4. DEVELOPMENT STRATEGIES FOR RAILWAY INFRASTRUCTURE

In this section, the present capacity, the backlog, the future transportation demand and the strategies of the VR will be discussed.

4.1 Future Rail Transportation Demand

In the transportation demand in Vietnam, VR's transportation volume is shown in the following Table 4.1.1.

Table 4.1.1
Transportation volume by rail (results and projection) (unit;10^9)

		Max. in past	Present state			Projection		
Year		1987	1996	1997	1998	1999	2010	2020
Pass.·km(a)		4.9	2.1	2.3	2.5	3.8	8.6	18.1
Ton·km(b)		1.0	1.7	1.5	1.3	1.5	6.0	16.4
TU	c = a + b	5.9	3.8	3.8	3.8	5.3	14.6	34.5
	ratio	(1.5)	3.8 = (1)			(1.4)	(3.8)	(9.1)

Note: TU is an index that shows the summation of passenger·km and ton·km

In the past (in 1987), VR scored the maximum transportation volume, and it was 5.9 $\times 10^9$(passenger + ton)·km(TU). At present, VR's transportation volume is 3.8 $\times 10^9$TU.

Therefore, in the past, VR transported 1.5 times of the present volume. In the future, the projection shows that the transportation volume will reach to the past maximum in 1999 and it will be nearly 4 times of the present in 2010 and exceed 9 times in 2020. The rail transportation demand by rail in 2010 and in 2020 varies by sections (See Figure 4.1.1, 4.1.2, 4.1.3 and 4.1.4). On these estimated figures the railway transportation in future have been studied.

Fig. 4.1.1
Cargo Transport by Section (2010)

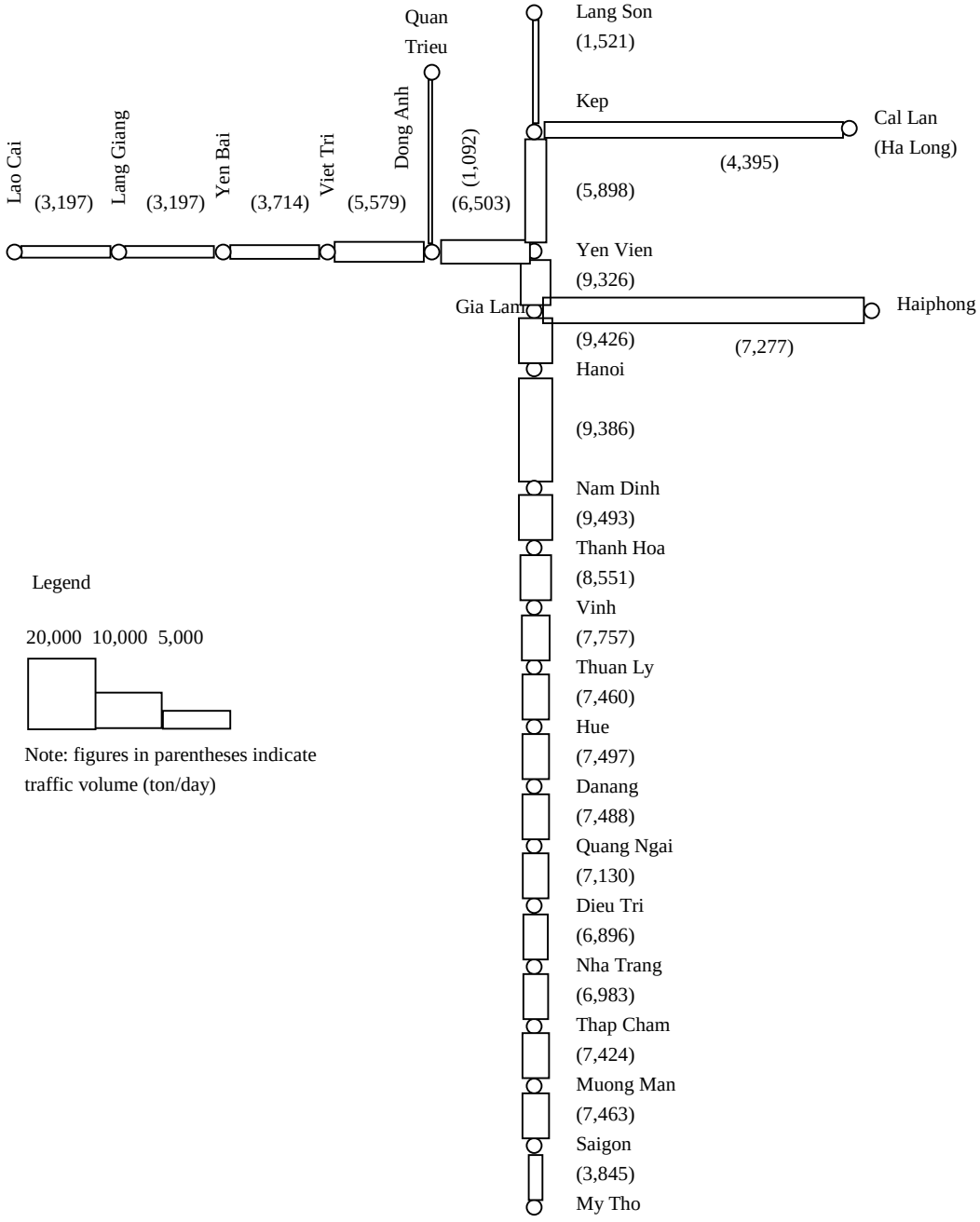


Fig. 4.1.2
Passenger Transport by Section (2010)

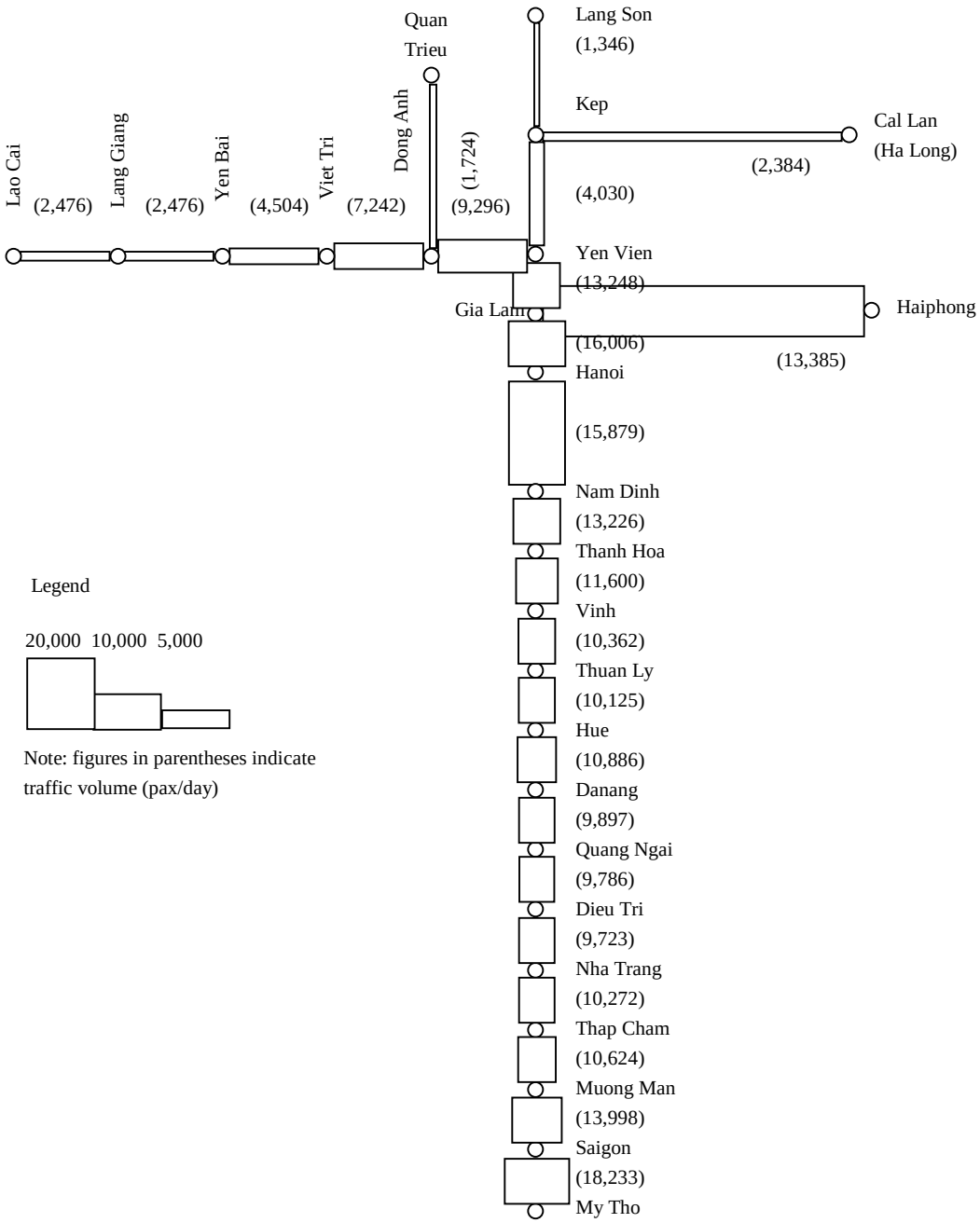


Fig. 4.1.3
Cargo Transport by Section (2020)

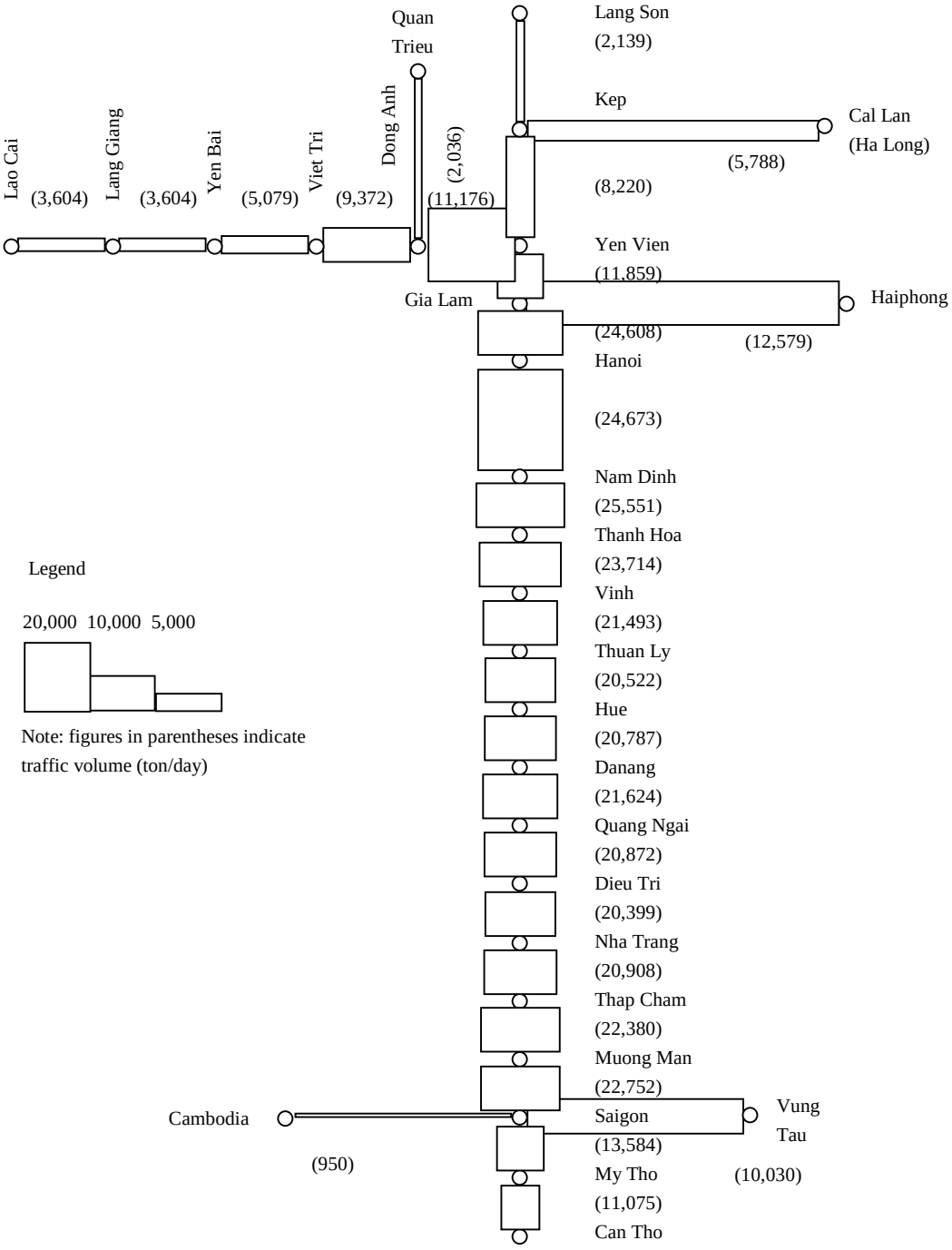
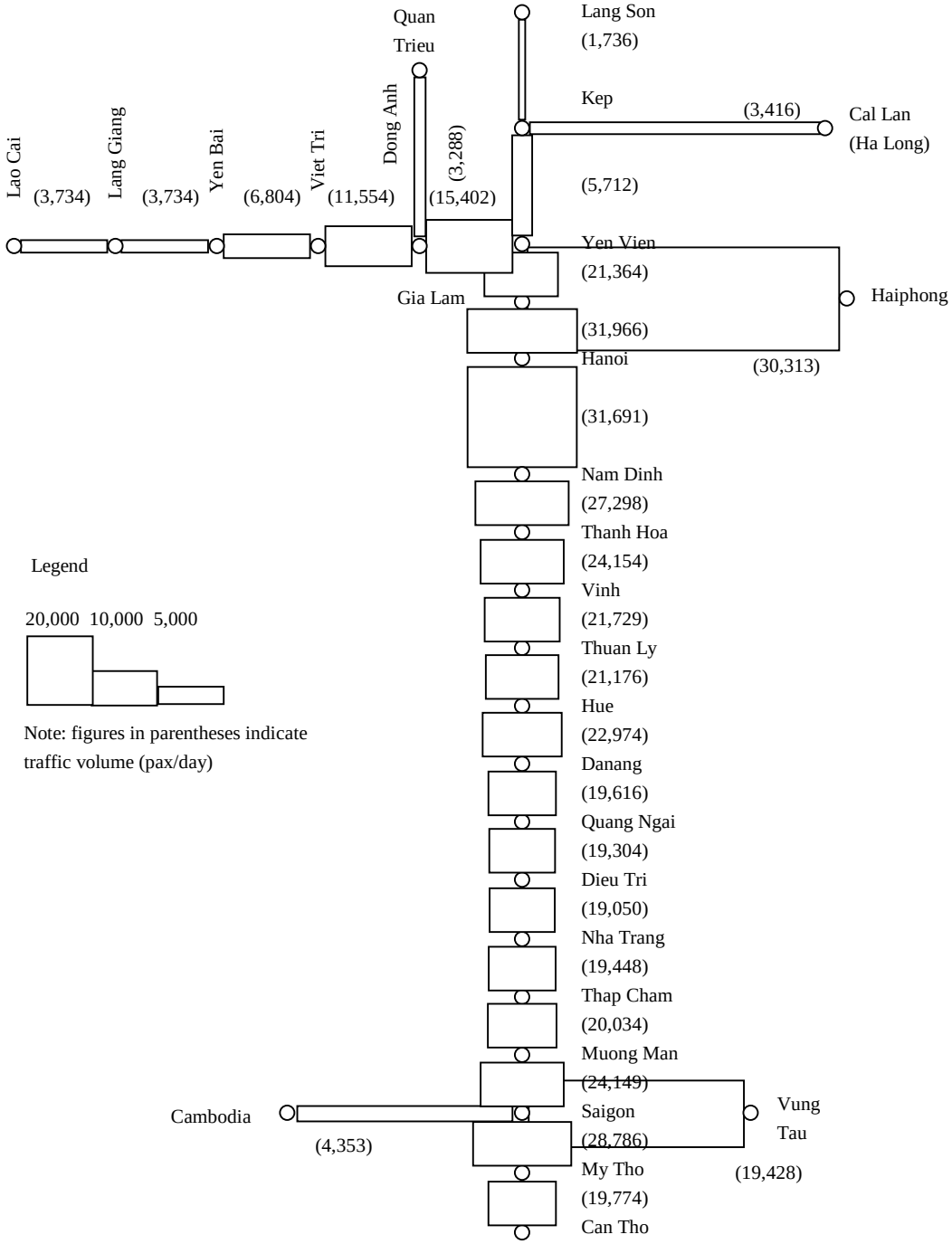


Fig. 4.1.4
Passenger Transport by Section (2020)



4.2 Strategies for Railway Infrastructure Development

1) Ways to Increase Railway Transport Capacity

In 1987, VR scored the maximum transportation volume in passenger·km. In ton·km, VR scored maximum in 1995. In total TU, the transportation volume/year has changed from 6×109 TU to 4×109 TU. In the past, there was a time that VR could transport nearly 1.5 times of the present transportation volume. This difference has been caused mainly by the deterioration of infrastructures and insufficient rolling stocks, i.e., insufficient investment. Therefore, if an emergent investment to compensate such backlog was done, the transportation capacity of the present VR would increase up to 1.5 times. The first stage of the investment must be to clear off such backlog, as quick as possible. But in some sections of VR railway network, train frequency has already reached to the limit. In such sections, even if such immediate investment is executed, the section will allow only 1 or 2 more trains operation than now (speed up effect is small). The emergent investment will raise the present capacity of the railway transportation, but it is up to 1.5 times. The main purpose of this investment is to level up the safety and trust of the railway and to get the nation wide support for the rail.

There are two types of enlarging the railway transportation abilities. One is the enlarging a train's transportation ability. The other is the increase of trains (train frequency).

(1) Enlarging (Increasing) the transportation ability of a train

This is achieved by the traction power up of a locomotive or making the train longer. The traction power-up is relatively easy by introducing more powerful locomotives. The train length, it is determined by the effective length of passing, departing or arriving tracks of stations.

(2) Increase of train frequency

As for the infrastructure, there are two ways:

- Shortening the distance between stations is the first thing to do for the train frequency up. If a distance between stations is made to a half, nearly twice as many as trains will be put to the section because a train's time in the section is cut to a half. Then, shortening the distance between stations shall be executed in order to put more trains.
- After the shortening the station distance, comes the double tracking. If the section is double-tracked, up-trains and down-trains can run the section on the separate track. Then every up-train (or down-train) can run successively on the same track (up-track or down-track) in the minimum interval after the preceding train. The double-tracking will be done from

the most congested sections, in most cases, the longer distance sections are more congested than the other sections, as the first case.

(3) Track capacity (the limit of train frequency on a single or double track line)

There is a simple rule based on experience as shown in the following:

Table 4.2.1
Train frequency and the track quantity

Train frequency/day	Note
Under 60	Single track is adequate.
60~80	Limit of single track.
More than 60~80	Double tracked sections must be introduced in congested sections.
More than 100	All sections must be double-tracked.
More than 250	The line shall be two double-tracked if various trains {long distance trains, short distance (commuter) trains, freight trains, etc.} are on the same track. And tracks shall be separated by the character, if the two double tracks are in use (e.g., long distance line, commuter line, freight line, etc.)

The above figures are not the strict result based on the calculation. But is available as a general idea. The section length between stations is assumed nearly 4~5km in single track section case.

2) Staged Investment with Modernization

In view of the high investment costs for the upgrading the existing railway infrastructure, a realistic strategy should be worked out. Staged investments and parallel modernization according to the demand and management capacity are the basic directions as explained in the following.

4.3 The First Stage Improvement (Regaining the Confidence of Customer)

The railway must clear off the backlog that has prevented the stable and reliable transportation to the customers. Such backlogs are as follows:

1) Sweeping away the infrastructure backlogs

(i) Lack of investment; the train speed shall be fundamentally determined by the train ability and the line alignment (curvature and gradient), if the railway infrastructure is sound. But in Vietnam, the train speed is also influenced by backlog of investment to infrastructure. Some portions of the infrastructure is deteriorated and hasn't enough support force at the normal train speed. Then a special speed limitation is applied to the structure. Such deteriorated structure must be replaced to a sound one by investment. Then the first stage of investment is to replace such deteriorated infrastructures with sound infrastructures. And if it is finished, trains can run in fewer speed limitations,

recover normal speed, get surer and safer running and VR will regain more reliability from the people.

(ii) New and effective technical standards shall be determined and applied; Low-leveled and old technical standards prevent the higher, safer, more effective transportation and better maintenance even if the adequate investment has been applied. So, many of the current facility or equipment standards shall be revised. For instance, narrower width of the formation level, shorter sleeper, smaller rail section, smaller curvatures, old signaling systems shall be improved based on the total revise of railway standard.

a) Bridges; There are approx. 1,800 bridges in VR. In these, nearly 110 bridges (6%) limit the train speed lower than the section speed limit. This is because of the inadequate support power of the bridge. These bridges must be newly built.

