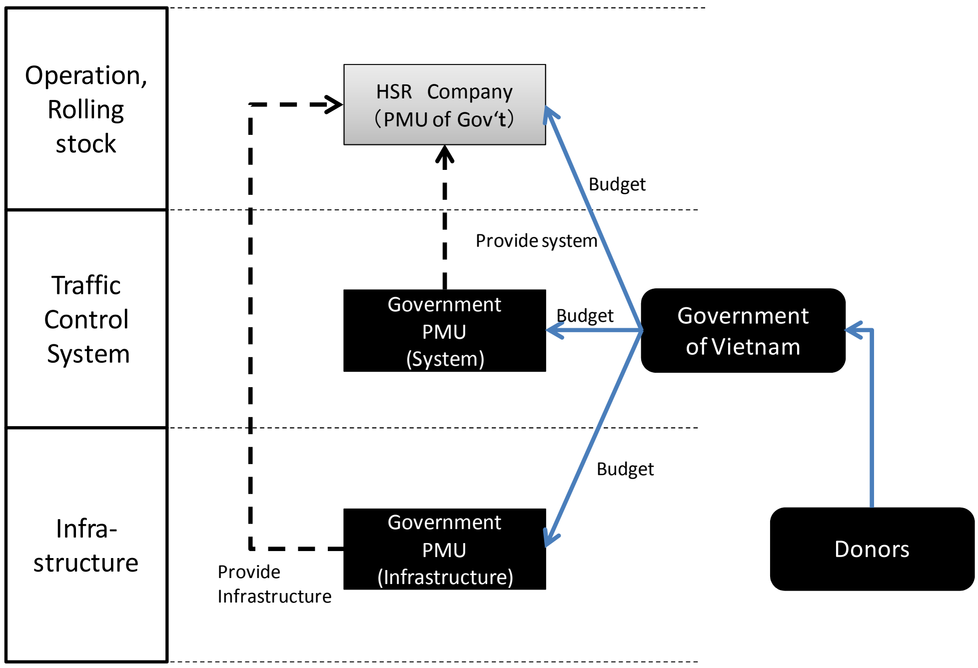
6.215 RFF in France started contracting out the development and maintenance of the infrastructure to private concessionaires. Concessionaires develop the infrastructure, carry out maintenance, and transfer the asset to the government after 30-50 years. The concessionaires receive availability payment from RFF, under the condition that the quality of the infrastructure is sufficient. More than half of the fund for the development of the infrastructure comes from subsidies by the government and RFF. Remaining parts are financed by self-financing and bank loans, partly guaranteed by RFF.

3) Implementing structure

6.216 As mentioned above, private participations are encouraged, but it does not necessarily mean that the high speed railway projects can be carried out only by the initiatives of privates. Railway projects with huge risks and heavy financial costs taken by privates cannot be successful or sustainable, and it can eventually lead to the increase in the responsibilities and financial costs of the government. This section tries to discuss the sharing of the responsibilities and costs between private and public, so that the projects can be carried out most efficiently.

6.217 Implementing structures are suggested separately for test operations and commercial operations. This is because the test operations do not generate any profits, and it is not possible to expect private investment or financing, while commercial operations are expected to generate certain profits.

(1) Implementing structure during initial section operation



Source: JICA Study Team

Figure 6.5.3 Implementing Structure (Initial Section Operation)

6.218 For initial section operations, High Speed Rail Company (HSR Company) carries out the operations using its own rolling stocks, while the government develops the traffic control system and infrastructure. As HSR Company does not generate revenues or profits through test operations, it is more appropriate to establish HSR Company as a state owned enterprise (SOE) or as a project implementation unit.

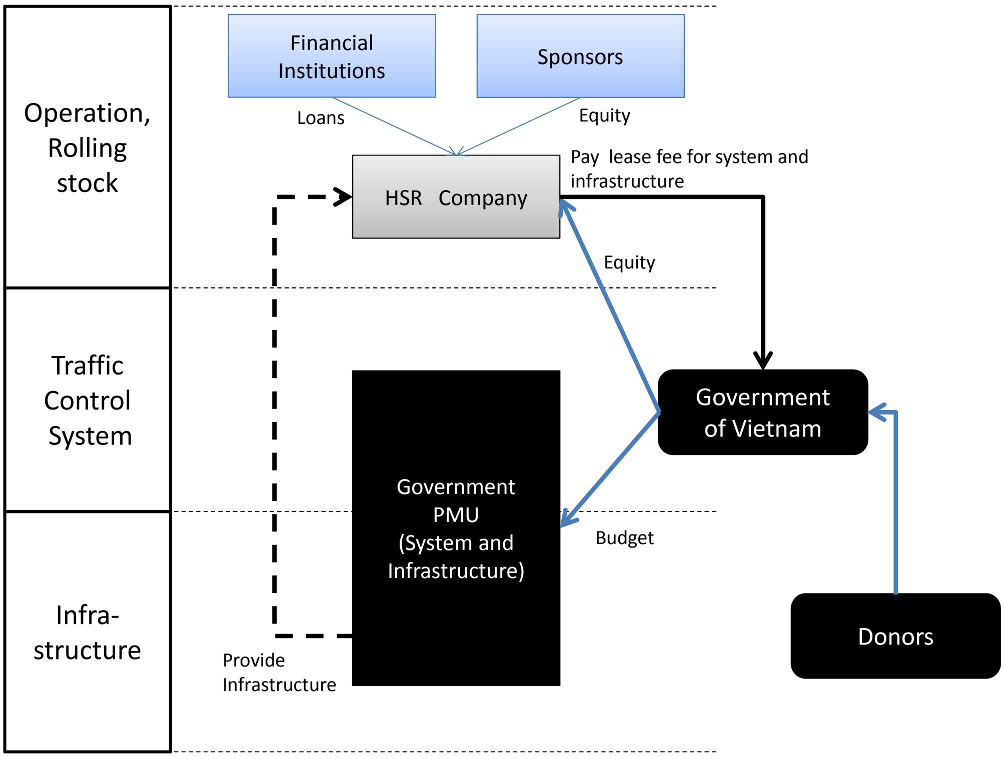
6.219 The expenses of HSR Company during the initial section operations are covered by state budget. Costs for initial section operations should not be transferred to HSR Company upon the commencement of commercial operations in a form of losses or deferred capital. If HSR Company succeeds such costs upon the commercial operations, HSR Company cannot be financially viable, and then it is not possible for HSR Company to access private investments and financing.

6.220 HSR Company is supposed to be established as a separate body from Vietnam Railways (VR). Staffs might be transferred from VR to HSR Company upon necessity.

(2) Implementing structure after commercial operation

(a) Implementing schemes

6.221 The implementing structures after the commencement of commercial operation are similar to the one for the test operations, although substantially different. Similar to the structure for the test operations, HSR Company owns rolling stocks and carries out the operation of high speed railways, while the traffic control system and the infrastructure are owned and developed by the government. The major difference to the test operations is that HSR Company carries out the operations on commercial basis, accessing to private investments and financings.



Source: JICA Study Team

Figure 6.5.4 Implementing Structure

6.222 HSR Company carries out operations of high speed railways, and it also carries out the maintenance of rolling stocks and infrastructures. This is because the consistency among the operation, maintenance of rolling stocks, and maintenance of infrastructure is the key to the safe and efficient operation of high speed railways.

6.223 The responsibilities of HSR Company are as follows;

(i) Operations of high speed railway

(ii) Ownership of rolling stocks

(iii) Maintenance of rolling stocks

(iv) Financing for rolling stocks

(v) Maintenance of traffic control system

(vi) Maintenance of system and infrastructure

6.224 The government will be responsible for;

(i) The development and ownership of the traffic control system and the infrastructure

(ii) Land acquisition and resettlement

6.225 Financial viability of HSR Company is the minimum requirement for the sustainability of the operations of high speed railways and also for attracting investors and financial institution. When HSR Company cannot achieve profits from operations, it would face difficulties in continuing operations. Therefore, the government supports, such as minimum guarantee for revenue, are essential.

6.226 The traffic control system and the infrastructure is developed by state budgets. As they do not generate any revenues or profits, it is not possible to finance the investment by private funding. The government would expect the supports by bilateral or multilateral donors.

(b) Ownership of HSR Company

6.227 This sub-section discusses the ownership of HSR Company. There are several alternatives for the ownerships of HSR Company, and each alternative has pros and cons.

Table 6.5.2 Alternatives for the Ownership of HSR Company

	Level of ownership by the government
A. Government initiative	a) 75-100% b) 65-74%
B. Co-initiative of government and private	35-64%
C. Private initiative	-34%

Source: JICA Study Team

Case A. Government Initiative

6.228 HSR Company under government initiative has two options for the levels of government shares; a) 75-100%, and b) 65-74%. Under the enterprise law (Article 104), a special resolution is passed by the approval by a number of shareholders representing at least 75% of the total voting shares, and an ordinary resolution by the approval by 65%. Therefore, if the government owns shares more than 75%, it can pass most of the resolutions by its own decisions. Similarly, if the government owns more than 65% of total shares, it can pass ordinary resolutions by itself, but not special resolutions. If the government prefers to have very strong controls on the management of HSR Company, it owns more than 75%.

6.229 When most of the shares are owned by the government, the government might wish to be involved in all managerial decisions of HSR Company. However, as it is generally pointed out, state owned enterprises cannot always achieve efficient management or post high profits, due to the inefficient management and lack of supervisions. In order to achieve the managerial efficiency or supervisions, the involvement of private investors as shareholders or board members would be more appropriate. The government should then limit its roles only to the supervisions of the management of HSR Company.

6.230 HSR Company under government initiatives is set up as a separate company from Vietnam Railways (VR). If the government decides to make HSR Company as a subsidiary of VR, the government will provide fund to VR first, and then VR uses the fund for the equity of HSR Company. Then the shares of HSR Company are owned by VR. Alternatively the government might want to own the shares of HSR Company by itself or through a stock holding company of the government.

Case B. Co-initiative of the government and private

6.231 When the government owns 35-64% shares, any shareholders cannot pass any ordinary resolutions by its own decisions. Involvement of private shareholders will let the management of HSR Company to make efforts to improve its profitability and operational efficiency.

6.232 The question for this option is whether there are any investors which can provide sufficient capital to HSR Company. Financial institutions can be candidates for the shareholders. Construction companies or developers which will be interested in rail civil works and the maintenance of rail infrastructure should not be shareholders, as they might be more interested in being awarded as contractors for civil works, and they tend to increase the contract prices.

Case C. Private initiative

6.233 In this case, the government owns minority shares (smaller than 34%) and majority is owned by private investors. As the government does not own more than 35%, it cannot reject special resolutions by itself. Decision making in the management will be carried out by the agreement of various shareholders.

6.234 Similarly, a question of Case C is that if there are any private investors interested in joining HSR Company as major shareholders, especially if they cannot expect high return on investment. At the same time, if they think that operational risks are too big but returns are small, private investors would not join HSR Company. Therefore, even HSR Company is under private initiatives, the government will have to take necessary measures to mitigate the risks of shareholders.

6.235 Letting private sector take too much risks tends to end up with the takeover by the government. Therefore, in any cases, the risk shares by the government will be essential to achieve efficient and sustainable operations of high speed railways.

6.236 If it is not possible for private investors to join HSR Company as shareholders from the beginning, the government might have to start from Case A Government initiatives. When HSR Company started operations and making certain profits, private investors would be more interested in the investment and purchases part of the shares owned by the government.

(c) Candidate financial institution

6.237 Loans by financial institutions are mainly necessary for the investments in rolling stocks, as the financing for the infrastructure will be made by state budget. Amounts to be financed by financial institutions will be indicated in Part II and III respectively.

6.238 Possible financiers are public financial institutions which also provide commercial lending. Syndicates of with such public financial institutions and private financial institutions would be also candidates. Minimum condition to access such credits is that the companies can secure sufficient profits and cash flows to ensure the repayment to financial institutions.

6.239 Candidates for such public financial institutions are explained as follows;

International Financial Corporation (IFC)

6.240 IFC, a member of the World Bank Group, is a development institution focused on the private sector. It has provided finance to many countries including Vietnam. Projects in Vietnam includes,

(i) Financing to Cai Lan International Container Terminal for new water container terminal in Quang Ninh Province

(ii) Financing to SN Power for the development of 1GW hydro power capacity

6.241 IFC also provided finance to railway projects in several counties, such as

(i) Kenya, Uganda (2006), investment program for the for the rehabilitation, operation and maintenance of the railways

(ii) Estonia (2001), financing for the replacement of locomotive fleet, track replacement and renovation, improvement of signaling and communications of the national railway company of Estonia

Asian Development Bank (ADB)

6.242 Asian Development Bank (ADB) provides concessional loans from ADF (Asian Development Fund), together with commercial based loans. ADB also has several experiences in Vietnam, such as;

(i) Thu Duc warter treatment (2000)

(ii) Phu My 2.2 Power plant (2002)

(iii) Phu My 3 Power plant (2002)

6.243 Thu Duc water treatment project was undertaken on a build-operate-transfer (BOT) basis under a 25-year contract, by which contractor Lyonnaise Vietnam Water Supply Company (LVWC) provides bulk water to HCMC Water Supply Company.

6.244 Phu My 2.2 and Phu My 2.3 projects are carried out also under BOT scheme for 20 years, under which the power producing companies sell power generated from the power plants on take-or-pay basis.

6.245 ADB also provided project finance to railway project in India and other counties, such as;

(i) India, Bangalore Metro Rail Transit System Project (2009)

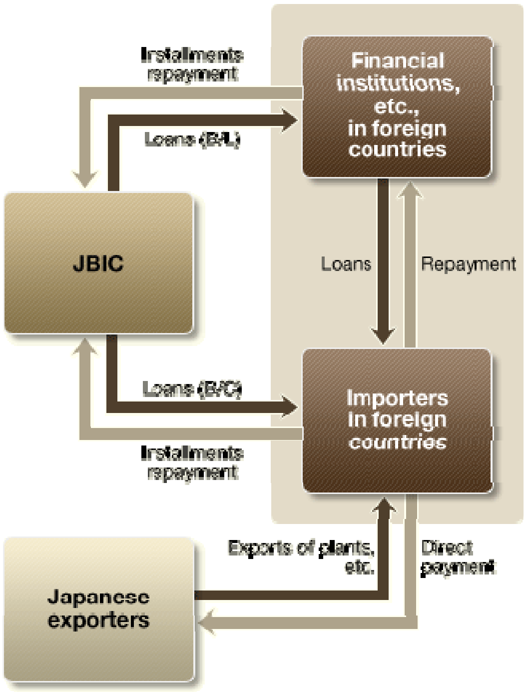
(ii) Philippines, North Luzon Expressway Rehabilitation and Expansion (2000)

6.246 The finance of Bangalore Metro Rail Transit System Project was provided to the operator, Bangalore Metro Rail Corporation Limited (BMRCL), which is a joint venture of the central government and local government (Karnataka). The finance was commercial based non-sovereign lending given to a public entity. The scope of Bangalore Metro Rail Transit System Project in India is to implement a metro rail project in Bangalore, including the development of 42.3 km rails, 40 stations, 2 station depots, signaling, electro-mechanical system, and other facilities and rolling stocks.

6.247 North Luzon Expressway Rehabilitation and Expansion project in the Philippines comprises of the rehabilitation, expansion and operation of 83.7 km of the existing expressway. At the end of the concession period, the concessionaire transfers the assets back to the Government.

Japan Bank for International Cooperation (JBIC)

6.248 Japan Bank for International Cooperation (JBIC) is a policy-based financial institution of Japan, which provides wide range of financial products, including lending, investment and guarantee operations. One of the important JBIC products is export loan, by which BIC provides loans to importers in foreign counties (outside Japan) for purchasing plants, ships and technology from Japan. It also provides overseas investment loans to meet long-term financing needs of Japanese firms for their international business development.



Source: Japan Bank for International Cooperation

Figure 6.5.5 Export Loan of JBIC

6.249 In Vietnam, JBIC has provided financing to the following projects;

(i) Export Loan to Petrovietnam (2011)

(ii) Phu My 2.2 Power plant (2002)

(iii) Phu My 3 Power plant (2002)

6.250 Under the export loans to PetroVietnam, JBIC committed to provide 95.8 million US dollars, and a private Japanese bank provided co-financing too. By this finance, PVN constructs a coal-fired power plant (600 MW x 2 units) with steam turbines purchased from Japanese firms, in Ha Tinh Province.

6.251 JBIC also provided finance to railway projects, including,

(i) UK, Loan for the Intercity Express Programme in the UK (2012)

(ii) Brazil, Support for Subway Project in São Paulo (2010)

6.252 In the loan for the Intercity Express Programme in the UK, JBIC and co-financing financial institutions provide project financing to a private company, Agility Trans West Line Limited (ATWL). ATWL procures 369 high-speed trains manufactured by a Japanese heavy industry company, Hitachi and develop railway depots for maintenance. ATWL then leases the high-speed trains to a train operator with maintenance service for a period of 30 years. ATWL is a joint venture set up by Hitachi and John Laing Investments Limited

6.253 The loan under Support for Subway Project in São Paulo project in Brazil was provided to a private concessionaire, Via Quatro. Via Quatro carries out the electrical investment and maintenance, while the civil works were carried out by the provincial government. JBIC provided a part of the financing to Via Quatro, together with Inter American Development Bank and others. Via Quatro receives fixed amount payment from the provincial government upon availability (availability payment). Minimum revenue revenue is also guaranteed by the government, while profits more than baselines are shared between the operator and the government.

4) Risk allocations

6.254 The responsibilities of the high speed railway are separated mainly to HSR Company and the government. The responsibilities of HSR Company are the ownership of rolling stocks, the operations of high speed railway, and the maintenance of rolling stocks and maintenance of the infrastructure. The development of the traffic control system and infrastructure is under the responsibility of the government. Land acquisitions and resettlements are also carried out under the responsibilities of the government. This is summarized as follows;

Table 6.5.3 Responsibilities in HSR Management

Activities		Responsibility
Operation		HSR Company
Maintenance	Rolling stocks	HSR Company
	Traffic control system	HSR Company
	Infrastructure	HSR Company
Ownership	Rolling stocks	The government
	Traffic control system	The government
	Infrastructure	The government

Source: JICA Study Team

6.255 The HSR projects are subject to risks with various characteristics. Then, it is necessary to allocate risks to those who can manage them most appropriately, depending on the characteristics of risks. Risks before completion and after the completion of the projects are explained separately.

(1) Risks before the completion of the projects

Table 6.5.4 Risk Shares Before Completion

Types of risks	Risks taken by		
	HSR Company	Government	Others
Land acquisition risks		✓	
Resettlement risks		✓	
Planning risks		✓	
Cost overruns (System, infrastructure)		✓	Contractors
Cost overruns (Rolling stocks)	✓		
Time overruns (System, infrastructure)		✓	Contractors
Time overruns (Rolling stocks)	✓		
Technical risks (System, infrastructure)		✓	Contractors
Technical risks (Rolling stocks)	✓		
Sponsor risks	✓		

Source: JICA Study Team

6.256 Land acquisition and resettlement are carried out only by the government, and thus associated risks are fully taken by the government. Any cost increases or losses of HSR Company due to the delays or problems in land acquisitions and resentment are also covered by the government.

6.257 Cost overruns, time overruns or technical risks of the traffic control system and the infrastructure are primarily under the responsibility of the government, and the government would transfer such risks to contractors. However, note that any cost increases due to the government instructions, such as modifications to the technical specifications, are covered by the government.

6.258 Cost overruns, time overruns or technical risks of the rolling stocks are under the responsibility of HSR Company. Similarly, any cost increases or losses due to the changes in the technical specifications directed by the government should be the responsibilities of the government This included the additional costs in rolling stocks due to the changes in technical specifications in infrastructure. When technical specifications of infrastructure are changed, rolling stocks might have to go through modifications too.

6.259 Sponsor risk is a risk which the HSR Company cannot receive sufficient capital from investors. This risk typically arises when sponsors are requested to provide additional capital during the project implementations. This risk is supposed to be covered by HSR Company.

(2) Risks after the completion of the projects

Table 6.5.5 Risk Shares After Completion

Types of risks	Risks taken by		
	HSR Company	Government	Others
Operational risks	✓		
Maintenance risks	✓		
Demand risks	✓	✓	

Types of risks	Risks taken by		
	HSR Company	Government	Others
Foreign exchange risks		✓	

Source: JICA Study Team

6.260 HSR Company is responsible for the operations of HSR and also the maintenance of rolling stocks and infrastructure, as the consistency between operations of HSR and maintenance of infrastructure is the key to the efficient and safe operations of HSR. In other words, any costs and losses due to poor maintenance of rolling stocks and maintenance are the responsibilities of HSR Company.

6.261 Demand risk is primarily under the responsibility of HSR Company, but it should be partly covered by the government. When actual demands are much smaller than the expected demands, the operator would not be able to continue operations due to the financial difficulties after the commencement of operations. Therefore, the government needs to provide financial supports such as revenue guarantee to HSR Company, so that the company can continue operation by securing sufficient profits.

6.262 Foreign exchange risks should be also guaranteed by the government. As most of the assets (rolling stocks) are purchased are imported and thus the debt of HSR Company will be also in foreign currencies. However, because the revenue of HSR Company is in domestic currency, the fluctuations in foreign exchange rate might negatively affect the profits of HSR Company. HSR Company is exposed to foreign exchange risks during the project period, and there are not any measures to cover such long term foreign exchange risks (e.g. currency swap or options).

Table 6.5.6 Common Risk Shares

Types of risks	Risks taken by		
	HSR Company	Government	Others
Institutional risks		✓	
Force majeure risks		✓	
Environmental risks	✓		

Source: JICA Study Team

6.263 Common risks, including institutional risks and force majeure risks are basically covered by the government. Institutional risks include any risks due to the changes in government rules and regulations, which might negatively affect the sustainability in the operations of high speed railways. Force majeure risks, such as natural disasters, are also covered by the guarantees by the government. Government might also access to external institutions (insurance company) to mitigate such risks. Environmental risk, which is a risk that the project might have negative impacts on the natural and social environment during the construction and operations, is under the responsibility of HSR Company.

6.6 Necessary Institutions and Legislation for Introducing High Speed Railway

1) Reinforcement of the Institute of High Speed Railway Project Implementation

6.264 As symbolized by the insufficient coordination between the Ministries of Transport and Construction regarding the construction criteria for subways, the vertically split administrative systems and protection of vested rights and interests make an obstacle for efficient implementation of public projects in Vietnam. To implement administrations based on the responsibility and overview into the future by Vietnamese people, it is strongly expected to introduce a system to place emphasis on the public nature and efficiencies through the installation of organization for consultation having strong functions for coordination between different ministries and agencies.

6.265 Success of railway undertakings depends on the operation and management after construction. As experienced in the case of Japanese National Railways, railways unwanted by railway operators, even if constructed, eventually ended up as unprofitable assets suffering difficulties in its management. Therefore, railway operators shall participate in railway project plans armored with due responsibilities and rights. In recent years, railway operators have not been positively involved in the investment in infrastructures as a result of the movement to vertical separation. To make railways sustainable, however, it is required to discuss operational problems of the system sufficiently at the time of construction and reflect the results in the construction.

6.266 General-purpose environmental regulations are now applied to railway noise. It is necessary, however, to implement special regulations on the problems including measuring methods of instantaneous noise such as that emitted by railways.

6.267 Regarding the organizations to certify the safety of newly constructed railway facilities and rolling stock, there are no competent organizations for urban railways and high-speed railways in Vietnam. It is urgently required for the government of Vietnam to train engineers and set up certifying organizations under its responsibility.

6.268 Railway projects require sustainable operation and maintenance after the projects have started. The people who have the ability to fulfill the responsibilities of railway operation and maintenance should lead the railway projects from the initial stage. Profitability of railway projects in Vietnam depends on the future strategy for railway development and a long-term railway improvement plan. It is urgently needed to obtain the knowledge of modern railway technologies to make a railway organization that is capable to fulfill the responsibilities of railway operation and maintenance.

6.269 Currently, Vietnam does not have any urban railways and its national railways are in dire need of modernization. For the high-speed railway, Vietnam will need assistance in the development of both managerial and technical personnel to fill every position.

6.270 VR should pursue efficient and safe operation by mastering the advanced modern railway technology. Re-education of railway employees for new technologies and new businesses is an indispensable scheme for making railway business sustainable. Mechanization and IT operation will generate surplus workforce. VR should develop new businesses that will increase transport services utilizing this surplus workforce.

6.271 The president of VR should take full control of the VR Corporation. The president should have the ability to control VR completely and also be fully accountable. The current organization of VR seems to be overly complicated and is divided into too many subdivisions. Instructions from the president may not reach the smallest units completely or in a timely manner.

6.272 The chain of command at VR should be reinforced. The president of VR should take full responsibility and information of the railway business.

6.273 The demand forecast and train operation plan are key elements in a railway project. The planning of railway is deeply related to the train operation plan, including the number of cars for one train set, speed, frequency, and the maintenance of facilities/equipment. Moreover, a future railway network plan should be drawn up when planning the first line. It should include connecting station structure with other lines/modes, space for additional lines/cars in anticipation of increase in demand, countermeasures against possible construction difficulties in the future, and innovation of railway technology.

6.274 The vertically-split cascade type administration and the protection of vested rights and interests make a barrier in the way of efficient service execution in Vietnam. To promote services based on the responsibility and prospect into the future by Vietnamese people, a deliberative council having a strong transversal coordinating function over ministries/agencies shall desirably be installed, thereby establishing a system with importance attached to public spirit and efficiency.

6.275 Success of a railway undertaking is governed by the operation after it has been constructed. As experienced in the Japanese National Railways, a railway unwanted by the railway operator eventually falls in the red to make it difficult to continue operation. This means that the operation plans for a railway shall be formulated in the presence of its promoter armed with responsibility and competence. The scheme to separate the super- and sub-structures of railways has thinned the involvement of railway operators in the investment into infrastructures. To make railways sustainable, therefore, a system is required to sufficiently discuss operational problems at the stage of construction and reflect the results thereof in the completed railways.

2) Establishment of the Organizations to Construct High-Speed Railways

6.276 Vietnam shall establish a high-speed railway operation undertaker and plan, design and procure equipment/facilities of high-speed railways to prepare for business promotion. For this purpose, Vietnam shall quickly start a high-speed railway operating organization. As a railway business promoting organization, Vietnam now has the railway administration bureau (VNRA) in the Ministry of Transport (MOT), with some railway related services borne by VNRA and others by the Ministry of Transport itself. There are the VR head office, a private company established with a 100% government capital, and a number of affiliated companies, such as passenger railway operating companies in Hanoi and Ho Chi Minh City, a freight railway operating company and others, with each having an independent personal management system. The head office, Vietnam Railway Company, is not directly related to train operation or commercial pursuits. Therefore, it is rather doubtful to what extent the worksite problems or customers' requirements are reflected in its policies. The hierarchical structure composed of the Ministry of Transport versus VNRA or VR head office versus affiliated railway operating companies makes the subject responsible for railway operation ambiguous. It belongs to anybody's guess, therefore, whether funds are directed to the most important services. The Shinkansen General Bureau was established for the first high speed railway operation in Japan. Thus, it is desirable to establish a high-speed railway operating subject having consistent responsibility to comprise the whole of planning, operation, commercial pursuits and maintenance. The railway operating subject shall adopt experts having sufficient knowledge and experience in these services, discuss operation plans and commercial strategies, reflect the results thereof in the construction work and review the operation and business policies whenever occasion arises even after inauguration.

