11.6 Implementation Program

To establish the implementation program of the road network projects, the scheduling concept and procedure was set up to include a future budgetary framework based on the actual road investment in the past and the planned investments for different authorities in-charge of the different elements of the road network in Hanoi.

11.6.1 Procedure

After estimating the costs and benefits for all the projects on an individual basis and in inter-related packages, the economic return was determined based on the benefit / cost ratio which was taken account as a ranking factor. On the other hand, a future budgetary framework was set up based on the past and planed road investments.

Other aspects, rather than the B/C ratio, were included in the established priority ranking criteria, such as the project status, social and physical environment and its expected development impact, in order to get more comprehensive prioritization and scheduling procedure. The work flow of the established procedure is as presented in Fig. 11-6-1.

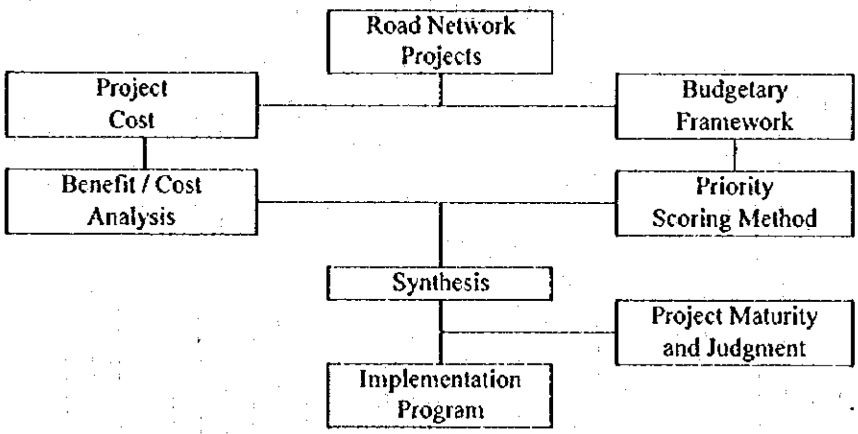


Fig. 11-6-1 Road Network Scheduling Work Flow

11.6.2 Budgetary Framework

In order to formulate an effective and useful masterplan, the scale of investment must be determined in a moderate range. If the total amount is far beyond the financial capacity, the plan will result in a mere dream. On the other hand, the masterplan has the nature of the long-term goal to be targeted. In this sense, a masterplan should aim at the maximum possible investment taking the future economic growth and budget increase into consideration.

In this procedure, the past and planned road investments in the study area either by the MOTC or HPC through TUPWS and districts offices were comprehensively analyzed to establish the following annual schedule.

11.6.3 Annual Schedule

The recommended road network in the master plan is composed of different projects covering a total of about 1,230 Km of which about 490 Km are improvement, upgrading and rehabilitation works and 740 kilometers for new construction schemes. The total number of the road and related structure projects in the plan is 53 projects which can be administratively set up as in the following three groups:

A:	National Highway	9 Projects
B:	Rural Hanoi	6 Projects
C-G:	Urban and Suburban Hanoi	38 Projects

These projects are composed of 27 segments or sub-projects for the national highways, 86 sub-projects for roads in rural areas and 104 sub-projects for urban and suburban roads. Structure projects include the construction of three long-span bridges over the Red River and two bridges over the Duong River as well as small bridges on new roads and the rehabilitation of 11 bridges in urban and rural areas.

In addition, four interchanges are required in the existing built-up area of the city together with grade-separation schemes for expressways in suburban areas. The road projects also include the development of the road networks in eight newly planned urbanized centers located in the suburban and rural areas of Hanoi.

Many project segments were grouped to be implemented into packages of related projects to maximize their benefits. On the other hand, the implementation schedule of 20 years was divided into three programs as follows:

Short Term	from	1996	to	2000
Medium Term		2001		2005
Long Term		2006		2015

The following items are taken into consideration when planning the starting year and the completion year of each project package:

(1) To set the starting year so to complete the package in the designated program period depending on its implementation period.
(2) To establish an increasing trend of annual investment without remarkable fluctuation taking into consideration the budgetary limitations and constraints.
(3) To implement a set of related projects and packages on optimum way that economizes the cost.
(4) To include the detailed engineering design just before the beginning of the implementation period of each project.

The proposed annual schedule for implementation, as presented in Table 11-6-1, mostly satisfies the criteria established above. As shown in the table, the main projects to be implemented in each program are shown in Table 11-6-2.

Table 11-6-1 Road Projects Implementation Program

Package	Project Name	Length [km]	Cost [b. VND]	Year																			
				96	97	98	99	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
A	NATIONAL HIGHWAYS	132.525	12,445.7																				
A01	National Highway 2 Improvement Project	5.500	96.6																				
A02	National Highway 3 Improvement Project	32.500	643.8																				
A03	National Highway 5 Extension Construction Project	10.700	537.0																				
A04	National Highway 32 Improvement Project	8.500	427.1																				
A05	National Highway 18 Construction Project	18.000	299.5																				
A06	Lang Hoa Lac Expressway Construction Project	2.750	113.1																				
A07	South Ring Road 3 Construction Project	19.525	4,787.7																				
A08	North Ring Road 3 Construction Project	28.800	4,570.7																				
A09	Noi Bai Expressway Upgrading Project	6.250	655.3																				
B	RURAL ROADS IMPROVEMENT	353.200	1,764.9																				
C	URBAN ROADS	72.025	10,991.9																				
C01	Ring Road 1 Improvement Project	6.500	967.9																				
C02	Ring Road 2 Improvement Project	17.000	2,340.1																				
C03	Red River Dike Improvement Project	19.300	1,626.9																				
C05	Urban Street Width Adjustment Project	9.935	1,784.3																				
C0601	Station Tunnel	1.500	656.5																				
C0602	Linh Quang - Cho Kham Thien	1.025	226.1																				
C0603	Yen Lang Drain Road	2.815	437.8																				
C0604	Lieu Giai Extension - North	0.590	206.3																				
C0605	Lieu Giai Extension - South	1.825	838.0																				
C0606	Nui Truc Extension	1.060	370.6																				
C0607	South Thang Long - Buoi Road	2.675	300.8																				
C07	West Lake Parkway Construction Project	3.900	281.6																				
C08	Hanoi Interchange Construction Project	2.600	700.0																				
C09	Hanoi Bridge Capacity Increase Project	1.300	654.9																				
D	HANOI NORTH DEVELOPMENT AREA	300.130	7,353.8																				
D01	Dong Anh Highway Construction Project	12.100	4,010.2																				
D02	Dong Anh New City Road Network	53.690	631.9																				
D03	Soc Son New City Road Network	59.450	686.8																				
D04	Gia Lam New City Road Network	127.870	1,457.4																				
D05	North Thang Long New City Road Network	47.010	567.5																				
E	NEW CBD ROAD NETWORK	73.400	1,567.7																				
E01	Ring Road 2 North Extension Project	7.800	422.4																				
E02	South Thang Long Road Project	1.890	87.4																				
E03	New Ring Road 2 Project	6.200	179.7																				
E04	New CBD Road Network	52.010	740.5																				
E05	Ring Road 3.5 Project	5.500	137.7																				
F	HANOI URBAN DEVELOPMENT CORRIDOR	199.995	3,611.7																				
F01	New Ring Road 2 Project	8.625	285.1																				
F02	Lang Ha - Ha Dong Road Project	5.500	148.9																				
F03	Lang Hoa Lac Expressway Construction Project	1.750	112.1																				
F04	Ring Road 3.5 Project	13.250	283.7																				
F05	Provincial Road 70 B (413) Upgrading Project	7.500	158.7																				
F06	Nhue River Road Project	13.760	127.6																				
F07	Ma Tri Road (to Ba Vi EWay)	4.250	84.4																				
F08	Bach Mai Airport Road	5.350	112.7																				
F09	Xuan La New City Road Network	18.920	311.3																				
F10	Yen Hoa New City Road Network	101.060	1,660.2																				
F11	Dai Kim New City Road Network (1)	20.030	329.1																				
G	HANOI SOUTH DEVELOPMENT AREA	48.250	1,632.4																				
G01	New Ring Road 2 Construction Project	5.580	184.6																				
G02	Linh Nam Road	3.250	88.1																				
G03	Red River Dike	7.500	217.6																				
G04	Ring Road 4 South	2.250	43.9																				
G05	Mai Dong Road	7.630	659.3																				
G06	Vinh Khai Extension	4.000	80.7																				
G07	Ring Road 3.5	2.400	46.8																				
G08	South Road Network	15.640	311.3																				
	TOTAL	1,189.5	39,398.1																				

Table 11-6-2 Main Road Projects Implementation Program

Project Code	Project Section	Sub-Rank
A Short Term Program [1996 - 2000]:		
A02	National Highway 3 Improvement	A-2
A06	Lang Hoa Lac Expressway Construction	A-2
A07	South Ring Road 3 Construction	A-1
C03	Red River Dike Improvement	A-2
C05	Urban Street Width Adjustment	A-3
C0605	Lieu Giai Extension Street - South	A-3
C0607	South Thang Long - Buoi Street	A-1
E01	Ring Road 2 North Extension Road	A-2
E02	South Thang Long Road	A-1
B Medium Term Program [2001 - 2005]:		
A03	National Highway 5 Extension Construction	B-2
A04	National Highway 32 Improvement	B-2
C02	Ring Road 2 Improvement Project	B-2
C0606	Nui Truc Extension	B-3
C09	Hanoi Bridge Capacity Increase Project	B-1
E03	New Ring Road 2 Construction	B-1
E04	New CBD Road Network	B-1
F02	Lang Ha - Ha Dong Road	B-2
F03	Lang Hoa Lac Expressway Construction	B-2
F07	Me Tri Road Construction	B-3
F08	Bach Ma Airport Road Construction	B-3
G01	New Ring Road 2 Construction	B-2
G02	Linh Nam Road	B-3
G04	Ring Road 4 South	B-3
G06	Minh Khai Extension Road	B-3
G07	Ring Road 3.5 Construction	B-3
C Long Term Program [2006 - 2015]:		
A05	National Highway 18 Construction [Hanoi Section]	C-2
A08	North Ring Road 3 Construction	C-2
A09	Noi Bai Expressway Upgrading	C-3
C01	Ring Road 1 Improvement Project	C-2
C0601	Station Tunnel	C-2
C0602	Linh Quang - Cho Kham Thien Street	C-3
C0603	Yen Lang Drain Street	C-3
C0604	Lieu Giai Extension Street - North	C-3
C07	West Lake Parkway Construction	C-2
C08	Hanoi Interchange Construction Project	C-2
D01	Dong Anh Highway Construction	C-1
E05	New Ring Road 3.5 Construction	C-3
F05	Provincial Road 70B Upgrading Project	C-3
F06	Nhue River Road Project	C-3
F09	Xuan La New City Rad Network	C-2
F010	Yen Hoa New City Road Network	C-1
F011	Dai Kim New City Road Network	C-1
G03	Red River Dike Road	C-3
G05	Mai Dong Road	C-3
G08	South Road Network	C-3