Table 4.3.1
Number of bridges to be renewed

Line	No. and length of bridges to be renewed	
	Number	Length
Hanoi – Saigon	88	13.3km
Hanoi – Lao Cai	3	0.3km
Hanoi – Dong Dang	4	0.7km
Hanoi – Haiphong	5	0.6km
Dong Anh – Quan Trieu	1	0.1km
Others	7	0.2km
Total	**108**	**15.1km**

b) Tunnels; Railway tunnels in Vietnam are 38 and their total length is approx. 10km. They are in 3 lines (Hanoi – Saigon, Hanoi – Dong Dang, and Kep – Luu Xa). Speed limitation is applied to most of all tunnels. Speed limitation is from 5km/h to 40km/h. and it is shown in the following table.

Table 4.3.2
Tunnels and speed limitation

Speed limit (km/h)	Tunnel		Note
	Quantity	Total length	
Hanoi – Saigon			
5km/h	1	445m	Phu Gia t.
15km/h	8	2,777m	
30km/h	6	914m	
40km/h	5	969	
No speed limit	6	2112	
Total	26	7217	
Hanoi – Dong Dang			
40km/h	8	1992	
Kep – Luu Xa			
40km/h	4	1141	
All total	38	10350	

The limitation of the train speed is to prevent the car's impact on the tunnel lining, to prevent the lining fall or the lining crack by train's vibration. These weak points shall be removed fundamentally.

Tunnels on Hanoi – Saigon line are fundamentally deteriorated by weathering and long usage. These tunnels shall be improved or newly built when the double tracking is implemented. Some of them shall be double tracked new tunnels in a relocated alignment and some others shall be enlarged and have new lining shifting trains temporarily to the newly constructed track. In 26 tunnels, Hai Van pass tunnels (8 tunnels from 735km to 776km) shall be implemented at first, because of the deterioration and to improve the shortage of the transportation capacity.

Tunnels on Dong Dang line and Kep – Luu Xa line shall be implemented rehabilitation work, such as stopping water leakage, lining reinforcement, or portal reinforcement, in a live line condition (using intervals of the train operation), because there is no investment of double-tracking in these sections.

Hai Van pass section has the worst alignment in VR, of continued steep gradients (max. 17‰) and small curvatures (min. 100m). This worst alignment begins at 750km and ends at 778km. This section is the highest hurdle to the train operation between Hanoi – Saigon. And most of trains need 2 hours to pass this section. In this section (750km to 778km), 6 tunnels are included. Therefore, a total renewal of alignment is essential, if VR shall survive in the 21 century. This section will be built in double tracks in a totally new alignment. The new length will be approx. 14 km and the tunnel section will be 10km or so (Fig. 4.3.1 Hai Van pass, plan and Fig. 4.3.2 Hai Van pass, profile).

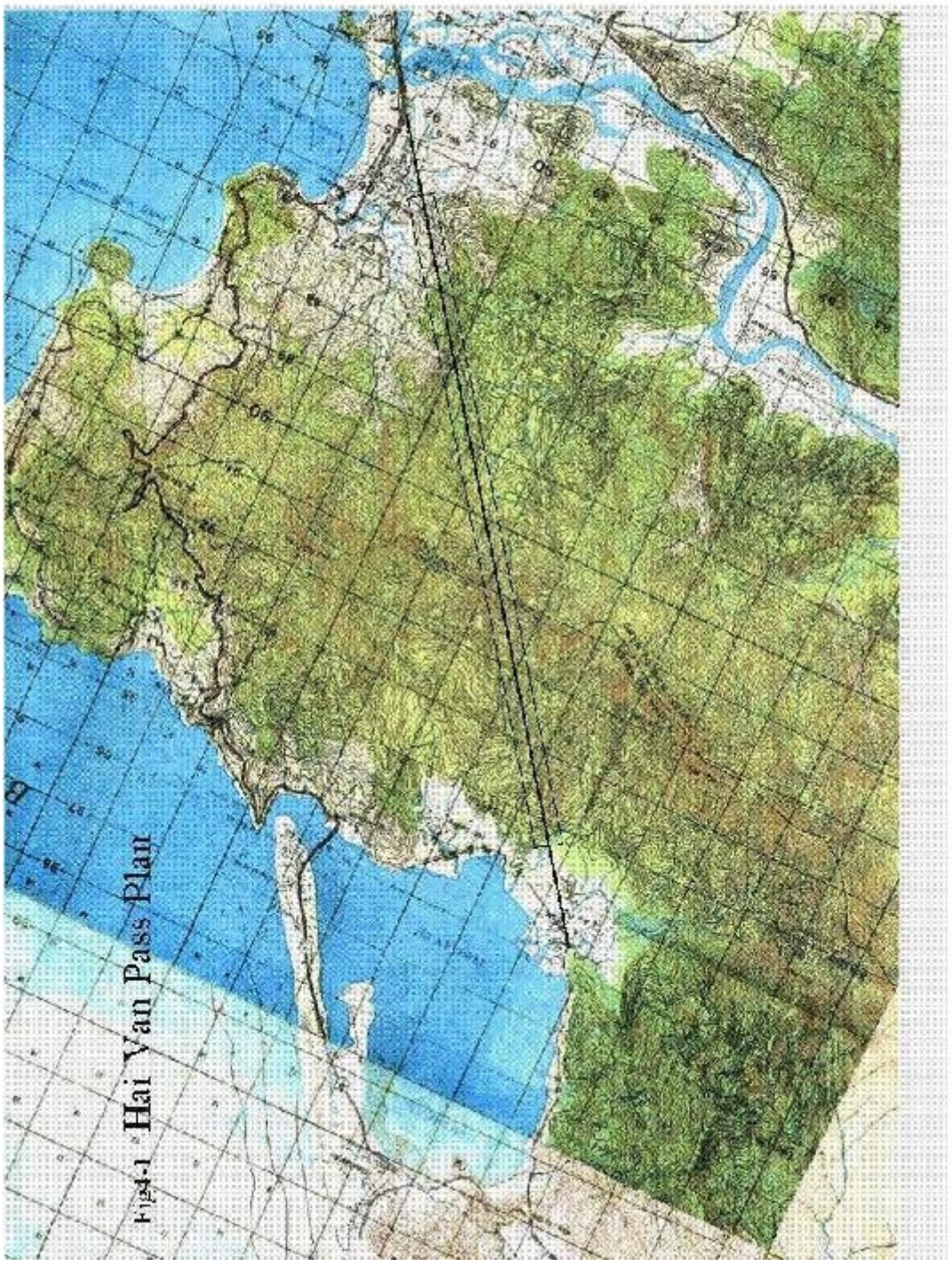


Fig. 4.3.1
Hai Van Pass Plan

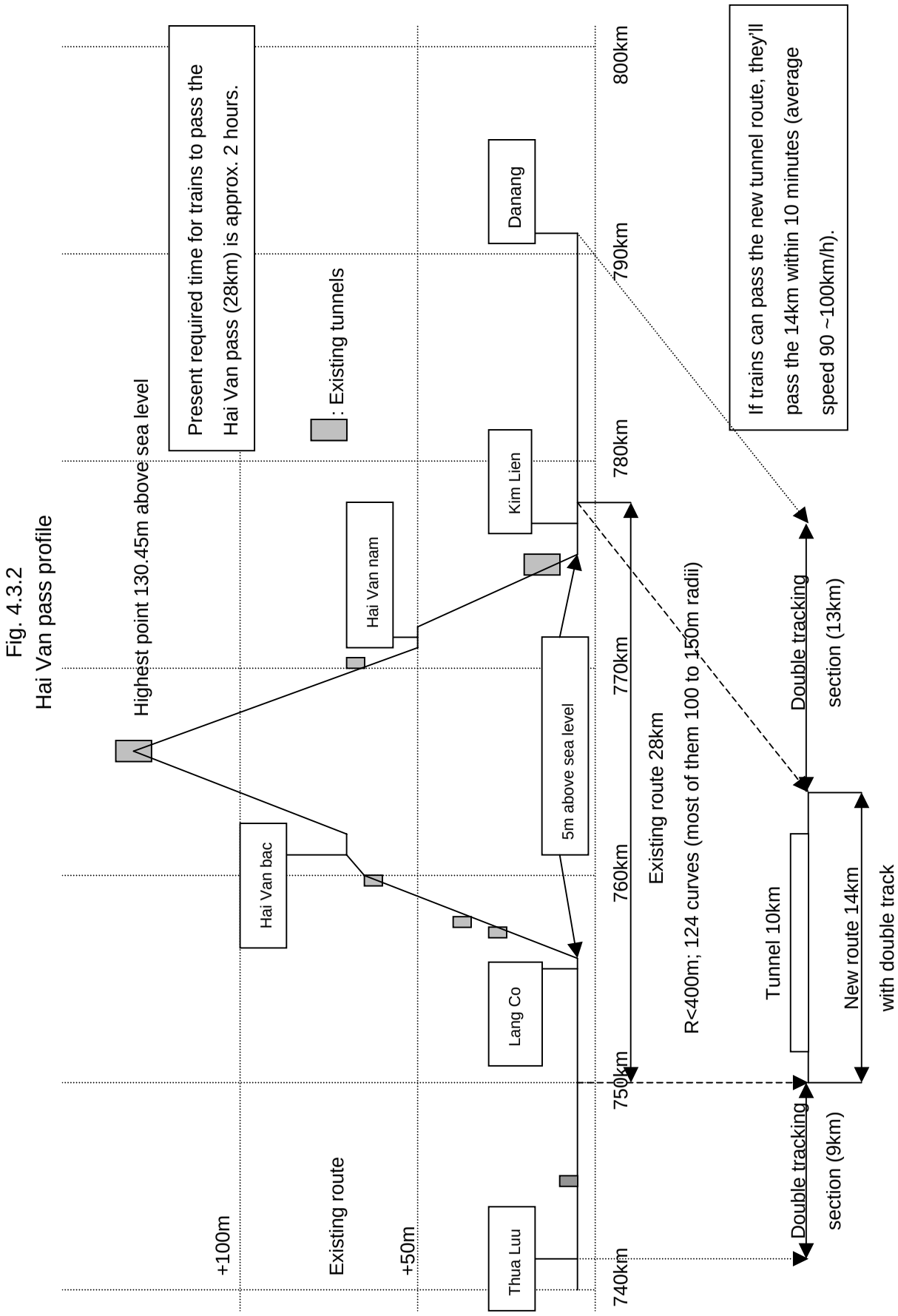


Fig. 4.3.2
Hai Van pass profile

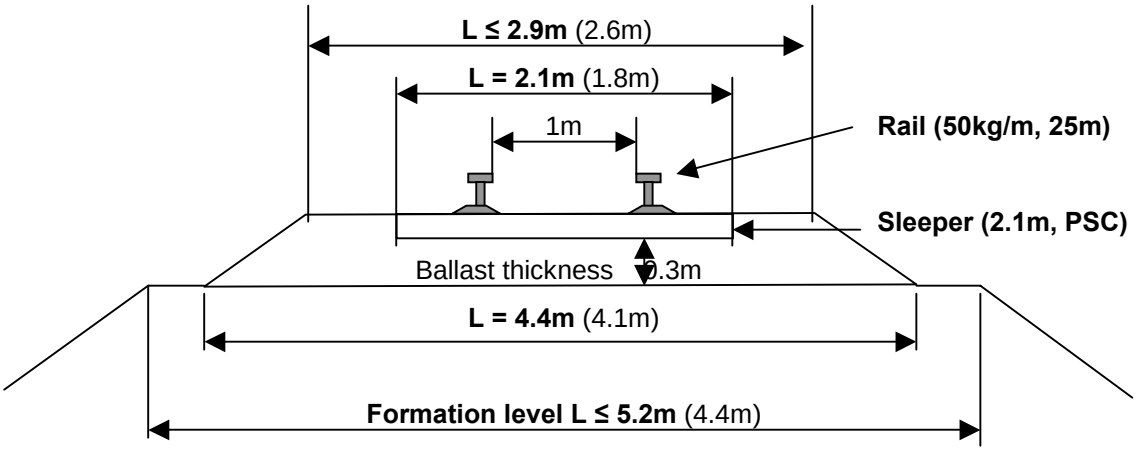
c) Track structure; As mentioned in railway structure of the present VR (3.2.2), the present track structure and embankment of VR have some weakness in the higher speed train operation and maintenance. Therefore such structures shall be improved when the investment such as double tracking or a new alignment is implemented. In the implementation, a new specification shown in the below table shall be suggested as an example.

Table 4.3.3
Comparison of Structures

Item	Present application	New specification
Rail	38 or 43kg/m, 12.5m long	50kg/m, 25m long
Sleeper	1.8m long, wood, steel, 2-block concrete	2 or 2.1m long pre-stressed concrete
Fastening	Proportioned fastenings from spikes to bolts, according to the sleeper's type	Elastic fastening
Ballast	30cm thick	30cm thick
Formation width	4.4m	5.2m or more

The new specification of track and embankment is an example and it is shown in the following Fig. 4.3.3.

Fig. 4.3.3
A new track structure in figure



Note: figures in parentheses are the present VR specification.

Bold letters are a new specification (a suggestion).

At the same time with the heavier rail adoption, mechanization of the track work shall be implemented. Ballast-tamping of the newly laid heavier and longer rail section (2600km) shall be done by the multiple tie tamper. A multiple tie tamper performs 100km length per year {(400m/day)×250days}. 5 multiple tie-tampers shall be installed in the first stage.

d) Communication cable; In the modernized railway, marketing information,

management information, operation & maintenance information, etc., shall be communicated and disposed in real time, and the information volume itself is coming enormous. Therefore, information trunk line must be equipped with enough capacity and reliability. One total communication cable system shall be equipped with through the VR network, i.e., 2600 km long, by the optical fiber system.

e) Signal renewal; It occurs often that trains stop at the signal-sites without any trouble or accident in the station yards. This is caused by having no real time interface between signals and trains.

Switches and signals shall be improved from manual to automatic system in the frequent train sections. Then, the small delays waiting go-signal won't happen.

(2) Sweeping away all backlogs in the upper part (railway management)

(i) Lack of investment; Deteriorated rolling stocks decrease attractiveness of the railway transportation.
(ii) Delay of adoption of newer and effective technology; VR workers can't show enough productivity under the stained or old technology standard.
(iii) Lack of sensitiveness to the customer; The better accommodation, for instance, passenger-seat, bed-length, clean window, air-condition, etc. such consideration to the passenger shall be essential and much more attractive passenger cars shall be installed for instance.

The above items are reduced to the problems of the rolling stocks and computerization. Rolling stocks will be totally discussed through 2000~2020 in the section 4.5.3. And the computerization will be discussed here.

<Computerization>

VR workers' productivity is comparatively in low level. The productivity shall be improved by improvement of hardware (facilities, equipment, rolling stocks) and software (working manuals & standards, institutional systems, group activities). As for the former, most of them have been stated in the 4.1 to 4.4. One thing must be added. Computer system shall be installed through the railway system. This investment will be one of the fundamental investments in VR. The latter (revise of manuals & standards, institutional systems, etc.) shall be executed at the same time with the introduction of the computer system. Introduction of computer systems is not so prevalent in VR. In every section of VR work, computer system shall be installed as fast as possible. Any railway work at site or office are quite fit for the computer system, as follows:

a) Ticketing; Customers can get any ticket at any place where the computer

system is prepared. This will be a great change to the customer. At the same time, VR can make better management plans and policies using the data of the ticket market. Ticketing system shall be installed big 30 stations at first, and the extension of this system will be extended easily by introducing computer terminals to smaller stations and travel agencies.

b) Train control; Long term, short term, or emergent change of train diagram, accompanied with the rolling stock and personnel rescheduling, train operation watching, dispatching, controlling, information between related sections will be done systematically and without mistake by the computer system on real time {C.T.C (Centralized Train Control) system}.

c) Work management; Planning, Scheduling, Implementation, Checking, Evaluation, most of the work at sites and offices of each SOE shall be put in the computer system and it will be managed with great effectiveness.

4.4 The Second Stage (Track Capacity Increase)

The second stage, include:

- the shortening distance between stations and,
- the double-tracking shall be applied in the infrastructure (in the lower part) and,
- the rolling stocks shall be prepared in the upper part, in order to catch up with the demand increase.

1) New stations

The track capacity is determined by the length between the neighboring two stations. In VR there are 300 section (station to station). In these 300 sections, there are 105 sections that have the length of more than 10 km, and their distribution by line-wise is as follows:

Table 4.4.1
Sections longer than 10km

Line	Sections more than 10km	Train no. in 1998	Train no. in 2020
Hanoi – Saigon	90	11~28	Demand increase 9 times in average.
Hanoi – Lao Cai	5	8~24	
Hanoi – Dong Dang	1	8~16	
Hanoi – Haiphong	1	20~22	
Hanoi – Quan Trieu	0	4	
Kep – Ha Long	5(3)	4~9	
Van Dien – Bac Hong	3		
Total	105(100)		

Note: In Ha Long line, two sections (Can Tho-Chi Linh , Chi Linh-Dong Trieu) are excluded.

As was explained in the section of 4.3, the first step to increase train capacity shall be

applied to the sections more than 10 km in the above table. And their distance shall be put half and each section shall have a new station for train-exchange.

(2) Double tracking

As was explained in the section 4.3, double tracking shall be introduced to the sections more than 60~80 trains/day. In 2020, the railway transportation demand will be as shown in the next table.

Table 4.4.2
Railway transportation demand in 2020 and necessary train numbers

Section	(a) Pass./day	(b) Tr./day	(c) Tons/day	(d) Tr./day	(e=b+d) Total tr./day	tr/day (1998)
Muong Man – Saigon	24,149	61	22,752	46	**107**	28
Hanoi – Nam Dinh	31,691 [1)]	80	24,673	50	**130**	28
Nam Dinh – Thanh Hoa	27,298	69	25,551 [3)]	52	**121**	24
Quang Ngai – Dieu Tri	19,304 [2)]	49	20,872 [4)]	42	**91**	14
Thuan Ly - Hue	21,176	53	20,522	42	**95**	11
Gia Lam – Yen Vien	21,364	54	11,859	24	**78**	20
Yen Vien – Kep	6,033	16	6,065	13	**29**	14
Kep – Lang Son	1,736	5	2,139	5	**10**	16
Kep – Ha Long	3,416	9	5,788	12	**21**	9
Yen Vien – Dong Anh	15,402	39	11,176	23	**62**	24
Dong Anh – Viet Tri	11,554	29	9,372	19	**48**	16
Viet Tri – Yen Bai	6,804	18	5,079	11	**29**	20
Yen Bai – Lao Cai	3,734	10	3,604	8	**18**	18
Dong Anh – Quan Trieu	3,288	9	2,036	5	**14**	2
Gia Lam – Haiphong	30,313	76	12,579	26	**102**	22
Saigon - My Tho	28,786	72	13,584	28	**100**	0
My Tho - Can Tho	19,774	50	11,075	23	**73**	0
Saigon - Vung Tau	19,428	49	10,030	21	**70**	0

Note: 1) Hanoi – Nam Dinh shows the maximum passengers in the north south line.
2) Quang Ngai – Dieu Tri shows the minimum passengers in the north south line.
3) Nam Dinh – Thanh Hoa shows the maximum tons in the north south line.
4) Thuan Ly – Hue shows the minimum tons in the north south line.
Column (a) is calculated under an assumption that a train carries 400 passengers.
Column (d) is calculated under an assumption that a train carries 500 tons.

Next to the shortening of the length between stations, comes “the double tracking”, as for the lifting up the track capacity. The section 4.3 and Table 4-2 explain the relation of the no. of trains and the track capacity. Following the idea, the above table shall be classified in the following table.

Table 4.4.3
Three groups of sections

Group	No. of trains	Sections
1	More than 80	All sections of Hanoi – Saigon line, Saigon – My Tho, Gia Lam – Haiphong
2	40< Trains <80	My Tho – Can Tho, Saigon – Vung Tau, Gia Lam – Yen Vien, Yen Vien – Dong Anh, Dong Anh- Viet Tri
3	Lesser than 40	Other sections

Group 1 has more than 80 trains a day in 2020. These sections shall be double tracked at first in order to meet the transportation demand. Group 2 has trains from 40 to 80 a day. If the commuter or local transportation is added to Group 2, each number of trains in these sections will exceed the single track's capacity 60~80. Then up to 2020 these sections shall be double-tracked next to the Group 1. Group 3 has fewer trains than 40 in 2020. Then sections in Group 3 shall remain in a single track.

The above passenger demand figures show only the long distance passenger figures, and their average travel length is 224.6km/passenger. Then, the commuter train transportation in 2020 shall be added to the above figures. In Vietnam, there is no mass transportation by rail (especially commuters' transportation) in big cities, i. e., neither in Hanoi nor in HCM City. But in 20 years, it will be a tremendous pressure to the railway network. Therefore, the railway network shown above must be responsible to the mass transportation too. In this study the mass transportation demand in big cities is not estimated nor projected. Then the area of the mass transportation in big cities is supposed as follows: Mass transportation zone is supposed to be 30km radius from the center of the two cities in 2020. Then tracks in 30km radius circle shall be double tracked or the railway in the area must have the enough transportation capacity. This 30km is based upon a hypothesis of 1-hour commuting time from residence to office including access time to stations of both sides (door to door).

