

**North-South Railway
Improvement Scoping Study
in the Socialist Republic of VietNam**

Final Report

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Abbreviations

ADB	Asian Development Bank
AFD	French Development Agency,
AHP	Analytic Hierarchy Process
ARDS2020	Adjustment of VietNam Railway Development Strategy till 2020 and vision to 2050
ATDS2020	Adjustment of Transportation Development Strategy 2020
ATP	Automatic Train Protection
ATS-P	Automatic Train Stop with Pattern
ATS-SN	Automatic Train Stop - SN type
BSIP	HaNoi - Ho Chi Minh City Railway Line Bridge Safety Improvement Project
B/C ratio	Benefit-Cost ratio
C/S	Construction Supervision
CTC	Centralized Train Control
D/D	Detail Design
DF/R	Draft Final Report
DJT	French Treasury General Department
DMP	Detailed Modernization Plan for N-S Railway
DS-ATC	Digital communication & control for Shikansen - Automatic Train Control
DSR	Debt Service Ratio
EIA	Environmental Impact Assessment
E/N	Exchange of Note
E/S	Consultancy Services
EIRR	Economic Internal Rate of Return
EXIM bank	Export and Import bank
F/S	Feasibility Study
FIRR	Financial Internal Rate of Return
FRG	French Republic Government
GOJ	Government of Japan
GDP	Gross Domestic Product
GOV	Government of VietNam
GPS	Global Positioning System
GSO	General Statistics Office of VietNam
HCMC	Ho Chi Minh City
HOUTRANS	Study on Urban Transport Master Plan and Feasibility Study in Ho Chi Minh Metropolitan Area
HSR	High Speed Railway
HSR F/S	Study for the Formulation of High Speed Railway Projects on HaNoi-Vinh and HCMC-NhaTrang Sections
ICD	Inland Container Depot
IC/R	Inception Report
IPPC	Intergovernmental Panel on Climate Change
JBIC	Japan Bank for International Cooperation
JIC	Japan International Consultants for Transportation Co., Ltd.
JICA	Japan International Cooperation Agency
JTC	Japan Transportation Consultants, Inc.
JRF	Japan Freight Railway Company
JRTT	Japan Railway Construction, Transport and Technology Agency
JTCA	Japan Transport Cooperation Association
KfW	Kreditanstalt Fur Wiederaufbau, Frankfurt am Main (German Reconstruction Bank)

LARAP	Land Acquisition and Resettlement Action Plan
L/A	Loan Agreement
LCC	Less-than-Car Load
LCC	Low Cost Carrier
LED	Light Emitting Diode
LEDS	Light Emitting Deformation Sensors
METI	Ministry of Economy, Trade and Industry of Japan
MOT	Ministry of Transport
MPI	Ministry of Planning and Investment
MSR	Middle Speed Railway
NATM	New Austrian Tunneling Method
NPV	Net Present Value
OC	Oriental Consultants Co., Ltd.
OCC	Operational Control Center
ODA	Official Development Assistant
OECF	Overseas Economic Cooperation Fund
OSV	On Site Visualization Monitoring
O&M	Operation and Maintenance
R.O.W.	Right of Way
RAP	Resettlement Action Plan
PRANETS	Positioning system for RAIL NETWORK and Safety operating
RBRP	HaNoi - Ho Chi Minh City Railway Bridges Rehabilitation Project
SAPI	JICA Special Assistance for Project Implementation
SCF	Standard Conversion Factor
SENS	Shield tunneling method, Extruded concrete lining, NATM, System
SSI	Solid State Interlocking
STEP	Special Terms for Economic Partnership
TOR	Terms of Reference
TRICC	Transport Investment and Construction Consultant Joint Stock Company
VAT	Value Added Tax
VINALINES	Vietnam National Shipping Lines
VINAMARINES	Vietnam Maritime Bureau
VITRANSS	The Comprehensive Study on the Sustainable Development of Transport System in VietNam
VNR	VietNam Railways
VNRA	VietNam Railways Authority

Chapter 1 Preface

1.1 Background and Objective of the Study

1.1.1 Background

Since the launch of DoiMoi policy in 1986, both passenger and freight transportation volume has dramatically increased as a result of economic development. The transportation sector has since then played a key role for the social and economic development in VietNam. While the road sector has the largest segment among transportation modes, the government of VietNam (GOV) is expecting the railway sector to play a greater role in view of energy efficiency, environmental concerns and traveling safety.

In VietNam's railway network, the North-South Unification Railway (N-S Railway) which was opened in 1935 is the most important and longest trunk line. It spans 1,726km and connects the two (2) largest national economic hubs. The importance of the N-S Railway for the national railway network is highlighted by its traffic volume share of about 55% (passenger number base) or about 85% (passenger-km base) for passengers and about 30% (tonnage base) or about 70% (ton-km base) for freight.

According to "The Comprehensive Study on the Sustainable Development of Transport System in VietNam (VITRANSS2)" conducted by JICA in May 2010, cross-sectional passenger volume is forecasted to increase by four (4) to five (5) times, and that of freight volume by three (3) to four (4) times by the year 2030 compared to the present level¹. As such, the study foresees that railway transportation demand will drastically increase. However, passenger volume may shift to air transport due to increased income levels and to road transport due to expressway completion. The current railway transportation capacity will thus become insufficient. In this context, the N-S Railway is identified as a special railway section where traffic demand has almost reached track capacity. This is leading to a diminishing railway share of other modes of transportation under growing traffic demand along the N-S transportation corridor, unless track capacity is increased for example through infrastructure improvement.

However, the railway infrastructure is generally in poor condition. Specific issues include bad alignment with sharp curves, missing transition curves, steep slopes, numerous aged bridges and culverts that are more than forty (40) years old, and obsolete facilities including track, signaling and telecommunication systems. With respect to rolling-stock including locomotives, wagons and coaches, problems such as insufficient capacity, inconsistent technical standards, and more than forty (40) year old equipment can be mentioned. This is partly because no substantial modernization has been made since construction of the railway network in VietNam started in the 19th century under the French colonial government. In addition, the wars against France and the USA as well as poor maintenance have exacerbated the problem.

Under such circumstances, GOV has submitted to the National Assembly a proposal for the construction of a High Speed Railway (HSR) running along the existing N-S Railway. The National Assembly, however, has not approved the proposal due to the large amount of investment required. Nevertheless, the necessity of HSR for VietNam remains unchanged in the long term transportation strategy, and many newly industrialized countries are now struggling for HSR projects. That is why JICA provided technical assistance for the "Study for the Formulation of High Speed Railway Projects on HaNoi-Vinh and HCMC-NhaTrang Sections (HSR-FS)" in 2011 upon request of GOV.

¹ The current railway transportation share is not large due to limited railway transportation capacity under growing overall transportation volume. This is witnessed by the fact that ticket reservation for passenger and cargo trains is difficult.

As for the existing N-S Railway, its importance is not diminished by the HSR project because freight transportation, medium distance and intra-regional passenger transportation still needs to be provided by the existing railway line. Particularly regarding freight transportation, GOV late last year (2013) explored the possibility of a Middle Speed Railway (MSR) instead of HSR. The MSR is expected to carry freight trains, despite the fact that no MSR freight train service exists anywhere else in the world. This idea is currently under revision for re-submission to the Prime Minister (1057/VPCP-KTN dated Feb. 18, 2014).

In this context, the investment needs for improving the existing railway in terms of infrastructure, facilities, and inspection/maintenance/repair quality are still large. VNR therefore came up with a five (5) bottleneck concept to acquire funds such as force accounts and foreign assistance including six (6) JICA yen loan projects. These improvement projects pay particular attention to travel time reduction and safety enhancement. Among the candidate projects, the HaiVan pass is attracting particular attention, because the section has many sharp curves with time-consuming speed restrictions. The section is also dangerous with disaster prone topographic conditions and a high risk of land slides.

1.1.2 Objective

Since the railway infrastructure of the N-S Railway is not exerting its expected function due to degradation, railway functional rehabilitation is listed as a top priority for the railway sector in the “Railway development master plan” in the Prime Minister’s decisions released in 1993, 2002 and 2009. The role of the existing N-S Railway may not be diminished even after launching of a HSR under the transportation role sharing scheme. This will be evident for freight transportation in particular.

The main objective of the study is to propose how to reduce travel time and enhance running safety of the existing N-S Railway through infrastructure and facility improvement in line with GOV concerns. However, improvement of the degrading existing N-S Railway is not separate from other issues such as fund availability, improvement priorities, implementation time schedules, regional development plans and the HSR project.

GOV has implemented numerous railway rehabilitation projects using both its own financing and foreign assistance. Consequently, the travel time between HaNoi and HCMC which in 1994 took 36 hours for passenger trains and 68 hours for freight trains had been shortened to 29.5 hours and 60 hours respectively in 2007 after completion of the Yen loan projects of “Railway bridges rehabilitation project (1), (2) and (3)”. Subsequent Yen loan projects which target 24 hours for passenger trains and 54 hours for freight trains after completion are currently being implemented with the following project names: “Bridge safety improvement project (I), (II), (III)”.

The government of Japan (GOJ) has assisted the improvement efforts via JICA Yen loan projects in response to GOV commitment for the N-S Railway. However, endless assistance is unrealistic considering the huge scale of the N-S Railway line and its total 1,726km distance. GOJ needs to identify the scope of assistance for improvement works while the GOV shall be responsible for the rest of the improvement efforts. Here, the implementation time schedule becomes an important factor because travel time reduction and safety enhancement are pressing issues. The HSR project is also on the horizon after which a substantial share of the long distance passenger volume may shift to HSR from the existing N-S Railway.

Take for example the bridge component: out of a total number of 1,485², at least 597 bridges are still waiting for improvement and the number may be greater due to fund unavailability for the bridges selected for implementation. It will be practical for GOJ assistance to select urgent and cost effective bridges while setting the implementation schedule along with traffic demand. Another example is the HaiVan tunnel construction

² This number was 1,454 when the Inception Report was submitted.

component. Since this is expected to be a costly project because of the over 7km length, a plan which has a long term perspective and which includes the time during which the HSR project will be launched is thus required. Improvement of other components such as alignment, track, level crossings with roads, long interlocking signaling sections, signaling and telecommunication, and rolling-stock shall be identified in the same manner.

The prime objective of this study is to identify priority infrastructure and facility components for improvement which are fit for GOJ assistance in terms of cost effectiveness. The goal is to reduce travel time and enhance running safety of the existing N-S Railway while taking the future HSR project into consideration. In addition, considering the fact that the travel time of freight trains is much longer than that of passenger trains, there is much potential to improve the management aspects such as freight train operation and cargo handling systems. Coupled with infrastructure and facility improvement, the travel time may then be drastically reduced. This issue is discussed in Chapter 8 together with improvement of operation and maintenance performance for sustainable railway operation and transportation service quality enhancement for modal traffic share increase, some of which will be proposed for optional JICA technical assistance.

1.2 Study Schedule

1.2.1 Institutional Setup

The study team comprises ten (10) members assigned from different companies including Japan Transportation Consultants, Inc. (JTC), Japan International Consultants for Transportation Co., Ltd. (JIC), and Oriental Consultants Co., Ltd. (OC), with JTC as the prime contractor. Specifics for each member with their expertise and other attributes are shown in [Tab. 1-2-1].

[Table 1-2-1] Study Team Member

No.	Position	Name	Comp any	Experience in JICA	Experience in Vietnam	Language skills
1	Team leader	Keiichi Aoki	JTC	○	○	○
2	Deputy leader	Tetsuo Wakabayashi*	JTC	○	○	○
3	Railway infrastructure	Hirokazu Nishi	JTC	○	○	△
4	Civil work structures	Kazumasa Yamaoka	OC	○	×	○
5	Tunnels	Kiyoshi Edo	JIC	○	○	○
6	Freight transportation	Kohji Nishimura	JTC	○	×	△
7	Signaling and telecommunication	Reiji Ishima	JIC	○	×	○
8	Rolling-stock and operation	Yoshinobu Miura	JTC	○	×	△
9	Economic and financial analysis	Atsushi Kamiyama	OC	○	○	○
10	Socio-environmental verification	Bogo Abe	OC	○	○	○

Note: Mr. Tetsuo Wakabayashi succeeded his tasks from Mr. Osamu Takagi in April 2014.

Source: Inception report

Out of the ten (10) members, eight (8) members (No. 1 to 8 in the table) participated in the 1st field mission to VietNam during which Mr. Edo visited on a different time schedule in order to avoid a double assignment with another HSR-F/S study. He still occasionally joined discussions on the HaiVan tunnel as an observer, because he has extensive knowledge of HSR tunnel planning.

Mr. Takagi was at first appointed Deputy Leader of this study, but due to personal reasons, his assignment was succeeded by Mr. Wakabayashi on April 16, 2014 upon agreement by JICA.

The study team recruited individual local assistants, with engineers from Transport Investment and Construction Consultant Joint Stock Company (TRICC), because the company has been engaged in various railway planning works including the “HaiVan tunnel

construction project” for VNR and “Adjustment to the Transport Development Strategy up to 2020 (ATDS2020)” for MOT. [Tab. 1-2-2] shows a list of local assistant members. The engineers not only sorted out data, made drawings, and accompanied the study team members to all meetings with counterpart agencies and on site surveys, but also provided information and data relevant to the study taken from past planning works entrusted by VNR.

[Tab. 1-2-2] Local Support Members

No.	Position	Name	Company
1	Assistant to Railway Planner cum Coordinator	Pham Tien Dung	TRICC
2	Assistant to Railway Infrastructure	Nguyen Thi Thuy Minh	TRICC
3	Assistant to Railway Freight Transportation	Ha Van Quang	TRICC
4	Assistant to Railway System	Nguyen Manh Hung	TRICC
5	Interpreter (1)	Nguyen Hoang Anh	Private
6	Interpreter (2)	Pham Khanh Ly	Private
7	Interpreter (3)	Nguyen Thi Phuong Thao	TRICC
8	Office Girl (for the 1 st mission)	Luu Thi Hong Anh	TRICC
(8)	Office Girl (for the 2 nd mission)	Nguyen Thi Lan Anh	TRICC

Source: Study team

All discussions with counterpart agencies were conducted in Vietnamese upon their request with the help of Interpreter (1), except for some Q&A sessions and major meeting records which were kept by Interpreter (2) and (3) in English followed by review by the Team Leader. The office girls were in charge of miscellaneous works such as letter documentation, document delivery, appointment making, transportation arrangements, photocopying, and office equipment maintenance.

The office and office equipment were also provided by TRICC on a contractual basis at the address below, because the location provided convenient access to JICA, the Japanese embassy, VNR, VNRA, and MOT.

Office location: 2nd Floor, No. 2/371 Kim Ma Street, Ba Dinh District, HaNoi,
Tel/Fax: +84 4 38460142

1.2.2 Time Schedule

The study was announced by JICA on November 11, 2013, and the study specification was delivered on December 4, 2013. The proposal submission deadline was set to December 20, 2013, appointment notification to JTC was made on January 9, 2013, and the study contract with JTC was concluded on February 3, 2014.

After a clarification meeting with JICA on February 13, 2014, and an internal kick-off meeting with the study team members on February 20, 2014, the data and information collection work and the 1st field mission preparation to VietNam were started.

The 1st field mission to VietNam was dispatched between March and April 2014 with a different time schedule for each individual member depending on their convenience. [Tab. 1-2-3] shows the actual schedule of the eight (8) members who joined the field mission.

[Tab. 1-2-3] The 1st Field Mission Schedule

No.	Name	Arrival	Departure	Arrival	Departure	Departure	Departure	Arrival	Departure
1	Keiichi Aoki		3/6				3/28		
2	Osamu Takagi	3/4				3/22			
3	Hirokazu Nishi			3/10			3/28		
4	Kazumasa Yamaoka			3/10			3/28		
5	Kiyoshi Edo	Observer						4/1	4/19
6	Kohji Nishimura			3/10	3/21				
7	Reiji Ishima			3/10			3/28		
8	Yoshinobu Miura			3/10			3/28		

Source: Study team

Various meetings were held and site surveys were conducted during the stay in VietNam as shown in [Tab. 1-2-4] and the records of meetings with counterpart agencies assigned by JICA were submitted to JICA in English together with a summary in Japanese during the stay in VietNam. These records are included in [Attachment 1-2-1].

[Tab. 1-2-4] Major Events during the 1st Field Mission

No.	Date	Event	Purpose
1	May. 7	JICA HaNoi (Person in charge)	Greeting
2		VNRA (Director)	Greeting
3	Mar. 10	TRICC (President)	Greeting
4		TRICC (Vice-president)	Information gathering
5		Embassy of Japan (MLIT attaché)	Greeting
6	Mar. 11	VNR (Deputy General Manager)	Kick-off meeting
7	Mar. 12	VNRA (Deputy Director)	Kick-off meeting
8	Mar. 13	MOT (Vice-minister)	Kick-off meeting
9	Mar. 14	Nippon Express HaNoi (Head)	Interview
10	Mar. 15	Site survey around DaNang	Track, Bridges, Tunnels, Crossings, etc.
11	Mar. 16	Site survey around Hue	Bridges, Stations, Tunnels, etc.
12	Mar. 17	Japan Trans City (Head)	Interview
13		TRICC (civil work)	Data collection
14	Mar. 18	TRICC (signaling & telecommunication)	Data collection
15		VNR (civil engineering)	Data collection
16		NYK (Head)	Interview
17	Mar. 19	Nissin (Head)	Interview
18	Mar. 20	VNR (train operation)	Data collection
19	Mar. 21	VNR (Track)	Data collection
20	Mar. 24	VNR (Director)	Reporting
21		VNR (signaling & telecommunication)	Data collection
22	Mar. 25	Site survey around HaNoi	Station, Workshop, Track, etc.
23	Mar. 26	JICA HaNoi (Deputy Chief Representative)	Reporting
24	Mar. 27	VNRA (Deputy Director)	Reporting
25		JICA expert to VNRA	Greeting for the new assignment

Note: The meeting records of No. 23 are classified.

Source: Study team

Site surveys were conducted in the area between DaNang and Hue, as well as HaNoi in order to get a general view of the site conditions of infrastructure and facilities of the N-S Railway line. [Tab. 1-2-5] shows the schedule of the site survey tour.

[Tab. 1-2-5] Site Survey Schedule

Date	Location	Infrastructure component	Stay
Mar. 14	HaNoi → DaNang	● Evening flight <VN1519>	Northern hotel
Mar. 15	DaNang → HaiVan pass → DaNang → Hue	● Six (6) approach road bridges to the HaiVan road tunnel ● HaiVan road tunnel (JICA project) ● Candidate south exits of planned new HaiVan railway tunnel ● Industrial area development near KimLien station ● KimLien station and its freight train yard facilities ● NamO bridge (rehabilitated by JICA project) ● Level crossing near ThanKhe station ● ThanKhe station ● DaNang station ● Inspection motor car ride to Hue ● Existing six (6) tunnels along HaiVan pass railway section ● Topological, track, and bridge conditions along the line	
Mar 16	Hue → HaiVan pass → Hue	● A bridge not listed in damage log book near KimLien station ● An adjacent candidate bridge listed in damage log book ● Candidate north exits of planned new HaiVan railway tunnel ● KimLien station and freight yard facilities ● AnCu station ● Back to Hue by car ● Evening flight <VN1544>	Camellia hotel
Mar. 25	HaNoi → VanDien → HaNoi	● HaNoi station ● HaNoi locomotive workshop ● Operation control center ● GiapBat freight terminal ● SSI interlocking system near GiapBat station ● Automatic barrier level crossing built by German assistance ● Type 6502 interlocking equipment in VanDien station ● Dual gauge turnout near VanDiet station	Lake Side hotel

Source: Study team

Reporting on the findings during the 1st field mission was made to JICA on April 9, 2014. Immediately after the JICA reporting, Interim Report compilation by each study team member started and the draft report was submitted to JICA for comments on April 25, 2014. Upon receiving JICA's comments on the Interim Report on May 19, 2014, an amendment was made and finalized during the 2nd field mission. Presentation material on the Interim Report to be used during the 2nd field mission was also prepared in parallel. The draft was submitted to JICA on May 16, 2014 for comments and was finalized on May 22, 2014.

In preparation for the 2nd field mission, a meeting among study team members to clarify the objective of the mission and the tasks of each member was held on May 13, 2014. Three (3) members of the team who were unable to be present at the meeting joined via video link because they were in HaNoi already.

The 2nd field mission to VietNam was dispatched between May and June 2014 with a different time schedule for each individual member depending on their convenience. [Tab. 1-2-6] shows the actual schedule of each of the ten (10) members who joined the field mission.

[Tab. 1-2-6] The 2nd Field Mission Schedule

No.	Name	Arr.	Arr.	Arr.	Arr.	Arr.	Arr.	Dep.	Dep.	Dep.	Dep.	Dep.	Dep.
1	Keiichi Aoki						5/19						6/5
2	Tetsuo Wakabayashi	5/11											6/5
3	Hirokazu Nishi				5/17						6/2		
4	Kazumasa Yamaoka					5/18							6/5
5	Kiyoshi Edo	5/11										6/4	
6	Kohji Nishimura			5/14				5/23					
7	Reiji Ishima		5/12										6/5
8	Atsushi Kamiyama						5/19						6/5
9	Yoshinobu Miura					5/18				6/1			
10	Bogo Abe						5/19		5/30				

Source: Study team

Various meetings were held and site surveys were conducted during the stay in VietNam as shown in [Tab. 1-2-7] and the records of meetings with counterpart agencies assigned by JICA were submitted to JICA in English together with a summary in Japanese during the stay in VietNam (refer to [Attachment 1-2-2]).

[Tab. 1-2-7] Major Events during the 2nd Field Mission

No.	Date	Event	Purpose
1	May 15	Site survey in HaNoi	Crossings
2	May 16	Saigon Railway Transportation Co.	Information gathering
3		Long An Brewery / Sapporo Beer	Information gathering
4	May 17	SongThan station	Information gathering
5	May 17-19	Site survey from HCMC to HaNoi by train	Track, Operation, Riding comfort
6	May 20	Panasonic Vietnam Corp. Logistic Group	Information gathering
7	May 21	Hanoi Railway Transportation Co.	Information gathering
8		JICA HaNoi Office	Reporting on Interim Report
9	May 22	VNR GiapBat locomotive office	Information gathering
10		VNR GiapBat station	Information gathering
11		RPMU Implementation Dept.	Information gathering
12		VNR Science & Technology Dept.	Information gathering
13		VNR YenVien freight station	Information gathering
14	May 23	Itochu Co.	Information gathering
15		VNR Railway Rescue and Natural Calamity Response Centre	Information gathering
16	May 24	Red River delta	Socio-environment
17	May 25	North central region	Socio-environment, bridges
18	May 26	TRICC Technology, Science and Environmental Center	Information gathering
19	May 27	VNR and VNRA	Q & A on Interim Report
20	May 28	TRICC Tunnel Department	Information gathering
21	May 29	VNRA Planning and Investment Department	Information gathering
22	May 29	VNR Infrastructure Department	Information gathering
23	May 30	VNRA JICA Expert	Greeting and reporting
24	May 30	VNR Planning & Project Preparation Department	Information gathering
25	June 2	TRICC Bridge Enterprise	Information gathering
26	June 4	Site survey in HaNoi Locomotive Workshop	Locomotives

Source: Study team

The site survey included a passenger train trip from HCMC to HaNoi during which the train speed was measured using a GPS-based smart phone application. Infrastructure and facilities at crossings, the signaling system, and bridges around the HaNoi area were inspected, along with the socio-environmental conditions in the HaNoi area.

Reporting on the findings during the 2nd field mission was made to JICA on June 19, 2014. Immediately after the JICA reporting, Draft Final Report compilation by each study member started and the draft report was submitted to JICA for comments on July 17, 2014. Upon receiving JICA's comments on the Draft Final Report, an amendment was made and finalized on July 25, 2014. Presentation material on the Draft Final Report to be used during the 3rd field mission was also prepared in parallel. The draft was submitted to JICA for comments on July 25, 2014 and was finalized on July 31, 2014.

The 3rd field mission to VietNam was dispatched in August 2014 with the time schedule and members shown in [Tab. 1-2-8]. The purpose of the 3rd field mission was to report on the Draft Final Report and to receive comments to be incorporated in the report. The records of meetings (in English) with counterpart agencies assigned by JICA together with a summary

in Japanese are included in [Attachment 1-2-3].

[Tab. 1-2-8] The 3rd Field Mission Schedule

No	Name		Arrival	Departure	
1	Keiichi Aoki		8/4	8/7	
2	Tetsuo Wakabayashi		8/4	8/7	

Source: Study team

Reporting on the findings during the 3rd field mission was made to JICA on August 4, 2014. Immediately after the JICA reporting, the Draft Final Report was amended based on the comments and submitted to JICA for comments on August 19, 2014. Upon receiving JICA's comments on the Final Report on September 2, 2014, an amendment was made and finalized on September 11, 2014 before the end of the contract period on October 31, 2014.

1.3 Findings of the Study

1.3.1 Kick-off Meetings with Counterpart Agencies

Presentation of the Inception Report was made beginning with the 1st field mission at counterpart agencies including MOT, VNR, and VNRA assigned by the JICA study specification in order to lay a foundation for mutual understanding on the purpose of the study. The official kick-off meeting with MOT was chaired by Vice-Minister Dong. The presentation material is included in [Attachment 1-3-1]. The following points in the presentation were discussed during the 1st field mission.

- Although this study focuses on improvement of the existing railway, the planned HSR project shall be included in the study, because the HSR is planned along the existing N-S Railway line so that a substantial volume of long distance passenger traffic is forecasted to be transferred to the HSR where modal integration between the railway lines is vital in order to enhance railway transportation mode share.
- New construction of the HaiVan tunnel instead of improvement of existing small tunnels on the HaiVan pass section is regarded as a high priority infrastructure component, because the travel time saving effect is large and the section has experienced numerous natural disasters such as landslides resulting in loss of human life.
- The HaiVan tunnel is proposed to be built with double track specification taking projected rapid transportation demand growth by VITRANSS2 into consideration. Furthermore, the tunnel is proposed to be built based on the Japanese HSR standard, because the difference in size between the existing railway and the Japanese HSR is so small that the tunnel can be used for the future HSR without any modification.
- While the tunnel is to be used for the existing railway before the HSR is launched, the same tunnel is proposed to be shared between the existing railway and the HSR after the HSR launch by taking appropriate safety measures in the same way as on the Seikan tunnel section of Hokkaido HSR line in Japan which will be opened in April 2016.
- If the tunnel is shared between the existing railway and the HSR, the new investment cost for the future HSR tunnel which is inflated by price escalation compared to the present cost can be saved while the additional cost due to the increase in tunnel cross sectional size including price escalation can be compensated by the new investment cost.
- The next proposed priority is bridge rehabilitation or replacement, since substantial travel time is lost because of speed limitations on bridges due to degraded bridge conditions and light train load design feature particularly on the south section of the N-S Railway. This is why priority railway investment funds have been allocated to bridge rehabilitation or safety improvement up to now.
- As for grade separation of level crossings on urban sections, the HaNoi and HCMC sections

are proposed to be excluded from this study, because urban railway construction projects are being implemented or planned and urban railway planning studies for both cities are currently under way using JICA technical assistance. Inclusion of these sections in this study would therefore complicate matters. As for DaNang, the relocation of DaNang station has been agreed between VNR and the city authority so that level crossings in the urban area will be demolished. As for NhaTrang, while there is no agreement between VNR and the city authorities, nothing definite can be proposed before such agreement, because the alignment of the railway on the city section is almost identical to DaNang and requires detailed discussions between the parties concerned.

- Since the size of the project would require a huge amount of JICA assistance if all the necessary infrastructure components are to be included for rehabilitation and upgrading, they must be selected according to priority by setting up certain criteria. The proposed criterion is cost-benefit analysis in which the cost is for rehabilitation or upgrading work and the benefit is savings in travel time. The financial and economic analysis in terms of FIRR and EIRR are to be evaluated for a project package composed of selected infrastructure components.
- Rolling-stock numbers are proposed to be studied whether or not the existing number of rolling-stock is capable of transporting traffic demand after the railway line capacity is increased by infrastructure and facility upgrading. In the meantime, train operation and maintenance capabilities are to be investigated for sustainable transportation performance and the opportunity of technical assistance is to be explored.
- Railway transportation quality, particularly in the field of freight transportation will be studied in order to assess the magnitude of potential clients and to assess the room for quality improvement.
- The socio-environmental aspects of the project package to be composed of selected priority infrastructure and facility components will be roughly assessed in order for the project package to be suitable for JICA assistance and to facilitate project implementation.

1.3.2 Initial Reaction in the Kick-off Meetings

A series of presentation and discussion opportunities were given by MOT, VNR, and VNRA and the following are the major points of their first reaction on the proposal made in the inception report presentation. There were many other expectations expressed by them, but they are not listed here because they are considered beyond the scope of this study. They include track elevation in urban areas, employee number reduction measures to prepare for future railway sector reform (VNR privatization), mountain pass sections other than HaiVan pass and KheNet pass suitable for new tunnel construction, track gauge conversion plans to standard, and design load standardization.

- Prioritization criteria shall not only consist of results of cost-benefit analysis but also of the railway operation safety enhancement effect such as reduced traffic accidents at level crossings and land slides on mountain sections (from MOT and VNR).
- Grade separation of level crossings in urban areas shall be included to the greatest extent possible such as the planned TanKien and SongThan sections in HCMC in view of reducing traffic accidents (from MOT and VNR).
- The study should concentrate on improvement of the existing railway and not touch issues related to the HSR project (from MOT).
- The existing railway improvement project should take the HSR project into consideration contrary to MOT's opinion (from VNR).
- The track sharing scheme between the existing railway and the HSR in the HaiVan tunnel section is not possible as long as safety is not assured (from MOT, VNRA, and VNR).

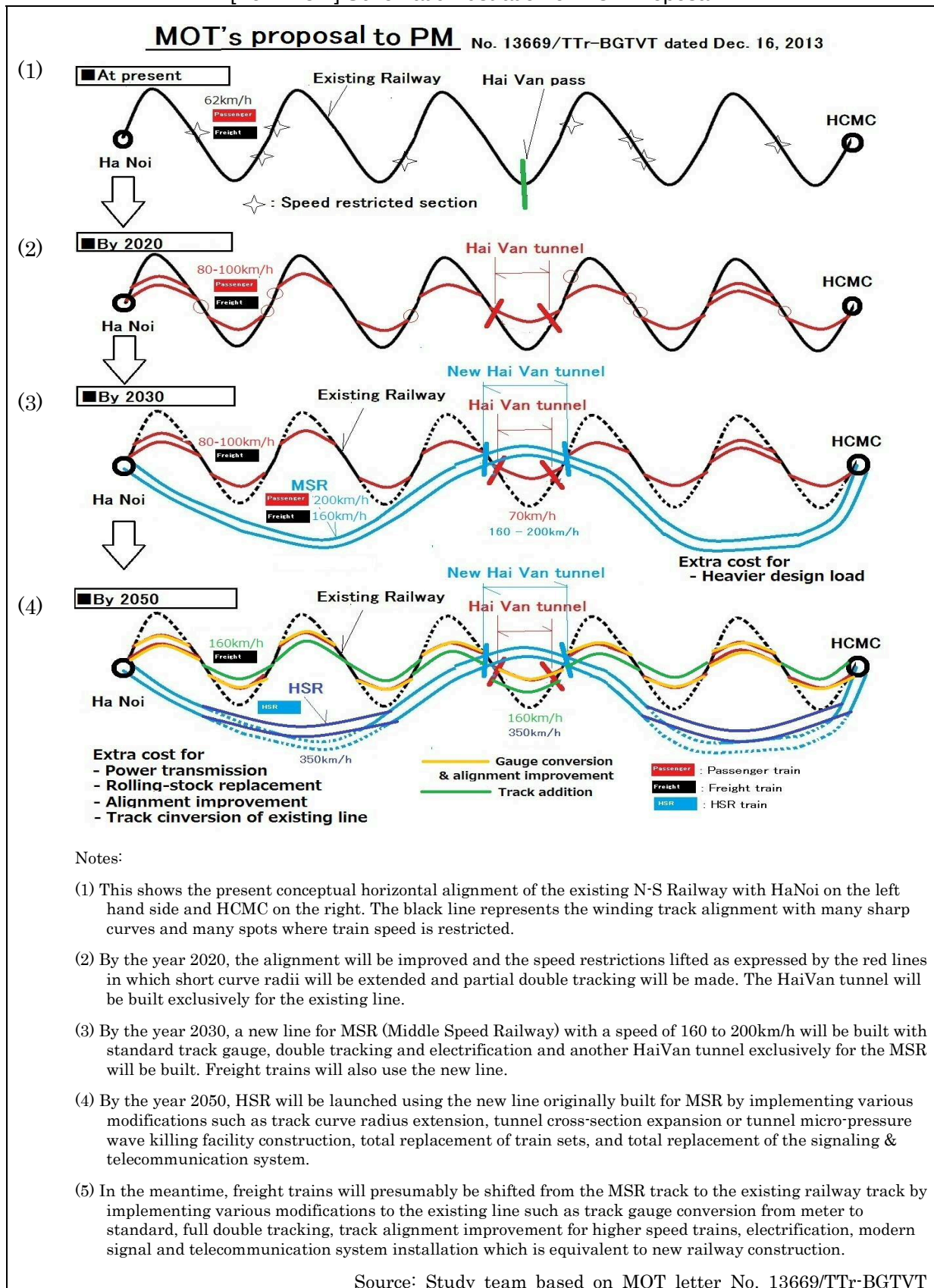
- The proposal to reduce the number of employees for safety operation is welcomed to prepare for railway sector reform or VNR privatization which is to be incorporated in the railway sector development strategy (from MOT and VNR).
- The signaling and telecommunication facility improvement component shall not be included in the study because it is to be invested in by the private sector after railway sector reform (from MOT).
- The signaling and telecommunication facility improvement component shall be included in the study because it belongs to the responsibility of the public sector even after railway sector reform (from VNR and VNRA).
- Since a series of studies have been conducted for the N-S Railway rehabilitation in the past, overlapping of the study subjects shall be avoided (from MOT).
- JICA is requested to provide Yen loan assistance as early as possible by immediately conducting a feasibility study based on this study (from MOT).
- The study shall be conducted on the premise that the gauge of the existing railway line shall remain the current one meter gauge at least until the year 2050 (from MOT and VNR).

1.3.3 Findings in the 1st Field Mission

The following are the findings accrued from the series of discussions with the counterpart agencies of this study and the sample site survey to capture the general idea of the conditions of candidate infrastructure and facility components during the 1st field mission.

- A question was raised on the track sharing scheme between the existing railway and the HSR on the basis that investment for the construction of a new tunnel exclusively for the HSR will be affordable in the future thanks to the economic development of VietNam and the success of railway sector reform aside from safety operation concerns.
- MOT submitted the railway sector development strategy on December 16 last year with letter No. 13669/TTr-BGTVT (refer to [Attachment 1-3-2]) in which MSR is proposed to be launched in advance of HSR, presumably in order to accommodate freight transportation and later to be upgraded to HSR for passenger transport dedicated trains (refer to [Box 1-3-1] for a schematic illustration of the proposal). But the proposal was returned for revision by the Prime Minister's office on February 18 this year with letter No. 1057/VPCP-KTN (refer to [Attachment 1-3-3]) with a comment that the proposal is not in compliance with what was proposed by HSR-F/S. MOT is currently working on a revision for re-submission. VNR proposed to the study team that we should collaborate with each other to compile the revised proposal.
- Grave concerns were expressed on safety issues associated with train operation, particularly traffic accidents at level crossings and calamities in mountainous areas. This is supposedly because of public attention on the large death toll caused by traffic accidents along the railway line and the recent land slide disaster on the HaiVan pass section.
- The conditions of the infrastructure and facilities are summarized as follows wherein the details will be discussed in Chapter 3.

[Box. 1-3-1] Schematic Illustration of MOT Proposal



(1) Track

- **Alignment:** Although VNR has a technical standard, it is not strictly observed in such aspects as minimum radius of curve, transition curve provision, and insufficient cant values on curved sections. Alignment near NhaTrang station is irrational while that of DaNang was agreed to be improved based on an agreement between VNR and the city authorities.
- **Track materials:** Rail head attrition due to tire skid is in critical condition, track materials such as fasteners and rail pads are decayed, and track maintenance is very insufficient so that the rail gauge and longitudinal rail level is irregular, ballast amount is insufficient, sleepers are often broken and of inappropriate type, and mud pumping is observed, partly due to an insufficient number of multiple tie tampers.
- **Level crossings:** Grade separation of level crossings needs agreement between VNR and corresponding municipal authorities. It has so far been carried out only in DaNang city. Since others are yet to be made, the study team is unable to present a definite plan.

(2) Bridges

- **Site inspection:** The study team visited a bridge at 750km350 in the north of HaiVan pass as a sample in order to get a general image of degraded bridges. The team also visited another bridge located in the surrounding area which is not listed in the table of candidate bridges for rehabilitation. The inspection didn't involve any engineering measurements but visual inspection only.
- **Damage assessment:** A damage assessment log of the bridges made by VNR Maintenance Company was available, but the quality or accuracy of the damage grade assessment was not as good as to be able to prioritize the bridges for improvement. Therefore some other prioritization criteria such as traffic density will be required.
- **Repair works:** Out of forty-one (41) bridges on which rehabilitation work is reported to be under way in the preliminary study to this study, some of them were confirmed to be certainly under way while others are under way for confirmation.

(3) Tunnels other than HaiVan

- **Site inspection:** The study team visited six (6) tunnels in the HaiVan pass section by an inspection motor car provided by VNR. It was discovered that the main problem of the existing tunnels is water leakage and resulting speed limitations. It was found that the alignment of the tunnels is straight except for very short ones in order for the local contractors to preform construction work. It is assumed that the other tunnels are in equal condition.
- **Total picture of tunnels:** The total number of tunnels on the N-S Railway is twenty-seven (27), the longest one being 1,188m. Out of these, five (5) tunnels are located on the HaiVan pass section, of which the longest one is 944m. These tunnels will not be in use after completion of the HaiVan tunnel.
- **KheNet tunnel:** There are no tunnels on the KheNet pass section at present, but a new tunnel is proposed to be constructed with financial assistance from EXIM bank of China. A feasibility study of the tunnel construction project is planned by VNR.
- **Remaining tunnels:** Out of the remaining twenty-two (22) tunnels, three (3) are undergoing rehabilitation work and nineteen (19) are at the planning stage for rehabilitation projects by VNR which shall be confirmed.

(4) Signaling and Telecommunication

- **Level crossing improvement:** Classification upgrading may improve safety standards

but may not contribute to reduced manpower as expected by VNR. Safety improvement measures with minimum costs will be required such as obstacle detectors.

- **Railway sector reform:** According to the Vice-Minister of MOT, signaling and telecommunication facility improvement is the responsibility of private investors after railway sector reform, but people in the field have a different opinion on this.
- **On-going projects:** The signaling and telecommunication system is being modernized and is currently being implemented on the HaNoi - Vinh section with French assistance (electronic interlocking (such as SSI) and CTC (Central Train Control) installation) and on the Vinh - HCMC section with Chinese assistance (relay interlocking, electric point machines, and supervision of train location).
- **Track sharing scheme between the existing railway and the HSR on the HaiVan tunnel section:** Safety assurance measures for the signaling and telecommunication system needs to be proposed to VNR to be acceptable.

(5) Rolling-stock and Train Operation

- **Speed limitations:** Spots where train speed is restricted such as bridges due to degradation and light design load, sections with missing transition curves, sharp curve sections with a minimum radius of less than 200m, steep gradients requiring additional locomotives, steel sleeper sections, and sections with mud pumping.
- **Rolling-stock:** Although MOT advised that rolling-stock upgrading is outside the scope of this study, it was found that there are several areas where technical assistance will be necessary. For example, locomotive operation marshaling between passenger and freight traffic is not balanced and inefficient, with locomotives being used exclusively for either passenger or freight trains. The container based freight transportation market is yet to be sufficiently tapped in VietNam while the potential demand is big due to its transportation quality (introduction of 12ft containers may be explored aside from the present marine containers of 20, 30, and 40ft).
- **Inspection and repair regime:** Facilities, machinery, and buildings are in general obsolete. While the NgocHoi workshop is scheduled to be modernized, others including those in DaNang and HCMC are yet to be modernized.
- **Train drivers:** Training to improve drivers' skills is another candidate area for technical assistance, because a large number of accidents is allegedly due to insufficient driver training although the causes are often not fully investigated and often hidden. It will become even more necessary because the train speed is planned to be increased after infrastructure improvement.
- **Train operation:** Aside from accidents, the cause of train schedule disorder is also unclear because it entails penalties charged to VNR by MOT. It is another potential area for technical assistance that the investigation and regulation setting need to be institutionalized in VNR.

(6) Freight Transportation Quality

- **Priority of client requirements:** Clients are more concerned about transportation quality in terms of safety, security, reliability, indemnity, and punctuality rather than quick delivery and price. This is one of the reasons why container transportation service is comparably favored.
- **Container transportation:** Container transportation is attractive compared to cargo trains due to transportation quality in terms of handling efficiency, safety, and sanitation, but container trains are in short supply.
- **Demand projection:** Transportation demand between HaNoi and HCMC may not

grow as high as forecasted by VITRANSS2 in view of Japanese manufacturing demand. Domestic consumption growth will be necessary to achieve the projection.

- **DaNang port:** The freight volume from DaNang port is expected to show high growth in view of cross-border transportation demand growth including transportation to and from Laos and Cambodia.
- **Highway network:** As the highway network is developed, railway transportation may lose its competitive edge compared to cargo trucks in terms of speed and price.
- **Transportation demand from Japanese manufacturers:** Since Japanese manufacturers import raw materials from abroad, process them in VietNam, and then in general export them, the domestic transportation volume may not grow as much as expected.
- **Competitive edge of VietNam:** Chronic corruption in the public sector, rapid economic development in neighboring countries, and worker quality (skillful and diligent but not creative, lacking discipline and ethics, and mentality of selfishness and dependency while lenient to others) may hinder further economic growth.

(7) HaiVan Tunnel

- **Given conditions for planning:** The HaiVan tunnel alignment shall be planned taking such conditions into consideration that the new DaNang station used for the existing railway and HSR will be built in the western suburbs of DaNang city, both AnCu station and KimLien station located at each end of the HaiVan pass section may be relocated or abolished, and tunnel size is flexible with regard to the use of single or double tracking.
- **Conditions which need to be decided:** Planning of the HaiVan tunnel will be influenced by such factors as whether the existing railway in the DaNang city area is used or abolished, the transportation strategy of DaNang city, modality of DaNang port access, ICD development around the KimLien area, the tourism development potential in the HaiVan pass cape area, and LienChieu port development.
- **Planning procedures in this study:** The HaiVan pass section railway alignment will be selected first between 1) VNR's proposed base alignment and 2) the HSR-F/S proposed base alignment by evaluating costs and benefits in consideration of the HSR project and the assumed city development plan. Then, four (4) options (A, B, C, and D) in accordance with the tunnel construction process road map for the existing railway and HSR will be compared with the selected alignment. In the end, the best option will be proposed by estimating demand (existing passenger, HSR passenger, container freight, and bulk freight), capacity (ditto), costs (initial costs, operation & maintenance costs, land acquisition costs, and facility renovation costs), and benefits (time savings, additional cost savings, and development flexibility). These details will be discussed in Chapter 6.

1.3.4 Findings in the 2nd Field Mission

The 2nd field mission was conducted with the purposes summarized below along with the Inception Report. Among them, the crucial subject was to set out prioritization criteria for infrastructure components which were required to be changed from the Inception Report due to the unexpected lack of information and since they were not yet articulated in the Interim Report. The criteria must be practical and down-to-earth rather than ideal which would only be possible in a country where detailed information is abundant.

- Additional information collection to the 1st field mission
- Reporting and confirmation of the findings of the 1st field mission
- Proposal of prioritization criteria for infrastructure components and their confirmation

with VNRA and VNR counterparts

- Preliminary prioritization of the infrastructure components to the extent possible
- Proposal presentation on the HaiVan tunnel construction plan
- Identification of areas for technical assistance
- Economical and financial project evaluation framework setting
- Preliminary socio-environmental study

The study team made a presentation of the Interim Report on May 27, 2014 with the joint participation of VNRA and VNR followed by a Q&A session. The presentation material is shown in [Attachment 1-3-4]. Various discussions and proposals were made which were summarized by Vice General Manager Ngo Anh Tao of VNR at the end of the Q&A session which is summarized in [Tab. 1-3-1] together with answers from the study team.

[Tab. 1-3-1] Proposals from VNR/VNRA and answers

VNR's opinion	Answer from the mission
VNR gives priority to capacity increase of freight transportation by shortening travel time in comparison to sporadic maximum speed-up while VNRA gives priority to speed-up of passenger trains.	Study team is of the same opinion as VNR. It shall be noted that discriminatory speed-up of freight trains is not possible so passenger train speed will be equally raised when freight train speed is raised.
VNRA requires that the conclusion of this study shall be in line with that of MOT's strategy (pending ATDS2020 as of May 27, 2014).	The study team is in a position to propose optimal solutions in its capacity based on Japanese experience confirming applicability to local conditions which may not necessarily coincide with MOT's strategy.
VNR gives priority to 56 (=41+15) bridges for rehabilitation.	The study team will consult with the VNR counterpart responsible for bridge maintenance to confirm the locations and condition of these bridges.
VNR requests BinhLoi bridge which is presently included in the HoaHung - TrangBom elevated railway project to be included in the N-S Railway project because the progress is too slow despite the urgency of the bridge replacement.	The study team understands the urgency and it shall be referred to in the Final Report, but the bridge replacement project is already in the process of local F/S in which the line is planned to be used for a double tracked urban railway.
VNR requests the NhaTrang loop line section to be included in the N-S Railway project, because the dialogue between VNR and the city authorities has just started.	The study team understands the substantial qualitative benefits once the short cut line is constructed and it shall be referred to in the Final Report, but more detailed studies based on the master plan of NhaTrang city will be necessary before the component can be included in this study.
VNR requests to include a slope protection component in the N-S Railway project, because the loss of human life due to landslides along the railway line is attracting public attention.	The study team understands the situation and is in a position to include it if the specific locations and scale of the component is available, but it shall be implemented as part of the disaster prevention technology development program which is under way using JICA technical assistance.
VNR requests KheNet tunnel which is under process of receiving China EXIM bank assistance to be included in the N-S Railway	The study team is in a position where it is too early to decide to take this component to include into prioritization process by cost and

project considering the diplomatic tension between VietNam and China.	benefit verification at this moment when Chinese assistance is not officially suspended.
VNR requests 23 small scale tunnels in the N-S Railway project, because using own budget funding for the tunnel rehabilitation projects for these tunnels means early implementation is not expected.	The study team has already investigated the tunnel rehabilitation study undertaken by TRICC and is in a position to include all of them in the study for prioritization.
VNR prefers the HSR-F/S based alignment with regard to the HaiVan tunnel route selection (it was officially confirmed during the interview with the VNR counterpart in charge although the above was a personal statement at the meeting).	The study team will make a fair comparison incorporating local conditions including geography, topography, station locations, and regional development plans.
VNRA prefers only two (2) cases of Option A and D with regard to roadmap analysis of HaiVan tunnel planning, because Options B and C are not plausible (since the initial proposal at the meeting was not this, it was confirmed that the initial comment was a mistake to be replaced with this).	After consultation with JICA, the study team is in a position to include Options B and C for comparative study along with JICA's comments.
VNR requests to include a double tracking component between HCMC and NhaTrang, because the traffic demand will soon surpass track capacity which is well recognized by the Minister of MOT.	The capacity is expected to be insufficient sometime between 2030 and 2035, but more detailed studies such as land availability for double tracking in terms of topographic conditions and drastic alignment changes at several sections (near CaNa St. and SongPhan St.) will be necessary before the component can be included in this study.

Source: Study team

1.3.5 Findings in the 3rd Field Mission

The 3rd field mission was conducted to collect feedback on the Draft Final Report from counterpart agencies on the Vietnamese side before compiling the Final Report. The main discussions focused on the legitimacy of (1) prioritization of infrastructure rehabilitation and (2) selection of options for the HaiVan tunnel roadmap.

The study team made a presentation based on the Draft Final Report on August 5, 2014 to the representatives of MOT, VNRA and VNR. The first secretary to the Embassy of Japan and the JICA expert to VNRA also attended the presentation, which was followed by a Q&A session.

The presentation material is shown in [Attachment 1-3-5] and the points of discussion can be summarized as follows.

- The Vietnamese side agreed with the methodology as well as the results of prioritization of infrastructure rehabilitation.
- The Vietnamese side agreed to apply Option D for the HaiVan tunnel roadmap plan provided that (1) the HSR project will be implemented in the future and (2) safety measures for track sharing between HSR and the conventional railway are taken.
- The infrastructure components which are not identified as the prioritized ones in the short-term under the study shall be studied for inclusion in coming yen loan assistance packages as soon as the conditions are met.
- The double tracking infrastructure component between NhaTrang and HCMC shall be excluded from the candidate infrastructure components for the time being according to

VNR's opinion.

1.3.6 Prioritization Method Change Based on Findings

Although this study was to be carried out based on existing information and data supplied by both VietNam and Japan and supplemented by sample site surveys to get a general view of the condition of candidate infrastructure components, it was found that some components still need further study for proceeding the prioritization exercise. Therefore, while the alternative idea to prioritize the infrastructure components practically based on the priority criteria may not be an ideal solution, it is necessary to uphold the primary objective of increasing the transportation capacity of the N-S Railway.

For the purpose of bringing the idea of prioritization criteria change into focus, the initial idea in the Inception Report can be summarized as follows.

- Transportation capacity increase is necessary to cope with growing demand.
- The following measures are needed to achieve this.
 - (1) Traveling time reduction
 - (2) Hauling capacity increase
 - (3) Dense train operation
- Causes of long traveling time
 - (1)-1 Speed restrictions at bridges, tunnels, crossings, curves, etc.
 - (1)-2 Low running speed or time loss due to addition of locomotives required because of hauling power shortage of locomotives
 - (1)-3 Waiting time loss due to trains traveling in opposite directions on single track sections or long signaling interlocking sections
- Cause of hauling capacity limit
 - (2)-1 Low design load of bridges
 - (2)-2 Short effective length of station yards
 - (2)-3 Shortage of locomotive hauling power
- Cause of unavailability of dense train operation
 - (3)-1 Unavailability of accurate freight train transportation planning due to incomplete signaling & telecommunication system
 - (3)-2 Unavailability of effective train operation planning skills or facilities
 - (3)-3 Unavailability of effective freight transportation planning incentives
- Expected remedial measures are as follows:
 - (a) Lift train speed restrictions on bridges through repairs
 - (b) Increase number of freight cars on trains by increasing bridge design loads
 - (c) Raise train speed at curved sections by increasing curve radii
 - (d) Raise train speed at slope sections by alleviating gradients
 - (e) Lift train speed restrictions in tunnels through repairs
 - (f) Raise train speed on improved alignment by building new tunnels
 - (g) Lift train speed restrictions at crossings through grade separation
 - (h) Curtail train waiting time at sections with two-way operation by shortening signaling interlocking sections
 - (i) Curtail train waiting time at sections with two-way operation by partial double tracking
 - (j) Enable dense train operation by upgrading signaling & telecommunication system
 - (k) Improve running performance of rolling-stock through upgrading
- In addition to the physical performance improvements listed above, managerial performance improvement via technical assistance is also necessary.

- The measures listed above will be allocated to the target years 2020, 2025, and 2030 to meet the transportation service quality required for each target year.

Contrary to initial expectations, it was found that there was a lack of availability of information and data, field conditions were different, and requests from the study counterparts were made which are summarized as follows:

- Although this study was to be carried out based on existing data, data is definitely in short supply in terms of VNR operational records and studies made by various entities such as bridge damage assessment records, progress of on-going projects, location of speed restrictions, scope of demand forecasts, and transportation data broken down by commodity and section. Specifically, the number of bridges with their condition and location was still under revision when the 2nd field mission ended.
- Extension of curve radii at curved sections is less effective for increasing train speed due to the lack of transition curves in front and behind almost all curved sections.
- Signaling & telecommunication modernization projects are ongoing with foreign aid and additional modernization plans must therefore wait for the progress of these projects.
- Accident cause analysis is not available so it is not possible to assess the effectiveness of ATS.
- Crossings in need of grade separation are located in urban areas where urban rail projects are being implemented and other crossings where train speed needs to be reduced have been built illegally and are therefore not listed in VNR's ledgers. The major concern for small scale crossings is for safety and manpower reduction at crossings rather than increases.
- VNR strongly requested to include components for disaster prevention, but detailed information and data for the study in order to make priority assessments had not been presented by the end of this study.
- MOT denied the inclusion of a rolling-stock component for public sector investment due to planned railway sector reform in which rolling-stock is to be purchased through private sector investment.
- Double tracking between NhaTrang and HCMC was requested to be included in the study and it will be necessary by the year 2030, but detailed site recognition is necessary before making any plans due to expected local conditions such as alignment modification and track shifting which need to be incorporated. On the other hand, when it comes to planning of the HaiVan tunnel, the study team was told that the entire stretch of the N-S Railway will remain single tracked by the year 2050 which is contradictory.
- It was informed that running speed restrictions in tunnels will not be lifted even after rehabilitation of most of the tunnels, but this is technically incorrect as appropriate speeds can be calculated.
- The speed restriction tables kept at VNR were found not to match actual site conditions on a number of locations when they were compared with GPS measurement records.
- Since the average passenger train speed already reaches 60km/h, there is not much room for further speed increases except for in the HaiVan and KheNet tunnels and on the HoaDuyet - ThanhLuyen section. However, freight trains still have great potential for speed increases.
- While the travel time of freight trains is far longer than that of passenger trains, VNR's major concern is rather on increasing freight train transportation capacity which is expected to be achieved by other measures than speed increases as elaborated in Chapter 8.

- While it is universal practice to give priority to passenger trains, virtually no freight train schedules are made and demand oriented train schedules are used as is the case in other developing countries.
- The effectiveness of travel time cuts through partial double tracking and shortening of signal interlocking sections is uncertain as long as freight train schedule planning is not achieved due to lacking signaling & telecommunication system performance.
- Room for freight transportation quality improvement is large since current freight transportation service does not meet client requirements.
- Sufficient information and data for the study to designate transportation service levels for the target years 2020, 2025, and 2030 is unavailable and other criteria to define target years are therefore needed.

In response to feedback from the 1st and 2nd field missions, it became clear that some modifications are necessary to implement the study toward the prime objective of increasing transportation capacity of the N-S Railway by way of motivating passenger and freight users to prefer railway transportation over other modes of transportation. Below is a summary of the policy applied in this report although a detailed discussion will be made in the corresponding section of this report.

- Since it was found that it is more effective to enhance transportation capacity by curtailing the travel time of freight trains to the level of passenger trains instead of cutting passenger train travel time, this study will place emphasis on such measures.
- This study emphasizes curtailing travel time by both improving groups of infrastructures in areas with high traffic demand and improving non-infrastructure aspects such as transportation planning, operation planning, and freight handling rather than sporadic speed increases of individual infrastructure components.
- The prioritization of infrastructure components will be carried out based on a cost and benefit analysis in which components need further consideration and the detailed study to estimate the costs or benefits will be considered as the long-term priority projects. In this context, some of the infrastructure components will be the long-term priority projects due to reasons as shown below.
 - As for the infrastructure component which will contribute to disaster prevention such as landslides, it will be classified as the long-term priority projects because the land slide prevention is primarily covered by maintenance works and the special field needed high technical verification and developed .
 - As for the alignment improvement component, since drastic improvement of train speed is not expected unless transition curves are inserted between straight and curved sections. Therefore, except for a 1km stretch in front of and behind bridge sections to be rehabilitated, it is recommended to be implemented as part of VNR's routine track improvement efforts in the long term since it requires large scale of land acquisition..
 - As for grade separation of railway crossings, most of the crossings where train speed restrictions are imposed have been built illegally by local people or communities. VNR has been trying to remove them but they have always been rebuilt immediately. Therefore, VNR is currently implementing a project to build a fence along the railway line. Considering the fact that grade separation is very expensive, the effect of the fence building operation deserves watching for the time being.
 - As for the signaling and telecommunication component, automatic obstacle detectors at level crossings and ATP were proposed in order to improve the train operation safety. But it is recommended to be implemented at a later stage depending on the progress of on-going projects using foreign assistance. Besides VNR judged not include

this project in the priority component since installation cost is large and they do not directly assist in increasing the train operation speed.

- As for the rolling-stock component, it will be excluded from the prioritization exercise upon MOT's request because this component is set to become the responsibility of private investors once the planned railway sector reform has been completed.
- As for the HaiVan tunnel construction component, it will be included because the time saving effect is indisputably large according to an F/S study carried out by VNR. Although the study does not consider the HSR plan from a long-term perspective, while this scoping study is required to do so.
- As for the target speed for trains running in the HaiVan tunnel, in case mixed operation of conventional trains and HSR trains will be employed on the tunnel section, it is set at 120km/h for passenger trains and 80km/h for freight trains as opposed to the initial proposal of 110km/h for both train types, because this is in line with MOT's strategy and the combined speed of 200km/h (=80+120) is within the proven maximum limit for combined speed of mixed operation in Japan.

Chapter 2 Review of Current Situation and Development Plan

2.1 Country Review

2.1.1. Natural and Physical Conditions

(1) Geography and Geology

The total land area of Vietnam's territory which occupies the east coast of the Indochina Peninsula is approximately 330,000km², which is approximately 0.87 times larger than Japan. The north-south length is approximately 1,650km, the east-west length is approximately 600km, and the narrowest width is only about 50km. Vietnam is geographically divided into 8 zones: Northwest, Northeast, Red River Delta, North Central Coast, South Central Coast, Central Highlands, Southeast and Mekong River Delta. The two largest regions in the north and south, the Red River Delta and Mekong River Delta, have approximately 70% of the total national population.

Major rivers are Hong River in the northern region, Ba River in the central region, and DongNai River in the southern region. In the Northwest of Vietnam, Mt. PhangXiPang (3,144 meter high) is located, which is the highest mountain in Vietnam and the Indochina peninsula. Mountains and hilly regions spread from the Northwest to the Central Highlands along a circular path.

The S-shaped country has a north-to-south distance of 1,650km and is about 50km wide at the narrowest point. The length of the coastline excluding dependent islands is 3,444km. Vietnam has territorial sea rights of 12 nautical miles, a contiguous zone of 24 nautical miles and an exclusive economic zone of 200 nautical miles.

The geology of Vietnam is divided into five (5) structural blocks: Northeast, Northwest, Truongson, KonTum and Nambo. The Northeast block is a part of the South China plate, in which strata and igneous rocks have been found dating from the Early Paleozoic period to the Quaternary period. The Northwest and Truongson blocks are regarded as Northwest-Southeast trending Paleozoic folded systems filled with thick (>12,000m) Paleozoic formations. Precambrian strata are widespread in the Red River Fault zone and Fansipan range in the Northwest block, and in the KonTum block. Archean rocks are found only in the KonTum block, which is regarded as a stable massif without Paleozoic sedimentary rocks. The Nambo block is covered with a very thick (>6,000m) sequence of Cenozoic formations deposited in a continental drift. During the Mesozoic period many such graven structures were formed and became basins for sedimentation. Igneous activity in Vietnam is divided into five (5) episodes from the Archean to Quaternary. The most important impediments to the description and interpretation of geology in Vietnam are lack of reliable radiometric and structural data, and scarcity of good outcrops.

(2) Land Uses

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

(3) Climate

The climate of Vietnam belongs to two (2) major climatic zones. The northern region from the HaiVan Pass located between Hue City and DaNang City has a highly humid tropical monsoon climate (warm and little rain in winter) and the southern region from the HaiVan Pass has a moderate tropical climate given the weak influence of monsoons (savanna climate). The northern region has four (4) seasons and is influenced by the Northeast and Southeast monsoons. The southern region is characterized by warm weather all year round with a rainy season (May to September) and a dry season (October to March). The average annual rainfall (1,000mm) of the southern region tends to be smaller than that of the northern region (1,700mm), and in the mountainous regions, where the rainfall often exceeds 4,000mm. In the typhoon season from July to November, serious weather disasters occur in the central part of the country. The average annual temperature is 24.0°C in HaNoi and 28.0°C in HCMC.

2.1.2. Social and Economic Review

(1) Population

The population status of Vietnam is shown in [Tab. 2-1-1]. The total population of Vietnam as of 2012 is 88,773 thousand, which is the 13th largest population in the world. Concerning the composition of the population, the ages of 0 to 14 make up 22.7% of the entire population, the ages of 15 to 59 make up 67.7% and the ages over 60 make up 11.6%. The average age is 27.4. The annual population growth rate for 2012 was approximately 1.1%. According to the rate of population by region to the total population in 2012 as shown by the fields filled with blue in the table below, the population is distributed among 6 regions in the country by a rate of about 10% to 20%. Among them, the two large cities in Vietnam, HaNoi City and HCMC, have 7.7% and 8.7% of the total population respectively. The area ratio of HaNoi City to the total area is 1.0% and that of HCMC is 0.6%. The population density of HaNoi City is 2,059 people/km² and that of HCMC is 3,666 people/km². It shows that there is a noticeable tendency in Vietnam for the population to concentrate in HaNoi and HCMC.

[Tab. 2-1-1] Population Distribution in Vietnam

Region	Population [thousand people]			Population rate	Population growth rate compared to 2011	Area	Area rate	Population density
	2010	2011	2012	[%]	[%]	[km ²]	[%]	[People/km ²]
Whole country	86,933	87,840	88,773	100	1.1	330,951	100	268
1) Red River Delta	19,803	20,022	20,237	22.8	1.1	21,051	6.4	961
HaNoi	6,589	6,726	6,844	7.7	1.8	3,324	1.0	2059
HaiPhong	1,858	1,880	1,904	2.1	1.3	1,524	0.5	1249
2) Northern inland & mountains	11,177	11,289	11,400	12.8	1.0	95,272	28.8	120
3) Northern central & coast	18,944	19,050	19,174	21.6	0.6	95,836	29.0	200
Hue	1090.9	1103.1	1,115	1.3	1.0	5,033	1.5	221
DaNang	926.8	951.1	973.8	1.1	2.4	1,285	0.4	758
4) Central Highlands	5,207	5,280	5,380	6.1	1.9	54,641	16.5	98
5) Southeast	14,546	14,876	15,192	17.1	2.1	23,598	7.1	644
HCMC	7,378	7,518	7,682	8.7	2.2	2,096	0.6	3666
DongNai	2,575	2,658	2,721	3.1	2.4	5,907	1.8	461
6) Mekong River Delta	17,255	17,322	17,391	19.6	0.4	40,553	12.3	429
CanTho	1,195	1,203	1,214	1.4	0.9	1,409	0.4	862

Note) The highlighted parts show figures as of 2012.

Source: General Statistic Office of Vietnam

(2) Economic, Industrial and Fiscal Conditions

The economic indicators of Vietnam are shown in [Tab. 2-1-2]. According to the GDP growth rate by industry, there has been a tendency toward declining growth rates in the

agriculture, forestry and fisheries industries. Vietnam's major agricultural products are pepper and cashew nuts, for which Vietnam boasts the largest volume of exports in the world, as well as rice and coffee in decreasing order of volume. As for industrial products in 2012, the number of two-wheeled vehicles produced was 4.2 million and that of automobiles produced 99 thousand. Recently, the number of cellphones produced has increased drastically and reached about 118 million in 2012. In addition, oil became one of the major export products which is comparable to conventional apparel products.

One problem for Vietnam's economy is that the economic growth is vulnerable to price fluctuations because personal consumption occupies about 70% of the GDP. The unemployment rate in 2012 decreased by 0.3% from the previous year but there are growing concerns that a future rise in the unemployment rate may affect the economy. In order for VietNam to achieve sustainable economic growth in the future against a decline in private consumption, an increase in official development investment is required.

[Tab. 2-1-2] Economic Indicators of Vietnam

Item	Unit	2008	2009	2010	2011	2012
1. GDP (*1)	billion USD	90.3	93.2	103.6	121.6	138.1
2. GDP per capita (*1)	USD	1,047.9	1,068.3	1,173.6	1,361.6	1,527.5
3. GDP growth rate (*2)	%	6.2	5.3	6.8	5.9	5.0
4. GDP growth rate by industry (*1)						
(1) Agriculture, forestry and fisheries industries	%	3.8	1.8	2.8	4.0	2.7
(2) Mining and manufacturing/ construction industries	%	6.3	5.5	7.7	5.5	4.5
(3) Service industry	%	7.2	6.6	7.5	7.0	6.4
5. Ratio to GDP (*1)						
(1) Personal consumption	%	70.9	68.5	66.6	66.3	64.5
(2) Fixed assets formation	%	36.5	37.2	35.7	29.8	27.2
(3) Exports	%	71.5	63.0	72.0	79.4	80.0
(4) Imports	%	85.2	73.3	80.2	83.5	76.5
6. Price increase rate	%	19.9	6.5	11.8	18.5	6.8
7. Exchange rate (*3)	VND/USD	16,302	17,065	18,613	20,803	20,828
8. Unemployment rate (urban areas)	%	4.7	6.5	4.4	3.6	3.3

Note) *1: Current market price, *2: Year-to-year comparison, *3: Value as of the end of December

Source: General Statistic Office of Vietnam, Statistical Yearbook of Vietnam, IMF, ADB

The balance of trade in 2012 has shown a surplus since 1993 according to the trade trends of VietNam shown in [Tab. 2-1-3]. The reason is considered that exports of mobile phones, computer electronics products and parts have increased while, on the other hand, imports of machinery and equipment and parts, iron and steel growth have slowed or decreased by the economic slowdown. VietNam's major export countries in 2012 were the United States (19.6 billion USD), Japan (13.1 billion USD), China (12.4 billion USD), Korea (5.6 billion USD) and Malaysia (4.5 billion USD) in decreasing order of amount.

On the other hand, VietNam's major import countries in 2012 were China (28.8 billion USD), Korea (15.5 billion USD), Japan (11.6 billion USD), Taiwan (8.5 billion USD) and Singapore (6.7 billion USD) in decreasing order of amount. Various goods are imported from China, which is essential for VietNam.

Exports in 2012 showed a steady increase but it is supposed that the trade surplus is temporary. Improving a chronic trade deficit, the role of foreign companies and investors is still necessary since the ratio of the export amount shared by foreign companies is still high

(63.1%). Exports of cellphones, computers and electronic components contributed to the trade surpluses in 2012 but it is quite important that such value-added industrial products are continuously produced and exported in order to maintain a sustainable trade surplus in the future. GOV will be required to have a long-term perspective and to actively attract foreign companies and investors.

[Tab. 2-1-3] Trade Trends of Vietnam

(Unit: 100 million USD)

Item	2008	2009	2010	2011	2012
1. Imports	807.1	699.5	848.4	1,067.5	1,137.8
Year-on-year increase rate (%)	-	-13.3	21.3	25.8	6.6
2. Exports	626.9	571.0	722.4	969.1	1,145.3
Year-on-year increase rate (%)	-	-8.9	26.5	34.2	18.2
3. Trade balance	-180.3	-128.5	-126.0	-98.4	7.5
4. Total amount of trade	1,434.0	1,270.5	1,570.8	2,036.6	2,283.1

Source: General Statistic Office of Vietnam

The national fiscal conditions of VietNam are shown in [Tab. 2-1-4]. The fiscal balance in 2011 showed a 99,100 billion dong deficit. In recent years, the ratio of the fiscal balance to GDP has been increasing year by year. The increase rate of revenues in 2011 over the previous year was 19.7%, and the ratio to GDP increased by 27.8%. In VietNam, in recent years, the ratio of tax revenues in the annual government revenue has reached about 90% and securing stable tax revenues through the promotion of coordination and harmonization with the global economy has been a challenge for VietNam. Since the annual expenditure tends to increase, much stricter national budgetary control is required to secure funds for development investment necessary for economic growth.

[Tab. 2-1-4] National Finances of VietNam

(Unit: 1 billion VND)

Item	2008	2009	2010	2011	2012
1. Fiscal balance	-22,217	-106,487	-60,405	-99,100	N/A
(Ratio to GDP)[%]	1.5	6.7	3.1	3.9	-
2. Annual revenue	430,549	454,786	588,428	704,267	N/A
(Growth rate)[%]	36.3	5.6	29.4	19.7	-
(Ratio to GDP)[%]	29.2	28.6	30.5	27.8	-
3. Annual expenditure	452,766	561,273	648,833	803,367	N/A
(Growth rate)[%]	13.4	24.0	15.6	23.8	-
(Ratio to GDP)[%]	30.8	35.3	33.6	31.8	-

Source: General Statistic Office of Vietnam

The status of the external debt of VietNam is shown in [Tab. 2-1-5]. The balance of the external debt of VietNam has been increasing and, the ratio of the external debt to GDP has also been increasing since 2008. But it is still considered that there is no big problem in the debt-paying ability due to continued infusion of funds from international organizations and bilateral ODA and private sector money. Generally, if the DSR (Debt Service Ratio) exceeds 20%, the foreign currency conditions are judged extremely bad. The DSR of Vietnam has been decreasing for the last 5 years, and was 1.7% in 2010, which is still a sound level. Accordingly, it is judged that there is no problem in its debt absorption capacity.

[Tab. 2-1-5] External Debt of VietNam

Item	2008	2009	2010	2011	2012
Total amount (billion USD)	25.0	28.7	35.1	N/A	N/A
Ratio to GDP [%]	27.6	30.8	33.9	-	-
DSR [%]	1.9	1.9	1.7	N/A	N/A

Source: IMF World Economic Outlook

2.1.3 Development Agenda and National Development Plan

The economic development of VietNam is specified in the “Strategy for Socio-economic Development 2010-2020” formulated by the 11th Party Congress of the Vietnam Communist Party, with the following general objectives.

- To strive to make VietNam a modern industrial country by 2020 with socio-political stability, agreement, democracy and discipline;
- To clearly improve the people’s physical and spiritual life;
- To firmly maintain independence and territorial unification;
- To continuously improve VietNam’s position in the international arena;
- To create firm premises for higher development in the next period.

Besides, based on the “Strategy for Socio-economic Development 2010-2020” and the “Five-year Socio-economic Development Plan for 2006-2010”, the “Five-year Socio-economic Development Plan for 2011-2015” formulated in the 13th National Assembly in the Resolution 10/2011/QH13 dated November 8, 2011, has the following objectives.

- To promote rapid economic development and sustainable innovation associated with the improvement of the growth model and economic restructuring towards higher quality, efficiency and competitiveness.
- To ensure social welfare and social security.
- To improve the material and spiritual life of the people.
- To enhance diplomatic activities to promote efficiency of international integration.
- To protect independence, sovereignty, unification and territorial integrity.
- To maintain political security and social order and safety.
- To create a foundation for the country to become a modernized and industrial nation by 2020.

2.2 Transportation Sector Review

The transportation volume by means of transport in Vietnam is shown in [Tab. 2-2-1]. As for the distribution of the total volume of passenger and freight transportation by means of transport in 2008, marine transport accounted for 58.75%, road 31.56%, airway 6.36% and railway 3.33%. As one characteristic of the transportation volume by means of transport since 2006, the inland waterway freight transportation volume has been exhibiting a high growth along with the development of container ports facing rivers and no significant change has been seen in the shares of other means of transport. In the railway sector, while freight transportation has grown as before, passenger transportation has declined drastically in recent years.

[Tab. 2-2-1] Nationwide Traffic Volume Transition by Mode

(Unit: Passenger= million person-km, Freight= million ton-km)

Mode	2006	2007	2008	2009	2010	2011
Total of passenger	63,909 (11)	71,865 (12)	78,180 (9)	85,203 (9)	97,932 (15)	110,392 (13)
Total of freight	113,550 (13)	134,883 (19)	172,859 (28)	199,070 (15)	217,767 (9)	224,011 (3)
1. Rail [share]	[4.91]	[4.68]	[4.12]	[3.40]	[3.14]	[2.98]
Passenger	4,334 (-5)	4,660 (8)	4,560 (-2)	4,138 (-9)	4,378 (6)	4,569 (4)
Freight	3,447 (17)	3,883 (13)	4,171 (7)	3,865 (-7)	3,961 (3)	4,099 (4)
2. Road [share]	[43.13]	[43.49]	[42.77]	[44.03]	[53.64]	[44.65]
Passenger	43,569 (13)	49,372 (13)	54,221 (10)	61,509 (13)	69,197 (13)	78,747 (14)
Freight	20,537 (16)	24,647 (20)	27,968 (14)	31,587 (13)	36,179 (15)	40,231 (11)
3. Water [share]	[41.82]	[41.45]	[42.69]	[42.80]	[42.32]	[41.64]
Passenger	3,189 (-6)	3,151 (-1)	3,246 (3)	3,048 (-6)	3,195 (5)	3,600 (13)
Freight (inland)	18,844 (5)	22,236 (18)	24,868 (12)	31,250 (26)	31,679 (1)	36,621 (16)
Freight (marine)	70,453 (14)	83,838 (19)	115,557 (38)	132,052 (14)	145,521 (10)	142,611 (-2)
4. Air [share]	[10.15]	[10.32]	[10.42]	[9.77]	[10.90]	[10.73]
Passenger	12,817 (15)	14,682 (15)	16,152 (10)	16,508 (2)	21,162 (28)	23,476 (11)
Freight	269 (13)	280 (4)	296 (6)	317 (7)	427 (35)	449 (5)

Note: The figures in parentheses () show the growth rate against the previous year in % and those in brackets [] show the average of passenger and freight in %.

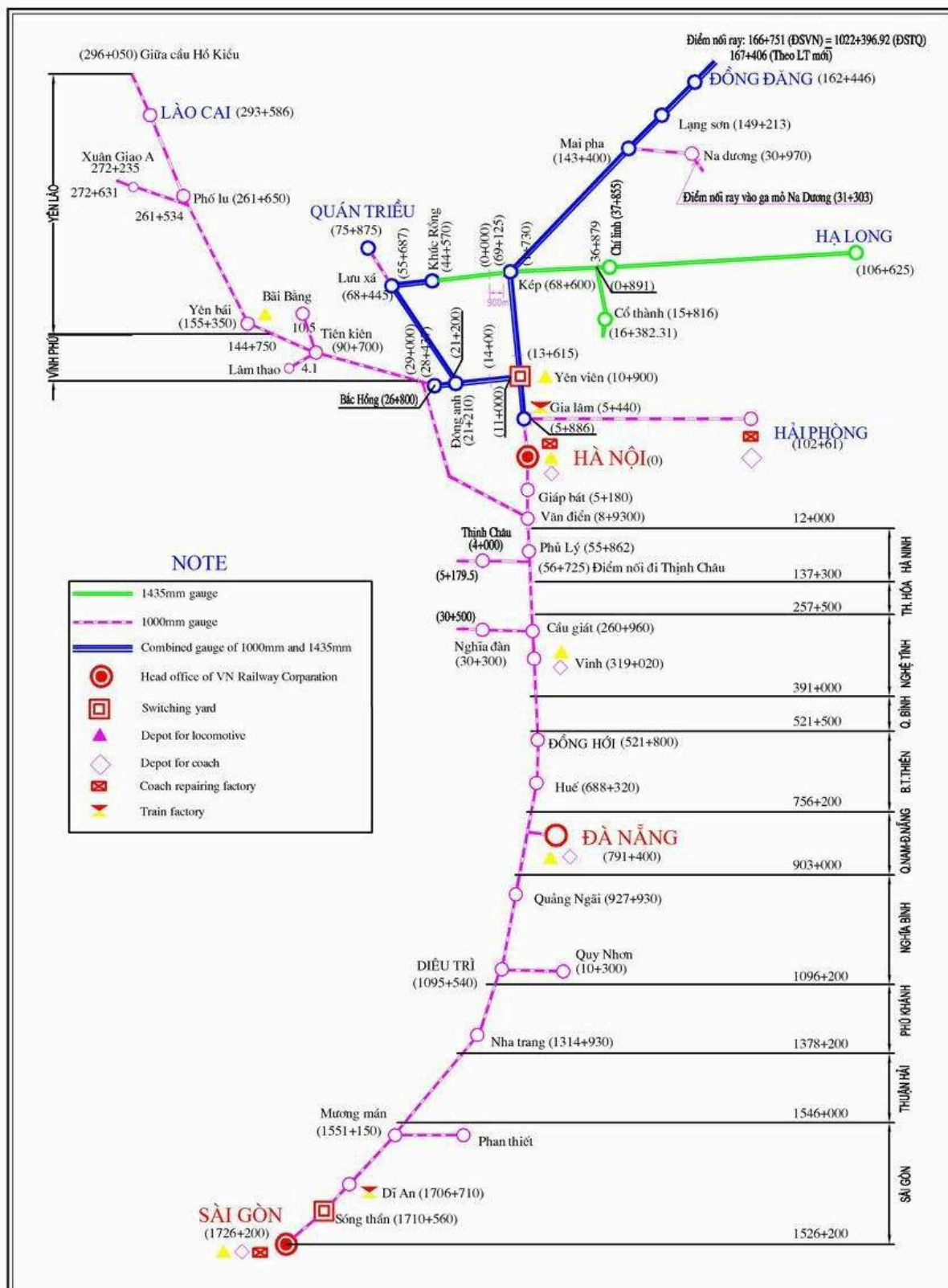
Source: General Statistics Office of Vietnam web site

2.2.1. Railway Sector

(1) Railway Management

In 2003, GOV decided to introduce a separated structure for the Vietnam Railway Federation to VNRA, which is an Government organization under MOT responsible for the whole national railway administration and VNR, which is a State Owned Enterprise directly controlled by the Prime Minister with responsibility to operate and do business on the national railway network. The progress at this stage includes ongoing renovation of railway structures under a new enterprise law and a new railway law (Railway Law, No. 35/2005/QH 11 enacted and promulgated in June 2005).

The railway network in Vietnam is shown in [Fig. 2-2-1]. The total route length is 3,143km, of which the total route length of trunk lines is 2,632km and that of feeder lines is 511km. There are three (3) types of rail gauges: meter gauge (1,000mm), standard gauge (1,435mm) and mixed gauge (combination of 1,000mm and 1,435mm). The ratio of the respective route length to the total route length is 85%, 6% and 9%, respectively. The railway density which indicates convenience of railway transportation is about 9km/1000km², which is higher than that of ASEAN countries but lower than that of other developing countries as well as advanced countries.



Source: VNR

[Fig. 2-2-1] Railway Network in VietNam

The technical specifications of seven (7) routes between major cities are shown in [Tab. 2-2-2]. The technical level and infrastructure building level of VietNam's railways are still low. As for the rail alignment of existing lines, there are many sharp curves with a radius of curve

of 150m to 300m. As for longitudinal slopes, there are sections with a maximum grade of 17%. As for railway structures such as bridges and box culverts, many of them were constructed over 60 years ago and are aging. Tunnels are also aging and water leaks often occur due to cracks caused by poor maintenance. Old-fashioned systems are used for the signal and telecommunications facilities. Many routes use a 14t axle load for structure design, which cannot cope with the load of heavy freight trains. As for the safety of railway operation, there are too many technical and institutional problems to bring out the characteristics of railway transport such as safe operation, larger transportation volume and speedy transportation, such as the existence of buildings such as residences on the railway premises, narrow spacing between crossings (number of sections with regular spacing: 1,446, with irregular spacing: 4,233). In recent years, the amount of investment in railway infrastructure has been increasing, but the effect has not yet become visible and labor productivity in the railway field is still low. As matters stand now, a significant growth in railway transportation volume cannot be expected unless modernization of railway infrastructure and improvement of services are continuously implemented in the future.

[Tab. 2-2-2] Technical Specifications of 7 Major Routes of VietNam Railway

No	Route	HaNoi - HCMC	GiaLam - HaiPhong	HaNoi - DongDang	HaNoi - LaoCai	DongAnh - QuanTrieu	Kep - HaLong	Kep - LuuXa
1	Total length [km]	1,726	96	167	285	55	106	56
2	Gauge [mm]	1,000	1,000	1,000 + 1,435	1,000	1,000 + 1,435	1,435	1,435
3	Gradient [%]	9-17	6	6-17	9-12	6	6	6
4	Min curve radius [m]	300	400	300	150	300	300	300
5	Train services [round trips/day]	18	14	16	19	17	14	-
6	Max train speed [km/h]	Passenger: 90, Freight: 50	Passenger: 70, Freight: 40	60	70	50	50	50
7	Track bed width [m]	4.4	4.4	5.0	4.4	5.0	6.4	5.0
8	Axle load [ton]	14	14	14	14	14	22	14
9	Rail type	P43	P43	P43	P43	P43	P43	P43
10	Turnouts	Tg1/10	Tg1/10	Tg1/10	Tg1/10	Tg1/10	Tg1/10	Tg1/10
11	Sleepers	2 block Concrete	2 block Concrete	2 block Concrete	K1, K2, iron	Standard Concrete	Standard Concrete	Standard Concrete
12	Fastening type	Hard spring	Hard spring	Elastic	Hard spring	Hard spring	Hard spring	Hard spring
13	Telecommunication	Low capacity line	Low capacity line	Low capacity line	Low capacity line	Low capacity line	Low capacity line	Low capacity line
14	Signaling	Semi-automatic system	Semi-automatic system	Semi-automatic system	Semi-automatic system	Semi-automatic system	Token	-

Source: Study Team based on data provided by VNR

(2) Transportation Volume

The N-S railway which opened in 1935 is the most important and longest trunk line boasting a 1,729km length and connecting the two (2) largest national economic bases. The importance of the N-S railway among the national railway network lines is prominent with its transportation share of about 55% (passenger number base) or about 85% (passenger-km base) for passengers and about 30% (tonnage base) or about 70% (ton-km base) for freight as shown in [Tab. 2-2-3] and [Tab. 2-2-4].

[Tab. 2-2-3] Railway Passenger Traffic Volume by Railway Line

(1,000 persons)

	2006	2007	2008	2009	2010	2011
Domestic	11,573	11,571	11,334	11,072	11,523	11,982
1 HaNoi - HaiPhong	1,269	1,209	1,186	1,192	1,242	1,372
2 HaNoi - LaoCai	3,309	3,386	3,412	3,408	3,087	3,324
3 HaNoi - DongDang	499	399	333	279	251	254
4 HaNoi - HaLong	137	128	99	81	36	52
5 HaNoi - QuanTrieu	237	159	138	117	75	95
6 HaNoi - HCMC	6,083	6,289	6,167	5,996	6,832	6,884
7 HaNoi - BacHong	39	1	0	0	0	0
International	7	7	6	7	23	32
1 HaNoi - LaoCai	0	0	0	0	0	0
2 HaNoi - DongDang	7	7	6	7	23	32
Total	11,580	11,578	11,340	11,080	11,546	12,014

(million-km)

	2006	2007	2008	2009	2010	2011
Domestic	4,333	4,683	4,494	4,138	4,378	4,571
1 HaNoi - HaiPhong	92	90	90	91	99	114
2 HaNoi - LaoCai	529	606	624	631	575	613
3 HaNoi - DongDang	29	23	19	15	15	16
4 HaNoi - HaLong	7	7	5	3	2	3
5 HaNoi - QuanTrieu	12	8	7	6	4	5
6 HaNoi - HCMC	3,661	3,949	3,749	3,391	3,682	3,820
7 HaNoi - BacHong	4	0	0	0	0	0

Source: VNR Statistical Report

[Tab. 2-2-4] Railway Freight Traffic Volume by Railway Line

(1,000 ton)

	2006	2007	2008	2009	2010	2011
Domestic	9,153	9,019	8,387	8,159	7,775	7,198
1 Hanoi - Hai Phong	511	399	408	435	421	414
2 Hanoi - Lao Cai	2,911	2,779	2,774	2,398	2,588	2,401
3 Hanoi - Dong Dang	1,429	1,746	1,283	1,260	1,115	1,097
4 Hanoi - Ha Long	999	833	785	801	470	344
5 Hanoi - Quan Trieu	79	87	47	135	121	121
6 Hanoi - HCMC	3,222	3,171	3,087	3,128	3,056	2,819
7 Hanoi - Bac Hong	1	4	4	1	3	2
International	1,411	1,645	1,037	885	797	626
1 Hanoi - Lao Cai	725	567	390	201	115	38
2 Hanoi - Dong Dang	686	1,078	647	684	682	588
Total	10,564	10,665	9,424	9,044	8,571	7,824

(million ton-km)

	2006	2007	2008	2009	2010	2011
Domestic	3,449	3,370	3,992	3,762	3,683	4,101
1 Hanoi - Hai Phong	120	117	117	126	133	141
2 Hanoi - Lao Cai	794	726	814	754	789	773
3 Hanoi - Dong Dang	391	405	331	241	201	214
4 Hanoi - Ha Long	62	58	54	52	32	23
5 Hanoi - Quan Trieu	22	33	18	34	32	33
6 Hanoi - HCMC	2,059	2,027	2,655	2,554	2,496	2,915
7 Hanoi - Bac Hong	1	3	2	0	1	2

Source: VNR Statistical Report

2.2.2. Roadway Sector

The total length of roads in Vietnam is 210,000 km. The breakdown is as follows: National Highways 17,300km, province roads 17,450km, local roads 36,400km, city roads 7,350km and the remaining village roads 131,500km. The share of paved roads is only about 26%. The main arterial roads are National Highway No. 1 (1,800km) which connects HaNoi and HCMC, National Highway No. 5 (130km) between HaNoi and HaiPhong, and National Highway No.18 (160km) between HaNoi and CaiLan Port. As for new projects, the construction plans for the First East-West Corridor (the Indochina peninsula crossing road connecting DaNang Port in Central Vietnam and Mawlamyine Port in Myanmar with a length of 1,600km) and the Second East-West Corridor (HCMC-Bangkok) have been at the planning stage.

Roads are a major means of transport in Vietnam and the domestic passenger and freight transportation volume commands more than 40% of the total volume as shown in [Tab. 2-2-1]. However, many of the about 7,900 bridges (total length about 225km) on National Highways and province roads have considerably decreased in strength due to poor maintenance and have problems with safety and transportation efficiency. [Tab. 2-2-5] shows the ratio of construction costs and maintenance costs in the road budget of selected countries. It shows that the ratio of road maintenance costs in Vietnam is the lowest.

[Tab. 2-2-5] Comparison of New Investment to Road Maintenance

Item	Vietnam	Japan	Spain	UK	France	Australia
Construction expenditure share (%)	90	79	80	53	38	42
Maintenance expenditure share (%)	10	21	20	47	62	58

Source: VITRANSS 2

The GOV's development strategy and plan specify that it is important to increase the efficiency of physical distribution and to establish a national transportation network in order to construct a modern industrial state. Concerning road traffic, the GOV promotes coordination with other means of transport, and to this end, it aims to construct and improve roads. Especially for metropolitan areas, in order to increase the efficiency of economic activities and improve the living environment, the GOV has been implementing road development projects with an objective of transport sharing with other means of transport.

2.2.3. Airway Sector

At present, there are 21 airports in Vietnam. Among these, the international airports are NoiBai International Airport in HaNoi City, TanSonNhat International Airport in HCMC which was renewed with a new terminal building, and DaNang Airport in DaNang City. In addition to these airports, the CamRanh Airport in KhanhHoa Province is planned to be made into an international airport, ThangLong Airport is planned to be constructed in DongNai Province and TraNoc Airport in CanTho City is planned to be expanded and repaired.

As shown in [Tab. 2-2-1], the passenger and freight transportation volume by air in Vietnam in recent years makes up about 10% of domestic passenger and freight transportation. Since the passenger air transportation volume has increased, it is caused by the increase in air passenger demand for both international and domestic flights with the economic growth in recent years as a backdrop. The GOV plans to repair and relocate existing airports and construct new airports toward economic development and modernization of the State specified in the transport development strategy. In HCMC, there are plans for using TanSonNhat International Airport in the western part of the City as an airport only for domestic flights, constructing a new international airport, LongThanh Airport, located about 40km to the east of the city and connecting the two airports by a rapid-transit railway.

2.2.4. Waterway Sector

There are 78 seaports with a total berth length of about 22,000m. The major ports are SaiGon Port, which is now under the project of relocation into CaiMep/ThiVai International Port, HaiPhong Port which is the largest port in the North, DaNang Port which is located in the Central part and has the third largest amount of cargo handled in the country and CaiLan Port which is the first port having a berth water depth of 12m in the North. Currently, however, in Vietnam's domestic ports including the major ports, large ships cannot enter ports due to the low water line, and there is no loading equipment for a large amount of cargo handled. Under such circumstances, it was difficult for HaiPhong Port and CaiLan Port to handle a large amount of cargo as demanded despite their expansion and improvement. Therefore a new international deep-sea port in the LachHuyen area was planned and constructed to respond to the growth of demand in cargo volume as well as the increase of larger vessels in the maritime transportation market. The MOT VINAMARINES (Vietnam Maritime Bureau) manages large-scale ports and VINALINES (Vietnam National Shipping Lines) operates them. In addition, there are 20 ports operated by local state organs and other dedicated ports operated by state-controlled or public-operated companies.

As shown in [Tab. 2-2-1], the passenger and freight transportation volume by maritime and inland waterways in VietNam has made up a little over 50% of the domestic passenger and freight transportation volume in recent years. The freight transportation volume by inland waterways has been increasing steadily. At present, a group of ports adjacent to HaiPhong Port for handling only containers in the northern region and CaiMep/ThiVai Port in the southern region are under development. The environment around freight transportation especially by maritime and inland waterways has been changing rapidly, and in the future, development of a freight transportation system with enhanced coordination with other means of transport is expected.

2.3 Railway Sector Development Strategy

2.3.1 Government Policy and Transport Development Strategy

The Prime Minister approved the Transport Development Strategy with Decision No. 35/2009/QĐ-TTĐ, "Approving adjustment to the Transport Development Strategy up to 2020 with a Vision toward 2030", on March 3rd, 2009. In this strategy, the following development orientations up to 2020 are specified for the railway sector:

- To complete the renovation and upgrading of existing railways up to national- and regional-railway technical standards with a speed of 120km/h
- To build new express railways and HSR
- To prioritize the building of the North-South HSR with a speed of 350km/h
- To rapidly develop iron-wheel transport in urban centers and railways in cities and suburbs as core mass transit systems, first in HaNoi and HCMC

Meanwhile, JICA conducted "The Comprehensive Study on the Sustainable Development of Transport System in VietNam (VITRANSS2)" in May, 2010 and mapped out a ten (10) year (2010 - 2020) plan setting 1) competitiveness, 2) modal integrity, 3) sustainability and safety as a vision for the transportation system as a whole, in which the share of railway mode related investment is the second largest of 11.8% (excluding HSR) after roadway mode of 62.5%, highlighting north - south corridor capacity enhancement in particular.

Against this backdrop, GOV submitted to the National Assembly a proposal for the construction of HSR running along the existing N-S railway. The National Assembly, however, did not approve the proposal due to the large amount of investment required. Nevertheless, the necessity of HSR for VietNam is unchanged in the long term transportation strategic

perspective while many newly industrialized countries are struggling for HSR projects. In this regard, upon request from GOV, JICA conducted technical assistance of the “Study for the Formulation of High Speed Railway Projects on HaNoi - Vinh and HCMC - NhaTrang Section (HSR-F/S)” from 2011 to 2013.

GOV adjusted and updated the Transport Development Strategy with Prime Minister’s Decision No. 355/2013/QĐ-TTg, “Approving adjustment to the Strategy for Transport Development toward 2020 with the Orientation toward 2030” on February 25, 2013 which has the aim of going further with the modernization and improvement of existing railway lines. The adjusted development orientations up to 2020 for major five subsectors are shown in [Tab. 2-3-1].