11.7.4 Financial Requirement

The road network development projects in this plan are under the jurisdiction of different authorities for implementation including the MOTC, HPC-TUPWS and District Offices. The funds required for each of the authorities' group of projects was estimated separately for each implementation program as presented in Table 11-6-3 and on annual base as in Fig. 11-6-2 for MOTC and TUPWS projects.

Table 11-6-3 Total Financial Requirements

[Unit: B.VND]

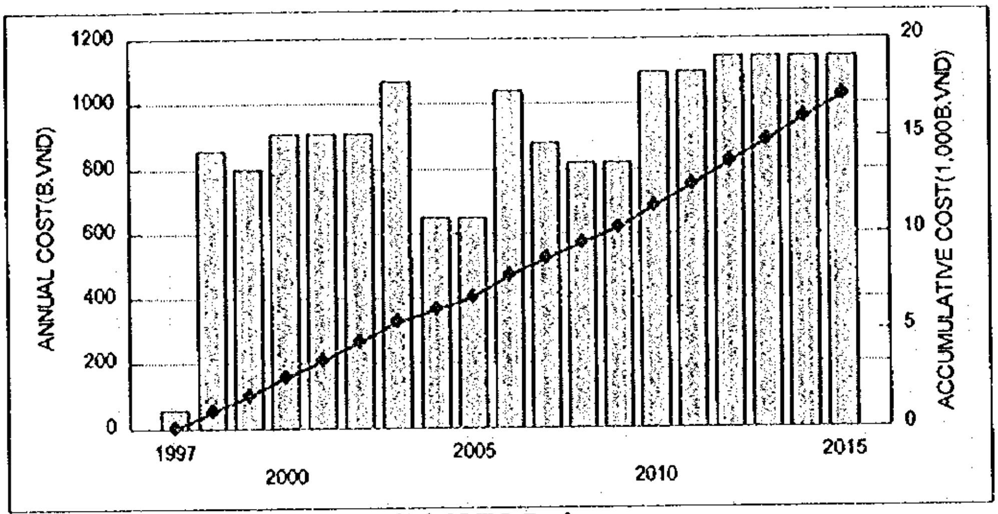
PROGRAM / ORGANIZATION	1996-2000	2001-2005	2006-2015	TOTAL
MOTC	2,620.1	4,466.1	10,613.0	17,699.1
TUPWS - Conventional	1,875.0	4,339.6	5,260.4	11,475.1
TUPWS - Development	298.6	1,816.3	3,064.6	5,179.4
TUWPS Total	2,173.6	6,155.9	8,325.0	16,654.4
DISTRICT	451.2	522.2	811.5	1,784.9
TOTAL	5,244.8	11,144.1	19,749.5	36,138.5

Under the MOTC there are the improvement and construction projects of the national highway network and two other bridges over the Red River [Dong Anh Bridge and New Chuong Duong Bridge]. In addition, the two projects of NH-6 and NH-32, which are partially under TUPWS at present, are included in this group as any major upgrading schemes are expected to be implemented by the MOTC. The total number of project packages is 11 with a total cost of about 17,700 billion VND to be used over the period of 20 years up to 2015.

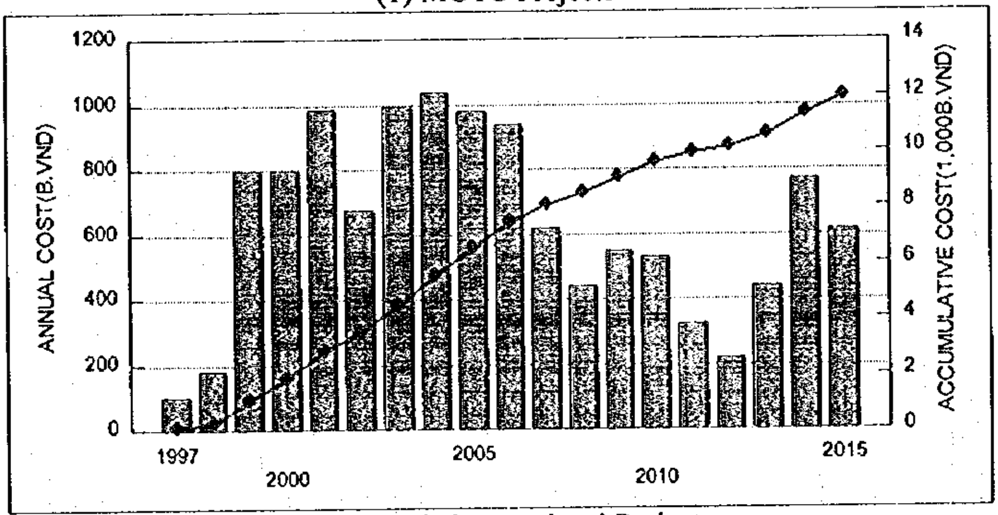
TUPWS Projects are divided into "Conventional Projects" which include all the improvement and construction of roads and bridges under their jurisdiction, and "Development Projects" which are the road projects required for the development of new urbanized areas and cities through a land development corporation. The first group of projects requires a total fund of about 11,500 billion VND and the second 5,200 billion VND with a grand total of 16,700 billion VND.

Improvement projects for rural roads are generally implemented under the District Offices and the financial program for these projects was established based on the annual road construction budget of each of the five rural districts as presented in Section 11.6.2. A total of about 1,800 billion VND is required to cover the improvement works for the rural road network.

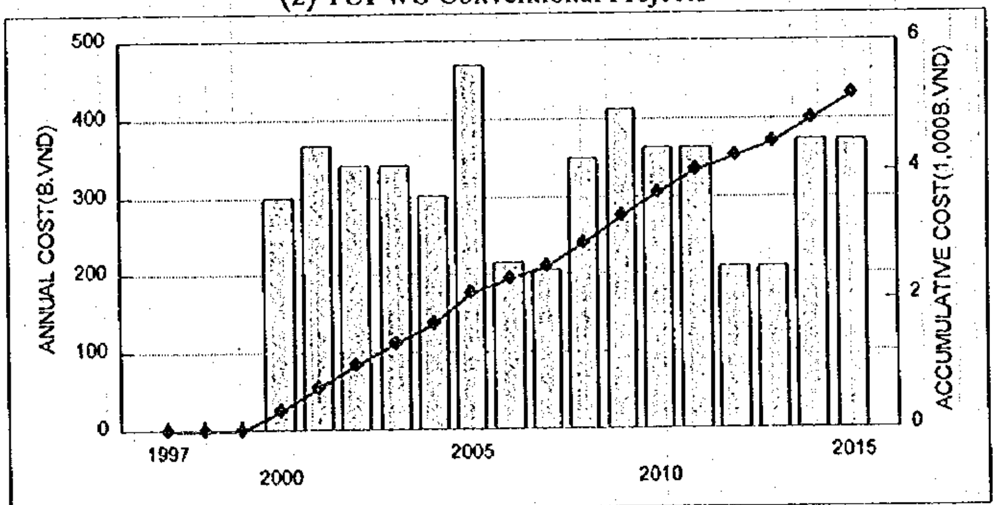
To implement the master plan road network projects, in order to improve the road transport infrastructure and system over the next twenty years to cope with the future transport demand resulting from the increasing economic growth, the road sector in Hanoi City requires a total of about 36,000 billion VND with an annual average of 1,800 billion VND.



(1) MOTC Projects



(2) TUPWS Conventional Projects



(3) TUPWS Development Projects

Fig. 11-6-2 Annual and Accumulated Financial Requirements

CHAPTER 12 BUS PLAN

12.1 Public Transport Demand

12.1.1 Total Potential Demand

The public transport potential demand in 1995, 2005 and 2015 is shown in Table 12-1-1. The total public transport demand in the year 1995 was 124,000 trips (person based, in this chapter person base trips are used without notice) per day and was estimated to increase by 7.8 times to 963 thousand trips per day in the year 2015.

Table 12-1-1 Public Transportation Demand (Daily) in 1995, 2005 and 2015

Year	1995	2005	2015
Public Transport Demand	123,879	605,290	963,245
Share of Public Transport	3.6%	8.1%	9.5%

The demand was calculated on 149 x 149 zone base and aggregated to a 18 x 18 zone base. The relation between aggregated zone system and traffic zone system is summarized in the Appendix A

12.1.2 Demand by Zone

Zones 2 (Hai Ba Trung), 3 (Dong Da), 5 (East Soc Son), 6 (West Soc Son), 7 (East Dong Da), 11 (South Gia Lam), 16 (Ha Dong) and 17 (Thanh Tri) will generate large volumes of trips more than 30,000 in 2005. Zone 7 (East Dong Anh) drops from this list but zone 17 (Thanh Tri) joins this list in 2015.

