JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

VIETNAM RAILWAYS (VR)

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

FINAL REPORT

TECHNICAL REPORT 1

ASSESSMENT OF EXISTING RAILWAY AND IMPROVEMENT OPTIONS

June 2013

ALMEC CORPORATION
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PREFACE

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

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

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

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

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

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

June 2013

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ABBREVIATIONS

AC	Alternating Current
ARC	Automatic Route Control
ATC	Automatic Train Control system
ATP	Automatic Train Protection
ATS	Automatic Train Stop
CS	Copper Steel
CTC	Centralized Traffic Controlling System
DS-ATC	High-speed railway signal system in Japan
EMU	Electric Multiple Units
GPS	Global Positioning System
GSM	Global System For Mobile Communications
HCMC	Ho Chi Minh City
JICA	Japan International Cooperation Agency
LCX	Leaky Coaxial Cable
NH	National Highway
NSHSR	North – South High Speed Railway
NS Line	North-South Line
O & M	Operation And Maintenance
OCC	Operation Control Center
PC	Prestressed Concrete
PRC	Programmed Route Control System for Station
SCADA	Supervisory Control and Data Acquisition System
SDH	Synchronous Digital Hierarchy
TCN	Standard of Ministry
TGV	Train A Grande Vitesse – high speed train
TRICC	Transport Investment And Construction Consultant Joint Stock Company
UIC	International Union Of Railways
UPS	Uninterrupted Power Source
USD	United States Dollar
VITRANSS2	The Comprehensive Study On The Sustainable Development Of Transport System In Vietnam
VND	Vietnamese Dong
VR	Vietnam Railways
VVVF	Variable Voltage Variable Frequency

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

1.1 Existing Conditions of the North-South Railway

1) General

1.1 The Hanoi–HCMC Railway Line (NS Line) was constructed a long time ago, with low technical specifications and speed on 1000 mm gauge. The non-electrified single-tracked railway has mostly old and deteriorated structures, preventing train operation from serving fast, frequent and comfortable trips which then results in the gradual decrease in its transportation market share (see Table 1.1.1).

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

2) Alignment

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

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

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

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

3) Structures

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

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

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

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

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

Table 1.1.1 Profile of Existing Line

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

Source: JICA Study Team

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

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

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

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

4) Tracks

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

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

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

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

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

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

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

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

5) Layout Density of Stations

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

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

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

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

6) Signaling and Communication Systems

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

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

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

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

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

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

7) Rolling Stock and Maintenance Facilities

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

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

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

8) Railway Operation

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

Hanoi Station	Vinh Station
	
Boarding and Alighting Passengers	
	
Railway sections in Hanoi Urban Area	Railway crossing Controlled by Security Staff with Slide Gate and Alarm System
	
Railway crossing Controlled by Security Staff with Cross Gate and Alarm System	Railway crossing Controlled by Security Staff with crossing Gate
	
Railway crossing with only Sign of Caution	Railway crossing (likely illegal)
	
An Example of Bridge Restoration	Typical Tunnel Condition
	

Source: JICA Study Team

Figure 1.1.1 Examples of Current Situation of Existing Railway

1.2 Main Bottlenecks in Existing Railway

1) General Assessment and Main Bottlenecks

1.17 The result of general assessment of existing railway revealed that it involves ; various problems regarding alignment, structure, track, station, squalling and telecommunication, rolling stock and maintenance facilities, railway operation, among others (see Table 1.2.1)

Table 1.2.1 Identified Main Problems of Existing Railways

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

Source: JICA Study Team.

2) Main Bottlenecks

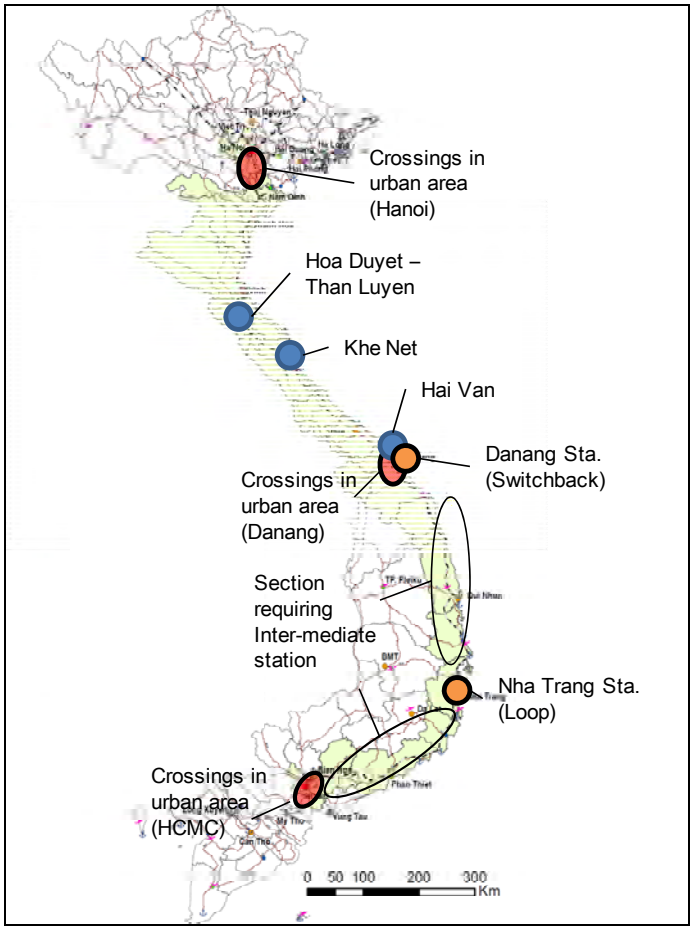
1.18 Main Bottlenecks facing existing railway which limit proper performance include following (see Figure 1.2.1);

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

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

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

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



Source: JICA Study Team

Figure 1.2.1 Locations of Bottlenecks

3) Most Critical Bottlenecks

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

(1) Hai Van Pass

1.20 Hai Van Pass section is located from km 750+356.80 (Near Lang Co station) to km 776+880 (Kim Lien station) in Thua Thien Hue and Danang. This section includes quite bad alignment; there are 175 curves which minimum curves are less than one of R=400 m as shown in Figure 1.2.3. In addition, this section requires auxiliary machine due to steep grade. Therefore, the operation speed in the section is significantly restricted.

1.21 Recommended measures include followings;

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

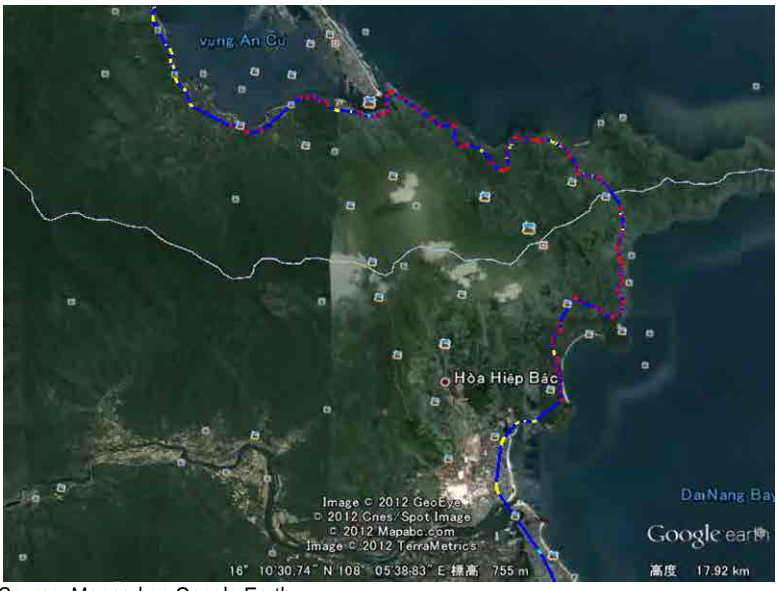
(ii) Construction of a tunnel which is 8,450 m single tunnel for 1,000 mm gauge. There are two reverse curves with R=1,000 m at two tunnel portals.[1]

[1] Although the mentioned construction is for the improvement of existing railway, the construction of a tunnel with the specification of High Speed Railway is also possible option for better investment efficiency in case that this section serves as test track section as explained in Chapter 5.5.

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

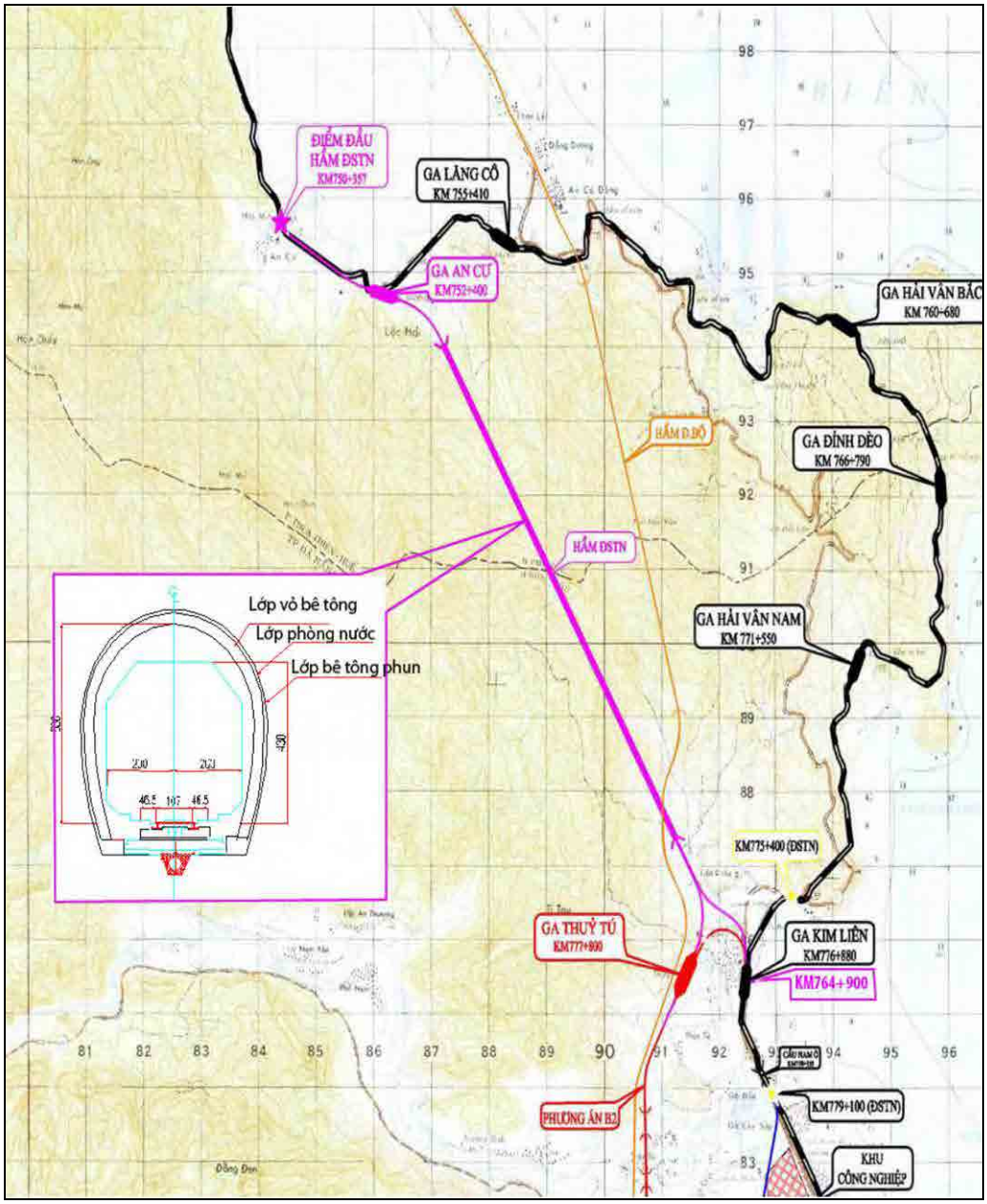
1.22 Roughly estimated construction cost is USD185 million

1.23 With this maximum design speed will increase to 100 km/h and approximately 60 minutes of operation time in this section will be shortened. The auxiliary machine will be unnecessary and train safety will ensured. In addition, the capacity of the section will increase.



Source: Mapped on Google Earth.

Figure 1.2.2 Realignment Plan of Hai Van Pass



Source: TRICC

Figure 1.2.3 Realignment Plan of Hai Van Pass

(2) Khe Net Pass Section

1.24 Khe Net Pass section is located from km 414+000 to km 423+000 in Quang Binh. This section includes quite bad alignment; there are 30 curves which minimum curvature are less than the one of R =400 m as shown in Figure 1.2.4. Thus, the operation speed in this section is restricted.

1.25 Recommended measures include followings;

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

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

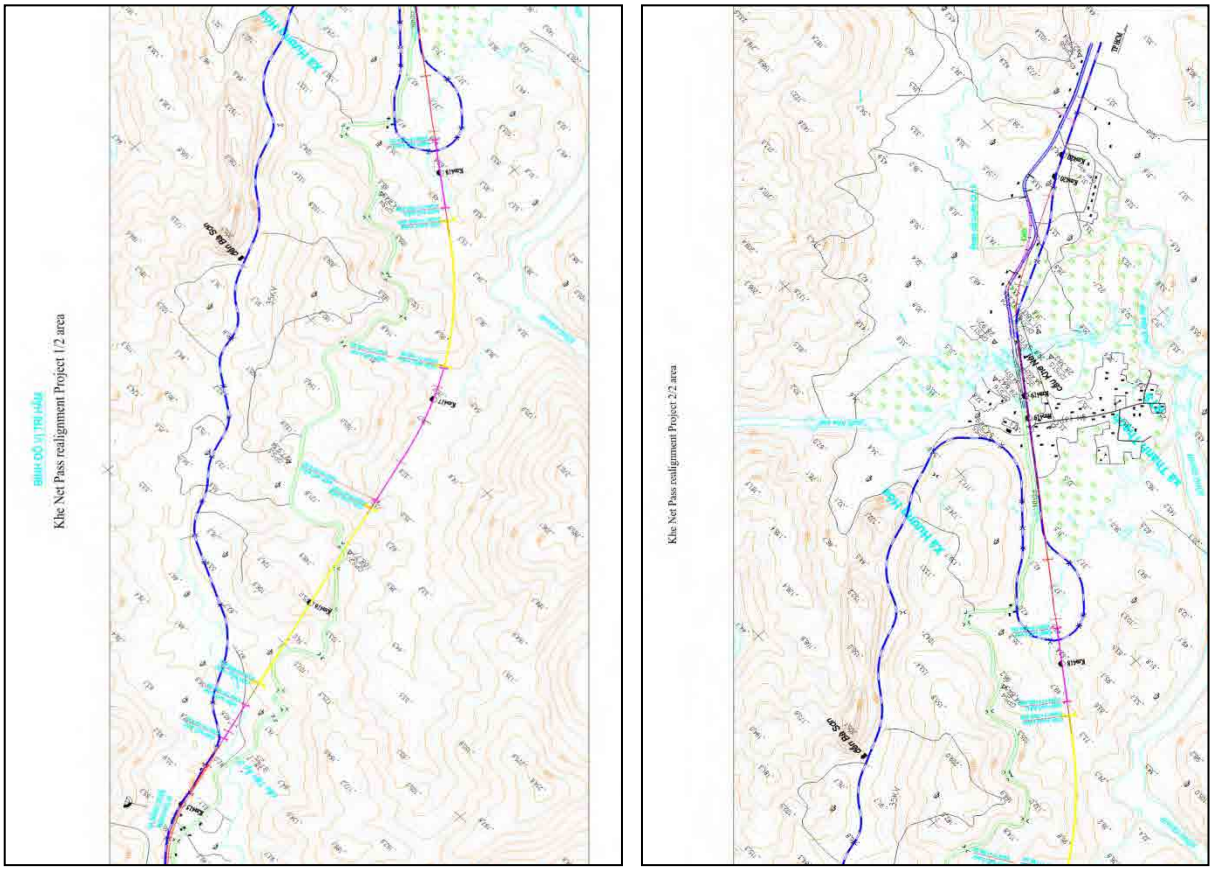
to the southern tunnel is 9 girders of 33 m.

(ii) Improvement of one railway station

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

1.26 The expected construction cost is USD49 million

1.27 Maximum design speed will increase to 100 km/h and approximately 8 minutes of operation time in this section will be shortened. Furthermore, it will ensure the train safety and also increase the capacity in the section.



Source: TRICC

Figure 1.2.4 Realignment Plan of Khe Net Pass

(3) Hoa Duyet–Thanh Luyen Section

1.28 Hoa Duyet–Thanh Luyen section is located from km357＋000 to km370＋000 in Ha Tinh. This section includes bad alignment; there are 18 curves which minimum curvature are less than the one of R=400m as shown in Figure 1.2.5. Thus, the operation speed in the section is restricted.

(a) Recommended Measures: Recommended measures include followings;

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

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

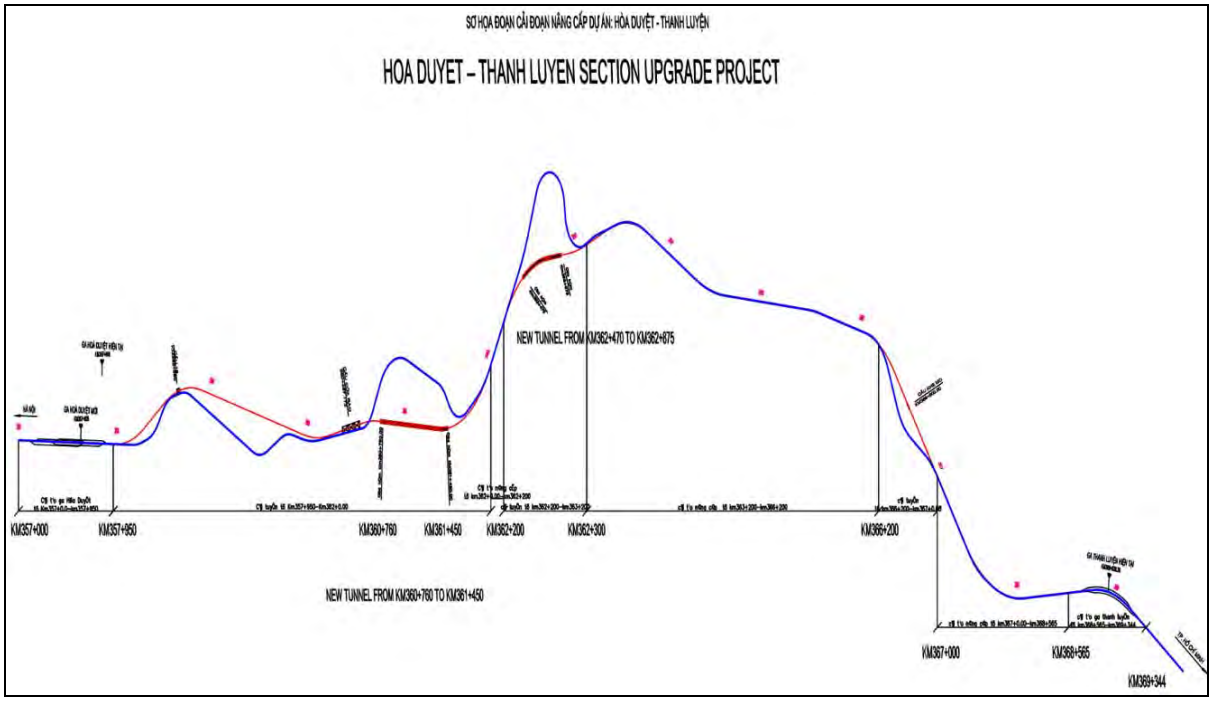
(iii) Construction of new tunnel for gause 1,000 mm (1,070 m in length)

(iv) Construction and connection of 29 culverts

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

1.29 The estimated Construction cost is USD64 million

1.30 Maximum design speed will increase to 100km/h and approximately 4 minutes of operation time in this section will be shortened. Furthermore, it will ensure the train safety and also increases the capacity in the section.



Source: TRICC

Figure 1.2.5 Hoa Duyet–Thanh Luyen Section Upgrade Project

4) Other Bottlenecks

1.31 While average distance between stations is about 10 km, there are sections with long station spacing. Of the total of 24 sections with more than 15 km between stations, 9 of them are located in Danang–Nha Trang section and 7 in Nha Trang–Phan Thiet section. (see Table 1.2.2)

1.32 Sections with small curvature also limit operating speed of trains. Of the total length of 1,726 km, the sections with less than 800 m radius total 251 km or 14.5% of the total. Those with less than 400 m radius amount 75 km or 4.3% of the total. (see Table 1.2.2)

1.33 Switch back sections in Danang and Nha Trang also cause longer travel time (See Figure 1.2.6).

Table 1.2.2 Distance between Stations and Characteristics of Curvature

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

Source: JICA Study Team

Danang Station | Nha Trang Station

Source: JICA Study Team

Figure 1.2.6 Switchback Sections in Danang and Nha Trang

1.3 Opportunities and Constrains to Improvement of Existing Line

1) Overview

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

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

(i) Converting to dual gauge for entire section of existing railway

(ii) Upgrading of existing railway to accommodate train operation at maximum speed of 200 km/h.

(iii) Mixed operation of passenger and freight trains at maximum speed of 200 km/h.

2) Analysis of Conversion of Existing Railway to Dual Gauge

1.36 The installation of dual gauge for the entire section, which is one of the alternatives for North South railway development discussed in Vietnam, is analyzed and the result is shown in the following paragraphs.

(1) Application Practices of Dual Gauge

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

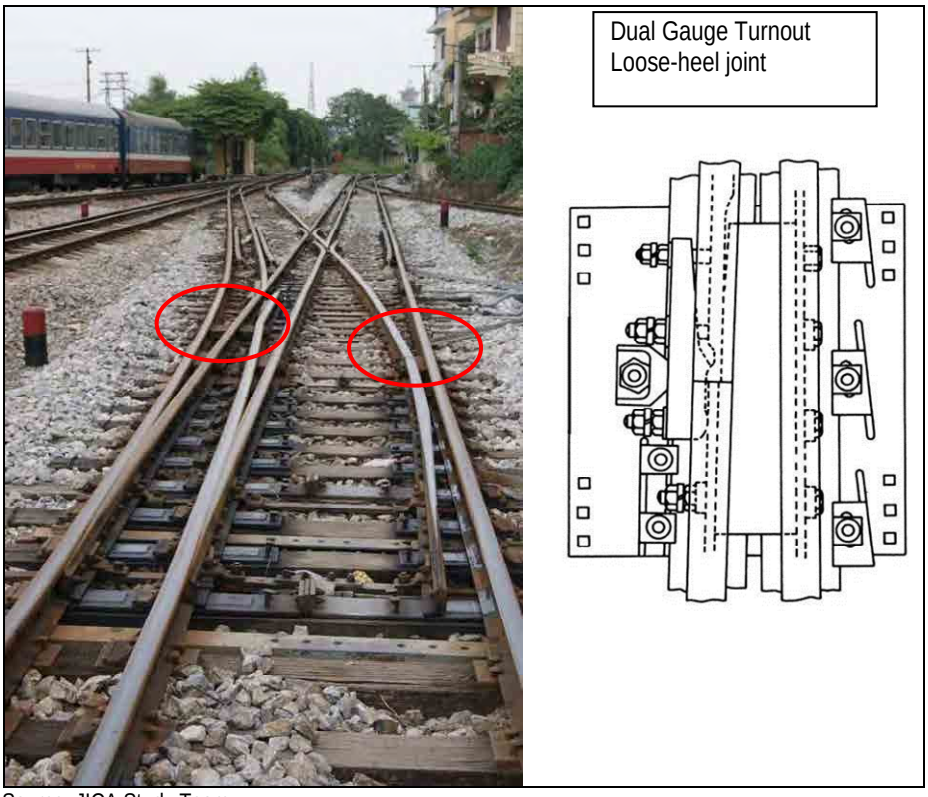
(2) Restriction of Speed Limit

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

1.39 In addition, the speed limit is engendered on turnouts because of the reasons below (only limited improvement of operation speed is achievable by introducing dual gauge; the improvement of alignment is necessary for realizing faster speed);

- Turnouts have complicated structures. Non-availability of scissors, diamond crossing and special turnouts restricts the track layout.
- Combinations of standard- and narrow-gauge tracks on the main line side and those on the branch side necessitate 28 different turnouts, which require design numbers for turnouts to be limited.

- The speed on the straight side of the turnout in Figure 1.3.1 is limited to 80–90 km/h while seven turnouts out of 28 can be used for 120 km/h.

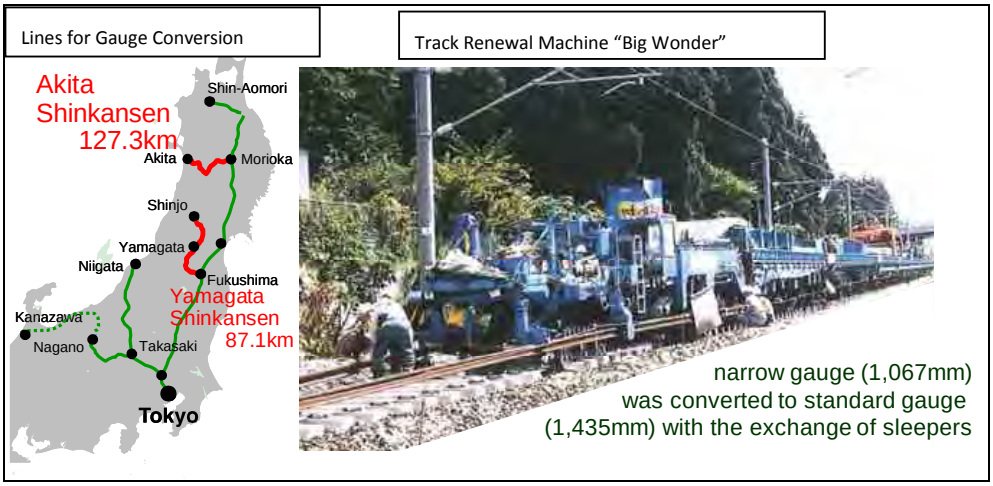


Source: JICA Study Team

Figure 1.3.1 Dual Gauge (Photo)

(3) Operational Suspension

1.40 The construction work is expected to be long and the train operation will be suspended during contraction period. Therefore, direct operation between Hanoi and HCMC will be suspended for long period. Figure 1.3.2 shows the lines and a machine utilized for converting narrow gauge to standard gauge in Japan. In case of Akita Shinkansen line in Japan (127.3 km comprising of 75.6 km single track and 51.7 km double track), the conversion work took 5 years to finish.



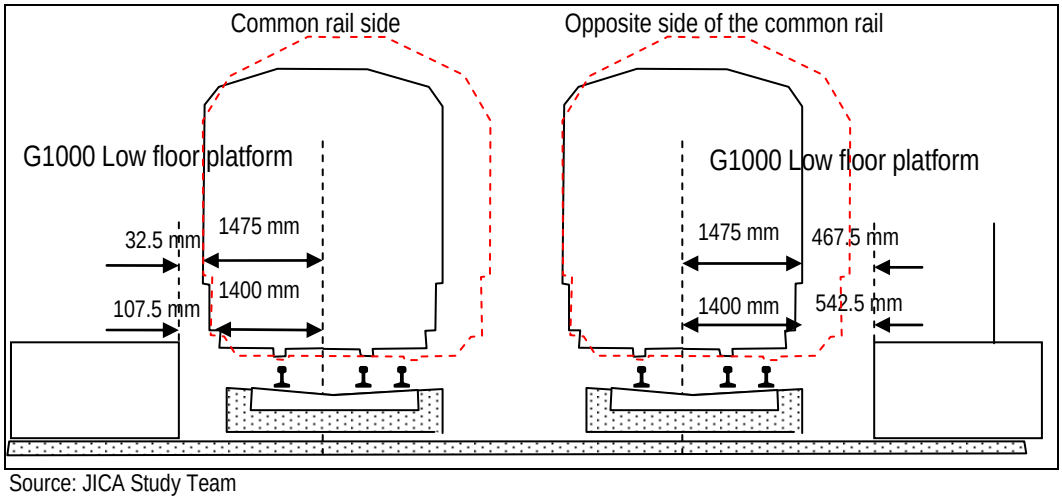
Source: JICA Study Team

Figure 1.3.2 Japanese Experiences of Gauge Conversion

(4) Construction Works

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

1.42 Many station spatial layouts have to be remodeled since the distance between the platform and the track is different between on the common rail side and on the opposite side, restricting the track layout (See Figure 1.3.3).



Source: JICA Study Team

Figure 1.3.3 Track Layout of Dual Gauge

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

(5) Operation and Maintenance

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

(6) Conclusion

1.45 From the above analysis, the plan to change the tracks studded with dual gauge to a standard gauge railway is difficult and costly to implement. Dual gauge can be introduced, however, at particular and limited locations.

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

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

(1) Construction Cost

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

at roads need to be grade separated. The cost of electrification shall also be added to the construction cost.

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

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

(2) Construction Period

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

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

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

(3) Possibility for further Upgrading up to 300 km/h

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

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

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

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

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

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

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

(2) Experiences in European Countries

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

(a) **Germany:** Freight trains were once operated at 140 to 160 km/h in the Bremen-Stuttgart section (710 km) and the Hamburg-Munich section (779 km) from 1991, which was reduced to 120 km/h in 1995 due to low profitability.

(b) **France:** Freight trains are operated at a maximum speed of 270 km/h eight times a day to transport mails, parcels and newspapers with remodeled TGV cars on the TGV Southeastern line. However, France does not have an idea to operate freight trains excluding aforementioned TGV remodeled cars on the same lines with high-speed passenger trains, as there are problems related to train operation diagrams and the time zone required for maintenance work. Rather, France has an idea to construct new lines for high-speed freight trains.

(3) Problems related to the Security and the Train Operation Diagrams in the Mixed Operation of 200 km/h Passenger Trains and 120 km/h Freight Trains

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

(a) Passenger Train Operation at 200 km/h

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

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

(b) Structure and Performance of Freight Trains

1.61 For high speed operation of freight train at 120 km/h, ATC system, which is a security system applied for Shinkansen, is need to be applied; the security devices and a high-reliability brake system for precise deceleration should be installed not only on locomotives but also on whole train-sets. On the other hand, container freight liner train system is also should be introduced for avoiding unexpected opens of door during operation and fall of cargo as well as breaks of

cargo car's axle caused by excessive heat. Thus, the current VN freight transport system should be totally changed; new rolling stock should be procured for freight liner system and base yards should be constructed.

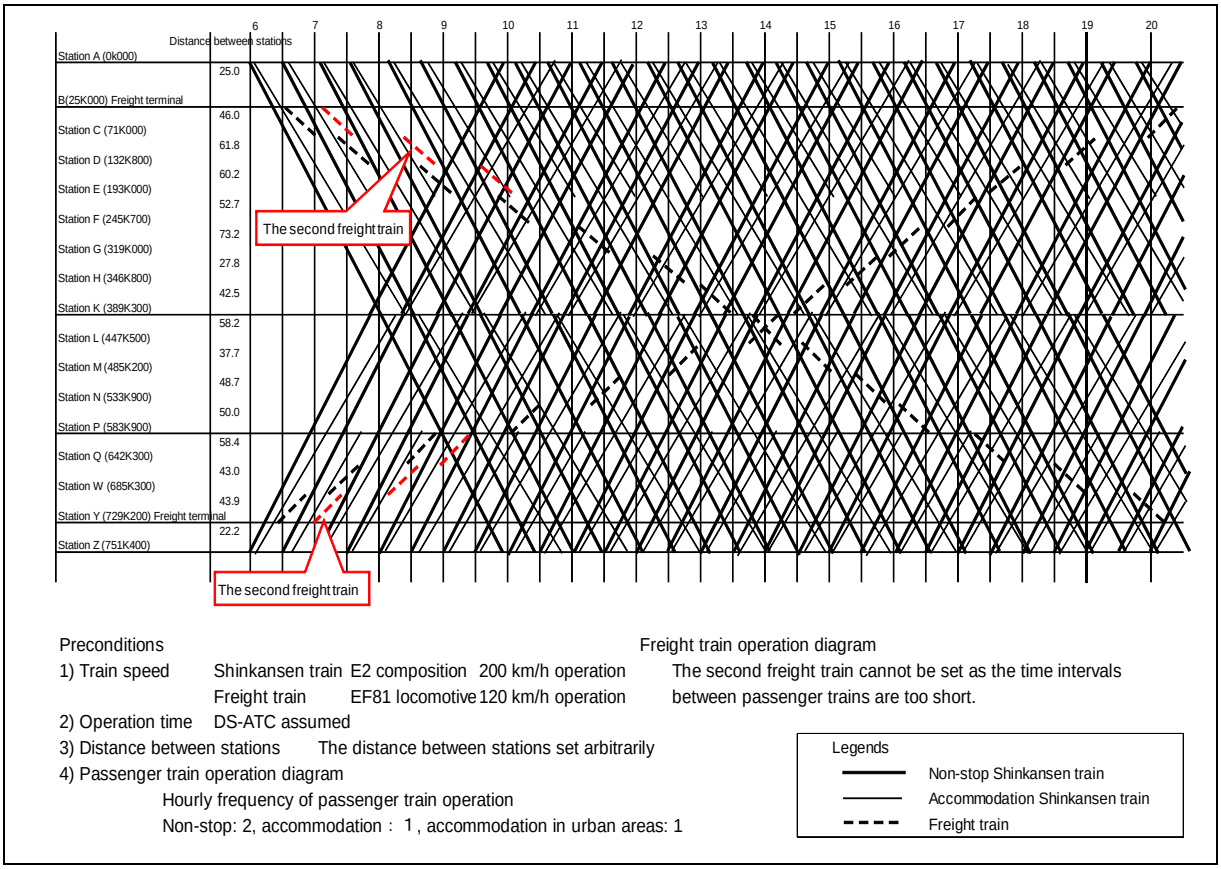
(c) Train Operation Diagrams

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

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

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

1.65 Considering these problems, the Study Team drew train operation diagrams to run 120 km/h freight trains mixed with 200 km/h passenger trains between Hanoi and Ho Chi Minh as shown in Figure 1.3.4. The operation diagrams are impractical as there is a great influence on passenger and freight trains.



Source: JICA Study Team

Figure 1.3.4 Passenger and Freight Train Operation Diagram

1.4 Alternative Improvement Options for the North-South Railway Line

1) Preparation of Alternative Improvement Options

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

1.67 There are multifold approaches to improve or upgrade existing non-electrified single track railway. Targets of improvement, therefore, have to be figured out first. The JICA Study Team has set up four possible upgrading or Improvement Options, namely A1, A2, B1 and B2.The targets of each options are as follows:[2]

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

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

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

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

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

1.69 Although, in the following paragraphs, these options are discussed for the entire North-south railway, practically, the most appropriate option (target improvement level) should be selected from them by section and phase.

2) Features of A1

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

(b) **Scope of Option A1:** Option A1 will consist of the following railway improvement projects and activities:

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

(ii) Renewal of Old Track Components: This includes (a) Replacement of old sleepers

[2] Detail process and result of these options are shown in Technical Report No. ×× -Improvement Options of Existing Railway

made of wood, steel and twin-block concrete, coming to durability limit with mono-block pre-stressed concrete sleepers, (b) Worn out T40 rails of 15 km long track are replaced with new 50K rails, dirty ballasts of 95 km long track are renewed, and 152 old switches with new ones, and (ic) Retrofitting pumping sections in a total of 74 km of embankments.

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

(iv) Renewal and Installment of Telecommunication Systems: Optical fiber cable system and dedicated digital telecommunication system are installed. Thunderbolt prevention system, grounding wires and stand-by equipment are also installed.

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

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

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

(c) **Investment Cost of Option A1:** The total investment cost of Option A1 is estimated at around USD1.5 billion. (see Table 1.4.1 for breakdown)

Table 1.4.1 Estimated Investment Cost of Option A1

No.	Items	Million USD
1	Track upgrade	248
2	Roadbed improvement	179
3	Steel bridge renovation	156
4	Concrete bridge renovation	86
5	Small bridge renovation	111
6	Tunnel retrofit	93
7	Signal and telecommunication	300
8	Crossing modernization	40
9	Crossing automation	48
	(A) Sub-total cost	1,260
10	Land acquisition	13
11	Construction services 2% of(1+2+3+4+5+6+7+8)	25
	(B)Sub-total cost	1,298
12	Contingency 5% of (B)	65
13	Tax and import tax, etc. 2% of (A)	126
	Total Project Cost	1,489

Source: JICA Study Team

3) Features of Option A2

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

(b) **Scope of Option A2:** Option A2 will consist of the following projects and activities:

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

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

(iii) Signaling and Telecommunication Systems

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

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

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

(c) **Investment Cost of Option A2:** The improvement projects under Option A2 are estimated to require a total investment of USD1.8 billion. (see Table 1.4.2 for breakdown)

Table 1.4.2 Estimated Investment Cost of Option A2

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

Source: JICA Study Team

4) Features of Option B1

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

(b) **Scope of Option B1:** Option B1 will consist of the following projects and activities:

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

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

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

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

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

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

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

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

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

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

(c) **Investment Cost of Option B1:** The total investment cost of Option B1 is estimated at USD14.5 billion. (see Table 1.4.3 for breakdown)

Table 1.4.3 Estimated Investment Cost of Option B1

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

Source: JICA Study Team

5) Features of Option B2

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

(b) **Scope of Option B2:** Option B2 will consist of the following projects and activities:

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

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

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

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

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

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

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

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

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

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

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

(c) **Investment cost of Option B2:** Implementation of Option B2 will require a total investment cost of about USD27.7 billion. (see Table 1.4.4 for breakdown)

Table 1.4.4 Estimated Investment Cost of Option B2

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

Source: JICA Study Team

6) Summary of Alterative Options

1.70 A technical overview of the four options (A1, A2, B1 and B2) is shown in Table 1.4.5. Option A1 and Option A2 are single track while Option B1 and Option B2 are double track.

1.71 The breakdown of cost for each plan by section is shown in Table 1.4.6. The scale of Improvement is significantly different among plans (1,797.5 million USD for Option A2, 14,467.8 million USD for Option B1 (8.0 times of Option A2) and 27,694.0 million USD for Option B2 (1.9 times of Option A2). As for A2, the sections in the central, where the improvements on passes in mountainous area are required, are costly than other sections.