[Tab. 2-3-1] Transport Development Orientation up to 2020

Sector	Development Orientation up to 2020
Roadway:	• The primary objectives of road transport are goods collection, short-distance or medium-distance freight transport, and passenger transport. • The total volume of passenger transport is estimated at 6,240 million passengers in 2020: The proportion of road passenger transport at 86% - 90%. • The total volume of freight transport is estimated at 2,090 million tons in 2020: The proportion of road freight transport at 65% - 70%. The North – South axis • Prioritize the investment in the completion, upgrading, and expansion of Highway 1 with 4 lanes. Concentrate on the investment in building some segments of freeways along the North – South route within an appropriate period of time, with due account taken of the general efficiency of the segments parallel to Highway 1. Invest in and clear the HCMC road, and upgrade the segment that crosses TayNguyen. Invest in the important segments along the coastal routes associated with sea dykes. In the North • Finish upgrading and expanding the local segments along Highway 1 with 4 lanes. Build new segments along the North – South freeway, and the freeway segments belonging to the two corridors and one economic belt VietNam – China, the convergent freeways and ring roads of HaNoi. Finish upgrading and classifying the remaining highways, clear and upgrade the highways belonging to the Northern ring road system, finish investing in the border patrol road system according to approved plans. In the Middle and TayNguyen • Finish upgrading and expanding the local segments along Highway 1 with 4 lanes. Build the segments belonging to the North – South freeway. Upgrade and build the roads belonging to the East – West economic corridor, and the horizontal roads that connect the coast to provinces in TayNguyen, connect VietNam’s harbors to neighboring countries such as Laos, Thailand, and Cambodia; classify the remaining highways. Build the bordering corridor and the border patrol system according to approved plans. In the South • Finish upgrading and expanding the Southern segments along Highway 1 with 4 lanes. Build the freeway segments belonging to the North – South freeway, and the freeways that connect HCMC with the gateways, important junctions, and ring roads of HCMC; clear the South West bordering road; finish upgrading and put into use the remaining highways in accordance with their classifications. Rural transport development • Maintain, strengthen, and upgrade the existing transport system in accordance with the technical standards of rural roads, satisfying the demands of industrialization and modernization of agriculture and rural areas. The proportion of hard roads, asphalted roads or concrete roads is 100% for district roads, 70% for commune roads, and 50% for village roads. • Finish building new roads to centers of communes without roads, to agricultural plantations, forestry plantations, and industrial points. Step by step build the system of tunnels and over-bridges at intersections along freeways, highways, and local roads, in order to ensure traffic safety. Emphasize the development of water transport in the Mekong Delta. • Consider using local materials, select road structures suitable for local conditions and climate, prioritize cement when building and upgrading rural roads. Transport industry development • Car and construction vehicle industry: focus on the assembly and manufacturing of buses, heavy trucks, agricultural trucks, and some types of construction vehicles to satisfy domestic demand and export.
Railway:	• The primary objectives of rail transport are long-distance or medium-distance freight transport; long-distance passenger transport in bulk, inter-provincial passenger transport, and public passenger transport in major cities. • The total volume of passenger transport is estimated at 6,240 million passengers in 2020: The proportion of rail passenger transport at 1% - 2%. • The total volume of freight transport is estimated at 2,090 million tons in 2020: The proportion of rail freight transport at 1% – 3%. The North – South axis

	- Focus on upgrading and modernizing the existing N-S railway. Keep considering potential solutions to make suitable plans for investment in North-South HSR. In the North - Finish upgrading and modernizing the local railroad segments belonging to the N-S railroad, and classify existing railroads. Consider building new high-speed railroads belonging to the two corridors and one economic belt VietNam – China, as well as routes to harbors and major economic zones. In the Middle and Tay Nguyen - Upgrade and modernize the existing railway segments belonging to the N-S railway in order to increase efficiency. Consider building some new railways: VungAng – ChaLo (MuGia), which connects the TayNguyen provinces, serve the extraction and production of aluminum in TayNguyen, and connects TayNguyen with harbors. In the South - Upgrade and modernize the existing railway segments belonging to the N-S railway in order to increase efficiency. Consider investing in the new railway using a gauge of 1.435 m that connects HCMC and VungTau, and HCMC with CanTho; consider building DiAn – LocNinh railroad to connect with the Trans-Asian Railway. Urban transport development - Reasonably develop urban transport and public transport infrastructure, allocate 16% - 26% of land for urban transport. Rapidly develop bus transport systems in major cities and quickly invest in mass public routes such as elevated railways and subways in order to undertake 25% - 30% of public passenger transport. Control the development of private motorcycles and cars, especially in HaNoi and HCMC. - Focus on investments in upgrading, expanding, and building new convergent routes, big intersections, bypasses, and ring roads. Boost the progress of some urban railway projects and suburban railways of HaNoi and HCMC. Transport industry development - Focus on building new passenger and freight cars that are modern, convenient, and diverse to serve domestic use and export. Manufacture some parts, components, and assemble modern locomotives.
Seaway:	- The primary objectives of sea transport include trans-oceanic freight transport, coastal routes, especially N-S transport, coal transport serving thermoelectric plants, and transport of crude oil serving oil refineries. Increase the market share of export and import transport to 25 – 30%. Develop coastal and island passenger transport routes. - The total volume of freight transport is estimated at 2,090 million tons in 2020: The proportion of sea freight transport at 9% - 14%. In the North - Prioritize the investment in building Lach Huyen International Harbor to receive ships up to 100,000 DWT (8,000 TEU); keep developing harbors, container terminals, and specialized ports to satisfy demand in each period; build passenger terminals in Ha Phong and QuangNinh. In the Middle and TayNguyen - Keep building, upgrading, and expanding NghiSon, CuaLo, VungAng, DaNang, DungQuat, and QuyNhon harbors in order to satisfy the demand in each period. Build specialized harbors serving thermoelectric plants and alumina export. Select and build international passenger terminals in Hue, Da Nang, and NhaTrang. Encourage foreign investors to invest in VanPhong International Transit port. In the South - Focus on the investments in building CaiMep – ThiVai International Harbor to receive ships up to 100,000 DWT (8,000 TEU). Keep investing in the efficient development of local harbors and terminals in accordance with approved plans. Build new ship channels into Hau River through QuanChanh Bo channel for ships up to 100,000 DWT, together with expanding and upgrading CanTho – CaiCui harbor to a major harbor in the South West. Transport industry development - Shipbuilding industry: focus on high-demand and competitive products to satisfy domestic demand and export. Build ships of 100,000 DWT or less; repair ships of 150,000 DWT or less.
Inland waterway:	- Primary objectives of inland water transport are domestic freight transport in bulk (coal, cement, fertilizers, building materials, etc.), and oversize and overweight cargo transport - The total volume of passenger transport is estimated at 6,240 million passengers in 2020: The proportion of passenger transport at 4.5% - 7.5% - The total volume of freight transport is estimated at 2,090 million tons in 2020: The proportion of inland water freight transport at 17% - 20% In the North - Complete the classification and ensure 24/24 operation of important inland water routes. Upgrade and build some new major harbors and freight terminals such as NinhPhuc, DaPhuc, VietTri, HoaBinh, and PhuDong Container Terminal. Upgrade and build some new ports and passenger terminals in HaNoi, HaiPhong, and QuangNinh. In the Middle and Tay Nguyen - Improve and upgrade some important river routes, focus on lengthening usable river segments. In the South - Finish classifying ships, and ensure 24/24 operation of primary water routes from HCMC to South West provinces, the routes along Tien river and Hau river. Build and upgrade inland freight and passenger terminals. Increase the capacity of water transport to 70% - 75% of transport proportion in the South West.
Airway:	Primary objectives of air transport are long-distance and international passenger and freight transport which have high economic value. Develop air transport into a safe and convenient means of transport towards the open market, which connects with regional and international air transport markets.

	• The total volume of passenger transport is estimated with 6,240 million passengers in 2020: The proportion of passenger transport at 1% - 1.7% • The total volume of freight transport is estimated with 2,090 million tons in 2020: The proportion of air freight transport at 0.1% - 0.2% The North – South axis • Develop the air network according to fan-shaped models with high frequency of use and good transit services in HaNoi and HCMC. In the North • Prioritize investments for upgrading and Cat Bi and NoiBai International Air Ports; NoiBai Airport is the gateway of the North. Safely and efficiently develop DienBien airport; restore GiaLam, Na San, and ThoXuan airports to satisfy the demands of socio-economic development. Consider building QuangNinh and LaoCai airports. In the Middle and Tay Nguyen • Focus on investments for upgrading, modernizing, and efficiently using Da Nang and CamRanh International Airports. Keep upgrading Chu Lai airport to an international freight transit airport in the region. Upgrade Vinh, PhuBai, TuyHoa, Pleiku, and BuonMaThuot airports to satisfy demand in each period. Consider developing LienKhuong Airport into an international airport. In the South • Focus on investments for upgrading and modernizing Tan Son Nhat International Airport. Keep upgrading Ca Mau, RachGia, and Con Dao airports to satisfy demand; ensure the efficient development of CanTho and PhuQuoc International Airports. Consider building VungTau airport. Encourage private – public cooperation to boost the investment in building LongThanh International Transit Airport. Transport industry development • Aviation industry: improve the capability of repairing and maintaining aircraft, aircraft engines, and specialized equipment; ensure autonomy when providing aircraft maintenance and repair services for domestic airlines, aiming at providing services for foreign airlines.
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Source: JICA Study Team based on Prime Minister's Decision No.355/2013/QĐ-TTĐ, "Approving adjustment to the Strategy for the Transport Development toward 2020 with the Orientation toward 2030", dated February 25th, 2013

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

- To start constructing some segments along the North-South HSR after basically completing the expressways.
- To make the technical standards of VietNam's road and railway system consistent and convenient for connecting with the road systems of ASEAN, the Greater Mekong Sub-region, and the Trans-Asian Railway.
- To develop a modern and civilized urban transport system and trunk passenger transport routes in big cities step by step.
- To keep developing the urban railway system in HaNoi and HCMC to reach 40% - 50% of public transport.

It is clearly mentioned that construction of the North-South HSR is planned to start from 2030 even though it was planned from 2020 in the previous strategy. The existing N-S railway shares the bulk of railway transport in VietNam but the line capacity will reach its limit under current conditions. To achieve the objectives specified in the strategy, the infrastructure and facilities of the existing N-S railway still need improvement and upgrading until and during the construction of the North-South HSR.

2.3.2 Passenger and Freight Traffic Volume by Transportation Mode

In the transport strategy, the passenger and freight traffic volume in 2020 are estimated at 6,240 million passengers and 2,090 million tons respectively. To roughly verify the estimated traffic volume, the volume by transportation mode from 2006 until 2012 published by the General Statistic Office in VietNam is summarized in [Tab. 2-3-2] and [Tab. 2-3-3] below.

[Tab. 2-3-2] Passenger Traffic Volume by Transportation Mode

(Unit: Million Passengers)

Mode	2006	2007	2008	2009	2010	2011	(2012)	2020
Railway	11.6 (0.8%)	11.6 (0.7%)	11.3 (0.6%)	11.1 (0.6%)	11.2 (0.5%)	11.9 (0.5%)	12.2 (0.4%)	62.4 (1.0%)
Roadway	1,331.6 (89.1%)	1,473.0 (89.9%)	1,629.0 (90.8%)	1,843.6 (91.4%)	2,132.3 (92.1%)	2,306.7 (93.2%)	2,606.9 (93.9%)	5,366.4 (86.0%)
Inland waterway	143.2 (9.6%)	144.5 (8.8%)	143.0 (8.0%)	151.3 (7.5%)	157.5 (6.8%)	142.4 (5.8%)	141.9 (5.1%)	280.8 (4.5%)
Airway	7.4 (0.5%)	8.9 (0.5%)	10.2 (0.6%)	10.9 (0.5%)	14.2 (0.6%)	15.1 (0.6%)	14.9 (0.5%)	62.4 (1.0%)
Total	1,493.8	1,638.0	1,793.5	2,016.9	2,315.2	2,476.1	2,775.9	6,240.0
Index (Previous year=100)	-	109.7	109.5	112.5	114.8	106.9	112.1	(100%)

Note: - The proportion of each transportation mode in 2020 is the minimum ratio as specified in the Strategy for Transport Development with Decision No. 355/QĐ-TTg.

- The statistics for the year 2012 are provisional.

Source: Study Team based on statistics published by the General Statistic Office in VietNam

[Tab. 2-3-3] Freight Traffic Volume by Transportation Mode

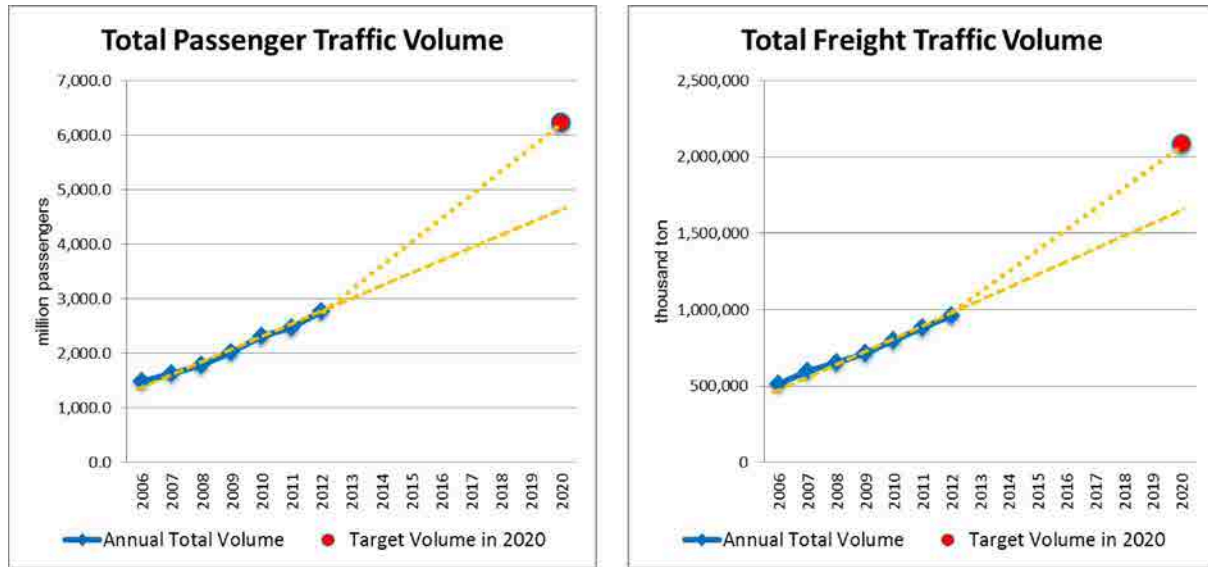
(Unit: Thousand Tons)

Mode	2006	2007	2008	2009	2010	2011	(2012)	2020
Railway	9,153 (1.8%)	9,050 (1.5%)	8,481 (1.3%)	8,248 (1.2%)	7,862 (1.0%)	7,285 (0.8%)	7,004 (0.7%)	20,900 (1.0%)
Roadway	338,623 (65.9%)	403,362 (67.6%)	455,898 (69.8%)	513,630 (71.8%)	587,014 (73.3%)	654,127 (73.9%)	722,156 (75.3%)	1,358,500 (65.0%)
Inland waterway	122,984 (23.9%)	135,283 (22.7%)	133,028 (20.4%)	137,715 (19.2%)	144,227 (18.0%)	160,165 (18.1%)	168,493 (17.6%)	355,300 (17.0%)
Seaway	42,693 (8.3%)	48,977 (8.2%)	55,697 (8.5%)	55,791 (7.8%)	61,593 (7.7%)	63,905 (7.2%)	61,476 (6.4%)	522,500 (25.0%)
Airway	121 (0.02%)	130 (0.02%)	131 (0.02%)	140 (0.02%)	190 (0.02%)	200 (0.02%)	179 (0.02%)	2,090 (0.10%)
Total	513,575	596,801	653,235	715,522	800,886	885,682	959,308	2,090,000
Index (Previous year=100)	-	116.2	109.5	109.5	111.9	110.6	108.3	(100%)

Note: - The proportion of each transportation mode in 2020 is the minimum ratio as specified in the Strategy for Transport Development with Decision No. 355/QĐ-TTg.

- The statistics for the year 2012 are provisional.

Source: Study Team based on statistics published by the General Statistic Office in VietNam



Source: Study Team based on statistics published by the General Statistic Office in VietNam
[Fig. 2-3-1] Passenger and Freight Traffic Volume

According to the statistics, the passenger and freight traffic volume increased approximately 10% year by year from 2006 to 2012. If the traffic volume increases annually by 10% from 2012 to 2020, the volume of passenger and freight in 2020 will be about 5,950 ($2,776 \times 1.1^8$) million passengers and 2,056 (959×1.1^8) million tons respectively, and these figures are not far from the estimated volume. On the other hand if the average rate of increase from 2006 to 2012 is applied, there is a gap between the target volume and estimated volume in 2020 for both passenger and freight as shown in [Fig. 2-3-1].

Since construction of the North-South HSR is planned to start from 2030, the proportion of railway transport in 2020 under the strategy seems to be lower than the one forecasted in VITRANSS2. According to the VITRANSS2 forecast, it is estimated that the growth rates of passenger and freight traffic volume from 2008 to 2030 are about four (4) or five (5) times and three (3) or four (4) times respectively.

If passenger traffic is estimated to grow as large as 62.4 million passengers by the year 2020 which is more than five (5) times the 2008 value assuming that target railway passenger transportation share grows at 1.0% up to the year 2020 from the current level of 0.4% while the share is set at 1.0 – 2.0% in the year 2020 by the strategy, existing railway transportation capacity needs to be expanded.

Unless the North-South HSR starts operation and shares the huge traffic demand on the N-S corridor as targeted in 2030, it is quite necessary to utilize the exiting N-S railway until then. It is therefore clear that the existing N-S railway must be improved and upgraded in order to satisfy transport demand to meet the economic development in VietNam.

2.3.3 Railway Transport Strategy and Master Plan

(1) Railway Transport Development Strategy

The Prime Minister approved the Strategy for Development of Vietnamese Railway Transport up to 2020 with the Vision toward 2050 with Decision No. 1686/QĐ-TTg on November 20, 2008. The strategy defined the specific key targets for the period to 2020 as follows:

- At least 13% and 14% share of passenger and freight traffic respectively
- To share 37% of passenger traffic on such main corridor as the North-South corridor
- To share 40% and over 45% of passenger and freight traffic respectively on the East-West

corridor

- To share 20% of urban passenger traffic.

However, the above key targets are not consistent with the development orientation to 2020 according to Decision No. 355/QĐ-TTg as shown in [Tab. 2-1-1]. GOV is going to revise and update the Railway Transport Development Strategy and the work is underway to be released anytime soon for the Prime Minister's approval.

According to MOT's Statement No. 13669/TTr-BGTVT dated December 16, 2013 regarding adjustment of strategy of Vietnam Railways till 2020 and vision till 2050, the following specific key targets for the period to 2020 are proposed to adjust the Strategy specified by Prime Minister's decision No. 1686/QĐ-TTg since the situation and economic conditions surrounding Vietnam have been changed after issuance of Decision No. 1686/QĐ-TTg in 2008:

- At least 1% - 2% of passenger demand and 1% - 3% of freight demand
- Giving priority to the upgrading and modernization of the N-S railway network with an average target speed of 80-90km/h for passenger trains and 50-60km/h for freight trains
- To study the development of a new double track gauge 1,435mm on the North - South axis with the operation of 160km/h below 200km/h train in the near future, and a combination of both passenger and freight train operation
- To share about 10% - 20% of urban passenger transport demand in HaNoi and HCMC and to speed up implementation of urban railway projects in HaNoi and HCMC

In compliance with the Government Office's Correspondence No.248/TB-VPCP on the announcement of conclusions of Prime Minister Nguyen Tan Dung for the government standing meeting on the North-South Express Railway Project and the amendment of Railway Strategy in Vietnam, as well as MOT's direction idea stated in Correspondence No.7607/MOT-DPI dated on 30th July 2013: Vietnam Railways (VNR) had arranged for the appraisal and evaluation of results of JICA's studies on the construction of a new railway on the North - South corridor, and held a Seminar titled "Direction for development of railway transportation on North - South corridor" with participation from ministries, sectors, unions, international donors, experts, universities, and relevant organizations and units.

After that, the Government Office issued Correspondence No.1057/VPCP-KTN on 18th February 2014 to request the study and consider comments from ministries, to cautiously review issues and contents in the Vietnam Railway Development Strategy till 2020 and vision to 2050 which need to be amended in compliance with the Prime Minister's direction stated in Correspondence No.248/TB-VPCP dated on 16th July 2013.

[Tab. 2-3-4] Transport Development Strategy, Railway Transport Strategy and Master Plan

GOV's Strategy and Plan	Previous decision	Latest decision	Related documents
Transport Development Strategy	Decision No. 35/2009/QĐ-TTg dated March 3, 2009	Decision No. 355/2013/QĐ-TTg dated February 25, 2013	Resolution No. 13- NQ/TW of the 4th Conference of the 11th Central Executive Committee of Communist Party dated January 16, 2012
Railway Transport Development Strategy	Decision No. 1686/QĐ-TTg dated November 20, 2008	To be revised in compliance with the Transport Development Strategy	- Government Office's letter No. 248/TB-VPCP dated July 16, 2013 regarding the Prime Minister's instruction on the adjustment of strategy of Vietnam Railways till 2020 and vision till 2050 - MOT's Statement No. 13669/TTTr-BGTVT dated December 16, 2013 regarding the adjustment of strategy of Vietnam Railways till 2020 and vision till 2050 - GOV's Statement No. 1057/VPCP- KTN dated February 18, 2014 regarding the adjustment of strategy of Vietnam Railways till 2020 and vision till 2050 - VNR's Official Letter No. 961/DS-KHTK regarding the explanatory report of the Prime Minister and Ministries on the amendment of Vietnam Railway Strategy dated April 24, 2014
Railway Transport Master Plan	Decision No. 1436/QĐ-TTg dated September 10, 2009	To be revised in compliance with the Railway Transport Development Strategy.	

Source: Study team

(2) Revised Railway Transport Master Plan

The Prime Minister issued Decision No. 1436/QĐ-TTg on September 10, 2009 and approved the comprehensive railway plan “The Revised Master Plan on Railway Transport Development of VietNam up to 2020 with a Vision to 2030” which was formulated in consistency with the aforementioned transport development strategy with Decision No. 35/QĐ-TTg and railway transport strategy with Decision No. 1686/QĐ-TTg.

The specific objectives and development plan are summarized in [Tab. 2-3-5].

[Tab. 2-3-5] 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 zones, ICDs, factories, etc. • Improvement of the competitiveness of transport service • Expansion of cross border traffic 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 North-South HSR sections •Conversion from single track to double track with electrification •Widespread use of urban railway networks	Up to 2020 • Improvement and upgrading of existing lines • Several North-South HSR sections (development) • YenVien - PhaLai - HaLong - CaiLan railway line (development) • LaoCai - HaNoi - HaiPhong line (development) • DongDang - HaNoi line (development) • DakNong - BinhThuan line (development) • Di An - LocNinh line (development) • VungAng - MuGai line (development) • ThapCham - DaLat Line (rehabilitation) • DongHa - LaoBao line (study) • Access lines to ports, industrial zones, economic zones and mining zones (development) • Railway hubs (HaNoi, HCMC, HaiPhong, DaNang, DieuTri (development) • Urban railway lines in HaNoi and HCMC (development)
	Up to 2030 •Urban railway networks in HaNoi, HCMC and other cities •Realization of North-South HSR •Construction of Highland central railway •Construction of railway in coastal provinces in the North Delta •Construction of railway in the Mekong River Delta	Up to 2030 • Highland central railway network (development) • Remaining sections of North-South HSR (development) • Urban railway network in HaNoi and HCMC (development) • Coastal railway corridor (development) • Other lines (development)
Railway Industry	Up to 2020 •Strive for self-manufacture of locomotives, materials, equipment, spare parts	Up to 2020 • Locomotives: manufacturing of diesel locomotives with 2,000 - 2,500 KW capacity for existing lines and new locomotives with 5,000 KW capacity for new electrified railway lines, developing EMU trains for commuter service, and striving for 1,100 - 1,200 locomotives • Cars: Development of a car-building industry for the domestic market and for export to regional countries, achieving 50,000 to 53,000 cars of all types • Railway spare parts and materials: satisfaction of local demand
	Up to 2030 •Fulfil demand for locomotives, materials, equipment, spare parts of new railway projects and urban railway projects	Up to 2030 • Development of manufacturing of railway spare parts and materials to meet domestic needs for new railway construction and demand for export
Traffic Safety	•Minimizing railway accidents based on three criteria (numbers of accidents, injuries, and casualties)	Up to 2020 • Infrastructure: Removal of all local crossings, construction of a crossing system with defences, collector roads, barriers and fencing along the line, flyovers at railroad crossings and establishing railway safety corridor in the overall network • Institutions and human resource development: comprehending legal documents and management apparatus for railway traffic safety, intensifying dissemination, education and popularization of law, etc. • Rescue: Accomplishment of an investment program in equipment for emergency rescue
		Up to 2030 • Completion of construction of separation works • Completion of construction of railroad crossings

Source: HSR-F/S

However, this plan needs to inherit the predecessor strategy and is slated to be revised in accordance with a new railway transport development strategy to be released in the near future.

2.3.4 Detailed Plan of Modernization for the N-S Railway

MOT has approved the Terms of Reference (TOR) of the Detailed Plan of Modernization of the N-S Railway by Decision No. 2564/QĐ-BGTVT on August 27, 2013 and designated VNRA to prepare the report as the executing agency. The purpose and requirements for preparation of the Detailed Plan is as follows:

- To prepare a comprehensive plan in full detail with regard to infrastructure, equipment, facilities and transport management and operation in order to improve and modernize the existing N-S Railway between HaNoi and HCMC in compliance with the orientation of the railway transport development as specified in Resolution No. 13- NQ/TW of the 4th Conference of the 11th Central Executive Committee of the Communist Party on January 16, 2012.
- To define basic criteria and propose advanced technical standards which can be applied properly to specific conditions when implementing improvement and modernization projects of the existing N-S Railway, so that the meter gauge national railway network will meet the standards as a whole.
- To identify essential railway projects which require investment and effective project implementation and which can be expected as planned so that the projects will be put into operation efficiently.
- To identify railway projects which will contribute to the socio-economic development of urban areas in the provinces and cities along the existing N-S Railway between HaNoi and HCMC.

The draft final report has been submitted to VNRA for evaluation and to consequently secure MOT's approval. According to the hearing from relevant agencies, it will be approved by MOT within a couple of months.

2.4 Railway Projects

2.4.1 Completed and Ongoing Railway Projects

The following railway projects are either under implementation or have been committed for implementation.

(1) N-S Railway Line:

- Bridges rehabilitation project (Phase I)
- Bridges rehabilitation project (Phase II and Amendment No. 1)
- Bridges safety improvement project (Phase (I), (II), and (III))
- Track structure replacement project on the Vinh - NhaTrang section
- Construction of safety corridor along the Right of Way (ROW), Phase 1 (According to Decision No. 1856/QĐ-TTg)
- 132 weak bridges improvement and upgrading project
- Water drainage system improvement project
- Telecommunication and signaling system modernization project on the HaNoi - Vinh section (Phase I)
- Telecommunication and signaling system modernization project on the HaNoi - Vinh section (Phase II)
- Telecommunication and signaling system modernization project on the Vinh - SaiGon section (Phase I)
- Crossing automatization with signal protection device project

- Level crossing improvement project
- Consulting engineering services for HaNoi urban railway construction project (Line 1, Phase I)

(2) Other Lines:

- Modernization of telecommunication and signaling system project on three (3) northern routes and HaNoi terminal (Phase I)
- YenVien - LaoCai railway upgrading project
- YenVien - PhaLai - HaLong - CaiLan railway line project

(3) Railway Industry:

- Modernization of operation control center project
- High performance locomotive and relevant facilities procurement project (Phase 1)
- Upgrading local assembly and manufacturing performance of rolling-stock

The name of the donors, rough investment amounts, and implementation periods are shown in [Tab. 2-2-1] below.

[Tab. 2-4-1] List of Railway Projects (past 10 years till now)

No	Project Name	Donor	Investment Amount	Implementation Period	
			USD (million)	Start	End
I	N-S Railway Line				
1	HaNoi - HCMC Railway Bridges Rehabilitation Project, Phase I	OECF (JICA)	135.0	Nov. '95	Oct. '00
2	HaNoi - HCMC Railway Bridges Rehabilitation Project, Phase II and Amendment No. 1			Dec. '98	Feb. '09
3	HaNoi - HCMC Railway Line Bridges Safety Improvement Project (I) (II) (III)	JBIC (JICA)	340.0	Oct. '05	Jul. '17
4	Track Structure Replacement Project in Vinh - NhaTrang Section	State budget	200.0	2008	Ongoing
5	Construction of Safety Corridor along ROW, Phase 1 (According to the Decision No. 1856/QĐ-TTg)	State budget	74.9	2008	2014
6	132 Weak Bridges Improvement and Upgrading Project	State budget	68.0	2008	Ongoing
7	Water Drainage System Improvement Project	WB	10.0	Oct. '08	Mar. '10
8	Project for Modernization of Telecommunication and Signaling system on HaNoi - Vinh section, Phase I	FRG	10.0	2003	2005
9	Project for Modernization of Telecommunication and Signaling system on HaNoi - Vinh section, Phase II	FRG	50.0	Nov. '09	2012 (expected)
10	Project for Modernization of Telecommunication and Signaling System - Vinh - Saigon section, Phase I	China Eximbank	150.0	Jan. '07	2013
11	Crossing Automatization with Signal Protection Device	State budget	N/A	2002	Ongoing
12	Amendment for Level crossing Project on HaNoi-HCMC Railway	State budget	42.0	2012	2015
13	Consulting Engineering Services for HaNoi City Urban Railway Construction Project (Line 1), Phase I	JICA	47.0	Sep. '09	Ongoing
II	Other Lines				
1	Project for Modernization of Telecommunication and Signaling System on 3 Northern Routes and HaNoi Terminal, phase I (in brief: 3+1)	China Eximbank	175.0	Oct. '06	2013
2	YenVien - LaoCai Railway Upgrading Project	ADB/AFD/ DJT	140.0	Nov. '08	2015
3	YenVien - PhaLai - HaLong - CaiLan Railway Line Project	State budget	200.0	2005	Ongoing
III	Railway Industry				
1	Modernization of Operation Control Center Project	KfW	12.8	2012	Ongoing
2	High Performance Locomotive and Relevant Facilities Procurement Project (Phase 1)	KfW	77.6	N/A	not fixed
3	Upgrading Local Assembly and Manufacturing Performance of Rolling-stock	State budget	20.0	N/A	2012

Source: JICA Study Team

2.4.2 Status of Each Project

The status of the projects listed in [Tab. 2-4-1] including the scope of projects, the progress and issues is summarized as follows.

(1) N-S Railway Line

1) HaNoi - HCMC Railway Bridges Rehabilitation Project, Phase I, Phase II and Amendment No. 1

Project Owner/ Implementing VNR/ RPMU

Agency:

Source of Financing: OECF (JICA): Approximately 135.0 million USD
GOV: Cost for resettlement and relocation of utilities

Project Objective:

- To provide safety and reliability of train services by replacement or reinforcement of deteriorated bridges, which would endanger train movement unless proper countermeasures are urgently taken.
- To strengthen the bridges to withstand the increased future axle load in place of the former small axle load.
- To reduce travel time by eliminating present speed restrictions to help realize on-time operation.
- To reduce passenger accidents caused by hitting bridge members.

Project Scope:

- Replacement or reinforcement of deteriorated bridges (in total 19 bridges) which will endanger train movement unless proper countermeasures are urgently taken
- Strengthen the bridges to withstand the increased future axle load in place of the former small axle load
- Installation and/or construction of related structures and equipment
- Consulting services include field investigations, detailed design, preparation of tender documents, tender assistance and construction supervision

Consultant(s) JTC and PCI in association with RICCC

Contractor(s) and Supplier(s):

- Mitsui Engineering & Shipbuilding Co., Ltd
- Mitsui Construction Co., Ltd
- Mitsui & Co., Ltd
- Rinkai Construction Co., Ltd
- Matsuo Bridge Co., Ltd
- Civil Engineering Construction Corporation No. 1
- Thang Long Bridge Construction Corporation

Implementation Schedule: (progress)

- Consulting Services: 1995-2005 (completed)
- Construction of Phase I: 1998-2000 (completed)
- Construction of Phase II: 2001-2004 (completed)
- + Amendment No. 1: 2003-2009 (completed)

Project Cost:

- Consulting Services: 17.9 million USD
- Construction Cost: 83.0 million USD

Issues and Countermeasure(s), if any

The project was delayed by six years from the planned duration since an additional construction phase and related amendment works were combined with the project. Besides, issuance of the defect liability certificate for the amendment No. 1 works was also much delayed due to supplier negligence.

2) HaNoi - HCMC Railway Line Bridges Safety Improvement Project (I)(II)(III)

Project Owner/ Implementing VNR/ RPMU

Agency:

Source of Financing: JBIC (JICA): Approximately 340.0 million USD
GOV: Cost for resettlement and relocation of utilities

Project Objective:

- Reducing travel time between Hanoi and HCMC as planned for the targeted high

	speed operation, 24 hours by the year 2010
Project Scope:	• Augmenting track capacity at/around bridges • Increasing safety of train operation at/around bridges • Rehabilitation of deteriorated 44 bridges including the 11.80km realigned track with and 31.738km non-realigned track • Installation and improvement of level crossings with warning system • Construction of underpasses and rail-over bridges in Ninh Binh and Do Len • Relocation of Ninh Binh station and new construction of station building and station yard • Purchase of O&M equipment • Training course for how to operate, handle and maintain purchased equipment to VNR staff concerned • Consulting services include field investigations, detailed design, preparation of tender documents, tender assistance and construction supervision
Consultant(s)	- JTC-OC-JIC - Japan Bridge & Structure Institute, Inc. (JBSI)-OC-Tonichi Engineering Consultants, Inc. (TEC)
Contractor(s) and Supplier(s):	- Mitsui Engineering & Shipbuilding Co., Ltd - Taisei Corporation - Rinkai Nissan Construction Co., Ltd - Tekken Corporation - Yokogawa Bridge Corporation - DPS Bridge Works Co., Ltd - Marubeni Corporation - Itochu Corporation - Civil Engineering Construction Corporation No. 1 - Thang Long Bridge Construction Corporation - Railway Construction JSC
Implementation Schedule: (progress)	- Consulting Services: 2005-2017 (under supervisory services) - Construction of CP1s: 2011-2016 (17 bridges with 4 packages: underway) - Construction of CP2: 2010-2013 (10 bridges: completed) - Construction of CP3s: 2014-2017 (16 bridges with 3 packages: underway) - Construction of CP4: 2013-2017 (1 bridge: underway) - Purchasing Equipment: 2009-2011 (completed)
Project Cost:	- Consulting Services: 23.1 million USD - Construction Cost: 310.3 million USD
Issues and Countermeasure(s), if any	The project cost became much higher than the planned cost by price escalation due to delay of construction, increase and inflation of material prices, labor costs and fuel fees and increase of management costs due to division of the construction packages. The project was delayed by about five years from the planned duration since the bidding process was prolonged due to failure of the bid and division of the construction packages.

3) Track Structure Replacement Project on the Vinh - NhaTrang Section

Project Owner/ Implementing VNR

Agency:

Source of Financing: GOV: Approximately 200.0 million USD

Project Objective: Replacement of concrete sleepers K1, K2 and steel sleepers by pre-stressed concrete, lengthening of track in stations, addition of 3rd track for stations that only have 2 track sections Vinh - NhaTrang of the N-S Railway line to be stable for train operation and to increase train speed.

Project Scope:	• To rehabilitate and upgrade the current railway sections that are using concrete sleepers K1, K2 and steel sleepers and the whole stations from Km 318 (signal post on the North of Vinh station) to Km 1314 (signal post on the North of NhaTrang station) with a total length of 671.55 km • To replace 342 sets of turnouts, rehabilitate and upgrade 92 stations • Phase I includes 2 purchasing packages, 4 consulting packages, 16 construction packages, 4 insurance packages, 2 unexploded ordnance clearance packages, 1 environment protection commitment package.
Consultant(s)	TRICC
Contractor(s) and Supplier(s):	Association of Railway Holding Company and Railway Construction Company No. 2
Implementation Schedule: (progress)	2010-2014 (ongoing)
Project Cost:	3,961 billion VND
Issues and Countermeasure(s), if any	None

4) Construction of Safety Corridor along ROW, Phase 1 (According to Decision No. 1856/QĐ-TTg)

Project Owner/ Implementing Agency:	VNR
Source of Financing:	GOV: Approximately 74.9 million USD
Project Objective:	• To re-organize the order and legal discipline for keeping the ROW between roadways and railways • To improve awareness of the whole society about the importance and management of the ROW between roadways and railways • To define and maintain the system of the ROW between roadways and railways • To complete the construction of frontage road systems, connecting roads to national roads, level crossings, auxiliary facilities to protect the ROW between roadways and railways in order to ensure traffic safety and decrease accidents on roadways and railways.
Project Scope:	• Upgrading and improving 260 level-crossings • Improving/ changing 10 local roads which are especially dangerous at legal level-crossing and building underpasses. • To prepare statistics for the revision of all locations which are violating the ROW of railways in 5 cities: HaNoi, HaiPhong, DaNang, DongNai and HCMC • This project has been divided into 3 phases with specific tasks
Consultant(s)	TRICC
Contractor(s) and Supplier(s):	Local construction companies
Implementation Schedule: (progress)	2008-2014 (ongoing)
Project Cost:	102 billion VND
Issues and Countermeasure(s), if any	None

5) 132 Weak Bridges Improvement and Upgrading Project

Project Owner/ Implementing Agency:	VNR
Source of Financing:	GOV: Approximately 68.0 million USD
Project Objective:	• Reducing travel time between Hanoi and HCMC • Augmenting track capacity at/around bridges • Increasing safety of train operation at/around bridges • Satisfying the structural capacity with the standard train load (T16)

Project Scope:	• Upgrading and improvement of 132 railway bridges between HanNoi - HCMC • The construction is divided into 16 packages
Consultant(s)	TRICC
Contractor(s) and Supplier(s):	- Joint operation of Railway Joint Stock Company and Railways Construction Joint Stock Company 2 - Construction Joint Stock Company No.6
Implementation Schedule: (progress)	2008-2014 (ongoing)
Project Cost:	Approximately 68.0 million USD
Issues and Countermeasure(s), if any	8 construction packages have been implemented but the remaining 8 packages have been suspended due to a lack of budget.

6) Water Drainage System Improvement Project (Natural Disaster Risk Management Project)

Project Owner/ Implementing Agency:	VNR/ RPMU
Source of Financing:	WB: Approximately 10.0 million USD GOV: Cost for resettlement and relocation of utilities
Project Objective:	• Minimizing damage caused by floods and storms to train passengers and inhabitants living along the HaNoi - HCMC Railway; • Railway infrastructure reinforcement to assure passing ability of traffic network during the rainy and storm season to timely respond to flood and storm control and rescue tasks when heavy torrential rains occur; • Ensuring stability of works, enhancing transportation safety and transportation means, to protect the lives and property of passengers and persons in charge of transportation, management and repair of track.
Project Scope:	• Improvement and reinforcement of 25 weak sections on the HaNoi-HCMC railway line scattered in 8 provinces including the provinces of HaTinh, QuangBinh, QuangTri, ThuaThienHue, QuangNam, BinhDinh, PhuYen and KhanhHoa. • New construction and replacement of 12 culverts under the HaNoi-HCMC railway line scattered in 4 provinces including the provinces of QuangBinh, QuangTri, ThuaThienHue and KhanhHoa. • Rehabilitation of drainage system at Hue Station in Hue city.
Consultant(s)	- TRICC
Contractor(s) and Supplier(s):	- Construction Joint Stock Company No.6
Implementation Schedule: (progress)	- Detailed drawing design: from September 2008 to February 2009 (Design Process will be implemented for each package to accelerate the bidding procedure of construction). - Construction period: from January to December, 2009
Project Cost:	- Approximately 10.0 million USD (174,634,870,000 VND)
Issues and Countermeasure(s), if any	None

7) Project for Modernization of Telecommunication and Signaling system on HaNoi - Vinh section, Phase I

Project Owner/ Implementing Agency:	VNR/ RPMU
Source of Financing:	FRG: Approximately 10.0 million USD GOV: Cost for resettlement and relocation of utilities
Project Objective:	• Renewal of signaling and telecommunications systems to improve the safety of operations to increase both the speed and transport capacity and provide a better reliability of train circulation.

Project Scope:	- For Signaling: New electronic interlocking (SSI technology Alstom) in 3 stations: VanDien, BimSon and ThanhHoa. New automatic level crossing equipment near VanDien station. Single track automatic block sections on both sides of ThanhHoa Station - For Telecommunications: An optical fibre cable along the 320 km of the line (24 fibres). A multi-service transmission network based on SDH technology (STM1 & STM4 Alcatel). 5 new PABX along the line, HaNoi, NamDinh, ThanhHoa, CauGiat and Vinh (Matra). A new specific telephone network dedicated to railway operation with terminals in all stations on the line. - Scope area: HaNoi - Vinh is the first 320 km section of the HaNoi - HCMC (formerly SaiGon) main line of VNR.
Consultant(s)	SYSTRA in association with Railway Investment & Construction & Consultant Company (RICC)
Contractor(s) and Supplier(s):	ALCATEL & ALSTOM CIT consortium
Implementation Schedule:	- Consulting Services: 2002-2005
(progress)	- Construction: 2002-2005
Project Cost:	- Consulting Services: 1.02 Million Euro
	(including preliminary studies for Phase II)
	- Construction Cost: 8.7 Million Euro and 35,466 Million VND
Issues and Countermeasure(s), if any	None

8) Project for Modernization of Telecommunication and Signaling system on HaNoi - Vinh section, Phase II

Project Owner/ Implementing Agency:	VNR/ RPMU
Source of Financing:	FRG: Approximately 50.0 million USD GOV: Cost for resettlement and relocation of utilities
Project Objective:	Renewal of signaling and telecommunications systems to improve the safety of operations to increase both the speed and transport capacity and provide better reliability of train circulation.
Project Scope:	- According to preliminary studies, the second phase should include: - For Signaling: New electronic interlocking on the remaining main stations of the line. Single track automatic block sections for the whole line. - For Telecommunications: A track to train radio system. A new optical cable for backup of the telecom network phase 1.
Consultant(s)	- SYSTRA
Contractor(s) and Supplier(s):	- ALSTOM – HASITEC
Implementation Schedule:	- Consulting Services: 2007-2014
(progress)	- Construction: 2007-2014
Project Cost:	- Consulting Services: N/A
	- Construction Cost: N/A
Issues and Countermeasure(s), if any	None

9) Project for Modernization of Telecommunication and Signaling System - Vinh - Saigon section, Phase I

Project Owner/ Implementing Agency:	VNR/ RPMU
Source of Financing:	China Eximbank: Approximately 150.0 million USD GOV: Cost for resettlement and relocation of utilities
Project Objective:	To eliminate the backward and degraded situation of the existing telecommunication-signaling system in order to put the infrastructure system into

	technical class to increase train speed, reduce travel time, ensure safety of train operation, reduce transportation fares, increase the competitiveness of the railway sector, serve passengers better and meet the higher and higher demand of both passenger and freight transportation.
Project Scope:	• To coordinate with other projects to execute as the first step the target of industrialization and modernization of the railway transportation sector in order to be ready for regional and international integration. • To continue the project of modernizing the telecommunication – signaling system on the HaNoi-Vinh sector by ODA of France, which is under execution, to form a comprehensive system of telecommunication and signaling for the Unification Railway. • To improve the skills of railway staff so that they can master advanced technology and conduct technology transfer. • Telecommunication system: invest in an optical cable transmission system of 24 wires G652/G655; SDH STM4/16 – STM1 equipment, digital circuit switches, digital dispatching information system; attached application interfaces: data transmission, teleconferencing, etc... • Signaling system: relay interlocking concentrating control signaling system, semi-automatic blocking together with axle-counting devices, electro-dynamic switches, train operation dispatching monitoring system and computer-monitoring system, etc... • Comprehensive company: substation, power source supplying to equipment; maintenance substation, constructions serving for equipment... • Environmental factors: the construction is within the ROW of railway and scope of stations which are along the railway on the Vinh – SaiGon section.
Consultant(s)	- China Railway Limited Company 6 - Telecommunication - Signal - Electricity Research Center - China Railway Design Consulting Limited Company
Contractor(s) and Supplier(s):	- CSGR
Implementation Schedule:	- Consulting Services: 2004-2014
(progress)	- Construction: Ongoing
Project Cost:	- Consulting Services: N/A
	- Construction Cost: 2.423,6 Billion VND
Issues and Countermeasure(s), if any	None

10) Crossing Automatization with Signal Protection Device

Project Owner/ Implementing Agency:	VNR
Source of Financing:	GOV: N/A
Project Objective:	• To ensure safety of train operation in order to enhance transportation quality and capacity
Project Scope:	• Installation of signal protection devices at crossings at all railways in Vietnam for automatization of crossings
Consultant(s)	- Investment and Construction Consulting Company - CadPro Software and Design Automation Company
Contractor(s) and Supplier(s):	- Telecommunication-Signal and Electricity Construction Company - Hanoi Railway Telecommunication and Signal Enterprise
Implementation Schedule:	- Consulting Services: 2002 - 2014 (ongoing)
(progress)	- Construction: Ongoing
Project Cost:	- Consulting Services: N/A
	- Construction Cost: N/A

Issues and Countermeasure(s), if any - Due to many reasons e.g. no continuous track circuits, too many level-crossings, etc., it is impossible to adjust the time of blocking level-crossings and has been hardly used even it is selected as a design sample.

11) Amendment for Level crossing Project on HaNoi–HCMC Railway

Project Owner/ Implementing VNR/ RPMU

Agency:

Source of Financing: GOV: Approximately 42.0 million USD

Project Objective: • To ensure traffic safety of roadways and railways

Project Scope: • Amendment of 630 level crossings on the HaNoi - HCMC railway which includes:
i) 350 level crossings with indicators, ii) 204 level crossings with automatic warning signals, iii) 43 level crossings with barrier arms, iv) 28 level crossings with protecting barriers
• Construction of the facilities such as underpasses, flyovers, frontage roads and fences

Consultant(s) - TRICC

Contractor(s) and Supplier(s): - N/A

Implementation Schedule: (progress) - 2010-2014 (ongoing)

Project Cost: - Disbursed about 10.3 Million USD

Issues and Countermeasure(s), if any - Due to a lack of budget, some packages have been suspended and temporarily postponed. The remaining packages will be transferred to another project and/or suspended until necessary funds are supplemented.

12) Consulting Engineering Services for HaNoi City Urban Railway Construction Project (Line 1), Phase I

Project Owner/ Implementing VNR/ RPMU

Agency:

Source of Financing: JBIC (JICA): Approximately 47.0 million USD

Project Objective: • To undertake detailed design activities for introducing and promoting a new national urban railway system in Hanoi;
• To provide the most efficient quality services in detailed design and technical specifications, contract documentation, and in selection of suppliers and contractors by outside independent entities which have experience in this field;
• To incorporate overseas knowledge and local experience in supporting activities for construction works such as land acquisition, EIA, RPMS, O&M, HIV/AIDS, etc.; and
• To conduct knowledge transfer to VNR and its entities.

Project Scope: • To conduct field investigations, surveys and data collection;
• To prepare basic design for Project 1 and Project 2 and integration design of the two Projects with other urban railway lines and other modes of transport;
• To prepare detailed design and cost estimates for Project 1 including: i) Ngoc Hoi station complex; ii) civil and elevated structures from Giap Bat to Gia Lam; iii) Long Bien Bridge; iv) signaling, telecommunications, electrification and electric supply system; v) electrical multiple units (EMU);
• To prepare prequalification documents, bidding documents and assist in the selection of contractors and suppliers;
• To monitor and assist during the land acquisition and resettlement process;
• To conduct environmental, social considerations and HIV/ AIDS/STIs prevention program during the pre-construction stage;
• To assist in the establishment of RPMU's integrated information technology and project management system (RPMS);

	• To assist in the establishment of an operation, management and maintenance system for the new company • To conduct a training program for VNR's staff capacity strengthening for establishment of a new O&M system for the new urban railway system.
Consultant(s)	Association of JTC-JARTS-JRC-JEC-Koken-TRICC-TEDI-TEDI South
Contractor(s) and Supplier(s):	N/A
Implementation Schedule: (progress)	Consulting Services: 2009-2015
Project Cost:	Consulting Services: Approximately 46.0 million USD
Issues and Countermeasure(s), if any	None

(2) Other Lines

1) Project for Modernization of Telecommunication and Signaling System on 3 Northern Routes and HaNoi Terminal, phase I (in brief: 3+1)

Project Owner/ Implementing Agency:	VNR/ RPMU
Source of Financing:	China Eximbank: Approximately 175.0 million USD GOV: Cost for resettlement and relocation of utilities
Project Objective:	• To replace the old telecommunication and signaling system by a digital telecommunication and signaling system • To upgrade the railway technical infrastructure system • To increase speed and reduce train operation, to ensure safety • To improve competitiveness of railway transport; then improve the railway staff capacity in accessing the new technology.
Project Scope:	• The scope of project implementation includes stations belonging to the railway lines: railway centers Ha Noi, Yen Vien - Lao Cai, Ha Noi - Đông Đăng, Đông Anh - Quan Trieu
Consultant(s)	N/A
Contractor(s) and Supplier(s):	Trung Hung Limited Holding Company (ZTE) - EPC contract
Implementation Schedule: (progress)	2005-2014 (ongoing)
Project Cost:	- 363,784,163 CNY (ODA) and 163,608,235,969 VND (GOV's fund)
Issues and Countermeasure(s), if any	- During the implementation of the project, because of some subjective reasons that have to adjust the project for the suitability of actual requirements and on October 14, 2010, Ministry of Transport issued decision No. 2990/QĐ-BGTĐT approving the adjusted project. Hence, for the suitability of the loan limitation on the preferential credit of 530 million CNY, the project is divided into 2 phases of investment: Phase I includes the urgent items that need to be implemented in advance; Phase II includes the remaining items that will be implemented after defining the investment source and approval by the related implementation authority. Based on the adjusted project that is approved by the Ministry of Transport, VNR has made the decision to approve the technical design and the construction estimation of package No. 1 – EPC contract package.

2) YenVien - LaoCai Railway Upgrading Project

Project Owner/ Implementing Agency:	VNR/ RPMU
Source of Financing:	ADB/AFD/DJT: Approximately 140.0 million USD GOV: Cost for resettlement and relocation of utilities

Project Objective:	• To facilitate trade and enable economic growth between northwestern VietNam and Yunnan Province in the People's Republic of China • To facilitate access to and from Haiphong Port in VietNam to Yunnan Province, especially for container traffic • To reduce transport costs • To improve rail traffic safety • To secure sufficient railway capacity to handle future traffic demand to the year 2020
Project Scope:	• Improvement of alignment at specific locations on approximately 285 km of existing track alignment from Yen Vien to Lao Cai • Replacement of worn out rails and switches on the main line • Replacement of old sleepers and fastenings and track ballast and improvement of embankments, including stabilization • Construction of about six (6) new bridges and rehabilitation of approximately 73 other war damaged and corroded bridges. • Construction of new intermediate station at Mai Tung, including passing loops • Rehabilitation of existing stations, station buildings, access roads, platforms, cargo yards, warehouses and providing new, or extending existing, passing loops where required • Construction of new warehouses, platforms, cargo yards or access roads at existing stations. • Provision of one overpass at existing at-grade crossing and upgrading of existing at-grade rail-road crossings by providing improved track crossing structures and safety fencing where required. • Consulting services
Consultant(s)	CECI and CDM Smith
Contractor(s) and Supplier(s):	- Namkwang Sampyo - Posco - ETP
Implementation Schedule:	- Consulting Services: 2004-2014 - Construction: Ongoing
(progress)	
Project Cost:	- Consulting Services: N/A - Construction Cost: N/A
Issues and Countermeasure(s), if any	None

3) YenVien - PhaLai - HaLong - CaiLan Railway Line Project

Project Owner/ Implementing Agency:	VNRA/ VNRA-RPMU
Source of Financing:	GOV: Approximately 200.0 million USD
Project Objective:	• To make railway transport more attractive by upgrading the railway line • To increase train speed by improvement of the track alignment and structure • To connect railway line to CaiLan Port which has a berth water depth of 12 m
Project Scope:	• Total length of 128km through the locations of HaNoi, BacNinh, HaiDuong and QuangNinh. The project is divided into 4 sub-projects as follows: • Sub-project 1: HaLong - CaiLan section & BanCo elevated bridge, divided into 23 packages, of which 9 construction packages, 3 purchasing packages, 11 consulting packages. • Sub-project 2: Lim - PhaLai section, divided into 26 packages of which 12 construction packages, 4 purchasing packages, 10 consulting packages. • Sub-project 3: PhaLai - HaLong section, divided into 37 packages of which 12 construction packages, 5 purchasing packages, 20 consulting packages.

Consultant(s)	• Sub-project 4: YenVien - Lim section.
Contractor(s) and Supplier(s):	TRICC-TEDI
	- Thang Long Bridge Construction Corporation - Civil Engineering Construction Corporation No.1 - Civil Engineering Construction Corporation No.8 - Civil Engineering Construction Corporation No.4 - Railway holding company, Railway construction holding company No. 2 - Construction Joint Stock Company No.6
Implementation Schedule: (progress)	- 2005-2014 (ongoing)
Project Cost:	- Approximately 200.0 million USD
Issues and Countermeasure(s), if any	None

(3) Railway Industry

1) Modernization of Operation Control Center Project

Project Owner/ Implementing Agency:	VNR/ RPMU
Source of Financing:	KfW: Approximately 12.6 million USD (10.6 million Euro) GOV: 35 billion VND
Project Objective:	• To modernize train operation control which is currently manually managed and improve the operation capacity • To supervise train location by GPS
Project Scope:	• Improvement of national OCC at HaNoi Station • Improvement of 3 regional OCCs located at HaNoi, DaNang and SaiGon • Installation of passenger information control systems at 8 stations; HaNoi, Vinh, DongHoi, Hue, DaNang, DieuTri, Nha Trang and SaiGon • Establishing connection with 158 working stations to be located at professional units that have direct relation to train operation, • Purchasing and installation of 392 OBU equipment (equipment on locomotives), GSM (Global System for Mobile), MMI/push button (Man-machine Interface) and antenna for 287 locomotives which are operating on the HaNoi-HCMC line
Consultant(s)	N/A
Contractor(s) and Supplier(s):	IVU Traffic Technologies AG - EPC contract
Implementation Schedule: (progress)	- 2006 - 2014 (to be completed at the end of 2015)
Project Cost:	- Total investment of 254,932 billion VND, in which ODA is 10,635,837 Euro (equally with 219,438 billion VND), government funds of 35,493 billion VND.
Issues and Countermeasure(s), if any	- During the implementation process, it was necessary to adjust some technical contents in comparison with the overall design. The contractors have been requested to research and supplement the equipment to measure the fuel consumption of each locomotive. Some items of equipment have to be out of scope for keeping the project cost since the EPC contract is a lump sum based contract.

2) High Performance Locomotive and Relevant Facilities Procurement Project (Phase 1)

Project Owner/ Implementing Agency:	VNR/ RPMU
Source of Financing:	KfW: Approximately 77.6 million USD

Other information: N/A

3) Upgrading Local Assembly and Manufacturing Performance of Rolling-stock

Project Owner/ Implementing VNR/ RPMU

Agency:

Source of Finance: GOV: Approximately 20.0 million USD

Other information: N/A

2.4.3 Transportation Investment for Railway Sector

According to VITRANSS2, VietNam has invested VND 113,000 billion for transportation infrastructure development by the end of 2007, realizing roughly 45% of the planned investments (including VITRANSS proposed and other projects) as shown in [Tab. 2-4-2].

[Tab. 2-4-2] Transportation Investment (1999 to 2007)

(Unit: billion VND)

Mode	Planned Investment			Actual Investment		
	VITRANSS*	Other	Total	VITRANSS	Other	Total
Road	121,684	71,783	193,468	72,566	28,207	90,774
Railway	7,440	4,782	12,222	1,428	902	2,329
Waterway	2,009	184	2,192	2,004	184	2,187
Maritime	20,234	8,111	28,346	9,370	803	10,173
Air	10,155	-	10,155	8,264	-	8,264
Total	161,524	84,860	246,383	93,632	20,096	113,729

Note: - VITRANSS was compiled in the year 1999.

- VITRANSS project funds include central and local funds, as well as FDI. Non-VITRANSS projects include MOT projects only.

Source: VITRANSS2

The actual investments for the railway sector from 1999 to 2007 was about 2% against total transportation investments while huge investments were made for the road sector. It is assumed that the proportion of railway investment excluding urban railways in the recent decade will be almost the same as the ones in the period from 1999 to 2007 since the remarkable investment for the existing railway such as the North - South HSR has not yet been made since then.

2.5 N-S Railway Investment Plan

2.5.1 Planned Projects for Investment

Since revision and adjustment of the railway transport development strategy and the railway transport master plan have not been approved and issued by GOV, there is no available railway development plan in compliance with the strategy under Decision No. 355/QĐ-TTg. For the purpose of evaluating whether projects relevant to the N-S Railway are in compliance with the railway development plan or not, the projects listed in the draft of the Detailed Modernization Plan for the N-S Railway (DMP) will be temporarily referred. This list is summarized in [Tab. 2-5-1] and [Tab. 2-5-2] although it is still under approval process of MOT.

[Tab. 2-5-1] Investment Plan from 2015 to 2020

No	Project Name	Scope of Works	Fund Resource	Project Cost USD (million)	Target Period
(1)	1st Priority Projects				
1)	Rehabilitation of Bottleneck Sections				
i)	Realignment and Improvement of HoaDuyet-ThanhLuyen Section	• Upgrading and improvement of the track with a total length of 4,719m • Realignment of the track with a length of 4,790m • Improvement of two stations • Rehabilitation/ improvement of 3 bridges/ 326m • Construction of 2 new tunnels/ 1,070m • Construction of 29 new culverts • Installation of signal & telecommunication system • Comprehensive water and power supply system in 2 stations	State budget	53.71	2014-2016
ii)	Realignment and Improvement of TanAp-KimLu Section and Construction of New KheNet Tunnel	• Upgrading and improvement of the track with length of 5,280m • Improvement of 25 curves. • Improvement of DongChuai station. • Construction of 3 new access bridges. • Construction of 2 tunnels/ 1,510m • Installation of signal-telecommunication system	Foreign funds & state budget	80.57	2014-2018
iii)	Realignment and Improvement of LangCo-KimLien and Construction of New HaiVan Tunnel	• Improvement of all the area of the HaiVan Tunnel • Construction of tunnels with a length about 7,800m • Construction of 3 approach bridges • Construction of 1 new station and improvement of 1 station. • Installation of signal-telecommunication system	Foreign funds & state budget	315.42	2014-2020
2)	Improvement of Track Structure				
i)	Replacement of Sleepers and Improvement of 2 Station Yards for Vinh-NhaTrang Section (Phase 2)	• To replace steel and concrete twin-block sleepers with PC sleepers • To lengthen track in station yards • To add track lines in 2 station yards	State budget	223.63	2014-2018
3)	Improvement and Rehabilitation of Bridges and Tunnels				
i)	Improvement of 311 Weak Bridges	Improvement and upgrading of 311 weak bridges to meet the T14 train load and the 120km/h design speed	State budget	121.63	2014-2018
ii)	Reinforcement of Weak Tunnels	Improvement and upgrading of 22 weak tunnels with a total length of 6,981m	Foreign funds & state budget	135.33	2014-2018
4)	Construction of Safety Corridor along Right of Way (ROW)				
i)	Construction of Safety Corridor along ROW, Phase 2 (According to Decision No. 1856/QD-TTg)	• Improvement and upgrading of existing level crossings and addition of new level crossings • Construction of ROW fence • Construction of frontage roads to close illegal local roads • Construction of overhead bridges with grade separation at intersections between railways and roadways, urban roads with high density of traffic • Marking the boundary of ROW	State budget	4.71	2014-2016
5)	Prevention of Climate Change				
i)	Raising rail level of sections affected by floods during the rainy season	• Raising rail level and widening of track bed • Installation of sub-ballast layer with 20cm thickness • Reinforcement of track beds and slopes • Replacement of stone slopes and ballast supplementation	State budget	44.86	2014-2017
ii)	Reinforcement of unstable embankment slopes	• Construction of concrete retaining walls to stabilize slopes • Installation of gabions or turf to reinforce slopes • Reinforcement of slopes by concrete mortar	State budget	161.93	2014-2016

		injection on sections where stones might fall			
iii)	Reinforcement of weak embankment sections where ballast mud pumping occurs	• Reinforcement of slopes and track bed • Construction of ballast stoppers • Replacement of stone slopes and supplementation of ballast • Protection of track settlement by concrete piles • Installation of sub-ballast layer with 20cm thickness	State budget	94.02	2014-2017
6)	<i>Modernization of Signal and Telecommunication</i>				
i)	Adjustment of Project for Modernization of Telecommunication and Signaling system on HaNoi - Vinh section, Phase II	• To supplement and adjust some equipment of telecommunication, signal and power supply • To adjust additional cost caused by escalation of labor costs, material costs and consulting fees, etc.	State budget	25.17	2014-2015
7)	<i>Improvement of Passenger and Freight Transportation Services</i>				
i)	Improvement and rehabilitation of passenger cars, freight stations and depots to connect sea harbors and branch lines	• Improvement of station layouts, freight yards, handling lines of freight stations to be connected to branch lines • Upgrading passenger stations in order to improve service quality of passenger transportation	State budget	34.42	2017-2020
ii)	Installation of waste treatment equipment on passenger cars	Installation of waste treatment equipment on passenger cars	BOT	13.95	2014-2016
iii)	Procurement of maintenance equipment, facilities and freight handling equipment	Motorization and automation of maintenance equipment for railway infrastructure, signal & telecommunication and freight handling	BOT & state budget	29.50	2014-2019
(2)	<i>2nd Priority Projects</i>				
1)	<i>Improvement of alignment on sections with small curve radius</i>	Improvement of sections with a horizontal curve radius $R < 400m$ and difficult topography, which cause low speed of train operation and high risk of unsafe train operation	State budget	90.19	2017-2020
2)	<i>Improvement of Track Structure</i>				
i)	Widening the embankment and replacement of sleepers and rails for the remaining sections	• Widening the embankment • Replacement of sleepers and rails for the remaining sections	State budget	554.62	2016-2020
3)	<i>Improvement of Weak Bridges</i>				
i)	HaNoi-HCMC Bridges Safety Improvement Project Phase II (56 Bridges)	Improve and upgrade 56 weak bridges to meet the T14 train load and the 120km/h design speed	Foreign funds & state budget	148.84	2016-2020
4)	<i>Grade Separation at Intersection of Highways and Big Urban Roads</i>				
i)	Construction of Safety Corridor along ROW, Phase 3 (According to the Decision No. 1856/QĐ-TTg)	• Improvement and upgrading the existing level crossings and addition of new level crossings • Construction of ROW fence • Construction of frontage roads to close illegal local roads • Construction of overhead bridges with grade separation at intersections between railways and roadways, urban roads with high density of traffic • Marking the ROW boundary	State budget	238.04	2015-2019
5)	<i>Modernization of Signal and Telecommunication</i>				
i)	Adjustment of Project for Modernization of Telecommunication and Signaling system on Vinh-SaiGon section, Phase II	• Installation of concentrating control signal system for 5 stations on the NhaTrang-SaiGon section • Installation of signal equipment for semi-automatic blocking together with axle-counting equipment on the Vinh-NhaTrang section • Installation of section-blocking equipment over optical cable for stations on the Vinh-SongThan section • Installation of train-operation monitoring system and computers for measurement, checking on the Vinh-SaiGon section • Measurement, checking instruments in the checking base for signal at Vinh and DaNang • Installation of signal equipment of controlling	Foreign funds & state budget	116.28	2016-2018

		- section switches on the Vinh-SaiGon section • Installation of UPS for stations which will have signal system on the Vinh-NhaTrang section and 5 stations on the Nha Trang-SaiGon section • Improvement of signal system at level crossings so that it meets the requirements of current regulations			
(3)	3rd Priority Projects				
1)	Construction of Safety Corridor along ROW at Remaining Sections				
i)	Construction of Safety Corridor along ROW at Remaining Sections	• Improvement and upgrading the existing level crossings and addition of new level crossings • Construction of ROW fence • Construction of frontage roads to close illegal local roads • Construction of overhead bridges with grade separation at intersections between railways and roadways, urban roads with high density of traffic • Marking the ROW boundary	State budget	154.06	2017-2020
2)	Improvement of Operation and Transportation Capacity				
i)	Expanding station lines and opening new stations	• Installation of additional track lines in stations with 2 tracks to extend station lines and ensure the usable length is $\geq 400\text{m}$ • Opening new stations on sections where operation capacity is limited to less than 25 pairs of trains	State budget	73.26	2017-2020
3)	Improvement of Rolling-stock and Maintenance Facilities				
i)	Procurement/manufacturing of new passenger and freight cars	Procurement/manufacturing of new passenger and freight cars	BOT	146.37	2017-2020
ii)	Rehabilitation and improvement of rolling-stock maintenance facilities	• Rehabilitation of rolling stock maintenance facilities for the railway line adapting to transport demand Vinh area; Vinh car enterprise workshop, Vinh locomotive enterprise workshop and spare unit HCMC area; SaiGon car enterprise workshop, SaiGon freight car enterprise workshop, DiAn car factory workshop and spare unit	State budget	7.04	2018-2020
4)	Improvement of Operation and Management Capacity				
i)	Ground train telecommunication radio system	Procurement and installation of equipment at the operation control center (OCC), stations, trains and ground mobile objects (shunting locomotives) and value added services	BOT	20.00	2016-2020

Note: The classification of priorities is as follows:

Priority 1:

To mainly concentrate on urgent projects such as rehabilitation of bottleneck sections, improvement of track structure, rehabilitation of weak bridges and tunnels, ensuring traffic safety and improvement of passenger and freight transport service.

Priority 2:

To continue implementation of projects for improvement of train speed and transport capacity.

Priority 3:

To implement remaining projects to achieve the objectives on speed and transport capacity.

Source: Study team based on draft DMP prepared by TRICC

According to the draft DMP, the objectives till 2020 are to divert development resources to the improvement, modernization of the existing N-S Railway line and to ensure the maximum train operation of average speed of 80 - 90km/h for passenger trains and 50 - 60km/h for freight trains. In case all of projects listed in [Tab. 2-5-1] are completed, the passenger train operation time from HaNoi to HCMC will be 21.28 hours according to the DMP analysis.

[Tab. 2-5-2] Investment Plan from 2020 to 2025

No	Project Name	Scope of Works	Fund Resource	Project Cost USD (million)	Target Period
1)	Construction of new HaTinh main station	- To remove ChuLe station (3 lines) - To open HaTinh new station (4 lines) - To construct 550m roadway to the station - To construct 1 road bridge to the station - To construct new telecommunication & signaling system - To construct station and station square - To construct housing, demand and need, track line and synchronized telecommunication signaling	State budget	9.30	2020-2022
2)	Relocation of DaNang station	- To construct new railway/ 22.79km - To rehabilitate 1 station and construct 2 new stations - To construct 6 bridges/ 760m - To install a new telecommunication and signaling system - To construct 3 station buildings	State budget	104.00	2020-2025
3)	Rehabilitation and relocation of NhaTrang section	- To remove 1.1km - To rehabilitate 1 station and construct 1 new station - To construct 1 new bridge - To install a new telecommunication and signaling system - To construct 3 station buildings	State budget	79.28	2020-2025
4)	Installation of long welded rail on remaining sections	Installation of long welded rail on remaining sections with a total length of 393.15km	State budget	87.77	2020-2025
5)	Grade separation at remaining intersections	Construction of 36 railway-over bridges	State budget	535.58	2020-2025
6)	Procurement of new locomotives for passenger and freight trains	Procurement of 14 passenger locomotives and 24 freight locomotives	Foreign fund	190.00	2020-2025
7)	Procurement/manufacturing of new passenger and freight cars	Procurement/manufacturing of 156 passenger cars and 532 freight cars	BOT	174.29	2020-2025

Source: JICA Study Team based on draft Detailed Modernization Plan for N-S Railway prepared by TRICC

The target after 2020 is to implement the projects to harmonize the plan of local government, improve the remaining sections and increase train operation speed. It is estimated that the passenger train travel time from HaNoi to HCMC will be 19.22 hours after completion of all projects listed in [Tab. 5-1-2].

2.5.2 Status of Projects Listed

Almost all projects listed in [Tab. 2-5-1] and [Tab. 2-5-2] are still under preparation and seem to have no actual progress yet but the status of projects is summarized as shown in [Tab. 2-5-3] and [Tab. 2-5-4] below.

[Tab. 2-5-3] Status of Planned Projects for Investment from 2015 to 2020

No	Project Name	Target Period	Status					
			Plan	F/S	T/A	B/D	D/D	C/M
(1)	1 st Priority Projects							
1)	Rehabilitation of Bottleneck Sections							
i)	Realignment and Improvement of HoaDuyet-ThanhLuyen Section	2014-2016	✓	✓				
ii)	Realignment and Improvement of TanAp-KimLu Section and Construction of New KheNet Tunnel	2014-2018	✓	✓				
iii)	Realignment and Improvement of LangCo - KimLien and Construction of New HaiVan Tunnel	2014-2020	✓	✓				
2)	Improvement of Track Structures							
i)	Replacement of Sleepers and Improvement of 2 Station Yards for Vinh-NhaTrang Section (Phase 2)	2014-2018	✓	✓				
3)	Improvement and Rehabilitation of Bridges and Tunnels							
i)	Improvement of 311 Weak Bridges	2014-2018	✓	✓				
ii)	Reinforcement of Weak Tunnels	2014-2018	✓	✓				
4)	Construction of Safety Corridor along Right of Way (ROW)							
i)	Construction of Safety Corridor along ROW, Phase 2 (According to Decision No. 1856/QĐ-TTg)	2014-2016	✓	✓	✓	✓	✓	✓
5)	Prevention from Climate Change							
i)	Raising rail level of sections affected by floods during the rainy season	2014-2017	✓					
ii)	Reinforcement of unstable embankment slopes	2014-2016	✓	✓	✓	✓	✓	✓
iii)	Reinforcement of weak embankment sections where ballast mud pumping occurs	2014-2017	✓					
6)	Modernization of Signal and Telecommunication							
i)	Adjustment of Project for Modernization of Telecommunication and Signaling system on HaNoi - Vinh section, Phase II	2014-2015	✓	✓	✓	✓	✓	✓
7)	Improvement of Passenger and Freight Transportation Services							
i)	Improvement and rehabilitation of passenger cars, freight stations and depots to connect to sea harbors and branch lines	2017-2020	✓					
ii)	Installation of waste treatment equipment on passenger cars	2014-2016	✓	✓	✓	✓	✓	✓
iii)	Procurement of maintenance equipment, facilities and freight handling equipment	2018-2020	✓					
(2)	2 nd Priority Projects							
1)	Improvement of alignment with small curve radius	2017-2020	✓					
2)	Improvement of Track Structures							
i)	Widening embankments and replacement of sleepers and rails for remaining sections	2016-2020	✓					
3)	Improvement of Weak Bridges							
i)	HaNoi-HCMC Bridges Safety Improvement Project Phase II (56 Bridges)	2016-2020	✓	✓				
4)	Grade Separation at Intersections of Highways and Big Urban Roads							
i)	Construction of Safety Corridor along ROW, Phase 3 (According to the Decision No. 1856/QĐ-TTg)	2015-2019	✓					
5)	Modernization of Signal and Telecommunication							
i)	Adjustment of Project for Modernization of Telecommunication and Signaling system on Vinh-SaiGon section, Phase II	2016-2018	✓					
(3)	3 rd Priority Projects							
1)	Construction of Safety Corridor along ROW at Remaining Sections							
i)	Construction of Safety Corridor along ROW at Remaining Sections	2017-2020	✓					
2)	Improvement of Operation and Transportation Capacity							
i)	Expanding station lines and opening new stations	2017-2020	✓					
3)	Improvement of Rolling-stock and Maintenance Facilities							
i)	Procurement/manufacturing of new passenger and freight cars	2017-2020	✓					
ii)	Rehabilitation and improvement of rolling-stock maintenance facilities	2018-2020	✓					
4)	Improvement of Operation and Management Capacity							
i)	Ground train telecommunication radio system	2016-2020	✓					

Note: T/A: Technical Assistance such as SAPROF, SAPI and Preparatory Surveys etc., B/D: Basic Design, D/D: Detailed Design, C/M: Construction Management

Source: Study team based on draft DMP prepared by TRICC

[Tab. 2-5-4] Status of Planned Projects for Investment from 2020 to 2025

No	Project Name	Target Period	Status					
			Plan	F/S	T/A	B/D	D/D	C/M
(1)	Construction of new HaTinh main station	2020-2022	✓					
(2)	Relocation of DaNang station	2020-2025	✓					
(3)	Rehabilitation and relocation of NhaTrang section	2020-2025	✓					
(4)	Installation of long welded rail at remaining sections	2020-2025	✓					
(5)	Grade separation at remaining intersections	2020-2025	✓					
(6)	Procurement of new locomotives for passenger and freight trains	2020-2025	✓					
(7)	Procurement/manufacturing of new passenger and freight cars	2020-2025	✓					

Note: T/A: Technical Assistance such as SAPROF, SAPI and Preparatory Surveys etc., B/D: Basic Design, D/D: Detailed Design, C/M: Construction Management

Source: Study team based on draft DMP prepared by TRICC

2.5.3 Issues on Project Implementation

According to [Tab. 2-5-1] and [Tab. 2-5-2], the total project cost to be invested from 2015 to 2025 for modernization of the existing N-S railway will be 4,067.8 million USD. Since the total project costs for past 10 years were summed up as approximately 1,125 million USD according to [Tab 2-4-1], the planned investment for the existing N-S railway will be about four (4) times compared with the actual investment made in the past decade.

[Tab. 2-5-5] shows the annual distribution of the planned investment from 2015 (2014) to 2025 in which the annual project cost is assumed to be equally distributed during the planned project period.

[Tab. 2-5-5] Annual Distribution of Projects to be Invested from 2015 to 2025

Unit: Million USD

Project	Total Projects Cost	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Investment Plan from 2015 (2014) to 2020													
1 st Priority Projects	1,338.85	296.22	296.22	283.63	205.53	162.21	49.98	45.06	0.00	0.00	0.00	0.00	0.00
2 nd Priority Projects	1,147.97	0.00	47.61	227.06	249.61	249.61	210.85	163.24	0.00	0.00	0.00	0.00	0.00
3 rd Priority Projects	400.73	0.00	0.00	4.00	97.42	99.77	99.77	99.77	0.00	0.00	0.00	0.00	0.00
Investment Plan from 2020 to 2025													
Planned Projects	1,180.22	0.00	0.00	0.00	0.00	0.00	0.00	198.25	198.25	198.25	195.15	195.15	195.15
Total	4,067.77	296.22	343.83	514.69	552.56	511.59	360.59	506.32	198.25	198.25	195.15	195.15	195.15

Source: Study team based on draft DMP prepared by TRICC

It will need more than 200 million USD a year from 2014 to 2020 to achieve the planned modernization as scheduled. Besides, some projects are expected to be financed by foreign investment due to the large scale of the project.

For implementing the projects and achieving the objectives of DMP, the following issues have to be considered.

- Difficulty of project financing due to the huge investment needed
- Unknown status of foreign investment
- Delay of projects caused by administrative matters in relation to land acquisition and resettlement

Chapter 3 Prioritization Direction and Methodology of Infrastructure to Improve Present Conditions

3.1 Direction of Prioritization

The following sections outline the challenges facing the existing N-S Railway line based on a survey of the present conditions regarding infrastructure and facilities. The infrastructure component improvement is the foundation for taking any other measures to enhance N-S Railway transportation capacity and attract users particularly for freight transport as elaborated in Chapter 8.

3.1.1 Track and Alignment Component

(1) Total Picture

1) Alignment

The northern and southern parts of the existing N-S Railway line consist of mainly flat sections and the alignment thus has few sharp curves or steep gradients. However, the alignment of the central part is not good since the N-S Railway passes through mountainous areas along the coastline.

Especially since it passes through three (3) high mountainous areas, the N-S Railway runs on topographical conditions with tunnels, sharp curves with a radius of less than 150m and steep gradients over 12 % in the KheNet, HaiVan and HoaDuyet - ThanhLuyen areas.

[Tab. 3-1-1] Horizontal Alignment

(Unit: km and (sections))

Alignment	HaNoi - Vinh	Vinh - DongHoi	DongHoi - DaNang	DaNang - DieuTri	DieuTri - NhaTrang	NhaTrang - SaiGon	Total
Straight	249.94	149.29	210.34	240.79	156.11	324.52	1331.00
R < 150m	-	2.3 (18)	11.9 (123)	-	-	-	14.2 (141)
150 ≤ R < 300	3.1 (14)	9.8 (55)	3.2 (27)	1.5 (5)	0.6 (2)	6.3 (23)	24.5 (126)
300 ≤ R < 600	27.6 (122)	19.9 (88)	20.8 (79)	26.5 (91)	29.4 (100)	38.9 (153)	163.0 (633)
600 ≤ R < 800	10.5 (56)	4.7 (14)	2.6 (9)	20.0 (82)	9.9 (35)	3.9 (12)	51.7 (208)
R > 800	27.8 (214)	16.8 (68)	20.8 (82)	15.3 (63)	23.4 (88)	37.5 (37)	141.5 (552)
Curves, Total	69.08 (406)	53.49 (243)	59.33 (320)	63.28 (241)	156.11 (225)	86.55 (225)	395.00 (1660)
Total length	319.02	202.78	269.67	304.07	219.39	411.07	1,726.00

Note: R = Radius of curve (m)

Source: Draft DMP for N-S Railway prepared by TRICC

[Tab. 3-1-2] Vertical Alignment

(Unit: km)

Profile	HaNoi - Vinh	Vinh - DongHoi	DongHoi - DaNang	DaNang - DieuTri	DieuTri - NhaTrang	NhaTrang - SaiGon	Total
$I \leq 6\%$	309.05	169.58	222.87	280.43	185.35	281.29	1,448.58
$6 < I \leq 12\%$	9.97	27.55	30.72	23.64	33.84	93.55	219.26
$12 < I \leq 15\%$	-	3.65	8.97	-	0.2	29.66	42.48
$I > 15\%$	-	2.00	7.11	-	-	6.57	15.68
Total length	319.02	202.78	269.67	304.07	219.39	411.07	1,726.00

Note: Regarding mountain passes:

Vinh - DongHoi: HoaDuyet - ThanhLuyen (357 to 369 km, maximum gradient = 6 ‰)

KheNet pass (415 to 420 km, maximum gradient = 17 ‰)

DongHoi - DaNang: HaiVan pass (755 to 765 km, maximum gradient = 17 ‰)

Source: Draft DMP for N-S Railway prepared by TRICC

2) Track

In general, the rails have been used for a long time and are of low quality. The rail surface is scaled, pock-marked, defective and worn out, especially on curved sections with small radius. Most of the existing type P43 rails are L= 12.5m in unit length.

Iron sleepers are still most commonly used but replacement to more durable PC (pre-stressed concrete) sleepers with better riding quality is under way. The existing sleepers are only stable when trains operate with a velocity of less than 80km/h. The wooden and steel material sleepers and concrete twin-block sleepers which were installed a long time ago are still used on some sections with bad conditions due to lack of track maintenance.

[Tab. 3-1-3] Rail Type by Section

(Unit: km)

Type	HaNoi - Vinh	Vinh - DongHoi	DongHoi - DaNang	DaNang - DieuTri	DieuTri - NhaTrang	NhaTrang - SaiGon	Total
P50; L=25.0m	9.67	6.05	7.55	41.95	17.00	46.04	128.27
P50; L=12.5m	3.58	0.00	0.00	0.00	0.00	0.00	3.58
P43; L=25.0m	76.95	55.06	29.92	6.58	63.80	24.82	257.13
P43; L=12.5m	215.59	141.67	191.30	255.12	138.98	338.69	1281.33
P38; L=12.5m	13.23	0.00	41.38	0.00	0.00	2.00	56.61
Total length	319.02	202.78	269.67	304.07	219.39	411.07	1,726.00

Source: Draft DMP for N-S Railway prepared by TRICC

[Tab. 3-1-4] Sleeper Types by Section

(Unit: km)

Type of sleeper	HaNoi - Vinh	Vinh - DongHoi	DongHoi - DaNang	DaNang - DieuTri	DieuTri - NhaTrang	NhaTrang - SaiGon	Total
TN1 (C)	42.53	16.05	7.95	61.80	3.00	30.18	161.51
K3 (C)	176.70	67.24	96.50	42.19	123.01	53.84	559.49
K2 (C)	1.73	10.31	4.63	16.79	0.00	0.00	33.44
K1 (C)	79.37	91.58	81.83	78.23	0.00	0.00	331.02
Iron	5.20	14.02	76.96	104.63	89.76	308.25	598.82
Wood	7.55	3.59	2.27	0.00	4.00	0.00	17.41
Others	5.94	0.00	0.00	0.00	0.00	19.27	25.21
Total	319.02	202.78	269.67	304.07	219.39	411.07	1,726.00

Note: "C" represents concrete and is currently being replaced with PC (pre-stressed concrete) sleepers.

The description of the types of concrete sleepers is as follows:

TN1: PC (pre-stressed concrete) sleeper with a height of 20.5 cm and elastic fastening

K3: Concrete twin-block sleeper with a height of 19 cm and elastic fastening

K2 and K1: Concrete twin-block sleeper with a height of 19 cm (K2) or 18 cm (K1) and hard fastening

Source: Draft DMP for N-S Railway prepared by TRICC

3) Crossings

There are currently 1,059 approved level-crossings along the existing N-S Railway line. Many level-crossings cross National Highway No. 1 which is a main road running parallel to the line. The rapid expansion of road traffic will likely lead to an increase in the number of level-crossings. In order to improve railway safety, it is necessary to improve the functions of the level-crossings.

[Tab. 3-1-5] Level-Crossing Types by Section

Type	HaNoi - Vinh	Vinh - DongHoi	DongHoi - DaNang	DaNang - DieuTri	DieuTri - NhaTrang	NhaTrang - SaiGon	Total
Class 1	18	1	6	9	4	15	53
Class 2	30	5	19	8	11	25	98
Class 3	251	69	167	142	93	186	908
Total	299	75	192	159	108	226	1,059

Note: Class is the standard regulated by MOT depending on traffic volume as defined in the following table of "Classification of Level Crossings" in "Circular – Regulation of Level Crossings" (33/2012/TT-BGTVT).

The figures shown above are slightly different from those in [Tab. 3-1-23] due to information sources with different purpose although both of them are made by VNR.

Classification of level-crossing	Site condition of the level-crossing		
	Intersection with main railway	Intersection with dedicated railway	Traffic volume (Note) (excluding main and dedicated railways)
Class 1	- Roadway classification of level 1, 2 or 3. - Urban street where electric trains, trolley buses and buses pass frequently.	-	More than 20,000
Class 2	- Roadway classification of level 4, 5 or 6. - Standard streets.	-	More than 5,000
Class 3	Roadway of other classification than the above.	- Roadway of various classifications - Various types of street	Less than 5,000

Note 1: This is an index expressed by the formula $A = N_t \times N_x$ in which A is traffic volume, N_t is the number of train sets passing through the level crossing during the day and night according to the train diagram or plan when designing the line, and N_x is a conversion number of cars passing through the level crossing during the day and night according to actual statistics or planned data.

Note 2: Dedicated railway line used for exclusive purposes such as industrial track or siding track while main railway is a railway line used for general passenger or freight transportation.

Source: Study team based on various raw data in VNR

(2) Information Supplied by VNR

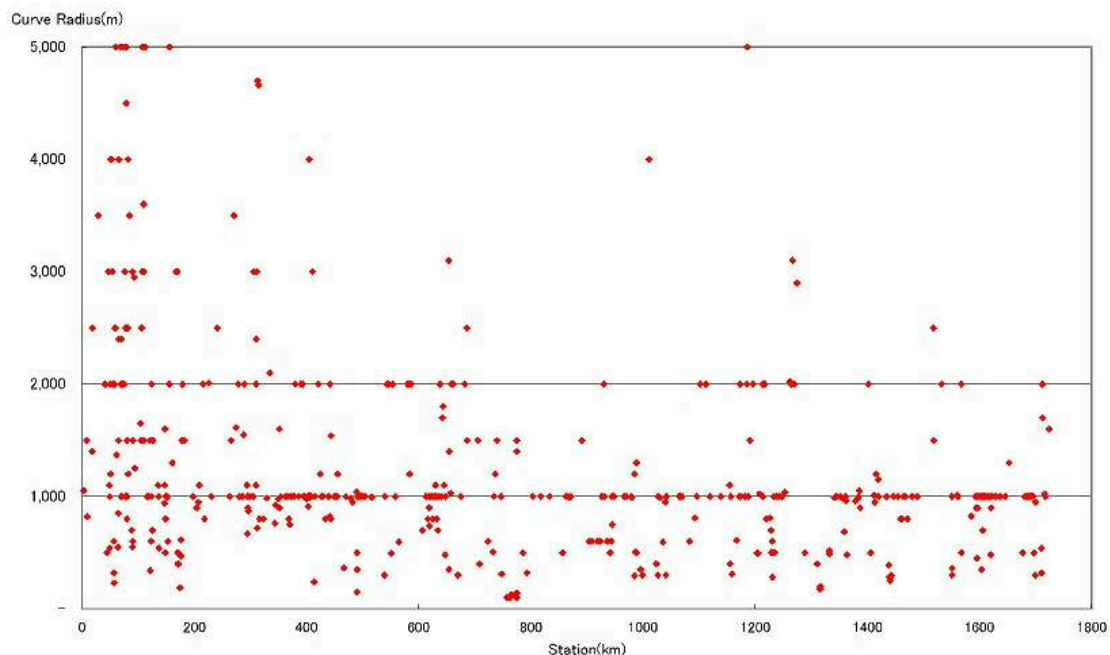
1) Documented Information

Maintenance records of existing track conditions were not available at VNR, but it was informed that they are available at the maintenance company. The study team could not collect them during the second field study in May 2014 due to limited time.

It was observed through visual site surveys riding on an inspection motor car that transition curves are not inserted between round curved sections and straight sections. In order to confirm if this is a fact, the study team checked out the information supplied by VNR, which is a list of curves between HaNoi and HCMC and discovered the following.

- Transition curve length figures are not marked on the alignment drawings for almost all curved sections.
- Transition curve length is marked as zero where the figure is specified.
- Transition curves should be symmetrical on the in and out sections of round curve sections but they are not.

The following figures describe the result of a curve characteristic analysis along the existing N-S Railway. There are many sharp curves on the HCMC side as shown in [Fig. 3-1-1] (the right side represents the HCMC side).

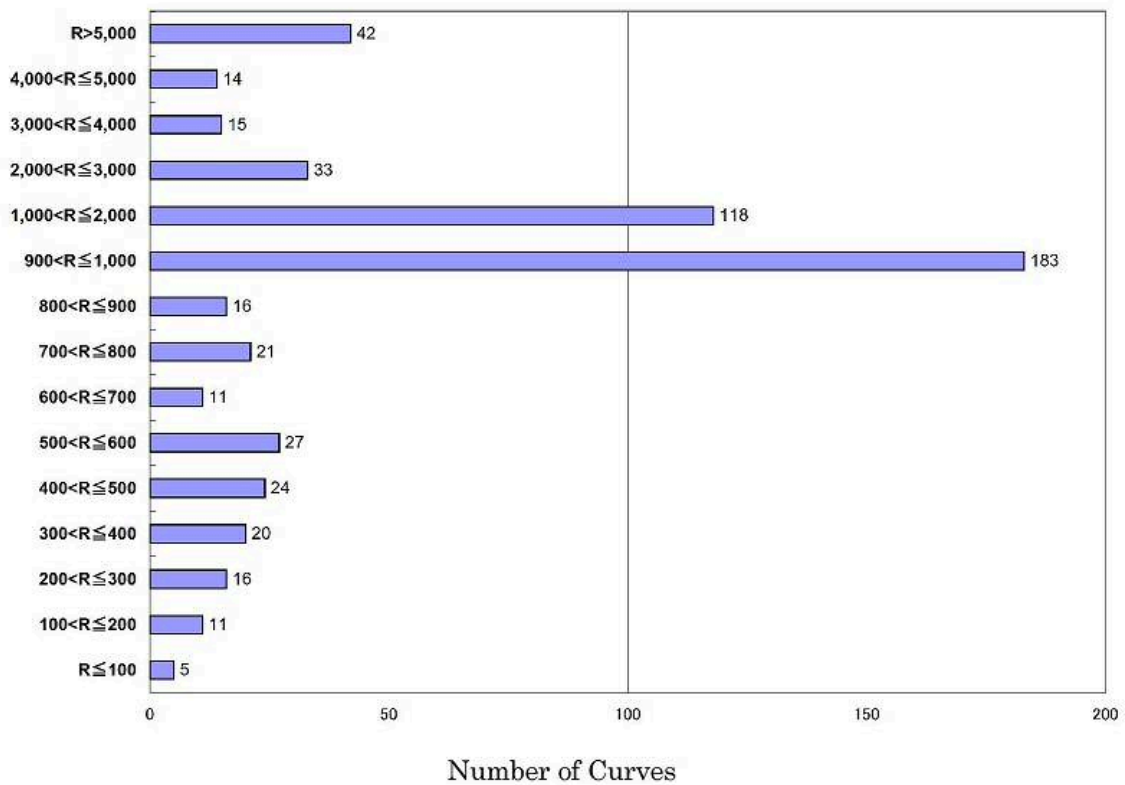


Note: The total number of curves between HaNoi and HCMC is 1,745, which is different from the number shown in [Tab. 3-1-1], although both of them were made by VNR for different purposes. This shall be confirmed during the study.

Station (km) means the location of curves measured from HaNoi.

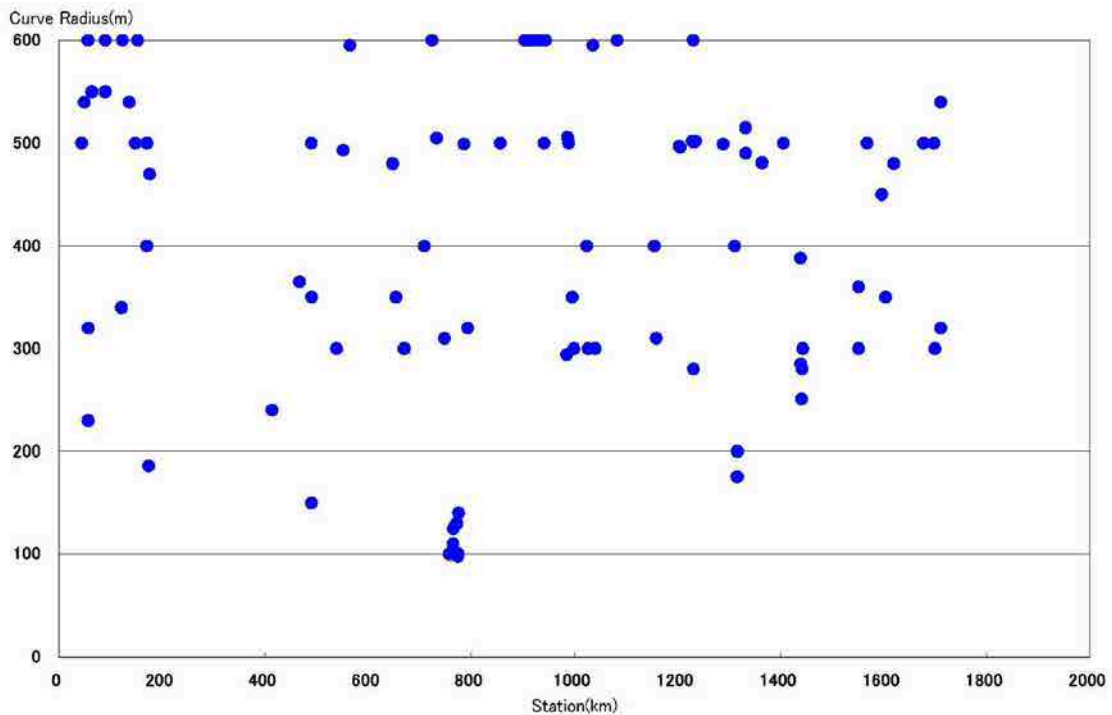
Source: Study team based on various raw data provided by VNR
[Fig. 3-1-1] Curved Section Distribution Chart

Many of the curve radiuses are between 900 m and 1,000 m, as shown in [Fig. 3-1-2].



Source: Study team based on various raw data provided by VNR
 [Fig. 3-1-2] Number of Curves by Size

Sharp curves with a radius of less than 600m are almost uniformly distributed between HaNoi and HCMC as shown in [Fig. 3-1-3].



Note: Station (km) means the location of curves measured from HaNoi.

Source: Study team based on various raw data provided by VNR
 [Fig. 3-1-3] Curved Section Distribution $R \leq 600$

2) Verbal Information

The following are the findings on the current track maintenance conditions confirmed during meetings with VNR.

- Track rehabilitation work is undertaken by Regional Management Maintenance Companies (RMMC)¹ and not by VNR itself.
- Major maintenance works are classified into track facility maintenance and ballast tamping.
- RMMC have their daily, monthly and annual track maintenance schedules to ensure safe train operation.
- Regarding existing track conditions in mountain tunnels, the rails and rail fastening system have rusted due to water leakage.
- A major problem for track maintenance is lack of standardization of track materials, some of which follow Chinese standards and others Russian and Austrian standards.
- Manual maintenance is carried out during dead periods between train operations, and the working time for maintenance by machine is about one hour per blocking section.
- Lack of budget is the main reason for insufficient maintenance.
- Almost all track maintenance is carried out manually; on the other hand, the changing of sleepers and tamping of ballast are carried out by tamping machines, namely, “Multiple Tie Tamperers.”
- VNR has four (4) sets of tamping machines made in Austria. One of the tamping machines is in ThanhHoa, which is located 175 km south of HaNoi. Another tamping machine which was made in China is small and uses gasoline for operation.

[Fig. 3-1-4] is a reference photograph of a tamping machine used by PNR (Philippine National Railways). The study team did not confirm the tamping machines in this study.



Source: Study team

[Fig.3-1-4] Multiple Tie Tamper of PNR

¹ Maintenance work for existing bridges and track is carried out by RMMC under the Department of Infrastructure Management of VNR directly. There are 11 RMMCs on the Hanoi - HCMC line. Each RMMC makes plans to require capital for railway infrastructure maintenance and repair and submits them to VNR for review and collection of funds. Then, VNR submits them to MOT, the State Planning Committee and MOF (hereinafter the Government) for approval. After approval, the Government allocates funds to VNR, which are raised from a general account and a certain percent of transportation tariffs once VNR has paid a so-called special-purpose tax. Then, VNR prepares a budget for RMMC, adding supplemental money out of its own business profit to the funds.

(5) Findings during the Site Survey

The existing track conditions observed during the site survey are as follows.

1) Rail and Sleepers

- Rail corrugation and rail defects were often found.
- Line alignment irregularities in terms of distance of rails and rail straightness were observed.
- The type of sleepers used varies, such as K1, K2, K3 and PC (pre-stressed concrete) types on the sections where the site survey was conducted. Recently, VNR has been replacing K1, K2 and K3 sleepers with PC sleepers. Refer to [Tab. 3-1-4] for all sleeper types.

Type K sleepers have a steel section connecting concrete blocks at both ends which is vulnerable to damage in train derailment accidents.

2) Roadbed

The roadbed type is basically ballast, and the ballast thickness is insufficient. The design standard requires 30 cm ballast thickness but the actual thickness is about 20 cm. Also, mud pumping was found at high groundwater locations.



Source: Study team

[Fig.3-1-5] Track Conditions at HaNoi Station



Source: Study team

[Fig.3-1-6] Track Conditions at GiapBat Freight Yard



Source: Study team

[Fig.3-1-7] Track Conditions at Level Crossing (10 k 400 m)



Source: Study team

[Fig.3-1-8] Track Conditions at ChoTia Station (25 k 500 m)



Source: Study team

[Fig.3-1-9] Track Conditions at 751 k 700 m



Source: Study team

[Fig.3-1-10] Track Conditions at KimLien Station (776 k 800 m)

3) Riding Comfort

Inspection by motorcar riding on the section between DaNang and Hue shows that riding comfort is not good with big rolling when entering curved sections. This is due to a lack of transition curves between curved sections and straight sections rather than unstable running due to centrifugal force caused by sharp curves. Transition curves need to be inserted to improve riding comfort as well as to ensure safe train operation together with curve radius extension for higher speed operation.

4) Weak Points of Tracks

The study team received a report of the weak points along the N-S Railway. This report indicates weak points with regard to flooding, landslides, road bed, etc. (see [Attachment 3-1-1]).

(3) Exemption

The main reason for insufficient maintenance, including alignment improvements such as sharp curves and transition curves, is shortage of budget, according to VNR. But this is an administrative issue within GOV for which a single project is not possible but for which a sector reform approach will be necessary.

In addition, track maintenance is a matter of daily management and alignment rectification involves substantial land acquisition, both of which do not fit with foreign assistance, including Japanese ODA.

In this context, it is proposed that the infrastructure component of alignment rectification shall be excluded from the prioritization exercise.

(4) Prioritization Criteria

For the purpose of increased train speed, VNR suggested expanding curve radii, but the problem with this approach is land acquisition. Therefore, the following steps are proposed as a way to cope with the improvement work for increasing train speed.

- Step 1: Improve track conditions by upgrading track maintenance frequency by deploying mechanized track maintenance measures in the first place.
- Step 2: Insert transition curves between round curves with a radius of less than 500m and straight sections with minimum scale of land acquisition.
- Step 3: Extend curve radii.

Although all the physical works in each step are to be carried out by VNR taking enough time, technical assistance on how to plan the magnitude of Step 1 will be necessary.

3.1.2 Bridge Components

(1) Total Picture

The total number of bridges between HaNoi and HCMC along the existing N-S Railway is 1,485 with a total length of 36.364 km. The list of rehabilitated bridges and those planned for rehabilitation, which was updated in this study, is shown in [Tab. 3-1-6].