Zones 5 (East Soc Son), 6 (West Soc Son), 7 (East Dong Anh), 8 (Central Dong Anh), 9 (West Dong Anh). 10 (North Gia Lam) and 11 (South Gia Lam) show high share of public transport use of over 10%. In 2015 Zones 16 (Ha Dong) and 18 (East Thanh Tri) also have similar public transport schemes.

Table 12-1-2 summarizes trip data and shares for public transport. Zones with high demand for public transport are far from central Hanoi in rural areas. Distances are too far to travel by bicycle therefore public transport is used instead. Zones 2 (Hai Ba Trung) and 3 (Dong Da) are the destinations of these trips.

Fig. 12-1-1(A) and 12-1-2 (A) illustrate public transport demand. Zones which are a long distance from central Hanoi show high demand.

12.1.3 Demand by Interzonal Movement

The movement between Soc Son and central Hanoi shows high demand in 2005 (Fig. 12-1-1 (B)). Owing to development of the HUDC, demand between Soc Son and HUDC also becomes high in 2015 (Fig 12-1-2 (B)).

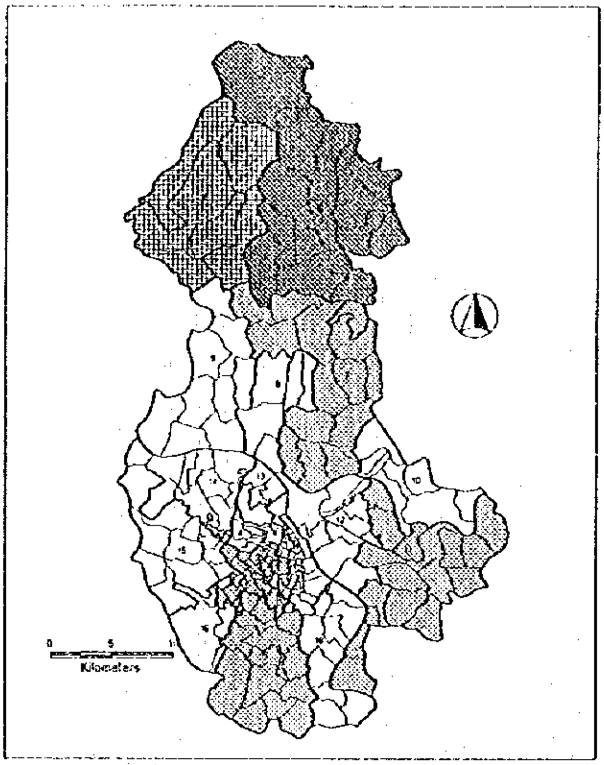


Fig. 12-1-1 (A) Public Transport Demand by Zone (2005)

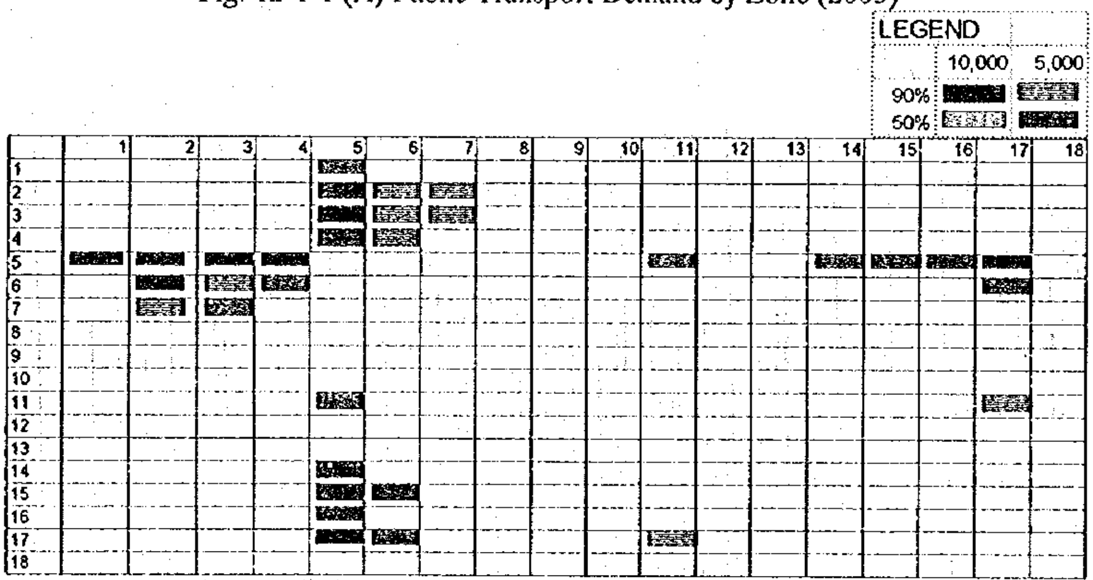


Fig. 12-1-1 (B) Public Transport Demand by Interzonal Movement (2005)

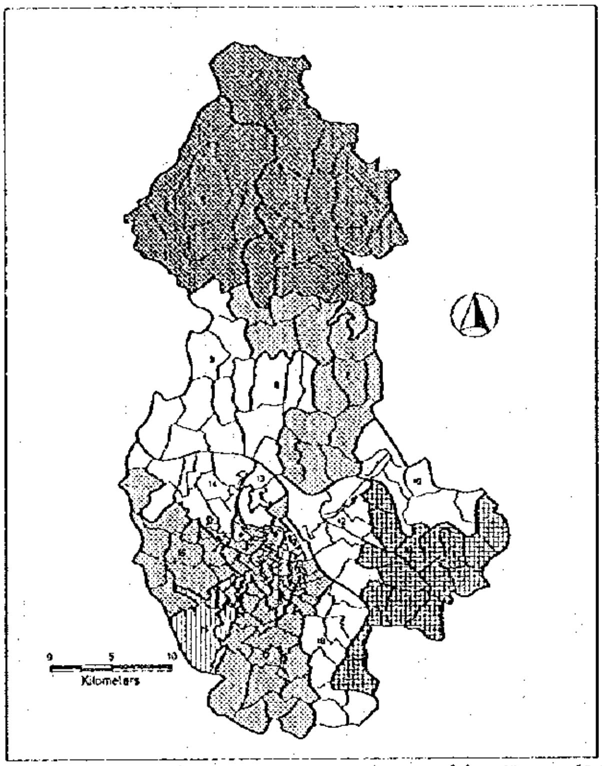


Fig. 12-1-2 (A) Public Transport Demand by Zone (2015)

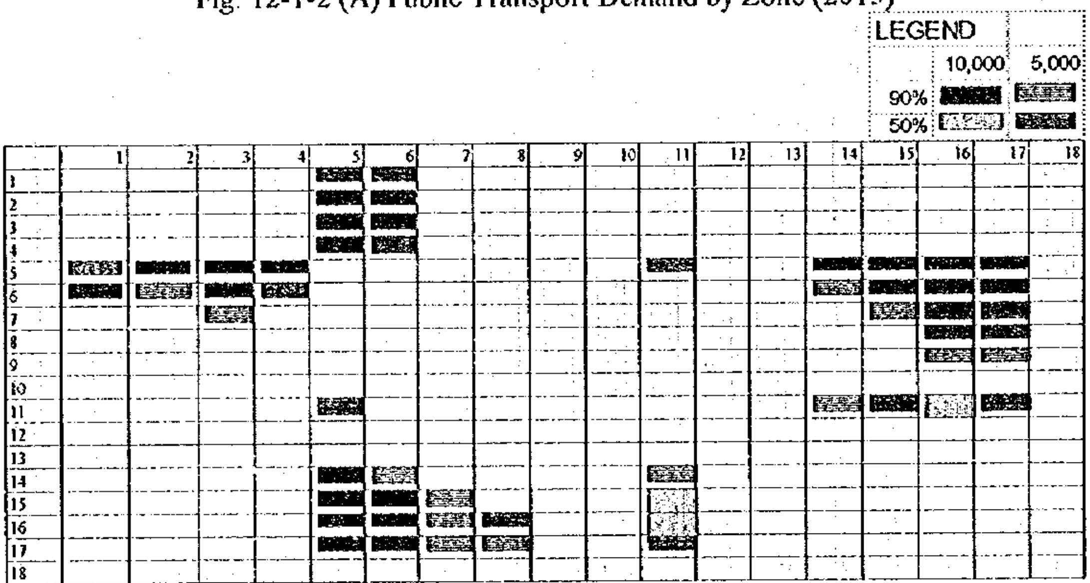


Fig. 12-1-2 (B) Public Transport Demand by Intezonal Movement (2015)

Table 12-1-2 Public Transport Demand by Aggregated Zone

Aggregated Zone		2005		2015	
		Daily Trips	Share(%)	Daily Trips	Share(%)
1	Hoan Kiem	19,649	6	31,217	7
2	Hai Ba Trung	39,798	6	56,806	8
3	Dong Da	45,190	6	72,270	8
4	Ba Dinh	29,101	5	46,595	7
5	East Soc Son	108,888	26	149,365	32
6	West Soc Son	65,931	23	91,047	34
7	East Dong Anh	41,119	12	43,180	16
8	Central Dong Anh	18,189	11	38,485	14
9	West Dong Anh	18,436	8	27,622	9
10	North Gia Lam	19,599	10	24,958	15
11	South Gia Lam	47,768	11	73,209	16
12	Central Gia Lam	9,791	4	26,821	7
13	East Ho Tay	2,158	3	3,017	4
14	West Ho Tay	23,594	3	39,949	3
15	Tu Liem	28,047	4	64,601	6
16	Ha Tay	30,287	7	83,200	10
17	Thanh Tri	41,403	5	68,515	6
18	East Thanh Tri	16,346	7	22,394	10

12.2 Public Transport Policy

12.2.1 Public Transport between Built-up Area and Rural Area

Major public transport demand will occur between the city center and rural areas. In the rural areas, bicycle is the main transport modes at present and this will continue without significant change. Based on the Study Teams projection, trips by bicycle in Soc Son District will be 3.15 times trips by motorcycle in 2005 and 1.48 times even in 2015.