Here, the Saigon station is in the midst of HCM City and from the Saigon station to the Mekong Delta region, there is no railway route now. And the demand projection shows a big transportation between Saigon and My Tho & Can Tho. Then, from the Saigon station to the Mekong Delta a new railway shall be constructed in double track, at first between Saigon and My Tho and then between My Tho and Can Tho.

The section Saigon and Vung Tau has also a high transportation volume. And this new line shall be constructed in double track like Saigon – My Tho – Can Tho line. These two lines will be available as the commuter lines in the HCM City metropolitan area.

The mass transportation in the 30km range shall be added to the long distant passenger and freight transportation in the big two cities' areas. Then the track-addition (a double tracking or two double tracking) in 2020 is considered as in the following table.

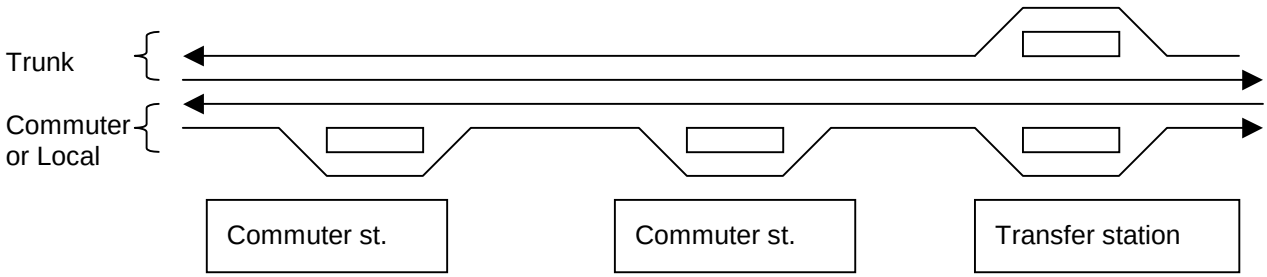
Table 4.4.4
Sections of a double track or two double track sections

Line or section	**Double tracked section** (length: km)		**Two double track section** (length: km)	
Existing lines				
Hanoi – Saigon	Hanoi- Saigon	1727		
Hanoi – Yen Vien	Gia Lam – Yen Vien	6	Hanoi – Gia Lam	5
Yen Vien – Lao Cai	Yen Vien – Viet Tri	62		
Gia Lam – Haiphong	Gia Lam – Haiphong	97		
Van Dien – Bac Hong	Van Dien – Bac Hong	40		
Dong Anh – Quan Trieu	Dong Anh – Thuong Dong	5		
Sub total		1937		5
New lines				
Airport line	Thuong Dong – Airport – Thon Ve	12		
Saigon – My Tho – Can Tho	Saigon – Can Tho	170		
Saigon – Vung Tau	Saigon – Vung Tau	78		
Sub total		260		
All total		2197		5

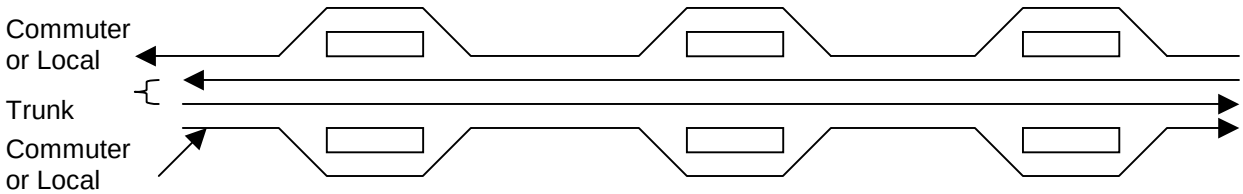
In 2020, the two double-track will come out in the most train crowed section. It is very important how to use 4 tracks. There are 2 ways of using. One is (a) line-wise using, and the other is (b) direction wise using.

Fig. 4.4.1
Track use; Line-wise and Direction-wise

(a) Line-wise use



(b) Direction-wise use



There are many merits and demerits in both using. Therefore, in the detail planning, such merits and demerits shall be compared and checked. Fig. 4.4.1 shows some examples of both uses at Hanoi station. Fig. 4.4.3 is some examples of Saigon station track layouts (not 4 tracks).

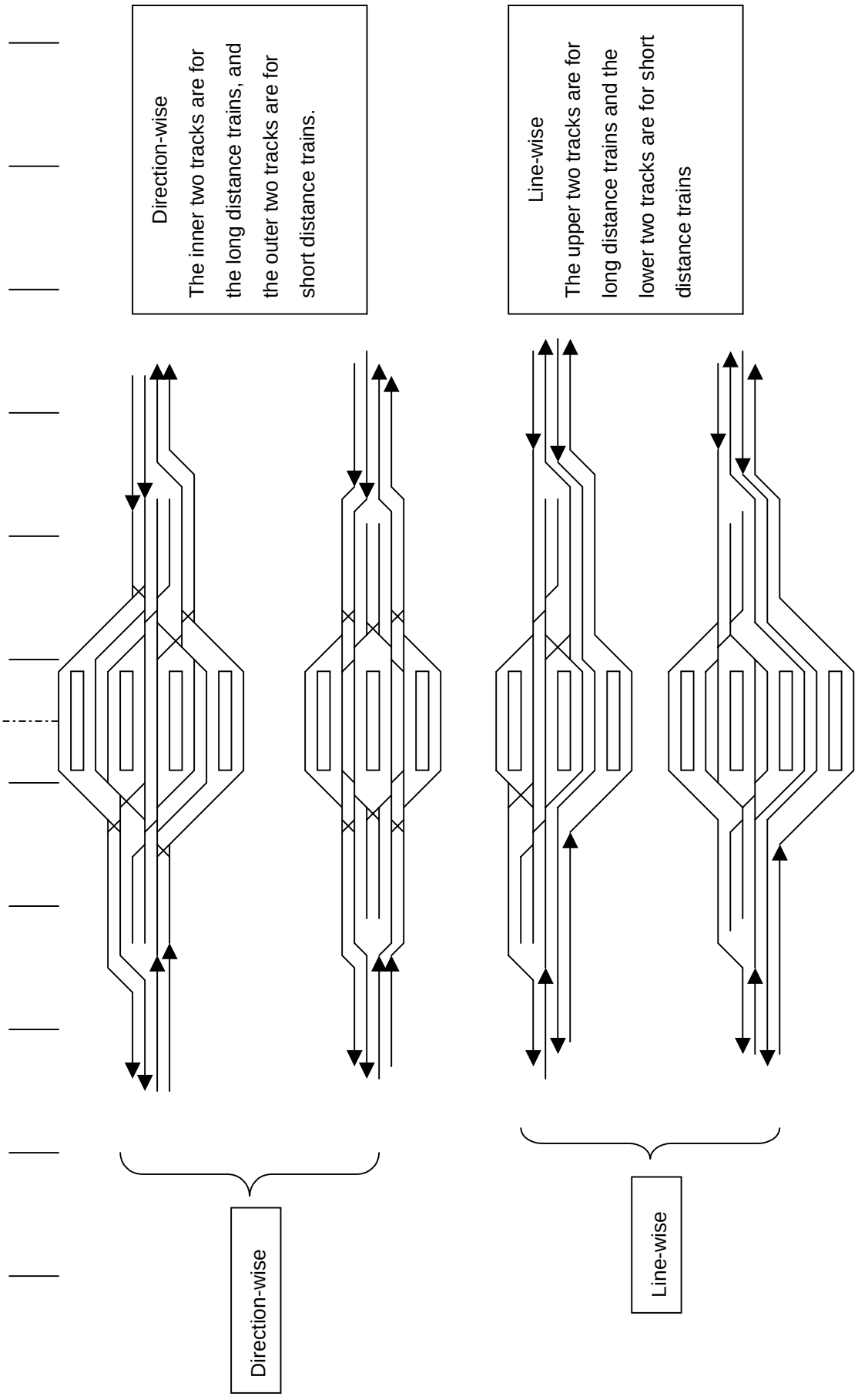
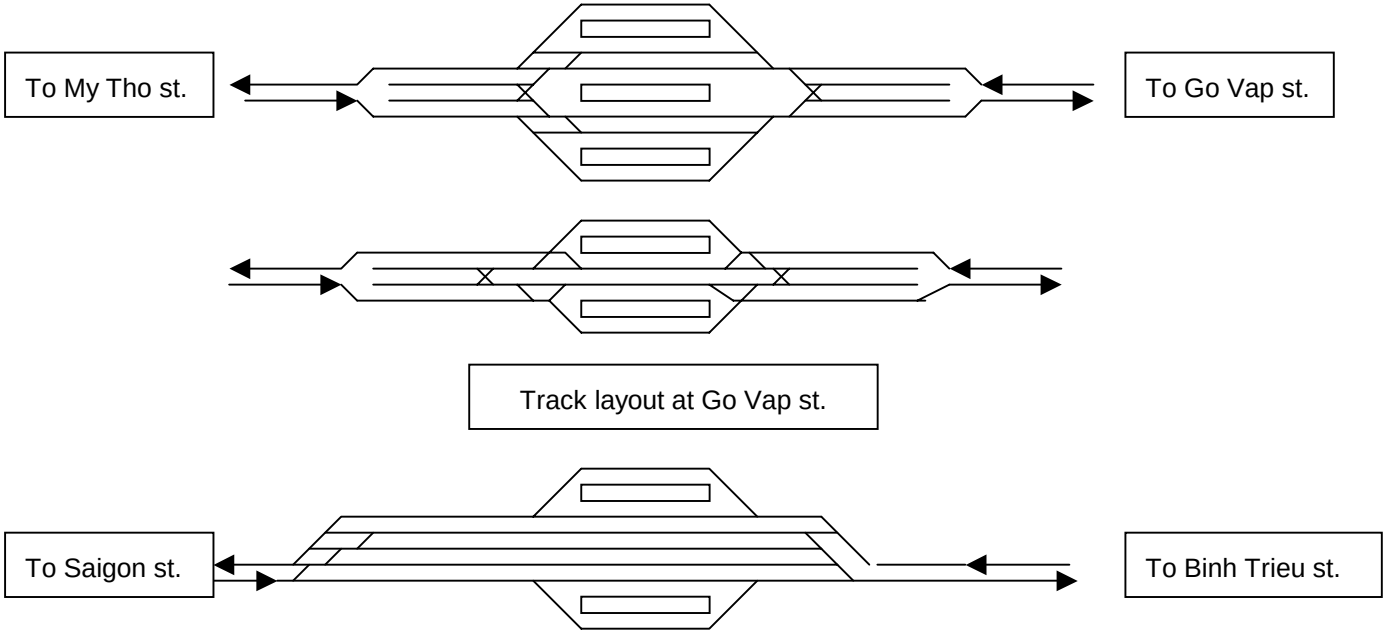


Fig. 4.4.2
Track layout at Hanoi st. in 2020

Fig.4.4.3
Track layout at Saigon st. in 2020



Go Vap st. will be a substitute station of Saigon st. that won't have enough space for train handling when it is elevated. The reasons are as follows:

① Go Vap st. is the nearest st. from Saigon st. (4km).

② Go Vap st. has enough space (500m long even ground).

③ Go Vap st. shall be on the ground (There is no reason to elevate the section between Go Vap st. and Binh Trieu st., because there is no road crossing from Go Vap. st. to Saigon River at present. And the section is already made grade separated by the railway section going in the cut bank).

④ The space of Go Vap st. shall be used for train passing, simple train arrangement, etc., in order to substitute for the elevated Saigon st.

3) New Railway Lines

In Vietnam there are several new railway construction planning, as follows:

- Bien Hoa – Vung Tau
- Di An – Loc Ninh
- Saigon – Can Tho

In the above projects, Saigon – Can Tho is a railway to the area so called "Mekong Delta". This district has 1/4 population of the total Vietnam, and it is densely inhabited, esp. along the line that connects the HCM City and Can Tho. Secondary, there is a strong need for a railway that penetrates the HCM City for a solution of road traffic jam. The present railway stops at the northern part of the HCM City. In the two meanings, (one is from the national trunk line transportation and the other is from the mass transportation in HCM City), Saigon – Can Tho line is the first need. If Saigon – Can Tho line is connected with the present Saigon station, it is most desirable in the above meaning. As for the first step, Saigon – My Tho (70km) shall be constructed to catch up the transportation demand. This section shall be constructed by double track and electrified from the start, to meet with the connection with the Hanoi line at Saigon station. And approx. 10km section from Saigon station, the line shall be an elevated railway. Other 2 lines shall be next to Saigon – My Tho line.

In order to make up a future VR network concept in the HCM City area, the following assumptions and conclusions are used in this study.

(1) Concept of future VR network in HCM City area (see Fig. 4.4.4)

a) From the transportation demand analysis, the next two lines has been completed and in use in 2020.
   - Saigon – My Tho – Can Tho line
   - Vung Tau – HCM City area

b) Hanoi – Saigon line has been double-tracked in 2020. This means that Saigon – Go Vap – Bien Hoa has been double-tracked and Saigon – Go Vap has been elevated (grade separated) when the above two lines are in operation in 2020.

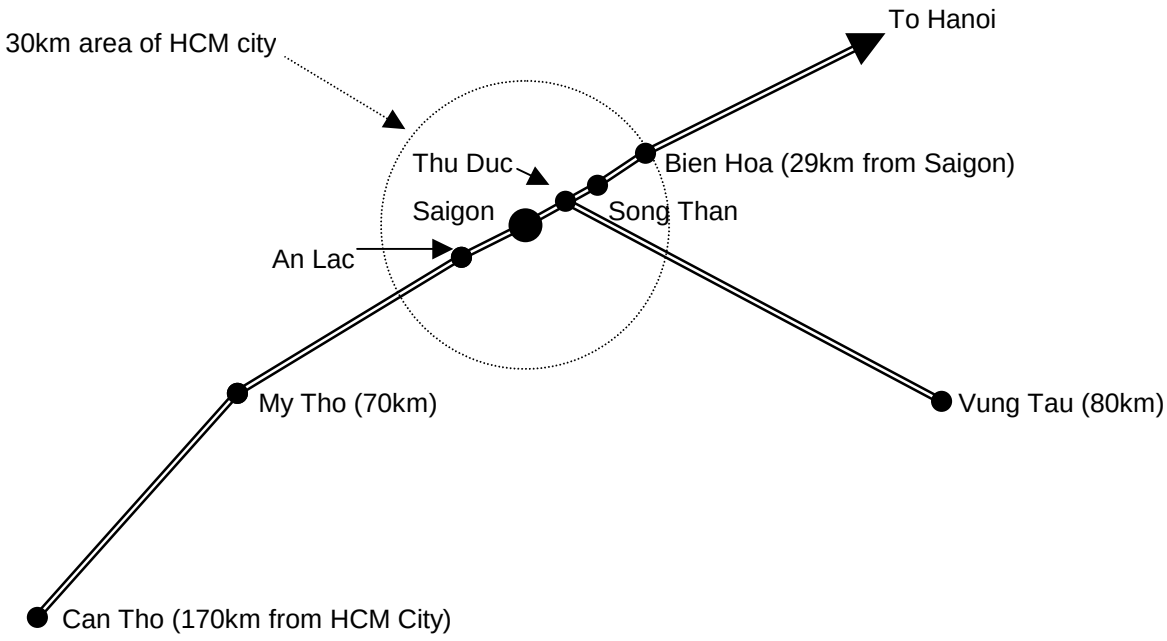
c) The VR lines shall also be available for the commuter services.

d) The Song Than freight station will be a central freight station in HCM City area in future too.

e) The VR lines shall be connected by rail to each other in order to make the rolling stock efficiency higher and its management easier (merits; one workshop, fewer depots, unified rolling stock dispatching and controlling, etc.)

Fig. 4.4.4
Future VR Network in HCMC Area

Fig. 4.4.5
Railway network in HCM City area in 2020



(2) Saigon – My Tho – Can Tho line

- The line shall be connected to the Hanoi – Saigon line, esp. to the Song Than freight station, because the line is supposed to convey much freight (28 freight-trains/day in 2020).
- The line shall be better to pass through the populated area in HCM City, to serve as a mass transportation in the HCM City.

(3) HCM City – Vung Tau line

- This line is supposed to carry the freight from/to the Vung Tau port. Then the first priority is to connect the line with the Song Than freight station (21 freight-trains/day).
- This line shall share a responsibility to serve a mass transportation in HCM City area too. Then its route is preferable to go through the HCM City.
- In this respect, the two routes are considered route-a (approx. 5.5km) and route-b (approx. 12km via Saigon st.).

Route-a is easier to be realized, because it is shorter, less construction cost and no new crossing with the Saigon River, if the route merges in the double tracked section of the Hanoi – Saigon line at Thu Duc junction (jnc.). On the other hand, Route-b has demerits as follows comparing with the route-a and

- is longer than route-a.
- must cross the Saigon River, newly.
- doesn't have no right of ways in the center of the HCM City and must go through the congested district in the HCM City.
- must have a connecting line with the Song Than freight station (it is the route-a itself).

From the above, the route-a is far better, at the first stage.
But it will reach the track capacity limit between Thu Duc jnc. and Saigon, because this section must allow two line's trains (Hanoi – Saigon line and Vung Tau – Saigon line). The demand analysis shows the figures as follows:

Table 4.4.5
Trains in 2020 (from Table 4.4.2)

Line or section	Pass. Trains	Fr. trains	Total
Muong Man – Saigon	61 +α_1	46	**107** +α_1
Saigon – Vung Tau	49 +α_2	21	70 +α_2
Saigon – My Tho	72 +α_3	28	100 +α_3
The merged section (Thu Duc jnc. – Saigon)	110 + α_1+ α_2	28	**138 + α_1+ α_2**

Note: α_1, α_2, and α_3 are the short-distance passenger (commuter) train numbers in the respective line (Muong Man – Saigon, Saigon – Vung Tau and Saigon – My Tho) in 2020, respectively.

The section that the two lines are merged shows the largest number of trains. Then this section will reach the track limit earliest in the HCM City area. And it must be a two-double tracked (four tracks) like the section Van Dien – Hanoi – Gia Lam.

The route-b is to be mainly considered as a commuter service. From the commuter-transport or mass transportation point of view, this route shall be constructed much earlier, in order to decrease the traffic jam in the HCM City and also as one of the essential transportation infrastructure to develop the east bank area of the Saigon River.

As a conclusion, the two routes shall be considered as follows:

a) At first, the merged section (approx. 12km) of Thu Duc jnc. – Saigon shall be double-tracked up to 2005 or 2010.
b) Vung Tau line with the route-a shall be connected to the merged line section up to 2020. (At the same time, the Saigon – My Tho line shall be constructed and completed.)
c) The three lines will develop the transportation demands and the merged section will reach the track limit.
d) Two double-tracking the merged section or the route-b shall be considered as the solution of the bottlenecked section (Thu Duc jnc. – Saigon). Addition of a new double-track to the section is only for the dissolution of this congested section. On the contrary the route-b shall be available not only for the dissolution of the congested section and also for the dissolution of the mass transportation problem in the HCM City area by having a new access route to the central part of the city. The biggest demerit of the route-b is the alignment. In the center of the city, it has no ROW (Right of Way). Therefore, at first, it must go by the road space (elevated or the underground). Secondly, the route-b must cross the Saigon River. This causes more construction cost. Still to have a new route to the city center is very attractive from the viewpoint of the mass transportation.

In the railway service in HCM City area another big point is the transportation between the Tan Son Nhat airport and the city center. This section will need a mass transportation system that will serve as the commuter service too. The airport situates on the west of the Go Vap station and it is easy to draw Go Vap jnc. – Airport – Saigon st. route on the west of the existing line. The second double tracking between the Go Vap jnc. and the Saigon station may be converted to the bypass route and this route shall be limited mainly to the passenger trains. This section shall be called as an Airport bypass line. This bypass length is approx. 7km and it is approx. 2km longer than the existing line.

Then the Existing line (Thu Duc junction – Go Vap junction; 6km) – Airport bypass (6.5km)– Existing line mostly in the Saigon station yard (1km) – Abolished section (3.5km) – Route-b (8km) – Route-a (5.5km) – Thu Duc junction will make a Northeast circle railway line (approx. 30km). This circle will be very effective for the passenger service, especially for the mass transportation in the HCM City area and also for the transportation between the airport and the HCM City area. As for the construction of the airport bypass part, an elevated railway and connected to the Saigon station is most preferable from the construction cost and train operation efficiency, but it may be difficult to have the unanimous affirm. In such case, this part can be underground. The circle line will be underground from the junction between Go Vap – Airport – to the east bank of the Saigon River. The underground part will be 12km or so. The length on the ground is from the east bank of the Saigon River to the Go Vap junction and nearly 18km. There will be several route-choice in the center of the HCM City. It is desirable to connect to the Saigon station, but if it is not possible in the route setting, another routes shall be considered, for instance, via the Duong Cach Mang Thang Tam, the Duong Nguyen Van Troi or the Dai Lo Phan Dinh Phung to the route-b.