[Tab. 3-1-6] Updated List of Bridges by Rehabilitation Status

Section		Hanoi - Vinh	Vinh - HCMC	Hanoi - HCMC		Note	
Rehabilitation is not required	Number of bridges	83	805	888			
	Total length (m)	2,354	27,731	30,085			
Under rehabilitation	Yen loan project	2	68	70	26	9	Completed by the year 2000 by railway bridges rehabilitation project (1)
						10	Completed by the year 2003 by railway bridges rehabilitation project (2)
						7	Completed by the year 2005 by railway bridges rehabilitation project (3)
					44	17	To be completed by 2015 by Bridge safety improvement project (I)
						27	To be completed by 2017 by Bridge safety improvement project (II)
						0	Bridge safety improvement project (III) is allocated to refill budget for the (I) and (II) projects
	Own finance (Rehabilitation of bridge L ≤ 50m until year 2000)	31	326	357		Completed by GOV own financing	
	Own finance (Weak bridges on Hanoi-Ho Chi Minh City route)	4	11	15		Progress of GOV own finance project will be monitored under the study	
	Own finance (Rehabilitation of bridge by development and investment fund)	0	13	13		Progress of GOV own finance project will be monitored under the study	
	Own finance (Stable railway infrastructure of Central Area from Quang Binh to Khanh Hoa)	0	14	14		Progress of GOV own finance project will be monitored under the study	
	Own finance (Major rehabilitation)	40	184	224		Progress of GOV own finance project will be monitored under the study	
	Own finance (Urgent Rehabilitation)	0	17	17		Progress of GOV own finance project will be monitored under the study	
	Bridges between Hanoi and Ngoc Hai is demolished because the section is elevated under the Yen loan project (Hanoi urban line No.1)	4	0	4		Under design stage	
Although they are under rehabilitation by 132 bridges rehabilitation project (MOT No.3303/Oct. 31, 2008), 54 bridges are expected to be not due to budget constrain	0	132	132	78	54	15	54 bridges were completed by the end of 2012
39						identical girders as Yen loan projects may be used due to high priority	
Sound		2	40	42		Expected to be financed by GOV but not budgetted yet so far	
Rehabilitation is required	Number of bridges	47	550	597	41	High priority	
					525	Small scale with less damage	
	Total length (m)	1,068	5,231	6,299			
Total number of bridges		130	1,355	1,485			

Source: Study team based on various raw data provided by VNR

In [Tab. 3-1-6], 132 bridges are under rehabilitation under the “132 Bridges Rehabilitation Project (MOT No. 3303/Oct. 31, 2008)” which is due for completion. However, 54 bridges are not expected to be completed due to budget constraints, of which 15 bridges are expecting Yen loan assistance for completion while the balance of 39 bridges are expecting financing from GOV which has not yet been confirmed.

(2) Information Supplied by VNR

1) Present Conditions of Groups of 41 Bridges and 132 Bridges

The bridges were sorted into the “41 bridges group” and the “132 bridges group” according to present conditions and structural data which were verified in the second field mission in May 2014. The detailed bridge conditions are listed in [Attachment 3-1-2].

2) Classification of Bridge Health

VNR has assessed bridge health and classified bridge conditions into A, B or C. The detailed information on these classifications given by VNR is as follows.

[Box. 3-1-1] VNR Comments on Bridge Health Classification

Regarding the current practice of classification of the technical condition of structures in VietNam, VNR doesn't follow the Japanese style of A (AA, A1, A2), B, C, and D specified by the Railway Technical Research Institute in which class A requires urgent repair work. Instead VNR assesses the priority of repair needs according to the present technical condition and construction documents. Therefore, the list of bridges that have been proposed for repair can be considered as having the classification A according to the Japanese standard.

On the other hand, the N-S Railway line was constructed based on various standards, including French, American, Chinese, Vietnamese, Japanese and Russian while VietNam mainly uses Russian and Chinese theories for calculation and design. Therefore, it cannot be synchronized. There are many structures from France and the US from during the recovery period after the war. Even though the structures have no damage or failure, they may not meet operational requirements due to the increased load and speed. They are included in the priority list.

The French standard is to run trains with a speed of less than 50 km/h. Currently, along the whole N-S Railway, there are three (3) types of load, as follows:

- On the HaNoi to Vinh section, the train load is 4.2 t/m
- On the Vinh to DaNang section, the train load is 4.1 t/m
- On the DaNang to SaiGon section, the train load is 3.6 t/m

Therefore, one of the main targets is to unify the train load into one in order to ensure efficient and safe train operation.

For reference, [Tab. 3-1-7] shows the classification of structure health assessment practiced in Japan.

[Tab. 3-1-7] Structure Health Classification in Japan

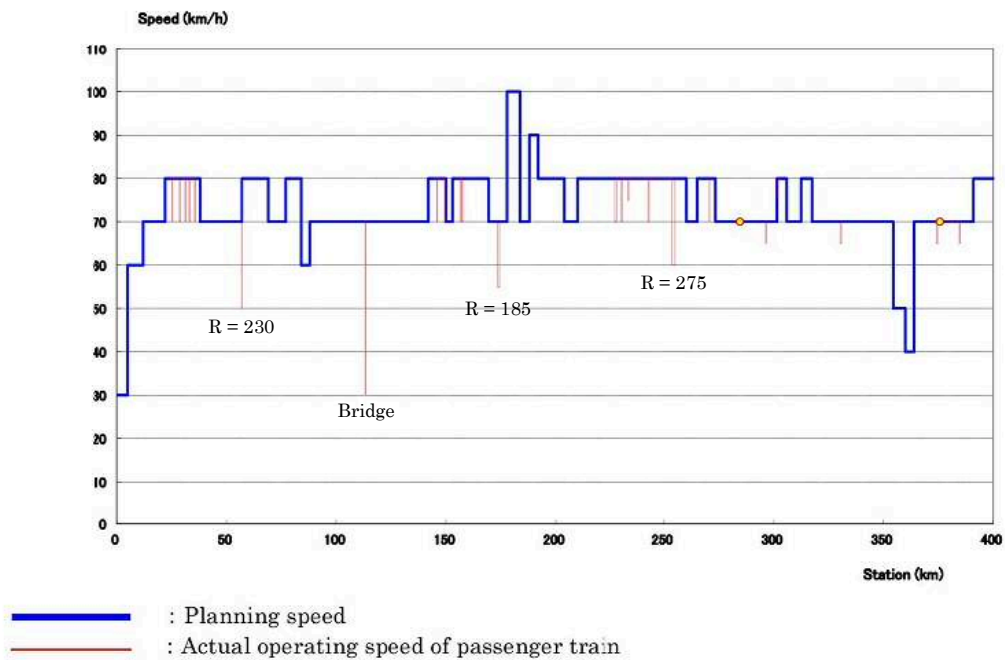
Soundness	Structure State
A	State that threatens operational safety, safety of passengers, public safety, guarantee of regular train operation, or deterioration that might cause this state
	AA Deterioration that threatens operational safety, safety of passengers, public safety, guarantee of regular train operation and which requires emergency countermeasures
	A1 Progressive deterioration that causes the performance of structures to drop, or heavy rain, floods, or earthquakes might impair the performance of the structure
	A2 Deterioration that might cause a future performance drop of the structure
B	Deterioration that might result in a future soundness rank of A
C	Slight deterioration
S	Sound

Note: Soundness ranks A1 and A2, and soundness ranks B, C and S may be categorized by individual railway operation in consideration of actual inspection circumstances.

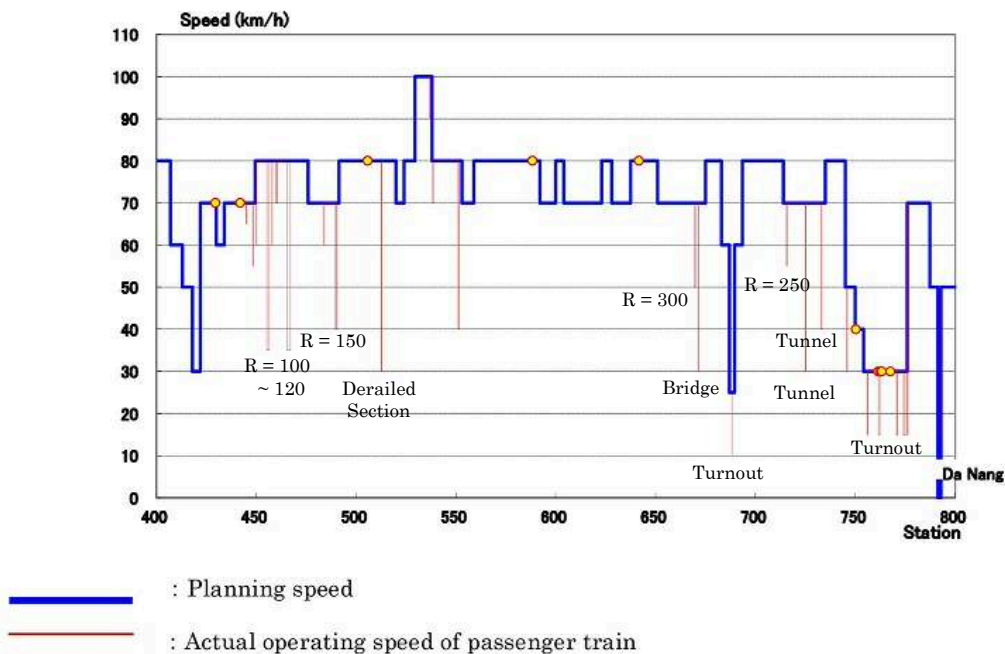
Source: Maintenance Standard for Railway Structures and Commentary
(Railway Technical Research Institute of Japan)

3) Actual Train Operation Speed

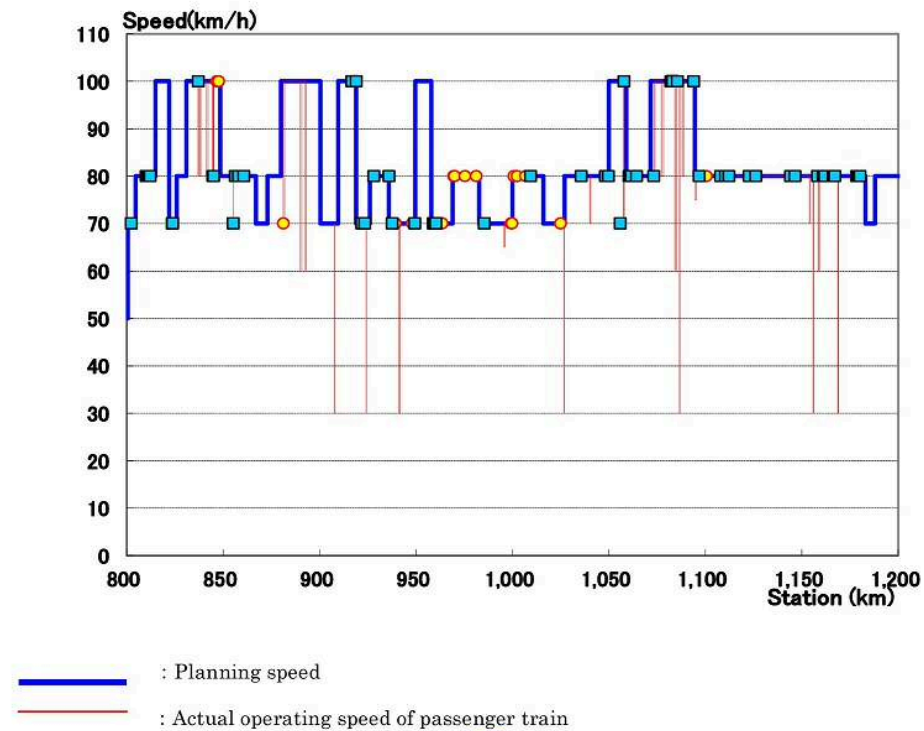
The actual passenger train and freight train speed on the existing N-S Railway line and the number of bridges where both passenger and freight train speed is restricted are shown below. These figures were created based on the Regulation on Operation Speed issued by VNR Decision dated April 8, 2014.



Source: Study team based on various raw data provided by VNR
[Fig. 3-1-11] Actual Operating Speed of Passenger Trains on the 0 km to 400 km section



Source: Study team based on various raw data provided by VNR
[Fig. 3-1-12] Actual Operating Speed of Passenger Trains on the 400 km to 800 km section

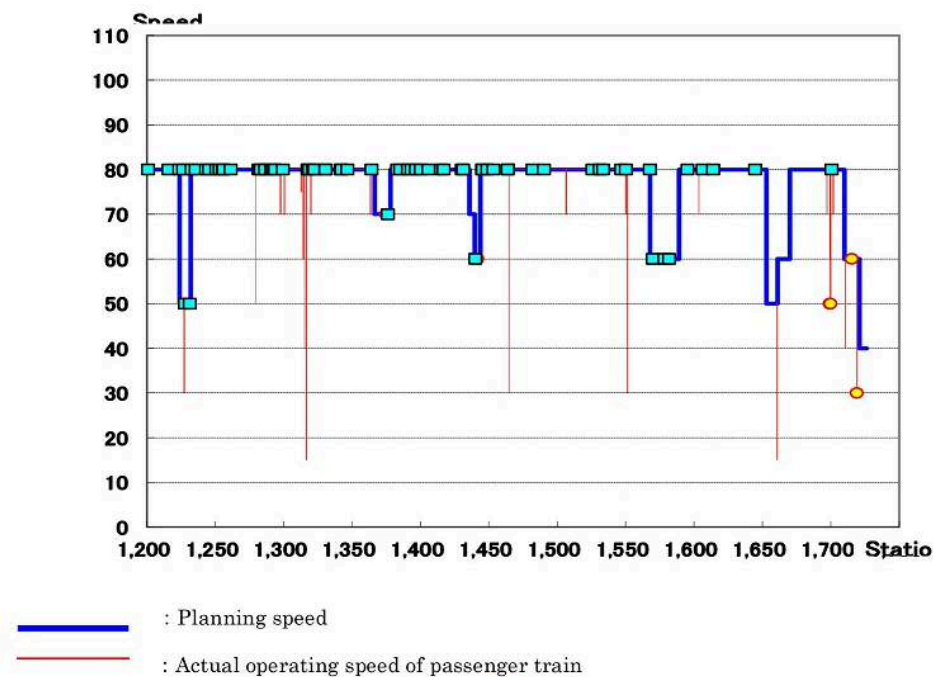


Number of the 41 group marked with ● is 21 (1 where speed is reduced)

Number of the 132 group marked with ■ is 64 (5 where speed is reduced)

Source: Study team based on various raw data provided by VNR

[Fig. 3-1-13] Actual Operating Speed of Passenger Trains on the 800 km to 1,200 km section

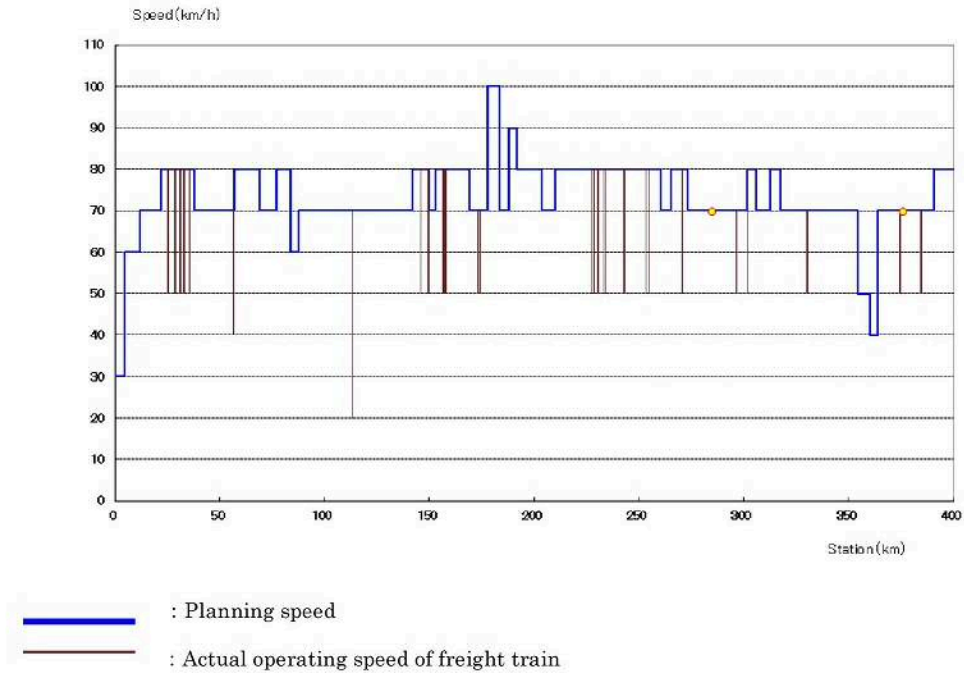


Number of the 41 group marked with ● is 16 (3 where speed is reduced)

Number of the 132 group marked with ■ is 68 (0 where speed is reduced)

Source: Study team based on various raw data provided by VNR

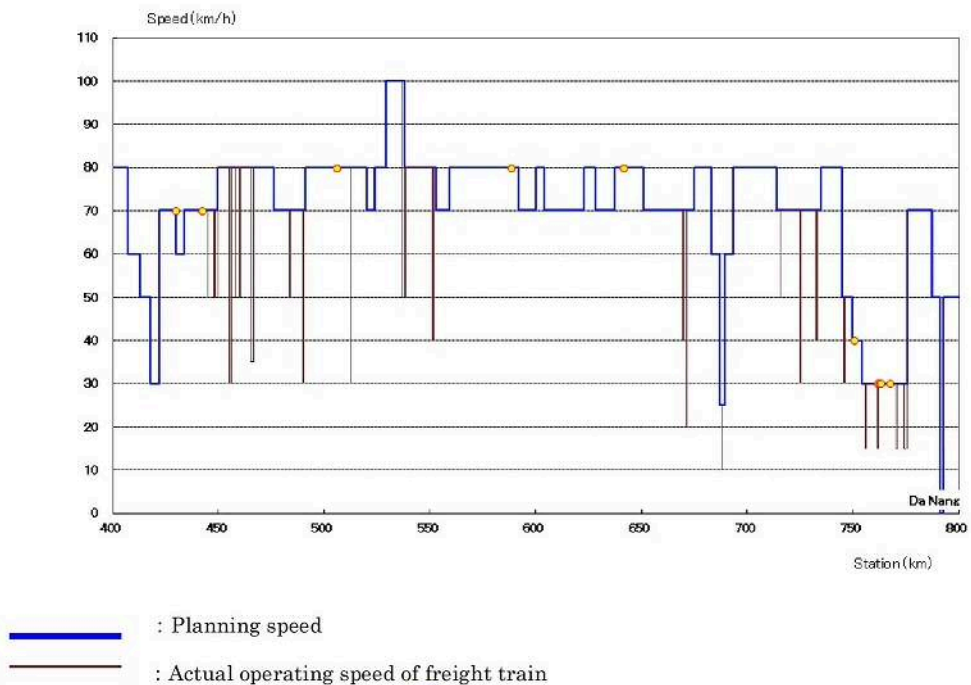
[Fig. 3-1-14] Actual Operating Speed of Passenger Trains on the 1,200 km to 1,726 km section



Number of the 41 group marked with is 2 (0 where speed is reduced)

Number of the 132 group marked with is 0

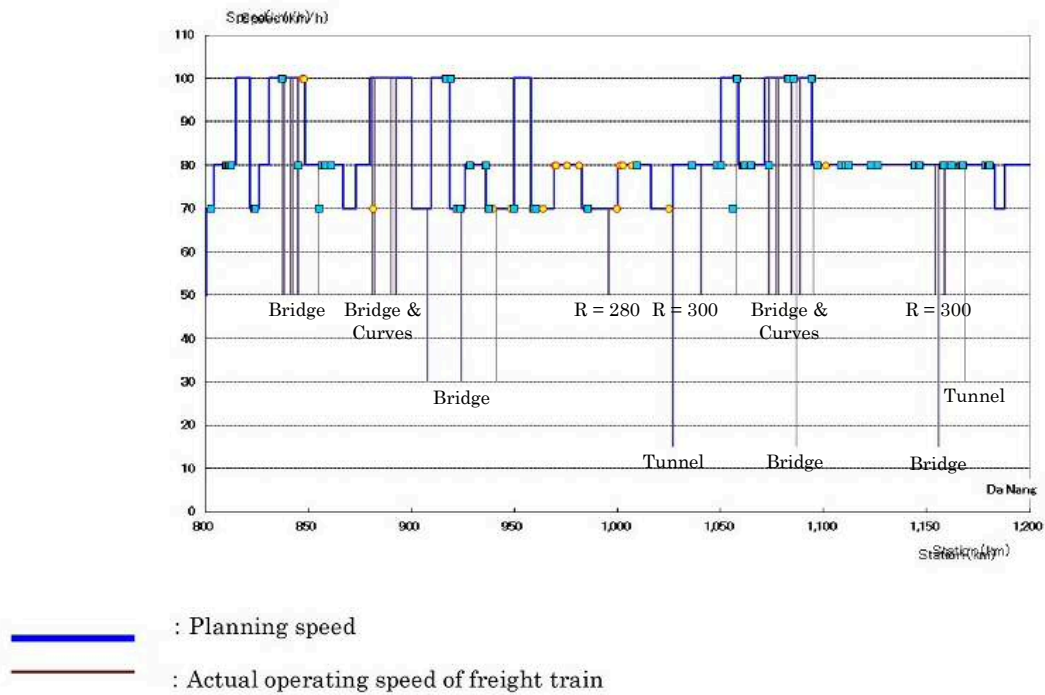
Source: Study team based on various raw data provided by VNR
 [Fig. 3-1-15] Actual Operating Speed of Freight Trains on the 0 km to 400 km section



Number of the 41 group marked with is 10 (0 where speed is reduced)

Number of the 132 group marked with is 0

Source: Study team based on various raw data provided by VNR
 [Fig. 3-1-16] Actual Operating Speed of Freight Trains on the 400 km to 800 km section

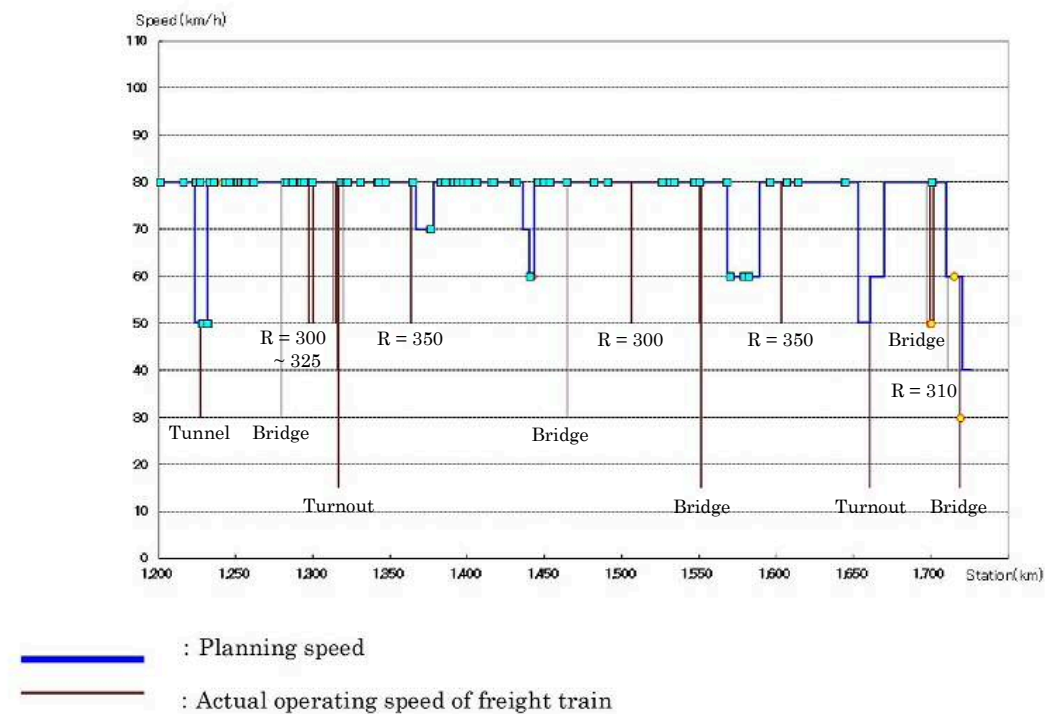


Number of the 41 group marked with ● is 21 (1 where speed is reduced)

Number of the 132 group marked with ■ is 64 (5 where speed is reduced)

Source: Study team based on various raw data provided by VNR

[Fig. 3-1-17] Actual Operating Speed of Freight Trains on the 800 km to 1,200 km section



Number of the 41 group marked with ● is 16 (3 where speed is reduced)

Number of the 132 group marked with ■ is 68 (0 where speed is reduced)

Source: Study team based on various raw data provided by VNR

[Fig. 3-1-18] Actual Operating Speed of Freight Trains on the 1,200 km to 1,726 km section

A detailed list of curves and operation speeds is included in [Attachment 3-1-3].

(3) Findings during the Site Survey

One truss bridge (at 750k350m) listed in [Tab. 3-1-19] was inspected by the study team during the first field survey on March 16, 2014. The structural conditions are as follows:

- Group Category: Listed in the 41 bridges group.
- Superstructure: Steel structure consisting of I section girders supporting a concrete slab.
- Foundation: Brick construction abutment.
- Piers: Brick construction plus reinforced concrete.
- General image: Refer to the following pictures.



Note: The pictures were taken on March 16, 2014.

Source: Study Team

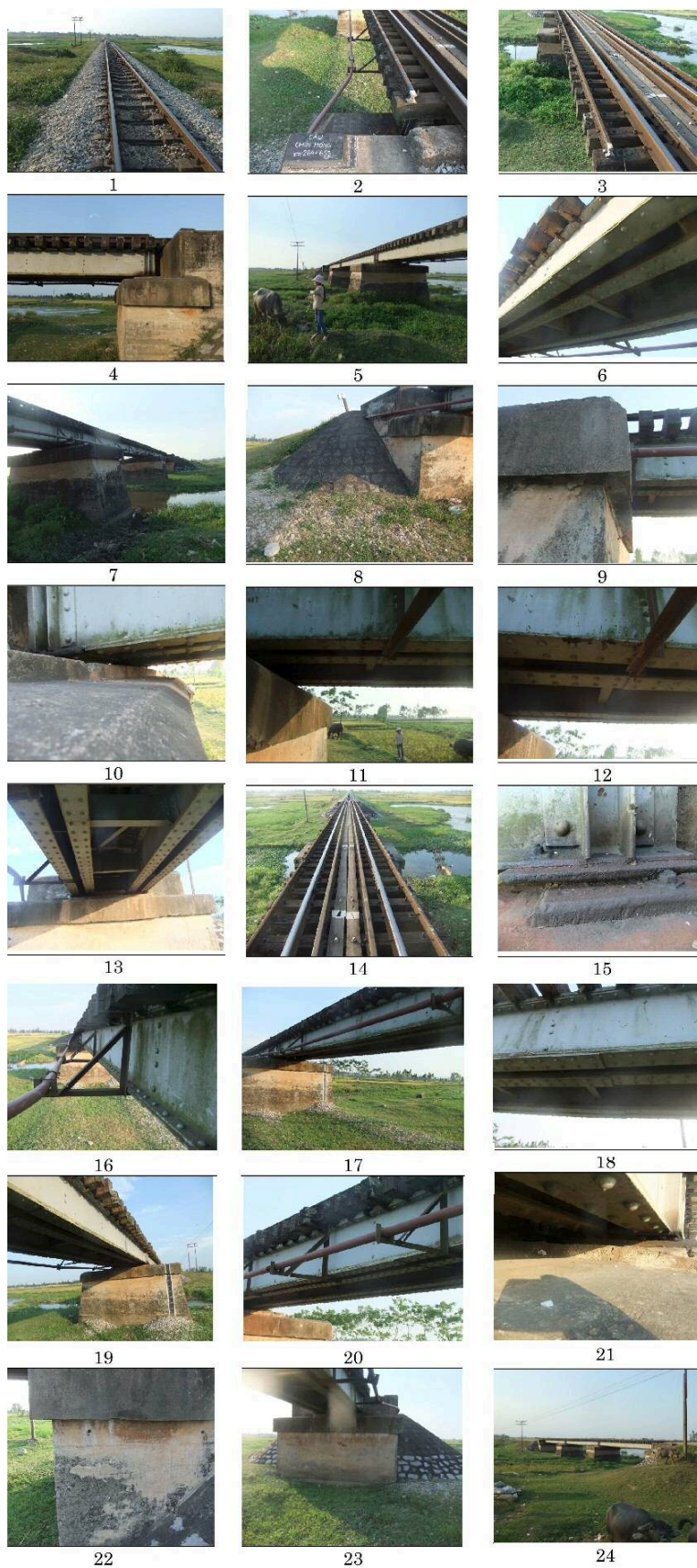
[Fig. 3-1-19] Bridge at 750k350m <No.8/41>

The findings on the bridge conditions are as follows:

- RC deck plate: Water leakage and efflorescence were found. There is high risk of deep penetration of cracks (refer to nos. 21 and 22)
- Main beam of girder: The girder is dangling due to dead load alone, which indicates insufficient girder stiffness (refer to nos. 9 and 10).
- Connection joint of girder: The lower flange of the main girder is not connected to the girder due to missing bolts (refer to nos. 17, 20 and 23).
- Transversal beam: The flange is missing (refer to no. 19).
- Foundation: Cracks are developing around the abutment (refer to nos. 5, 6, 7 and 8).
- Bearings: Degradation is progressing (refer to no. 16).

One steel girder bridge (at 284k655m) listed in [Tab. 3-1-20] was inspected by a civil expert of the study team during the second field survey on May 25, 2014. The structural conditions are as follows:

- Group Category: Listed in the 41 bridges group.
- Superstructure: Steel I-beam girder.
- Abutments: Concrete.
- Piers: Concrete.
- General image: Refer to the following pictures



Note: The pictures were taken on May 25, 2014.

Source: Study team

[Fig. 3-1-20] Bridge at 284k655m <No.1/41>

The findings on the bridge conditions are as follows:

- Main beam of girder: The girder is rusty due to lack of maintenance (refer to nos. 11, 12 and 16).
- Foundation: Degradation is progressing (refer to nos. 8, 9 and 22).
- Bearings: Degradation is progressing (refer to nos. 10 and 15).

The following bridges were not inspected this time, but photographs were supplied by TRICC for visual inspection for the study team to get a general idea of the damaged bridges.



Note: This bridge is listed in the 132 bridges group.

Source: TRICC

[Fig. 3-1-21] Bridge at 810k112m <No.3/132>



Note: This bridge is listed in the 132 bridges group.

Source: TRICC

[Fig. 3-1-22] Bridge at 810k112m <No.4/132>



Note: This bridge is listed in the 132 bridges group.

Source: TRICC

[Fig. 3-1-23] Bridge at 811k595m <No.5/132>



Note: This bridge is listed in the 132 bridges group.
Source: TRICC
[Fig. 3-1-24] Bridge at 812k168m <No.6/132>



Note: This bridge is listed in the 132 bridges group.
Source: TRICC
[Fig. 3-1-25] Bridge at 856k472m <No.14/132>



Note: This bridge is listed in the 132 bridges group.
Source: TRICC
[Fig. 3-1-26] Bridge at 858k041m <No.15/132>



Note: This bridge is listed in the 132 bridges group.

Source: TRICC

[Fig. 3-1-27] Bridge at 860k799m <No.16/132>



Note: This bridge is listed in the 41 bridges group.

Source: TRICC

[Fig. 3-1-28] Bridge at 847 k 779 m <No.10/41>



Note: This bridge is listed in the 41 bridges group.

Source: TRICC

[Fig. 3-1-29] Bridge at 939k419m <No.12/41>



Note: This bridge is listed in the 41 bridges group.

Source: TRICC

[Fig. 3-1-30] Bridge at 948k105m <No.13/41>



Note: This bridge is listed in the 41 bridges group.

Source: TRICC

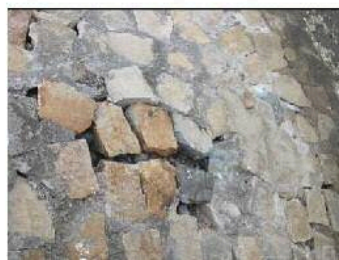
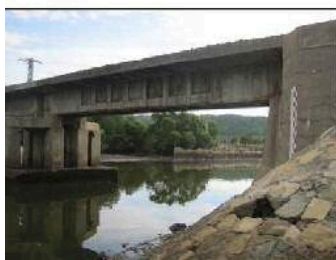
[Fig. 3-1-31] Bridge at 963k650m <No.14/41>



Note: This bridge is listed in the 41 bridges group.

Source: TRICC

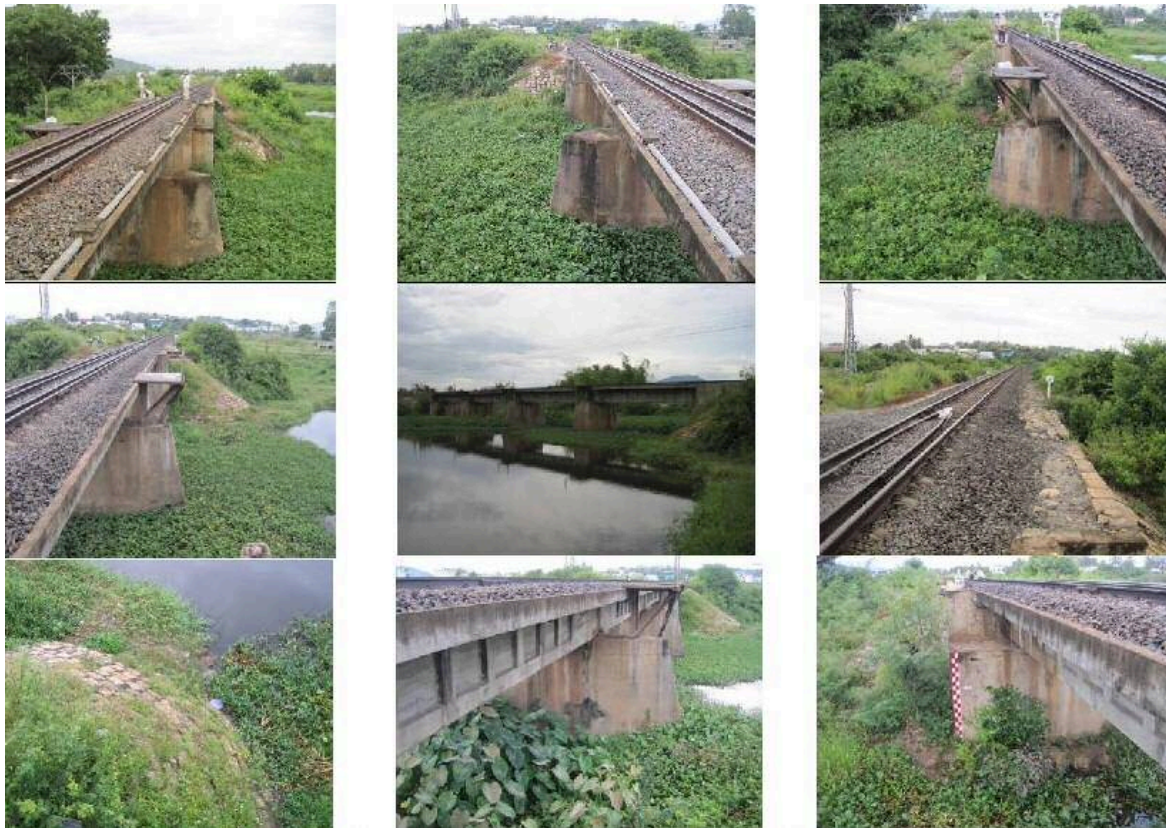
[Fig. 3-1-32] Bridge at 975k380m <No.17/41>



Note: This bridge is listed in the 132 bridges group.
This picture was taken in September 2010.

Source: TRICC

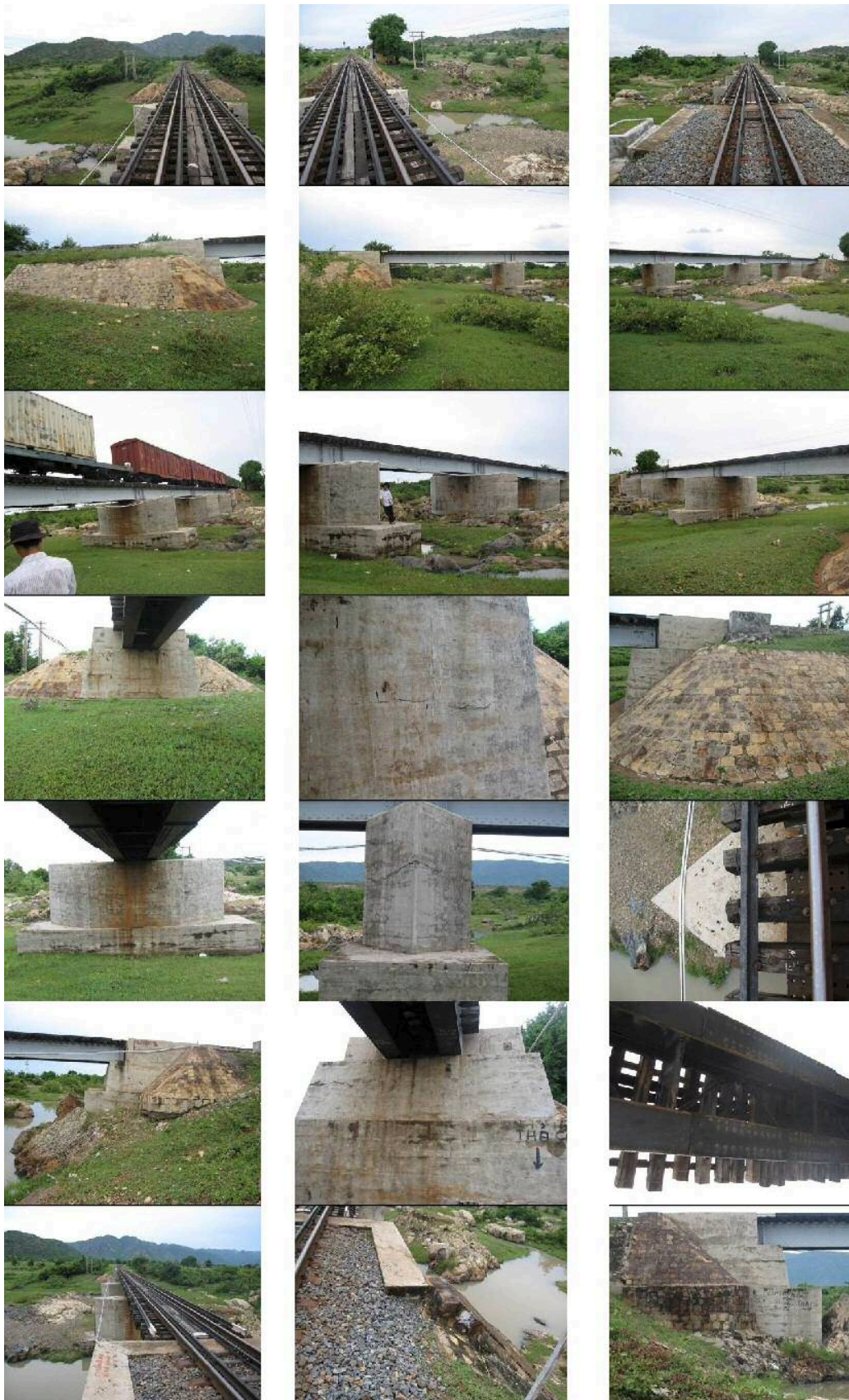
[Fig. 3-1-33] Bridge at 1,292k192m



Note: This bridge is listed in the 132 bridges group.
This picture was taken in September 2010.

Source: TRICC

[Fig. 3-1-34] Bridge at 1,317k936m <No.13/132>



Note: This bridge is listed in the 132 bridges group.
This picture was taken in September 2010.

Source: TRICC

[Fig. 3-1-35] Bridge at 1,453k484m <No.14/132>



Note: This bridge is listed in the 132 bridges group.
This picture was taken in September 2010.

Source: TRICC

[Fig. 3-1-36] Bridge at 1,531k123m <No.15/132>

The study team members also took the following bridge photographs when they visited HCMC on May 14, 2014.



Note: This bridge is listed in the 41 bridges group.

Source: Study Team

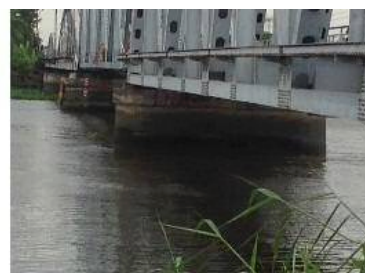
[Fig. 3-1-37] Bridge at 1,699k245m <No.40/41>



Note: This bridge is listed in the 41 bridges group.

Source: Study Team

[Fig. 3-1-38] Bridge at 1,699k806m <No.41/41>



Note: This bridge is listed in the 41 bridges group.

Source: Study Team

[Fig. 3-1-39] Bridge at 1,717k089m

(4) Exemption

It is specified by JICA to carry out the study based on documented information alone. Responsible evaluation and taking site conditions into consideration by visiting all bridge sites is not possible in the limited time frame of this study period.

The first screening method is described in section 6.1.1 and 6.2.

3.1.3 Tunnel Component other than HaiVan Tunnel

(1) Present condition of tunnels on the N-S Railway

About 100 years have passed since completion of all tunnels on the existing N-S Railway by France. Most of these tunnels have horizontal alignment with a small curve radius; especially the alignments on the HaiVan pass section are smaller than any alignments on other sections. The problem with the present condition of tunnels is that there is a large amount of water leakage and significant crack development at arches and side wall faces in tunnels. For that reason, all trains run at a restricted speed in these tunnels (refer to [Tab. 3-1-11]).

The tunnels on the existing N-S Railway are located in the Central section between Vinh and NhaTrang and not on the North and South sections as shown in [Tab. 3-1-8] and the total number of the tunnels is twenty seven (27) with a total length of 8.4 km.

The total tunnel length ratio against total structure length is only 0.5% in which the highest density section of tunnel length is found on the Hue-DaNang section with a ratio of 3.2 %. [Tab. 3-1-8] shows the number and accumulated length of tunnels by section between major stations.

[Tab. 3-1-8] Number of Tunnels and Total Length between Major Stations

Section		North		Central			South		Total
		HaNoi - ThanHoa	ThanHoa - 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	1,726.2
Tunnel	Number	0	0	5	9	13	0	0	27
	Length (km) & Ratio	0	0	0.7 (0.2%)	3.3 (3.2%)	4.4 (0.8%)	0	0	8.4 (0.5%)

Source: Final Report on Study for the Formation of HSR Projects, JICA, June 2013

(2) Major Bottleneck Sections and Recommendations for Improvement

Major bottleneck sections mentioned by VNR on the present condition are the sections between HoaDuyet and ThanhLuyen, the KheNet pass section, and the HaiVan pass section. VNR has drafted a series of pre-F/S reports to improve the alignment by constructing new tunnels. The pre-F/S reports include the HoaDuyet – ThaLayen section to be budgeted by own financing. The KheNet pass section is planned to be financed by China. The HaiVan pass section is planned to receive a Japanese ODA Yen loan. These are shown in the draft report on “Detailed Modernization Plan (DMP) for the North-South Railway” compiled by VNR in 2013. Here, VNR is expecting Japan to conduct an F/S for the HaiVan tunnel. The general features of the major bottlenecks on each section are shown in [Tab. 3-1-9].

[Tab. 3-1-9] Numbers and Total Length between Major Bottlenecks

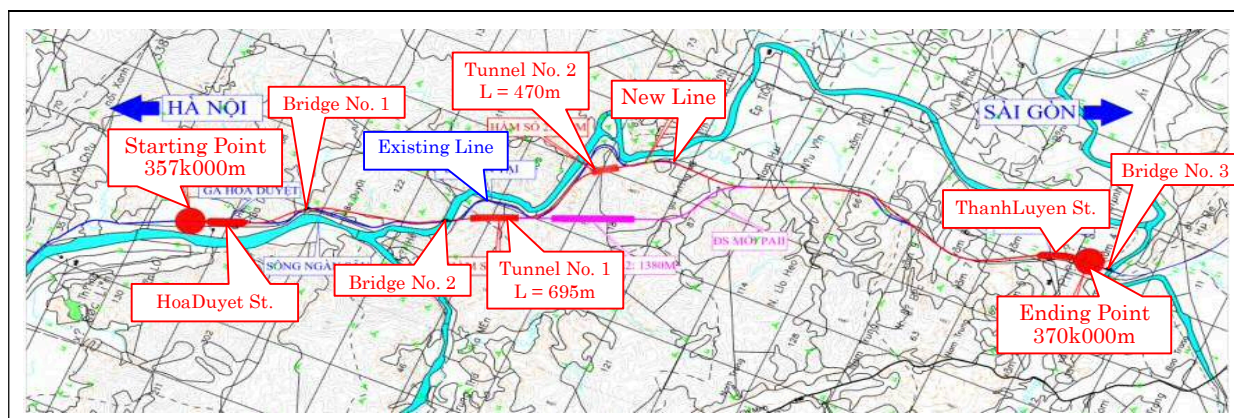
Section	HoaDuyet – ThanhLuyen section < Vinh – Hue >	KheNet pass section (DongChuoi St. – KimLu St.) < Vinh – Hue >	HaiVan pass section (LangCo St. – KimLien St.) < Hue – DaNang >
Total length	11.6 km	11.0 km	21.5 km
Number of curves with radius of $R \leq 500\text{m}$	18 / 27 (66.7 %)	31 / 33 (93.9 %)	127 / 133 (95.4 %)
Number of curves with radius of $R \leq 300\text{m}$	12 / 27 (44.4 %)	24 / 33 (72.7 %)	124 / 133 (93.2 %)
Minimum curve radius	138 m	125 m	97 m
Steepest gradient (‰)	6 ‰	17 ‰	17 ‰
Minimum travel time	14 minutes	18 minutes	52 minutes
Average running speed	49.7 km/h	36.7 km/h	24.8 km/h

Source: Study team based on various raw data provided by VNR

(3) Recommendations for Improvement of the HoaDuyet and ThanhLuyen Section

1) Short-cut Tunnel Construction

[Fig. 3-1-40] shows the proposed alignment between the HoaDuyet and ThanhLuyen section by short-cut tunnel construction.



Note: The red line shows the adopted plan, and the pink line shows an alternative plan.

Source: Draft DMP for N-S Railway prepared by TRICC

[Fig. 3-1-40] Proposed New alignment by Short-cut Tunnel

2) General Features of the New Tunnel

The general features of the proposed new tunnel in terms of volume and rough cost estimate are shown in [Tab. 3-1-10].

[Tab. 3-1-10] General Features of Tunnel between HoaDuyet – ThanhLuyen Section

No.	Item	Unit	Volume
1	Improvement of old line	km	4.719
2	Construction of new line	km	4.790
3	Number of station improvement	stations	2
4	Construction of new bridges	bridges / m	3 / 326
5	Construction of new tunnels	tunnels / m	2 / 1,070
6	Construction of new culverts	units	29

Note: The total cost is roughly estimated to be USD 53.71million.

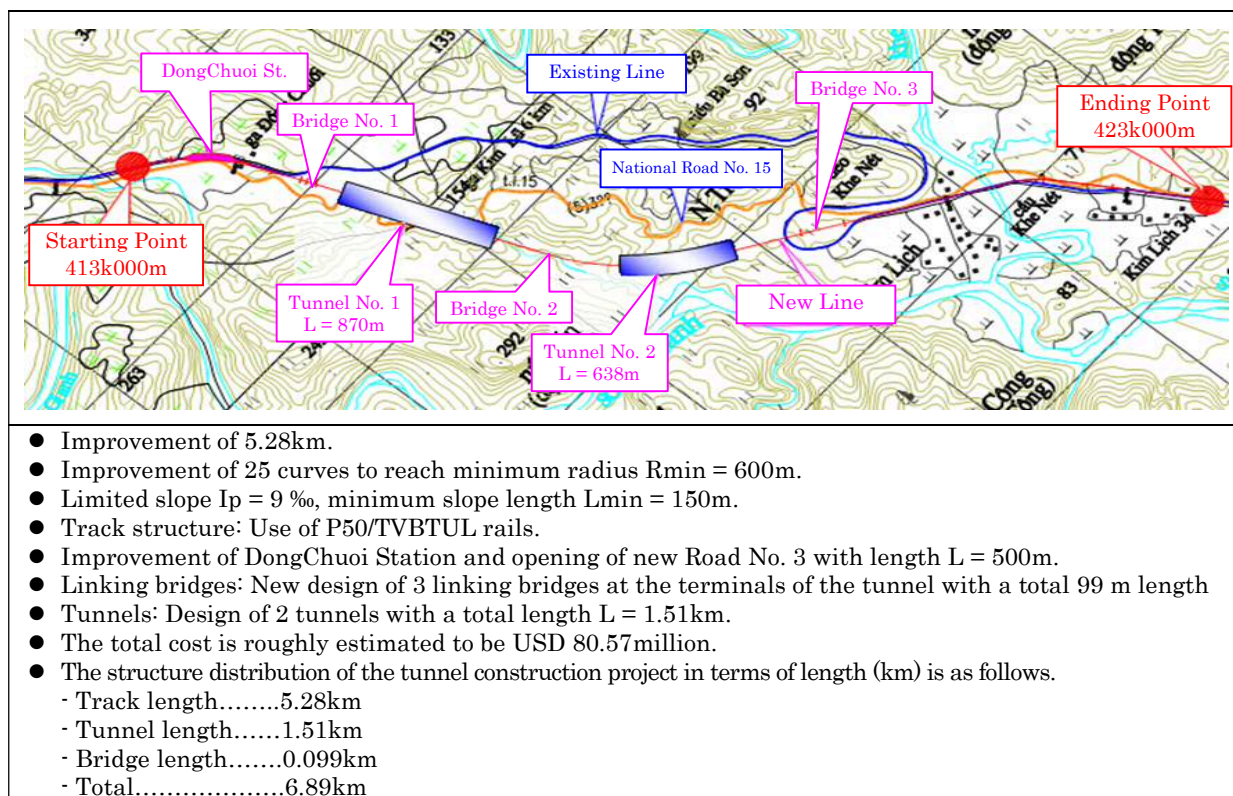
Source: Draft DMP for N-S Railway prepared by TRICC

Construction items are summarized as follows.

- Renovation of 12.344km of track including 4.719km upgrading and improvement work and 4.790km of new line construction.
- Renovation of HoaDuyet station with 950m in length and renovation of ThanhLuyen station with 779m in length.
- Improvement and construction of three (3) bridges with total length of 326m.
- Construction of two (2) new tunnels with a total length of 1,070m.
- Construction of twenty-nine (29) new and connecting culverts.
- Renovation and construction of new digital optical fiber cable layout, semi-automatic road closure signals, and centralized electrification. Improvement of utility architecture system of the two synchronized stations.
- The total cost is roughly estimated to be USD 53.71 million.

(4) General Features of the Proposed KheNet Tunnel

[Fig. 3-1-41] shows the proposed new alignment by new tunnel construction in terms of construction items, volume, and rough cost estimate.



Source: Draft DMP for N-S Railway prepared by TRICC

[Fig. 3-1-41] Proposed New alignment of Proposed KheNet Tunnel

(5)Present Conditions

1) Present Conditions by Tunnel and Improvement Plan

[Tab. 3-1-11] shows the present conditions of the tunnels in terms of mileage of each tunnel, length with alignment features, restricted train speed, planed maximum train speed, etc. The data is from the year 2013.

[Tab. 3-1-11] Present Situation of All 27 Tunnels on the N-S Railway Line

No.	Name of Tunnel	Kilometerage of Center of Tunnel	Length (m)	Curve Radius (m)	Gradient (%)	Restricted Speed in 2014 ¹⁾ (km/h)		Max. Speed on Section in 2014 (km/h)	Max. Speed in Tunnel after Improvement (km/h)	Progress of Recon-struction as of April 2014
						P ²⁾	F ²⁾			
1	Tunnel No. 1	455k432m	63.77	245	1.7	35	30	80	60	
2	Tunnel No. 2	455k765m	250.06	154	1.5, 0.7	35	30	80	50	
3	Tunnel No. 3	456k245m	114.46	120	0.9, 1.0	35	30	80	50	
4	Tunnel No. 4	466k255m	100.84	130.5	1.5, 1.13	35		80	45	
5	Tunnel No. 5	466k496m	193.44	Straight	1.35	35		80	45	
Subtotal (Vinh ~ Hue)			722.57							
6	Tunnel No. 6	725k210m	220.72	350, 400	0.47, 1.1	30		70	50	
7	Tunnel No. 7	732k815m	344.00	505	4.14, 4.54	40		70	-	Done
8	Tunnel No. 8	746k135m	445.00	510	4.39, 5.93	-	30	50	-	Done
9	Tunnel No. 9	757k285m	169.40	100	13.0, 17.0	-		30	-	Done
10	Tunnel No. 10	757k841m	124.20	200	15.0	-		30	-	Done
11	Tunnel No. 11	759k513m	129.04	100	15.0	-		30	30	
12	Tunnel No. 12	766k049m	564.17	Straight	15.3, 12.3	-		30	30	
13	Tunnel No. 13	770k663m	325.70	Straight	14.0, 17.0	-		30	-	Done
14	Tunnel No. 14	774k674m	944.62	98, 1,400	15.3, 14.9	-	15	30	30	
Subtotal (Hue ~ Da Nang)			3,266.85							
			HaiVan Pass Section							
15	Binh De	998k399m	273.39	300	6.3	-		70	90	
16	PhU Cu	1,023k833m	170.18	400	7.0, 8.0	30	15	70	70	
17	Chi Thanh	1,168k704m	325.00	800	8.0, 3.2	30		80	90	
18	Babonneau	1,224k816m	1,198.20	420	3.8, 2.0	-		50	50	
19	Vung Ro 4	1,227k120m	371.23	500	0.3	30		50	50	
20	Vung Ro 3	1,228k115m	159.46	700	3.8, 5.3	-		50	50	
21	Vung Ro 2	1,228k702m	249.99	500	1.6, 1.0	-		50	50	
22	Vung Ro 1	1,229k252m	60.39	Straight	7.8	-		50	50	
23	Bai Gio	1,231k188m	402.58	350	8.7, 7.1	-		50	50	
24	Co Ma	1,234k464m	407.30	502	3.5, 4.5	-		80	90	
25	Ro Tuong	1,290k277m	219.03	Straight	1.0,4.6	-		80	90	
26	Ru Ri	1,306k740m	517.96	500, 800	8.5, 7.9	-		80	90	
27	Ngoc Hoi	1,310k888m	76.25	400	1.9	-		80	90	
Subtotal (DaNang ~ NhaTrang)			4,430.96							
Total			8,420.38							

Note: 1) “-” shows that the operation speed of the tunnel section is not restricted.

2) The “P” and “F” columns show the restricted speed for passenger and freight trains respectively.

Source: Study team based on various raw data provided by VNR

Five (5) tunnels were improved/ renovated in 1998 with French technology and funding. No other tunnels have been improved/ renovated/ reconstructed on the section between Hue and DaNang. Sections for tunnel renovation are included in [Tab. 3-1-11]. The total length of the renovated tunnels is 1.4 km.

The number of the balance of tunnels for which improvement work has not been carried out of the total number of tunnels is twenty-two (22) with a total length of 7.0 km in which the number between Hue and Da Nang section is four (4) with a total length of 1.86km as shown in [Tab. 3-1-12].

Train speed is restricted in the twenty-two (22) tunnels because there is a large amount of water leakage and a lot of crack development and expansion on the tunnel walls. Almost all trains are running with restricted speed of about below half the

planned maximum speed.

[Tab. 3-1-12] Tunnels between Hue and DaNang Section without Reconstructed Tunnels

No.	Name of Tunnel	Kilometerage of Center of Tunnel	Length of Tunnel	Restricted Speed in 2014 (km/h)		Max. Speed on Section in 2014 (km/h)
				Passenger	Freight	
6	Tunnel No. 6	725k210m	220.72 m	30		70
11	Tunnel No. 11	759k513m	129.04 m	–		30
12	Tunnel No. 12	766k049m	564.17 m	–		30
14	Tunnel No. 14	774k674m	944.62 m	–	15	30
Total between Hue – DaNang			1,858.55 m	–		–
Total of 22 Tunnels			7,012.62 m	–		–

Source: Study team based on various raw data provided by VNR

2) Funding Scheme for the Improvement Work

The funding for the improvement work is basically to be appropriated by the GOV's own funds, but due to budget constraints foreign funding is an option as far as the HaiVan tunnel project is concerned. The F/S for the improvement of these tunnels was conducted by VNR with its own funds and completed by the end of March 2014.

3) Unit Cost Estimation

The rough cost for the twenty-two (22) tunnels is calculated to be 135.32 million USD for the total length of 6,981 m as shown in [Tab. 3-1-13] according to the “Detailed Modernization Planning (DMP) for the North-South Railway (2014)” of VNR. It says that the average unit cost per kilometer by simple calculation is 19.4million USD/km. This unit cost is assumed to be estimated based on conventional mountain tunneling method of NATM with all face excavation. This means that the unit cost may be new construction cost instead of improvement work cost.

Besides, assuming that this cost is for new construction, this unit cost of 19.4million USD/km is evaluated to be too expensive for single track cross section tunnel of 32m² based on the fact that the unit cost of Japanese HSR tunnel for double track with 64m² cross section with the all face excavation method is about 20.0 million USD/km and that the unit cost of the new HaiVan road tunnel with the all face excavation method is about 8.5million USD/km although the cross sectional size is different from railway tunnels. Taking these factors into consideration, it is assumed that the fare unit cost may be 4 to 5million USD/km for single track tunnel new construction.

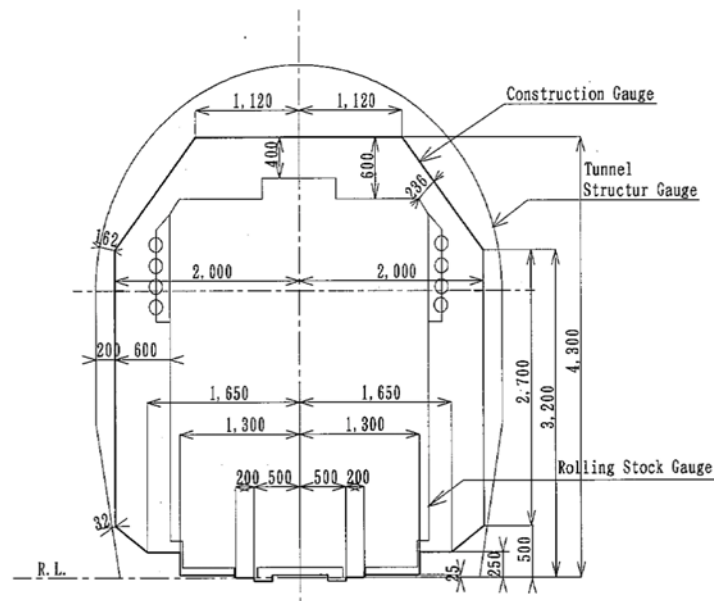
[Tab. 3-1-13] Reconstruction Cost of Tunnels

No.	Section	Number of tunnels	Reconstruction length (m)	Cost (million USD)	Unit cost (mln. USD/km)
1	Vinh – DongHoi	5	693.0	13.43	19.4
2	DongHoi – DaNang	4	1,892.9	36.69	19.4
3	DaNang – DieuTri	2	440.0	8.53	19.4
4	DieuTri – NhaTrang	11	3,955.2	76.67	19.4
Total		22	6,981.1	135.32	19.4

Source: Draft DMP for N-S Railway prepared by TRICC

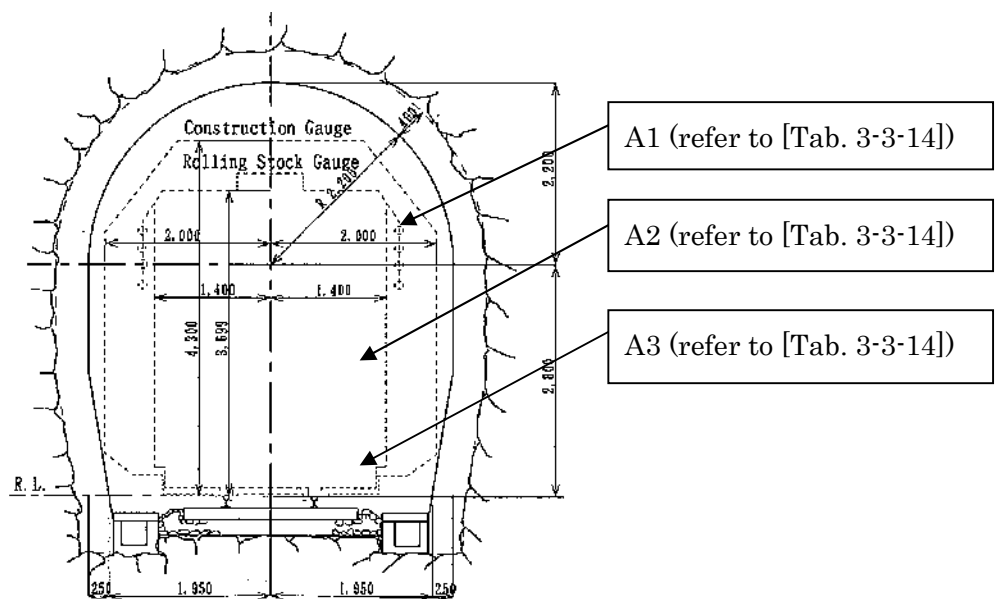
4) Working Plan

[Fig. 3-1-42] shows the rolling stock gauge and construction gauge of a single track tunnel specified by VNR and [Fig. 3-1-43] shows the actual excavation cross section which complies with the gauge specification.



Source: VNR

[Fig. 3-1-42] Rolling-stock Gauge and Construction Gauge of VNR



Source: VNR

[Fig. 3-1-43] Tunnel Excavation Cross Section

[Tab. 3-1-14] shows an area size calculation breakdown of the inner area and excavation area of tunnels on the existing railway line.

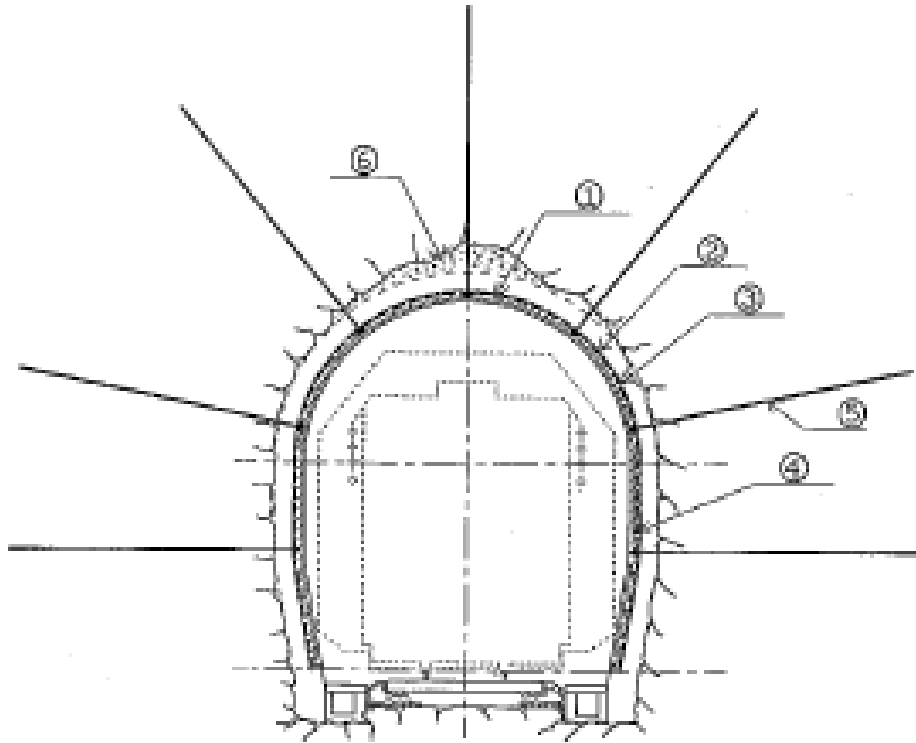
[Tab. 3-1-14] Tunnel Area Calculation

Area	Inner area of existing tunnel (m ²)	Excavation area of existing tunnel (m ²)
A1	$2.2 \times 2.2 \times 3.14 = 15.2$	$2.6 \times 2.6 \times 3.14 = 18.1$
A2	$(2.2 + 2.2) \times 1.28 = 5.6$	$(2.6 + 2.6) \times 1.28 = 6.1$
A3	$(2.2 + 2.2 + 3.9) \times 1.52 / 2 = 6.3$	$(2.4 + 2.4 + 3.9) \times 1.52 / 2 = 6.3$
Total	27.1	30.5

Source: Study team

The “reconstruction” schematic chart based on the “National Railway Construction Standard” of VNR established in July 2007 for one meter gauge of third class standard

which shall be applied to the N-S Railway is shown in [Fig.3-1-44]. Reconstruction here refers to improvement work instead of new construction.



Source: VNR

[Fig. 3-1-44] Reconstruction Schematic Cross Section of Tunnel

5) Standard Procedure for Tunnel Improvement Work

The standard procedure for tunnel improvement work is shown below.

- Chipping of concrete lining ($t = 15\text{cm}$)
- Erection of supporting steel ($H = 100$ with interval of 1.0m)
- Lining with wire mesh
- Spraying of concrete ($t = 15\text{cm}$)
- Placing of rock bolts ($\phi 25\text{mm}$ and $L = 4\text{m}$ with 7 bolts/section)
- Backfilling of crown with aerated mortar

[Fig.3-1-45] shows a sample image of an existing railway tunnel and that of a newly designed (rehabilitated or improved) railway section.

1. Sample image of the existing railway before improvement



2. Sample image of rehabilitated or improved tunnel on the existing railway



Source: Study team

[Fig. 3-1-45] Sample Images of Old and New Tunnels

(6) Exemption

VNR has a plan to improve the twenty-two (22) tunnels mentioned above. According to a meeting with VNR, foreign assistance is an option for the improvement work funding in the same way as for the new HaiVan tunnel project.

The total cost for the twenty-two (22) tunnels is estimated to be 135.32 million USD which amounts to nearly equal the cost of 7 km of new tunnel construction of Japanese HSR tunnel in sound rock. However, since the estimated cost is assumed to be for new construction instead of improvement work, it is necessary to recalculate the improvement cost.

As for the question which of the total twenty-two (22) tunnels are exempted from the prioritization process, all of them should not be exempted because the prioritization procedure is not complicated as long as travel time saving amount and unit cost (new construction and improvement) are available. In addition, the risk factor for natural disasters is incorporated as requested by VNR.

(7) Prioritization Criteria

Prioritization is basically made based on cost effectiveness and taking the risk factor of natural disasters into consideration. However, the scale of the study doesn't allow for visits to all tunnels, evaluation of present conditions including the urgency to natural disaster prevention, and making of a comprehensive comparison study among other infrastructure including bridges, earthwork, and track.

As an alternative, it is proposed to select tunnels on sections where the transportation

volume and traveling time loss are large, and track capacity is small such as the Vinh – Hue, Hue – DaNang, DaNang – NhaTrang sections taking the acceptability of Japanese ODA into consideration. The cost will be calculated by unit costs and tunnel size as shown in [Tab.3-1-14].

3.1.4 Rolling Stock and Operation Plan

(1) Rolling Stock

1) Locomotives

Six (6) types of locomotives are currently operated on the N-S Railway as shown in [Fig. 3-1-46] and [Tab. 3-1-15].



D9E



D11H



D12E



D13E



D19E



D20E

Source: VNR

[Fig. 3-1-46] Locomotives Operated on the N-S Railway

[Tab. 3-1-15] Technical Data of Locomotives Operated on the N-S Railway

No	Type of locomotive	Made in	Length (m)	Power capacity (HP)	Weight (ton)	Axle Load (ton)	Max speed (km/h)	Operation section	Fuel tank capacity (lit)	Quantity
1	D9E	USA	11.64	900	52	13 (4axle)	114	All sections	2200	33
2	D11H	Rumania	14	1100	56	14 (4axle)	100	DongHoi – DieuTri	2200	23
3	D12E	Czech Republic	13.3	1000	56	14 (4axle)	80	DongHoi – DieuTri	2200	40
4	D13E	India	14.3	1300	72	12 (6axle)	96	HCMC – DieuTri HaNoi – DaNang	3000	24
5	D19E	China	17.18	1900	81	13.5(6axle)	120	HaNoi – DongHoi HCMC – DieuTri	3000	60
6	D20E	Germany	19.18	2000	81	13.5 (6axle)	120	DongHoi – DieuTri	3500	16

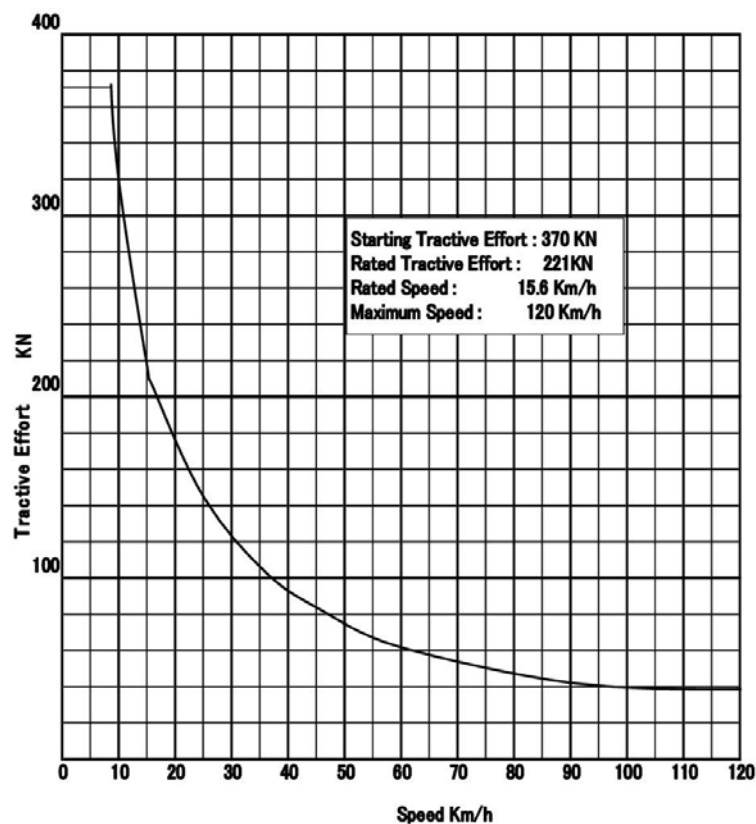
Source: VNR

The main locomotive in use is the D19E type diesel-electric locomotive made in China which has a power output of 1,900 HP.

The most powerful locomotive used by VNR is the D20E type diesel-electric locomotive made in Germany which has a power output of 2,000 HP. The D20E locomotive is used on the DongHoi – DieuTri section where the HaiVan pass is also located.

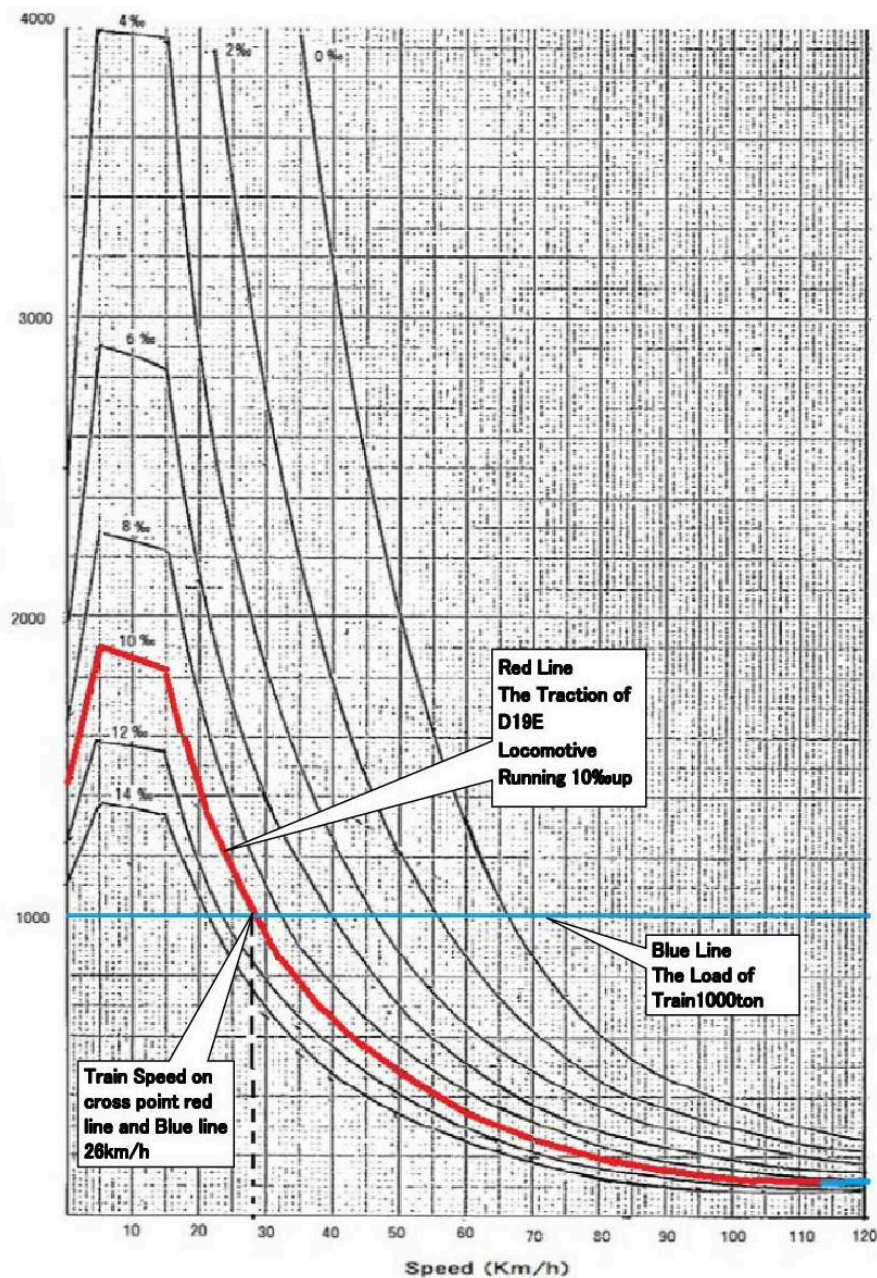
The power output of the other four (4) locomotive types is low, and there are concerns that this might prevent the increase in transportation capacity of the N-S Railway.

The tractive effort curve and load curve of the D19E type locomotive, the main locomotive operated on the N-S Railway, are shown in [Fig. 3-1-47] and [Fig. 3-1-48].



Source: VNR

[Fig. 3-1-47] Tractive Effort Curve of D19E Locomotive



Source: VNR

[Fig. 3-1-48] Load Curve of D19E Locomotive

The rated speed (permissible speed) of the D19E locomotive is 15.6 km/h according to the tractive effort curve shown in [Fig. 3-1-47]. The equilibrium speed is around 28km/h when the D19E locomotive is hauling a 1,000 ton load and is climbing a 10 % slope as shown in [Fig. 3-1-48].

Based on the above two (2) curves, it seems that the maximum gradient which the D19E locomotive can climb when hauling a 1,000 ton train is 17 %.

There are many sharp curves and gradients over 10 % on the N-S Railway.

In order to increase the transportation capacity of the N-S Railway, it is necessary to introduce more powerful locomotives with a power output higher than that of the D19E locomotive, and to improve the efficiency of locomotive operation.

2) Coaches

VNR possesses many different types of coaches. The typical coaches operated on the N-S Railway are shown in [Fig. 3-1-49].



Soft Seat Sleeper



Soft Seat Sleeper



Soft Seat Coach A



Restaurant Car HC

No	Type of Coach		Weight (ton)		Axle Load (ton)	Length	Max Speed (Km/h)
	Specification	Sign	Tare	Load			
1	Soft Seat Sleeper	An	32	10	10.5	20676	120
2	Hard Seat Sleeper	Bn	32	10	10.5	20676	120
3	Soft Seat Coach	A	8	37	11.25	20676	120
4	Hard Seat Coach	B	10	32	10.5	19720	120
5	Restaurant Car	HC	10	30	10	20900	120

Note: Tare means weight without load.

Source: VNR

[Fig. 3-1-49] Typical Passenger Coaches Operated on the N-S Railway

Most trains operated on the N-S Railway are night trains and therefore consist of both sleepers and coaches.

3) Freight Cars

The freight cars used by VNR can be classified into box cars, open freight cars, tank cars and container cars. There are also other types of cars used for track work such as ballast hopper cars and rail transport cars. Information on the typical freight cars used by VNR is shown in [Fig. 3-1-50].

There are currently an insufficient number of freight cars to meet the future increase in freight transport demand. Also, VNR's freight trains have a maximum speed of 80km/h, although container cars will have to be operated at 110km/h in the future.



Box Wagon **G**



Open Top Wagon **H**



Open Top Wagon Low wall **N**



Low Floor Wagon



Container Wagon **M**



Tank Wagon **P**

No	Type of Car		Weight (ton)		Axle Load (ton)	Length C – C	Max Speed (Km/h)	Quantity
	Specification	Sign	Tare	Load				
1	Box Car	G	19.8	35	13.7	14.9	80	2035
2	Open Freight Car	H.N	17	40	14.25	15	80	1621
3	Container Car	M.MV	17	35	13	13.6	80	584
4	Tank Car	P	18	30	12	12.3	80	179

Note: The tare means weight without load.

Source: VNR

[Fig. 3-1-50] Typical Freight Cars Operated on the N-S Railway

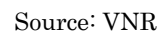
(2) Operation

1) Operation Plans

VNR only publishes time tables for passenger trains as these are the only trains with a regular schedule. Operation plans for freight trains are made in the following way.

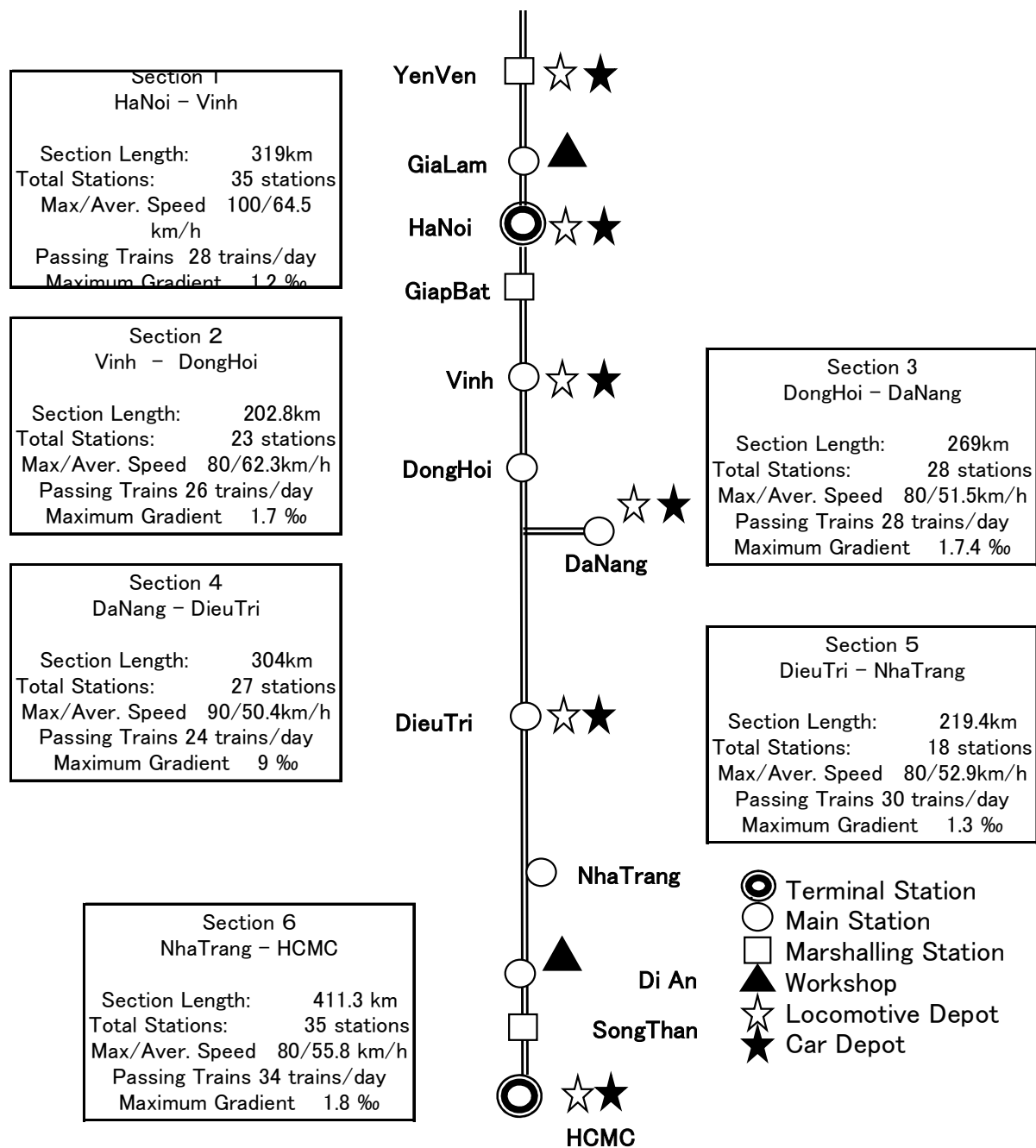
- First, a train is composed based on the transportation request from the shipper(s).
- A transportation order is then made and the operation plan is sent to the parties concerned.
- Freight trains are treated as non-regular trains because they are operated only according to demand.

The effective timetable made for the period between 29th and 30th April 2011 is shown in [Fig. 3-1-51]. VNR's train diagrams follow the 24-hour system and consist of 10-minute scale diagrams marked in 10-minute increments. Information on the locomotives operated on each day is also recorded on the diagram.



2) Overview of the N-S Railway

3-41



Source: Study team

[Fig. 3-1-52] Overview of the N-S Railway

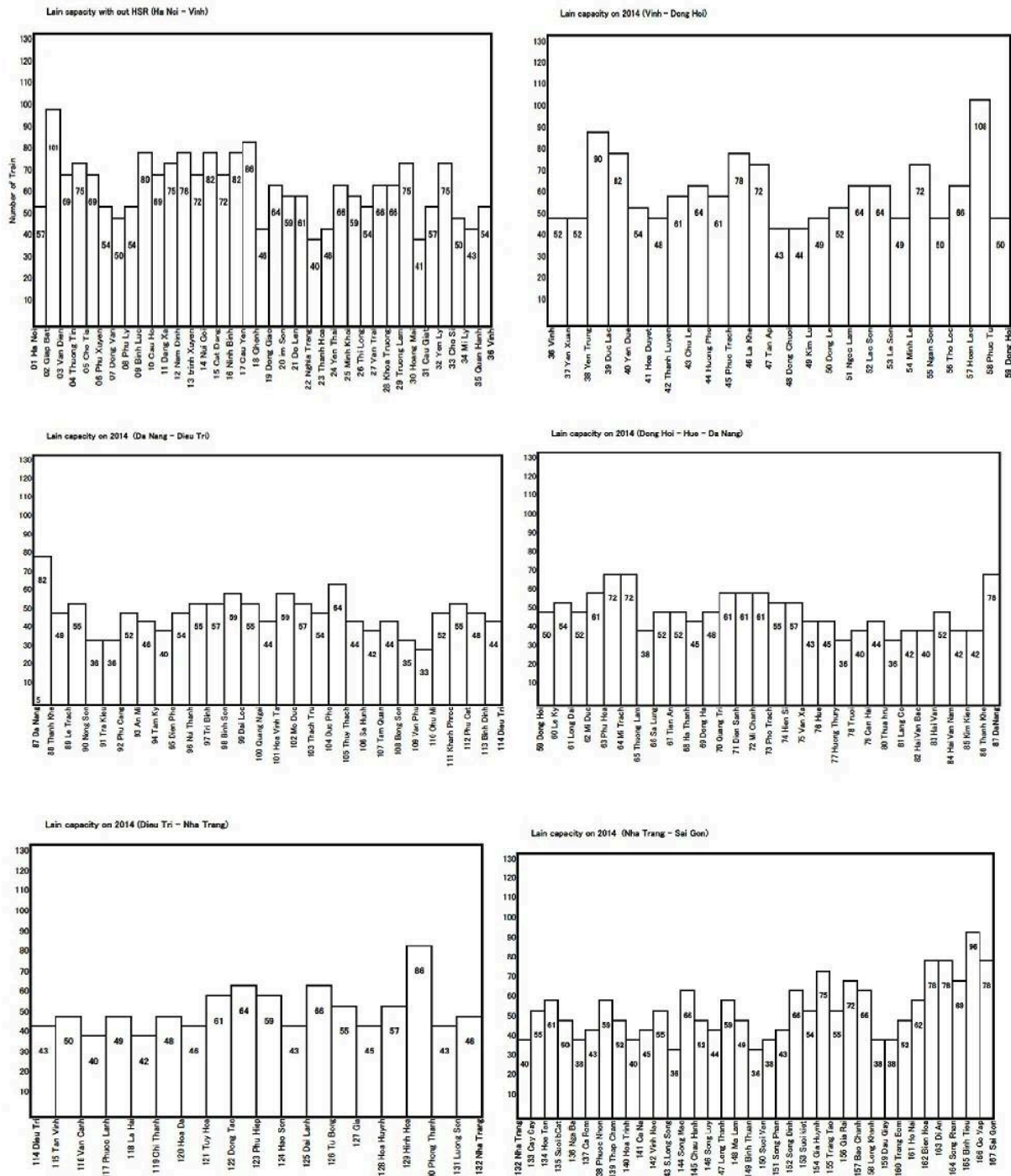
3) Line Capacity

The entire line between HaNoi and HCMC was divided into six (6) sections, and the average operation time and line capacity between all stations on each section were then calculated based on the passenger train timetable published in May 2013 and the planned freight train timetable published in July 2013.

The average operation time between stations was obtained by adding the operation times of freight trains and passenger trains and then calculating their mean value. The line capacity of each section is shown in [Fig. 3-1-53].

As can be seen from the table, there are differences in line capacity between some of the sections. This is due to the long operation time between stations on sections with low line capacity. Long operation times are likely the result of long distances between

stations or low train speed.



Source: Study team

[Fig. 3-1-53] Line Capacity in 2014

4) Train Operation Plans

A comparison between the number of trains based on plans/timetables and actual operation records for the six (6) sections between HaNoi and HCMC on the N-S Railway is shown in [Tab. 3-1-16].

The planned number of trains is based on VNR's train timetable for 2013. The number of freight trains actually operated was calculated from the transport records for 2011. Since all passenger trains are scheduled trains, the number of planned trains was

used in place of the number of passenger trains actually operated.

The shortest operation time for passenger trains operated between Ha Noi and HCMC on the N-S Railway was 29h55m, with a scheduled speed of around 57km/h. On the other hand, freight trains had an operation time of more than 60hours and their scheduled speed was less than 27km/h.

Since the number of freight trains actually operated was lower than the planned number, there is room to increase the number of freight trains in the future. However, the cycle time (time between departure and arrival of a car) of freight cars tends to be very long because freight trains have a low scheduled speed. Since higher transport demand requires an increase in the number of freight trains, the shortage of freight cars is already a problem and is expected to become worse in the future. To resolve this problem, it is necessary to reduce the freight car cycle time by increasing the number of freight cars, and to improve the scheduled speed of freight trains so that it approaches that of passenger trains.

As for container trains, high-speed container cars with a possible operation speed around 110km/h should be introduced since there are currently very few container cars in operation.

[Tab. 3-1-16] Comparison between Operation Plans and Records for Number of Trains

Station-Station			Section 1	Section 2	Section 3		Section 4	Section 5	Section 6
			HaNoi - Vinh	Vinh - DongHoi	DongHoi - Hue	Hue - DaNang	DaNang - DieuTri	DieuTri - NhaTrang	NhaTrang - HCMC
Number of trains according to timetable	Regular (Passenger)	Up	9	8	9	8	6	8	10
		Down	9	8	9	8	6	8	10
		Total	18	16	18	16	12	16	20
	Non- Regular (Freight)	Up	6	6	6	6	6	6	6
		Down	6	6	6	6	6	6	6
		Total	12	12	12	12	12	12	12
	Total		30	28	30	28	24	28	32
Number of passenger trains			18	16	18	16	12	16	20
Number of freight trains according to transport records	Demand		5,470	5,671	5,519	5,370	5,693	5,084	4,213
	Container	Volume	2,018	2,093	2,037	1,982	2,101	1,876	1,555
		Trains	2	2	2	2	2	2	2
	Bulk	Volume	3,447	3,573	3,478	3,384	3,587	3,203	2,655
		Trains	3	3	3	3	3	3	2
	Freight Total		6	6	6	6	6	5	4
Total train number by records			24	22	24	22	18	21	24
Difference in train numbers between operation plan and operation records in 2013			6	6	6	6	6	7	8

Source: Study team

3.1.5 Signaling and Telecommunication

(1) On-going Projects for Modernization of Telecom and Signaling System

[Tab. 3-1-17] shows an overview of the on-going projects for modernization of the telecom and signaling system of the N-S Railway. These two (2) major modernization projects cover the renewal and improvement of the signaling and telecommunication of the N-S Railway.

The “Modernization of Telecommunication and Signaling System of Railway Section of

HaNoi – Vinh Project” is funded by France. Introduction of electronic interlocking (SSI) as well as electric point machines and train detection by axle counters at each station except HaNoi is in progress under the project. Introduction of CTC (Centralized Traffic Control) is also planned and an automatic block system will be in operation through CTC. The introduction of a digital telecommunication system and optical fiber cable network are also in progress. The introduction of electronic interlocking will be completed by the end of 2014. HaNoi station still has old signaling equipment awaiting future renewal and an elevated plan as part of the HaNoi Line 1 project.

The “Modernization of Telecommunication and Signaling System of Railway Section Vinh – SaiGon Project” is funded by China. Introduction of 6502-type relay interlocking as well as electric point machines and train detection by axle counters at each station is in progress under the project. As for block operation between stations, an automatic block system is planned using train detection by axle counters, and will be in operation after completion of the whole project. Supervision of train location by an OCC (Operational Control Center) is planned by transmitting train detection data by axle counters at each station through a digital telecommunication channel. The introduction of a digital telecommunication system and an optical fiber cable network is also in progress. The project is divided into two (2) phases, Phase 1 and 2. Phase 1 will be completed by the end of 2014 and Phase 2 has been approved for project preparation by MOT.

[Tab. 3-1-17] On-going Telecom and Signaling System Modernization Projects

No.	Name of Project	Outline
1	“Modernization of telecom and signaling system of railway section HaNoi – Vinh Project”	● Signal system: electronic interlocking type SSI central control ● Digital communication system, optical fiber transmission cable ● Starting time: 2002 ● Implemented: HaNoi - Vinh (Phase 1 (2002-2005)) ● Under implementation: stations on the Hanoi - Vinh section and branch lines of PhuLy - BimSon, BimSon - Bim Son Industry, CauGiat - NghiaDan (Phase 2 was started in 2007) ● Financing: French ODA
2	“Modernization of telecom and signaling system of Railway section Vinh – Sai Gon Project”	● Signal system: Interlocking relay type 6502 ● Digital communication system, optical fiber transmission cable ● Starting time: 2002 ● Phase 1 (2004 - 2014) ● Implemented: TuyHoa - NhaTrang (sample) ● Under implementation: until 30/4/2014, complete the construction of Phase 1 as scope of Decision No. 3151 QĐ-BGTVT issued on October 29, 2014 ● Phase 2 (MOT has approved to prepare the project with Decision No. 2000/QĐ-BGTVT issued on July 11, 2013) ● Implementing the related process of selecting a Consultant for project preparation. ● Finance: China EXIM Bank

Source: VNR

In addition to the above two (2) major modernization projects, the OCC modernization project funded by Germany is also in progress as shown in [Tab. 3-1-18].

[Tab. 3-1-18] On-going OCC modernization project

No.	Name of Project	Outline
1	“Modernization of Operational Control Center (OCC)”	● Covering all lines of VNR (total length of around 2,600km) ● Supervising train location by GPS. ● The total of about 350 locomotives with on-board GPS equipment ● Voice and data communication between the OCC center and trains via GSM and GPRS ● Passenger Information System for eight big passenger stations ● Computerized timetable ● Renovation of the National OCC in HaNoi and three Regional OCCs in HaNoi, DaNang, and HCMC ● To be completed by the end of 2015 ● Financing: German ODA

Source: RPMU of VNR

(2) Signaling

[Tab. 3-1-19] shows the current situation of signaling equipment and system of 165 interlocking stations. As mentioned under item (1) above, introduction of electronic interlocking on the HaNoi – Vinh section, 6502-type relay interlocking on the Vinh – HCMC section, electric point machines, etc. is in progress. The number of SSI-type and 6502-type interlocking systems has increased in recent years as the projects are progressing.

[Tab. 3-1-19] Type of Signal Equipment and Interlocking System

No.	Type of signal equipment	Interlocking system	Unit	Quantity				Total
				HaNoi RSATC	Vinh RSATC	DaNang RSATC	SaiGon RSATC	
1	Color light Signal, decentralized electrical supply type TM-95	Relay Interlocking electric lock box mechanical switch	Station	1	3	43	21	68
2	Color light Signal, type centralized electrical supply TM-2001	Relay Interlocking electric lock box mechanical switch	Station	0	18	7	7	32
3	Color light Signal, type 6036	Relay interlocking, point machine CP-6	Station	1	0	0	0	1
4	Color light Signal, centralized electrification type 6502	Relay interlocking, electric point machine	Station	0	0	4	26	30
5	Color light Signal, centralized electrification type SSI	Electronic interlocking , electric point machine L90	Station	16	17	0	0	33
		Electronic interlocking , hydraulic switch C1H	Station	1	0	0	0	1
	Total		Station	19	38	54	54	165

Note: The quantitative data shown here includes all remaining stations which will be completed in the second quarter of 2014.

Source: VNR

[Tab. 3-1-20] shows samples of detailed data of signal equipment and interlocking systems. A few samples for each type of signal equipment are shown. Under the modernization projects, various types of electric point machines from different suppliers have been introduced. Train detection by axle counters has also been introduced.