Table 1.4.5 Summary of Four Options (A1, A2, B1 and B2)

		A1 (Committed)	A2	B1	B2
Railroad track	Track	Single	Single	Double	Double
	Electrification	Non-electrified	Non-electrified	Non-electrified	Electrified
	Gauge	1,000 mm	1,000 mm	1,000 mm	1,435 mm
	Minimum radius of curvature	100m (existing)	100 m (existing)	800m	1,200m
	Withstand load	14 ton (existing)	14 ton (existing)	14 ton (existing)	17 ton (class EA17)
Maximum train speed	Passenger train	90 km/h (existing)	90 km/h (existing)	120 km/h	150 km/h
	Freight train	60 km/h (existing)	60 km/h (existing)	70 km/h	Container: 120 km/h Bulk: 80 km/h
Travel Time (Hanoi - Saigon)		29.1 h	25.4 h	15.6 h	12.7h
Facilities	Alignment improvement	• Same as existing	• 3 bottlenecks, Hai Van Pass, Khe Net Pass, Hoa Duyet to Thon Luyen	• Substandard curvatures • 3 bottlenecks	• Substandard curvatures • 3 bottlenecks
	Effective length for station	Minimum 350m (existing)	Minimum 350 m (existing)	450 m	450 m
	Crossing	Level crossings (existing)	Automated level crossings	Automated level crossings	Grade separation
	Signaling	• Automatic interlocking system / semi-automatic block system in some stations (existing)	• Automatic interlocking system in all stations • Semi-automatic block system	• ATS • Automatic interlocking system in all stations • Automatic block system	• ATS • Automatic interlocking system in all stations • Automatic block system
Rolling stock		Diesel – electric locomotive	Diesel – electric locomotive	Diesel – electric locomotive	Electric train (passenger) Electric locomotive (freight)
Train Frequency (up + down)		• 32 trains/ day (existing)	• 50 trains/ day1)	• 116 trains/ day2)	• 122 trains/ day2)
Estimated Investment (approximately)		• 1,5003) Million USD	• 1,800 Million USD	• 14,500 Million USD	• 27,700 Million USD

Source: JICA Study Team

1) Maximum frequency based on the improvement of 18 new intermediate stations, 2) Based on the traffic demand analysis on 2030 year, 3) Improvement of some projects to maintain the operation speed and safety

Table 1.4.6 Investment Cost of Improvement Plans of Existing Railway

(Unit: Million USD)

			North		Central			South		Total
			Hanoi-hanh Hoa	Thanh Hoa-Vinh	Vinh-Hue	Hue-Danang	Danang-Nha Trang	Nha Trang-Phan Thiet	Phan Thiet-HCMC	
Length (current, km)			175.2	143.8	369.3	103.1	523.5	236.2	175.1	1726.2
Existing Railway	A2	1.Khe Net Pass realignment Project	-	-	47.5	-	-	-	-	47.5
		2.Hai Van Pass realignment Project	-	-	-	181.2	-	-	-	181.2
		3.Hoa Duyet-Thanh Luyen section upgrade project	-	-	62.5	-	-	-	-	62.5
		4.Construction pass-by new stations	-	2.7	5.4	.7	3.5	18.8	0.8	53.8
		5. Signaling and Telecommunication facilities for new stations and for whole line	59.1	46.7	109.7	37.7	172.2	102.0	80.0	607.5
		6. Signal protection device for level crossing on Hanoi-Ho Chi Minh City	Included in item 5							
		7.Vehicle workshops and facilities for the increased transportation capacity	43.8	123.8	5.0	5.0	5.0	43.8	3.8	230.0
		8. Vehicle purchase for the increased transportation capacity2)	170.7	-	-	-	-	-	170.7	341.3
		7.Land Acquisition	1.0	1.3	2.7	2.5	1.1	2.7	1.2	12.5
		8.Construction Services	5.5	3.5	4.6	4.5	3.8	3.3	5.3	30.5
		9.Contingency	14.0	8.9	11.9	11.7	9.8	8.5	13.6	78.3
		10. Tax and import tax etc	27.4	17.3	23.0	22.7	19.1	16.5	26.5	152.4
		Total 2)	321.4 (140.7)	204.2	272.2	268.0	224.5	195.6	311.7 (141.0)	1,797.5
	B1	1. Civil Work	136.3	138.6	490.1	299.4	818.9	202.6	54.5	2,140.4
		2. Track work	133.7	109.7	280.2	70.7	399.4	180.2	133.6	1,307.5
		3. Station	151.0	103.0	212.0	75.0	244.0	94.0	116.0	995.0
		4. Electricity	489.7	401.8	1,026.5	258.9	1,463.0	660.0	489.2	4,789.1
		5. Depot & others	108.8	50.0	91.3	145.0	113.8	91.3	122.5	722.5
		6. Rolling Stock2)	726.3	-	-	-	-	-	726.3	1,452.5
		7. Land Acquisition	158.4	120.3	147.7	45.7	330.7	140.7	143.0	1,086.4
		8. Construction Services	20.4	16.1	42.0	17.0	60.8	24.6	18.3	199.1
		9. Contingency	96.2	47.0	114.5	45.6	171.5	69.7	90.2	634.6
		10.Tax and import tax etc	174.6	80.3	210.0	84.9	303.9	122.8	164.2	1,140.7
		Total l2)	2,195.3 (1,469.0)	1,066.8	2,614.2	1,042.2	3,906.1	1,585.7	2,057.6 (1,331.3)	14,467.8
	B2	1. Civil Work	315.0	251.3	753.6	414.3	1,223.8	435.4	290.4	3,683.8
		2. Track work	239.0	196.1	501.0	126.4	714.1	322.1	238.8	2,337.5
		3. Station	490.9	147.5	497.8	167.3	478.5	189.5	268.4	2,239.8
		4. Electric city	1,068.4	876.7	2,239.5	564.9	3,192.1	1,439.9	1,067.3	10,448.8
		5. Depot & others	166.3	0.0	132.5	47.5	193.8	132.5	166.3	839.0
		6.Rolling Stock2)	1,434.5	-	-	-	-	-	1,434.5	2,869.1
		7.Land Acquisition	250.7	148.6	189.4	54.3	453.7	195.2	139.5	1,431.3
		8.Construction Services	45.6	29.4	82.5	26.4	116.0	50.4	40.6	391.0
		9.Contingency	200.5	82.5	219.8	70.0	318.6	138.3	182.3	1,212.0
		10.Tax and import tax etc.	371.4	147.2	412.4	132.0	580.2	251.9	346.6	2,241.8
		Total 2)	4,582.3 (3,147.8)	1,879.4	5,028.5	1,603.1	7,270.7	3,155.2	4,174.7 (2,740.2)	27,694.0

Source: TRICC and JICA Study Team

Note: 1) The breakdown of A1 (on-going and committed) is not included in the table. 2) Cost for rolling stock is included in the sections where terminal stations are located. Figures in the parenthesis show the cost excluding rolling stocks.

1.72 Brief evaluation of each option excluding A1 (consisting of committed and ongoing projects) is as follows;

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

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

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

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

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

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

2 OPERATION CONTROL

2.1 Operation Control

2.1 Safety is the most important requirement for train operation, which is largely governed by signals, platform equipment, automatic crossing operation and design of structures. For railways, the next most important factor after safety is reliability of transport. What contributes to this mission is operation control.

2.2 Delays in daily train operation are often caused by changes in meteorological conditions, accidents at crossings and failures of signals, rolling stock, tracks and other equipment. The prompt and correct respond to and deal with such situations is train-dispatching services. A series of the deeds to issue and support commands and instructions of train dispatch are generally called operation control.

2.2 Phased Development of Operation Control

1) Initial Phase

2.3 At the initial phase, railway operators organize a train dispatch center and install direct telephones connected to passenger and signal stations, train crew depots (train operation depots and conductor depots), rolling stock depots, track maintenance depots, signal depots, telecommunication depots and other field organizations, through which the center collect reports on train operation status from station masters on duty and signal men for operation adjustment and issuance of commands and instructions to recover normalcy.

2) Phase 2

2.4 Railway operators additionally install an indicator to show the train at stop on each track at the train dispatch center, or a system to indicate the train number on each track at the track display board. In Japan, this is implemented by utilizing track circuit conditions without relying on the reports on train operation status, thereby facilitating quick assessment of train delays and expediting action for operation adjustment.

3) Phase 3

2.5 Railway operators incorporate the function of a signal control device into the above indicator to introduce the centralized traffic control (CTC) system, thereby enabling collective train control at the train dispatch center. This is to centralize the signal handling implemented at stations in the past for the purpose of operation control. As trains, hitherto controlled by signalmen at stations based on the commands obtained through the train dispatch telephone, are now directly controlled by the train dispatcher, the system realizes quick operation adjustment while significantly cutting manpower.

2.6 Although funds invested into equipment temporarily increase, its economic effect due to the efficient staff assignment is significant. Railway operators have introduced the system, therefore, to improve the efficiency of management.

4) Phase 4

2.7 When the frequency of train operation has increased as a result of double-tracking, railway operators introduce the automatic route control (ARC) system, while adopting the standard station track layout simultaneously. Under this system, routes are automatically

controlled at midway stations other than terminal stations or large-scale stations (with more than four departure/arrival tracks). Without increasing the number of staff members, more trains can be operated as a result.

2.8 As the introduction of ARC requires standardization of train operation patterns, however, the system was adopted only for Tokaido Shinkansen with simple operations before it was extended to Okayama. The hourly operation of three Hikari trains and six Kodama trains were controlled in the past by the ARC system. However, the ARC system does not suit the operation control of freight trains studded with promiscuous operation patterns.

5) Phase 5

2.9 As train types diversify (with operation patterns increased), computers are introduced, in case the ARC system does not cope with). Computers implement programmed route control (PRC) to facilitate the work of statistics on train delays and train operation.

2.10 The introduction of CTC with PRC relieved the train dispatchers from signal handling, which was previously a principal part of train dispatch services, and allowed them to devote themselves to the original work of operation adjustment. The computerized operation control system can significantly change the cost of equipment depending on the development concept of users.

2.11 As mentioned above, operation control has progressed and been renewed as the frequency of train operation increases and operation facilities are improved.

2.3 Present Status of the Operation Control of Vietnam Railways

2.12 The present status of the technology division of VR is as follows.

2.13 Operation control is still at an initial stage in that train operation adjustment is implemented by means of train dispatching telephones alone without using textual dispatching facilities such as facsimiles or telegraphic machines.

2.14 The Ha Noi–Saigon section (1,726.2 km) is divided into three segments, each under an independent dispatching office for operation control. A dispatching center (an adjusting room) was set to perform adjustment between the three dispatching offices that are in charge of the following segments.

(a) **Hanoi–Dong Hoi Segment (58 sections):** Ha Noi train dispatching office

(b) **Dong–Dieu Tri Segment (55 sections):** Da Nang dispatching office

(c) **Dieu Tri–Saigon segment (53 sections):** Saigon dispatching office

2.15 To perform transport businesses, VR has three divisions for general affairs, planning and statistics, and professional technology in addition to an adjustment room and three train-dispatching offices. It has 163 members in total including about 30 at three divisions and 82, 26 and 24 members, respectively, at the Hanoi, Da Nang and Saigon dispatching offices (82 members at the Hanoi dispatching office include those for train operation adjustment and dispatching).

2.16 The assignments of the planning and statistics divisions: the records of passenger and freight transport, car-kilometers and revenue

2.17 The assignments of the technology division: the transport planning, technological rules and control of dispatching

2.18 Planned train operation diagrams are posted on the walls of dispatching offices. Train operation diagrams for the day are manually created. Hand-written diagrams to record actual train operation are kept for five years.

2.4 Operation Control Recommended for the Improved Options of Existing Lines

2.19 The preparation and facilities stated in Phase 2 are considered sufficient for the control of number of trains (A-1) as current frequency and that is envisaged in the scenario (A-2).

2.20 For the options (B-1) and (B-2), the operation control at the phase 3 seems to be sufficient. Introduction of ARC described for the phase 4 is little effective when freight trains are operated. For the operation of approximately 150 trains, PRC expected at the phase 5 is premature, in view of the time of the completion of CTC introduction.

3 TRAIN OPERATION

3.1 Option A-1

1) Outline of Existing Line

3.1 Trains are hauled by diesel locomotives on the 1.726 km-long single-tracked North-South line between Hanoi and Saigon, which is studded with 166 stations at intervals of 10 km on an average. The train speed is 70 to 80 km/h for 90% of the entire route. To set departure/arrival routes, each station is equipped with the class 2 relay interlocking system to locally manipulate switches. The individual section blocking system is used to allow the presence of only one train between adjacent stations.

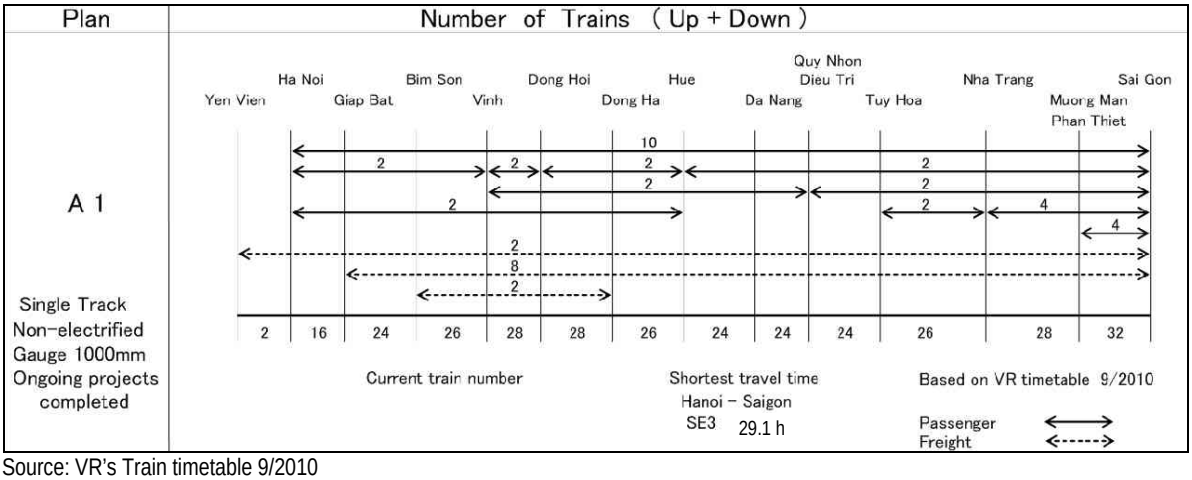
2) Train Operation

(1) Frequencies of Passenger and Freight Trains

3.2 Passenger trains are operated directly from Ha Noi to Sai Gon and vice versa, or between different areas located within the section. It takes 29.1 hours to cover the Ha Noi–Saigon section by the fasted SE3 train through-operation and 41 hours by TN2 trains due to frequent siding along the route to avid trains in the opposite direction or those running at higher speed.

3.3 Regarding freight trains, two trains are operated on the up- and down-tracks in the Yen Vien–Saigon section, eight trains in the Giap Bat–Saigon section and two trains in the Bim Son–Dong Ha section, when all trains in the two directions are counted together.

3.4 In the Muong Man–Saigon section, 32 passenger and freight trains are operated on the up- and down-tracks.



Source: VR's Train timetable 9/2010

Figure 3.1.1 Number of Trains for A-1

(2) Train Speed

3.5 The train speed on the North-South line is 100 km/h for 0.3% of the route and 70 to 80 km/h for 90% of the entire route length. However, the train speed is reduced to 15 to 60 km/h on 36 bridges, 15 to 50 km/h in 7 tunnels and 30 to 75 km/h on some curves.

Table 3.1.1 Train Speed

Train speed	km/h	25	30	40	50	60	70	80	90	100	Total
Running distance	Km	2.5	30.7	13.4	47.2	80.8	811.2	721.9	11.0	5.9	1724.78
	%	0.1	1.8	0.8	2.7	4.7	47.0	41.9	0.6	0.3	

Source: Vietnam Railways (2011)

(3) Line Capacity

3.6 JICA Study Team has calculated the number of trains to be set on each section between stations of the North-South line (166 stations), by taking into consideration the operation time (on up- and down-tracks) and the route setting time after locally manipulating switches.

3.7 The line capacity is 30 trains or over in the Hai Van and Dong Chuoi–Kim Lu sections, where trains consume much time due to low-speed operation on steep gradient and in tunnel sections.

3.8 Even if the tracks between stations or those for departure/arrival at stations were increased at the sections (33% of the total) having a ling capacity of 30 to 40 trains, the capacity may increase only to 50 trains or so. Therefore, it is impossible to draw an ideal train operation diagram or cut train hours. To set 60 trains or over, it is necessary to construct two-train crossing stations in 102 sections (60%). This requires discussions on the electrification over the entire route.

$$\text{Line capacity (No. of trains)} = \frac{1.440}{\text{Operation time + Signal handling time}} \times \text{Line utility ratio (0.6)}$$

Table 3.1.2 Line Capacity

Line capacity	30 or over	40 or over	50 or over	60 or over	70 or over
Section between stations	16	39	47	41	23
Percentage	10%	23%	28%	25%	14%

Source: JICA Study Team

3.9 The transport improvement projects in the case A-1 include repair/remodeling of bridges, reinforcement of Khe Net and Hai Van passes, procurement of locomotives and modernization of telecommunication facilities.

3.10 These measures are to improve facilities and raise the safety level and. therefore, do not contribute to the improvement of transport capacity, with the number of trains remaining unchanged.

3.2 Option A-2

1) Prerequisite Conditions

3.11 The transport improvement projects in the option A-2 are to install new stations in long single-track sections that now make a bottleneck in train operation, thereby increasing the line capacity. New stations will be constructed with track conditions kept unchanged.

- Single-track operation
- Non-electrification
- Meter-gauge
- Installation of new stations

2) Installation of New Stations

3.12 JICA Study Team will verify the effect of 18 new stations to be built for the North-South line to increase the frequency of train operation.

Table 3.2.1 New Stations

No.	Section	new station
1	Mỹ lý – Quán Hành	Km298+800
2	Đồng Lê – Ngọc Lâm	Km442+950
3	Thượng Lâm – Sa Lung	Km580+950
4	Hương Thủy – Truồi	Km707+400
5	Trà Kiệu – Phú Cang	Km831+800
6	Bồng Sơn – Vạn Phú	Km1026+260
7	Vạn Phú – Phù Mỹ	Km1042+250
8	Vân Canh – Phước Lãnh	Km1129+600
9	La Hai – Chí Thạnh	Km1160+500
10	Nha Trang – Cây Cầy	Km1321+800
11	Ngã Ba – Cà Rom	Km1372+000
12	Cà Ná – Vĩnh Hảo	Km1446+015
13	Lòng Sông – Sông Mao	Km1474+550
14	Ma Lâm – Mương Mán	Km1541+500
15	Mương Mán – Suối Vận	Km1557+900
16	Suối Vận – Sông Phan	Km1575+950
17	Long Khánh – Dầu Dây	Km1655+600
18	Dầu Dây – Trảng Bom	Km1672+400

Source: JICA Study Team

3) Line Improvement

3.13 Tunnels will be constructed through the Khe Net and Hai Van passes, a bottleneck at present for the transport by the North-South line, to ensure safe and stable transport, cut the operation time and increase the frequency of train operation.

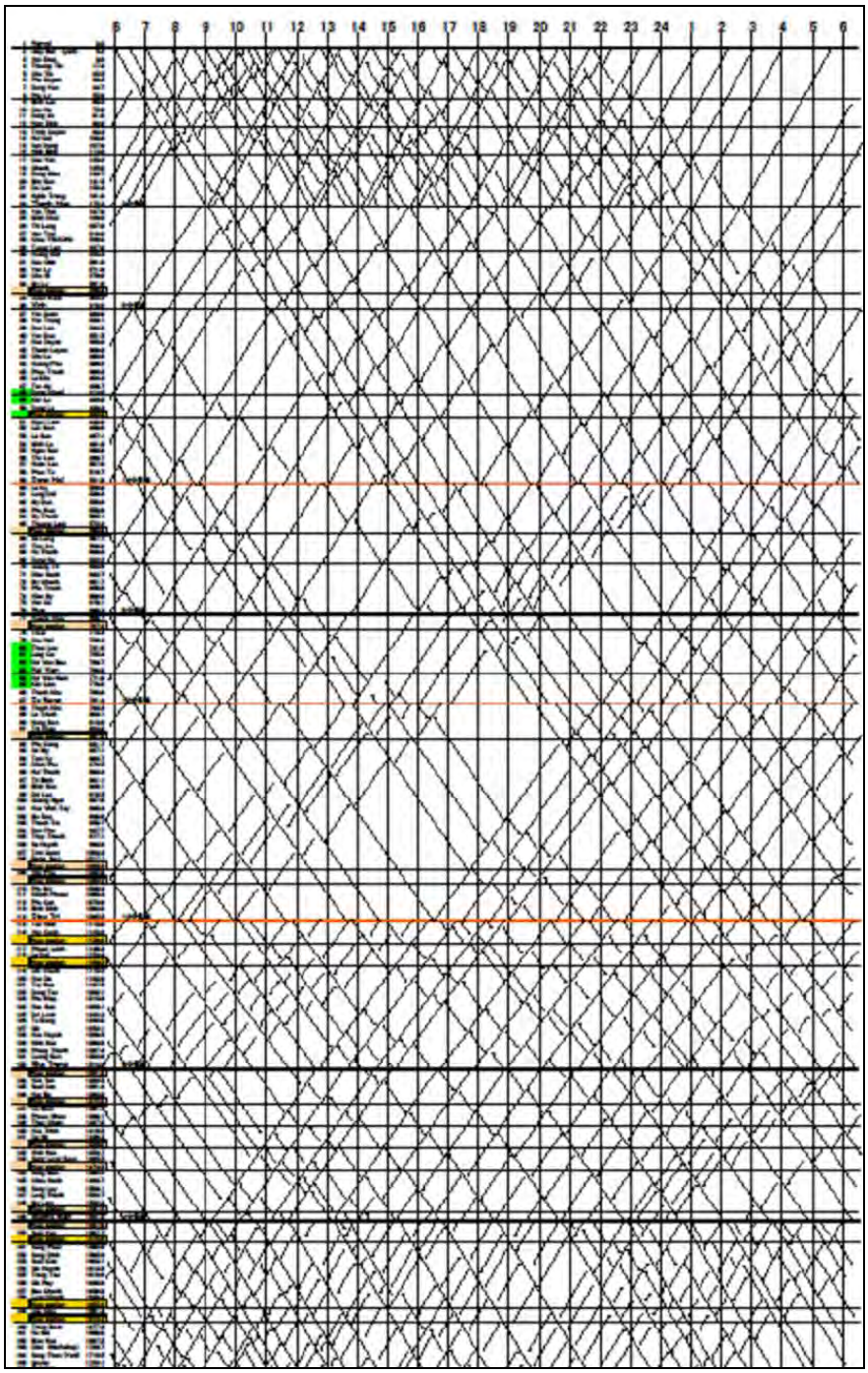
Table 3.2.2 Effect of Tunneling

Effect of tunneling	Hai Van pass	60 minutes cut
	Khe Net pass	8 minutes cut

Source: JICA Study Team.

4) Drawing Train Operation Diagrams

3.14 JICA Study Team has drawn train operation diagrams based on the existing standard operation time for the North-South line.

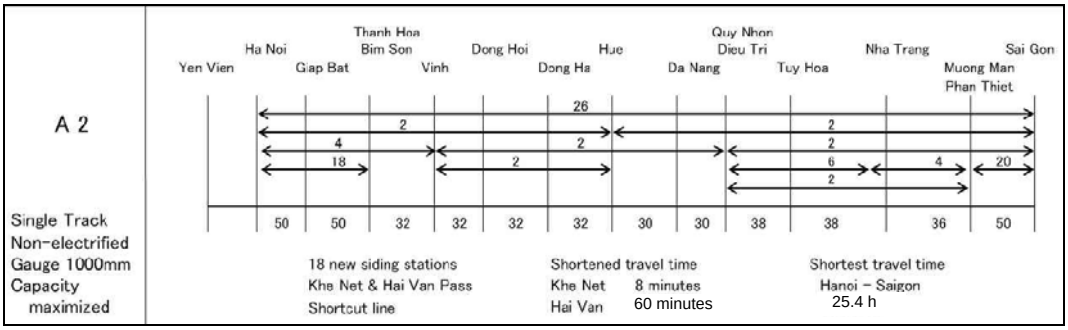


Source: JICA Study Team

Figure 3.2.1 A-2 Train Operation Diagram

5) Conclusion

3.15 In the sections where the line capacity is 30 trains or over to make a bottleneck in the train operation diagrams at present, 18 crossing stations will be built. JICA Study Team has verified that the frequency of train operation will be increased by 50 in the Ha Noi–Thanh Hoa section and by 50 in the Muong Man–Saigon section, as a result.



Source: JICA Study Team

Figure 3.2.2 Number of Trains for Option A-2

3.3 Option B-1

1) Prerequisite Conditions

3.16 In the case B-1, JICA Study Team will set train operation diagrams to improve transport based on the demand forecast in case double-track operation is implemented. JICA Study Team will discuss the effect to improve transport in case the North-South line is double tracked.

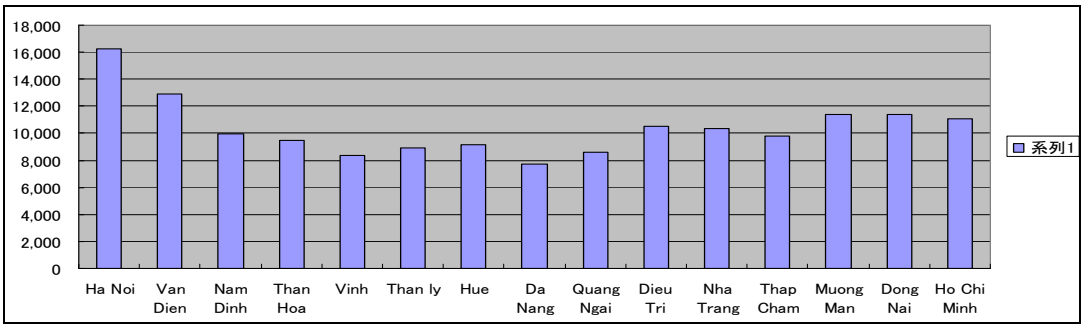
Table 3.3.1 Prerequisite Conditions for the Option B-1

Prerequisite conditions for the option B-1	• Double-track operation • Non-electrification • Meter-gauge • 120 km/h operation for passenger trains • 80 km/h operation for freight trains

Source: JICA Study Team.

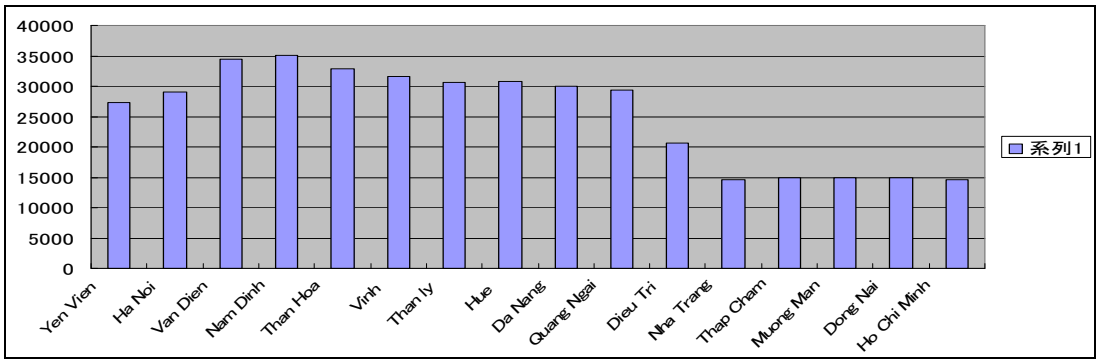
2) Demand Forecast

3.17 JICA Study Team uses the VITRANSS2 demand forecast data for the case B-1.



Source: VITRANSS2

Figure 3.3.1 Volume of Passenger Transport: Series 1



Source: VITRANSS2

Figure 3.3.2 Volume of Freight Transport: Series 1

3) Train Composition

(1) Locomotive

3.18 For the verification, JICA Study Team uses the DF200 type locomotive used for non-electrified sections in Japan.

- Operation speed: 120 Km/h
- Hauling capacity: 1,000 t

(2) Passenger car

- A passenger train is composed of 15 cars to a capacity of 1,000 passengers.
- Power source car: 1
- Dining car: 1
- Passenger car: 13

4) Operation Time

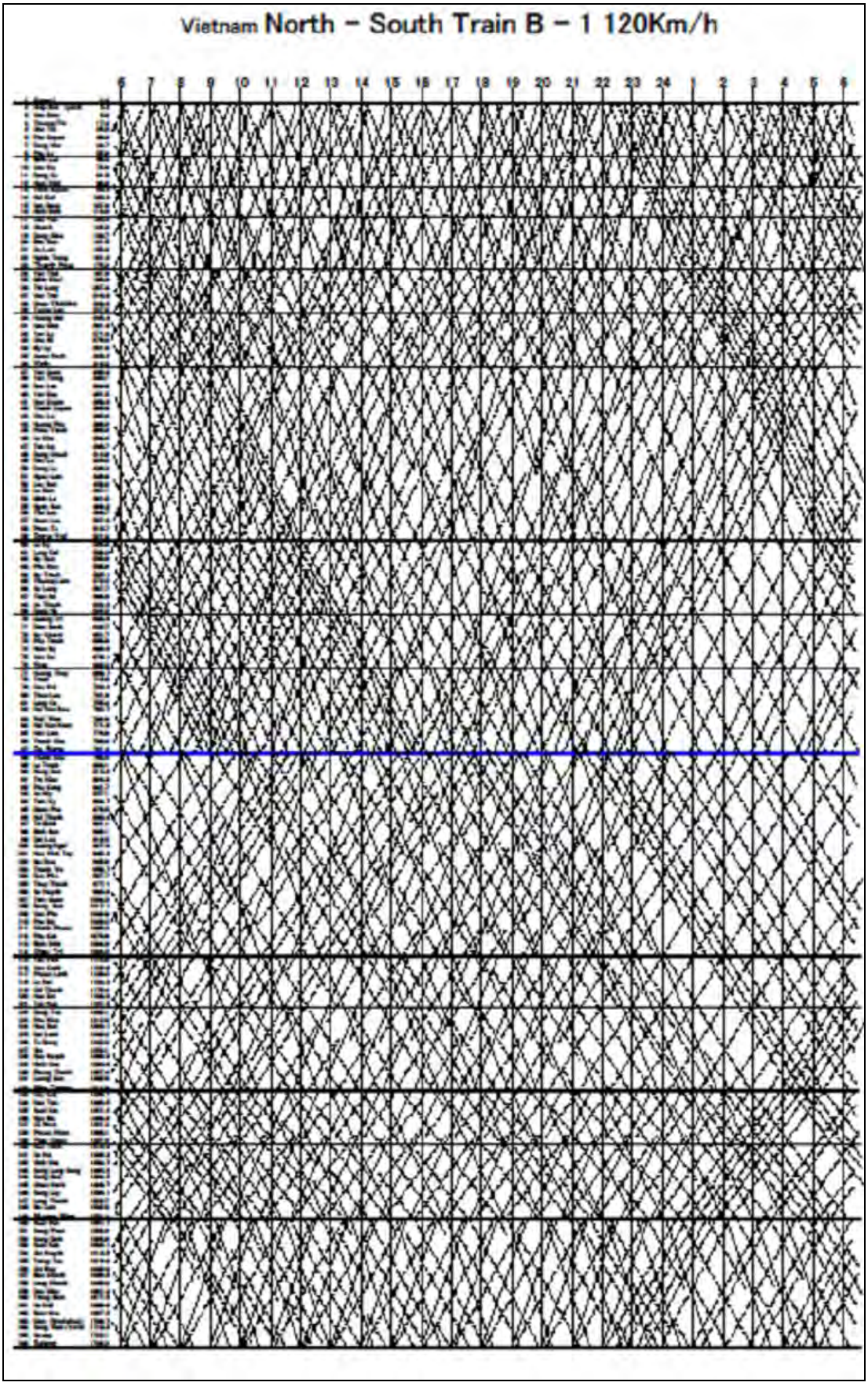
Table 3.3.2 Operation Time of B-1

Down						Up					
	Station	Operation time	Dwell time				Station	Operation time	Dwell time		
			120 km/h						120 km/h		
1	Hanoi	0.0				166	Saigon	1726.2			
23	Thanh Hoa	175.2	1:31:15	0:05:00	1:36:15	149	Muong Man	1551.2	1:31:00	0:05:00	1:36:00
36	Vinh	319.0	1:15:00	0:05:00	2:56:15	132	Nha Trang	1314.9	2:02:15	0:05:00	3:43:15
59	Dong Hoi	521.8	1:45:15	0:05:00	4:46:30	114	Dieu Tri	1095.5	1:54:00	0:05:00	5:42:15
76	Hue	688.3	1:27:00	0:05:00	6:18:30	87	Da Nang	791.4	2:37:30	0:05:00	8:24:45
83	Non-stop at Hai Van	766.8	0:41:00	-	6:59:30	83	Non-stop at Hai Van	766.8	0:13:30	-	8:38:15
87	Da Nang	791.4	0:13:30	0:05:00	7:18:00	76	Hue	688.3	0:41:00	0:05:00	9:24:15
114	Dieu Tri	1095.5	2:37:00	0:05:00	10:00:00	59	Dong Hoi	521.8	1:26:45	0:05:00	10:56:00
132	Nha Trang	1314.9	1:53:30	0:05:00	11:58:30	36	Vinh	319.0	1:45:00	0:05:00	12:46:00
149	Muong Man	1551.2	2:02:45	0:05:00	14:06:15	23	Thanh Hoa	175.2	1:15:15	0:05:00	14:06:15
166	Saigon	1726.2	1:31:30		15:37:45	1	Hanoi	0.0	1:31:30		15:37:45
			14:57:45	0:40:00	15:37:45				14:57:45	0:40:00	15:37:45
			Scheduled speed		110 Km/h				Scheduled speed		110 Km/h

Source: JICA Study Team

5) Drawing Train Operation Diagrams

3.19 The Study team has drawn train operation diagrams based on the demand forecast for passenger and freight trains in the option B-1.



Source: JICA Study Team

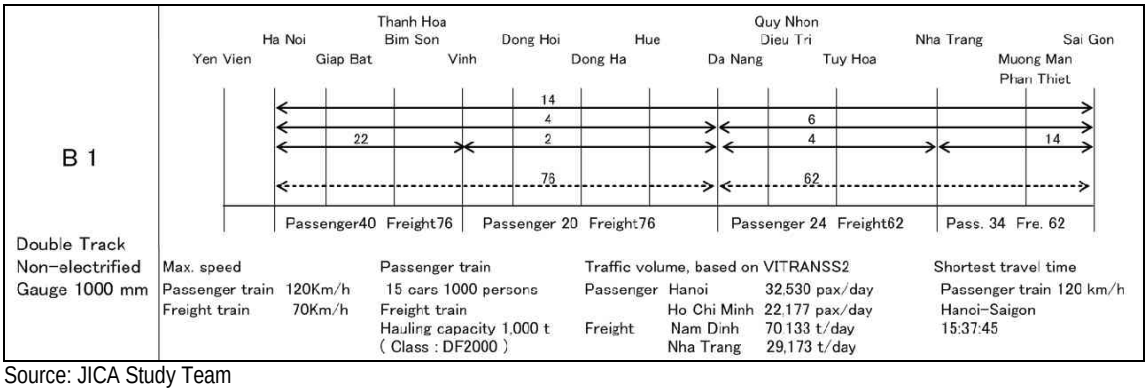
Figure 3.3.3 B-1 Train Operation Diagram

6) Conclusion

3.20 Maximum 40 passenger trains can run in the Ha Noi–Vinh section and minimum 20 in the Vinh–Da Nang section. 76 freight trains can run in the Ha Noi–Da Nang section and 62 in the Da Nang–Sai Gon section.

3.21 JICA Study Team ensures the operating frequency of passenger and freight trains based on the demand forecast for 2030 in VITRANSS2.

Figure 3.3.4 Number of Trains for Option B-1



Source: JICA Study Team

3.4 Option B-2

1) Prerequisite Conditions

3.22 The option B-2 addresses a transport improvement project assuming an electrified standard-gauge double-track line, for which JICA Study Team will set train operation diagrams based on the demand forecast.

Table 3.4.1 Prerequisite Conditions for the Option B-2

Prerequisite conditions for the option B-2	• Standard gauge • Double-track operation • Electrification • 150 km/h operation for passenger trains • 120 km/h operation for container trains • 80 km/h operation for freight trains

Source: JICA Study Team

2) Demand Forecast

3.23 JICA Study Team uses the demand forecast data in VITRANSS2 for the discussion on projects in the option B-2 as same as option B-1.

3) Train Composition

(1) EMU

3.24 For the verification, JICA Study Team will use the “Hakutaka” type EMU running at 160 km/h in Japan.

- Composition: 5M10T
- Operation speed: 150 km/h
- Passenger capacity: 962 passengers

Source: JICA Study Team

Figure 3.4.1 “Hakutaka” type EMU

(2) Electric Locomotive

3.25 For the verification, JICA Study Team will use the EF81 type electric locomotive used for the electrified sections in Japan

- Operating speed: 120 km/h
- Hauling capacity: 1,100 t

Source: JICA Study Team

Figure 3.4.2 EF81 Type Electric Locomotive

4) Operation time

(1) Operation Time of Passenger Trains

Table 3.4.2 Operation Time of Passenger Trains of B-2

Down						Up					
	Station	Operation time	Dwell time				Station	Operation time	Dwell time		
			150km/h						150km/h		
1	Hanoi	0.0				166	Saigon	1726.2			
23	Thanh Hoa	175.2	1:13:30	0:05:00	1:18:30	149	Muong Man	1551.2	1:13:30	0:05:00	1:18:30
36	Vinh	319.0	1:00:45	0:05:00	2:24:15	132	Nha Trang	1314.9	1:38:15	0:05:00	3:01:45
59	Dong Hoi	521.8	1:24:30	0:05:00	3:53:45	114	Dieu Tri	1095.5	1:31:30	0:05:00	4:38:15
76	Hue	688.3	1:10:15	0:05:00	5:09:00	87	Da Nang	791.4	2:06:15	0:05:00	6:49:30
83	Non-stop at Hai Van	766.8	0:33:15	-	5:42:15	83	Non-stop at Hai Van	766.8	0:11:15	-	7:00:45
87	Da Nang	791.4	0:11:00	0:05:00	5:58:15	76	Hue	688.3	0:33:00	0:05:00	7:38:45
114	Dieu Tri	1095.5	2:06:00	0:05:00	8:09:15	59	Dong Hoi	521.8	1:10:00	0:05:00	8:53:45
132	Nha Trang	1314.9	1:31:15	0:05:00	9:45:30	36	Vinh	319.0	1:24:30	0:05:00	10:23:15
149	Muong Man	1551.2	1:38:45	0:05:00	11:29:15	23	Thanh Hoa	175.2	1:00:45	0:05:00	11:29:00
166	Saigon	1726.2	1:13:45		12:43:00	1	Hanoi	0.0	1:13:45		12:42:45
			12:03:00	0:40:00	12:43:00				12:02:45	0:40:00	12:42:45
			Scheduled speed		135Km/h				Scheduled speed		135Km/h

Source: JICA Study Team

(2) Operation Time of Freight Trains

Table 3.4.3 Operation Time of Passenger Trains of B-2

Down

	Station	Operation time	Dwell time		
			120km/h		
1	Hanoi	0.0			
23	Thanh Hoa	175.2	1:31:15	0:05:00	1:36:15
36	Vinh	319.0	1:15:00	0:05:00	2:56:15
59	Dong Hoi	521.8	1:45:15	0:05:00	4:46:30
76	Hue	688.3	1:27:00	0:05:00	6:18:30
83	Non-stop at Hai Van	766.8	0:41:00	–	6:59:30
87	Da Nang	791.4	0:13:30	0:05:00	7:18:00
114	Dieu Tri	1095.5	2:37:00	0:05:00	10:00:00
132	Nha Trang	1314.9	1:53:30	0:05:00	11:58:30
149	Muong Man	1551.2	2:02:45	0:05:00	14:06:15
166	Saigon	1726.2	1:31:30		15:37:45
			14:57:45	0:40:00	15:37:45
			Scheduled speed		110 Km/h

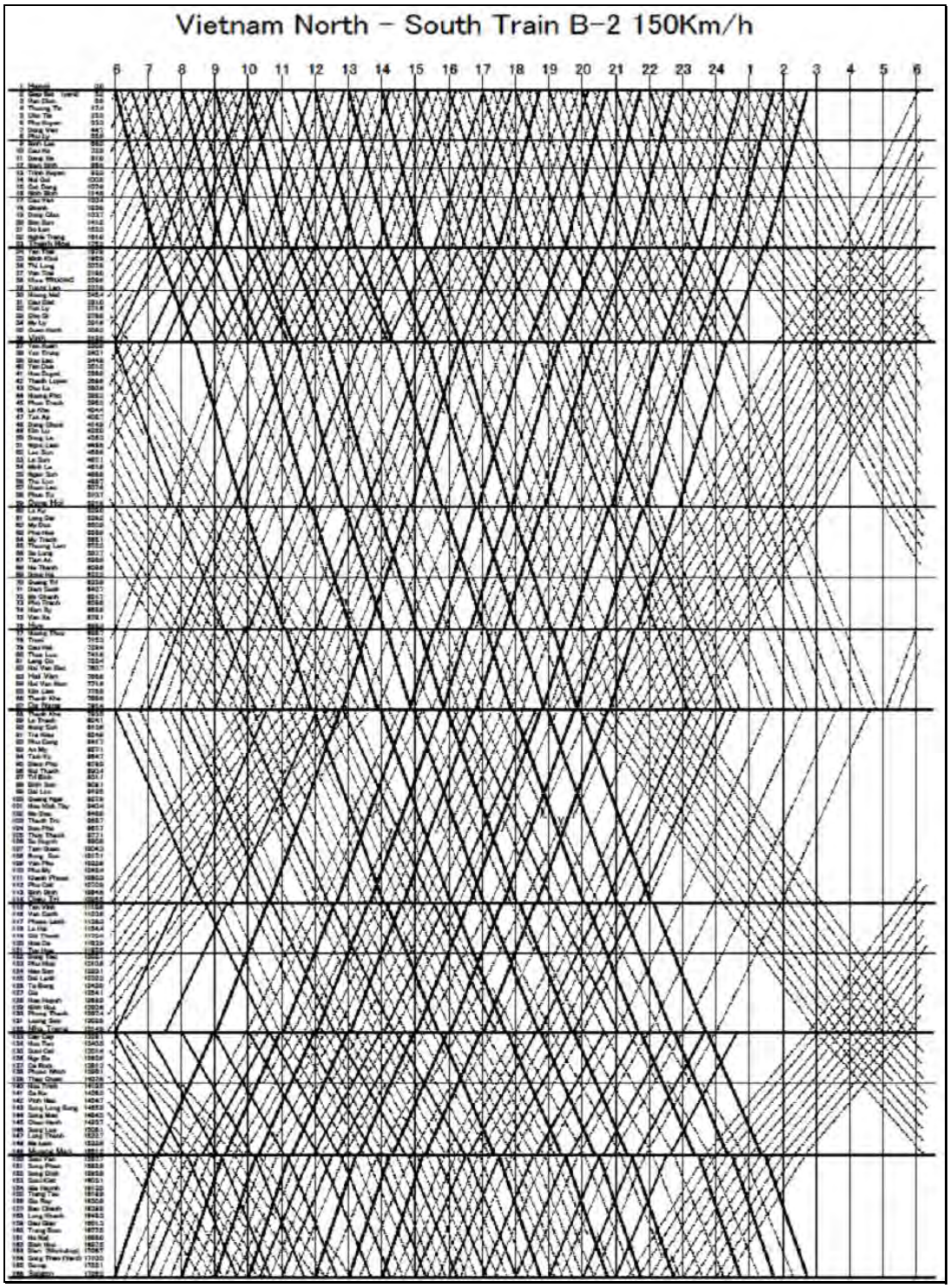
Up

	Station	Operation time	Dwell time		
			120km/h		
166	Saigon	1726.2			
149	Muong Man	1551.2	1:31:00	0:05:00	1:36:00
132	Nha Trang	1314.9	2:02:15	0:05:00	3:43:15
114	Dieu Tri	1095.5	1:54:00	0:05:00	5:42:15
87	Da Nang	791.4	2:37:30	0:05:00	8:24:45
83	Non-stop at Hai Van	766.8	0:13:30	–	8:38:15
76	Hue	688.3	0:41:00	0:05:00	9:24:15
59	Dong Hoi	521.8	1:26:45	0:05:00	10:56:00
36	Vinh	319.0	1:45:00	0:05:00	12:46:00
23	Thanh Hoa	175.2	1:15:15	0:05:00	14:06:15
1	Hanoi	0.0	1:31:30		15:37:45
			14:57:45	0:40:00	15:37:45
			Scheduled speed		110 Km/h

Source: JICA Study Team

5) Drawing Train Operation Diagrams

3.26 The Study team will set the operation diagrams for passenger and freight trains for the case B-2 based on the demand forecast.