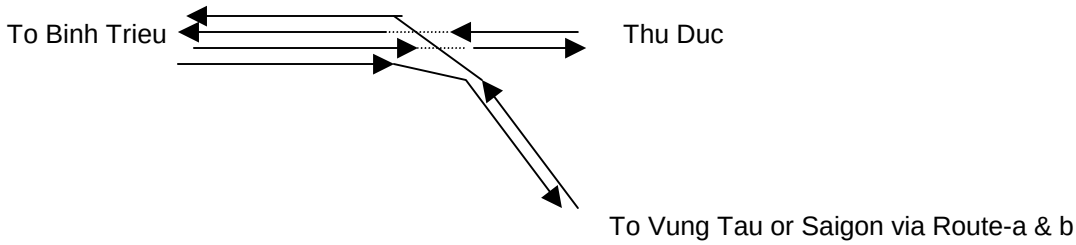
The development of the railway network in the HCM City area is supposed as the following table:

Table 4.4.6
Stage construction of the VR network in the HCM City area

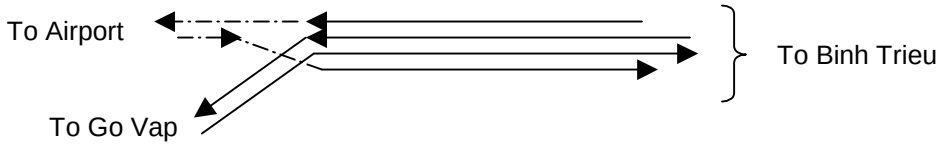
Line or section	~ 2005 or ~2010	~2020	After 2020
Route-a – to Vung Tau		Construction	
Thu Duc jnc. – Go Vap jnc.	A double tracking		Two double tracking
Go Vap jnc. – Saigon st.	A double tracking		
Airport bypass			Construction
Saigon st. – to My Tho		Construction	
Saigon st. – Route-b			Construction

The rough track layouts of the main junction sites in the HCM City area will be in the following after the final stage:

Thu Duc junction

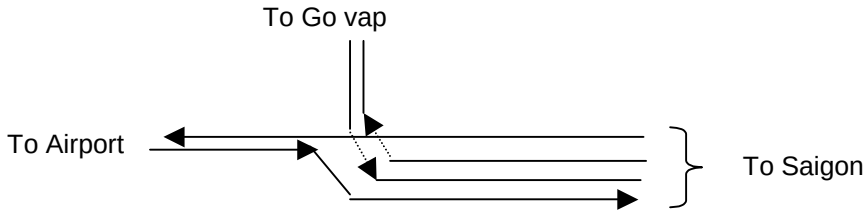


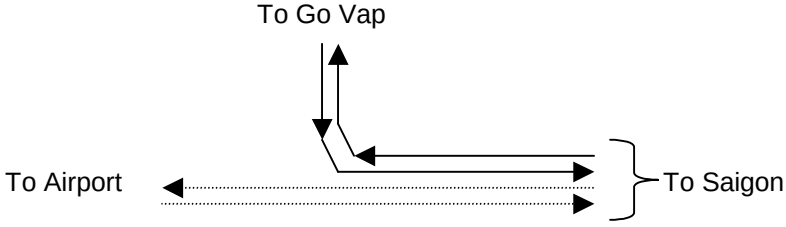
Go Vap junction



Saigon station junction

a) a case that both lines are elevated.

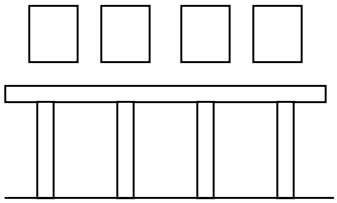




The followings are the main cross sections of the railway alignments in the HCM City area.

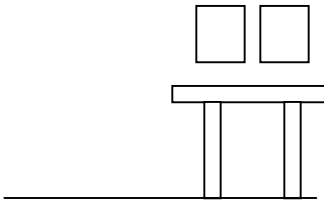
A case; The bypass route and the existing route are both elevated.

The existing line or the My Tho line & the airport bypass or the circle line are parallel on the elevated structure.

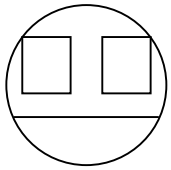


A case; The bypass route is underground and the existing route is elevated.

Saigon jnc. – Saigon (in a case of the Airport bypass is underground and it is a double track shield tunnel).



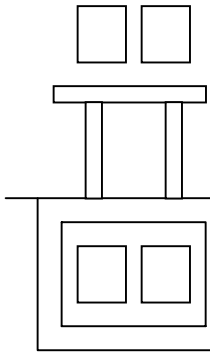
The existing line or My Tho line on the elevated structure



The airport bypass or the circle line

A case; The bypass route and the circle line is under the existing line or the My Tho line.

In this case, the airport bypass or the circle line shall be constructed at the same time with the existing or the My Tho lines' elevation work. This is most unfavorable.



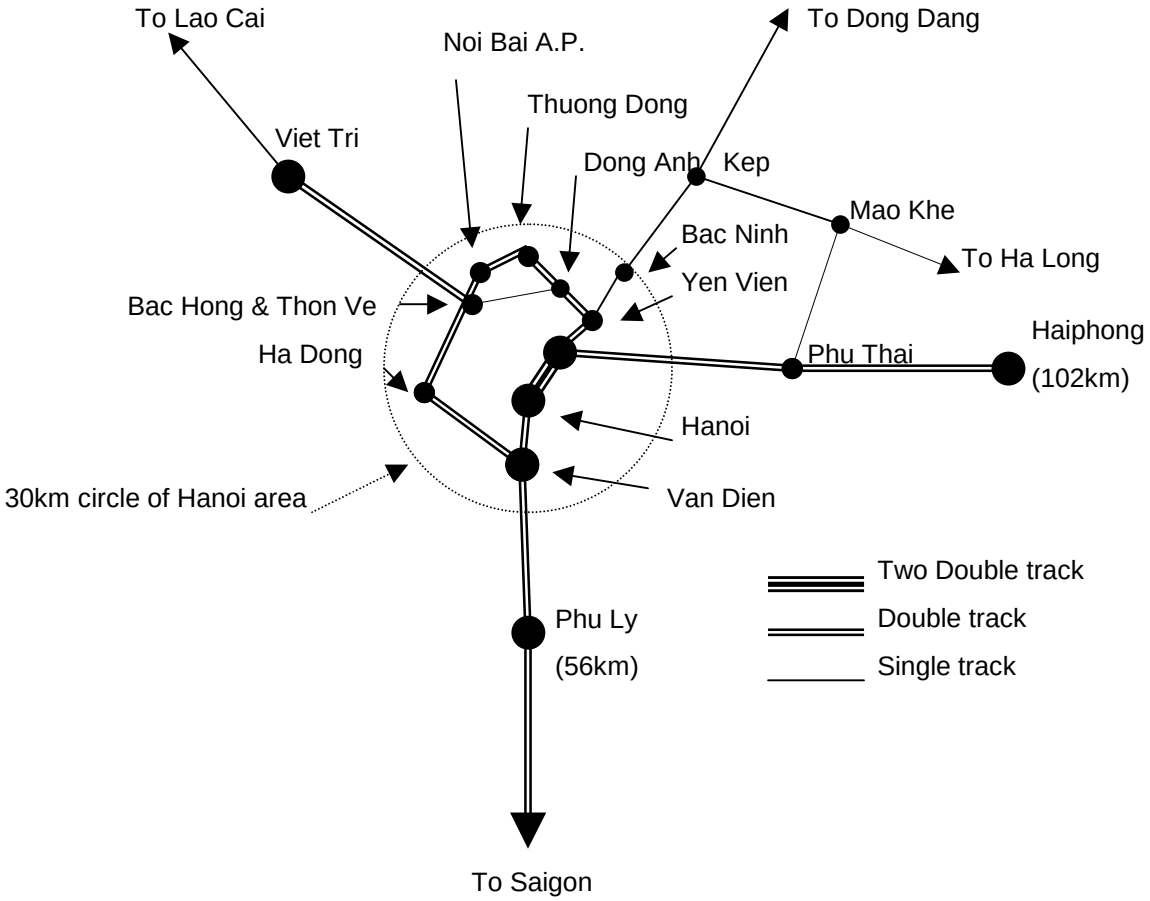
Existing line or My Tho line

Airport line or Circle line

(4) Concept of future VR network in Hanoi area

The conceptual plan for future VR network for Hanoi area is shown in Figure 4.4.6

Fig. 4.4.6
Railway Network in Hanoi Area in 2020



(5) Noi Bai Airport line

New line that connects Dong Anh – Airport – Thang Long bridge line shall be constructed. This line serves as an airport passenger line and also as a commuter line in the Hanoi metropolitan area 30km range. This line is shown in Fig. And the new line length is nearly 12km. The airport section (2km) and the crossing section (2km) with the Lao Cai line (Bac Hong – Thach Loi), this new line shall be elevated structure to evade the same level crossing.

Fig. 4.4.7
Route of Airport Line

(6) A new railway line which short-cuts Hanoi – Ha Long and connects Phu Thai and Mao Khe

The transportation demand forecast in 2020 on the section Kep – Ha Long shows the following figures:

Table 4.4.7
Demand forecast in 2020 of the section Kep – Ha Long

Section	Passengers/day	Tons/day	Total (TU)
Kep – Ha Long	3416	5788	9204

Note: The figures are from "Demand analysis".

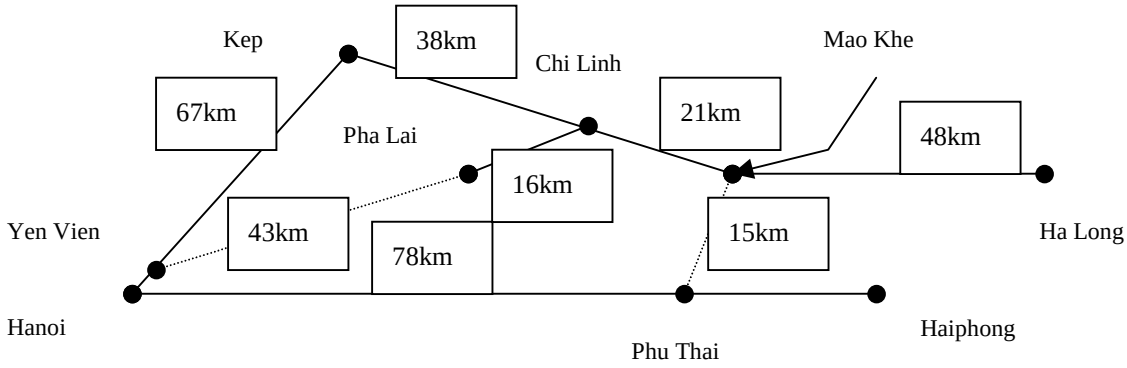
Transportation of this line is nearly 10000TU/day. It means approximately 20 trains/day. The line's biggest trouble is its 1435mm gauge. Most of the figures are the the transportation between Ha Long and Hanoi. This means that all the transportation shall be changed at Kep from 1435mm gauge trains to 1000mm gauge trains or vice versa. Everyday more than 12 freight trains must transship their freights to another trains at Kep, it will cause tremendous trouble. Then such troubles shall be evaded. If Phu Thai and Mao Khe is connected by rail of 1000mm gauge and the rail gauge of Mao Khe – Ha Long is converted to 1000mm, Hanoi – Ha Long will become 78 + 15 + 48 = 141km (b) without the troublesome transshipment from 1435mm gauge to 1000mm or vice versa. The present length is Hanoi – Kep – Ha Long is 174km (a), then (b) is approx. 30km shorter than (a). There is an idea that Yen Vien – Pha Lai is connected by rail, too. So the three routes shall be evaluated as follows:

Table 4.4.8
Comparison of the three routes

	(b) New line length	© Improving length	(d = b + c)	
			Km	Evaluation
Yen Vien – Kep – Ha Long	0	107km	107km	O better
Yen Vien – Pha Lai – Ha Long	43km	69km	112km	Δ
Gialam – Phuthai – Ha Long	15km	48km	63km	⓪ Best

Gialam – Phuthai – Ha Long route needs the 15km length new line and the 48km new track laying parallel with the existing rail. This route is the shortest and the construction cost is also the lowest in the three. If the Gia Lam – Haiphong line is double-tracked, the transportation is very smooth. In this planning, there is a defect that the section Kep – Mao Khe remains in 1435mm gauge. This section has little chance to be improved, because of the little transportation demand.
See the following figure. Then the transportation figures on Ha Long line will transfer to the new line.

Fig. 4.4.8
Alternatives of Ha Long line



And as for Hanoi – Kep, the demand in 2020 will be decreased as follows:

Table 4.4.9
Demand in 2020 between Yen Vien and Kep on the two routes' comparison

Route choice		(a) Present route via Kep is adopted	(b) Route via Phu Thai is adopted	The demand via Phu Thai
Yen Vien – Kep	Passenger	6033 (16 trains)	1736 (5 trains)	3416 (9 trains)
	Freight	6065 (13 trains)	2139 (5 trains)	5788 (12 trains)
	TU	12098 (29 trains)	3875 (10trains)	9204 (21 trains)

From the above, if the demand of Kep –Ha Long route has an alternative of the route via Phu Thai, the section Yen Vien – Kep shall remain in a single track, because of the low transportation demand of the section. 30km range from Hanoi up to Bac Ninh shall be considered from the different thought of the mass transportation in big cities. But, it will remain in single track, because of transportation demand up to 2020.

In the case (b) is adopted, the issue of 1435mm gauge and 1000mm gauge arises. Kep – Ha Long is now a 1435mm-gauge track. And Hanoi – Haiphong line is 1000mm gauge. In this case 1000mm shall be chosen in the following reasons:

(1) The demand is mostly Hanoi – Ha Long clients. Therefore, if trains cannot run between Hanoi-Ha Long without transfer of freights or passengers, the transportation is almost meaningless. It is easy to reach Hanoi, using Hanoi – Haiphong line via a new line Phu Thai – Mao Khe 15km. Hanoi – Haiphong line is the 1000mm-gauge track. On the contrary, to reach Hanoi by 1435mm gauge, the tremendous investment shall be necessary (via Kep, Kep – Hanoi 67km shall be double tracked by 1435mm gauge. Via Mao Khe – Phu Thai route, Phu Thai – Hanoi 78km shall be double tracked by 1435mm).
(2) 1435mm adoption makes influence and troubles to all lines of VR that are connected to Hanoi. The total hazard of adopting 1435mm shall be far greater in VR.
(3) The construction cost and the total length between Hanoi and Ha Long is much cheaper and shorter, via Phu Thai – Mao Khe new line using Hanoi – Haiphong line (detail shall be explained in the following), if 1000mm-gauge track is chosen.

Then the connection line Phu Thai – Mao Khe shall be constructed in single track by 1000mm gauge. Mao Khe – Ha Long shall be constructed as follows:

(1) Mao Khe – Ha Long; a single track of 1000mm shall be laid parallel with the existing 1435mm track, allowing the train operation of the present 1435mm gauge between Kep –Ha Long.

(2) The train-service will be done as follows:
- Ha Long – Mao Khe – Phu Thai – Hanoi in 1000mm gauge train and,
- Ha Long– Kep in 1435mm gauge train.

(3) If the transportation volume in Ha Long line follows the projection, the two sections (Phu Thai – Mao Khe and Mao Khe – Kep) will remain in single track up to 2020. And the train service will be 1000mm trains and 1435mm trains by paralleled tracks between Mao Khe and Ha Long. If the transportation demand exceeds the single track capacity in the Mao Khe – Ha Long, 1435mm gauge track shall be removed and 1000mm gauge track shall be laid. In this case, Phu Thai – Mao Khe shall be double-tracked also. And the section Mao Khe – Kep will remain in 1435mm gauge track or stopping the railway service shall be studied like Kep – Luu Xa, if the section's transportation volume will remain low.

The above Mao Khe and Phu Thai aren't the confirmed points, they are one of example plans of connecting the two lines. Further studies shall confirm the most-fit alignment.

The total length of new lines amounts 275 km of which 24km will be elevated in HCMC and Hanoi areas. (See table 4.4.10)

Table 4.4.10
New lines constructed up to 2020

Section	Length	Elevated section	Note
Saigon – My Tho – Can Tho	170km	10km	#1
Saigon (Bien Hoa) – Vung Tau	78km		#2
Mao Khe – Phu Thai	15km		
Airport line	12km	4km	#1
Total	275km	24km	

#1: Elevated section length is an assumption
#2: The route in the HCM City is not mentioned here

4.5 Modernization of the railway transportation

All the investments will be accompanied with the idea of railway modernization. Every investment will improve the railway system and level up the efficiency and productivity. Some of the examples are as follows:

1) Introduction of EMU trains

In replacing or getting new passenger cars, {locomotives + passenger cars} combination must be reconsidered. As explained in the former sections, the

multiple unit trains are far productive (efficient) in the passenger transportation. Then EMU should be introduced to main lines by electrification; especially in the commuter transport sections.

2) Electrification

Electrification has much merit, such as easier operation, easier maintenance, lighter weight and higher power, higher speed, higher productivity, etc. Based on the transportation demand, Hanoi-Saigon 1728km , Hanoi-Haiphong 100km shall be electrified and other sections in the table 4.5.1 shall be electrified. In them, the commuter transportation sections, Hue – Danang section shall be the first implementing sections.

Table 4.5.1
Electrified section in 2020

Line	Section	Route km	Note
Existing lines			
Hanoi –Saigon		1713	
Hanoi- Hanoi junct.	Hanoi – Yen Vien	11	Commuter section
Lao Cai line	Yen Vien- Viet Tri	62	Ditto
Quan Trieu	Dong Anh – Airport junct.	5	Ditto
Haiphong line	Gia Lam – Haiphong	97	Ditto
Kep – Ha Long	Mao Khe – Ha Long	48	
Loop line	Van Dien – Bac Hong	40	Commuter section
Total		1976	
New lines			
Can Tho line	Saigon – My Tho – Can Tho	170	Commuter section
HCM City - Vung Tau	HCM City - Vung Tau	80	Commuter section
Short cut line	Phu Thai – Mao Khe	15	Single track
Air port line	Airport junct. – Loop line	12	Commuter section
Total		277	
All total		2253	

3) Introduction of Workshops and Depots for the electrified rolling stock

With the introduction of the electrification, the maintenance of ELs (electric locomotives) and EMUs (electric multiple units) shall be prepared. Everyday maintenance shall be in each depot and the large-scale maintenance (over-hauling) shall be done in workshops. Two main workshops shall be prepared in Hanoi, and HCM City areas, respectively. As for the depots fundamentally in Hanoi, Danang and Saigon. Then 2 workshops and 3 depots shall be planned.

Table 4.5.2
Workshops and depots for electrified rolling stocks (unit; VND)

	Quantity	Unit cost	Total amount	Note
Workshops	2	$255*10^9$	0.5×10^{12}	Hanoi, HCM City
Depots	3		0.8×10^9	Hanoi, Danang, HCM City
Total	5		1.3×10^9	

In above depots, Hanoi depot and Saigon depot shall be relocated by the elevation of the railways. Therefore, if the sequential implementation is available, the construction will be saved.

4) Prevention of accident at crossings

The same level crossing between railways and roads causes traffic jam in heavy traffic roads, collision accidents, life loses and vehicle loses. Traffic jams are coming worse and worse in two big cities; Hanoi and HCM City. Life loses are more than 100 every year. Accidents at crossings shall be decreased by setting a train-approaching alarm or automatic crossing barrier, or totally removed by the level separation of the railway from the road. All these improvement shall be done by the cooperation of related authorities, local government, authority of road management and authority of railway management.

In 2020, the road traffic will increase greatly and the train frequency will go up 3 times to 10 times in general. Then the traffic accident at crossings will become much, much worse if the condition of the crossing won't be improved. Crossings' number between the road and the railway is shown in the following table and the two improving methods are also explained below:

Table 4.5.3
Number of the level crossing

Line	With barrier	Without barrier	Total	Crossings in the double tracked section
Hanoi – Saigon	191	446	637	637
Hanoi – Dong Dang	29	71	100	
(Hanoi – Kep)	19	49	68	68
(Kep – Dong Dang)	10	22	32	
Gia Lam - Haiphong	20	33	53	58
Yen Vien – Lao Cai	43	28	71	
(Yen Vien – Viet Tri)	25	22	47	47
(Viet Tri – Lao Cai)	16	8	24	
Kep – Ha Long	20	24	44	44
Bac Hong – Van Dien	18	0	18	18
Dong Anh – Quan Trieu	7	30	37	
(Dong Anh – 5km)	1	3	4	4
(5km – Quan Trieu)	6	27	33	
Mai Pha – Na Duong	0	5	5	
Chi Linh – Co Thanh	1	2	3	
Cau Giat – Nghia Dan	6	7	13	
Dieu Tri – Quy nhon	2	2	4	
Muong Man - Phan Thiet	0	0	0	
Kep – Luu Xa	0	17	17	
Phu Ly – Kien Khe	2	6	8	
Total	339	671	1010	876

a) From manned or unmanned crossings to crossings equipped with automatic train approaching alarm set.
There are approx. 1000 level crossings in Vietnam. Nearly 33% of the crossings are manned and the other crossings have no equipment for arousing caution. These crossings shall be improved and equipped with alarms and crossing bars when a crossing is in the double tracked sections. Double tracked sections are shown in the table 4.4.4.

b) Level separation; As for the crossings of great volume of road traffic, such as some of Hanoi's or HCM City's, the railway level and the road level shall be separated. Fig. 4.5.1 shows example profiles of the grade separation in two cities, Hanoi and HCM City.
   - The railway between Hanoi station and River Hong in the north (2km) and between Hanoi station and Giap Bat station in the south (5km) shall be lifted up and all the crossings between the sections shall be removed. Fig.4.5.2 and Fig.4.5.3 show images of the elevated railway sections. Track layout shall be considered enough for the most simple and effective train operation, and also the easiest and most understandable for passengers.
   - At HCM City the crossings between Saigon station and Go Vap station (4km) shall be removed by elevating the railway in the section. Fig.4.4.4 shows an image of the elevated railway section.
   - New lines; In the Saigon – My Tho line, the section in the HCM City (10km) shall be elevated.