People who have no motorcycle belong to the transport poor group in terms of long distance trips such as trips from their villages to the city center.

Table 12-2-1 Ratio of Bicycle Trips to Motorcycle Trips

District	2005	2015
Soc Son	3.15	1.48
Dong Anh	1.75	0.86
Gia Lam	1.68	0.79

In view of the above, it is considered that bus services between rural areas and city center are a matter of basic human need.

12.2.2 Public Transport in Built-up Area and its Outskirts

Vietnam National Railways stops daytime commuter operation between Giap Bat and Gia Lam from January 1996. The Hanoi Bus Company operates 12 routes and transports around 100,000 passengers a day, which is 6.8% of total non-walk trips. Transport services in Hanoi are, therefore, very poor. In response such a poor service level, demand for public transport is very low.

The dominant transport modes in Hanoi are two-wheelers both bicycle and motorcycle. The increase in ownership of motorcycles has been remarkably high since the late 1980s, from 11,000 units in 1985 to 46,000 in 1995, to be checked. This demonstrates the preference for private modes of transport, motorcycles at present and passenger cars in futures as incomes rise.

Hanoi's urban population is forecast to grow from 1.27 million of 1995 to 3.37 million of 2015. To provide for this increase in urban population the urbanized area of Hanoi will expand and travel distances will become longer as from an average of 5.15 Km in 1995 to 6.74 Km of 2015. This travel distance increase of 1.63 Km will mainly be due to population newly located in the expanded urbanized areas. These new migrants would either be possible public transport users due to their longer trip length or possible passenger car user if they have sufficient income.

Because of the preservation policy of Hanoi city, the increase of car traffic would cause major traffic capacity problems in the city center. Transfer of passenger car demand to public transport services must be the key objective of public transport policy.

The traffic condition under Do-Nothing Case shows the congestion caused by 2 times the expected number of cars projected for 2015. It is expected that this level of congestion will not occur until 2015 but at some time thereafter. In order to prevent such a situation occurring travelers who are living in built-up area and adjacent areas must be encouraged to use public transport. This mode shift must occur before they become "car capture".

(3) Favorable Public Transport Mode in the Built-up Area

1) Criteria

- Similarity to Private Transport Modes: Almost all of Hanoi citizens have no custom to use any public transport. In consequence, to attract them the public transport modes must have a high image.
- Good Accessibility to a Mode: Hanoi travelers are extremely reluctant to walk. In consequence the new public transport modes must provide a high level of accessibility. This requires a dense network of public transport routes, flexible boarding/alighting along the routes and possible rerouting on demand within some range.
- High Frequency of a Mode: The public transport service need to be of high frequency, at fixed interval and reliable. This will need minimize actual and perceived waiting times.
- No Heavy Burden to Road Network: The central area of Hanoi has a dense road network is composed of relatively narrow streets except in the French Quarter. These streets are often too narrow for regular size bus operation. Therefore, medium/small size bus should be used.
- Cheap Transport Modes: Bus fares are present is in range of 1,000 VND and 2,000 VND. The fare for the new public transport must be in the same range.
- Mass Transit: Increase in traffic demand is inevitable. As mentioned before, total traffic demand in Hanoi built-up area is to be forecast to increase from 1.44 million trips a day of 1995 to 2.65 million in 2015, which is an increase 1.84 times. Mass transit is fundamental requirement for Hanoi urban public transport.
- Punctuality: One of the basic requirement of public transport in a modern city is punctuality and reliability. Road based public transport is affected by traffic congestion. Segregated public transport systems are able to achieve much high levels of punctuality and reliability..

2) Qualitative Evaluation

Public transport modes considered in this study are: taxi; regular size bus; mini bus, micro bus; and railway. Bus size is classified as shown in Table 12-2-2.

Table 12-2-2 Classification of Bus Size

Bus Size	Maximum Seating Passengers	Maximum Standing Passengers	Note (called in the report as)
Regular Size	around 40	around 35	regular bus
Medium Size	around 24	around 20	minibus
Micro Size	around 9	0	microbus

Qualitative evaluation was undertaken in relation to the above conditions. The results of this analysis are shown in Table 12-2-3. The Table shows the highest rank is mini/micro buses and the second is Taxi. They received high scores because of their similarity to the private transport mode. Another group is the mass transit modes, railway and regular size bus. These two groups must be combined to form an integrated public transport network.

Table 12-2-3 Qualitative Evaluation of Considered Public Transport Modes

Evaluation Items/Modes	Taxi	High Class Mini-bus	Regular Size Bus	Mini/ Micro-bus	Railway
Good Accessibility	A	A	C	B	C
High Frequency	A	B	B	A	C
No Heavy Burden to Roads	A	B	C	A	A
Cheaper Mode	C	C	A	A	C
Mass Transit	C	B	A	B	A
Punctuality	B	B	C	B	A

Based on the qualitative evaluation shown in Table 12-2-3 mini/micro buses were chosen as the priority public transport mode for the time being. Mini/micro buses, however, have short comings from mass transit point of view. When a railway service becomes economically and financially feasible, a combination of mini/micro buses and railways would offer the best public transport system.

12.2.3 Public Transport Policy

Based on the qualitative evaluation above and because the roads in the built up area of Hanoi are generally rather narrow for regular size bus operation, mini/micro-buses should be utilized in the built up area.

Two types of bus service can be proposed for Hanoi urban area. Standard class mini/micro-bus services are suitable for point to point shuttle transport flexible in relation to demand, and have inexpensive fares with seats secured. An upper class mini-bus can provide better quality of transport with larger capacity, air conditioning and other facilities for more passenger comfort.

Trip purposes of bus passengers to/from the rural area are peddling, shopping and visiting relatives. Due to the trip purposes no interchange is generally required. Bus sizes should correspond to demand, but the larger size would be most appropriate because of the trip purposes. Frequency would be a lower priority than bus size.

The existing railway (Yen Vien - Van Dien Section) requires a lot of investment to use for commuter transport because replacement of Long Bien Bridge and implementation of a double track. Without any implementation it can operate in 50 minutes headway. The improvement of this section is not included in this master plan. However, replacement of Long Bien Bridge and elevated works of this line in built-up area are preferable from long haul service improvement point of view. More detailed study on railway will be described in Chapter 13.

12.3 Bus Fleet Requirement

The bus plan is urgent but it is affected by many unknown factors which to be resolvved. It fortunately has an elastic nature. The fleet can be respond to actual demand and routes also can be easily adjusted to fit to demand. It is understood regarding the bus plan that a medium term plan is more important than a long term plan and the method of fleet reinforcement is the most important subject.

12.3.1 Passenger-Km

The 5 urban districts and outskirts, including the suburban area of aggregated zones 11, 12, 13, 14, 15, 16, 17 and 18 (adjacent areas of Tu Liem, Thang Tri and Gia Lam to the 5 Hanoi urban districts) were considered as the urban area. Following this definition, passenger-Km were calculated using the 149 x 149 public transport OD matrix and zone to zone distance matrix.

Table 12-3-1 Passenger.Km

(unit: 1,000 passenger.km)

Year	Intra Urban Area	Urban/Rural to Rural
2005	2.271	19,545
2010	3,638	25,175

12.3.2 Productivity of Bus Operation

From the results of surveys result on the operation of Hanoi Bus Company (HBC) and experience of the Study Team, the productivity of bus operation were projected as shown in Table 12-3-2.

Table 12-3-2 Indicators of Bus Operation

Indicator	Micro-bus	Mini-bus	Regular Size Bus
Average Number of Passengers	8	18	35
Average Daily Operating Distance	160	140	200
Passenger-km per Unit	1,280	2,520	7,000

12.3.3 Fleet

Fleets required in 2005 and 2015 were estimated based on the following assumptions:

a) Urban bus transport is shared by mini-bus and micro-bus. Shares are 30 % for mini-bus and 70 % for micro-bus.
b) Rural - urban and rural - rural bus transport is operated by regular size bus.
c) Five percent of fleet is for reserve.
d) No railway system is introduced.

The fleet projection is shown in Table 12-3-3. This projection matches the potential demand. In consequence it is the maximum expected fleet size. If 70 % of the potential demand was achieved only 70 % of these fleet sizes are required.

Table 12-3-3 Bus Fleet

	Micro-bus	Mini-bus	Regular
Year of 2005			
Demand (Passenger-km/day)	1,590,357	681,582	19,545,031
Passenger-km/unit/day	1,280	2,520	7,000
Fleet required	1,305	284	2,792
Year of 2015			
Demand (Passenger-km/day)	2,546,639	1,091,416	25,175,054
Passenger-km/unit/day	1,280	2,520	7,000
Fleet required	2,089	455	3,596

The maximum expected amount of procurement cost of buses becomes as seen in Table 12-3-4.

Table 12-3-4 Bus Procurement Costs

(unit: BVND)

	Micro-Bus	Mini-Bus	Regular
Procurement Costs (1997-2005)	195.8	56.8	1927.8
Procurement Costs (2006-2015)	117.6	34.2	482.4

12.4 Operator

12.4.1 Financial Viability

Operating costs of the HBC was estimated based on the survey data collected by the Study Team as shown in Table 12-4-1. Estimated costs included indirect costs of 60 % of direct expenses.