Source: JICA Study Team

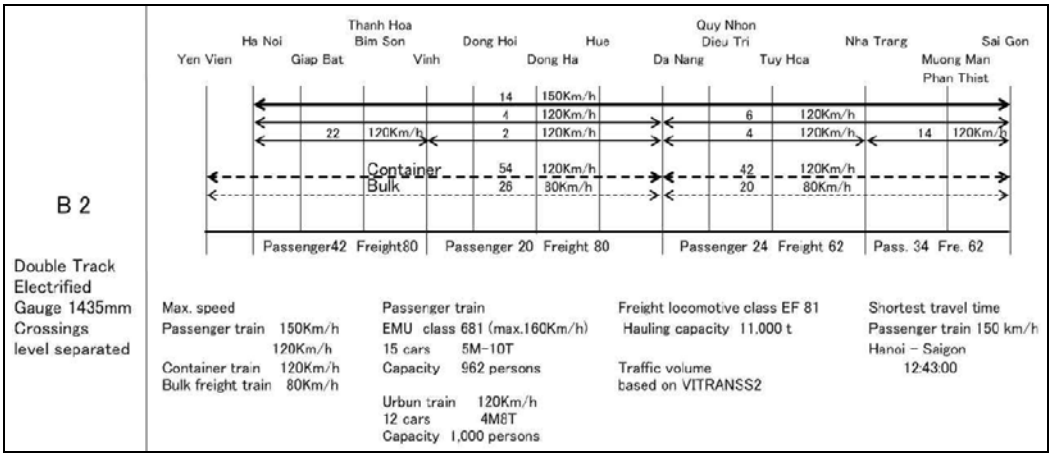
Figure 3.4.3 B-2 Train Operation Diagram

6) Conclusion

3.27 As passenger trains run as fast as at 150 km/h, container trains will be operated at 120 km/h as freight trains during the time zone when revenue service passenger trains are in operation.

3.28 The passenger trains for through-operation between Ha Noi and Saigon run at

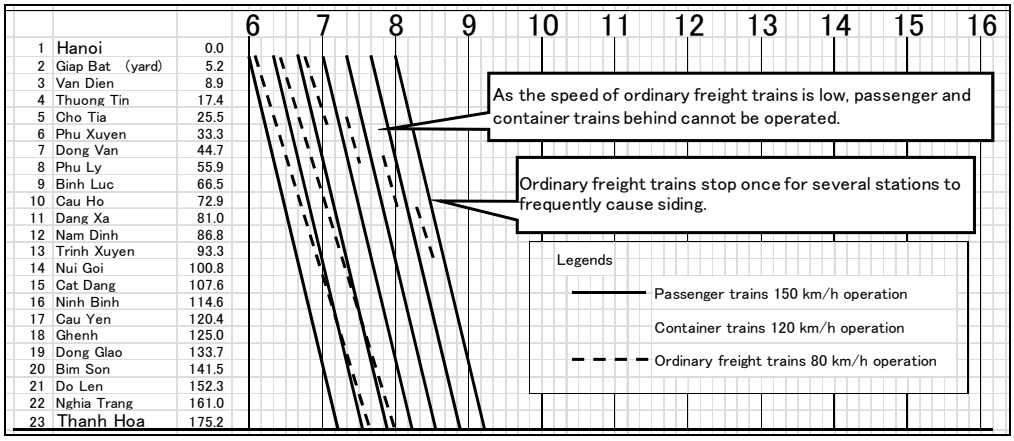
150 km/h and those between regions at 120 km/h. Eighty freight trains, more than in the option B-1, can be set to guarantee a sufficient transport capacity against the forecast demand.



Source: JICA Study Team

Figure 3.4.4 Number of Trains for Option B-2

3.29 Freight trains to run at 80 km/h will be overtaken frequently by high-speed passenger and container trains to cause great loss on the train operation Therefore, low speed freight trains will be operated after the operation of revue service passenger trains of the day has ended.



Source: JICA Study Team

Figure 3.4.5 Basic Idea of Operation Diagram of Freight Trains 80 km/h

4 INFRASTRUCTURE AND STATION

4.1 Option A-1

1) General

4.1 A1 consist by such projects that are either ongoing projects or committed projects. The construction method of each projects are examined in the each respective scheme, and the expense of each projects had been estimated on respective scheme of Vietnam Railway. The cost of Signal operation system and Signal protection device on level crossing are increased more than first scheme for modernizations.

4.2 Base conditions of A1 are followings:

(i) Upgrading existing single railway (gauge: 1000 mm, non-electrification, level crossing);

(ii) Replace and/ or improvement of existing track, ballast and bridge, tunnel whichever had come its durable term;

(iii) Upgrade telecommunication system, signal system, level crossing;

4.3 Project name of A1 are as followings:

4.4 In the case of Railway replace or improvement:

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

4.5 In the case of Upgrading/ replacing the existing bridges:

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

4.6 In the case of Signaling – Telecommunication System:

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

2) Summary on the Projects of A1

(1) Vinh–Nha Trang Superstructure Replacement Project

(a) **Objectives**

- Improve railway infrastructure, speed and load of the railway, develop ability to ensure train operation safety;
- Put Vinh–Nha Trang section into grade II, gauge 1000 mm (excluding hill railroad);

(b) **Scope of Project:** Start from Vinh station to Nha Trang station: 671.55km in length (from Km 318+198 - Km1314+000).

(c) **Specifications**

- Gauge: grade 2 gauge 1000mm;
- Design speed Vmax=100 Km/h;
- Plane: like existing one, local alignment Rmin = 600 m;
- Ip like existing one
- Ldd ≥ 400 m;
- Superstructure on main line Rail P50; L=25 m; PC sleeper;
- Track formation: Advantage 5,7 m; Disadvantage: ballast retaining wall;

(d) **Scale of Project**

- Replacement of RC K1, K2, steel sleepers by PC sleepers, strengthening track and laying more track no. 3 for double-track stations on Hanoi–Ho Chi Minh City Railway, Vinh–Nha Trang section;
- Alignment: upgrade 49 points R<600m total length 20,09Km;
- Track formation: embankment, expand track formation with length 671,55 km;
- Construct ditch for drainage is 21,37 km long;
- Construct ballast retaining wall with length 35,77 km.
- Consolidate slope 62.935 km.
- Overhaul superstructure of main line is 671,55 km long;
- Replace 342 turnout sets on main line;
- Construct 11 new RC bridge and 55 culverts on alignment;
- Upgrade 107 level crossings;
- Upgrade 92 stations, of which laying more track no. 3 for existing 07 stations of double tracks, lengthen the track in 17 stations, overhaul 68 stations.

(e) **Land Use Area:** Permanent land occupation for alignment of station expansion is 21,26 ha.

(f) **Project Cost:** 3.960 billion VND by scheme; in which 1.414 billion VND in stage 1;

(g) **Fund:** State fund;

(h) **Duration: 3 years**

(2) Hanoi–Vinh and Nha Trang–HCMC Sections Track Structure Strengthening Projects

(a) **Objectives:** Improve railway infrastructure, ability to ensure running train safety;

(b) **Scope of Project:** Hanoi–Ho Chi Minh City railway from Km0 - 318+198 and Km1314–Km 1726;

(c) **Specifications**

- Gauge: grade 2 gauge 1000 mm;
- Design speed Vmax=100 km/h;
- Plane: like existing one, local alignment Rmin = 600 m;
- Ip like existing one;
- Ldd ≥ 400 m;

- Superstructure on main line Rail P50; L=25 m; PC sleeper;
- Track formation: 5,7 m;

(d) **Scale of Project**

- Overall overhaul, replacement for existing rail, sleeper with rail P50 in 15.48 km length;
- Remake ballast foundation, replacement for existing sleepers with PC
- Sleeper: 95 km.
- Synchronous weak soil treatment: 74,38 km;
- Replacement for 152 turnout sets on main line

(e) **Project Cost:** 3.689 bill VND;

(f) **Fund:** State fund;

(g) **Duration:** 3 years;

(3) 44 bridges improvement project Hanoi-Hochiminh City Railway Line Bridges Safety Improvement Project (44 Bridges)

(a) **Objectives**

- To enhance safety during train operation;
- To enhance safety for other traffic activities and the residents living along the railway under the Project scope;
- To shorten train routes;

(b) **Scope of project:** Hanoi–Hochiminh City Railway Line Km111+700–1551+700

(c) **Specifications**

- Design Class: permanent bridge, 1000mm-gauge track;
- Train Load: T15D;
- Load of Road on Bridge: Steel-girder bridge 300Kg/m^2; ballasted concrete-girder bridge 1,000 kg/m^2;
- Design Speed: Vpassenger=100 km/h; Vfreight=80 km/h (in some bridges, this speed can be increased to 120 km/h if possible);
- Clearance of Railway Bridge: Height H=5.3 m; Width B= 4 m;
- Flood Frequency: P=1% for bridges on realigned section
- Horizontal Alignment: Rmin = 300 m; and R min ≥ 200 m on Cua Rao bridge
- Ip: as present
- L effective Length ≥ 500 m;
- Track Bed: 5.7 m on rail-welding case and Bmin = 5.5 m for the remaining.

(d) **Scope of Investment**

- Rehabilitating 44 bridges and access roads (of which 8 bridge will be realigned and the remaining 36 bridges will be located at the same places);
- Upgrading and improving 22 level crossings, of which 10 level crossings will be of automatic warning type, 2 level crossings will be of signage type, and the remaining 10 will be of guardsmen type;

- Constructing 3 railroad under-bridges and 23 box culverts;
- Upgrading, improving, and constructing 14 underpasses;
- Constructing 2 flyovers to the south of Ninh Binh station and to the south of Do Len station;
- Constructing Ninh Binh station;
- Purchasing 12 types of equipment for repairing and maintaining railway and bridges.

(e) **Land Use Area:** 74.53ha of land will be permanently used for realignment section due to station expansion.

(f) **Project Cost:** VND2,498 billion;

(g) **Fund:** VND1,102 billion from State budget + ¥19,663 billion Yen from ODA loan;

(h) **Duration:** 7 years (2005–2012);

(4) 132 bridges Safety Improvement Project; Improvement and Upgrading of Remaining Weak Bridges on Hanoi–Hochiminh City Railway Line (132 bridges);

(a) **Project Objectives:** To use a uniform 4.1T/m load for Belgium locomotive-using trains on the entire Hanoi–Hochiminh City Railway Line. The load of upgraded bridges must be equivalent to that of standard trains, namely T14 for reused girders and abutments, and T16 for new abutments.

(b) **Scope of project:** Hanoi–Hochiminh City Railway Line, Km791+400 - 1726+200

(c) **Specifications**

- Track Gauge: 1,000 mm-gauge track;
- Track Class: 2
- Train Load: T14 for reused girders and abutments, and T16 for new abutments;
- Design Flood Frequency: P=1% for medium-span and long-span bridges, and P=2% for small-span bridges and culverts.
- Minimum width of Track Bed on Straight Line: B=5.7 m;
- Horizontal Curve Radius: Rmin = 600 m;
- Maximum Vertical Gradient: Ip =12‰; Minimum length of slope: L=150 m.

(d) **Scope of investment:** Improving and upgrading 132 weak bridges on Da Nang–Hochiminh City section to use a uniform 4.1T/m load for Belgium locomotive-using trains on the entire Hanoi - Hochiminh City Railway Line.

(e) **Land Use Area:** 15.1ha of land will be permanently used for realignment section due to station expansion.

(f) **Project Cost:** VND1,433 billion;

(g) **Fund:** State fund;

(h) **Duration:** 4 years (2008–2012)

(5) 566 Bridges Safety Improvement Project Hanoi–Ho Chi Minh City Railway Line Bridges Safety Improvement Project (566 bridges)

(a) **Project Objectives:** Upgrading and improving bridges in order to ensure train operation safety;

(b) **Scope of Project:** The North-South Railway Line from Km791+400 to Km1726+200.

(c) **Specifications**

- Grade of Track: grade 2 – 1000 mm gauge;
- Design Speed Vmax=100 km/h;
- Horizontal Alignment: same as the existing; local realignment Rmin = 600 m;
- Ip same as the existing;
- Ldd ≥ 400 m;
- Superstructure: Main line Rail P50; L=25 m; PC sleeper;

(d) **Scale of Investment:** Upgrading, improving 566 bridges on Da Nang–Ho Chi Minh City section to unify the operated train load with Belgium +4,1T/m on the whole Hanoi–Ho Chi Minh Line.

(e) **Project Cost:** 2,284 billion Vietnam Dong;

(f) **Fund:** State budget;

(g) **Duration:** 8 years (2012–2020);

(6) Weak 22 Tunnels Consolidation Project; Reinforcement of Weak Tunnels on Hanoi–Ho Chi Minh City Railway Line

(a) **Project Objectives:** To ensure the safety of train operation and remove the speed limit locations;

(b) **Scope of Project:** The North-South railway line from Km455+432–Km1310+888

(c) **Specifications**

- Railway Grade: grade 2 with gauge 1000 mm;
- Designed Speed Vmax=100 km/h;
- Horizontal Alignment: as existing; local realignment: Rmin = 60 0m;
- Ip is as existing;
- Ldd ≥ 400 m;
- Superstructure of Main Line: Rail P50; L=25 m; pre-stressed concrete sleeper;

(d) **Scale of Investment:** This project is only for rehabilitation and reinforcement of the weak tunnel to ensure train operation safety, removing the speed limit and meet transportation need of this railway line. The project essentially keep technical standards of the line, such as: horizontal alignment, profile, limited gradient. So, scale of investment is:

- Reinforcement, repairing and upgrading locally tunnel lining structure;
- New-built of tunnel lining in some manic damaged section.

(e) **Project Cost:** 1.911 billion VND;

(f) **Fund:** State Fund;

(g) **Duration:** 4 years (2012-2015);

Table 4.1.1 List of 22 Tunnels in Line

No	Name of Tunnel	Chainage	Length (m)
1	Tunnel No. 1	Km455+432	63.77
2	Tunnel No. 2	Km455+765	247.44
3	Tunnel No. 3	Km456+245	114.46
4	Tunnel No. 4	Km466+255	100.67
5	Tunnel No. 5	Km466+496	193.44
6	Tunnel No. 6	Km725+210	220.72
7	Tunnel No. 11	Km759+513	161.75
8	Tunnel No. 12	Km766+049	564.17
9	Tunnel No. 14	Km774+674	944.62
10	Binh De	Km998+399	273.39
11	Phu Cu	Km1023+833	170.18
12	Chi Thanh	Km1168+704	325.31
13	Baponeau	Km1224+816	1198.2
14	Vung Ro 4	Km1227+120	371.23
15	Vung Ro 3	Km1228+115	159.46
16	Vung Ro 2	Km1228+702	257.99
17	Vung Ro 1	Km1229+252	60.39
18	Bai Gio	Km1231+188	402.58
19	Co Ma	Km1234+464	407.4
20	Ro Tuong	Km1290+277	219.03
21	Ru Ri	Km1306+740	375.1
22	Ngoc Hoi	Km1310+888	76.25

Source: TRICC

(7) HN–Vinh Signaling–Telecommunication (Phase 2); Hanoi–Vinh Railway Signaling and Communication System on Hanoi–Hochiminh City Railway Line, Phase II

(a) **Project Objectives**

- To replace the obsolete railway signaling and communication system currently used on Hanoi–Vinh section with new signaling and communication system which applies advanced and modern technologies;
- To ensure uniformity with and optimal effectiveness for signaling and communication items invested in Phase I of this Project;

(b) **Scope of Project:** Hanoi–Hochiminh City Railway Line Km0+000–319+020 and branch lines

(c) **Specifications:** In accordance with next project Vinh–SG signaling–telecommunication (Phase 1)

(d) **Scope of Investment**

- **Communication System**
  - Installing communication systems for stations on branch lines so that these systems can be uniform with those of stations on main line, namely:
    - Phu Ly–But Son branch line;

- Bim Son–Bim Son Industrial Park branch line; and
- Cau Giat –Nghia Dan branch line.

− SDH equipment at a transmission speed of STM-1 (potential be increased to STM-4), de-multiplexers/multiplexers D&I, and dedicated digital telephone system will be used for the following branch lines:

− Establishing protective rings at Vinh and Hanoi cities
  - Establishing rings for signaling transmission lines.
  - Connecting to VNPT at Hanoi, Nam Dinh, Thanh Hoa, Cau Giat, and Vinh via interchange trunk lines.
  - Establishing data communication system.

- **Signaling System**
  − Installing centrally electrifying equipment (micro-processing interlocking) for 34 stations;
  − Installing axle counter-based blocking equipment for 34 stations;
  − Establishing Central Train Control (CTC) on Hanoi–Vinh section.
  − Synchronization and Training System;

(e) **Land Use Area:**

(f) **Project Cost:** VND 1,082 billion (ODA loan: VND847 billion)

(g) **Fund:** ODA loan from French Government and Vietnam reciprocal capital;

(h) **Duration:** 4 years (2007–2010); Project is on the way.

(8) Vinh–SG Signaling–Telecommunication (Phase 1); Modernization of Signaling and Telecommunication System on Vinh–Ho Chi Minh City Section on The North-South Railway Line-Phase 1"

(a) **Project Objectives:** Reject the backward and weakness of the existing signaling and telecommunication system

(b) **Scope of Project:** Km 319+020–Km 1726 section on North-South railway line

(c) **Scale of Project**

- **Telecommunication System**
  − Transmission system
    - Building the optical cable suspension line – Type of G625 - 12 strands with 1.150km long and the add – and - drop system from Vinh station to Nha Trang Station;
    - Installing device to connect the loop protection: 1.0 point;
    - Installing SDH transmission device and NMS transmission network management system from Vinh to Nha Trang.
  − Switching System: Switching devices (all in the switching monitoring and management system: 26.000 telephones and installing subscriber: 950 telephones.
  − Specialized Communication System: Building the coaxial cable along the line and installing dialog box at section: 1.577 km; building the local communication system: 95 stations; installing devices (including the

monitoring system): 97 stations; clock and time distribution system: 97 stations.

- Other sync Communication Items: Installing lightening protection and earthing system: 95 stations; stand-by equipment: 97 stations; maintenance vehicle: 11 stations. Technical assistance: 97 stations.

- **Signaling System**
  - Interlocking device in station: Building, installing devices of centralized control station to control relay interlocking in combination with axle counter for 316 turnouts of stations from Da Nang to Sai Gon.
  - Block system: Building the semi-automatic block section in combination with the axle counter for 72 stations from Da Nang to Sai Gon.
  - Train operation monitoring system and computer-base measurement:
  - Building train operation monitoring system and computer-base measurement for 54 stations from Dieu Tri to Sai Gon.
  - Turnout control system at section: 04 sets (at Chu Lai, My Trang, Ru Ri and Giac Lan).
  - Building the signal maintenance and inspection station: 4 stations.
  - Technical assistance: Supporting for 72 stations from Da Nang to Sai Gon.
- **Other Relevant Sync Works**
  - Station: 120 stations, power feeding: 116 stations, superstructure: serve the signal installation of 72 stations from Da Nang to Sai Gon.

(d) **Project Cost:** 3.059 billion Vietnam Dong (in which foreign loan of 2.003 billion Vietnam Dong);

(e) **Fund:** Chinese preferential loan and Vietnamese counterpart fund;

(f) **Duration:** 3 years (2011–2013);

(9) Operation Control Center Railway Operation Control Center (OCC) Modernization

(a) **Project Objectives:** Investing in railway signaling and telecommunication infrastructure, promoting the efficiency of investment projects for the future and existing railway infrastructure to improve the train operation schedule, dispatching passenger and freight train operation, dispatching rolling stocks; management and maintenance of infrastructure is a pressing demand to allow the high transport capacity to meet the better services for customers, providing better transportation services, attracting a mass volume transport. OCC is invested with high level of modern and has ability to extend and can connect with other relevant system on the North- South Railway line.

(b) **Scope of Project**

- OCC at the head office of Vietnam Railways, Hanoi.
- OCC of the North region is placed at Hanoi OCC.
- OCC of the South region is placed at Sai Gon passenger Transport Company, Ho Chi Minh City.
- Stations have operations of shunting, stations on all railway lines of Vietnam.

(c) **Specification:** Current EU norms applied to railway transport and relevant Vietnamese standards.

(d) **Scale of Investment**

- Main Operation Control Center
  - Main OCC and OCC of the north region: Equipping the host, workstation system for dispatcher.
  - Planning Unit: Equipping communication system, prints; control station system; planning station system.
  - Unit of stand-by control and training: Equipping host integrated COM and ADM; host system- simulation system; control station system; and communication system.
  - Unit of management, maintenance and overhaul: Equipping communication system and control station system.
- OCC of the South Region: Equipping the work station for dispatcher; prints and projector.
- Equipping for Locomotive: Equipment such GPS, GSM, WLAN, MMI/push-button, antenna over 350 locomotives of Vietnam Railways.
  - At stations: Equipping laptop and portable equipments for data input; equipping WLAN system for stations without GSM wave.
  - Other relevant sync works;

(e) **Project Cost:** 246 billion Vietnam Dong (ODA loan: 210 billion Vietnam Dong ~ 10.2 million EURO)

(f) **Fund:** Germany ODA loan and Vietnamese counterpart fund;

(g) **Duration:** 36 months (2007-2010), Project is on the way.

(10) Crossing Automatization with Signal Protection Device

4.7 This project is concerned to next level crossing adjustment project. Signal safety system and warning device of level crossing would be installed by this project except civil works.

(11) Amendment for Level crossing Project on Hanoi–Ho chi Minh City Railway

4.8 Adjustment of level crossing project on the North-South Railway Line;

(a) **Project Objectives**

- Improving, upgrading, and gathering the level crossing system on the North – South Railway line to improve the traffic safety.
- Concentrating the investment on the level crossings with high traffic volume.
- Priority over the new collector to gather level crossings and decrease intersections on the North-South Railway line.
- For the favorable locations of intersection, priority to design the grade interchange (underpass) instead of intersection at grade (level crossing).

(b) **Scope of Project:** The North-South Railway Line;

(c) **Specification**

- Grade of track: grade 2 – 1000 mm gauge;
- Gauge: 1000 mm – single track.
- Design load: 14 Tons/axial.
- Minimum radius Rmin = 300 m.
- Limited gradient iP = 6%.
- Length of the shortest grade Lmin = 150 m.
- Superstructure: Rail P43 L= 25 m; PC sleeper;

(d) **Scale of Investment:** Total intersections of 111

- Level crossing protected with side board: 21 Level crossings
- Level crossing protected with automatic warning signal: 31 Level crossings
- Level crossing protected with barrier: 33 Level crossings
- Level crossing protected with trolley barrier: 22 Level crossings
- Underpass: 04 Underpasses
- Collectors: 30.306 m
- Fence: 52.800m

(e) **Land Use Area:**

(f) **Project Cost:** 873 billion Vietnam Dong;

(g) **Fund:** State fund;

(h) **Duration:** 3 years (2012-2015);

3) The Structure Length being Applied to the Examination of A1 and A2 Plan

4.9 The structure length is shown by the Table 4.1.2 bellow.

Table 4.1.2 Structural Length Applied to the Examination of A1 and A2 Plan

Type of Structure		Scope of Station and Alignment		Total
		Station	Alignment	
Bridge	Bridge for flood sewage	22,521	22,125	22,521
	River bridge	17,459	17,364	17,459
	Viaduct	107	107	107
Tunnel	Tunnel	8,236	8,236	8,236
Roadbed	Flat ground	113,351	78,358	113,351
	Excavation	178,816	178,066	178,816
	Embankment	1,295,345	1,243,973	1,295,345
	Embankment + Excavation	65,655	49,605	65,655
	Semi-embankment	24,258	11,660	24,258
Total		1,725,749	1,609,494	1,725,749

Source: TRICC

4.10 The detail structure types are shown as attached “Types of foundation structure in line” (Table 4.1.3).

Table 4.1.3 Samples of Types of Foundation Structure in Line

Starting Point	Ending Point	Station, Line	Type of Foundation	Length	Center of Station	Station name	Bridge Name
Km+000	Km+600	Station	flat	600	Km000+000	Hanoi station	
Km+600	Km1+887	Line	flat	1287			
Km1+887	Km1+893	Line	Bridge for flood evacuation	5			Kim Lien bridge
Km1+893	Km3+677	Line	flat	1784			
Km3+677	Km3+683	Line	Bridge for flood evacuation	6			Giap Bat bridge
Km3+683	Km4+387	Line	flat	704			
Km4+387	Km5+750	Station	flat	1363	Km5+180	Giap Bat station	
Km5+750	Km5+965	Line	flat	215			
Km5+965	Km5+975	Line	Bridge for flood evacuation	10			Tien bridge
Km5+975	Km8+144	Line	flat	2169			
Km8+144	Km8+196	Line	Bridge for flood evacuation	52			Van Dien bridge
Km8+196	Km8+624	Line	flat	428			
Km8+624	Km9+645	Station	flat	1021	Km8+930	Van Dien station	
Km9+645	Km11+272	Line	flat	1627			
Km11+272	Km11+288	Line	River bridge	17			Ngoc Ho bridge
Km11+288	Km12+560	Line	flat	1272			
Km12+560	Km13+000	Line	flat	440			
Km13+000	Km13+150	Line	flat	150			
Km13+150	Km13+550	Line	flat	400			
Km13+550	Km13+800	Line	flat	250			
Km13+800	Km14+580	Line	flat	780			
Km14+580	Km14+581	Line	flat	1			
Km14+581	Km14+599	Line	Bridge for flood evacuation	17			Quan Ganh bridge
Km14+599	Km14+780	Line	flat	181			
Km14+780	Km15+300	Line	flat	520			
Km15+300	Km15+580	Line	flat	280			
Km15+580	Km16+600	Line	flat	1020			
Km16+600	Km17+000	Line	flat	400			
Km17+000	Km17+762	Station	flat	762	Km17+450	Thuong Tin station	
Km17+762	Km18+087	Line	flat	325			
Km18+087	Km18+093	Line	Bridge for flood evacuation	6			Thuong Tin bridge
Km18+093	Km19+300	Line	flat	1207			
Km19+300	Km19+480	Line	flat	180			
Km19+480	Km22+000	Line	flat	2520			
Km22+000	Km22+073	Line	flat	73			
Km22+073	Km22+091	Line	Bridge for flood evacuation	17			Ngoai Lang bridge
Km22+091	Km22+200	Line	flat	109			
Km22+200	Km22+400	Line	flat	200			
Km22+400	Km22+550	Line	flat	150			
The middle data continuing above is omitted.							
Km1699+741	Km1699+979	Line	River bridge	238			Large Dong Nai bridge
Km1699+979	Km1700+607	Line	Fill	628			
Km1700+607	Km1700+637	Line	Bridge for flooding evacuation	30			Cho Don bridge
Km1700+637	Km1702+075	Line	Fill	1437			
Km1702+075	Km1702+106	Line	Bridge for flooding evacuation	31			Chui bridge
Km1702+106	Km1703+650	Line	Fill	1545			
Km1703+650	Km1705+700	Line	Cut	2050			
Km1705+700	Km1706+300	Line	Fill	600			
Km1706+300	Km1707+100	Station	Flat	800	Km1706+710	Di An station	

Starting Point	Ending Point	Station, Line	Type of Foundation	Length	Center of Station	Station name	Bridge Name
Km1707+100	Km1709+000	Line	Cut	1900			
Km1709+000	Km1709+850	Line	Fill	850			
Km1709+850	Km1710+900	Station	Flat	1050	Km1710+560	Song Than bridge	
Km1710+900	Km1712+300	Line	Fill	1400			
Km1712+300	Km1713+300	Line	Cut	1000			
Km1713+300	Km1715+354	Line	Fill	2054			
Km1715+354	Km1715+439	Line	Bridge for flooding evacuation	85			Go Dua bridge
Km1715+439	Km1717+840	Line	Fill	2402			
Km1717+840	Km1718+610	Station	Flat	770	Km1718+340	Binh Trieu station	
Km1718+610	Km1718+944	Line	Fill	334			
Km1718+944	Km1719+234	Line	River bridge	290			Binh Loi bridge
Km1719+234	Km1720+235	Line	Fill	1000			
Km1720+235	Km1720+303	Line	Bridge for flooding evacuation	69			Rach Lang bridge
Km1720+303	Km1720+700	Line	Fill	397			
Km1720+700	Km1721+300	Line	Cut	600			
Km1721+300	Km1722+540	Station	Flat	1240	Km1722+130	Go Vap station	
Km1722+540	Km1725+543	Line	Fill	3003			
Km1725+543	Km1725+588	Line	Bridge for flooding evacuation	45			Ba Xep bridge
Km1725+588	Km1725+610	Line	Fill	23			
Km1725+610	Km1726+724	Station	Flat	1114	Km1726+200	Sai Gon station	

Source: TRICC
Legend:
1. Station: is the scope from signal post to signal post
2. Line: is the scope out of signal post
3. Flat: : is track formation without cutting or filling that smaller than 0,5m
4. Cut + Fill : is track formation that semi-cut and semi-fill
5. Semi-fill: is track formation that one side is flat and the other side is fill
6. Flyover: is railway bridge which is spanning over roadway

4.2 Option A-2

1) General

4.11 In order to increase train numbers per day according the objection of option A2, shortening of train operation time and installation of pass-by station/interchange station were examined. It was result that 18 pass-by stations are necessary to operate 50 train numbers per day. The cost of option A2 had been estimated according to each construction plan of the new projects and the construction scheme of feature projects being committed. It was understand that the following projects are required in order to operate as 50 train numbers per day.

- Leave as existing single railway (gauge: 1000 mm, non-electrification, level crossing)
- For saving operation time, upgrade alignment at 3 pass sections of Hai Van and Khe Net Pass, Hoa Duyet–Thanh Luyen section
- Construct 18 pass-by stations/ interchange stations for saving the time related interchange.
- Upgrade telecommunication system, signal system, safety device for level crossing, by the scope of 18 interchange stations and whole line
- Purchase of additional vehicles, expansion of vehicle yard, purchase of maintenance facility for locomotives, passenger car, flight cars whichever necessary for increased transport capacities.

4.12 Project name of option A2 are as followings:

- In the case of realignment:
  - Khe Net Pass realignment project
  - Hai Van Pass realignment project
  - Hoa Duyet–Thanh Luyen section upgrade project.
- In the case of improve sectional capacity:
  - Construct pass-by new stations.
  - Signaling and Telecommunication facilities for new stations and for whole line
  - Signal protection device for level crossing on Hanoi-Ho Chi Minh City
  - Vehicle workshops and facilities for the increased transportation capacity
  - Vehicle purchase for the increased transportation capacity

2) Summary on the Projects of Option A2

(1) Khe Net Pass Realignment Project

4.13 Realignment of railway line at area of Khe Net pass The North-South Railway Line.

(a) **Project Objectives:** Ensure train operation safety and increase capacity of the railway section;

(b) **Scope of Project:** The North-South Railway line from Km414+000–Km423+000;

(c) **Specifications**

- Railway grade: grade 2 with gauge 1000 mm;
- Designed speed: Vmax=100 Km/h;

- Horizontal alignment: Rmin = 600 m; Difficulty R=250 m
- Ip =9%;
- Ldd = 500 m;
- Superstructure of main line Rail P50; L=25 m; Pre stressed concrete sleeper;
- Minimum foundation 5,4 m;
- Limit gauge is 5,3 m in height, 4,4 m in width;
- Passing siding: Passing siding for people is 2,2 m in height, 2,0 m in length and 1,0 m in depth; Passing siding for car is 2,8 m in height, 4,0 m in length and 2,5 m in depth;

(d) **Scale of Investment**

- New- built of railway tunnel for gauge 1000 mm, improvement of 1 station, new-built of railway, level crossing and some bridges and culverts in section.
- Improvement of 6.021 m; from Km431+700-420+490;
- Tunnel No.1 is 870 m in length; Tunnel No.2 is 638.2 m in length;
- Approaching bridge in the Northern of tunnel is 5 girders of 33 m, between 2 tunnels is 19 girders of 33 m and the southern of tunnel is 9 girders of 33 m are necessary.

(e) **Project Cost:** 1.024 billion VND;

(f) **Fund:** State Fund;

(g) **Duration:** 4 years.

(2) Hai Van Pass Realignment Project/Hai Van Pass Railway Rehabilitation Project

(a) **Project Objectives:** To increase transport speed and volume, to reduce travel time over the two Passes, and to ensure optimal safety in all cases;

(b) **Project Scope:** From Lang Co station Km750+356.80 to Kim Lien station Km776+880;

(c) **Specifications**

- Track class: class 2 and 1,000 mm gauge;
- Design speed: Vmax = 100 Km/h;
- Horizontal alignment: Rmin = 600 m; in difficult cases: R=250 m;
- Ip =9%;
- L effective length = 500 m;
- Superstructure on main line: Rail P50; L=25 m; pre-stressed concrete sleepers;
- Minimum track bed: 5.4 m;
- Clearance: height H=5.3 m, width B= 4.4 m;
- Niche: niche for inhabitant people: 2,2 m tall, 2.0 m long and 1.0 m deep; niche for cars/wagons: 2.8 m tall, 4.0 m long, and 2.5 m deep.

(d) **Investment Scope**

- Alignment: The direction after the curve on the south of Hai Bridge is straight. The railway branches off to the right of the existing railway and passes the

low-lying rice fields. It then passes Hai Van mountain via a tunnel which has two curves with R= 1,000 m and L=70 m. After passing the tunnel, it lies on tangent. Afterward, it passes low-lying rice fields and adjoins the existing railway at the north of Kim Lien station through a curve with R=600m and L=60m.

- Stations: constructing new An Cu station in front of the north tunnel portal. The station has 4 tracks (not considering the main line) with an effective length of ≥ 500 m. The distance between tracks is 4.50m without platforms and 6.50m with intermediate platforms. Constructing one 4m-wide basic platform and two 3.5 m-wide & 300 m-long intermediate platforms. Constructing new stations, buildings, accommodation, station platforms, station squares, power and water systems. Keep Kim Lien station layout while increasing its height to suit with the new railway. Upgrade signaling system and passenger platforms.
- Tunnel: the tunnel is 8450 m long. There are two reverse curves with R=1,000m at the two tunnel portals.
- Cross-section: single tunnel with 1,000 mm gauge and niches in its middle.
- Bridges: constructing new Hoi Mit bridge (L=71 m), Hoi Can bridge (L=71 m), and Hoi Dua bridge (L=30 m) in front of the north tunnel. Constructing new Bridge Km762+467 (L=50 m), Bridge Km763+171 (L=71 m), and flyover Km763+355 (L=42 m) behind the south tunnel.

(e) **Project Cost:** D 184.68 million;

(f) **Fund:** State Fund or ODA loan

(g) **Duration:** 6 years

(3) Hoa Duyet–Thanh Luyen Section Upgrade Project

4.14 Upgrading and improving this section to ensure the train operation safety;

(a) **Scope of Project:** Hoa Duyet–Thanh Luyen section from Km357+000 to Km370+000;

(b) **Specifications**

- Grade of track: grade 2 – 1000 mm gauge;
- Design speed Vmax=100 km/h;
- Horizontal alignment: same as the existing; local realignment Rmin = 600 m;
- Ip same as the existing;
- Ldd ≥ 400 m;
- Superstructure: Main line Rail P50; L=25 m; PC sleeper
- Track bed: 5,7 m;

(c) **Scale of Investment**

- Upgrading and improving 4.719 km of track;
- Realigning 4.790 km of track;
- Upgrading and improving Hoa Duyet station with 950 m track length.
- Upgrading and improving Thanh Luyen station with 779 m track length
- Upgrading and improving, building 3 bridges with total of 326 m track length

- Building newly 1070 m track in tunnel.
- Building newly and connecting 29 culverts
- Upgrading and improving and building new optical cable system with digital electric exchange, semi-automatic block signal; centralized control turnout.
- Upgrading and improving the power and water architecture system of Hoa Duyet station and Thanh Luyen station in sync with the line.

(d) **Project Cost:** 1.334 billion Vietnam Dong;

(e) **Fund:** State budget;

(f) **Duration:** 3 years;

(4) Construction Pass-by New Stations

4.15 Increase of traffic capacity between sections by constructing new stations

(a) **Project Objectives:** To increase the traffic capacity of the entire railway to 25 train sets/day-night;

(b) **Project Scope:** Hanoi–Hochiminh City Railway Line;

(c) **Specifications**

- Track class: class 2 and 1,000 mm gauge;
- Design speed: Vmax = 100 km/h;
- Horizontal alignment: Rmin = 600 m; in difficult cases: R=300 m
- Ip: as present;
- L effective length ≥ 400 m;
- Superstructure on main line: Rail P50; L=25 m; pre-stressed concrete sleepers;
- Minimum track bed: 5.7 m;

(d) **Investment scope:** Constructing 18 new stations on Hanoi–Hochiminh City Railway Line

(e) **Land Use Area:** 36 ha

(f) **Project Cost:** VND 948 billion;

(g) **Fund:** State Fund;

(h) **Duration:** 4 years

(5) Signaling and Telecommunication Facilities for New Stations and for Whole Line

- This Project planned for 18 pass-by stations and whole line
- The detail of this project shall be explained in appendix of signal explanation.

(6) Signal Protection Device for Level crossing on Hanoi–Ho Chi Minh City

- This Project planned for whole north south line
- The detail of this project shall be explained in appendix of signal explanation.

(7) Vehicle Workshops and Facilities for the Increased Transportation Capacity

- The detail of this project shall be explained in appendix of workshop explanation.

(8) Vehicle Purchase for the Increased Transportation Capacity

3) The Construction of 18 New Pass-by Stations

(1) The Reasons Why 18 New Pass-by Stations are the Main Factor in Order to Increase Track Capacity to 50 Trains (25 train pairs)

4.16 With reference to the experience of operation in Vietnam and in Japan, the track capacity of 50 trains (25 pairs of trains) is suitable with the general conditions of the single-track railway. A greater capacity will require huge investment not only in infrastructure but also in locomotives and cars due to a considerable increase in stabling time of cars. Therefore, we adopt the alternative of maximizing the track capacity to 25 pairs of trains.