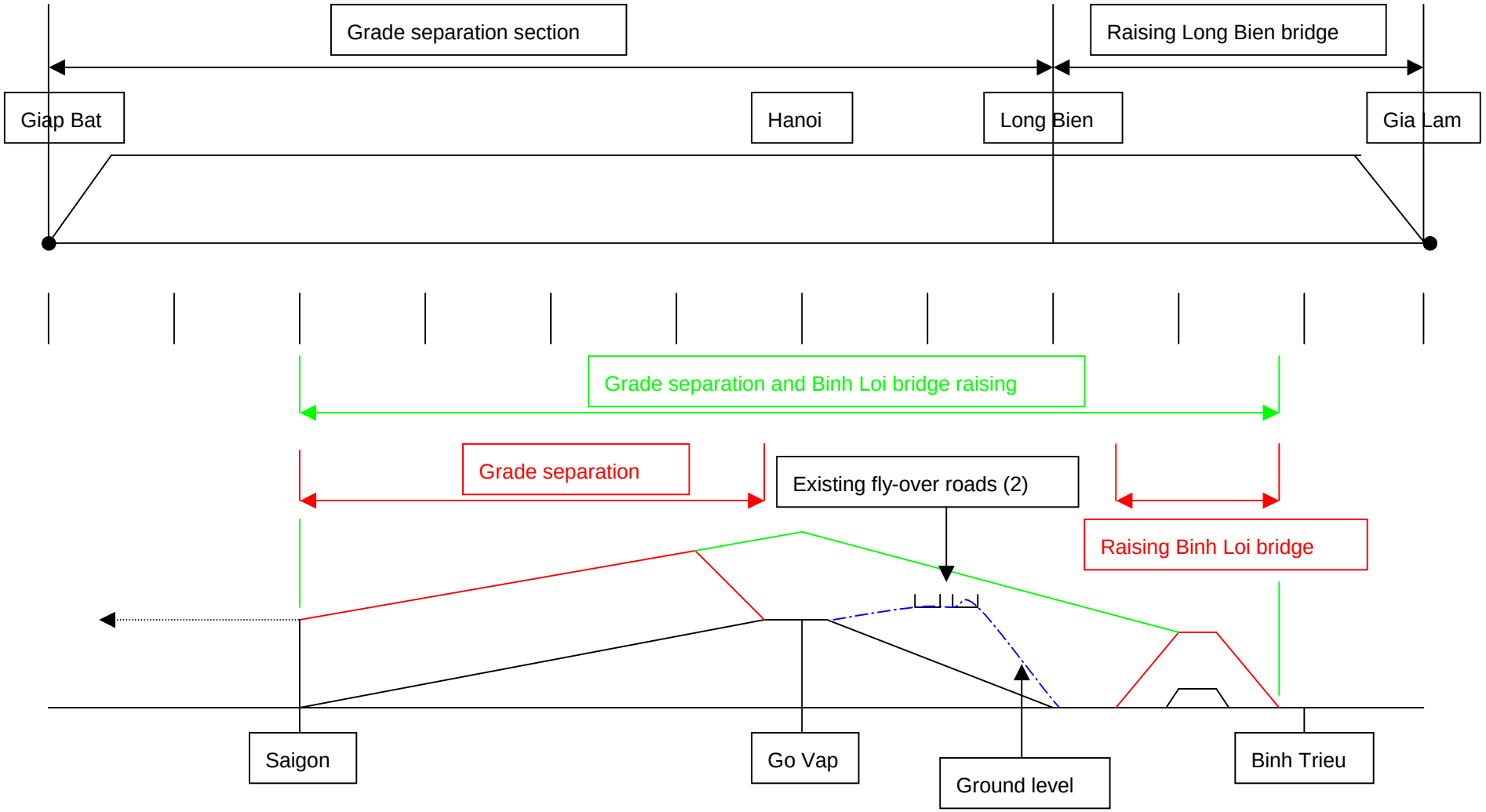
In the Noi Bai airport line, the airport part (2km) and the part where the airport line crosses with the Lao Cai line (2km) shall be elevated.

Table 4.4.5
Elevated railway sections

Line	Section	Length
Existing lines		
Hanoi – Hanoi junct.	Hanoi – Long Bien	2
Hanoi – Saigon	Hanoi – Giap Bat	5
	Go Vap – Saigon	4
New lines		
Saigon – My Tho	In HCM City	10
Air port line	Air port station Crossing part with Lao Cai line	2 2
Total		**25**

As for the other heavy traffic crossings, they shall be removed by elevating the road portion at the site, if there aren't another crossings of such heavy traffic in its short distance.

Fig. 4.5.1
Grade separation profiles (Giap Bat-Gia Lam and Saigon-Go Vap)



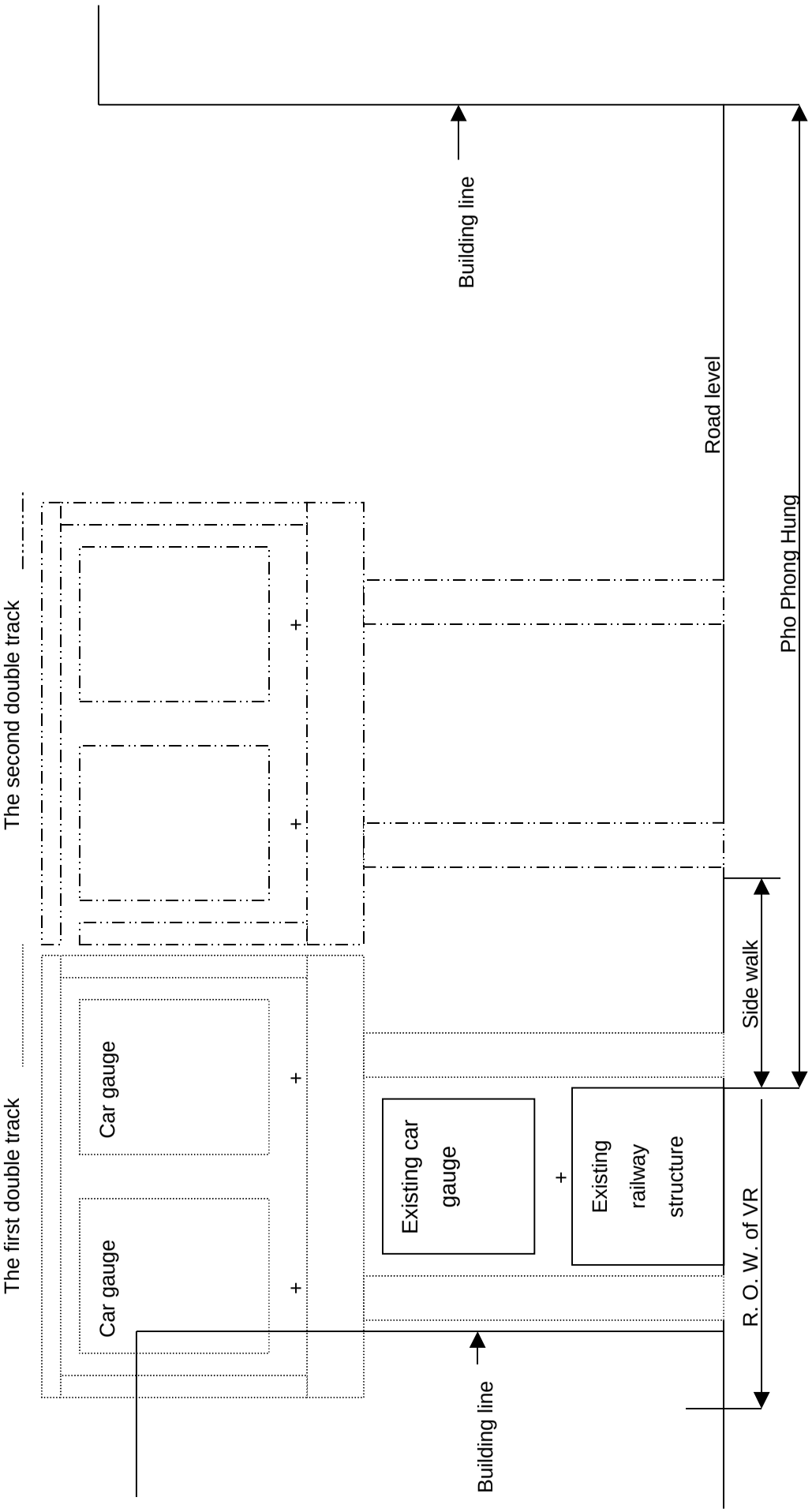
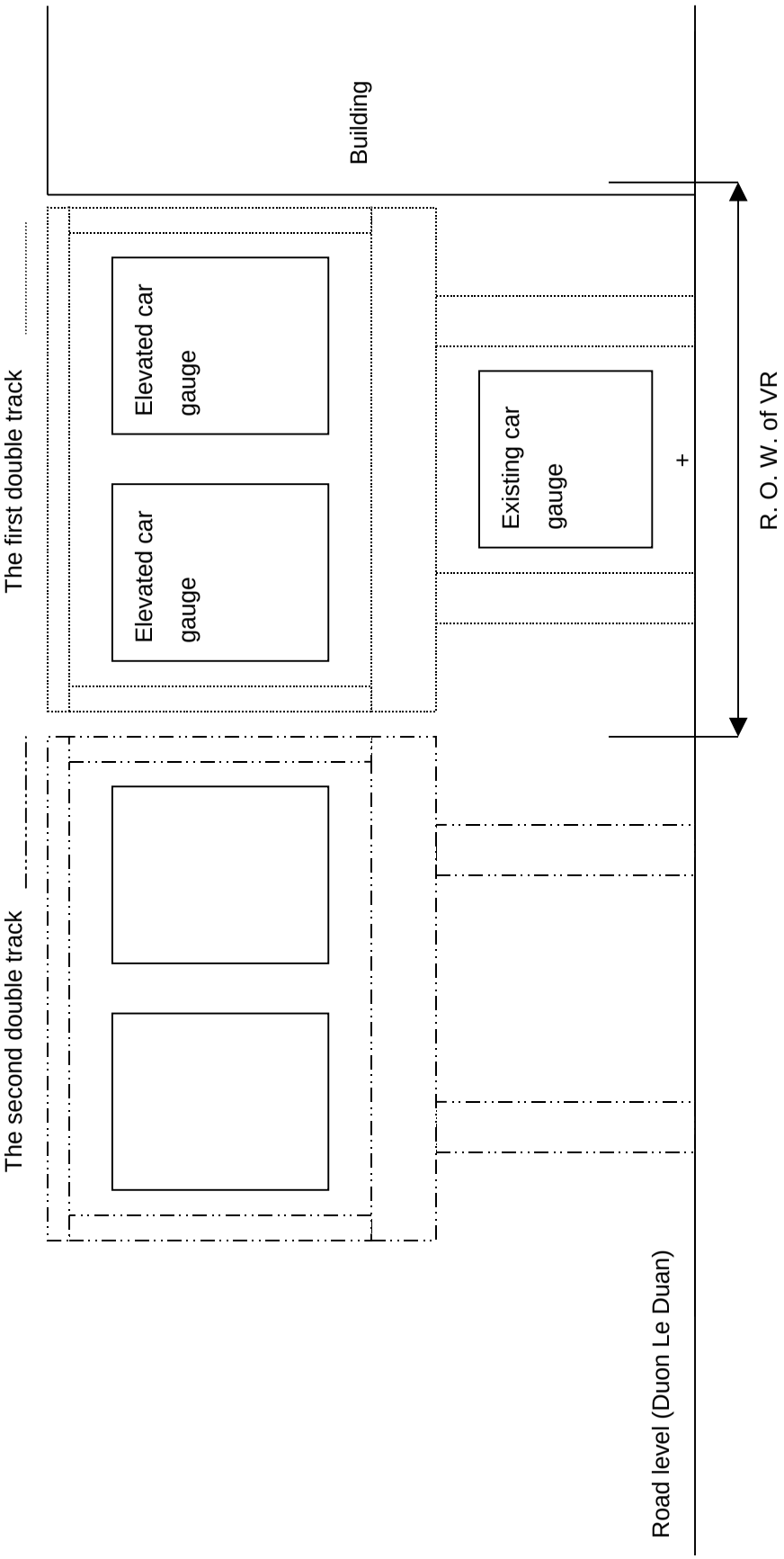


Fig. 4.5.2
An image of the two double track between Hanoi and Long Bien (from Hanoi to Long Bien)

Fig. 4.5.3
An image of the two double track between Hanoi and Giap Bat (from Hanoi to Giap Bat)



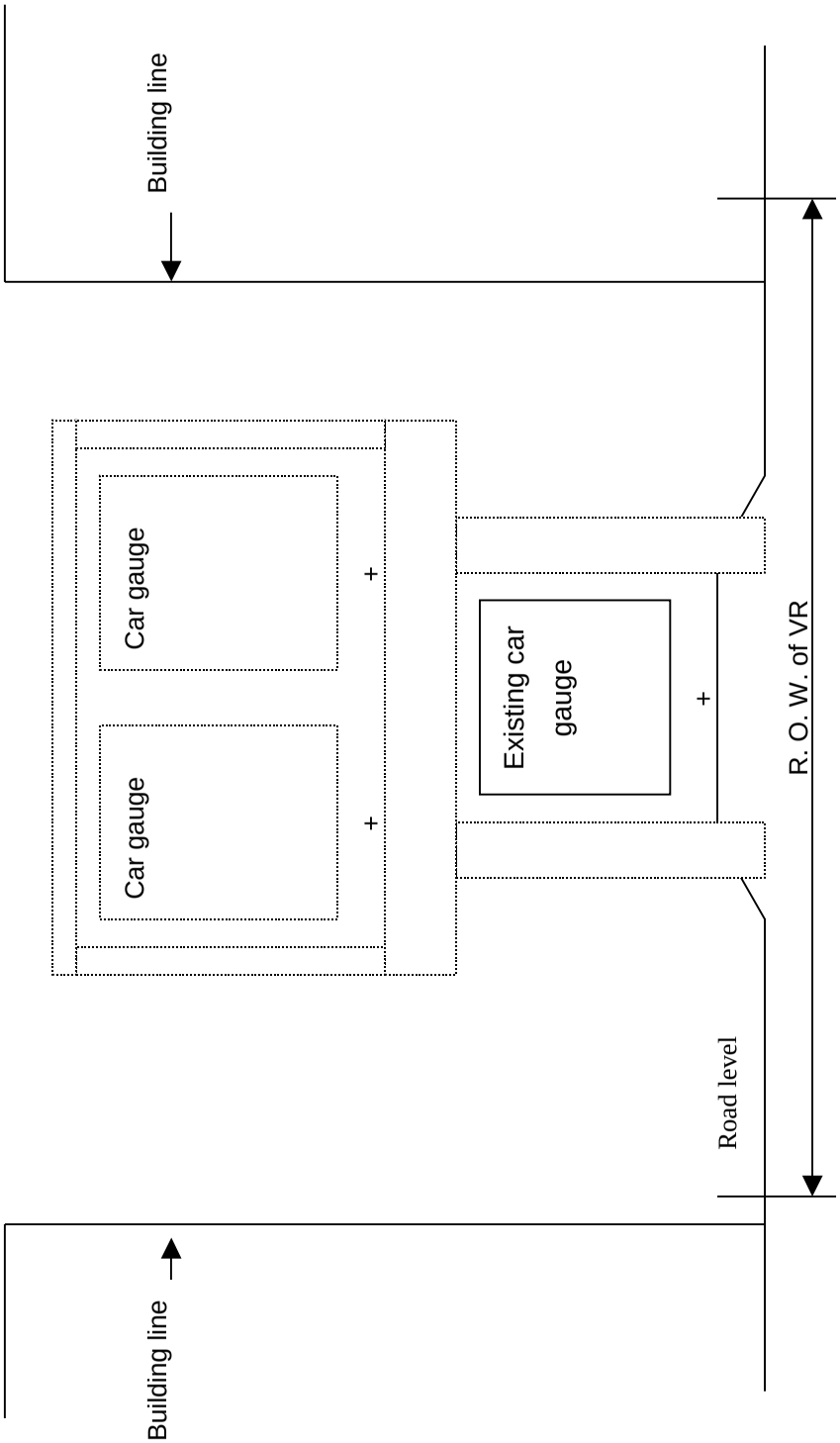


Fig. 4.5.4
An image of the elevated double track in HCM City (Go Vap – Saigon; from Go Vap side)

4.6 New and Large-scale freight stations

Freight trains will be changed from trains of multi-purpose to a single purpose trains, e.g., from trains of many kinds of freight wagons (small lots, many kinds, and many destinations) to trains of larger units, fewer kinds and fewer destinations. Concretely, they will be trains of oil tank lorries, trains of containers, trains of ores, trains of cement, etc. and their destination is one or two. Then the loading or unloading lot of goods/train becomes larger. And a freight station's hinterland will be much larger than the present. A freight station's hinterland for general goods will be a 100km range. Then VR's freight stations will be at every 100km distance. The total length of VR route-km is 2600km, then 2600/100 = 26 freight stations for general goods. Other cases are for freight stations for the important ports, mines, industry parks, and ultra large factories. Then the freight stations shall be reorganized in 30 or so. In the big cities, Hanoi and HCM City, they will have 2 or 3 freight stations including neighboring area. In this long-term strategy, the large-scale freight stations are assumed that every province has one large-scale freight station. Therefore, they are 31 on the existing lines (from 3.2.1 Network, Table 3-2) and 4 on the Mekong Delta line and 1 on the HCM City – Vung Tau line. In total, 36 new large-scale freight stations are assumed. Table 4-26 shows the present freight stations and their handling freight volume and new large-scale freight stations and their handling volume in 2020. The difference is clear. In 1997, the best 30th freight station handles 70,000 tons/year (approx. 200 tons/day). On the contrary, in 2020 if the freight stations are got together and are made large-scaled, the 28th freight station will handle 450,000 tons/year (approx. 1,500 tons/day). More than 100 freight stations are rationalized and the newly united freight stations will show high productivity and also high scale merit. And Fig. 4.6.1 is an imaginary example of a new large-scale freight station handling freight from containers to oil.