[Tab. 3-1-20] Samples Statistics on Signal Equipment and Interlocking System

No	Station	Type of signal equipment	Signal	Point Machine	Train Detection	Power Supply	Interlocking		
							Type	Number of routes	Installation year
1	Hanoi	TM-95	Color light	Turn-out HKD	No	Decentralization (1phase)	Relay	11	?
2	Giap Bat	SSI	Color light	L90	Axle counter sensor	Centralization (3 phase)	Electronic (SSI)	12	2014
3	Van Dien	SSI	Color light	C1H	Axle counter sensor	Centralization (3 phase)	Electronic (SSI)	3	2006
4	Thuong Tin	SSI	Color light	L90	Axle counter sensor	Centralization (3 phase)	Electronic (SSI)	3	2012
5	ChoTia	SSI	Color light	L90	Axle counter sensor	Centralization (3 phase)	Electronic (SSI)	2	2012
6	LeKy	TM-95	Color light	Turn-out HKD	No	Decentralization (1phase)	Relay	3	4/1996
7	Hue	TM-95	Color light	Turn-out HKD	No	Decentralization (1phase)	Relay	4	12/1995
8	Tam Ky	TM-95	Color light	Turn-out HKD	No	Decentralization (1phase)	Relay	3	3/1997
9	Thuong Lam	TM-2001	Color light	Turn-out HKD	No	Centralization (1 phase)	Relay	3	12/2001
10	Truoi	TM-2001	Color light	Turn-out HKD	No	Centralization (1 phase)	Relay	3	12/2001
11	Hai Van Nam	TM-2001	Color light	Turn-out HKD	No	Centralization (1 phase)	Relay	2	9/2006
12	Dong Hoi	Electrification 6502	Color light	CII-6	Axle counter sensor Tiefenbach	Centralization (1 phase)	Relay	4	12/2004
13	Lang Co	6502	Color light	CII-6	Axle counter sensor Tiefenbach	Centralization (1 phase)	Relay	4	12/2004
14	Kim Lien	6502	Color light	CII-6	Track circuit	Centralization (1 phase)	Relay	4	12/2002
15	Thanh Khe	Mixed Equipment TM-95 and signal control at small station	Color light	Turn-out HKD and ZD-6	Track circuit	Centralization (1 phase)	Relay	2	2004
16	Luong Son	TM95	Color light	Turn-out HKD	No	Decentralization (1phase)	Relay	3	1995
17	Phong Thanh	TM95	Color light	Turn-out HKD	No	Decentralization (1phase)	Relay	3	1995
18	Hoa Huynh	TM95	Color light	Turn-out HKD	No	Decentralization (1phase)	Relay	3	1995
19	Phuoc Lanh	TM2001	Color light	Turn-out HKD	No	Centralization (1phase)	Relay	3	1996
20	La Hai	TM2001	Color light	Turn-out HKD	No	Centralization (1phase)	Relay	3	1996
21	Chi Thanh	TM2001	Color light	Turn-out HKD	No	Centralization (1phase)	Relay	3	1996
22	Cay Cay	6502	Color light	ZD6	Axle counter sensor	Centralization (1phase)	Relay	3	2013
23	Hoa Tan	6502	Color light	ZD6	Axle counter sensor	Centralization (1phase)	Relay	3	2013
24	Suoi Cat	6502	Color light	ZD6	Axle counter sensor	Centralization (1phase)	Relay	3	2013

Source: VNR

[Tab. 3-1-21] shows the current situation of the block system. As mentioned under item (1) above, an automatic block system with one (1) section will be in operation through CTC on the section of HaNoi-Vinh after completion of the modernization project. Similarly, an automatic block system with one section is planned using train detection by axle counters on the section of Vinh-HCMC after completion of the total modernization project. Currently, the

section still uses the semi-automatic block system.

[Tab. 3-1-21] Block System

No.	Block system	Unit	Quantity	Note
1	Semi-automatic block system	system	130	Type 64D
2	Automatic block system	system	34	Automatic block system to block one section

Source: VNR

(3) Telecommunication

[Tab. 3-1-22] shows the current situation of telecommunication channels along the N-S Railway. As mentioned under item (1) above, introduction of digital telecommunication equipment and an optical fiber cable network is in progress which leads to an increase of telecommunication channels.

[Tab. 3-1-22] Telecommunication Channel along North-South Railway

STT	Transmission line	Overview
1	Concrete pole bare wires	- Concrete pole bare wires with 1, 2 or 3 beams 8 wire pairs or 1, 2 beams 4 wire pairs. - Material of transmission wire pair is bimetal (copper core with galvanized cover) with a 3mm diameter, or galvanized iron wire with a 4mm diameter.
2	Copper cable line	370km underground cable and plastic hanger cable, with mainly includes copper cable class 4 type 4*4*1.2mm, 7*4*1.2mm or high frequency cable 1x4x0.9 serving for long transmission line at joining points of station in crowded telecommunication centers and complicated geology which is incapable of installation of bare wire and local copper cable type twisted pair from 10x2x0.5 to 200x2x0.5 used for local telecommunication at all stations along the railway.
3	Optical fiber cable line	- HaNoi – Vinh Section: underground optical fiber cable type G.652 24fo: 300km - Vinh – NhaTrang Section: underground optical fiber cable type G.652 12fo: 1,000km suspension optical cable type G.652 12fo: 1,000km - NhaTrang – SaiGon Section: underground optical fiber cable type G.652 24fo: 400km

Source: VNR

(4) Level Crossings

[Tab. 3-1-23] shows the statistics on level crossings as of 2013. There are four (4) types of level crossings in VNR namely 1) Level crossings with barrier & guardsmen, 2) Level crossings with automatic warning (without guardsmen), 3) Level crossings with sign boards, and 4) Livelihood level crossings. VNR doesn't manage the "Livelihood level crossings". The signaling division of VNR manages automatic warning equipment and other facilities of the "Level crossings with barrier & guardsmen" and the "Level crossings with automatic warning".

[Tab. 3-1-23] Number of Level Crossings as of 2013

No.	Level Crossing		Quantity		Notes
	(in English)	(in Vietnamese)	All lines of VNR (including N-S)	N-S Railway Line	
1	Level crossing with barrier & guardsmen	ĐN có chắn có gác (DN: Đường ngang)	636	416	
2	Level crossing with automatic warning	DN CBTD (CBTD: Cảnh báo tự động)	328	270	Without guardsmen
3	Level crossing with sign board	Biển Báo	553	373	
4	Livelihood level crossing	DN dân sinh	4,354	2,644	Not managed by VNR

Source: VNR

[Fig. 3-1-54] shows sample photos of a “Level crossing with barrier & guardsmen”. There are two (2) types of barriers, slide-type and bar-type. When a train approaches a Level Crossing, guardsmen operate the barriers in order to ensure safety by stopping encroaching cars, motor bikes, and people. The guardsmen wait in a cabin by the side of the level crossing and take necessary action. Two (2) red lamps flash one after the other as a warning signal when a train approaches.



(a) Slide-type barrier



(b) Bar-type barrier

Source: Study team

[Fig. 3-1-54] Level Crossing with Barrier & Guardsmen

[Fig. 3-1-55] shows a sample photo of a “Stopping Signal”. Stopping signals are installed about 100m apart from level crossings. If there is an obstacle at a level crossing when a train is approaching, guardsmen manually turn on the stopping signal in order to inform the train driver and stop the train.



Source: Study team

[Fig. 3-1-55] Stopping Signal

[Fig. 3-1-56] shows sample photos of a “Level crossing with automatic warning”. It automatically starts warning by detecting approaching trains with an axle counter. In addition to two (2) red warning lamps, it has a yellow lamp which indicates malfunction of the warning equipment. The “Level crossing with automatic warnings” usually has no barrier and no guardsman as shown in (a) of [Fig. 3-1-56]. However, some of them have barriers and guardsmen as shown in (b) of [Fig. 3-1-56] in order to increase the safety level.



(a) Without barrier



(b) With barrier

Source: Study team

[Fig. 3-1-56] Level Crossing with Automatic Warning

In addition to the four (4) types of level crossings shown in [Tab. 3-1-23], a “Totally automatic level crossing” which has automatic warning signals and automatic barriers is in test operation. [Fig. 3-1-57] shows sample photos of a “Totally automatic level crossing”.



(a) Warning signal and barriers during automatic operation



(b) Level crossing control equipment

Source: Study team

[Fig. 3-1-57] Totally Automatic Level Crossing

VNR installed “Totally automatic level crossings” in 2003 and decided to use them in 2006 after a test period. Its control unit, shown in (b) of [Fig. 3-1-57], was provided by a German supplier. Presently, two (2) “Totally automatic level crossings” are in operation. However, it is still used for testing purposes even after long operational experience. VNR has no plans for further installation. One reason is that people don’t follow rules which results in a high probability of accidents. Another reason is the high installation cost.

Malfunction of level crossing control equipment often happens mainly because of the hot and humid conditions of VietNam. If a malfunction occurs, barriers will be kept open and the guardsmen will deal with it. Consequently, even the “Totally automatic level crossings” require guardsmen.

The responsibility for accidents at level crossings is classified by type of level crossing as follows:

- For “Level crossings with barrier & guardsmen”, the responsibility of the guardsmen lies only until the level crossing is properly closed with barriers. After closing it with barriers, even if people encroach into the level crossing, it is a violation of the law and therefore the responsibility of the person causing the accident.
- “Level crossings with automatic warning” (without guardsmen) have the role of informing passing people of approaching trains. People are responsible for checking the warning signal and are therefore also responsible for any accidents.
- For “Totally automatic level crossings”, all responsibility for accidents lie with VNR if the automatic barriers and warning signals malfunction.

[Tab. 3-1-24] shows the number of accidents at level crossings in 2013. The table clearly indicates that most accidents occurred at Livelihood level crossings. According to the Railway Rescue and National Calamity Response Centre of VNR, VNR tries to prevent accidents at Livelihood level crossings by constructing a fence along the railway line and entrusting the guard work to local people. VNR is forced to focus on accident prevention at Livelihood level crossings while they are not managed by VNR.

It was also found out that the number of accidents at “Level crossings with automatic warning” is larger than that at “Level crossings with barrier & guardsmen”. It can be assumed that guardsmen have an important role in preventing accidents at level crossings and that the “Level crossings with automatic warning” without guardsmen have a higher probability of accidents.

[Tab. 3-1-24] Accidents at Level Crossings in 2013

No.	Level Crossing	Number of accidents	Notes
1	Level crossing with barrier & guardsmen	9	
2	Level crossing with automatic warning	25	Without guardsmen
3	Level crossing with sign board	5	
4	Livelihood level crossing	150	Not managed by VNR

Source: VNR

(5) Accidents due to Subjective Cause

VNR classifies accidents into “subjective cause” and “objective cause” accidents. Accidents due to objective causes are those caused by external elements such as intrusion into level crossings when trains are passing. The responsibility for these accidents lie with the external element such as the people who trespassed. In contrast, accidents due to subjective causes are those caused by internal elements at VNR such as driver human error or technical problems of wagons. The responsibility for these accidents lie with VNR.

Here, the study team collected and analyzed detailed information on accidents due to subjective causes in the past five years in order to confirm whether there is a need to prevent human error and improve safety or not. Since the N-S Railway has no Automatic Train Protection (ATP) system, introduction of ATP may be worth discussing for improvement of safety on the whole N-S Railway line.

[Tab. 3-1-25] shows the classification of a total of 79 accidents due to subjective causes in the past 5 years, from 2010 to May 2014. According to the table, the number of accidents due to technical problems is larger than that due to human error. Especially, the number of wagon problems accounts for more than half of the total number of technical problems. Accordingly, appropriate countermeasures against technical problems will contribute to the decrease of accidents due to subjective causes and lead to stable train operation.

[Tab. 3-1-25] Accidents due to Subjective Causes from 2010 to May 2014

year	Number of accidents	
	Subjective	Objective
2010	19	452
2011	19	512
2012	16	447
2013	15	399
2014	10	(not available)
(total)	79	(not available)

Classification according to type		Number of accidents due to subjective causes
Technical problem	Wagon	17
	Track	10
	Signaling	1
	Others	1
Human error	Driver	4
	Level crossing guardmen	7
	Others (workers, etc.)	9
(Cannot be classified due to lack of information)		30
(Total)		79

Note: The classification according to type shown above is done by the Study team using raw data of accidents provided by VNR. It may be different from VNR's official classification.

Source: Railway Rescue and National Calamity Response Centre of VNR

As for human error, [Tab. 3-1-25] indicates that the number of human errors by drivers is rather small. The number of human errors by guardsmen, such as forgetting to close barriers and closing barriers late, is larger. The number of human errors by workers during shunting, maintenance, and construction work is also larger.

Prevention of human error by guardsmen at level crossings is considered important. One countermeasure candidate is installing “Obstacle detectors” which automatically detect

obstacles at level crossings when trains are approaching. Also, while they are still under testing, introduction of “Totally automatic level crossings” as shown in [Fig. 3-1-57] may need to be reviewed in the future for level crossings with less traffic volume than roads.

Prevention of human error by workers is also essential. Provision of effective training to shunting, maintenance, and construction staff is considered one countermeasure in order for them to follow regulations strictly and to learn appropriate skills.

As shown in [Tab. 3-1-25], the number of human errors by drivers is small. The priority of countermeasures against human error by drivers such as introduction of ATP may therefore be low, compared to countermeasures against accidents at level crossings. However, taking the 2005 derailment accident at HaiVan pass due to over-speed by driver human error into account, and also considering the fact that a few accidents by driver human error still happened in the past five years, introduction of ATP will be necessary in the future in order to prevent future big accidents.

3.2 Prioritization Methodology

3.2.1 Two Step Screening

This study shall be implemented on the basis of utilizing some existing data/information from VITRANSS2 (The Comprehensive Study on the Sustainable Development of Transport System in VietNam), HSR F/S (Study for the Formulation of High Speed Railway Projects on HaNoi-Vinh and HCMC-NhaTrang Sections), Draft ARDS2020 (Adjustment of VietNam Railway Development Strategy till 2020 and vision to 2050), Draft Master Plan (M/P) based on Draft ARDS2020, as well as certain data/information collected through on-site interviews and site surveys as required.

The study team considers there to be three (3) major measures to improve the transport capacity of the N-S Railway: a) Reduction of travel time, b) Increase of traction force, and c) Realization of high-density train operation. Factors preventing the realization of improved transport capacity of the N-S Railway by major measures are as follows:

a) Factors preventing reduction of travel time

- Speed restrictions at bridges, tunnels, level crossings and curves
- Speed reductions due to insufficient locomotive power output on steep slopes which require time-consuming coupling and uncoupling of assistance locomotives
- Time wasted while waiting for trains to pass each other on long, single-track sections between stations

b) Factors preventing increase of traction force

- Insufficient bridge design load
- Insufficient effective length at station yards
- Insufficient locomotive power output

c) Factors preventing high-density train operation

- Difficulty developing transportation plans due to insufficient functions of signaling & telecommunication facilities
- Lacking ability of train operation plans
- Irrational freight transportation plans

Therefore, policies considered for solving the impeditive factors mentioned above are as follows:

- Lifting of speed restrictions through the rehabilitation of damaged bridges
- Increasing traction force through the rehabilitation of aging bridges in order to raise design load
- Increasing train speed through the improvement of track alignment on sharp curved sections
- Increasing train speed through the improvement of track alignment on steep gradient sections
- Lifting of speed restrictions through the rehabilitation of aging tunnels
- Increasing train speed through the improvement of track alignment through new tunnel construction
- Lifting of speed restrictions through the replacement of level crossings with overpasses or underpasses
- Reduction of time wasted while waiting for trains to pass each other on long, single-track sections between stations through the construction of new stations or signal cabins
- Lifting of speed restrictions through the construction of new partial double-tracked sections on the existing single-track route
- Realization of high-density train operation through modernization of signaling and telecommunication facilities and equipment
- Modernization of rolling stock (e.g. locomotives, passenger coaches, freight wagons)

Assuming three-staged quality targets in 2020, 2025 and 2030 for train operation of the N-S Railway (e.g. increased train speed, reduction of delays, measures to prevent natural disasters and train accidents), the infrastructure rehabilitation and modernization plan for the divided three terms of 2020, 2025 and 2030 should be developed from the policies for solving the impeditive factors mentioned above.

Although, the study team ran into various difficulties after the commencement of this study such the problems listed below, the lack of information was supplemented by site visits, hearings with field officers directly in charge of a subject, data collection from local consultants assisting VNR studies, and assumptions based on equivalent Japanese experience.

- Unavailability of required and envisaged data/information for the study;
- Unavailability of basic data/information managed by the railway operator;
- Existence of unforeseen requests and critical issues for the study which were raised by counterparts;
- Existence of a restructuring program for the railway sector;
- Small contribution related to the impact of increasing train speed at locations where the infrastructure is to be rehabilitated and modernized; and
- The issue that freight train operation is more serious than infrastructure, especially for freight train operation.

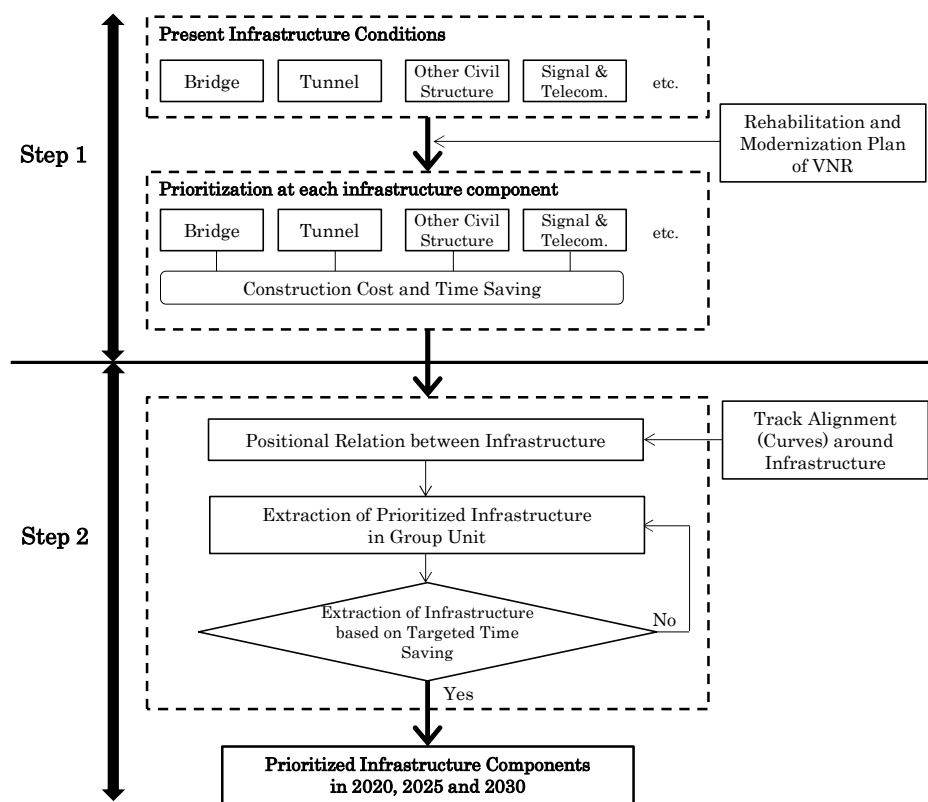
Because of these problems, the study team considered it difficult to equitably and automatically prioritize what infrastructure is most important, and to define transport quality levels for each target year for the completion of prioritized infrastructure to be rehabilitated and modernized. Therefore, the study team applied the two-step screening method shown in [Fig. 3-2-1] as an alternative. The general prioritization process of each step is as follows:

Step 1 Prioritization of each infrastructure component and estimation of costs and benefits (time saving and safety enhancement).

Step 2 Organization of locations at each infrastructure and extraction of prioritized infrastructure according to time saving targets.

In Step 1, prioritized infrastructure by infrastructure component was screened and selected in advance. This was required since there is a big difference in the accuracy of available data/information for each infrastructure and this data is often not consistent with other infrastructure.

In Step 2, all subjected prioritized infrastructure was set up in a screening matrix in order to understand the comparison between the positional relation between the infrastructure and geopolitical information. Construction cost and time saving data by subjected prioritized infrastructure was then put into the screening matrix.



Source: Study team

[Fig. 3-2-1] General Prioritization Process by Two Step Screening Method

3.2.2 Screening Matrix

This section explains the extraction method for the prioritized infrastructure in Step 2. As shown in [Fig. 3-2-1], the infrastructure which was selected in Step 1 was put into the screening matrix in order to comprehensively and collectively evaluate the entire infrastructure of the whole length of the N-S Railway. Furthermore, curve data had to be entered as alignment so as to enhance the effectiveness between rehabilitation of infrastructure and alignment modification before and after the prioritized infrastructure.

The infrastructure to be rehabilitated was prioritized in accordance with the above screening matrix. Even though the infrastructure has construction cost attributes and time saving effects, it is in fact not possible to achieve a time saving effect by rehabilitating solitary infrastructure components. For example, if certain infrastructure with a one minute time-saving potential is located adjacent to some other infrastructure with a five minute

time-saving potential, it is basically ineffective to rehabilitate the latter. In other words, it is not until both structures are rehabilitated that the time-saving effect of both can be realized. Moreover, if both are rehabilitated, the construction costs for on-site access roads are lower than otherwise.

Additionally, if infrastructure to be rehabilitated is located adjacent to infrastructure with a potential five-minute time-saving effect, the rehabilitation has a higher profound time-saving effect if both structures are located on a section with high transportation density as compared to a section with low transportation density.

In consideration of the above conditions, the study team adopted a method where higher priority was attached to groups of infrastructure to be rehabilitated on sections with high transportation density through the use of a screening matrix (refer to [Tab. 3-2-1]). Meanwhile, the construction cost and time saving data for the infrastructure to be rehabilitated was put into the screening matrix.

The screening matrix includes not only columns for data/information for the target years 2020, 2025 and 2030, but also columns for the analysis of target year setting as described in the next section. The target year setting was analyzed by utilizing the screening matrix reflected and selecting various data for each year.

[Tab. 3-2-1] Screening Matrix Concept

Location	Bridge, tunnel, ... (Size, Cost, Benefit, ...)	2020, 2025, 2030 (Costs and benefits)
HaNoi : : : HCMC	● Cells for prioritization analysis ● Mathematical or systematic method will not be available. ● Special requests will be incorporated if the supporting data is convincing.	Cells for stepwise prioritization analysis
Sub-total by section		Input data for economic and financial project evaluation

Source: Study team

3.2.3 Target Year Setting

The prioritized infrastructure components for the target years of 2020, 2025 and 2030 should essentially be proposed on the basis of factor analysis of speed degradation under existing run curves, awareness of the train delay situation obtained from actual train operation records, and safety measure aspects based on accident data for passenger and freight trains. However, it was difficult to obtain the above data/information because VNRA and VNR either do not have such data/information or because it was held back as classified.

In connection with what has been mentioned above, based on utilizing available data/information for the limited targets of bridges and tunnels, the study team devised a method which can easily provide useful data for cost-benefit analysis of each target year above.

Considering a distributive method of the prioritized infrastructure for the target years of 2020, 2025 and 2030, first of all, the study team adopted a method with which the prioritized infrastructure to be selected for achieving a targeted service level in 2020 were extracted. In particular, although the main targeted service level to be achieved for the N-S Railway is time savings in each target year, since there is no data provided by MOT, VNRA and VNR, the study team assumed that the target values for achieving a certain service level in 2020 were utilized by the values stated in “Regulation on Operation Speed in 2014 (VNR)” issued in Decision No. 408/QĐ-ĐS dated 08 April 2014. That is to say, the study team regarded the targeted service level in 2020 to be achieved if the speed restrictions mentioned in the Decision have been eliminated until 2020. In other words, the target values to be promptly

realized until 2020 consist of the time savings to be achieved through elimination of speed restrictions.

●Target Time Saving: ▲One (1) hour between HaNoi and HCMC

Source: Study team based on the “Regulation on Operation Speed in 2014 (VNR)” issued by Decision No. 408/QĐ-ĐS dated 08 April 2014.

In regard to the above target time saving, the prioritized infrastructure to be rehabilitated until 2020 was composed of the number of higher priority infrastructure components required to achieve the target saving time in 2020. However, if it was impossible to achieve the target time saving through rehabilitation of all prioritized infrastructure, the study team regarded that infrastructure to be the prioritized infrastructure to be rehabilitated until 2020. On the other hand, if the target time saving for 2020 could be achieved through rehabilitation of only part of the prioritized infrastructure, the study team regarded that the remaining infrastructure would be distributed to 2025 and 2030.

Chapter 4 Demand Forecast

4.1 Available Data

Base data used for demand forecast is VITRANSS2. In addition, HSR2012 and HSR2013 are used as updated versions of it. Furthermore demand forecast analysis prepared by MOT is also referred to. Here, VITRANSS2 represents the “Comprehensive Study on the Sustainable Development of Transport System in Vietnam,” HSR2012 represents the Interim Report on the “Study for the Formulation of High Speed Railway Projects on HaNoi-Vinh and HCMC-NhaTrang Sections” and HSR2013 represents its final report, all of which are conducted by JICA.

4.1.1 VITRANSS2, HSR2012, HSR2013

(1) General View

The VITRANSS2 was completed in May 2010. The traffic model for demand forecast is updated in the HSR2012 as well as the HSR2013 in its final report.

In VITRANSS2, sectional passenger demand in 2008 and 2030 without HSR are forecasted as shown in [Tab. 4-1-1]. Passenger number on Hue-DaNang section in 2030 is estimated at approximately 18,000 per day, which is 3 times of 2008 number.

As shown in [Fig. 4-1-4], forecasted freight transportation by rail reaches 155.1 thousand tons per day in 2030, which is approximately 6 times the 25.5 thousand tons in 2008. Sectional freight demand in 2008 and 2030 are as shown in [Tab. 4-1-1]. Highest growth of 14 times the 2008 volume appears between QuangNgai and DieuTri section with average annual growth rate of 13%. Other sections also show high growth rate of 10 to 12% annually.

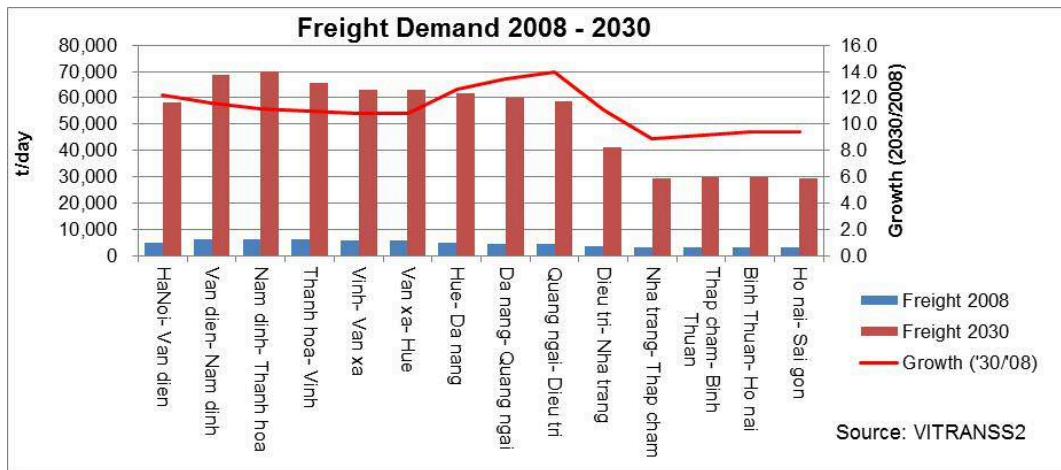
[Tab. 4-1-1] VITRANSS2 Demand Forecast

Section	Passenger (Unit: Passenger per day)				Freight (Unit: Ton per day)			
	2008	2030	2030/2008	Annual Growth	2008	2030	2030/2008	Annual Growth
Ha Noi - Van Dien	6,095	32,530	5.3	8%	4,737	58,022	12.2	12%
Van Dien - Nam Dinh	6,054	25,871	4.3	7%	5,940	68,896	11.6	12%
Nam Dinh - Thanh Hoa	6,520	19,889	3.1	5%	6,301	70,133	11.1	12%
Thanh Hoa - Vinh	6,737	19,011	2.8	5%	5,998	65,682	11.0	11%
Vinh - Dong Hoi	5,735	16,729	2.9	5%	5,849	63,191	10.8	11%
Dong Hoi - Hue	6,579	17,873	2.7	5%	5,849	63,191	10.8	11%
Hue - Da Nang	6,135	18,308	3.0	5%	4,872	61,743	12.7	12%
Da Nang - Quang Ngai	5,877	15,501	2.6	5%	4,462	59,897	13.4	13%
Quang Ngai - Dieu Tri	6,134	17,254	2.8	5%	4,204	58,762	14.0	13%
Dieu Tri - Nha Trang	6,600	21,057	3.2	5%	3,728	41,256	11.1	12%
Nha Trang - Thap Cham	6,820	20,638	3.0	5%	3,293	29,173	8.9	10%
Thap Cham - Muong Man	6,861	19,629	2.9	5%	3,254	29,757	9.1	11%
Muong Man - Dong Nai	7,186	22,720	3.2	5%	3,147	29,714	9.4	11%
Dong Nai - Sai Gon	6,930	22,177	3.2	5%	3,093	29,225	9.4	11%

Source: VITRANSS2

(2) Peculiar Feature of Freight Demand

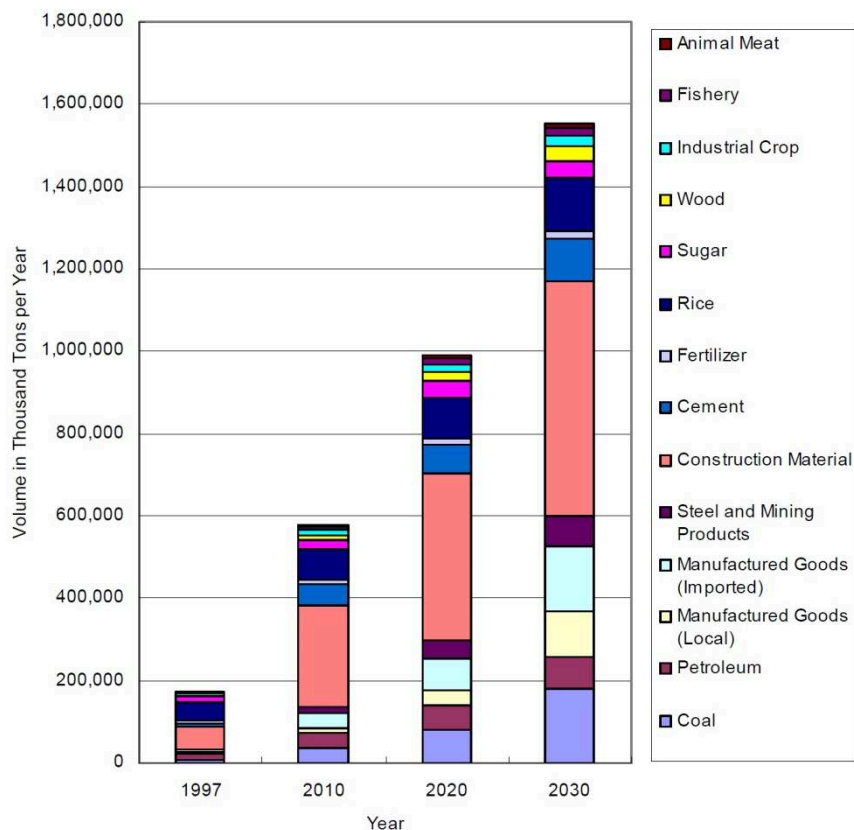
The figure shown below illustrates freight demand forecast and its growth between HaNoi and HCMC. It shows that the highest demand growth appears around Hue, DaNang, QuangNgai and DieuTri. Freight transportation volume in 2030 between Hue and DaNang is projected to be approximately 62 thousand tons per day, which is 13 times the 2008 value.



[Fig. 4-1-1] Freight Demand Forecast and Growth Rate by VITRANSS2

Consumption volume forecast made by VITRANSS2¹ in 2010, 2020 and 2030 is as shown in the figure below. As shown in the figure, future consumption volume is assumed to maintain constant growth up to 2030. If the freight demand growth goes along with the consumption volume trend, the transportation demands may soon exceed single track capacity in the near future. Since the constant growth for 20 years looks improbable, the VITRANSS2 estimate of the freight demand growth is considered to be skeptical.

Projection of Consumption Volume by Commodity Group

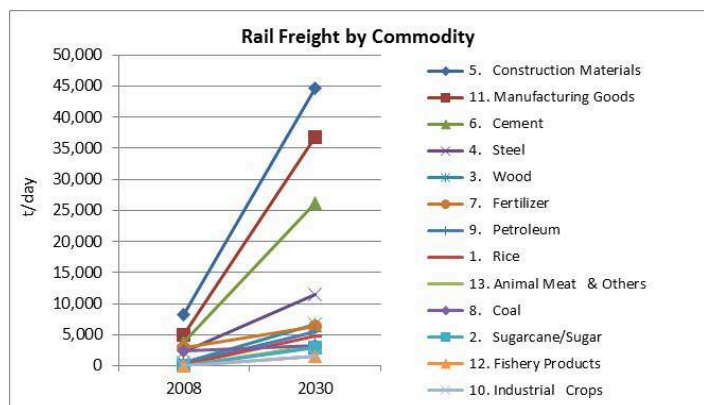


Source: VITRANSS2

[Fig. 4-1-2] Consumption Volume by Commodity by VITRANSS2

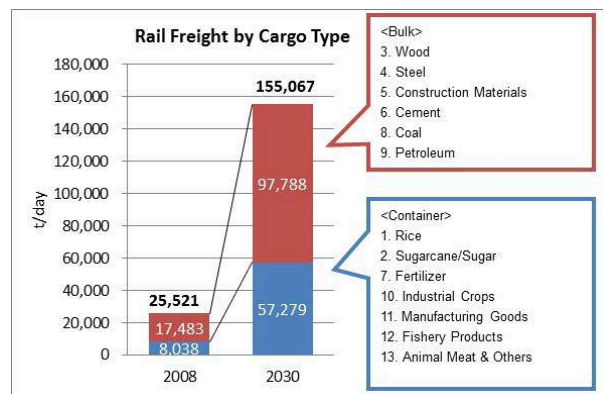
¹ Consumption volume is composed of consumption of commodities by domestic market and the volume of the commodities produced for exports.

As for the commodity-wise investigation in the VITRANSS2, transportation growth by commodity is shown in the figure below on the left-hand side. It shows that construction materials, manufacturing goods, and cement are the top three (3) items showing the highest growth. While commodities are categorized into container and bulk, container freight is forecasted to take account of 37% of total freight transportation in 2030 as shown in the figure below on the right hand side.



Source: VITRANSS2

[Fig. 4-1-3] Commodity-wise Growth 2008-2030



Source: VITRANSS2 arranged by Study Team

[Fig. 4-1-4] Commodities Classified as Container and Bulk

4.1.2 MOT Report

MOT carried out the “Detailed Plan of Modernization for North-South Railways” (MOT Study) as part of an engineering study for the “Strategy of Vietnam Railways till 2020 and vision till 2050.” In the MOT study, demand forecast for 2020 is made assuming two (2) cases of “Basic Alternative” and “High Alternative.” Here, the N-S Railway is assumed to achieve the planned operation speed with average of 80-90km/h for passenger trains and 50-60km/h for freight trains.

As shown in the tables below (one for passengers and another for freight), the demand in 2020 between the Hue and DaNang section counts approximately 2.0 to 2.3 times of 2011 figure for passengers and 1.5 to 1.8 times for freight transportation. However, MOT Report has no freight transportation forecast by commodity.

[Tab. 4-1-2] MOT Report Demand Forecast (Passenger)

Unit: Pax/day

SECTION	2009	2010	2011	2020 (Basic)	20/11 (Basic)	2020 (High)	20/11 (High)
HaNoi - Nam Dinh	5,377	5,683	5,963	13,040	2.1	14,904	2.4
Nam Dinh - Thanh Hoa	5,780	6,125	6,423				
Thanh Hoa - Vinh	5,760	6,065	6,396				
Vinh - Dong Hoi	4,703	5,034	5,377	10,740	2.0	12,274	2.3
Dong Hoi - Hue	4,974	5,284	5,661	11,315	2.0	12,932	2.3
Hue - Da Nang	4,807	5,186	5,561				
Da Nang - Quang Ngai	4,693	5,024	5,268	11,123	2.1	12,712	2.4
Quang Ngai - Dieu Tri	4,929	5,237	5,515				
Dieu Tri - Nha Trang	5,441	5,781	6,131	12,274	2.0	14,027	2.3
Nha Trang - Thap Cham	5,903	6,279	6,654	14,575	2.1	16,658	2.4
Thap Cham - Muong Man	6,002	6,366	6,741				
Muong Man - Saigon	6,458	6,867	7,270				

Source: MOT

[Tab. 4-1-3] MOT Report Demand Forecast (Freight)

Unit: Ton/day

SECTION	2009	2010	2011	2020 (Basic)	20/11 (Basic)	2020 (High)	20/11 (High)
HaNoi - Nam Dinh	5,214	5,048	5,374				
Nam Dinh - Thanh Hoa	5,086	5,065	5,622	8,835	1.6	10,602	1.9
Thanh Hoa - Vinh	4,824	4,692	5,367				
Vinh - Dong Hoi	5,087	4,873	5,671	8,766	1.5	10,520	1.9
Dong Hoi - Hue	4,812	4,667	5,519				
Hue - Da Nang	4,636	4,564	5,370	8,355	1.5	10,027	1.8
Da Nang - Quang Ngai	5,112	4,953	5,869				
Quang Ngai - Dieu Tri	4,873	4,573	5,518	8,903	1.6	10,684	1.9
Dieu Tri - Nha Trang	4,309	4,202	5,084	7,533	1.5	9,041	1.8
Nha Trang - Thap Cham	3,840	3,752	4,602				
Thap Cham - Muong Man	3,590	3,431	4,307	6,848	1.6	8,219	2.0
Muong Man - Saigon	3,135	2,956	3,731				

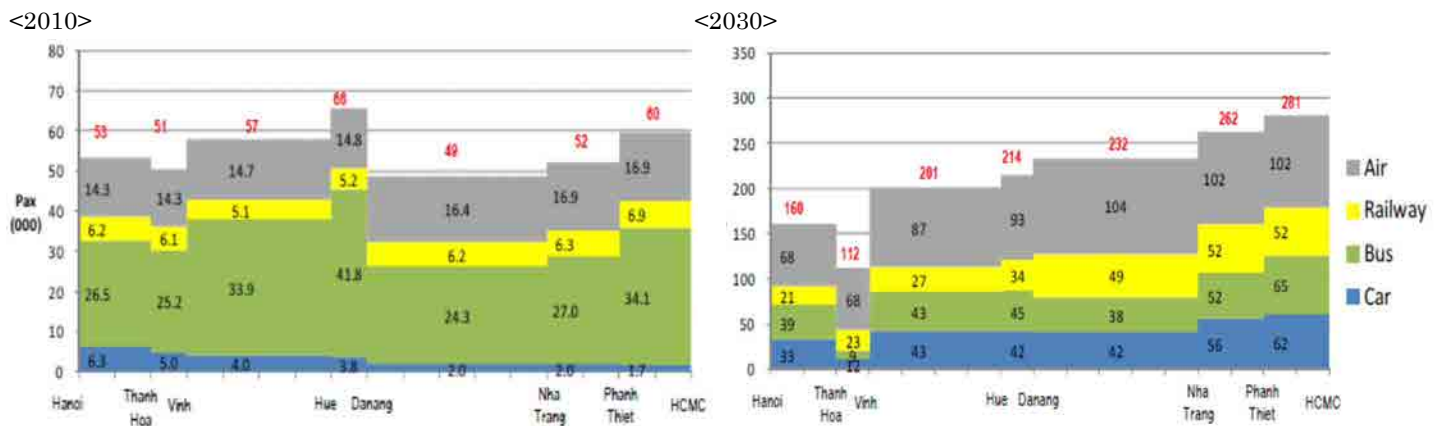
Source: MOT

4.1.3 HSR2012 and HSR2013

The study for the “Formulation of High Speed Railway Projects on HaNoi-Vinh and HCMC-NhaTrang Section” was carried out by JICA in 2012. The interim report was released in May 2012 (HSR2012) and the final report was released in June 2013 (HSR2013). Demand forecasts in these reports were made by updating VITRANSS2 forecasts.

In these studies, it is assumed that HSR is to be launched in two (2) sections: between HaNoi and Vinh and between NhaTrang and HCMC.

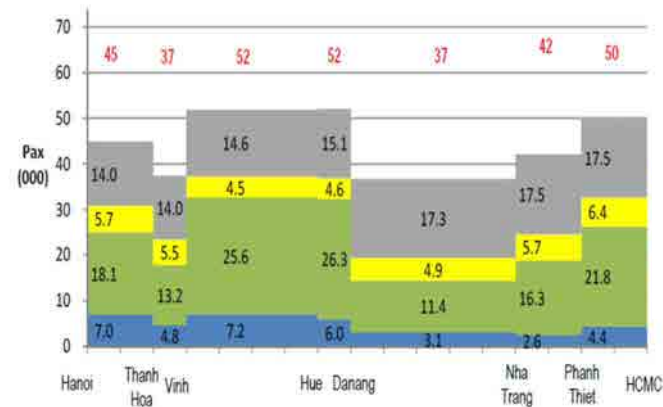
The following figures summarize the comparison between HSR2012 and HSR2013 with regard to sectional demands in 2010 and 2030.



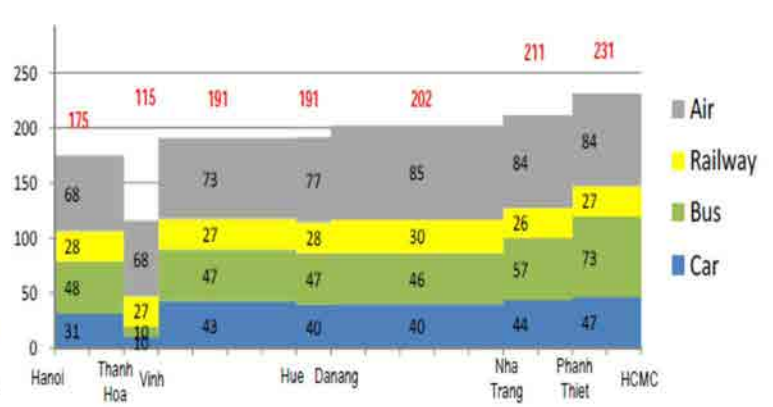
Source: HSR2012

[Fig. 4-1-5] HSR2012 Sectional Demand Forecast- 2010 and 2030 (Passenger)

<2010>



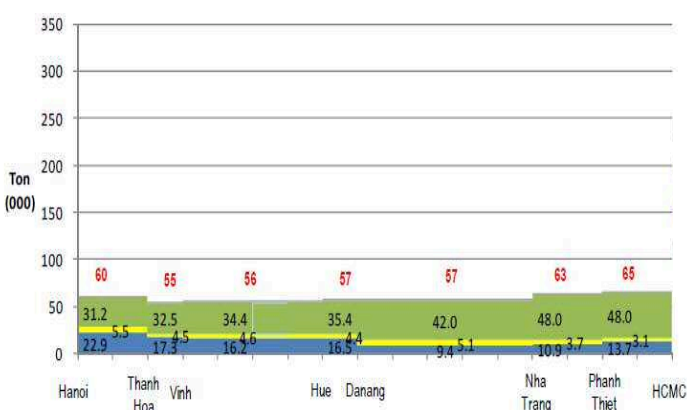
<2030>



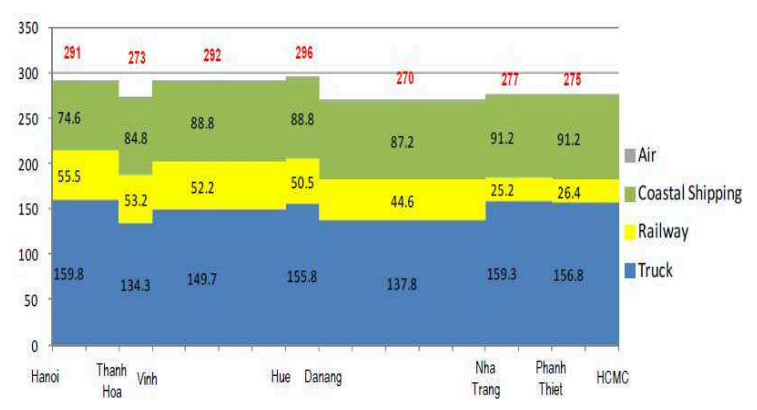
Source: HSR2013

[Fig. 4-1-6] HSR2013 Sectional Demand Forecast- 2010 and 2030 (Passenger)

<2010>



<2030>



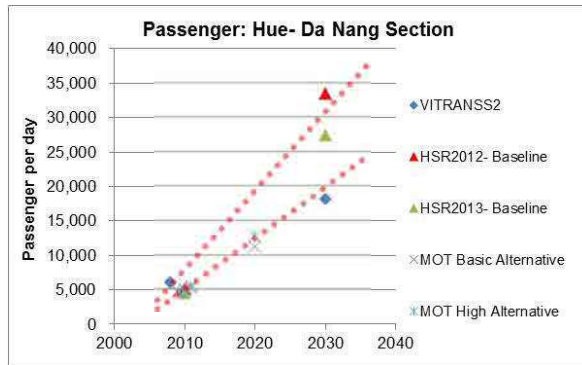
Source: HSR2012

[Fig. 4-1-7] HSR2012 Sectional Demand Forecast- 2010 and 2030 (Freight)

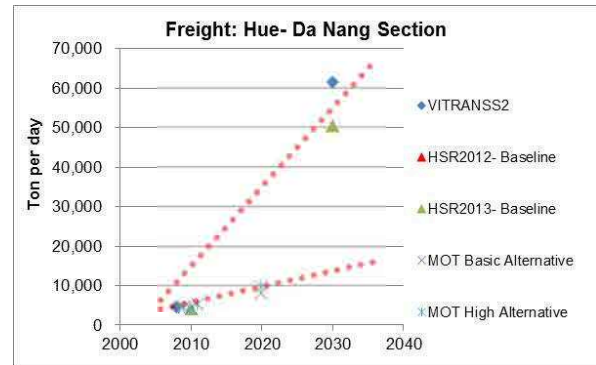
4.2 Data Generation

4.2.1 Comparison of Demand Forecasts in Various Studies

Demand forecasts to be used in this study shall be generated based on the existing forecasts including VITRANSS2, HSR2012, HSR2013, and the MOT Report. Passenger and freight demand forecasts taken from various studies are summarized as shown in the figures below.



Source: VITRANSS2, HSR2012/2013, MOT
[Fig. 4-2-1] Comparison of Demand Forecast (Passenger)



Source: VITRANSS2, HSR2012/2013, MOT
[Fig. 4-2-2] Comparison of Demand Forecast (Freight)

Passenger demand in MOT Report is shown almost the same trend as VITRANSS2, but it was upwardly revised in HSR2012 and HSR2013. In the Hue-DaNang section, HSR2012 forecast takes the highest forecast value.

As for the freight demand forecast, there are big differences between VITRANSS2, HSR 2012/2013 and the MOT Report. Particularly, as mentioned in section 4.1, the VITRANSS2 demand growth forecast looks too great and the same is true for HSR 2012/2013 as compared to the MOT Report.

4.2.2 Base Data for Demand Forecast

(1) Passenger Demand

Basic demand growth for passengers is taken from the HSR2012, but passenger demand will be affected by HSR operation because it runs parallel to the N-S Railway. Since this effect is incorporated in the HSR2013, the base case is taken from the HSR2012 and the HSR2013 value is taken for the HSR operation case in this study.

(2) HSR Passenger Demand

HSR transportation demand is forecasted in the HSR2013 at all cases when HSR is in partial operation between the HaNoi and Vinh section, in partial operation between the NhaTrang and HCMC section, and in full operation between HaNoi and HCMC. However, HSR launch is independently assumed in this study based on the latest information. Furthermore, the HSR demand forecast is made only for the year 2030. Therefore, HSR demand growth is also assumed based on the demand growth shown in the HSR2012.

(3) Freight Demand

The freight demand forecast is taken from the MOT Report because the value looks fair enough. But, since a commodity-wise forecast is not available in the MOT Report, separation of container and bulk is made in this study based on the composition in 2030 of the VITRANSS2.

4.3 Demand Forecast

4.3.1 Passenger Demand Forecast

(1) Data for Demand Forecast

The latest information on the HSR launch time schedule is that the NhaTrang-HCMC section is 2031, the HaNoi-Vinh section is 2034 and the whole section is 2050. The figure below shows applied data to take demand forecast at each section of the launches.

	CR							HSR						
Year	HaNoi-Thanh Hoa	Thanh Hoa- Vinh	Vinh- Hue	Hue- Da Nang	Da Nang- Nha Trang	Nha Trang-Phan Thiet	Phan Thiet-HCMC	HaNoi-Thanh Hoa	Thanh Hoa- Vinh	Vinh- Hue	Hue- Da Nang	Da Nang- Nha Trang	Nha Trang-Phan Thiet	Phan Thiet-HCMC
2015-2030	CR only													
2031-2033	CR only but demand attracted by HSR (Nha Trang- HCMC)					CR with HSR operation (Nha Trang- HCMC)								
2034-2049	CR with HSR operation (HaNoi- Vinh)		CR only but demand attracted by HSR (HaNoi-Vinh)		HSR operation (HaNoi- Vinh)			HSR operation (Nha Trang- HCMC)						
2050-	CR with HSR operation (Whole Section)							HSR operation (Whole Section)						

Legend:

HSR 2012 data (2010- 2030)

HSR 2013 data (start from 2031 converted from 2030 data)

HSR 2013 data (start from 2034 converted from 2030 data)

HSR 2013 data (start from 2050 converted from 2030 data)

Source: Study Team

Source: Study Team

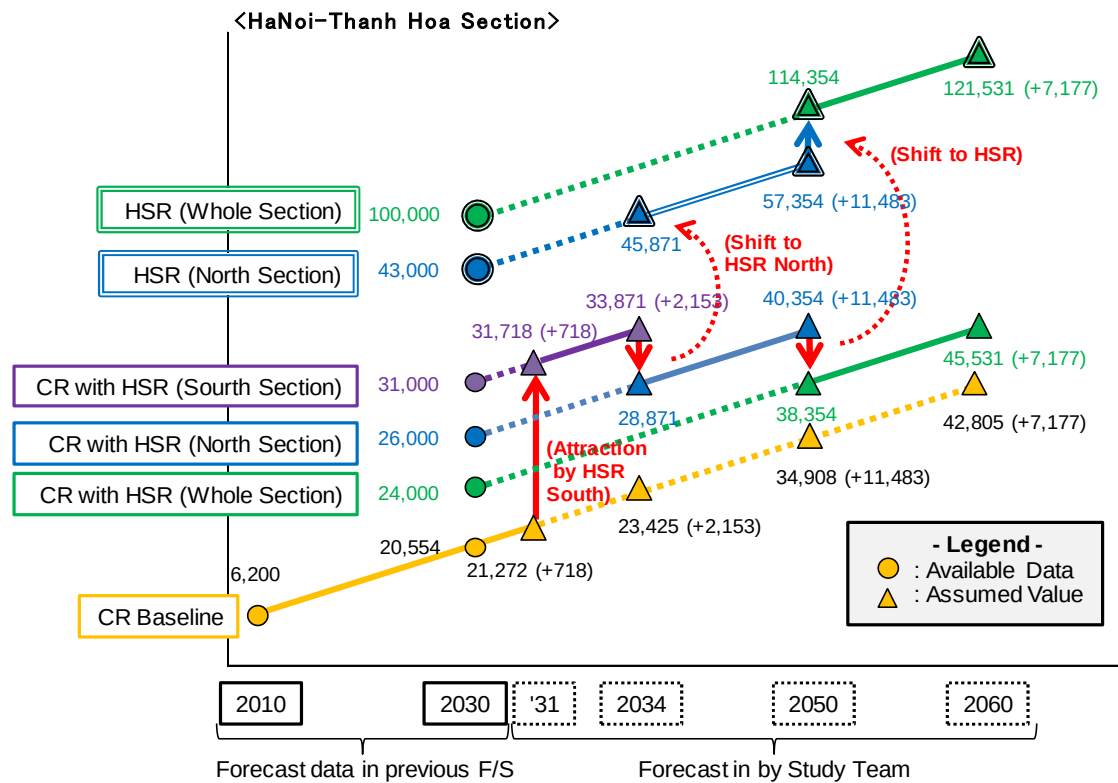
[Fig. 4-3-1] Base Data for Each Section and Year Bracket

(2) Passenger Demand Forecast

Passenger demand growth is given for the demand of Baseline case in the forecasted year between 2010 and 2030. Future passenger demand is assumed based on the growth of this duration by linear interpolation. This growth rate is applied to the previous year of the HSR launch. After the HSR launch, the demand growth rate is assumed to keep up with the same trend as before the HSR launch.

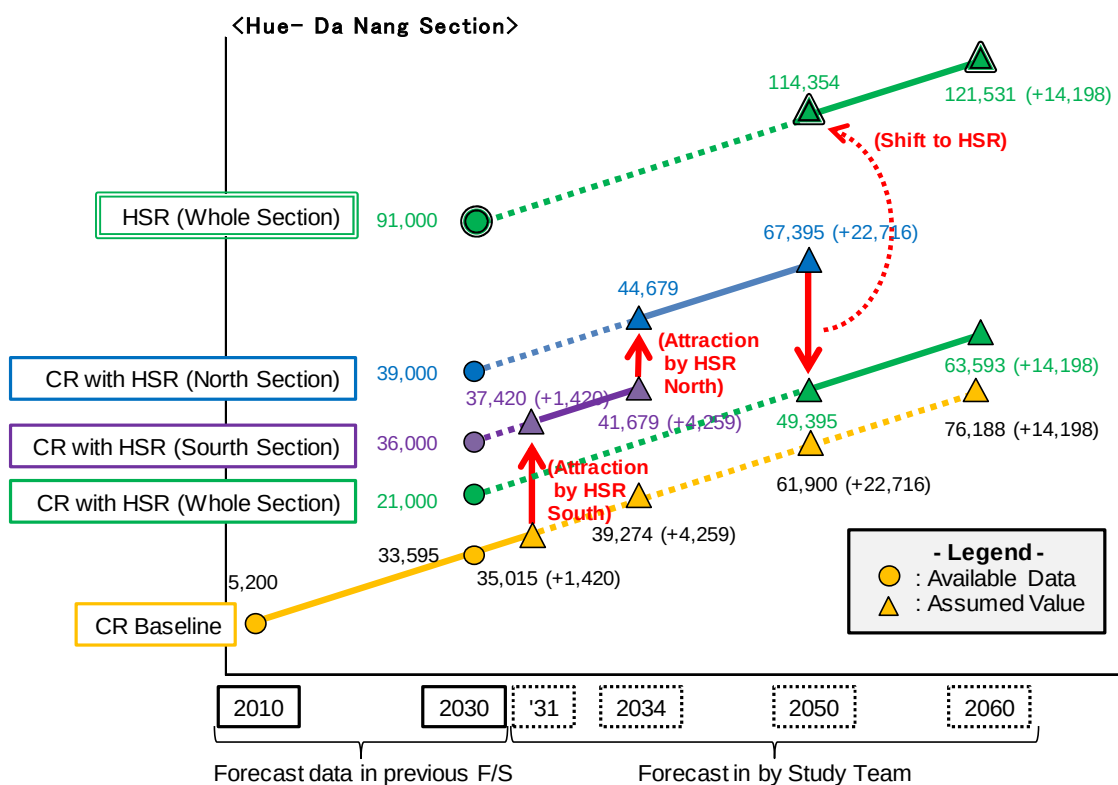
Since HSR demand growth is shown in neither the HSR2012 nor the HSR2013, it was estimated in this study by applying the same passenger volume growth rate of conventional railway passenger demand at the base year of the HSR launch. The concept is illustrated in the figures shown below.

In this figure, the circle marks represent available data and the triangle marks represent generated data based on the circle-marked data where linear interpolation of the available data trend is applied to generate demand forecasts knowing that it may not be possible for such a long span time schedule. However, there are no other practical solutions under the circumstances of extremely limited data availability.



Source: Study team

[Fig. 4-3-2] Conceptual Drawing of Demand Forecast in this Study (1)

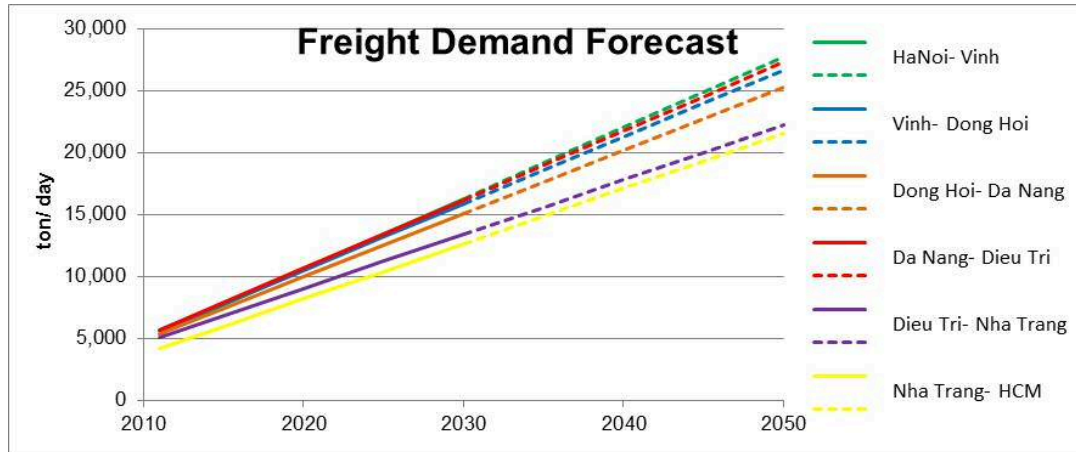


Source: Study team

[Fig. 4-3-3] Conceptual Drawing of Demand Forecast in this Study (2)

4.3.2 Freight Demand Forecast

Based on the freight transportation demand in 2010 and 2020 referred to in the High Alternative case of the MOT Report, demands in intermediate years up to 2020 and after 2031 are assumed by linear interpolation. Annual growth rate is approximately 9 to 11%.



Source: MOT arranged by Study Team

[Fig. 4-3-4] Assumed Freight Transportation Demand

4.3.3 Demand Forecast

(1) Conventional Railway Passenger

The demand forecast is made based on the demand forecasts shown in the various studies mentioned above considering the events that affect passenger demand at each year of the events as follows:

- 2015-2030: Based on conventional railway demand in 2010, which is the Base Case according to the HSR2012, demand forecast in the intermediate years up to 2030 is made by linear interpolation.
- 2031-2033: Based on conventional railway demand in 2030 which is the HSR Operation Case (NhaTrang-HCMC section) according to the HSR2013, demand forecast from 2031 to 2033 is made by applying the same demand growth rate assumed in the Base Case of the HSR2012.
- 2034-2049 (HaNoi-DaNang section): Demand between HaNoi and DaNang is based on conventional railway demand in 2030 which is the HSR Operation Case in North Section (HaNoi-Vinh) according to the HSR2013. Annual demand growth rate from 2034 to 2049 is made by applying the same demand growth rate assumed in the Base Case of the HSR2012.
- 2034-2049 (DaNang-HCMC section): Demand between DaNang and HCMC is based on conventional railway demand in 2030 which is the HSR Operation Case in the South Section (NhaTrang-HCMC) according to the HSR2013. Annual demand growth rate from 2034 to 2049 is made applying the same demand growth rate assumed in the Base Case of the HSR2012.
- 2050-: Based on conventional railway demand in 2030 which is the HSR Operation Case (whole section) according to the HSR2013, demand forecast after 2050 is made by applying the same demand growth rate of the Base Case of the HSR2012.

(2) HSR Passenger

- 2031-2049 (between HaNoi-Vinh and between DaNang-HCMC): Based on the HSR demand forecast in 2030 which is the HSR Operation Case (each section) according to the HSR2013, demand forecast from 2031 to 2049 is made by applying the same demand

growth rate assumed in the Base Case of the HSR2012.

- 2050-: Based on the HSR demand forecast in 2030, which is the HSR Operation Case (whole section) according to the HSR2013, demand forecast after 2050 is made by applying the same demand growth rate assumed in the Base Case of the HSR2012.

(3) Freight Transportation

- Based on the freight transportation demand in 2010 and 2020, which is the High Alternative case of the MOT Report, demand forecasts in the intermediate years up to 2020 and after 2031 are made by linear interpolation.
- Effects by the HSR launch are not taken into account in the freight demand forecast.
- As for the composition ratio of container and bulk, 37% and 63% shown in the year 2030 of the VITRANSS2 are applied. Categorization of commodities into container and bulk are assumed, using the transportation situation in Japan as a reference.

[Tab. 4-3-1] Demand Forecast on Each Section (Conventional Railway)

Unit: Passenger/ day

Year	HaNoi - Thanh Hoa	Thanh Hoa - Vinh	Vinh - Hue	Hue - Da Nang	Da Nang - Nha Trang	Nha Trang - Phan Thiet	Phan Thiet - HCMC
2015	9,789	10,446	10,613	12,299	16,876	17,743	18,216
2016	10,506	11,315	11,715	13,719	19,012	20,032	20,479
2017	11,224	12,184	12,818	15,138	21,147	22,320	22,742
2018	11,942	13,054	13,920	16,558	23,282	24,609	25,006
2019	12,659	13,923	15,023	17,978	25,417	26,897	27,269
2020	13,377	14,792	16,125	19,398	27,553	29,186	29,532
2021	14,095	15,661	17,228	20,817	29,688	31,475	31,795
2022	14,812	16,530	18,330	22,237	31,823	33,763	34,058
2023	15,530	17,400	19,433	23,657	33,958	36,052	36,322
2024	16,248	18,269	20,535	25,077	36,094	38,340	38,585
2025	16,966	19,138	21,638	26,496	38,229	40,629	40,848
2026	17,683	20,007	22,740	27,916	40,364	42,918	43,111
2027	18,401	20,876	23,843	29,336	42,499	45,206	45,374
2028	19,119	21,746	24,945	30,756	44,635	47,495	47,638
2029	19,836	22,615	26,048	32,175	46,770	49,783	49,901
2030	20,554	23,484	27,150	33,595	48,905	52,072	52,164
2031	31,718	30,869	34,103	37,420	59,135	31,289	37,263
2032	32,435	31,738	35,205	38,840	61,271	33,577	39,526
2033	33,153	32,608	36,308	40,259	63,406	35,866	41,790
2034	28,871	24,477	44,410	44,679	65,541	38,154	44,053
2035	29,589	25,346	45,513	46,099	67,676	40,443	46,316
2036	30,306	26,215	46,615	47,519	69,812	42,732	48,579
2037	31,024	27,084	47,718	48,938	71,947	45,020	50,842
2038	31,742	27,954	48,820	50,358	74,082	47,309	53,106
2039	32,459	28,823	49,923	51,778	76,217	49,597	55,369
2040	33,177	29,692	51,025	53,198	78,353	51,886	57,632
2041	33,895	30,561	52,128	54,617	80,488	54,175	59,895
2042	34,612	31,430	53,230	56,037	82,623	56,463	62,158
2043	35,330	32,300	54,333	57,457	84,758	58,752	64,422
2044	36,048	33,169	55,435	58,877	86,894	61,040	66,685
2045	36,766	34,038	56,538	60,296	89,029	63,329	68,948
2046	37,483	34,907	57,640	61,716	91,164	65,618	71,211
2047	38,201	35,776	58,743	63,136	93,299	67,906	73,474
2048	38,919	36,646	59,845	64,556	95,435	70,195	75,738
2049	39,636	37,515	60,948	65,975	97,570	72,483	78,001
2050	38,354	37,384	42,050	49,395	65,705	67,772	69,264
2051	39,072	38,253	43,153	50,815	67,840	70,061	71,527
2052	39,789	39,122	44,255	52,235	69,976	72,349	73,790
2053	40,507	39,992	45,358	53,654	72,111	74,638	76,054
2054	41,225	40,861	46,460	55,074	74,246	76,926	78,317
2055	41,943	41,730	47,563	56,494	76,381	79,215	80,580
2056	42,660	42,599	48,665	57,914	78,517	81,504	82,843
2057	43,378	43,468	49,768	59,333	80,652	83,792	85,106
2058	44,096	44,338	50,870	60,753	82,787	86,081	87,370
2059	44,813	45,207	51,973	62,173	84,922	88,369	89,633
2060	45,531	46,076	53,075	63,593	87,058	90,658	91,896

Source: Study Team

[Tab. 4-3-2] Demand Forecast on Each Section (HSR)

Unit: Passenger/ day

Year	HaNoi - Thanh Hoa	Thanh Hoa - Vinh	Vinh - Hue	Hue - Da Nang	Da Nang - Nha Trang	Nha Trang - Phan Thiet	Phan Thiet - HCMC
2015							
2016							
2017							
2018							
2019							
2020							
2021							
2022							
2023							
2024							
2025							
2026							
2027							
2028							
2029							
2030							
2031					42,289	51,263	
2032					44,577	53,526	
2033					46,866	55,790	
2034	45,871	33,477				49,154	58,053
2035	46,589	34,346				51,443	60,316
2036	47,306	35,215				53,732	62,579
2037	48,024	36,084				56,020	64,842
2038	48,742	36,954				58,309	67,106
2039	49,459	37,823				60,597	69,369
2040	50,177	38,692				62,886	71,632
2041	50,895	39,561				65,175	73,895
2042	51,612	40,430				67,463	76,158
2043	52,330	41,300				69,752	78,422
2044	53,048	42,169				72,040	80,685
2045	53,766	43,038				74,329	82,948
2046	54,483	43,907				76,618	85,211
2047	55,201	44,776				78,906	87,474
2048	55,919	45,646				81,195	89,738
2049	56,636	46,515				83,483	92,001
2050	114,354	109,384	107,050	119,395	151,705	155,772	152,264
2051	115,072	110,253	108,153	120,815	153,840	158,061	154,527
2052	115,789	111,122	109,255	122,235	155,976	160,349	156,790
2053	116,507	111,992	110,358	123,654	158,111	162,638	159,054
2054	117,225	112,861	111,460	125,074	160,246	164,926	161,317
2055	117,943	113,730	112,563	126,494	162,381	167,215	163,580
2056	118,660	114,599	113,665	127,914	164,517	169,504	165,843
2057	119,378	115,468	114,768	129,333	166,652	171,792	168,106
2058	120,096	116,338	115,870	130,753	168,787	174,081	170,370
2059	120,813	117,207	116,973	132,173	170,922	176,369	172,633
2060	121,531	118,076	118,075	133,593	173,058	178,658	174,896

Source: Study Team

[Tab. 4-3-3] Demand Forecast on Each Section (Freight by Cargo Type)

Unit: t/ day

Year	HaNoi- Vinh		Vinh- Dong Hoi		Dong Hoi- Da Nang		Da Nang- Dieu Tri		Dieu Tri- Nha Trang		Nha Trang- HCM	
	Container	Bulk	Container	Bulk	Container	Bulk	Container	Bulk	Container	Bulk	Container	Bulk
2015	2,860	4,882	2,891	4,935	2,763	4,718	2,922	4,989	2,528	4,315	2,214	3,780
2016	3,071	5,243	3,090	5,275	2,951	5,039	3,127	5,339	2,690	4,592	2,378	4,060
2017	3,282	5,604	3,289	5,615	3,140	5,360	3,332	5,688	2,852	4,870	2,543	4,341
2018	3,494	5,964	3,488	5,955	3,328	5,681	3,537	6,038	3,015	5,147	2,707	4,622
2019	3,705	6,325	3,687	6,294	3,516	6,002	3,742	6,388	3,177	5,424	2,872	4,902
2020	3,916	6,686	3,886	6,634	3,704	6,323	3,946	6,738	3,340	5,701	3,036	5,183
2021	4,127	7,046	4,085	6,974	3,892	6,644	4,151	7,087	3,502	5,979	3,200	5,464
2022	4,339	7,407	4,284	7,314	4,080	6,965	4,356	7,437	3,664	6,256	3,365	5,744
2023	4,550	7,768	4,483	7,653	4,268	7,286	4,561	7,787	3,827	6,533	3,529	6,025
2024	4,761	8,129	4,682	7,993	4,456	7,608	4,766	8,136	3,989	6,810	3,694	6,306
2025	4,973	8,489	4,881	8,333	4,644	7,929	4,971	8,486	4,152	7,088	3,858	6,586
2026	5,184	8,850	5,080	8,673	4,832	8,250	5,175	8,836	4,314	7,365	4,022	6,867
2027	5,395	9,211	5,279	9,012	5,020	8,571	5,380	9,185	4,476	7,642	4,187	7,148
2028	5,606	9,571	5,478	9,352	5,208	8,892	5,585	9,535	4,639	7,920	4,351	7,428
2029	5,818	9,932	5,677	9,692	5,396	9,213	5,790	9,885	4,801	8,197	4,516	7,709
2030	6,029	10,293	5,876	10,032	5,585	9,534	5,995	10,234	4,964	8,474	4,680	7,990
2031	6,240	10,653	6,075	10,371	5,773	9,855	6,200	10,584	5,126	8,751	4,844	8,270
2032	6,451	11,014	6,274	10,711	5,961	10,176	6,404	10,934	5,288	9,029	5,009	8,551
2033	6,663	11,375	6,473	11,051	6,149	10,497	6,609	11,283	5,451	9,306	5,173	8,832
2034	6,874	11,735	6,672	11,391	6,337	10,818	6,814	11,633	5,613	9,583	5,338	9,112
2035	7,085	12,096	6,871	11,731	6,525	11,140	7,019	11,983	5,776	9,860	5,502	9,393
2036	7,297	12,457	7,070	12,070	6,713	11,461	7,224	12,332	5,938	10,138	5,666	9,674
2037	7,508	12,818	7,269	12,410	6,901	11,782	7,428	12,682	6,100	10,415	5,831	9,954
2038	7,719	13,178	7,468	12,750	7,089	12,103	7,633	13,032	6,263	10,692	5,995	10,235
2039	7,930	13,539	7,667	13,090	7,277	12,424	7,838	13,381	6,425	10,969	6,160	10,516
2040	8,142	13,900	7,866	13,429	7,465	12,745	8,043	13,731	6,588	11,247	6,324	10,796
2041	8,353	14,260	8,065	13,769	7,653	13,066	8,248	14,081	6,750	11,524	6,488	11,077
2042	8,564	14,621	8,264	14,109	7,841	13,387	8,453	14,430	6,912	11,801	6,653	11,358
2043	8,775	14,982	8,463	14,449	8,030	13,708	8,657	14,780	7,075	12,078	6,817	11,638
2044	8,987	15,342	8,662	14,788	8,218	14,029	8,862	15,130	7,237	12,356	6,982	11,919
2045	9,198	15,703	8,861	15,128	8,406	14,350	9,067	15,479	7,400	12,633	7,146	12,200
2046	9,409	16,064	9,060	15,468	8,594	14,672	9,272	15,829	7,562	12,910	7,310	12,481
2047	9,621	16,424	9,259	15,808	8,782	14,993	9,477	16,179	7,725	13,187	7,475	12,761
2048	9,832	16,785	9,458	16,147	8,970	15,314	9,682	16,528	7,887	13,465	7,639	13,042
2049	10,043	17,146	9,657	16,487	9,158	15,635	9,886	16,878	8,049	13,742	7,804	13,323
2050	10,254	17,507	9,856	16,827	9,346	15,956	10,091	17,228	8,212	14,019	7,968	13,603
2051	10,466	17,867	10,055	17,167	9,534	16,277	10,296	17,578	8,374	14,297	8,132	13,884
2052	10,677	18,228	10,254	17,507	9,722	16,598	10,501	17,927	8,537	14,574	8,297	14,165
2053	10,888	18,589	10,453	17,846	9,910	16,919	10,706	18,277	8,699	14,851	8,461	14,445
2054	11,099	18,949	10,652	18,186	10,098	17,240	10,910	18,627	8,861	15,128	8,626	14,726
2055	11,311	19,310	10,851	18,526	10,286	17,561	11,115	18,976	9,024	15,406	8,790	15,007
2056	11,522	19,671	11,050	18,866	10,475	17,882	11,320	19,326	9,186	15,683	8,954	15,287
2057	11,733	20,031	11,249	19,205	10,663	18,204	11,525	19,676	9,349	15,960	9,119	15,568
2058	11,945	20,392	11,448	19,545	10,851	18,525	11,730	20,025	9,511	16,237	9,283	15,849
2059	12,156	20,753	11,647	19,885	11,039	18,846	11,935	20,375	9,673	16,515	9,448	16,129
2060	12,367	21,113	11,846	20,225	11,227	19,167	12,139	20,725	9,836	16,792	9,612	16,410
2061	12,578	21,474	12,046	20,564	11,415	19,488	12,344	21,074	9,998	17,069	9,776	16,691
2062	12,790	21,835	12,245	20,904	11,603	19,809	12,549	21,424	10,161	17,346	9,941	16,971
2063	13,001	22,195	12,444	21,244	11,791	20,130	12,754	21,774	10,323	17,624	10,105	17,252
2064	13,212	22,556	12,643	21,584	11,979	20,451	12,959	22,123	10,485	17,901	10,270	17,533
2065	13,423	22,917	12,842	21,923	12,167	20,772	13,163	22,473	10,648	18,178	10,434	17,813
2066	13,635	23,278	13,041	22,263	12,355	21,093	13,368	22,823	10,810	18,455	10,598	18,094
2067	13,846	23,638	13,240	22,603	12,543	21,414	13,573	23,172	10,973	18,733	10,763	18,375
2068	14,057	23,999	13,439	22,943	12,731	21,736	13,778	23,522	11,135	19,010	10,927	18,655
2069	14,269	24,360	13,638	23,282	12,920	22,057	13,983	23,872	11,297	19,287	11,092	18,936
2070	14,480	24,720	13,837	23,622	13,108	22,378	14,188	24,221	11,460	19,564	11,256	19,217
2071	14,691	25,081	14,036	23,962	13,296	22,699	14,392	24,571	11,622	19,842	11,420	19,497
2072	14,902	25,442	14,235	24,302	13,484	23,020	14,597	24,921	11,785	20,119	11,585	19,778
2073	15,114	25,802	14,434	24,642	13,672	23,341	14,802	25,270	11,947	20,396	11,749	20,059
2074	15,325	26,163	14,633	24,981	13,860	23,662	15,007	25,620	12,109	20,674	11,914	20,339
2075	15,536	26,524	14,832	25,321	14,048	23,983	15,212	25,970	12,272	20,951	12,078	20,620
2076	15,747	26,884	15,031	25,661	14,236	24,304	15,417	26,319	12,434	21,228	12,242	20,901
2077	15,959	27,245	15,230	26,001	14,424	24,625	15,621	26,669	12,597	21,505	12,407	21,181
2078	16,170	27,606	15,429	26,340	14,612	24,946	15,826	27,019	12,759	21,783	12,571	21,462
2079	16,381	27,967	15,628	26,680	14,800	25,267	16,031	27,368	12,921	22,060	12,736	21,743
2080	16,593	28,327	15,827	27,020	14,988	25,589	16,236	27,718	13,084	22,337	12,900	22,023
2081	16,804	28,688	16,026	27,360	15,177	25,910	16,441	28,068	13,246	22,614	13,065	22,304
2082	17,015	29,049	16,225	27,699	15,365	26,231	16,645	28,418	13,409	22,892	13,229	22,585
2083	17,226	29,409	16,424	28,039	15,553	26,552	16,850	28,767	13,571	23,169	13,393	22,865
2084	17,438	29,770	16,623	28,379	15,741	26,873	17,055	29,117	13,734	23,446	13,558	23,146

Source: Study Team

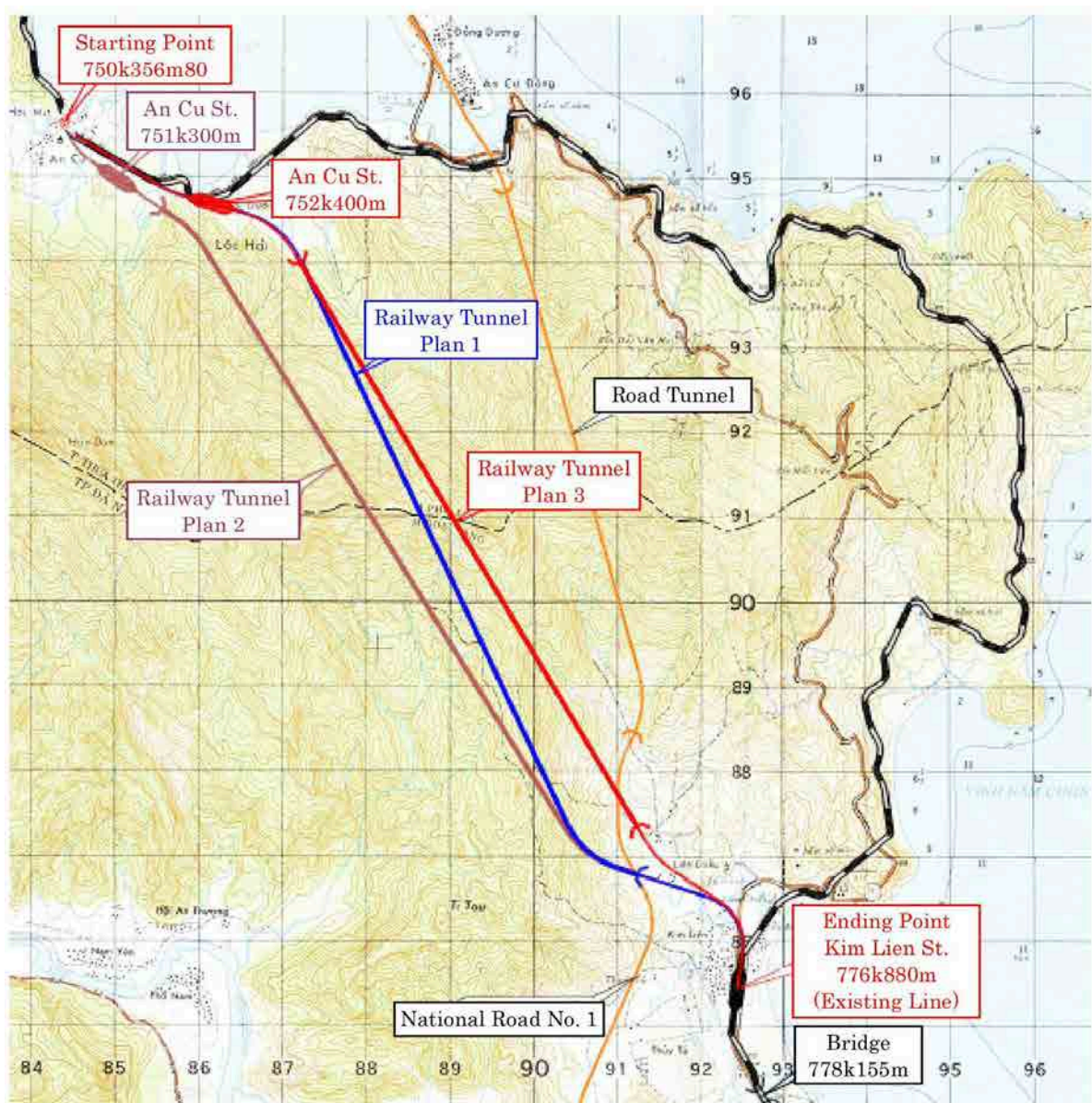
Chapter 5 HaiVan Tunnel Component

5.1 Present Condition

5.1.1 HaiVan Pass Section

The HaiVan pass section is one of the major bottleneck sections listed by VNR based on the present conditions. VNR has drafted a series of Pre-F/S reports to improve the alignment by constructing new tunnels in the HaiVan pass section. This project is targeting a Japanese ODA Yen Loan.

The objectives of this project are to increase the speed and capacity of transportation, to reduce the time of train operation through the HaiVan pass section and to ensure absolute safety in all situations. The section of this project drafted by VNR is from 750k356m (near LangCo Station) to 776k880m (KimLien Station) (refer to [Fig. 5-1-1]). In this part, the section from LangCo Station to KimLien Station is called the HaiVan pass section.



Source: VNR

[Fig. 5-1-1] Map of HaiVan Pass Section and HaiVan Tunnel planned by VNR

5.1.2 Facilities

(1) Alignment

A comparison of horizontal and vertical alignment on the HaiVan pass section and other sections is shown in [Tab. 5-1-1] and [Tab. 5-1-2] respectively.

The HaiVan pass section consists of 56.5% curved sections, and the share of curved sections with a radius under 150m is 48.6% which is very high compared to other sections. The share of steep sections with a vertical gradient over 12‰ in the HaiVan pass section is 74.0% which is also very high compared to other sections. From these results, it is indicated that the HaiVan pass section has many small curved and steep sections.

[Tab. 5-1-1] Comparison of Horizontal Alignment

(Unit: km and (%))

Alignment	HaiVan Pass Section (LangCo – KimLien)	DongHoi – DaNang Section	Total of Railway Line (HaNoi – SaiGon)
$R < 150\text{m}$	10.4 (48.6%)	11.9 (4.4%)	14.2 (0.8%)
$150 \leq R < 300\text{ m}$	1.0 (4.8%)	3.2 (1.2%)	24.5 (1.4%)
$300 \leq R < 600\text{ m}$	0.5 (2.4%)	20.8 (7.7%)	163.0 (9.4%)
$600 \leq R < 800\text{ m}$	0.0 (0.0%)	2.6 (1.0%)	51.7 (3.0%)
$R > 800\text{ m}$	0.1 (0.6%)	20.8 (7.7%)	141.5 (8.2%)
Curves, Subtotal	12.1 (56.5%)	59.3 (22.0%)	395.0 (22.9%)
Straight	9.3 (43.5%)	210.3 (78.0%)	1,331.0 (77.1%)
Total Length	21.5 (100.0%)	269.6 (100.0%)	1,726.0 (100.0%)

Note: R= Radius of curve (m)

Source: Study team based on various raw data provided by VNR

[Tab. 5-1-2] Comparison of Vertical Alignment

(Unit: km and (%))

Alignment	HaiVan Pass Section (LangCo – KimLien)	DongHoi – DaNang Section	Total of Railway Line (HaNoi – SaiGon)
$I \leq 6\text{‰}$	4.63 (21.6%)	222.87 (82.6%)	1,448.58 (83.9%)
$6 < I \leq 12\text{‰}$	0.95 (4.4%)	30.72 (11.4%)	219.26 (12.7%)
$12 < I \leq 15\text{‰}$	8.78 (40.9%)	8.97 (3.3%)	42.48 (2.5%)
$I > 15\text{‰}$	7.11 (33.1%)	7.11 (2.6%)	15.68 (0.9%)
Total Length	21.47 (100.0%)	269.67 (100.0%)	1,726.00 (100.0%)

Note: Regarding mountain passes:

Vinh - DongHoi: HoaDuyet - ThanhLuyen (357 to 369km, max gradient = 6‰)

KheNet pass (415 to 420 km, maximum gradient = 17‰)

DongHoi - DaNang: HaiVan pass (755 to 765 km, maximum gradient = 17‰)

Source: Study team based on various raw data provided by VNR

(2) Tunnels

The study team visited six (6) tunnels on the HaiVan pass section with an inspection motor car provided by VNR. It was found that the main problem of the existing tunnels is the large amount of water leakage and significant crack development at arches and side wall faces. For these reasons, all trains run with restricted speed in these tunnels.

The remaining three (3) weak tunnels on the HaiVan pass section are shown in [Tab. 5-1-3], and the present conditions of some existing tunnels on the HaiVan pass section are shown in [Fig. 5-1-2].

[Tab. 5-1-3] Remaining Weak Tunnels on the HaiVan Pass Section

No.	Name of tunnel	Center of tunnel	Length (m)	Gradient (‰)	Speed Restriction	Planned maximum speed
11	Tunnel No. 11	759k513m	129.04	14.5 (18)	30 km/h	30 km/h
12	Tunnel No. 12	766k049m	564.17	5.5 (10)	30 km/h	30 km/h
14	Tunnel No. 14	774k674m	944.62	14	15 km/h	30 km/h

Source: VNR



Source: Study team

[Fig. 5-1-2] Present Conditions of Existing Tunnels on the HaiVan Pass Section

5.1.3 Train Operation

A comparison of travel speed on the HaiVan pass section and other sections is shown in [Tab. 5-1-4]. The average travel time of passenger and freight trains passing through the HaiVan pass section is 69 minutes and 94 minutes respectively, and the respective travel speeds are 21.2km/h and 13.7km/h. The average travel speed of passenger and freight trains passing through the Hue-DaNang section are 39.6km/h and 19.0km/h respectively.

The travel speed on the Hue-DaNang section is the lowest of the sections between major stations along the N-S Railway line because of the very low travel speed on the HaiVan pass section. The reason for the very low travel speed is that the HaiVan pass section has many small curved sections, many steep sections and some tunnels with large amount of water leakage and many cracks at the arches and side wall faces as described in section 5.1.2 and the maximum operation speed on the HaiVan pass section is 30km/h. In addition, it is necessary to couple an assisting locomotive to freight trains between LangCo Station and KimLien Station to pass through the HaiVan pass section because of the steep alignment. So additionally freight trains need time for coupling and uncoupling an assistance locomotive.

[Tab. 5-1-4] Comparison of Travel Speed based on Time Table as of July 2013

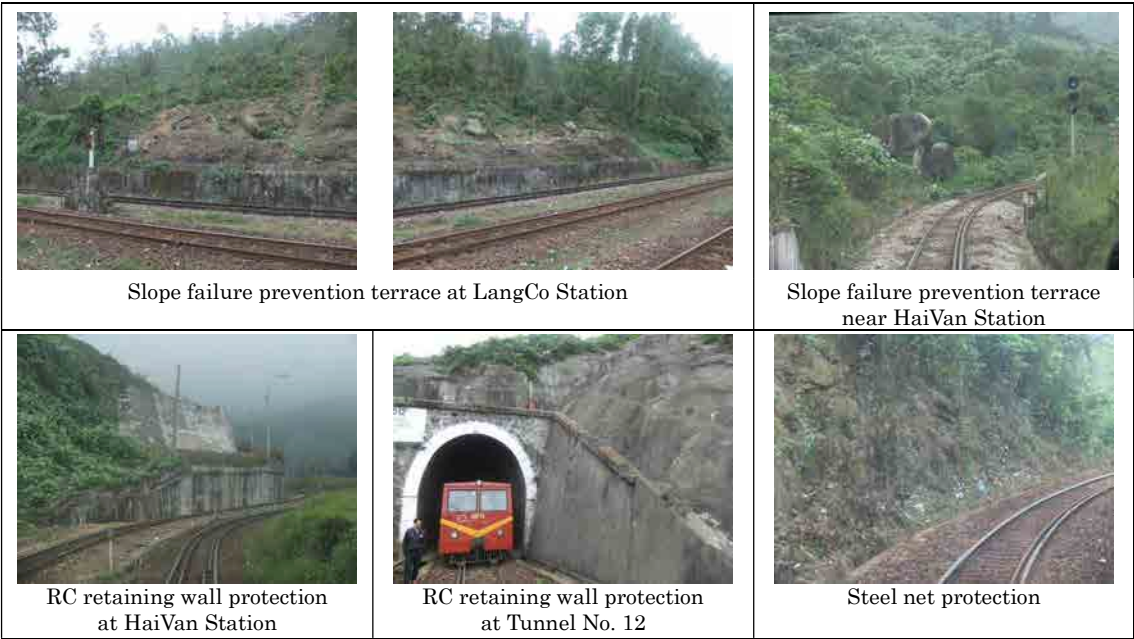
Section	Distance (km)	Travel Speed (km/h)			
		Passenger Train		Freight Train	
		Fastest	Average	Fastest	Average
Hanoi – Vinh	319.02	64.9	53.4	35.9	27.2
Vinh – DongHoi	202.78	56.1	50.0	31.1	27.1
DongHoi – Hue	166.52	60.6	55.4	35.6	26.2
Hue – DaNang	103.08	44.8	39.6	22.1	19.0
DaNang – DieuTri	304.14	64.7	56.3	32.6	26.4
DieuTri – NhaTrang	219.39	65.2	59.6	39.8	33.2
NhaTrang – SaiGon	411.27	63.1	54.8	36.7	30.9
Hanoi – SaiGon	1,726.20	58.5	51.7	27.5	24.9
HaiVan Pass Section (LangCo – KimLien)	21.47	25.8 [0h50m]	21.2 [1h01m]	16.3 [1h19m]	13.7 [1h34m]

Source: Study team based on various raw data provided by VNR

5.1.4 Disaster and Train Accident Risk

The number of landslide prevention structures and slope failure prevention terraces were observed along the HaiVan pass section (refer to [Fig. 5-1-3]). It is indicated that there is a risk of landslide disasters on the HaiVan pass section.

The existing railway line runs along the mountain slopes on the HaiVan pass section. Actually, during the rainy season, the mountain slopes and rocks often collapse and fill up the track with earth, sand and trees which have fallen down on the existing railway. There is therefore a possibility that trains get caught in a landslide disaster on the HaiVan pass section.



Source: Study team

[Fig. 5-1-3] Slope Conditions on the HaiVan Pass Section

Over-speed operation by drivers is one of VNR’s safety matters of concern, because VNR has experienced a fatal accident caused by excess speed. A news report on this accident on the HaiVan pass section is shown in [Box. 5-1-1].

[Box. 5-1-1] News Report on Train Accident on the HaiVan Pass Section

Title: Vietnam Train Derail Kills 11, Injuring 200
Source: CHINA VIEW www.chinaview.cn
Date: 2005-03-13 08:15:09
Article: HANOI, March 12 (Xinhuanet)

At least 11 people were killed and some 200 others injured when a train derailed in Vietnam’s central ThuaThienHue province on Saturday.

Of the 11 deaths, six died on the spot and five in hospitals. Dozens of the injured passengers were in a serious condition, Vietnam’s central television reported Saturday.

The accident occurred in PhuLoc district when the train was traveling from capital HaNoi to HCMC.

All rescue forces are being mobilized to take those injured people to hospitals in ThuaThienHue and nearby city of DaNang. Meanwhile, local authorities are investigating the cause for the accident.

The train left HaNoi on Friday night with 500 passengers and 29 staff.

Source: Study team

5.1.5 Major Issues on Current HaiVan Pass Section

The following issues are the findings of the study team during a site visit by inspection car for maintenance and the results of the above analyses related to the HaiVan pass section.

- **Small curve radius:** There are many curved sections with small radius on the HaiVan pass section.
- **Steep vertical gradient:** There are many steep sections with a vertical gradient over 12‰ on the HaiVan pass section.
- **Water leakage in tunnels:** Most of the mountain tunnels have a problem with water leakage which requires trains to slow down.
- **Slow travel speed:** Because of the above three issues, the travel speed of passenger and freight trains is very low on the HaiVan pass section.
- **Land slide risk:** There is a risk of landslide disasters on the HaiVan pass section.

From the content of the above five major issues of the current HaiVan pass section, unless the horizontal and vertical alignment is drastically changed, it is very difficult to solve the above five major issues only by the rehabilitation and improvement of the existing N-S Railway line. So the construction of tunnels on the HaiVan pass section is necessary.

5.2 Planning Methodology

5.2.1 Conditions for Planning

Although this study covers a wide range of infrastructure improvements over the whole N-S Railway, it had to be carried out in a very short period of time and with limited man power. There is thus a limit as to the contents and accuracy of the study. Existing material and data were used to make a general survey of the proposed new HaiVan Tunnel, and a two-day site survey was also conducted. It is recommended to carry out a more specific survey and analysis as part of the upcoming feasibility study. In this context, the basic conditions for route selection were identified as follows.

(1) Railway Stations

- 1) Build New DaNang Station (jointly used by both HSR and the N-S Railway) as a relocation of the present DaNang Station.
- 2) Keep KimLien Station as an Inland Container Depot (ICD) because the LienChieu Port construction plan is under way off the coast near KimLien Station, and also because the construction of an industrial estate is planned near the coast.
- 3) Relocate AnCu Station as a passenger station to an appropriate location.

(2) Railway Line Route

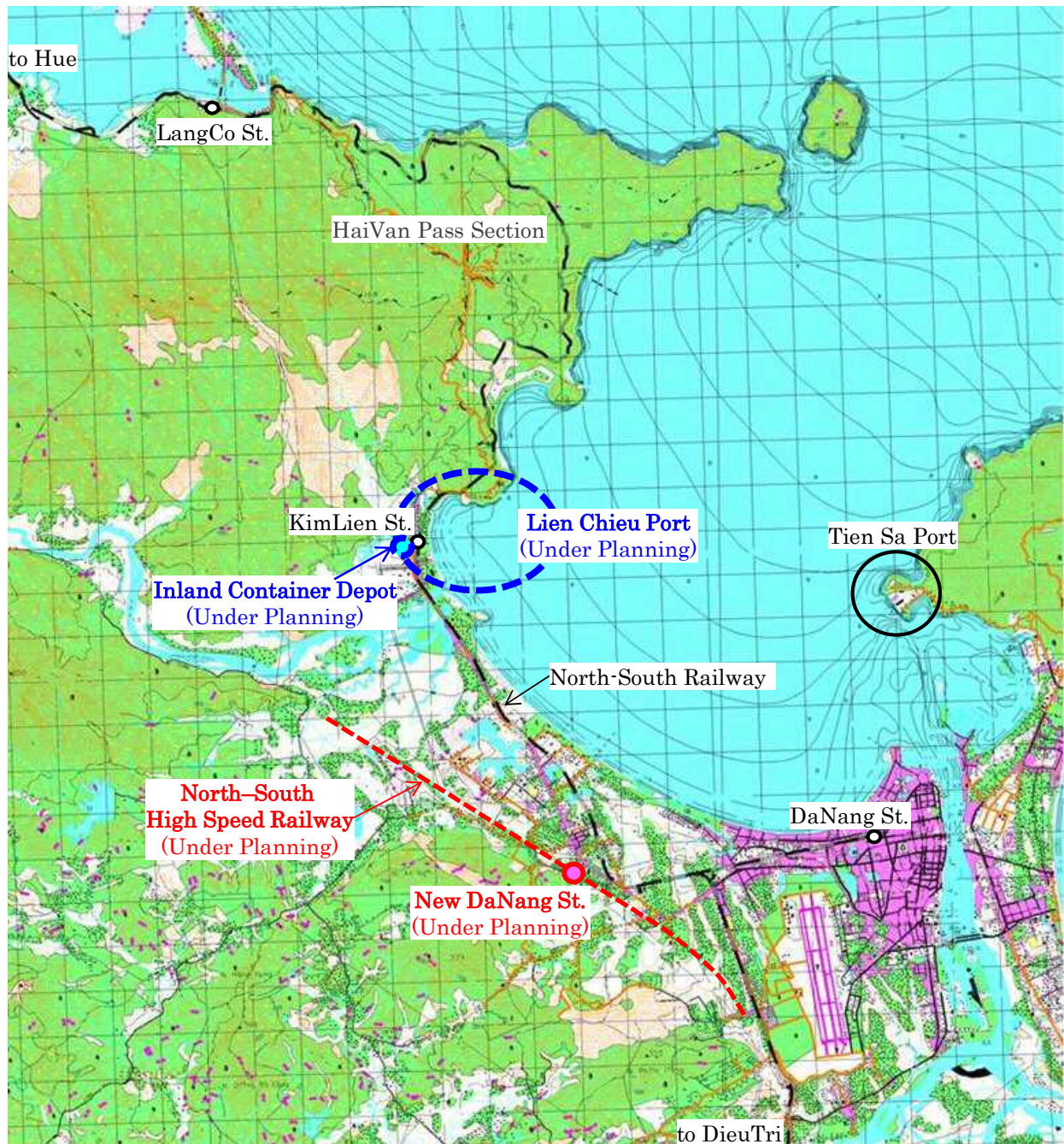
- 1) The N-S Railway which currently runs through the center of DaNang will be relocated to the eastern suburbs, and it is still unclear whether the existing line will be used as an urban train line or a freight line. However, since both the existing and the new line will arrive at New DaNang station, it is possible that the two (2) lines will be connected in the future.
- 2) In the future, it is possible that the existing HaiVan pass section of the N-S Railway will be used for the transportation of bulk freight or as a passenger line for tourists.
- 3) In light of the above points, the following two (2) routes are considered as tentative alignments for the HaiVan Tunnel.
 - **Alternative 1:** Appropriate alignment on the shortest route along with HSR-F/S

- **Alternative 2:** Alignment with small curves along with VNR F/S

(3) Gauge

- 1) Adopt standard gauge (1,435mm) for the HSR, but adopt meter gauge (1,000mm) for the N-S Railway.
- 2) Adopt dual gauge in case the HSR and the N-S Railway will both be operated on the same route.