Table 12-4-1 Estimated Expenses of Hanoi Bus Company (HBC)

Line No.	Distance (Km)	Working Hour	Service per Hour	Total of Svc Hour	Total of Ruuning km	VOC (M.VND)	Indirect Cost(MVND)	Total Cost(MVND)
1	12.0	13.0	14.2	184.6	4,430.4	30.2	18.1	48.3
2	12.3	14.0	7.1	99.4	2,445.2	16.6	9.9	26.5
3	13.0	12.0	10.4	124.8	3,244.8	21.9	13.1	35.0
4	12.0	11.0	4.8	52.8	1,267.2	8.6	5.1	13.7
5	17.0	12.5	5.0	62.5	2,125.0	13.9	8.3	22.2
6	22.0	13.0	4.8	62.4	2,745.6	17.6	10.5	28.1
7	18.0	13.0	2.6	33.8	1,216.8	7.9	4.7	12.6
8	19.0	9.0	1.6	14.4	547.2	3.5	2.1	5.6
9	18.0	10.0	1.7	17.0	612.0	4.0	2.4	6.4
10	13.0	13.0	4.0	52.0	1,352.0	9.1	5.4	14.5
11	8.5	10.0	4.0	40.0	680.0	4.8	2.8	7.6
12	7.5	7.0	1.6	11.2	168.0	1.2	0.7	1.9
Total	172.3	137.5	61.8	754.9	20,834.2	139.3	83.1	222.4

Daily passengers were estimated from result of the survey. Assuming that all passengers paid 1,000 VND, weekday daily fare revenue is 103.5 MVND. (Table 12-4-2). This revenue is optimistic as students generally use discounted prepaid pass cards

Expected expenses are 199.6 MVND and expected revenue is 103.5 MVND. This means that the Hanoi Bus Company would produce a deficit of 96.1 MVND/day.

Table 12-4-2 Estimated Fare Revenue of Hanoi Bus Company

Line No	Daily Passengers	Revenue (MVND)
1	34,272	34.3
2	16,782	16.8
3	22,628	22.6
4	4,360	4.3
5	4,208	4.2
6	6,560	6.6
7	2,958	3.0
8	2,774	2.8
9	1,514	1.5
10	4,200	4.2
11	1,034	1.0
12	2,186	2.2
Total	103,476	103.5

From these result the following conclusions are apparent:

a) A fare of 1,000 VND per trip is not enough to allow HBC to cover their costs.
b) If we assume the optimistic condition that all passengers pay 1,929 VND and the

share of indirect cost is 60 % of direct cost, it becomes break even price for HBC. (1,000VND x 199.6 / 103.5 = 1,929). It should be noted, however, that the decrease of ridership caused by increase in fare is not included in this calculation.

c) If a newly established bus company can operate with indirect expenses of 100 % of direct costs and other assumptions aforementioned are applicable, to this company, 2,410 VND becomes break even price. (1,000VND x 124.7 x 2 / 103.5 = 2,410 VND)
d) In general we must assume some decrease of ridership in corresponding to an increase of fare. Discriminate curves between fare increase and ridership decrease by a break even point are calculated and shown in Fig. 12-4-1.

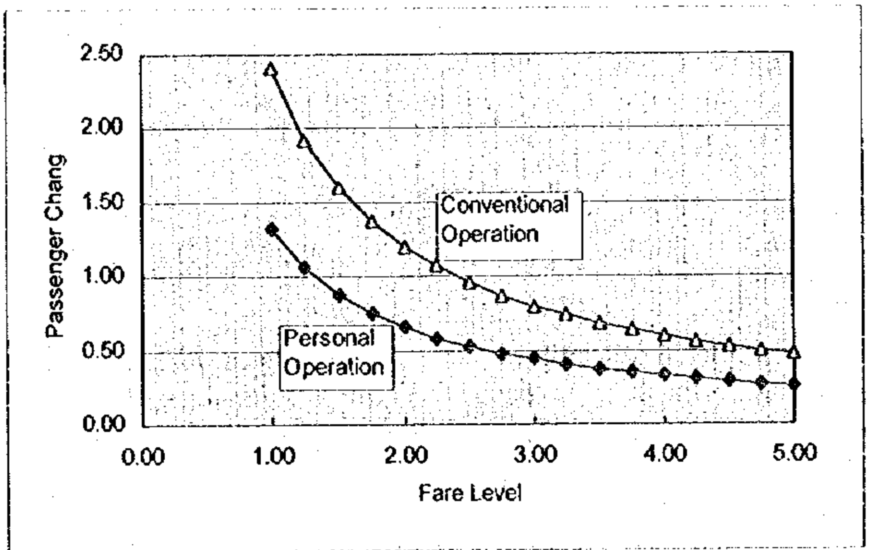


Fig. 12-4-1 Discriminatory Curves between Fare Level and Ridership

It is inconceivable that a fare rise of 2.5 times causes only 5 % decease in ridership. It means 2.5 times fare escalation can not make newly started bus company survive. In such a condition it is natural that no private bus company has an interest in operating a commercial business in Hanoi.

12.4.2 Personal Operator

The reason why a private bus operator can not viably operate in Hanoi is the existence of high indirect costs, which needs to be the same amount as direct expenditure. The question is how to reduce these indirect costs.

Many countries in the world, where citizens do not have enough income to sustain private public transport companies by relatively expensive fare, have syndicates of personal public transport operators. Personal operators don not need an office, secretary, accountants and even maintenance facilities. Due to these factors, The indirect cost for a personal operator is low.

Fig. 12-4-1 shows that a personal operator can manage with a decrease of ridership of 35 % and two times of fare in the case where indirect cost equals 10% of direct cost. We anticipate that a 2,000 VND will attract more than 65 % of the passengers of the 1,000

VND fare case.

Services of personal bus operators have some problems as follows;

a) Services tend to be concentrated on high demand routes and on high demand time period.
b) Safety measures like as maintenance, training of drivers and speed control tend to be disregarded.

12.4.3 Bus Holding Company (BHC)

The aforementioned section concluded that a personal bus operator system is financially feasible but it has some problems of quality of service. In order to solve these problems the Study Team proposes the organization to control personal operators effectively by bus rental contract.

The organization must have buses and rent them to personal operators. It makes a fixed price monthly rental contract for the bus with driver and the driver operates bus under the contract.

The rent must reflect the profitability of the route. In another words, drivers who make contracts to operate profitable routes pay higher rents and drivers to operate unprofitable routes pay lower rents. This rent operation can provide equal profitability to all of drivers in no relation to route operated.

The contract should include a specification of the following;

- Route,
- Operation schedule,
- Rental charge (varied by route and operation schedule),
- Rules for continuation,
- Responsibility of lessor and lessee, and
- Penalties.

Existing bus companies, bus terminal companies and other related companies should be absorbed in the organization during this 10 years. When Hanoi citizens' income level increases up and they can pay sufficiently expensive fares to sustain a public transport company, the organization may change to the sole bus/railway operator in Hanoi.

Based on the said contract the organization can control and maintain some level of quality of service. Hereafter the said organization shall be called as the Bus Holding Company (BHC).

12.5 Bus Holding Company (BHC)

12.5.1 Nature of BHC

BHC is the company to serve the public in the field of public transportation in Hanoi. We expect BHC has the following functions;

a. to be the sole bus holding company,
b. to monitor, supervise and control personal bus operators based on the contract,
c. to decide bus fares under supervision of HPC and
d. to have tax exemption permission.

12.5.2 Major Activity of BHC

(1) Fleet Reinforcement

Based on the growth of the demand, BHC must reinforce its own bus fleet. BHC can apply for a loan from an export and import bank (EXIM bank) in the case where BHC imports buses. When BHC starts using locally manufactured buses, BHC needs some financial aid from G to G base (for example OECF loan) or project loan from private banks secured by purchased buses.

(2) Maintenance and Repair

To maintain the fleet in good condition, BHC must provide maintenance and repair capability. The final target is its own workshop but the first stage is to make a comprehensive repair and maintenance contract with dealer.

To keep a strong bargaining power for the repair and maintenance contract, selection of models is quite important.

(3) Rental Contract and Selection of Drivers

In order to keep service quality of public transport at a high level selection of drivers and their contract are quite important. Selection, monitoring, advice and elimination in cases of breach of contract are required.

(4) Bus Terminals and Bus Stops

Bus terminals and major bus stops must be established or improved for easy transfer. Existing facilities owned by each bus terminal company must be transferred to BHC within the next 10 years.

12.5.3 Financial Viability of BHC

Financial viability should be investigated from the points of view of affordability of the personal operator and the from investment scale and fleet size.

(1) Average Trip Length

Based on the simulation results trip behavior by area was calculated as shown in Table 12-5-1.

Table 12-5-1 Trip Length by Area

	Central 4 Districts	Tu Liem/ Thanh Tri from/to Central 4 District	Gia Lam to/from Central 4 Districts	Tu Liem and Thanh Tri	Gia Lam	Rural Area to/from Central 4 District or Rural Area
2005						
Person.km	17,184	110,959	736,673	141,457	7,263	19,545,031
Trips	3,389	6,286	20,488	5,573	804	517,382
Trip Length (Km)	5.07	17.65	35.96	25.38	9.03	37.8
2015						
Person.km	188,768	343,082	756,807	324,893	52,770	25,175,054
Trips	51,796	29,565	22,652	20,876	12,430	720,211
Trip Length (Km)	3.64	11.60	33.41	15.56	4.25	35.0

The transfer from other modes (mainly from the bicycle mode) will be remarkable in 2015. It can be seen that in addition to the larger amount of trips the average trip length will be shorter.

Trip lengths in thel 4 districts will become shorter in 2015 and the number of trips in 2015 will be 15 times the number of trips in 2005. The increase in trips to/from Tu Liem and/or Thanh Tri is mainly caused by the increase of population in the Hanoi Urban Development Corridor (HUDC, see Chapter 8). The reason for the shortening of trip lengths in Tu Liem/Thanh Tri is the increase of employment in this area.

Because Gia Lam grows earlier than other areas, the demand in 2005 is high but it becomes constant because the Gia Lam built-up area becomes self sustained in nature. It can be seen that trips terminating in Gia Lam increase from 7,000 to 53,000.

Demand from the rural area is very high. Realization of this potential is highly dependent on the fare pricing policy. Even so, it is very clear that the big demand shift from bicycle to bus will occur in the rural area. The trip length is 35 km or more.

Affordability of Personal Operators

Micro-bus in the 4 central districts, mini-bus from Gia Lam to city center and regular bus from rural areas to the city center were examined for 2005 as example to investigate the viability of a personal bus operator.