4.17 The number of sections must be increased to meet the track capacity of the sections.

Table 4.2.1 Track Capacity of Sections

Track Capacity of Sections	Hanoi - Vinh	Vinh - Dong Hoi	Dong Hoi - Da Nang	Da Nang - Dieu Tri	Dieu Tri - Nha Trang	Nha Trang - Sai Gon	Total
25 pairs of train / Day-night	0	0	5	4	9	0	18

Source: TRICC

4.18 The measures for implement of 50 trains per day are as follows:

(i) Traction increase method of train to reach 85% of permissible velocity of existing railway which solved 8 sub-sections;

(ii) Improving Hai Van pass and Khe Net pass which solve 9 sub-sections;

(iii) Improving turnout signal in 25 sub-section;

(iv) Replacing turnouts in 9 stations;

(v) Improving 12 slow speed points;

(vi) Other solutions: 18 sub-sections;

(vii) Newly opened 18 pass-by stations

(2) Time Saving Minutes according to the Option A1and Option A2

4.19 The summary of time saving minutes according to the option A1and option A2 is shown by Table 4.2.2.

Table 4.2.2 Outline of Time Saving by A1 and A2

No	Project's Name	Time Saving	
1	44 Bridge Improvement Project	36.19	A1
2	22 Tunnel Improvement Project	18.46	A1
3	Hoa Duyet - Thanh Luyen Section Improvement Project	4.25	A2
4	Khe Net Tunnel Project	8.03	A2
5	Hai Van Tunnel Project	59.93	A2
6	Construct new 18 pass-by stations	149.62	A2
	Total improved time	126-276	

Source: JICA Study Team based on TRICC data

4.20 The calculation of time saving value is done by next steps.

- Calculation of saving time by relevant improvements to release the limited speed
- Examination of effective countermeasures to get 50 trains per day through any operation time saving measures
- The measures that have been examined are improvement of signal, replacement of obsolete turnouts, improvements of bridges, tunnels and track.
- Open new 18 pass-by stations for time saving on interchange matters.

4.21 At last 18 additional new stations had been selected for option A2. The above examination report is keeping separately as detail report.

(3) Description on the Construction of Pass-by Stations

(a) General of 18 New Pass-by Stations

4.22 On Hanoi–Ho Chi Minh City railway, there are some sections of restricted topography and plane, which results in low speed; and the long section, which also lengthens train operation time; so these decreases passing capacity of the section and affect general passing capacity of whole railway. To improve passing capacity of the section, as studying the solutions of constructing more siding stations and laying 3rd arrival and departure track that is the most effective. Namely:

4.23 The construction of 18 new siding stations on 18 sections: 13 stations of double tracks and 05 stations of 3 tracks (including main line). New stations mainly consist of siding tracks, with standard length L available=450 m, and length of station foundation L min station foundation = 600m; the platforms are constructed at minimum dimension in stations, length of platform L platform=200m for staff's travel.

4.24 Three existing stations are Tran Tao, Bao Chanh, Ho Nai, which are constructed the 3rd track. The construction and upgrade of new stations and tracks (03-track station) is to avoid two adjacent stations having 02 advantageous tracks in train operation work. And three existing stations shall be upgraded additionally.

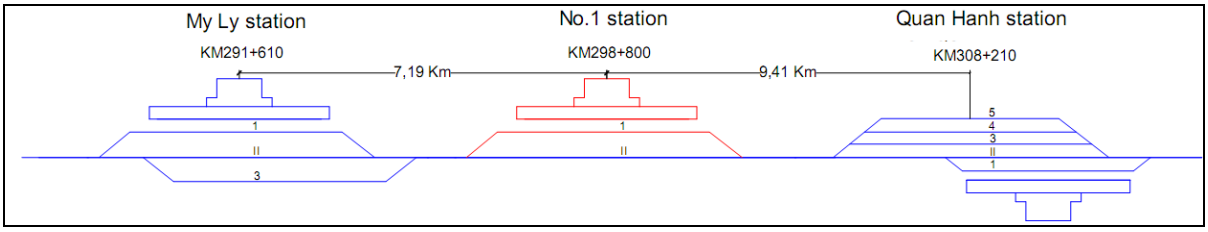
Table 4.2.3 Summary of Sections of 18 New Pass-by Stations

No	Section	Section Length (Km)	Train Operation Time (minute)	Name of New Station	Chainage of New Station Centerline	Length of New Sections		Remark (including main line)
						Section 1	Section 2	
1	My Ly–Quan Hanh	16.600	17	1	Km 298+800	7.190	9.410	Double-track station
2	Dong Le–Ngoc Lam	13.240	18	2	Km 442+950	6.620	6.620	Double-track station
3	Thuong Lam–Sa Lung	15.326	17	3	Km 580+950	8.750	6.576	Double-track station
4	Huong Thuy–Truoi	16.600	19	4	Km 707+400	8.700	7.900	Double-track station
5	Tra Kieu–Phu Cang	16.963	16	5	Km 831+800	7.023	9.940	Double-track station
6	Bong Son–Van Phu	15.650	16	6	Km 1026+260	9.160	6.490	Double-track station
7	Van Phu–Phu My	16.610	19	7	Km 1042+250	9.500	7.110	Double-track station
8	Van Canh–Phuoc Lanh	16.005	19	8	Km 1129+600	6.211	9.794	Double-track station
9	La Hai–Chi Thanh	16.000	21	9	Km 1162+500	8.131	7.869	Double-track station
10	Nha Trang–Cay Cay	14.080	18	10	Km 1321+800	6.805	7.275	Double-track station
11	Nga Ba–Ca Rom	18.142	19	11	Km 1372+000	8.212	9.930	Three-track station
12	Ca Na–Vinh Hao	18.606	21	12	Km 1446+015	9.704	8.902	Double-track station
13	Long Song–Song Mao	18.952	21	13	Km 1474+550	9.012	9.940	Double-track station
14	Ma Lam–Muong Man	18.305	19	14	Km 1541+500	8.655	9.650	Double-track station
15	Muong Man–Suoi Van	16.570	19	15	Km 1557+900	6.750	9.820	Three-track station
16	Suoi Van–Song Phan	15.140	20	16	Km 1575+950	8.230	6.910	Three-track station
17	Long Khanh–Dau Giay	11.960	21	17	Km 1655+600	6.240	5.720	Three-track station
18	Dau Giay–Trang Bom	16.190	18	18	Km 1672+400	11.080	5.110	Three-track station

Source: TRICC

(b) Sketch of 18 New Pass-by Station Location

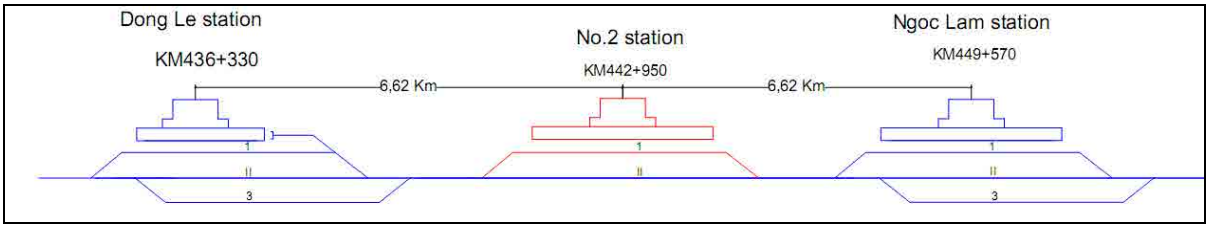
- **My Ly–Quan Hanh Section**
  - Length of existing section: 16.6 km
  - Location of new station: Center of station Km298+800; Distance between 2 new sections L1 = 7.19 km and L2 = 9.41 km.



Source: TRICC

Figure 4.2.1 Layout of Station (My Ly – Quan Hanh)

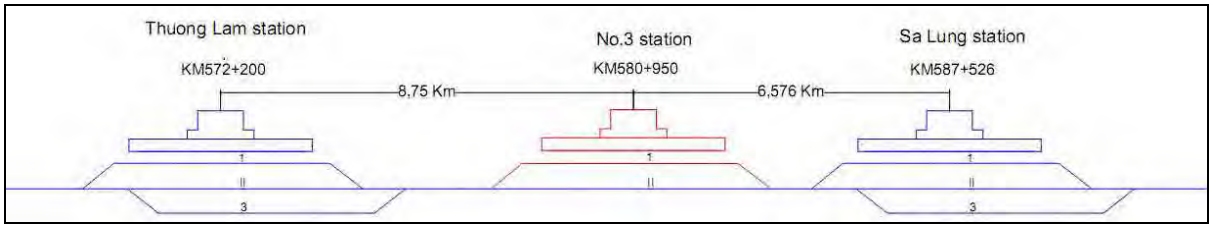
- **Dong Le–Ngoc Lam Section**
  - Length of existing section: 13,24 km
  - Location of new station: Center of station Km442+950; Distance between 2 new sectionsL1= 6,35 km; L2=6,65 km.



Source: TRICC

Figure 4.2.2 Layout of Station (Dong Le – Ngoc Lam)

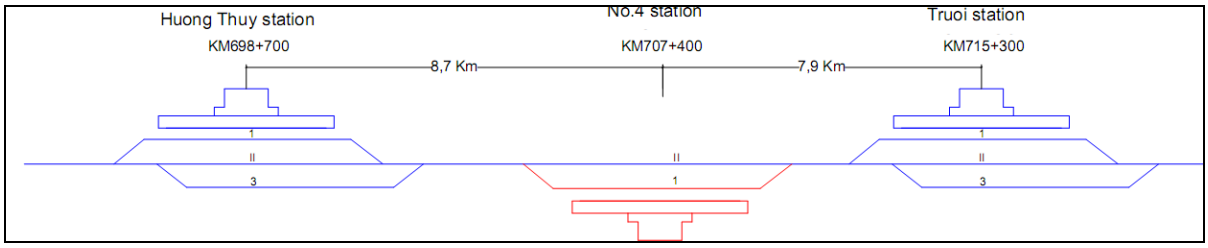
- **Huong Lam–Sa Lung Section**
  - Length of existing section: 15,326 km
  - Location of new station: Center of station Km580+950; Distance between 2 new sectionsL1= 8,75 km; L2=6,576 km.



Source: TRICC

Figure 4.2.3 Layout of Station (Thuong Lam – Sa Lung)

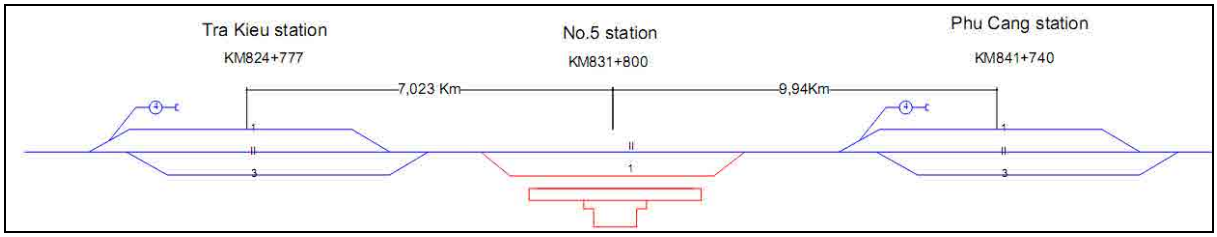
- **Huong Thuy–Truoi Section**
  - Length of existing section: 16,6 km
  - Location of new station: Center of station Km707+400; Distance between 2 new sections L1= 8,70 km; L2=7,9 km.



Source: TRICC

Figure 4.2.4 Layout of Station (Huong Thuy – Truoi)

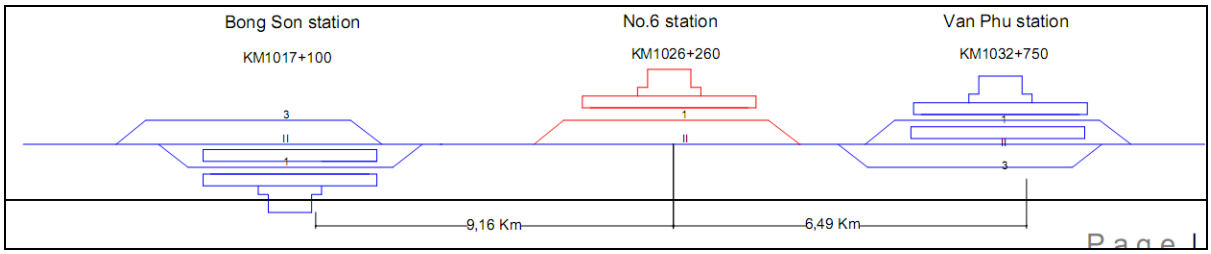
- **Tra Kieu–Phu Cang Section**
  - Length of existing section: 16,963 km
  - Location of new station: Center of station Km831+800; Distance between 2 new sectionsL1= 7,023 km; L2=9,94 km.



Source: TRICC

Figure 4.2.5 Layout of Station (Tra Kieu – Phu Cang)

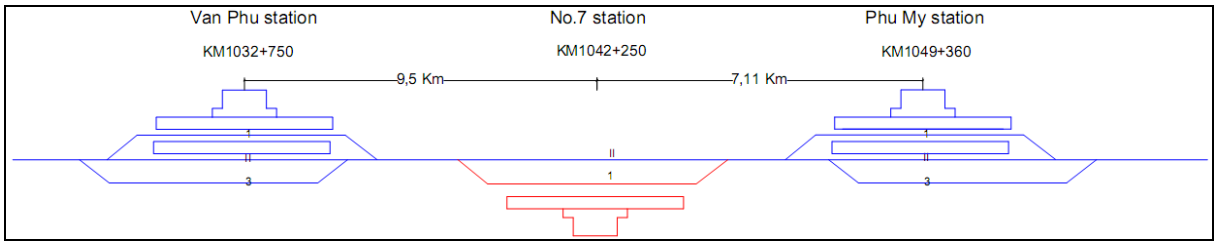
- **Bong Son–Van Phu Section**
  - Length of existing section: 15,65 km
  - Location of new station: Center of station Km1026+260; Distance between 2 new sectionsL1= 9,16 km; L2=6,49 km.



Source: TRICC

Figure 4.2.6 Layout of Station (Bong Son – Van Phu)

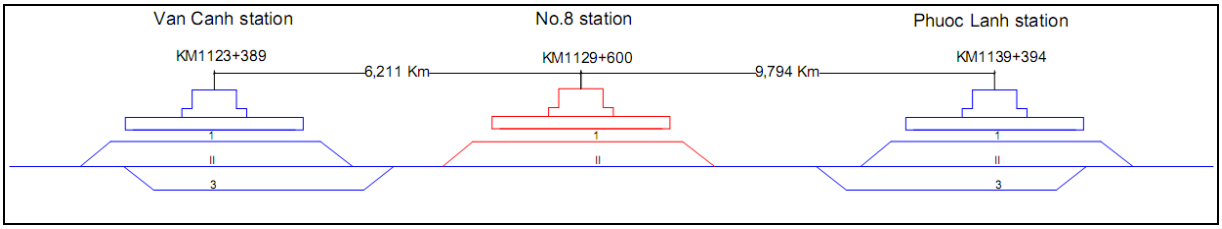
- **Van Phu–Phu My Section**
  - Length of existing section: 16,61 km
  - Location of new station: Center of station Km1042+250; Distance between 2 new sectionsL1= 9,5 km; L2=7,11 km.



Source: TRICC

Figure 4.2.7 Layout of Station (Van Phu – Phu My)

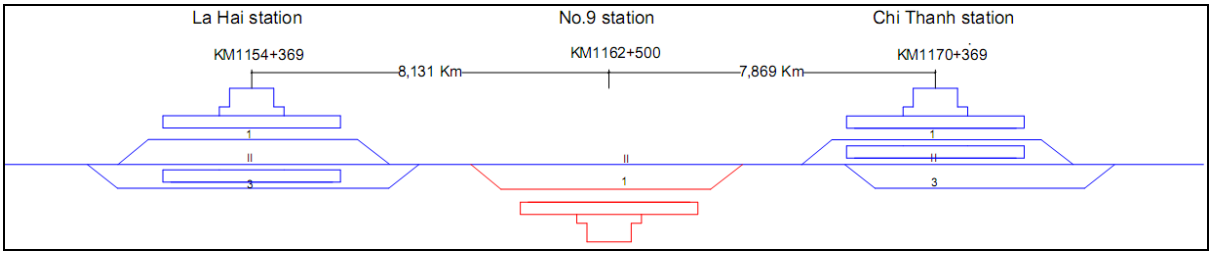
- **Van Canh–Phuoc Lanh Section**
  - Length of existing section: 16,005 km
  - Location of new station: Center of station Km1129+600; Distance between 2 new sectionsL1= 6,211 km; L2=9,794 km.



Source: TRICC

Figure 4.2.8 Layout of Station (Van Canh – Phuoc Lanh)

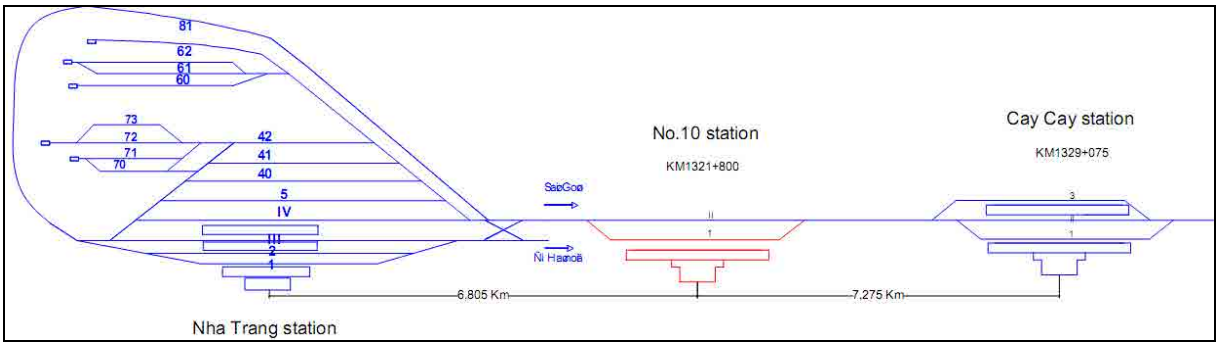
- **La Hai–Chi Thanh Section**
  - Length of existing section: 16,00 km
  - Location of new station: Center of station Km1162+500; Distance between 2 new sectionsL1= 8,131 km; L2=7,869 km.



Source: TRICC

Figure 4.2.9 Layout of Station (La Hai – Chi Thanh)

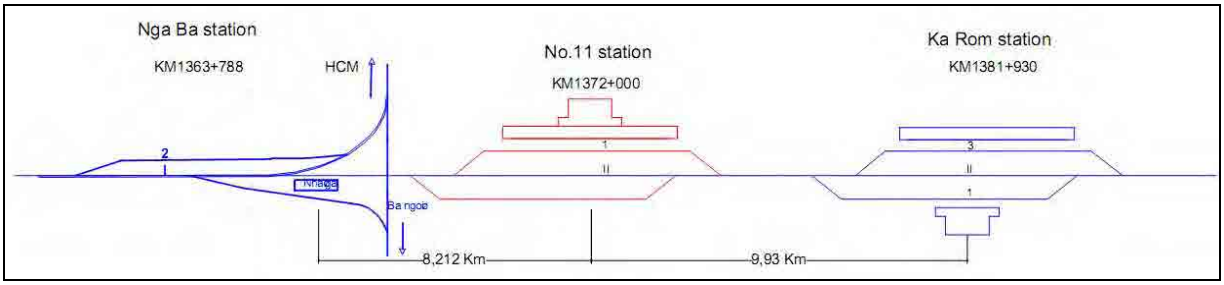
- **Nha Trang–Cay Cay Section**
  - Length of existing section: 14,08 km
  - Location of new station: Center of station Km1321+800; Distance between 2 new sectionsL1= 6,805 km; L2=7,275 km.



Source: TRICC

Figure 4.2.10 Layout of Station (Nha Trang – Cay Cay)

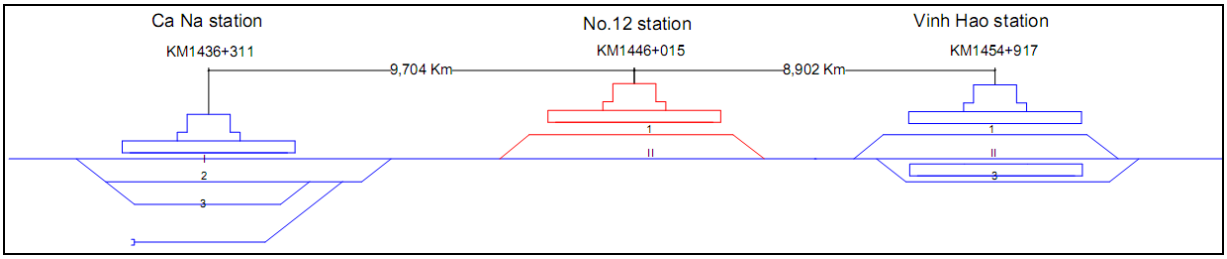
- **Nga Ba–Ca Rom Section**
  - Length of existing section: 18,142 km
  - Location of new station: Center of station Km1372+000; Distance between 2 new sections L1= 8,212 km; L2=9,93 km.



Source: TRICC

Figure 4.2.11 Layout of Station (Nga Ba – Ca Rom)

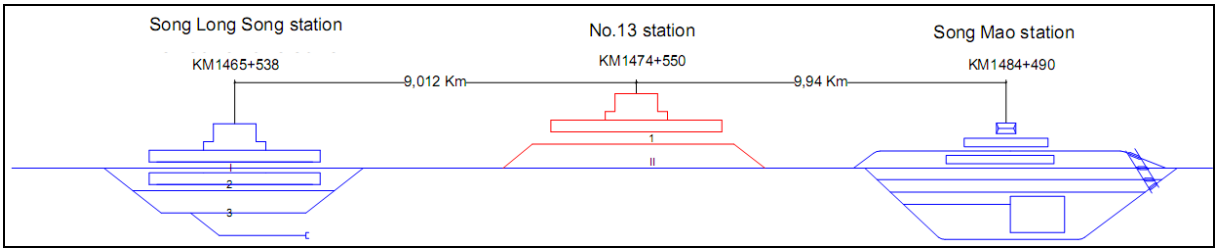
- **Ca Na–Vinh Hao Section**
  - Length of existing section: 18,606 km
  - Location of new station: Center of station Km1446+015; Distance between 2 new sections L1= 9,704 km; L2=8,902 km.



Source: TRICC

Figure 4.2.12 Layout of Station (Ca Na – Vinh Hao)

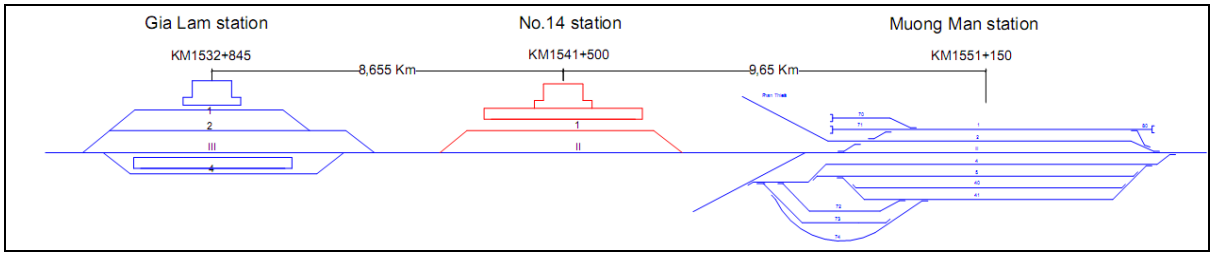
- **Long Song–Song Mao Section**
  - Length of existing section: 18,952 km
  - Location of new station: Center of station Km1474+550; Distance between 2 new sectionsL1= 9,012 km; L2=9,94 km.



Source: TRICC

Figure 4.2.13 Layout of Station (Long Song – Song Mao)

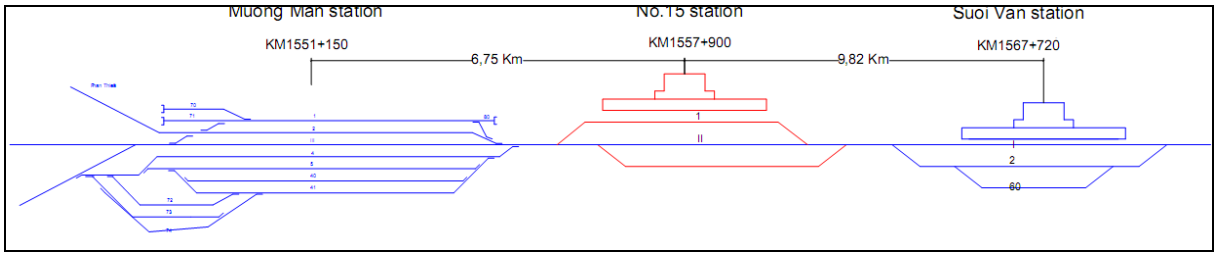
- **Ma Lam–Muong Man Section**
  - Length of existing section: 18,305 km
  - Location of new station: Center of station Km1541+500; Distance between 2 new sectionsL1= 8,655 km; L2=9,65 km.



Source: TRICC

Figure 4.2.14 Layout of Station (Ma Lam – Muong Man)

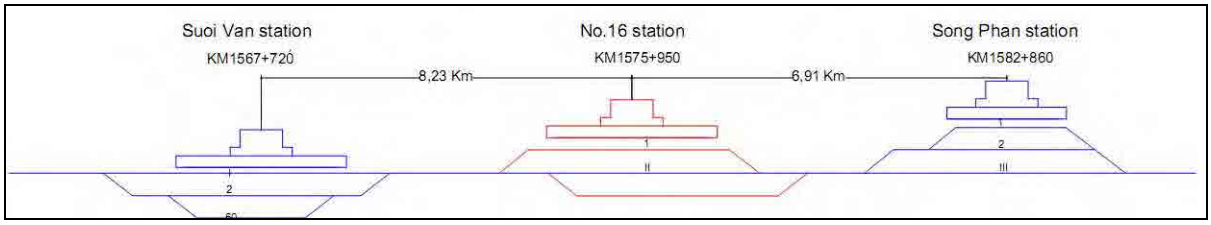
- **Muong Man–Suoi Van Section**
  - Length of existing section: 16,57 km
  - Location of new station: Center of station Km1557+900; Distance between 2 new sections L1= 6,75 km; L2=9,82 km.



Source: TRICC

Figure 4.2.15 Layout of Station (Muong Man – Suoi Van)

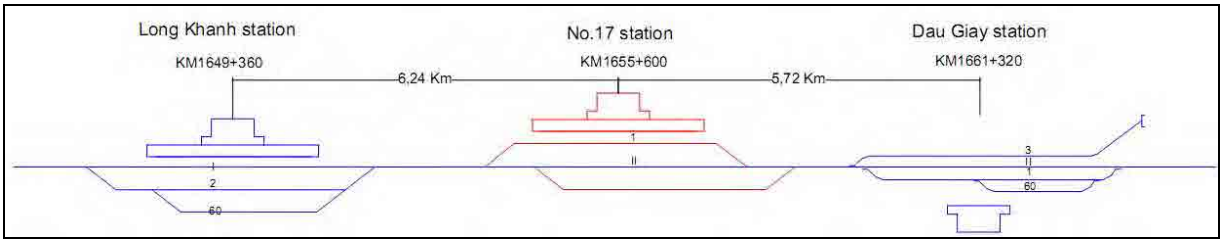
- **Suoi Van–Song Phan Section**
  - Length of existing section: 15,14 km
  - Location of new station: Center of station Km1575+950; Distance between 2 new sectionsL1= 8,23 km; L2=6,91 km.



Source: TRICC

Figure 4.2.16 Layout of Station (Suoi Van – Song Phan)

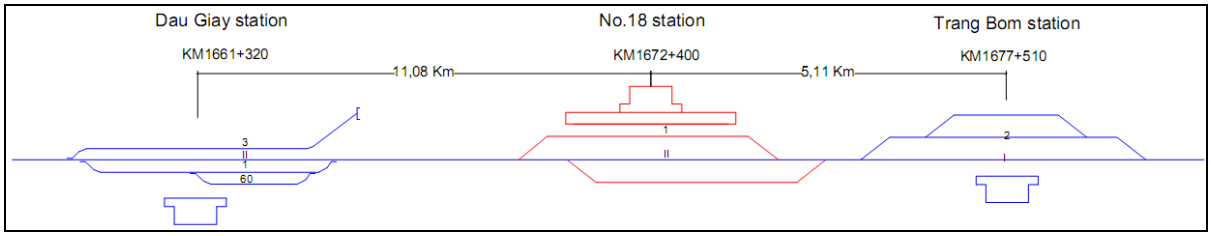
- **Long Khanh–Dau Giay Section**
  - Length of existing section: 11,96 km
  - Location of new station: Center of station Km1655+600; Distance between 2 new sectionsL1= 6,24 km; L2=5,72 km.



Source: TRICC

Figure 4.2.17 Layout of Station (Long Khanh – Dau Giay)

- **Dau Giay–Trang Bom Section**
  - Length of existing section: 16,19 km
  - Location of new station: Center of station Km1672+400; Distance between 2 new sections L1= 11,08 km; L2=5,11 km.



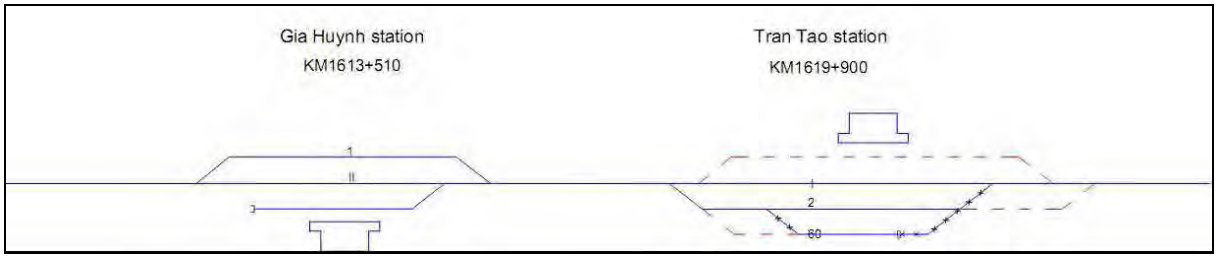
Source: TRICC

Figure 4.2.18 Layout of Station (Dau Giay – Trang Bom)

(c) 3 Stations Upgrading and Adding Track

- **Trang Tao Station: Km1619+900**

4.25 Open a new track on the left of alignment in the direction HN to HCM city; extension of track no.2 in the direction HCM city; upgrading loading - unloading track no.60.

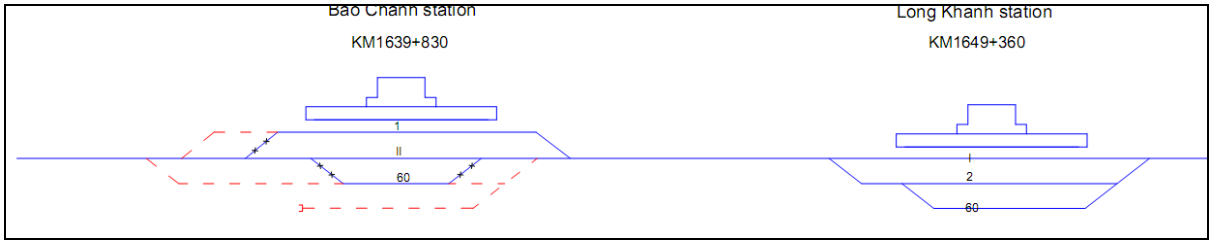


Source: TRICC

Figure 4.2.19 Layout of Station (Gia Huynh – Tran Tao)

- **Bao Chanh Station: Km1639+830**

4.26 Extension of track No.1 and loading - unloading track no.60 in the direction Ha Noi => Loading - unloading track no.60 becomes to arrival – departure track; adding new loading – unloading track other.

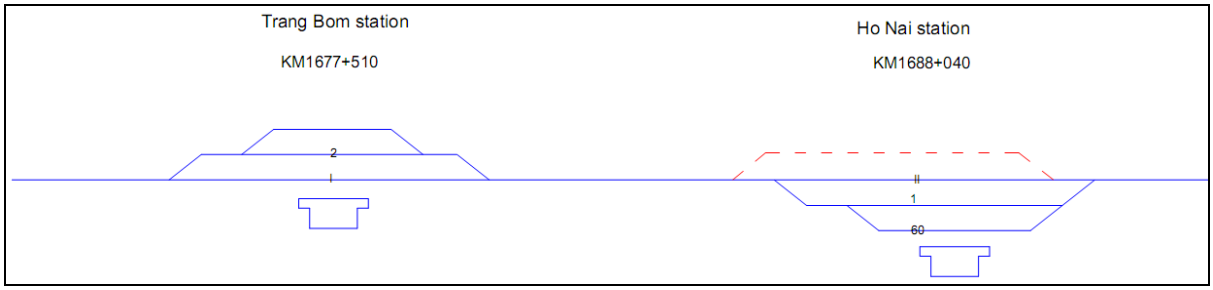


Source: TRICC

Figure 4.2.20 Layout of Station (Bao Chanh – Long Khanh)

- **Ho Nai Station: Km1688+040**

4.27 Open a new track on the left of alignment in the direction HN to HCM City



Source: TRICC

Figure 4.2.21 Layout of Station (Trang Bom – Ho Nai)

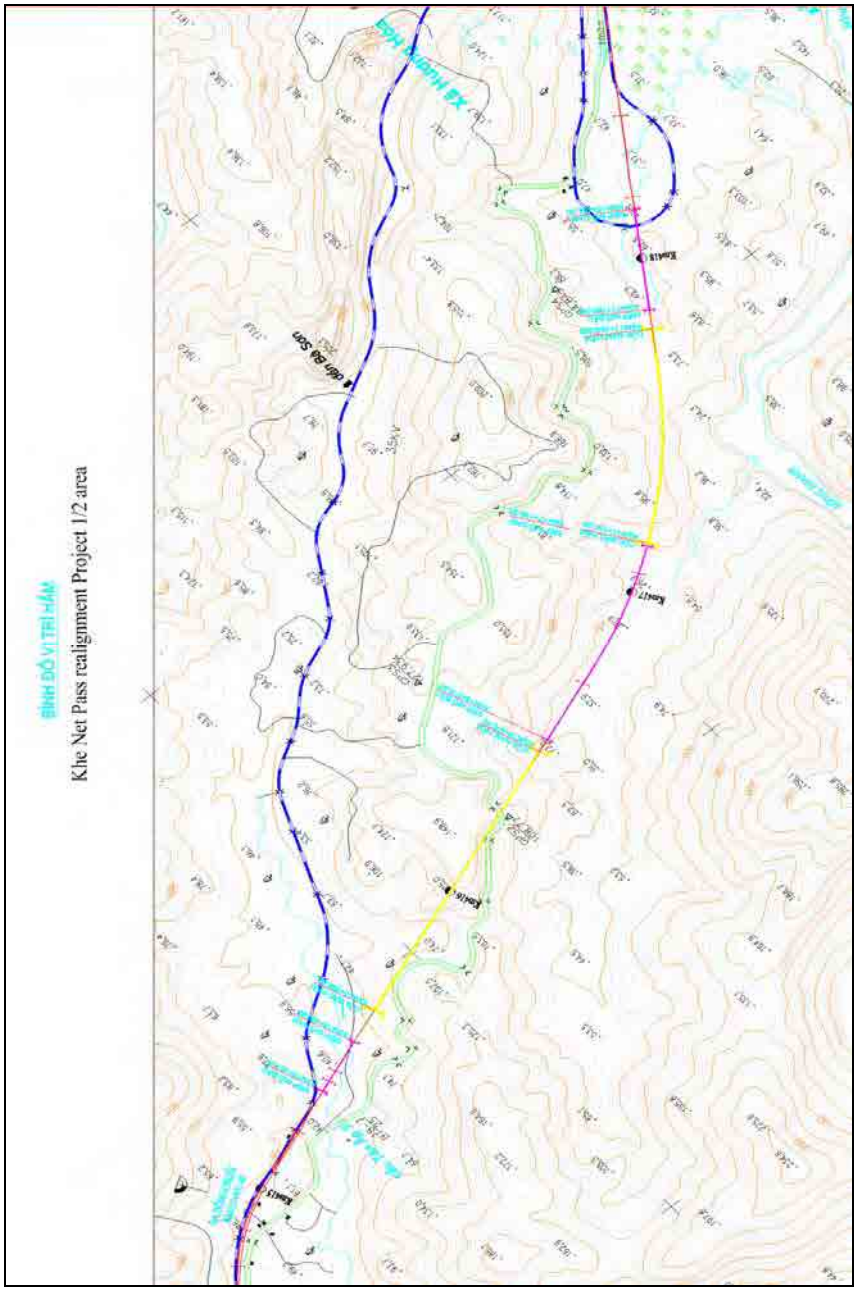
4) Scheme of Khe Net Pass, Hai Vanh pass, Hoa-Luy Section Project

4.28 Scheme of three projects is shown by the Table 4.2.4.

Table 4.2.4 Scheme of Three Projects

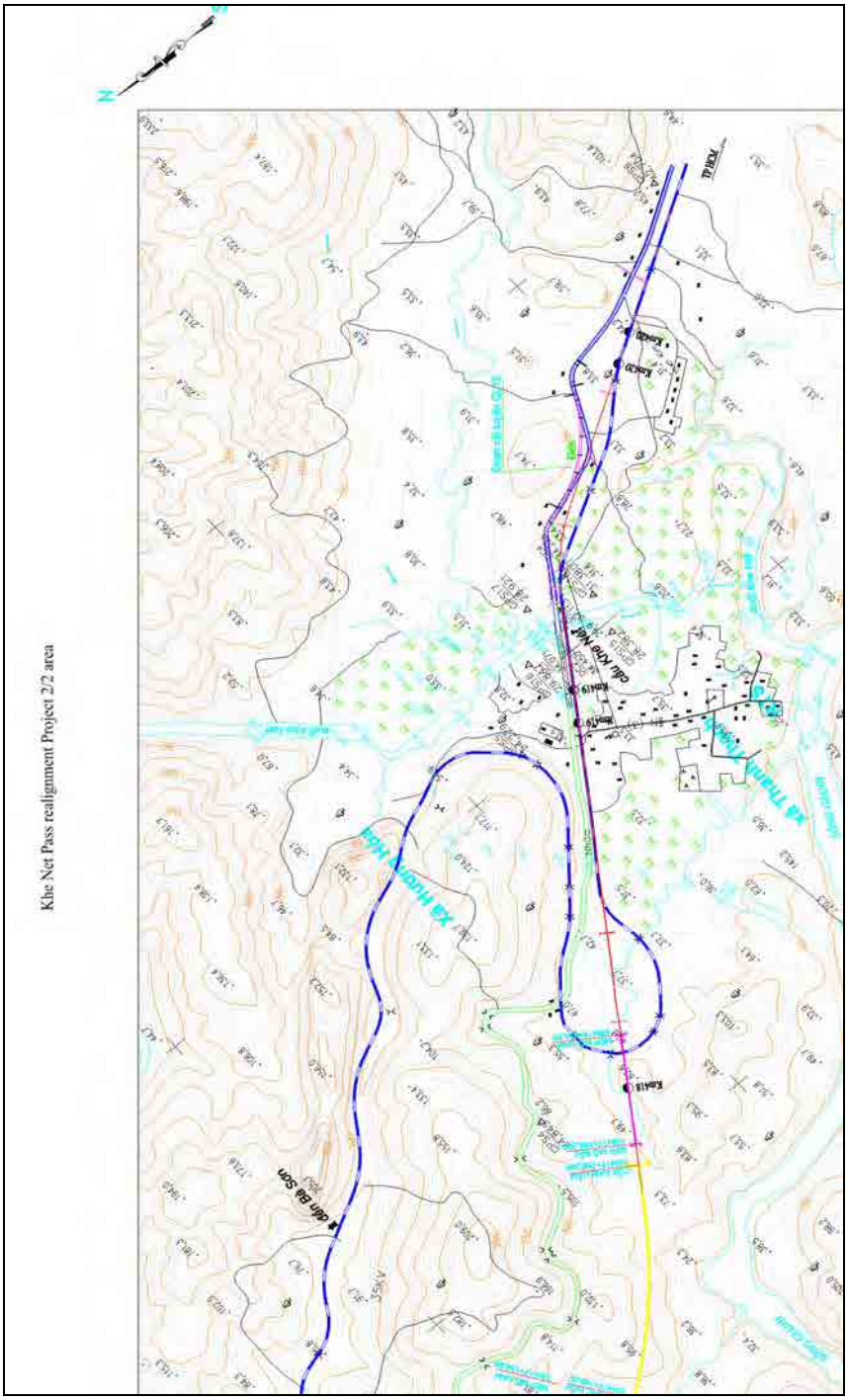
List	Original section Length and Shortening Distance	Scheme
1. Khe Net Pass realignment Project	8.8km original distance shorten 2km	In order to improve the sharp curve of existing root connected with a loop track being useful to go up the pass, we plan a tunnel under Khe Net pass
2. Hai Van Pass realignment Project	21k470m Original distance shorten 11k900m	Alignment is improved if we would construct a new tunnel instead of existing continuous curves being away from the mountain pass.
3. Hoa Duyet – Thanh Luyen section upgrade project	6k365m Original distance shorten 4k765m	Alignment would be improved if we connect with two tunnels instead of curve roots being escape from two pass roots.