The conditions mentioned above are illustrated in [Fig. 5-2-1].



Source: Study team

[Fig. 5-2-1] Location Map around DaNang Area

5.2.2 Proposed Construction Standard

The proposed construction standard for studying the alignment and structure of HaiVan is shown in [Tab. 5-2-1].

[Tab. 5-2-1] Proposed Construction Standard

Item	Conventional	HSR	Remarks
Gauge (mm)	1,000	1,435	Same as HSR
Design max speed (km/h)	Passenger 120 Fright Container 80 Bulk 60	350	MSR 200
Min curve radius (m)	800	6,000	Same as HSR
Min gradient (‰)	12	25	Same as HSR
Track center (m)	4.0	4.3	Same as HSR
Max axle load (t)	14	16	Same as HSR
Track structure	Ballast track	Slab Track on bridges and in tunnels Ballast track on fill and cut sections	Same as HSR

Source: Study team

In addition, the technical specifications for each structure are described in section 5.5.3 Technical Specification.

5.2.3 Demand Forecast

(1) Methodology of Demand Forecast

The base data used for the demand forecast are VITRANSS2, HSR2012 and HSR2013 as the updated version of them, and the MOT Report. A detailed data comparison and methodology of demand assumption are described in Chapter 4.

CR								HSR							
Year	HaNoi-Thanh Hoa	Thanh Hoa- Vinh	Vinh- Hue	Hue- Da Nang	Da Nang- Nha Trang	Nha Trang- Phan Thiet	Phan Thiet- HCMC	HaNoi-Thanh Hoa	Thanh Hoa- Vinh	Vinh- Hue	Hue- Da Nang	Da Nang- Nha Trang	Nha Trang- Phan Thiet	Phan Thiet- HCMC	
2015-2030	CR only														
2031-2033	CR only but demand attracted by HSR (Nha Trang- HCMC)					CR with HSR operation (Nha Trang- HCMC)									
2034-2049	CR with HSR operation (HaNoi- Vinh)		CR only but demand attracted by HSR (HaNoi-Vinh)					HSR operation (HaNoi- Vinh)						HSR operation (Nha Trang- HCMC)	
2050-	CR with HSR operation (Whole Section)							HSR operation (Whole Section)							

Legend:

		HSR 2012 data (2010- 2030)
		HSR 2013 data (start from 2031 converted from 2030 data)
		HSR 2013 data (start from 2034 converted from 2030 data)
		HSR 2013 data (start from 2050 converted from 2030 data)

Note: This figure is identical to [Fig. 4-3-1]

Source: Study team

[Fig. 5-2-2] Base Data for Each Section and Year Bracket

(2) Conventional Railway Passengers

The demand forecast for the HaiVan section is made based on the demand forecast shown in the above various reports on the HaiVan section. The forecast is made at each year bracket depending on the event of the years.

- 2015-2030: Based on conventional railway demand in 2010 which is the Base Case according to the HSR2012, demand forecast in the intermediate years up to 2030 is made

by linear interpolation.

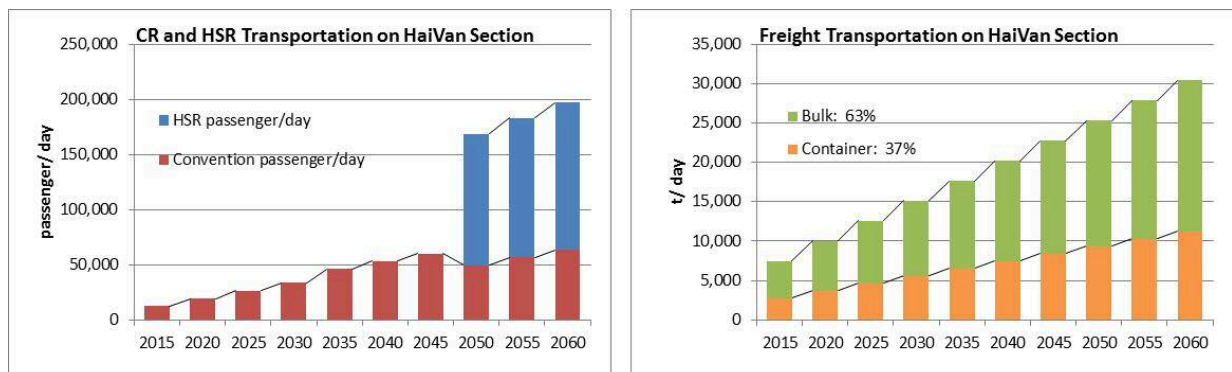
- 2031-2033: Based on conventional railway demand in 2030 which is the HSR Operation Case (NhaTrang-HCMC section) according to HSR2013, demand forecast from 2031 to 2033 is made by applying the same demand growth rate assumed in the Base Case of HSR 2012.
- 22034-2049 (HaNoi-DaNang section): Demand between HaNoi and DaNang is based on conventional railway demand in 2030 which is the HSR Operation Case on the North Section (HaNoi-Vinh) according to HSR2013. The annual demand growth rate from 2034 to 2049 is made by applying the same demand growth rate assumed in the Base Case of HSR 2012.
- 2034-2049 (DaNang-HCMC section): Demand between DaNang and HCMC is based on conventional railway demand in 2030 which is the HSR Operation Case on the South Section (NhaTrang-HCMC) according to HSR2013. The annual demand growth rate from 2034 to 2049 is made applying the same demand growth rate assumed in the Base Case of HSR 2012.
- 2050-: Based on conventional railway demand in 2030 which is the HSR Operation Case (whole section) according to HSR2013, demand forecast after 2050 is made by applying the same demand growth rate of the Base Case of HSR 2012.

(3) HSR Passengers

- 2031-2049 (between HaNoi-Vinh and between DaNang-HCMC): Based on the HSR demand forecast in 2030 which is the HSR Operation Case (each section) according to HSR2013, demand forecast from 2031 to 2049 is made by applying the same demand growth rate assumed in the Base Case of HSR 2012.
- 2050-: Based on the HSR demand forecast in 2030 which is the HSR Operation Case (whole section) according to HSR2013, demand forecast after 2050 is made applying the same demand growth rate assumed in the Base Case of HSR 2012.

(4) Freight Transportation

- Based on demand of freight transportation in 2010 and 2020, referred to High Alternative case in the MOT report. Demands in intermediate years up to 2020 and after 2031 are assumed by linear interpolation.
- The effect from HSR operation are not taken into account for freight demand.
- Ratio of container and bulk, 37% and 63%, is applied as shown in the ratio in the year 2030 of VITRANSS2. Categorization of each commodity into container and bulk are assumed with reference to the transportation situation in Japan.



Source: Study team

[Fig. 5-2-3] Demand on Hai Van Section

(5) Passenger and Freight Transportation Demand Forecast on the HaiVan Section

The passenger and freight transportation demand forecast on the HaiVan section is shown in [Tab. 5-2-2].

[Tab. 5-2-2] Demand Forecast for Conventional Railway

	Unit: passengers/ day		Unit: t/ day		
	CR & HSR		Freight		
	CR	HSR	Total	Container	Balk
2015	12,299		7,481	2,763	4,718
2016	13,719		7,990	2,951	5,039
2017	15,138		8,500	3,140	5,360
2018	16,558		9,009	3,328	5,681
2019	17,978		9,518	3,516	6,002
2020	19,398		10,027	3,704	6,323
2021	20,817		10,536	3,892	6,644
2022	22,237		11,045	4,080	6,965
2023	23,657		11,555	4,268	7,286
2024	25,077		12,064	4,456	7,608
2025	26,496		12,573	4,644	7,929
2026	27,916		13,082	4,832	8,250
2027	29,336		13,591	5,020	8,571
2028	30,756		14,100	5,208	8,892
2029	32,175		14,610	5,396	9,213
2030	33,595		15,119	5,585	9,534
2031	37,420		15,628	5,773	9,855
2032	38,840		16,137	5,961	10,176
2033	40,259		16,646	6,149	10,497
2034	44,679		17,155	6,337	10,818
2035	46,099		17,665	6,525	11,140
2036	47,519		18,174	6,713	11,461
2037	48,938		18,683	6,901	11,782
2038	50,358		19,192	7,089	12,103
2039	51,778		19,701	7,277	12,424
2040	53,198		20,210	7,465	12,745
2041	54,617		20,720	7,653	13,066
2042	56,037		21,229	7,841	13,387
2043	57,457		21,738	8,030	13,708
2044	58,877		22,247	8,218	14,029
2045	60,296		22,756	8,406	14,350
2046	61,716		23,265	8,594	14,672
2047	63,136		23,775	8,782	14,993
2048	64,556		24,284	8,970	15,314
2049	65,975		24,793	9,158	15,635
2050	49,395	119,395	25,302	9,346	15,956
2051	50,815	120,815	25,811	9,534	16,277
2052	52,235	122,235	26,320	9,722	16,598
2053	53,654	123,654	26,830	9,910	16,919
2054	55,074	125,074	27,339	10,098	17,240
2055	56,494	126,494	27,848	10,286	17,561
2056	57,914	127,914	28,357	10,475	17,882
2057	59,333	129,333	28,866	10,663	18,204
2058	60,753	130,753	29,375	10,851	18,525
2059	62,173	132,173	29,885	11,039	18,846
2060	63,593	133,593	30,394	11,227	19,167

Note: Hue- Da Nang Section

Dong Hoi- Da Nang Section

Source: Study Team

5.2.4 Planning Procedure

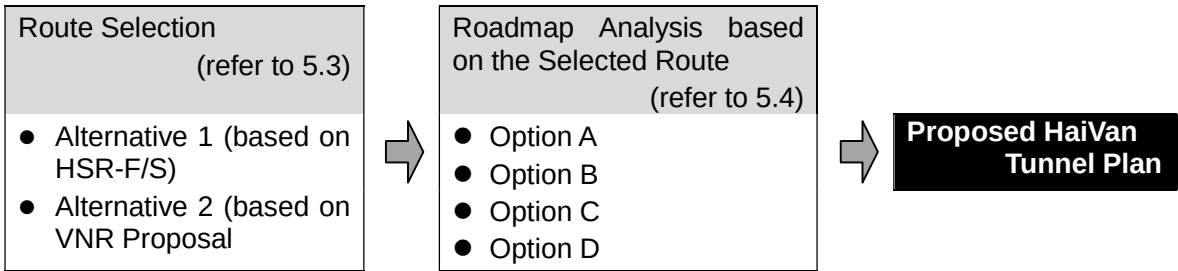
(1) Basic Policy

The first priority factor in planning the new HaiVan Tunnel is to select an appropriate route which affects travel time between stations and smooth operation of HSR in the future. Therefore, a comparison of alternative alignments and routes must be conducted in the first place.

In the meantime, tunnel cross section is determined by the operation scheme of the conventional railway, MSR and HSR and time schedule of those constructions in accordance with the GOV’s policy. In order to identify the correlative relationship of the operation scheme and construction time schedule among the conventional railway, MSR and HSR, the roadmap analysis to be articulated in 5.4 is proposed although the tunnel cross section alternatives are not directly related to route selection.

With regard to the specifics of route selection and roadmap analysis to be articulated in 5.3 and 5.4 respectively, two (2) route alternatives and four (4) roadmap options are considered based on HSR-F/S and related documents produced by VNR. Therefore, the analysis shall be made in comparison with a combination of route alternatives and roadmap options, which is eight (8) combinations (two (2) route alternatives × four (4) roadmap options).

However, since the influence of route selection on the roadmap analysis option is not large as mentioned above and the study period is limited, it is necessary to simplify the study procedure. An independent procedure between route selection and roadmap analysis is thus proposed to be carried out in this study as shown in [Fig 5-2-4] in which the roadmap analysis will be made only after selection of the route.



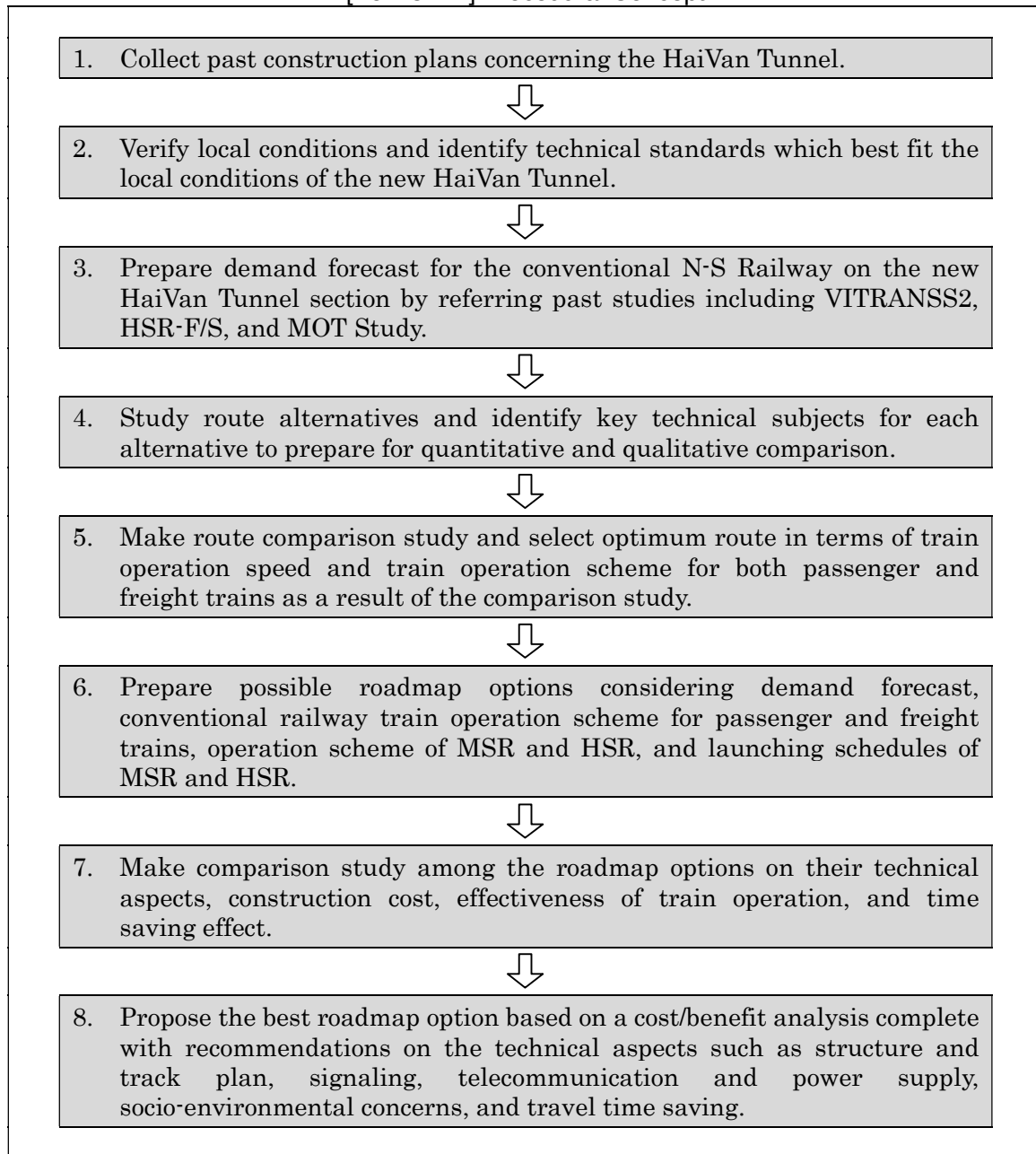
Source: Study team

[Fig. 5-2-4] Basic Policy for Planning HaiVan Tunnel

(2) Procedural Concept

The procedural concept for planning the new HaiVan Tunnel is shown in [Box. 5-2-1].

[Box. 5-2-1] Procedural Concept



Source: Study team

5.3 Alignment

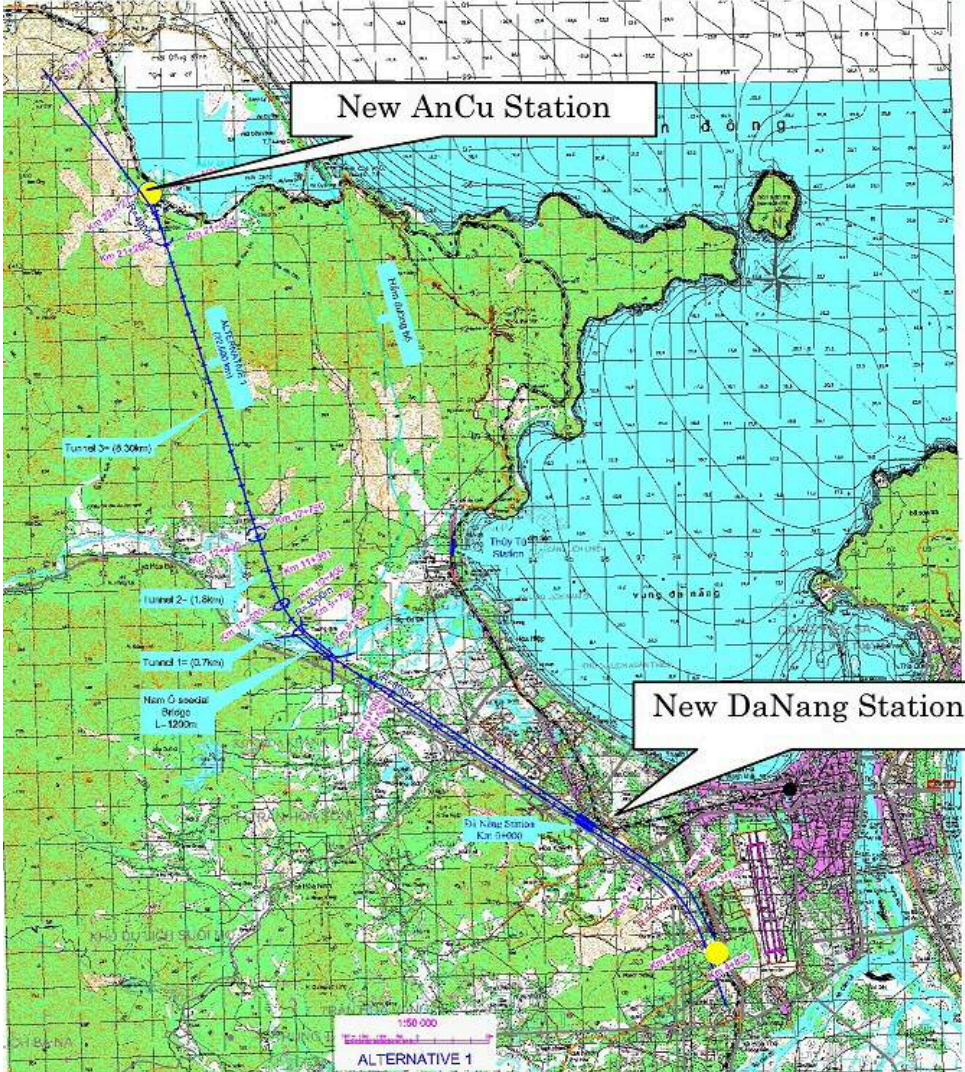
5.3.1 Alignment Planning

This section describes how to select the railway route on the HaiVan Tunnel section. The following two (2) alternatives were prepared for the alternative study.

(1) Alternative 1

1) Plan Alignment

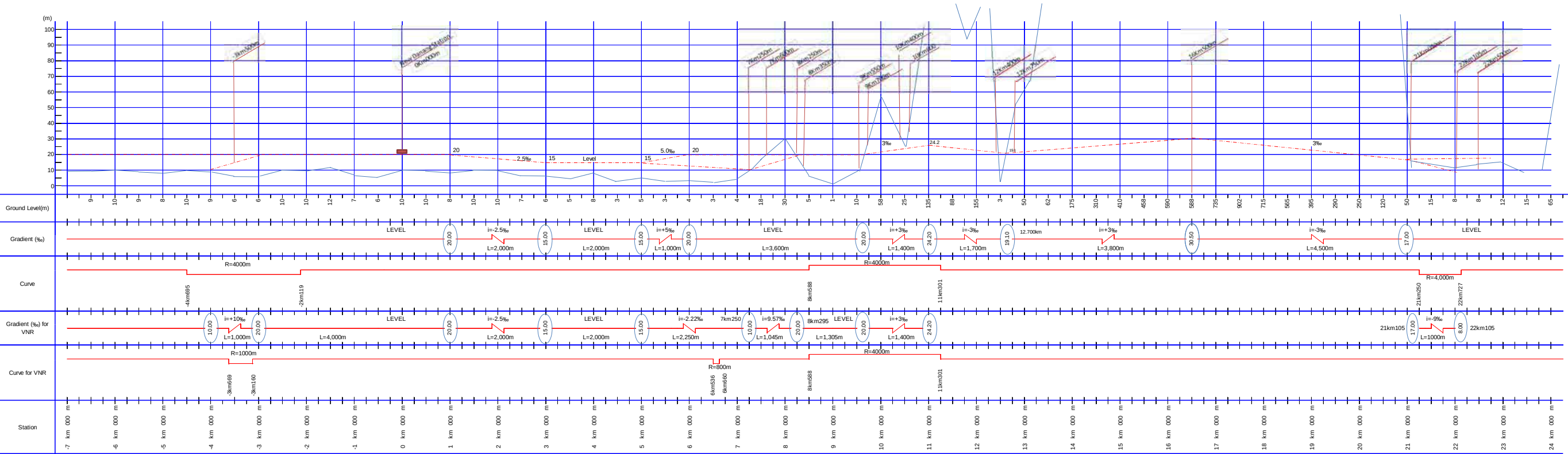
Here, the radius of $R=4,000\text{m}$ in the plane alignment of HSR was used and the longitudinal profile is shown in [Fig. 5-3-1] and [Fig. 5-3-2]. The ground level was determined based on the contour line in [Fig. 5-3-1].

Planning Concept	Connect stations with minimum distance and good alignment. This alternative is based on HSR-F/S.
Route Alignment	
Note	Minimum curve radius of $R=6,000\text{m}$ was proposed by HSR-F/S, but it is geographically difficult to apply the radius on the HaiVan section because of the following reasons. 1) It is necessary to keep the flat section of the turnout section for Option D at the North Mine Mouth Tunnel. 2) It is advisable to avoid, as much as possible, planning curve sections in mountain tunnels. 3) It is advisable to avoid crossover with the future road plan on the south side of New Da Nang Station.

Source: Study team

[Fig. 5-3-1] Route Plan of Alternative 1

2) Longitudinal Profile

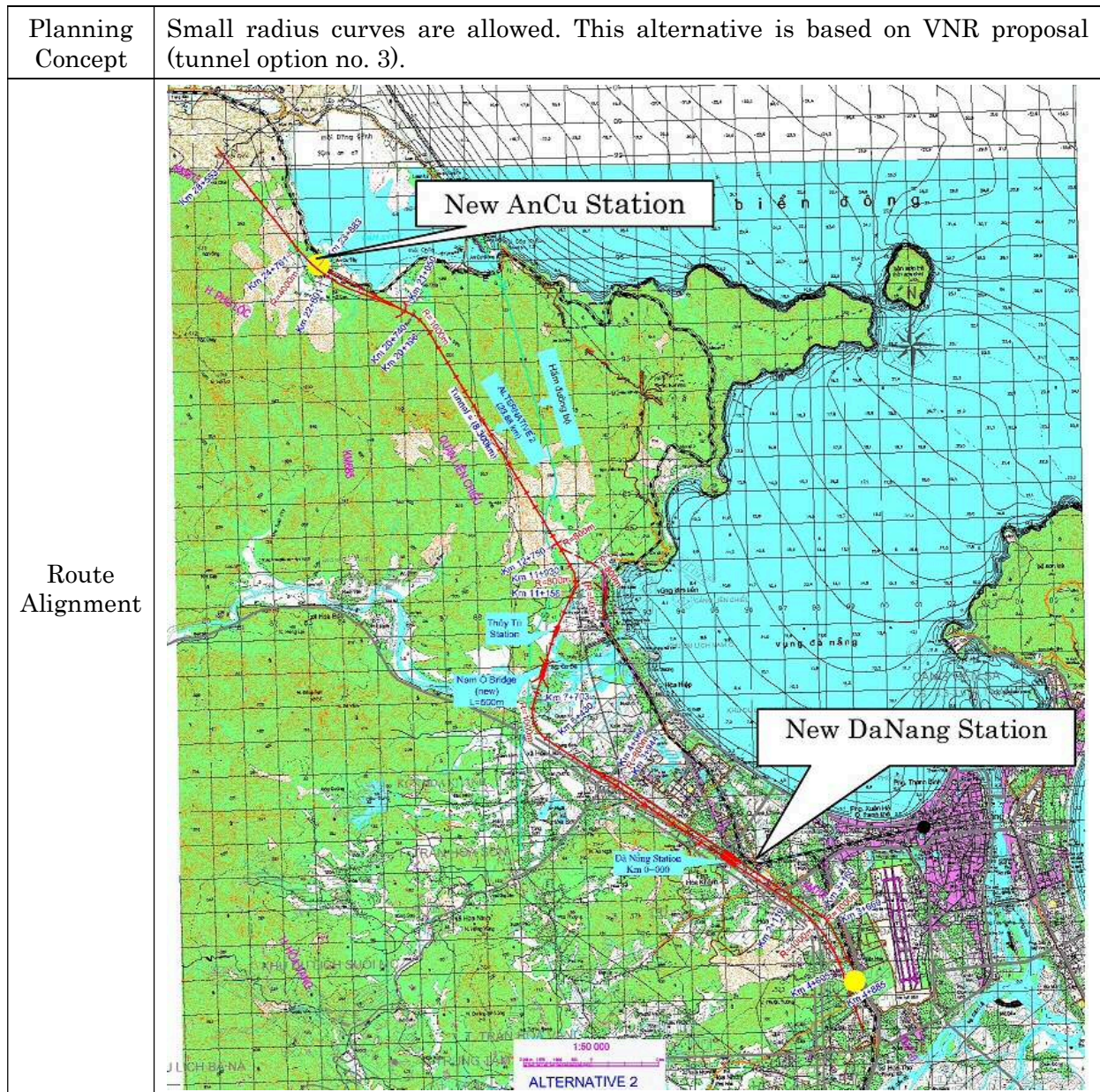


[Fig.5-3-2] Longitudinal Profile of Alternative 1

Source: Study team

(2) Alternative 2

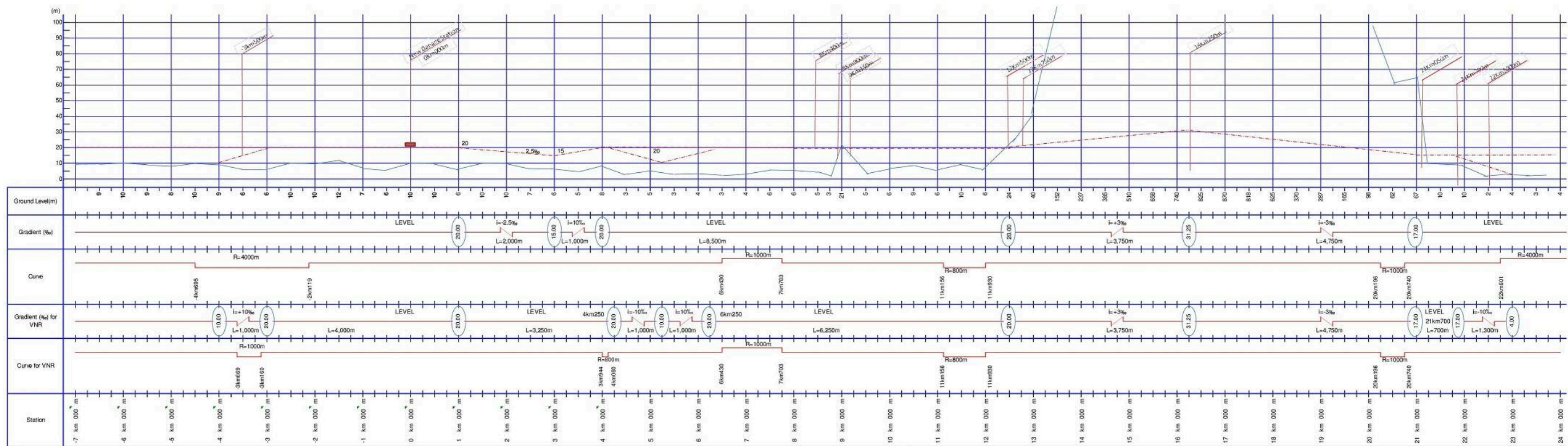
1) Plan Alignment



Source: Study team

[Fig. 5-3-3] Route Plan of Alternative 2

2) Longitudinal Profile



[Fig.5-3-4] Longitudinal Profile of Alternative 2

Source: Study team

Below are some pictures taken to capture the general site conditions of Alternative 2 during our site visit.



Note: - Pictures were taken on March 15, 2014.

- The yellow dot and lines show the planned tunnel mouth and route respectively.

Source: Study team

[Fig. 5-3-5] Alternative 2 South Side Tunnel Mine Mouth



Note: - Pictures were taken on March 15, 2014.

- The yellow arrow shows the planned tunnel mouth.

Source: Study team

[Fig.5-3-6] Alternative 2 North side Tunnel Mine Mouth

5.3.2 Comparison of Alternative Plans

The two (2) routes proposed in Section 5.3.1 are compared in [Tab. 5-3-1]. From the route comparison on the HaiVan Tunnel section, Alternative 1 has advantages with regard to the following points. So the study team selected Alternative 1 for the roadmap analysis followed by the next section.

- Alternative 1 has better alignment having potential to increase speed of HSR in the future (radius of curvature over 4,000 m).
- The total length of Alternative 1 is about 1.4km shorter than that of the Alternative 2.
- The travel time of Alternative 1 is shorter than that of the Alternative 2 because of the difference in total length and alignment (operation speed).

[Tab. 5-3-1] Comparison Study on HaiVan Tunnel Route

No	Item	Alternative 1	Alternative 2
Quantitative comparison	1 Outline of the plan	Connect two (2) stations with minimum distance and secure good alignment. This plan is based on HSR-F/S.	Small curves are allowed. This plan is based on option No. 3 proposed by VNR for the N-S Railway.
	2 Alignment ● Minimum curve radius ● Maximum gradient	● $R_{min} = 4,000m$ ● $i_{max} = 10\%$	● $R_{min} = 800m$ ● $i_{max} = 10\%$
	3 Route length for N-S Railway (AnCu St. – Connecting point with existing N-S Railway) ● Tunnel ● Bridge ● Viaduct	Overall 27.385km ● Tunnel: 10.8km = 0.7 + 1.8 + 8.3 ● Bridge: 1.2km ● Viaduct: 10.6km	Overall 28.768km ● Tunnel: 8.3km ● Bridge: 0.5km ● Viaduct: 15.8km
	4 Highest speed ● Combined operation (N-S Railway and HSR) ● Segregated operation between N-S Railway and HSR	● Passenger: 120km/h Freight: 80km/h (Container) ● N-S Railway: Ditto HSR: 300km/h	● Passenger: 120km/h Freight: 80km/h (Container) ● N-S Railway: Ditto ● HSR: 300 km/h (But the speed on sections before and after the tunnel is limited to 140-160km/h by small curves ($R = 800m$ or $1,000m$)).
	5 Running Time (AnCu St.-New DaNang St.) ● N-S Railway ● HSR combined operation ● HSR segregated operation	● 21 minutes (Passenger Train) ● 11 minutes ● 7 minutes	● 22 minutes (Passenger Train) ● 12 minutes ● 9 minutes
Qualitative comparison	6 Constructability based on terrain conditions	Good	Good
	7 Intersection with National Road No.1	Yes	Yes
	8 Intersection with electrical feeder line	Yes	Yes
	9 Connection to existing N-S Railway (operation of bulk freight and sightseeing trains)	Possible	Possible
	10 Accessibility to KimLien Station (ICD) and LienChu Port (Plan)	Possible (via existing N-S Railway)	Possible (via existing N-S Railway)
	11 Through operation with Urban Railway in DaNang	Possible	Possible

Source: Study team

5.4 Roadmap Analysis

5.4.1 Study Methodology and Procedure

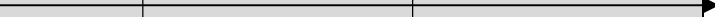
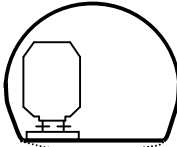
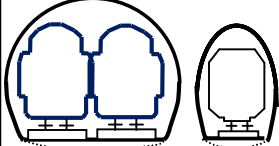
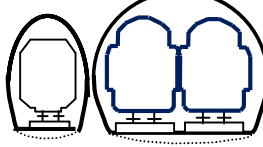
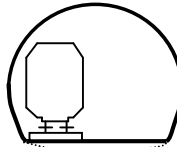
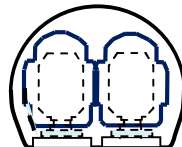
(1) Conceptual Alternatives of Tunnel Development

Roadmap is defined as a tunnel development time schedule in line with various investment costs and transportation demand transition in which tunnel cross section, track number, launching schedule of HSR, and number of tunnels are studied.

Basic information and data for the optimal roadmap selection exercise will be based on the N-S Railway Master plan by VNR and HSR-F/S by JICA. According to them, the implementation time schedule for the N-S Railway improvement and HSR project are as shown in the shadowed cell portion in [Tab. 5-4-1]. It says that new tunnels for the existing line between Hue and DaNang need to be completed by the year 2020 and the construction of new tunnel for HSR may need some time to catch up with the launching schedule of around the year 2040. This will be a reference time schedule for the alternative roadmaps for comparison.

The latter half of [Tab. 5-4-1] where cells are not shadowed shows the variety of conceptual alternatives for comparison to be articulated in section 5.4.3.

[Tab. 5-4-1] Tunnel Development Concept Alternatives

Year	2020	2030	2040	2050
Time schedule assumed in the N-S railway M/P and HSR-F/S				
Time schedule reference	N-S railway M/P ➢MG track ➢ST line ➢Ballast track ➢Both passenger and freight trains use the tunnel		Operation	
	HSR-F/S ➢New track construction ➢SG track ➢DT line ➢Slab track ➢Electrified ➢Dedicated tunnel for HSR	Test line operation 	Construction of Hue-DaNang section 	Operation
Separate alternative (1) <1 st Step> ➢ DT tunnel with HSR standard construction ➢ CR train uses the tunnel <2 nd Step> ➢ ST tunnel with CR standard construction ➢ HSR and CR use different tunnels separately		1 st step 		2 nd step 
Separate alternative (2) <1 st Step> ➢ ST tunnel with CR standard construction ➢ CR uses the tunnel <2 nd Step> ➢ DT tunnel with HSR standard construction ➢ HSR and CR use different tunnels separately		1 st step 		2 nd step 
Shared alternative <1 st Step> ➢ DT tunnel with HSR standard construction ➢ CR train uses the tunnel <2 nd Step> ➢ No more tunnel construction ➢ HSR and CR use the same tunnel together		1 st step 		2 nd step 

Note: HSR= High Speed Railway MSR= Middle Speed Railway CR= Conventional Railway
 MG= Meter gauge SG= Standard gauge DT= Double Track ST= Single Track

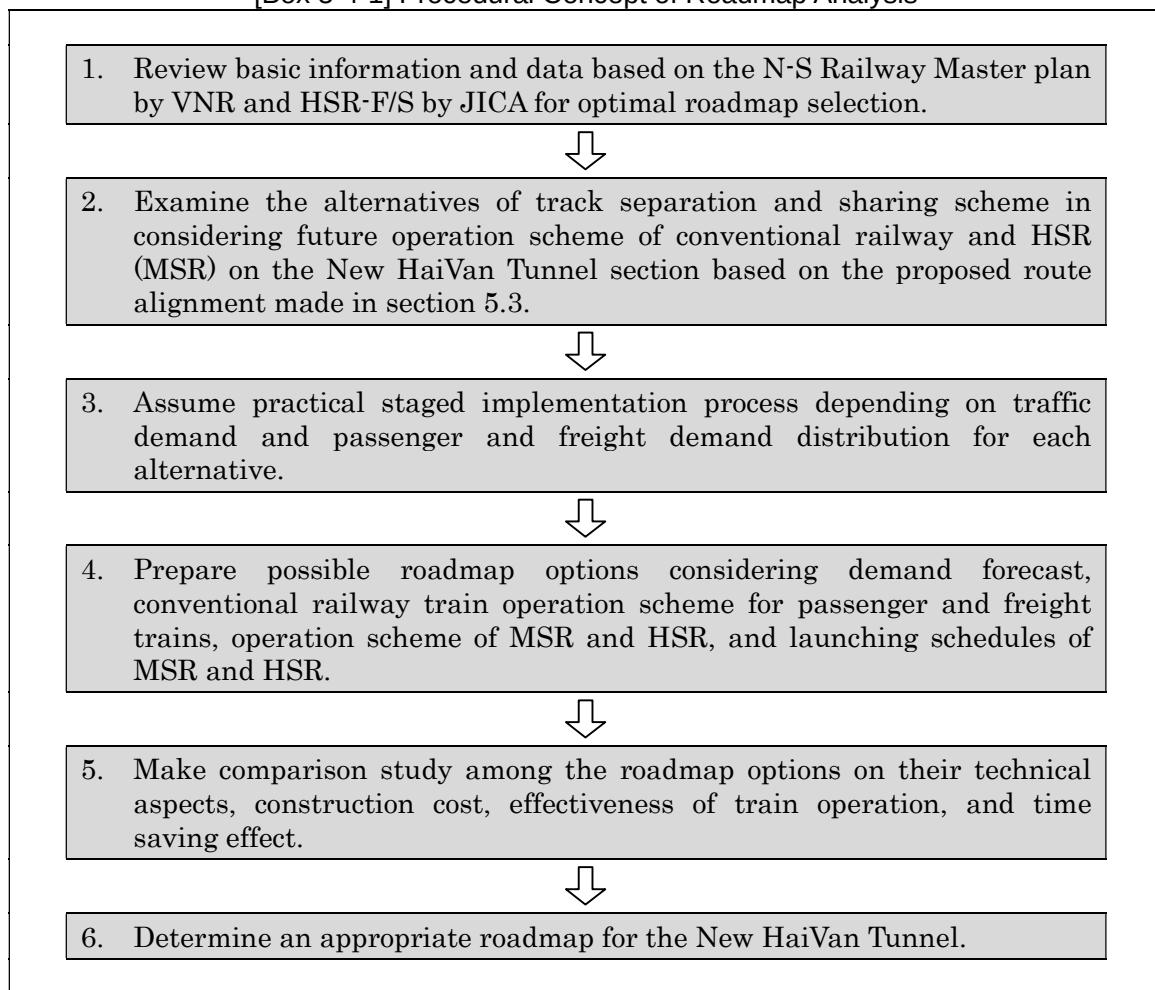
Source: Study team

(2) Procedural Concept of Roadmap Analysis

The flow chart shown in [Box. 5-4-1] illustrates the procedural concept for how the optimal tunnel construction roadmap selection will be implemented. Based on the optimal route alignment selection proposed in section 5.3, several roadmap options incorporating the Separate and Shared alternatives mentioned above will be proposed in considering the practical staged implementation process for each operation.

Among possible roadmap options based on the Separate and Shared alternatives mentioned above, the optimal roadmap option will be proposed based on a quantitative cost/benefit comparison as well as a qualitative comparison in terms of technical aspects, construction cost, effectiveness of train operation, and time saving effect.

[Box 5-4-1] Procedural Concept of Roadmap Analysis



Source: Study team

5.4.2 Operation Plan

(1) Fluctuation in the Number of Trains of the Conventional Railway and HSR

[Tab. 5-4-2] shows the projected number of passenger and freight trains to be operated on the conventional railway based on transportation demand.

[Tab. 5-4-2] Projected Number of Trains per Year on the Conventional Railway

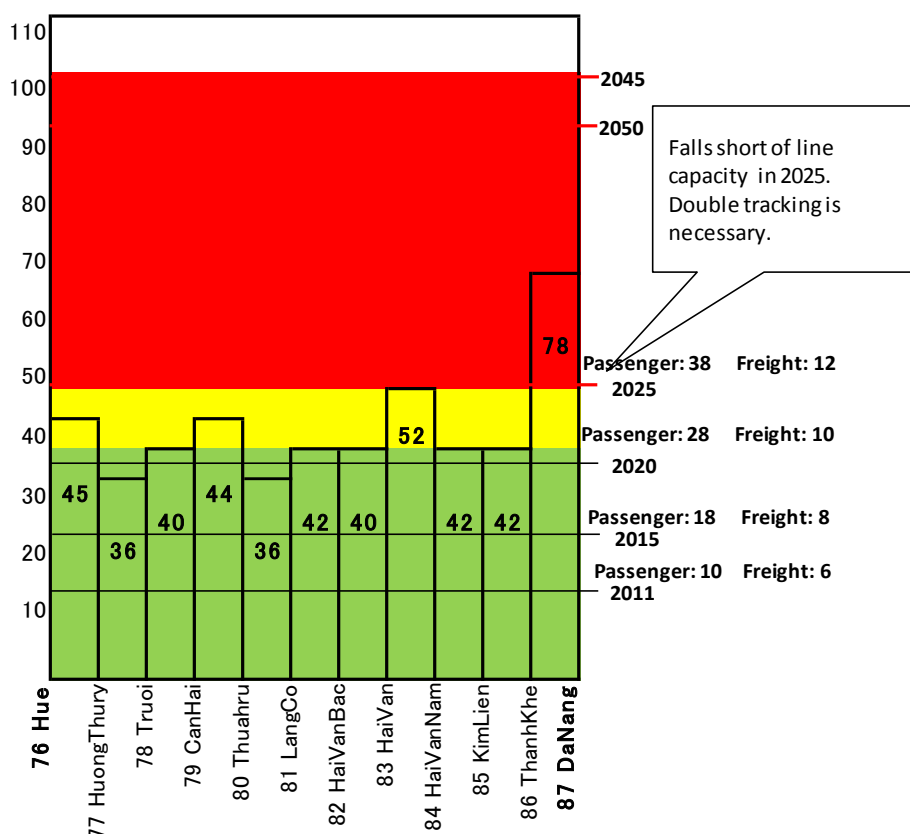
Section Hue-DaNang		Conventional railway line								
Year		2011	2015	2020	2025	2030	2035	2040	2045	2050
Freight	Container	3	3	4	5	6	7	8	9	10
	Bulk	4	5	6	8	9	11	12	14	15
	Freight Total	7	8	10	13	15	18	20	23	25
Passenger		10	19	29	39	48	67	77	87	71
Total		17	27	39	52	63	85	97	110	96
HSR		0	0	0	0	0	0	0	0	92

Source: Study team

The number of freight trains is projected to grow steadily until 2050, while the number of passenger trains shows a rapid increase from 2025.

The passenger transport volume of the conventional railway line is likely to decrease when the HSR is opened for service in 2050.

[Fig. 5-4-1] shows a comparison between the number of trains per year and the current line capacity between stations of the conventional railway based on VNR's train timetable.



Source: Study team

[Fig. 5-4-1] Line Capacity and Number of Trains of the Conventional Railway

In [Fig. 5-4-1], the bar chart and the numbers on the bars show the line capacity, while the horizontal lines and corresponding numbers show the number of trains per year. The train speed between Hue and DaNang is low because of the existing¹ mountain lines such as at HaiVan pass. The lowest line capacity on this section is therefore only 36 trains per day.

The number of trains operated on this line is currently 22 to 28 trains per day, so there is still not a shortage of line capacity on this section. However, as shown in [Tab. 5-4-2], the number of trains based on the transportation demand in 2025 amounts to a total of 50 trains which includes 38 passenger trains and 12 freight trains. This means that the number of required trains significantly exceeds the line capacity.

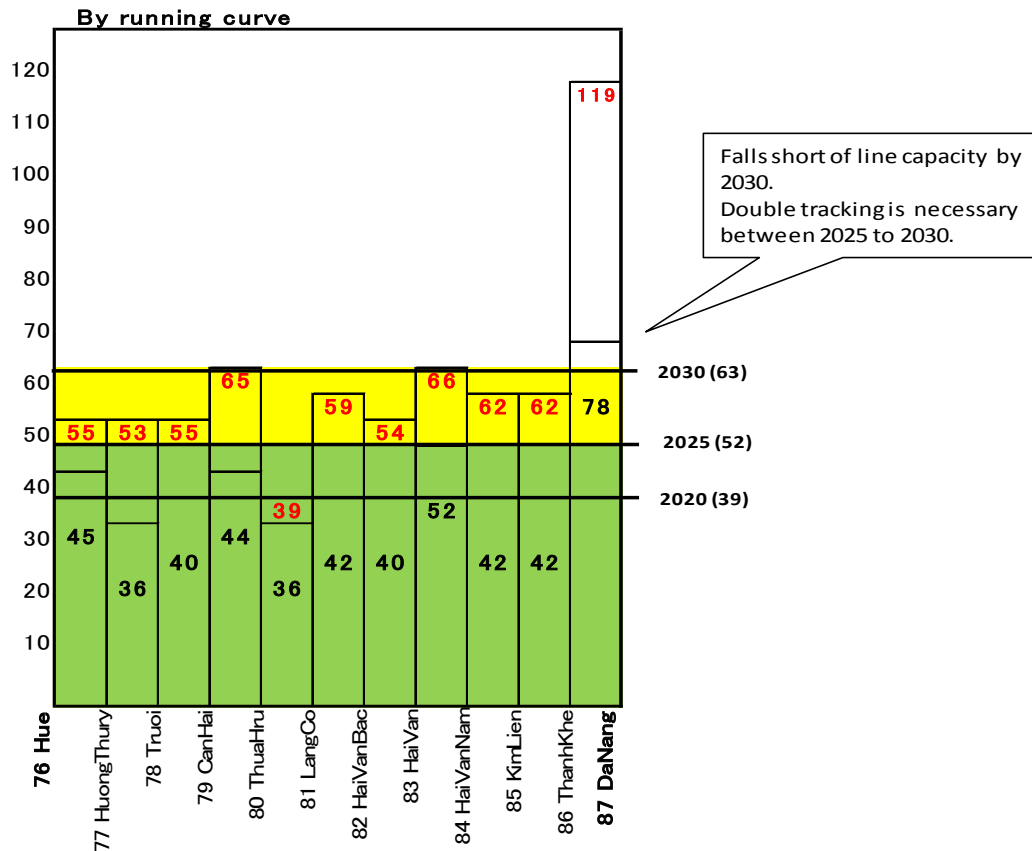
In order to solve this problem, it is therefore necessary to either double track this line or construct a completely new line.

(2) Stages for Double Tracking the Conventional Railway

The line capacity in [Fig. 5-4-1] is calculated from the actual operation times which are based on VNR's train timetable. According to these calculation results, the number of trains already exceeds the line capacity in 2025.

[Fig. 5-4-2] shows the line capacity calculated from the theoretical train operation time between stations based on the train running curve. This has then been added to the bar chart showing the actual line capacity. The bar chart which is based on the train running curve also shows that the line capacity will overflow sometime between 2025 and 2030. Accordingly, it therefore seems necessary to double track the existing line in 2025.

¹ The term "existing railway line" is defined as the route along the coast around the HaiVan pass, while the term "conventional railway line" is defined as meter gauge track railway line of current VNR railway line vis-à-vis standard gauge track railway line of MSR or HSR.



Source: Study team

[Fig. 5-4-2] Line Capacity and Number of Trains by Train Running Curve

5.4.3 Basics of Tunnel Construction Roadmap

(1) Tunnel Construction Roadmap by VNR

The roadmap described in the HaiVan tunnel project F/S prepared by VNR is to construct a single track tunnel for the conventional railway first and construct another double track tunnel for HSR later. It is also planned to operate MSR prior to HSR service launch.

The study team is not optimistic about this plan for the following reasons.

- Freight train service at a speed of around 200km/h is not realized anywhere in the world yet.
- The conversion cost from MSR to HSR is huge due to total replacement of facilities such as train sets, power feeding system, track structure upgrading, alignment rectification, and signaling and telecommunication systems, unless the infrastructure and facilities are constructed based on the HSR standard from the beginning.
- Railway service must be suspended during the conversion period, unless the infrastructure and facilities are constructed based on the HSR standard from the beginning.
- If the infrastructure and facilities are constructed based on the HSR standard from the beginning, there is no point in launching MSR instead of HSR because the train set cost reduction effect is comparatively small.
- Since the cost of the tunnel construction for MSR, HSR, and existing railway is almost the same on condition that the conventional railway is to be electrified in the future, it

is better to build HSR standard tunnels from the beginning.

- Since it is a general trend in the world for conventional railways to be electrified seeking higher speed and energy efficiency, it is not a plausible assumption for VietNam not to be electrified by the year 2050.

Therefore, the study team proposes to operate HSR instead of MSR from the start, although it is necessary to consult with GOV's strategy concerning train operation in the future which shall be investigated based on costs and benefits.

(2) HSR Tunnel Cross Section

Although there are choices for HSR tunnel type of double track tunnel (Single bore tunnel typically used for Japanese HSR) and parallel single track tunnels (Twin bore tunnel typically used for European HSR), Single bore tunnel is proposed due to the cost saving point of view. Besides, tunnel construction cost will be saved greatly if Japanese HSR standard tunnel is applied, because the cross sectional area is much smaller than for European tunnels and the size is almost the same as conventional railway tunnels. Therefore, Japanese HSR standard tunnel is applied in this study for the New HaiVan Tunnel construction.

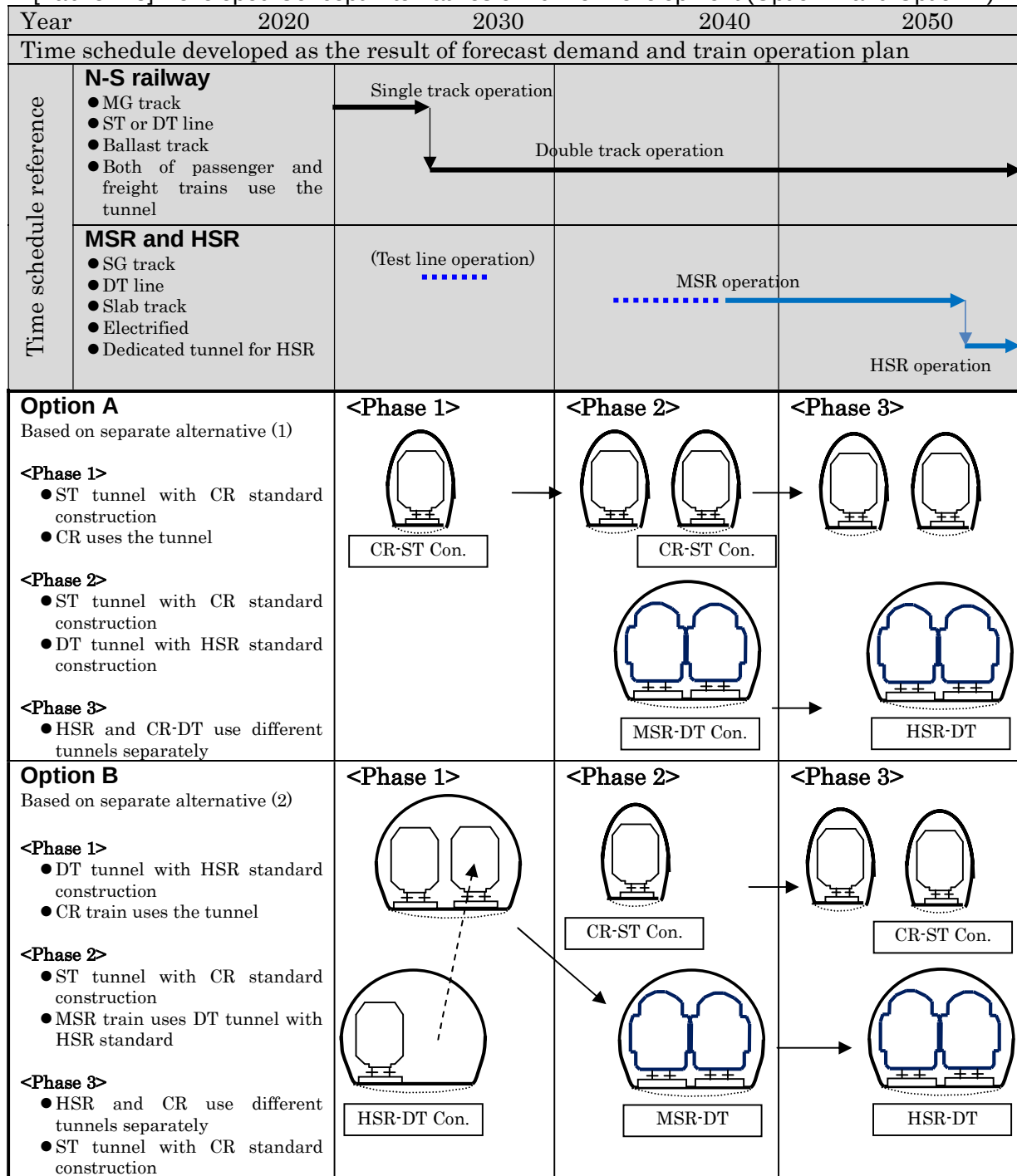
In addition to this, the following factors will be taken into consideration in the study.

- It is true that even the Japanese HSR standard tunnel size is a bit larger than that of conventional railway, therefore the cost will be a bit higher and the added cost will be inflated as time passes due to price escalation.
- In the same way, the construction cost of a brand new tunnel for HSR at a later stage will be larger than that of the present cost.
- The question is which price is smaller between inflated HSR construction cost plus tunnel construction cost for the existing railway and a bit expensive HSR tunnel cost at present.
- In addition to this, if the tunnel shared alternative is applied, brand new tunnel construction will not be needed at a later stage.
- It is fair to make a comparison incorporating O&M cost and upgrading cost depending on the transportation volume demand transition.

(3) Options for Tunnel Development

Based on the demand forecast, transportation volume, train operation plan and the aforementioned basics of the tunnel construction roadmap, the conceptual alternatives illustrated in [Tab. 5-4-1] are developed into four (4) options as shown in [Tab. 5-4-3] and [Tab. 5-4-4] namely Option A, Option B, Option C, and Option D which will be articulated in sections 5.4.4 and 5.4.5.

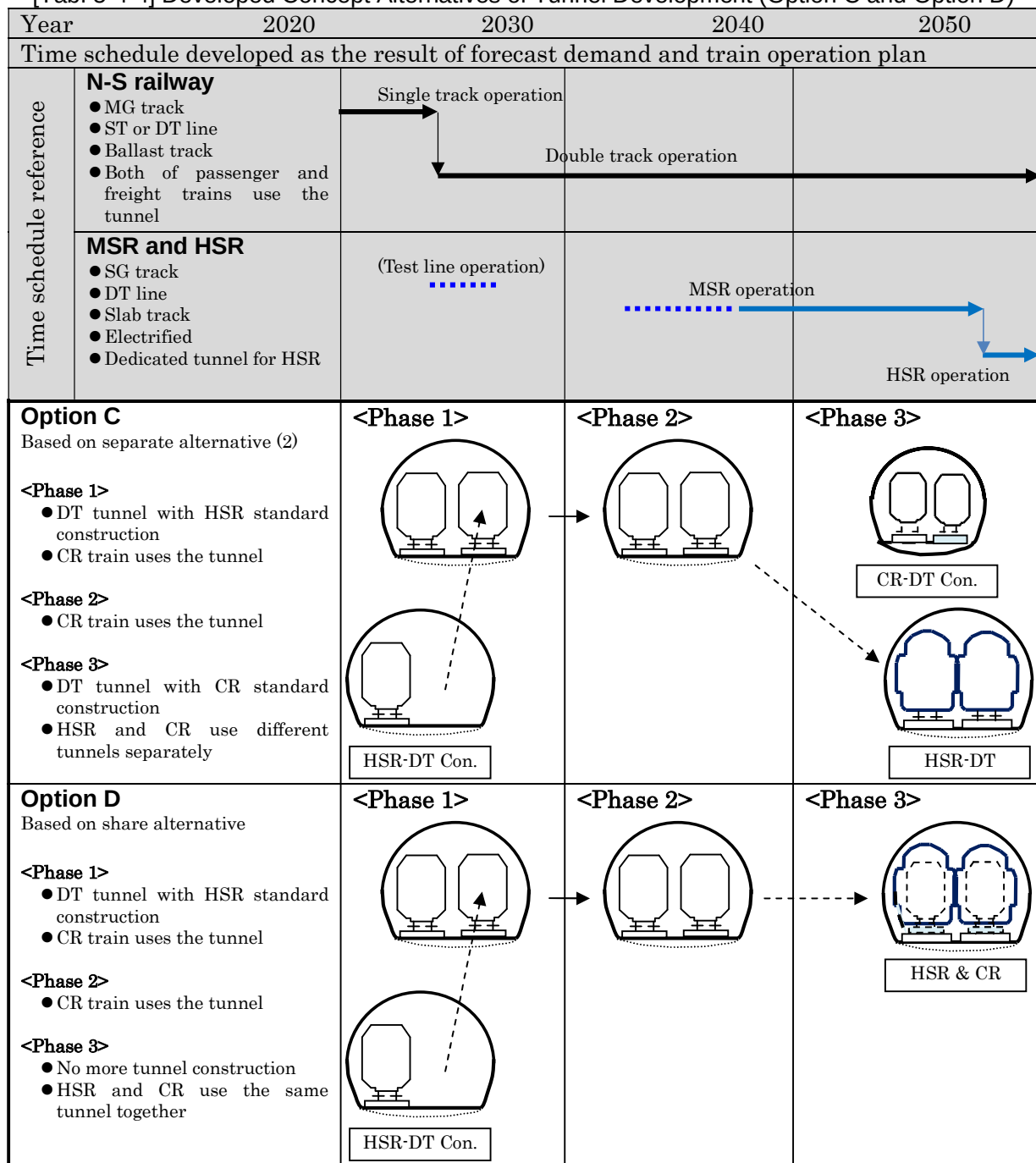
[Tab. 5-4-3] Developed Concept Alternatives of Tunnel Development (Option A and Option B)



Note: HSR= High Speed Railway MSR= Middle Speed Railway CR= Conventional Railway
 MG= Meter gauge SG = Standard gauge DT = Double Track ST = Single Track
 Con.= Construction

Source: Study team

[Tab. 5-4-4] Developed Concept Alternatives of Tunnel Development (Option C and Option D)



Note: HSR= High Speed Railway MSR= Middle Speed Railway CR= Conventional Railway
 MG= Meter gauge SG = Standard gauge DT = Double Track ST = Single Track
 Con.= Construction

Source: Study team

5.4.4 Study Options for Tunnel Construction Roadmap

Four (4) roadmap options of Option A to D as shown in [Tab. 5-4-5] are prepared for the comparison exercise based on the railway development strategy prepared by VNR, HSR-F/S by JICA, and the study team. Each option consists of three (3) implementation phases depending on the train operation scheme of conventional railway, MSR, and HSR and their relevant events including new tunnel construction. Specific notes for each option are as follows.

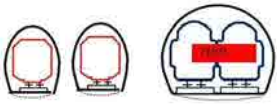
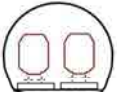
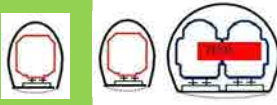
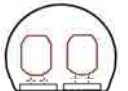
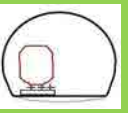
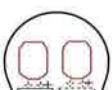
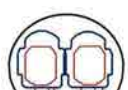
Option A is considered to be the basic case because this option was made by VNR. Option B and C are derivatives of Option A. Based on hearings with VNR, the number of tracks of the tunnel is not decided yet. Option D is a fresh proposal made by the study team in which the track is shared by the conventional railway and HSR.

It shall be noted that Option A and B include MSR operation sometime between 2030 and 2040 in advance of HSR operation sometime around 2050 in accordance with the development plan prepared by VNR.

As for Option D, it will be necessary to consider if freight train service may be shifted to container trains so that container trains will be able to share the same track with HSR on the HaiVan tunnel section with a higher speed of 80km/h, because the present type of freight trains which use bulk cargo wagons may not be able to share the track with HSR in this option from a safety point of view.

Regarding increasing the speed of freight trains which is planned to be 80km/h in the future by VNR, containerization of freight trains will be necessary not only for Option D to share the same tunnel with HSR trains but also to increase the freight train speed in the other options (Options A to C).

[Tab. 5-4-5] Study Options for Tunnel Construction Roadmap

Year	2020	2025	2030	2050
Phase	Phase 1	Phase 2		Phase 3
Event	For the time being	for Option C and D	for Option A and B	HSR is launched
Operation	Single track conventional train operation	Limit transportation volume in case double track is not ready. And increase transportation volume in case double track is available.	MSR is launched	HSR is launched
Option A	Build brand new single track tunnel with conventional standard. Conventional train runs on single track in single track tunnel with conventional standard.	Limit transportation volume waiting for MSR to be launched..	Build additional brand new single track tunnel with conventional standard. Conventional train runs on double track in two single track tunnels with conventional standard. Build brand new double track tunnel with HSR standard. MSR train runs on double track	Replace and upgrade facilities to allow HSR to use the MSR facility.
				
Option B	Build brand new double track tunnel with HSR standard. Conventional train runs on single track in double track tunnel with HSR standard.	Conventional train runs on double track in double track tunnel with HSR standard.	Build brand new single track tunnel with conventional standard. MSR is launched in existing double track tunnel with HSR standard and passenger volume shifts from conventional railway to MSR which allows conventional train to run in single track tunnel with HSR standard.	Build additional brand new single track tunnel with conventional standard. Conventional train runs on double track in two single track tunnels with conventional standard. Replace and upgrade facilities to allow HSR to use the MSR facility.
				
Option C	Build brand new double track tunnel with HSR standard. Conventional train runs on single track in double track tunnel with HSR standard.	Conventional train runs on double track in double track tunnel with HSR standard.	Conventional train runs on double track in double track tunnel with HSR standard.	Build brand new double track tunnel with conventional standard. Conventional train runs on double track in double track tunnel with conventional standard. Replace and upgrade facilities to allow HSR to use the MSR facility.
				
Option D	Build brand new double track tunnel with HSR standard and triple track line. Conventional train runs on single track in double track tunnel with HSR standard.	Conventional train runs on double track in double track tunnel with HSR standard and triple track line.	Conventional train runs on double track in double track tunnel with HSR standard and triple track line.	Conventional train and HSR run on double track in double track tunnel with HSR standard and triple track line.
				

Note 1: Green colored cells means the timing of new construction.

Note 2: Yellow colored cells means the timing of upgrading work.

Source: Study team

5.4.5 Technical Proposal for Each Option

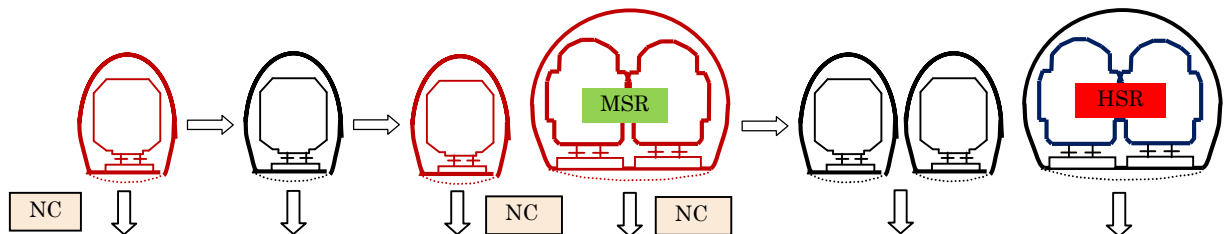
The technical proposals including track structure, electric facilities, operation method, and maximum service speed are made here.

(1) Option A

[Tab. 5-4-6] shows the technical proposal for Option A. MSR operation will launch prior to HSR operation in the same tunnel by giving additional works such as track structure conversion, train set replacement, and electrification facility replacement.

[Tab. 5-4-6] Technical Proposal for Option A

Phase 1 (2020-)	Phase 2 (2025-2030-2040)		Phase 3 (204-2050~)
CR trains operate on ST with MG tunnel.	Due to limit of transportation volume, MSR waits for launching.	New ST tunnel is constructed with CR standard. MSR operates on new tunnel with HSR standard in 2030-2040.	The tunnel is exclusively used for HSR by upgrading facilities such as electrification and CR trains will be relocated to a new tunnel of either ST or DT depending on traffic demand.



Item	Phase 1 (2020-)	Phase 2		Phase 3 (2040-2050-)	
		(2025)	(2030-)		
Track number	ST for CR	ST for CR	DT for MSR ST for CR	Two ST for CR	Dedicated HSR DT tunnel
Passenger or freight train	Both	Both	Both	Both	Passenger
User	CR	CR	MSR	CR	HSR
Track	MG with ballast	MG with ballast	SG with slab	MG with ballast	SG with slab
Electrification	No	No	AC 25Kv	No	AC 25Kv
Signaling	One blocking between stations	One blocking between stations	ATC	One blocking between stations	ATC
Operation mode	Day & night	Day & night	Day & night	Day & night	Except 0 am to 4 am
Operating maximum speed	Pas: 80km/h Fre: 60km/h	Pas: 80km/h Fre: 60km/h	Pas: 200km/h	Pas: 80km/h Fre: 60km/h	Pas: 320km/h

Note: The time frame between 0 am and 4 am is allocated for facility maintenance in line with Shinkansen standard.

HSR= High Speed Railway MSR= Middle Speed Railway CR= Conventional Railway MG= Meter gauge

SG= Standard gauge DT= Double Track ST= Single Track Pas.= Passenger Fre.= Freight

NC= New construction

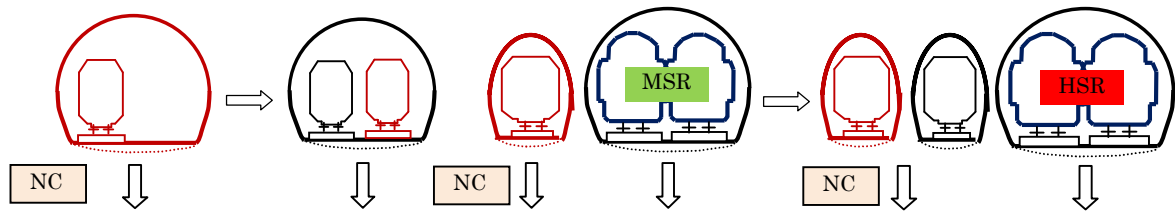
Source: Study team

(2) Option B

[Tab. 5-4-7] shows the technical proposal for Option B as a variation of Option A in which a double track tunnel for the conventional railway is constructed in Phase 1 instead of a single track tunnel in Option A.

[Tab. 5-4-7] Technical Proposal for Option B

Phase 1 (2020-)	Phase 2 (2025-2030-2040)		Phase 3 (2040-2050-)
CR trains operate on ST-MG with HSR cross section tunnel.	CR trains run on DT with HSR standard tunnel in 2025	New construction with CR standard. MSR starts running in HSR standard tunnel in 2030~2040.	The tunnel is exclusively used for HSR by upgrading facilities such as electrification. New ST tunnel will be constructed with CR standard.



Item	Phase 1 (2020-)	Phase 2		Phase 3	
		(2025)	(2030-)	(2040-2050-)	
Track number	ST for CR	ST for CR	DT for MSR	Two STs for CR	Dedicated HSR DT tunnel
Passenger or freight train	Both	Both	Both	Both	Passenger
User	CR	CR	CR and MSR	CR	HSR
Track	MG with ballast	MG with ballast	CR: MG (ballast) MSR: SG (slab)	MG with ballast	SG with slab
Electrification	No	No	CR: No MSR: AC 25kv	No	AC 25Kv
Signaling	One blocking between stations	One blocking between stations	ATC	One blocking between stations	ATC
Operation mode	Day & night	Day & night	Day & night	Day & night	Except 0 am to 4 am
Operating maximum speed	Pas: 80km/h Fre: 60km/h	Pas: 80km/h Fre: 60km/h	Pas: 200km/h	Pas: 80km/h Fre: 60km/h	Pas: 320km/h

Note: The time frame between 0 am and 4 am is allocated for facility maintenance in line with Shinkansen standard.
 HSR= High Speed Railway MSR= Middle Speed Railway CR= Conventional Railway MG= Meter gauge
 SG= Standard gauge DT= Double Track ST= Single Track Pas.= Passenger Fre.= Freight
 NC= New construction

Source: Study team

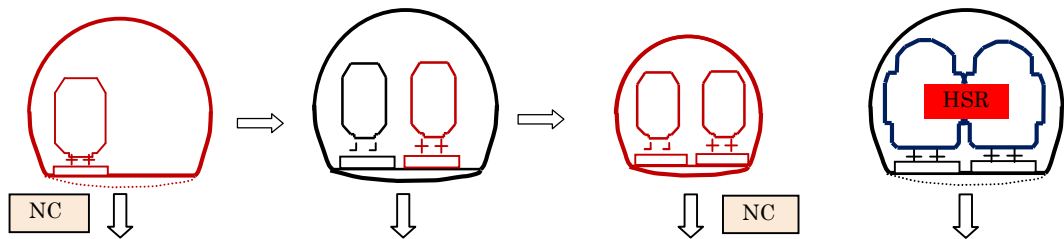
(3) Option C

[Tab. 5-4-8] shows the technical proposal for Option C in which there is no MSR service prior to HSR operation.

In the year 2050, the track structure will be replaced from ballast to slab and electrification work will be made in order for HSR to use the tunnel exclusively. A brand new double track tunnel dedicated to the conventional railway has to be built before the HSR launch.

[Tab. 5-4-8] Technical Proposal for Option C

Phase 1 (2020-)	Phase 2 (2025-2030-2040)	Phase 3 (2040-2050-)
CR trains will be operated on ST laid out in HSR-DT standard tunnel.	DT tracking work (red line) will be made for CR operation in 2025.	New DT tunnel for CR will be built.
		The tunnel will be exclusively used for HSR by upgrading facilities such as electrification and CR train will be relocated to a new DT



Item	Phase 1 (2020-)	Phase 2 (2025-2030-2040)	Phase 3 (2040-2050-)
Track number	ST for CR	DT for CR	Dedicated new DT tunnel
Passenger or freight train	Both	Both	Both
User	CR	CR	CR
Track	MG with ballast	MG with ballast	MG with ballast
Electrification	No	No	No
Signaling	One blocking between stations	One blocking between stations	One blocking between stations
Operation mode	Day & night	Day & night	Day & night
Operating maximum speed	Pas: 80km/h Fre: 60km/h	Pas: 80km/h Fre: 60km/h	Pas: 80km/h Fre: 60km/h

Note: The time frame between 0 am and 4 am is allocated for facility maintenance in line with Shinkansen standard.
 HSR= High Speed Railway MSR= Middle Speed Railway CR= Conventional Railway MG= Meter gauge
 SG= Standard gauge DT= Double Track ST= Single Track Pas.= Passenger Fre.= Freight
 NC= New construction

Source: Study team

(4) Option D

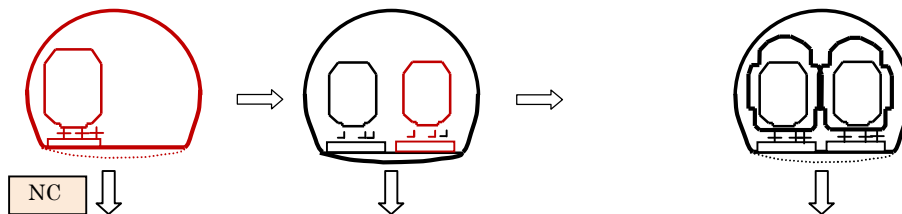
[Tab. 5-4-9] shows the technical proposal for Option D in which there is no MSR service prior to HSR operation in the same way as in Option C. This is an option in which the tunnel is used by both of the conventional railway and HSR at the Phase 3.

For that purpose the track structure is dual gauge consisting of one meter gauge (1,000mm) and standard gauge (1,435mm) on concrete slab (dual gauge slab track) on which the service speed of HSR trains will be decreased in the tunnel section.

Besides, freight train service will be made by container trains in order to increase the safety standard to match that of HSR. Safety should also be secured by an additional signaling system equal to HSR for the conventional railway train on the tunnel section.

[Tab. 5-4-9] Technical Proposal for Option D

Phase 1 (2020-)	Phase 2 (2025-2030-2040)	Phase 3 (2040-2050-)
CR trains operate on a ST laid out with dual gauge structure in DT HSR standard tunnel.	CR runs on DT with HSR standard tunnel in 2025.	Both CR trains and HSR trains including container freight operate on DT with dual gauge structure of MG and SG.



Item	Phase 1 (2020-)	Phase 2 (2025-2030-2040)	Phase 3 (2040-2050-)	
Track number	ST for CR	DT for CR	CR train shares the track with the HSR train	HSR train shares the track with CR train
Passenger or freight train	Both	Both	Passenger & container freight	
User	CR	CR	CR	HSR
Track	MG with slab and dual gauge configuration	MG with slab and dual gauge configuration	Dual gauge slab track with MG and SG	
Electrification	No	No	No	AC 25Kv
Signaling	One blocking between stations	One blocking between stations	One blocking between stations→ Refer to [Tab. 5-5-15]	ATC
Operation mode	Day & night	Day & night	Except 0 am to 4 am	Except 0 am to 4 am
Operating maximum speed	Pas: 80km/h Fre: 60km/h (container)	Pas: 80km/h Fre: 60km/h (container)	Pas: 80km/h Fre: 60km/h (container)	Pas: 120km/h

Note: The time frame between 0 am and 4 am is allocated for facility maintenance in line with Shinkansen standard.
 HSR= High Speed Railway MSR= Middle Speed Railway CR= Conventional Railway MG= Meter gauge
 SG= Standard gauge DT= Double Track ST= Single Track Pas.= Passenger Fre.= Freight
 NC= New construction

Source: Study team

5.4.6 Selection Method among Options

The numerical evaluation of pros and cons of tunnel construction roadmap among Option A, B, and D will be made as follows.

- Select technical attributes representing costs and benefits to be supplied for numerical evaluation among the four (4) roadmap options.
- Estimate traffic demand at each phase (Phase 1 to Phase 3 described in section 5.4.4) in the tunnel construction roadmap (trains/day/both ways).
 - Passenger traffic demand for HSR up to the year 2030 is obtained from the HSR-F/S and the demand afterward is calculated by extrapolation.

- Passenger traffic and freight traffic demand for the existing railway are obtained from the railway transportation strategy prepared by VNR.
- Freight traffic demand by commodity is calculated by assuming the commodity distribution in Japan may be applicable because these kind of statistics are not available in VietNam.
- This exercise is necessary to calculate freight traffic demand for containers and bulk.
- Calculate railway transportation capacity for each phase (Phase 1 to Phase 3 described in section 5.4.4) in the tunnel construction roadmap (trains/day/both ways).
 - Calculate passenger traffic capacity of HSR.
 - Calculate passenger and freight (both for container and bulk) traffic capacity of the existing railway.
- Decide the timing for the conventional railway when single track will need to be converted to double track and decide the timing for when HSR will become necessary.
- Assume optimal train operation pattern for HSR and conventional railway by passenger and freight distinction.
- Calculate cost items such as initial construction, operation and maintenance, facility upgrading or replacement.
- Estimate benefits including travel time saving and accident risk alleviation (the accident risk alleviation component was omitted in the end due to difficulties in expressing it in monetary terms).
- Compare costs and benefits among the four (4) options and propose the best technical solution in terms of cost-effectiveness.

The aforementioned evaluation items for the comparison exercise are summarized in the form of [Tab. 5-4-10] below. This shows just the form and the actual evaluation table is found in section 5.5.10.

[Tab. 5-4-10] Evaluation Items for Each Option

1. Construction cost item	Cost (million USD)
1-1 Tunnel construction cost	
1-2 Peripheral infrastructure construction cost	
1-3 Track work cost	
1-4 Signaling facility cost only for Option D	
1-5 Power supply facility work cost for HSR (MSR)	
1-6 Signaling and telecommunication facility cost for existing line and HSR (MSR)	
1-7 Right of way cost	
Subtotal	
2. Operation and maintenance cost (million USD)	
2-1 Operating cost	
2-2 Track maintenance and replacement cost	
2-3 Electric equipment maintenance and replacement cost	
Subtotal	
3. Time saving (min)	
4. Cost & benefit analysis (total cost/ time saving) (million USD/min)	

Source: Study team

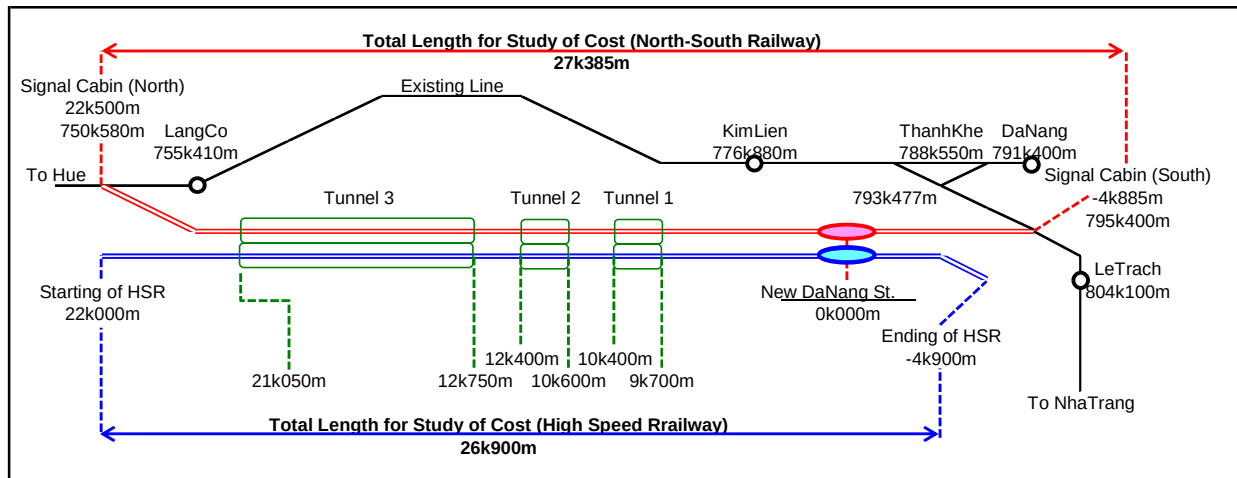
5.5 Recommendations

5.5.1 Section for Cost Estimation

In preparation for cost estimation of the HaiVan Tunnel, a section to calculate the cost shall be unified for the conventional railway as well as HSR (MSR). It is necessary to make a cost/benefit comparison study among the roadmap options of A to D and this is set as shown in [Fig. 5-5-1] and [Fig. 5-5-2] in this study.

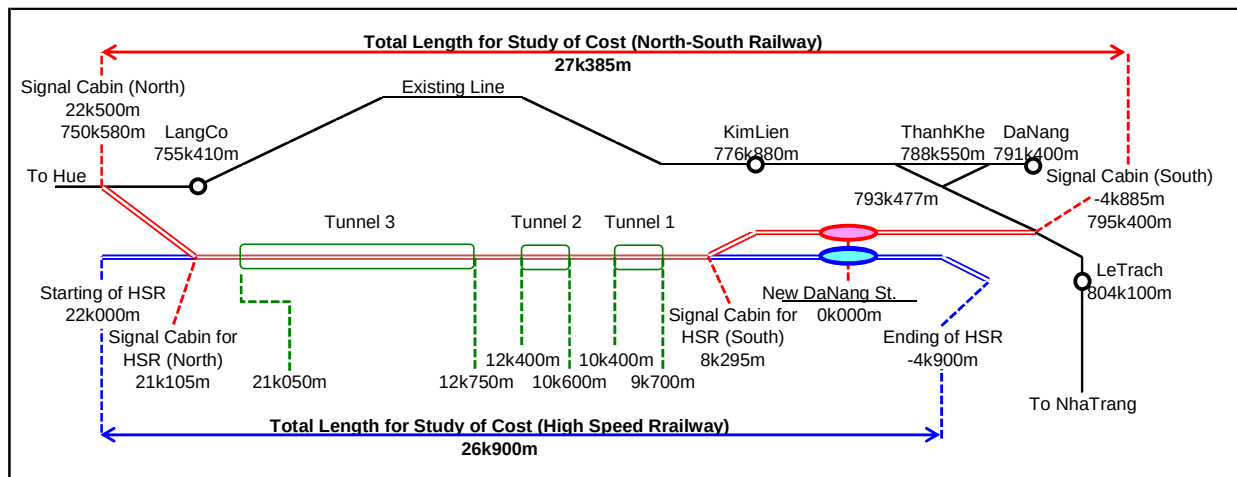
- For conventional railway: Between -4km885m and 22km500m with a total length of 27km385m.
- For HSR (MSR): Between -4km900m and 22km000m with a total length of 26km900m.

Here, the kilometerage mentioned above is measured setting New DaNang Station as 000km000m.



Source: Study team

[Fig. 5-5-1] Section for Cost Estimation for Option A to C



Source: Study team

[Fig. 5-5-2] Section for Cost Estimation for Option D

5.5.2 Legitimacy of the Project

The legal documents such as the GOV's strategy and master plan relevant to the HaiVan tunnel construction plan are summarized as shown in [Tab. 5-5-1].

[Tab. 5-5-1] Official Documents Authorizing the HaiVan Tunnel Plan

Strategy/ Plan	Related Documents
Railway Transport Development Strategy	Decision No. 1686/QĐ-TTg dated November 20, 2008 regarding approval of the Strategy for Development of Vietnamese Railway Transport up to 2020 with a Vision toward 2050
Railway Transport Master Plan	Decision No. 1436/QĐ-TTg dated September 10, 2009 regarding adjustment of the Master Plan on Railway Transport Development of Vietnam up to 2020 with a Vision to 2030
Others	- Government Office's letter No. 248/TB-VPCP dated July 16, 2013 regarding Prime Minister's instruction on the adjustment of strategy of Vietnam Railways till 2020 and vision till 2050 - MOT's Statement No. 13669/TTr-BGTVT dated December 16, 2013 regarding adjustment of strategy of Vietnam Railways till 2020 and vision till 2050 - GOV's Statement No. 1057/VPCP-KTN dated February 18, 2014 regarding adjustment of strategy of Vietnam Railways till 2020 and vision till 2050 - VNR's Official Letter No. 961/DS-KHTK regarding to explanatory report of the Prime Minister and Ministries on amendment of Vietnam Railway Strategy dated April 24, 2014 - Draft Detailed Plan of Modernization for N-S Railway (still under appraisal process by MOT)

Source: Study team

Although some of the legal bases referred to above might be revised in accordance with GOV's new decision and/or policy which are not released yet, they are used for reference.

5.5.3 Technical Specification

The technical specifications of the conventional railway, MSR, and HSR to estimate the HaiVan Tunnel construction cost is set as shown in [Tab. 5-5-2] based on the planned VNR standard (the current standard will be revised along with the speed increase plan of the conventional railway) and proposed HSR standard shown in HSR-F/S.

[Tab. 5-5-2] Railway Technical Specification for HaiVan Tunnel Cost Calculation

Technical Parameter	Specification		
	Conventional Railway	MSR	HSR
Maximum Design Speed	Passenger: 120km/h Container Freight: 80km/h Bulk Freight: 60km/h	Passenger: 200km/h	Passenger: 350km/h
Train Operation Mode	Option A-C: Separate operation Option D: Mixed operation but freight for bulk will be separated from new tunnel section		
Track Number	Option A-C:Single track for existing railway (to be double tracked in the future) Double track for HSR (MSR) Option D: Single track for a section where only existing railway operates Double track for mixed operation		
Gauge	1,000mm	1,435mm	
Electric Power Supply	None	AC 25kV, AT feeding system	
Signaling	Refer to 5.5.6		
Minimum Curve Radius	800m	6,000m	
Maximum Gradient	12‰	25‰	
Axle Load	T-14	T-16	
Embankment Formation Width	Single track: 5.8m Double track: 9.8m	Double track: 11.8m	
Track Structure	Option A-C: - Section for conventional railway: 50kg rail with PC sleeper on ballast track - Section for HSR (MSR): 60kg rail on slab track Option D: - Section for conventional railway: 50kg rail with PC sleeper on ballast track - Section for mixed operation: Dual gauge with 60kg rail on slab track		

Source: Study team

The target train speed and track capacity in 2020 will be V=80-90km/h and more than 25 trains per day respectively according to the draft DMP (Detailed Modernization Plan for N-S

Railway).

The infrastructure of MSR will be constructed based on the HSR standard to meet HSR operation in the future. The maximum train speed for passenger and freight (container) trains on the HaiVan Tunnel section is set at 120km/h and 80km/h respectively in case of mixed operation.

5.5.4 Structure Plan

(1) Standard Formation Width of Structures other than Tunnels

The standard formation width of structures necessary for the calculation of construction cost of structures other than tunnel structures is calculated as follows depending on the selection of single track or double track solution to be applied in the roadmap analysis.

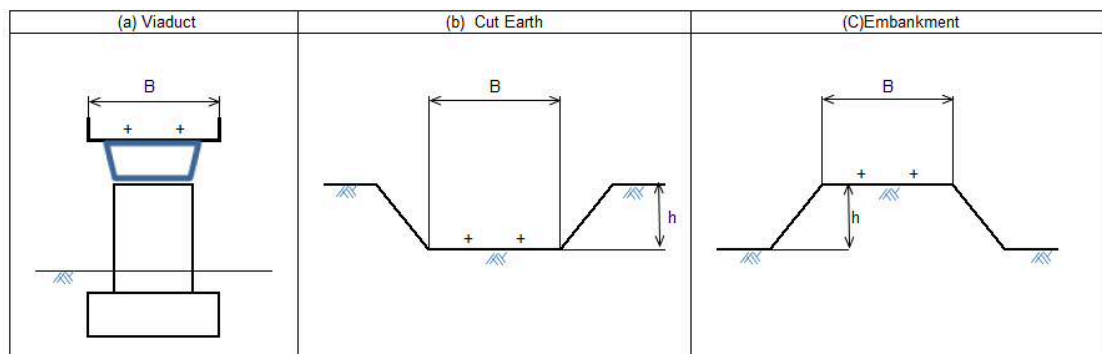
1) Conventional Railway

- (a) Single track: $B = 5.8\text{m}$
- (b) Double track: $B = 9.8\text{m}$

Here “B” represents the standard formation width of structures as illustrated in the figure below.

2) HSR

In case of HSR, the double track solution alone is applicable and the double track $B = 11.8\text{m}$.

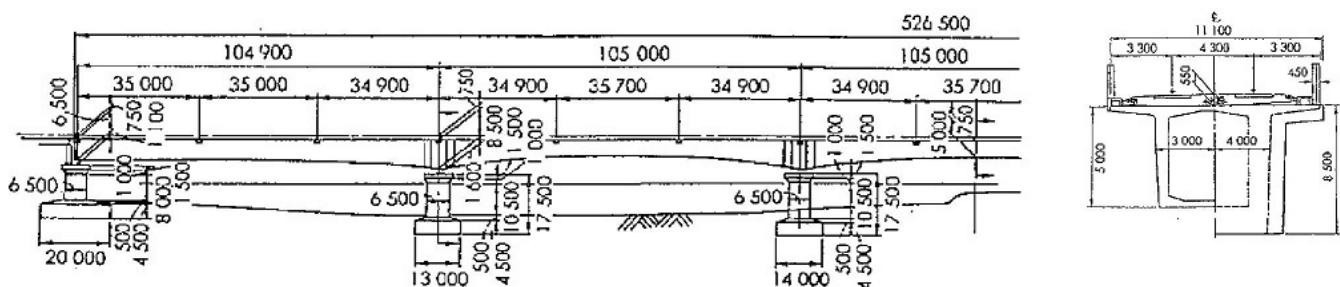


Source: Study team

[Fig. 5-5-3] Type of Structures

(2) Special Bridge Section

In this study a “PC Box Continuous Beam Type Bridge” as shown in [Fig. 5-5-4] is recommended for the purpose of reducing noise and vibration.



Source: Railway Technical Research Institute/ Reference and Guidebook for Structure Planning

[Fig. 5-5-4] Example of Long Span Bridge in Japan

(3) Stations

1) Conventional Railway

Elevated type stations are recommended for the purpose of separating train operation and passengers in this study with the following configuration.

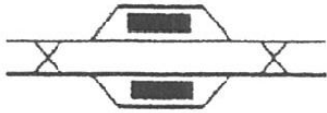
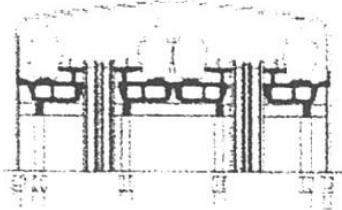
- (a) Two (2) tracks and two (2) platforms of opposite platforms type
- (b) Ground level floor is used for concourse and ticketing space
- (c) The 2nd floor is used for platforms and track
- (d) Station length of L= 400m
- (d) Station width at platform of B1= 7.0m (inclusive of walls)
- (e) Distance between track center and edge of platform of B2= 1.5m
- (f) Distance between tracks of B3= 4.0 m

Accordingly the total width of B= $2 \times (B1+B2)+B3 = 2 \times (7.0+1.5)+4.0 = 21\text{m}$

2) HSR

Elevated type stations are recommended for the purpose of separating train operation and passengers in this study with the following configuration. NhaTrang Station shown in the HSR-F/S with the configuration summarized in [Tab. 5-5-3] is applied in this study.

[Tab. 5-5-3] Configuration of HSR Station

Station Name	Track Layout	Station Section	Platform Type	Platform Length (m)	Platform Width (m)
Nha Trang			Island Platform	260 m	10.5+10.5

Source: HSR-F/S

(4) Classification of Structure Types

The structure type distribution along the HaiVan tunnel planning of the route “Alternative 1” section is summarized here depending on the roadmap analysis options of “Option A” to “Option D”. Since the route alternative of “Alternative 1” was selected in section 5.3, the following descriptions are on “Alternative 1”.

1) Structure Type Distribution of HSR

(a) Structure Type Distribution by Location

[Tab. 5-5-4] shows the structure type distribution by location to be applied for all the Options of A, B, C, and D.

[Tab. 5-5-4] Structure Type Distribution by Location (HSR)

Structure Type	Station		Length (m)
Viaduct	-4km900m	~ -0km130m	4,770
Station	-0km130m	~ 0km130m	260
Viaduct	0km130m	~ 7km250m	7,120
Embankment (High)	7km250m	~ 7km600m	350
Cut Earth	7km600m	~ 8km250m	650
Embankment (High)	8km250m	~ 8km295m	45
Embankment (High)	8km295m	~ 8km350m	55
Special Bridge	8km350m	~ 9km550m	1,200
Embankment (High)	9km550m	~ 9km650m	100
Mine Mouth(M/M)	9km650m	~ 9km700m	50
Tunnel	9km700m	~ 10km400m	700
Mine Mouth	10km400m	~ 10km450m	50
Cut Earth	10km450m	~ 10km550m	100
Mine Mouth	10km550m	~ 10km600m	50
Tunnel	10km600m	~ 12km400m	1,800
Mine Mouth	12km400m	~ 12km450m	50
Viaduct	12km450m	~ 12km700m	250
Mine Mouth	12km700m	~ 12km750m	50
Tunnel	12km750m	~ 21km050m	8,300
Mine Mouth or Buffer Tunnel (BT)	21km050m	~ 21km100m	50
Viaduct	21km100m	~ 21km105m	5
Viaduct	21km105m	~ 22km000m	895
Total Length			26,900

Note: 1) In this study, 0km000 is set at the center of New DaNang Station and the plus marked direction (toward HaNoi) is set to Hue, tentatively.

2) The cells surrounded by the red line show the section where HSR and conventional railway merges in “Option D” of the roadmap analysis.

Source: Study team

(b) Structure Type Share for Options A, B, and C

The structure type distribution referred to in [Tab. 5-5-5] is sorted out by structure type for Options A, B, and C.

[Tab. 5-5-5] Structure Type Share for Options A, B, and C (HSR)

Structure Type	Length (m)
Cut Earth	750
Embankment (Low)	0
Embankment (High)	550
Viaduct	13,040
Special Bridge	1,200
Mine Mouth	250
Buffer Tunnel	50
Tunnel	10,800
Station of HSR	260
Total	26,900

Source: Study team

(c) Structure Type Share for Option D

The structure type distribution referred to in [Tab. 5-5-6] is sorted out by structure type for Option D because this option includes dual gauge section.

[Tab. 5-5-6] Structure Type Distribution for Option D (HSR)

Structure Type	Length (m)	
	Separation	Integration
Cutting	650	100
Embankment (Low)	0	0
Embankment (High)	395	155
Viaduct	12,785	255
Special Bridge	0	1,200
Mine Mouth	0	300
Tunnel	0	10,800
HSR Station	260	0
Subtotal	14,090	12,810
Total	26,900	

Source: Study team

2) Structure Type Distribution of Conventional Railway (VNR)

(a) Structure Type Distribution by Location for Options A, B, and C

[Tab. 5-5-7] shows the structure type distribution by location to be applied for Options A, B, and C. Here, VNR refers to as conventional railway.

[Tab. 5-5-7] Structure Type Distribution by Location for Options A, B, and C (VNR)

Structure Type	Station		Length (m)
Embankment (Low)	-4km885m	~ -4km000m	885
Embankment (High)	-4km000m	~ -3km500m	500
Viaduct	-3km500m	~ -0km200m	3,300
Station	-0km200m	~ 0km200m	400
Viaduct	0km200m	~ 7km250m	7,050
Embankment (High)	7km250m	~ 7km600m	350
Cutting	7km600m	~ 8km250m	650
Embankment (High)	8km250m	~ 8km295m	45
Embankment (High)	8km295m	~ 8km350m	55
Special Bridge	8km350m	~ 9km550m	1,200
Embankment (High)	9km550m	~ 9km650m	100
Mine Mouth	9km650m	~ 9km700m	50
Tunnel	9km700m	~ 10km400m	700
Mine Mouth	10km400m	~ 10km450m	50
Cutting	10km450m	~ 10km550m	100
Mine Mouth	10km550m	~ 10km600m	50
Tunnel	10km600m	~ 12km400m	1,800
Mine Mouth	12km400m	~ 12km450m	50
Viaduct	12km450m	~ 12km700m	250
Mine Mouth	12km700m	~ 12km750m	50
Tunnel	12km750m	~ 21km050m	8,300
Mine Mouth	21km050m	~ 21km100m	50
Viaduct	21km100m	~ 21km105m	5
Embankment (Low)	21km105m	~ 22km500m	1,395
Total Length			27,385

Note. In this study, 0km000 is set at the center of New DaNang Station and the plus marked direction (toward HaNoi) is set to Hue, tentatively.