Rental charges of three type of buses are calculated and shown in Table 12-5-2

Table 12-5-2 Rental Charge Calculation

unit: 1,000 VND)

Model	Micro-bus	Mini-bus	Regular-bus
Premises			
Purchased Price	150,000	200,000	600,000
Other Initial Costs	1,000	1,000	1,000
Depreciation Months	60	60	60
Insurance Costs	6 % of Purchased Price		
Interest Rate per Annum.	6 %		
Repair/Maint. Costs per Annum	6% of Purchased Price		
Costs			
Monthly Vehicle Charge	2,919	3,886	11,619
Monthly Insurance Charge	750	1,000	3,000
Overhead	1,000	1,000	1,000
Repair/Maintenance Costs	750	1,000	3,000
Rent			
Monthly Rent (Summing up of Costs)	5,419	6,886	18,619
Monthly Rent (Rounded)	5,400	6,900	18,600

Using these rental charge the viability of personal operators for the three types of buses were projected. Before the calculation of viability must be fixed fare structures. Present fare structures were examined and figures for 2005 were assumed as follows;

The current fare in the built-up area is 1,000 VND per ride. It should be raised to 2,000 VND. The fare between the rural and urban areas is currently calculated on the basis of 110 VND/km/passenger. It should also be increased by two times. Other expenses in Table 12-5-3 were estimated as half of rent.

The reason of small profit of minibus is short running distance. If it runs 160 kms the profit increase to 38.6 MVND a year.

Table 12-5-3 Sale and Expenditures of Personal Operator

Items	Unit	Micro	Mini	Regular
Sales (Yearly, 5x306)	MVND	154.5	169.4	470.0
1 Running	km	160	140	200
2 Trip Length	km	5.07	35.96	37.8
3 Ave. No. of Passengers	psn	8	18	35
4 Fare	VND	2000	7900	8300
5 Ave. sales a day (1x3x4/2/1000000)	MVND	0.505	0.554	1.537
Costs	MVND	118.4	155.0	433.6
6 Rent (Yearly)	MVND	64.8	82.8	223.2
7 Fuel, Oil and Tires	MVND	21.2	30.8	98.8
8 Other Expenses	MVND	32.4	41.4	111.6
Profit before Tax	MVND	36.2	14.4	36.7

Viability of BHC

If potential 100% of demand in 2005, 1,305 micro-buses, 284 mini-buses and 2,792 regular buses are required, the account profile pro forma of the BHC in 2005 becomes as is shown in Table 12-5-4.

In general life of bus is longer than 10 years long if it is well maintained. In Table 12-5-4 life of bus is assumed as 10 years.

Table 12-5-4 Account and Profile of BHC in 2005 Single Year

(Unit: BVND)

Items/Model	Micro-bus	Mini-bus	Regular-bus
Sale (a)	80.5	22.4	593.2
Rental Charge (yearly)	0.0648	0.0828	0.2232
Rental Units	1,305	284	2,792
Operability	0.952	0.952	0.952
Expenditure (b)	65.2	17.9	463.4
Loan Payment (incl. interest)	26.1	7.7	228.9
Overhead and Other Expenses	39.1	10.2	234.5
Profits (a)-(b)	15.3	4.5	129.8
Total Profit	149.6		
Amount of Loan by Model	195.8	56.8	1,675

12.5.4 Fleet

If it is assumed that incremental of trip demand is served by additional buses, the increase of fleet size can be estimated as shown in Fig. 12-5-1. In the calculation to assess this the following assumptions were made:

a) The existing Karosa (90 passengers capacity), W50IFA (60 passengers) and PAZ (50 passengers) were considered as regular size bus, total 159 units,
b) The existing Hyundai (24 passengers) was considered as mini-bus, total 18 units.

The Karosa, W50IFA and PAZ group were scheduled to be fazed out in this 10 years, and all the Hyundai after 10 years because they were put into service in 1995. Fig 12-5-1 shows the case to were 100% of potential demand is realized but it can be expected that actual demand will be lower than the case presented in Fig. 12-5-1. The profit of BHC also will become large. Although the account of micro-bus rental shows it may loose money, regular bus rental may make large profits and the total profit becomes large (Fig. 12-5-2).

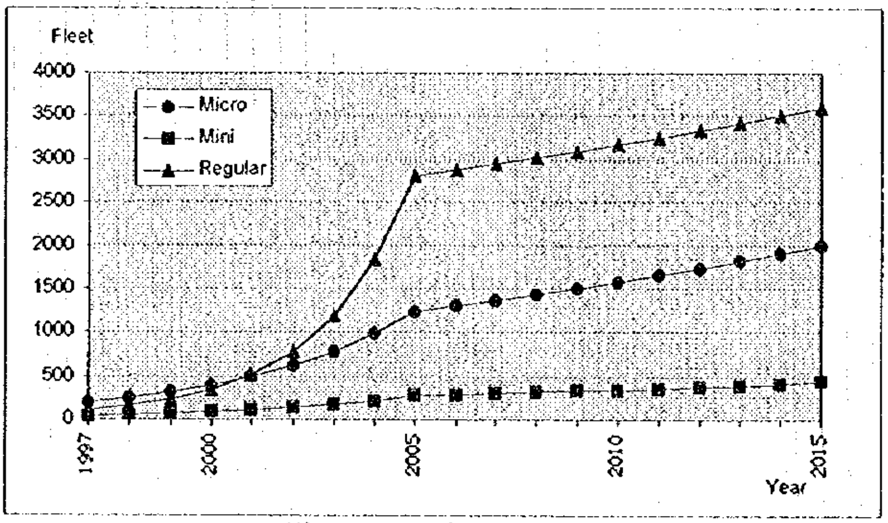


Fig. 12-5-1 Fleet Increase

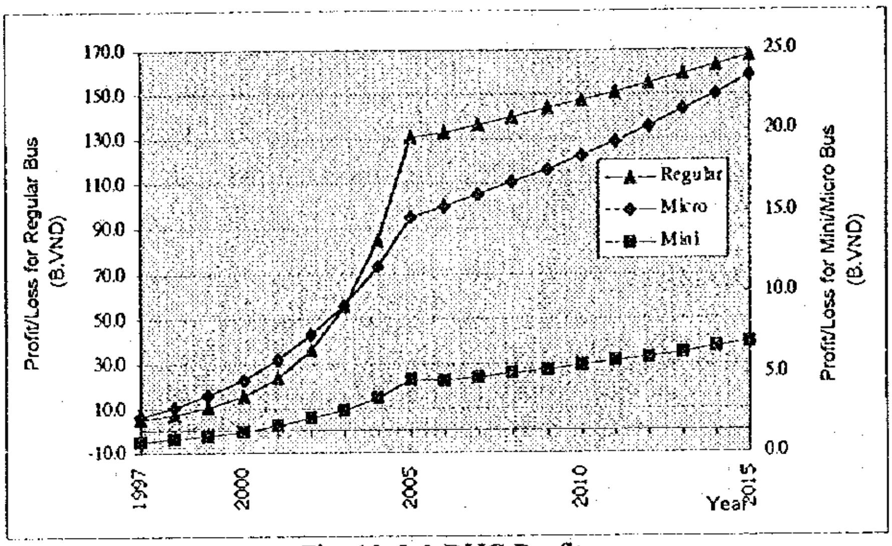


Fig. 12-5-2 BHC Profits

12.6 Bus Routes and Terminals

12.6.1 Routing Policy

Public transport demand was assigned to the future road network. Forecast passenger flows in 2005 and in 2015 are shown in Fig. 12-6-1 and Fig. 12-6-2 respectively.

Findings from these figures are as follows;

a) The largest demand flow is along NH No. 3.
b) The flow along Noi Bai expressway is also large, especially the flow passing over the Thanh Long Bridge which is bigger than the flow crossing the Chuong Duong bridge.
c) The flow along Dong Anh highway/Dong Anh Bridge is also very high after the highway and bridge are constructed.
d) NH No.5 shows the largest flow, with the exception of flows from the north direction. A part of the flow diverges to Thanh Tri Bridge.
e) In the built-up area, including HUDC, the flow spreads in many directions and large flow can not be seen.

Considering lessons from demand flow assignment on the road network, the insufficient terminal capacities and the behavior of users the rural - urban routes should be formulated in the following way;

a) To start from a village and collect a load of passengers in the village,
b) To take the shortest route to central Hanoi after collecting passengers,
c) To pass through one of the inter city bus terminals if it is located along the route,
d) To go into built-up area of Hanoi,
e) To pass through built-up area and return to the village.

This routing policy should apply not only routes from villages far from central Hanoi but also from villages closer to central Hanoi. In the latter case, however, smaller size buses will tend to be used because of the balance of time to collect passengers and time to transport them to destination.

In the city demand is dissipated. Routes should be of short distance with cheap cost using small size bus to match the demand. A point to point and demand responsive nature (free alighting/boarding along route) would be highly appreciated. Due to the demand responsive nature of the service small size bus is necessary.

The proposed routing policy has a strong traditional color. After the bus transport service are established it is recommended that the system should be transformed into a more functional system.