3) Necessity of the Law Enactment in the Future

6.277 To realize a high-speed railway in Vietnam, it is desirable to institute laws corresponding to the Nationwide Shinkansen Construction Law in Japan as to in 6.2.2) (1). This law shall stipulate the coordination in advance regarding the procedure to determine high-speed railway construction plans, sections, periods and standards for construction, methods to secure budgets and the subjects of construction and business promotion. It is also desired to systematize the installation of a deliberative council in order to realize and authorize railway construction plans by incorporating the opinion of third parties.

6.278 Although the noise emitted from railways is currently controlled in accordance with the environmental noise regulations applicable to general purposes.

6.279 Regulations on the noise emitted from non-stationary sources, such as that of railways, shall be established including the prescriptions on the measuring methods.

6.280 There are no organizations currently to certify the safety of the equipment/facilities of urban or high-speed railways in Vietnam. To authenticate the safety of newly installed railway equipment/facilities and rolling stock, therefore, the Vietnamese government shall urgently train engineers and an organization for that purpose.

6.281 To this end, the Vietnamese government shall quickly prepare text books and improve the environment for training and train engineers having the knowledge of advanced technologies. These engineers shall take the initiative in preparing technical standards and equipment handling manuals for high-speed and urban railways.

4) Reinforcement of Railway Master Plans and Authorization of Comprehensive Land Utilization Plans

(a) Necessity to Formulate Railway Comprehensive Master Plans

6.282 In the Hanoi city, projects of the urban railway lines 1, 2, 3 and 2A are now in progress. In parallel other urban railway construction plan to utilize the VR lines is under discussion. Although the concepts of VR construction plans are proposed in fragments, there are no plans currently in chronological harmony and linked with other projects. Therefore, the Hanoi line 1 project is at a stalemate with the issue how to deal with the transport on the Haiphong line remaining ambiguous. Haiphong line cargo transport is not considered enough. The concept of the high-speed railway operation of the linkage to the Hanoi station has not been discussed, either. In constructing a railway, the project promoter shall prepare a comprehensive railway construction plan that is in conformity not only with related railways but also with transit facilities, grade-separated crossings, roads and other public facilities construction plans.

6.283 Railway construction projects are now promoted individually without paying attention to the overall linkage with other projects or the construction work schedules thereof. Conflicts with road construction plans or other public projects are totally neglected, let alone the conformity with land utilization plans. First of all, Vietnam shall create a railway master plan that is in conformity with road construction and other public project plans from the viewpoint of the construction work schedule, based on which Vietnam shall specify, release to the public and authorize the lands required for public projects in the future. It is reported that the Tokaido Shinkansen construction project was accelerated thanks to the appropriation of the lands that had been prepared based on the concept of Tokaido bullet trains before World War II.

(b) Necessity of Coordination and Dissemination of Plans

6.284 In Vietnam, project plans are formulated in accordance with the law on city planning schemes and others. Plans of railways, city construction, and private sector development are drawn up by consultants individually on request, consultants are supposed to survey other plans they are related to for the purpose of coordination. Due to the lack of comprehensive and transversal control ability, however, planners cannot perform coordination between different plans. It is essential that Vietnam improve the capability of planners to deal with widely-range services, while eliminating such institutional problems as the ill effects of vertically split administration and inappropriate transversal communications between divisions/sections. Furthermore, as those concerned make little effort to make already-established plans widely known or disseminate its knowledge, it is not easy to survey other plans, even if only those related to their own plans are counted. It is desirable, therefore, to adopt a system to eventually summarize all public land utilization plans and rules thereon in a sheet of city planning scheme after coordinated in advance between different divisions/sections by a deliberating council included stakeholders and widely disseminate its knowledge among people in the same way as in Japan.

5) Enactment of Land-Related Laws on Readjustment/City Redevelopment and Organization of a Land Expropriation Committee

(a) Urban Planning and Zoning Act

6.285 In Japan legal force is given to the Urban Planning Law to realize the urban planning, by applying necessary restriction to construction of buildings based on the Building Standard Law. The urban planning is formulated on an all-prefectures level and a cities, towns and villages level. Whenever planning a new project or changing some existing plans, the urban council is to be referred to, and the newest urban planning map is created. All project plans are woven into city planning.

6.286 In Vietnam, urban plan is made by consultants and it does not reflect new projects. An authorized urban planning map should be provided. All constructors should make buildings according to the urban plan and the building standard law. For this purpose, the urban plan should be decided under the agreement of people concerned at the opened council. Impartial scholars should join the discussion at the council to decide/amend the urban plan.

(b) Improvement of the Land Acquisition System and Introduction of Land Readjustment/Multi-Level Replotting

6.287 It is pointed out by mass media that there are problems in the cost and period of the public facilities construction work in Vietnam. Land acquisition is now under severe conditions, in particular. This requires a system to authorize the evaluation and fair amounts of indemnification.

6.288 Regarding the land purchase for road construction in the past, there was reportedly a case where the cost of the lands remained unsold near the completed road skyrocketed when compared with the cost at which a land had been purchased. This caused the land seller a feeling of intolerable unfairness and dissatisfaction. Similar problems have been experienced in Japan as well. As a means to solve this problem, reduced land replotting by readjustment or multi-level replotting in urban development is conceivable like in Japan. Vietnam is expected to adopt a system to produce public lands through readjustment when railways or roads are constructed in cities and make the gains from the development be enjoyed among the stakeholders in the related areas. Land readjustment is a method to promote development of regional areas when roads, parks, railways or stations are constructed, with the lands required therefor appropriated in pieces by those living in the area. Multi-level replotting is a technique to construct a large-scale building by appropriating the whole of the sites of small-scale buildings and distribute the floors of the completed buildings in proportion to the right of land and house. If the concept of Promotion of integrated land development in metropolitan areas and railway line special measure Act in Japan is introduced, collective replotting to the lands for public projects through land readjustment scheme will become possible. Furthermore, internalization of developmental gains will smoothly accelerate the projects for railway construction and development of residential areas.

6.289 In introducing these systems, Vietnam shall accomplish consciousness innovation of the nation to the effect that lands are public assets so public projects should get land allocation priority and people should cooperate.

(c) Introduction of a System of Land Expropriation Committee

6.290 As a procedure to purchase lands for public use, the city or district people's committee has a land indemnification committee to perform negotiations for indemnification and compulsory purchases when necessity arises. In actuality, however, land purchasing negotiations often have a difficult sailing. This requires a standard on the fair amount of indemnification and a system to authorize the evaluation thereof.

6.291 It is difficult to determine the amount of indemnification. To obtain the consent of land owners, a third party organization, which is deemed to be fair and square, shall be established where the final amount of indemnification is to be determined. In this regard, Vietnam shall refer to the concept of land utilization for public purposes and the procedure of implementation stipulated in the German land expropriation law. A land expropriation committee composed of third party members farsighted for land prices, who are distant from administrative authorities or project owners, like the one in Japan, shall be thought as effective to solve the problems involved in non-compulsory land purchasing negotiations.

6.292 The arbitration price decided by the land expropriation committee is based on the land cost at the project starting point in the land expropriation law. The increased land price by the execution of the project is ignored.

6) Schedule of Institute Preparation

6.293 Legal items required to implement public projects are all specified in relevant laws in Vietnam. However, their implementation lacks smoothness in actuality. This implies that there may be problems in the provisions of existing laws. Nevertheless, it is more important than anything else that government officials in charge shall acquire a habit to address their services with a vision and induce basic concepts of public opinions and policies.

6.294 As the laws required before the inauguration of the high-speed railway project, Vietnam shall enact a law on the procedure to construct high-speed railways by referring to the nation-wide Shinkansen network construction law in Japan and adopt the rules on the railway construction deliberating council by referring to the deliberating councils for building social capitals and for transport policies in Japan in order to formulate fair and square plans to construct high-speed railways and perform verification of their sustainability.

6.295 Besides the laws on the construction of high-speed railways, the laws/provisions that are immediately required include the Land Readjustment Act, multi-level replotting on Urban Redevelopment Act and provisions on the method to evaluate the fair amounts of indemnification of the compulsory expropriation procedure in the Land Law. As a measure required other than the above, Vietnam shall desirably reinforce the control of the development/ utilization of land and newly built architectures in accordance with city planning schemes and discuss the measure for fairness of the evaluation of land purchasing prices to guarantee the impartiality between the transferred and remained land owners and a taxation system for the beneficiaries of developmental gains.

6.296 The desirable institute and regulations are expected to form as far as early stage. Especially land treatment regulations are expected to form quickly.

6.297 For planning of high speed railway, the procedure of high speed railway construction like Japanese Nationwide Shinkansen development Act should be formed at first. At the same time, the organization of organization for effective operation of high speed railway should be discussed.

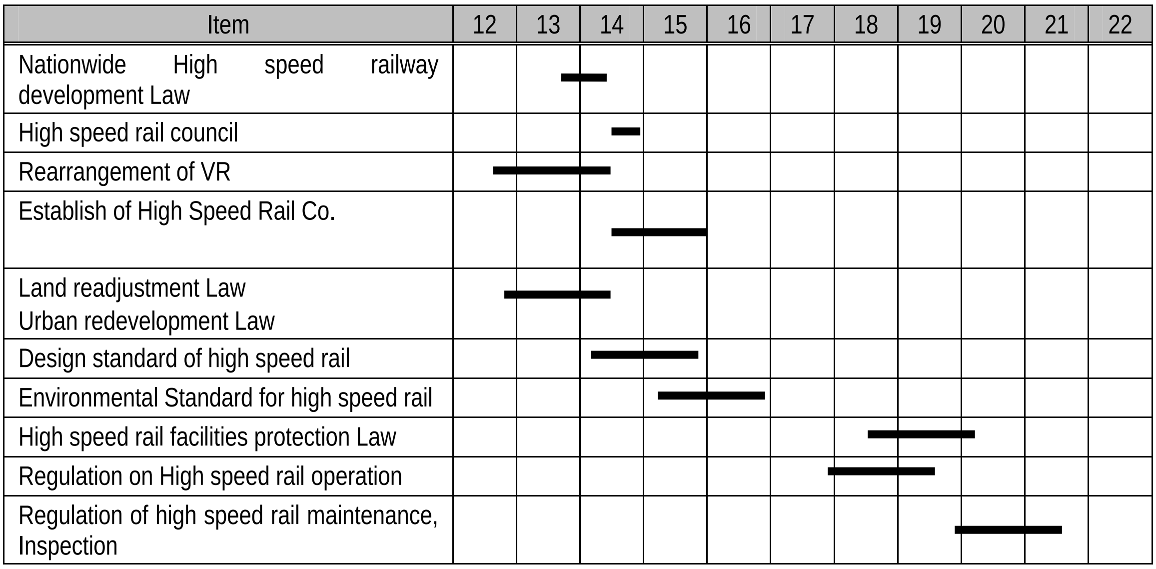
6.298 Necessary period to prepare the laws and standards for high speed railway is shown in Table 6.6.1 and Figure 6.6.1.

Table 6.6.1 Desirable Period of Institution Preparation

Year	High Speed Railway	Institute, Law & Standard
2013	National Assembly	Nationwide High speed railway development Law High speed rail council
2014		Rearrangement of VR, High speed Railway Co. Land readjustment Law (Land & Railway Law) Urban redevelopment Law
2015		Design standard for high speed rail
2016		Environmental Standard for high speed rail
2017	Test line design	High speed rail facilities protection Law
2018	Test line construction	
2019		Regulation on High speed rail operation
2020		
2021	Driver training	Regulation of high speed rail maintenance, Inspection
2022	Detail design	
2023	Test line operation	
2024	Construction Start	
2025		
2027	Partial operation	
2030	Construction work finish	
2031	Operation Start	

Source: JICA Study Team

Figure 6.6.1 Working Schedule



Source: JICA Study Team

6.7 The Nature of Railway Industry and How to Raise Supporting Industries

1) Supporting Industries

6.299 Before coming to the captioned topics, we will describe below the supporting industries in a general sense and the policy now being promoted by the Vietnamese government to raise those specific to the railway industry in the country.

(a) Supporting industries in a general sense

6.300 One of the core industries often cited as one supported by a number of peripheral industries may be the automobile industry. A car, which is composed of approximately 20 thousand parts, is assembled by using those supplied by respective part manufacturers. These parts are normally manufactured through a number of manufacturing processes, such as those of iron manufacture, casting, forging, machining, welding, assembling, heat treatment, painting and plating. The materials used to manufacture parts include metals/plastics and also rubber, glass and fiber materials.

6.301 In this manner, the automobile industry has a far-reaching effect over widely ranged industries and absorbs employment opportunities in these fields. To perform a role in the automobile industry, therefore, a number of countries are energetically deploying campaigns to invite manufacturing plants in the automobile industry. Furthermore, the automobile industry is now strengthening its ties not only with the industries of conventional parts, raw materials, interior fixings and auxiliaries but also with those in the fields of IT software and financing organizations, thereby extending more and more its base of activities.

6.302 Besides the automobile industry, such manufacturing industries as those of aircraft, household electric appliances and personal computers are also thought to have widely spread peripheral industries. Although it is impossible to assemble final products or manufacture basic raw materials in such industries, there are movements in some countries to invite foreign funds for investment into these industries, raise technological levels and incorporate domestic industries into a framework of international work division, thereby aiming at connecting such schemes to the prosperity and development of the country.

(b) Raising supporting industries in Vietnam

6.303 Japan-based enterprises stationed in Vietnam are now manufacturing, among others, the products in the motorcycle, clothing and footwear industries, followed by several others in the production of printers and other electronic appliances. In discussing manufacturing these products in Vietnam, it is an important subject for foreign enterprises to what extent they can procure relevant parts and materials in the country.

6.304 The development of supporting industries in Vietnam is so meager that the country cannot help but rely on import for most parts at the moment. The local procurement rates of parts and materials is 20 to 30% for Japan-based enterprises stationed in the country, while the corresponding figures in Indonesia, Malaysia and Thailand are said to be 40 to 60%. In order to invite foreign enterprises into Vietnam, this suggests that it is essential for the country to by all means reinforce the supporting industries as a whole.

6.305 There are two methods for Vietnam to raise supporting industries. One is to raise domestic industries and the other to invite foreign enterprises having plants under their umbrella in supporting industries. If Vietnam wants to quickly raise supporting industries, the latter may be preferable.

6.306 As a matter of fact, the Vietnamese government has already adopted "A Policy to Improve the Environment for Investment and Raise Supporting Industries in Vietnam" for that purpose and put in force the following measures to facilitate the advancement of foreign enterprises into the country.

(i) Specification of investment-encouraged fields

(ii) Favored treatment in taxation

(iii) Exemption of import tax

(iv) Preferential accounting practices

6.307 For enterprises considering advancement into Vietnam, it is difficult to secure profit margins from the demands in Vietnam alone. Therefore, they will also bear in mind the necessity of export to surrounding countries, with the technological levels and prices of their products strongly armored against international competitions. The automobile industry in Thailand is a case of success in this regard. There are similar cases of successful enterprises in Vietnam as well, such as those manufacturing wire harnesses for automobile use.

6.308 Success in raising supporting industries in Vietnam by inviting foreign enterprises depends on whether the quality and prices of their products can cope with international competitions.

(c) Raising, education and training of engineers to develop supporting industries

6.309 As mentioned above, the Vietnamese government has already recognized the importance of supporting industries and deployed appropriate measures. Whether this stance of the government yields fruits depends on the quality levels and prices of products to win international competitions and the guarantee of human resources who support the efforts of the government.

6.310 What is essential to attain this purpose is to raise, educate and train relevant engineers. It seems extremely unfortunate but the education/training system in Vietnam doesn't incorporate "on-the-job training" sufficiently, as already referred to in the section on the education/training system in Vietnam. Education/training is by no means the thing to restfully be entrusted to a vocational training school. It is thought that a training method for a senior to guide his/her juniors at the actual workplace constitutes an efficient education system. Although such a system may be related to a custom prevailing in the country, the "on-the-job training" is indispensable for Vietnam as far as the country desires to quickly raise human resources for related engineering in the future. In an age when technologies are quickly advancing in particular, the country will not be able to keep abreast of the times by relying on vocational training schools alone while totally ignoring the importance of "on-the-job training."

6.311 Some Japan-based enterprises who have advanced into Vietnam are practicing not only "on-the-job training" but also "small-group activities or those for improvement." It is expected that such education/training systems widely spread across the country in the future.

2) Railway Industry

6.312 If we assess railways as a system, they consist of a variety of elements including tunnels, bridges, viaduct structures, track beds and tracks, stations and related equipment/facilities (automatic fare collection systems, escalators, elevators, etc.), rolling stock, substations for electricity- supply to trains, telecommunication/signal system for train operation, IT systems for train control and operators/dispatchers and other members.

6.313 From the viewpoint of railway industry in Vietnam, these elements are related to civil engineering/construction, architectures and components related to equipment/facilities, manufacture of rolling stock, industries related to IT, power/electricity and signal/telecommunication.

6.314 Suppose rolling stocks, for example. It is (1) similar to an automobile in terms of the number of components (approximately 20 thousand pieces), which is almost the same as that of the parts composing a unit automobile and (2) virtually the same as an automobile in the sense that it consumes quantities of raw materials such as metals, plastics and rubber, fibers and glass panels. Furthermore, the rolling stock industry is related to the technologies and manufacturing industries referred to below. In Japan, the parts of rolling stock are manufactured by different suppliers, who constitute widely-spread railway supporting industries. Unlike in the case of automobile industry, however, the volume of parts manufactured for the railway industry is rather limited. Therefore, they are not the part suppliers exclusively dedicated to the railway industry, but mostly part suppliers common to automobile and other industries, except a wheel tire manufacturer who virtually monopolizes manufacture and supply of tires. In this sense, the railway supporting industries do not close within the field of rolling stock, but closely linked with other industries. As a matter of fact, rolling stock technologies are progressing while keeping pace with the development of those in other industries.

(i) Rolling stock body: Iron work structure, sheet metal, window glass, destination indicator, pantograph

(ii) Rolling stock interior finish: Seat, interior equipment, toilet

(iii) Running gear: Bogie, wheel, motor, brake system, bearing, vibration preventive rubber, damper

(iv) Rolling stock component: Control unit, air conditioning system

(v) Rolling stock signal system

6.315 Even the rolling stock manufacturing industry alone indicates that it embraces extensively wide areas of supporting industries. This holds true with the railway-related industries other than the above-mentioned rolling stock manufacturing industry.

6.316 Railways have a mission to operate trains to transport a large number of passengers safely every day. This implies the importance of their management, maintenance and control. For this purpose, it is important to maintain organically combined organizations and implement education/training of related employees.

6.317 Vietnam is now operating inter-city trains, for which the country has accumulated know-how. Given the rapidly developing societies and economy, however, it is expected that transport demands sharply increase in the future. To run high-speed trains at high densities to cope with such transport demands, the method of management, maintenance and control shall drastically be reviewed.

6.318 As Vietnam is totally unfamiliar with technologies of electrification, special consideration shall be required for the means to acquire the technologies of construction and maintenance of electrified railways. At the moment, several projects on urban railways are under way in Hanoi and Ho Chi Minh. For the construction and management of HSR, it is of utmost importance to acquire the technologies of such urban railways in advance.

3) The Railway Industry and its Supporting Industries in Vietnam

6.319 The railway industry in Vietnam shall be broadly divided into two sectors: One is the HSR-related sector and the other the urban-railway-related sector. The industry has supporting industries such as those for (1) structures and tracks, (2) rolling stock, (3) electrification and overhead- contact wire equipment, (4) signal and telecommunication facilities and (5) various computer systems for train operation. Furthermore, HSR-related sector has those in the fields of (1) to (5) dedicated to high-speed train operation.

6.320 In these technical fields, technology transfer is called for at and after the time of construction, with the technologies acquired expected for utilization in operation and maintenance.

6.321 What becomes important in the course of operation and maintenance of railways for a long period of time is the consumable supplies and materials, typically rails, turnouts, EMU brake parts, pantographs and overhead - contact wires. Regarding rails and turnouts, those of higher-class specifications will be required as trains run more in number at higher speed from now on.

6.322 In regard to rails, Vietnam seems to be reliant in large part on import at the moment. As the production of rails is closely linked with the iron manufacturing industry, the country shall discuss the domestic production of rails in consideration of the situations in surrounding countries for comparison, based on the progress of the domestic iron manufacturing project now under way together with the costs and technologies of production.

(a) Structures and tracks

6.323 Regarding the structures and tracks, the records in the past indicate that there are no particular problems in the construction work of general railway structures or tracks. To construct structures and tracks applicable to 300 km/h operation for HRS, however, more stringent standards on construction and maintenance are required. The special construction and maintenance work for slab tracks and high-speed turnouts will also require dedicated machines/tools and technical guidance for a certain period of time.

6.324 VNR-related construction companies have technologies at sufficiently high levels and are keen to introduce new technologies. Therefore, they seem to be able to execute construction work of structures and tracks applicable to 300 km/h operation, if they have chances to receive technical transfer from the stage of construction. As the scope of the construction work for HRS is far extensive, however, it is desirable to invite not only VNR-related companies but also others in the field of construction work to the construction project and discuss other measures including the conditions for competition at the same time.

6.325 During the high economic growth period of Japan from the 1950s to the 1970s, there seems to have been an unimaginably great contribution by the construction sector to the economic development of the country. In Vietnam as well, a similar effect will actualize, if economic growth and investment continues steadily from now on.

(b) Rolling stock

6.326 It seems appropriate for rolling stock manufacturing technologies to start from the production of EMUs for urban railways and develop to the production of HSR rolling stock. The Gia Lam railway workshop, VNR, is currently assembling/manufacturing diesel locomotives by partly using imported parts. It may well be possible for Vietnam to manufacture commuter transporting EMUs for the electrified urban railways in the future by following similar processes, while gradually tapering off imported parts, as suppliers of rolling stock parts and components increase in the country. For reference, in manufacturing DLs, Japan once manufactured diesel engines for a long period of time based on the license contracts with foreign countries. Regarding motors, a source of driving power, that make a base of manufacturing industry, a foreign manufacturing company has already advanced into Vietnam, who can be utilized for the production of motors.

(c) Electrification and overhead- contact wire laying work

6.327 As Vietnam has not experienced electrified railways so far, it is an urgent subject for the country to acquire technologies therefor from the urban railways to be constructed in the future. As HSR features high-speed operation, however, the construction and maintenance of overhead- contact wires and turnouts for high-speed operation require dedicated machines/tools and technical guidance for a certain period of time.

6.328 Production of components and equipment for substations, power distribution and others for power supply systems required for electrification has already been started in Vietnam by overseas companies that have advanced into the country. There are no problems in particular, therefore, in the supply of these components and equipment.

6.329 Vietnam will soon be required to manufacture overhead- contact wires, a consumable component in the power supply system, in the country, as electrified sections including those for urban railways increase in number in the future.

(d) Signal and telecommunication systems

6.330 To improve the safety of HSR and urban railways to be constructed in the future in Vietnam, ATC, CTC and other security systems will be introduced. Despite that there are several electronic interlocking systems in use around Hanoi that have been introduced through the cooperation of France, VNR is still using interlocking systems of an old-fashioned relay type version at a number of stations. It is thought that introduction of new interlocking systems will significantly contribute to the improvement of efficiency and safety of existing VNR railways, if domestic production of related devices is promoted as a first-aid means for modernization.

6.331 Furthermore, optical cables for telecommunication equipment are essential to control train operation, signals, power supply systems and various other components. At the moment, however, VNR is using telecommunication systems mostly composed of metallic cables, though optical cables are also gradually making their debut. Demands for optical cables will increase in the future. As the domestic manufacture of optical cables and related devices has already started, it is possible to utilize the domestic products to cope with the increases in demands.

(e) Various computer systems to control train operation

6.332 Regarding the various computer systems to control train operation, Vietnam has already accumulated a certain degree of normal IT technologies. Unfortunately, however, It is hardly enough in the case of such specific fields as train operation control. This inadequacy does not come from the nature of IT technologies themselves, but it is presumably related to the non-existence of the necessity to control trains at high densities or at three-minute intervals as seen in Japan. However, such necessities will arise sooner or later in Vietnam as well in the fields of HSR and urban railways.

6.333 The HSR accident in China indicates the immaturity in the field of these technologies for Chinese HSR. In Korea, some enterprises are now rising with the manufacture of train operating systems besides manufacturing rolling stock.

6.334 Although a large amount of investment is required for enterprises who intend to manufacture hardware items, it may be an idea to participate in the global railway industry by duly playing a role in such particular fields.

6.8 Environmental and Social Considerations

1) Necessity of Further Environmental and Social Considerations Exercises

6.335 A comparative study of alternatives on the HSR alignments and station locations, was carried out in accordance with the JICA Guidelines for Environmental and Social Considerations 2004 and 2010 in this study. Four aspects, i.e. convenience and integrated development, environmental and social considerations (natural environment, living environment, and social environment), high-speed serviceability and economical efficiency were taken into consideration for comparison of the alternatives which include “Zero Option” namely without HSR projects case. Finally, through the alternative comparison exercises including consultations with stakeholders, the optimal alternative has been selected. However, in order to go forward the HSR projects in environmentally sound and socially acceptable manners, further environmental and social considerations exercises are necessary throughout the projects implementation.

(a) Implementation of Detail Environmental Impact Assessment (EIA) Study

6.336 In Vietnam, the Law on Environmental Protection was promulgated on November 29, 2005 (enacted in 2006). In accordance with this Law, Decree No 29/2011/ND-CP on Provisions of Strategic Environmental Assessment, Environmental Impact Assessment and Environmental Protection Commitment was issued on April 18, 2011. The Decree stipulates the target projects which EIA is required. Since all projects in which investment is decided by the National Assembly or the Prime Minister require EIA reporting as per the Decree, the HSP projects require EIA reporting which shall be made concurrently with formulation of the investment project, i.e. when a feasibility study report is prepared.

6.337 On the other hand, various agencies and organizations which are envisioned to be funding sources of the HSR projects, have respective guidelines or policies on environmental and social considerations or safeguard. If the HSR projects will strive to receive funds or any other supports from these agencies and organizations, a detail and comprehensive environmental and social considerations study will be essential which meets their requirements in terms of its contents, quality, and process.. In preparing an EIA report, consultations with stakeholders, such as local residents, should take place after sufficient information has been disclosed and records of such consultations should be prepared. Holding consultations is required, especially when the items to be considered in the EIA are being selected and when the draft EIA report is being prepared.

(b) Special Considerations for Environmental Impacts Peculiar to High-speed Train Operation

6.338 In this study, the preliminary examinations on railway noise and vibration pollution regarding high speed railways were conducted and various possible mitigation measures were discussed. However, the detail mitigation measures should be examined in subsequent EIA study. In addition, it is necessary to establish national railway noise and vibration standards/regulations on high-speed railways legally together with its monitoring/measurement and evaluation methods. At the same time, in order to secure the appropriate mitigation measures by the project proponent, the capacities of regulatory authorities such as MONRE and DONRE should be strengthened.