Table 4.6.1
Big freight stations in 1997 and in 2020

Fr. Station	1997		Fr. station (by province)	2020	
	10^3tons/year	No.		10^3tons/year	No.
Lam Thao	828	1	Phu Tho	2265	10
Bim Son C.N.	745	2	Thanh Hoa	2265	10
Thanh Hoa	69	30			
Mao Khe	571	3	Ha Long	2113	12
Uong Bi	106	21			
Lao Cai	569	4	Lao Cai	1315	16
Pom Han	429	6			
Lang Vang	163	12			
Co Thanh	478	5	Hai Duong	5274	4
Song Than	361	7	Dong Nai & HCM	11076	1
Bien Hoa	1				
Di An	5				
Hoa Hung (Saigon)	21				
H.P. cang	271	8	Haiphong	5961	3
Vat Cach	138	16			
Van Dien	271	9	Hanoi	7356	2
Giap Bat	224	10			
Yen Vien nam	160	13			
Gia Lam	100	24			
Dong Anh	73	29			
Luu Xa B	220	11	Thai Nguyen	805	20
Dong Ha	158	14	Quang Tri	447	28
Na Duong	145	15	Lang Son	619	24
Dong Dang	114	19			
Vinh	134	17	Nghe An	2643	8
Thinh Chau	100	23			
Ninh Binh	107	20	Ninh Binh	838	21
Dong Giao	86	25			
Danang	105	22	Danang	2535	9
Hue	80	26	Thua Thien-Hue	788	22
Duc lac	74	27	Ha Tinh	921	20
Yen Bai	74	28	Yen Bai	568	25
Quang Ngai	16		Quang Ngai	1283	17
Nam Dinh	12		Nam Dinh	1844	13
Dieu Tri	31		Binh Dinh	1503	15
Ha Dong	52		Ha Tay	1000	19
Tuy Hoa	14		Phu Yen	555	27
Muong Man	12		Binh Thuan	557	26
Thap Cham	9		Ninh Thuan	1200	18
Nha Trang	17		Khanh Hoa	1815	14
New freight stations on new lines					
Vung Tau			Baria-Vung Tau	4137	5
My Tho			Tien Giang	3232	6
Can Tho			Can Tho	3103	7
Vinh Long			Vinh Long	676	23

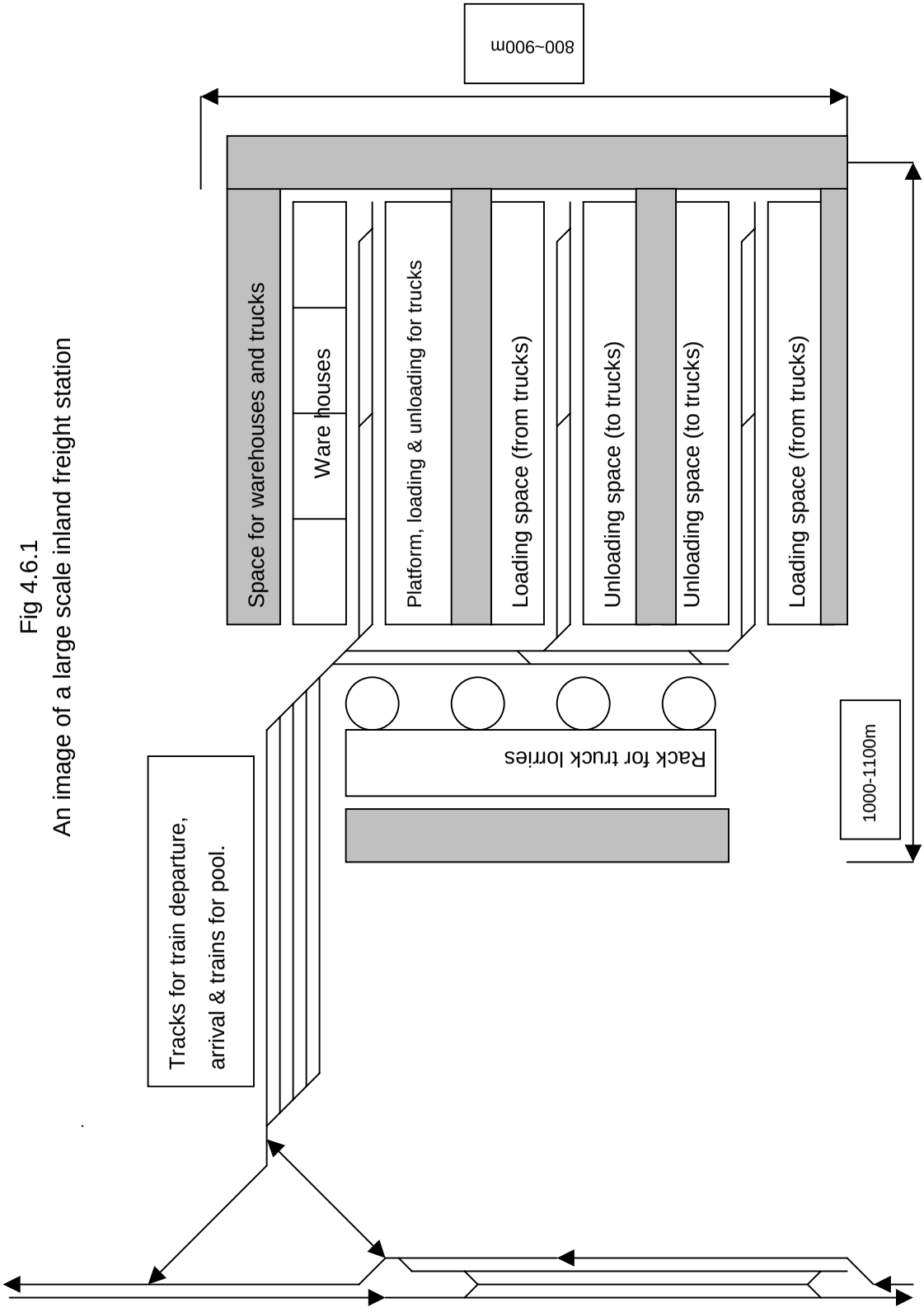


Fig 4.6.1
An image of a large scale inland freight station

New stations for commuters' transportation

Electrified and double- tracked sections have enough afford for many trains. This afford shall be used for the commuters' transportation in big cities such as Hanoi and HCM City. Introduction of EMU's high acceleration and high deceleration peculiarity makes it feasible to set new stations in short distance. Then in double-tracked and EMU sections new stations shall be installed in every 2km distance in average. In the strict meaning of the mass transportation a station interval in the core region shall be approx. 1km distance. In the VR case, (Hanoi area, HCMC area) the distance shall be approx. 2km in average, because each line has the characteristic of suburban transportation, too. Stations on Saigon – My Tho line are supposed to be 1 station/every 2km in the 30km range, and 1 station/every 4km in 30 to 100km, respectively.

Table 4.6.2
New stations for commuters' transportation

Section	Route km	No. of existing stations	New stations
Existing lines			
Hanoi – Do Xa	29	9	6
Hanoi – Bac Hong	26	7	6
Gia Lam – Tuan Luong	33	10	6
Van Dien – Bac Hong	40	3	17
Saigon – Bien Hoa	29	7	8
Sub total			43
New lines			
Saigon – Ben Duc (Saigon –My Tho line)	30 [#1]		15[#2]
HCM City – Long Thanh (Saigon – Vung Tau line)	30[#1]		15[#2]
Airport line	12		6
Sub total			36
All total			79

[#1] *;30 is the distance km from Saigon station.*

[#2]*; 15 is the number in 30km.*

4.7 Rolling stock

As for the rolling stocks, sweeping away the backlogs is realized by replacing old ones with new ones, and transport capacity increase is realized by increasing total number of rolling stocks according to the transport demand. But, practically these renewals are executed in the form of scrap and purchase according to the car life span and the transport demand. So, table 4.7.1~6 show the transition of rolling stock in 2010 and 2020.

All trains of VR are pulled or pushed by locomotives, i.e.,{ locomotive + passenger cars} or {locomotive + freight wagons}. Locomotives, passenger cars and freight

wagons are not fully maintained and replacement to new ones is not sufficient, too. At first, smooth replacement to new rolling stocks is essential. And at second, {locomotive(s) + passenger cars} shall be reconsidered. In passenger transportation EMU (Electric Multiple Unit) train system is much easier for train control and train handling. Then the productivity of passenger cars will be much improved if such multiple unit trains are introduced.

In Vietnam, introduction of DMU shall need further study (effectiveness, technology etc). Basic transportation concept is;

(1) EMU shall be introduced to main lines by electrification; especially in the commuter transport sections.
(2) Freight trains and night trains with sleepers' cars will be hauled by DL or EL.

By this concept, more speedy and higher reliable transportation system shall be realized by minimum investment.

Table 4.7.1
Number of FC

	Owned at the beginning of the period	To be scrapped	To be purchased	Owned at the end of the period
1998	3831<2810>			
2010		3448	6530	6913
2020		383	8679	15209
Total		3831	15209	

Note1) numbers are as of operable for 1000mm gauge.
2) number in brackets < > are actually required for operation.

Table 4.7.2
Number of PC

	Owned at the beginning of the period	To be scrapped	To be purchased	Owned at the end of the period
1998	785<535>			
2010		418	533	900
2020		173		727<280>
Total		591	533	

Note1) numbers are as of operable for 1000mm gauge.
2) number in brackets < > are actually required for operation.

Table 4.7.3
Number of DL

	Owned at the beginning of the period	To be scrapped	To be purchased	Owned at the end of the period
1998	316<108>			
2010		154	193	355
2020		162		193<72>
Total		316	193	

Note1) numbers are as of operable for 1000mm gauge.
2) number in brackets < > are actually required for operation.

Table 4.7.4
Number of EC

	Owned at the beginning of the period	To be scrapped	To be purchased	Owned at the end of the period
1998	0			
2010			356	356
2020			1617	1973
Total			1973	

Note) numbers are as of operable for 1000mm gauge.

Table 4.7.5
Number of EL

	Owned at the beginning of the period	To be scrapped	To be purchased	Owned at the end of the period
1998	0			
2010			40	40
2020			390	390
Total			430	

Note) numbers are as of operable for 1000mm gauge.

Table 4.7.6
Total

	Owned at the beginning of the period	To be scrapped	To be purchased	Owned at the end of the period
1998	4932<3453>			
2010		4020	7652	8564
2020		718	10686	18492
Total		4738	18338	

Note1) numbers are as of operable for 1000mm gauge.
2) number in brackets < > are actually required for operation.

(1) Locomotives;

Existing number of DL in 1998 is 316. But this figure is surmised to hold quite a number of surplus DLs as compared to actual required number. These DLs are manufactured in from 1963 to 1990. Generally, legal depreciation span of rolling stocks is set to 15 years, but it will be extended to 30 years by the careful and periodical overhaul. So, the number of required DLs becomes 355 in the first stage and 72 in the second stage in proportion to increase of transportation volume. But, in this process, it is assumed that the number of DLs should be rationalized to actual required number and low powered DLs (e.g. D4H, D5H) should be substituted for higher powered ones.

(2) Passenger cars;

Existing number of PCs in 1998 is 785. Like the case of DLs, this figure is surmised to hold surplus PCs. Basically, a quite number of PCs that are used for passenger trains should be replaced to EMU. So, the number of required PCs

will become 900 in the first stage and 280 in the second stage.

(3) Freight wagons;

Existing number of FCs in 1998 is 3831. Like a case of DL and PC, this figure is surmised to hold surplus FC. These FCs are manufactured in from 1960's or 1970's. The number of required FCs is 6913 in the first stage and 15209 in the second stage in proportion to the increase of transportation volume on the assumption that the number of FC is rationalized and depreciation span could be extended to 30 years.

(4) Practical implementation plan;

According to this plan, total number of owned PC in 2020 is 727 as compared to actual required number in operation; 280. Balance 447 has become to be surplus. So, it would be more rational that 75 local trains made up of 6 EC in Hanoi~Saigon should be remained in combination EL+6PC in 2020, and be replaced with EMU according to car life-span up to 2030. In this case, investment for 75 trains made up of 6 EC equivalent to 5.7×1012 VND has become will be spend between 2020 and 2030. Likewise, total number of owned DL in 2020 is 193 as compared to actual required number in operation; 72. Balance; equivalent to 4.3×1012 VND shall be spent between 2020 and 2030.

4.8 Preliminary Investment Plan

1) Estimated Investment Costs

The total investment amount is roughly VND 103 x 10^{12}(US$7.3 billion for infrastructure and VND 76 x 10^{12} (US$ 5.5 billion) for rolling stock and operation/ maintenance system, respectively (See Table 4.8.1 and Table 4.8.2).

2) Investment Plan by Line

The investment plans by line have been prepared for Hanoi-Saigon (See Figure 4.8.1), Hanoi – Haiphong (See Figure 4.8.2), Hanoi – Lao Cai (See Figure 4.8.3), Hanoi – Dong Dang (See Figure 4.8.4) and Hanoi – Airport Loop (See Figure 4.8.5).

Table 4.8.1

Estimated Cost for Infrastructure

Stage	Invest item	Quantity	Unit cost (10^9VND)	Invest amount (10^{12}VND)	Note
The first stage (Getting the reliability)	Bridge renewal	110 (18.2km)	126/km	2.3	
	Tunnels	8		3.4	Invest amount is the double tracking of the new 23km
	Tracks Multiple tie tamper	2600km 5	3.2/km 25/machine	8.3 0.1	
	Optic fiber cable	2600km	0.6/km	1.6	
	Signals and switches	Big st. 20 Small st. 420	25/st. 3.1/st.	0.5 1.6	
	ATS [#1]	440	1.3/st.	0.5	
	Sub total			**18.3**	
The second stage (Transportation capacity up)	Setting a new st. in longer section >10km	100 sections	3.8/st.	0.4	
	Double tracking	(1936-23)km	13/km	24.9	Excluding Thua Luu – Kim Lien 23km
	Single tracking	48km	13/km	0.6	Mao Khe – Ha Long
	Two double tracking	5km	25/km	0.1	
	New railway (1) Double track (2) Single track	275 260 15	 50/km 20/km	 13.0 0.3	Can Tho[#2] line, Vung Tau line, Noi Bai airport line, Phu Thai – Mao Khe line.
	Sub total			**39.3**	
Grade up	Electrification	2253+5	13/km	29.4	
	Workshops & Depots	5	255/piece	1.3	For electrified rolling stocks
	Stations for commuters	79	3.8/st.	0.3	
	Large scale freight stations	36	189/st.	6.8	Track length 7km/st.
	Crossing alarm	590	0.5	0.3	
	Grade separation	[#3]D.T.;(14+5)km N.L.10km, Relocation; 3depots	255/km 126/km Relocation; 255/depot	4.8 1.3 0.8	
	Sub total			**45.0**	
Total				**102.5**	

[#1] ATS; Automatic Train Stop

[#2] In the cost, 2 bridges over Mekong River are not included. The unit cost consists of material cost and labor cost. It is fundamentally Japanese cost. The material cost is assumed fundamentally the same in Japan and Vietnam. On the contrary, the labor cost is different. Then the labor cost is modified into Vietnamese from Japanese by multiplying some coefficient.

[#3] D.T.= Double track section 14km (Hanoi – Gia Lam 5km ,Hanoi – Giap Bat 5km, Saigon – Go Vap 4km, the second Hanoi – Gia Lam 5km), N.L. = New lines.

Table 4.8.2

Estimated Cost for Rolling stock, Operation and Maintenance System

Invest item	Quantity			Unit cost (10^9VND)	Amount (10^{12}VND)		
	~2010	~2020	Total		~2010	~2020	Total
Rolling stock							
Loco. (DL)	193		193	38/loco.	7.3		7.3
Loco. (EL)	40	390	430	35.3/loco.	1.4	13.8	15.2
Passenger cars	533		533	5.0/car	2.7		2.7
Freight wagons	6530	8671	15201	1.6/wagon	10.4	13.9	24.3
EMU	356	1617	1973	12.6/car	4.5	20.4	24.9
C.T.C.			440 st.	45.6/12st.			1.7
Ticketing system			30	126/30st.	0.1		0.1
Maintenance system					0.1		0.1
Total							**76.3**

Figure 4.8.1
Main line-wise investment plan (at 2020)

(Hanoi-Saigon)

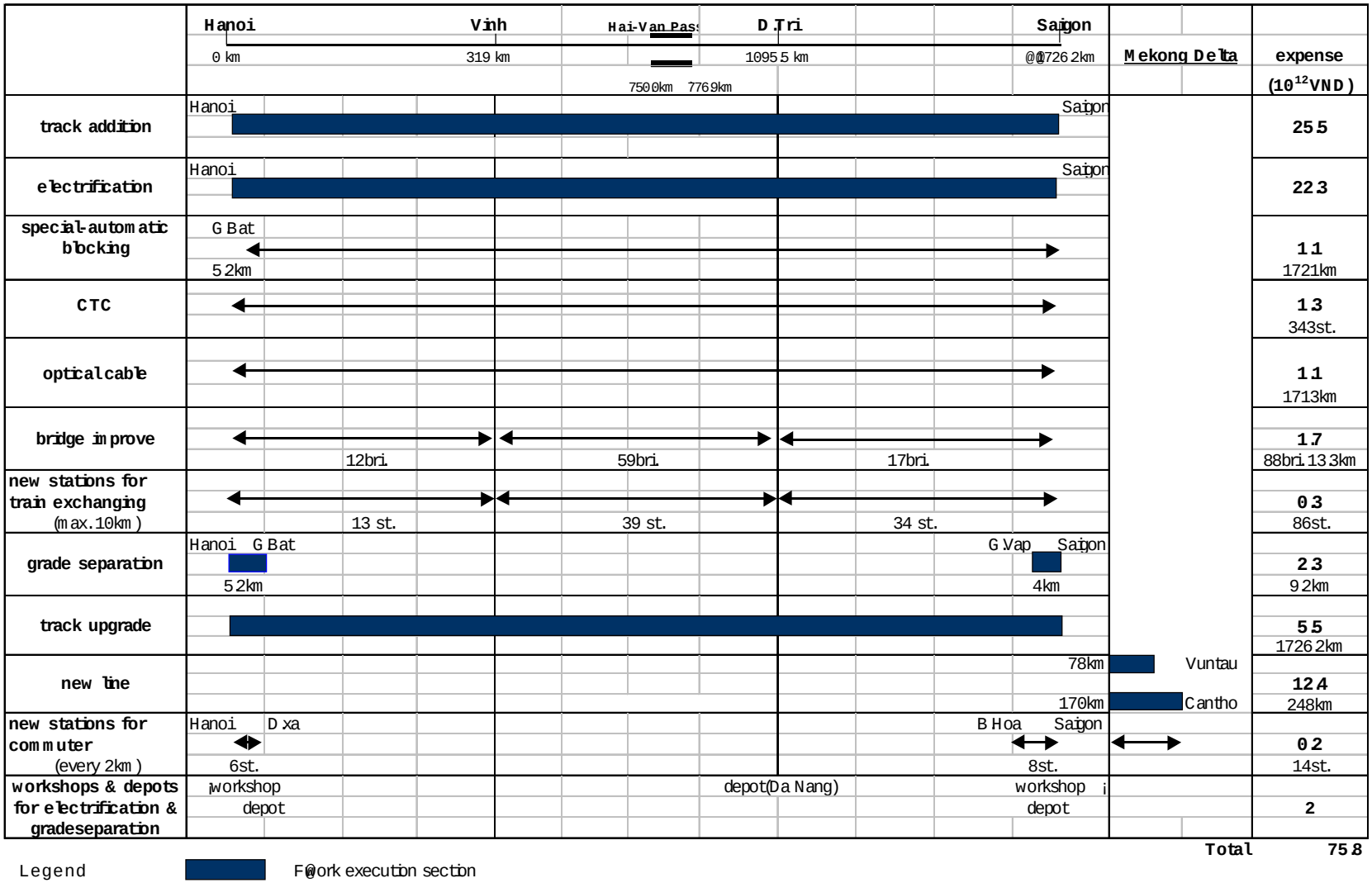


Figure 4.8.2
Main line-wise investment plan (at 2020)

Hanoi - HaiPhong

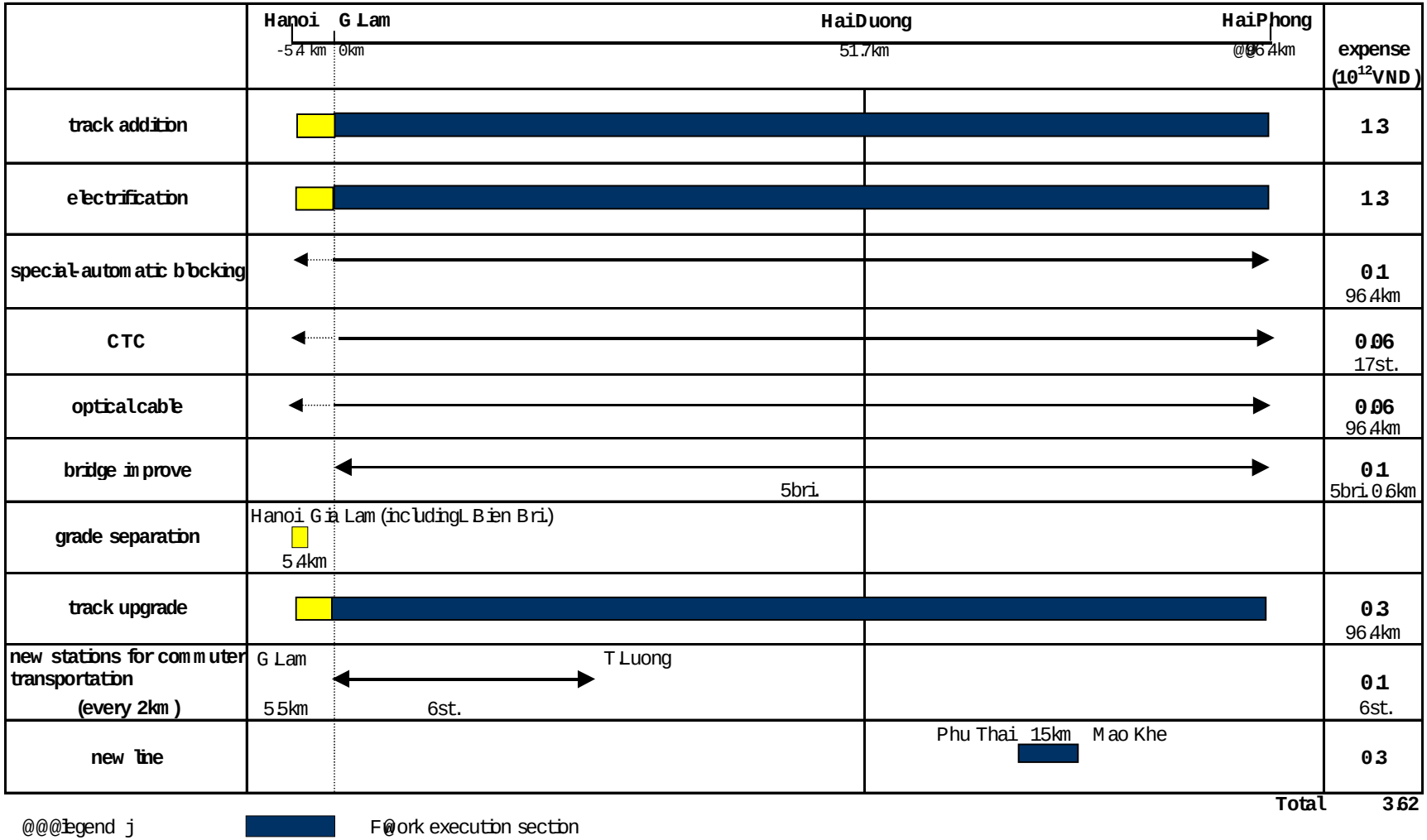


Figure 4.8.3
Main line-wise investment plan (at 2020)