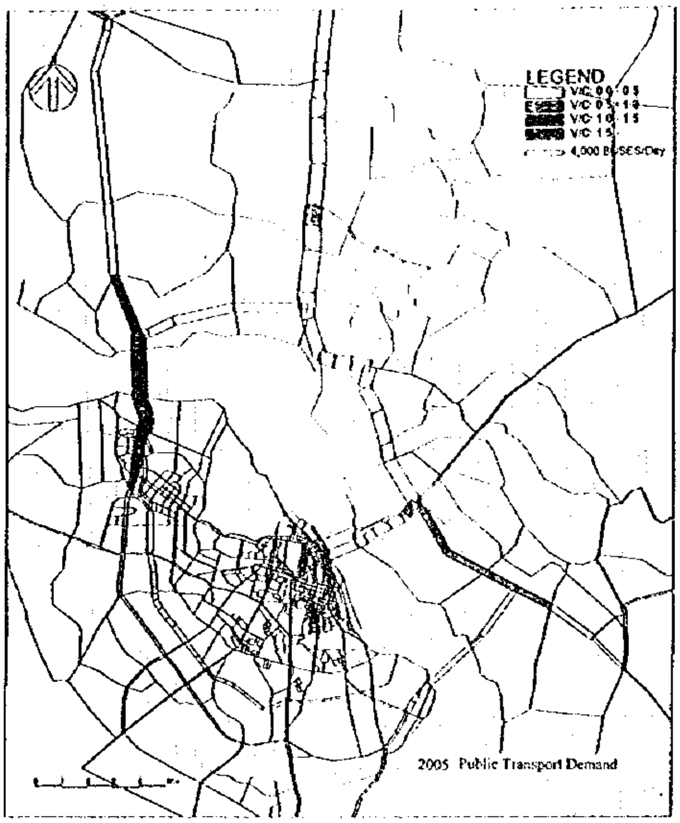


Fig. 12-6-1 Public Transport Demand (2005)

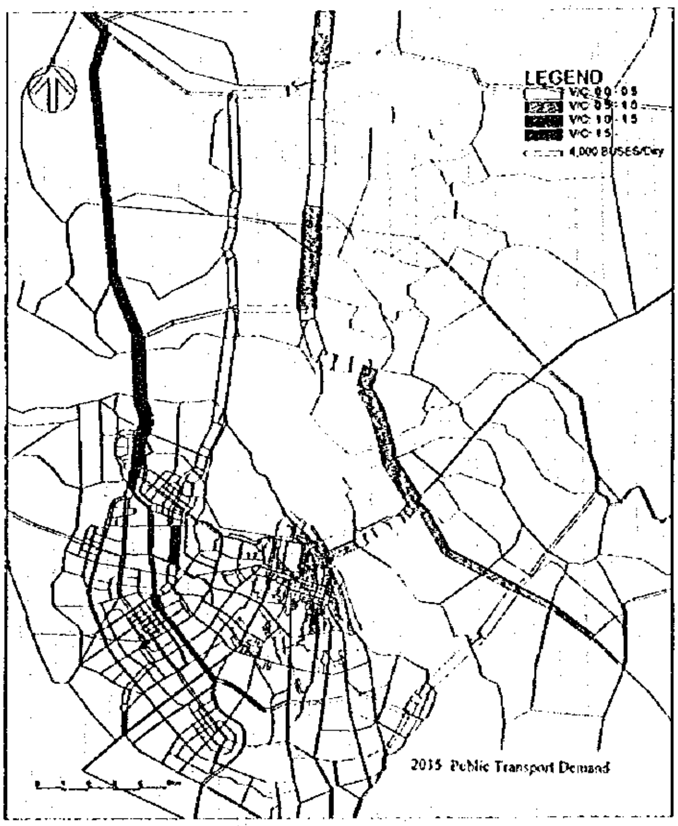


Fig. 12-6-2 Public Transport Demand (2015)

12.6.2 Junction Terminals

Two existing inter-city bus terminals and one new terminal are proposed to function as junction terminals. There are as follows:

Giap Bat Bus Terminal

The existing bus terminal is located adjacent to NH No.1-A and VNR Giap Bat Station . The terminal has 3 ha of land and handles an average 150 buses, and a maximum of 400 buses a day from outside urban Hanoi. Hinterland of this terminal is limited and then main role of this terminal is to accommodate inter-city buses.

The front yard (1 ha) is used as bus stop for city buses to transport alighting passengers from inter city buses to the city center. This area would be used as the intra-city bus terminal. (See Fig. 12-6-3). Existing terminal building are usable until 2015 but some improvements are needed.

Gia Lam Bus Terminal

The existing Gia Lam Bus Terminal is located 800m from NH No.1-B (north side). It has 2 ha land. The terminal is served by around 100 inter-city buses per day in 1995. Present city bus services connecting with the Hanoi urban area use the front yard of the terminal building. It has little space, therefore mixed use of the inter city bus departure range (back side of terminal building) should be examined.

It is forecast that 2,542 buses will use this terminal in 2005. Based on 10 % peak rate 254 buses movements will be concentrated in one hour. If it takes 3 minutes for alighting and boarding, therefore, the terminal needs 13 berths. 10 berths in the front yard and 3 berths in the backyard would be utilized. (See Fig. 12-6-4).

Nghia Tan Bus Terminal

Bus flows from NH No.32, Airport Highway and NH No.3 through Dong Anh bridge are assigned to the Nghia Tan bus terminal. This terminal would be located along the Airport Highway in Nghia Tan Town. This terminal is expected to serve 1,318 buses in 2005. To accommodate 1,318 buses, it needs 4 has. The terminal plan is shown in Fig. 12-6-5.

Table 12-6-1 Requirements to Rural and Urban Junction Terminals
(Not include buses from/to outside of Hanoi Province)

(unit: vehicle)

	Giap Bat		Gia Lam		Nghia Tan	
Year	Rural Side	Urban Side	Rural Side	Urban Side	Rural Side	Urban Side
2005	42	73	2,542	4,719	1,318	2,310
2015	172	273	3,010	4,905	1,740	2,936