6.339 There is a possibility to cause interference of radio wave reception by high-speed train operation and some disturbances on electromagnetic waves especially around AC feeding relating facilities. There is also a possibility to cause impacts on living environment and agricultural activities by sunshine obstruction near the elevated structures. These potential impacts should be discussed in detail in subsequent EIA study. Since there is no law, regulation and guideline on these impacts in Vietnam, necessary law, regulations and guidelines should be prepared on these impacts. Especially, compensation framework or guidelines should be prepared in advance or in parallel with the detail EIA study.

(c) Implementation of Social Impact Assessment (SIA) Study

6.340 Along the HSR alignment, some impacts on social infrastructures such as irrigation and water supply facilities and roads, social services such as education and health care, and local economy and livelihood are expected. In particular, there is also likely to cause unequal distribution of benefits and damages between those residents living near the HSR station and those residents living near the HSR alignment but far away from the HSR station. Considering these potential impacts, it is necessary to conduct a detail social impact assessment (SIA) study as part of EIA including detail survey of local communities as well as social infrastructures and services. The detail and concrete mitigation measures should be planned based on the SIA study and presented to the local stakeholders and people so that the HSR projects are accepted in a manner that is socially appropriate to the areas in which the projects are planned.

(d) Continuous and Sufficient Consultations with Local Stakeholders, Local People and Vulnerable Social Groups

6.341 Once the HSR projects are decided by the National Assembly, a feasibility study together with detail EIA study will be carried out. During these studies, more site specific consultations with local stakeholders such as affected individuals or groups (including illegal dwellers) and local residents will be required. In addition to these official consultations, continuous and sufficient communications and dialogues with local stakeholders along the HSR alignment should be carried out via disclosure of sufficient information from an early stage of the projects and outcomes of such consultations should be incorporated into the contents of projects plans. In the consultations, appropriate considerations should be given to vulnerable social groups, such as women, children, the elderly, the poor, and ethnic minorities, all members of which are susceptible to environmental and social impacts and may have little access to decision-making processes within society.

2) Preparation of Necessary Plans for Land Acquisition, Resettlement and Rehabilitation

6.342 In Vietnam there is a fundamental law on land acquisition, namely the Law on Land which was promulgated on November 26, 2003. Under this law, several derivative decrees and circulars have been issued. Among them, Decree No.197/2004/ND-CP, Decree No.181/2004/ND-CP, Decree No.84/2007/ND-CP and Decree No.69/ND-CP are major regulations of land acquisition and resettlement relating to the HSR projects. In accordance with these law and decrees, a Compensation, Support and Resettlement (CSR) plan needs to be prepared and approved for land acquisition.

6.343 On the other hand, similarly the case of EIA mentioned above, if the HSR projects will strive to receive funds or any other supports from the finding agencies and institutions, a detail and comprehensive resettlement action plan (RAP) will be essential which meets their requirements in terms of its contents, quality, and process.

6.344 Since the HSR projects are now in the planning stage and expected to be decided by the National Assembly in the near future, an official household survey (i.e. census, inventory of asset loss, socio-economic survey) on the potential project affected peoples (PAPs) to prepare a RAP is not authorized at this moment. Thus, in accordance with the JICA Guidelines, a resettlement and rehabilitation policy framework (RRPF) has been drafted up in this study containing basic idea and direction on resettlement and rehabilitation for preparation of CSR plan and RAP. Thus, when these plan are prepared, the contents of RRPF should be taken into consideration. In particular the CSR plan is requested to meet the requirements of potential funding sources so that the CSR plan can be regard as a satisfactory RAP. Among the discrepancies identified between Vietnamese law and decreases and potential funding agencies' policies and guidelines, compensation based on full replacement cost is one of crucial issues to be incorporated. If the potential funding agencies or institutions will require the RAP in advance to the preparation of CSR plan, necessary coordination should be done among the organizations concerned.

3) Change of Forest Use Purposes for the HSR Projects

6.345 In Vietnam, the Law on Forest Protection was promulgated on December 3,2004. In accordance with this Law, No.23/2006/ND-CP on the Implementation of the Law of Forest Protection and Development was also issued on March 3, 2006. The selected optimal alternative (alignment and station location) has avoided passing through or locating in protected forest and protection forest areas. However, the alignment needs to pass through some production forest areas. Decree No.23/2006/ND-CP stipulates necessary procedures of change of forest use purposes in addition to forest protection and development planning and plans, etc. The project proponent of the HSR projects should take necessary actions to comply with this Decree including preparation of a report on assessment of environmental impacts of the change of forest use purposes.

7 CONCLUSION AND RECOMMENDATIONS

1) Conclusion

7.1 Conclusions of the study are as follows:

(1) In order to meet future transport demand along the north-south corridor quantitatively and qualitatively, provision of high-speed railway services is inevitable. Without HSR, congestions on roads and air transport will be significant.

(2) Upgrading of existing railway to meet high-speed operation is not only technically difficult but also require lengthy construction periods and high cost which is comparable to that of new line. Closure of rail operation for long time is also unavoidable.

(3) While the development of full section of HSR is economically justified only around 2040, it is important to improve existing railway for short to medium term. The most appropriate level of improvement of the existing railway is to maximize the transport capacity of single track with meter gauge. The proposed improvement includes, among others, removal of bottlenecks, improved efficiency of railway operation and services which must be completed by 2020-25. Farther improvement including double tracking will be undertaken for sections where demand is high. The improvement of the existing railway (in terms of safety, speed, comfort, convenience, etc.) as a precondition to HSR development will also benefit potential users along the HSR alignment.

(4) Detailed study on priority sections shows that both of them will be economically feasible around 2030 of which southern section shows higher viability. Financial viability of the project is low as is usually the case in railway project. However, operating cost can be covered with fare revenue in both sections. Southern section shows higher viability, too.

(5) Development of HSR must be implemented in phases according to the proposed road map which include following steps:

(i) South priority section will be opened by 2031 while the north priority section by 2036.

(ii) Danang – Hue section will be opened by 2039, while the remaining section during the 2040s.

(6) In order to ensure effective development of HSR both in terms of technical and operational aspects, early construction of a test track is inevitable. It is preliminarily concluded that priorities for the initial sections are in the order of (1) Thu Thiem – Long Thanh and (2) Ngoc Hoi – Phu Ly, though differences are insignificant.

(7) Management organizations of HSR must be distinguished from that of existing railway. Organization during the preparation and construction must be directly managed by the Government.

(8) Human resource development can be done in the most effective manner using test track and through on-going urban rail projects. Training covers, among others, construction technologies, operation, maintenance and management.

(9) Development of institutions is necessary to cover (i) regulation on HSR development, (ii) formulation of railway development plan, (iii) inter-agency coordination and public information on the project, (iv) related institutions for land acquisition and business activities.

(10) Project financing requires an establishment of effective mechanisms to introduce private sector's financing, while efficient operation is maintained. For this HSR company is established and financing for non-revenue generating infrastructure is the responsibility of the Government.

2) Recommendations

7.2 Recommendations are as follows:

(1) While this study can provide a useful basis for future discussions in the National Assembly, it is proposed to use Q&A which is prepared in the study based on the comments and inquiries raised by various experts and organizations.

(2) It is proposed to formulate a long-term HSR development program based on the road map prepared in the study for effective monitoring of the project.

(3) It is proposed to construct test track section which functions as the core for various preparatory activities and to establish a solid implementation mechanism for effective implementation of such a significant national project.

(4) Involvement of local authorities who are part of the implementing body and also direct beneficiaries is important for effective development of HSR. It is proposed to establish a coordinating committee between the Central Government and local authorities to strengthen coordination for plan formulation, land acquisition, and sharing a part of construction cost.

(5) It is also necessary to establish adequate public information and participation to the project, because the project is not well perceived nor understood by many stakeholders.

(6) While the development of HSR is a long-term undertaking, it is important to improve the existing railway. It is proposed to conduct a detailed study and formulate a plan for improvement of existing railway in integration with proposed HSR wherein Test Track for Danang – Hue section must be studied in detail.

3) Further Steps

7.3 The construction plan of new railway line with standard gauge proposed in this report provides a good base for various options with regards to aspects such as specification of rolling stocks (maximum operating speed 160km/h – 320km/h), connection with existing railway, etc. Reflecting on the history of railway development in Japan, it is noted that Japan has indeed a great deal of experience in the planning, construction, operation, etc., and it is deemed that such experiences will greatly contribute to the railway development in Vietnam. JICA is willing to provide further cooperation to Vietnam to achieve sustainable development of railway sector and to enhance friendly relationship between the two countries.

APPENDIX 5A

Life Cycle Cost for each Track Structure

Table 5A.1 Life Cycle Cost Comparison of Slab Track and Ballast Track

Unit: 1000 dollars

		Construction costs per km	Annual maintenance expense per km	LCC (current value)	
Japan	Slab track	2100	18.75	2271	10 year LCC
	Ballast track	1550	81.25	2290	10 year LCC
Vietnam	Slab track	1525	7.5	1595	50 year LCC
	Ballast track	975	32.5	1277	50 year LCC

Source: JICA Study Team

Calculation condition:

(1) The cost performance of Japan is a value of reference data.

(2) The cost performance of Vietnam calculated by using the ratio, rate 0.25 for a personnel expense to Japanese cost, rate 0.40 for a work operating some machines and the tariff rate 0.2 for an import material.

(3) The maintenance expense of ballast track was assumed by 4.3 times to the slab track.

(4) Discount rates are 4% per year in Japan and, and 12% per year in Vietnam.

Table 5A.2 Calculation of Life Cycle Cost

Unit: 1000 dollars

Annual	Discount Rate	Japan : 20 Million T / Year							
		Slab Track				Ballast Track			
		Construction Costs	Maintenance Expense	Maintenance Expense Current Value	Current Value Total	Construction Costs	Maintenance Expense	Maintenance Expense Current Value	Current Value Total
0	1	2100	18.75	18.75	2,118.8	1550	81.25	81.25	1,631.3
1	0.961538			18.03	2,136.8		18.75*4.3↑	78.13	1,709.4
2	0.924556			17.34	2,154.1			75.12	1,784.5
3	0.888996			16.67	2,170.8			72.23	1,856.7
4	0.854804			16.03	2,186.8			69.45	1,926.2
5	0.821927			15.41	2,202.2			66.78	1,993.0
6	0.790315			14.82	2,217.0			64.21	2,057.2
7	0.759918			14.25	2,231.3			61.74	2,118.9
8	0.73069			13.70	2,245.0			59.37	2,178.3
9	0.702587			13.17	2,258.2			57.09	2,235.4
10	0.675564			12.67	2,270.8			54.89	2,290.3
10	0.675564			12.67	2,270.8			54.89	2,290.3
11	0.649581			12.18	2,283.			52.78	2,343.
12	0.624597			11.71	2,294.			50.75	2,393.
			Sub total	170.8			Sub total	740.3	
			50 year LCC		2,270.8		50 year LCC		2290.3

Source: JICA Study Team

Table 5A.3 Calculation of Unit Price using Life Cycle Cost of Vietnam

Unit: 1000 dollars

Annual	Discount Rate	Vietnam : 20 Million T / Year							
		Slab Track				Ballast Roadbed Track			
		Construction Costs	Maintenance Expense	Maintenance Expense Current Value	Current Value Total	Construction Costs	Maintenance Expense	Maintenance Expense Current Value	Current Value Total
0	1	1525	7.5	7.50	1,532.5	975	32.5	32.50	1,007.5
1	0.961538		18.75*0.4↑	6.70	1,539.2		81.25*0.4↑	29.02	1,036.5
2	0.924556			5.98	1,545.2			25.91	1,062.4
3	0.888996			5.34	1,550.5			23.13	1,085.6
4	0.854804			4.77	1,555.3			20.65	1,106.2
46	0.208289			0.04	1,594.7			0.18	1,276.9
47	0.208289			0.04	1,594.7			0.16	1,277.0
48	0.208289			0.03	1,594.7			0.14	1,277.2
49	0.208289			0.03	1,594.8			0.13	1,277.3
50	0.208289			0.03	1,594.8			0.11	1,277.4
			Sub total	69.8			Sub total	302.4	
			50 year LCC		1,594.8		50 year LCC		1277.4

Source: JICA Study Team

APPENDIX 5B

Railway Technical Research Institute (RTRI) Report

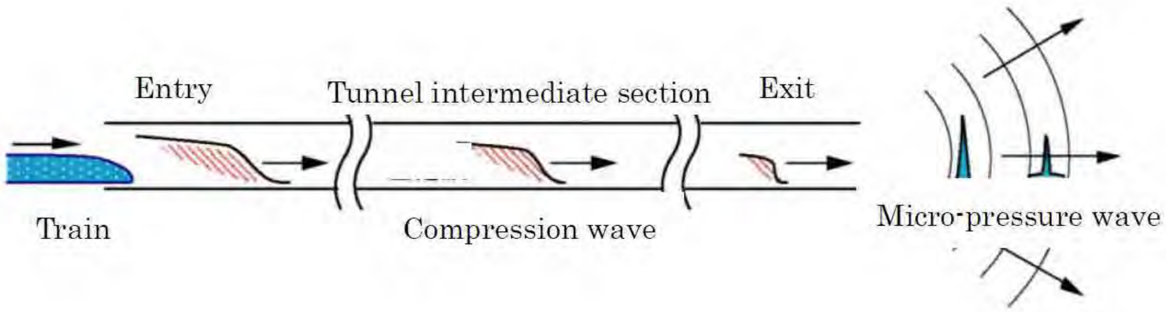
1 STUDY ON TUNNEL CROSS-SECTION

1.1 Phenomenon of Tunnel Micro-Pressure Waves and Measures for Suppression in Japan

1) Phenomenon of tunnel micro-pressure waves

1.1 When training operation started to prepare for revenue service to/from Hakata, Sanyo Shinkansen, in March, 1975, complaints were lodged at the local JNR Construction Work Offices from wayside residents to the effect that pulse-shaped micro-pressure waves (tunnel micro-pressure waves) were radiated from the exit of long slab-track tunnels to cause strong blasting sound to shake doors and windows of the houses. While investigating this phenomenon, the Railway Technical Research Institute (RTRI), Japanese National Railways (JNR), promoted the development of portal buffer tunnel and other measures against the phenomenon[1) - 3)]. Thanks to these efforts, however, revenue service operation has been realized now at 300 km/h without causing any problem of micro-pressure waves (with series 500 and N700 Sanyo Shinkansen cars and series E5 Tohoku Shinkansen cars).

1.2 When a train enters a tunnel, it generates compression waves, which are propagated through the tunnel at the speed of sound and reach the exit side portal, when part of the compression waves are emitted outward as pulse-shaped compression waves to cause a phenomenon of micro-pressure waves (Figure 5B.1). As shown in Figure 5B.1, the phenomenon of tunnel micro-pressure waves can be divided into three steps for analysis: (1) formation of compression waves, (2) propagation of compression waves and (3) radiation of micro-pressure waves.



Source: RTRI.

Figure 5B.1 Phenomenon of Tunnel Micro-Pressure Waves

(a) Formation of Compression Waves

1.3 The equation (1) gives the maximum wave front pressure gradient $(\partial p/\partial t)_{max, ent}$ of the compression wave generated in the vicinity of the entry side portal when a train enters a tunnel. The value is approximately in proportion to the third power of the tunnel entry speed of the train.

$$\left(\frac{\partial p}{\partial t}\right)_{max,ent} = \frac{1}{2}\frac{\rho V^3}{\kappa d}\frac{1-(1-R)^2}{(1-M)\{M+(1-R)^2\}} \quad \text{.................................} (1)$$

Where:

p: Pressure of compression wave

t: Time

M: Train Mach number (= V/c, c: Speed of sound in air)

R: Ratio of cross-sectional areas, train to tunnel (= Train cross-sectional area/tunnel cross-sectional area)

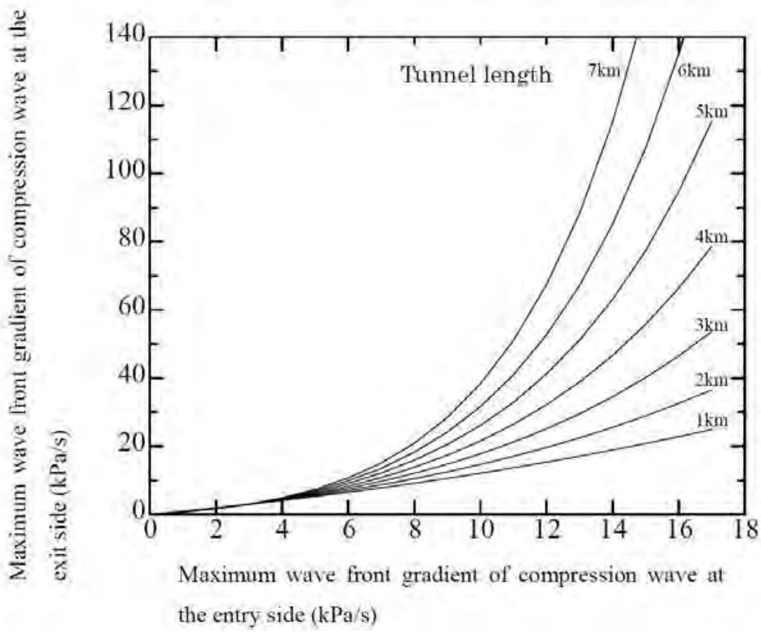
ρ: Density of air

κ: A parameter dependent on the profiles of train head and tunnel portals

d: Tunnel diameter

(b) Propagation of Compression Waves

1.4 When it is being propagated, the compression wave normally changes it profile to make the pressure gradient smaller in ballasted track tunnels and larger in slab track tunnels. Based on site surveys[4)], a formula to estimate the changes in the wave front pressure gradient has been obtained. Figure 5B.2 illustrates the relation between the maximum pressure gradient at the entry side portal and that at the exit side portal of Shinkansen slab track tunnel.



Source: RTRI.

Figure 5B.2 Relation between the Maximum Pressure Gradient of Compression Waves at the Entry Side and that at the Exit Side (a slab track Shinkansen tunnel)

(c) Radiation of Micro-Pressure Waves

1.5 The equation (2) gives the magnitude P_{max} of the micro-pressure wave radiated from the tunnel portal.

$$P_{\max} = \frac{2A_{tun}}{\Omega cr}\left(\frac{\partial p}{\partial t}\right)_{\max,ext} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Where:

A_{tun}: Main tunnel cross-sectional area

Ω: Radiation solid angle (spatial expanse toward the open section viewed from the tunnel portal)

r: Distance from the center of the portal to the measuring point

$(\partial p/\partial t)_{max,\ ent}$: Maximum wave front pressure gradient of the compression wave that has arrived at the exit side portal

1.6 The equation (2) indicates that the magnitude P_{max} of the micro-pressure wave is in proportion to the maximum wave front pressure gradient of the compression wave, $(\partial p/\partial t)_{max,\ ent}$, that has arrived at the exit side portal and in reverse proportion to the distant r from the portal exit and the radiation solid angle Ω.

1.2 Measures to Supress Tunnel Micro-Pressure Waves

1.7 As mentioned above, the magnitude of the micro-pressure wave is in proportion to the maximum wave front pressure gradient of the compression wave that has arrived at the exit side portal. Therefore, it makes the basic philosophy for the tunnel micro-pressure wave suppression measures to decrease the maximum wave front pressure gradient of the compression wave that has arrived at the exit side portal, through such means as (1) construction of tunnel buffering work, (2) utilization of branches (inclined shafts, vertical shafts, adits), (3) connection to the adjacent tunnel with a slit shelter and (4) measures on the rolling stock side (long head noses, smaller cross-sectional areas, optimization of head profile) , etc. Below explained are the measures (1) to (3) on the ground side[5)].

(a) Construction of Buffer Tunnels

1.8 The purpose of the buffer tunnel is to decrease the maximum wave front pressure gradient of the compression wave when a train enters the tunnel, thereby aiming at reducing the micro-pressure waves radiated from the tunnel exit side portal. In more concrete terms, the tunnel buffering work referred to above is a hood having a cross-sectional area 1.4 to 1.6 times that of the main tunnel, installed at the train entry side portal (opposite to the exit side portal from where micro-pressure waves are radiated) with appropriate openings cut on the sides or at the ceiling. See Figure 5B.3 for two cases of buffer tunnel for Shinkansen.

1.9 The factors for the buffer tunnel to contribute to the reduction of micro-pressure waves include its length, the buffer tunnel to tunnel cross-sectional area ratio and, the size/position of openings and the head car nose profile. If the size or position of openings is inappropriate, the effect to reduce micro-pressure waves will be limited. The ratio α of the maximum wave front pressure gradient of compression waves before and after the installation of a buffer tunnel is given by the equation (3).

$$\alpha = \frac{D}{D+L} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where:

L: length of buffer tunnel

D: An attribute length

1.10 The value of D is approximately 12 m for the combination of the buffer tunnel of Sanyo Shinkansen and series 0 rolling stock. In the case of the buffer tunnel installed at the tunnel train entry side portal, the equation (1) and (3) give the maximum wave front pressure gradient $(\partial p/\partial t)_{max,\ ent}$ of the compression wave generated in the tunnel as:

$$\left(\frac{\partial p}{\partial t}\right)_{\max,\mathrm{ent}} = \frac{1}{2}\frac{\rho V^3}{\kappa d}\frac{1-(1-R)^2}{(1-M)\{M+(1-R)^2\}}\alpha$$

$$= \frac{1}{2}\frac{\rho V^3}{\kappa d}\frac{1-(1-R)^2}{(1-M)\{M+(1-R)^2\}}\frac{D}{D+L} \quad \cdots\cdots\cdots\cdots\cdots\cdots (4)$$

1.11 When L = 0 (no buffer tunnel), α = 1. Therefore, the equation (4) becomes the same as the equation (1).

Source: RTRI.

Figure 5B.3 Two Cases of Buffer Tunnel for Shinkansen

(b) Utilization of Branches (inclined shafts, vertical shafts, adits)

1.12 There are a number of comparatively long tunnels having branches (inclined shafts, vertical shafts, adits and water channels) for the reasons of maintenance and construction work. Measures to use these branches are to separate part of the compression waves propagating in the main tunnel into these branches and reduce the maximum wave front pressure gradient in the main tunnel. The ratio β of the maximum wave front pressure gradient of the compression wave passing in the main tunnel to that in branches is given by the equation (5).

$$\beta = \frac{2}{2+n},\ n = \frac{A_b}{A_{tun}} \quad \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots \quad (5)$$

Where:

n: Ratio of the cross-sectional areas, branch to main tunnel

A_b: Cross-sectional area of the branch

1.13 The equation (5) indicates that the effect of a branch depends on the cross-sectional area of the main tunnel and that of the branch shaft. It is sufficient for the branch to be deep to the extent that the wave separated into it and reflected at its end doesn't return until the wave front of the compression wave in the main tunnel passes the separating point. The length for this requirement is normally approximately 30 m. Therefore, wind/pressure preventive iron doors, if required, shall be installed at the places beyond the 30 m-distant points from the separating point. The equation (5) suggests that the larger the cross-sectional area, the larger the effect of the branch to reduce the pressure gradient. If the cross-sectional area of the branch is too large, however, the train will generate a new compression wave when it passes the separating point. After propagating in the main tunnel, this compressive wave will radiate new compression waves, to potentially pose a problem6). For this reason, the cross-sectional area of the branch shall be determined in consideration of the merit (suppression of micro-pressure waves) and the demerit (formation of new pressure waves) simultaneously.

(c) Connection to the Adjacent Tunnel with a Slit Shelter

1.14 The compression waves propagated from the main tunnel into the shelter will be released gradually through the slits of the shelter as a measure to suppress the effect of micro-pressure waves. See Figure 5B.4 for a case of slit shelter installed for Tohoku Shinkansen. For such shelters, approximately 20 cm wide slits are cut along the total length on both sides. Judging from the records of Joetsu Shinkansen, it is thought that the micro-pressure waves generated at the portal opposite to that where a shelter is connected is sufficiently small against the target set to suppress the effect of micro-pressure waves.

Source: RTRI.

Figure 5B.4 A Slit Shelter Installed for Shinkansen

1.3 Discussions

(a) Target Reduction Level of Tunnel Micro-Pressure Waves

1.15 There are no laws, ministerial ordinances or other official standards on the tunnel micro-pressure waves in Japan, unlike the case of the wayside noise under legal control. At the moment, however, the Ministry of the Environment is discussing the problem of low-frequency noise, while classifying the micro-pressure waves as sort of a low-frequency noise, in that the Ministry already issued "A handbook to the solution of low-frequency noise problems 2004,"7) for example. It is also conceivable that official standards will be established on low-frequency noise in the future. This will require setting a target to suppress micro-pressure waves to comply with the official standards. However, no evaluation standards have been issued so far by the Ministry of the Environment. To suppress micro-pressure waves, therefore, the following non-official targets are adopted for the Shinkansen tunnels based on the experience of JNR and JR in Sanyo, Tohoku and Joetsu Shinkansen railways.

(i) The maximum pressure of micro-pressure waves shall be 50 Pa or less at a point 20 m distant from the portal center.

(ii) The maximum pressure of micro-pressure waves shall be 20 Pa or less at houses (outdoor) in the vicinity of the portal.

1.16 The target in (i) is an approximate value to prevent blasting noise in the vicinity of the portal, while that in (ii) is to prevent the vibration of household furnishings. In the present case, it is unknown whether houses exist close to the portal, we observe the target (i) to maintain the maximum pressure of micro-pressure waves at 50 Pa or less at a point 20 m distant from the portal center. For tunnels with private houses existing close to the portal, therefore, the length of the buffer tunnel calculated in this study may be insufficient.

(b) Procedures for Discussions

1.17 In this study, we follow the procedures below to determine the length of the buffer tunnel to limit the magnitude of the micro-pressure waves at 50 Pa or less at a point 20 m distant from the portal when series E equivalent cars enter a tunnel at a speed of 350 km/h.

(i) Calculation of the maximum pressure gradient at the exit side portal to limit the magnitude of the micro-pressure waves to 50 Pa at a 20 m distant point (equation (2)). We calculate the maximum pressure gradient at the exit side portal to make the magnitude of the micro-pressure waves at 50 Pa at a point 20 m distant from the portal by using the equation (2). As the value of the radiation solid angle Ω that expresses the spatial expanse in the vicinity of tunnel portal differs depending on the topography and track conditions (elevated structures, waterways, etc.) , we adopt $\Omega = \pi$, which is a typical value. Therefore, the magnitude of the micro-pressure waves will become larger than that obtained in this study, if the portal is in a small area. As a result, the required buffering work will become longer than that calculated in this study.

(ii) Calculation of the maximum pressure gradient at the entry side portal corresponding to that at the exit side portal calculated in i) (Figure 5B.2). Based on the tunnel length while referring to Figure 5B.2, we calculate the maximum pressure gradient at the entry side portal corresponding to that at the exit side portal calculated in 1).