Source: JICA Study Team



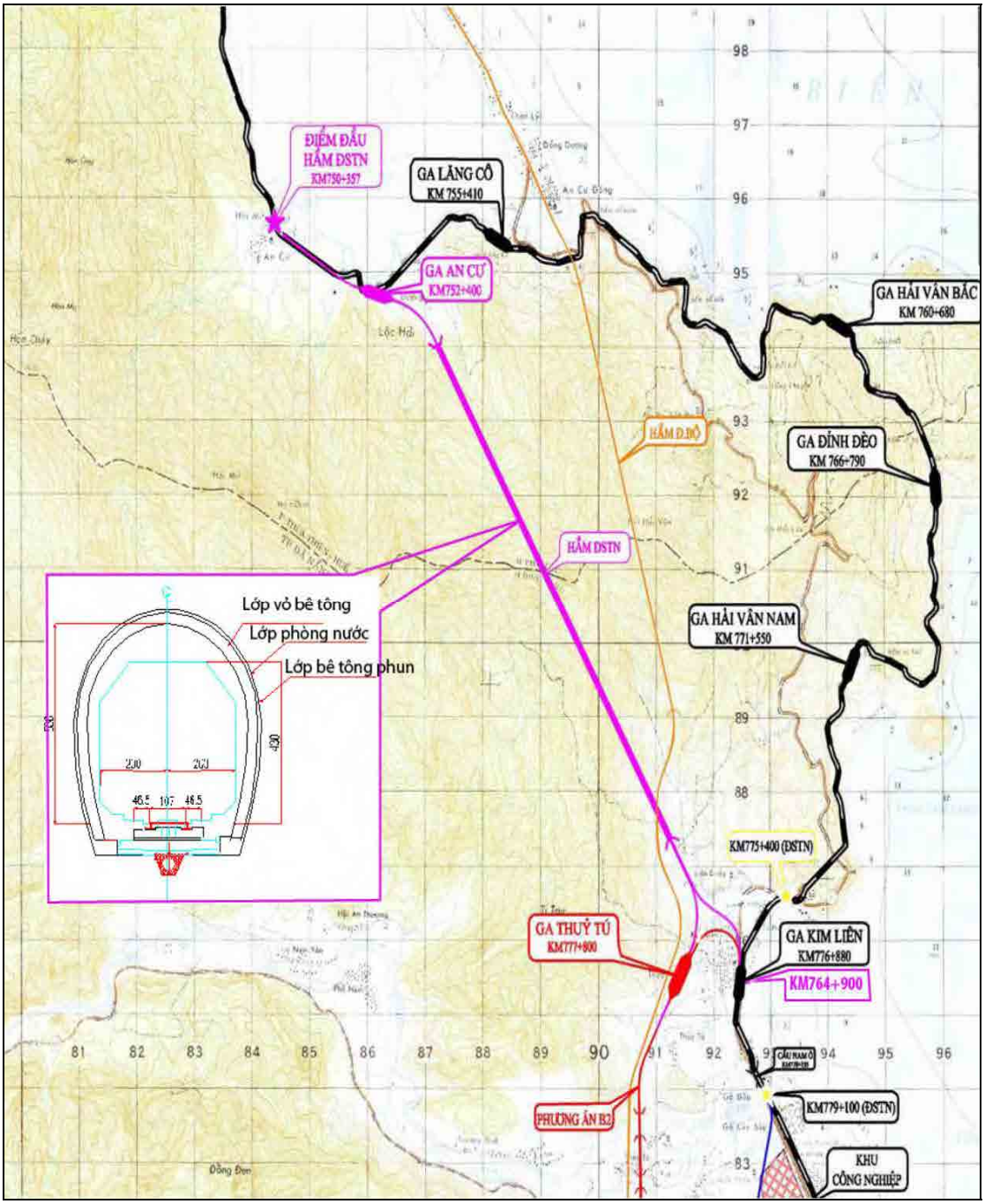
Source: TRICC

Figure 4.2.22 Realignment Plan of Khe Net Pass (1/2)



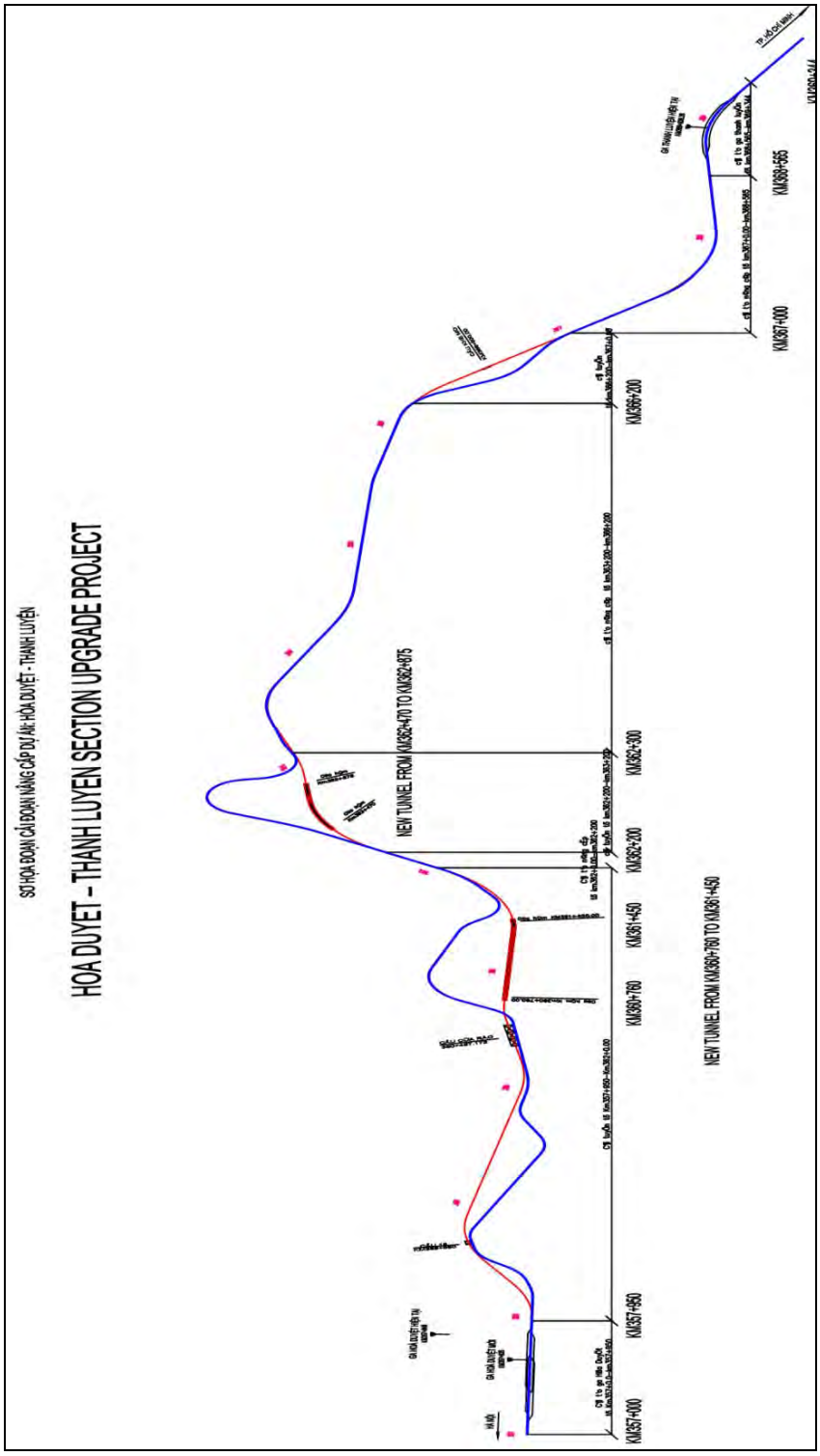
Source: TRICC

Figure 4.2.23 Realignment Plan of Khe Net Pass (2/2)



Source: TRICC

Figure 4.2.24 Realignment Plan of Hai Van Pass



Source: TRICC

Figure 4.2.25 Hoa Duyet–Thanh Luyen Section Upgrade Project

4.3 Option B-1

1) Technical Standard

4.29 Option B1 will be adapted in Vietnam Railway code (22 TCN 362-2) with operational speed V=120 km/h on the gauge of 1,000 mm. Technical standard are shown in Table 4.3.1.

Table 4.3.1 Design Standard

No.	Content		unit	Standard/Others	Note
1	Gauge		mm	1000	VR Standard
2	Line Style			Double track Non-Electrification	
3	Transportation Volume		t / year	Over 10 Million ton	VNR Standard
4	Maximum design speed	Passenger	Km/h	120	VR Standard
		Freight container		70	VR Standard
		Freight Bulky		70	VR Standard
5	Minimum Curve Radius （Inevitable）		m	800 400	VR Standard
6	Maximum Gradient （Inevitable）		‰	12 (18)	VR Standard
11	Construction Gauge		mm	4,880	VR Standard
13	Distance between two tracks centers		mm	4,000	VR Standard
14	Distance from track center to shoulder		mm	2,900	VR Standard
15	Width of Formation		mm	9,800	VR Standard
16	Axial Load		ton	16	
17	Level Crossing			Existence	
18	Track Structure			Ballast structure	
	Rail			P50	
	Sleeper （Main Track） (Side Track）			PC sleeper RC-2block Sleeper	
	Ballast thickness under sleeper		mm	250～300	

Source: JICA Study Team

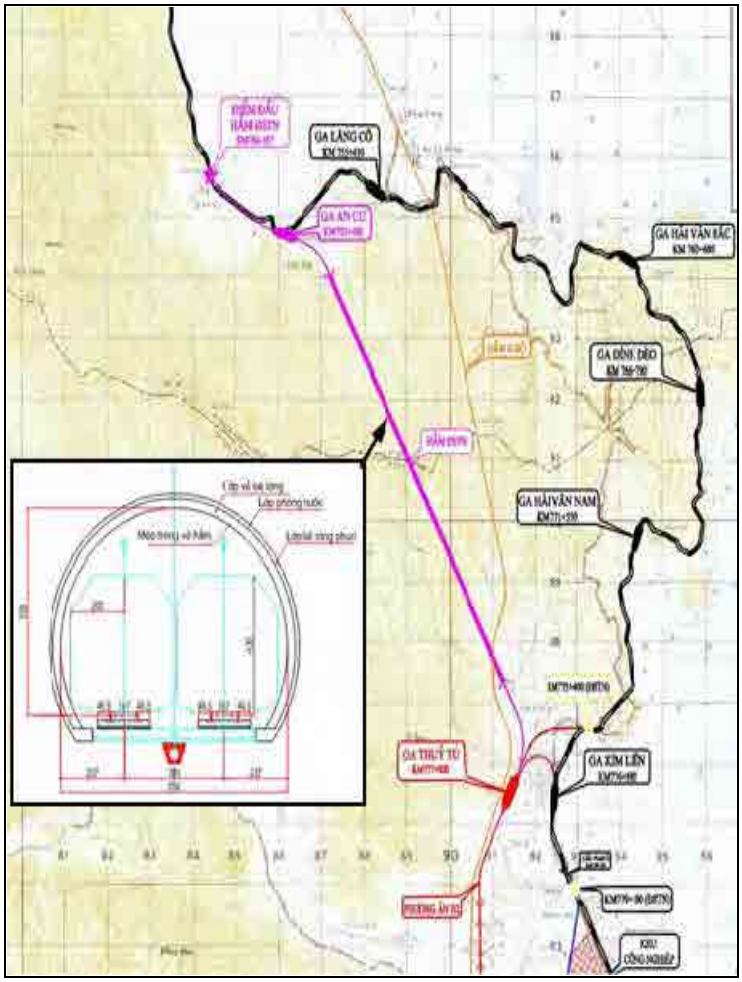
2) Alignment

(1) Improvement of Alignment

4.30 Current alignment of curved section with curve radius less than R=800m will be improved more than R=800m exclude in station yard alignment and reach to long bridge section. In case of railway alignment requirement will not be satisfied, i.e. such as necessary straight line length & curved line length can't be planned, I.P. point will be moved or combined plural curved line.

(2) Re Alignment

4.31 The Khe Net Pass and Hai Van Pass section has small radius of R=100 m～200 m continuously, and alignment between Hoa Duyet Station and Thanh Luyen station will be realigned to Option A-2. By the new improvement plan at Hai Van section, new alignment length will be shortened approximately 10km and three stations will be abolished. And Khe Net section, new alignment length will be shortened approximately 2Km. The new alignment plan will be shown in Figure 4.3.1 and the result of alignment study will be referred to material separately.



Source: TRICC

Figure 4.3.1 Realignment Plan at Hai Van Pass

3) Civil Structures

4.32 Structural plans are as follows:

(a) **Embankment:** Basically widening of embankment method will be used as shown in Figure 4.3.2

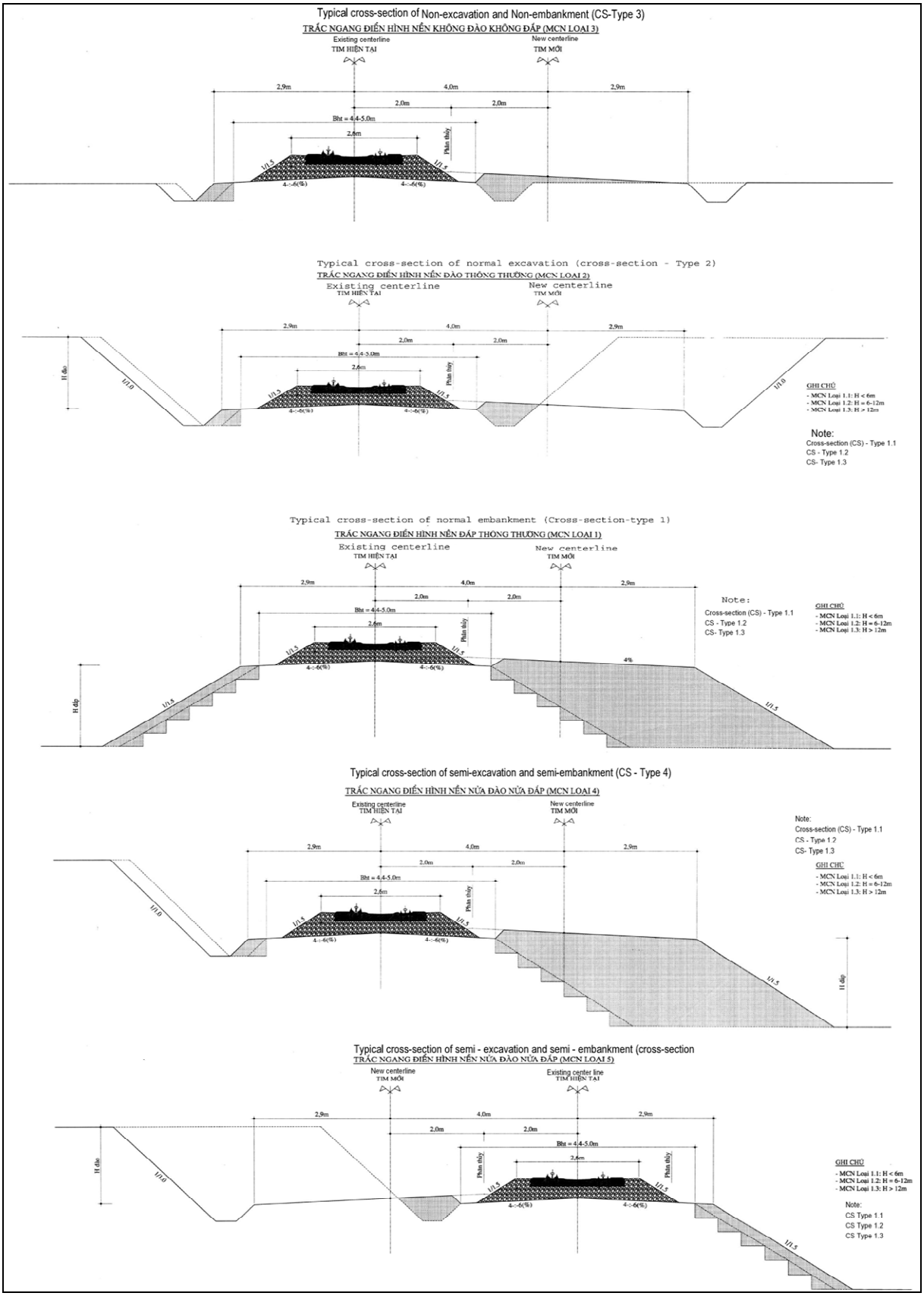
(b) **Cutting Section:** Basically widening of cutting method will be used as shown in Figure 4.3.2

(c) **Bridges:** According to health check of current bridges, new single track bridges will be constructed beside healthy bridges generally, otherwise new double track bridges will be constructed. Structural form will be adopted in Vietnam regulations shown below table. In this study, vertical alignment and overhead clearance under bridge will be arranged with current one.

Table 4.3.2 Bridge Span Length and Structural Plan

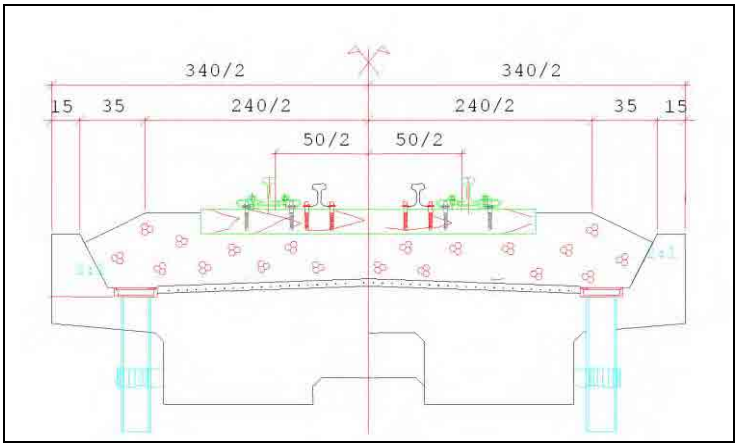
Bridge Span Length (m)	Structural Form	Drawings
5 ‹ L ≦ 14	RC Girder, T-Beam	Figure 4.3.3
15 ‹ L ≦ 25	Through Steel Plate Girder	Figure 4.3.4
30 ‹ L ≦ 67.5	Pony Steel Truss Girder	Figure 4.3.5
30 ‹ L ≦ 67.5	Through Steel Truss Girder	Figure 43.6

Source: JICA Study Team



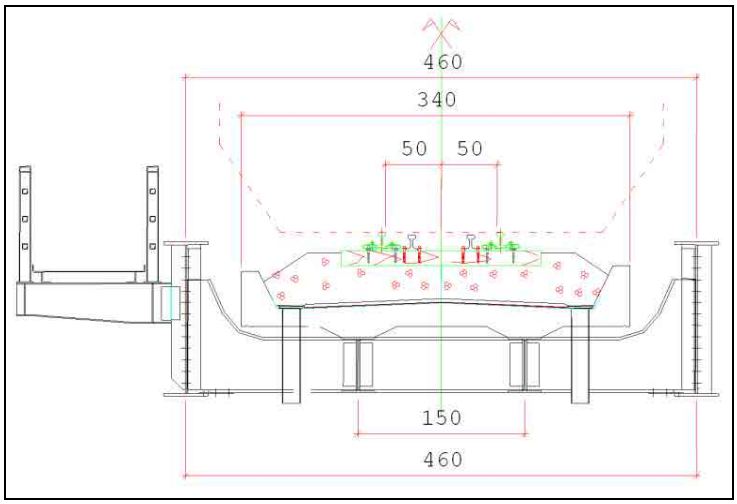
Source: TRICC

Figure 4.3.2 Embankment & Cutting Section Drawings



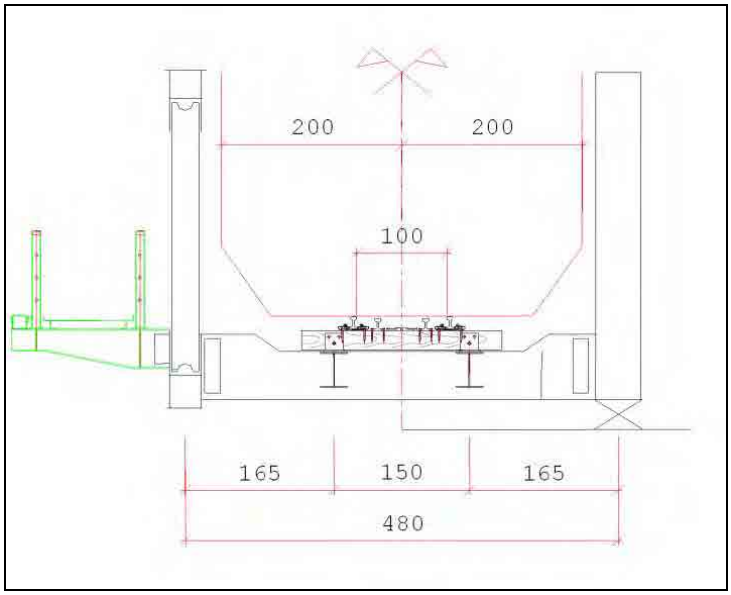
Source: TRICC

Figure 4.3.3 RC Girder, T-Beam



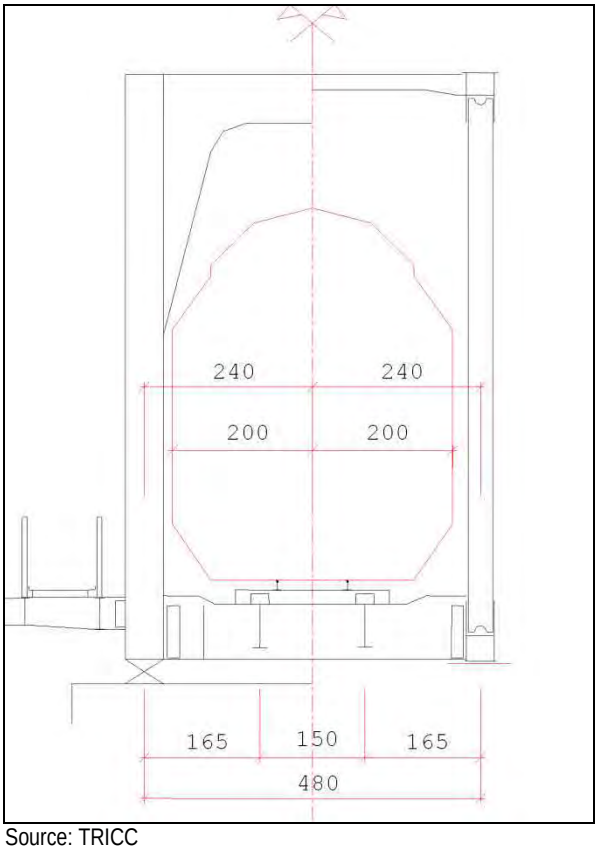
Source: TRICC

Figure 4.3.4 Through Steel Plate Girder



Source: TRICC

Figure 4.3.5 Pony Steel Truss Girder



Source: TRICC

Figure 4.3.6 Trough Steel Truss Girder

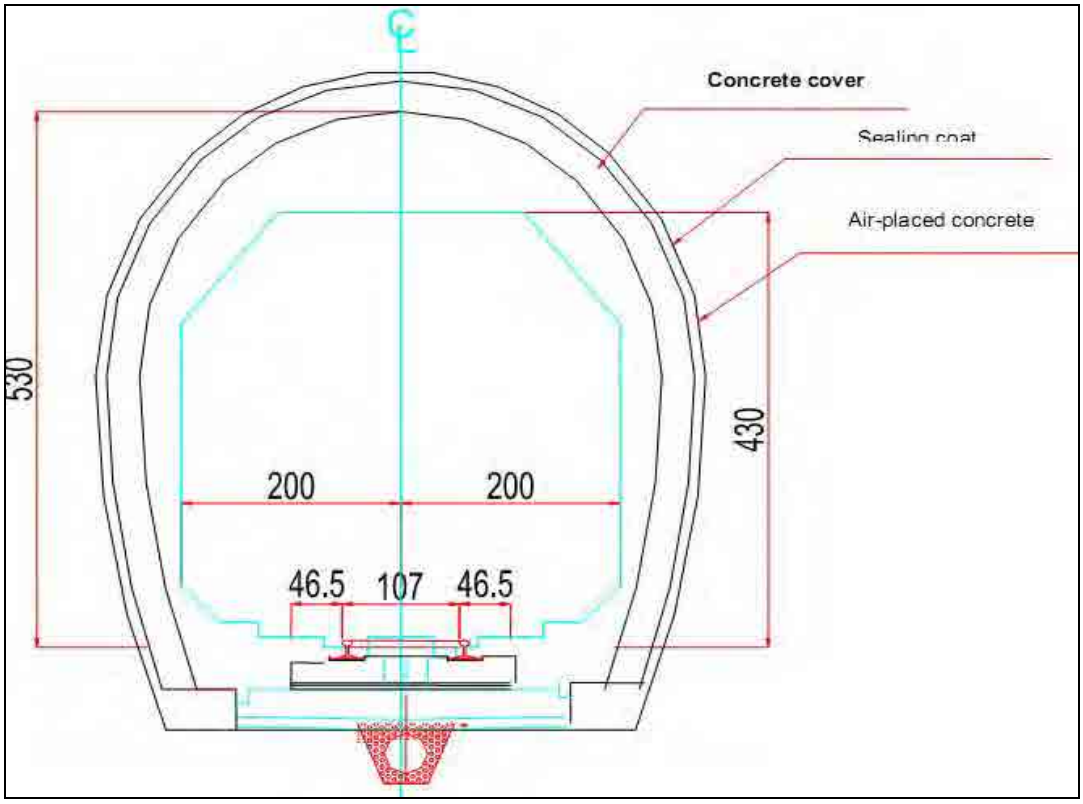
(d) **Tunnel**

4.33 New single-track tunnel with be constructed in running parallel with current line, and new double track tunnel will be constructed in alignment route change section. New section and abolish section are shown in below Table 4.3.3. Reference drawing is shown in Figure 4.3.7 & Figure 4.3.8

Table 4.3.3 Old and New Tunnel Section

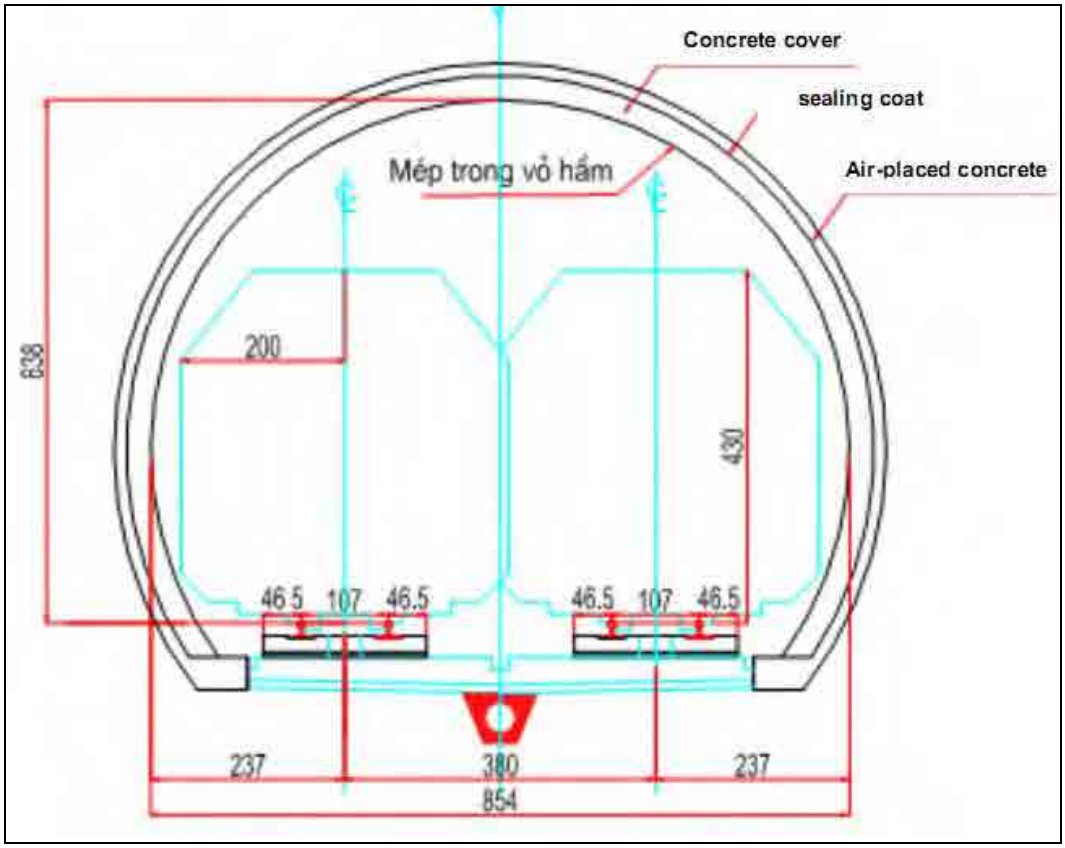
No	Existing Tunnels			New Tunnels			Remark
	Name	Location	Length (m)	Name	Location	Length (m)	
I							
1	K.Net 1	-	-	K.Net Tunnel 1	Km415+905	870	D
2	K.Net 2	-	-	K.Net Tunnel 2	Km417+459	638	D
3	Tunnel No. 1	Km455+432	63.77	Tunnel No. 1	Km455+432	65	S
4	Tunnel No. 2	Km455+765	247.44	Tunnel No. 2	Km455+765	250	S
5	Tunnel No. 3	Km456+245	114.46	Tunnel No. 3	Km456+245	120	S
6	Tunnel No. 4	Km466+255	100.67	Tunnel No. 4	Km466+255	100	S
7	Tunnel No. 5	Km466+496	193.44	Tunnel No. 5	Km466+496	200	S
II							
8	Tunnel No. 6	Km725+210	220.72	Tunnel No. 6	Km725+210	220	S
9	Tunnel No. 7	Km732+987	344	Tunnel No. 7	Km732+987	350	S
10	Tunnel No. 8	Km746+135	445	Tunnel No. 8	Km746+135	450	S
	Tunnel No. 9	Km757+235	169.4	-	-	-	
	Tunnel No. 10	Km757+841	124.2	-	-	-	
	Tunnel No. 11	Km759+513	161.75	-	-	-	
	Tunnel No. 12	Km766+049	564.17	-	-	-	
	Tunnel No. 13	Km770+663	325.7	-	-	-	
III							
9	Tunnel No. 14	Km774+674	944.62	-	-	-	
11	Hai Van Tunnel	-	-	Hai Van Tunnel	Km757+172	10035	D
IV							
12	Bình Đê	Km998+399	273.39	Bình Đê	Km998+399	280	S
13	Ph Cũ	Km1023+833	170.18	Ph Cũ	Km1023+833	170	S
V							
14	Chí Th nh	Km1168+704	325.31	Chí Th nh	Km1168+704	350	S
15	Baponeau	Km1224+816	1198.2	Baponeau	Km1224+816	1200	D
VI							
16	Vũng Rô 4	Km1227+120	371.23	Vũng Rô 4	Km1227+120	380	S
17	Vũng Rô 3	Km1228+115	159.46	Vũng Rô 3	Km1228+115	170	S
18	Vũng Rô 2	Km1228+702	257.99	Vũng Rô 2	Km1228+702	270	S
19	Vũng Rô 1	Km1229+252	60.39	Vũng Rô 1	Km1229+252	70	S
20	Bãi Gió	Km1231+188	402.58	Bãi Gió	Km1231+188	410	S
21	Cổ Mã	Km1234+464	407.4	C Mã	Km1234+464	410	S
22	Rọ Tượng	Km1290+277	219.03	R T ng	Km1290+277	230	S
23	Rù Rì	Km1306+740	375.1	Rù Rì	Km1306+740	380	S
24	Ngọc Hồi	Km1310+888	76.25	Ng c H i	Km1310+888	80	S

Source JICA Study Team based on TRICC data
Note: D: Double track S : Single track



Source: TRICC

Figure 4.3.7 Single Track Tunnel Section

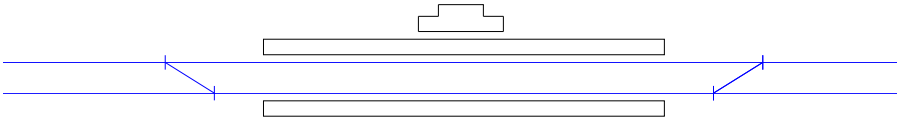


Source: TRICC

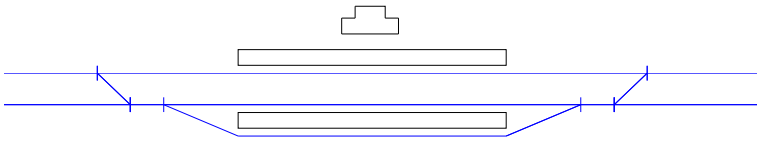
Figure 4.3.8 Double Track Tunnel Section

(e) **Station:** Track alignment plans in station yard are classified 7 types as follows; alignment layout plan between Hanoi and Saigon are shown in Figure 4.3.9. Because of route change at Hai Van Pass section, 3 stations are deleted in this Figure. And Passenger's station and Freight station will be separated at Da Nang station by topographic condition.

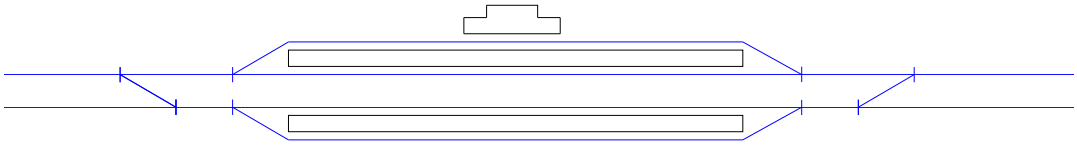
Type 1: Station with two main rail routes for passenger transport and train stop in special conditions.



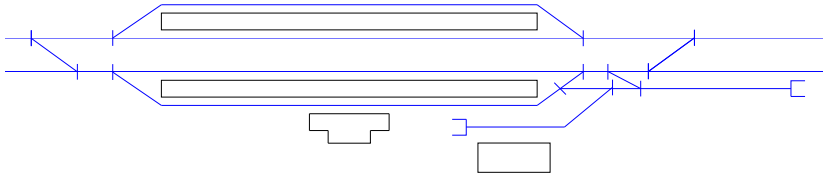
Type2: two main rail routes and 1 station rail route for passenger transport and train crossing support.



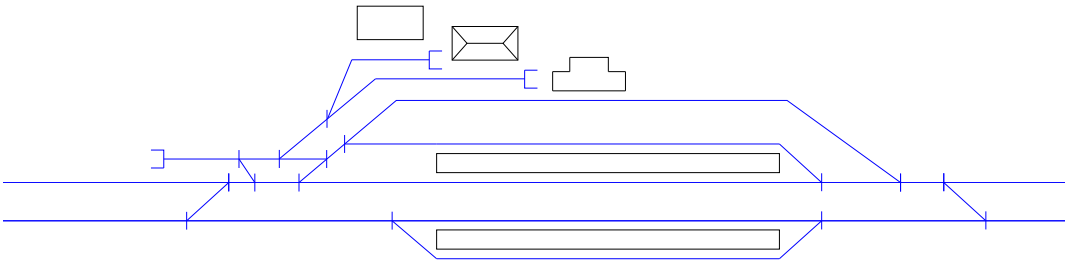
Type 3: two main rail routes and two station rail routes for two direction, catering passenger transport, train stop and crossing.



Type 4: two main rail routes, two station rail routes and freight handling rail, catering other tasks, train crossing and freight handling, capacity of 30,000 – 50,000 tons per year.



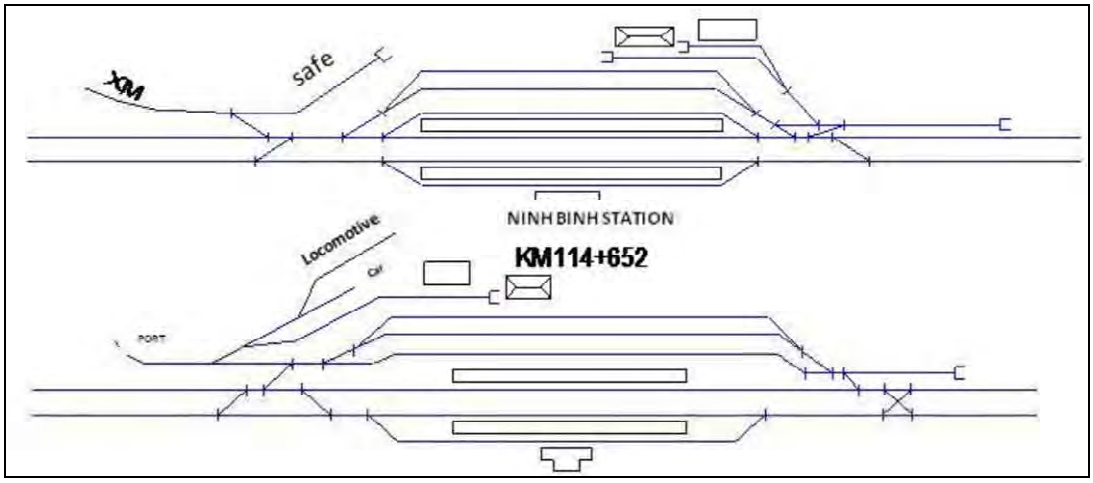
Type 5: 3 main rail routes and 3 station and freight handling rail routes, catering other task, train stop, crossing and freight handling, capacity of 50,000 – 100,000 tons per year.



Source: TRICC

Figure 4.3.9 Station Layout Plan between Ha Noi and Sai Gon

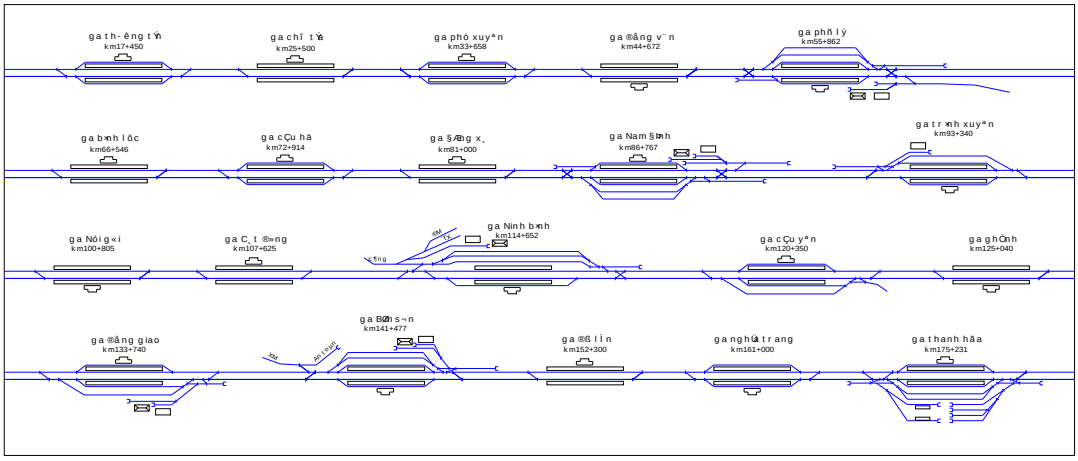
4.34 Type 6: two main rail routes, 3 station and freight handling rail routes, catering passenger transport, train stop and crossing and cargo handling, capacity of 100,000 – 150,000 tons per year.



Source: TRICC

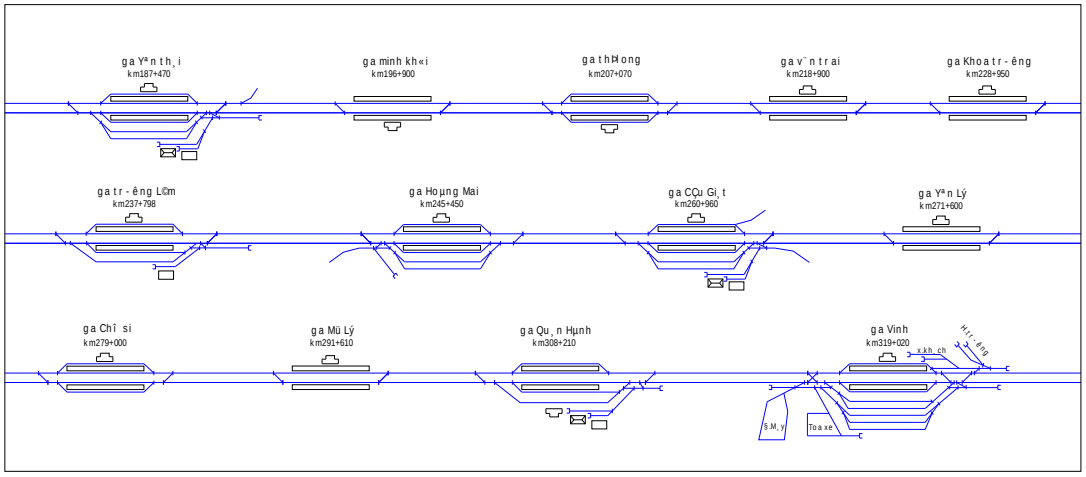
Figure 4.3.10 Station Model by Sections

4.35 Type 7: Technical and city stations where sectoral technical tasks are performed: 2 main rails, >4 station rail routes for locomotive or car formation, freight and passenger transport.