Hanoi – LaoCai

	Hanoi (-10.6km) / Yen Vien (0km, Airport) / Viet Tri (62.1km) / Yen Bai (144.7km) / LaoCai (296.5km)	expense (10^{12}VND)
track addition	Hanoi (Hanoi-Gia Lam 2-double track 5.4km)	0.8
electrification	Hanoi	0.8
special-automatic blocking & colour-light signal		0.3
CTC		0.1 (38st.)
optical cable		0.2 (274.1km)
bridge improve	2bri. / 1bri.	0.1 (3bri. 0.3km)
new stations for train exchanging (max 10km)	5 st.	0.1 (5st.)
grade separation	Hanoi Gia Lam (including L.Bien Bri.) 5.4km	0.3 (2km)
track upgrade		0.9 (274.1km)
new stations for commuter transportation (every 2km)	Hanoi – D.Anh 2st.	0.1 (2st.)
		Total 3.4

Legend: Work execution section

Fig 4.8.4 Main line-wise investment plan(at 2020)

(Hanoi ~Dong Dang)

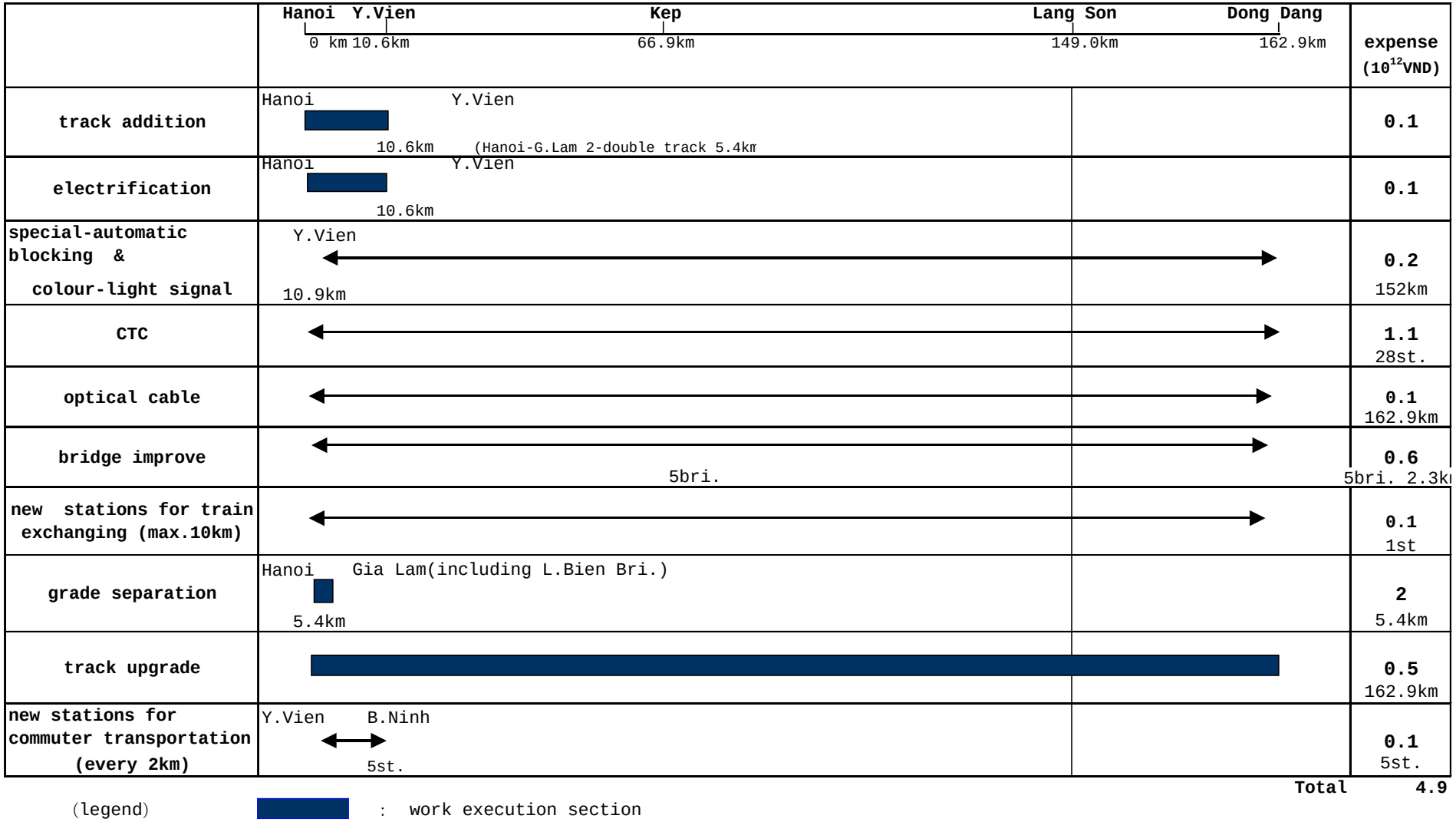
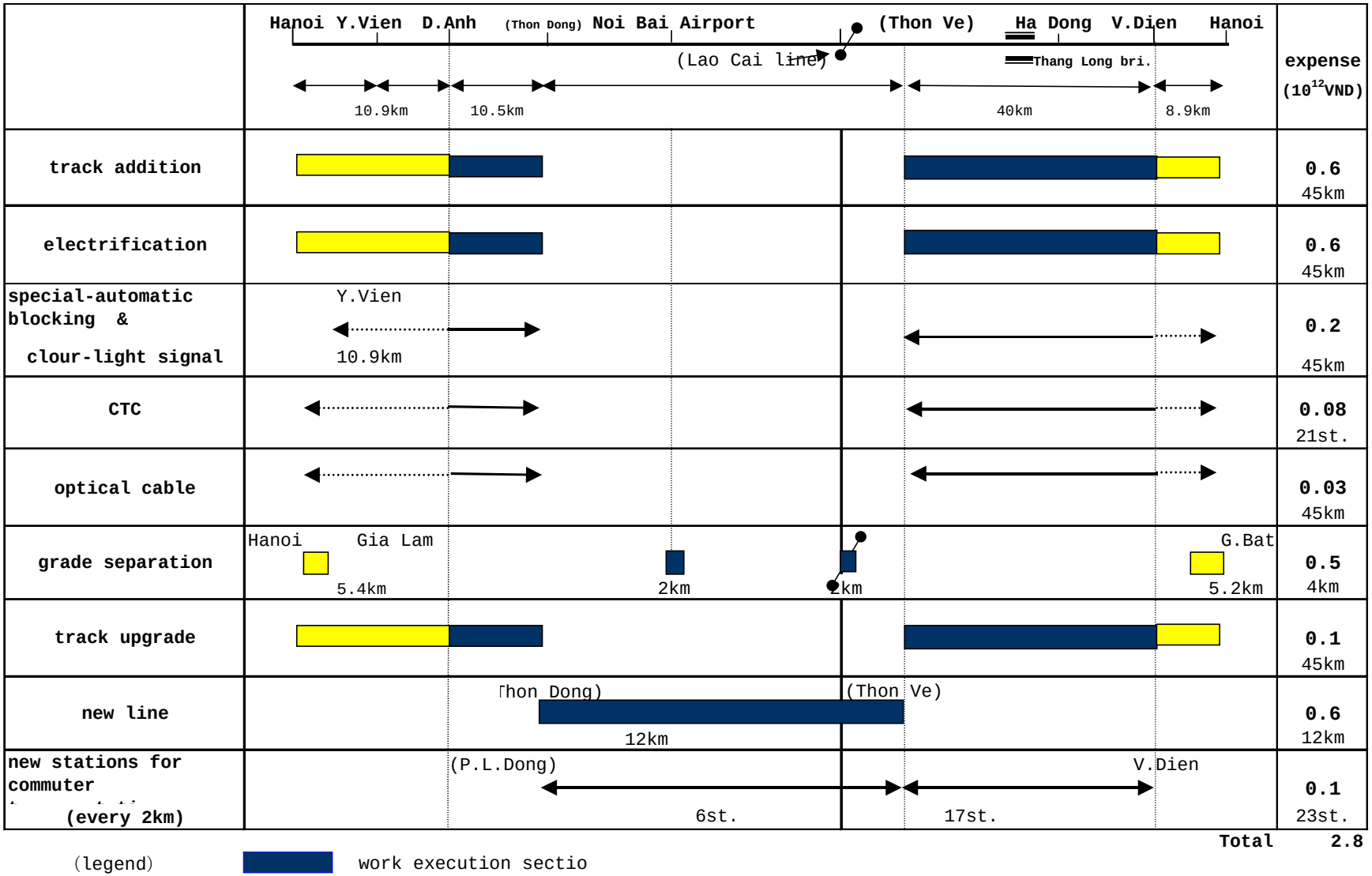


Fig 4.8.5 Main line-wise investment plan(at 2020)

Loop:Hanoi～Airport



4.9 The effect of the investment

The investment of railway sector will need approx.175×10^{12}VND during 20 years from 2000 to 2020, if the transportation demand will increase as projected. What effect will be produced by such amount of investment to the railway. In this section several effects, such as the productivity of employees, speed up, financial influence and railway cost will be explained roughly.

1) Increase in railway productivity.

VR has nearly 42,300 employees at present. And if the infrastructure part is separated from so-called the upper part, VR has 29,000. {20 SOEs (13, 440) and PMU (98) are deducted}. At present, these employees transport 4×10^9 TU in 1998. The same number of employees is expected to transport 14.6×10^9 TU (4.2 times as much as the present volume) in 2010, when the first stage is finished. And in 2020, two cases are assumed. Namely, one case is 40 thousand employees and the other case is 60 thousand employees. Total work volume is 34.5×10^9 TU (9.1 times of the present), then the productivity up is 9.1 times in the former and 6.1 in the latter. 9.1 times is a very high productivity as shown in the highest figures in Japanese railway companies. And 0.58 is also very high productivity in Asian railway figures. And this figure can be attainable. The below table shows several countries' railway productivity. VR's productivity will go up to the highest level in Asia.

Table 4.9.1
Railway productivity in Asian countries

Country	(a) Pass. $\times$km (10^9)	(b) Ton$\times$ km (10^9)	(c = a + b) TU (10^9)	(d) Workers (10^3)	(e = c/d) Productivity (10^6)
Japan					
JR East	127.3		127.3	64.1	2.0
JR Central	50.6		50.6	21.5	2.4
JR West	54.9		54.9	43.4	1.3
JR Shikoku	1.9		1.9	3	0.6
JR Kyushu	8.4		8.4	9	0.9
JR Hokkaido	4.6		4.6	10	0.6
JR Freight		24.3	24.3	8	3.0
China	354.6	1287	1641.6	1908.6	0.9
Taiwan	9.3	1.4	10.7	16.7	0.6
Korea	22.3	13.8	36.1	34.2	1.1
Indonesia	15.9	3.9	19.8	35.7	0.6
Malaysia	1.4	1.4	2.8	6.0	0.5
Thailand	12.3	3.4	15.7	26.3	0.6
India	343.7	278.7	622.4	1583.5	0.4
Bangladesh	3.4	0.7	4.1	55.4	0.1
Vietnam					
At present	2.5	1.3	3.8	42.3	**0.1**
2010	8.6	7.5	14.6	40	**0.4**
2020 (1)	18.1	28.7	34.5	60	**0.58**
(2)				40	**0.86**

The most of the data are from figures of 1996 (UN record).
(1) shows a case of 60 thousand employees.
(2) shows a case of 40 thousand employees.

2) Increase in productivity of rolling stock

Table 4.9.2
Comparison of rolling stock quantity

	1998 (a)	2020 (b)	c = b/a
Transportation volume (10^9TU)	4	35	8.8
DL	316	193	
EL	0	390	
Total	316	583	1.8
Passenger cars	785	727	
EMU		1973	
Total	**785**	**2700**	**3.4**
Freight wagons	**3831**	**15209**	**4.0**

The total railway transportation volume by TU increases 8.8 times, on the other hand the rolling stock doesn't increase so much, as shown in the above table. Productivity of the rolling stock increases nearly 130% (nearly 2.3 times).

3) Speed up

a) Removing the speed limits on deteriorated structures,
b) replacing with new rolling stock that fits for the higher speed,
c) adoption of heavier and longer rail,
d) quick and short train handling at stations (modernized signals and enough information),
e) increased stations (decreased waiting time for train-exchange),
f) double track sections,
g) electrified sections,
h) train approach alarm at heavy traffic crossings, etc.,

All the investments will make the train's speed faster. This effect will be clear in every kind of train. And the local train will show the most noticeable effect. Two assumptions are shown below:

Case 1: The fastest train between Hanoi – Saigon "S1"

- All the deteriorated structures (bridges and tunnels) have been repaired or renewed.
- The total length of track (1713km) has been graded up to 50kg/m and 25m length rail.

- The all route (1713km) has been double- tracked. And all curvatures smaller than R = 400m have been removed and improved to the larger curvature.
- Hai Van pass has changed to a new shortened route (750km to 778km, 28km is shortened to 14km and in the shortened route, there is no speed limited radius),
- The all route has been electrified.

In the above condition, the only constraint of the train speed is the curvature of R = 400m. It is V = $3.5\sqrt{400}$ = 70km/h. Then trains can run more than 70km/h in most sections.

- The power and the speed of EMU or EL has been increased.
- The technical level of track maintenance is high enough for the 70 ~ 120 km/h.

If the above conditions are added, the express train like S1 can run at 80km/h through the line. Then, 1713km/80km/h ~ 21 hours.

An example speed curve is shown in Appendix A-1. This section is 105km long, (or 90km after double-tracking) by removing curve sections with R<400m. 2 hours and 50 minutes will be shortened to 57minutes, or approx. 1 hour. Nearly 2hours will be saved.

Case 2: Hanoi – Haiphong (102km); At present the fastest train runs in 2 hours with one stop at Hai Duong. The average speed is 50km/h. This line has been electrified and double-tracked. Then a EMU train can run more than 70km/h with one stop. Then at least, 1 hour 10 minutes is available between Hanoi – Haiphong (50-minute saving).

Effects of EMU

The EMU has a high ability of acceleration and deceleration, comparing with trains by locomotives. The running curve comparison has been done between a type of EMU and the D12E of VR. The results are shown in Appendix 4-A and summarized in the following.

As shown in Table 4.9.3, stopping every station case was compared in the same condition, i.e., the alignment is improved more than R>400m and no restrictions on the track. Therefore, the difference is the acceleration and deceleration difference. If the EMU can be adopted, from Phu Ly to Hanoi, it takes less than 18 minutes by local train, and by non-stop train, it is only 26 minutes.

Table 4.9.3
Running Time Comparison (D12E and EMU on Section Hanoi – Phu Ly 56km)

	D12E (a)	EMU (b)	Saving c = a – b
Non-stopping	64'34''	38'17" (183 type)	26'16"
Stopping every station	66'26''	48'47" (205 type)	17'39"

For Bien Hoa – Saigon section, non-stopping D12E takes more time than Stopping-every-station D12E. It is caused by the difference of the speed limitation of the present state and of the improved state. As seen in Appendix Figure A-4, the top speed in the former is 56km/h or 30km/h, on the contrary in the latter, the top speed is allowed up to 70km/h by the improving of the alignment. On the section above, it takes 20 minutes by non-stop train, and approx. 26 minutes by local (stopping every station) train, when EMU is introduced.

Table 4.8.4
Running time comparison (D12E and EMU on Section Bien Hoa – Saigon)

	D12E (a)	EMU (b)	Saving c = (a) – (b)
Non stopping	39'36''	19'20''(183 type)	20'16''
Stopping every station	38'10''	26'3''(205 type)	12'07''

The difference between D12E locomotive and EMU is also clear. In Hanoi – Phu Ly case and in Bien Hoa – Saigon case, in both cases EMU's acceleration & deceleration ability shortens the arrival time nearly 1/2 to 2/3 of Diesel Locomotive trains. If the station intervals are much shorter, the difference will become larger. Therefore, in the commuter service or mass transportation in big cities, the EMU is indispensable.

The commuter transportation in big cities, especially in Hanoi and HCM City shall need the quick introduction of EMUs. For instance, EMU trains will transport you in less than 30 minutes from Bien Hoa to Saigon station, or in 40 minutes from Phu Ly to Hanoi. Double tracking and Electrification shall introduce you a fast, safe and punctual transportation.

4) Improvement of reliability and comfort

Investment to infrastructure and rolling stock, and easy-buy of tickets will raise the customers reliability to VR. It will increase the attractiveness of VR. Safety punctuality, riding comfort will also be improved.

5. CANDIDATE PROJECTS FOR MASTER PLAN

5.1 The First Priority Group of The Projects

1) Infrastructure Development

In Vietnam, the train speed is also influenced by the backlog of investment to infrastructures. Some portion of the infrastructure is deteriorated and hasn't enough support force to the normal train speed. Then the first stage of investment is to replace such deteriorated infrastructures with sound infrastructures. Below are the concrete items and figures of such infrastructures to be renewed.

(1) Bridges: Nearly 110 bridges (6% of the total bridges in number) limit the train speed lower than the train speed limit of the section that the bridge itself is included. These bridges must be newly built or rehabilitated.

(2) Tunnels: There are 38 tunnels in VR. In these, speed limitation V≤30km/h applied tunnels are 20 and all of them belong to Hanoi – Saigon line. In Hai Van Pass section there are 7 tunnels. The Hai Van Pass section has the worst alignment in VR. Therefore, a total renewal of the alignment of this section is essential. This section will be built in double tracks. And the new length will be approx. 14 km and the tunnel section will be 10km or so. The tunnel face section for boring is a double track section of approx. 70m^2.

There are 3 more sections where the tunnels shall be necessary to be improved. But they come next to the Hai van pass section improving.

(3) Track structure: Together with the graded up track structure (heavier & longer rail, new fastening, longer sleeper and the wider formation level) the mechanized track maintenance shall be implemented. This upgrading of the track structure shall be implemented at the same time with (double tracking) work. That is, a new track will be mostly constructed in parallel with the existing track. As soon as the new track is completed train will use the new line then old track will be converted to the new track. To complete double track, in the double tracking sections such implementation is the best way of the upgrading track structure.

(4) Communication cable: A total communication cable system shall be laid all over the VR network, i.e., 2600 km long, by the optical fiber.

(5) Signal renewal: Switches and signals shall be improved from manual to automatic system in the frequent train sections. Signal and communication renewal work shall be done at the same time with the double tracking, because the double tracking changes the train operation and yard operation

completely. But in the sections where the double tracking will not be carried out, the signal and communication improvement shall be done independently, together with track upgrading if possible.

2) Operation Improvement

(1) Rolling stock: more reliable rolling stocks with higher speed than the present shall be introduced by applying the new rolling stock's standard which is available in 2020.

Table 5.1.1
Rolling Stock Renewal Plan[1)]

	Owned at the beginning of the period	To be scrapped	To be purchased	Owned at the end of the period
1998	4932<3453>			
2005		2961	1554	3525
2010		1059	6098	8564
Total		4020	7652	

Note: 1) numbers are as of operable for 1000mm gauge.
2) the number in parenthesis is the rolling stock actually required for operation.

(2) Computerization: Computerization of VR offices is badly needed to improve the management information system and increase efficiency and productivity. Other specific areas to be attended include:

(a) Ticketing: Customers can get any ticket at any place where the computer system is prepared. Ticketing system shall be installed at big 30 stations in VR at first and later introduced to smaller stations.

(b) Train control: The computer system on real time {C.T.C (Centralized Train Control) system} shall be introduced, in order to increase efficiency, safety accuracy of the train operation.

5.2 The Second Priority Group of the Projects

The second batch will be mainly for the track capacity increase including the following projects.