(iii) Calculation of the length of the buffer tunnel to obtain the maximum pressure gradient at the entry side portal calculated in ii) (equation (4)).

1.18 We calculate the length L of the buffer tunnel to obtain the maximum pressure gradient at the entry side portal by applying the equation.

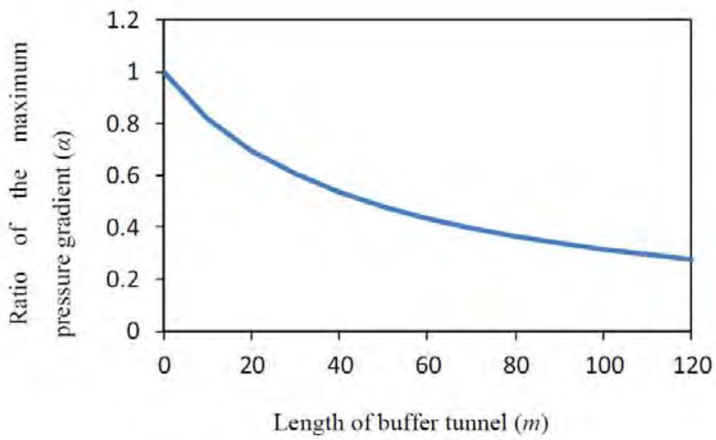
(c) Conditions for Discussions

1.19 Table 5B.1 summarizes the particulars of the tunnels and trains used for the discussion. The conditions of the tunnels are three cross-sectional areas and five lengths, or 15 different tunnels in total when different cross-sectional areas and lengths are combined. As the dimensions of the series E trains are unknown, we used those of E 954, Allow-Line trains, whose nose length at the head and cross-sectional areas at different positions are approximately equal to those of series E cars. We estimated the values of these parameters based on the data obtained from the tests in the field and quoted in the reference 8). Figure 5B.5 shows the values of the maximum pressure gradient at different points with the value at the tunnel entry side taken as unity (equation (3)), when the attribute length L is 46 m as given in Table 5B.1.

Table 5B.1 Particulars of Tunnels and Trains for Discussion

Tunnel	Cross sectional area (m^2)	63.4	70.0	80.0
	Equivalent diameter (m)	8.98	9.44	10.1
	Total length (km)	1, 3, 5, 7, 8.15		
	Track structure	Slab track		
Train	Type	E954 (Arrow-Line)		
	Cross sectional area (m^2)	10.8		
	Compression wave formation parameter κ	1.7		
	Maximum entry speed V (km/h)	350		
Buffer Tunnel	Attribute length D (m)	46		

Source: RTRI.



Source: RTRI.

Figure 5B.5 Relation between the Maximum Pressure Gradient and the Length of Buffer Tunnel (D = 46 m)

1.4 Results from Discussions

(a) Required Length of Buffering Work

1.20 Table 5B.2 summarizes the required length of the buffer tunnel to limit the magnitude of the micro-pressure waves to the target value or less obtained through the procedure 1.4 (b). Figure 5B.6 shows the relation between the length of tunnel and the required length of the buffer tunnel. As the train speed used for the discussion in this study is 350 km/h, higher than the maximum speed of Shinkansen in Japan (300 km/h), even tunnels having the same cross-sectional area as that of Shinkansen (63.4 m^2) require a buffer tunnel approximately as long as 60 m, even though their length is only 1 km. Tunnels longer than 5 km will require an extremely long buffer tunnel, say 90 to 110 m in length. Even buffer tunnel with a length of 50 to 60 m is required for Shinkansen when trains run at a maximum speed of 260 km/h[9)]. The magnitude of micro-pressure waves increased in proportion to the third power or over of the train speed, the values obtained through the above discussions seem to be appropriate.

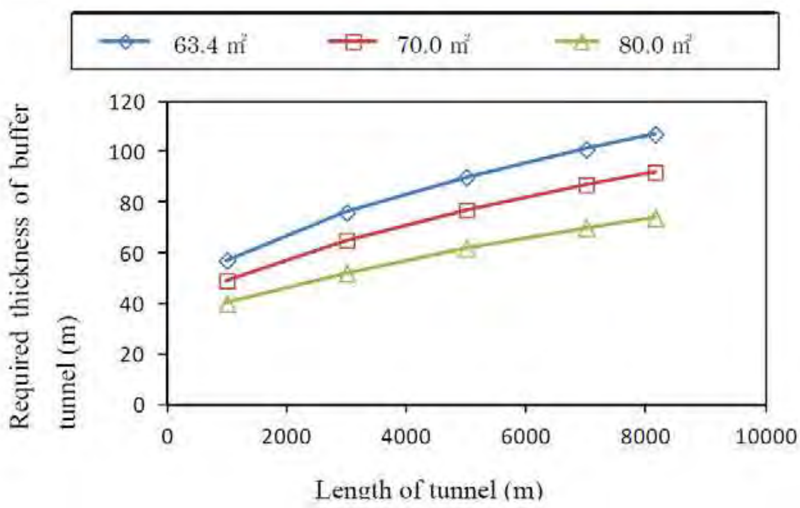
1.21 The larger the tunnel cross-sectional area is, the smaller the generated micro-pressure waves become. The required length of the buffer tunnel will be approximately 15% and 20% smaller, with tunnels having a cross-sectional area of 70 m^2 and 80 m^2, respectively. However, tunnels having a cross-sectional area of 80 m^2 require a maximum 75 m-long buffer tunnel, longer than any buffer tunnel currently existing in the country.

Table 5B.2 Required Length of Buffer Tunnel

(Target: 50 Pa or less at a point 20 m distant from the portal at a train speed of 350 km/h)

Total Length of Tunnel	Cross-Sectional Area		
	63.4 m^2	70.0 m^2	80.0 m^2
1 km	57 m	49 m	40 m
3 km	76 m	65 m	52 m
5 km	90 m	77 m	62 m
7 km	101 m	87 m	70 m
8.15 km	107 m	92 m	74 m

Source: RTRI.



Source: RTRI.

Figure 5B.6 Required Length of Buffer Tunnel

(b) Main Points to be Noted on Study Results

1.22 In this study, we assumed several preconditions for the calculation of the length of the buffer tunnel. Main points to be noted on the study results are as follows:

(i) We assumed the radiation solid angle $\Omega = \pi$ in the equation (2). As the value of radiation solid angle differs depending on the topology in the vicinity of tunnel portal, the magnitude of the micro-pressure waves will become larger in small areas or at places where waterways and the like exist. Therefore, the required length of the buffering work at such places will become longer than that obtained through this study.

(ii) We used the relation between the maximum pressure gradients at the entry side portal and at the exit side portal of Shinkansen tunnels (Figure 5B.2). As the relation between the maximum pressure gradient at the entry side and that at the exit side differs depending on the material/equipment shafts and track conditions in the tunnel, the relation between the maximum pressure gradient at the two points will potentially be different from that in Figure 5B.2 in the case of overseas tunnels of different structures.

(iii) We assumed the values of compression wave formation κ and attribute length D based on the field test data of E 954. Even with the cars having a nose length at the head and cross-sectional area similar to those of the series E and E954 cars, the micro-pressure wave may be different in case the open/close pattern of the buffering work openings is not appropriate.

(c) Conclusions

1.23 The required length of the buffer tunnel to suppress the magnitude of the micro-pressure waves generated by a train entering a tunnel at a speed of 350 km/h at 50 Pa or less at a point 20 m distant from the exit side portal of the tunnel and found that even tunnels having a cross-sectional area equivalent to that of Shinkansen (63.4 m^2) require an approximately 60 m long buffer tunnel irrespective of their length. Although the required length of buffer tunnel becomes smaller with tunnels having larger cross-sectional areas, it has been predicted that even tunnels with a cross-sectional area of 80m^2 require a maximum 75 m-long buffer tunnel, longer than any buffer tunnel currently existing in the country.

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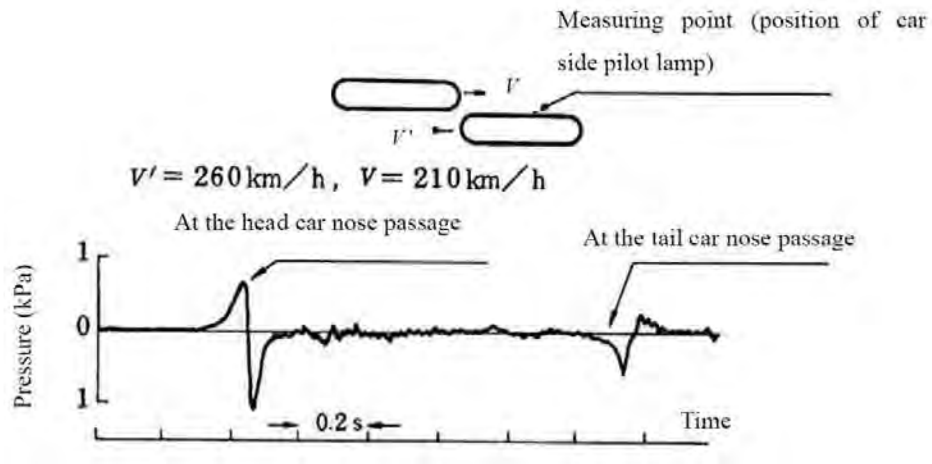
2 STUDY ON THE DISTANCE BETWEEN TRACK CENTERS

2.1 Phenomenon of Tunnel Micro-Pressure Waves and Measures for Suppression in Japan

2.1 When two trains cross each other, both trains are subjected to aerodynamic effects. These effects are stronger as train speed is higher. When a train crosses the head or tail of the opposite train, the train is subjected to a force in the lateral direction (perpendicular to the track). This phenomenon takes place because the subject train is subjected to the pressure changes occurring on the car body surface of the head and tail of the opposite train. Pressure changes in the two-rain crossing are related to the motion of rolling stock (running stability, ride comfort).

2.2 Figure 5B.7 illustrates an example of the pressure changes on the side of the subject train facing the opposite train[1)] (hereinafter referred to as the “adjacent side”). In the two-train crossing in open sections (other than tunnel sections), the pressure on the other side (hereinafter referred to as the “far side”) is almost the same as the atmospheric pressure without affected by the crossing with the opposite train. Therefore, the pressure changes on the adjacent side in Figure 5B.7 are the same and one as those on the subject train as they are. The peak pressure changes in Figure 5B.7 are those working on the both parallel sides of intermediate cars, which can be used as well for the evaluation of the air pressure working on the noise insulating walls at train passage.



Source: RTRI.

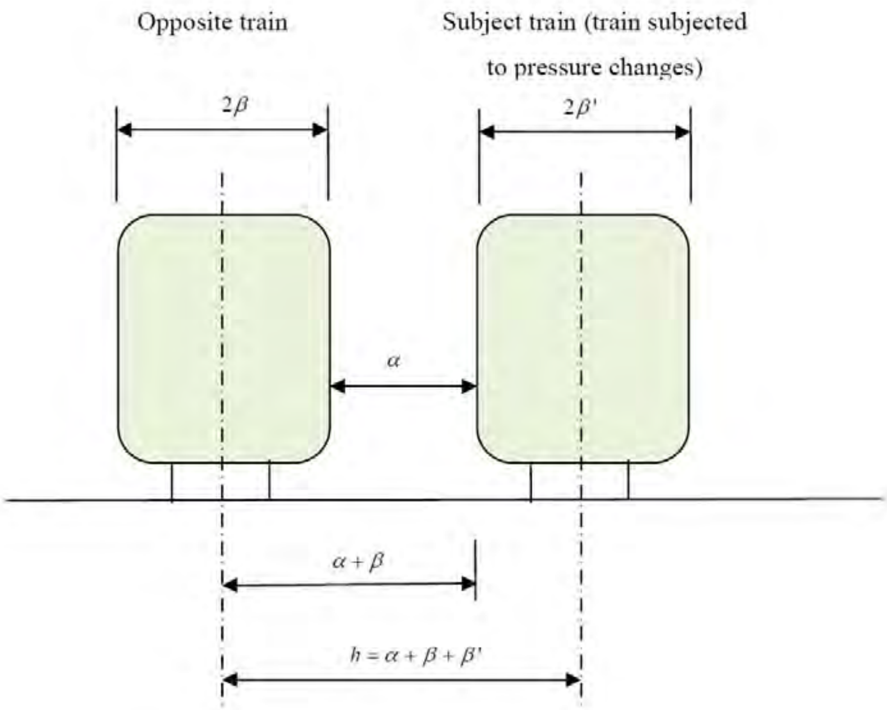
Figure 5B.7 Pressure Changes at Two-Train Crossings

2.3 Problems in the two-train crossing at flat places include the wind pressure on the train head and car side window glasses and lateral shock on the trains caused by the wind pressure at crossing (that potentially leads to overturn or derailment of trains). The effect of the two-train crossing on the walls and buildings existing to the side of the trains is also thought to be sort of a phenomenon stemmed from the two-train crossing.

2.4 The effect of the pressure changes caused by the opposite train at crossing on the rolling stock motion is dependent only on the distance between track centers, once the profile of head car nose and the train speed have been specified. Therefore, we shall discuss the distance between track centers based on the evaluation of running stability and ride comfort at crossing.

2.5 In the two-train crossing in tunnels, the pressure changes by the opposite train are thought to diffract toward the far side of the subject train and subsequently become uniform over the entire cross-section of the tunnel. Therefore, the pressure working on the train into the lateral direction (direction of sleepers) of the track is smaller than in open sections. This also holds true with the effect of pressure changes on the rolling stock motion. The effect on the window glasses is problematic rather in tunnels as the passenger compartments are airtight.

2.6 The adjacent side of the subject train is subject to positive-negative pulsed pressure changes when the head of the opposite train passes and negative-positive pressure changes when the tail of the opposite train passes. The peak value of pressure changes and pulse widths are dependent on the speed of the opposite train V, speed of the subject train V', car width of the opposite train 2β, car width of the subject train 2β', distance between train sides α, (distance between track centers h = α + β + β'), train head profile and train tail profile. See Figure 5B.8 for the symbols referred to above. The magnitude of the pressure changes is in proportion to the second power of the speed of the opposite train V and the pulse width is in reverse proportion to the sum of the speed of the opposite train V and that of the subject train V'.



Source: RTRI.

Figure 5B.8 Car Width and Distance between Car Sides

2.7 We shall also assess the pressure changes due to the opposite train on the head and tail of the subject train. As the separation between the head/tail of the subject train and the opposite train in the direction perpendicular to the track is larger than the separation between the sides of intermediate cars and the opposite train, however, the pressure changes on the head and tail are thought to be smaller than those on intermediate cars.

2.2 Discussions

(a) Procedures for Discussions

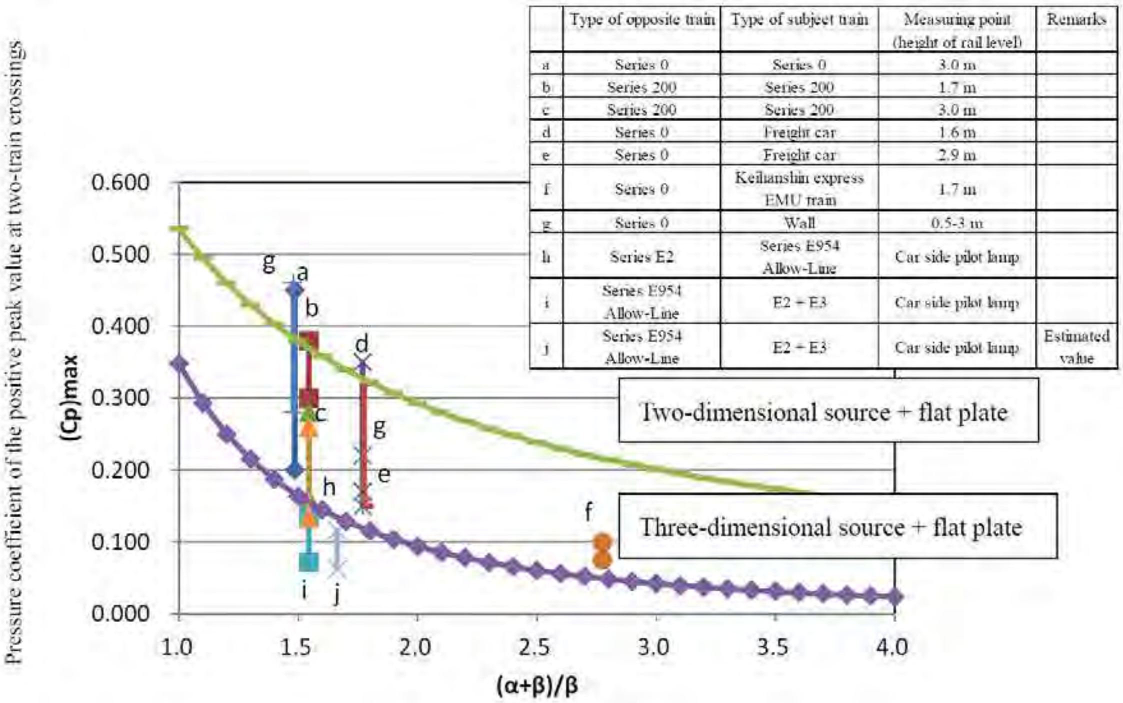
2.8 In normal cases of two-train crossing, the distance between track centers in a speed range 300 to 400 km/h will be determined principally constrained by aerodynamic effects. A yardstick for discussions is to guarantee the ride comfort at the same level as that currently adopted for two-train crossings in Shinkansen.

2.9 In the case of Shinkansen (series 0 and 200), Table 5B.3 and Figure 5B.9 show the relations between (i) the peak value of positive pulsed pressure at head passage $(\Delta p)_{max} = 1/2 \times \rho V^2 (C_p)_{max}$ and (ii) pressure coefficient $(C_p)_{max}$, the distance between train sides α, car width of the opposite train 2β and car width of the subject train 2β'. See the points and rows a to g in Table 5B.3 and Figure 5B.9[2)]. In the case of Shinkansen (series 0 and 200), when the peak value of the positive pulsed pressure at the passage of the train head is taken as unity, the peak values of the negative pulsed pressure at the passage of head and tail are −1.2 to −1.6 and −0.8 to −1.3, respectively. The pressure coefficient $(Cp)_{max}$, which depends on the nose profile of the train, becomes smaller as the car cross- sectional area becomes larger or the nose of the head becomes longer.

Table 5B.3 Pressure Coefficient at Two-Train Crossings

	Type of opposite train	Type of subject train	Distance between track centers h (m)	Width of the opposite train 2β (m)	β (m)	Width of the subject train 2β' (m)	2β' (m)	Distance between sides α (m)	Non-dimensional distance (α + β)/β	Pressure coefficient (*Cp*) max
a	Series 0	Series 0	4.2	3.38	1.69	3.38	1.69	0.82	1.485	0.200
									1.485	0.450
b	Series 200	Series 200	4.3	3.38	1.69	3.38	1.69	0.92	1.544	0.300
									1.544	0.380
c	Series 200	Series 200	4.3	3.38	1.69	3.38	1.69	0.92	1.544	0.160
									1.544	0.280
d	Series 0	Freight car	4.3	3.38	1.69	2.62	1.31	1.30	1.769	0.170
									1.769	0.350
e	Series 0	Freight car	4.3	3.38	1.69	2.62	1.31	1.30	1.769	0.150
									1.769	0.220
f	Series 0	Keihanshin express EMU train	6.1	3.38	1.69	2.8	1.4	3.00	2.775	0.075
			(Reverse calculation)			(Estimation)			2.775	0.100
g	Series 0	Wall	2.5	3.38	1.69	0.00	0.00	0.81	1.479	0.280
									1.479	0.460
g	Series 0	Wall	3.0	3.38	1.69	0.00	0.00	1.31	1.775	0.150
									1.775	0.320
h	Series E2	E954 + E955	4.3	3.38	1.69	3.38	1.69	0.92	1.544	0.133
									1.544	0.259
i	Series E954 Allow-Line	E2 + E3	4.3	3.38	1.69	3.38	1.69	0.92	1.544	0.0720
									1.544	0.134
j	Series E954 Allow-Line	Estimation	4.5	3.38	1.69	3.38	1.69	1.12	1.663	0.0625
									1.663	0.116

Source: RTRI.



	Type of opposite train	Type of subject train	Measuring point (height of rail level)	Remarks
a	Series 0	Series 0	3.0 m	
b	Series 200	Series 200	1.7 m	
c	Series 200	Series 200	3.0 m	
d	Series 0	Freight car	1.6 m	
e	Series 0	Freight car	2.9 m	
f	Series 0	Keihanshin express EMU train	1.7 m	
g	Series 0	Wall	0.5-3 m	
h	Series E2	Series E954 Allow-Line	Car side pilot lamp	
i	Series E954 Allow-Line	E2 + E3	Car side pilot lamp	
j	Series E954 Allow-Line	E2 + E3	Car side pilot lamp	Estimated value

Source: RTRI.

Figure 5B.9 Distance-Dependent Attenuation of the Pressure Coefficient

2.10 The curve at the top in Figure 5B.9 represents the theoretical value of the pressure coefficient at the positive peak value at two-train crossings, when the adjacent side of the subject train is modeled as a flat plate and the head of the opposite train is assumed as a two-dimensional source. The curve at the bottom represents the corresponding value under the same assumptions as above, in which the two-dimensional source shall be read as a three-dimensional source.

2.11 These values are given by the following equations, respectively.[3)]

Two-dimensional source + flat plate model:

$$(C_p)_{\max} = \frac{2\beta}{\pi}\frac{1}{(\alpha+\beta)} - \frac{\beta^2}{\pi^2}\frac{1}{(\alpha+\beta)^2} \quad \cdots\cdots\cdots \quad (6)$$

Three-dimensional source + flat plate model:

$$(C_p)_{\max} = \frac{2\beta^2}{3\sqrt{3}}\frac{1}{(\alpha+\beta)^2} - \frac{\beta^4}{27}\frac{1}{(\alpha+\beta)^4} \quad \cdots\cdots\cdots \quad (7)$$

2.12 The values a to g in Figure 5B.9 prove that the pressure coefficient $(Cp)_{max}$ becomes smaller as the non-dimensional distance (α + β) / β, the distance between the center of the opposite train and the sides of the subject train that is normalized with respect to β become larger.

2.13 In this study, we calculate the pressure coefficient $(Cp)_{max}$ of the series E5 equivalent cars from the measured values, estimate the peak value of positive pulsed pressure for different values of non-dimensional distance (α + β) / β and train speed and calculate the distance between track centers to make the peak value of positive pulsed pressure approximately equal to the present value.

(b) Conditions for Discussions

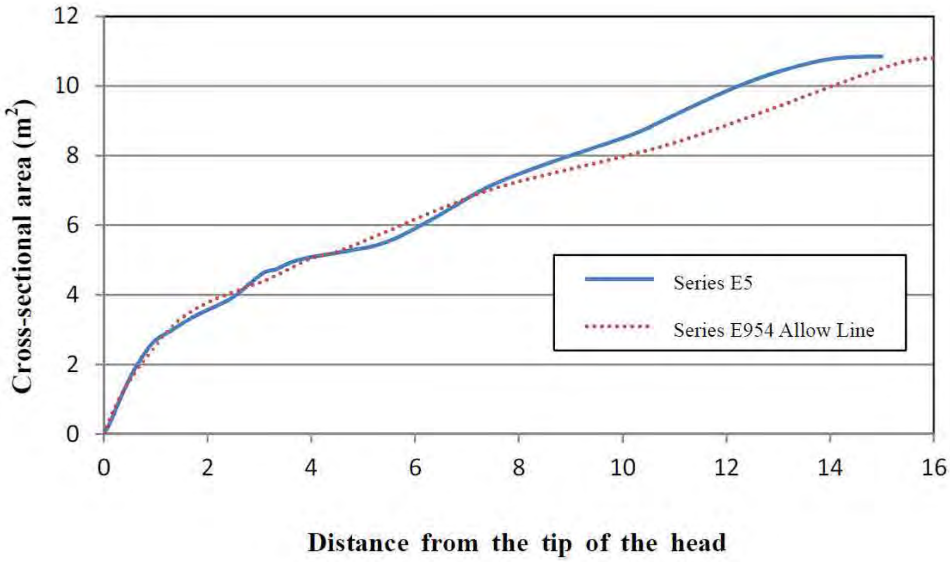
2.14 The distance between track centers is normally determined in consideration of the characteristics of the rolling stock motion when two train cross. To cut the time for discussion in this Report, however, we calculate the distance between track centers to make the peak value of positive pulsed pressure at two-train crossings almost the same as the current value, under the assumption that the vibration characteristics of the rolling stock subjected to external force remain at the present level. See the Table 5B.4 for the current situation and the conditions 1 to 4 assumed for discussions.

Table 5B.4 Conditions at Present and for Discussions

Conditions	Car type	Distance between Track Centers $h(=\alpha+\beta+\beta')$ (m)	Maximum Speed V (km/h)	Remarks
1	Series 0	4.2	210	Present level
2	Series 200	4.3	260	Present level
3	Series E2	4.3	275	Present level
4	Series E954 Arrow Line	4.3	320	Present level
5	Series E954 Arrow Line	4.3	350	
6	Series E954 Arrow Line	4.5	350	

Source: RTRI.

2.15 It is desirable to use the measured data of series E5 cars for discussions. Unfortunately, however, the data was not obtainable. In place thereof, therefore, we used the measured data of the series 954 Allow-Line, series E5 equivalent cars. See Figure 5B.10 for the distribution of the values of cross-sectional area of the heads of Series E5 and series E954 Arrow-Line cars4) and Figure 5B.11 for the pictures of the heads of these cars. Despite that the head of the series E954 Allow-Line is 16 m long, 1 m longer than that of series E5 cars in actuality, Figure 5B.10 suggests that the heads of these cars are similar to each other. This holds true as well, from the viewpoint of the pressure generated at crossings.



Source: RTRI.

Figure 5B.10 Distribution of the Values of Cross-Sectional Area at Different Points used for Discussions

(a) Head of series E5

(b) Head of series E954 Arrow-Line

Source: RTRI.

Figure 5B.11 Pictures of the Head Profiles used for Discussions

2.3 Results of Discussions

(a) Pressure Coefficient of the Series E2 and E954 Allow-Line

2.16 The values of the pressure coefficient of series 0 and 200 in Table 5B.3 and Figure 5B.9 and also the value of the current rolling stock, with the opposite cars assumed as the series E2 and E954 cars were calculated. The equation (8) gives the value of pressure coefficient from the peak value of positive pulsed pressure at the passage of the head of series E2 and E954 Allow-Line cars, with the density of air set as ρ = 1.225 kg/m^3.

$$\left(C_p\right)_{\max} = \frac{(\Delta p)_{\max}}{\frac{1}{2}\rho V^2} \quad \cdots\cdots \quad (8)$$

2.17 See the values h and i in Table 5B.5 and Figure 5B.9. However, the values disperse in wide ranges. The value of the pressure coefficient is smaller in case the opposite train is composed of series E2 cars than the values when the opposite train is composed of series 0 or 200 cars. The value of the series E954 Allow-Line cars is further smaller than any value mentioned above. This is because the values of the cross-sectional area of series E2 and E954 Allow-Line cars are smaller than those of series 0 and 200 and the nose of the head is longer. See Table 5B.6.