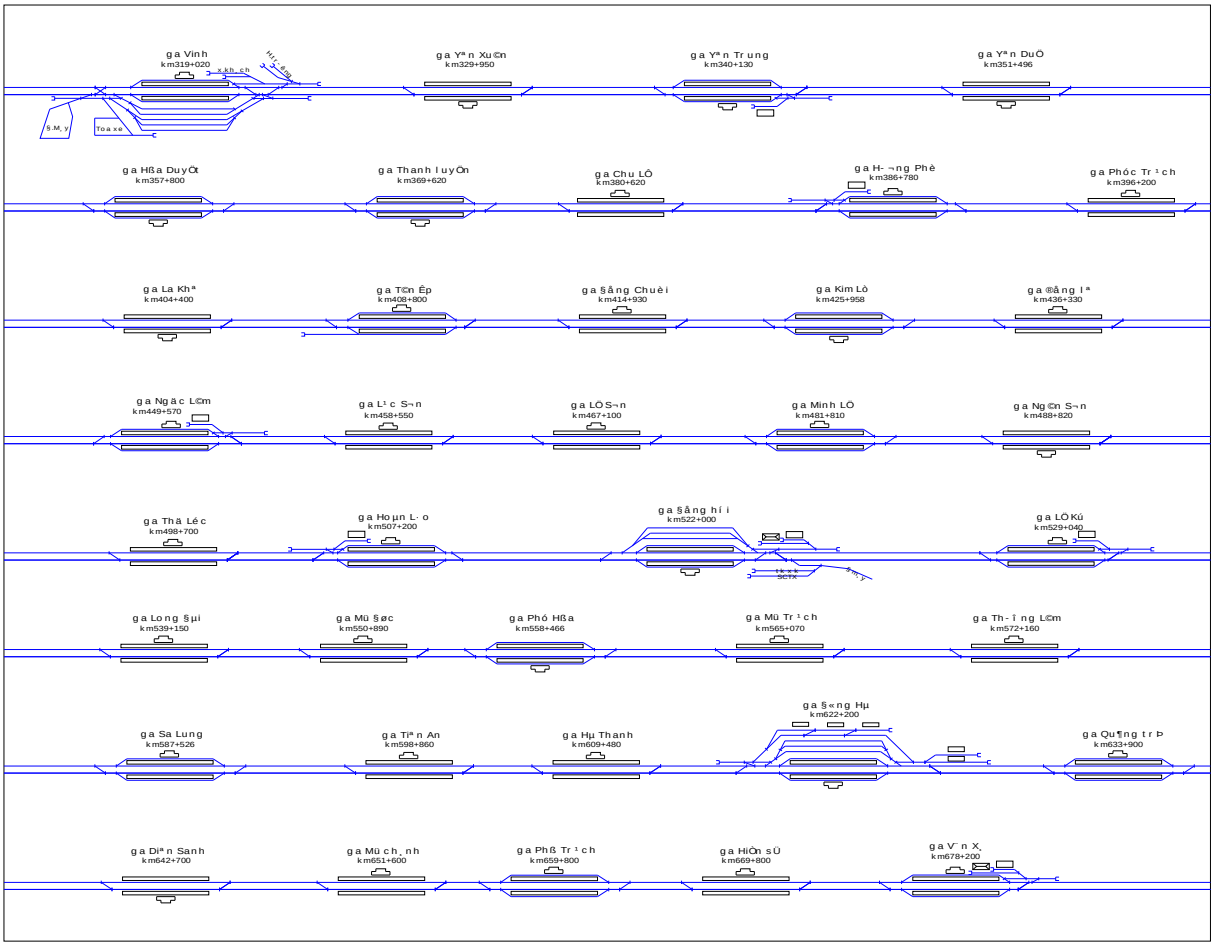
Source: TRICC

Figure 4.3.11 Hanoi–Thanh Hoa Section



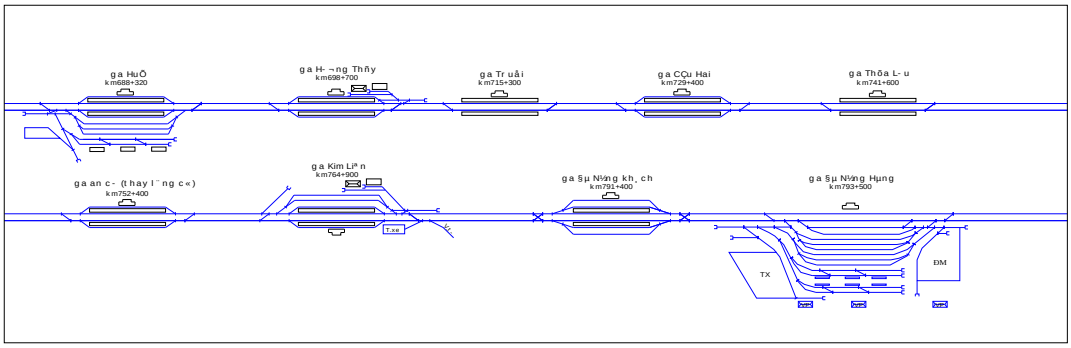
Source: TRICC

Figure 4.3.12 Thanh Hoa–Vinh Section



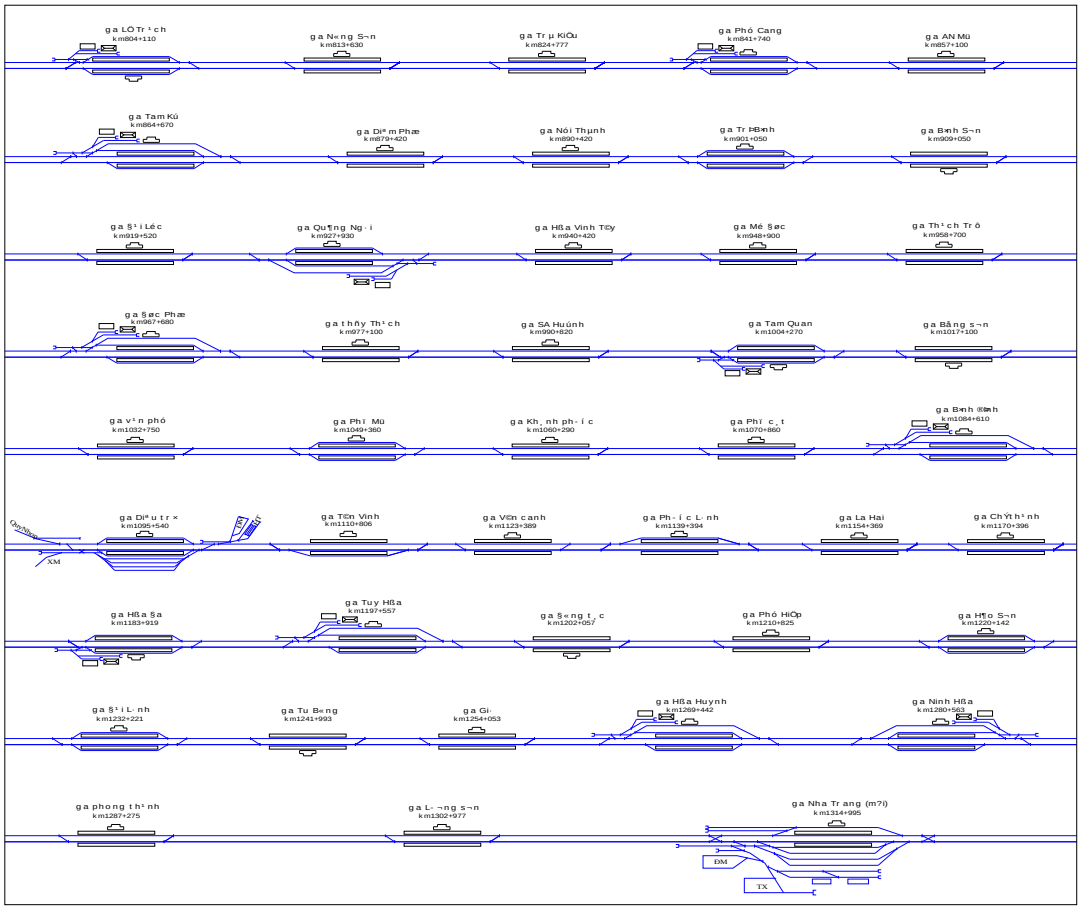
Source: TRICC

Figure 4.3.13 Vinh–Hue Section



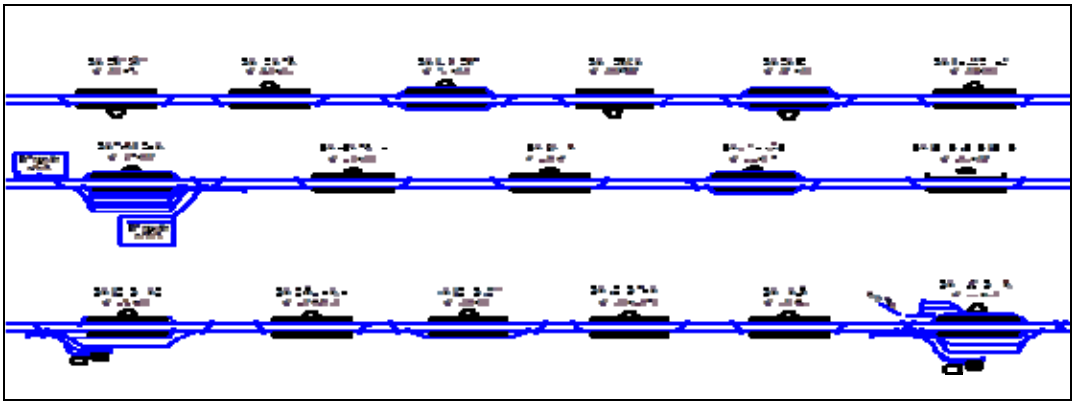
Source: TRICC

Figure 4.3.14 Hue–Da Nang Section



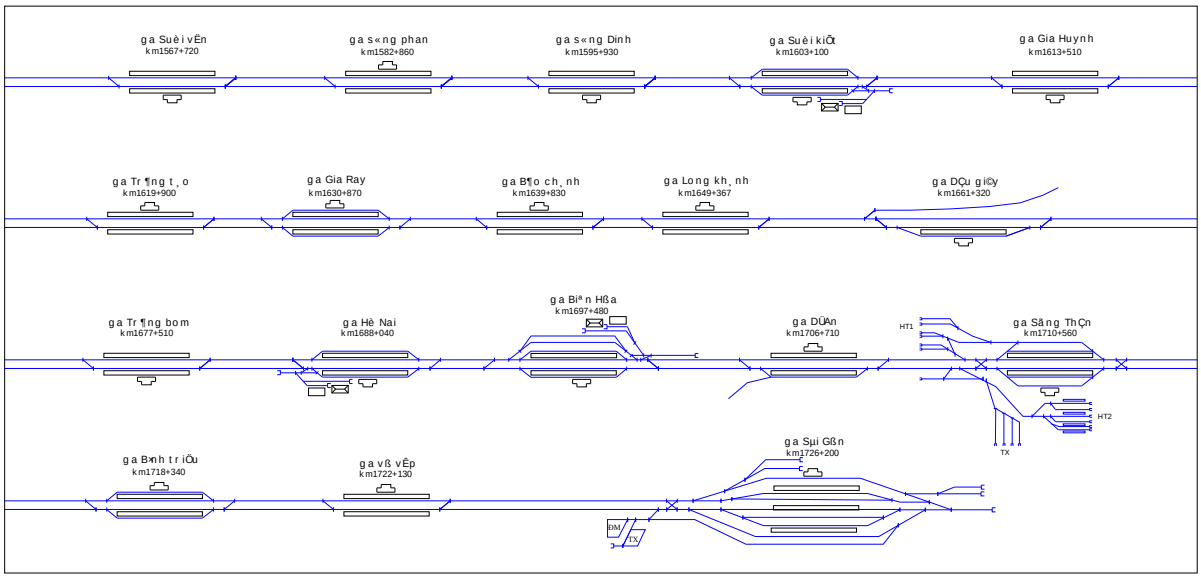
Source: TRICC

Figure 4.3.15 Da Nang–Nha Trang Section



Source: TRICC

Figure 4.3.16 Nha Trang–Muong Man Section



Source: TRICC

Figure 4.3.17 Muong Man–Sai Gon Section

(f) **Quantity Calculation:** Quantity result of each section is shown below individually. Add up in 7 sections is shown by Table 4.3.4.

Table 4.3.4 Add Up Sections

Section No.	From ~ to ~	Chainage	Original Length(km)	New Length (km)
Sec. 1	Ha Noi - Thanh Hoa	000+000 ~ 175+750	175.750	175.750
Sec. 2	Thanh Hoa - Vinh	175+750 ~ 319+400	143.650	143.650
Sec. 3	Vinh - Hue	319+400 ~ 688+815	369.415	367.415*
Sec. 4	Hue - Da Nang	688+815 ~ 794+362	105.547	95.047*
Sec. 5	Da Nang - Nha Trang	794+362 ~ 1315+277	520.915	520.915
Sec. 6	Nha Trang - Phan Thiet	1315+277 ~ 1551+570	236.293	236.293
Sec. 7	Phan Thiet - Sai Gon	1551+570 ~ 1726+000	174.430	174.430

Source: JICA Study Team based on TRICC data

4.36 The lengths of Sec. 3 & 5 are shortening due to the new tunnels in Khe Net Pass and Hai Van Pass. Quantity in every type of civil works is shown by Table 4.3.5

Table 4.3.5 Summary of Quantity

1. Fill (SHOULD BE CONFIRMED FROM 319+020 TO 340+000)

Embankment (m)		Length of Type 1 (m)	Type 1.1	Type 1.2	Type 1.3	Length of Type 4 (m)	Type 4.1	Type 4.2	Type 4.3	Type 3
Ha Noi - Thanh Hoa	Sec. 1	93,000	93,000	0	0	28,700	28,700	0	0	24,100
Thanh Hoa - Vinh	Sec. 2	99,100	82,500	16,600	0	28,100	28,100	0	0	0
Vinh - Hue	Sec. 3	244,700	244,500	200	0	8,300	7,100	1,200	0	26,600
Hue - Da Nang	Sec. 4	48,300	46,800	0	1,500	1,800	1,800	0	0	18,300
Da Nang - Nha Trang	Sec. 5	320,200	248,900	71,300	0	51,800	50,200	1,600	0	48,600
Nha Trang - Phan Thiet	Sec. 6	160,900	138,600	22,300	0	11,600	11,600	0	0	34,100
Phan Thiet - Sai Gon	Sec. 7	16,900	16,900	0	0	0	0	0	0	147,600
Total for all line		983,100	871,200	110,400	1,500	130,300	127,500	2,800	0	299,200

2. Cut (SHOULD BE CONFIRMED FROM 319+020 TO 340+000)

Cut (m)		Length of Type 2 (m)	Type 2.1	Type 2.2	Type 2.3	Length of Type 5 (m)	Type 5.1	Type 5.2	Type 5.3
Ha Noi - Thanh Hoa	Sec. 1	4,900	4,900	0	0	2,400	2,000	400	0
Thanh Hoa - Vinh	Sec. 2	1,300	700	600	0	300	300	0	0
Vinh - Hue	Sec. 3	39,000	39,000	0	0	5,200	5,200	0	0
Hue - Da Nang	Sec. 4	2,800	2,800	0	0	7,700	3,000	4,700	0
Da Nang - Nha Trang	Sec. 5	50,800	49,500	1,300	0	0	0	0	0
Nha Trang - Phan Thiet	Sec. 6	7,000	7,000	0	0	0	0	0	0
Phan Thiet - Sai Gon	Sec. 7	5,200	5,200	0	0	0	0	0	0
Total for all line		111,000	109,100	1,900	0	15,600	10,500	5,100	0

3. Tunnels

Tunnels (m)		Total Length (m)
Ha Noi - Thanh Hoa	Sec. 1	0
Thanh Hoa - Vinh	Sec. 2	0
Vinh - Hue	Sec. 3	5,800
Hue - Da Nang	Sec. 4	10,900
Da Nang - Nha Trang	Sec. 5	4,400
Nha Trang - Phan Thiet	Sec. 6	0
Phan Thiet - Sai Gon	Sec. 7	0
Total for all line		21,100

4. Bridges

		5m~14m	15m~25	30m ~ 67.5m	> 67.5m	Total Length of Br
Ha Noi - Thanh Hoa	Sec. 1	194	237	597	723	**1,751**
Thanh Hoa - Vinh	Sec. 2	247	266	641	512	**1,666**
Vinh - Hue	Sec. 3	1,269	1,031	2,053	4,334	**8,687**
Hue - Da Nang	Sec. 4	446	673	963	753	**2,835**
Da Nang - Nha Trang	Sec. 5	2,375	2,251	4,057	11,789	**20,472**
Nha Trang - Phan Thiet	Sec. 6	1,365	853	1,176	477	**3,871**
Phan Thiet - Sai Gon	Sec. 7	237	216	328	882	**1,663**
Total for all		6,133	5,527	9,815	19,470	**40,945**

Source: TRICC

4.4 Option B-2

1) Technical Standard

4.37 Option B2 will be adapted in Vietnam Railway code (22 TC362-2) with operational speed V=150 km/h on the gauge of 1,435 mm. Technical standard are shown in following Table 4.4.1.

Table 4.4.1 Design Standard

No.	Content		Unit	Standard/Others	Note
1	Gauge		mm	1,435	VR Standard
2	Line style			Double Track Electrification	
3	Transportation Volume		t / year	Over 20Million ton	VR Standard
4	Maximum design speed	Passenger	Km/h	150	VR Standard
		Freight container		120	VR Standard
		Freight Bulky		80	VR Standard
6	Minimum Curve Radius （Inevitable）		m	1200 400	VR Standard
7	Radius of Vertical Alignment		m	5,000	
8	Maximum Cant		mm	190	
	Permissible deficiently of Cant			80	
9	Transitional Curve （Sine curve）		m	L1 = 1.0C L2 = 0.0075CV L3 = 0.0065CdV	
10	Maximum gradient （Inevitable）		‰	12(18)	
11	Car Clearance		mm	3,400	
12	Construction Gauge		mm	4,880	VR Standard
13	Distance between two tracks centers		mm	4,000	VR Standard
14	Distance from track center to shoulder		mm	4,000	VR Standard
15	Width of Formation		mm	12,000	VR Standard
16	Axial Load	Electric train	ton	16	
		Electric Locomotive			
17	Level crossing			None	
18	Track structure			Ballast syructure	
	Rail			60Kg Long-Rail	
	Sleeper			PC sleeper (43//25m)	
	Ballast thickness under sleeper		mm	250～300	

Source: JICA Study Team

2) Alignment

(1) Improvement of Alignment

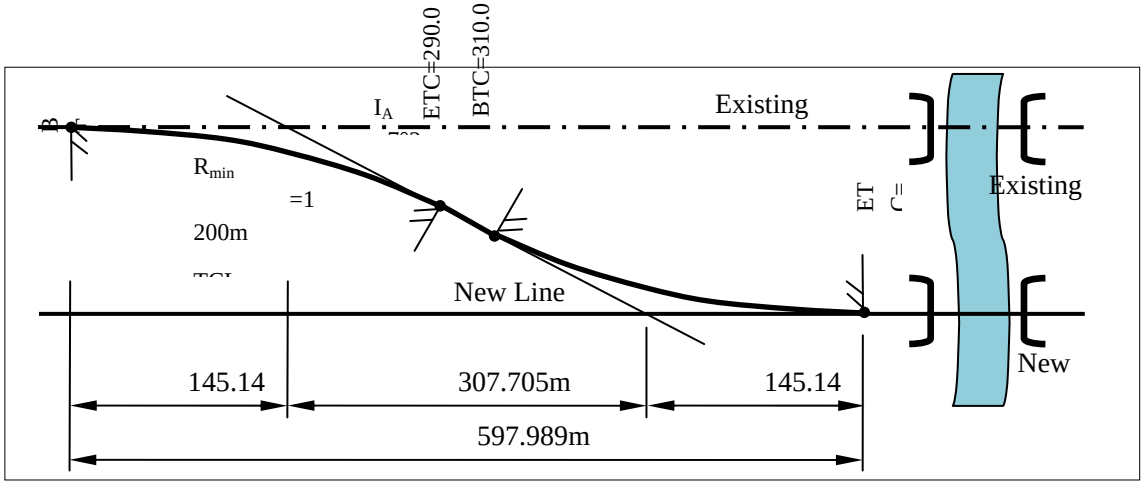
4.38 The section with a radius less than 1200 will be improved into one single curved section. As a result, all the section will have been improved and all of it will have a curve radius more than 1200 m.

(2) Realignment of Tunnel

4.39 Using same result in Option B-1 study;

(3) Approach Section to the Bridge

4.40 Approach to the bridge is given in Figure 4.4.1 below; the length to the current bridge is dictated by the alignment requirement, not the requirement of construction site works i.e. a transitional curve of length 135m with minimum curve length of 20 m.



Source: JICA Study Team

Figure 4.4.1 Approach Section to the Bridge

3) Civil Structures

4.41 Civil Structural plans are as follows;

(1) Embankment

4.42 The method for building new embankments and widening of existing embankments will be assumed as follows;

(i) New embankment is shown in Figure 4.4.2.

(ii) Widening of embankment is shown in figure 4.4.3 and it is applied to all the embankment length exclude new embankment section.

(2) Cutting section

4.43 Cutting section is shown in Figure 4.4.4 and the application section is all the cutting section length.

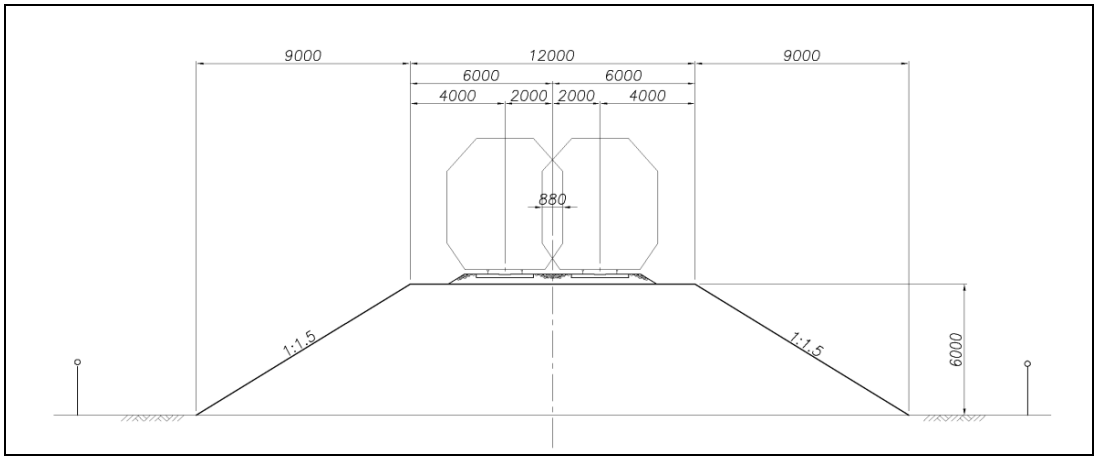
(3) Bridges

4.44 Bridge will be constructed at grade separation crossing section due to removing of level crossing in addition to current river bridge length. The grade-separated bridge is assumed to have a width equal to the road width plus 2.0m, i.e. each side will have an extra 1.0m of guard space along its length. Structural plan is shown Table 4.4.2 below; with considering maintenance and noise countermeasure in high-speed operation.

Table 4.4.2 Bridge Span Length and Structural Plan

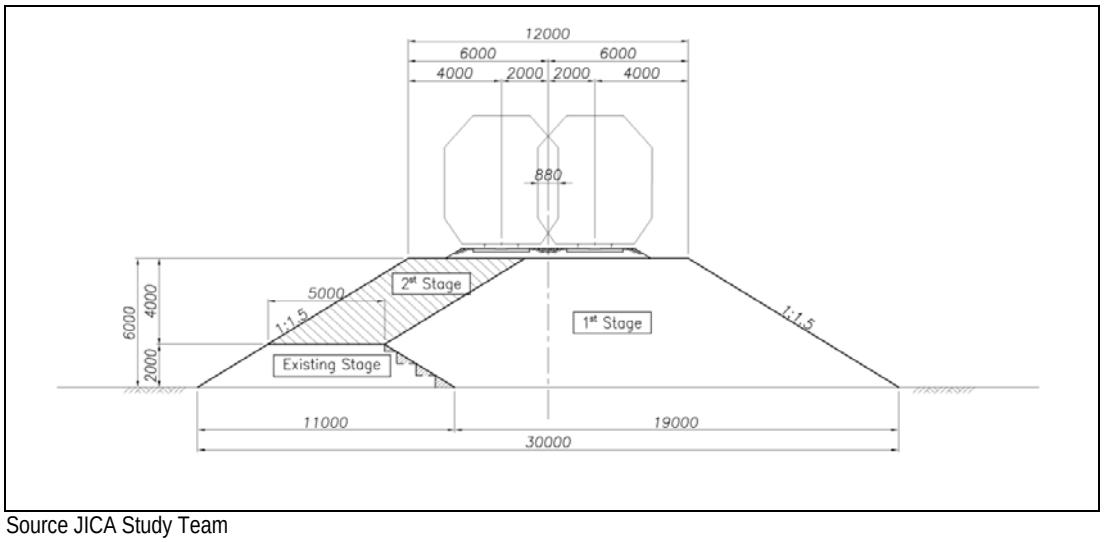
Bridge Span Length (m)	Structural Form	Drawings
L ≦ 6	Box Culvert	Figure 4.4.5
6 < L ≦ 20	RC Girder T-Beam	Figure 4.4.6
20 < L ≦ 40	PC girder I shape Girder	Figure 4.4.7
40 < L ≦ 50	PC Box Girder	Figure 4.4.8

Source: JICA Study Team
Note: Length of Box culvert is internal length.



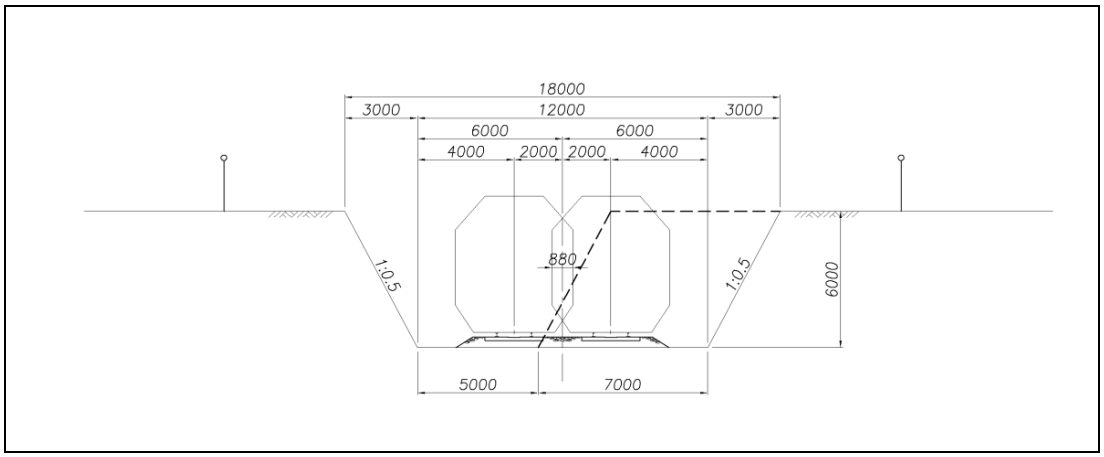
Source: JICA Study Team

Figure 4.4.2 New Embankment



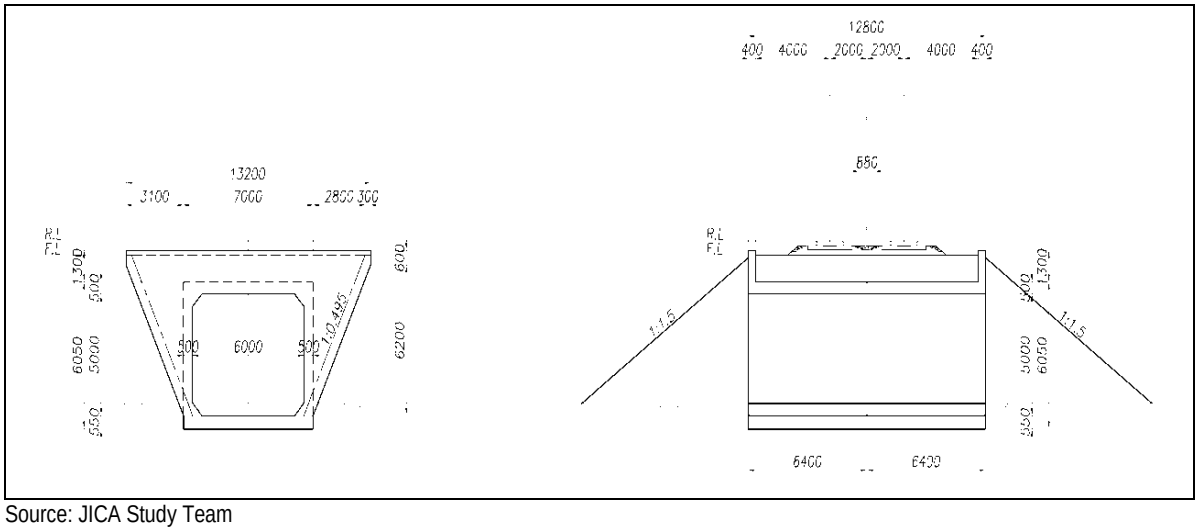
Source JICA Study Team

Figure 4.4.3 Widening of Embankment



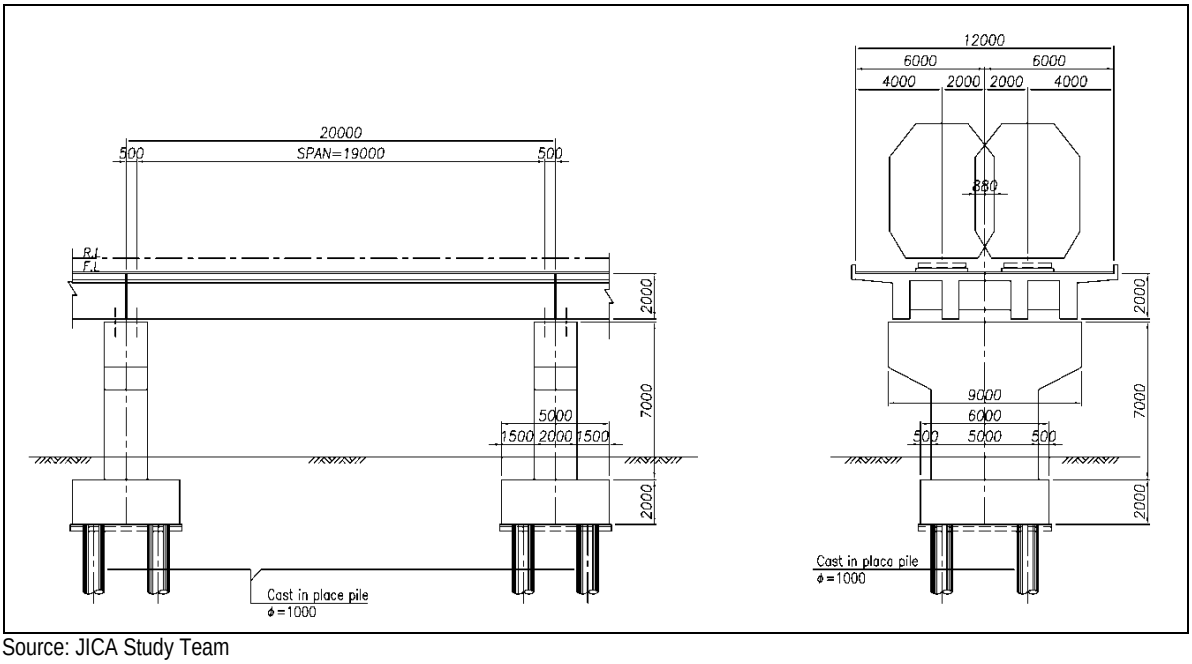
Source JICA Study Team

Figure 4.4.4 Cutting Section



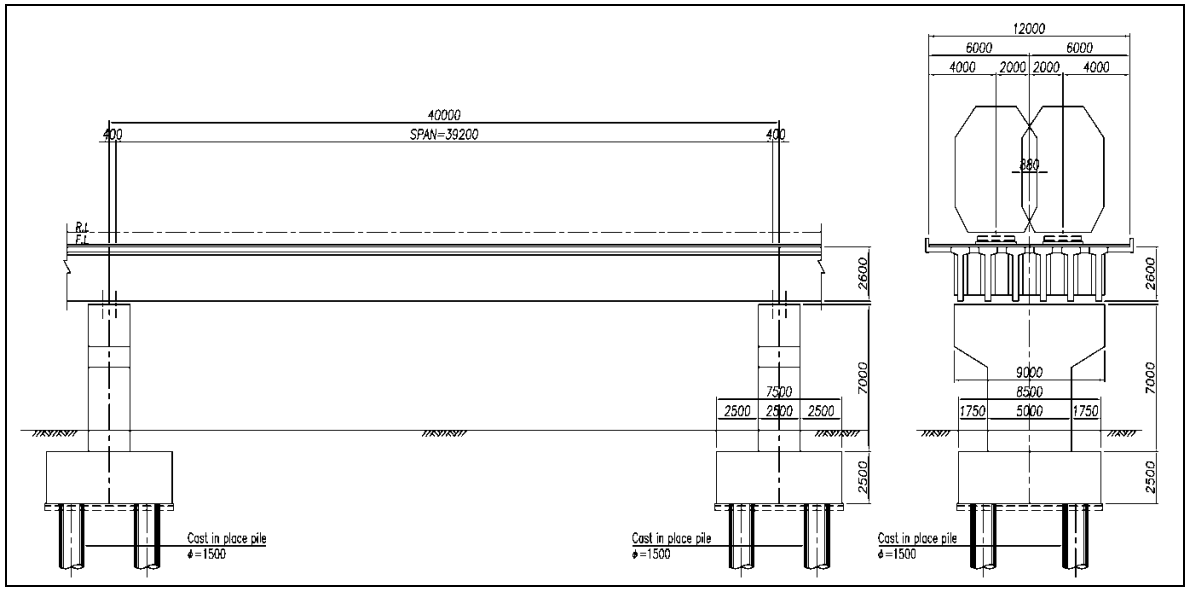
Source: JICA Study Team

Figure 4.4.5 Box Culvert



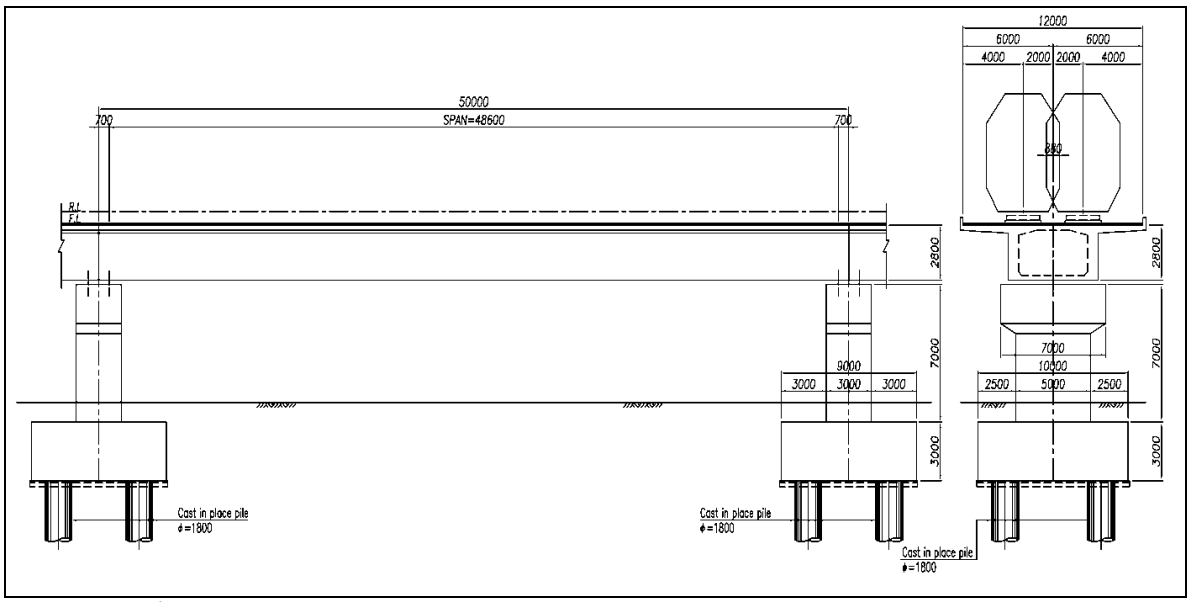
Source: JICA Study Team

Figure 4.4.6 RC Girder T=Beam



Source: JICA Study Team

Figure 4.4.7 PC Girder I-Shape Girder

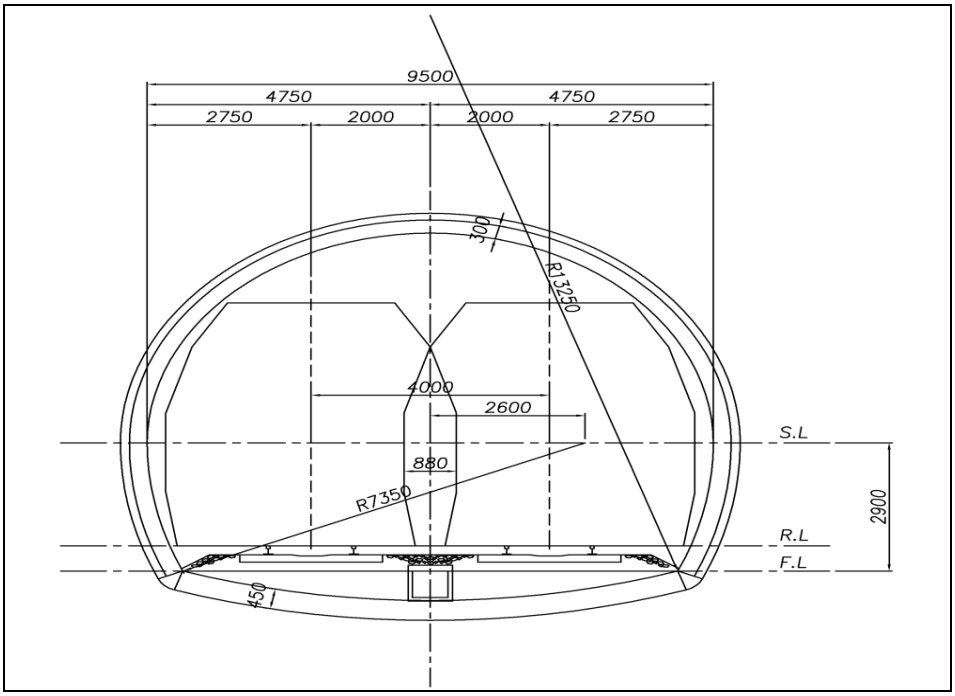


Source: JICA Study Team

Figure 4.4.8 PC Box Girder

(4) Tunnel

4.45 Since the construction gauge is different with current line, the tunnel is planned with change the alignment as double track new tunnel shown in Figure 4.4.9 as follows;



Source: JICA Study Team

Figure 4.4.9 Double Track Tunnel

(5) Station

4.46 Track alignment plan in station yard are classified 5 types include freight station shown in Table 4.4.3 as below;

Table 4.4.3 Station Form and Application

Station Type	Platform	Application	Track layout
Terminal station	3 Island 6Lines	Ha Noi	Figure 4.4.10A
Terminal Station (Dead end station)	3 island 8 Lines	Sai Gon	Figure 4.4.10B
Internal big station	2 island 4 Lines	Station type Ⅰ、Ⅱ、Ⅲ in 【Table 4-3-3】 。 exclude Ha Noi, & Sai Gon	Figure 4.4.10C
Internal small station	2 Separate 4 Lines	Station type Ⅳ in 【Table4-3-3】	Figure 4.4.10D
Freight station		In proportion to Current Line	Figure 4.4.10E