Source: Study team

(b) Structure Type Share for Options A, B, and C

The structure type distribution referred to in [Tab. 5-5-8] is sorted out by structure type for Options A, B, and C.

[Tab.5-5-8] Structure Type Share for Options A, B, and C (VNR)

Structure Type	Length (m)
Cutting	750
Embankment (Low)	2,280
Embankment (High)	550
Viaduct	11,105
Special Bridge	1,200
Mine Mouth	300
Tunnel	10,800
VNR Station	400
Total	27,385

Source: Study team

(c) Structure Type Distribution by Location for Option D

[Tab. 5-5-9] shows the structure type distribution by location to be applied for Option D. Here, VNR refers to as conventional railway.

[Tab. 5-5-9] Structure Type Distribution by Location Applied for Option D (VNR)

Structure Type	Station		Length (m)
Embankment (Low)	-4km885m	~ -4km000m	885
Embankment (High)	-4km000m	~ -3km500m	500
Viaduct	-3km500m	~ -0km200m	3,300
Station	-0km200m	~ 0km200m	400
Viaduct	0km200m	~ 7km250m	7,050
Cutting	7km250m	~ 7km600m	350
Cutting	7km600m	~ 8km250m	650
Embankment (High)	8km250m	~ 8km295m	45
Embankment (High)	8km295m	~ 8km350m	55
Special Bridge	8km350m	~ 9km550m	1,200
Embankment (High)	9km550m	~ 9km650m	100
Mine Mouth	9km650m	~ 9km700m	50
Tunnel	9km700m	~ 10km400m	700
Mine Mouth	10km400m	~ 10km450m	50
Cutting	10km450m	~ 10km550m	100
Mine Mouth	10km550m	~ 10km600m	50
Tunnel	10km600m	~ 12km400m	1,800
Mine Mouth	12km400m	~ 12km450m	50
Viaduct	12km450m	~ 12km700m	250
Mine Mouth	12km700m	~ 12km750m	50
Tunnel	12km750m	~ 21km050m	8,300
Mine Mouth	21km050m	~ 21km100m	50
Viaduct	21km100m	~ 21km105m	5
Embankment (Low)	21km105m	~ 22km500m	1,395
Total Length			27,385

Note. In this study, 0km000 is set at the center of New DaNang Station and the plus marked direction (toward HaNoi) is set to Hue, tentatively.

Source: Study team

(d) Structure Type Share for Option D

The structure type distribution referred to in [Tab. 5-5-10] is sorted out by structure type for Option D.

[Tab. 5-5-10] Structure Type Share for Option D (VNR)

Structure Type	Length (m)	
	Separation	Integration
Cutting	1,000	100
Embankment (Low)	2,280	0
Embankment (High)	545	155
Viaduct	10,350	255
Special Bridge	0	1,200
Mine Mouth	0	300
Tunnel	0	10,800
VNR Station	400	0
Subtotal	14,575	12,810
Total	27,385	

Source: Study team

5.5.5 Track Plan

(1) Alternatives for Track Structure Type

The type of track structures will be determined by considering the conditions such as operation alternatives (track separation or sharing between existing and HSR), single track or double track and HSR (MSR) operation in future as shown in [Tab. 5-5-11].

1) Single and Double Track Section of Separate Alternative

In principle, ballast track will be applied to single and double track section of the separate alternative in consideration of the following.

In general, track lines newly constructed in Japan adopt ballast-less track on viaducts, bridges and tunnels for maintenance cost saving purposes. Currently existing railway in VietNam adopts ballast track on all sections because of familiarity of maintenance. However, it is necessary to take sufficient countermeasures to prevent mud pumping particularly in tunnel sections when ballast track is chosen.

2) Single Track and Double Track Section of Shared Alternative (Option D)

In principle, slab track will be applied to single and double track sections of the shared alternative in consideration of the following.

Since slab track is generally applied to sections in tunnels, bridges, and viaducts for HSR in Japan, this alternative in which track is shared by the existing railway as well as HSR uses slab track as well. Besides, since the track width for HSR is larger than that of existing, if the track is constructed based on the existing line standard, HSR has no option but to use separate track. Therefore, slab track with dual gauge according to the HSR standard is applied from the beginning of construction to prepare for future use of HSR considering economy and constructability although the initial construction cost is higher.

[Tab. 5-5-11] Track Structure Type by Option and Phase

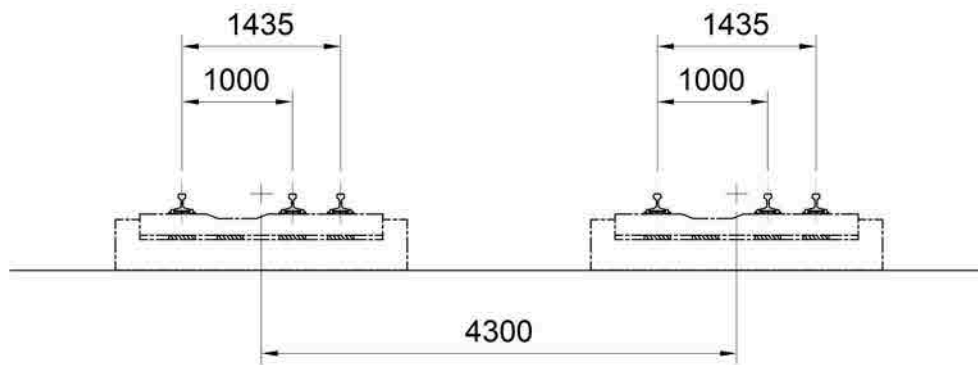
Option		Existing Line	HSR (MSR)
Separate track alternative	Open section	Ballast track	Slab track: Viaduct, Bridge and Tunnel Ballast track: Others
	Tunnel section	Ballast track	Slab track
Shared track alternative (Option D)	Open section	Slab track: Dual gauge section	Slab track: Viaduct, Bridge and Tunnel
		Ballast track: Other than dual gauge section	
	Tunnel section	Slab track: Dual gauge section	Slab track

Note: Ballast track is applied to single track of existing line, double track on cutting and embankment sections.

Source: Study team

(2) Standard Track Cross Section

Although the track gauge size of most of the existing railway in VietNam is 1,000mm which is different from the standard gauge size of 1,435mm which is widely used in the world, this is not a peculiar condition to VietNam. The standard cross section of slab track with dual gauge structure is shown in [Fig. 5-5-5].

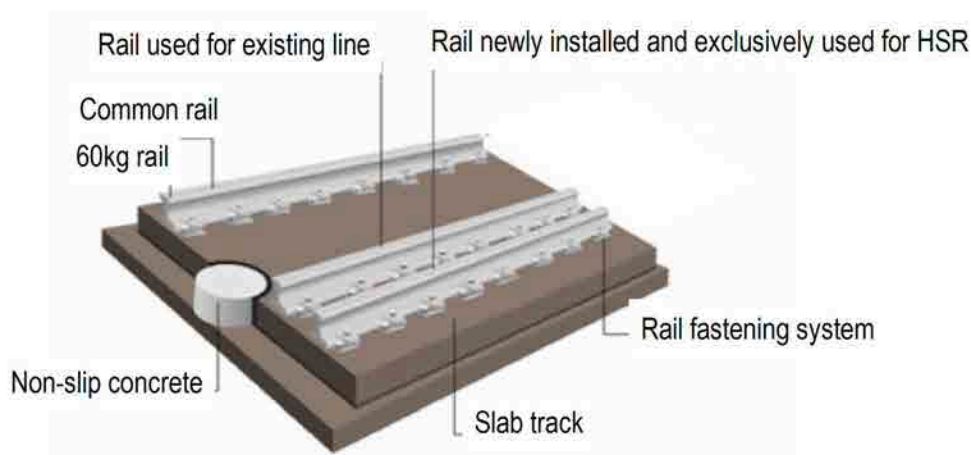


Source: Study team

[Fig. 5-5-5] Dual Gauge Track Structure for Option D

Dual gauge is a type of track that provides train operation with two separate gauges. A dual-gauge track configuration usually consists of three (3) rails (two (2) gauge size rails), one for both gauges as a common rail and others for each gauge size. However at a time when this is not possible, four (4) rails on a slab are required. In a normal three (3) rail type dual-gauge configuration, the two (2) outer rails give the wider gauge (1,435mm), while one of the outer rails and the inner rail give a narrower gauge (1,000mm), as shown in [Fig. 5-5-6].

In Japan, dual gauge is used when standard gauge HSR lines join the narrow-gauge (1,067mm) system, which is the national standard. For example, part of the Ōu line became part of the Akita Shinkansen and was upgraded to dual gauge. As a special case, Seikan Tunnel also applies dual gauge track for future use of HSR as shown in [Fig. 5-5-6].



Source: JR TT

[Fig. 5-5-6] Explanatory Drawing of Dual Gauge for Seikan Tunnel

5.5.6 Signaling and Telecommunication, Power Supply

(1) Signaling System for Mixed Operation on Dual Gauge Section

Regarding Option D, a signaling system is required for mixed operation of HSR and freight trains on a dual gauge section at HaiVan Tunnel. Japan has two examples of the signaling system for mixed operation of Shinkansen and existing line trains in a dual gauge section. [Tab. 5-5-12] shows an overview of the two examples.

[Tab. 5-5-12] Japanese Examples of Signaling System for Dual Gauge Section

	Japanese Example 1 <u>Hokkaido Shinkansen</u>		Japanese Example 2 <u>Akita Shinkansen</u>	
Applied section and Operation record	- Mixed operation of about 82 km including Seikan-Tunnel section of 54km - To be in operation by the end of March 2016 for opening of the Shin-aomori and Shin-Hakodate section		- Mixed operation of about 13km between Jinguji and Mineyosigawa stations in the Ou line - It has been in operation since 1997	
Type of train	Shinkansen	Freight	Shinkansen	existing-line trains
Maximum speed	140km/h	100km/h	130km/h	110km/h
ATP	DS-ATC	DS-ATC	ATS-P	ATS-SN
Signaling	Cab signal	Cab signal	Lineside signal	Lineside signal
Train detection	Track circuit	Track circuit	Track circuit	Track circuit
Block system	Cab signal block system	Cab signal block system	Automatic block signalling for single line	Automatic block signalling for single line
Features	- ATC and Cab signal are to be applied to both Shinkansen and Freight trains. - The maximum speed of Shinkanssen at the mixed operation section will be 140km/h, the same maximum speed of current limited express train at the Seikan-Tunnel section, due to the problem of passing each other in a tunnel.		- ATS-P has been applied to Shinkansen train, considering the applied section as "an existing line" - ATS-SN has been applied to conventional trains. - Morioka station is the border of Sinkansen and conventional train sectoins. Shnkansen train changes signalling between ATC and ATS-P at Morioka station.	

Source: Study team

One Japanese example is Hokkaido Shinkansen, which has a dual gauge section of about 82km at Seikan Tunnel. The dual gauge section is regarded as "Shinkansen line" and both Shinkansen and freight trains are operated with DS-ATC (Digital communication & control for Shinkansen - Automatic Train Control) and cab signal. As well as Shinkansen trains,

freight trains are equipped with DS-ATC on-board equipment. Considering the impact of wind pressure which occurs when two trains pass each other at the tunnel, the maximum speed of Shinkansen trains at the tunnel section is limited to 140 km/h. The dual gauge section is under construction and will be in operation by the end of March 2016.

The other Japanese example is Akita Shinkansen, which has a dual gauge section of about 13km between Jinguji and Mineyoshigawa on the Ou line. The dual gauge section is regarded as “an existing line” and both Shinkansen and existing-line trains are operated with lineside signals. As an ATP, ATS-P (Automatic Train Stop with Pattern) is applied to Shinkansen trains and ATS-SN (Automatic Train Stop - SN type) is applied to existing-line trains. Shinkansen trains have both DS-ATC and ATS-P on-board equipment. The dual gauge section has been in operation since 1997 and it has a 17 -year operational track record.

Based on the two Japanese examples shown above, two methods are proposed as the signaling system for the dual gauge section at HaiVan Tunnel. [Tab. 5-5-13] shows an overview of the two methods. Method 1 is based on the signaling system applied to the Seikan Tunnel section of Hokkaido Shinkansen, and Method 2 is based on the signaling system applied to the Akita Shinkansen section. Since both are based on Japanese proven methods, they have no issues from a technical or safety aspect. At the dual gauge section, both Shinkansen and existing-line trains are detected by the only train detection system, managed by the only interlocking system regarding route setting and signal aspects, and protected by the only ATP system. Safety is thus consistently guaranteed.

Comparing the proposed two methods, Method 1 is recommended because the same signaling, DS-ATC and cab signal, can be applied to the whole section of the HSR line with no need to change signaling at the border of the dual gauge section, and also because Method 1 is capable of future speed increase for HSR. Method 1 is a precondition for the cost estimation in section 5.5.1.

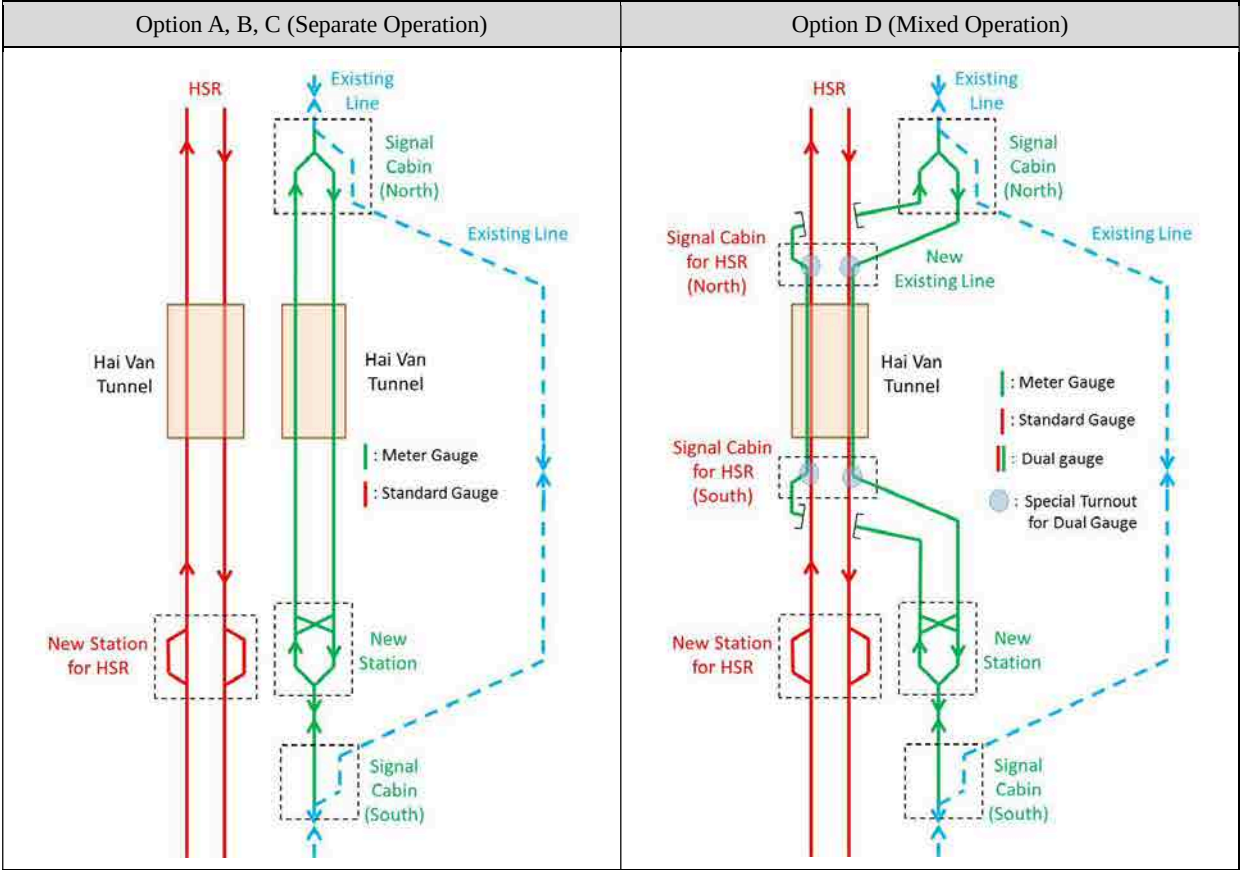
[Tab. 5-5-13] Proposed Signaling Systems for the Dual Gauge Section at HaiVan Tunnel

	Method 1		Method 2	
Type of train	HSR	Freight	HSR	Freight
Maximum speed	120km/h	80km/h	120km/h	80km/h
ATP	DS-ATC	DS-ATC	ATS-P	ATS-P or ATS-SN
Signaling	Cab signal	Cab signal	Lineside signal	Lineside signal
Train detection	Track circuit	Track circuit	Track circuit or Axle counter	Track circuit or Axle counter
Block system	Cab signal block system	Cab signal block system	Automatic block signaling for double line	Automatic block signaling for double line
Overview	- ATC and Cab signal are to be applied to both HSR and Freight trains. > Method 1 is based on Japanese example 1, "Hokkaido Shinkansen", which will be in operation in March 2016 > Method 1 uses the technology of HSR and is capable of future speed increase for HSR.		- ATS-P is to be applied to Shinkansen train, considering the applied section as "an existing line" - ATS-P or ATS-SN is to be applied to Freight train. > Method 2 is based on Japanese example 2, "Akita Shinkansen", which has been in operation since 1997. > Method 2 uses the technology of conventional lines and is not capable of future speed increase for HSR.	
Features	- The same signalling (DS-ATC) can be applied to the whole section of the HSR line including Hai Van Tunnel with no change of signalling required.	- The change of signalling and ATP is required at the border of the Hai Van Tunnel section between ATC and lineside signal with no ATP. - All the Freight trains which pass Hai Van Tunnel need to have ATC on-board equipment. - Drivers need to be trained regarding ATC operation.	- The change of signalling and ATP is required at the border of the Hai Van Tunnel section between ATC and lineside signal with ATS-P. - Drivers need to see lineside signals in the Hai Van Tunnel section. - Each Shinkansen train needs to have both ATC and ATS-P types of on-board equipments.	- The change of ATP is required at the border of the Hai Van Tunnel section between ATS-P or SN and no ATP. - All the Freight trains which pass Hai Van Tunnel need to have ATS-P or SN on-board equipment. - Drivers need to be trained regarding ATS-P or SN operation.

Source: Study team

(2) Signal Cabin and Interlocking

[Fig. 5-5-7] shows a model of alignment for each option at the HaiVan Tunnel section. In Option A, B, or C, the HSR and the existing new lines are separated. The HSR new line has a new HSR station. The new existing line has a new station and two signal cabins at the junction with the old existing line. In Option D, mixed operation of HSR and freight trains is applied to the dual gauge section. In addition to the new stations and signal cabins shown in Option A, B, or C, four special turnouts for dual gauge are built at the north and south borders of the dual gauge section and two signal cabins for HSR are constructed for the control of point machines for special turnouts. Each station or signal cabin has interlocking equipment.



Note: The model figure shown above is assumed that in Option A, B, or C, the new existing line at HaiVan Tunnel is a double line when the operation of HSR starts. The tunnel for the new existing line will be either one tunnel for double line (as shown above) or two tunnels for single line.

Source: Study team

[Fig. 5-5-7] Model of Alignment for each Option at HaiVan Tunnel Section

[Tab. 5-5-14] shows a list of the section lengths shown in [Fig. 5-5-7]. The section lengths are calculated by referring to the track data shown in [Fig. 5-5-1] and [Fig. 5-5-2]. The cost items which are calculated with the unit cost are to use the section length shown in [Tab. 5.5-14].

[Tab. 5-5-14] List of Section Length at HaiVan Tunnel Section

Section			Length (km)	
Option A, B, C	HSR	(North Border) - (South Border)	26.900	
	Existing Line	Signal Cabin (North) - New Station	22.500	27.385
		New Station - Signal Cabin (South)	4.885	
Option D	HSR	Dual Gauge Section	12.810	26.900
		Separate Line	(North Border) - Signal Cabin for HSR (North)	0.895
			Signal Cabin for HSR (South) - (South Border)	13.195
	Existing Line	Dual Gauge Section	12.810	27.385
		Separate Line	Signal Cabin (North) - Signal Cabin for HSR (North)	1.395
			Signal Cabin for HSR (South) - New Station	8.295
			New Station - Signal Cabin (South)	4.885

Source: Study team

(3) ATP, Block System and Train Detection

As mentioned in (1), ATP, Block system, and Train detection for HSR at the HaiVan Tunnel section are DS-ATC, cab signal, and track circuit, respectively. ATP, Block system, and Train detection for the existing line at the HaiVan Tunnel section vary depending on the option. [Tab. 5-5-15] shows a corresponding list for the existing line at the HaiVan Tunnel section.

[Tab. 5-5-15] ATP, Block System and Train Detection for Existing Line at HaiVan Tunnel section

	Section		ATP	Block System	Train Detection
Option A, B, C	Existing Line	Signal Cabin (North) - New Station	None	Semi-automatic	Axle Counter
		New Station - Signal Cabin (South)			
Option D	Existing Line	Signal Cabin (North) - Signal Cabin for HSR (North)	DS-ATC	Cab signal	Track circuit
		Dual Gauge Section			
		Signal Cabin for HSR (South) - New Station			
		New Station - Signal Cabin (South)	None	Semi-automatic	Axle Counter

Source: Study team

In Option A, B, or C, the new existing line is separated from HSR and "no ATP", "semi-automatic", and "axle counters" are applied to the whole section, following the current signaling system in VNR, where there is no track circuits between stations and the arrival or the departure of trains is detected with axle counters. Here, the introduction of ATP should be judged by VNR considering the prevention of accidents and improvement of safety. Accordingly, it is fundamental to follow the current signaling system in VNR which has no ATP.

In Option D, DS-ATC, cab signals, and track circuits are applied to the dual gauge section which is regarded as "HSR section". Furthermore, considering the change of signaling by freight trains, the same set of DS-ATC, cab signals, and track circuits are applied to the approach sections from Signal Cabin (North) and New Station. The changing operation of signaling by freight trains is to be done at Signal Cabin (North) and New Station. As for DS-ATC and track circuit equipment for the dual gauge section, two sets of equipment are required, one for meter gauge and the other for standard gauge.

(4) Telecommunication

For the new HSR line, a whole set of telecommunication equipment and facilities for HSR are introduced. For a new route of the existing line, referring to the current overhead telecommunication cables along the railway line, about the same volume of telecommunication channels through optical fiber and metal cables is introduced along the new route of the existing line.

(5) Power Supply

For the new HSR line, a whole set of power supply equipment and facilities for HSR are introduced. The feeding voltage of HSR is AC 25 kV. For the new route of the existing line, since it has no electrification, only power receiving facilities for new signaling equipment and facilities at new stations or signal cabins are introduced.

(6) Equipment and Facilities for MSR

In Option A and B, MSR will be in operation first and later it will be upgraded to HSR. Considering the future upgrade to HSR, the same equipment and facilities for HSR will be introduced for MSR for signaling & telecommunication and power supply. ATP and Block system for MSR is DS-ATC and cab signal, the same as those of HSR. When MSR is upgraded to HSR and the maximum speed increases, a review of the approach lock sections followed by software modification of electronic interlocking will be required

5.5.7 Right of Way

(1) Conventional Railway

The right of way (R.O.W.) necessary for the construction of the new HaiVan tunnel is calculated as follows depending on the selection of single track or double track solution to be applied in the roadmap analysis.

1) Single Track

(a) Viaduct section

$$\text{R.O.W.} = B + 2 \times a = 5.8 + 2 \times 0.5 = 6.8\text{m}$$

(b) Cutting section (assumed cutting depth is 5m)

$$\text{R.O.W.} = B + 2 \times 5\text{m} \times \text{Slope ratio} + 2 \times a = 5.8 + 2 \times 5 \times 1.5 + 2 \times 1.0 = 22.8\text{m}$$

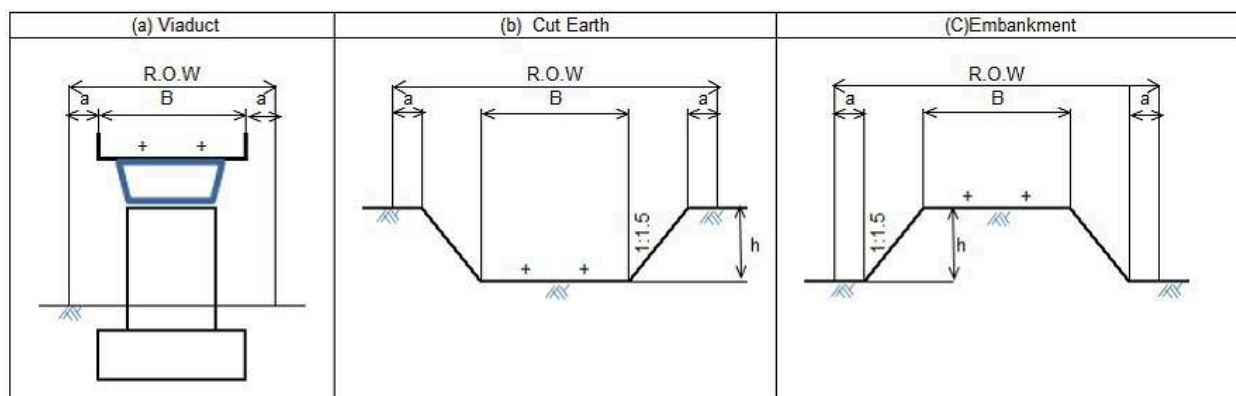
(c) High embankment section (assumed average height is 6m)

$$\text{R.O.W.} = B + 2 \times 6\text{m} \times \text{Slope ratio} + 2 \times a = 5.8 + 2 \times 5 \times 1.5 + 2 \times 1.0 = 25.8\text{m}$$

(d) Low embankment section (assumed average height is 3m)

$$\text{R.O.W.} = B + 2 \times 3\text{m} \times \text{Slope ratio} + 2 \times a = 5.8 + 2 \times 3 \times 1.5 + 2 \times 1.0 = 16.8\text{m}$$

Here, “B” and “a” represent “standard formation width of structures” and “distance between edge of structure and R.O.W. for drainage, fence and others” respectively as shown in [Fig. 5-5-8].



Source: Study team

[Fig. 5-5-8] R.O.W. of Structures

2) Double Track

(a) Viaduct section

$$\text{R.O.W.} = B + 2 \times a = 9.8 + 2 \times 0.5 = 10.8\text{m}$$

(b) Cutting section (assumed cutting depth is 5m)

$$\text{R.O.W.} = B + 2 \times 5\text{m} \times \text{Slope ratio} + 2 \times a = 9.8 + 2 \times 5 \times 1.5 + 2 \times 1.0 = 26.8\text{m}$$

(c) High embankment section (assumed average height is 6m)

$$\text{R.O.W.} = B + 2 \times 6\text{m} \times \text{Slope ratio} + 2 \times a = 9.8 + 2 \times 5 \times 1.5 + 2 \times 1.0 = 29.8\text{m}$$

(d) Low embankment section (assumed average height is 3m)

$$\text{R.O.W.} = B + 2 \times 3\text{m} \times \text{Slope ratio} + 2 \times a = 9.8 + 2 \times 3 \times 1.5 + 2 \times 1.0 = 20.8\text{m}$$

(2) HSR

In case of HSR, the double track solution alone is applicable.

(a) Viaduct section

$$\text{R.O.W.} = B + 2 \times a = 11.3 + 2 \times 0.5 = 12.3\text{m}$$

(b) Cutting section (assumed cutting depth is 5m)

$$\text{R.O.W.} = B + 2 \times 5\text{m} \times \text{Slope ratio} + 2 \times a = 11.3 + 2 \times 5 \times 1.5 + 2 \times 1.0 = 28.3\text{m}$$

(c) High embankment section (assumed average height is 6 m)

$$\text{R.O.W.} = B + 2 \times 6\text{m} \times \text{Slope ratio} + 2 \times a = 11.3 + 2 \times 5 \times 1.5 + 2 \times 1.0 = 31.3\text{m}$$

(d) Low embankment section (assumed average height is 3 m)

$$\text{R.O.W.} = B + 2 \times 3\text{m} \times \text{Slope ratio} + 2 \times a = 11.3 + 2 \times 3 \times 1.5 + 2 \times 1.0 = 22.3\text{m}$$

(3) Summary of R.O.W. for Viaducts, Cuttings and Embankments

The above calculated figures are summarized in [Tab. 5-5-16].

[Tab. 5-5-16] R.O.W. by Structure Type

Description	R.O.W (m ² /m)	Length(m)				Area(m ²)			
		Option A	Option B	Option C	Option D	Option A	Option B	Option C	Option D
1) Conventional railway									
(1) Single Track									
(a) Viaduct	6.8	12,610	14,610	2,000	4,500	85,748	99,348	13,600	30,600
(b) Cut Earth	22.8	1,500	1,500		2,000	34,200	34,200	0	45,600
(c) Embankment (High)	25.8	1,100	1,100		90	28,380	28,380	0	2,322
(d) Embankment (Low)	16.8	2,790	5,580	2,790	2,790	46,872	93,744	46,872	46,872
Sub Total						195,200	255,672	60,472	125,394
Check	km	9,000	11,395	2,395	4,690				
(2) Double Track									
(a) Viaduct	10.8	4,300	4,300	10,650	8,100	46,440	46,440	115,020	87,480
(b) Cut Earth	26.8			750		0	0	20,100	0
(c) Embankment (High)	29.8	500	500	1,050	500	14,900	14,900	31,290	14,900
(d) Embankment (Low)	20.8	885	885	2,280	885	18,408	18,408	47,424	18,408
Sub Total						79,748	79,748	213,834	120,788
Check	km	5,685	5,685	14,730	9,485				
2) HSR									
(a) Viaduct	12.3	13,040	13,040	13,040	13,040	160,392	160,392	160,392	160,392
(b) Cut Earth	28.3	750	750	750	750	21,225	21,225	21,225	21,225
(c) Embankment (High)	31.3	550	550	550	550	17,215	17,215	17,215	17,215
(d) Embankment (Low)	22.3	0	0	0	0	0	0	0	0
Sub Total						198,832	198,832	198,832	198,832
Check	km	14,340	14,340	14,340	14,340				
Total						473,780	534,252	473,138	445,014

Source: Study team

(4) Stations

1) Conventional Railway

The right of way for conventional railway is calculated as follow.

$$\text{R.O.W.} = 400\text{m} \times (32\text{m} + 2 \times 3\text{m}) = 15,200\text{m}^2$$

Here, it was assumed that the station length= 400m, station width= 32m, and the distance between the station and R.O.W. for passenger= 3m.

2) HSR

The same standard as NhaTrang Station of HSR-F/S is applied in this study with the station area= 26,100m².

5.5.8 Time saving effect

The deference of train travel time for each option of A to D of new HaiVan Tunnel construction on the section between Hue and DaNang for the conventional railway is summarized as shown in [Tab. 5-5-17].

[Tab. 5-5-17] Time Saving Effect

Passenger Train		Operating time	Defferential time between existing line and each plan	
1	Existing conventional line	2:36	...	
2	HaiVan tunnel Conventional single track line	1:33	1-2	1:03
3	HaiVan tunnel Conventional double track line	1:33	1-3	1:03
4	HaiVan tunnel Conventional double track line Plan "D"	1:35	1-4	1:01
5	MSR (200Km/h)	0:26	1-5	2:10
6	HSR (320Km/h) Plan "A.B.C"	0:17	1-6	2:19
7	HSR(120Km/h) Plan "D"	0:26	1-7	2:10
Freight Train		Operating time	Defferential time between existing line and each plan	
1	Existing conventional line	3:48	...	
2	HaiVan tunnel Conventional single track line	1:51	1-2	1:57
3	HaiVan tunnel Conventional double track line	1:51	1-3	1:57
4	HaiVan tunnel Conventional double track line Plan "D"	1:52	1-4	1:57

Source: Study team

The current travel time between Hue and DaNang is taken from the train timetable of VNR.

The travel time after completion of the new HaiVan tunnel is calculated by referring to the train timetable of VNR for the Hue and ThanhKhe section and by incorporating the section length of each option of A to D and the planned train speed for the new construction section.

It is assumed that the train types that can pass through the new HaiVan Tunnel are limited to passenger and container freight trains.

As the calculation result in the table shows, the time saving effect from the new HaiVan Tunnel construction is evident. Of the total travel time of about 1.5 hours between Hue and New DaNang, about 80% is spent for the Hue-ThanhKhe section which is outside the tunnel section.

5.5.9 Cost Estimation

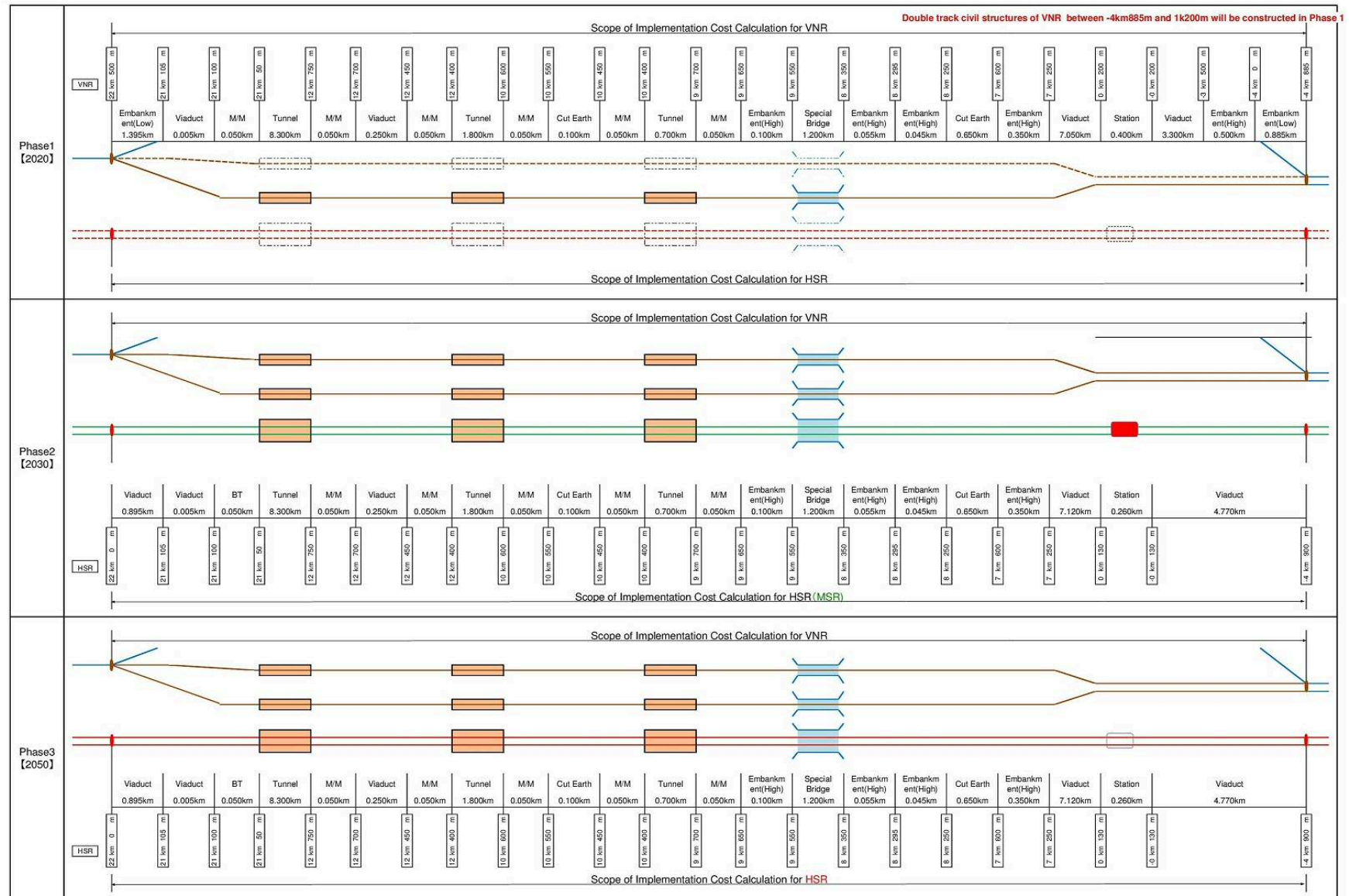
(1) Civil Work Cost

1) Rough Quantity Estimation

[Fig. 5-5-9] to [Fig. 5-5-12] explain the approximate quantity of structures at each construction phase for each roadmap option. The section in terms of kilometerage commonly applied for cost estimation to all of the roadmap options are as follows.

- For conventional railway:
Between -4km885m before and after 22km500m of AnCu Station with a total length of L=27km385m
- For HSR:
Between -4km900m before and after 22km000m of AnCu Station with a total length of L=26km900m

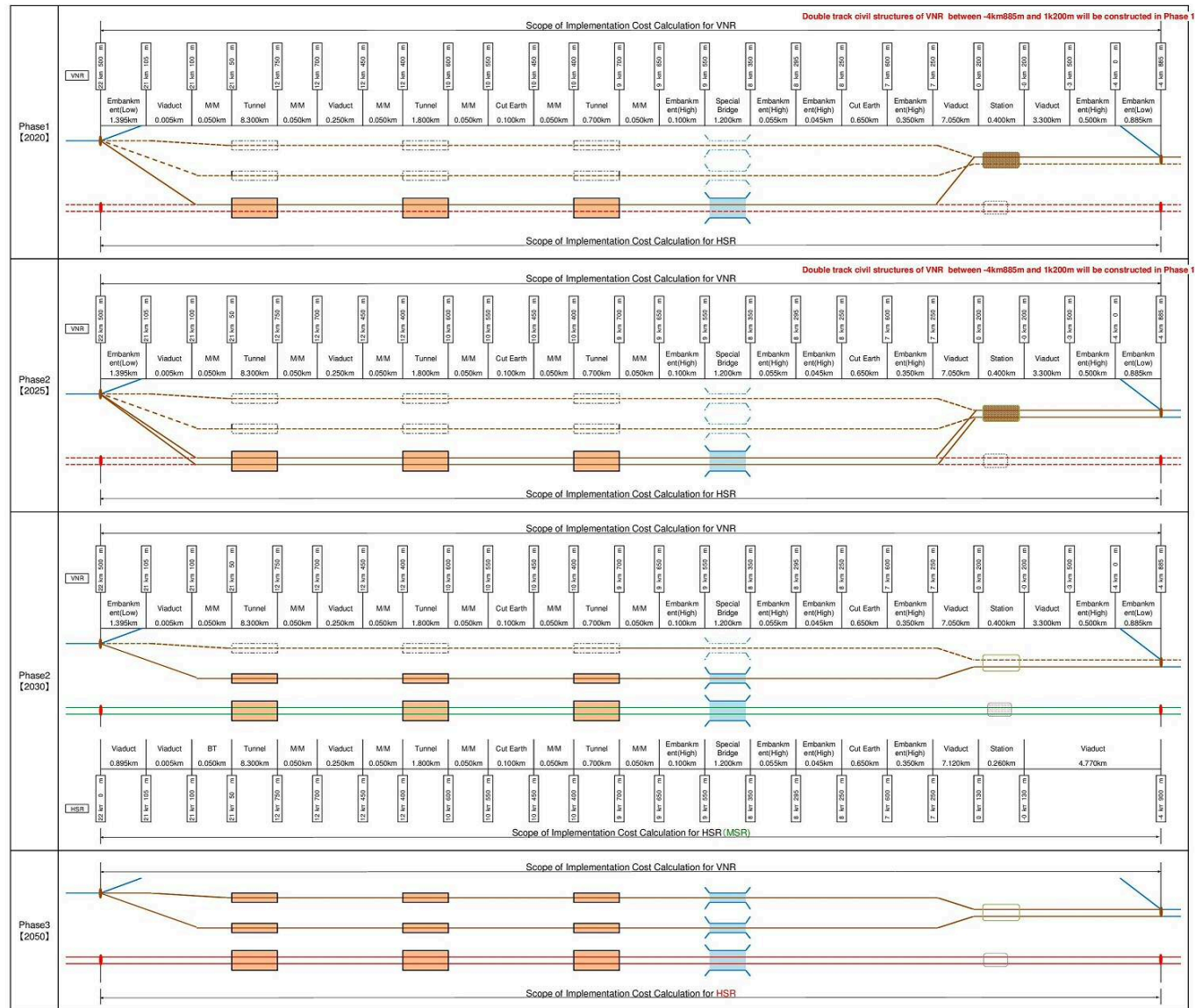
a) Option A



[Fig. 5-5-9] Rough Quantity Estimation for Option A

Source: Study team

b) Option B



[Fig. 5-5-10] Rough Quantity Estimation for Option B

Source: Study team

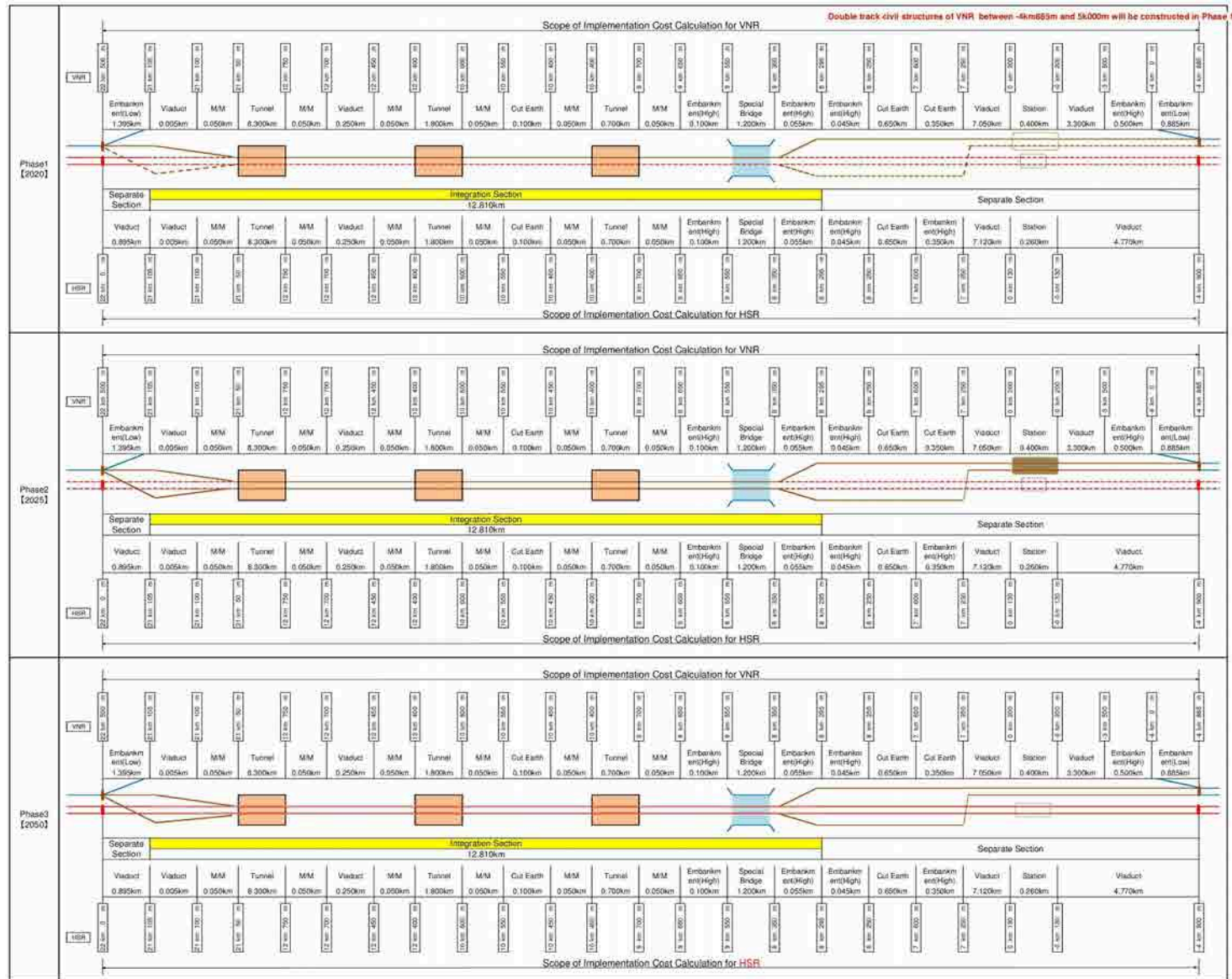
c) Option C



[Fig. 5-5-11] Rough Quantity Estimation for Option C

Source: Study team

d) Option D



Source: Study team

[Fig. 5-5-12] Rough Quantity Estimation for Option D

2) Civil Work Cost for Conventional Railway Construction

The cost for conventional railway (referred to as VNR hereunder) construction is estimated based on the ratio of standard formation widths between conventional railway and HSR. It is described with the following formulae.

Cost of VNR= (Formation width of VNR) ÷ (Formation width of HSR) × Cost of HSR

Here, VNR formation width for single track of B=5.8m

VNR formation width for double track of B=9.8m

HSR formation width for double track of B=11.8 m

The construction cost of VNR is shown in [Tab. 5-5-18] and [Tab. 5-5-19].

[Tab. 5-5-18] Construction Cost Estimation of VNR

No.	Description	Unit	Standard formation width or Volume			Standard formation width or Volume		
			HSR (Double Track)	VNR (Single Track)	VNR (Double Track)	HSR (Double Track)	VNR (Single Track)	VNR (Double Track)
1	Cut Earth	Volume (m3/m)	$1/2 \times (11.3 + 26.3) \times 5.0$ 94.0	$1/2 \times (5.8 + 20.8) \times 5.0$ 66.5	$1/2 \times (9.8 + 24.8) \times 5.0$ 86.5	1.000	0.707	0.920
2	Embankment (Hight)	Volume (m3/m)	$1/2 \times (11.3 + 29.3) \times 6.0$ 121.8	$1/2 \times (5.8 + 23.8) \times 6.0$ 88.8	$1/2 \times (9.8 + 27.8) \times 6.0$ 112.8	1.000	0.729	0.926
3	Embankment (Low)	Volume (m3/m)	$1/2 \times (11.3 + 20.3) \times 3.0$ 47.4	$1/2 \times (5.8 + 14.8) \times 3.0$ 30.9	$1/2 \times (9.8 + 18.8) \times 3.0$ 42.9	1.000	0.652	0.905
4	Viaduct	Width(m)	11.3	5.8	9.8	1.000	0.513	0.867

Source: Study team

[Tab. 5-5-19] Summary of Construction Costs

No.	Description	Unit	Unit Cost Mil.US\$		
			HSR (Double Track)	VNR (Single Track)	VNR (Double Track)
Double Track for future HSR					
1	Cut Earth	km	4.2	3.0	3.9
2	Embankment (Hight)	km	5.4	3.9	5.0
3	Embankment (Low)	km	2.1	1.4	1.9
4	Viaduct	km	17.0	8.7	14.7
5	Special Bridge on River	km	36.1	18.5	31.3
6	Mountain Tunnel	km	20.9	8.9	17.4
7	Mine Mouth at Tunnel	km	This cost is put in cost of Tunnel		
8	Buffer Tunnel	km	31.4	-	-

Source: Study team

3) New HSR Station Construction Cost

The construction cost for the new HSR station (New DaNang Station) is estimated to be the same as for NhaTrang Station shown in the HSR-F/S excluding the station plaza cost.

[Tab. 5-5-20] Civil Work and Architectural Cost in HSR-F/S (1)

Station Name =		NhaTrang (Elevated)
1. Civil Work	million USD	63.5
2. Architecture Work	million USD	21.9
3. E&M	million USD	9.1
4. PT & Turnout	million USD	4.9
Total	million USD	99.4

Source: HSR-F/S

4) New Conventional Railway Station Construction Cost

It is assumed that civil work and architectural structure of the new conventional railway station is at the same level of grade separation as HSR. The cost for civil work and architectural structure of the new conventional railway station is estimated based on the ratio of platform floor areas between HSR and conventional railway. The cost of the HSR station is taken from the HSR-F/S in this study.

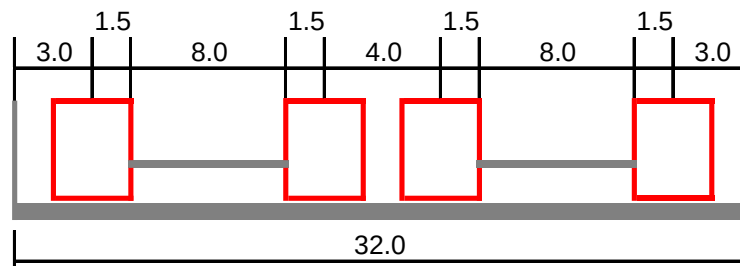
[Tab. 5-5-21] Civil Work and Architectural Cost in HSR-F/S (2)

Station Name =		NhaTrang (Elevated)
Platform area	m ²	10,400
1. Civil Work	million USD	63.5
2. Architecture Work	million USD	21.9
Total	million USD	85.4
Unit cost for platform area	million USD/ m ²	8,200

Source: HSR-F/S

Here is the scale of the new conventional railway station.

- Station length= 400m
- Station width= 32m
- Station width:
Width of B1= 8.0m
Distance between track center and platform edge of B2= 1.5m
Distance between tracks of B3= 4.0m
Distance between outer track center and station wall of B4= 3.0m
Total width of B= $2 \times B1 + 4 \times B2 + B3 + 2 \times B4 = 2 \times 8.0 + 4 \times 1.5 + 4.0 + 2 \times 3.0 = 32\text{m}$
- Platform area= $400\text{m} \times 32\text{m} = 12,800\text{m}^2$
- Refer to [Fig. 5-5-13] for the calculation above.



Source: Study team

[Fig. 5-5-13] Station Width

As a result, the civil work and architectural construction cost of the new conventional railway station is estimated as follows.

$$12,800 \text{ m}^2 \times 8,200 \text{ USD/m}^2 = 105 \text{ million USD}$$

(2) Aggregate Construction Cost

Construction cost including other than the civil work component such as signaling and telecommunication facilities for options A, B, C, and D by construction phase for the conventional railway and HSR (or MSR) are calculated as shown in [Tab. 5-5-22] to [Tab. 5-5-25] respectively.

1) Option A

[Tab. 5-5-22] Construction Cost Summary of Option A

(Unit: million USD)

Railway Year	Phase1 (2020)	Phase2 (2025)	Phase 2 (2030)	Phase3 (2050)	Total
Conventional railway					
Cut, Fill, Viaduct, Bridge	150.9	0.0	83.5	0.0	234.4
Tunnel	96.1	0.0	96.1	0.0	192.2
Track	18.6	0.0	18.6	0.0	37.2
Station	105.0	0.0	0.0	0.0	105.0
Electricity	13.2	0.0	1.8	0.0	15.0
Right of way	70.0	0.0	0.0	0.0	70.0
Subtotal	453.8	0.0	200.0	0.0	653.8
HSR (or MSR)					
Cut, Fill, Viaduct, Bridge	0.0	0.0	271.2	0.0	271.2
Tunnel	0.0	0.0	227.3	0.0	227.3
Track	0.0	0.0	84.1	0.0	84.1
Station	0.0	0.0	99.4	0.0	99.4
Electricity	0.0	0.0	181.1	0.3	181.4
Right of way	3.7	0.0	0.0	0.0	3.7
Subtotal	3.7	0.0	863.1	0.3	867.1
Total	457.5	0.0	1063.1	0.3	1520.9

Source: Study team

2) Option B

[Tab. 5-5-23] Construction Cost Summary of Option B

(Unit: million USD)

Railway Year	Phase1 2020	Phase2 2025	Phase 2 2030	Phase3 2050	Total
Conventional railway					
Cut, Fill, Viaduct, Bridge	78.1	10.7	83.5	83.5	255.8
Tunnel	0.0	0.0	96.1	96.1	192.2
Track	18.6	18.6	14.5	14.5	66.2
Station	105.0	0.0	0.0	0.0	105.0
Electricity	13.2	1.8	3.0	0.0	18.0
Right of way	78.6	0.0	0.0	0.0	78.6
Subtotal	293.5	31.1	197.1	194.1	715.8
HSR (or MSR)					
Cut, Fill, Viaduct, Bridge	139.7	0.0	131.5	0.0	271.2
Tunnel	227.3	0.0	0.0	0.0	227.1
Track	0.0	0.0	84.1	0.0	84.1
Station	0.0	0.0	99.4	0.0	99.4
Electricity	0.0	0.0	181.1	0.3	181.4
Right of way	3.7	0.0	0.0	0.0	3.7
Subtotal	370.7	0.0	496.1	0.3	867.1
Total	664.2	31.1	693.2	194.4	1582.9

Source: Study team

3) Option C

[Tab. 5-5-24] Construction Cost Summary of Option C

(Unit: million USD)

Railway Year	Phase1 2020	Phase2 2025	Phase 2 2030	Phase3 2050	Total
Conventional railway					
Cut, Fill, Viaduct, Bridge	78.1	10.7	0.0	138.7	227.5
Tunnel	0.0	0.0	0.0	187.9	187.9
Track	18.6	18.6	0.0	29.0	66.2
Station	105.0	0.0	0.0	0.0	105.0
Electricity	13.2	1.8	0.0	3.0	18.0
Right of way	69.9	0.0	0.0	0.0	69.9
Subtotal	284.8	31.1	0.0	358.6	674.5
HSR (or MSR)					
Cut, Fill, Viaduct, Bridge	139.7	0.0	0.0	131.5	271.1
Tunnel	227.3	0.0	0.0	0.0	227.1
Track	0.0	0.0	0.0	84.1	84.1
Station	0.0	0.0	0.0	99.4	99.4
Electricity	0.0	0.0	0.0	181.1	181.1
Right of way	3.7	0.0	0.0	0.0	3.7
Subtotal	370.7	0.0	0.0	496.1	866.8
Total	655.5	31.1	0.0	854.7	1541.3

Source: Study team

4) Option D

[Tab. 5-5-25] Construction Cost Summary of Option D

(Unit: million USD)

Railway Year	Phase1 2020	Phase2 2025	Phase 2 2030	Phase3 2050	Total
Conventional railway					
Cut, Fill, Viaduct, Bridge	148.1	24.8	0.0	0.0	172.9
Tunnel	0.0	0.0	0.0	0.0	0.0
Track	18.6	18.6	0.0	0.0	37.2
Station	105.0	0.0	0.0	0.0	105.0
Electricity	13.2	1.8	0.0	5.4	20.4
Right of way	65.8	0.0	0.0	0.0	65.8
Subtotal	350.7	45.2	0.0	5.4	401.3
HSR (or MSR)					
Cut, Fill, Viaduct, Bridge	48.8	0.0	0.0	222.1	270.9
Tunnel	225.7	0.0	0.0	0.0	225.7
Track	0.0	0.0	0.0	93.8	93.8
Station	0.0	0.0	0.0	99.4	99.4
Electricity	0.0	0.0	0.0	196.2	196.2
Right of way	3.7	0.0	0.0	0.0	3.7
Subtotal	278.2	0.0	0.0	611.5	889.7
Total	628.9	45.2	0.0	616.9	1291.0

Source: Study team

5) Total Construction Cost Summary

The total construction costs for options A, B, C, and D are summarized as shown in [Tab. 5-5-26]. The ratio of cost of options A, B, and C against Option D is shown in the same table. As it shows, all other options are more expensive than Option D.

[Tab. 5-5-26] Total Construction Cost Summary

(Unit: million USD)

Evaluation Item	Option A	Option B	Option C	Option D
Construction Cost	1,520.9	1,582.9	1,541.3	1,291.0
Comprising with Option D	1.18	1.23	1.19	1.00

Source: Study team

The costs calculated above are based on the current price level, because the purpose of the calculation is not for economic and financial analysis but for cost/benefit comparison analysis. Therefore, the actual costs in the future such as for phase 1, 2, and 3 are expected to be much more expensive than these values due to price escalation.

5.5.10 Selection of Optimum Plan for HaiVan Tunnel

(1) Benefit Estimation

1) Passenger Trains

(a) Benefit Calculation

The benefit of the tunnel construction is defined as travel time saving. Here, the differences of scheduled traveling time of present conventional passenger trains before and after the new HaiVan Tunnel construction for each option of A to D are estimated and compared for the Hue and DaNang section.

The calculation result is shown in [Tab. 5-5-27]. The time saving for passenger trains before and after the new HaiVan Tunnel varies from 61 to 63 minutes for the conventional railway and 130 to 139 minutes for HSR (or MSR) depending on the option.

[Tab. 5-5-27] Time Saving Before and After Tunnel Construction for Passenger (Hue-DaNang)

Item		Scheduled (h:min)	Formula	Time saving (h:min)	Time saving (min)
1	Conventional railway (present)	2:36	1-1		
2	Conventional railway by new HaiVan single track tunnel (Option A, B, and C)	1:33	1-2	1:03	63
3	Conventional railway by new HaiVan double track tunnel	1:33	1-3	1:03	63
4	Conventional railway by new HaiVan double track tunnel	1:35	1-4	1:01	61
5	MSR (200km/h)	0:26	1-5	2:10	130
6	HSR (320km/h) (Option A, B, and	0:17	1-6	2:19	139
7	HSR (120km/h) (Option D)	0:26	1-7	2:10	130

Source: Study team

(b) Cost Benefit Comparison

The cost benefit comparison is defined as the value of construction cost shown in 5.5.9 divided by benefit (time saving shown in (a) above) here. The value is calculated for the four (4) options and the results are summarized in [Tab. 5-5-28]. As the value gets smaller, the cost effectiveness gets better.

As it shows the smallest value is for Option D with the value of 7.95 million USD/minute for the conventional railway and 6.08 million USD/minute for the HSR.

[Tab. 5-5-28] Cost/Benefit Analysis Summary for Passenger Trains

Option	Railway type	Phase1 2020-2025	million US\$/min	Phase 2 2025-2040	million US\$/min	Phase3 2040-2050	million US\$/min	Total	million US\$/min
Option A	Convention	453.8	7.20	200.0		0		653.8	10.38
	HSR(MSR)	3.7		863.1	6.64	0.3		867.1	6.24
	Total	457.5		1,063.1		0.3		1,520.9	
Option B	Convention	293.5	4.66	228.2		194.1		715.8	11.36
	HSR(MSR)	370.7		496.1	3.82	0.3		867.1	6.24
	Total	664.2		724.3		194.4		1,582.9	
Option C	Convention	284.9	4.52	31.1		358.6		674.6	10.71
	HSR	370.6		0		496.1		866.7	6.24
	Total	655.5		31.1		854.7		1,541.3	
Option D	Convention	350.7	5.75	45.2		104.8		500.7	7.95
	HSR	278.2		0		512.1		790.3	6.08
	Total	628.9		45.2		616.9		1,291.0	

Source: Study team

2) Freight Train

(a) Benefit Calculation

The benefit of the tunnel construction is defined as travel time saving. Here, the differences of scheduled traveling time of present conventional freight trains before and after the new HaiVan Tunnel construction for each option of A to D are estimated and compared for the Hue and DaNang section.

The calculation result is shown in [Tab. 5-5-29]. The time saving for freight trains before and after the new HaiVan Tunnel varies from 117 minutes.

[Tab. 5-5-29] Time Saving Before and After Tunnel Construction for Freight (Hue-DaNang)

	Item	Scheduled time (h:min)	Formula	Time savin (h:min)	Time saving (min)
1	Conventional railway at present	3:48	1-1		
2	Conventional railway by new HaiVan single tunnel For A, B,C Option	1:51	1-2	1:57	117
3	Conventional railway by new HaiVan double tunnel	1:51	1-3	1:57	117
4	EXL by new HaiVan double tunnel For D Option	1:52	1-4	1:57	117

Source: Study team

(b) Cost Benefit Comparison

The cost benefit comparison is defined as the value of construction cost shown in 5.5.9 divided by benefit (time saving shown in (a) above) here. The value is calculated for the four (4) options and the results are summarized in [Tab. 5-5-30]. As the value gets smaller, the cost effectiveness gets better.

As it shows the smallest value is for Option D with the value of 4.28 million USD/minute for the conventional railway.

[Tab. 5-5-30] Cost/Benefit Analysis Summary for Freight Trains

(Unit: million USD)

Option	Railway type	Phase1 2020-2025	million US\$/min	Phase 2 2025-2030	million US\$/min	Phase3 2040-2050	million US\$/min	Total	million US\$/min
Option A	Conventional	453.8	3.88	200.0		0		653.8	5.59
Option B	Conventional	293.5	2.51	228.2		194.1		715.8	6.12
Option C	Conventional	284.9	2.44	31.1		358.6		674.6	5.77
Option D	Conventional	350.7	3.00	45.2		104.8		500.7	4.28

Source: Study team

(2) Proposal for HaiVan Tunnel Construction Option

Among options with no track sharing scheme of Option A, B, and C, Option A is the most cost effective solution with 10.38 million USD/minute for conventional passenger railway and 6.24 million USD/minute for HSR as shown in [Tab. 5-5-28] and 5.59 million USD/minute for freight trains as shown in [Tab. 5-5-30], while Option D is the most cost effective solution with 7.95 million USD/minute for conventional passenger railway, 6.08 million USD/minute for HSR, and 4.28 million USD/minute for freight trains as shown in the same tables if the track sharing scheme is allowed.

[Tab. 5-5-31] compares the summary characterizing Option A and D. As it shows, Option D is the most cost effective solution in terms of quantitative evaluation including construction cost and time schedule, but qualitative evaluation is needed because Option D requires several challenges such as dual gauge installation with complex structure, signaling work, track and electricity equipment maintenance work, and track and electricity equipment maintenance cost. [Tab. 5-5-32] summarizes the points of the discussion.

[Tab. 5-5-31] Quantitative Evaluation of Option A and D

Evaluation item		Option A	Option D
Total Construction cost (million USD)			
	Passenger (Conventional)	653.8	500.7
	Passenger (HSR)	867.1	790.3
Construction cost/ Time saving (million USD/minute)	Passenger (Conventional)	10.38	7.95
	Passenger (HSR)	6.24	6.08
	Freight (Conventional)	5.59	4.28
General evaluation		○	◎

Source: Study team

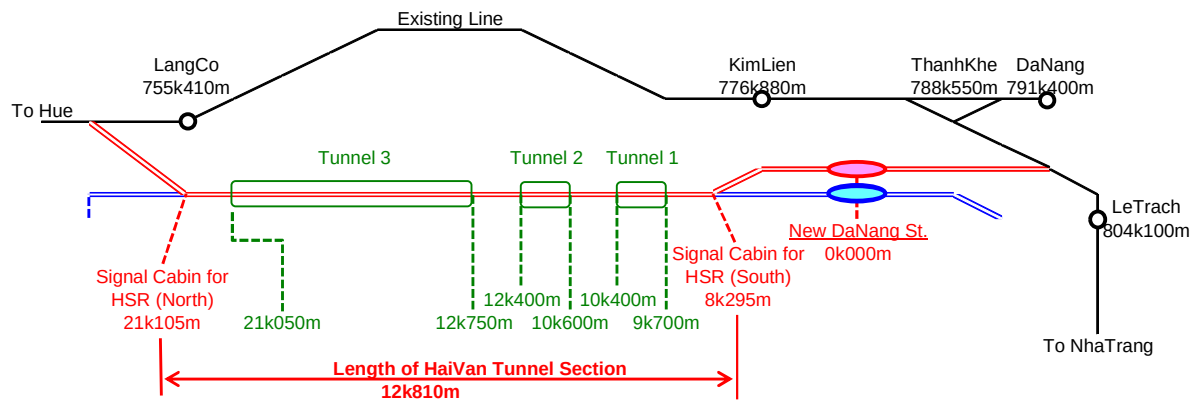
[Tab. 5-5-32] Qualitative Evaluation of Option A and D

Evaluation item	Option A	Option D
Difficulty of track work	○	△
Difficulty of signaling and telecommunication work	○	△
Difficulty of train operation	○	△
Operation & Maintenance cost	○	△
Difficulty of track maintenance work	○	△
Difficulty of electricity equipment maintenance work	○	△
General evaluation	○	△

Source: Study team

(3) Line capacity of Option D after 2050

The timing when traffic demand will reach line capacity in case of Option D is verified here. The length of the section for verification is 12.81km between Hue and DaNang as shown in [Fig. 5-5-14].



Source: Study team

[Fig. 5-5-14] Section Length between Signal Cabins

The type of trains running on this section are HSR and passenger and container freight trains of the conventional railway. Assuming that the maximum speeds are 120km/h for HSR and conventional railway passenger trains and 100km/h for container freight trains, the times necessary to pass this section are 6min 30sec for the 120km/h trains and 8min for the 100km/h trains. The line capacity of double track section is calculated by the following formula.

$$N = 2 \times \frac{1440}{T + t_c} \times 0.6$$

Here, N: Line capacity (trains)

T: Time needed to pass section (min)

T_c: Time needed for operation arrangement
assumed to be 0.5min for double track section

[Tab. 5-5-33] shows the expected traffic volume in terms of number of trains per day in 2050, 2055, and 2060 calculated by traffic demand forecast for each corresponding section. Here, the demand forecast is made assuming that the traffic demand growth trend up to 2050 will continue after 2050.

[Tab. 5-5-33] Traffic Volume Forecast and Line Capacity

Traffic Volume		(Unit: trains)		
Year		2050	2055	2060
Freight		10	11	12
Passenger		71	81	91
Conventional railway total		81	92	103
HSR		92	97	103
Grand total		173	189	206
Number of train	120km/h	163	178	194
	100km/h	10	11	12

Line Capacity			
Length of tunnel section		(km)	12.81
Running time	120km/h	(min:sec)	6:30
	100km/h	(min:sec)	8:00
Line Capacity	120km/h	(trains)	216
	100km/h	(trains)	164

Source: Study team

The above table tells that the line capacity of the section is 216 trains for the 120km/h

trains and 164 trains for 100km/h trains.

In the year 2055, the number of trains based on the demand forecast is 178 trains for 120km/h trains with an accumulated travel time of 19 hours and 17 minutes ($=178 \times 6\text{min}30\text{sec}$) and 11 trains for 100km/h trains with an accumulated travel time of 1 hour and 28 minutes ($=11 \times 8\text{min}0\text{sec}$). The total sum of both is 20 hours and 45 minutes which is less than the line capacity by 3 hours and 15 minutes.

In the year 2060, the number of trains based on the demand forecast is 194 trains for 120km/h trains with an accumulated travel time of 21 hours and 1 minutes ($=194 \times 6\text{min}30\text{sec}$) and 12 trains for 100km/h trains with an accumulated travel time of 1 hour and 36 minutes ($=12 \times 8\text{min}0\text{sec}$). The total sum of both is 22 hours and 37 minutes which is still less than the line capacity by 1 hour and 23 minutes. However, the line capacity will be saturated sometime after 2060 considering the allowance time necessary for adjustment and train schedule management of bulk freight trains at the junctions of conventional railway and HSR located at both sides of the tunnel section.

[Tab. 5-5-34] shows the demand forecast and the corresponding train numbers between 2011 and 2060 used for the above calculation.

[Tab. 5-5-34] Demand Forecast and Train Numbers

Section	Hue – Da Nang		container	1000	balk		1100	Sleeper		700	Day train		720			
	Year			2011	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060		
Freight	Demand			5445	7481	10027	12573	15119	17665	20210	22756	25302	27817	30394		
	Container	37	Volume	2009	2760	3700	4639	5579	6518	7457	8397	9336	10264	11215		
			train	3	3	4	5	6	7	8	9	10	11	12		
	Balk	63	Volume	3431	4714	6318	7922	9526	11131	12734	14339	15943	17527	19151		
			Train	4	5	6	8	9	11	12	14	15	16	18		
Freight Total				7	8	10	13	15	18	20	23	25	27	30		
Passenger with out HSR	Demand			6620	12299	19398	26496	33595	46099	53198	60296	49395	56484	63593		
	Sleeper	70	Volume	4634	8609	13579	18547	23517	32269	37239	42207	34577	39539	44515		
			train	7	13	20	27	34	47	54	61	50	57	64		
	Day train	30	Volume	1986	3690	5819	7949	10079	13830	15959	18089	14819	16945	19078		
			train	3	6	9	12	14	20	23	26	21	24	27		
Passenger Total				10	19	29	39	48	67	77	87	71	81	91		
Total Train number				17	27	39	52	63	85	97	110	96	108	121		
Type of train			E-2	16 cars	Capacity 1300											
	Year			2011	2015	2020	2025	2030	2035	2040	2045	2050	2055	2060		
HSR	Demand			0	0	0	0	0	0	0	0	119395	126494	133593		
	Train			0	0	0	0	0	0	0	0	92	97	103		

Source: Study team

Chapter 6 Prioritization

6.1 First Screening

6.1.1 Identification of Short-term and Long-term Priority Projects

The 1st screening process was made by considering the short-term and long-term projects which were identified by the limited information and data currently available. The long-term projects require complicated coordination among other related projects and relevant parties. Besides, it will take time until commencement in a view of the necessity of resettlement and land acquisition. Among the long-term projects, the projects which are expected to have a significant impact and should be implemented soon after the conditions are met were defined as “Long-term Priority Projects”.

The short-term projects were prioritized through a comparison of costs and benefits in the 2nd screening process. As a result of this prioritization exercise, the highest priority projects were selected as “Short-term Priority Projects”.

6.1.2 Bridge Component

(1) Target Bridges for the First Screening

At the beginning of the implementation of this study, VNR considered 132 bridges to be under rehabilitation as part of the “132 Bridges Rehabilitation Project (MOT No. 3303/Oct. 31, 2008)” which is due for completion. However, 54 bridges are not expected to be completed due to budget constraints, and out of these, 15 bridges are expected to receive Yen loan assistance for completion while the remaining 39 bridges are expected to be financed by GOV. The “41 bridges Rehabilitation Project” is also expected to receive Yen loan assistance for completion.

But during the second field mission, the study team confirmed that 15 bridges out of the “132 Bridges Rehabilitation Project” and 32 bridges out of the “41 bridges Rehabilitation Project” are to be requested Yen loan assistance, while the remaining 9 bridges are undergoing a selection/evaluation process by VNR as shown in [Tab. 6-1-1]. However, it was confirmed that VNR’s selection/evaluation process had not been completed by the end of this study.

[Tab. 6-1-1] Updated List of Bridges by Rehabilitation Status

Section		Hanoi - Vinh	Vinh - HCMC	Hanoi - HCMC		Note
Rehabilitation is not required	Number of bridges	83	805	888		
	Total length (m)	2,354	27,731	30,085		
Under rehabilitation	Yen loan project	2	68	70	9	Completed by the year 2000 by railway bridges rehabilitation project (1)
					26	Completed by the year 2003 by railway bridges rehabilitation project (2)
					7	Completed by the year 2005 by railway bridges rehabilitation project (3)
					44	To be completed by 2015 by Bridge safety improvement project (I)
					27	To be completed by 2017 by Bridge safety improvement project (II)
					0	Bridge safety improvement project (III) is allocated to refill budget for the (I) and (II) projects
	Own finance (Rehabilitation of bridge L ≤ 50m until year 2000)	31	326	357		Completed by GOV own financing
	Own finance (Weak bridges on Hanoi-Ho Chi Minh City route)	4	11	15		Progress of GOV own finance project will be monitored under the study
	Own finance (Rehabilitation of bridge by development and investment fund)	0	13	13		Progress of GOV own finance project will be monitored under the study
	Own finance (Stable railway infrastructure of Central Area from Quang Binh to Khanh Hoa)	0	14	14		Progress of GOV own finance project will be monitored under the study
	Own finance (Major rehabilitation)	40	184	224		Progress of GOV own finance project will be monitored under the study
	Own finance (Urgent Rehabilitation)	0	17	17		Progress of GOV own finance project will be monitored under the study
	Bridges between Hanoi and Ngoc Hoi is demolished because the section is elevated under the Yen loan project (Hanoi urban line No.1)	4	0	4		Under design stage
Rehabilitation is required	Although they are under rehabilitation by 132 bridges rehabilitation project (MOT No.3303/Oct. 31, 2008), 54 bridges are expected to be not due to budget constrain	0	132	132	78	54 bridges were completed by the end of 2012
					54	identical girders as Yen loan projects may be used due to high priority
					39	Expected to be financed by GOV but not budgetted yet so far
Rehabilitation is not required	Sound	2	40	42		
	Number of bridges	47	550	597		41
Rehabilitation is required	Total length (m)	1,068	5,231	6,299		525
	Total number of bridges	130	1,355	1,485		

Source: Study team based on various raw data provided by VNR

Under such circumstances, it was not possible for the study team to include the remaining 9 bridges due to the deadline of study report submission to JICA. In addition to this, one (1) more bridge was excluded from the “41 Bridges Rehabilitation Project” because it is located on the HaiVan pass section. Accordingly, the 46 bridges (= (41 – 9 – 1) + 15 bridges) shown in [Tab. 6-1-2] shall proceed to the next screening stage.

[Tab. 6-1-2] List of Target Bridges for the First Screening

No.	Bridge	Station	Bridge Location	Existing Bridge			
				Span Arrangement	Superstructure	No. of Substructure	Span Length (m)
1/41	Chin Mong	284 + 655	Nghe An	3 × 12.10	I-550 Overlapping	4	36.30
2/41	Huong tan	375 + 852	Ha Tinh	3 × 12.50	I-550 Overlapping	4	37.50
3/41	Khe be	429 + 570	Quang Binh	1 × 16.46	4I-550 Overlapping, concrete trough	2	16.46
4/41	Khe chu	441 + 995	Quang Binh	1 × 16.46	4I-550 Overlapping, concrete trough	2	16.46
5/41	Rong truoc	505 + 835	Quang Binh	10.38 + 12.60 + 12.48 + 10.80	RC-Beam	5	46.26
6/41	Sa lung	588 + 400	Quang Tri	1 × 64.00	Steel Truss	2	64.00
7/41	Rong lon	641 + 700	Quang Tri	21.12 + 40.81	I-920+VN71	3	61.93
9/41		846 + 741	Quang Nam	3 × 11.30	Prestressed RC+concrete +I-756	4	33.90
10/41		847 + 779	Quang Nam	3 × 16.40	I-902	4	49.20
11/41	Ong Bo	881 + 325	Quang Nam	2 × 30.50	Steel Truss	3	61.00
12/41		939 + 419	Quang Ngai	33.0 + 32.30	I-910+reinforced concrete	3	65.30
13/41		948 + 105	Quang Ngai	5 × 7.00	Reinforced Concrete	6	35.00
14/41		963 + 650	Quang Ngai	89.6 + 38.40	I-910+reinforced concrete	3	128.00
15/41		969 + 593	Quang Ngai	3 × 11.30	Reinforced Concrete	4	33.90
16/41		970 + 25	Quang Ngai	3 × 11.00	Reinforced Concrete	4	33.00
17/41		975 + 380	Quang Ngai	4 × 9.00	I-800+reinforced concrete	5	36.00
18/41		981 + 275	Quang Ngai	4 × 9.00	Steel girder I 760	5	36.00
19/41		999 + 363	Binh Dinh	4 × 16.40	I-760	5	65.60
20/41		999 + 725	Binh Dinh	13.28 + 12.36	I-910 1Concrete Beam	3	25.64
21/41		1,000 + 750	Binh Dinh	4 × 13.20	I-910+reinforced concrete	5	52.80
22/41		1,002 + 365	Binh Dinh	3 × 11.00	Reinforcement Concrete from List	4	33.00
23/41		1,006 + 956	Binh Dinh	6 × 11.30	2I-910	7	67.80
24/41	Cau Cao	1,024 + 943	Binh Dinh	5 × 11.30	I-550 concrete plate+Prestressed RC	6	56.50
25/41		1,062 + 325	Binh Dinh	2 × 16.44	Steel girder I910	3	32.88
26/41		1,085 + 982	Binh Dinh	4 × 9.00	I-550 reinforced concrete plate	5	36.00
32/41		1,282 + 344	Khanh Hoa	3 × 11.10	Reinforced Concrete	4	33.30
33/41	Thuan my	1,283 + 608	Khanh Hoa	3 × 13.90	Reinforced Concrete	4	41.70
35/41		1,285 + 733	Khanh Hoa	4 × 6.60	Reinforced Concrete	5	26.40
37/41	Hiep My	1,375 + 77	Khanh Hoa	2 × 31.55	Plating steel truss	3	63.10
40/41	Dg.Nai nho	1,699 + 245	Dong Nai	3 × 41.90	French Truss	4	125.70
41/41	Dg.Nai lon	1,699 + 860	Dong Nai	4 × 56.00	French Truss	5	224.00
3/132	Bau Khe	810 + 112		1 × 59.1	Reinforced Concrete	2	65.30
4/132	La Tho	811 + 12		1 × 50.7	Steel	2	58.10
5/132	Lo	811 + 595		1 × 43.9	Steel	2	54.10
6/132	Ong Ngo	812 + 168		1 × 59.1	Steel	2	68.30
14/132	Cau	856 + 472		1 × 59.1	Steel	2	66.75
15/132	Cau	858 + 41		1 × 59.1	BTCT RC	2	68.30
16/132	Cau	860 + 799		1 × 7.0 + 1 × 43.9	Steel	3	59.55
66/132	So Dua	1,215 + 876		1 × 67.5	Steel	2	76.70
75/132	Cau	1,250 + 937		2 × 43.9	Concrete	3	94.30
76/132	Cau	1,253 + 223		1 × 50.7	Concrete	2	57.70
78/132	Cau	1,256 + 73		2 × 43.9	Concrete	3	96.40
84/132	Cau	1,292 + 192		1 × 50.7	Concrete	2	55.80
87/132	Cau Doi	1,317 + 517		2 × 12.0	Reinforced Concrete	3	20.10
114/132	Cau	1,453 + 484		1 × 59.1	Steel	2	69.30
120/132	Ma Lam	1,531 + 123		1 × 50.7	Steel	2	63.00

Source: Study team based on various data from VNR

(2) BinLoi Bridge

BinhLoi Bridge which crosses SaiGon River is located on the section between BinhTrieu Station (1,718k340m) and GoVap Station (1,722k130m). VNR requested the study team to include BinLoi Bridge in the list of target bridges for the first screening in a meeting with the study team during the second field mission in May 2014, because VNR gives this bridge a high priority for reconstruction.

However, it is recommended to implement reconstruction of BinhLoi Bridge at a later stage due to its background and further coordination with the urban railway development project as mentioned below.

1) Background of BinhLoi Bridge Construction included in TrangBom-HoaHung Railway Project (hereinafter referred to as BinhLoi Bridge Project)

Although Vietnam's largest city, HoChiMinh City, has been steadily developing as the center of the Vietnamese economy, the growth of the economy has caused a concentration of economic activities and population in the city, resulting in the occurrence of traffic jams, environmental pollution, noise and vibration, and traffic accidents. Accordingly, as a measure to prevent traffic jams from occurring at level crossings, the city authorities have restricted the passing of trains on the N-S Railway line in the city in the mornings and evenings. This is not only causing a major problem for train operations, but also means that the railway is not being used for commuter transportation and trains are not stopping at intermediate stations inside the city. In the future, it is expected that there will be an increase in demand for transportation and an evolution towards longer commuting distances, which will reduce the city's functions and productivity as well as further worsen the city environment.

The HCMC-PC (HCMC People's Committee), MOT, and the former VNR recognized that development of the city's public transport system is an extremely important policy target from economic and environmental points of view, and the elevation of the existing railway inside HCMC was decided based on the city's overall development plan formulated in 1991. A F/S was completed in December 1999, and a funding allocation directive was given by the Prime Minister to the related institutions.

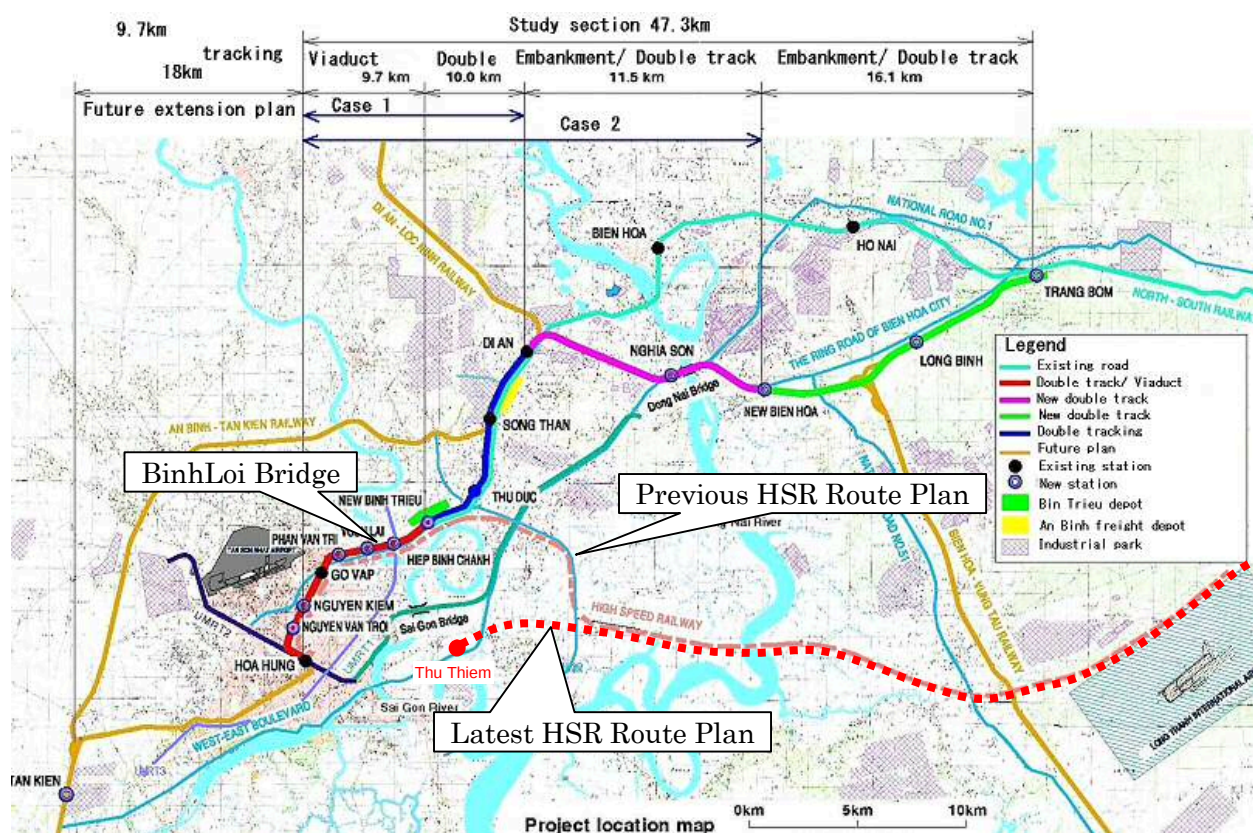
On the other hand, JICA and HCMC-PC conducted the "Study on Urban Transport Master Plan and Feasibility Study in Ho Chi Minh Metropolitan Area (HOUTRANS)" in 2004. The study concluded that the priority of urban railway construction was high, and a Yen Loan was extended to Urban Railway Line No. 1 in 2007. However, since the Urban Railway Line No.1 by itself would not be sufficient as an urban transportation network, the HCMC-PC once again turned its attention to this project, and approval for its implementation was obtained from the Prime Minister in July 2008.

In addition, one of the background factors which rapidly increased the priority of this project inside the GOV was a decision by the Prime Minister to extend the HSR that uses Japanese technology into HCMC. Because there is an approximately 10km section of the route extension into the city that exactly overlaps with the route of this project, and since the terminus is also HoaHung Station, delays in formulating the planning of this project would obstruct the implementation of the HSR project.

Against this background, the Ministry of Economy, Trade and Industry of Japan (METI) conducted the "Study on HCMC Elevated Railway Project between HoaHung-TrangBom Section in Socialist Republic of Vietnam" in March 2010. In this study, BinhLoi Bridge was planned as a double-tracked bridge, and the HSR was planned to go along the section in parallel between New BinhTrieu Station and HoaHung Station of the TrangBom-HoaHung Railway on a separate track.

But in the HSR-F/S conducted by JICA and VNR in June 2013, ThuThiem Station,

which is located in the new development area in District 2, was selected as the terminus in HoChiMinh City. So the TrangBom-HoaHung Railway is being planned as an individual project in the local F/S which is underway by VNR.



Source: Study on HoChiMinh Elevated Railway Project between HoaHung-TrangBom Section in Socialist Republic of Vietnam, Ministry of Economy, Trade and Industry of Japan (METI), March 2010 [Fig. 6-1-1] Outline of TrangBom-HoaHung Railway Project and Location of BinhLai Bridge

2) Coordination with Urban Railway Development Project

Although the reconstruction of BinhLai Bridge would substantially contribute to effective train operation, as mentioned above, BinhLai Bridge is planned as part of large scale urban railway development project which is different in nature compared to a long distance railway development project such as the target project of this study. Therefore, if BinhLai Bridge were to be included in the candidate bridge list for reconstruction of this study, it would further disturb the processing of the urban railway development plan.

In addition, while an in-depth study will be required to incorporate the use of the bridge either as part of the urban railway or long distance railway, information and data on this bridge together with related persons were not available during the short time period of this study, in contrast with the other simple bridge components targeted by this study.

6.1.3 Tunnel Component other than HaiVan Tunnel

[Tab. 6-1-3] shows the present situation of all 27 tunnels on the existing N-S Railway line with speed restrictions in 2014. Five (5) tunnels, Tunnel No. 7 - No. 10, and No. 13 have been reconstructed, and three (3) of the remaining 22 ($= 27 - 5$) tunnels are on the HaiVan pass section. If the HaiVan Tunnel will be constructed, it is not necessary for these three (3) tunnels on the HaiVan pass section to be reconstructed. Accordingly, 19 tunnels ($27 - 5 - 3$) except eight (8) tunnels ($= 5 + 3$), which are Tunnel No. 7 - No. 14, shall proceed to the next screening stage.

[Tab. 6-1-3] Present Situation of All Tunnels on the N-S Railway Line

No.	Name of Tunnel	Kilometrage at Center of Tunnel	Length (m)	Curve Radius (m)	Gradient (%)	Restricted Speed in 2014 ¹⁾ (km/h)		Max. Speed on Section in 2014 (km/h)	Max. Speed in Tunnel after Improved (km/h)	Progress of Reconstruc- tion as of April 2014	Tunnels to Proceed to Next Screening Stage
						P ²⁾	F ²⁾				
1	Tunnel No. 1	455k432m	63.77	245	1.7	35	30	80	60		○
2	Tunnel No. 2	455k765m	250.06	154	1.5, 0.7	35	30	80	50		○
3	Tunnel No. 3	456k245m	114.46	120	0.9, 1.0	35	30	80	50		○
4	Tunnel No. 4	466k255m	100.84	130.5	1.5, 1.13	35		80	45		○
5	Tunnel No. 5	466k496m	193.44	Straight	1.35	35		80	45		○
Subtotal (Vinh ~ Hue)			722.57								5
6	Tunnel No. 6	725k210m	220.72	350, 400	0.47, 1.1	30		70	50		○
7	Tunnel No. 7	732k815m	344.00	505	4.14, 4.54	40		70	-	Done	
8	Tunnel No. 8	746k135m	445.00	510	4.39, 5.93	-	30	50	-	Done	
9	Tunnel No. 9	757k285m	169.40	100	13.0, 17.0	-		30	-	Done	
10	Tunnel No. 10	757k841m	124.20	200	15.0	-		30	-	Done	
11	Tunnel No. 11	759k513m	129.04	100	15.0	-		30	30		
12	Tunnel No. 12	766k049m	564.17	Straight	15.3, 12.3	-		30	30		
13	Tunnel No. 13	770k663m	325.70	Straight	14.0, 17.0	-		30	-	Done	
14	Tunnel No. 14	774k674m	944.62	98, 1,400	15.3, 14.9	-	15	30	30		
Subtotal (Hue ~ Da Nang)			3,266.85								1
			HaiVan Pass Section								
15	Binh De	998k399m	273.39	300	6.3	-		70	90		○
16	PhU Cu	1,023k833m	170.18	400	7.0, 8.0	30	15	70	70		○
17	Chi Thanh	1,168k704m	325.00	800	8.0, 3.2	30		80	90		○
18	Babonneau	1,224k816m	1,198.20	420	3.8, 2.0	-		50	50		○
19	Vung Ro 4	1,227k120m	371.23	500	0.3	30		50	50		○
20	Vung Ro 3	1,228k115m	159.46	700	3.8, 5.3	-		50	50		○
21	Vung Ro 2	1,228k702m	249.99	500	1.6, 1.0	-		50	50		○
22	Vung Ro 1	1,229k252m	60.39	Straight	7.8	-		50	50		○
23	Bai Gio	1,231k188m	402.58	350	8.7, 7.1	-		50	50		○
24	Co Ma	1,234k464m	407.30	502	3.5, 4.5	-		80	90		○
25	Ro Tuong	1,290k277m	219.03	Straight	1.0,4.6	-		80	90		○
26	Ru Ri	1,306k740m	517.96	500, 800	8.5, 7.9	-		80	90		○
27	Ngoc Hoi	1,310k888m	76.25	400	1.9	-		80	90		○
Subtotal (DaNang ~ NhaTrang)			4,430.96								13
Total			8,420.38								19

Notes: 1) “-” indicates that the operation speed of the tunnel section is not restricted.

2) The “P” and “F” columns show the speed restrictions for passenger and freight trains, respectively.

Source: Study team based on data provided by VNR

6.1.4 Other Civil Work Structures

(1) Civil Work Structures other than Bridges and Tunnels

The following measures are applicable to increase train speed and thereby increase transport capacity aside from reconstruction of bridges and tunnels. However, in this study, the following measures require further consideration and detailed study to proceed with the prioritization exercise and will therefore be designated “Long-term Priority Projects” for the reasons shown below.

- Alignment rectification of single curved sections
 - ➔ Since there are still many sharp curve sections with less than 400m curve radius, it is necessary to improve such sections to lift speed restrictions, improve riding comfort and enhance safety.

Meanwhile, the time saving effect is limited in comparison to the improvement work cost entailing large scale land acquisition by inserting transition curves between straight and curved sections. Therefore, it is recommended to implement this component on a long-term basis to select suitable alignment to minimize the scale of land acquisition and minimize the project cost since such curve sections are widely dotted along the railway line.

- Station yard improvement including modification of track layout, replacement of turnouts, etc.
 - ➔ Since they are outmoded, some station yard and track layouts need to be improved for smooth marshaling of trains and handling of freight transportation. This improvement contributes to help increase track capacity and efficiency of freight handling.
Currently transport demand doesn't reach track capacity and highly dense freight handling is not required in those stations. Therefore, it is recommended to implement this component on a long-term basis considering the transport and freight demand in the future.
- Addition of interlocking/signal cabins for passing on sections with long distances between stations
 - ➔ Since the N-S Railway has single track operation, trains pass each other at stations. Some sections have long distances between stations and the waiting time required for other trains to pass is thus longer on such sections. Addition of interlocking/ signal cabins helps reduce such waiting time and thus leads to travel time savings.
Passenger trains are given operation priority on the line and freight trains are the largest beneficiary of the time saving effect through the addition of interlocking/signal cabins. Since the freight train timetable is not strictly managed at present as mentioned in section 8.1, it is first necessary to plan freight train operation in accordance with the daily train diagram. Therefore, it is recommended to implement this component based on the freight trains to be regularly operated under strict management of the train operator
- Partial double tracking of sections with long distances between stations
 - ➔ Since the N-S Railway has single track operation, trains pass each other at stations. Some sections have long distances between stations and the waiting time required for other trains to pass is thus longer on such sections. In order to increase track capacity and reduce travel time by dissolving such waiting time, partial double tracking is proposed.
The areas which require double tracking are located in the southern, densely populated parts of the N-S Railway. Since double tracking work has a significant impact on the project areas due to land acquisition and resettlement, and geographical conditions need to be examined in order to reduce the project cost, it is necessary to carefully examine the double tracking sections. Currently track capacity is within demand and the passenger train operation speed is maximized under existing conditions. It is therefore recommended to implement this component considering local conditions before track capacity reaches the limit as is expected in 2030. Besides, since the HSR project is on the horizon, the impact of HSR on the N-S Railway should be discussed for the time being.
- Grade separation at crossings
 - ➔ Train speed is restricted adjacent to crossings to prevent accidents. Grade separation is proposed as one alternative to eliminate such risks and to reduce travel time.
Most of the crossings where train speed restrictions are imposed have been built illegally by local people or communities. VNR has been trying to remove them and

is now implementing a project to build a fence along the railway line. Since grade separation is much more expensive than fence building, it is recommended to implement this component after confirming the effect of the fence building for the time being.

(2) Individual Civil Work Projects

VNR requested the study team to include the following five (5) individual projects in the list of target components for the first screening in a meeting with the study team during the second field mission in May 2014, because VNR gives these projects a high priority for implementation.

- HoaDuyet and ThanhLuyen Section
- KheNet Tunnel
- NhaTrang Loop Line Section
- Double Tracking between NhaTrang and HCMC
- Slope Protection

The study team understands the high importance and necessity of these projects and the situation that VNR gives them high priority. However, as a result of the Q&A sessions with VNRA, VNR and the study team shown in [Tab. 1-3-1,], these projects are classified as “Long-term Priority Projects” and will be implemented soon after conditions are met.

6.1.5 Signaling and Telecommunication

(1) OCC and Signaling & Telecommunication Facilities and Equipment

The two (2) major modernization projects shown in [Tab. 3-1-17] cover the renewal of signaling & telecommunication equipment and facilities for the whole of the N-S Railway. The OCC modernization project shown in [Tab. 3-1-18] also covers the renewal and renovation of the OCC. After completion of the projects, however, it may be possible to get technical assistance for the integration of the signaling and OCC systems from different countries, such as France, China, and Germany.

(2) Level Crossings

Regarding level crossings, VNR has to concentrate on preventing accidents at Livelihood level crossings. Since this would be VNR’s own responsibility, countermeasures against accidents at Livelihood level crossings do not proceed to the second screening stage.

As for countermeasures against human errors by level crossing guardmen, [Tab. 3-1-25] indicates that the number of human errors made by guardmen is small compared to the number of accidents at Livelihood level crossings and the number of technical problems. Therefore the priority is considered low and countermeasures against human errors made by guardmen do not proceed to the second screening stage.

However, obstacle detectors which automatically detect obstacles at level crossings when a train is approaching, are worth reviewing from the point of safety improvement and prevention of human errors by guardmen at level crossings. If the train speed and the line capacity increase in the future, the possibility of accidents will be higher and the need for obstacle detectors may get larger. In this case, installation of obstacle detectors should be reviewed as an application of Japanese technology since Japan has much experience of their installation and operation. An overview of obstacle detectors is described in Section 8.4.3 (1).