Table 5B.5 Values of the Pressure Coefficient of Current Rolling Stocks

(a) Pressure coefficient of series E2

	Car type	Speed km/h
Opposite train	E2	275
Subject train (measured car)	E954 + E955	300

Car number	Reading (0-P)	Value of pressure	Pressure coefficient
	mm	Pa	(Cp)max
1	10.1	927	0.259
4	10.8	991	0.277
8	8.9	817	0.228
11	7.1	651	0.182
14	6	550	0.154
16	8	734	0.205
	Average value	778	0.218

	Car type	Speed km/h
Opposite train	E2	275
Subject train (measured car)	E954 + E955	320

Car number	Reading (0-P)	Value of pressure	Pressure coefficient
	mm	Pa	(Cp)max
1	9.2	844	0.236
4	10.9	1000	0.280
8	10	917	0.257
11	5.2	477	0.133
14	6.5	596	0.167
16	8.1	743	0.208
	Average value	763	0.213

Pressure coefficient	(Cp)max
Minimum value	0.133
Maximum value	0.259
Average value	0.203

(b) Pressure coefficient of series E954 Arrow-Line

	Car type	Speed km/h
Opposite train	E954 Allow	300
Subject train (measured car)	E2 + E3	275

Car number	Reading (0-P)	Value of pressure	Pressure coefficient
	mm	Pa	(Cp)max
1	6.2	569	0.134
7	4.3	394	0.093
10	5.6	514	0.121
11	4.8	440	0.104
14	5	459	0.108
16	4.1	376	0.088
	Average value	459	0.108

	Car type	Speed km/h
Opposite train	E954 Allow	320
Subject train (measured car)	E2 + E3	275

Car number	Reading (0-P)	Value of pressure	Pressure coefficient
	mm	Pa	(Cp)max
1	4.5	413	0.085
7	3.8	349	0.072
10	5.2	477	0.099
11	6.4	587	0.121
14	4.9	450	0.093
16	4.9	450	0.093
	Average value	454	0.094

Pressure coefficient	(Cp)max
Minimum value	0.072
Maximum value	0.134
Average value	0.101

Source: RTRI.

Table 5B.6 Car Cross-Sectional Area and Length of Head

Car Type	Cross-Sectional Area (m)	Length of Head (m)
Series 0	12.2	4.7
Series 200	12.2	5.5
Series E2	11.2	9.1
Series E954 Arrow Line	10.8	16.0

Source: RTRI.

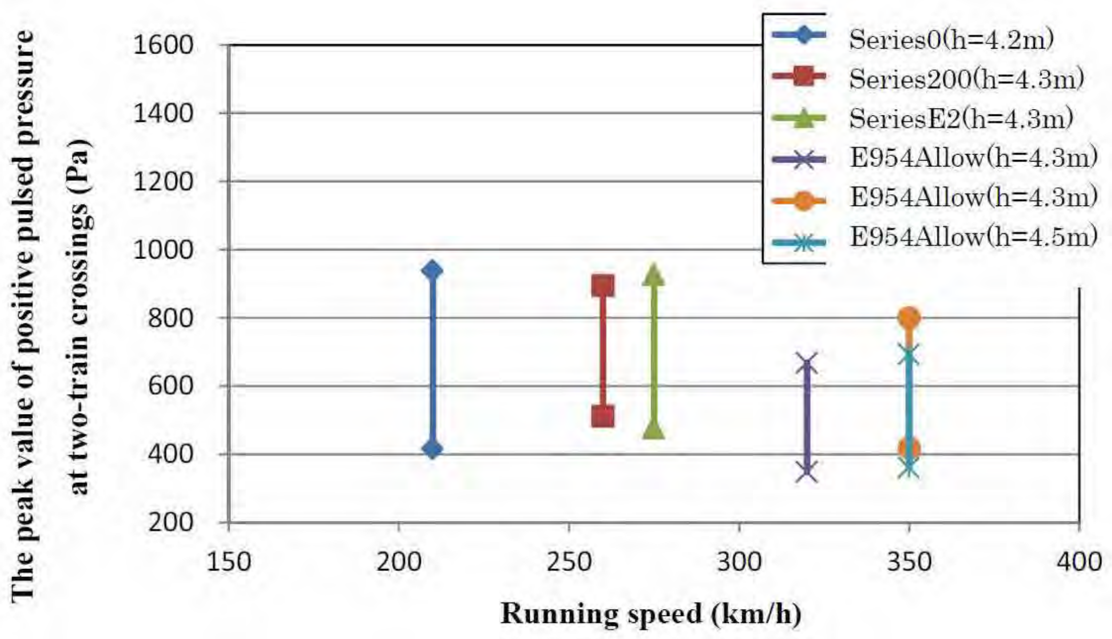
(b) Pressure coefficient of the SeriesE954 Allow-Line (when the distance between track centers h = 4.5m)

2.18 The pressure coefficient i of the Series E954 Allow-Line in Figure 5B.9 is the value in the case where the distance between track centers h = 4.3 m. The value i is close to the curve under the assumption of three-dimensional source + flat plate. While assuming that the dependency of the pressure coefficient of positive pulses on the non-dimensional distance (α + β) / β is almost the same as that at the passage of the head of the E954 Allow-Line cars, we calculate the pressure coefficient when the distance between track centers h = 4.5 m. See the row j in Table 5B.3 and the point j in Figure 5B.9 for the results.

(c) Pressure generated in running at the maximum speed

2.19 Figure 5B.12 shows the peak value of positive pulsed pressure generated when the train runs at the maximum speed given in Table 5B.4, which was calculated by the equation (9) by using the air density ρ = 1.225 km/m^3 and the values of pressure coefficient in Figure 5B.9.

$$(\Delta p)_{\max} = \frac{1}{2}\rho V^2 (C_p)_{\max} \qquad \text{..} \quad (9)$$



Source: RTRI.

Figure 5B.12 Peak Value of Positive Pulsed Pressure to Reflect the Dispersion of the Values of Pressure Coefficient

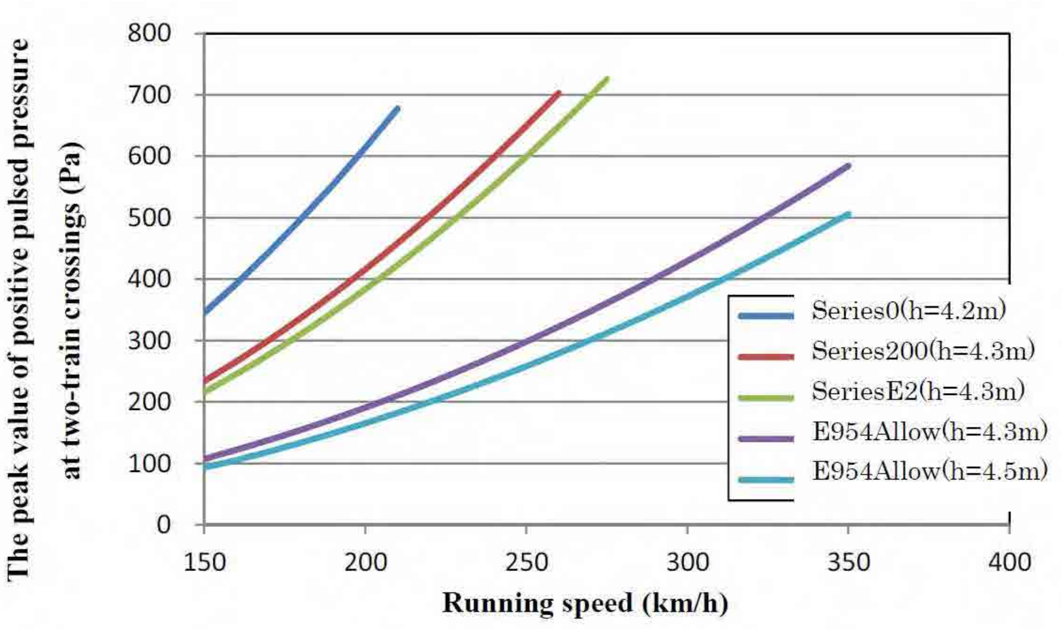
2.20 Figure 5B.12 indicates that the current peak value of positive pulsed pressure (series 0, 200, E2 and E954 Arrow –Line cars (distance between track centers h = 4.3 m)) is in the range of 400 to 900 Pa, while that of the series E954 (distance between track centers h = 4.5 m) cars, the object of this study, is in the range of 400 to 800 Pa when the cars run at a speed of 350 km/h, which is in the current range to mean that the situation is not worsened.

2.21 As a next step, we discussed the dependency of the peak value of positive pulsed pressure on speed. Table 5B.7 summarizes the average values of pressure coefficient under different conditions read from Figure 5B.9, while Figure 5B.13 illustrates the peak value of positive pulsed pressure obtained by using the values of the pressure coefficient in Table 5B.7. The peak values of positive pulsed pressure in Figure 5B.13 are those up to the maximum speed shown in Table 5B.4. Figure 5B.13 indicates that the current peak value of positive pulsed pressure is approximately 700 Pa, which means that the peak value generated by the series E954 cars running at 350 km/h doesn't exceed the current level whichever the distance between track centers h may be 4.3 or 4.5 m.

Table 5B.7 Values of Pressure Coefficient used to Estimate the Peak of Positive Pulsed Pressure in Consideration of the Speed Effect

Car Type	Distance between Track Centers *h* (m)	Pressure Coefficient $(C_p)_{\max}$
Series 0	4.2	0.325
Series 200	4.3	0.220
Series E2	4.3	0.203
Series E954 Arrow Line	4.3	0.101
Series E954 Arrow Line	4.5	0.0874

Source: RTRI.



Source: RTRI.

Figure 5B.13 Values of the Peak of Positive Pulsed Pressure in Consideration of the Speed Effect

2.4 Conclusions

2.22 In the study for the Formulation of High Speed Railway Projects on Hanoi-Vinh and Ho Chi Minh-Nha Trang Sections, we discussed the distance between track centers in double-track sections to maintain the pressure imposed on the side of the subject train facing the opposite train composed of series E5 equivalent cars running on the adjacent track in the opposite direction. As a result, we found that the peak value of the positive pulsed pressure on the side of the subject train doesn't exceed the present level (a state where series E2 cars are running at a maximum speed of 275 km/h) whichever the distance h between track centers may be, 4.3 or 4.5 m.

2.23 The distance between track centers is normally determined in consideration of the characteristics of the rolling stock motion when two trains cross each other. To cut the time for discussion in this Report, however, we calculated the distance between track centers to make the peak value of positive pulsed pressure at two-train crossings almost the same as the current value, under the assumption that the vibration characteristics of the rolling stock subjected to external force remain at the present level. In discussing the distance between track centers in detail in the future, therefore, it is desirable to take into consideration the characteristics of the motion of rolling stock.

References for Chapter 2

1) Working group on the Facilities/equipment, electric engineering and rolling stock, Shinkansen Test Track, (Oyama district) , Test Report 1980, Interim Report, Railway Technical Research Institute, No. 81-5, 1981, pp. 136-139

2) S101 Magnetically-Elevated Railways SE Group, Group Study S101, “Magnetically-Elevated Railways SE” Study Report, Interim Report, Railway Technical Research Institute, No. B-83-5, 1983, pp. 170-171

3) U191 Magnetically-Levitated Railways 1SE Group, Magnetically-Levitated Railways SE (No. 1), Interim Report, Railway Technical Research Institute, No. 80-76, 1980, pp. 126-128

4) Shinkansen Technologies to haul the Age of over 300km/h or over, Railway Technologies, San-ei Shobo, 2012 pp. 43.

APPENDIX 6A

Existing Law and Standard Concerning to Railway Construction

1. Concerning to Transportation

6.1 Table 6A.1 summarizes the existing laws and criteria on railways.

Table 6A.1 List of Statute Concerning to Transport

No	Legal Document	Code	Date of Published	Remark
1	Railway Law	No.35/ 2005/ QH11	27/06/2005	
2	Detailed implementation Rules for Railway Law	No.76/ 2005/ QD-BGTVT 22TCN-340-05	30/12/2005	
3	Decree Detailed implementation Rules and Guideline for some Articles in the Railway Law	No.109/ 2006/ ND-CP	22/09/2006	Government decision
4	Decree Amending and supplementing a number of articles of the government's Decree No.109/2006/ND-CP	No.03/2012/ND-CP	19/01/2012	
5	Decision Railway Grade Standard Different grade 1435mm /1000mm gauge	34/ 2007/ QD-BGTVT TCVN 8893:2011	25/07/2007 2011	
6	Decision on approving the adjusted Master Plan on development of Vietnam's railway transportation	No.1436/QD-TTg	10/9/2009	up to 2020, with a vision toward 2030
7	Decision on Rolling Stock Safety Environment Inspection Rules	http://moj.gov.vn/vbpq/en/Lists/Vn bn php lut/View_Detail.aspx?ItemID=633658/2005/QD-BGTVT	2005	
8	Railway Technical Grade Classes of Railway Technologies	2011: TCVN 8893	2011-	
9	Technical Standard of design of 1435mm gauge lines	TCVN-4117-1985	1985	
10	Norm for railway technology on the design of 1000mm gauge lines		9/02/1976	
11	Norm on Speed, heavy cargo, diagram	No.69/ 2005/12/09	9/12/2005	
12	Notification on Transport	No.01/ 2006/ QD-BGTVT	2006	
13	Technical Norms for operation of Vietnam Railways	No.1597/ GTVT-KHCN	2/08/1999	
14	Design Standard of Tunnel	TCVN 4527-88	5/02/1988	
15	Procedure of train operation	No.76/ 2005/ QD-BGTVT 22TCN-342-05	30/12/2005	
16	Railway Engineering Classifications	22TCN-362-07	25/07/2007	
17	Design Rule on engineering geological investigation and stabilize the formation level	22TCN-171-87	11/12/1987	
18	Rule on the Design of traffic civil engineering construction and Environmental Impact Assessment for Establishing Feasibility Study	22TCN-242-98	27/03/1998	
19	Design Standard on traffic civil engineering in Earthquake Anticipated areas	22TCN-221-95	3/05/1995	
20	Technical Norm on Railway	22TCN-340-05	30/12/2005	

No	Legal Document	Code	Date of Published	Remark
	Management			
21	Permanent way maintenance Rule	396/DS-PC	12/03/1981	Regulation for Railway Track Maintenance
22	standard on railway operation	No.76/2005/QD-BGTVT	2005	
23	Guideline of transport	No.519/ QD-DS		
24	Technical Rule on the repair of railway infrastructure (Bridges, drainage ditches, tunnels and tracks)		25/02/2000	
25	Urban Railway Standard for Mass Rapid Transit (MRT)	TCVN 8585:2011	22/2/2011	General Technical Requirements
26	National Technical Regulation on Railway Signaling	QCVN 06:2011/BGTVT	2011	
27	National Technical Regulation on Railway Operation	QCVN 08:2011/BGTVT	2011	
28	"Technical Norms for Operation of Vietnam Railway"	No.22 TCN-240-99	1999	Industry Standard
29	Signal Standard	No.22 TCN34-05	2005	
30	Decree on investment in important projects and works	No.66/2006/QH11	29/6/2006	
31	Decision on approval of Vietnam Railway Development Strategy to the year 2020 and vision to the year 2050	No.1686/QD-TTg	20/11/2008	Prime Minister
32	Joint circular Guiding the regime of financial management at the state enterprises engaged in public utility activities in transport mean registry	97/1997/TTLT	31/12/1997 1/01/1998	
33	Decision Technical and environmental protection requirements of railway means of transport	22/2006/QD-BGTVT	2006	promulgating branch standard 22 TCN 348-06
34	Decision Railway traffic means-passenger carriages-Technical requirements upon manufacture or assembly of new ones	21/2006/QD-BGTVT	4/05/2006 23/05/2006	promulgating branch standard 22 TCN 347-06
35	Decision Means of railway transport passenger carriage's direction-changing tracks-technical requirements upon manufacture and installation	53/2006/QD-BGTVT	29/12/2006 30/01/2007	promulgating branch standard 22TCN359-06
36	Decision Means of railway transport- Diesel locomotives - technical requirements upon manufacture assembly and importation	47/2006/QD-BGTVT	27/12/2006 28/01/2007	promulgating branch standard 22 TCN 357-06
37	Decree on ensuring railway traffic order and safety	39/ CP	05/07/1996 1/09/1996	
38	Regulation on crossing level and provision on level crossing protection organization	737/2001/QD-BGTVGT	2001	

Source: Compiled by the Study Team
Legend: TCN: Standard of the Ministry
TCVN: Standard of Vietnam Government
DS-PC: Regulation of VR (Implementation criteria of companies)

2. Concerning to Construction

Table 6A.2 List of Statute Concerning to MOC

No	Legal Document	Code	Date of Published	Remark
1	Construction Law	No.16/ 2003/ QH11	26/11/2003	
2	Housing Law	No.56/2005/QH11	1/7/2006	
3	Law Urban Planning	No.30/2009/QH12	17/06/2009	
4	Law on Cultural Heritage	No.28/2001/QH10	29/06/2001	
5	Directive on work of urban design	No.09/2003/CT-TTg	7/4/2003	
6	Decree promulgating the statute on management of urban planning	91/CP 17/08/1994	17/08/1994	
7	Decree on construction planning	No.08/2005/ND-CP	8/2/2005	
8	Order for Construction of underground facilities in urban area	No.41/ 2007/ ND-CP	22/03/2007	
9	Order for Quality management of Facilities Construction	No.209/ 2004/ ND-CP	16/12/2004	
10	Circular on guiding construction-related judicial assessment	No.35/ 2009/ TT-BXD	5/10/2009	
11	Circular on application of foreign construction standards to construction activities in Vietnam	No.40/ 2009/ TT-BXD	1/2/2010	
12	Decree on the formulation, evaluation, approval and management of urban planning	37/2010/ND-CP 07/04/2010	25/05/2010	
13	Design Standard on road and railway Tunnels	TCVN 4527-88	5/02/1988	
14	Technical Standard of design of 1435mm gauge lines	TCVN-4117-1985	1985	
15	Decision Promulgating Vietnam construction standard	TCXDVN 395 2007	2007	Mineral admixtures for roller-compacted concrete
16	Building Code for Underground Structure	QCVN08/ 2009/ BXD	1/10/2009	Circular No.28/2009/TT-BXD
17	Building Code for Underground Structure Second Edition	QCVN08/ 2009/ BXD	14/08/2009	Second Edition
18	Directive on the work of urban planning and construction management	30/1999/CT-TTg 26/10/1999	26/10/1999	
19	Decision On issue the Orientation for Sustainable Development Strategy in Vietnam	153/ 2004/ QD-TTg	08/2004	
20	Standard Design of Civil Structures for Traffic in Earthquake Areas	22TCN-221-95 Ministry of Transport	1995-5-03	
21	Design rule on bridges and drainage ditches based on the critical state	22TCN 18-79	19/09/1979	
22	Decision promulgating the provisional regulation on contribution of comments to the preparation and execution of traffic construction projects	19/2004/QD-BGTVT	22/10/2004	
23	Decision Providing for the application of new materials and/or new technologies in the construction of traffic works in Vietnam	30/2006/QD-BGTVT	10/08/2006 7/09/2006	
24	Decree on monitoring quality of construction work	No.209/2004/ND-CP	2004	
25	Decree on management of investment projects on the construction of works	16/2005/ND-CP	7/02/2005 5/03/2005	
26	Decree on monitoring quality of construction work	No.49/2008/ND-CP	2008	

No	Legal Document	Code	Date of Published	Remark
27	Decree on cost management &construction work project management	No.83/2009/ND-CP	2009	
28	Decree on cost management of work investment and construction	No.112/2009/ND-CP	2009	
29	Law on fire prevention and fighting	27/2001/QH10	29/06/2001 4/10/2001	
30	Law on dikes	79/2006/QH11	29/11/2006 1/07/2007	

Source: JICA Study Team

6.2 Circular on application of foreign construction standards to construction activities in Vietnam provides the rule of application of foreign construction standards.

Table 6A.3 List of Procedure and Norm for Road Construction

No	Name of Procedure/Norm	Code	Utilization Purpose
I	Survey		
1.	Topographical measurement	96TCN 43-90	Survey
2.	Highway survey	22TCN 263-2000	Survey
3.	Geologic test hole drilling	22TCN 259-2000	Survey
4.	Design survey on highway foundation on soft ground	22TCN 262-2000	Survey for design
5.	Defining general elasticity module for highway pavement by Benkelman deflection measurement	22TCN 251-98	Survey
6.	Environmental impact assessment during the formation of feasibility project and transportation work designing	22TCN 220-95	Survey
II	Design		
7.	Expressway – Design requirement	TCVN 5729-1997	Design
8.	Highway – Design requirement	TCVN 4054-1998	Design
9.	Highway design standard	22TCN 273-01	Design
10.	Street, square and urban design	20TCN 104-83	Design
11.	Soft pavement design	22TCN 211-93	Design
12.	Solid pavement design	22TCN 223-95	Design
13.	Flood run-off properties analysis	22TCN 220-95	Design
14.	Drainage network design	TCXDVN 51-84	Design
15.	Road, street and square lighting design standard	TCXDVN 295:2001	Design
16.	Design of bridge and culvert in limit state	22TCN 18-79	Design
17.	Bridge design standard	22TCN 272-01	Design
18.	Tunnel technical dimension	11TCN 19-84	Design
19.	Traffic signal regulation	22TCN 237-01	Design
20.	Green-space quota	529/BXD/VTK-1997	Design
III	Reference standards		
21.	International Lighting Standard	CIE 115-1995	Reference
22.	Highway design standard	TCVN 4054-85	Reference
23.	Rural street design	22TCN 210-92	Reference

Source: JICA Study Team

3. Concerning to Ministry of Industry and Trade (MOIT)

Table 6A.4 Statute Concerning to MOIT

No	Legal Document	Code	Date of Published	Remark
1	Bidding Law	No.61,/2005/QH-11		
2	Law on Electric	No.28/2004/QH11	11/7/2005	
3	Order Execution guide and detail regulation	No.105/ 2005/ ND-CP	2005	
4	Order High pressure circuit safety	No.106/ 2005/ ND-CP	2005	
5	Decision promulgating the charter on organization and operation of the Vietnam Register	791/2001/QD-BGTVT	26/03/2001 10/04/2001	
6	Law on State enterprises	14/2003/QH11	26/11/2003 1/07/2004	
7	Law on inspection	22/2004/QH11	15/06/2004 1/10/2004	
8	Law on Technology transfer	80/2006/QH11	29/11/2006 1/07/2007	
9	Law on product and goods quality	5/2007/QH12	21/11/2007 1/07/2008	
10	Law on information technology	67/2006/QH11	29/06/2006 1/01/2007	

Source: JICA Study Team

4. Concerning to Ministry of Natural Resources and Environment (MONRE)

6.3 Legal framework on environmental impact assessment – EIA and others.

Table 6A.5 List of Main Legal Documents related to Environmental Protection and Land

No	Legal Document	Code	Date of Published	Remark
1	Law on Environmental Protection	No.52/2005/ QH11	29/11/2005	(Ex 1993)
2	Decree on Providing Guidance for the Implementation of the Law on Environmental Protection;	No. 80/2006/ NĐ-CP	09/08/2006	
3	Decree Detail regulations and Guidance implementation the Law on Environmental Protection	21/ 2008/ ND-CP	28/02/2008	
4	Decree on Government regulating strategic environmental assessment, EIA and environmental protection commitment	No. 29/2011/ NĐ-CP	18/04/2011	
5	Circular on Ministry of Natural Resources and Environment regulating details for several articles	No. 26/2011/ TT-BTNMT	18/7/2011	regulating details for several articles in Decree 29/2011/ ND-CP
6	Law on Environmental Tax	No.57/2010/ QH12	15/11/2010	
7	Decision on Promulgating branch standard	22 TCN 348-06: 22/2006/ QD-BGTVT	04/05/2006	"Technical and environmental protection requirements of railway means of transport"
8	Decision on Promulgating the Regulation on quality, technical safety and environmental protection inspection of railway vehicles	58/2005/ QD-BGTVT	07/11/2005	
9	Circular on Guiding the technological and environmental evaluation of investment projects	55/2002/ TT-BKHCNMT	23/07/2002	
10	Decision Publicizing the list of vietnamese environmental standards for compulsory application	35/2002/ QD-BKHCNMT	25/06/2002	

No	Legal Document	Code	Date of Published	Remark
11	Decision on Promulgating branch standard “Technical and environmental protection requirements of railway means of transport”	22/2006/QD-BGTVT 22 TCN 348-06:	04/06/2006	
12	Decision on Compulsory application of Vietnamese Standard (TCVN) on the Environment	22/ 2006/ QD-BTNMT	18/12/2006	
13	Circular Guidance the SEA, EIA and Environmental Protection Undertakings	08/ 2006/ TT-BTNMT	8/09/2006	
14	Land Law	No.13/2003/ QH11	26/11/2003	
15	Decree on providing supplementary regulations on the issuance of land use certificate, land reclamation, land right performance, orders and procedures of compensation, support, resettlement in case the government require for land reclamation and handle land-related claims.	No. 84/2007/ NĐ-CP	25/05/2007	
16	Decree on additionally providing for land use planning, land prices, land recovery, compensation, support and resettlement	No.69/2009/ NĐ-CP	13/8/2009	
17	Circular Ministry of Natural Resources and Environment providing details for compensation, support, resettlement and orders, procedures of land reclamation, transfer and lease.	No.14/2009/ TT-BTNMT	01/10/2009	
18	Decree on Land Utilization for Public Purposes	181/ 2004	2004-	
19	Hanoi PC Decision Hanoi City Land Ordinance	108/2009	2009	
20	Strategic Environment Evaluation and Protection Involvement	Decree No. 29/2011/ ND-CP	2011-4-18	
21	Decision on preservation, rehabilitation and recovery of historic-cultural heritages and beauty spots	No. 05/2003/ QĐ-BVHTT	06/02/2003	Information promulgating regulations
22	Decision on preservation and value promotion of historic-cultural heritages and beauty spotstill 2020;	No. 1706/2001/ QĐ-BVHTT,	24/07/2001	Information approving the Master Plan
23	Decision on preservation, rehabilitation and recovery of historic-cultural heritages and beauty spots	No. 05/2003/ QĐ - BVHTT	06/02/2003	
24	Law on cultural heritage	No. 28/2001/ QH10	29/06/2001	
25	Law on Amending and supplementing a number of articles of the law on cultural heritages	32/2009/QH12	18/06/2009	
26	Decision on Hanoi Ancient Citadel Heritage area awarded as the special national heritage	No. 1272/QĐ-TTg	12/8/2009	
27	Decision on Commission of Exploration Regulation, archaeological excavations	No. 86/2008/ QĐ-BVHTTDL	30/12/2008.	Ministry of Culture, Sports and Tourism
28	Law on Protection and Development the Forest	29/2004/QH11	3/12/2004	
29	http://moj.gov.vn/vbpq/en/Lists/Vn bn php lut/View_Detail.aspx?ItemID=5163 Decision Promulgating the Regulation on organization and operation of the Cultural Heritage Department	64/2006/QD-BVHTT	04/08/2006	
30	Decree On management and protection of underwater cultural heritage	86/2005/ND-CP	08/07/2005	
31	Decree detailing the implementation of a number of articles of the cultural heritage law	92/2002/ND-CP	11/11/2002	
32	Order on Declaration of Law on Environment	No 19/ 2005/ L-CTN	1/01/2005	