Source: JICA Study Team

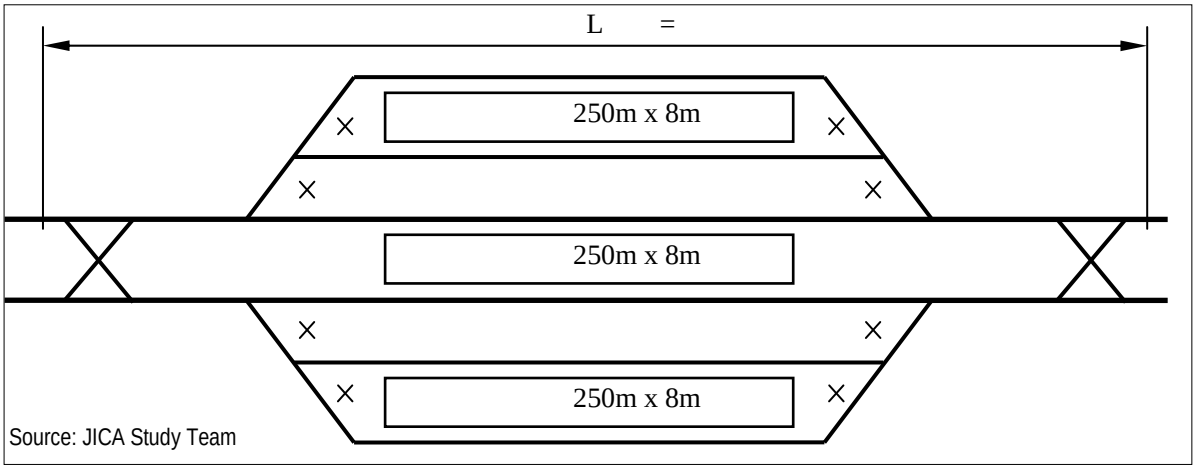
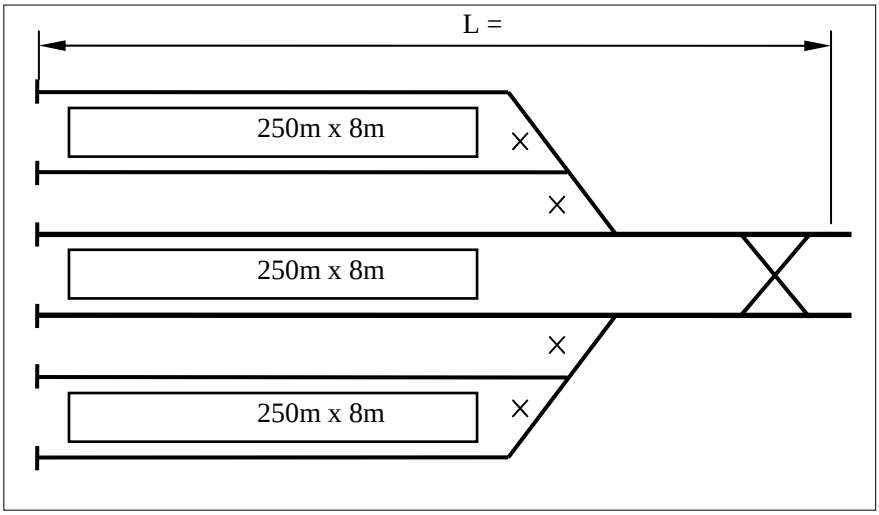
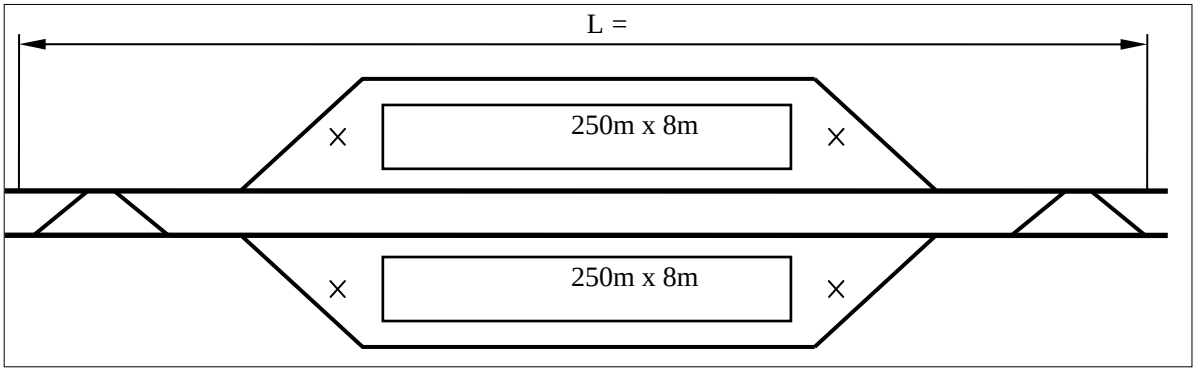


Figure 4.4.10 A Terminal Station (Ha Noi)



Source: JICA Study Team

Figure 4.4.11 B Terminal Station (Sai Gon) (Dead End Station)



Source: JICA Study Team

Figure 4.4.12 C Internal Big Station (2 Island Platform 4 Lines)

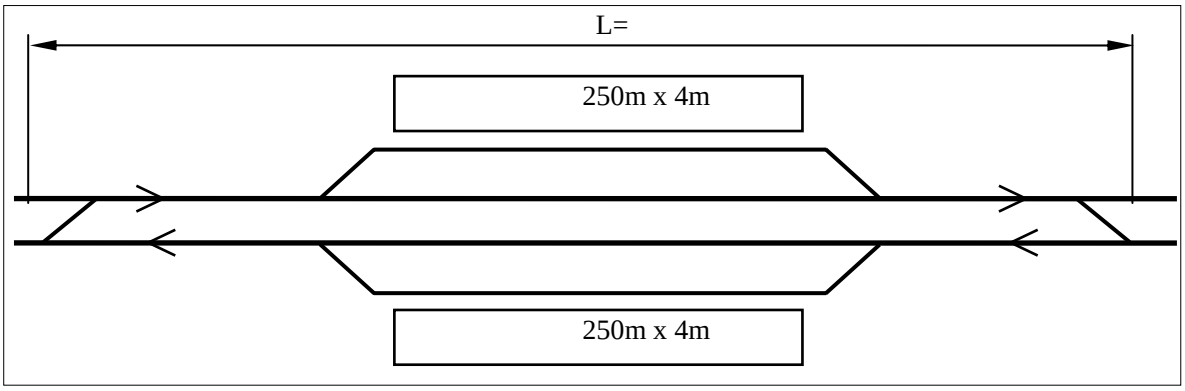
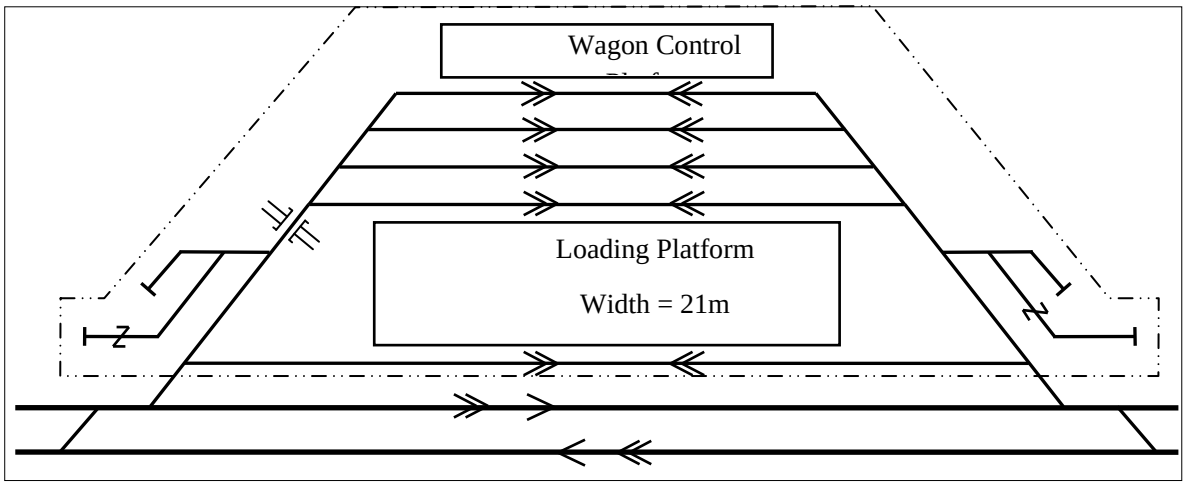


Figure 4.4.13 D Internal Small Station （2 Island Platform 4 Lines)

Source: JICA Study Team



Source: JICA Study Team

Figure 4.4.14 E Freight Station

Table 4.4.4 Classification of Current Line

No	Classification of Class and Station Name	Classification of Station Function	Number of Track	Note
I	Station Type I	6 Stations		
1	Ha Noi	Passenger Train formation	11	Station in city
2	Giap Bat	Freight train formation	14	Hanoi junction station
3	Bim Son	Freight	6	Station in town
4	Da Nang	Passenger Train formation	11	Station in city
5	Song Than	Freight train formation	11	HoChiMinh city junction station
6	Sai Gon	Passenger Train formation	6	Station in city
II	Station Type II	8 Stations		
1	Van Dien	Freight	4	Hanoi junction station
2	Nam Đinh	Passenger	6	Station in city
3	Thanh Hoa	Section	6	Station in city
4	Vinh	Section	7	Station in city
5	Dong Hoi	Section	4	Station in city
6	Hue	Passenger	7	Station in city
7	Dieu Tri	Section	8	Station in town
8	Nha Trang	Section	8	Station in city
III	Station Type III	12 Station		
1	Phu Ly	Intermediate	4	Station in city
2	Ninh Binh	Intermediate	4	Station in city
3	Dong Giao	Intermediate	5	Station in town
4	Cau Giat	Intermediate	7	Station in town
5	Đong Ha	Intermediate	7	Station in city
6	Lang Co	Intermediate	5	Station in gap base
7	Kim Lien	Intermediate	4	Station in gap base
8	Thanh Khe	Intermediate	2	Da Nang junction station
9	Quang Ngai	Intermediate	4	Station in city
10	Quy Nhon	Intermediate	4	Station in city
11	Thap Cham	Intermediate	6	Station in city
12	Muong Man	Intermediate	7	Station in town
IV	Station Type IV			
	140 remaining Stations	Passing	2-3	

Source: JICA Study Team
Note: 6-Freight Station is computed for this study by reference of current condition.

(6) Quantity calculation

4.47 Quantity result of each section is shown below table individually;

(a) Add up 7 Sections in Table below

Table 4.4.5 Add Up Sections

Section No.	From ~ to ~	Chainage	Original Length (km)	New Length (km)
Sec. 1	Ha Noi–Thanh Hoa	000+000 ~ 175+750	175.750	175.750
Sec. 2	Thanh Hoa–Vinh	175+750 ~ 319+400	143.650	143.650
Sec. 3	Vinh–Hue	319+400 ~ 688+815	369.415	367.415*
Sec. 4	Hue–Da Nang	688+815 ~ 794+362	105.547	95.047*
Sec. 5	Da Nang–Nha Trang	794+362 ~ 1315+277	520.915	520.915
Sec. 6	Nha Trang–Phan Thiet	1315+277 ~ 1551+570	236.293	236.293
Sec. 7	Phan Thiet–Sai Gon	1551+570 ~ 1726+000	174.430	174.430

Source: JICA Study Team
Length of Sec. 3 & 5 are shorten due to the new tunnels in Khe Net Pass and Hai Van Pass

(b) Quantity in Every Type

- New Embankment: The length of new embankment= improvement curved length +Bridge approach length; (Bridge approach length assumed 1,000 m in over 50 m length bridge)
- Widening of embankment: The length of Widening of embankment= Total Length-(the Length of new embankment, Cutting, Bridge, Tunnel and Station)
- Cutting Length = cutting length in current line exclude route changing length)
- Bridge Length = current Bridge Length + new bridge length by grade separation
- Tunnel length = Route change length + current Tunnel length in non-route change
- Stations: Station length & area are shown in Table 4.4.6

Table 4.4.6 Length and Area of the Station

No	Type of Station		Length	Area	Note
1	Terminal Station	Ha Noi	870 m	≈25,000 m^2	3 island 6 lines
		Sai Gon	570 m	≈18,000 m^2	3 island 6 lines
2	Internal Big Station		710 m	≈16,000 m^2	2 island 4 lines
3	Internal Small Station		560 m	≈12,000 m^2	2 separate 4 lines
4	Freight Station			70,000 m^2	

Source: JICA Study Team

(c) Summary of Quantity

Table 4.4.7 Summary of Quantity

1. Fill

New Embankment (m)		For modified curves with radius less than 1200m	For access to river bridges of over 50m length	Total Length (m)
Ha Noi - Thanh Hoa	Sec. 1	66,700	10,000	76,700
Thanh Hoa - Vinh	Sec. 2	40,900	12,000	52,900
Vinh - Hue	Sec. 3	158,700	70,000	228,700
Hue - Da Nang	Sec. 4	26,100	20,000	46,100
Da Nang - Nha Trang	Sec. 5	220,100	76,000	296,100
Nha Trang - Phan Thiet	Sec. 6	74,100	16,000	90,100
Phan Thiet - Sai Gon	Sec. 7	79,300	6,000	85,300
Total for all line		665,900	210,000	875,900

Widening Embankment (m)		Section Length	Length of other structures	Total Length* (m)	Remark
Ha Noi - Thanh Hoa	Sec. 1	175,750	97,809	78,000	
Thanh Hoa - Vinh	Sec. 2	143,650	64,947	78,800	
Vinh - Hue	Sec. 3	367,415	323,562	43,900	shorten 2km for Khe Net pass
Hue - Da Nang	Sec. 4	95,047	74,772	20,300	shorten 10.5km for Hai Van pass
Da Nang - Nha Trang	Sec. 5	520,915	376,574	144,400	
Nha Trang - Phan Thiet	Sec. 6	236,293	129,476	106,900	
Phan Thiet - Sai Gon	Sec. 7	174,430	153,087	21,400	
Total for all line		1,713,500	1,220,227	493,700	shorten 12.5km for Khe Net and Hai Van pass

* Length is rounded to 100m

2. Cut

Cut (m)		Total Length* (m)
Ha Noi - Thanh Hoa	Sec. 1	2,600
Thanh Hoa - Vinh	Sec. 2	2,100
Vinh - Hue	Sec. 3	56,400
Hue - Da Nang	Sec. 4	9,300
Da Nang - Nha Trang	Sec. 5	28,200
Nha Trang - Phan Thiet	Sec. 6	24,700
Phan Thiet - Sai Gon	Sec. 7	54,800
Total for all line		178,100

* Length is rounded to 100m

3. Tunnels

Tunnels (m)		Total Length (m)
Ha Noi - Thanh Hoa	Sec. 1	0
Thanh Hoa - Vinh	Sec. 2	0
Vinh - Hue	Sec. 3	5,800
Hue - Da Nang	Sec. 4	10,900
Da Nang - Nha Trang	Sec. 5	4,400
Nha Trang - Phan Thiet	Sec. 6	0
Phan Thiet - Sai Gon	Sec. 7	0
Total for all line		21,100

4. Bridges and Over-road Bridges

BRIDGEs (m)		RC Box	RC T girder	PC I girder	PC Box	Total Length
Ha Noi - Thanh Hoa	Sec. 1	46	337	506	858	1,747
Thanh Hoa - Vinh	Sec. 2	104	243	802	493	1,642
Vinh - Hue	Sec. 3	457	1,344	2,440	4,246	8,487
Hue - Da Nang	Sec. 4	0	918	1,157	747	2,822
Da Nang - Nha Trang	Sec. 5	765	2,743	5,107	11,665	20,280
Nha Trang - Phan Thiet	Sec. 6	33	1,793	1,502	517	3,845
Phan Thiet - Sai Gon	Sec. 7	22	297	345	989	1,653
Total for all bridges		1,427	7,675	11,859	19,515	40,476

Over-road Bridges (m)		RC Box	RC T girder	PC I girder	PC Box	Total Length
Ha Noi - Thanh Hoa	Sec. 1	181	1,783	312	96	2,372
Thanh Hoa - Vinh	Sec. 2	235	372	118	0	725
Vinh - Hue	Sec. 3	922	311	92	0	1,325
Hue - Da Nang	Sec. 4	251	152	105	62	570
Da Nang - Nha Trang	Sec. 5	563	1,784	157	0	2,504
Nha Trang - Phan Thiet	Sec. 6	250	705	56	0	1,011
Phan Thiet - Sai Gon	Sec. 7	257	515	322	0	1,094
Total for all RFOs		2,659	5,622	1,162	158	9,601

Bridges + Over-road Bridges (m)		RC Box	RC T girder	PC I girder	PC Box	Total Length
Ha Noi - Thanh Hoa	Sec. 1	227	2,120	818	954	4,119
Thanh Hoa - Vinh	Sec. 2	339	615	920	493	2,367
Vinh - Hue	Sec. 3	1,379	1,655	2,532	4,246	9,812
Hue - Da Nang	Sec. 4	251	1,070	1,262	809	3,392
Da Nang - Nha Trang	Sec. 5	1,328	4,527	5,264	11,665	22,784
Nha Trang - Phan Thiet	Sec. 6	283	2,498	1,558	517	4,856
Phan Thiet - Sai Gon	Sec. 7	279	812	667	989	2,747
Total for Bridges and RFOs		4,086	13,297	13,021	19,673	50,077

5. Stations

STATIONs (unit & length(m) & area (m2))		Terminal Type			Major Intermediate Type			Through-Trains Type			Freight Type	
		unit	Length (m)	Area (m2)	unit	Length (m)	Area (m2)	unit	Length (m)	Area (m2)	unit	Area (m2)
Ha Noi - Thanh Hoa	Sec. 1	1	870	25,000	8	5,680	128,000	14	7,840	168,000	3	210,000
Thanh Hoa - Vinh	Sec. 2	0	0	0	2	1,420	32,000	11	6,160	132,000	0	0
Vinh - Hue	Sec. 3	0	0	0	3	2,130	48,000	37	20,720	444,000	1	70,000
Hue - Da Nang	Sec. 4	0	0	0	4	2,840	64,000	4	2,240	48,000	1	70,000
Da Nang - Nha Trang	Sec. 5	0	0	0	3	2,130	48,000	41	22,960	492,000	0	0
Nha Trang - Phan Thiet	Sec. 6	0	0	0	2	1,420	32,000	15	8,400	180,000	0	0
Phan Thiet - Sai Gon	Sec. 7	1	570	18,000	1	710	16,000	16	8,960	192,000	1	70,000
Total for all		2	1,440	43,000	23	16,330	368,000	138	77,280	1,656,000	6	420,000

Source: JICA Study Team

5 TRACK

5.1 Option A-1

1) Outline

5.1 The following project is carried out in order to maintain an operational speed and present train number per day as exist at present along the line that is of length 1726km. A1 is drawn up based on projects that are already being implemented by Vietnam Railways for replacement of facilities. The next project will be done in sections where degradation is severe along the N-S line and the working life has been exceeded.

2) The Item of Track Construction

(a) Renewal of the Track Materials which Reached a Durable Term Limit

5.2 Such works, extension of the effective track length on some stations, some countermeasure against a mud pumping failure, ballast renewal, sleeper replacement, replacement of track panel and other track improvement work are needed to perform.

(b) The Ballast Renewal in sections where the ballast deteriorated and the mud pumping failure has generated

(c) The track replacement in sections where bridges are replaced because of its durable term limit

(d) The track replacement in sections where tunnels have to be improved because of its deterioration.

(e) The track work in level crossing sections to be improved

3) The Result of Track Improvement in A1

5.3 After implementation, the project shall contribute to maintain safety and speed of train operation (speed improvement only at speed restricted locations).

4) The Items of Track Improvement work

5.4 The project list for track improvement work is shown by Table 5.1.1

Table 5.1.1 Project List of A-1 for Track Work

No	Project	Calculated Year
1	Vinh–Nha Trang superstructure replacement project	12-2007
2	Hanoi–Vinh and Nha Trang–HCMC sections track structure strengthening projects	2011
3	44 bridges improvement project	12-2007
4	132 bridges safety improvement project	10-2008
5	566 bridges safety improvement project	2011
6	Weak 22_tunnels consolidation project	2011
11	Amendment for Level crossing Project on Hanoi – Ho chi Minh City Railway	12-2015

Source: JICA Study Team based on TRICC's Data
Remarks: project number 7, 8, 9, 10 of plan A1 are signal matter

5.2 Option A-2

1) Outline

5.5 In this plan, track is assumed improving to increase the number of train to 50 trains per day from 32-36 trains per day. Aiming at this, the following projects are required to implement.

2) The Item of Track Construction

- The improvement of track alignment on three passes of Khe Net pass, Hai Van pass and Hoa Duyet－Thanh Luyen section: The track installation on realignment section along the pass, withdrawal of an existing track.
- Track work under the construction of 18 pass-by stations: The additional track installation for exchanging trains on pass-by new stations.
- Additional track installation for the extension of vehicle yard: New track installation on new depot yard premise being enlarged.

3) The Result of Track Improvement in Option A2

- Improve transport capacity: from 32-36 trains to 50 trains /day

4) The items of Track Improvement Work

- The project list for track improvement work is shown by Table 5.2.1

Table 5.2.1 Project List of Option A-2 for Track Work

No	Project	Calculated Year
1	Khe Net Pass realignment Project	2010
2	Hai Van Pass realignment Project	2007
3	Hoa Duyet–Thanh Luyen section upgrade project	2011
4	Construction pass-by new stations	2011
7	Vehicle workshops and facilities for the increased transportation capacity	2011

Source: JICA study team based on TRICC's data
Remarks: Project number of 5, 6 of plan A2 are signal matter and project number 8 is vehicle matter.

5.3 Option B-1

1) Outline

5.6 Option B1 is the project of double tracking by 1,000 mm gauge line.

2) Track Work Execution Plan

5.7 The conditions of the work execution plan for the track construction are as follows:

(i) The existing 1m gauge track shall be reused as present conditions in principle.

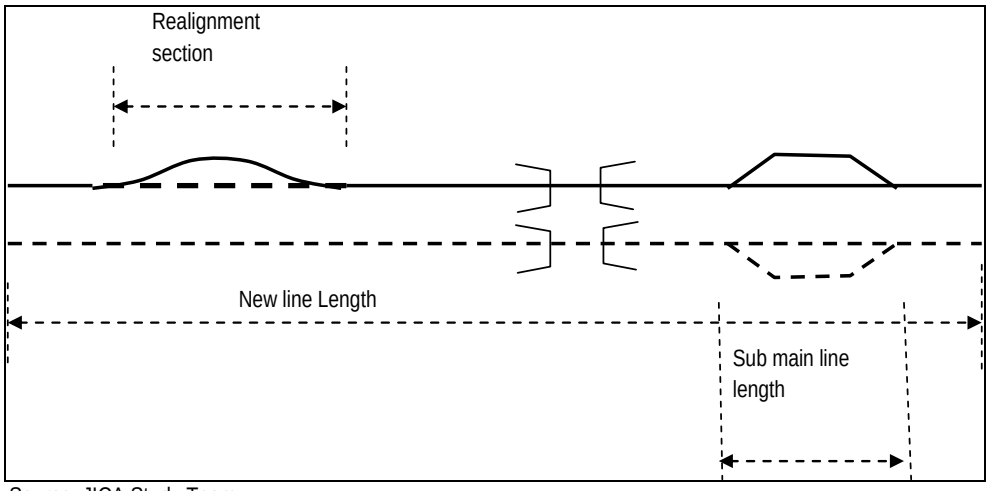
(ii) The realignment sections that are planned to improve with a curve radius of 800m shall install new track line.

(iii) New line construction shall be placed along the existing line.

(iv) The bridges on existing line shall be reused as it is.

(v) Single-track bridges shall be constructed for the new line.

(vi) In case of the existing bridge is reached a durable period, a double track bridge shall be constructed for old and new line.



Source: JICA Study Team

Figure 5.3.1 Layout of Construction Procedures

5.8 Total length of track work shall consist:

- Length of alignment improved section
- Length of new line
- Length of sub main line

5.9 Track construction length =0.2Ｌ＋1.0Ｌ＋600m x（166 stations — 70 stations）

5.10 Track construction length =20％ of existing line length as for alignment improved sections+ 100％ of new line length+ 600 m length of sub main line x (166 station -70 station) = 1714 km x 0.2 + 1714 km +57.6 km = 2114 km

5.11 Withdrawal length of the existing track = 20％ of existing line length = 1714 kmx 0.2=342.8 km

3) Specification of Track Construction Work

- The design specification is set to gauge 1000 mm, 50 kg rail (P50 rail), design speed 120 km/h, and axle load 14tf.

- The track structure design is with Pre-stressed Concrete sleeper, 38 sleepers per 25m length track, and 250 mm of ballast thicknesses.
- The Continuous Welded Rail is applied between stations with a curve radius of 500m or more.
- The track in station area is installed with a jointed rail.

5.4 Option B2

1) Outline

5.12 Option B2 is the project making double track with a 1435 mm gauge track structure.

2) Track Work Execution Plan

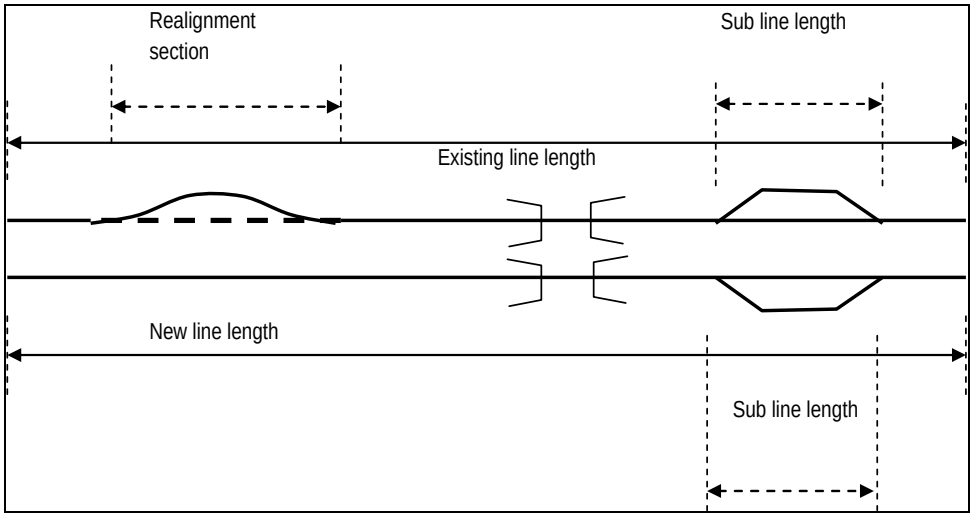
5.13 The conditions of the work execution plan for the track construction are as follows.

(i) A new line is built along with an existing line.

(ii) The existing track of 1m gauge shall be abolished when the single track system of 1435 mm gauge track are constructed and starting its operation.

(iii) The realignment sections that are planned to improve with a curve radius of 1200m shall install new foundation and track.

(iv) The bridges shall be either two parallel structures or one double track structure.



Source: JICA Study Team

Figure 5.4.1 Layout of Construction Procedures

(a) Since the gauge is changed, existing track cannot be reused at a bridge, through where track distance is small, where the alignment is to be improved, and where embankment height is being changed.

(b) The reuse of 1m gauge existing track could be possible where a changed value of banking height is so small, and somewhere not changed the foundation height in station.

(c) Assuming that 25% length of the whole existing line could be reused its rail, and such reusing section the track could expand the gauge with the replacement of sleepers.

(d) New track shall be installed for the 75% length of existing track remained.

(e) Total length of track construction work is including:

- New line of 1435 m gauge
- Sub main line of above new line
- Replacement length of existing line as renewal section
- Sub main line of above renewal line

- Gauge widening sections of existing line being reused

(f) Length of sub main line assumes about 5% of the whole line.

(g) Length of new track installation = 1714 km x {(1.0+0.05) + (0.75+0.05)} =3171 km

(h) Section to be expand the track gauge =1714 km x0.25=428.5 km

(i) Withdrawal length of the track =1714 km x (0.75+0.05) =1371 km

3) Specification of Track Construction Work

- The design specification is set to gauge 1435 mm, 60 kg rails (P60 rail), design speed 150 km/h, and axle-load 17tf.
- Track structure design is with pre stressed concrete sleeper, 41 sleepers per 25 m length, and 250 mm of ballast thicknesses.
- The Continuous Welded Rail is applied to main line where the curve radius of 500 m or more in principle.
- The sub main line on station part is applied a track structure with jointed rail.

6 POWER SUPPLY SYSTEM

6.1 General

6.1 As the double-tracking/electrification project, the Study team will propose an innovated system to have blended the most reliable and advanced technologies and equipment/facilities that are widely in use and fully proven in Japan. For the maintenance of the system after introduction, JICA Study Team will also adopt a thoroughly deliberated system in principle.

1) Power Receiving System

6.2 Railway substations will be connected through a normal service circuit and a spare circuit via T-branches separately with different transmission routes of the extra-high tension transmission network of Vietnam Electricity (EVN). The location of T-branches and the voltage of power are subject to the negotiation with EVN. The receiving voltage shall preferably be that of the 220 KV transmission network.

2) Feeding Circuit

(1) Composition of Feeding Circuit

6.3 A sectioning post will be set at the center between the adjacent substations A and B in AC-electrified sections. Power is normally supplied from these substations A and B up to the sectioning post.

6.4 In case either one of the substations has failed, feeding is extended, in that power is supplied from the substation remaining intact to the failed substation over-passing the sectioning post in between. To limit the length of power shutdown section at accidents or during maintenance work, an auxiliary sectioning post will be set between a substation and its adjacent sectioning post.

(2) Power Supply to Feeding Circuits

(a) Power Supply through AC Auto Transformers

6.5 JICA Study Team will propose adoption of autotransformer (AT feeding) system, the standard version for AC electrification in Japan, among various feeding systems used in AC electrified railways.

(b) Direction-side Different- Phase Feeding System

6.6 Single-phase AC electrification railways receive three-phase AC current from electric power companies and convert it into two single-phase AC currents having 90-degree different phases and supply them separately to the feeding circuits on the different sides of the substation, as adopted for the narrow-gauge and Shinkansen railways in Japan. JICA Study Team will recommend for Vietnam to adopt this system, which is called the different- side different- phase feeding system (power of different phases is supplied to different sides, with both up- and down-trains on the same side supplied with power of the same phase).

3) Contact Wire Voltage

6.7 The standard contact wire voltage is 25.5 KV, with fluctuation ranges of effective value a specified below.

Table 6.1.1 Contact Wire Voltage

Standard Voltage	25.5 KV
Maximum Voltage	27.5 KV
Minimum Voltage	19.0 KV
Instantaneous Minimum Voltage	17.5 KV

Source: JICA Study Team

6.2 Substations and Related Facilities

1) Installation of Power Supply Substations

6.8 While assuming that the substation lands are prepared, JICA Study Team will construct substations and related facilities outdoor. Power supply substations will be placed at 50 Km intervals in principle. A sectioning post will be placed at the center between adjacent substations (at 25 Km intervals) as a standard layout.

6.9 To limit the length of power shutdown section at accidents or during maintenance work, an auxiliary sectioning post will be placed between a substation and its adjacent sectioning post. Dead sections will be set directly downstream of substations, sectioning posts and auxiliary sectioning posts.

2) Installation of Auto Transformer (AT Transformer)

6.10 An AC transformer will be installed approximately at the center between a substation and its adjacent feeding post (approximately at 12.5 Km intervals) in principle.

3) Feeding Transformer

6.11 To reduce the unbalance and voltage fluctuations of the power source system (the three-phase side of EVN), JICA Study Team will propose adoption of roof-delta connection transformers, which have long been studied and developed for practical use in Japan and adopted for Aomori Shinkansen (opened in December 2010).

6.12 The allowable degrees of voltage unbalance stipulated in Japan are as follows. These values are used in Japan without any problem.

Table 6.2.1 Feeding Transformer

Degrees Of Voltage Unbalance	3% or less (averaged over two hours)
	5% (instantaneous)
Voltage Fluctuations	3% or less (averaged over two hours)
	5% (instantaneous)

Source: JICA Study Team

4) Substation Protective Devices

6.13 JICA Study Team will install protective devices at substations in accordance with law and technological standards.

6.3 Monitor and Control System

6.14 JICA Study Team will introduce a centralized monitor and control system (SCADA system) to ensure smooth operation of machines and devices at substations, sectioning posts and, auxiliary sectioning posts and in power distribution rooms. JICA Study Team will propose to set the system at two places in view of the length of the entire route.

6.4 Principal Work to be undertaken by the Civil Engineering Side

6.15 JICA Study Team will entrust the following work to the civil engineering side:

(i) Acquisition of lands for substations

(ii) Land formation for substations

(iii) Drain ditches in the substation premises

(iv) Approach roads to substations

(v) Pile striking work

6.5 Principal Work to be undertaken by the Architecture Side

6.16 JICA Study Team will entrust the following work to the architecture side:

(i) Substation buildings

(ii) Water supply and drainage facilities

(iii) Passes in the substation premises

(iv) Cabling and piping routes in the architecture

(v) Fences and pile striking work

6.6 Contact Wire Equipment

6.17 To cope with the high speed operation in recent years, a CS simple catenary type contact wire has been developed in Japan to use cupper/steel shielded trolley wire (CS trolley wire), which has already been adopted for Aomori Shinkansen. JICA Study Team will propose for Vietnam to adopt this simple catenary contact wire system. The CS simple catenary contact wire has the following tensile force.

Table 6.6.1 Contact Wire Equipment

Name	Wire Type mm^2	Standard Tensile Force KN (Kgf)
Messenger wire	PH, 150	19.6 (2,000)
Trolley wire	GT-CS, 110	19.6 (2,000)

Source: JICA Study Team

1) Feeding Line

6.18 The feeding line is the main wire to supply power to contact wires (trolley wires). Types of feeding wire and their tensile force are as follows.

Table 6.6.2 Feeding Line

Wire Type	Standard Tensile Force KN (Kgf)
PH 356	19.6 (2,000)
Heat resistant aluminum alloy with aluminum shield steel core TACSR/AC730	19.6 (2,000)

Source: JICA Study Team

2) Contact Wire Supports

(a) **Pole:** JICA Study Team will adopt precast/pre-stressed concrete poles featuring low-costs and long durability for installation at 50 m intervals. At elevated places, JICA Study Team will adopt the so-called throwing-in planting method while entrusting the civil engineering side with the work to drill holes having a diameter of approximately1m to withstand overturning moments, into which poles are planted.

(b) **Beam:** JICA Study Team will adopt angle steel cage and V-shaped trust beams for fixed beams.

(c) **Movable Bracket:** JICA Study Team will use movable brackets to support contact wires.

(d) **Supports in Tunnel:** JICA Study Team will adopt steel pipe piers fixed at the ceiling in principle as the support in tunnel.

(e) **Insulator:** JICA Study Team will use suspension insulators; stem insulators and other insulators to support feeding wires, contact wires and other wires, steady braces and pull-off arms and other auxiliaries at poles, beams and arms or to electrically separate feeding wires from contact fires.

3) Contact Wire Facilities Monolithic With Civil Structures

6.19 The contact wire facilities to be constructed as monolithic with civil structures are as follows:

- Pole foundation, support foundation, structures in tunnel (ceiling piers, branches, machine/material shafts, maintenance paths), grounding
- Structures to cross pipes and the like are subject to negotiation with the civil engineering side at the design stage.

6.7 Facilities for Lighting and Power

6.20 The facilities of lighting and power will be designed as those for power to be supplied to loads other than the power required to run electric cars. Major loads are lighting at stations and rolling stock bases and power to operate machines. The facilities of power to be supplied to such loads will be composed of systems normally used by electric railways and bulk users. Power will be supplied for train operation and marketing windows through duplicated circuits in principle.

6.21 As the reliability of power reception seems to differ from area to area, emergency power generators will be installed to ensure the reliability of power source.

1) Contents of System

(1) Power Distributing Stations

6.22 Power distributing stations will be constructed at stations and rolling stock bases to receive high-voltage power from the transmission network of EVN or the Vietnamese electric power company. Power will be transmitted to the loads at stations through cables after the voltage is dropped at power distributing stations. The status of machines and equipment will remotely be monitored and controlled through a system incorporated in the SCADA system.

(2) Power Distributing Lines

- High-voltage power distributing lines (three-phase 6.5 KV power cables) will be laid to supply power to the facilities existing between stations.
- Power cables will be laid in the cable ducts installed by the civil engineering side in open sections and attached to the walls in tunnel.
- Power will be supplied to maintenance bases, signal and telecommunication machine rooms and substations existing between stations through high-voltage cables branched from the power transmission network.

7 SIGNALING AND TELECOMMUNICATION

7.1 Option A-1

1) General

7.1 Three projects on the signaling and telecommunication are on-going between Hanoi and Saigon (refer to (2)(a)-(c)). Level crossing projects on the North-South Railway line are proposed (refer to (2)(d)). They all aim to upgrade the safety or to replace the obsolete railway signaling and communication system currently used on Hanoi-Saigon sections. Two other projects on the signaling and telecommunication are completed from 2005 to now between Hanoi and Saigon. One of them is listed below for understanding the on-going projects (refer to (2)(e)) as well. The outlines and scopes of the projects are stated below.

2) Related Projects

(1) Modernization of the Signaling and Telecommunication System of the Hanoi-Vinh Railway (Phase II) Project (On-going Project)

7.2 The Objectives of this project are to replace the obsolete railway signaling and communication system currently used on Hanoi Vinh section with new signaling and telecommunication system which applies advanced and modern technologies

(a) **Scope of Project:** Hanoi–Vinh (319 km) and branch lines

(b) **Scale of Investment**

- Signaling system
- Electric interlocking equipment for 31 stations
- Axle counter-based block equipment for 34 stations
- Centralized Traffic Control system (CTC) on Hanoi-Vinh section
- Telecommunication system
- Using SDH devices of STM-1 transmission speed, upgradable to STM-4
- Dedicated digital telephone system
- Installing communication systems for stations on branch lines so that these systems can be uniform with those of stations on main lines

(c) **Implementation Schedule:** 2007–2010

(2) Modernization of the Signaling and Telecommunication System of Vinh–Sai Gon Railway (Phase I) (On-going Project)

7.3 The objectives of this project are to reject the backward and weakness of the existing signaling and telecommunication system

(a) **Scope of Project:** The North-south railway line (319km-1,726km section)

(b) **Scale of Investment:**

- **Signaling System**
  - Relay interlocking equipment in combination with axle counter for 316 turnouts of stations on Da Nang–Sai Gon

- Semi-automatic block equipment in combination with axle counter for 72 stations on Da nang–Sai Gon
- Computerized train control and monitoring system for 54 stations from Dieu Tri to Sai Gon
- Turnout control system at Chu Lai, My Trang, Ru Ri and Giac Lan
- Other related facilities in the project

- **Telecommunication System**

- Transmission system
- Optical fiber cable system (Type of G625-12 strands) with 1,150 km long from Vinh to Nha Trang
- SDH transmission device and network management system from Vinh to Nha Trang
- Dedicated telecommunication system
- Switching device (26,000 subscribers)
- Other telecommunication works

(c) **Implementation Schedule:** 2010–2013

7.4 Some signaling and telecommunication systems between Vinh and Da Nang seem to have not been committed yet. The sections are proposed to be equipped with the foregoing similar systems.

(3) Modernization of Operation Control Center (OCC) (On-going Project)

7.5 The objectives of this project are to enhance the capacity to set up the train operation diagram, improve the operation control of passenger and freight train and rolling stocks.

(a) **Scope of Project:**

- OCC at the head office of Vietnam Railways, Hanoi
- OCC of the North region is placed at Hanoi OCC
- OCC of the South region is placed at Sai Gon
- Stations operate coupling service, all stations on all railway lines of Vietnam.

(b) **Scale of Investment**

7.6 Main Operation Control Center

- Equipping the host, work stations for dispatchers

7.7 OCC of the South region

- Equipping the work stations for dispatchers

7.8 Equipment for locomotives

- Equipment such as GPS, GSM, WLAN, Man Machine Interface push-button, antenna over 350 locomotives of Vietnam Railways

7.9 At stations

- Equipping laptop and portable equipments for data input

- Equipping WLAN system for stations without GSM wave

7.10 Other relevant works

(c) **Implementation Schedule:** 2007–2010

(4) Adjustment of Level crossing Projects on the North-South Railway Line (Proposed Project)

7.11 The objectives of this project are:

(i) Improving, upgrading and gathering the level crossing system on the North-South

(ii) Railway line to improve the traffic safety

(iii) Concentrating the investment on the level crossings with high traffic volume

(iv) Priority over the new feeder to gather level crossings and decrease intersections on the North- South Railway line

(v) For the favorable locations of intersection, priority to design the grade interchange (underpass) instead of intersection at grade(level crossing)

(a) **Scope of Project:** The North-South Railway Line

(b) **Scale of Investment**

- Level crossing protected with side board: (21 crossings)
- Level crossing protected automatic warning signal: (31 crossings)
- Level crossing protected with barrier:(33 crossings)
- Level crossing protected with trolley barrier: (22 crossings)
- Underpass: (4 underpasses)
- Total: 111 intersections
- Other works

(c) **Duration:** 3 years (2012-2015)

(5) Modernization of the Signaling and Telecommunication System of the Hanoi-Vinh Railway (Phase I) Project (Completed Project)

7.12 The Objectives of this project are to replace the obsolete railway signaling and communication system currently used on Hanoi–Vinh section with new signaling and telecommunication system that applies advanced and modern technologies.