(1) Construction of New Stations to Expand Line Capacity

The track capacity is determined by station spacing. In VR there are 301 stations and there are 300 sections. In these 300 sections, there are 105 sections that have the length of more than 10 km, and their line-wise distribution by is as follows:

Table 5.2.1
Estimated No. of Trains, 2010

Section	No. of trains in 2010					No. of trains in 1998
	(a) No. of Pass/day	(b=a/400) No. of pass trains/day	(c) Tons/day	(d=c/500) No. of freight trains/day	(e=b+d) total No. of trains/day	
Hanoi – Nam Dinh	15879	40	9386	19	**59**	28
Quang Ngai – Dieu Tri	9786	25	7130	15	**40**	14
Thap Cham – NhTrang	10272	26	6983	14	**40**	16
Muong Man – Saigon	13998	35	7463	15	**50**	28
Gia Lam – Yen Vien	13248	34	9326	39	**73**	20
Yen vien – Kep	4213	11	8650	18	**29**	14
Kep – Lang Son	1346	4	1521	4	**8**	16
Kep – Ha Long	2384	6	4395	9	**15**	9
Yen Vien – Dong Anh	9296	24	6503	14	**38**	24
Dong Anh – Viet Tri	7242	19	5579	12	**31**	16
Viet Tri – Yen Bai	4504	12	3714	8	**20**	20
Yen Bai – Lao Cai	2476	7	3193	7	**14**	18
Dong Anh – Quan Trieu	1724	5	1092	3	**8**	2
Gia Lam – Hai Phong	13385	34	7277	15	**49**	22

In the above table, all sections in the Hanoi – Saigon line, Gia Lam – Yen Vien and Gia Lam – Hai Phong exceed 40 trains/day and putting more trains becomes more difficult in 2010. The commuter transportation will be added in 2010 and the train numbers will exceed the single track capacity 60 ~80 in some of these sections. Therefore, shortening the interval length between stations and double tracking are necessary for such sections.

Table 5.2.2
Sections Longer Than 10km, and Number of Trains Operated

Line	No. of Sections more than 10km	Number of trains operated	
		(1999)	2010
Hanoi – Saigon	**90**	11 to 28	40~60
Hanoi – Lao cai	**5**	8 to 24	14~40
Gia lam – Lang son	**1**	6 to 16	8~73
Gia lam – Hai phong	**1**	4 to 22	49
Hanoi – Quan trieu	0	2	8
Kep – Ha long	5(3)	4 to 9	16
Van dien – Bac hong	3	2	
Total	105(100)		

(2) Double tracking

In order to increase the line capacity further some sections may need double tracking such as Hanoi – Saigon line, Hanoi – Hai Phong line, Hanoi – Yen Vien.

Table 5.2.3
Double Tracked Sections

Line or section	Sections	Length (km)
Hanoi – Saigon	Hanoi – Phu Ly Hue – Da Nang Bien Hoa – Sai Gon	56 90 29
Hanoi – Yen Vien	Ha Noi – Yen Vien	11
Gia Lam – Hai Phong	Gia Lam – Hai Duong	52
Total		238

Hue – Danang (including Thua Luu – Da nang) section shall be electrified because of the long and new Hai Van Pass tunnel (10km length). The electrified section is 90km between Hue and Danang, from the viewpoint of the effective locomotive operation.

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5.3 Further Options

1) New Railway Lines

Mekong delta area is the most populated area and its socio-economic activities are very active. Therefore, the first new railway line in Vietnam shall be HCM City to Can Tho, especially Saigon station to My Tho. This line can also serve as a commuter line along its 70km.

2) Modernization of the railway transportation

Further options to modernize and improve the efficiency and productivity of railway are as follows:

(1) Introduction of EMU and DMU trains: Multiple unit trains are far more productive (efficient) in the passenger transportation which will be introduced for commuter transportation and trains without sleepers' cars. The commuter trains in the electrified sections shall be all EMU.

(2) Electrification: Electrification has much merit, such as easier operation, easier maintenance, lighter weight and higher power, higher speed, higher productivity, etc. The commuter sections and Hue – Da nang section will be electrified because of the long new tunnel (l = 10km). All sections of Hanoi – Hai phong line shall be electrified which is about 100 km.

Table 5.3.1
Possible Electrified Sections

Line	Section	Length km
Existing lines		
Hanoi –Saigon	Hanoi – Phu Ly	56
	Hue – Da Nang	90
	Bien Hoa – Saigon	29
Hanoi- Hanoi junct.	Hanoi – Yen Vien	11
Hai phong line	Gia Lam – Hai Phong	97
Total		265
Cantho line (New)	Saigon – My Tho	70

(3) Workshops and depots for the electrified rolling stock: Electrification and introduction of EL and EMU require workshops and depots for maintenance of electrified rolling stocks. Two workshops will be necessary in Hanoi and HCM City, and 3 depots in Hanoi, Danang and HCM City.

Table 5.3.2
Workshops and Depots for Electrified Rolling Stocks (VND)

	Quantity	Unit cost	Total amount	Note
Workshops	2	255×10^9	0.5×10^{12}	Hanoi, HCM City
Depots	3		0.8×10^9	Hanoi, Da nang, HCM City
Total	5		1.3×10^9	

(4) Crossing Improvement: Approx. 1000 level crossing must be provided with alarm equipment or alarm and crossing barrier.

At-grade crossings with heavy trafficked roads Hanoi and HCM City may require grade separation. Possible sections include:

(a) The section between Hanoi station and Gia lam in the north (5.4km) and between Hanoi station and Giap bat station in the south (5km).
(b) The section between Saigon station and Go vap station (4km).
(c) The section in the HCM City (10km) of new HCM city – My Tho line.

5.4 Preliminary Estimate of Investment Costs (Rough summation)

The investment costs required for the possible projects are shown in the following Table.

Table 5.4.1
Investment Cost for Infrastructure

Stage	Investment item	Quantity	Unit cost (10^9VND)	Invest amount (10^{12}VND)
The first stage (Getting the reliability)	Bridge renewal	39 (8.4km) [#3]	126/km	1.1
	Tunnels	7		3.4 [#5]
	Track upgrade	2600km	3.2/km	8.3 [#6]
	Multiple tie tamper	5	25/machine	0.1
	Optic fiber cable	2600km	0.6/km	1.6
	Signals and switches	Big st. 20 Small st. 420	25/st. 3.9/st.	0.5 1.6
	ATS [#1]	440	1.3/st.	0.5
	Sub total			**17.1**
The second stage (Track capacity up) up to 2010	Setting a new st. in longer sections >10km	100 sections	3.8/st.	0.4
	Double tracking	(238-23)km	13/km	2.8 [#7]
	New railway [#2]	60km	50/km	3.0
	Sub total			**6.2**
Grade up	Electrification	335km	13/km	4.4
	Workshops and depots	Workshop;2 Depots; 3	255/piece	1.3
	Stations for commuters	26	3.8/st.	0.1
	Crossing alarm	590	0.5	0.3
	Grade separation	[#4]D.T.;14km N.L.10km, Relocation; 3 depots	255/km 126/km Relocation; 255/depot	3.6 1.3 0.8
	Sub total			**11.8**
Total				**35.1**

[#1] ATS; Automatic Train Stop
[#2]; Mytho line 70km shall be constructed up to 2010.
[#3]; 39 (8.4km) is the figure of the bridges renewed in the 2000 ~2010 period. Other 72 bridges shall be renewed in 2010~2020 period. In the figure of 8.4km, the Long bien bridge (length = 1.6km) is calculated by the double tracked length 3.2km, to meet with the unit price.
[#4]; D.T.= Double track section, N.L. = New lines.
[#5]; 3.4 shows the figure of the double-tracking cost of 23km between Thua luu and Da nang. ***In this section 7 Hai van pass tunnels are included.***
[#6]; Track upgrade shall be introduced with the double tracking work, if the track upgrade is included in the double-tracking section.
[#7]; $3.0 \times 10^{12} = (238 - 23) \times 13 \times 10^{9}$. 23km is excluded from the double tracking. Because this 23km has been calculated in the former item "tunnel".

Table 5.4.2
Investment Cost for Rolling Stock, Operation and Maintenance System

Invest item	Quantity			Unit cost (10^9 VND)	Invest amount (10^{12}VND)			Note
	2005	2010	Total		2005	2010	Total	
Rolling stock								
Loco. (DL)		193	193	38/loco.		7.3	7.3	
Loco. (EL)		40	40	35 /loco.		1.4	1.4	
Passenger cars	82	451	533	5.0/car	0.4	2.3	2.7	
Freight wagons	1472	5058	6530	1.6/wagon	2.4	8.1	10.5	
EMU		356	356	13/car		4.6	4.6	
C.T.C.			440 st.	45.6/12st.			1.7	
Ticketing system			30	126/30st.		0.1	0.1	
Maintenance system						0.1	0.1	
Total							**28.4**	

5.5 Preliminary Implementation Plan by Line

Implementation plan for the project lines are preliminarily worked out as shown in the following figures.

Fig5-1 Main line-wise investment plan(at 2010)

(Hano

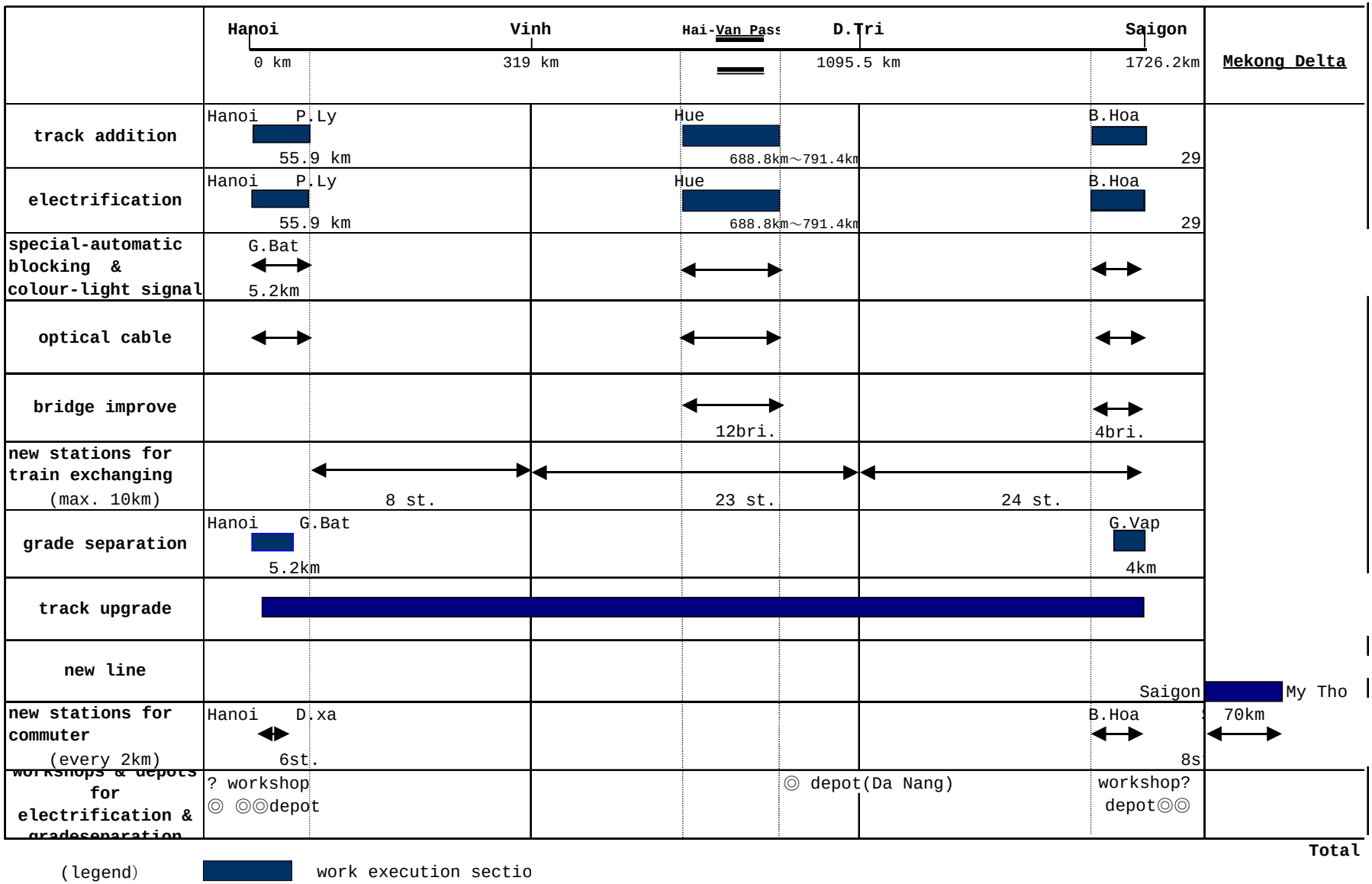

Fig5-2 Main line-wise investment plan(at 2010)

（Hanoi～Hai Phong）

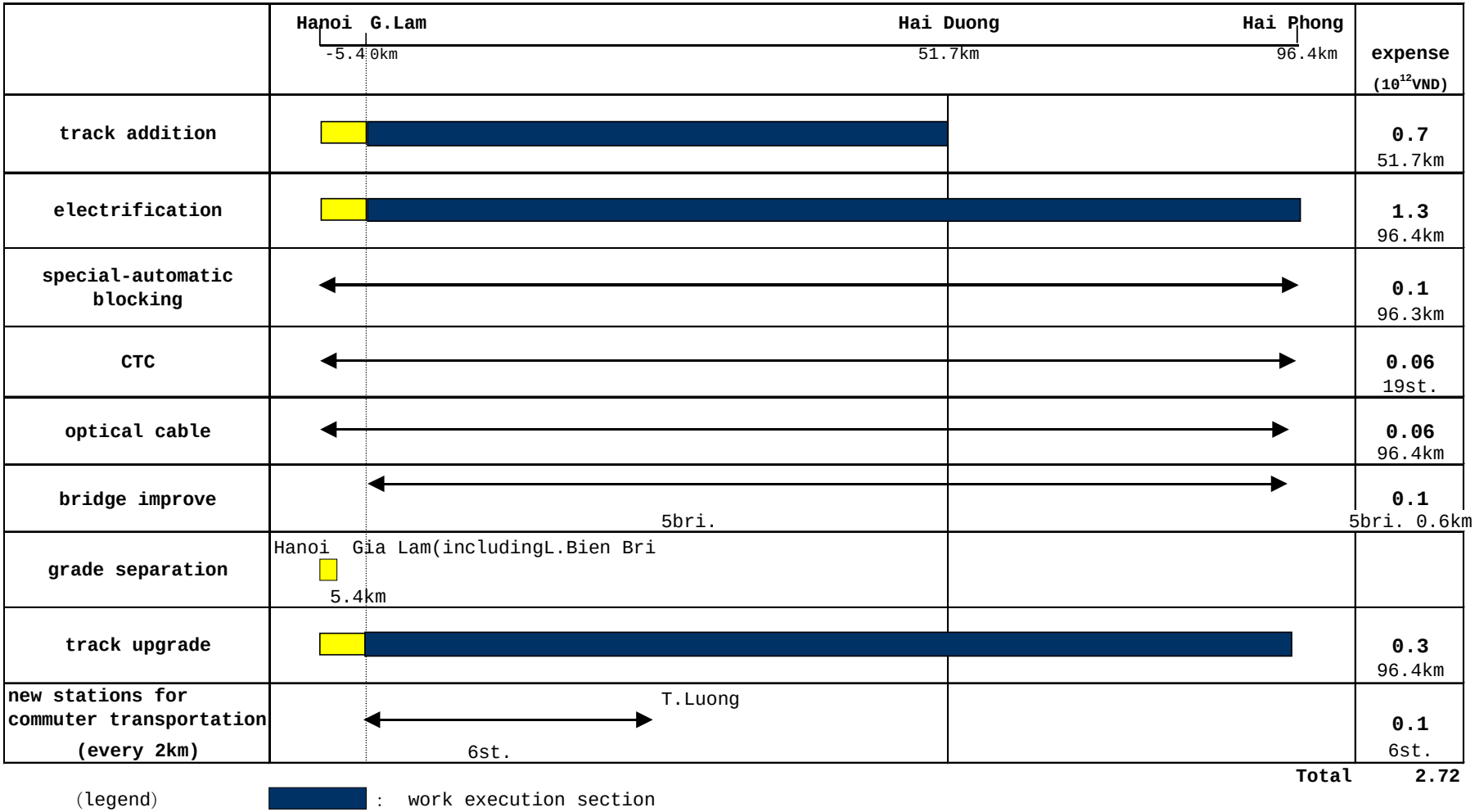

Fig5-3 Main line-wise investment plan(at 2010)

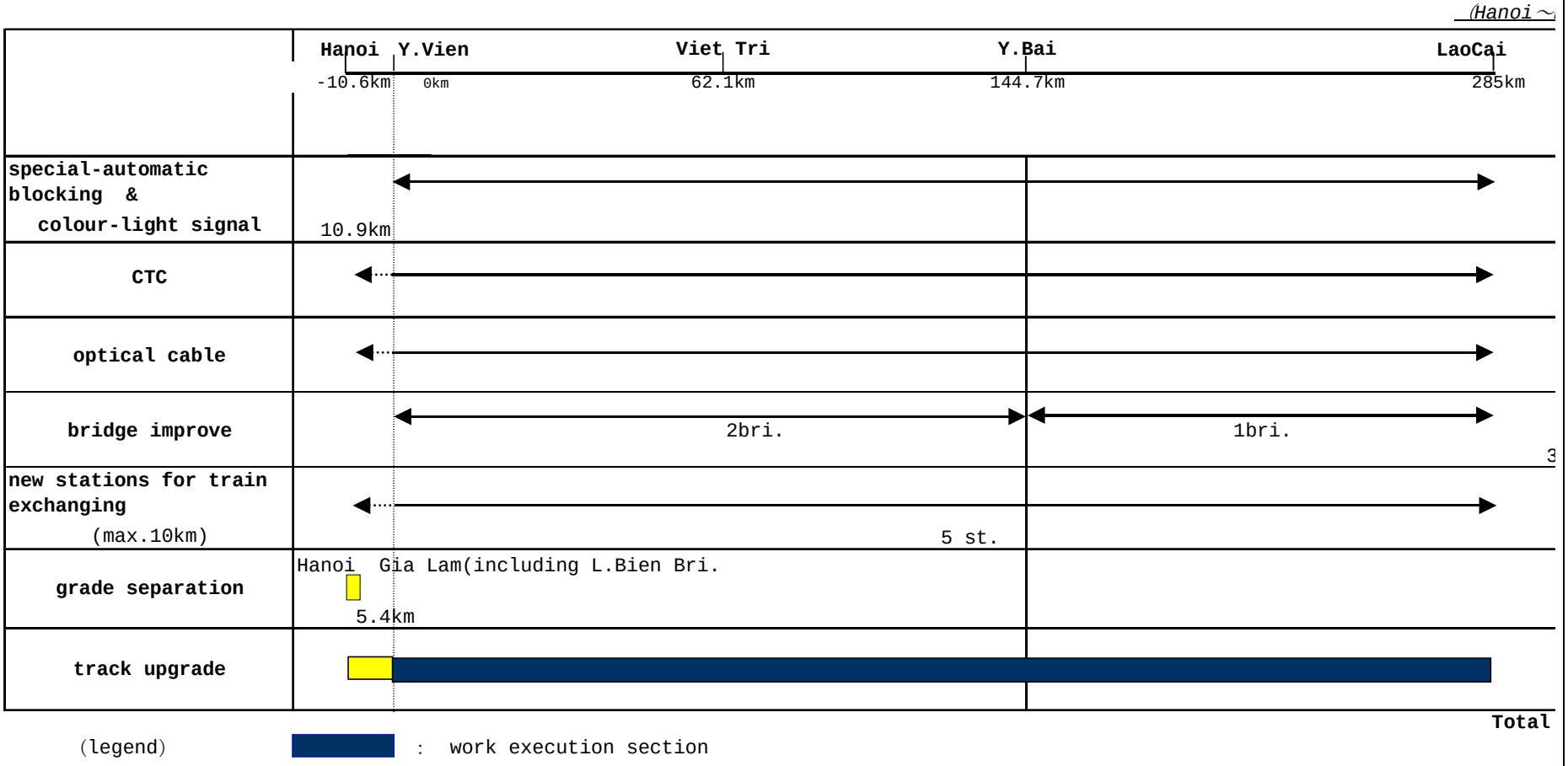

Fig5-4 Main line-wise investment plan(at 2010)

Hanoi Dong Dang j

	Hanoi Yen Vien 0 km 106km — Lang Son 149.0km — Dong Dang 162.9km	expense (10^{12}VND)
track addition	Hanoi Yen Vien 106km	01
electrification	Hanoi Yen Vien 106km	01
special-automatic blocking & colour-light signal	Yen Vien 109km	02 152km
CTC		11 28st.
optical cable		01 162.9km
bridge improve	4bri.	01 4bri. 0.7km
new stations for train exchanging(max 10km)		01 1st
grade separation	Hanoi Gia Lam (including L. Bien Bri.) 5.4km	14 5.4km
track upgrade		05 162.9km
new stations for commuter transportation (every 2km)	Yen Vien 2st.	001 2st.
		Total 3.71

@@@legend j F@ork execution section