No	Legal Document	Code	Date of Published	Remark
33	Decree on organization, operation, of the Natural Resources and Environmental Inspection	65/ 2006/ ND-CP	23/6/2006	
34	Decree on Detail regulations and Guidance implementation the Law on Environmental Protection	80/ 2006/ ND-CP	9/08/2006	
35	Decree on Stipulates the environmental protection in preparation, appraisal, approval and organize the operation strategies, plans, programs, and development projects	140/ 2006/ ND-CP	22/11/2006	
36	Decree on the environmental protection fee upon wastewater	67/ 2003/ ND-CP	06/2003	
37	Decree control of extinction-threatened creatures	32/ 2006/ ND-CP	30/03/2006	On management of endangered, rare, vulnerable forest flora, fauna
38	Decree control of extinction-threatened florae	48/ 2002/ ND-CP	22/04/2002	
39	Ministry of Natural Resources and Environment providing guidance for several articles stipulated at Decree No. 84/2007/NĐ-CP	No.06/2007/ TT-BTNMT	15/06/2007	
40	Decision on compulsory application of Vietnamese Standard (TCVN) on the Environment	22/ 2006/ QD-BTNMT	18/12/2006	
41	Circular on guiding the elaboration of reports on the assessment of environmental impacts for construction planning projects	10/2000/ TT-BXD	08/08/2000	
42	Circular on guiding the making and evaluation of reports on the assessment of environmental impacts of investment projects	490/1998/ TT-BKHCNMT	29/04/1998	
43	Circular on guiding the drawing and evaluation of reports on the assessment of environmental impact of investment projects	1100/TT-MTg	20/08/1997	
44	Circular on organization of Appraisal Council for SEA, EIA report	13/ 2006/ TT-BTNMT	8/09/2006	
45	Circular Guidance the SEA, EIA and Environmental Protection Undertakings	08/ 2006/ TT-BTNMT	8/09/2006	
46	Decision on approval of National Environmental Protection Strategy toward 2010 and orientation toward 2020	256/ 2003/ QD-TTg	2/12/2003	
47	Decision on issue the Orientation for Sustainable Development Strategy in Vietnam	153/ 2004/ QD-TTg	08/2004	
48	EIA procedure in preparation the F/S and design for transportation works	22 – TCN 242 - 98	27/03/1998	
49	Law on Water Resource		1/01/1999	

Source: JICA Study Team

Table 6A.6 List of Other Environmental Data:

No	Legal Document	Code	Date of Published	Remark
1	National Technical Standards for the allowable limits on heavy metals in land	QCVN 03: 2008/BTNMT:		
2	National Technical Standards for surrounding atmosphere quality	QCVN 05: 2009/BTNMT		
3	National Technical Standards for several toxic substances in the surrounding atmosphere	QCVN 06: 2009/BTNMT		
4	National Technical Standards for surface water quality	QCVN 08: 2008/BTNMT		
5	National Technical Standards for underground water quality	QCVN 09: 2008/BTNMT		
6	National Standards for industrial waste water	QCVN 24: 2009/BTNMT		
7	National Technical Standards for noise	QCVN 26: 2010/BTNMT		
8	National Technical Standards for vibration	QCVN 27: 2010/BTNMT		
9	Environmental allowable limits in public and residential areas	TCVN 7210: 2002		Vibration caused by means of road transport
10	Standard - Noise generated by land traffic means when gathering speed	TCVN 5948-1999		Permitted maximum noise level. related to Noise Acoustics
11	Standards related to vibration Permitted maximum levels for the environment of public places and populated areas	TCVN 6962:2001		Vibrations and seismism - Vibrations caused by construction and industrial production activities
12	National Technical Standards for surrounding atmosphere quality	QCVN 05: 2009/ BTNMT		
13	National Technical Standards for several toxic substances in the surrounding atmosphere	QCVN 06:2009/BTNMT		
14	The National Technical Standards for noise	QCVN 26: 2010/ BTNMT		
15	National Technical Standards for vibration	QCVN 27:2010/BTNMT		
16	Environmental allowable limits in public and residential areas	TCVN 7210 : 2002		Vibration caused by means of road transport
17	Technical standards for noise along railway lines	TCCS 03: 2009/VNRA		
18	Technical standards for vibration and oscillation along railway lines	TCCS 04: 2009/VNRA		
19	The National Technical Standards for noise;	QCVN 26: 2010/BTNMT	2010	
20	The National Technical Standards for vibration	QCVN 27: 2010/BTNMT	2010	
21	Vibration caused by means of road transport	TCVN 7210 : 2002	2002	Environmental allowable limits in public and residential areas.

Source: JICA Study Team

5. Concerning to Ministry of Science and Technology (MOST)

6.4 According to the Vietnam Law, there is a Law for procedure to make regulation and standard. At first the standard should be made and after it regulation shall be made. There is a format for regulation and standard in Vietnam.

Table 6A.7 List of Statute Concerning to MOST

No	Legal Document	Code	Date of Published	Remark
1	Vietnam Standard and Technical Regulation Act	No.68/ 2006/ QH11	29/06/2006	Revised 1/01/2007
2	Order on Implementation of Standard Act	No.127/ 2007/ ND-CP	8/2007	
3	Norm on the License of Standard	No.24/ 2007/ QD-BKHCN	2007	
4	Circular on compose and apply of Standard Act	No.21/ 2007/ TT-BKHCN	28/9/2007/	Procedure for Technical Regulation
5	Circular on Guiding the Elaboration, Appraisal and Promulgation of Technical Regulations	No.23/ 2007/ TT-BKHCN	28/9/2007/	Procedure for Technical Standard
6	Law on science and technology	21/2000/QH10	9/06/2000 1/01/2001	

Source: Compiled by the Study Team
Legend: TCN: Standard of the Ministry
TCVN: Standard of Vietnam Government
DS-PC: Regulation of VR (Implementation criteria of companies)

APPENDIX 6B

Institutional Framework for Construction and Operation of Japan's HSR

1. High-speed Railway Line Construction Procedure in Japan

1) Japanese Institute and Procedure for Public Work (Council System)

6.1 In Japan, the procedure to decide and implement an important project is laid down by the law. The Minister consults the council which is composed of concerned persons and acknowledged experts to summarize the opinions. Under the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) are Land Council, Development of social Infrastructure Council and Transport Policy Council.

6.2 **Land Council:** Minister of MLIT consults Land Council about comprehensive and fundamental policy of land use, development and maintenance. The Council consists of 6 members of the House of Representatives, 4 members of Representatives of the House of Councilors and less than 20 acknowledged scholars of erudition and experience (professors, governors, businessmen and concerning persons of mass media).

6.3 **Development of Social Infrastructure Council (Ex. Urban Planning Central Council):** Minister of MLIT consults Development of social Infrastructure Council about the important matters concerning real estate business, land for housing, architecture, qualified architect and public facilities. The Council is composed of acknowledged scholars of erudition and experience (professors, businessmen, commentators and persons from media).

6.4 **Transport Policy Council:** Minister of MLIT consults Transport Policy Council about the important matters concerning transport policy. The Council is composed of acknowledged scholars of erudition and experience (professors, businessmen, consultants, representatives of labor unions and persons from media). Transport Policy Council has 8 branch councils. (transport system, technology, tourism, over land transport, maritime affairs, port, aviation and weather)

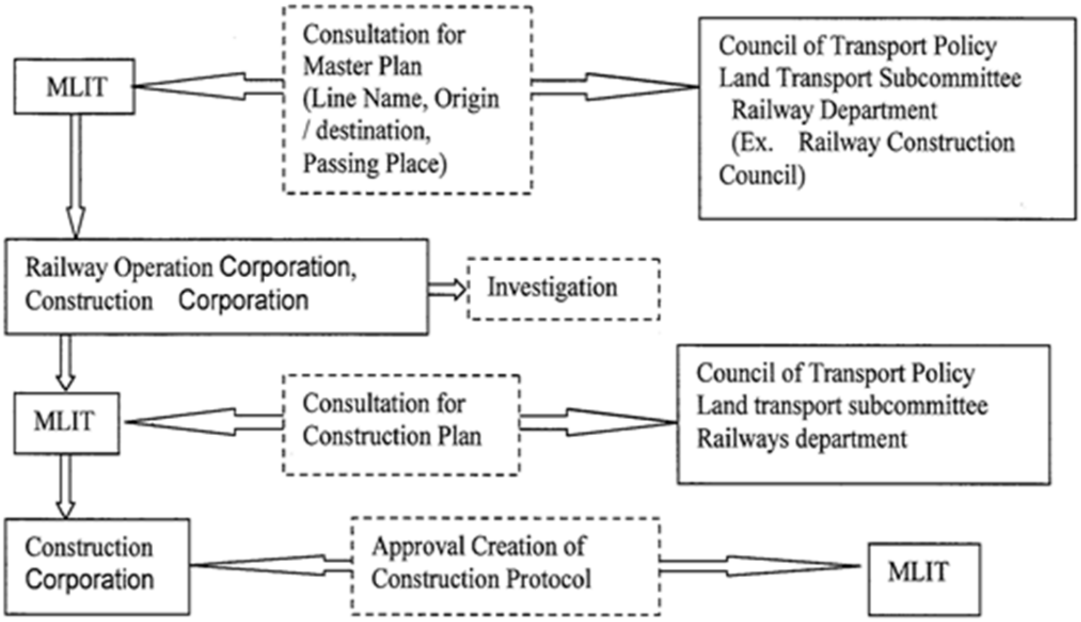
6.5 The land transport branch of Transport Policy Council has a task force for Railway. The discussion about every high speed railway line is held at the subcommittee under the Railway task force.

2) Japanese High Speed Railway Construction Procedure

6.6 There is Nationwide Shinkansen Railway Development Act in Japan. The Minister of MLIT should decide the Master Plan for constructing high speed railway lines considering the demand of railway transport, main direction of land development and effective development of high speed railways. Based on the Master Plan, the Minister orders the study of constructing high speed railway line. The Minister nominates a construction corporation and an operating corporation for the construction line. Since a railway does not achieve its goal only by being built, operation of the railway is the key point that follows. So having enough discussion with a management of operating corporation is indispensable before the construction begins. The Minister is supposed to negotiate with the operating corporation and get an agreement before nominating a construction corporation. The

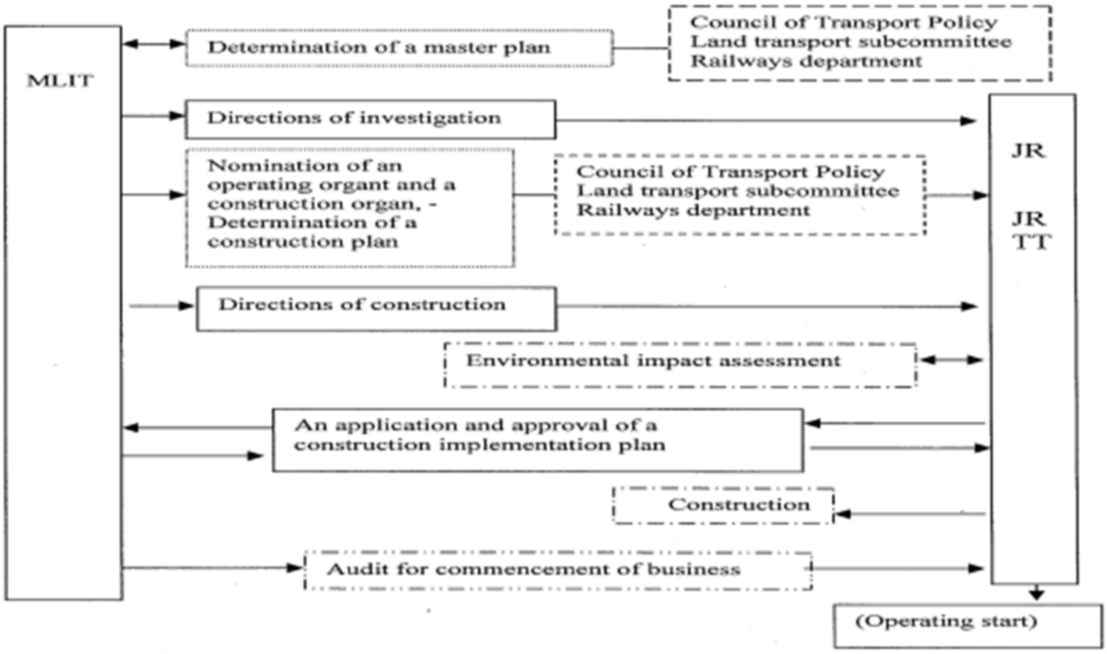
Minister has to determine the construction plan for a new line defined by the master plan. When it is done, the Minister has to instruct the construction corporation to start the construction. The construction corporation is required to submit the construction work implementation plan which indicates a route name, the section of construction work, construction method, and the matter defined in MLIT ordinance and to get the approval of the Minister. For the purpose of securing the land of Shinkansen construction site, action restricted area may be specified. In this area, the character of land must not be changed, and it is not allowed to rebuild or extend or newly build a building.

6.7 The flow of Shinkansen construction in Japan is shown Figure 6B.1



Source: JICA Study Team

Figure 6B. 1 Flow of Shinkansen Construction



Source: JICA Study Team

Figure 6B. 2 Example of Central Shinkansen Construction Procedure

6.8 Japanese high speed railway lines (Shinkansen) are constructed according to the following procedure.

(i) Enactment of Nationwide Shinkansen Railway Development Act

(ii) MLIT consults the Council of Transport Policy about the Master Plan of Nationwide Shinkansen.

(iii) The Council of Transport Policy suggests that Railway Department of Land Transport Subcommittee discuss the Shinkansen Master Plan.

(iv) Governmental Decision of Nationwide Shinkansen network development

(v) MLIT consults the Council of Transport Policy about the individual Shinkansen line construction.

(vi) MLIT nominates the construction corporation and operating corporation after negotiating with them.

(vii) MLIT gives the instruction of investigation of the Shinkansen construction line to the construction corporation.

(viii) MLIT consults the Council of Transport Policy about the construction plan.

(ix) MLIT gives the instruction of construction of the Shinkansen to the construction corporation

(x) The construction corporation makes a detail design and makes an environmental impact assessment

(xi) The construction corporation submits the construction implementation plan to MLIT and gets the approval.

(xii) The construction corporation signs contracts of the construction work with construction companies.

(xiii) The construction corporation supervises and tests the Shinkansen construction work

(xiv) The construction companies hand over the finished products to the construction corporation

(xv) Inspection of the construction work by the construction corporation and operating corporation

(xvi) Shinkansen facilities are transferred from construction corporation to operating corporation

(xvii) MLIT makes an assessment of safety of the Shinkansen operation

(xviii) Start the operation by operating corporation

3) Land Acquisition Procedure and the Role of Local Government

6.9 After the plan of the construction route of the Shinkansen is determined through governmental Council of Transport Policy, if needed action restricted area will be prepared so that the present condition of the land may not be changed. Furthermore, in a city planning area, it is officially announced as a supplementary plan to have been incorporated in town planning decision adjusted with other plans including various kinds of public projects.

6.10 People are required to get permission to build new buildings. Since it is included in building permission whether it conforms to city planning other than construction standards. The planned public works investment plan site can be prevented from construction of a building which becomes an obstacle. A public-works lot needs to determine, authorize and announce a plan beforehand officially.

6.11 In Japan, the development of station squares and side road of railway lines are carried out according to the city plan funded by local government. Every prefecture has its own city plan for urban area control. The City Plan is authorized after discussed at City Plan Council. All the development plans are discussed at City Plan Council attended by the office staff concerned and acknowledged scholars of erudition and experience. Information of the authorized projects on the City Plan is all available to the public. Any building construction requires an approval from Architecture Authority. The building plan should meet the condition of Architecture Act and the City Plan. Construction in the sites for a public project is restricted to such buildings that will not disturb the public project implementation.

6.12 An acquisition of public-works sites, such as the Shinkansen site, is normally done through negotiations between the project owner and the land owner, but in case the negotiation cannot reach an agreement, an arbitrary purchase based on Land Expropriation Law will be the solution.

6.13 When a dispute arises about acquisition of a public-works site, Land Expropriation Committee judges the proper compensation price. Land Expropriation Committee is composed of a third party members including governmental officers who have experience and knowledge about law, economy and land price and they are required to obtain the consent of the Parliament for the nomination. They are believed to be capable of making a fair judgment about public welfare. The Land Expropriate Committee makes decisions about a land acquisition or land surrender, and the amount of compensation and time of surrender. Project owner and land owner should accept the decision of Land Expropriation Committee.

6.14 "Project authorization" and "expropriation decision" are the needed procedures prescribed in Land Expropriation Law. The Minister of MLIT or a governor of the prefecture judges the project authorization to see if the project is necessary for the benefit of public interest and is worth the expropriation of the private land.

6.15 The compensation land price is worked out based on the date of the notification of authorization of the project, and not affected by the increased price after the project commencement.

2. Japanese Legislation for High-speed Railway Construction and Operation

1) Laws on High-speed Railway Construction and Operation

6.16 There are many Laws and Regulations related High speed railway construction and operation. The lists of laws and Regulations are shown Table 6B.1 and Table 6B.2.

Table 6B. 1 Laws on High-speed Railway Construction and Operation in Japan

1	Ministry of land, infrastructure and transport establish Act (No.100, 16/7/1999)
2	Nationwide Shinkansen Railway Development Act (No.71, 18/5/1970)
3	Railway Business Act (No.92, 4/12/1986)
4	Railway Operation Act (No.65,16/3/1900)
5	Act on Special Provisions Concerning the Punishment for Conduct Impending the Safety of the Train Operation on the Shinkansen Railway (No.111, 22/6/1964)
6	Basic Environment Law (No.91, 19/11/1993)
7	Act for Assessment of Environmental Impact (No.81, 13/6/1997)

Source: JICA Study Team

Table 6B. 2 Regulations on High-speed Railway in Japan

1	Order for Enforcement of the Nationwide Shinkansen Railway Development Act
2	Ordinance for Enforcement of the Nationwide Shinkansen Railway Development Act
3	Ministerial Ordinance for Transport policy Council
4	Ministerial Ordinance for Transport Council
5	Regulation for enforcement of Railway business Act
6	Regulation of Shinkansen railway structure
7	Regulation of Shinkansen railway driving
8	Ministerial Ordinance to Provide the Technical Standard on Railway
9	Notice concerning to periodical inspection for facilities and rolling stocks
10	Ministerial Ordinance to ensure the safety of operation
11	Ministerial Ordinance concerning to operator license of driving car
12	Regulation for railway transport
13	Regulation for facilities inspection
14	Regulation for report of railway accident
15	Regulation for management and report of railway driver's quality
16	Regulation for audit of railway enterprise
17	Public notice concerning the regular inspection of facilities and rolling stock
18	Public notice on setting technical standard for special railway
19	Public notice on setting environmental standard for Shinkansen railway noise

Source: JICA Study Team

(a) Nationwide Shinkansen Railway Development Act (Act No. 71 of May 18, 1970)

6.17 This Act is enacted for the purpose of developing the nationwide Shinkansen railway network considering the significance of the functions of established high-speed transportation network across the nation, thereby contributing to the development of the national economy, expansion of the living sphere of the citizens, and regional development.

6.18 The Minister of MLIT should determine the master plan which defines the route of the Shinkansen construction that is appointed by the government ordinance in consideration of the demand of railway traffic and the other major concerns of national land development, in order to achieve an effective use of the Shinkansen line.

(i) The Minister can nominate the construction corporation and operating corporation which performs the construction of the line.

(ii) The Minister has to get an agreement from the operating corporation and construction corporation beforehand.

(iii) The Minister has to decide the development plan of high speed railway construction defined by the master plan along the area appointed by the government ordinance based on the result of investigation.

(iv) The Minister has to talk to an operating corporation and has to get consent before making a decision about the development plan.

6.19 The construction corporation must draw up a construction implementation plan of the construction line which includes a route name, the section of construction, and construction method based on the development plan, and must get the approval of the Minister. The construction corporation has to talk to the operating corporation before a construction implementation plan is drawn up.

6.20 The Minister can designate the action restricted area in order to make the high speed railway construction carried out smoothly. The action restricted area should be presented to general inspection with the drawing and displays which announces the act restricted area publicly. In the action restricted area specified by the Minister, the character of land must not be changed, and it is not allowed to rebuild or extend any building. In case any party suffers a loss because of this restriction, the construction corporation must compensate for the loss which is due to the party. The construction corporation and the sufferer discuss the compensation of the loss. When the two parties cannot reach an agreement, they may request arbitration to the Expropriation Commission under Land Expropriation Law.

6.21 The construction corporation or its consignee may enter the restricted area when they are obliged to do so for the purpose of investigation or survey for the construction of high speed railway. Those who step into the land occupied by others have to notify the occupant of the land concerned beforehand.

6.22 The Minister has to consult the Council of Transport Policy about the following matters;

(i) The determination and changes regarding the high speed railway master plan.

(ii) The nomination of the operating corporation or a construction corporation

(iii) The determination and changes regarding the high speed railway development plans

(b) Order for Enforcement of the Nationwide Shinkansen Railway Development Act (Cabinet Order No. 272 of September 25, 1970)

6.23 The Basic Plan under the Nationwide Shinkansen Railway Development Act shall stipulate the name of the railway, origin, terminus, and major way points of the Construction Line under the said paragraph.

6.24 In the case where the Minister of MLIT intends to make decision on the Basic Plan pursuant to the provisions of the Act, the Minister of Land, Infrastructure, Transport and Tourism shall do so based on the results of the research on the matters set forth hereunder.

6.25 Prospect for the volume of the transportation demand for the Shinkansen Railway

(i) Economic effect to be brought about by the reduced transportation time required and increased transportation capability by the development of the Shinkansen Railway

(ii) Prospect for revenue and expenditure and the impacts imposed by the development of the Shinkansen Railway on the revenue and expenditure of the other railways

6.26 The Development Plan under the Act shall stipulate the matters set forth hereunder for each Construction Line.

(i) Propulsion method

(ii) Maximum design speed

(iii) Estimated total costs required for the construction

(iv) any other matters required

6.27 The Development Plan in the preceding paragraph may be determined for each section of the Construction Line in accordance with the time to implement the construction thereof.

(c) Ordinance for Enforcement of Nationwide Shinkansen Railway Development Act (Ordinance of the Ministry of Transport No. 86 of October 1, 1970)

6.28 The instruction to research the Construction Line pursuant to the provision of the Nationwide Shinkansen Railway Development Act (Act No. 71 of 1970) shall be implemented with respect to the matters listed hereunder with determined date where a report on the research is to be submitted.

(i) Matters related to the transportation capacity to be supplied to accommodate with the demand in the transportation volume and the like.

(ii) Matters related to geographical and geological features and the like.

(iii) Matters related to the development of the technologies for the facilities and train vehicles

(iv) Matters related to the costs required for construction

(v) Any other matters required

(d) Act on Special Provisions Concerning the Punishment for Conduct Impeding the Safety of the Train Operation on the Shinkansen Railway (Act No. 111 of June 22, 1964)

6.29 This Act shall provide for the special provisions and other provisions to the Railway Operation Act (Act No. 65 of 1900) concerning the punishments for such conducts that impede the safety of the train operation on the Shinkansen Railway (any such Shinkansen Railway pursuant to the Act No. 71 of 1970) considering that such train on the Shinkansen Railway that is capable of operating at the speed of two hundred kilometers per hour (200km/h) or more in its predominating section

(e) Ordinance for Enforcement of the Act on Special Provisions Concerning the Punishment for Conduct Impeding the Safety of the Train Operation on the Shinkansen Railway ((Ordinance of the Ministry of Transport No. 66 of September 15, 1964)

6.30 The facilities that are provided for under the Ordinance of the Ministry of MLIT as the facility for the purpose of ensuring the safety of the train operation as is stipulated under Article 2 Paragraph 1 of the Act on Special Provisions Concerning the Punishment for Conduct Impeding the Safety of the Train Operation on the Shinkansen Railway (Act No. 111 of June 22, 1964) shall comprise the following items.

(f) Railway Business Act (Act No. 92 of December 4, 1986)

6.31 The purpose of this Act is to secure the safety of transportation and protect the benefit of users of railways, etc. as well as to ensure the sound advancement of railway business, etc. by making the operation of railway business, etc. appropriate and reasonable, and thus to advance the public welfare.

(g) Railway Operation Act (Act No. 65 of March 16, 1900)

6.32 The construction of a railway, the structure and operation of rolling stocks shall be in accordance with the regulations stipulated under the Ordinance of the Ministry of MLIT. In addition to what is provided for under this Act and other specific laws and regulations, the specific matters of railway transportation shall be in accordance with the regulations stipulated under the Railway Transportation Ordinance. The Railway Transportation Ordinance shall be provided for by means of the Ordinance of the Ministry of MLIT.

2) Laws on Land Control and Land Acquisition

6.33 Shinkansen work site acquisition procedure begins after the plan of the construction route of the Shinkansen line is determined through governmental Council of Transport Policy. A restraining area will be announced so that the present land condition may not be changed according to necessity of the Shinkansen Plan.

6.34 Furthermore, in a city area, it is officially announced as a comprehensive plan adjusted with other various kinds of local government's projects and national projects in City Plan Council of each prefecture. Private building construction are required to get the local governmental approve before the construction. Local government checks according to the City Plan and Building Standard Act not to violate the public plan.

6.35 Laws for land control are shown in Table 6B.3

Table 6B. 3 Land Control Law

1	National Spatial Planning Act (No.205, 26/5/1950)
2	National Land Use Planning Act (No.92, 25/6/1974)
3	City Planning Act (No.100, 15/6/1968)
4	Building Standard Act (No.201, 24/5/1950)
5	Land Expropriation Act (No.219, 9/6/1951)
6	Land Readjustment Act (No.119, 20/5/1954)
7	Urban Redevelopment Act (No.38, 3/6/1969)
8	Promotion of integrated land development in metropolitan areas and railway line Special measures Act (No.61, 28/6/1989)

Source: JICA Study Team

(a) National Spatial Planning Act (Act No.205, May 26, 1950)

6.36 The purpose of this Act is to promote the use, improvement and conservation of national land, from a comprehensive viewpoint of policies for the economy, society, culture with consideration for natural conditions of national land, by formulating National Spatial Strategies and taking other measures, in combination with measures by the National Land Use Planning Act (Act No. 92 of 1974), and thereby contributing to the realization of the economy and society in which present and future citizens can live rich lives with peace of mind. The term "National Spatial Strategies" as used in this Act shall mean the comprehensive and basic plans to promote the use, improvement and conservation of national land.