(3) ATP

As for the introduction of ATP, [Tab. 3-1-25] indicates that the number of human errors made by drivers is small and that the priority of countermeasures such as introduction of ATP is considered low compared to countermeasures against accidents at level crossings.

Accordingly, the introduction of ATP does not proceed to the second screening stage.

However, considering the 2005 derailment accident at HaiVan pass due to excessive speed caused by the driver's human error, and also noticing the fact that a number of accidents caused by driver human error still occurred in the past five (5) years, introduction of ATP will be required in the future in view of preventing big accidents. If the train speed and the line capacity increase in the future, the possibility of accidents will be higher and the need for ATP may get larger in order to achieve a higher level of safety. In this case, installation of ATP should be reviewed as an application of Japanese technology since Japan has much experience of ATP installation and operation. An overview of ATP is described in Section 8.4.3 (2).

6.1.6 Target Infrastructure Components in Step 1 Screening

The infrastructure components that were qualified in the 1st screening in Sections 6.1.1 to 6.1.5 are summarized in [Tab. 6-1-4], and the priority infrastructure components subject to this study shall be "Bridge Reconstruction" and "Tunnel Reconstruction" as the "Short-term Priority Projects".

As for the "Bridge Reconstruction" component in the table, the bridges for the 1st screening were chosen from a candidate bridge list prepared by VNR for improvement work implementation with the purpose of preventing further deterioration and improving safety, and thereby lifting train speed restrictions and shortening travel time. The same principle is applied to the "Tunnel Reconstruction" component in the table.

[Tab. 6-1-4] Target Infrastructure Components in Step 1 Screening

No.	Infrastructure Component	Analysis Subject
1	Bridge reconstruction	○
2	Tunnel reconstruction	○
3	Alignment rectification of single curved sections	×
4	Station yard improvement including modification of track layout, replacement of turnouts, etc.	×
5	Addition of interlocking/signal cabins for passing on sections with long distances between stations	×
6	Partial double tracking of sections with long distances between stations	×
7	Grade separation component at railway crossings	×
8	Signaling and telecommunication facility improvement	×
9	Addition of rolling-stock and strengthening of relevant facilities including inspection, maintenance, and repair	×
10	BinhLoi bridge reconstruction	×
11	KheNet tunnel construction	×
12	New tunnel between HoaDuyet and ThanhLuyen section	×
13	Alignment improvement in NhaTrang loop line section	×
14	Land slide prevention measure component	×
15	Double tracking project between HCMC and NhaTrang	×

Source: Study team

6.2 Bridge Component

6.2.1 Prioritization

(1) Determination of Priority for Bridges under this Study

1) Objective

The evaluation criteria for prioritization of bridges were set as shown in [Tab. 6-2-1].

Since these evaluation criteria cannot directly ensure quantitative evaluation, prioritization of bridges is not objective and remains vague. Therefore, this section includes a study made according to the Analytic Hierarchy Process (AHP) of five (5) target criteria to determine their priority.

[Tab. 6-2-1] Evaluation Criteria for Prioritization of Bridges

Item No.	Evaluation criterion
1	Soundness of Existing Bridge
2	Design Load of Freight Trains
3	Structure Type of Girder
4	Accessibility to Construction Site
5	Bridge Length

Source: Study team

2) Outline of the Analytic Hierarchy Process (AHP)

AHP features the hierarchical structurization of a multi-purpose decision-making subject in terms of an overall objective – evaluation criteria (comparative item or element) – alternative relationship. Even when decision-making must rely on experience, instinct, image, etc., this method can be used to select an alternative through conversion into qualitatively meaningful numerical values by weighing based on a pair comparison between evaluation criteria. Namely, this method is effective as a method to convert various concepts, based on different ways of thinking and criteria, into one mass weight. Basically, AHP consists of the following three (3) stages:

a) First (1st) Stage: Hierarchical Structurization of Subject

A subject under complicated circumstances is decomposed into hierarchical structures. The top layer of the hierarchy consists of one element that comprises an overall objective (goal). For lower levels, several elements are determined from the relationship with the level immediately above, in compliance with the subjective judgment of the decision-maker. The alternative comes at the bottom of this hierarchy.

b) Second (2nd) Stage: Pair Comparison of Elements

Elements at each level are comparatively weighted. Namely, a pair comparison between elements on one level is made with reference to a relationship element of the level immediately above. Assuming “n” to be a prime number for comparison, the decision-maker will perform pair comparisons of $n \times (n-1)/2$ pieces. Besides, using a scale of importance, values used in the pair comparison are determined to be 1/9, 1/8, $\dots$, 1/2, 1, 2, $\dots$, 8, and 9. The content of the individual numerical figures are shown in [Tab. 6-2-2].

[Tab. 6-2-2] Content of Individual Numerical Figures

Scale of Importance	Definition
1	Equal importance
3	Weak importance
5	Strong importance
7	Very strong importance
9	Absolute importance

Note: 2, 4, 6, and 8 are to be used for respective intermediate levels.

A fraction is used when the level of importance is low.

Source: Study team

c) Third (3rd) Stage: Calculation of Priority

From the pair comparison matrix (known) obtained above, the weight (unknown) between elements at each level is calculated. A geometric average is used for calculation of the weight between elements.

Using the result of the weighing calculation between elements at each level, the weight of the layer as a whole is calculated. In this way, the priority of each alternative relative to the target is determined.

(2) Bridges Concerned and Evaluated Items

The hierarchical analysis made for the 46 bridges is shown in [Tab. 6-1-1] in Section 6.1.1.

The evaluation criteria for the hierarchical analysis of the bridges concerned are described in [Tab. 6-2-3].

[Tab. 6-2-3] Evaluation Criteria for Hierarchical Analysis of Bridges Concerned

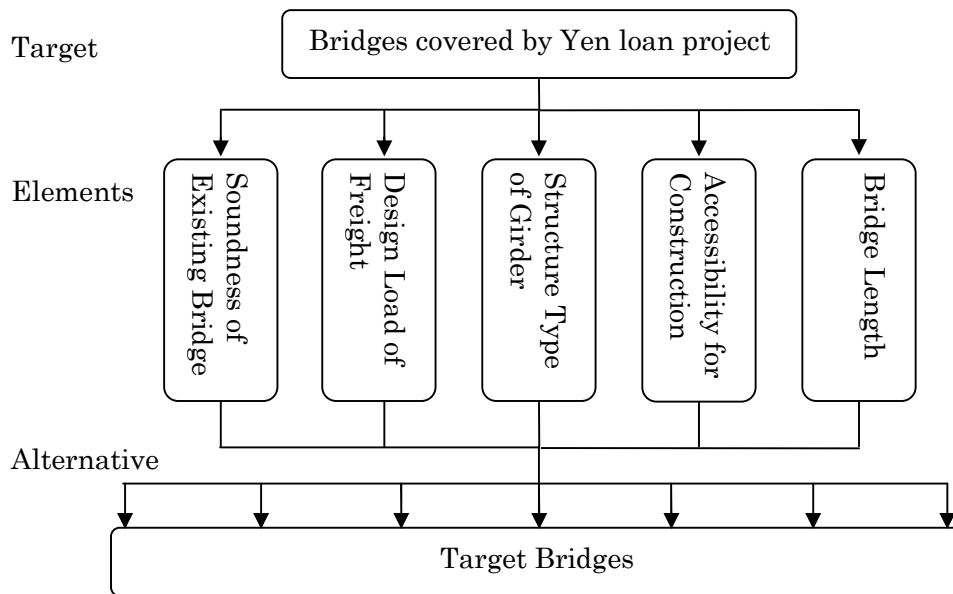
Item No.	Evaluation Criterion	Evaluation Method
1	Soundness of Existing Bridge	Bridge soundness is judged from documented information on their present condition supplied by VNR. And JST referred judgment of bridge soundness by VNR and TRICC in this study.
2	Design Load of Freight Trains	Currently, along the whole N-S Railway, there are three (3) types of freight train loads, as follows: - From HaNoi to Vinh section, the train load is 4.2 t/m - From Vinh to DaNang section, the train load is 4.1 t/m - From DaNang to SaiGon section, the train load is 3.6 t/m
3	Structure Type of Girder	Almost all bridges are of the simple beam type, and the bridge material is either steel or reinforced concrete. Concrete type bridges have priority since the ductility of concrete is less than that of steel.
4	Accessibility to Construction Site	Access during construction is to be ranked using information from sources such as Google.
5	Bridge Length	Long-span bridges will be prioritized.

Source: Study Team

(3) Study of the Priority Order among Bridges Covered by the Hierarchical Analysis

1) First (1st) Stage: Hierarchical Structurization of Subject

The comparison items (elements) for the selection of bridges to be covered by Yen loan project are workability (accessibility to construction site) and investment effects (bridge length).



Source: Study team

[Fig. 6-2-1] Hierarchical Structurization for First Screening

2) Second (2nd) Stage: Pair Comparison of Elements

In this stage, a pair comparison is made for each comparison item (element).

For weighing the pair comparison between elements, implementation and averaging of questionnaire comments, etc., will enable reflection of various concepts, differing ways of thinking, standards and thoughts. In this stage, it was decided to collect comments through questionnaires from members of the study team and to use the results of these questionnaires. [Tab. 6-2-4] shows the weights of the pair comparison.

[Tab. 6-2-4] Weights of Pair Comparison

	(1) Soundness of Existing Bridge	(2) Design Load of Freight Trains	(3) Structure Type of Girder	(4) Accessibility to Construction Site	(5) Bridge Length
(1) Soundness of Existing Bridge	1	3	3	7	1
(2) Design Load of Freight Trains	1/3	1	1	7	1/3
(3) Structure Type of Girder	1/3	1	1	7	1/3
(4) Accessibility to Construction Site	1/7	1/7	1/7	1	1/7
(5) Bridge Length	1	3	3	7	1

Source: Study team

3) Third (3rd) Stage: Calculation of Priority

The priority is calculated by taking the geometric average of the pair comparison results between elements. The calculation results are shown in [Tab. 6-2-5].

Score allocation is as shown in [Tab. 6-2-6].

Then, the score (any score classification will be acceptable) is determined for each element of each alternative. The score is multiplied by the weight of each element for overall evaluation of each bridge. The score of each element is shown in [Tab. 6-2-7] for each bridge.

[Tab. 6-2-5] Calculation of Priority

Evaluation Criteria	Calculation of geometric average	Priority of element
(1) Soundness of Existing Bridge	$(1 \times 3 \times 3 \times 7 \times 1)^{1/5} = 2.290$	$2.290 / 6.693 = 0.342$
(2) Design Load of Freight Trains	$(1/3 \times 1 \times 1 \times 7 \times 1/3)^{1/5} = 0.951$	$0.951 / 6.693 = 0.142$
(3) Structure Type of Girder	$(1/3 \times 1 \times 1 \times 7 \times 1/3)^{1/5} = 0.951$	$0.951 / 6.693 = 0.142$
(4) Accessibility to Construction Site	$(1/7 \times 1/7 \times 1/7 \times 1 \times 1/7)^{1/5} = 0.211$	$0.211 / 6.693 = 0.032$
(5) Bridge Length	$(1 \times 3 \times 3 \times 7 \times 1)^{1/5} = 2.290$	$2.290 / 6.693 = 0.342$
	Total	6.693
		1.000

Source: Study team

[Tab. 6-2-6] Score Allocation

Element	Classification	Score
Soundness of Existing Bridge	Progressive deterioration that causes the performance of structures to drop, or heavy rain, floods or earthquakes that might impair the performance of the structure. (A1)	5
	Deterioration that might cause a future performance drop of the structure.(A2)	4
	Deterioration that might result in a future performance drop of the structure. (B)	3
	Slight deterioration. (C)	2
	Sound. (S)	1
Design Load of Freight Trains	- From DaNang to SaiGon section, the train load is 3.6 t/m	5
	- From Vinh to DaNang section, the train load is 4.1 t/m	3
	- From HaNoi to Vinh section, the train load is 4.2 t/m	1
Structure Type of Girder	Reinforced Concrete Girder	5
	Steel Girder	3
Accessibility to Construction Site	$0 \text{ km} < D^* < 1 \text{ km}$	5
	$1 \text{ km} \leq D^* < 3 \text{ km}$	3
	$D^* \geq 3 \text{ km}$	1
Bridge Length	$L \geq 150 \text{ m}$	5
	$100 \text{ m} \leq L < 150 \text{ m}$	4
	$50 \text{ m} \leq L < 100 \text{ m}$	3
	$30 \text{ m} \leq L < 50 \text{ m}$	2
	$L < 30 \text{ m}$	1

Note: * “D” is the distance between the bridge and a nearby main road.

Source: Study team

[Tab. 6-2-7] Score of Each Element for 46 Bridges

No.	Kilometrage	(1) Soundness of existing bridge	(2) Design load of freight trains	(3) Structure type of bridge girder	(4) Accessibility to construction site	(5) Bridge length
No 1/41	284 k 655 m	5	1	3	2	2
No 2/41	375 k 852 m	4	3	3	3	2
No 3/41	429 k 570 m	4	3	3	1	1
No 4/41	441 k 995 m	4	3	3	3	1
No 5/41	505 k 835 m	4	3	5	1	2
No 6/41	588 k 400 m	4	3	3	3	3
No 7/41	641 k 700 m	4	3	3	3	3
No 9/41	846 k 741 m	4	5	5	1	2
No 10/41	847 k 779 m	5	5	3	1	2
No 11/41	881 k 325 m	4	5	3	3	3
No 12/41	939 k 419 m	4	5	3	2	3
No 13/41	948 k 105 m	4	5	5	2	2
No 14/41	963 k 650 m	5	5	5	2	4
No 15/41	969 k 593 m	5	5	5	3	2
No 16/41	970 k 025 m	5	5	5	3	2
No 17/41	975 k 380 m	5	5	3	3	2
No 18/41	981 k 275 m	4	5	3	3	2
No 19/41	999 k 363 m	5	5	3	3	3
No 20/41	999 k 725 m	5	5	3	3	1
No 21/41	1000 k 750 m	5	5	3	3	3
No 22/41	1002 k 365 m	5	5	3	3	2
No 23/41	1006 k 956 m	5	5	5	3	3
No 24/41	1024 k 943 m	5	5	3	3	3
No 25/41	1062 k 325 m	5	5	3	3	2
No 26/41	1085 k 982 m	4	5	3	3	2
No 32/41	1282 k 344 m	5	5	5	3	2
No 33/41	1283 k 608 m	2	5	5	3	2
No 35/41	1285 k 733 m	4	5	5	3	1
No 37/41	1375 k 077 m	4	5	3	3	3
No 40/41	1699 k 245 m	2	5	3	3	4
No 41/41	1699 k 860 m	2	5	3	3	5
No 3/132	810 k 112 m	5	5	5	3	3
No 4/132	811 k 012 m	5	5	3	3	3
No 5/132	811 k 595 m	5	5	3	3	3
No 6/132	812 k 168 m	5	5	3	3	3
No 14/132	856 k 472 m	5	5	3	3	3
No 15/132	858 k 041 m	5	5	3	3	3
No 16/132	860 k 799 m	5	5	5	2	3
No 66/132	1215 k 876 m	5	5	3	3	3

Source: Study team

The score is multiplied by the weight of each element for overall evaluation of each bridge. It may be determined that the bridge with the largest total sum has the highest priority. The results are shown in [Tab. 6-2-8].

[Tab. 6-2-8] Calculation of Priority Order (46 Bridges)

No.	Kilometrage	Calculation of priority order
No 1/41	284 k 655 m	$5 \times 0.342 + 1 \times 0.142 + 3 \times 0.142 + 2 \times 0.032 + 2 \times 0.342 = 3.026$
No 2/41	375 k 852 m	$4 \times 0.342 + 3 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 3.000$
No 3/41	429 k 570 m	$4 \times 0.342 + 3 \times 0.14 + 3 \times 0.14 + 1 \times 0.03 + 1 \times 0.34 = 2.594$
No 4/41	441 k 995 m	$4 \times 0.342 + 3 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 1 \times 0.34 = 2.658$
No 5/41	505 k 835 m	$4 \times 0.342 + 3 \times 0.14 + 5 \times 0.14 + 1 \times 0.03 + 2 \times 0.34 = 3.220$
No 6/41	588 k 400 m	$4 \times 0.342 + 3 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.342$
No 7/41	641 k 700 m	$4 \times 0.342 + 3 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.342$
No 9/41	846 k 741 m	$4 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 1 \times 0.03 + 2 \times 0.34 = 3.504$
No 10/41	847 k 779 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 1 \times 0.03 + 2 \times 0.34 = 3.562$
No 11/41	881 k 325 m	$4 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.626$
No 12/41	939 k 419 m	$4 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 2 \times 0.03 + 3 \times 0.34 = 3.594$
No 13/41	948 k 105 m	$4 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 2 \times 0.03 + 2 \times 0.34 = 3.536$
No 14/41	963 k 650 m	$5 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 2 \times 0.03 + 4 \times 0.34 = 4.562$
No 15/41	969 k 593 m	$5 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 3.910$
No 16/41	970 k 025 m	$5 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 3.910$
No 17/41	975 k 380 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 3.626$
No 18/41	981 k 275 m	$4 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 3.284$
No 19/41	999 k 363 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 20/41	999 k 725 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 1 \times 0.34 = 3.284$
No 21/41	1000 k 750 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 22/41	1002 k 365 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 3.626$
No 23/41	1006 k 956 m	$5 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 4.252$
No 24/41	1024 k 943 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 25/41	1062 k 325 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 3.626$
No 26/41	1085 k 982 m	$4 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 3.284$
No 32/41	1282 k 344 m	$5 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 3.910$
No 33/41	1283 k 608 m	$2 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 3 \times 0.03 + 2 \times 0.34 = 2.884$
No 35/41	1285 k 733 m	$4 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 3 \times 0.03 + 1 \times 0.34 = 3.226$
No 37/41	1375 k 077 m	$4 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.626$
No 40/41	1699 k 245 m	$2 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 4 \times 0.34 = 3.284$
No 41/41	1699 k 860 m	$2 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 5 \times 0.34 = 3.626$
No 3/132	810 k 112 m	$5 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 4.252$
No 4/132	811 k 012 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 5/132	811 k 595 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 6/132	812 k 168 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 14/132	856 k 472 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 15/132	858 k 041 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 16/132	860 k 799 m	$5 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 2 \times 0.03 + 3 \times 0.34 = 4.220$
No 66/132	1215 k 876 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 75/132	1250 k 937 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 76/132	1253 k 223 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 78/132	1256 k 073 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 84/132	1292 k 192 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 87/132	1317 k 517 m	$5 \times 0.342 + 5 \times 0.14 + 5 \times 0.14 + 3 \times 0.03 + 1 \times 0.34 = 3.568$
No 114/132	1453 k 484 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 3 \times 0.03 + 3 \times 0.34 = 3.968$
No 120/132	1531 k 123 m	$5 \times 0.342 + 5 \times 0.14 + 3 \times 0.14 + 1 \times 0.03 + 3 \times 0.34 = 3.904$

Source: Study team

Consequently, the priority order among bridges becomes as follows:

[Tab. 6-2-9] Priority Order among Bridges (46 Bridges)

No	Calculation of the priority order		⇒	No	Calculation of the priority order	
No	1/41	284 k 655 m		No	14/41	963 k 650 m
No 2/41	375 k 852 m	3.00		No 3/132	810 k 112 m	4.25
No 3/41	429 k 570 m	2.88		No 15/132	858 k 041 m	4.25
No 4/41	441 k 995 m	2.94		No 75/132	1250 k 937 m	4.25
No 5/41	505 k 835 m	3.22		No 76/132	1253 k 223 m	4.25
No 6/41	588 k 400 m	3.34		No 78/132	1256 k 073 m	4.25
No 7/41	641 k 700 m	3.34		No 84/132	1292 k 192 m	4.25
No 9/41	846 k 741 m	3.50		No 19/41	999 k 363 m	3.97
No 10/41	847 k 779 m	3.56		No 21/41	1000 k 750 m	3.97
No 11/41	881 k 325 m	3.63		No 23/41	1006 k 956 m	3.97
No 12/41	939 k 419 m	3.59		No 24/41	1024 k 943 m	3.97
No 13/41	948 k 105 m	3.54		No 4/132	811 k 012 m	3.97
No 14/41	963 k 650 m	4.56		No 5/132	811 k 595 m	3.97
No 15/41	969 k 593 m	3.91		No 6/132	812 k 168 m	3.97
No 16/41	970 k 025 m	3.91		No 14/132	856 k 472 m	3.97
No 17/41	975 k 380 m	3.91		No 66/132	1215 k 876 m	3.97
No 18/41	981 k 275 m	3.28		No 114/132	1453 k 484 m	3.97
No 19/41	999 k 363 m	3.97		No 16/132	860 k 799 m	3.94
No 20/41	999 k 725 m	3.57		No 15/41	969 k 593 m	3.91
No 21/41	1000 k 750 m	3.97		No 16/41	970 k 025 m	3.91
No 22/41	1002 k 365 m	3.91		No 17/41	975 k 380 m	3.91
No 23/41	1006 k 956 m	3.97		No 22/41	1002 k 365 m	3.91
No 24/41	1024 k 943 m	3.97		No 32/41	1282 k 344 m	3.91
No 25/41	1062 k 325 m	3.63		No 120/132	1531 k 123 m	3.90
No 26/41	1085 k 982 m	3.28		No 11/41	881 k 325 m	3.63
No 32/41	1282 k 344 m	3.91		No 25/41	1062 k 325 m	3.63
No 33/41	1283 k 608 m	2.88		No 37/41	1375 k 077 m	3.63
No 35/41	1285 k 733 m	3.23		No 41/41	1699 k 860 m	3.63
No 37/41	1375 k 077 m	3.63		No 12/41	939 k 419 m	3.59
No 40/41	1699 k 245 m	3.28		No 20/41	999 k 725 m	3.57
No 41/41	1699 k 860 m	3.63		No 87/132	1317 k 517 m	3.57
No 3/132	810 k 112 m	4.25		No 10/41	847 k 779 m	3.56
No 4/132	811 k 012 m	3.97		No 13/41	948 k 105 m	3.54
No 5/132	811 k 595 m	3.97		No 9/41	846 k 741 m	3.50
No 6/132	812 k 168 m	3.97		No 6/41	588 k 400 m	3.34
No 14/132	856 k 472 m	3.97		No 7/41	641 k 700 m	3.34
No 15/132	858 k 041 m	4.25		No 18/41	981 k 275 m	3.28
No 16/132	860 k 799 m	3.94		No 26/41	1085 k 982 m	3.28
No 66/132	1215 k 876 m	3.97		No 40/41	1699 k 245 m	3.28
No 75/132	1250 k 937 m	4.25		No 35/41	1285 k 733 m	3.23
No 76/132	1253 k 223 m	4.25		No 5/41	505 k 835 m	3.22
No 78/132	1256 k 073 m	4.25		No 1/41	284 k 655 m	3.03
No 84/132	1292 k 192 m	4.25		No 2/41	375 k 852 m	3.00
No 87/132	1317 k 517 m	3.57		No 4/41	441 k 995 m	2.94
No 114/132	1453 k 484 m	3.97		No 33/41	1283 k 608 m	2.88
No 120/132	1531 k 123 m	3.90		No 3/41	429 k 570 m	2.88

Source: Study team

6.2.2 Cost Estimation

(1) Unit Cost Analysis of Existing Bridge Reconstruction

The unit cost of bridge reconstruction in this study is estimated using cost data of the “HaNoi - HCMC Railway Line Bridges Safety Improvement Project” (hereinafter referred to as BSIP).

The study team selected TraBong Bridge (907k756m), SongVe Bridge (941k273m), and SongLong SL Bridge (1,416k831m) from BSIP for the unit cost estimation. The reasons for selecting these three (3) bridges are as follows:

- The BSIP costs are close to current costs because BSIP was contracted in late 2013.
- The bridges are truss type which will also be adopted as the typical bridge type for future reconstruction projects.
- The bridge spans are 62.3m, 54.6m, 49.8m, and 43.0m, and these span types will be adopted for coming projects.

The reconstruction cost of each BSIP bridge is shown in [Tab. 6-2-10], and the adopted unit cost for bridge reconstruction in this study is shown in [Tab. 6-2-11]. These costs use the exchange rate in April 2014 applied to JICA projects.

[Tab. 6-2-10] Reconstruction Cost Analysis of BSIP Bridges

Work Item	Unit	F.C. (1,000JPY)	L.C. (1,000VND)	Total (1,000JPY)
Bridge Construction (Steel Girder)				
TraBong Bridge	/m	618	272,293	1,952
SongVe Bridge	/m	627	324,028	2,215
SongLong SL Bridge	/m	602	285,811	2,002
Sub-total		1,847	882,133	6,169
Average	/m	616	294,044	2,056
Railway Formation				
TraBong Bridge	/m	0	1,020	5
SongVe Bridge	/m	0	1,388	7
SongLong SL Bridge	/m	0	3,091	15
Sub-total		0	5,499	27
Average	/m	0	1,833	9
Track Work				
TraBong Bridge	/m	36	5,943	65
SongVe Bridge	/m	39	7,335	75
SongLong SL Bridge	/m	66	4,642	88
Sub-total		141	17,921	229
Average	/m	47	5,974	76

Note: Exchange rate used in this study is VND 1 = JPY 0.0049 based on the rate in April 2014.

Source: Study team summarized data of BSIP

[Tab. 6-2-11] Adopted Unit Cost for Bridge Reconstruction in this Study

Work Item	Unit	F.C. (1,000JPY)	L.C. (1,000VND)	Total (1,000JPY)	Total (USD)
Bridge Unit Cost (Bridge Construction + Track Work)	/m	663	300,018	2,133	20,741
Approach Unit Cost (Railway Formation + Track Work)	/m	47	7,807	85	829

Note: Exchange rates used in this study are VND 1 = JPY 0.0049 and USD 1 = JPY 102.82 based on the rates in April 2014.

Source: Study team

(2) Total Cost of Existing Bridge Reconstruction

The reconstruction cost of the 46 bridges estimated by using the unit cost mentioned above is shown in [Tab. 6-2-12]. The total reconstruction cost is 108.94million USD.

[Tab. 6-2-12] Reconstruction Cost of 46 Bridges

No.	Bridge	Kilometrage	Location	Investment Plan of 47 Bridges				Reconstruction Cost (mln. USD)
				Span Arrangement	No. of Substructure	Span Length (m)	Bridge Length (m)	
1/41	ChinMong	284 + 655	NgheAn	1 × 50.0	4	50.00	58.00	2.03
2/41	HuongTan	375 + 852	HaTinh	1 × 50.0	4	50.00	58.00	2.03
3/41	KheBe	429 + 570	QuangBinh	1 × 43.0	2	43.00	51.00	1.89
4/41	KheChu	441 + 995	QuangBinh	1 × 43.0	2	43.00	51.00	1.89
5/41	RongTruoc	505 + 835	QuangBinh	1 × 58.0	5	58.00	66.00	2.20
6/41	SaLung	588 + 400	QuangTri	2 × 43.0	2	86.00	94.00	2.78
7/41	RongLon	641 + 700	QuangTri	2 × 43.0	3	86.00	94.00	2.78
9/41		846 + 741	QuangNam	1 × 50.0	4	50.00	58.00	2.03
10/41		847 + 779	QuangNam	1 × 58.0	4	58.00	66.00	2.20
11/41	OngBo	881 + 325	QuangNam	1 × 75.0	3	75.00	83.00	2.55
12/41		939 + 419	QuangNgai	2 × 50.0	3	100.00	108.00	3.07
13/41		948 + 105	QuangNgai	1 × 43.0	6	43.00	51.00	1.89
14/41		963 + 650	QuangNgai	1 × 150.0	3	150.00	158.00	4.11
15/41		969 + 593	QuangNgai	1 × 43.0	4	43.00	51.00	1.89
16/41		970 + 25	QuangNgai	1 × 43.0	4	43.00	51.00	1.89
17/41		975 + 380	QuangNgai	1 × 50.0	5	50.00	58.00	2.03
18/41		981 + 275	QuangNgai	1 × 50.0	5	50.00	58.00	2.03
19/41		999 + 363	BinhDinh	2 × 43.0	5	86.00	94.00	2.78
20/41		999 + 725	BinhDinh	1 × 50.0	3	50.00	58.00	2.03
21/41		1,000 + 750	BinhDinh	1 × 66.0	5	66.00	74.00	2.36
22/41		1,002 + 365	BinhDinh	1 × 50.0	4	50.00	58.00	2.03
23/41		1,006 + 956	BinhDinh	2 × 43.0	7	86.00	94.00	2.78
24/41	CauCao	1,024 + 943	BinhDinh	1 × 75.0	6	75.00	83.00	2.55
25/41		1,062 + 325	BinhDinh	1 × 43.0	3	43.00	51.00	1.89
26/41		1,085 + 982	BinhDinh	1 × 50.0	5	50.00	58.00	2.03
32/41		1,282 + 344	KhanhHoa	1 × 43.0	4	43.00	51.00	1.89
33/41	ThuanMy	1,283 + 608	KhanhHoa	1 × 54.0	4	54.00	62.00	2.11
35/41		1,285 + 733	KhanhHoa	1 × 43.0	5	43.00	51.00	1.89
37/41	HiepMy	1,375 + 77	KhanhHoa	1 × 58.0	3	58.00	66.00	2.20
40/41	Dg.NaiNho	1,699 + 245	DongNai	3 × 43.0	4	129.00	137.00	3.67
41/41	Dg.NaiLon	1,699 + 860	DongNai	4 × 58.0	5	232.00	240.00	5.81
3/132	BauKhe	810 + 112		1 × 59.1	2	59.10	65.30	2.18
4/132	LaTho	811 + 12		1 × 50.7	2	50.70	58.10	2.03
5/132	Lo	811 + 595		1 × 43.9	2	43.90	54.10	1.95
6/132	OngNgo	812 + 168		1 × 59.1	2	59.10	68.30	2.25
14/132	XaLaoThep	856 + 472		1 × 59.1	2	59.10	66.75	2.21
15/132	RocTra	858 + 41		1 × 59.1	2	59.10	68.30	2.25
16/132	SuoiThot	860 + 799		1 × 7.0 + 1 × 43.9	3	50.90	59.55	2.06
66/132	SoDua	1,215 + 876		1 × 67.5	2	67.50	76.70	2.42
75/132		1,250 + 937		2 × 43.9	3	87.80	94.30	2.78
76/132		1,253 + 223		1 × 50.7	2	50.70	57.70	2.03
78/132		1,256 + 73		2 × 43.9	3	87.80	96.40	2.83
84/132		1,292 + 192		1 × 50.7	2	50.70	55.80	1.99
87/132	Doi	1,317 + 517		1 × 59.1	2	59.10	69.30	2.27
114/132		1,453 + 484		1 × 59.1	2	59.10	69.30	2.27
120/132	MaLam	1,531 + 123		1 × 50.7	2	50.70	63.00	2.14
Total								108.94

Source: Study team

6.2.3 Benefit Estimation

The procedure and outline of benefit estimation for the reconstruction of the selected existing 46 bridges are shown below.

(1) Methodology for Benefit Estimation

The time saving effect by reconstruction of existing bridges is estimated based on the following procedure.

- Current operation speed of freight trains on the 46 targeted bridges is assumed to be restricted based on the soundness of bridges shown in [Tab. 6-2-6] and [Tab. 6-2-7]. Specifically, the bridges diagnosed as having a soundness rank A1 shall be restricted to 30 km/h, rank A2 to 40 km/h, rank B to 50 km/h, and rank C to 60 km/h. These restricted speeds are assumed from the BSIP data.
- The current required time to pass through the section around the target bridges while taking into account deceleration and acceleration is estimated based on the current operation speed mentioned above.
- The future operation speed of freight trains on the 46 targeted bridges is assumed to be the same as the maximum operation speed of each section as of April 2014.
- The future required time to pass through the section is estimated based on the future operation speed mentioned above, in the same way as when estimating the current required time.
- The difference between the current and the future required time shall be the time saving effect achieved by the reconstruction of existing bridges.

(2) Result of Time Saving Effect

The estimated time saving effect for freight trains achieved through reconstruction of existing bridges is shown in [Tab. 6-2-13]. The total time saving on the section between HaNoi and SaiGon is estimated to be 40 minutes.

[Tab. 6-2-13] Time Saving Effect by Bridge Reconstruction

Section	At Present <Fastest Freight Train>		After Bridge Reconstruction		
	Scheduled Time	Scheduled Speed (km/h)	No. of Bridges	Time Saving (minutes)	Speed Increase (km/h)
HaNoi-Vinh (GiapBat)	8h44m	35.9	1	- 1	+ 0.1
Vinh-Hue	13h16m	27.8	6	- 3	+ 0.2
Hue-DaNang (KimLien)	4h00m	22.1	0	-	—
DaNang-NhaTrang (KimLien)	10h47m	38.4	33	- 31	+ 1.6
NhaTrang-SaiGon (SongThang)	13h56m	36.7	6	- 5	+ 0.3
HaNoi-SaiGon (GiapBat-SongThang)	61h56m	27.5	46	- 40	+ 0.4

Source: Survey team

(3) Result of Cost Benefit Analysis

The ratio of cost to time saving effect by reconstruction of existing bridges is shown in [Tab. 6-2-14]. It shows that the ratio on the section between HaNoi and SaiGon is 2.72 million USD/minutes.

[Tab. 6-2-14] Cost Benefit Analysis for Bridge Reconstruction

Section	Cost of Existing Bridge Reconstruction (million USD)	Time Saving by Existing Bridge Reconstruction (minutes)	Time Saving - Cost Ratio (million USD/ minutes)
HaNoi-Vinh (GiapBat)	2.03	- 1	2.03
Vinh-Hue	13.56	- 3	4.52
Hue-DaNang (KimLien)	0.00	-	-
DaNang-NhaTrang (KimLien)	75.01	- 31	2.42
NhaTrang-SaiGon (SongThang)	18.34	- 5	3.67
HaNoi-SaiGon (GiapBat-SongThang)	108.94	- 40	2.72

Source: Survey team

6.3 Tunnel Component other than HaiVan Tunnel

6.3.1 Prioritization

(1) Prioritization Principle

The prioritization principle for the selected 19 tunnels in the first screening in this study is that sections with a series of tunnels at regular 1 to 2km intervals and successive restrictions of maximum operation speed shall be given higher priority. Consequently, two (2) sections which include five (5) tunnels from Tunnel No. 1 to Tunnel No. 5 and six (6) tunnels from Tunnel No. 18 (Babonneau Tunnel) to Tunnel No. 23 (BaiGio Tunnel) (refer to [Tab. 6-1-2]) were given preliminary priority.

(2) Selection of Tunnel Reconstruction Sections

1) Location of Five (5) Tunnels (No.1-No.5) vis-a-vis Stations

The five (5) tunnels from Tunnel No. 1 to Tunnel No. 5 are located on the section between NgocLam Station (449km570m) and LeSon Station (467km101m) over a distance of 17.531km as shown in [Tab. 6-3-1].

The series of three (3) tunnels with a total tunnel length of 428m is located on the section from 455k432m to 456k245m over a distance of 813m. However, the ratio of total tunnel length to the distance between the two stations (8.98km) is only 4.8 %. There are also curved sections with a radius of less than 150m near the tunnels and the maximum operation speed on the sections near the tunnels is restricted to 30 km/h. The ratio of the reconstruction cost to the time saving effect between stations after tunnel reconstruction is therefore expected to be minimal. Consequently, the series of three (3) tunnels is proposed to be excluded from the priority components.

For the same reasons, the series of two (2) tunnels between LocSon Station and LeSon Station shall be excluded from the priority components.

[Tab. 6-3-1] Location of Five Tunnels vis-a-vis Stations

No.	Name of Tunnels and Stations	Kilometrage at Center of Tunnel	Length (m)	Curve Radius (m)	Gradient (‰)
	NgocLam St.	449k570m			
1	Tunnel No. 1	455k432m	63.77	245	1.7
2	Tunnel No. 2	455k765m	250.06	154	1.5, 0.7
3	Tunnel No. 3	456k245m	114.46	120	0.9, 1.0
	Loc Son St.	458k550m			
4	Tunnel No. 4	466k255m	100.84	130.5	1.5, 1.13
5	Tunnel No. 5	466k496m	193.44	Straight	1.35
	Le Son St.	467k101m			

Source: Study team

2) Location of Six (6) Tunnels (No.18-No.23) vis-a-vis Stations

The six (6) tunnels from Tunnel No. 18 to Tunnel No. 23 are located on the section between HaoSon Station (1,220k140m) and DaiLanh Station (1,232k200m) over a distance of 12.060km as shown in [Tab. 6-3-2].

The series of six (6) tunnels with a total tunnel length of 2,442m is located on the section from 1,224k816m to 1,231k188m over a distance of 6,370m. The ratio of total tunnel length to the distance between the two (2) stations (12.06km) is 20.2%. Considering the ration of reconstruction cost to time saving effect after tunnel reconstruction, this series of six (6) tunnels is eligible for proceeding to the next step of estimating reconstruction costs and benefits.

[Tab. 6-3-2] Location of Six Tunnels vis-a-vis Stations

No.	Name of Tunnels and Stations	Kilometrage at Center of Tunnel	Length (m)	Curve Radius (m)	Gradient (‰)
	HoaSon Station	1,220k140m			
18	Babonneau	1,224k816m	1,198.20	420	3.8, 2.0
19	Vung Ro 4	1,227k120m	371.23	500	0.3
20	Vung Ro 3	1,228k115m	159.46	700	3.8, 5.3
21	Vung Ro 2	1,228k702m	249.99	500	1.6, 1.0
22	Vung Ro 1	1,229k252m	60.39	Straight	7.8
23	Bai Gio	1,231k188m	402.58	350	8.7, 7.1
	DaiLanh Station	1,232k200m			

Source: Study team

6.3.2 Cost Estimation

(1) Unit Cost Analysis of Existing Tunnel Reconstruction

According to the VNR report described in Section 3.1.3, the unit cost of existing tunnel reconstruction is evaluated to be 19.4million USD/km. However, this unit cost is evaluated to be too expensive for single track 32m² cross-section tunnels since the unit cost of Japanese double track HSR tunnels with 64m² cross-section constructed with the all face excavation method is only about 20.0million USD/km.

It is recommended that the unit cost of existing tunnel reconstruction to be applied in this study in terms of m² unit of tunnel cross section be decided based on the values in the HSR-F/S. The result of the calculation is shown in [Tab. 6-3-3]. The table shows that the proposed unit cost of reconstruction for existing railway line single track tunnel is 6.4million USD/km.

[Tab. 6-3-3] Unit Cost of Existing Tunnel Reconstruction

No.	Tunnel Type	Inner Area (m ²)	Excavation Area (m ²)	Unit Cost (million USD/km)	Remarks
1	HSR Double Track Tunnel	63.40	72.89	20.9	$20.9/72.89 = 0.287$ (million USD/km/m ²)
2	Conventional Railway Double Track Tunnel	51.45	60.73	17.4	$17.43 = 60.73 \times 0.287$
3	Conventional Railway Single Track Tunnel	24.66	31.15	8.9	$8.94 = 31.15 \times 0.287$
4	Recommended Conventional Railway Single Track Tunnel	24.66	31.15	6.4	$6.4 = 8.9 \times 60\% \times 120\%*$

Note: * The share of construction costs other than excavation for new tunnel construction is assumed to be 60%.

The extra cost ratio for existing tunnel reconstruction on the live line is assumed to be 20%.

Considering the ratios above, the unit cost is calculated to be 6.4million USD/km.

Source: Study team

(2) Total Cost of Existing Tunnel Reconstruction

The reconstruction cost of six (6) tunnels, Tunnel No. 18 (Babonneau Tunnel)-Tunnel No. 23 (BaiGio Tunnel), estimated using the unit cost mentioned above is shown in [Tab. 6-3-4]. The total reconstruction cost is 16.54million USD.

[Tab. 6-3-4] Reconstruction Cost of Six Tunnels (No.18-No.23)

No.	Name of Tunnels and Stations	Kilometrage at Center of Tunnel	Length (m)	Unit Cost (million USD/km)	Reconstruction Cost (million USD)
18	Babonneau St.	1,224k816m	1,198.20	6.4	7.67
19	VungRo 4	1,227k120m	371.23	6.4	3.28
20	VungRo 3	1,228k115m	159.46	6.4	1.02
21	VungRo 2	1,228k702m	249.99	6.4	1.60
22	VungRo 1	1,229k252m	60.39	6.4	0.41
23	BaiGio St.	1,231k188m	402.58	6.4	2.58
Total		-	2,441.85	-	16.54

Source: Study team

6.3.3 Benefit Estimation

The procedure and outline of benefit estimation for the six (6) selected tunnels are shown below.

(1) Alignment of the Target Section

The alignment and train speed regulations in 2014 on the target section between HaoSon Station and DaiLanh Station, including the series of six (6) tunnels subject to reconstruction cost estimation and benefit, is shown in [Tab.6-3-5].

The maximum speed on the section from 1,224k000m to 1,232k000m, including the series of selected six (6) tunnels, is restricted to 50km/h. Especially the maximum speed in the VungRo 4 Tunnel is restricted to 30km/h because of weathered tunnel lining.

As for the alignment, the target section has no curved sections with a radius of less than 300m or steep gradient sections with a vertical gradient over 12%. Since the alignment of the target section is comparatively good, a time saving effect is expected as a result of the tunnel reconstruction.

[Tab. 6-3-5] Alignment of the Target Section

Stations & Tunnels	Kilometrage	Curve Radius 1) (m)	Gradient 2) (%)	Maximum Speed (km/h)
HoaSon Station	1,220k140m			
	1,220k140m ~ 1,224k000m			80
	1,220k542m ~ 1,220k777m	405		
	1,221k025m ~ 1,221k244m	500		
	1,221k700m ~ 1,221k924m	408		
	1,221k968m ~ 1,222k181m	500		
	1,222k725m ~ 1,222k900m		6.8	
	1,222k900m ~ 1,223k100m		9.7	
	1,223k100m ~ 1,223k300m		11.4	
	1,223k149m ~ 1,223k377m	485		
	1,223k300m ~ 1,223k500m		8.2	
	1,223k409m ~ 1,223k577m	506		
	1,223k500m ~ 1,223k700m		9.7	
	1,223k700m ~ 1,224k000m		7.8	
	1,223k708m ~ 1,223k937m	403		
	1,224k000m ~ 1,232k000m			50
	1,224k000m ~ 1,224k125m		7.3	
	1,224k102m ~ 1,224k236m	420		
Babonneau Tunnel	1,224k217m ~ 1,225k415m			
	1,226k175m ~ 1,226k605m	299		
Vung Ro 4 Tunnel	1,226k934m ~ 1,227k306m	Restricted Speed →		30
	1,226k935m ~ 1,227k285m	500		
Vung Ro 3 Tunnel	1,228k035m ~ 1,228k195m			
	1,228k462m ~ 1,228k826m	500		
Vung Ro 2 Tunnel	1,228k577m ~ 1,228k827m			
	1,228k961m ~ 1,229k215m	500		
	1,229k175m ~ 1,229k325m		-7.8	
Vung Ro 1 Tunnel	1,229k222m ~ 1,229k282m			
	1,229k327m ~ 1,229k426m	500		
	1,229k475m ~ 1,229k650m		-8.9	
	1,229k650m ~ 1,229k950m		-8.0	
	1,229k950m ~ 1,230k100m		-6.8	
	1,230k100m ~ 1,230k275m		-9.0	
	1,230k211m ~ 1,230k461m	317		
	1,230k275m ~ 1,230k550m		-7.9	
	1,230k623m ~ 1,230k763m	280		
	1,230k700m ~ 1,230k930m		-9.2	
	1,230k814m ~ 1,230k927m	360		
	1,230k930m ~ 1,231k150m		-8.7	
	1,230k942m ~ 1,231k043m	350		
Bai Gio Tunnel	1,230k987m ~ 1,231k389m			
	1,231k150m ~ 1,231k450m		-7.1	
	1,231k424m ~ 1,232k049m	501		
	1,231k450m ~ 1,231k650m		-9.5	
	1,231k650m ~ 1,231k800m		-7.2	
	1,231k800m ~ 1,231k968m		-6.8	
	1,232k000m ~ 1,232k200m			80
Dai Lanh Station	1,232k200m			

Notes: 1) The column “Curve Radius” shows curved sections with a radius of less than 600m.

2) The column “Gradient” shows sections with a vertical gradient of over 6 %.

Source: Study team based on VNR data

(2) Methodology for Benefit Estimation

In this section, the time saving effect achieved by reconstruction of existing tunnels is estimated based on the train performance curve for freight trains calculated under certain conditions. Since the existing tunnels subjected to this estimation are coterminous, it is possible that the effects of existing tunnel reconstruction overlap each other. The procedure used to estimate the time saving effect by existing tunnel reconstruction is as follows:

- The current freight train operation schedule between stations including the selected tunnels is assumed to be the same as that of VNR's train operation timetable.
→According to VNR's train operation timetable as of July 2013, the current train schedule between HaoSon Station and DaiLanh Station is approximately 20minutes.
- The current freight train operation schedule between stations including the selected tunnels is estimated using the train performance curve calculated based on the conditions after existing tunnel reconstruction.
→The estimated train schedule between HaoSon Station and DaiLanh Station based on the train performance curve is approximately 16minutes.
- The time saving effect by reconstruction of the existing tunnels is assumed to be the difference between the current train schedule and the estimated train schedule based on the train performance curve.
→The time saving effect by reconstruction of existing tunnels between HaoSon Station and DaiLanh Station is 4minutes (= 20minute-16minutes).

The result of the time saving effect estimation for freight trains by reconstruction of existing tunnels is shown in [Tab. 6-3-6].

[Tab. 6-3-6] Time Saving Effect by Tunnel Reconstruction btw. HaoSon St. and DaiLanh St.

At Present (a)		After Tunnel Reconstruction (b)		Difference (c)= (a)-(b)	
Scheduled Time (min.)	Scheduled Speed (km/h)	Estimated Time (min.)	Estimated Speed (km/h)	Time Saving (min)	Speed Increase (km/h)
20	36.2	16	45.2	- 4	+ 9.0

Source: Survey team

(3) Result of Cost Benefit Analysis

The ratio of cost to time saving effect by reconstruction of existing tunnels is shown in [Tab. 6-3-7]. It shows that the ratio is 3.3million USD/minute.

[Tab. 6-3-7] Cost Benefit Analysis for Tunnel Reconstruction

Cost of Existing Tunnel Reconstruction (million USD)	Time Saving by Existing Tunnel Reconstruction (minutes)	Time Saving-Cost Ratio (million USD/minute)
16.54	4.0	4.135

Source: Survey team

6.4 Second Screening by Matrix Analysis

6.4.1 Results of Analysis in Step 1

The location of the bridges and tunnels targeted for reconstruction in Step 1 screening, which include 46 bridges and 6 tunnels, are listed in [Tab. 6-4-1] and [Tab. 6-4-2]. Details on the location and reconstruction of each target can be found in [Attachment 6-4-1].

Most of the bridges and tunnels targeted for reconstruction in Step 1 screening are on the

section between DaNang and NhaTrang. On this section, much of the railway infrastructure was badly damaged during the War and constructed in accordance with old French standards which were less stringent than current Vietnamese standards. Also, the construction standards for this section have not been unified. For example, the design load of the old French standards was lighter than that of the current Vietnamese standards. Therefore, it is necessary to reconstruct much of the railway infrastructure on this section, and many of these structures are selected as targets for Step 1 screening.

[Tab. 6-4-1] Location of Bridges and Tunnels Targeted for Reconstruction in Step 1 between HaNoi and DienTri

Kilometrage	Main Station	Bridge	Tunnel
0k000m	HaNoi		
284k655m		1/ 41 Chin Mong	
319k200m	Vinh		
375k852m		2/ 41 Huong Tan	
429k570m		3/ 41 Khe Be	
441k938m		4/ 41 Khe Chua	
505k850m		5/ 41 Rong Truoc	
521k800m	DongHoi		
588k400m		6/ 41 Sa Lung	
641k700m		7/ 41 Rong Lon	
688k320m	Hue		
791k400m	DaNang		
810k112m		3/132 Bau Khe	
811k012m		4/132 La Tho	
811k595m		5/132 Lo	
812k168m		6/132 Ong Ngo	
846k741m		9/ 41 Hon Hop	
847k779m		10/ 41 Thep	
856k472m		14/132 Xa Lao	
858k041m		15/132 Roc Tra	
860k799m		16/132 Suoi Thot	
881k325m		11/ 41 Ong Bo	
939k419m		12/ 41	
948k105m		13/ 41	
963k650m		14/ 41	
969k593m		15/ 41	
970k025m		16/ 41	
975k380m		17/ 41	
981k275m		18/ 41	
999k363m		19/ 41	
999k725m		20/ 41	
1,000k750m		21/ 41	
1,002k365m		22/ 41	
1,006k956m		23/ 41	
1,024k943m		24/ 41 Cau Cao	
1,062k325m		25/ 41	
1,085k982m		26/ 41	
1,095k930m	DienTri		
Subtotal	-	32 bridges	0 tunnels

Source: Study team

[Tab. 6-4-2] Location of Bridges and Tunnels Targeted for Reconstruction in Step 1 between DienTri and SaiGon

Kilometrage	Main Station	Bridge	Tunnel
1,095k930m	DienTri		
1,215k876m		66/132 So Dua	
1,224k816m			13 Babonneau
1,227k120m			14 VungRo 4
1,228k115m			15 VungRo 3
1,228k702m			16 VungRo 2
1,229k252m			17 VungRo 1
1,231k188m			18 BaiGio
1,250k937m		75/132	
1,253k223m		76/132	
1,256k073m		78/132	
1,282k344m		32/ 41	
1,283k608m		33/ 41 Thuan My	
1,285k733m		35/ 41	
1,292k192m		84/132	
1,314k930m	NhaTrang		
1,317k517m		87/132 Doi	
1,375k077m		37/ 41 Hiep My	
1,453k484m		114/132	
1,531k123m		120/132	
1,551k150m	BinhThuan		
1,699k245m		40/ 41 Rach Cat	
1,699k860m		41/ 41 Ghenh	
1,726k200m	SaiGon		
Subtotal	–	14 bridges	6 tunnels
Total	–	46 bridges	6 tunnels

Source: Study team

6.4.2 Results of Analysis in Step 2

A summary of the analysis results in Step 1 by main section is shown in [Tab. 6-4-3].

[Tab. 6-4-3] Summary of Analysis Results in Step 1 by Main Section

Section	No. of Bridges and Tunnels	Cost (million USD) (a)	Time Saving (minutes) (b)	Time Saving – Cost Ratio (mln. USD/minute) (a)/(b)
HaNoi – Vinh	1 + 0 = 1	2.03	- 1	2.03
Vinh – Hue	6 + 0 = 6	13.56	- 3	4.52
Hue – DaNang	0 + 0 = 0	0.00	0	–
DaNang – NhaTrang	33 + 6 = 39	91.55	- 35	2.62
NhaTrang – SaiGon	6 + 0 = 6	18.34	- 5	3.67
Total	46 + 6 = 52	125.48	- 44	2.85

Source: Study team

If all targeted bridges and tunnels are reconstructed, the total time saving between HaNoi and SaiGon is estimated to be approximately 44 minutes, and the total reconstruction cost is estimated to be approximately 125.5 million USD. Most targeted bridges and tunnels are located between DaNang and NhaTrang, and the total time saving on this section is estimated to be approximately 35 minutes by reconstruction of 33 bridges and 6 tunnels at a cost of 91.6 million USD. On this section, the ratio of cost to time saving effect is 2.62 million USD/minute and the effect of reconstruction is comparatively high by observing just this index.

The time saving target by reconstruction of existing railway infrastructure is set to one (1) hour between HaNoi and SaiGon as mentioned in Section 3.2. However, as seen in [Tab. 6-4-3], if all bridges and tunnels targeted in Step 1 are reconstructed, the total time saving between HaNoi and SaiGon cannot reach this time saving target.

- Time Saving Target: **▲One (1) hour** between HaNoi and SaiGon
- Total Time Saving by Reconstruction of Bridges and Tunnels Targeted in Step1:
Approximately **▲ 44 minutes** between HaNoi and SaiGon

Therefore it is necessary to reconstruct at least all bridges and tunnels targeted in Step 1 to achieve the target time saving. All bridges and tunnels targeted in Step 1 shall therefore be prioritized infrastructure components by the year 2020 (see [Tab. 6-4-4]).

Furthermore, in this section, the time saving shall be estimated for freight trains, but it is expected that the operation speed of passenger trains will also be increased and the travel time of passenger trains will be drastically reduced.

[Tab. 6-4-4] Number of Prioritized Infrastructure Components by Target Year

Section	Year 2020			Year 2025	Year 2030
	Bridge	Tunnel	Subtotal		
HaNoi – Vinh	1	0	1		
Vinh – Hue	6	0	6		
Hue – DaNang	0	0	0		
DaNang – NhaTrang	33	6	39		
NhaTrang – SaiGon	6	0	6		
Total	46	6	52		

Source: Study team

6.4.3 Proposed Infrastructure Development Policy for the N-S Railway

The study team proposes the following policy for infrastructure development of the N-S Railway.

(1) Short-term Priority Projects to be Implemented until 2020

- It is proposed to reconstruct the prioritized infrastructure components which consist of the 46 bridges and 6 tunnels targeted in Section 6.4.2 in one shot of package. However, it is possible to divide the 46 bridges into packages and put into implementation referring to the priority order among the 46 bridges by AHP, future traffic demand by section, etc.
- It is worth noting that these prioritized infrastructure components are also recognized as high priority components in the DMP (Detailed Modernization Plan for the N-S Railway) scheduled to be implemented by 2020.
- The prioritized infrastructure components for rehabilitation constitutes a part of Option A1 of the alternative improvement options for the N-S Railway in HSR F/S, and Option A1 is a baseline plan that consists of single tracking, minimum required measures to maintain the safety levels of structures, current maximum operation speed of 90 km/h for passenger trains, etc.
- It is proposed to implement other measures articulated in Chapter 8 by the capacity of Vietnamese side such as improving operation planning and management efficiency and taking safety measures aside from the afore mentioned physical measures of speed-up so that transportation capacity will be increased.
- Those infrastructure improvement components not to be selected as short-term priority projects are proposed to be implemented as part of the operation and maintenance efforts of VNR, because the projects eligible for Japanese ODA require

advanced technology and fair sized project packages.

- The infrastructure components for the KheNet tunnel, HoaDuyet - ThanhLuyen section improvement and alignment improvement of sections with small curve radius are expected to be given higher priority as pointed out by VNR. They will contribute with a large time saving effect but are defined as “Long-term Priority Projects” since they still need further consideration and more detailed study to estimate costs and benefits. In this connection, these projects are recommended to be implemented as soon as conditions are met after verifying the costs and benefits in a separate study.

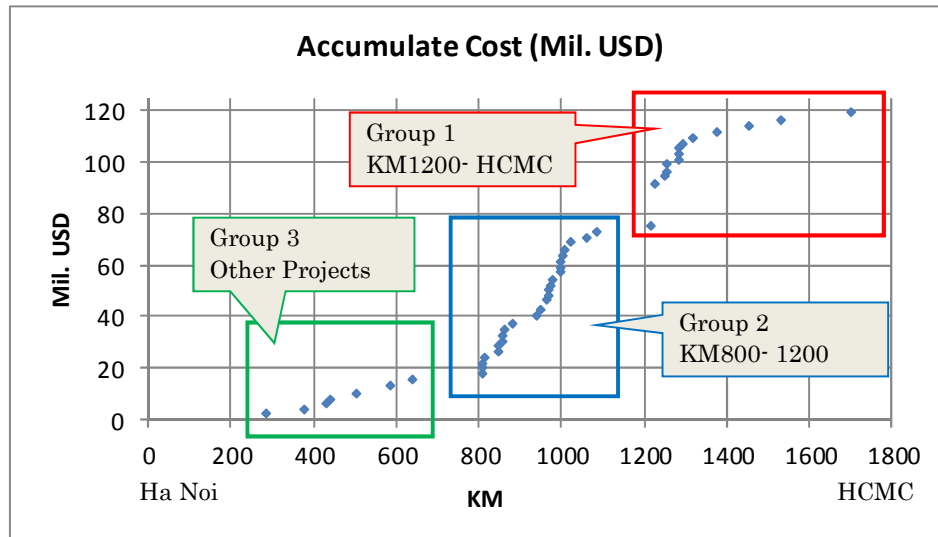
(2) Long-term Priority Projects to be Implemented after 2020

- During the first and second field mission, the study team collected documents and data and interviewed related persons. However, it was discovered that some of the components are difficult to classify by the target years 2025 and 2030 since they still need further consideration and more detailed study. Therefore, these components such as BinhLoi Bridge, alignment improvement of the NhaTrang loop section, double tracking between NhaTrang and SaiGon, landslide protection in mountainous areas etc. are defined as “Long-term Priority Projects” to be implemented after 2020.
- There is a high possibility that a high speed railway will open after 2050 and a middle speed railway will open between 2030 and 2040. Considering that the project life of railway projects is about 40 years, the residual value of infrastructure development of the N-S Railway will remain even after opening of HSR and mainly freight and local passenger transport will use the N-S Railway. Therefore reconstruction of the prioritized infrastructure components targeted in this study is still beneficial. It is therefore necessary to review the infrastructure development of the N-S Railway considering the future opening of HSR.

Chapter 7 Economic and Financial Analysis

7.1 Project Formulation

The selected prior projects described in the previous chapters are spread across various locations on the N-S Railway. Accumulation of estimated project cost and chainage of those project sites are as shown in [Fig. 7-1-1].



Source: Study team

[Fig. 7-1-1] Chainage and Accumulated Cost for the Priority Projects

As shown in [Fig. 7-1-1], these projects are divided into three (3) groups, namely Group 1, Group 2, and Group 3.

Group 1 consists of 14 bridges and one (1) tunnel, the nearest site to the largest economic zone of HCMC among the three (3) groups. It is located between chainage KM 1215 and KM 1699, and includes the biggest tunnel improvement project at KM 1227.

Group 2 consists of 25 bridge projects with a length of approximately 300 kilometers, located between chainage KM 810 and KM 1085. Those bridges are located in short intervals.

Group 3 consists of seven (7) bridges, with fewer projects within the longer route distance of approximately 360 kilometers.

From the viewpoint of the scale of budget for railway improvement, efficiency of project management, etc., it is viable to combine those project groups into two (2) components. Furthermore, priority is determined in consideration of the characteristics of each area such as population, potential for economic growth, and future demand attraction produced by coming HSR projects.

Therefore, these priority projects should be combined into two (2) components, namely Component 1 from KM 1215 to KM 1699, and Component 2 from KM 285 to KM 1085. If the two components are implemented separately, the target year for completion of Component 1, HCMC side, is 2020, and 2025 for Component 2.

[Tab. 7-1-1] Description of Project Components

	Component 1	Component 2
KM Start	KM 1215.876	KM 284.655
KM End	KM 1699.860	KM 1085.982
Bridge (Number and Total Length)	15 (Total L= 1283.5m)	32 (Total L= 2224.4m)
Tunnel (Number and Total Length)	6 (Total L= 2442m)	-
Total Project Cost (Million USD)	52.82	72.66
Total Savig Time (sec)	969.68	1,652.87

Source: Study Team

7.2 Project Cost

7.2.1 Construction and Procurement Cost

As described in Chapter 6, cost for construction, procurement and land acquisition are summarized as shown in [Tab. 7-2-1]. These costs are nominal prices and include tax and duties.

[Tab. 7-2-1] Cost for Project Components

Unit: Million USD

	Component 1	Component 2	Total
Permanent Works	52.8	72.7	125.5

Source: Study Team

7.2.2 O&M Cost for New Infrastructure

Annual O&M Cost of the infrastructure is assumed at 3.0% of the cost for permanent works.

[Tab. 7-2-2] O&M Cost for Project Components

Unit: Million USD

	Component 1	Component 2	Total
Maintenance Cost	1.6	2.2	3.8

Source: Study Team

7.2.3 Other Conditions

Project cost includes other ancillary costs such as consulting fee, administration fee and physical contingency. The following conditions were reflected in the project cost calculation:

- **Land Acquisition Cost:** not considered
- **Consulting Fee:** 5%
5% of construction and procurement cost is the usual rate applied to calculate consulting fees in large scale investment projects undertaken using a Japanese Loan.
- **Administration Fee:** 10%
10% of Consulting Fee
- **Physical Contingency:** 5%
5% of Base Cost + Consulting Fee

7.2.4 Separation into Local and Foreign Portions

For conversion of financial cost to economic cost, it is necessary to deduct tax and subsidies from the local portion of the project cost. The above project cost is separated into local and foreign portions by applying a ratio for each category of cost as shown in [Tab. 7-2-3].

[Tab. 7-2-3] Ratio of Local/ Foreign Portion

	Local Portion (%)	Foreign Portion (%)
Permanent Works	70	30

Source: Study Team

7.2.5 Calculation of Economic Cost and Financial Cost

For economic analysis, financial costs are converted to economic costs by deducting the tax and subsidies and applying a standard conversion factor (SCF) to the portion of non-trade goods.

- **Standard Conversion Factor (SCF): 0.9**

For the calculation of the economic cost, a standard conversion factor (SCF) is applied to the portion of non-trade goods. The SCF is determined by referring to the value adopted in a recent World Bank project in VietNam.¹

- **Value-added Tax (VAT): 10%**

VAT included in the financial costs is transferred from investors to the National Treasury. Therefore, VAT is deducted from the financial cost of the local portion of the project cost.

For the financial analysis, financial costs shall be converted into nominal costs by reflecting the inflation of prices in VietNam. It is necessary to take inflation of financial cost into account; however, both the inflation rate and exchange rate have recently been very volatile due to the influence of the world economic situation in the past decade. Therefore, in the adoption of the median of 10 years, the inflation factors of 7.5% for the local portion and 1.5% for the foreign portion are applied for converting project cost to nominal cost.

[Tab. 7-2-4] Applied Inflation Factor for Local and Foreign Portions

											Unit: %
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Median
Inflation Factor	8.82	6.7	12.63	19.89	6.52	11.75	18.13	6.82	6.04	6.3	7.82

											Unit: %
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Median
USD Price Index	1.69	1.57	0.56	0.95	0.62	2.35	9.17	7.63	8.47	0.18	1.63

Source: IMF - World Economic Outlook Databases and GSO, arranged by Study Team

Based on these assumptions, the economic cost and financial costs for project components are calculated as shown in [Tab. 7-2-5].

¹ Source: Feasibility Study for Promotion of International Infrastructure Projects in FY2009, Study on the Elevating of Urban Railway in Ho Chi Minh City, VietNam, Ministry of Economy, Trade and Industry (March 2010)

[Tab. 7-2-5] Economic and Financial Cost for Project Components

Component 1 from KM 1215 to KM 1699, Component 2 from KM 285 to KM 1085

Unit: Million USD

		Financial Cost (2014 Price)			Economic Cost		
		Component 1	Component 2	Total	Component 1	Component 2	Total
Local	Construction & Procurement	37.0	50.9	87.8	30.2	41.6	71.9
	Land Acquisition	0.0	0.0	0.0	0.0	0.0	0.0
	Consulting Fee	1.8	2.5	4.4	1.5	2.1	3.6
	Administration Fee	0.2	0.3	0.4	0.2	0.2	0.4
	Physical Contingency	1.9	2.7	4.6	1.6	2.2	3.8
	Overall Project Cost	40.9	56.3	97.3	33.5	46.1	79.6
	O&M Cost (per annum)	1.6	3.8		1.3	3.1	
Foreign	Construction & Procurement	15.8	21.8	37.6	15.8	21.8	37.6
	Land Acquisition						
	Consulting Fee	0.8	1.1	1.9	0.8	1.1	1.9
	Administration Fee	0.1	0.1	0.2	0.1	0.1	0.2
	Physical Contingency	0.8	1.1	2.0	0.8	1.1	2.0
	Overall Project Cost	17.5	24.1	41.7	17.5	24.1	41.7
	O&M Cost (per annum)						
Total	Construction & Procurement	52.8	72.7	125.5	46.1	63.4	109.5
	Land Acquisition	0.0	0.0	0.0	0.0	0.0	0.0
	Consulting Fee	2.6	3.6	6.3	2.3	3.2	5.5
	Administration Fee	0.3	0.4	0.6	0.2	0.3	0.5
	Physical Contingency	2.8	3.8	6.6	2.4	3.3	5.7
	Overall Project Cost	58.5	80.5	139.0	51.1	70.2	121.3
	O&M Cost (per annum)	1.6	3.8		1.3	3.1	

Source: Study Team

7.2.6 Cost Schedule

Annual cost schedule, the rate of investment for each year, is assumed as follows.

[Tab. 7-2-6] Annual Cost Schedule for the Project Components

	1st year	2nd year	3rd year	4th year	5th year
Cost Schedule	15%	20%	30%	20%	15%

Source: Study Team

7.3 Economic Analysis

7.3.1 Case Setting for Economic Analysis

For economic analysis, the study cases, namely Case 1 and Case 2, are selected from a combination of project components. Case 1 is not separated into components and the target year of completion of all projects is 2019. Case 2 is separated into two phases, Component 1 to be completed in 2019 and Component 2 to be completed in 2024.

[Tab. 7-3-1] Economic Cost for Case 1 and Case 2

Case 1 (Component 1+2: All Projects in One Package): Target Year = 2020

Component 1, 2						
Year	2015	2016	2017	2018	2019	2020~
Cost Schedule	15%	20%	30%	20%	15%	0%
Total (Mil.USD)	18.2	24.3	36.4	24.3	18.2	0.0
O&M Cost (per annum)						3.1

Case 2: Component 1 (Target Year = 2020), Component 2 (Target Year = 2025)

Component 1						Component 2					
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025~
Cost Schedule	15%	20%	30%	20%	15%	15%	20%	30%	20%	15%	0%
Total (Mil.USD)	7.7	10.2	15.3	10.2	7.7	10.5	14.0	21.1	14.0	10.5	0.0
O&M Cost (per annum)						1.3	1.3	1.3	1.3	1.3	3.1

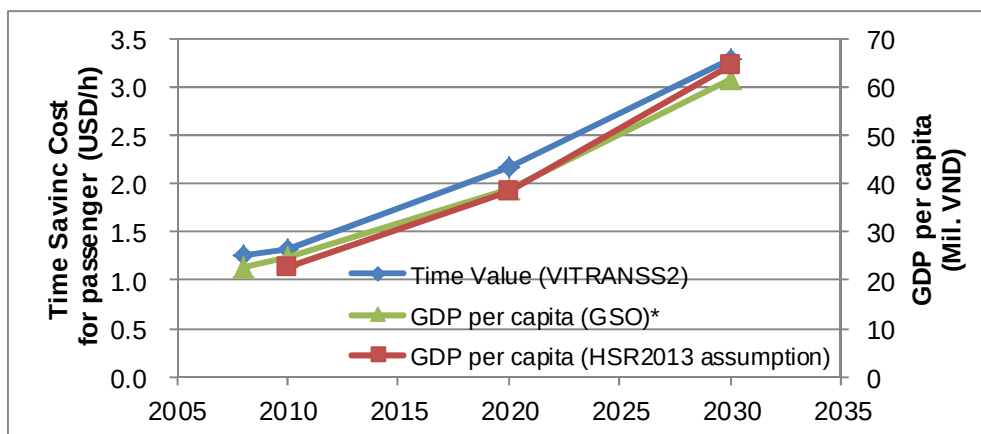
Source: Study Team

7.3.2 Assumptions regarding Economic Benefit

(1) Time Value

Economic benefit is assumed to be the passengers' time value, which was estimated based on the VITRANSS2 and HSR-F/S. The passengers' time value was assumed to grow in the future at the same rate as the GDP per capita growth. The result of the time value calculation is as shown in [Fig. 7-3-1].

The assumed time value for person-minutes is approximately 2.2 yen in 2010, 3.7 yen in 2020 and 5.6 yen in 2030. The latter value is approximately equal to one sixth (1/6) of the current time value in Japan.²



Note: GSO's GDP per capita for 2020 and 2030 is calculated at 4.7% growth, average from 2008 to 2012. GSO refers to General Statistics Office of VietNam.

Source: Study team

[Fig. 7-3-1] Time Value and GDP Growth

Minimum wage is escalated at approximately 10% every year corresponding to the inflation of consumer prices. Since the revision of the wage law in May 2013, the minimum wage is designated to the level to assure the minimum quality of life for the laborer and his/her family. According to this revision, minimum wage in 2014 is expected to be a 15 to 17% escalation from the year 2013.³

In consideration of this situation, the time value adopted for VITRANSS2 shall be multiplied by 1.5 times as shown in [Tab. 7-3-2].

[Tab. 7-3-2] Time Value for Passengers

Year	VITRANSS2 Time Value (USD/h)	Time Value for This Study	
		(USD/h)	(USD/ pax·min.)
2010	1.3	2.0	0.033
2020	2.2	3.3	0.054
2030	3.3	5.0	0.083

Source: Study Team

(2) Time Saving

Time saving value is adopted from the evaluation as described in Chapter 6.

7.3.3 Preconditions for Economic Analysis

The evaluation of the project formations is made for two (2) cases, "Case 1" is configured with the Component 1 to be completed in the year 2020, and Component 2 to be completed in the year 2025. The other case, "Case 2," is configured with both Component 1 and 2 to be

² Time value in Japan: 36.35 yen/ person-minutes (non-commercial purpose passenger car in 2008, by MLIT)

³ Reference: JBIC (August 2012), JETRO (October 2013) etc.

implemented as one component and to be completed in the year 2020.

Economic internal rate of return (EIRR), net present value (NPV), and cost-benefit ratio (B/C ratio) will be used as evaluation indicators to evaluate the economic analysis results. The economic analysis uses a discounted cash flow analysis for the cost-benefit analysis. This method compares economic benefits and economic costs.

- **Evaluation Period:** 40 Years

Project life is 40 years after the year 2020 up to 2059.

- **Social Discount rate:** 8%

This adopts a recent value applied to various projects under World Bank or JICA loan.⁴

- **Opportunity Cost of Capital:** 8.5%

This adopts a recent value applied in a railway project, with reference to the F/S for Urban Railway in HCMC, carried out in VietNam in September 2009.⁵

7.3.4 Result of Economic Evaluation for Project Components

The results of the economic analysis for the two cases are summarized as shown in [Tab. 7-3-3]. The cost-benefit ratios of both cases exceed 4.0 and EIRRs are 19.4% for Case 1 and 20.9% for Case 2. Both values exceed the above mentioned assumed social discount rate of 8.0%. Therefore, it shows that Case 2 is much more economically viable than Case 1.

[Tab. 7-3-3] Result of Economic Evaluation for Project Components

	Case 1 (open in 2020) One Component	Case 2 (open in 2025) Two Component	Unit
Cost	121,732	98,993	1,000US\$
Benefit	499,134	456,552	1,000US\$
B/C	4.1	4.6	
ENPV	377,401	357,559	1,000US\$
EIRR (upto 2059)	19.4%	20.9%	

Source: Study Team

7.4 Financial Analysis

7.4.1 Case Setting for Financial Analysis

Case setting for the financial analysis is basically the same as the economic analysis. Cost schedules for Case 1 and Case 2 are as shown in [Tab. 7-4-1].

⁴ Source: Feasibility Study for Promotion of International Infrastructure Projects in FY2009, Study on the Elevating of Urban Railway in Ho Chi Minh City, VietNam, Ministry of Economy, Trade and Industry (March 2010)

⁵ ditto

[Tab. 7-4-1] Financial Cost for Case 1 and Case 2

Case 1 (Component 1+2: All Projects in One Package): Target Year= 2020

Component 1, 2						
Year	2015	2016	2017	2018	2019	2020~
Cost Schedule	15%	20%	30%	20%	15%	0%
Local Potion	14.6	19.5	29.2	19.5	14.6	0.0
Foreign Potion	6.3	8.3	12.5	8.3	6.3	0.0
O&M Cost (per annum)						3.8

Case 2: Component 1 (Target Year= 2020), Component 2 (Target Year= 2025)

Component 1						Component 2					
Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025~
Cost Schedule	15%	20%	30%	20%	15%	15%	20%	30%	20%	15%	0%
Local Potion	6.1	8.2	12.3	8.2	6.1	6.1	11.3	16.9	11.3	8.4	0.0
Foreign Potion	2.6	3.5	5.3	3.5	2.6	2.6	4.8	7.2	4.8	3.6	0.0
O&M Cost (per annum)						1.6	1.6	1.6	1.6	1.6	3.8

Source: Study Team

7.4.2 Assumptions regarding Income

(1) Fare in the Future

Future fare revenue of VNR on the N-S Railway is assumed based on the Passenger-Km revenue and transportation for the whole of VNR.

[Tab. 7-4-2] Achieved Trip and Revenue of the whole of VNR

		Unit: Thousand VND								
	Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Freight	Transport Volume(ton)	8,281,847	8,771,002	8,687,964	9,153,244	9,019,398	8,387,424	8,159,066	7,774,757	7,197,585
	Transport Volume(ton-Km)	2,674,911,291	2,681,033,130	2,927,527,906	3,446,608,971	3,900,202,927	4,106,128,895	3,807,095,231	3,900,668,605	4,100,545,983
	Average transport distance(Km)	323	306	337	377	432	490	467	502	570
	Revenue	606,033,612	649,609,143	657,852,575	796,597,000	999,393,000	1,189,426,000	1,073,837,000	1,163,146,000	1,566,217,738
Passenger	Transport Volume(passenger)	11,586,383	12,941,137	12,768,570	11,572,796	11,571,232	11,333,806	11,072,375	11,047,729	11,981,849
	Transport Volume(passenger-Km)	4,041,713,827	4,376,385,203	4,557,622,255	4,333,651,433	4,659,483,872	4,492,260,997	4,138,054,317	4,377,860,733	4,571,080,043
	Average transport distance(Km)	349	338	357	374	403	396	374	396	382
	Revenue	1,045,758,007	1,169,779,612	1,274,293,659	1,350,693,000	1,543,225,000	1,726,433,000	1,692,411,000	1,860,482,000	2,360,291,957
Parcel	Transport Volume(ton)	103,155	107,479	98,662	91,062	95,657	92,291	88,397	86,766	87,467
	Transport Volume(ton-Km)	50,517,100	55,166,486	51,764,407	52,498,154	58,733,969	59,153,825	57,443,725	60,196,670	62,024,786
	Revenue	28,372,906	31,942,971	31,993,204	35,315,000	41,268,000	49,443,000	50,077,000	50,165,000	61,235,898
Total	Total revenue	1,680,164,525	1,851,331,726	1,964,139,438	2,182,605,000	2,583,886,000	2,965,302,000	2,816,325,000	3,073,793,000	3,992,394,842

Source: VNR

From these statistics, average fare per Passenger-Km is calculated as shown in [Tab. 7-4-3].

[Tab. 7-4-3] Average Fare

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Transport Volume (Mil. pax-km) (a)	4,042	4,376	4,558	4,334	4,659	4,492	4,138	4,378	4,571
Passenger Revenue (Mil. VND) (b)	1,045,758	1,169,780	1,274,294	1,350,693	1,543,225	1,726,433	1,692,411	1,860,482	2,360,292
Average Fare (VND/pax-km) (b/a)	259	267	280	312	331	384	409	425	516
Average transport distance (km)	349	338	357	374	403	396	374	396	382

Source: VNR arranged by Study Team

Furthermore, it is necessary to take into account increases of fare in the future. Overlooking the past trend, per Passenger-KM fare will be increased by VND 50 every 5 years. According to this assumption, the future fare is assumed as shown in [Tab. 7-4-4].

[Tab. 7-4-4] Assumed Future Fare

Unit: VND/passenger-km									
	2015- 2019	2020- 2024	2025- 2029	2030- 2034	2035- 2040	2040- 2044	2045- 2049	2050- 2054	2055- 2059
Assumed Fare	516	566	616	666	716	766	816	816	816

Source: Study Team

(2) Fare Revenue in the Future

Fare revenue in the future is assumed based on the revenue achieved as shown in the statistics above, and applies the passenger demand growth for the N-S Railway based on the forecast made by the MOT. This assumed value is based on the whole revenue of VNR, thus the revenue from the N-S Railway is calculated at the rate of 84% of the whole, which corresponds to the ratio of Passenger- Km between HaNoi and HCMC in comparison with the whole VNR Passenger- Km.

[Tab. 7-4-5] Rate of Passenger-Km for N-S Railway

Unit: Million passenger-km

	2002	2003	2004	2005	2006	2015	Rate in 2015
Domestic Total	3,697	4,042	4,376	4,558	4,336	6,175	100%
HaNoi-HCMC	3,191	3,363	3,710	3,890	3,663	5,182	84%

Note: Value in 2015 is assumed by applying trend between 2002 and 2006.

Source: Study Team based on VITRANSS2

[Tab. 7-4-6] shows the extraction of the assumed fare revenue in the future in key years.

[Tab. 7-4-6] Assumed Fare Revenue

Unit: Million USD/ year

	2015	2020	2025	2030	2035	2040	2045	2050	2055
Assumed Revenue for Hanoi-HCMC	95	154	223	300	387	482	586	659	732

Source: Study Team

(3) Other Revenue

After completion of the improvement of the infrastructure, the current maintenance cost will be replaced by the maintenance cost of the new facilities. The maintenance cost for the new facilities is accounted as a cost, but the elimination of the maintenance cost for the old facilities shall be accounted as a benefit item.

Maintenance cost for old bridges is assumed with reference to the F/S of Rehabilitation on 44 Bridges carried out by MOT. This was assumed to be 5.2 Million VND per meter in 2015 prices. It is applied for the total length of bridges focused on priority projects, and the resulting 0.846 Million USD reduction shall be considered as a benefit of the project.

On the other hand, there are no data available showing the existing maintenance expenses for tunnels. Therefore, the benefit for reduction of maintenance cost for tunnels is not taken into account in this evaluation.

7.4.3 Assumptions regarding Expense

(1) Maintenance Cost for New Bridges

The annual maintenance cost for new infrastructure is assumed at 3% of its construction cost.

(2) VNR Operation Cost

Achieved value of VNR income and expense is as shown in [Tab. 7-4-7]. As described in the above sub-section, 84% of the whole VNR expense is estimated as the expense for the HaNoi-HCMC section.

The table below shows the extraction of the assumed expense in the future in key years.

[Tab. 7-4-7] Assumption of Expense

Unit: Million US

	2015	2020	2025	2030	2035	2040	2045	2050
Assumed Expense for Hanoi-HCMC	154	191	228	265	302	339	376	413

Source: Study Team

7.4.4 Preconditions for Financial Analysis

- **Evaluation Period:** 40 Years

Duration of loan repayment, 40 years from the year 2020.

- **Opportunity cost of Capital:** 8.5%

This adopts a recent value applied in a railway project, with reference to the F/S

for Urban Railway in HCMC, carried out in VietNam in September 2009.⁶

7.4.5 Result of Financial Analysis for Project Components

The results of the financial analysis for the two (2) cases are summarized as shown in [Tab. 7-4-8]. The B/C ratios of both cases exceed 1.0 and FIRR are 10.8% for Case 1 and 11.2% for Case 2. These values exceed the above mentioned assumed social discount rate of 8.5%. Therefore it shows that Case 2 is much more economically viable than Case 1.

[Tab. 7-4-8] Result of Financial Evaluation for Project Components

	Case 1 (open in 2020) One Component	Case 2 (open in 2025) Two Component	Unit
Cost	2,933,438	2,907,870	1,000US\$
Benefit	3,128,603	3,120,569	1,000US\$
B/C	1.1	1.1	
ENPV	195,166	212,699	1,000US\$
FIRR (upto 2059)	10.8%	11.2%	

Source: Study Team

7.5 Conclusions and Recommendations

According to the results of the economic and financial analysis, Case 2, that is separation of project implementation into two (2) components, is much more economically viable than Case 1. Both economic and financial viability seem totally adequate for the project life of 40 years. However, since the difference is not as large as the scale of calculation analysis and considering the reasons described in 6.4.3, one component implementation of the Case 1 is recommendable.

It is noted that the above result is a preliminary analysis for selection of the most optimum options for formulation of the priority project, and calculations are made with various assumptions under various constraints. Therefore, it is necessary to undertake further detailed analysis of economic and financial viability of the project in the F/S stage.

⁶ Source: Feasibility Study for Promotion of International Infrastructure Projects in FY2009, Study on the Elevating of Urban Railway in Ho Chi Minh City, VietNam, Ministry of Economy, Trade and Industry (March 2010)

Chapter 8 Railway Transportation Quality

8.1 Operational Aspects

8.1.1 Rolling-stock

(1) Locomotives

The locomotives operated on the N-S Railway line are as shown in [Tab. 8-1-1]. Because there are many types of locomotives with different power output and the hauling capacity depends on the type of locomotive, it is difficult to unify the hauling capacity of freight trains, and thus it is difficult to control the freight train operation schedule.

[Tab. 8-1-1] Technical Data of Locomotives

No	Type of locomotive	Made in	Length (m)	Power capacity (HP)	Weight (ton)	Axle Load (ton)	Max speed (km/h)	Operation section	Fuel tank capacity (lit)	Quantity
1	D9E	USA	11.64	900	52	13 (4axle)	114	All sections	2,200	33
2	D11H	Rumania	14	1,100	56	14 (4axle)	100	DongHoi-DieuTri	2,200	23
3	D12E	Czech Republi	13.3	1,000	56	14 (4axle)	80	DongHoi-DieuTri	2,200	40
4	D13E	India	14.3	1,300	72	12 (6axle)	96	HCMC-DieuTri Hanoi - Da Nang	3,000	24
5	D19E	China	17.18	1,900	81	13.5 (6axle)	120	HaNoi-DongHoi Saigon - Dieu Tri	3,000	60
6	D20E	Germany	19.18	2,000	81	13.5 (6axle)	120	DongHoi-DieuTri	3,500	16

Source: VNR

(2) Passenger cars and freight cars

The average operating rate of VNR's rolling-stock is about 75%. However, based on the total number of passenger cars possessed by VNR and the total number of trains in operation, the operating rate of passenger cars seems to be less than 70%.

According to VNR's operation statistics on train accidents, there were 29 train accidents caused by technical problems between January 2010 and May 2014. Out of these accidents, 17 were caused by rolling-stock and all of them involved either passenger or freight cars. It seems like freight cars cause more technical problems which influence transportation quality than locomotives.

It appears that about 10% of the freight cars operated on the N-S Railway line are suspended because of breakdowns. Since it is common practice in VietNam that rolling-stock which require minor repairs are fixed on the spot and then put back into operation, the train schedule is further disturbed by adding the time spent for repairs, which also leads to worsened turnover of freight cars.

When it comes to improving the transportation capacity of the N-S Railway line, the most important thing, along with improving the railway infrastructure and facilities, is improving the rolling-stock inspection and maintenance system and operation scheduling in order to achieve a better freight car turnover. However, since freight trains are non-regular trains without a fixed operation plan, it is very difficult to make a long-term-rolling stock operation schedule.

8.1.2 Operation Planning

(1) Train Operation Time

[Tab. 8-1-2] shows the N-S Railway line trains with the shortest and longest operation

times, respectively. The shortest operation time for a passenger train is 29hours 30minutes and the scheduled speed is 58.5km/h. The average delay is about 30-40 minutes. In May 2014, the study team investigated the actual train delay by making a record of a long-distance train (SE2) from HCMC to HaNoi. The travel time from HCMC to HaNoi is 32.5hours. The train arrived at HaNoi Station with a delay of about 30minutes which is within the allowable range for long distance trains operated on single-track sections.

According to hearings with several Japanese companies doing business in VietNam, they did not point out train schedule delay as an inconvenient factor, while it is a key transportation quality factor in case of passenger trains.

Freight trains have a very long operation time due to the low scheduled speed and long idling time on route with around 30% or 40% operation time. Out of this, the time required for locomotive changes amounts to about 4.5hours, while the rest consists either of waiting time or adjustment time.

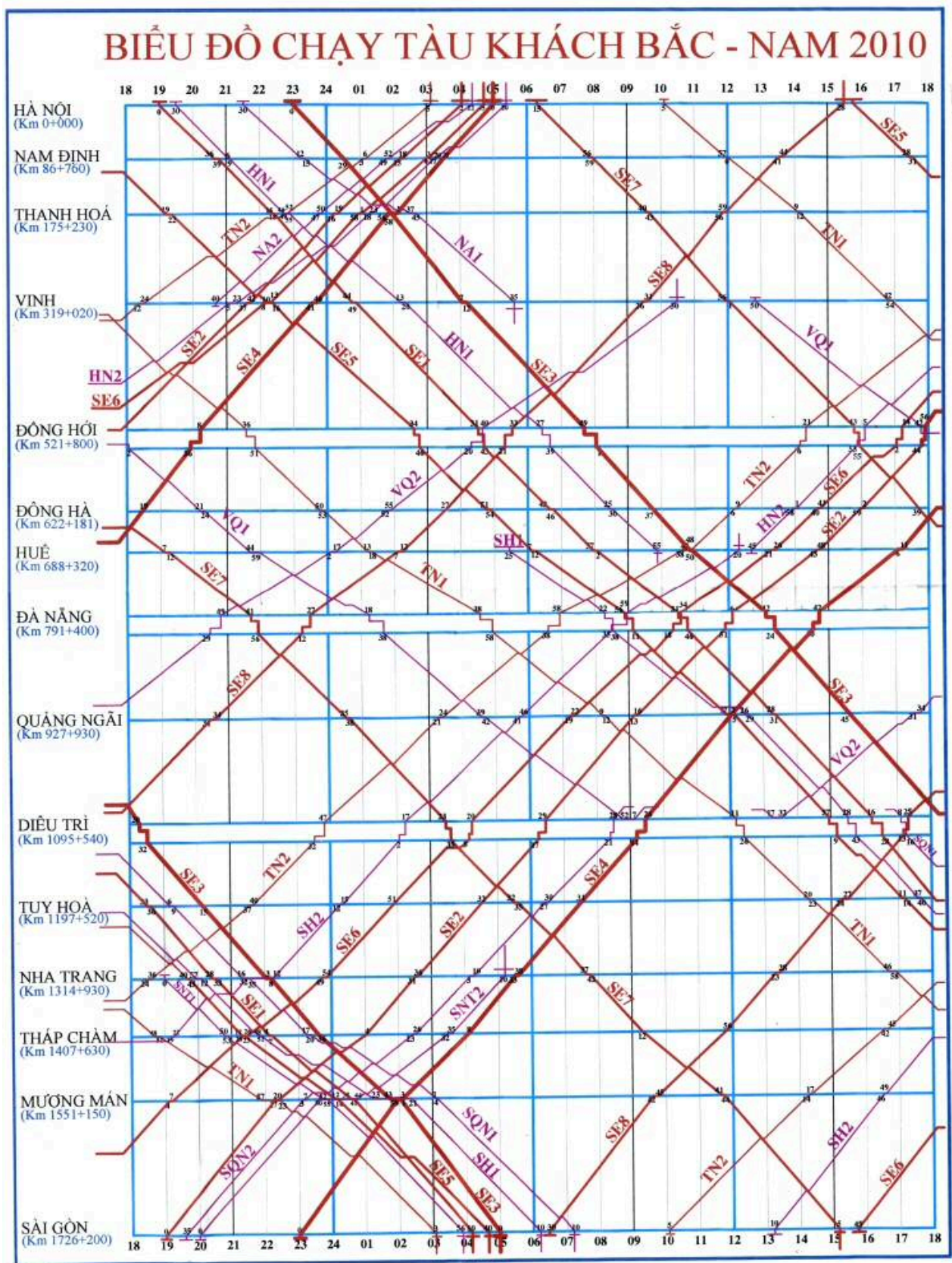
[Tab. 8-1-2] Comparison of Operating Time and Scheduled Speed

		Operation time		Scheduled speed (km/h)	Stoppage time			Remarks
					Total	Loco change	Adjustment	
Passenger	Down	Shortest	29:30	58.5	*****	*****	*****	SE3
		Longest	57:37	30.0	*****	*****	*****	SE5
	UP	Shortest	29:30	58.5	*****	*****	*****	SE4
		Longest	58:26	29.5	*****	*****	*****	SE6
	Average		41:53	41.5	*****	*****	*****	
Freight	Down	Shortest	63:31	27.1	17:30	4:00	13:00	SBN1
		Longest	78:18	22.1	29:16	5:00	18:00	GS1
	UP	Shortest	64:58	26.6	19:34	4:00	15:00	ZBN2
		Longest	78:03	22.1	26:51	5:00	18:00	GS2
	Average		70:45	24.4	23:15	4:30	16:00	

Source: VNR

(2) Train Diagram Planning

[Fig. 8-1-1] shows a train plan diagram for daily operation and [Tab. 8-1-3] is a timetable of long-distance freight trains leaving HaNoi. By comparing these two (2) sets of data, it is understood that the freight train diagram is not incorporated in the daily plan diagram. In other words, freight trains are not planned in the operation management although the schedule time is described in the timetable. It is assumed that freight train operation is not considered to be liable to comply with VNR's timetable.



Source VNR

[Fig. 8-1-1] Train Diagram (YenVien-ThiLong)

[Tab. 8-1-3] Time Table of Freight Trains (From Yen-Vien to Thi-Long)

LÝ TRÌNH	TÊN GA	SBN1	HBN1	HBN3	SY1	GS1
10+900	YÊN VIÊN				23:30	
5+440	GIA LÂM				23:57	
0+ 000	HÀ NỘI				0:17	
5+ 180	GIÁP BÁT	23:30	5:30	10:40	0:30 01:30	14:15
8+ 930	VĂN ĐIỀN	23:37	5:35	10:47	1:37	14:22
17+ 400	THƯỜNG TÍN	23:49	05:47 05:53/HBN2	11:00 11:15/HBN4	1:49	14:37 14:45/SE8
25+ 500	CHỢ TĨA	23:59	6:05	11:28	2:00	14:59
33+ 340	PHÚ XUYỀN	0:10	6:16	11:42 11:55/SBN2	02:13 02:23/TN2	15:12
44+ 670	ĐỒNG VĂN	0:25	6:30	12:10	02:39 03:04/SE2	15:30
55+ 860	PHỦ LÝ	0:40	6:44	12:24	03:20 03:47/SE4	15:48
66+ 540	BÌNH LỤC	0:55	07:00 07:06/SE20	12:38	04:03 04:19/SE24	16:05
72+ 910	CẦU HỘ	1:04	7:16	12:46	4:29	16:15
81+ 000	ĐẶNG XÁ	01:16 01:29	7:28	12:56	4:41	16:27
86+ 760	NAM ĐỊNH	01:39 02:18	7:38	13:04	4:51	16:36
93+315	TRÌNH XUYỀN	02:28 02:55	7:48	13:12 13:18/SE8	5:00	16:46
100+ 800	NÚI GÔI	3:07	08:00 08:38/HBN4	13:30	5:11	16:59 17:17/SE6
107+ 620	CÁT ĐĂNG	03:18 03:34	8:49	13:39	5:20	17:29
114+ 620	NINH BÌNH	3:46	8:59	13:49	5:30	17:40
120+ 350	CẦU YÊN	3:53	9:07	13:56	5:38	17:49
125+ 040	GÈNH	3:59	09:15 09:23/SBN2	14:02	05:46 05:52/SE20	17:56
133+ 740	ĐỒNG GIAO	4:19	9:45	14:22	6:14	18:21 18:48/SY2
141+ 500	BỈM SƠN	4:33	9:59	14:36	6:28	19:04
152+ 300	ĐỎ LÊN	4:47	10:13	14:50	6:42	19:20
161+ 000	NGHĨA TRANG	05:02 05:09	10:26	15:03	6:55	19:35
175+ 230	THANH HOÁ	05:31 06:01	10:48 11:45/SE8	15:23 15:53	07:17 07:47	19:59 20:31/HBN2
187+ 870	YÊN THÁI	06:19 06:25	12:03	16:11	8:05	20:50
196+ 900	MINH KHÔI	6:38	12:14	16:22	8:18	21:05
207+ 000	THỊ LONG	6:52	12:27	16:36	8:32	21:22 21:48/TN2

Source: VNR

(3) Train Operation Rule

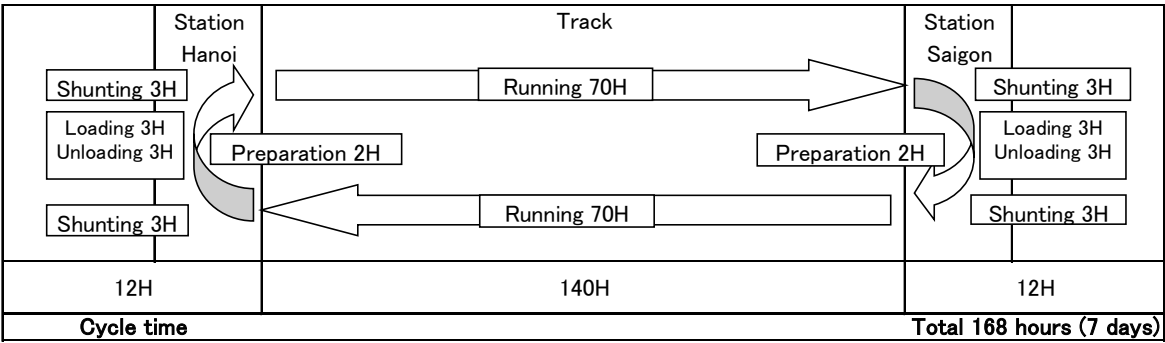
According to both railway operation companies (HaNoi passenger company and Saigon passenger company), there is no standard priority rule applied to train operation when trains are delayed due to accidents, disasters, etc. The only rule to be applied is giving priority to passenger trains over freight trains although the details are not documented. Therefore, in the event of any operational trouble, it is up to the train dispatcher to decide on which train should be given priority. In Japan, trains are classified by passenger, freight, commuter and traveling distance, etc. The priority of train operation is decided according to the train type when trains are delayed. This standard priority rule is applied nationwide in Japan.

On the other hand, because there is no standard priority rule in Vietnam, the magnitude of influence caused by train delays depends on the ability and experience of the train dispatcher. Therefore, even when transport disorders similar to ones in the past occur, the impact of the train delay is not foreseeable and the results vary wildly.

(4) Operation Planning for Freight Cars

VNR manages a total track length of 2,600km, and the 1,726km long N-S Railway line occupies around 66% of this. In total, VNR has around 4,400 freight cars, and based on the ratio of the track length it seems that around 2,900 cars are operated on the N-S Railway.

Assuming the operating rate of freight cars is 75%, it would seem that around 2,200 cars are used on the N-S Railway. [Fig. 8-1-2] shows the average cycle time of freight trains operating on the N-S Railway.



Source: Study team

[Fig. 8-1-2] Freight Train Cycle Time

Assuming an average cycle time of 168hours (7 days), the number of usable freight cars on the N-S Railway line is around 314 cars per day.