(a) **Scope of Project:** Hanoi–Vinh (319 km)

(b) **Scale of Investment**

- **Signaling System**
  - Modernizing signaling system (Electric interlocking equipment) for three stations, including Van Dien, Thanh Hoa and Bim Son.
  - Modernizing 09 automated level crossing control systems in the area.
  - Installing 01 new fully automated level crossing (automatic alarm and barrier).
- **Telecommunication System**
  - Providing 24 fiber-based cable system along the railway line of 319 km with capacity of 622 M bits/s.

- Providing optic cable – based communication networks for 36 railway stations on 355km long, linking all railway stations between Hanoi and Vinh.

- **03 stations use copper cable, 25 pairs**
  - Dedicated telephone system
  - Installing new five PABX systems for Hanoi, Nam Dinh, Thanh hoa, Cau Giat, Vinh

7.2 Option A-2

1) General

7.13 The option A-2 proposes to construct eighteen (18) new interchange stations to maximize the transport capacity on existing single track as well as maintaining current operating speed. The interchange stations are equipped with signaling and telecommunication systems needed. As well, one thousand and forty seven (1,047) of level crossings are equipped with automated level crossings consisting of alarm warnings and automatic barriers.

2) Outline of Signaling and Telecommunication Systems for New 18 Stations

- Interlocking device: Electric Interlocking Device
- Block system: mono block system between stations using token-less block system or Semi-automatic block system
- Signal Device: color lighted fixed signal
- Train detection:

7.14 For stations, continuous track circuits are used. Between stations, axle counters are used in consistency with the on-going projects.

7.15 Centralized Traffic Control system (CTC):

- Local equipment of CTC in the 18 stations

3) On-going Projects to be Completed

7.16 Train operation dispatchers monitor and control train operation effectively using CTC so as to maximize the existing single track transport capacity on the base of the modernization of the signaling and telecommunication system of the Hanoi–Vinh railway (phase II) project (on-going project) and the modernization of the signaling and telecommunication system of Vinh–Saigon Railway (Phase I and the rest) projects (on-going project) in A-1.

4) Outline of Automated Level crossings Projects for 1,047 Sites

7.17 Class I class II and class III of level crossings are proposed to be all equipped with automated alarm warnings and automatic barriers to upgrade the safety in the level crossings excluding residential level crossing opened by local residents. The level crossings on the North-South railway lines are listed in Table 7.2.1.

(a) **Class I:** The trunk line intersects the roads of class III (or of higher class) or the roads in cities and towns.

(b) **Class II:** The railway intersects the roads of class IV and V or the roads in the minor towns.

(c) **Class III:** includes level crossings that are not listed as standard level crossings of class I and II.

Table 7.2.1 Level crossings in Provinces

No.	Administrative Border Line	Road			Total
		Class I	Class II	Class III	
1	Hanoi	6	4	83	93
2	Ha Nam	1	2	25	28
3	Nam Dinh	0	4	38	42
4	Ninh Binh	3	5	14	22
5	Thanh Hoa	5	6	53	64
6	Nghe An	2	10	46	58
7	Ha Tinh	1	3	23	27
8	Quang Binh	0	1	74	75
9	Quang Binh	1	7	61	69
10	Thua Thien Hue	2	7	53	62
11	Da Nang	4	4	21	29
12	Quang Nam	0	1	59	60
13	Quang Ngai	4	3	37	44
14	Binh Dinh	1	3	55	59
15	Phu Yen	1	6	39	46
16	Khanh hoa	5	10	72	87
17	Ninh Thuan	0	1	27	28
18	BInh thuan	0	2	59	61
19	Dong Nai	4	9	46	59
20	Binh Duong	2	1	4	7
21	Ho Chi Minh City	7	7	13	27
Total		49	96	902	1047

Source: TRICC

7.18 Level crossings that intersect others on the same sectional level are equipped with one of the following types:

- Trolley or barrier (guarded level crossings) ---------- 333 sites
- Automated Level crossings (automatic alarm and barrier)--- 02 sites

7.19 (One of them is suspended.)

- Automatic warning (unguarded level crossings) ---------- 277 sites
- Warning board (unguarded level crossings)

7.20 As well, there are many level crossings opened by local residents.

- Residential level crossings----------2,842 sites

7.3 Option B-1

1) General

7.21 As for signaling and telecommunication systems in option B-1, electric interlocking devices will be adopted to upgrade the safety and maintainability of the line and multiple block systems will be employed to strengthen the transport capacity. Automatic train protection system (ATP) with speed checking function will be adopted to prevent drivers from train operating error. Centralized traffic control system will be installed to arrange the train operations effectively overall line. Automated level crossings with alarm warning and automatic barrier function will be installed in the 1,047 sites to upgrade the safety in the level crossings. As for a backbone network, synchronous digital hierarchy (SDH) system will be installed.

7.22 The train radio system provides wireless communication not only between dispatchers in the operation control center (OCC) and train crew but also between the dispatchers and operating and maintenance (O & M) staff.

2) Signaling System

7.23 Option B-1 is to strengthen the transport capacity and increase in maximum operating speed to 120 kph in double tracking (1,000 gauges) with frequency of approximately 190 trains per day.

(1) Block System and Train Detection

7.24 To enhance the transport capacity, it is necessary to run more trains in term of frequency. The average distance between stations from Hanoi to Saigon is 10.48km. Three (3) block sections will be installed between stations on average. The length of a block section will be approximately 3.5km on average. Train locations between stations will be detected by using continuous track circuits.

(2) Signal System and Automatic Train Protection

7.25 The color lighted fixed signal will be used and the automatic train protection system with speed checking function will be adopted to prevent the train from exceeding the maximum operating speed of 120 km/h.

(3) Interlocking Devices for Stations

7.26 Electric interlocking devices will be proposed as interlocking devices for stations. Train locations in the stations will be detected using continuous track circuits. Electrical switch machine will be employed to turn points in the stations.

(4) Automated Level Crossing

7.27 Automated level crossings with alarm warning and automatic barrier function will be installed in the 1,047 sites to upgrade the safety, excluding level crossings opened by local residents.

(5) Operation Control Center (OCC) and Centralized Traffic Control System (CTC)

7.28 Operation Control Center will be installed in Hanoi and Ho Chi Minh City to monitor and control train operations for 1,726 km of railways. The OCCs will be equipped with central equipment of CTC and the stations with local equipment of CTC.

(6) Other Signaling Works

7.29 Electrical power will be supplied from the nearest transmission lines of Electricity of Vietnam (EVN). In case of no EVN transmission line near the railway, the transmission lines for power supply to signaling equipment will be installed along the railway lines. The OCCs and stations will be equipped with stand-by electrical power generator and uninterruptible power system (UPS).

3) Telecommunication System

(1) Telecommunication Systems Stated below are Installed for B – 1

- Back-bone Network System (Synchronous digital hierarchy (SDH) nodes)
- Train Radio System
- Cables for telecommunication lines
- Automatic Telephone System
- Dispatch Telephone System
- Dedicated Telephone System
- Block Telephone System
- Wayside Telephone System
- Public Address System
- Passenger Information system
- Electric Clock System
- Wayside Disaster Prevention system
- Power Supply Equipment

(2) Synchronous Digital Hierarchy (SDH) Nodes

- The Synchronous Transfer Module-16(STM-16) nodes are installed at the OCC and main stations.
- The Synchronous Transfer Module-1(STM-1) nodes are installed at the intermediate stations between main stations to form a branch network.

(3) Train Radio System

- The train radio system provides wireless communication not only between dispatchers in the operation control center (OCC) and train crew but also
- between the dispatchers and operating and maintenance (O & M) staff. It also provides wireless voice and data communication channels to support the operation, failure recovery and maintenance requirements of the railway systems.
- The section of Hanoi–Ho Chi Minh City will be equipped with wireless communication system due to a little tunnel sections. The tunnel sections will be equipped with Leaky Coaxial cable (LCX).
- Optical fiber transmission lines are used to connect the central radio equipment and base radio stations.

7.4 Option B-2

1) General

7.30 As for signaling and telecommunication systems in option B-2, they are similar to the systems in B-1. The most different are not including automated level crossings due to grade separation, and including signaling equipment (ex. Impedance bonds) and shield cables immune to electro-magnetic induction by AC electrification of the line. Optical fiber cables immune to electro-magnetic induction by AC electrification will be adopted as backbone network system for railway telecommunication.

2) Signaling System

7.31 B-2 is to strengthen the transport capacity and increase in maximum operating speed to 150 kph in double tracking (1,435 gauge) with frequency of approximately 140 trains per day. In B-2, grade separation in the intersection between railways and roads and electrification of railways will be adopted. Accordingly, automated level crossings will be no necessary and the signaling and telecommunication systems for AC electrification of railway will be needed.

(1) Block System and Train Detection

7.32 It is necessary to run multiple trains between stations to increase in frequency of trains operating between stations so as to strengthen the transport capacity of the line. The average distance between stations from Hanoi to Saigon is 10.48km. Three (3) block sections will be installed between stations on average. The distance of a block section will be approximately 3.5km long on average. Train location between stations will be detected using divided –multiple frequency track circuits for electrification of the railways.

(2) Signal System and Automatic Train Protection

7.33 Color lighted fixed signal will be proposed in accordance with the maximum operating speed of 150 kph and automatic train protection system with speed checking function will be adopted.

(3) Interlocking Devices for Stations

7.34 Electric interlocking devices will be proposed as interlocking devices for stations. Train locations in the stations will be detected using continuous AF track circuits. Electrical switch machine will be employed to turn points in the stations.

(4) Operation Control Center (OCC) and Centralized Traffic Control System (CTC)

7.35 Operation Control Center will be installed in Hanoi and Ho Chi Minh City to monitor and control train operations for 1,726km of railways. The OCCs will be equipped with central equipment of CTC and the stations with local equipment of CTC.

(5) Other Signaling Works

7.36 Electrical power will be supplied from the nearest transmission lines of Electricity of

7.37 Vietnam (EVN). In case of no EVN transmission line near the railway, the transmission lines for power supply to signaling equipment will be installed along the railway lines. The OCCs and stations will be equipped with stand-by electrical power generator and uninterruptible power system (UPS).

3) Telecommunication System

7.38 Telecommunication systems stated below are installed for B-2.

- Back-bone Network System(Synchronous digital hierarchy (SDH) nodes)
- Train Radio System
- Cables for telecommunication lines
- Automatic Telephone System
- Dispatch Telephone System
- Dedicated Telephone System
- Block Telephone System
- Wayside Telephone System
- Public address system
- Passenger Information System
- Electric Clock System
- Wayside Disaster Prevention system
- Power Supply Equipment

4) Signaling and Telecommunication Equipment Immune to AC Electrification of Railways

- Divided –multiple frequency track circuits, impedance bonds and other signaling equipment immune to electro-magnetic induction by AC electrification of railways will be adopted.
- Optical fiber cables immune to immune to electro-magnetic induction by AC electrification of railways will be adopted as backbone network system for railway telecommunication.
- Signaling and telecommunication shielded cables immune to electro-magnetic induction by AC electrification of railways will be adopted along the railways.

8 ROLLING STOCK

8.1 Option A-1

8.1 In Option A-1, the train timetable and the number of trains are the same as present. Therefore, any additional investment for rolling stock is unnecessary.

8.2 Option A-2

1) General

8.2 In option A-2, the number of trains will be increase but the train speed is the same as present. Therefore, most rolling stock which VR owns now can be used in option A-2. New investment is needed for the rolling stock which still run short. The specs of new rolling stock are assumed to be equal to existing rolling stock. New locomotives should be the same type as present D19E.

2) Basis for Calculation

- 26 trains on Hanoi–Saigon section will be divided to 14 passenger trains and 12 freight trains.
- The other trains on other sections are all passenger trains.
- All passenger train sets have 15 passenger cars.
- All freight train sets have 35 freight cars.
- All locomotives are used for both passenger trains and freight trains.
- All rolling stocks are maintained under VR maintenance system.
- Diesel locomotive needs to refuel within 1,000km operation.
- Refueling locomotive takes about 3 hours.
- The station for change locomotives.
  - Trains between Hanoi–Saigon: Dong Hoi, Da Nang, Dieu Tri
  - Trains between Vinh–Dieu Tri: Da Nang
  - Trains between Hue–Saigon: Dieu Tri
  - Other trains do not change locomotive.

3) Required Rolling Stocks on Operation

8.3 The number of required rolling stocks on operation is estimated by rolling stock operation chart considered in each section. The number is shown below tables 8.2.1, 8.2.2, 8.2.3 and 8.2.4.

Table 8.2.1 Number of Locomotives

Section	Number of Trains (Round Trip)	Required Number of Locomotives
Hanoi–Dong Hoi	13	19
Dong Hoi–Da Nang	14	13
Da Nang–Dieu Tri	14	14
Dieu Tri–Saigon	16	27
Hanoi–Hue	1	2
Hanoi–Vinh	2	4
Hanoi–Thanh Hoa	9	11
Vinh–Dieu Tri	1	3
Vinh–Hue	1	2
Hue–Dieu Tri	1	2
Dieu Tri–Nha Trang	3	5
Nha Trang–Muong Man	2	2
Muong Man–Saigon	9	14
Total		118

Source: JICA Study Team

Table 8.2.2 Number of Passenger Trainsets

Section	Number of Trains (Round Trip)	Required Number of Passenger Trainsets
Hanoi–Saigon	7	28
Hanoi–Hue	1	2
Hanoi–Vinh	2	4
Hanoi–Thanh Hoa	9	11
Vinh–Dieu Tri	1	3
Vinh–Hue	1	2
Hue–Saigon	1	3
Dieu Tri–Saigon	2	5
Dieu Tri–Nha Trang	3	5
Nha Trang–Muong Man	2	2
Muong Man–Saigon	9	14
Total		79

Source: JICA Study Team

Table 8.2.3 Freight Trainsets

Section	Number of Trains (Round Trip)	Required Number of Freight Trainsets
Hanoi～Saigon	6	36

Source: JICA Study Team

Table 8.2.4 Required Rolling Stocks Including on-standby and On-Maintenance

Items	Operation (Trainsets)	Standby (Trainsets)	Maintenance (Trainsets)	Total (Trainsets)	Required Rolling Stocks
Locomotives	118	5	20	143	143
Passenger cars	79	9	2	90	1,350
Freight cars	36	2	2	40	1,400

Source: JICA Study Team

8.3 Option B-1

1) General

8.4 In option B-1, the speed of passenger trains will be increased to 120 km/h. Therefore, Locomotives and passenger cars for passenger trains should be purchased. Existing D19E and D20E locomotives and freight cars could be applied to freight trains.

2) Major Technical Specification of New Rolling Stocks

- Locomotive for passenger train
  - Diesel - Electric Locomotive
  - Capacity ≧ 1,920kW
  - Design speed ≧ 120 km/h
- Passenger car
  - Design speed ≧ 120 km/h
  - Passenger Capacity : 1,000 / trainset

3) Basis for Calculation

- 62 freight trains go through Hanoi–Saigon section. The other freight trains run on Hanoi–Da-Nang Section
- All passenger trainsets have 15 passenger cars
- All freight trainsets have 35 freight cars
- Locomotives are maintained under Japanese maintenance system as below
  - Monthly Inspection (1day): Every 90 days
  - Bogie Inspection or Overhaul maintenance(40 days): Every 600,000 km
- Passenger and Freight cars are maintained under VR maintenance system.
- The station for change locomotives
  - Passenger Trains between Hanoi–Saigon: Da Nang
  - Freight Trains between Hanoi–Saigon: Dong Hoi, Da Nang, Dieu Tri
  - Other trains do not change locomotive.

4) Required Rolling Stocks on Operation

8.5 The number of required rolling stocks on operation is estimated by rolling stock operation chart considered in each section. The number is shown in Table 8.3.1, Table 8.3.2, Table 8.3.3, Table 8.3.4 and Table 8.3.5.

Table 8.3.1 Locomotives for Passenger Trains

Section	Number of Trains (Round Trip)	Required Number of Locomotives
Hanoi–Da Nang	9	14
Da Nang–Saigon	10	17
Hanoi–Vinh	11	11
Vinh–Da Nang	1	2
Da Nang–Nha Trang	2	4
Nha Trang–Saigon	7	8
Total		56

Source: JICA Study Team

Table 8.3.2 Locomotives for Freight Trains

Section	Number of Trains (Round Trip)	Required Number of Locomotives
Hanoi–Don Hoi	38	45
Don Hoi–Da Nang	38	33
Da Nang–Dieu Tri	31	25
Dieu Tri–Saigon	31	41
Total		144

Source: JICA Study Team

Table 8.3.3 Passenger Trainsets

Section	Number of Trains (Round Trip)	Required Number of Passenger Trainsets
Hanoi–Saigon	7	14
Hanoi–Da Nang	2	4
Hanoi–Vinh	11	11
Vinh–Da Nang	1	2
Da Nang–Saigon	3	6
Da Nang–Nha Trang	2	4
Nha Trang–Saigon	7	8
Total		49

Source: JICA Study team

Table 8.3.4 Freight Trainsets

Section	Number of Trains (Round Trip)	Required Number of Freight Trainsets
Hanoi–Saigon	31	124
Hanoi–Da Nang	7	21
Total		145

Source: JICA Study Team

Table 8.3.5 Required Rolling Stocks including On-standby and On-maintenance

Items	Operation (Trainsets)	Standby (Trainsets)	Maintenance (Trainsets)	Total (Trainsets)	Required Rolling Stocks
Locomotives for Passenger	56	3	5	64	64
Locomotives for Freight	144	5	10	159	159
Passenger cars	49	4	3	56	840
Freight cars	145	4	6	155	5,425

Source: JICA Study Team

8.4 Option B-2

1) General

8.6 In option B-2, the gauge will widen to1,435 mm and haul line will be electrified. All Rolling Stock should be replaced.

8.7 For the maximum speed of passenger trains will be increased to 150 km/h, EMUs (Electric Multiple Units) will introduce for passenger trains. EMUs have advantages below compared with locomotive – hauled trains. For that reason EMUs are more suitable for middle-high speed trains.

- Acceleration and braking performance
- Higher velocity on curve
- Energy saving by regenerative brake
- Reliability: a train can continue operation though one car has trouble.
- Lighter axle loads contribute toward reducing track wear.

8.8 Locomotives for freight trains will be replaced to Electric Locomotives.

2) Major Technical Specification of EMU

Table 8.4.1 EMU for Express Train

Item	Specification
Track gauge	1435 mm
Power supply	AC25kV 50Hz
Maximum operating speed	150 km/h
number of car	12 cars
Passenger Capacity	About.1000 persons
Maximum Axle load	14t
Length (other cars)	25000 mm (25.0 m)
Maximum width	About 3380 mm (3.38 m)
Bogie type	Bolster less type
Control system	VVVF Inverter-Converter control System with IGBT 3level PWM
Power capacity	4,900 kW/ train or more
Brake system	Electric command brake equipment with regenerative brake

Source: JICA Study Team

Table 8.4.2 EMU for Local Train

Item	Specification
Track gauge	1435 mm
Power supply	AC25 kV 50Hz
Maximum operating speed	120 km/h
Number of car	8 cars
Passenger Capacity	About.1500 persons
Maximum Axle load	17t or less
Length (other cars)	25000 mm (25.0 m)
Maximum width	About 3380 mm (3.38 m)
Bogie type	Bolster less type
Control system	VVVF Inverter-Converter control System with IGBT 3level PWM
Power capacity	3,920 kW/ train or more
Brake system	Electric command brake equipment with regenerative brake

Source: JICA Study Team

3) Major Technical Specification of Other Rolling Stocks

- Locomotive
  - Electric Locomotive
  - Capacity 2,550 kW
  - Design speed 120 km/h
  - 25kV AC 50Hz
  - Gauge : 1,435 mm
- Container Freight car
  - Design speed 120 km/h
  - Gauge : 1,435 mm
- General Freight car
  - Design speed 80 km/h
  - Gauge : 1,435 mm

4) Basis for Calculation

- 10 container freight trains go through Hanoi–Saigon section, 44 container freight trains run on Hanoi–Da-Nang Section, and 32 container freight trains run on Da Nang–Saigon Section.
- 20 general freight trains go through Hanoi - Saigon section. 6 general freight trains run on Hanoi–Da-Nang Section.
- Container freight trainsets have 22 cars.
- General freight trainsets have 35 cars.
- EMUs are maintained under Japanese maintenance system as below
  - Monthly Inspection (1day): Every 90 days
  - Equipment Inspection or Overhaul maintenance(40 days) : Every 600,000 km
- Locomotives are maintained under Japanese maintenance system as below
  - Monthly Inspection (1day): Every 90 days
  - Bogie Inspection or Overhaul maintenance(40 days) : Every 600,000 km
- Freight cars are maintained under maintenance system as below
  - Monthly Inspection (1day): Every 90 days
  - Repair or Overhaul maintenance(20 days) : Every 30 months

5) Required Rolling Stocks on Operation

8.9 The number of required rolling stocks on operation is estimated by rolling stock operation chart considered in each section. The number is shown in tables 8.4.3, 8.4.4, 8.4.5, 8.4.6, 8.4.7.

Table 8.4.3 EMU Trainsets for Express Trains

Section	Number of Trains (Round Trip)	Required Number of EMU Trainsets
Hanoi–Saigon	7	14

Source: JICA Study Team

Table 8.4.4 EMU Trainsets for Local Trains

Section	Number of Trains (Round Trip)	Required Number of EMU Trainsets
Hanoi–Da Nang	2	2
Hanoi–Vinh	11	9
Vinh–Da Nang	1	1
Da Nang–Saigon	3	5
Da Nang–Nha Trang	2	2
Nha Trang–Saigon	7	8
Total		27

Source: JICA Study Team

Table 8.4.5 Locomotives for Freight Trains

Section	Number of Trains (Round Trip)	Required Number of Locomotives
Hanoi–Saigon Container	5	10
Hanoi–DaNang Container	22	44
Da Nang–Saigon Container	16	32
Hanoi–Saigon General	10	40
Hanoi–Da Nang General	3	6
Total		132

Source: JICA Study Team

Table 8.4.6 Freight Trainsets

Section	Number of Trains (Round Trip)	Required Number of Freight Trainsets
Hanoi–Saigon Container	5	10
Hanoi–Da Nang Container	22	44
Da Nang–Saigon Container	16	32
Container	Total	86
Hanoi–Saigon General	10	40
Hanoi–Da Nang General	3	6
General	Total	46

Source: JICA Study Team

Table 8.4.7 Required Rolling Stocks including On-standby and On-maintenance

Items	Operation (Trainsets)	Standby (Trainsets)	Maintenance (Trainsets)	Total (Trainsets)	Required Rolling Stocks
EMUs for Express	14	2	3	19	228
EMUs for Local	27	5	3	35	280
Locomotives	132	3	11	146	146
Container Freight	86	5	4	95	2,090
General Freight	46	2	3	51	1,785

Source: JICA Study Team

9 DEPOT AND WORKSHOP

9.1 Option A-2

1) Location and Capacity

9.1 According to the Rolling Stock procurement option A-2, additional locomotive becomes 67 while current number of locomotive is 76 and additional passenger car becomes 1043 while current number is 307. It is anticipated that current facilities have not enough space for stabling and inspection for those rolling stocks. Freight cars will not increase so new facilities are only for passenger cars and passenger locomotives.

9.2 Based on the train operation plan required location of the depots and stabling yard are as Table 9.1.1 bellow.

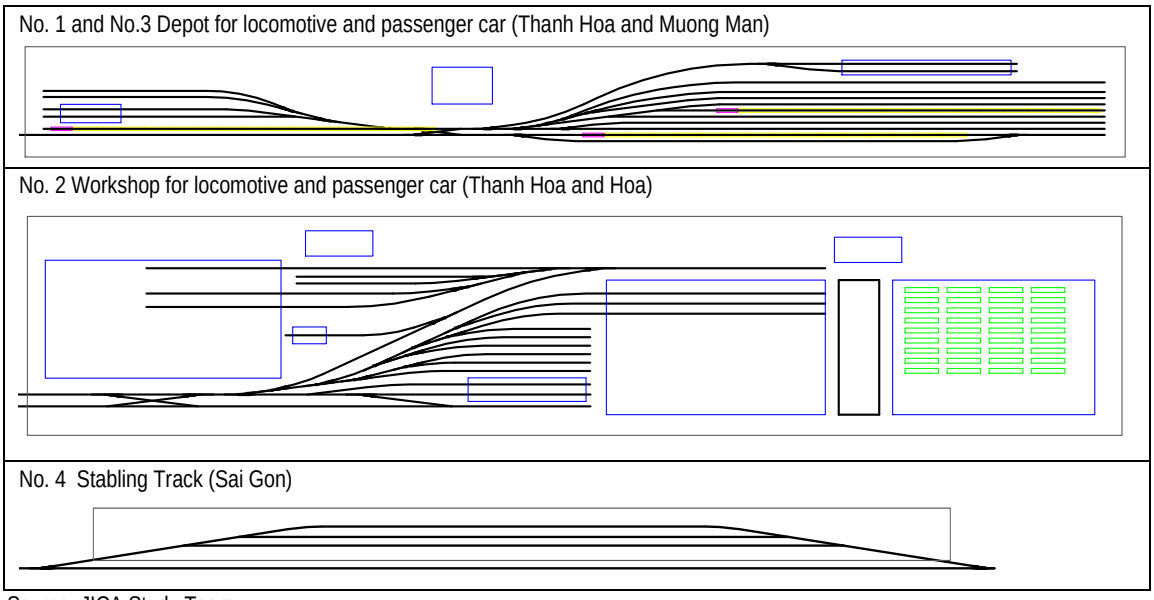
Table 9.1.1 Location of Depot and Workshop for A-2

No.	Category	Location	Rolling Stock Type
1	Depot	Tang Hoa	Locomotive, passenger car
2	Workshop	Tang Hoa	Locomotive, passenger car
3	Depot	Muong Man	Locomotive, passenger car
4	Stabling tracks	Sai Gon	Passenger car

Source: JICA Study Team based on TRICC data

2) Layout

9.3 Typical layouts of the facilities are indicated below.



Source: JICA Study Team

Figure 9.1.1 Typical Layout for Option A-2

9.2 Option B-1

1) Location and Capacity

9.4 According to Rolling stock procurement plan, 147 additional locomotives, 840 passenger cars, and 3915 additional freight cars are required. For stabling and inspection for these rolling stocks, several depots and workshops are required. Based on the train operation plan location for the depot and workshops are indicated in the following table. As track is changed to double track so that a maintenance depot with track work vehicles is also required and it will be integrated in the depot.

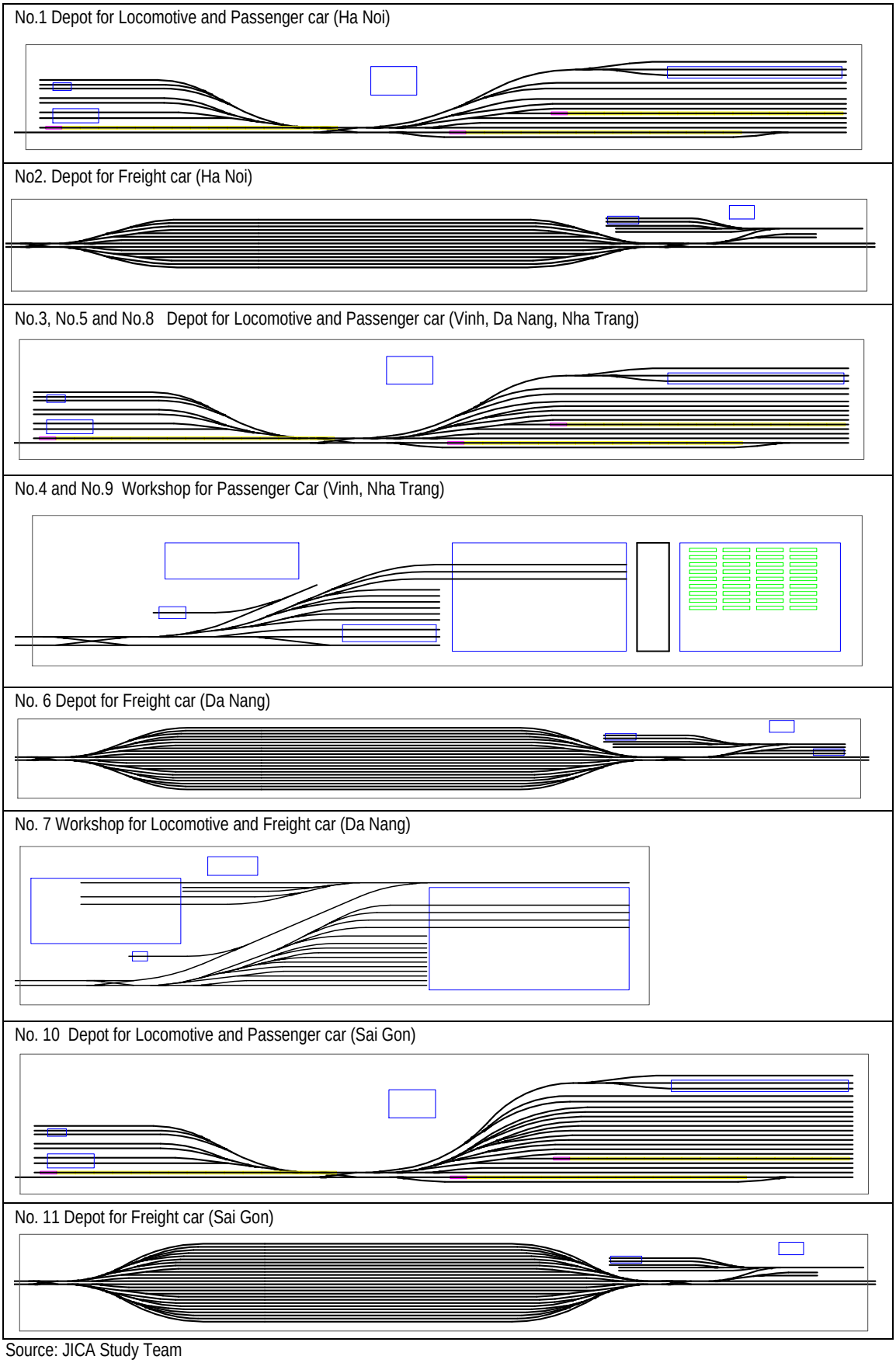
Table 9.2.1 Location of Depot and Workshop for B-1

No.	Category	Location	Type of car	Facility Maintenance
1	Depot	Ha Noi	Locomotive passenger car	○
2	Depot	Ha Noi	Locomotive & Freight car	
3	Depot	Vinh	Locomotive & Passenger car	○
4	Workshop	Vinh	Passenger car	
5	Depot	Da Nang	Locomotive & Passenger car	○
6	Depot	Da Nang	Locomotive & Freight car	
7	Workshop	Da Nang	Locomotive & Freight car	
8	Depot	Nha Trang	Locomotive & Passenger car	○
9	Workshop	Nha Trang	Passenger car	
10	Depot	Sai Gon	Locomotive & Passenger car	○
11	Depot	Sai Gon	Locomotive & Freight car	

Source: JICA Study Team Based on TRICC Data

2) Layout

9.5 Typical layouts of the facilities are indicated below.



Source: JICA Study Team

Figure 9.2.1 Typical Layout for Option B-1

9.3 Option B-2

1) Location and Capacity

9.6 According to Rolling Stock procurement plan 228 EMUs for express train and 280 EMUs for local train and 146 locomotives and 3875 freight wagons are required. For stabling and inspection for these rolling stocks several depots and workshops are required. Based on the train operation plan location for the depot and workshops are indicated in the following table. Facility maintenance depot with track work vehicles is also required and it will be integrated in the depot.

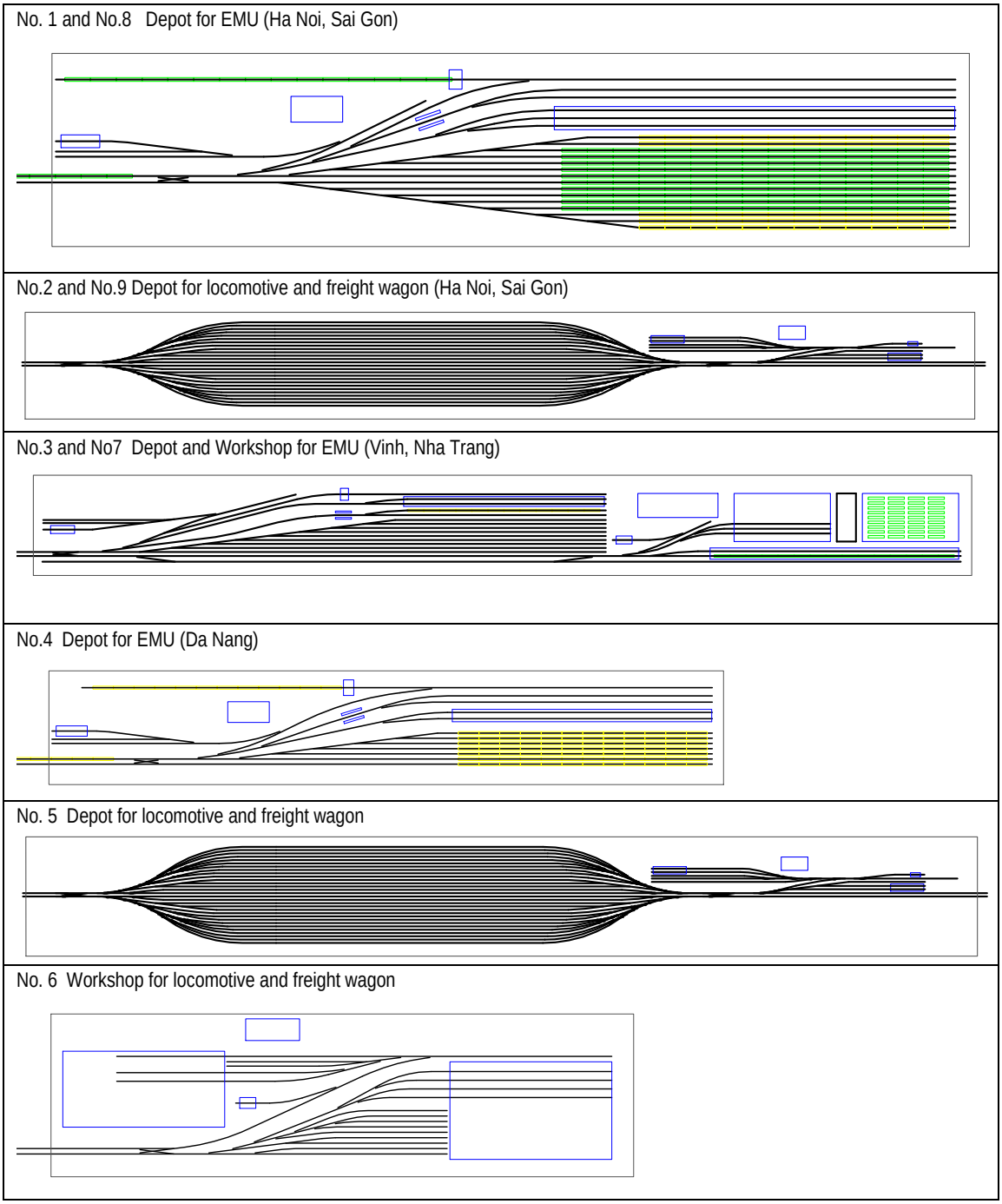
Table 9.3.1 Location of Depot and Workshop for B-2

No.	Category	Location	Type of car	Facility Maintenance
1	Depot	Ha Noi	EMU	○
2	Depot	Ha Noi	Electric locomotive Freight wagon	
3	Depot and workshop	Vinh	EMU	○
4	Depot	Da Nang	EMU (local)	○
5	Depot	Da Nang	Electric locomotive Freight wagon	
6	Workshop	Da Nang	Electric locomotive Freight wagon	
7	Depot and workshop	Nha Trang	EMU (local)	○
8	Depot	Sai Gon	EMU	○
9	Depot	Sai Gon	Electric locomotive Freight wagon	

Source: JICA Study Team Based on TRICC Data

2) Layout

9.7 Typical layouts of the facilities are indicated below.



Source: JICA Study Team

Figure 9.3.1 Typical Layout for Option B-2

10 INVESTMENT COST OF EXISTING IMPROVEMENT OPTIONS

10.1 Investment Cost of 3 Options

10.1 The cost estimations of 3 options are shown in Tables 10.1.1 to 10.1.6.

Table 10.1.1 Estimated Investment Cost of Alternative A2

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

Source: JICA Study Team based on TRICC data.

Table 10.1.2 Cost Breakdown of Alternative A2

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

Source: JICA Study Team based on TRICC data.

Table 10.1.3 Estimated Investment Cost of Alternative B1

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

Source: JICA Study Team

Table 10.1.4 Cost Breakdown of Alternative B1

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

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

Source: JICA Study Team

Table 10.1.5 Estimated Investment Cost of Alternative B2

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

Source: JICA Study Team

Table 10.1.6 Cost Breakdown of Alternative B2

Item	Unit	Volume	Unit Price (USD)	Cost (USD mil.)	Remark
Cut					
Cut	m^3	6,500,000	12	78	
Reinforced road bed	M	130,000	285	37	12m wide
Barrier	M	68,000	75	5	
Slope protection	M	551,000	100	55	
Subtotal of Cut				175	
Embankment					
Fill	m^3	81,600,000	15	1,224	
Reinforced road bed	M	1,390,000	285	396	12m wide
Slope protection	M	1,950,000	100	195	
Barrier	M	2,780,000	75	209	
Subtotal of Embankment				2,024	
Bridge					
L<20	M	10,230	18,500	189	double track
20<L<50	M	14,590	21,500	314	double track
50<L	M	20,500	25,000	513	double track
Subtotal of Bridge				1,015	
Tunnel	M	21,850	21,500	470	Double Track
Track					
Ballast track	M	1,717,000	800	1,374	60K rail
Gauge widening	M	1,717,000	525	901	
Turn-out	no.	435	145,000	63	#12
Subtotal of Tunnel				2,338	
Station	m^2	1,018,000	2,200	2,240	163 stations
Electric Power					
Sub-power station	no.	36	68,750,000	2,475	
SCADA	no.	2	12,500,000	25	
Overhead catenary	km	1,714	1,000,000	1,714	
Feeder line	km	1,714	625,000	1,071	
Major station	no.	7	2,500,000	18	
Normal station	no.	159	1,250,000	199	
Depot	no.	4	12,500,000	50	
Subtotal of Electric Power				5,551	
Signal & Telecommunications	km	1,722	2,845,000	4,899	ATS
Depot					
Hanoi	no.	1		166	Depot
Vinh	no.	1		133	Depot & Workshop
Da Nang	no.	1		241	Depot & Workshop
Nha Trang	no.	1		133	Depot & Workshop
Sai Gon	no.	1		166	Depot
Subtotal of Depot				839	
Rolling Stock					
EMU for express	no.	228	3,125,000	713	
EMU for local	no.	280	2,500,000	700	
Locomotives	no.	146	5,000,000	730	
Freight car	no.	3,875	187,500	727	
Subtotal of Rolling Stock				2,869	

Item	Unit	Volume	Unit Price (USD)	Cost (USD mil.)	Remark
Land Acquisition	ha	1,400	1,022,000	1,431	
Total				23,850	

Source: JICA Study Team

10.2 Investment Cost of 7 Sections of Options A2, B1 and B2

10.2 The investment cost of 7 sections of options A2, B1 and B2 are shown in Table 10.2.1.

Table 10.2.1 Investment Cost of 7 Sections of Options A2, B1 and B2

(Unit : Million USD)

Plan / Section	A-2	B-1	B-2
Hanoi-Thanh Hoa L=175.2 km	321	2,195	4,582
Thanh Hoa-Vinh L=143.8 km	204	1,067	1,879
Vinh-Hue L=369.3 km	272	2,614	5,028
Hue-Da Nang L=103.1 km	268	1,042	1,603
Da Nang-Nha Trang L=523.5 km	224	3,906	7,271
Nha Trang-Phan Thiet L=236.2 km	196	1,586	3,155
Phan Thiet-HCMC L=175.1 km	312	2,058	4,175
Total L=1726.2 km	1,797	14,468	27,694

Source: JICA Study Team