(b) National Land Use Planning Act (Act No.92, Jun 25, 1974)

6.37 The purpose of this Act is to effect the comprehensive and systematic use of national land by providing for the necessary matters concerning the formulation of national land use plans, preparing land use master plans, and taking measures concerning the control of land transactions and other measures for the sake of coordinating land use, in combination with measures by the National Spatial Planning Act

6.38 Considering that national land is a finite resource for citizens both present and future, and that such land is a common foundation for various activities related to living and production, national land shall be used based on the basic principles of ensuring a healthy and culturally-rich living environment and the balanced development of national land, while giving a priority to the public welfare and the conservation of the natural environment, and while paying due attention to the natural, social, economic, and cultural conditions of the area.

6.39 National land use plans shall specify basic matters concerning the use of national land, and the national government shall formulate the National Plan for national areas, prefectures may formulate Prefectural Plans for their prefectural areas, and municipalities may formulate Municipal Plans for their municipal areas. The national government's plans other than the National Plan shall be based on the National Plan so far as the use of national land is concerned.

6.40 Prefectures shall develop their land use master plans based on the national land use plan; shall specify five areas: urban area, agricultural area, forest area, natural park area, and natural conservation area; and shall specify matters relating to the adjustment of land use. The heads of the relevant administrative agencies and relevant municipalities shall take measures relating to restrictions on the land use so that proper and reasonable land use is ensured in accordance with land use master plans.

6.41 For the purpose of eliminating the adverse effects that speculative land transactions and steep rises in land prices have on citizens' lives, and to ensure the proper and reasonable use of land, the following measures shall be taken relating to restrictions on land transactions:

6.42 At the nationwide level, if a contract for a large-scale land transfer is made or a large-scale ownership right to land is established, the person who acquires the right is required to notify the prefectural governor or the [mayor] of designated cities (hereinafter referred to as the "prefectural governor, etc.") of the purpose of use, the transaction price of the land, etc. The prefectural governor, etc. may recommend that the purpose of use be changed if the purpose of use in question does not conform to various land use plans.

6.43 According to the degree of increase in land prices, etc., the prefectural governor, etc. may make it mandatory to notify him/her prior to land transactions and may specify areas where the purpose of use and transaction price of the land is to be subject to examination and recommendation (monitored areas or supervised areas). Also, the prefectural governor may specify areas where all land transactions are subject to permission (regulated areas).

6.44 The prefectural governor, etc. shall issue a notification on idle land if land pertaining to permission under Article 14 or notification under the provisions of Article 23 etc. is in a state of [under][low] use or disuse for two years and when it is specifically necessary to do so to promote the effective and proper use of such land in light of the various land use plans. A person who receives such notification is required to submit a plan concerning the use or disposition of the land. The prefectural governor, etc. may recommend that the plan in question should be changed, etc.

(c) City Planning Act (Act No. 100 of June 15, 1968)

6.45 This Act was enacted for the purpose of promoting the sound development and orderly improvement of cities by stipulating the details of city planning and decision procedures thereof, city planning restrictions, city planning projects and any other necessary matters concerning city planning, thereby contributing to well-balanced national development and the promotion of public welfare.

6.46 City plans shall be established based on the fundamental principle that healthy, cultural urban lifestyles and functional urban activities should be secured while maintaining a healthy balance with the agriculture, forestry and fishery industries, and that reasonable land use under due regulation should be promoted for this reason.

(i) National and local governments are obliged to endeavor to adequately implement improvement, development and other plans for cities.

(ii) City residents shall cooperate with measures that national and local governments enact to achieve the purpose of this Act and are obliged to make efforts to develop a good urban environment.

(iii) National and local governments are obliged to endeavor to propagate knowledge and provide information on city planning to the residents of cities.

(d) The Building Standard Act (Act No.201, May 24, 1950)

6.47 In order to carry out the construction of the building much to the governmental restriction for safety and land use policy, construction of building cannot be started unless it receives the check of a specification check inspection body.

6.48 The minimum standard of the building which the Building Standard Law defines can be classified into what is called "simple substance regulation" and "group regulation" from the contents. Simple substance regulation is a general standard about the site of each building for securing safety.

6.49 An administrative agency has the authority that can issue against a dangerous building or illegal architecture to order the command to cease, or correct the construction, or exclude the building.

(e) Land Expropriation Act (Act 219, Jun9, 1951)

6.50 Article 29 of the Constitution of Japan provides that private property may be used for public project under the proper compensation. Land Expropriation Act provides the condition and procedure to expropriate and use the private land for public interest. It is determined compensation of the loss for using the land required is public interest. When a dispute arises about acquisition of a public-works lot, Land Expropriation Committee judges the dispute. Land Expropriation Committee is composed of independent members who have excellent experience and knowledge about law, economy, or administration. The governor of the prefecture nominates 7 Committee members with agreement of the Parliament. Both project owner and land owner are obliged to follow the decision of Land Expropriation Committee.

(f) Land Readjustment Act (Act No.119, May 20, 1954)

6.51 A land readjustment project is planned to improve public facilities, such as road, park, and river and adjust the housing land for the better use of housing site. Main characterictic are as follows;

(i) The land owner offers his land portion by portion (land area decrease), which is utilized for public use such as road and park, and some portions acquired are sold to increase the fund.

(ii) The project fund consists of disposal income of reserved land and the budget for public facilities improvement (a part of land value is included).

(iii) Construction of public facilities, housing site improvement, the compensation for moving of houses, etc. are funded by this.

(iv) As for a landowner, the area of the land after a land readjustment project becomes small compared to before, but public facilities such as road, park are improved and the shape of land is arranged, therefore the high land utility value is obtained.

(g) Urban Redevelopment Act (Act No.38, Jun 30, 1969)

6.52 A middle-to-high-rise institution building (which is called “a redevelopment building”) is constructed, giving the floors (which is called “landholder space”) of the building and the land shared to the right holders of land, building, etc. corresponding to the rights before the redevelopment project starts from the entrepreneur.

6.53 This is called right conversion. Those who do not wish right conversion receive the equivalent amount of money to the right from the entrepreneur. The extra floor (reserved space) is built in addition to landholder space, and usually working expenses are covered by selling off the reserved space.

(h) Promotion of Integrated Land Development in Metropolitan Areas and Railway Line Special Measures Act（Land & Railway Act) No.61, 28/6/1989

6.54 The railway project owner can request to relocate his lands to the appointed place where railway facilities shall be constructed under the land readjustment project.

3) Technical Standards for Railway

6.55 The list of Technical Standards is shown Table 6B.4.

Table 6B. 4 List of Standard related High Speed Railway

1	Technical Standard for Japanese Railway
2	Explanation of Fire Prevention Standards for Underground Stations
3	Environmental Quality Standards for Shinkansen Super express Railway Noise
4	JNR Standard for Shinkansen drive treatment
5	JNR Standard for Shinkansen safety drive
6	JNR Standard for Shinkansen work execution under closure of track
7	JNR Standard for Shinkansen using of vehicle for construction work
8	JNR Standard for Shinkansen using of vehicle for maintenance work
9	JNR Standard for Shinkansen Railway fundamental structure
10	JNR Standard for Shinkansen Track structure
11	JNR Standard for Shinkansen track maintenance
12	JNR Standard for Shinkansen track inspection
13	JNR Standard for Shinkansen fundamental structure
14	JNR Standard for Shinkansen maintenance work treatment

Source: JICA Study Team

(a) Ministerial Ordinance to Provide the Technical Standard on Railway

6.56 This Ministerial Ordinance is set forth to secure the safe and stable transport and thereby to contribute to the promotion of public welfare, by establishing the necessary technical standards for facilities to be used for rail transportation, and rolling stock structure and handling.

(b) Technical Standard for Japanese Railway

6.57 This Ministerial Ordinance is set forth to secure the safe and stable transport and thereby to contribute to the promotion of public welfare, by establishing the necessary technical standards for facilities to be used for rail transportation, and rolling stock structure and handling.

(c) Explanation of Fire Prevention Standards for Underground Stations

6.58 After the subway fire accident in Deagu, Korea in February 2003, a “Study Group for Fire Prevention of Underground Railways” was established to examine the current status of subway fire prevention equipment and the circumstances of the accident, in order to promote a comprehensive study on preventing fires in underground railways in Japan, and a report was issued in March 2004. Based upon this report, the Ministry of MLIT reviewed approved specification for Ministerial Ordinance Article No. 29 (Facilities of Underground Stations), which is the so-called “Fire Prevention Standards”. The structure and main points are shown below. However, these shall be studied separately depending upon the structure and facility.

(i) Scope of Application

- This standard applies to underground stations and tunnels connected to underground stations.

- Underground stations include cases where the starting and terminal stations in urban areas are underground, stations built due to crossing with roads overhead, and cases where railway tracks are underground.
- The standard does not apply to cut and fill sections and stations in tunnels in mountain regions.

(ii) Main Points - Fireproofing of structures, etc.

- Fireproofing of structural materials and interior dressing
- Maximum fireproofing of floors of rooms of train dispatch stations to ensure habitability
- Maximum fireproofing of fittings (desks, lockers, etc.)
- Stores are classified into two types:
  + Convenience station store: Passengers can enter a store.
  + Simple concession stand: This is a simple, face-to-face, small store which passengers cannot enter.
- Convenience station stores require compartmentalization to prevent fire and smoke, and the installation of automatic fire alarm equipment and sprinkler equipment.
- As compartmentalization is difficult for simple concession stands due to their structure, the structural materials, interior and fittings such as bookshelves must be non-flammable.
- Compartmentalization of underground substations for fire prevention.

(d) Environmental Quality Standards for Shinkansen Super Express Railway Noise

6.59 In accordance with the provisions of Article 16 of the Basic Environment Law (Law No. 91 of 1993), the environmental conditions relating to Shinkansen Super Express Railway noise standards are notified as follows.
The standards for regulating the environmental conditions of Shinkansen Super Express Railway noise are established as follows according to Article 9 of the Basic Law for Environmental Quality Standards and the target dates for achievement thereof. The maintenance of the standards is desirable to preserve the living environment and to contribute to protecting people’s health.

6.60 The values of the environmental quality standards are established for each category of area shown in Table 6B.5. Prefectural governors shall designate the category of area.

Table 6B. 5 Standard Value of Shinkansen Noise Restriction

Category of area	Standard value [in dB]
I II	70 or less 75 or less

Note: Area category I refers to areas used mainly for residential purpose and area category II refers to other areas, including commercial and industrial areas, where the normal living conditions shall be preserved.
(1) Measurements shall be carried out by recording the peak noise level of each of the Shinkansen trains passing in both directions, in principle, for 20 successive trains.
(2) Measurements shall be carried out outdoors and in principle at the height of 1.2 meters above the ground.

Source: JICA Study Team

(e) Technical Standard of Japanese Railway

Table 6B. 6 List of Ministerial Ordinance to Provide the Technical Standard on Railway

Chapter 1 General Rule	Objective	Page1
	Definitions	2
	Implementation Standard	4
	Submission of Documents	6
	Prevention of Danger	6
	Prevention of Extreme Noise	6
	Measures To Be Provided for Smooth Transport of the Elderly and the Handicapped	7
	Emergency restoration setup	8
Chapter 2 Staff	Safety Assurance of Train Operation	8
	Training and Training of Staff	8
	Duties of Crew to Operate a Motive Power Unit	9
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	Guide way Alignment	11
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	Cant	12
	Gauge widening	14
	Transition Curve	15
	Gradient	17
	Vertical Curve	19
	Construction Gauge	19
	Width of Formation Level	22
	Distance between Track Centers	23
	Track	25
	Structures	27
	Facilities to Abate Extreme Noise	28
	Buildings	29
	Facilities to Prevent Disasters and Other	29
	Protection of Below Bridges	29
	Facilities of Underground Stations	29
	Prevention of Rolling Stock Runaways	35
	No Trespassing to Guide Way	36
	Evacuation Facilities	36
	Wayside Posts	36
Chapter 4 Station and Halt	Track Layout at Station and Halt	37
	Station Facilities	37

	Maintenance of Facilities and Rolling Stock	184
	Inspection and Field Test of Newly Installed Facilities and Newly Manufactured Rolling Stock	184
	Inspection and Monitoring of Main Track and Overhead Electric (Catenary) Line over the Main Track and Inspection of Train	185
	Regular Inspection of Facilities and Rolling Stock	186
	Record	189
Chapter 10 Train Operation	Loading Limitation of Car, etc.	191
	Display of Dangerous Cargo	191
	The maximum Number of Coupled Cars, etc.	192
	Brake for Train	192
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	Operation on Main Track Outside of Station and Halt	194
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	Prevention of Danger to Train Operation	207
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	Prevention of Danger for Car Loaded with Hazardous Materials	209
	Relationship between Railway Signal and Train Operation	210
	Indicated stop aspect by signal	210
	Inaccuracy of Signal Display	210
	Prohibition of Dual Use of Signal	211
	Conditions of Signal Aspect to Indicate to	211
	Other Items Concerning Signal Display	211
	Action to be Taken for Indication to Proceed	222
	Sign and Display	222
	Special Railway	224

Source: JICA Study Team

APPENDIX 6C

Current Institutional Situation of Vietnam Railway Project Implementation

1. Legislation of Vietnam Government

6.1 There are 18 Ministries and 4 offices in Vietnam Government as follows: Ministries of Vietnam Government are as follows; Ministry of National Defence, Ministry of Public Security, Ministry of Foreign Affairs, Ministry of Justice, Ministry of Finance, Ministry of Transport, Ministry of Construction, Ministry of Education and Training, Ministry of Agriculture and Rural Development, Ministry of Industry and Trade, Ministry of Planning and Investment, Ministry of Health

6.2 Ministry of Science and Technology, Ministry of Natural Resources and Environment, Ministry of Information and Communications, Ministry of Home Affairs, Ministry of Labor, War Invalids and Social Affairs, Ministry of Culture, Sports and Tourism, Government Inspectorate, State Bank of Viet Nam, Committee on Ethnic Minority Affairs, Government Office

6.3 Legal system in Vietnam is shown in Table 6C.1

Table 6C. 1 Legal System in Vietnam

Category	Competent Authorities
Constitution	National Assembly
Law	National Assembly
Resolution of National Assembly	National Assembly
Ordinance	National Assembly Standing Committee
Resolution of the National Assembly Standing Committee	National Assembly Standing Committee
Order of the President, Decision by the President	President
Resolution of the Government	Government
Decree by the Government	Government (equivalent to a Ministerial Ordinance)
Decision by the Prime Minister	Government
Instruction by the Prime Minister	Government
Decision by a Minister, Decision by a Head	Ministers, Head of the Organizations equivalent to a Ministry and Head of the Organizations directly under the Government
Instruction by a Minister, Directive by a Head	Ministers, Head of the Organizations equivalent to a Ministry and Head of the Organizations directly under the Government
Circular by a Minister	Ministers, Head of the Organizations equivalent to a Ministry and Head of the Organizations directly under the Government
Resolution at the Supreme People's Court Judge Conference	Supreme People's Committee
Decision, Instruction and Circular by the Head of the Supreme People's Court	Supreme People's Committee
Decision by Director of the Institute of the Supreme People's Procuracy	Institute of Supreme People's Procuracy
Joint Law and Norm Documents	Ministries, Organizations equivalent to a Ministry and directly under the Government
Contact Information between the Supreme People's Court, Institute of Supreme People's Procuracy, Ministers, Organizations equivalent to a Ministry and directly under the Government	Supreme People's Court, Institute of Supreme People's Procuracy, Ministers, Organizations equivalent to a Ministry and directly under the Government
Joint Resolution of the Agreement and Contact Information between Governmental Authorities, political and social Organizations	Ministries, Governmental Organizations, political and social Organizations
Resolution by the People's Council, Decision and Instruction by the People's Committee	Resolution by the People's Council, People's Committee

Source: JICA Study Team

2. Legislation and Criteria on Railway Construction

1) Legislation on Railways

6.4 The Vietnam Railway Corporation (VR), or the former Vietnam Railway, has been only one railway business undertaker for more than 100 years since the inauguration of railway operation in Vietnam. In the meantime, the government has adopted technical regulations on single-track and non-electrified railways, special handling for train operation at stations, facilities and equipment and manuals on the maintenance of rolling stock.

6.5 When the Vietnamese National Railways was privatized in 2003, the Vietnam Railway Administration (VNRA) was organized within the Ministry of Transport (MOT) as an administrative entity to control and supervise railways as a whole. In 2005, the government enacted the Railway Law (09/2005/L-CTN).

6.6 The Railway Law sets forth only a framework for railway businesses and does not specify detailed rules for actual implementation of services. After 2005, therefore, technical rules were adopted in VR as a decision or direction (Ministerial Ordinance) by the Minister of Transport, following the procedure to implement technical criteria and standards.

6.7 As the Railway Law and the existing technical rules are for existing non-electrified railways, they do not necessarily correspond to electrification or high-frequency high-speed operation by urban railways or high-speed railways. Specifications on the qualification of train crew also assume the system of assistant engine drivers at the age of steam locomotives, which do not suit the training of the drivers for modern powering cars, either. Therefore, a proposal is offered for licensing EMU drivers in a JICA technical cooperation scheme for the Urban Railway Bureaus, Hanoi and Ho Chi Minh.

6.8 In 2009, the government of Vietnam adopted Technical Regulations and Urban Railway Standards through the cooperation by Japan, based on which the Ministry of Transport issued the new railway technical criteria in February 2011. On the other hand, the Ministry of Construction issued the National Building Code (QCVN 08:2009/BXD Vietnam Building Code for Urban Underground Structures) in 2009 based on the subway standards in Russia, which is now under review, however, as it is inconsistent with the subway standards in Japan and Western Europe and contains particulars that cannot cope with advanced technologies.

6.9 In 2011, the government of Vietnam also adopted three Vietnamese National Standards, i.e., (i) Vietnam Standard TCVN 8893:2011Grading for Railway lines, (ii) Vietnam Standard QCVN 06:2011/BGTVT National Technical Regulation on Railway Signaling and (iii) Vietnam Standard QCVN 08:2011/BGTVT National Technical Regulation on Railway Operation, by revising correspondingly the VR regulations in the past on the grading of railway lines, signaling and railway operation.

6.10 In Vietnam, foreign countries constructing railways in the country with their own capitals are allowed to rely on their own technical criteria. Therefore, it will be possible for Japan to apply Japanese criteria to the Japan’s ODA scheme to construct new urban railways or high-speed railways in Vietnam. Nevertheless, it is required to support Vietnam to prepare its own technical standards and design railways considering the inconvenience and economical disadvantages in managing railways constructed to different criteria of different countries.

6.11 Vietnam is now introducing technologies on urban railways, electrification, subways and high-speed railways from EU and Japan. China is also providing widely-ranged technological regulations on existing railways, including those on geological surveys, three-rail tracks, tracks for exclusive use by freight trains, retailing walls, stations, yards, diesel locomotive depots, rolling stock bases, environmental preservation measures, track construction work, control of the schedule of construction work, completion inspection, water supply and draining systems and track maintenance work.

2) Legislation and Procedure for the Implementation of Public Projects

6.12 The Constitution of the Socialist Republic of Viet Nam (1992) confirms the right of citizens to own and protect the ownership of a house. In addition, the Government has enacted a number of laws, decrees and regulations that constitute the legal framework for land acquisition, compensation, assistance and resettlement. The principal documents include the Law on Land of 2003, providing Vietnam with a comprehensive land administration law; Decree No. 197/2004/ND-CP, on compensation, assistance, rehabilitation and resettlement in the event of land recovery by the State, as amended by Decree No. 17/2006/NĐ-CP; Decrees No. 188/2004/ND-CP and 123/2007/ND-CP, Decree No. 84/2007/ND-CP specifying the methods for land pricing and land price frameworks in the event of land recovery by the State and Decree No. 69/2009/ND-CP dated 13/8/2009 providing additional guidelines on land use, compensation, assistances and resettlement.

6.13 Laws, decrees and decisions relevant to public disclosure of information include the Law on Land, No. 13/2003/QH11, Article 39, requiring disclosure of information to the displaced persons prior to recovery of agricultural and non-agricultural lands of a minimum of 90 and 180 days minimum respectively. MONRE also issued Circular No. 14/2009/TT-BTNMT on the allocation of new residential land or a resettlement house or monetary compensation for displaced persons that need to relocate and on granting authority to People's Committees to determine whether certain structures built after 1 July 2004 violated approved land use.

6.14 At the local level, on September 29, 2009, the Hanoi People's Committee issued Decision No. 108/2009/QD-UBND that provides updated guidelines on land compensation, assistances and resettlement for development projects in Hanoi.

6.15 In Vietnam, laws required for the implementation of public projects are virtually comprehensive in a sense. However, their application is not satisfactory, presumably because of problematic provisions in the existing laws and, among others, the basic concept in policies and public opinions different from those in Japan. Furthermore, Vietnam is now using Chinese rules on outsourcing procedures, inspection and supervision, as it is not much experienced in such conventions in the transition process from socialism to a free economy system, to which attention shall be paid.

6.16 Lands shall be acquired in accordance with the Land and Railway Laws. After approving a project, the government sets the Committee for Land Acquisition in the District People's Committee to create a plan for land acquisition. For the Land Acquisition Committee, the government nominates the Vice Chairman of the District People's Committee as the Chairman and the project promoter as a member, respectively. In case the relocation of inhabitants is required, a framework for life restoration is created based on a plan prepared beforehand. The inhabitant relocation plan is prepared first, which is submitted for approval to the government for the projects approved by the government or to local governments for those approved at local levels. Those approved by the central government need not be re-submitted to local governments. After the approval of a railway project, local governments will take charge of land acquisition at the cost of the project promoter. The procedures to acquire railway lands starting from the installation of demarcation posts are prescribed in the direction in the revised Railway Law 03/2012/ND-CP. There are three objects for compensation: lands, architectures and marketing life, for each of which the contents of compensation are set forth in prefectural ordinances (Ordinance No. 108 for Hanoi). The indemnification for lands is basically done by providing lands prepared by the project promoter or payment of compensation money.

6.17 It is pointed out by mass communication media that there are problems in the costs and periods of the construction work for public facilities in Vietnam. Regarding the land acquisition to be implemented under difficult conditions in particular, the government is required to set standards on the fair amount of compensation money and institute systems to authorize the evaluation thereof. In the case of land acquisition for road construction in the past, it is reported that the costs of the lands remained unsold in the areas adjacent to newly constructed roads skyrocketed after the construction work when compared with the cost at which lands were sold to constructors, to cause feeling of unfairness and complaint among land sellers. Similar problems were also reported in Japan. It is thought that a means to solve this problem is exchanging lands with those of reduced areas for land readjustment or with those of grade separation for urban redevelopment. It is expected for Vietnam to create lands for public use through land readjustment in the projects of railway construction and road improvement in urban areas and devise systems to enjoy the profit from development uniformly by all people living in the area for development. The land readjustment is a technique to share lands among those living in the relevant area in constructing roads, parks, railways, stations and other public facilities, in order to promote the development of communities.

6.18 Although project plans have been prepared in accordance with the Urban Planning Law and other laws, the formulation of plans for railways, roads, urban construction and development has been contracted individually with consultants. This involves problems of insufficient coordination between different plans due to the lack of comprehensive and transversal management ability. Therefore, it is essential to eliminate the disadvantages of vertically split administrative systems, inefficient communications between different divisions and departments and other problems in administrative systems, while improving the ability of planning staff simultaneously. It is also desirable to adopt a system similar to that in Japan to perform prior-coordination between different divisions through the meetings of related personnel, summarize all public projects and regulations on land utilization eventually in a planning sheet and make them widely known among those concerned.

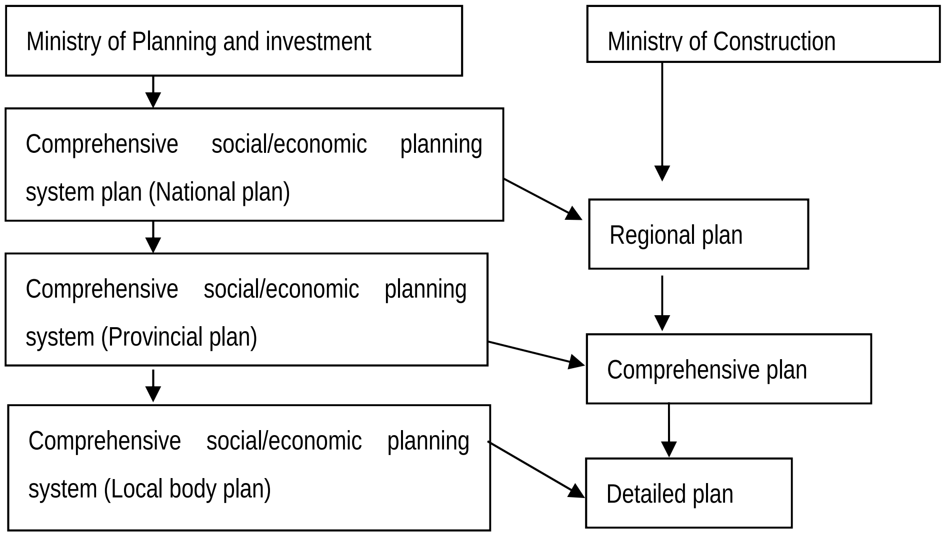
6.19 On Article 4, State Budget Law No. 01/2002/QH11, stipulates that the budget of local People’s Committee is included in the national budget. This means that some amount in the national budget is also allocated to the projects implemented by the Hanoi City People’s Committee, because the local governments are regarded as the local organizations of the central government in Vietnam. In railway construction projects in Japan, it is often the case that station plazas and frontage roads are constructed with the cost shared with local autonomous bodies. In contrast, even the cost for the work executed through consultation with local governments is required of and supplied from the central government in Vietnam. It seems, therefore, that local governments do not bear the cost for the projects in which the central government involves.

3. Procedure for Railway Construction

1) The Land Utilization System in Vietnam

6.20 There are three laws on the land utilization in Vietnam: land law, construction law and urban planning law. Ministries in charge are Ministries of Construction, Natural Resources and Environment, and Planning and Investment. The Ministry of Planning and Investment draws up a social and economic development strategy, which is a long-term non-concrete conceptual plan, unlike the plan on urban or national land development. The Ministry of Planning and Investment performs hearing from the Ministries of Education and Training, Industry, and Agriculture to collect information, establish an overall comprehensive plan and determine the targets or facilities required in the future. The Ministry of Construction creates a concrete implementation plan on the positions and sizes of projects. The Ministry of Natural Resources and Environment implements land control, in that it determines the land utilization for the approved development project. There are three division-wise separated plans those are called the social/economic plans, spatial plans and the construction plan (the master plan), respectively.

6.21 The social and economic development plan is a strategy to set concrete targets for development and investment and has a role to integrate proposals including division-wise plans (traffic, industries, training, welfare, etc.).



Source: JICA Study Team

Figure 6C.1 Flow of the Social and Economic Development Plan

6.22 To develop a land, a construction plan shall be applied for to obtain approval.

6.23 On January 1, 2010, the City Planning Law, the first of its kind in Vietnam, was enacted. The spatial plan is a proposal on the detailed land utilization and spatial arrangement of architectures and infrastructures at the land development site.