With a 48ton loading weight and an 85% loading efficiency, it seems that about 23 cars can be connected to a train hauling 1,100ton. The freight train operation records for 2011 show that 6 trains were operated per day. Based on the above data, the number of required freight cars per day on the N-S Railway can be calculated as follows:

$23 \text{ cars/train} \times 6 \text{ trains/day} \times \text{cycle time (7 days)} = 966 \text{ cars}$

Much of the freight handled by VNR consists of less-than-carload (LCL) goods (small volume cargo). Because the freight car loading efficiency drops to 65% in case of LCL, around 27 freight cars are required per train. In this case, the number of required freight cars per day becomes:

$27 \text{ cars} \times 6 \text{ trains} \times 7 \text{ days} = 1,134 \text{ cars}$

Assuming a freight car failure rate of 10%, the number of usable freight cars is around 1,980 in total.

Based on the above preliminary calculations, VNR would seem to suffer from a permanent shortage of freight cars. The following countermeasures are necessary in order to

eliminate the freight car shortage:

- Increase the scheduled speed of freight trains and shorten the cycle time of freight cars.
- Improve the freight loading efficiency.
- Provide a transport system capable of meeting customer needs.

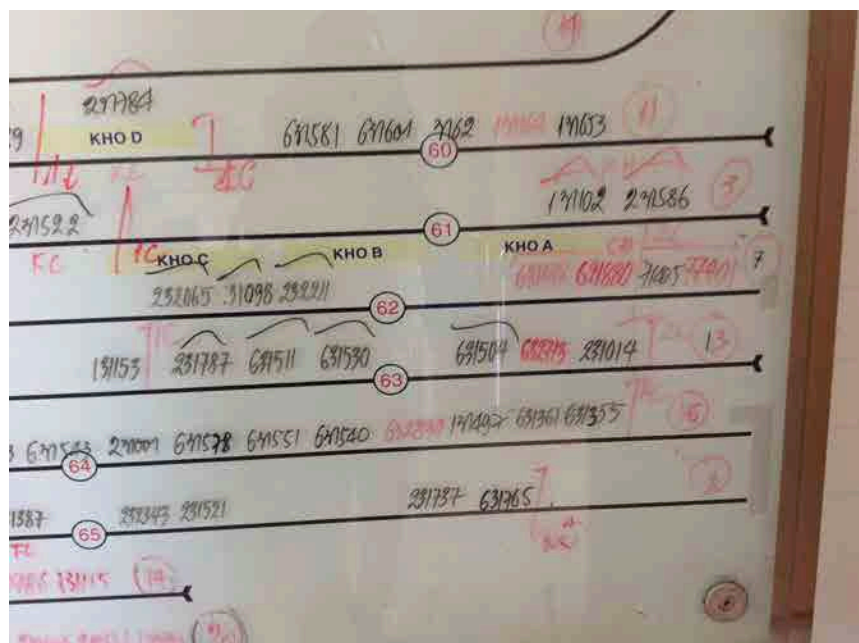
(5) Wagon Maintenance

In Japan, the occurrence of wagon breakdowns has been reduced significantly by introducing a preventive maintenance policy as part of the regular inspection process of rolling-stock (locomotives, wagons and containers). On the other hand, there is no regular inspection in Vietnam but daily check-up inspections only. As a consequence, there are numerous rolling-stock breakdown incidents.

[Fig. 8-1-3] shows a storage wagon management board found in the SongThan Freight Station in which the figures represents wagon numbers. Wagons which have broken down are marked in red color. Here, 36 wagons are marked on the board, out of which five (5) wagons are broken down. The breakdown incidence is therefore just under 14%.

Another example was found in GiapBat Freight Station where 10% or more of the wagons were broken down. Therefore, it is assumed that this is a common phenomenon found all over the country in VietNam. To make the situation worse, broken down wagons are not forwarded to rolling stock depots, and the repair work is undertaken by station staff because there is no stand-by wagons prepared for wagon shortage.

A number of broken down wagons was observed on the storage track of a station during the study team's site inspection which prevented smooth shunting work. In addition, the on-site makeshift repair work hindered the start of the cargo handling operation, because the loading area is not available if the repair work has not been completed. This is an additional reason for delays of making up freight train departure and disturb freight train schedule.



Note) The black numbers indicate wagon numbers and the red ones broken wagons.

Source: Study Team

[Fig. 8-1-3] Storage Wagon Management Board (SongThan Station)

(6) Loading and Unloading

Freight trains stop at any station for loading and unloading of the cargo, or connecting and separating wagons, depending on the request of the forwarding company. The number of freight train stops at stations increase on the way according to the requests of the forwarding company. Freight trains are delayed at each station by loading and unloading work. According to hearing to Japanese transportation companies, composite freight trains composed of box and container wagons are always delayed while container block trains are not delayed.

Since container loading and unloading work is not possible at way-stations because containers require special loading equipment, container block trains are not delayed. On the other hand, since the work is possible for box wagons, freight trains that connect box wagons are delayed.

8.2 User Service Aspect

8.2.1 Passenger Service

The most popular means of transportation in VietNam are motorcycles. Thanks to the small space required for turning and parking, motorcycle transportation has established a status as the most popular means in Vietnamese society (see [Fig. 8-2-1]). However, the increase of the number of motorcycles causes severe traffic jams and traffic accidents. In addition, the situation is expected to be exacerbated as car transportation gets popular in the future, and will become the most serious social problem in VietNam. Moreover, oil consumption in VietNam will rise with increasing car and motorcycle numbers. As a result, the affordable amount of crude oil for export in VietNam may decrease, and it may damage the trade balance as well. Due attention must be paid to cut costs for air pollution due to vehicle gas emissions. Therefore, it will be necessary to suppress the increase of car and motorcycle numbers by shifting the transportation mode toward railway to cope with the situation, and to achieve sustainable development in VietNam in the future. To that end, there are various problems to be solved for current railway transportation to promote railway use by Vietnamese passengers. The current state and problems of passenger transportation are listed below.



Source: Study Team

[Fig. 8-2-1] Motorcycles crowding on Road

(1) Accessibility to Stations

Since railway stations are located in city centers in VietNam, accessibility to stations is good for people living in urban areas on foot or by motorcycle taxi. However, for those who are living in areas far from city centers, accessibility to railway stations is not good because the distance between stations is more than 3km in urban areas and more than 10km in rural areas. Railway stations used to be places where people liked to congregate when the population size was small, but they are becoming places where people like to congregate. Now, the question is how to provide accessibility to railway stations for those living far from railway stations and how to provide mobility for those wanting to reach destinations far from railway stations. Currently they are not provided at railway stations and it will be an issue in the future when the population will grow and livelihood areas will expand. Unless accessibility to railway stations from surrounding areas of cities is improved, passenger volume growth is not expected.

(2) No Frequent Service of Train Operation

If train service is not convenient for passengers, it will not be used. Passengers will not prefer railway transportation if it is not convenient in terms of train schedule and time accuracy. Current train operation frequency is scarce and inconvenient. It is wrong to imagine that the number of trains shall be increased only after the number of passengers is increased. On the contrary, the number of passengers will increase because the number of trains has been increased.

(3) Poor Seat Reservation and Sales System

Use of the Internet is getting much more popular as cellular phone use is getting common. Wi-Fi communication areas are expanding in cities, and Internet service is becoming a part of people's everyday life. However, seat reservation for long-distance trains is not available, and passengers must visit station or travel agents to buy tickets. On the other hand, airline tickets including LCC together with occupation status and confirmation information are available on the Internet. The railway ticket sales system is much less developed compared with the system for airlines.

(4) Obsolete Railway Facilities

Long-distance train cabins are places where travelers spend a long time. However, the sanitary conditions are insufficient, and facilities such as rest rooms are becoming outdated and inconvenient. No attention at all is paid to passenger riding comfort. Unless the environment to spend time in the wagons for passengers is not improved, passengers will not use train service any more. It is therefore useless to try to improve only train speed.

8.2.2 Freight Service

In VietNam, the amount of distribution is increasing along with economic growth. Distribution is equivalent to blood vessels for an economy. Production at factories and sales at shopping centers will not work as long as the distribution system is not established. In the same way as for passenger transportation service described in section 8.2.1, railway freight transportation service is a crucial factor for sustainable development in VietNam in terms of road congestion alleviation and air pollution reduction by suppressing the increase in truck transportation. A social cost must be paid if no action is made to cope with this problem.

Recently, truck transportation cost is rising due to overload control which is getting stricter (see [Fig. 8-2-2]). Accordingly, production costs are rising as well. The production cost rise will hamper the competitiveness of VietNam in the global market. Therefore, excessive increase of truck transportation costs will become a factor obstructing the economic growth of VietNam. As for railway freight transportation, the cost advantage is growing because of the the rising costs of truck transportation. Now, the railway freight transportation is required to become a central player for the Vietnamese distribution infrastructure by solving problems

pertaining to railway freight transportation.



Source: Study Team

[Fig. 8-2-2] Truck Overloading Control

Current conditions and the pertaining problems of railway freight transportation are listed as follows.

(1) Deterioration of Equipment

There is a lot of equipment which is deteriorated and broken—not only railway track equipment but also warehouse facilities and material handling facilities. Persons in charge who operate the equipment on site can most correctly judge which equipment to upgrade according to priority. However, the companies which manage the equipment and the companies which actually manage it are divided in VietNam. Therefore, it is thought that necessary equipment replacement management is not enforceable.

(2) Shortage of Vehicles and Inspection Facilities

Because transport demand cannot be met due to the shortage of wagons, when wagons are broken down, there are no available standby wagons. Moreover, because the number of vehicle inspection facilities is not enough, it takes a long time to replace broken down wagons and repair them. Therefore, there is no choice but to repair broken down wagons temporarily at a nearby stations and and used them again. Therefore, inefficient wagon operation and train operation delays are daily events.



Source: Study Team

[Fig. 8-2-3] Damaged Warehouse (GiapBat Station)

(3) Lack of Preventive Maintenance Policy for Wagons

A preventive maintenance policy for wagons is not integrated in the regular inspection regime and by chance maintenance policy is dominating as was mentioned above in section (2). Therefore, the wagon failure rate has been rising. As a result, the freight transportation capacity and operation efficiency of the wagons are decreasing, and accidents during train operation are rising.

(4) Shortage of Loading Equipment for Efficient Container Loading

For container loading, loading equipment exclusively for containers such as reach stackers and gantry cranes is necessary. However, exclusive container use loading equipment is not installed at freight stations in VietNam (except those provided by forwarders), and container loading is done with general use cranes (see [Fig. 8-2-4]). Therefore, container loading work takes a lot of time. In addition, cargo is often damaged due to shaking during container loading work.

(5) Disjointed Management at Each Station for Freight Transportation

Each station accepts freight independently, and freight management is done by standalone personal computer systems or paper documents at each station (see [Fig. 8-2-5]). Freight transportation information is transmitted to other stations by fax. Effective freight management is therefore not possible. Moreover, information collection and distribution at department of management of freight from/to each station regarding freight operation is done manually, and timely information on the status of freight is not available. Therefore, the department of management of freight is not able to collectively control all of the cargo.



Source: Study team

[Fig. 8-2-4] Crane Used for Container Loading (GiapBat Station)



Source: Study team

[Fig. 8-2-5] Freight Transport Reception Desk (SongTang Station)

(6) Discriminatory Marketing to Freight Forwarders

The official policy is that freight from any company is acceptable for railway freight transportation according to hearings with the department of management conducted by the study team. In reality, however, only selected companies with established long term business transactions are eligible for transportation contracts according to hearings conducted at stations. It is assumed that the railway freight transportation market is closed and available only to limited members and outsiders are discriminated against.

8.3 Recommendations and Candidates for Technical Assistance

Suggestions for improvement are described here based on the problems mentioned in section 8.1.2 and 8.2.

8.3.1 Train Operation

(1) Clarification of Diagram of Freight Train

Regarding freight trains, it is necessary to designate stations where wagons are connected and disconnected in the freight handling plan, and to prohibit freight handling work at stations not designated in the plan. It is necessary for freight trains to stop at stations where loading and unloading work is planned, and the plan shall be made public for user convenience.

(2) Conceptual Change for Freight Train Schedule

It is necessary for the railway management to establish a rule to make train schedules regardless of passenger or freight trains, while the rule is currently applied for only passenger trains, so that train schedule disorders or accidents are quickly monitored and restored.

(3) Preventive Wagon Maintenance

It is necessary to decrease the wagon failure rate by changing the maintenance concept of regular inspections and introducing a preventive maintenance concept as part of the regular inspection regime.

(4) Wagon Inspection and Repair at Major Freight Station Depots

It is necessary to equip inspection and repair depots at major freight stations so that any trouble occurring to wagons can be checked and spare wagons quickly deployed while doing

minor repairs before forwarding wagons for major repairs.

8.3.2 Passenger Handling

(1) Passenger Access to Stations

It is necessary to provide passenger access to stations. Specifically, access routes for buses to arrive at and depart from stations, and bicycle and motorcycle parking space near stations. Particularly, it is necessary to provide bicycle and motorcycle parking in station premises where passengers can get on buses or trains, so that the idea of "Motorcycle is a transportation mode used from the home to the station", "Train is a transportation mode used from stations to stations", and "Bus is a transportation mode used from the station to the destination" will be established. This style of public image must be established by making stations into transportation hubs.

(2) Enhance Operation Frequency by Regular Train Setting

It is wrong to set the train schedule based on actual passenger numbers. It is necessary to think about setting the train schedule according to passenger convenience. If this idea is applied, it is effective to set train schedule at fixed regular time schedule. Train operation frequency will increase by setting such a train schedule. There might be few passengers in the beginning, but the number of passengers will increase when passengers are informed that frequent train service is available with a fixed regular time schedule every day, and passengers start to purposely use trains.

(3) Seat Reservation and Ticket Sales System

It is necessary to provide information for passengers on seat availability of long-distance trains on the Internet. Confirmation whether train tickets which passengers want shall be able to be bought not only at train stations or travel agents but also on the Internet. Passengers should only come to the station when they actually get on the train and getting train tickets issued at the station.

(4) Station and Passenger Wagon Accommodation

Passenger service quality improvement should be judged by listening to the opinions of station staff who attend passenger and railway accommodation in stations and passenger wagons should be upgraded according to passenger's satisfaction ratings. It is necessary to modernize passenger accommodation for passengers such as rest rooms, waiting rooms, and seats. VietNam has a lot of travelers from abroad. Travelers from industrialized countries are used to use comfortable accommodation in stations and passenger wagons in their home countries. It is necessary to conduct hearings in order to decide which accommodation should be upgraded to improve service quality. Moreover, currently motorcycles are allowed to run in station premises (see [Fig.8-3-1]), but this is dangerous for passengers and may break railway equipment. It is therefore necessary to prevent motorcycles from encroaching into station premises.



Source: Study team

[Fig. 8-3-1] Motorcycle Running on Platform

8.3.3 Freight Handling

Regarding railway freight transportation, box wagons are the major means for bulk transportation. Bulk transportation using box wagons entails loading and unloading work at arrival and departure stations. Since cargo handling operation is currently done by manpower, it is inefficient and requires a lot of time (see [Fig. 8-3-2]). On the other hand, since the chance of loading work in case of truck transportation is only in collection and delivery of cargo, it is efficient with a shorter loading time. No matter how much the train speed is raised in the future, the effect of transportation time cut is very small compared with the time to be reduced by cutting cargo handling time potential which may be about a half of the present time. Considering the fact that the box wagons used in VietNam are getting outdated, it is high time to replace them by modernizing the freight transportation facilities. Conversion from box wagon transportation to container transportation is recommended, coupled with brand new container wagons instead of replacement by brand new box wagons. Considering the fact that domestic freight transport is expected to increase in the future, it is worth investigating the possibility of introducing small size domestic use containers for railway transportation.



Source: Study Team

[Fig. 8-3-2] Cargo Handling (SongThan Station)

Suggestions for freight railway transportation improvement are listed below.

- Introduce a container wagon freight transportation system for various types of standard containers including a new type of small size domestic use containers instead of replacing existing box wagons with brand new ones.
- Introduce loading and unloading equipment dedicated to containers such as reach stackers.
- Increase the number of container freight stations equipped with container yards for container loading and unloading operation.
- Introduce a nationwide railway freight management system that enables freight shippers to reserve freight trains and monitor freight transportation status.
- Provide equal opportunity to all potential railway freight transportation users in terms of the conditions of freight transportation contract.

8.4 Candidates for Japanese Technology Application

8.4.1 Landslides

There are many weak spots with respect to landslides for train operation along the N-S Railway line. JICA efforts for landslide safety monitoring which are applicable to the N-S Railway line are described in this section.

(1) Development of Landslide Risk Assessment Technology along Transport Arteries in Vietnam by JICA¹

- Cooperation Period: from November 2011 to November 2016
- Project: Technology Cooperation
- Task: Water Resources and Disaster Prevention
- Introduction of this Project

Three quarters (3/4) of the national roads in Vietnam are located on slope areas of which 30% pass through mountainous areas. Landslides due to heavy rains and typhoons are recurring every year. Because of this, Vietnam is suffering from serious damage in terms of economy and human life.

However, there are insufficient human resources specializing in landslide countermeasures at the Traffic Institute of Science and Technology, which is a research institute of MOT. Therefore, capacity building has become a pressing issue.

In this JICA technical cooperation program, joint development of landslide risk evaluation technology was focused in which human resource development is expected to be taken advantage of. As a result, this program is expected to contribute to the reduction of landslide risk along the transport arteries in VietNam.

(2) On Site Visualization Monitoring (OSV)²

1) Current Status of Light Emitting Devices used in OSV in Japan

Information storing into PC regarding data collected for infrastructure condition monitoring and printing them out for reporting purposes at any later time are widely applied in Japan. As for presentation of the measured data, it is usually done via printed material or PC monitor.

¹ Source: JICA website.

² Source: JICA Special Assistance for Project Implementation (SAPI) applying on-site visualization and dust monitoring at Bangalore Metro construction site.

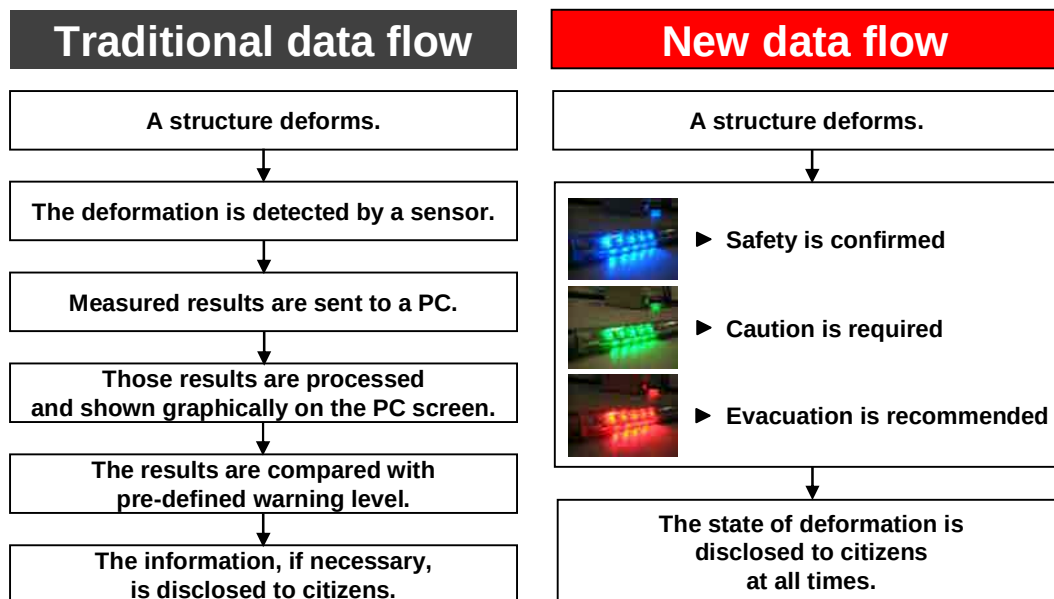
Although the time required for data processing has recently been reduced dramatically, the term “real-time” is not accurate per se, because at least several seconds are required to process raw data into visible format on the PC monitor or printed material. More importantly, what is supplied on the information about such as real time condition of deformation is not where the event is happening, but where the person in charge is watching on the PC monitor, which may be far away from the actual site. In addition, technical problems associated with data collection and transmission, or human errors in machine operation could jeopardize correct management of measured information, thus putting construction workers and neighboring households into danger if necessary information is not transmitted to them properly.

It is also the case that the majority of construction sites involving dangerous steep slopes or high walls are not monitored at all due to budget constraints. Therefore, most of us are exposed to potential dangers at those un-monitored sites since nothing is measured, and therefore, nothing about them is known.

Use of flashing lights as a warning sign has been used for many years. However, the way the warning lights have been used is somehow limited such that one or a very limited number of light devices are used to activate warning lights when pre-determined conditions are met. In case of falling rock detection for example, a wide zone is monitored by a single long rope set at a certain height above ground. A piece of rock falling at an arbitrary position could be trapped by the rope or temporarily deform the rope, thus switching on the warning light. This approach could tell that something has happened, but it does not tell us exactly where the rock has fallen, how much deformation has occurred before the rock fall, or if there is any similar dangerous location on the slope and so on. Therefore, it can be said that both the quality and the quantity of information that can be gathered and transmitted to us using this traditional method are in many ways very limited.

A totally new approach designed for infrastructure monitoring has been proposed by Professor S. Akutagawa of Kobe University in Japan in 2006. What characterizes this new approach is the use of “light emitting sensors”. For example, a new deformation sensor used in this approach is capable of: 1) measuring displacement and 2) showing it by the designated color of LED (Light Emitting Diode) in real time. The same concept can be applied to monitoring of strain, inclination, earth pressure, water pressure, temperature, etc. Since these new devices are equipped with a light emitting function or used together with specially designed data converters with light emitting capability, the monitored data are translated in real time into colored light visually identifiable by workers and inhabitants. In comparison with the traditional method in which the monitored data are basically processed by data loggers or PCs, the new method using light emitting sensors could lead to the establishment of a totally new approach for the safety monitoring of infrastructure. The new approach is termed “On-Site Visualization”. Prof. Akutagawa and his associate member companies (general contractors, consultant companies and manufacturers) established a research consortium in January 2010, which aims for the development and deployment of effective light emitting sensors and relevant strategies to promote the concept of the OSV in wide engineering disciplines.

Traditional monitoring and monitoring by OSV are compared in [Fig. 8-4-1].



Source: JICA SAPI on Delhi Metro and JICA SAPI on Bangalore Metro
 S. Akutagawa, On site visualization as a new paradigm for field measurement in rock engineering,
 Proceedings of ISRM INTERNATIONAL SYMPOSIUM AND 6th ASIAN ROCK MECHANICS
 SYMPOSIUM, New Delhi, India (Keynote).pp, KN34-45, 23-27 October 2010
 [Fig. 8-4-1] Comparison between Traditional Monitoring and OSV

2) Current Status of Light Emitting Devices used for OSV

Based on the fundamental development research in 2006 at Kobe University, Prof. Akutagawa jointly worked with a partner company in the OSV consortium, to manufacture the first model of Light Emitting Deformation Sensors, LEDS for short, in 2007. Since then, the member companies started development of various light emitting sensors. [Fig. 8-4-2] shows six (6) different types of sensor, each of which is briefly described hereafter.



Light Emitting
Deformation Sensor



Light Emitting Deformation Sensor
For Rockbolt



Light Emitting Deformation Sensor
For Ground anchor



Light Emitting
Inclination Sensor



Light Emitting Converter +
Arbitrary Sensor



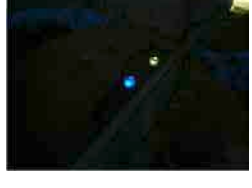
Laser Pointer

Source: JICA SAPI on Delhi Metro and JICA SAPI on Bangalore Metro
 [Fig. 8-4-2] Light Emitting Sensors Developed by the OSV Group

[Tab. 8-4-1], [Tab. 8-4-2] and [Tab. 8-4-3] explain summaries of: 1) application of LEDS at Kobe University as basic experiments, 2) application of LEDS in the field, and 3)

application of LEC in the field respectively. [Fig. 8-4-3] shows the locations of these activities in Japan.

[Tab. 8-4-1] Experiments Conducted at Kobe University

Photo	Description
	Simulation of Landslide Student-hand-made LEDSs were used to simulate landslides. Four wood panels were prepared to represent moving blocks of the slope while three LEDSs were installed with the initial color of white. As one of the panels was moved, the induced displacements were picked up by the LEDS, and their color changed from white to blue. This was the very first on-site visualization experiment using the LEDS made by students.
	Simulation of Rock Fall A rock net was supported by LEDS so that trapped rocks would pull the net, and therefore pull the LEDSs to change their color. Like in this example, LEDSs can be used as part of support structures of various forms used in engineering applications.
	Visualization of Water Flow An LEDS was affixed to a structure at one end, and the other end was put in a stream of water flow. As the flow speed increases, the tension in the LEDS increases, enabling real-time representation of flow speed as the color of LEDS. A similar practice would make it possible to visualize wind using the LEDS.
	Watching Scaffolding at a Construction Site Scaffolding is generally used at most construction sites. Materials used vary nation by nation. In this example, steel pipes are used as main structural elements of the scaffold, which was covered by wind breaking sheets. Four LEDSs were used to monitor any unexpected movement of the scaffold structure to visualize the safety condition of the construction site.
	Watching Structural Damages During Earthquake In the event of an earthquake, LEDSs installed on any structure can perform as a real-time deformation viewer during the quake, and as an automatic structural damage viewer when the quake shock finishes. As judging the danger level of the buildings in an earthquake-hit urban area is very demanding, in terms of man power and time, the LEDSs can be used as automatic damage viewers.
	Monitoring Soil Wall Failure by Light Emitting Inclination Sensor Light Emitting Inclination Sensors, initially hand-made by students, were used to visualize soil wall failure. Heavy rain or earthquakes cause damages in various forms to residential areas. In this experiment, several LEIS were installed before the soil wall was intentionally damaged. After the damage, only the LEIS in the damaged zone were lit up showing the zone of severe damage. This type of application shows the use of light emitting sensors during natural disasters can help identify the area of damage quickly and make rescue operations more effective.
	Visualizing Bridge Inclination by Laser Beams Laser pointers were used as alternative Light Emitting Sensors. As a laser pointer can be fixed to the selected point of a structure, the subsequent movement or inclination of that particular point can be visualized as a shift of the laser beam spot on a screen properly set up at a distance. Installation and visualization of a laser pointer is relatively simple and this method is recommended to be used at night as you get the maximum visibility of the laser beam spot.

Source: JICA SAPI on Delhi Metro and JICA SAPI on Bangalore Metro

[Tab. 8-4-2] Examples of Field Application of LEDS (Part 1)

Photo	Description
	Safety Monitoring at an Open Cut Excavation Site Safety monitoring was performed at a late stage of a tunnel construction site. The tunnel was constructed by a cut and cover method and the LEDSs were mounted between the retaining wall and steel columns to monitor what they call “unexpected small displacement”. While a worker loosened one of the strut beams, the closely positioned LEDSs changed their colors showing to everyone around that the movement occurred just by a small amount within a range of assured safety.
	Monitoring an Old Shotcreted Slope An old shotcreted high slope was chosen as a test case to install LEDSs for the first time in the field. Four LEDSs were installed, each measuring displacement between two points approximately 5 m apart. As the site was by a national roadway with substantial traffic, lighting up of LEDS was only allowed during a limited time in the evening. However, the visibility of the LEDSs installed in the range of 100 m or more was excellent. This was a good example to demonstrate how the use of LEDSs could help maintenance works, since the safety over a wide area can be checked at a single glance.
	Monitoring Tunnel Convergence (Hokkaido) LEDSs having a 1 m long light-emitting part were used to monitor extra convergence displacement of a tunnel in which soft and squeezing ground conditions were observed occasionally. LEDSs were installed on its side wall to ensure the further displacement after extra reinforcement of shotcrete was confined to its minimum level.
	Monitoring of a High Slope at a Tunnel Portal Stability of a high slope just outside of a tunnel portal was monitored by two LEDSs. To ensure additional visibility of the LEDSs, an optional LED unit, cabled from the original sensor, was hung on the sidewall of the tunnel entrance.
	Safety Monitoring During Repair Work Part of a concrete lining was damaged due probably to environmental factors such as underground water or aging concrete. To ensure safety during repair work of the damaged section, LEDSs were installed to visualize deformation during the work involving some drilling into the damaged rock mass.
	Tunnel Loading Experiment A scaled-down experiment was conducted to load tunnel lining concrete to its final state. While oil jacks gave loading to the lining, three LEDSs were mounted to monitor deformation during the test.
	Monitoring Reinforced Soil Wall During Road Tunnel Construction An LEDS was installed between the reinforced soil wall and a steel column to ensure that the construction works nearby did not affect the reinforced ground. As this site was right in the middle of Tokyo in a heavily populated area with heavy traffic, maximum care had to be paid to achieve safety throughout the construction just beneath the road.
	Monitoring Landside Near a Lake An identified zone of landslide near a dam lake was monitored by an LEDS and a laser pointer. This was necessary to ensure safety during casting concrete for reinforcement piles to be constructed to stop landslide displacement.

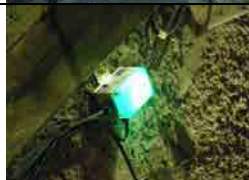
Source: JICA SAPI on Delhi Metro and JICA SAPI on Bangalore Metro

[Tab. 8-4-3] Examples of Field Application of LEDS (Part 2)

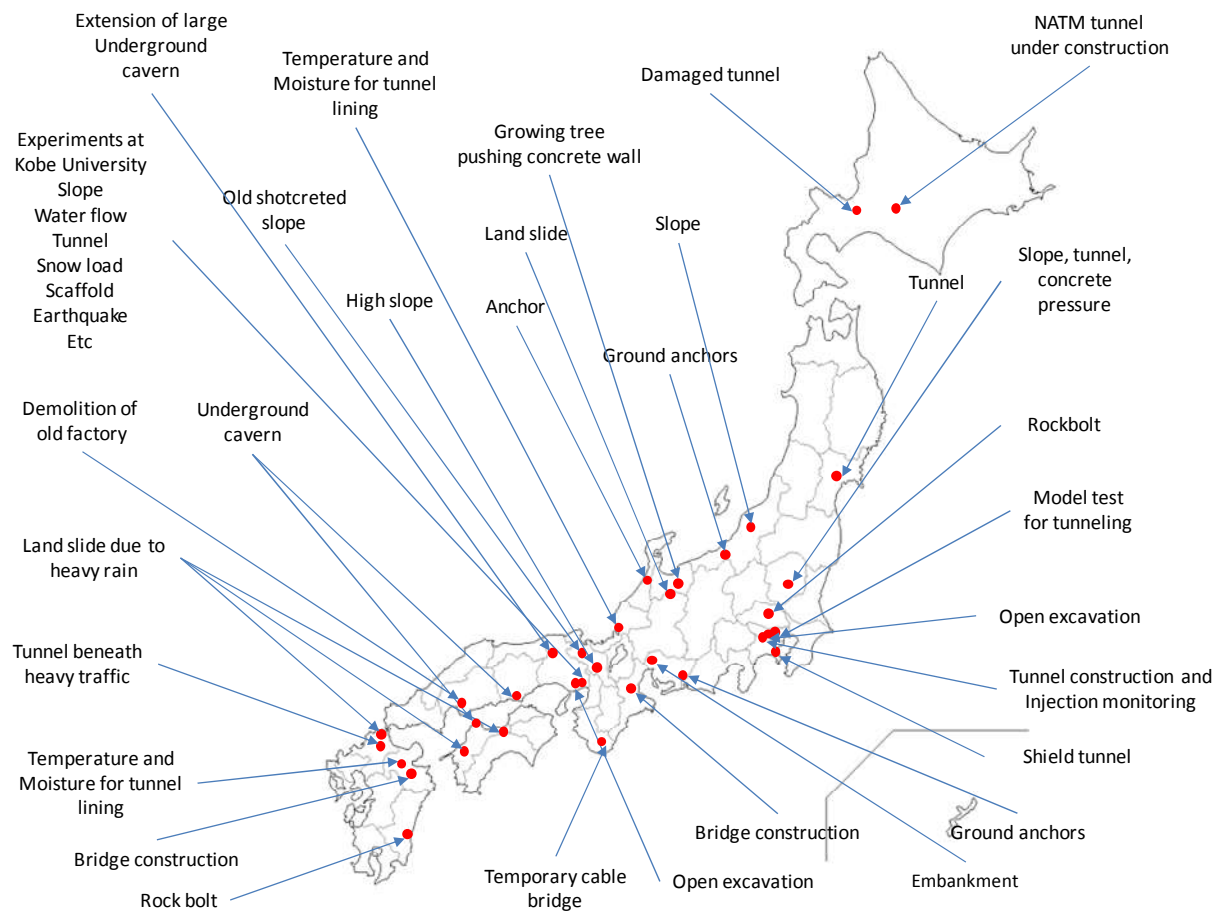
Photo	Description
	Watching Temporary Structures During Bridge Construction Several LEDSs were mounted on a temporary structure used during bridge construction. A cable suspended bridge was used as the temporary structure for which the safety monitoring was performed by using the LEDSs. The LEDSs were used to measure axial force of the main cables during construction.
	Safety Monitoring of a Wood Structure Repair and maintenance works had to be performed for one of the old facilities near a power generation plant. A wood frame that had to support a cable to be suspended over a distance of 400 m was monitored by 4 LEDSs. A specially designed optional LED board was prepared so that a machine operator was able to have a good view of 4 LED units.
	LEDS for Rock-bolts The modified LEDS for rockbolts was developed and tested in a lab. In this example, three relative displacements were measured from one rockbolt and their colors were shown in the LED unit box outside the rock mass. Further cost reduction and simplification of the device is awaited for field application.
	LEDS for Ground Anchors The modified LEDS for ground anchors was developed and tested in a lab. Generally, estimation of axial force of a ground anchor requires use of an oil jack and several men, and it is a costly practice. Once the newly developed LEDS for a ground anchor is installed, its axial force in usual condition, or after heavy rain, earthquake, etc., can be simply visualized by the color of LED attached on its cap.

Source: JICA SAPI on Delhi Metro and JICA SAPI on Bangalore Metro

[Tab. 8-4-4] Application of OSV Monitoring

Photo	Description
	Visualizing Pressure of Fresh Concrete for Tunnel Lining A portion of an NATM tunnel had to be heavily reinforced in the concrete lining. To ensure and visualize how fresh concrete is poured into the steel form through re-bars reaching to far corners, LECs were used jointly with pressure sensors so that a confirmation could be visually identified when the fresh concrete reached the pre-installed pressure sensors at the far corners in the form.
	Checking Safety During Tunneling Under Special Conditions An NATM tunnel had to be constructed with an overburden of only 30 cm due to the constraints of the project. After the top thin layer was completed as a reinforced concrete structure sitting on reinforced ground, the tunnel was driven while allowing daily traffic above. Three displacement sensors were used with LECs to make sure that the traffic load during tunnel construction was within the expected range and the tunnel structure remained safe.
	Checking Axial Forces in Ground Anchors Some movement was observed on a slope near a highway construction site. To stop its movement, additional anchors were installed while the axial forces in the existing anchors were monitored.
	Checking Temperature and Moisture Temperature and moisture were visualized during a concrete curing process. To optimize moisture and temperature during the concrete aging process, LECs were used together with moisture and temperature sensors. Workers were able to use visualized information to control their work.
	Checking Acid Content in Underground Water Water quality can also be monitored by OSV. Injection for soil reinforcement uses materials with various chemical ingredients. A pH sensor can be connected to LEC to monitor and show the acid content of underground water.

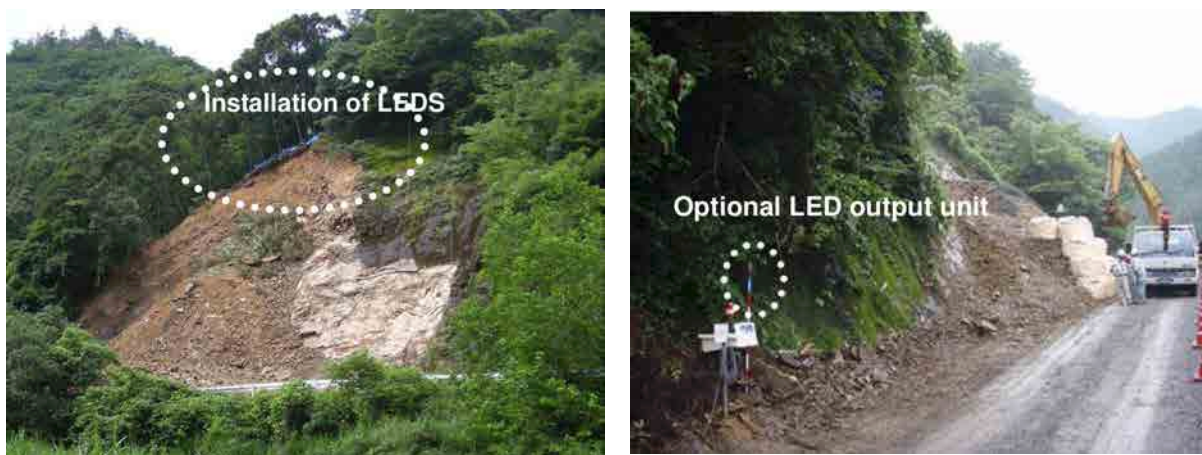
Source: JICA SAPI on Delhi Metro and JICA SAPI on Bangalore Metro



Source: OSV Consortium

[Fig. 8-4-3] Laboratory Experiments and Field Applications of LEDS

Another example of OSV monitoring application for landslides in Japan is shown in the figures below.



Watching safety after a natural disaster is also an essential requirement for successful execution of OSV monitoring. Heavy rainfall caused a landslide, and workers then had to remove the soil from the landslide to clear the road for traffic. In order to observe the stability of the landslide area, a LEDS was mounted on the upper side of the landslide area and the optional LED output unit was placed near the workers for better visual identification.

The photo was taken by DIA consulting in Ehime prefecture.

Source: OSV Consortium

[Fig. 8-4-4] OSV Monitoring of Landslide in Japan

8.4.2 Tunnels

(1) Tunneling Method

The cost estimation for the New HaiVan tunnel is made assuming that NATM (New Austrian Tunneling Method) is the most suitable tunneling method considering the geometric condition of granite and referring to the HaiVan road tunnel construction method of NATM. This tunneling method is widely applied in the world and nothing peculiar to Japan. However, since the SENS method which is developed in Japan as a combination of the NATM method shield tunneling method, the method is presented here as a possible application in VietNam in the future together with technology transfer for other tunnels.

(2) SENS Method

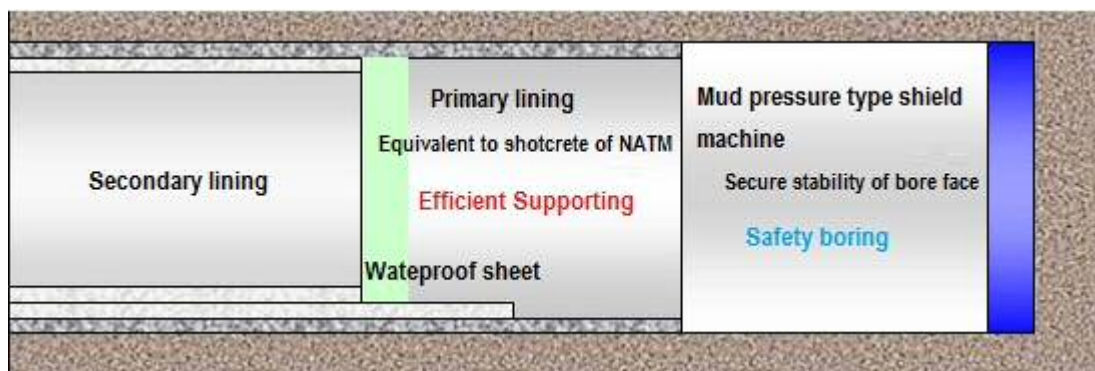
The SENS (Shield tunneling method, Extruded concrete lining, NATM, System) tunneling method was developed to cut costs and enhance safety for unconsolidated ground. This method has a combination of advantages both of shield tunneling method which is good for safety and easy construction and the NATM tunneling method which is good for cost cutting. The peculiar features of the method are summarized below.

1) Peculiar Features of the SENS Method

- Shield Tunneling Method:
Proceed tunnel excavation by securing the stability of the tunnel face using a mud pressure type shield machine.
- Extruded Concrete Lining:
While the first lining was applied by the segment automatically assembling equipment immediately after boring in the traditional mud pressure shield machine at present, the SENS method applies extruded concrete lining at the same time as boring work which is more efficient and economical.
- NATM, System:
After confirming the stability of the primary lining by a measuring device, the secondary lining is applied using water proof work and in situ concrete casting automatically at the tail section of the machine.

2) Construction Process by SENS Method

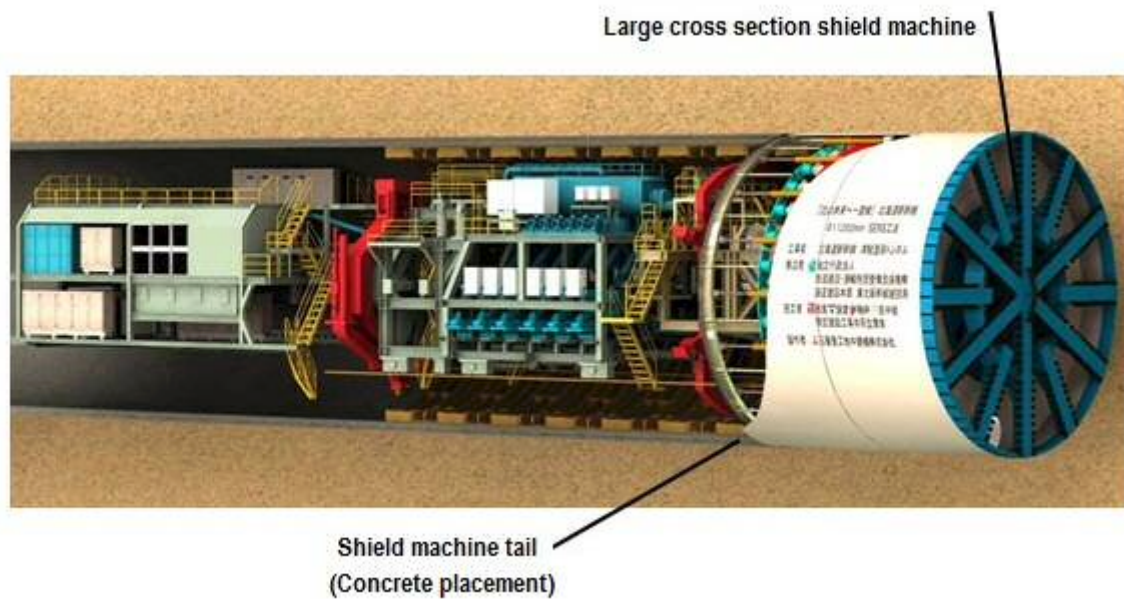
[Fig. 8-4-5] illustrates the peculiar features of the SENS method.



Source: JRJT and Kajima Corporation

[Fig. 8-4-5] SENS Method

The SENS method was first applied at Sanbongibara Tunnel (4,280m) on the Tohoku HSR Line. Thereafter, it was applied at Tsugaruyomogida Tunnel (6,190m with diameter of 11.3m) on the Hokkaido HSR Line which was an improved version of the first SENS method in terms of drilling mechanism and casting form, applicable for long distances and rapid construction. [Fig. 8-4-6] shows the mechanism of the machine.



Source: JR TT and Kajima Corporation

[Fig. 8-4-6] Mechanism of SENS Machine

The improved version of the SENS method enables minimization of the space required for the construction yard for the departure shaft and cut and cover method, shortens the construction schedule, and cuts costs by newly developed practical work of the advanced construction method in small overburden zone by large scale diameter shield machine. [Fig. 8-4-7] shows the construction site of the shield machine by the advanced departure method in small overburden zone.



Source: JR TT and Kajima Corporation

[Fig. 8-4-7] Improved SENS Shield Machine

(3) Applicability of the SENS Method in VietNam

Procurement of the SENS machine is as follows if the SENS method is applied for a tunnel construction of unconsolidated ground in VietNam.

Since the SENS shield machine for double track tunnel diameter is available only in Japan, it has to be imported from Japan. Also, machine components and work methods for

primary concrete lining by Extruded Concrete Lining in equivalent of NATM lining method are from Japan. The same is true for the advanced construction method of SENS in small overburden zone.

8.4.3 Signaling and Telecommunication

(1) Obstacle Detectors for Level Crossings

As shown in 3.1.5 (4) and 6.1.4 (2), Obstacle Detectors for level crossings would be effective from the view of safety improvement and prevention of human error by guardsmen.

Obstacle detectors have been introduced at many level crossings in Japan. Obstacle detectors automatically detect obstacles at level crossings when trains are approaching and inform the train driver by turning on special flashing signals equipped near the level crossing. Totally automatic level crossings without guardsmen are common in Japan and the obstacle detectors contribute to the improvement of safety at level crossings in Japan.

There are several types of obstacle detectors. The latest type is the “3D Laser Radar Obstacle Detector”. [Fig. 8-4-8] shows sample photos of an installation example of the system. The system emits laser pulses from its laser head, scans the detection area of the level crossing in horizontal and vertical directions, and measures the obstacle by analyzing the returned laser pulse. East Japan Railway Company and some other railway operators have actively introduced 3D Laser Radar Obstacle Detectors in recent years.



Source: http://www.ihl.co.jp/3DLaserRadar/en/pdf/3dlr_2008.pdf
[Fig. 8-4-8] Japanese 3D Laser Radar Obstacle Detector

(2) ATP

As shown in 3.1.5 (5) and 6.1.4 (3), the need for installation of ATP (Automatic Train Protection) will get larger for prevention of future big accidents and also for future speed and line capacity increase.

Almost all Japanese railway lines have ATP and Japan has much experience regarding the installation and operation of ATP. The types of ATP in Japan are roughly classified into two, the “varied-frequency-type ATS” (Automatic Train Stop) and “ATS-P” (Automatic Train Stop with Pattern). The varied-frequency-type ATS line-side system varies the oscillation frequency from ground coil according to the change of aspects of the signal, and the on-board equipment recognizes the varied frequencies as multiple signals and applies warning and braking. In contrast, ATS-P line-side equipment transmits digital information on distance to the signal, etc. through transponders, and ATS-P on-board equipment generates a speed restriction curve and controls train speed.

ATS-P has a higher level of safety thanks to speed control with speed restriction curve,

compared to the varied-frequency-type ATS. However, installation of the varied-frequency-type ATS is recommended because of the following reasons.

- The cost of the varied-frequency-type ATS is lower than that of ATS-P.
- The size of the on-board equipment of the varied-frequency-type ATS is smaller than that of ATS-P on-board equipment. The smaller on-board equipment is better because available space in existing locomotives is very limited.
- Speed control with speed restriction curve is better avoided because the limited braking performance of existing locomotives may not be able to follow the speed restriction curve.

As for the varied-frequency-type ATS, the initial type, ATS-S, was improved for higher level of safety with the addition of a function of the prevention of signal passing at danger and the function of speed checking. The various types of improved varied-frequency-type ATS has been introduced on JR (Japan Railway) lines in Japan, such as ATS-SN by East Japan Railway Company, and ATS-SF by Japan Freight Railway Company. The improved various-frequency-type ATS is recommended.

8.4.4 Rolling-stock and Operation Plan

(1) Passenger Cars

In order to improve passenger transportation efficiency and quality, diesel car type trains for regional transportation as commuter trains instead of locomotive hauling trains are recommended. Diesel car type trains is the best solution for regional transportation in terms of operation scheduling efficiency, environmental issues, and energy saving if electrification is not affordable. Here, a hybrid diesel car type train developed in Japan is the most advanced version of the diesel car type train and will contribute to the passenger transportation modernization of VNR.

(2) Freight Cars

In order to improve freight transportation efficiency and quality, introduction of container transportation is recommended, because it will enable high speed operation at the same level of passenger trains. Application of Japanese container freight car operation experience and technology which has over 40 years of operation with high speed on narrow gauge track will contribute to the improvement of VNR's freight transportation performance.

(3) Operation Planning and Operation Management

As mentioned in section 8.1 and 8.3, freight train operation is not managed based on train diagrams but on an ad-hoc basis. In other words, freight trains are non-regular type trains while passenger trains are regular type trains. In order to ensure safe and stable operation of railway transportation, all trains must be controlled by placing them as regular type trains under a unified train diagram.

Introduction of Japanese style operation management methods and technology based on a theory on train speed and hauling capacity of power unit will be effective for the improvement of train operation technology of VNR. This will also contribute to improve efficiency of crew dispatch management and to modernize the rolling-stock check-up and maintenance regime.

8.4.5 User Interface and Handling

In Japan, separation and privatization of Japanese National Railways was implemented in 1987. Railway domestic container transportation service started 50 years ago and currently container transportation accounts for about 70% of all railway freight traffic volume.

The geographical condition in both Vietnam and Japan are similar and the countries are long and narrow, stretching from the south to the north and bordering the sea. In Japan, the

railway is interconnected from Hokkaido to Kyushu via Tokyo over a stretch of about 2,000km of country size in the same way as the N-S Railway in Vietnam. The Shinkansen has long distance traveler transportation service, but freight trains running on the existing railway are responsible for freight transportation service. Freight trains run the longest distance and operate on an approximately 1,700km distance between Sapporo and Fukuoka every day.

Therefore, it is believed that knowhow and technology based on the wide range of experience in Japan can greatly contribute to the progress of Vietnamese railways. The candidate subjects that may be useful to improve the present situation are described in section 8.3 and listed below.

(1) Management Structure Re-organization

Currently, the business management company and the equipment management company are separated from each other in Vietnam. Therefore, in the event that equipment is updated based on business necessity, it is not certain that the information will be transmitted to the management company. On the other hand, the freight railway company in Japan owns complete sets of facilities and equipment such as freight stations, locomotive depots, rolling stock depots, locomotives, wagons, and containers except the main line. Therefore, once the business management organization agrees with the equipment management organization on the judgment of capital investment to improve user convenience to increase income or organizational operation to reduce costs, it will be implemented quickly. Cost reduction and income increase measures of the Vietnamese railway business will become possible if current Japanese experience is referred.

(2) Innovation of Railway Domestic Containers

In Japan, the mainstay of income of railway freight transportation is domestic service using small containers (see [Fig. 8-4-9]). The Japanese domestic railway container is designed for small size and narrow roadway transactions. Therefore, it is believed to be applicable to Vietnam where road infrastructure maintenance is insufficient. In addition, various container types such as refrigeration, freezing, tank, open, and side opening have been developed in Japan (see [Fig. 8-4-10]) depending on user requirements. This container development technology and operation/handling knowhow may be taken advantage of for the container transportation service in Vietnam.



Source: Study team

[Fig. 8-4-9] Japanese Domestic Use Container (12ft)



Wing Container



Tank Container

Source: Study team

[Fig. 8-4-10] Various Types of Container in Japan

(3) Maintenance and Operation of Container Freight Stations

In container freight stations, railway track equipment for shunting and storage purposes is needed alongside container loading and custody space in harbor container yards. Therefore, special expertise and knowhow are necessary for the design of container freight stations so that they can work efficiently. The freight railway company in Japan operates about 120 container freight stations, and has accumulated a considerable amount of experience and knowhow in designing new freight stations and improving equipment. Especially, in order to curtail stop time of trains at intermediate stations, Japanese original freight stations called "E&S freight stations" (that is, integrated arrival-departure and loading line) are designed and have been managed (see [Fig. 8-4-11]). E&S freight stations can be designed at areas that are smaller than for conventional freight stations. Therefore, it is believed that this type of station may contribute to effective freight handling not only in middle size stations but also freight stations located in urban areas where wide space is not available.

Conventional Freight Station



①Arrival → ②Uncoupling → ③Shunting → ④Loading/Unloading
④Loading/Unloading → ③Shunting → ②Coupling → ①Departure

E&S Freight Station



①Arrival → ②Loading/Unloading → ③Departure

Source: Study Team

[Fig. 8-4-11] E&S Freight Station

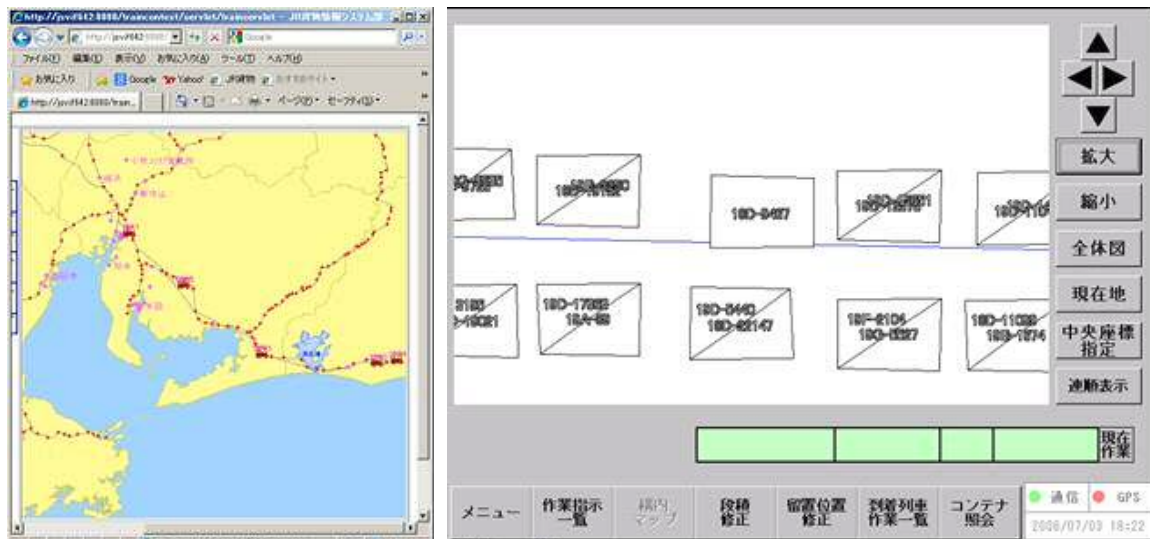
(4) Design and Management of Inspection Equipment

In Japan, preventive maintenance under regular inspection regime is practiced for all rolling-stock including locomotives, wagons, trains, and diesel railcars. About 500 freight

trains with 20 wagons on average are operated every day. However, the number of malfunctioning wagons during operation is about 20 in a year. Out of this, the number of malfunctioning due to poor maintenance is several in a year. Stringent inspection standards are established and observed regarding what kind of inspections are necessary and how frequently they shall be made in order to decrease the failure rate. Moreover, equipment development and worker education for maintenance are implemented. Considering the fact that a lot of accidents due to wagon trouble are recorded in Vietnam, regular inspection standards and knowhow on education performed in Japan might be useful to decrease accidents in Vietnam.

(5) Introduction of a Nationwide Freight Management System

In Japan, an integrated system that can manage railway container transportation in the entire country is operated. This system can manage the position and the situation of a container starting from bringing the container to the departure station to taking out the arrival station in real time (see [Fig. 8-4-12]). Moreover, cargo information such as article, weight, arrival and departure shipper, and forwarder can be shared among the entities concerned in the entire country. The department of the management section is able to identify the transportation situation at any station where the system terminal is installed. This system is also accessible to forwarders via the Internet and they can monitor the transportation situation and apply freight forwarding. The technology and knowhow accumulated by developing and operating the freight management system in Japan might be quite useful for upgrading the freight management system in Vietnam.



Running Train Location

Container Location in Freight Station

Source: Study Team

[Fig. 8-4-12] Nationwide Freight Management System

(6) Introduction of Safety Management

In Japanese railway companies, a substantial amount of the budget and personnel are allotted to safety management. The safety section investigates the cause of accidents and countermeasure to prevent accidents from happening in the future are put into practice. The basis of safety management in Japan is represented by a slogan "Mechanism making to prevent accidents occurring beforehand". Efforts to prevent accidents from happening are persistently implemented through various measures such as improvement of equipment, maintenance of rules, and implementing safety training for employees. Considering the fact that a lot of accidents occur in Vietnam which cause serious problems for railway operation, the safety management practiced in Japan might be very useful to improve the reliability of railway transportation and thus increase revenue.

8.5 Implementation Priority of Transportation Quality Upgrading

Although physical improvement such as rehabilitation of infrastructure prioritized in Chapter 5 and 6 will certainly contribute to increase train running speed and thus cut travel time between HaNoi and HCMC, this effect will be accelerated if the measures described in this Chapter are implemented. Some of the measures are basic attributes for railway operation to perform peculiar features of railway transportation vis-à-vis other modes of transportation, and others are recommended to be implemented to increase ridership, cut operational costs, and increase revenue.

However, most of the measures will not be successfully implemented by external resources alone such as ODA and therefore diligent efforts exerted by the railway operator are required, which means that collaboration of resources between the railway operator and external assistance in terms of not only fund resources but also human resources including technology and knowhow are required. [Tab. 8-5-1] and [Tab. 8-5-2] summarize candidate players to implement the measures and effects in which the measures can be either conditions for providing ODA loans, subject for the provision of technical assistance, and components for funding.

[Tab. 8-5-1] Implementation Priority of Quality Upgrading (Part 1)

Priority	Subject	VNR self-effort	Tap Japanese technology & knowhow	Candidate for Japanese ODA	Condition for Japanese ODA	Note	Traveling time reduction and train schedule rectification effect	Revenue hike	Efficiency improvement/ cost cutting	Operational rate improvement of facilities	Service quality improvement
A	Standardization of technical specification for locomotive	Yes	Yes (Technical assistance for compilation)				Yes		Yes (Due to maintenance work efficiency improvement)	Yes	
A	Establishment of inspection and repair regime based on preventive maintenance philosophy	Yes	Yes (Technical assistance for manual compilation and field training program in Japan)				Yes (Reduction of delay due to break down)			Yes (Reduction of breakdown rate)	Yes
B	Modernization of inspection and repair facilities for rolling-stock	Yes	Yes (Inspection and repair workshop tour in Japan)	Yes (Fund for workshop & depot construction)	Preventive maintenance regime needs to be established		Yes (Reduction of delay due to break down)		Yes (Due to maintenance work efficiency improvement)	Yes (Reduction of number of rolling-stock under inspection)	
C	Increase number of freight wagon	Yes	Yes (Technical assistance for freight operation table compilation)	Yes (Fund for freight wagon procurement)	Preventive maintenance regime needs to be established	Procurement under PPP scheme is an option		Yes			Yes
A	Establishment of train operational rule	Yes					Yes			Yes	Yes
B	Stimulate railway ridership increase in the urban area	Yes						Yes			Yes
B	Improve passenger train ticket reservation market	Yes						Yes			Yes
C	Modernization of passenger train coach accommodation	Yes						Yes			Yes

Note: A= Immediate implementation, B: Implement after A, C: Implement after A and B

Source: Study team

[Tab. 8-5-2] Implementation Priority of Quality Upgrading (Part 2)

Priority	Subject	VNR self-effort	Tap Japanese technology & knowhow	Candidate for Japanese ODA	Condition for Japanese ODA	Note	Traveling time reduction and train schedule rectification effect	Revenue hike	Efficiency improvement/cost cutting	Operational rate improvement of facilities	Service quality improvement
A	Modernization of loading/unloading facility of freight train	Yes		Yes (Fund for cargo handling equipment procurement and facility construction)	Freight station classification needs to be made	Procurement under PPP scheme is an option	Yes (Reduction of train departure delay due to cargo handling)	Yes	Yes (Due to station work efficiency improvement)	Yes	Yes
B	Transform to container based freight train transportation	Yes	Yes (Technical assistance for introduction of domestic use container transportation system)	Yes (Fund for container and container freight car procurement)	Freight station classification needs to be made	Procurement under PPP scheme is an option	Yes (Operation speedup)		Yes (Due to cost cutting for cargo handling)	Yes	Yes
C	Freight information sharing	Yes	Yes (Training to introduce Japanese style management system and technical assistance for management system design)	Yes (Fund for system development)	Freight station classification needs to be made			Yes	Yes (Due to station work efficiency improvement)		Yes
A	Stringent train schedule management of freight train	Yes	Yes (Training to Japanese style train diagram making and application)				Yes (Eliminate unscheduled stop on route for cargo handling)	Yes (Attract new client due to on-schedule operation)		Yes (Rational rolling-stock management plan becomes possible)	Yes
A	Classification of freight station	Yes	Yes (Technical assistance to container depot designing skill, Japanese container depot tour, training on freight station work)	Yes (Fund for station facility building)		Procurement under PPP scheme is an option	Yes		Yes	Yes (Eliminate freight car parking at stations en route)	Yes
B	Transparent freight consignment contract sealing	Yes						Yes (Attract new client due to transparent business practice)			Yes

Note: A= Immediate implementation, B: Implement after A, C: Implement after A and B

Source: Study team

Chapter 9 Socio-Environmental Verification

9.1 Legal Framework Update

Concerning the environmental legal framework for railway projects in VietNam, the latest laws, decrees, documents and related regulations are listed as follows:

- Environmental Law No. 52/2005/QH¹ dated 29 November 2005
- Railway Law No. 35/2005/QH¹² dated 16 June 2005
- Decree No. 109/2006/ND-CP³ dated 22 September 2006 for guiding the execution of Railway Law
- Decree No. 29/2011/ND-CP dated 18 April 2011 for environmental assessment works and environmental protection commitment
- Document No. 26/2011/TT-BTNMT dated 18 July 2011 for specifying some details of Decree No. 29/2011/ND-CP
- Documents of No. 28/2011/TT-BTNMT for examining noise and vibration, No. 29/2011/TT-BTNMT for examining surface water and No. 31/2011/TT-BTNMT for examining sea water
- Document No. 56/2013/TT-BGTVT dated 27 December 2013 for examining self-decomposition toilet installation on passenger wagons
- Document No. 02/2009/TT-BGTVT dated 03 April 2009 for examining quality, safety and environmental protection of railway transport means
- National Regulations on Air Quality No. 05:2008, Hazardous Atmosphere No. 06:2008, Home Sewage No. 14:2008, Industrial Sewage No. 40:2011, Noise No. 26:2010, Vibration No. 27:2010, and Hazardous Waste No. 07:2009
- Level Crossing Regulation to be issued in conjunction with Decision No. 15/2006/QD-BGTVT of 30 March 2006 of Minister of Transport
- Document No. 1665/TTg-CN dated 17 October 2006 of Prime Minister on management and performance of land acquisition and ordinance survey for transport construction projects
- Document No. 7576/BGTVT-CG dated 4 December 2006 of Ministry of Transport on land acquisition works in transport projects
- Document No. 3820/VPCP-CN dated 10 July 2007 of Government's Office on land acquisition for railway renovation, upgrading and construction projects
- Document No. 8161/BGTVT-CG dated 27 December 2006 of Ministry of Transport on execution of Document No. 1665/TTg-CN issued by Prime Minister
- Document No. 3103/VPCP-CN dated 7 June 2007 of Government's Office on performance and organization costs for land acquisition in transport construction projects

The environmental legal framework for railway projects in VietNam, therefore, is considered rather complete as a whole, due to a composition of basic laws (Environmental Law and Railway Law) and related Decrees as well as Documents for endorsing its implementation.

¹ http://www.moj.gov.vn/vbpq/en/Lists/Vn%20bn%20php%20lut/View_Detail.aspx?ItemID=5961

² http://www.moj.gov.vn/vbpq/en/Lists/Vn%20bn%20php%20lut/View_Detail.aspx?ItemID=6820

³ http://www.moj.gov.vn/vbpq/en/Lists/Vn%20bn%20php%20lut/View_Detail.aspx?ItemID=4888

Its content is considered basically proper for dealing with both fundamental issues of natural environment and social environment and covering all related aspects/items in both these issues.

In fact, these legal materials have been found with the most issuances after 2005. This implies a new approach including the formation of EIA and resettlement practices for carrying out new projects in VietNam, if so required.

Therefore, in order to improve the environmental aspects of the VietNam railway, this legal framework should be implemented step by step in an orderly manner to properly solve the critical environmental problems of the VietNam railway.

9.2 Environmental Verification

9.2.1 Lessons Learned from Past Projects

The N-S Railway, formerly known as HaNoi-Saigon railway line, was constructed in the 1830s by the French colonial regime to connect HaNoi in the North with Saigon (presently HCMC) in the South for transporting passengers and goods/raw materials to both ends by basically meandering along the National Route No.1 and making stops at all cities along its way.

Therefore, it was essentially made as a pastoral train line and, apart from two (2) short sections running in the plains of the Red River Delta in the North and South Eastern Zone in the South, the major part of this railway passes through the long and narrow coastal corridor of Central VietNam, whose middle part undulates with some mountainous passes branched from the AnNamite (TruongSon) Range such as KheNet, HaiVan, DeoCa, CuMong, etc.

Besides, as Central VietNam is formed between the AnNamite (TruongSon) Range on the West and the East Sea (South China Sea), this corridor is largely faced with monsoon climatic influences from the Pacific Ocean.

In particular, its middle part with mountainous passes from ThuaThien-Hue to PhuYen has been annually influenced by the severe climatic conditions of heavy and long rains, storms, and typhoons during the monsoon rainy seasons.

The AnNamite (TruongSon) Range is a mountain range approximately 1,100 km long, spreading from Southern Yunnan (China) towards region Central Highlands of VietNam. Its highest points range from approximately 2,500m to 2,800m. In Central VietNam, it runs parallel to the central coast in a gentle curve, dividing this corridor from Laos on the West.

Its eastern slope rises steeply, forming numerous short rivers flowing into the middle part of Central VietNam. The western slope, however, is gentle, forming high plateaus in regions of Southern Laos and the Central Highlands of VietNam.

As a matter of fact, in Central VietNam, the N-S Railway has its major part running throughout the lowland corridor, but some parts in the middle of the railway have slopes and tunnels, where annual storms, torrents and typhoons frequently cause natural calamities.

In the past, the N-S Railway had been experienced with serious damages to subgrade caused by natural calamities in this region. Particularly the section between Hue and DaNang with many slopes and tunnels on both sides of HaiVan pass has been subjected to annual storms and torrents in monsoon seasons, causing severe destructions of subgrade and periodic suspension of train operation.



Source: VN News

[Fig. 9-2-1] N-S Railway Damaged by Storm and Typhoon in Central VietNam

Besides this, due to heavy rain in monsoon seasons and uncontrolled water discharge from hydroelectric reservoirs in region Central Highlands during these periods, large areas in South Central Coast from ThuaThien-Hue to PhuYen have been subjected to frequent submersions, causing serious annual damage to human lives and property, particularly during the period from August to November.

In 2012 and 2013 (Haiyan typhoon), successive severe inundations had caused high casualties of human lives and properties as well as serious damage to railways and stations in many provinces in the area. Train operation was suspended for about one month in the area. Passengers from trains had to be transferred to bus service for continuing their travels.



Source: VNR

[Fig. 9-2-2] Flooding Situation in Central VietNam

Therefore, according to Department of Science and Technology of VNR, during the rainy seasons VNR has to collect daily weather forecasts in the region from National Centre for Hydro-Meteorology Forecasting to inform day by day the N-S Railway train conductors so they can carefully check the rail conditions before making the decision for train operation in each section. They have to substantially reduce train speed in the risky sections.

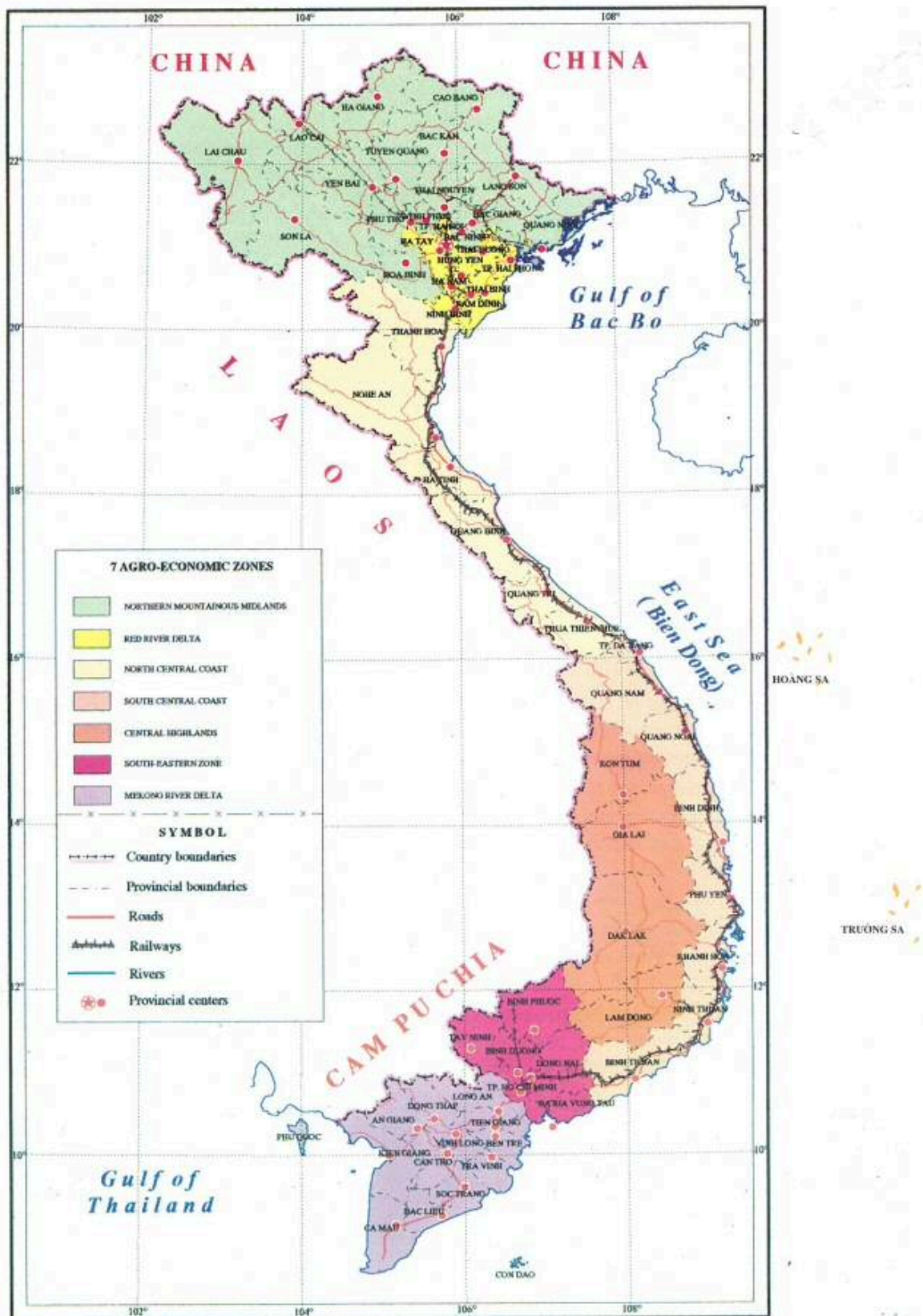
9.2.2 Environmental Concerns for the Project

VietNam is the easternmost country in Indochina peninsula. It is bordered by China to the north, Laos to the northwest, Cambodia to the southwest, and the East Sea (South China Sea) to the east.

Its landform possesses two fertile regions on both sides: the Red River Delta in the North

and the Mekong River Delta in the South. Central VietNam, however, is largely formed as a long corridor with coastal lowlands and some mountainous passes branched from the AnNamite (TruongSon) Range in the middle.

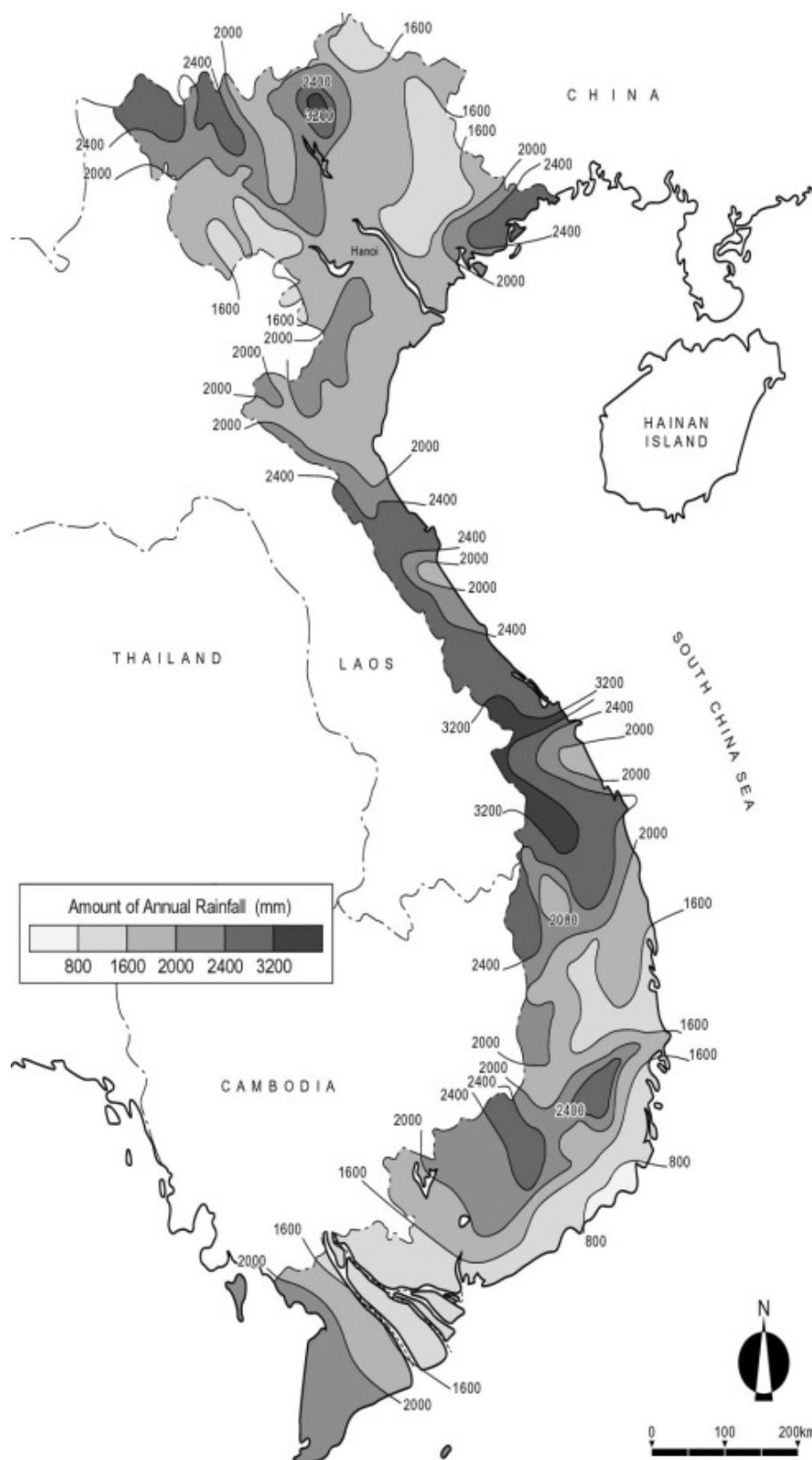
The N-S Railway passes partly through regions of the Red River Delta and South Eastern Zone at both ends, but its major part passes throughout the regions of North Central Coast and South Central Coast of Central VietNam. Its natural characteristics are shown in the following figures.



Source: VietNam Agriculture, MARD
 [Fig. 9-2-3] Seven Agro-Economic Regions of VietNam



Source: Ministry of Natural Resources and Environment
[Fig. 9-2-4] VietNam Natural Resources and Environment



Source: VITRANS Technical Report 11

[Fig. 9-2-5] Map of Rainfall Precipitation in VietNam

The N-S Railway, therefore, is found running throughout the seashore of Central VietNam by facing the East Sea (South China Sea), where the hydro-meteorological characteristics are largely influenced by the specific climatic conditions of this maritime region.

According to VITRANSS2 Technical Report 7, the climate in the North and South Central Coasts is basically transitional, influenced by the northern and southern monsoon climates but segregated by the HaiVan pass. The rainy season coincides with the northeast winds (September-December) and the dry season with southwest winds. The average annual rainfall in this region ranges between 1,500-3,000 mm, of which about 80% falls during the rainy months.

From the regional conditions of the natural environment as notified above, the most concerns for the natural environment are as follows:

- Subgrade could be damaged by seasonal storms and typhoons, particularly in the areas with slopes and tunnels in Central VietNam.
- Submersion in the lowland corridor along the seashore of the region of the South Central Coast could happen during monsoon rainy seasons.
- Besides, as the alignment of the N-S Railway line was initially set along the lowland seashore, greenhouse effects could cause an increase of the sea level in the future⁴.
- Hazards or risks to biological habitats, rare species, indigenous people, national parks, natural conservations and historical/archaeological sites could not be found in areas of the N-S Railway now.
- However, for the construction of new HaiVan tunnel as well as the move of big in-city stations such as DaNang and NhaTrang to new locations, the preparation of EIA and LARAP for related projects is considered necessary.

Another concern is the beautiful scenic views along the N-S Railway such as seashores, rivers, mountains, ecological habitats, local villages, etc. in North, South, and Central VietNam. This aspect should be carefully preserved for future developments of the N-S Railway. In the future, the operation of luxury passenger trains with special services for tourism development will certainly be necessary.



Source: Duong Sat Viet Nam

[Fig. 9-2-6] A Natural Scenic View of the N-S Railway

⁴ Study Report on Climate Changes, Sea Level Rise Scenarios for Vietnam (Ministry of Natural Resources and Environment, June 2009) http://www.preventionweb.net/files/11348_ClimateChangeSeaLevelScenariosforVi.pdf

9.2.3 Possibilities of Greenhouse Effects Reduction

According to Wikipedia, the greenhouse effect or global warming is a process by which thermal radiation by solar and infrared radiations on various gases, particularly Carbon Dioxide, Methane, Sulfuric Gases and various evaporations, emitted from the Earth's surface is absorbed in the Earth's atmosphere and then back toward the Earth's surface, resulting in a gradual elevation of the Earth's surface temperature.

At the beginning, this natural greenhouse effect made life possible with a balancing mechanism of the absorbed warming heat with airflows on the Earth's surface. However, as human economic and industrial activities on our planet Earth have been largely intensified year by year, the natural greenhouse effect could not be maintained as it was in the beginning. Earth's surface temperature has increased year by year, resulting in recent thawing of icebergs in the North and South poles.

In 2007, Intergovernmental Panel on Climate Change (IPPC) released its Fourth Assessment Report (AR4). This report implied changes in world climate such as an increase of 0.76°C in mean temperature in the period of 1906-2005 and predicted an increase in the next 50 years will be double the range of the previous 50 years. Temperature increases inland will be gradually higher than ocean temperatures, causing more big scale storms and typhoons in many regions of the world. Sea level is found increasing with a margin of approximately 1.8 mm per year.

Based on the scenarios of IPPC, the Ministry of Environment and Natural Resources of VietNam had made a report on three (3) situations of the increasing temperature and sea level in VietNam. VNR has also made a study report on related effects from to the N-S Railway. Depending on regional characteristics in VietNam, the increases were estimated at the ranges of 0.5 to 2.0°C for mean temperature and 65-100cm for sea level by end of century 21. From this situation, there are no actual risks from greenhouse effects to the present the N-S Railway, but prevention measures in the future are considered important.

The reduction of greenhouse effects, therefore, is considered necessary. However, this is a global issue. Among the factors causing greenhouse effects, only Carbon Dioxide, Methane and Sulfuric gases have been reported as major gases emitted from human activities, where Carbon Dioxide, as the major factor could be gradually and effectively reduced by the application of strict regulations and related technological researches.

Therefore, the worldwide campaigns for technical research and strict regulations for reducing the emission of these gases as well as national programs of forestation in large scale should be largely implemented accordingly. The big industries responsible for environmental damage should be internationally imposed for financial sponsorships of related researches and large forestation programs.

9.3 Social Verification

9.3.1 Social Aspects of the N-S Railway

As aforementioned, VietNam is composed of seven (7) agro-economic regions. The North South Railway of 1,726 km is found passing through four (4) regions on its north-south direction, starting from HaNoi-city of region Red River Delta in the North, passing through two (2) regions of Central VietNam (North Central Coast and South Central Coast) and ending at HCMC in the South Eastern Zone of the South.

This railway is found passing through 21 provinces. In the Red River Delta region, it passes through four (4) provinces (HaNoi, HaNam, NamDinh and NinhBinh). In the North Central Coast region, it passes through six (6) provinces (ThanhHoa, NgheAn, HaTinh, QuangBinh, QuangTri and Hue-ThuaThien) and in the South Central Coast region it passes

through eight (8) provinces (DaNang-city, QuangNam, QuangNgai, BinhDinh, PhuYen, KhanhHoa, NinhThuan and BinhThuan). In the South Eastern Zone of the South, it passes through three (3) provinces (DongNai, BinhDuong, BienHoa and HCMC).

The following table shows the major socio-environmental features of the provinces related to the N-S Railway.

[Tab. 9-3-1] Major Socio-Environmental Features of the N-S Railway

REGION (Railway Distance)	Province	Population (Density)	Major Socio-Environmental Features In Related Province/City	Main Station (Km-position)	Notes
RED RIVER DELTA (about 120km)	Ha Noi	6,844,000 (2,059/km2)	Present National Capital HoanKiem Legend Lake Many Historic Sites of ThangLong Capital	HaNoi (0km)	Red River Delta Province
	Ha Nam	790,000 (860 /km2)	Production Base of Construction Materials Ancient Temple of Truc'NguDongSon	PhuLy (56km)	-id-
	Nam Dinh	1,837,000 (1,112/kKm2)	Former National Base of Textile Industry Beach Resort Business	NamDinh (87km)	-id-
	Ninh Binh	915 (665/km2)	Ancient Capital of Dinh & Le Dynasties CucPhuong National Park PhatDiem Catholic Cathedral	NinhBinh (115km)	-id-
NORTH CENTRAL COAST (about 580km)	Thanh Hoa	3,426,000 (308 /km2)	SamSon Beach & Many Resort Sites Temple of BaTrieu	ThanhHoa (176km)	Ceoastal Province
	Nghe An	2,962,000 (179/km2)	Birthplaces of PhanBoiChau & HoChi Minh Natural Reservation of PuMat etc.	Vinh (319km)	-id-
	Ha Tinh	1,230,000 (206/km2)	Birthplace of Poet NguyenDu Pagoda of HuongTich & Temple of BichChau	-	-id-
	Quang Binh	858,000 (106/km2)	PhongNha KeBang National Park Birthplace of Gen.VoNguyen Giap	DongHoi (522km)	-id-
	Quang Tri	608,000 (128/km2)	HoChiMinh Trail in VietNam War BenHai River as Border of North-South VietNam	DongHa (622km)	-id-
	Hue-ThuaThien	1,114,500 (221/km2)	Ancient Capital of Hue World Heritage of Nguyen Dynasty Huong River & ThienMu Pagoda	Hue (688km)	-id-
SOUTH CENTRAL COAST (about 870km)	Da Nang	973,000 (758/km2)	Famous Beach Resort City Former US Marine Base VietNam Submaribe Base	DaNang (791km)	-id-
	Quang Nam	1,450,000 (139/km2)	World Heritage of HoiAn City MySon Champa Vestiges	TamKy (865km)	-id-
	Quang Ngai	1,228,000 (238/km2)	Ancient SaHuynh Civilization LySon Fishing Base	QuangNgai (928km)	-id-
	Binh Dinh	1,501,800 (248/km2)	Vestiges of Champa Civilization Ancient DoBan Temple	QuyNhon (1,084km)	-id-
	Phu Yen	877,000 (173/km2)	VungRo Fishing Port Temple Nhan of DaRang River	TuyHoa (1,198km)	-id-
	Khanh Hoa	1,183,000 (227/km2)	Nhatrang Beach Resort City CamRanh Naval Base	NhaTrang (1315km)	-id-
	Ninh Thuan	576,700 (172/km2)	CaNa Beach Resort Site of Atomic Power Plants	ThapCham (1,408km)	-id-
	Binh Thuan	1,193,500 (153/km2)	PhanThiet Resort City MuiNe Resort Beach	PhanThiet (1,551km)	-id-
SOUTH EASTERN ZONE (about 156km)	Dong Nai	2,720,000 (461/km2)	CatTien National Park BienHoa National Industrial Park	BienHoa (1,697km)	Inland Province
	Binh Duong	1,748,000 (649/km2)	BinhDuong International Industrial Zone LaiThieu Fruit Garden	ThuDuc (1,713km)	-id-
	HCMC	7,681,000 (3,666/km2)	VietNam Metropolitan City Saigon River Port Saigon Catholic Cathedral	Saigon (1,726km)	-id-

Source: Population Data from VN Statistics 2012, Station Data from VNR Information, Social Features from Tourist Information etc.

As shown in the table above, the provinces passed by the N-S Railway possess a diversification of natural and social characteristics from North to South VietNam.

As the railway was initially made to stop at all related cities and communities on its way, it was basically constructed near the national route A1 for entering the in-city stations. From this positional background, it has many level crossings.

However, with the rapid growth of urban populations in the last few decades, this N-S railway is now passing through numerous places with very dense populations, particularly the areas around big stations and particularly the areas of illegal occupation of the railway safety corridor in HaNoi and HCMC.

At these places, former VNR workers were initially permitted to have temporary houses for living. However, their families have gradually made permanent houses and business premises as well. Moreover, local people make thousands of illegal crossings in these areas, causing risks of frequent traffic accidents and obstructing the safety of daily train operation. Nowadays, despite no land right ownership, they have official residency in these illegally occupied areas.



Source: Study Team

[Fig. 9-3-1] Situation of Illegal Land Occupation and Crossings in HaNoi Area

A preliminary field survey on the actual situation of the N-S Railway along with brief interviews to VNR and local people was carried out for two (2) days (May 24 and 25), starting from HaNoi (Red River Delta) to NgheAn (North Central Coast).

Findings from this preliminary field survey are as follows:

- Illegal land occupation in the railway safety corridor is extremely serious in HaNoi from KhamThien area nearby HaNoi station to ThuongTin station (about 50 km). This serious situation is reportedly similar in the South from ThuDuc station to Saigon station (about 30 km). In other sections of the N-S Railway, this situation is reportedly not so serious.
- People in illegally occupied land insisted they have lived there for several decades. Their houses are small with an average land area of 20-30 m² located inside the railway safety corridor with some places only about 2m to the railway. They have water and electric supplies for living and doing many kinds of business. Some houses were made with 3-5 floors.
- They complained about the bad living environment (noise, vibration, air quality and many wastes thrown from trains) and risks of infectious diseases but insisted they have become used to this situation after several decades. As most VNR trains still have toilets with direct discharge to railway lane, train officers, in principle, have to lock toilets when trains entering city, areas but they sometimes forget.
- This situation of illegal occupation of the safety corridor in HaNoi and HCMC areas is so severe that future resettlement plans, e.g. double-track construction, in these sections will be not feasible from requirements of huge compensation costs and very complicated works.
- In these areas, local people have made thousands of illegal crossings for community use. There are also crossings for individual houses. TRICC reported a total number of about 4,500 illegal crossings found along the N-S Railway.
- Local people in these areas, however, insisted no such worries about traffic accidents, even for possible increases of train numbers and speed in the future. They referred to

the situation of increasing train numbers during annual festival seasons. In fact, there are hundreds of train traffic accidents in the safety corridor and crossings annually.

- Their most concerns, however, are hygienic problems and infectious risks, especially wastes discharged from train toilets and debris thrown by passengers onto railway from passing trains.
- VNR people working in stations and at level crossings expressed their capability for handling increases of train numbers and train speed in the future, if so required. At each crossing with a guard, they are working in 3 shifts. In the Hanoi area, they are informed by radio from HaNoi station about 10-15 minutes before each train comes.
- The number of crossing guards in HaNoi area is around 500. The average salary is 3 million VND per month. For basic living expenses, this salary is somehow adequate but for increasing work for more trains, they want a higher salary to cope with the increasing living costs.
- Both VNR people and local people living nearby the railway expressed their hope for proper improvements as well as good management (no improper business manners) to be implemented by VNR.

The following table shows the preliminary results from this socio-environmental verification survey.

[Tab. 9-3-2] Preliminary Results from Socio-Environmental Verification Survey
(from HaNoi to ThanhHoa and NgheAn)

No.	Verification Item	Verification Result
1	Situation of Railway Safety Corridor	Serious Illegal Occupation of Safety Corridor in HaNoi areas
2	Situation of Level Crossings	So Many Illegal Crossings Found Everywhere in HaNoi Area
3	Risks of Railway Traffic Accident	High Risks of Railway Traffic Accidents at Illegal Crossings
4	Risks of Causing Obstructions to Local People Life	Stop of Economic Activities During Train Passing Time
5	Risks of Nuisances from Noise & Vibration	Possible Risks to HealthCare for Children and Aged/Sick People
6	Risks of Bad Quality of Air and Water	Need for Further Investigation/Study from Now
7	Risks of Spreading Infectious Diseases	Risks from Direct Discharge of Toilet Wastes etc. onto Railway.
8	Station Structure	Very Old Style and Lack of Various Services/Conveniences
9	Station Operation	Operation for Train Arrivals and Departures only
10	Situation of Passenger Boarding & Getting Off	Scrambling and Dangerous for Children and Old People
11	Situation of Loading & Unloading of Freight Train	Depending on Situation and No Security
12	Safety Control and Services in Station	Need More Improvements
13	Railway Maintenance Situation	Deteriorated Rail and Weak Railway Foundation ,Not Clean
14	Possibility for Double Tracks Construction	Except Illegal Occupation Areas of HaNoi and HCMC
15	Presence of Indigenous People and Rare Species	Not Available
16	Hazard to National Park or Natural Conservation	Not Available
17	Hazard to Archaeological and Historic Sites	Not Available

Source: Study team

9.3.2 Lessons Learned From Past Projects

Concerning the social environment, major lessons learned from past projects, therefore are listed up as follows:

- As the N-S Railway was initially constructed nearby National Route No.1 for using the in-city stations, it has gradually caused serious social problems. Particularly, the serious problems of illegal occupation of the railway safety corridor and the fact that so many level crossings include about 4,500 illegal crossings where railway traffic accidents have frequently happened.
- Serious situations of illegal occupation of railway safety corridor were observed in big cities such as HaNoi and HCMC a long time ago. This was due to railway workers who were initially permitted to have temporary houses nearby these stations, but their families constructed permanent houses or business premises later in these land areas.

- Apart from level crossings managed by VNR, local people have made various illegal crossings in these illegally occupied land areas by themselves for community use and sometimes for their personal use also. This situation has caused various risks of traffic accidents and reduction of train speed in these areas.
- The situation of illegal occupation of the railway safety corridor happened due to basic neglects in control of railway environment from VNR in the beginning.
- There is a need to construct fences on both sides of the railway to abolish illegal crossings and to secure the railway safety corridor. At the same time, however, there is a need to establish more legal crossings with automatic warnings and barriers in these urban areas. This implementation should be done in collaboration with local communities. From technical and financial capabilities, VNR can perform this implementation.
- In farming areas, there is no need for fence construction but flash warning installations for preventing the intrusion of local people and animals are considered necessary. Also, on both sides of tunnel entrances, passages with nail obstructions could be made for preventing the intrusion of animals.
- For reducing the travel time of the N-S train, it will be appropriate to move the in-city stations to outside locations for avoiding level crossings, illegal safety corridor occupations, accidents, and reducing train speed time. The plan for relocating DaNang station for alignment rectification (to reduce about one hour of travel time when passing through the new HaiVan tunnel) is in a good direction. NhaTrang station should be in the same situation (to reduce travel time by about 30 minutes). Therefore, along with the improvement of railway infrastructures, signaling system, and alignment rectification, the travel time of the N-S Railway will be significantly reduced.
- The present situation of the direct discharge of toilet waste onto railway tracks could risk spreading infectious diseases to people living nearby. The installation of modern lavatory equipment in passenger cars is considered very urgent for comfortable travels and environmental protection purposes. Equipment for effective and convenient use by local people is basically necessary.
- Recent resettlement works in urban areas for carrying out railway projects have proved very difficult for implementation (example of YenVien NgocHoi Railway No.1). LARAP or RAP, therefore, should be carefully prepared with proper stakeholders meetings to make consent to affected families prior to the implementation of resettlement works.
- In many stations, safety control operation and train management systems have been carried out in an old style, causing slower speeds than necessary. This situation has caused delays for train arrivals and departures. Renovation of stations with safe passages and platforms, as well as the application of modern station operation and management, therefore, are considered quite necessary.

9.3.3 Social Concerns of the Project

From the lessons learned from the past projects, the major concerns for the Project could be listed up as follows:

- Possibility of illegal occupation of railway ROW by local people;
It is recommended to put a ROW post to secure safety of trains running and to conduct periodic patrol to check out the situation.
- Possibility of building illegal crossings by local inhabitants;
In order to prevent this situation, it is recommended to construct solid fences on both sides of railway. It is necessary to increase the number of legal crossings with

automatic warnings in community areas. Safety education should be carried out in related local communities.

- Possibility of discharging wastes and debris from trains;

It is recommended to install modern lavatory equipment for passenger cars and to forbid passengers from throwing debris onto the railway (VNR's plan for installing septic tanks for self-decomposition in toilets for passenger cars should be carefully tested for effectiveness).

- Possibility of spreading environmental and infectious diseases in areas along the railway;

It is recommended to carry out studies on risks of environmental and infectious diseases in areas along the railway for making proper measures for inhabitant health protection. Hazards for noise and vibration as well as quality of air and water should be checked throughout the year.

- Possibility of improper services and management in stations and trains;

Many railway stations in VietNam are found in very old types without safe passages to platforms. Various personal businesses are found on platforms and inside passenger cars. It is recommended to construct safe passages and platforms in stations and to establish strict railway regulations for station and train operation and management.

In order to enhance railway ridership, as recently implied by Minister of Transport, VNR should comply with better services and management. A comparative check on travel conditions by train, bus and airplane is shown in the following table.

[Tab. 9-3-3] Comparison Of Travel Conditions By Train, Bus and Airplane

Item	Train	Bus	Airplane	Note
Travel Time HaNoi-HCM	About 32hrs (Express Train)	About 25hrs (Deluxe Bus)	About 2.5hrs (In Average)	Airplane Fastest
Price	0.9-1.3 millionVND	0.7-0.8 millionVND	1.5-3.5 millionVND	Bus: Cheapest
Comfortable Trip	Fair	Somehow Good	Good	Airplane: Good
Merits	High Safety Friendly Trip Family Travel	Low Price Many Buses Drive-In Services	Fast Travel Compact Trip Easy For Baggage	Train: Good For Big Family Trip
Demerits	Long Trip Unpunctuality Bad Toilet	Low Safety Unreliability of Car Conditions	High Price No Flight in Bad Weather No Bulk Baggage	Airplane: Expensive
Others	No Operation during Flooding Period	Unreliability of Car and Driver Conditions	Price Variation Upon Boarding Time and Season	Need for Good Railway

Source: Study team

Besides, in terms of large volume and cost, freight transport by railway is found definitely superior to transports by trucks and airplanes. However, the management of security control as well as the reception-delivery system are still in primitive manners.

From this background and the N-S Railway as the backbone of VietNam railway, VNRA and VNR have to work together for a proper program to modernize the N-S Railway, not only for infrastructures and facilities but also for operation and management. With the implementation of proper improvements for development, this railway line will certainly be attractive to all passengers and users in the near future.