6.24 The Ministry of Construction creates a master plan on the national city planning system and submits it to the Prime Minster for approval. The Provincial Governments or the People's Committee of the cities directly controlled by the central government (hereinafter referred to as direct control cities) draws up a comprehensive plan of direct control cities, comprehensive plan of new cities, technological infrastructure plan of direct control cities and zoning plan and a detailed plan on the zones crossing the administrative boundaries between plural rural districts and urban districts, new urban areas and other important areas, except city planning schemes attributable to the responsibilities of the Ministry of Construction, direct control cities and investors of construction investment projects.

6.25 From the administrative viewpoint, the Ministry of Construction or Departments of the Province or cities take charge of spatial plans (master plans or land utilization plans). In the past, plans were mostly prepared by the Vietnam Institute of Architecture and Urban and Rural Planning (VIAP), an organization that has succeeded the National Institute for Urban and Rural Planning (NIURP). In the process to decentralize the formulation/implementation of city planning schemes, however, other organization including those in the private sector have started plan-preparation support services (consulting) for local bodies. As far as the three largest cities are concerned, they have been maintaining their own independent planning organizations. In regard to the city planning schemes stipulated by the city planning law, there are following different types.

(i) Comprehensive plans prepared for direct control cities, provincial capital cities, cities, towns and new cities

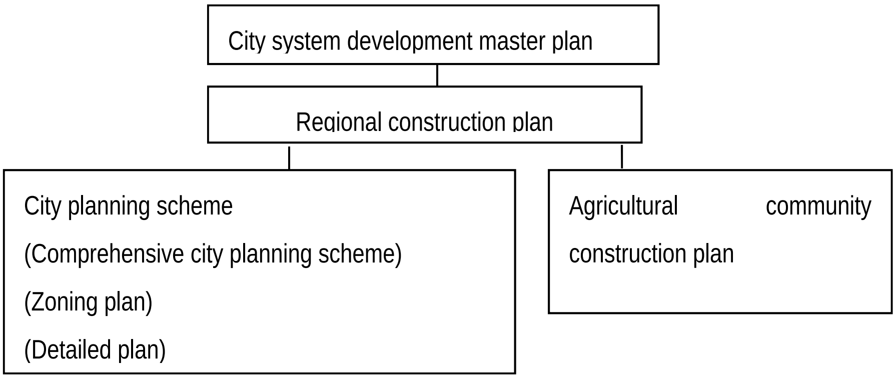
(ii) Zoning plans prepared for the districts in cities, towns and new city areas

(iii) Detailed plans prepared on request for development demands, city management or construction investment

(iv) Technological infrastructure plans, an item in the comprehensive plans, zoning plans and detailed plans

6.26 Regarding the authority to approve the formulation and projects of city planning schemes, the Prime Minister approves the formulation and projects of (1) the comprehensive plans for direct control cities, first class provincial capitals and new cities having a population larger than that of the third class cities and spreading over plural provinces, (2) technological infrastructure plans for direct control cities classified as a special city, (3) comprehensive plans, zoning plans and city planning schemes for useful areas having special significance from the political, economic, social and historical viewpoints.

6.27 As the planning organizations tend to overlook the social and economic aspects, so the planners (affiliated with the Ministry of Planning and Investment) of social/economic plans fail to notice the spatial and environmental aspect of the investment programs. The inadequate linkage between social/economic plans and physical plans relates to the duplicated administrative powers between central and local organizations. Procedures to evaluate and approve projects are so complicated that 14 formal approvals of different categories are required to perform investment, taking one year or over to acquire approval for it.



Source: JICA Study Team

Figure 6C.2 Spatial Plans

2) Procedure to Acquire Lands for Public Projects in Vietnam

6.28 Land acquisition is being performed in accordance with the Land Law and the Railway Law, with the procedure to purchase lands for railways set forth in the Railway Law supplementary governmental ordinance 2012/ND-CP. After a project has been approved, a committee on land acquisition is organized in the district people’s committee, where a land acquisition plan is formulated. The land acquisition committee is chaired by the vice-chairperson, district people’s committee. The project promoter is a member of this committee. In case relocation of inhabitants is required, a plan is formulated to establish a framework for life reconstruction. In this process, the committee creates an inhabitant relocation plan and offers it to the government in case it is for a government-level project. After a railway project has been approved, the local government (people’s committee) takes charge of the land acquisition service, with the expenses borne by the project promoter. The Railway Law revising governmental ordinance 03/2012/ND-CP prescribes the procedure to acquire railway lands starting by installing boundary stakes. There are three categories of the object of indemnification: lands, architectures and others (indemnification for business life) with the level of indemnification for each of these categories stipulated in the prefecture-level ordinance (ordinance No. 108 in the case of Hanoi city). A land prepared by the project promoter is provided for land indemnification and only compensation money is for other categories in principle. The amount of compensation money is specified for tenants as well.

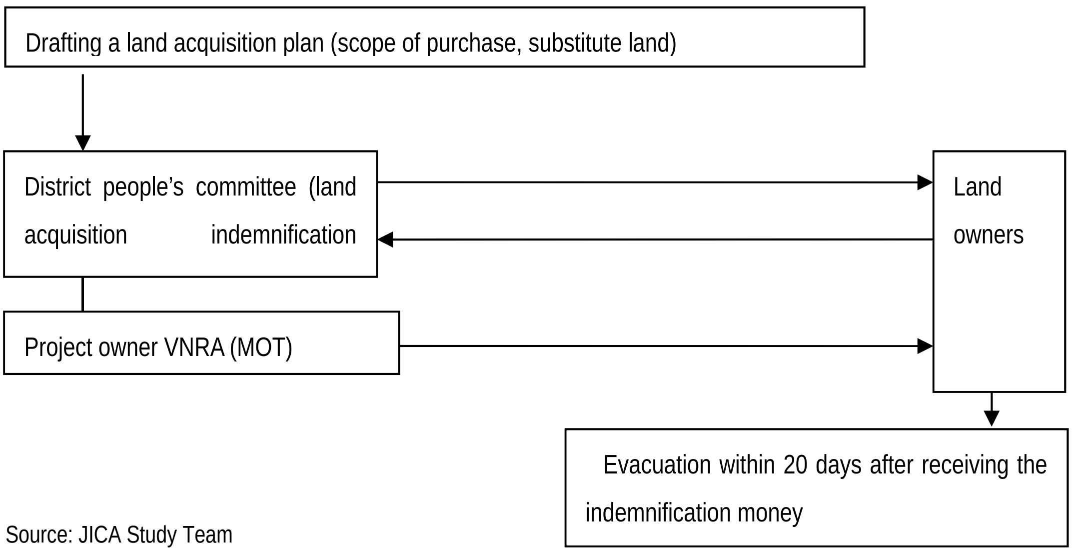
6.29 In creating a project in Vietnam, the project promoter formulates “a comprehensive plan on land acquisition” by him/herself or through a consulting company on request at the stage of planning survey. The project promoter shall submit it to the government in case the project is at the government-level or to the local government in case the project is at the local level to obtain approval. The local people’s committee has a land acquisition support committee composed of approximately 20 members in the division/section in charge of drafting policies. Land purchase service is performed by the Land Development Fund /indemnification consulting committee, an organization different from the land acquisition support committee.

6.30 The project promoter prepares lands where inhabitants are to be relocated. In case the project promoter cannot prepare the required lands, it prepays money to the “city land development fund” and requests it to prepare lands for substitution. The land acquisition consulting committee belonging to the district or the organization in charge of indemnification is supposed to implement surveys for the purpose of land acquisition. The land acquisition consulting committee is instituted by the district people’s committee and normally chaired by its deputy chairperson. The project promoter is a member of the consultation committee.

6.31 After the government has approved the project, the local people's committee organizes the indemnification committee to promote negotiation with the land owner. VR does not participate in this committee. The committee on project execution acts in cooperation with the indemnification committee. The Ministry of Transport determines the amount of indemnification through consultation with the Ministry of Planning and Investment and the People's Committee.

6.32 In case the land-owner has a complaint in land purchase, he/she is allowed to appeal it to the district people's committee. When the complaint cannot be solved at the district people's committee, he/she can present the case before the chairperson of the committee or a judge on economic affairs. The indemnification committee is installed for each project. After determining a project, the project promoter makes it widely known. In case consensus with a house owner cannot be established through negotiation, the project promoter can resort to compulsory execution, in that he/she is allowed to move the house owner to the house proposed as indemnification.

6.33 A conflict arises sometimes for the reason that substitute items for indemnification are not balanced with the lands or architectures sold by the owner. In the case of a land purchase for road construction in the past, the land that remained intact without affected by the road construction was transacted at an extremely high amount compared with the indemnification money received by the ex-owner who had evacuated the land.



Source: JICA Study Team

Figure 6C.3 Flow of the Procedure to Acquire Lands

3) Roles of Different Organizations for the Management, Control and Maintenance of Railways in Vietnam

6.34 The Ministry of Construction (MOC), a competent Ministry for city planning schemes, is in charge of the parts of the projects under government control. The people's committee at each level implements the city planning schemes comprehensively in each local area though limited to overall plans. Relegated local city transport bureaus frequently implement detailed discussions thereafter. The Ministry of Transport (MOT), whose important duties are to formulate medium- and long-term urban transport strategies, is in charge of the discussions on the construction of infrastructures related to public transport. The Ministry also takes charge of public transport strategies in cities, discussions on the construction of transport infrastructures in suburban areas, traffic safety, criteria on the construction of various transport infrastructures and formulation of guidelines to the management, control and upkeep of transport-related organizations.

6.35 The local people's committee (PC) functions as an organization to implement the master plans at higher ranks formulated by the Ministries of Construction and Transport and services to create public transport networks and draft traffic policies and maintenance / upkeep duties for urban transport infrastructures.

4) Procedure for Railway Construction Work

6.36 The Ministry of Transport implements the plans of railway construction work. The railway master plan is created by MOT and not by VNRA. VR prepares railway construction plans based on the master plan of the government. Plans are ranked by which funds providers existing etc. Depending on their contents, projects are divided into two groups: one is a group of those for which VR can judge the necessity of investment and the other is a group of those for which the government approves the construction work. The projects to be submitted to the National Assembly require a pre-feasibility study before submission thereto. Others are assigned to VRA or VR based on the judgment divisions. In more concrete terms, the construction of a new railway is assigned to VNRA and remodeling of existing railways is to VR in principle. After investment is approved, methods of fundraising are concretized to determine the investors, government investments, foreign or domestic enterprises capitals. A feasibility study is performed normally under a contract with a consultant or by the project promoting organization. Construction work is contracted after the plan of feasibility study has been approved. The project promoter (VR, VNRA) requires the local people's committee to purchase the lands for the railway.

VR, Formulation of construction project plans

VNRA, Preparation of a draft by the Minister of Transport

MOT, Consultation with the related Ministries and Agencies
(Ministries of Planning/Investment and Construction)

Prime Minister's Office, Screening the projects, submission to the National Assembly for decision and to the Prime Minister for judgment

The National Assembly, resolution and approval

Source: JICA Study Team

Figure 6C.4 Flow of the Procedure for Railway Construction Plans

4. Organization of Railway Project Implementation

1) MOT and VNRA

6.37 MOT is the decision-making body of a railway project and project implementation organization is VNRA. VNRA superintends and guides consultants and related organization in the stage of feasibility study. Project Management Unit (PMU) is established in VNRA after the supply of a project fund. This PMU selects consultant and construction contractor, and performs supervision of investigation, design, and construction, and project management to commencement of operation. VNRA is an organization which takes charge of new line constructions (not improvement of existing railways). VNRA is taking charge of the new railway line construction between Yen Vien - Pha Lai by the Vietnam government budget.

6.38 VNRA is an organization affiliated with MOT. The organization is assigned headquarters in Hanoi and consists of the offices of eight departments and three domestic branches which are railway institution checking section. VNRA is in charge of the administration concerning the rail traffic of the whole country. The main roles of the organization are shown below.

(i) The secular development, five years and the single fiscal year plan concerning rail traffic, and decision of a project and presentation to the Minister of Transport.

(ii) Supervision and the budgetary process of a railway social infrastructure project.

(iii) Adjustment of Railway Act and ordinance nominated by the Minister of Transport.

(iv) Presentation to the Minister of Transport of a railway standard, economy and a technical provision, a policy norm, specific criteria of control and supervision and the inspection

(v) Adjustment and instruction concerning spread and education of Railways Act.

(vi) Supervision and investigation in connection with safety of railway transportation business

(vii) A personnel training program, decision and enforcement of a regulation concerning railway operation.

(viii) Approval concerning construction of railway line or station.

(ix) The supervisor and auditor of the business plan and the budget of VR

2) VR (Vietnam Railway)

(a) Relation of VNRA and VR

6.39 Vietnam Railway Administration (VNRA) is a bureau of the Ministry of Transport. VNRA decides and executes railway policy and development plan/program, draws up the railway act and railway standards, proposes international cooperation programs, and executes new railway projects.

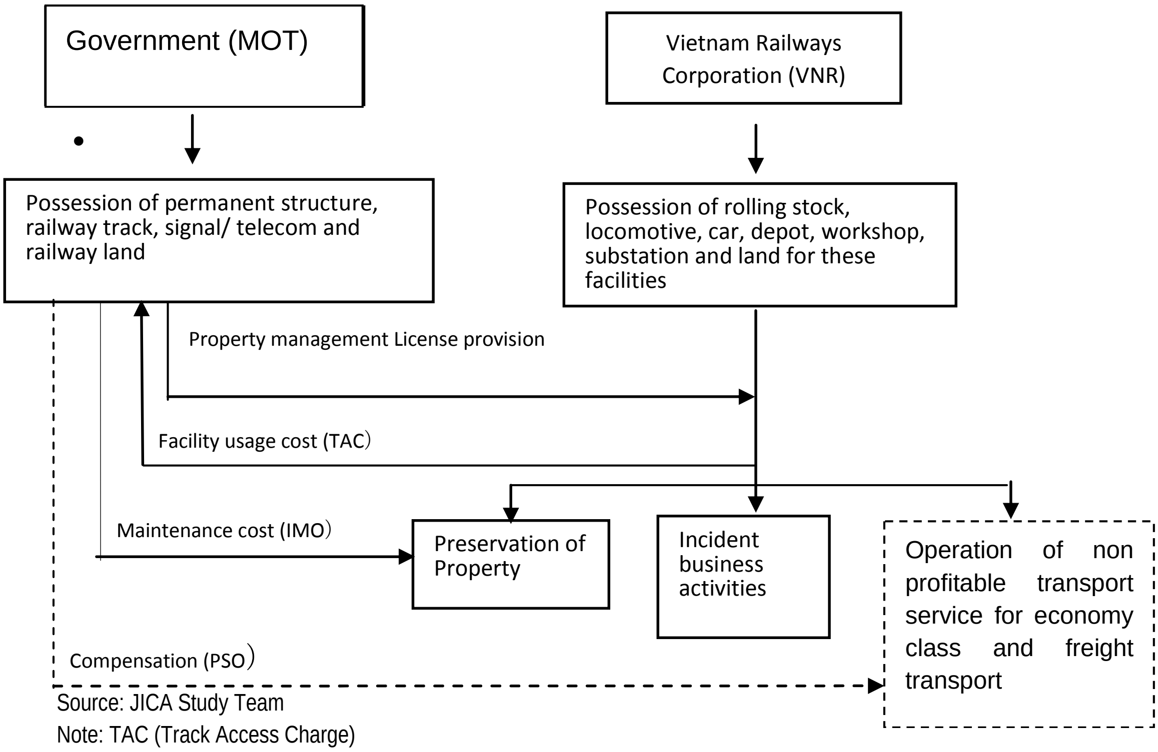
6.40 VR is a public corporation of railway management and operation funded 100% by the government and administered by MOR. Infrastructures, such as tracks and bridges, are owned by the government. The state-owned VR which has only rolling stocks operates the railway system paying the rental fee of railway facilities to the government.

6.41 In 2003, the Vietnamese government decided to introduce a separated structure for VNRA and VR. Prior to the reorganization, Vietnam introduced current system in 1995, where investment and maintenance costs of infrastructure are borne by the state budget and VR pays fees for its usage.

- 2003 Establishment of Vietnam Railways Corporation based on the former Vietnam Railway Union under Decision No. 34/2003 QD-TTg dated March 4, 2003 of the Prime Minister

- 2005 The Law on Railways was approved by the National Assembly. It is the highest legal base for a sustainable development of VR.

6.42 Role of MOT and VR is shown in Figure 6C.5



Source: JICA Study Team
Note: TAC (Track Access Charge)
IMO (Infrastructure Maintenance & Operation)
PSO (Public Service Obligation)

Figure 6C.5 Role of MOT and VR

(b) VR Organization

6.43 Under the Prime Minister decision 1883 dated on 13 November 2009, VR own the right to manage, operate and maintain the national railway system with the following assets:

- Station: land and facilities in station such as buildings, warehouses, and ground facilities, etc.; and
- Locomotive and car depots: land, depot facilities.
- VR administrates following properties that owned by the Government.
- Bridges, tunnels, tracks including related land areas and superstructures; and signals and telecommunication systems.

6.44 The government has made a commitment to provide grant funds for rehabilitation, infrastructure upgrading, and maintenance expenses. Previously, these had been paid by the railway sector. VR is organized into the headquarters and several branch organizations. The Headquarters is located at Hanoi. The Branch organizations are categorized into seven sections by financing and kinds of work, as follows:

- Transport section: consisting of Transport Operation Center/ Hanoi Passenger Transport Company, Saigon Passenger Transport Company, Freight Transport Company and Rail Traction Union.
- Infrastructure section: organized into 15 Railway Management Companies and 5 Telecommunication and Signaling Management Companies.
- Construction section: consisting of Construction Companies and Material of Construction Companies.

- Industry section: consisting of Gia Lam Company, Hai Phong Car Joint Stock Company, Di An Train Company.
- Material & Service section: consisting of various Material Companies, Hotels, Tourist & Service Companies, Print Companies, Health care Companies. etc.
- Project Management section: consisting of PMU of railway projects and 3 regional PMUs
- Non-production section: Railway vocational colleges.

6.45 The railway service and train operation sections are managed by three transport companies and a Railway Traction Company.

6.46 VR's international business has been restricted into four main business groups: two passenger train operating entities (North and South), a freight train operating company and a looser grouping of regional infrastructure administrations.

(c) Operation Framework of VR

6.47 Vietnam Railways is the sole provider of rail service and control enterprises to implement construction projects and maintenance activities on the existing railway infrastructure and other commercial activities. Though the separation of infrastructure management from operation management has been defined, operation and maintenance of infrastructure is still done by railway management companies of Vietnam Railways.

6.48 Passenger service of VR is operated by two companies: Hanoi Passenger Company and Saigon Passenger Company. Each company operates transport service in a half of the country (North and South). Freight service is operated by one freight transport company.

6.49 VR has a total of 42,430 personnel (all personnel data in 2008) as follows:

- Management board
- Director board

6.50 Office companies of 16 functional departments with about 300 staffs to support board of directors and they do not exchange to operation companies staff.

6.51 Transport Division has a total of 21,827 staffs and only president, vice president and treasurer of every companies are nominated by Management board. Those consists of:

- Transport operation center
- Hanoi passenger transport company

6.52 Hanoi PCs depot, Transport companies of north area from Quang Binh, Stations (Hanoi, Vinh, Donghoi and Hue)

- Saigon passenger transport company

6.53 Saigon PCs depot, Transport companies of south area from Danang, Stations (Nhatrang, Tapcham, Dieutri, Danang)

- Freight transport company

    6.54 Hanoi, Saigon FCs operation enterprises, Vinh, Danang FCs depots, Hathai, Haguang transport enterprises, Stations (Giapbat, Yenvien, Songthan, Butson, Thinhson, Hoangmai, Dongha, Dongdang, Tienkien, Lamthao, Laocai, Xuangiao, Haiphong), Saigon handling company

6.55 Rail traction union

6.56 Gialam train company, Hanoi locomotive enterprise, Danang locomotive enterprise, Yenvien locomotive enterprise, Vinh locomotive enterprise, Saigon locomotive enterprise

6.57 Infrastructure Division has 14,171 staffs, in which:

- Track and bridge maintenance companies: 15
- Signal and telecommunication maintenance companies: 5

6.58 Construction Division has 4,070 staffs, in which:

- Track and bridge engineering and construction companies: 9
- Signal and telecommunication installation company: 1
- Engineering and consultant company: 1

6.59 Industry bloc has 562 staffs, in which:

- Haiphong carriage joint-stock company
- Dian train company
- Others

6.60 Material and transport service bloc has 1,394 staffs, in which:

- Hotels: 16
- Print companies: 2
- Materials and transport companies: 8

6.61 Project management units (PMU) have 135 persons, in which:

- Railway PMU
- PMU region 1
- PMU region 2
- PMU region 3

6.62 Non productive bloc has 271 staffs, in which: Vocational training college No.1 & No.2

(d) Current fields of operation of VR

6.63 Currently VR lines are not electrified and signal system is mainly semi-automatic system. VR operates only inter- city train transport with using diesel locomotives now. Train frequency is low level. The scheduled train number is less than 40/ day at every line. Modernization of signaling system of VR line is ongoing with foreign cooperation. Hanoi elevated railway project is also proceeding. The electrification and automatic signal system are introducing to Hanoi urban railway.

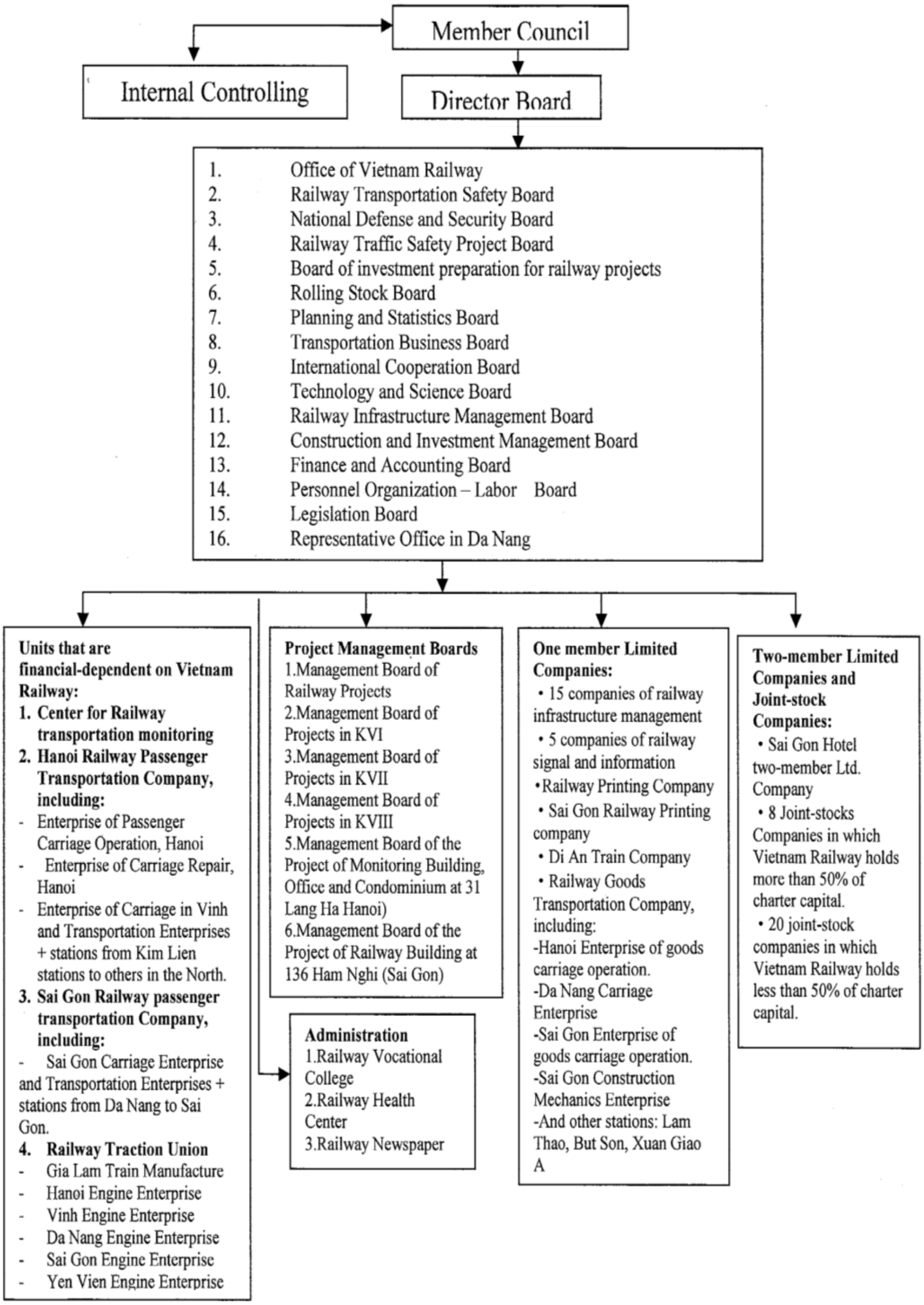
6.64 Main operations of VR as follows:

- Manage, operate and maintenance the national railway infrastructure system;
- Control the national railway transport;

- Run business based on railway traction
- Operate transport service, domestic and international multi-modal transport
- Railway, road, inland waterway and air transport services and agents
- Consult, survey, design, manufacture, newly-build and repair railway vehicles, spare parts and other mechanical products;
- Consult, survey, design, construct traffic works, irrigational works, industrial and civil works;
- Produce and run business on construction materials, consumer goods, foodstuff and beverage;
- Operate tourist, hotels, import and export of commodities, printing and labor exports;
- Telecommunication service (VR is an investor or shareholder)
- Information technology service
- Mass media service
- Survey, consult, design, install and maintenance telecommunication works and IT works
- Produce and supply telecommunication and IT materials and equipment;
- Financial, credit, banking and insurance services;
- Advertisement service;
- Run business on real estate and railway infrastructure system;
- Run business on petroleum and gas, lubricant for railway sector;
- Preventive medical activities;
- Auction sale of real estates
- Cooperated and associate with domestic and foreign organizations related to railway activities and other fields as stipulated by the law;
- Other industries as stipulated by the law;
- Other duties and operations
- Organize countermeasures and rescue to cope with natural disasters
- Provide 3-level vocational trainings such as vocational college, vocational high school and vocational primary school as the regulation. Provide retraining and level-up skills of labors in the requirements of production, business and service establishments. Conduct scientific research and hi-tech application according to the law. To join-venture and associate with universities, academic institutes and other institutions in training and improving professional skills of human resources;
- Press and mass media;
- Environment sanitation and epidemic prevention;
- To perform other tasks assigned by the state
- VR formulates the railway development strategy and planning as follows;

- Manage the state investment for the railway development
- Supervise financial investment, the subsidy companies and associated companies
- Run the railway transport; manage and maintenance the railway infrastructure
- Conduct scientific research & development; human resource training
- Invest in subsidies and associated companies concerning capital, branch name and technology
- Run the subsidies and associated companies by appointing the leadership member.

6.65 The organization frame of VR (Vietnam Railway Company) is shown in Figure 6C.6



Source: VR

Figure 6C.6 Organization Chart of Vietnam Railway (up to 31 December 2011)