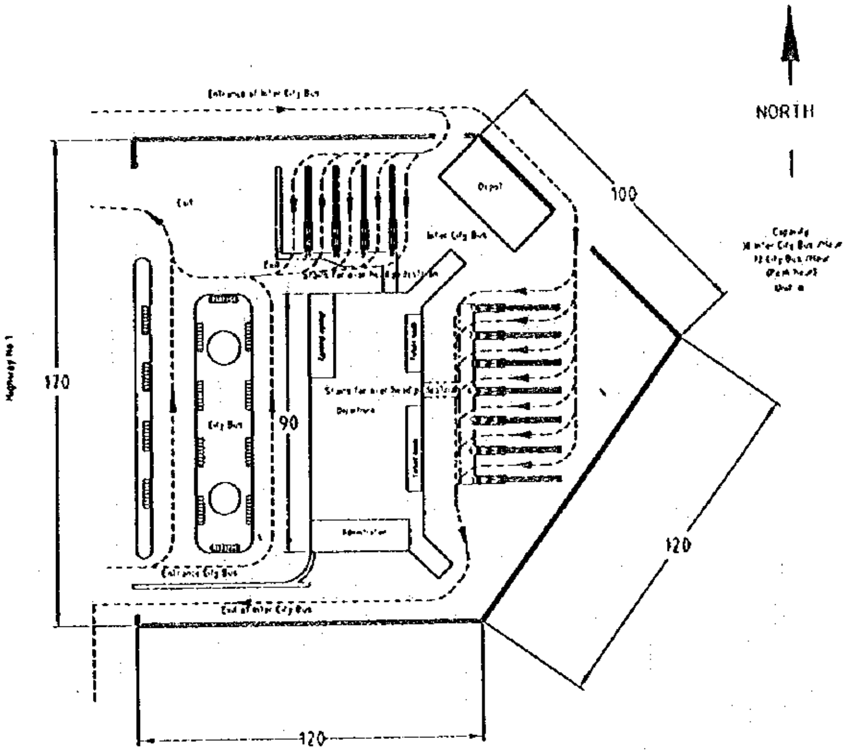


Fig. 12-6-3 Plan of Giap Bat Terminal Improvement

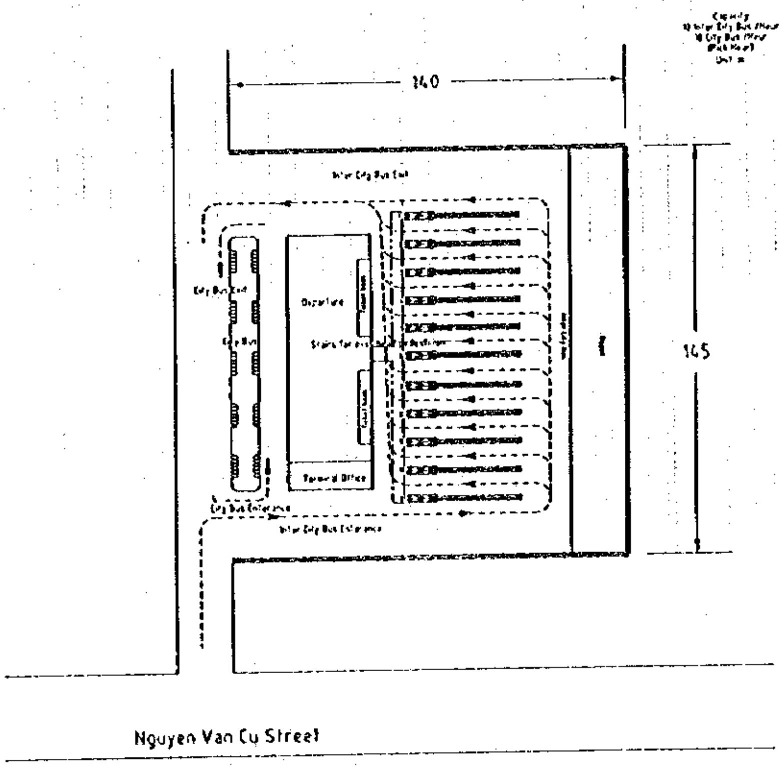


Fig. 12-6-4 Plan of Gia Lam Terminal Improvement

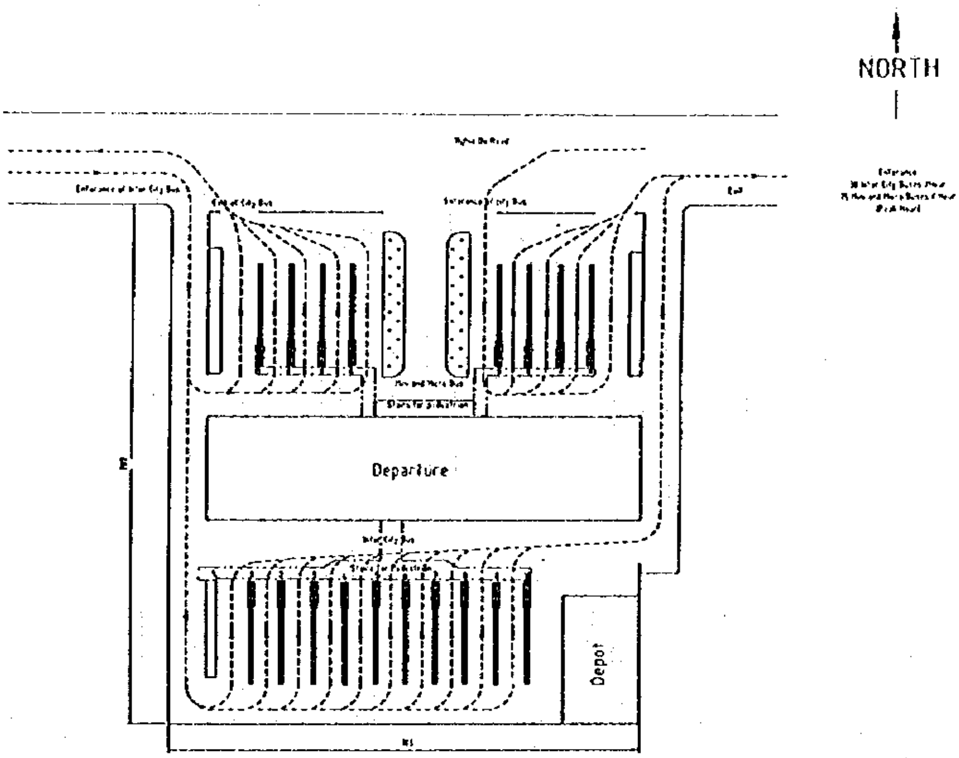


Fig. 12-6-5 Plan of Nghia Tan Terminal Improvement

Capacity
360 City Bus/Hour
(Peak Hour)
Unit: m

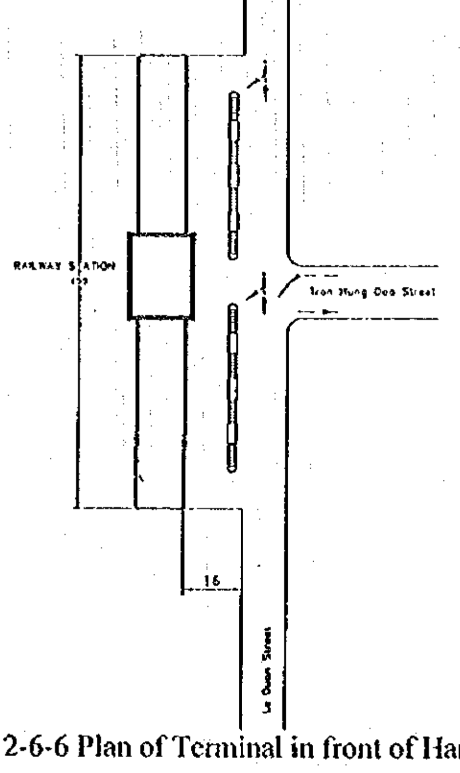


Fig. 12-6-6 Plan of Terminal in front of Hanoi Station

Table 12-6-2 Transfer Passengers at Rural and Urban Junction Terminals
(Not include passengers from/to outside of Hanoi Province)

(unit: passenger)

Year	Giap Bat			Gia Lam			Nghia Tan		
	Rural Side	Urban Side	Transfer Rate	Rural Side	Urban Side	Transfer Rate	Rural Side	Urban Side	Transfer Rate
2005	1,442	1,313	0.91	88,965	84,926	0.85	46,100	41,573	0.90
2015	6,018	4,907	0.82	105,332	88,287	0.84	60,871	52,839	0.87

12.6.3 Hub Terminal in the City

The proposed network of short length and point to point bus routes in the build-up area, requires a hub terminal. Because it is very difficult to find out appropriate space for hub terminal in the center of the city, we propose to utilize the forecourt of Hanoi station as a large bus stop.

The maximum use of the forecourt gives 16 berths. Assuming that the maximum capacity of 1 berth is 20 buses, 320 buses can be accommodated. We expect that a waiting room at Hanoi Station could be used by bus passengers. A plan of the large bus stop is attached. (See Fig. 12-6-6). It is also expected that a hub bus terminal could be constructed in the switching yard at the back of Hanoi Station, when the station is modernized. The construction costs and implementation schedule are shown in Table 16-2-1.

12.6.4 Rural Terminals

Three kinds of terminals are considered. Most of terminals are established in villages or towns of origin/destination of the routes. This kind of terminals must include parking space, a work shop and control center. BHC would be responsible for bus schedule controller.

12.6.5 Terminal Construction/Improvement

New construction/improvement program of terminals is planned in accordance with accounting conditions of BHC. Expected construction/improvement schedule is shown in Table 12-6-3.

Table 12-6-3 New Construction/Improvement Schedule

Period	Terminal	Estimated Costs (BVND)
1997 - 2000	Hanoi Station, Gia Lam	4.4
2000 - 2005	Nghia Terminal	42.8
2006 - 2015	Giap Bat	6.3

Construction costs including maintenance tools is 22.0 BVND.

12.7 Bus Maintenance Center

It is recommended that the maintenance center be opened when the BHC accounts allow it to do so. Fig. 12-7-1 shows the maintenance center plan.

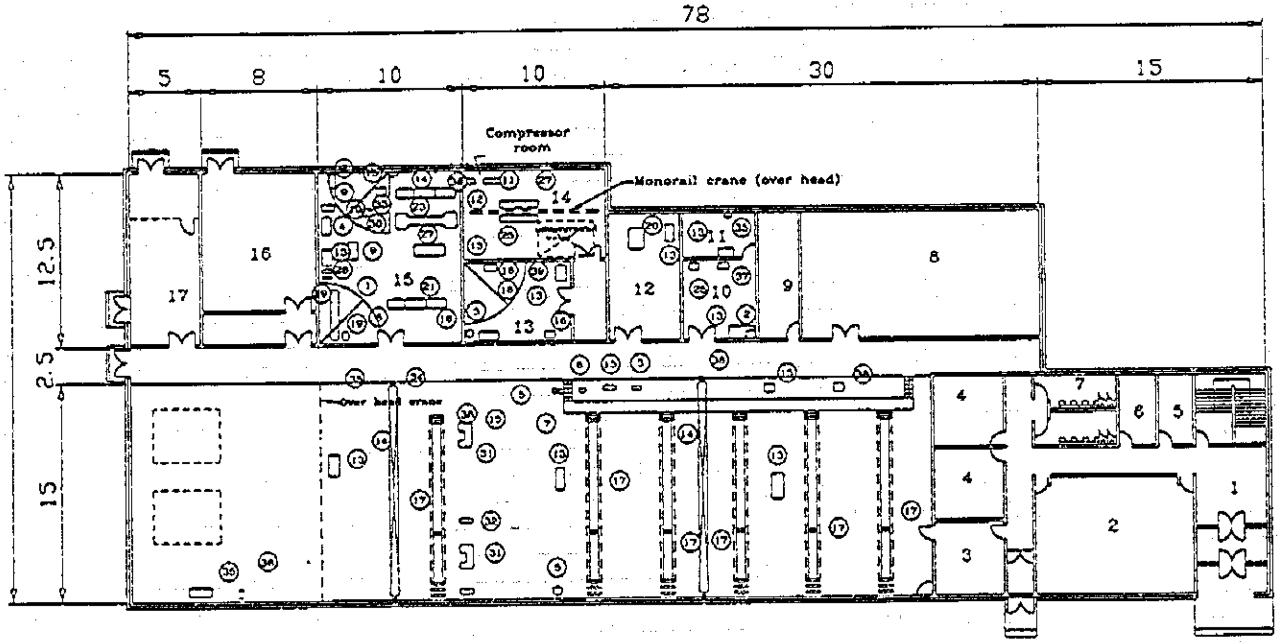
12.8 Implementation Program

The BHC concept is quite new and a little radical. It is recommended that a pilot enterprise should be established to execute small scale social experiment. Two years experimental operation of 40 buses gives many lessons and HPC can evaluate the viability and benefits of the BHC concept. When the experimental business result in success, establishment of the BHC will become easy task.

HPC should form a committee to study the BHC as soon as possible. The first alternative for the BHC is for HPC to employ several experts experienced in management, operation and finance, and establishes a BHC by itself.

The second alternative is for HPC to reorganize the existing Hanoi Bus Company to form a bus holding business. This is the most realistic alternative. The success of this alternative depends on the person in charge, because a bus operators tend to be experienced in bus operation rather than bus rental. It may be good idea to recruit a new manager of the bus holding and renting division.

The third alternative is to select a company as a partner and establish the bus holding company together. HPC would entrust the partner to manage the company. A newspaper reported that the Daewoo Co. had an interest in operating a bus service in Hanoi. Also the paper reported a comment of a Daewoo manager that Daewoo could compensate the loss on the bus operation by other businesses activities. The BHC concept is mutually beneficial. Daewoo would not need to loose money endlessly due to unprofitable bus operation. HPC would not need to be afraid of that Daewoo will cease bus operation at some future date. Similar operations may be available in the case of newly established bus manufacturers in Vietnam. They would be able to sell exclusively a large amount of buses to the bus holding company. In addition, they can expect some profit share from the bus holding company operation. In both cases HPC can procure the bus services necessary for the citizens of Hanoi.



No.	Area	No.	Area	No.	Area
1	Entrance Hall	7	Toilet	13	Engine Repair Room
2	Administration Room	8	Spare Parts Storage	14	Engine Test Room
3	Worker's Office	9	Tool Storage	15	Machine Shop
4	Locker Room	10	Electric Room	16	Mechanical Room
5	Storage	11	Battery Room	17	Power and Generator Room
6	Hot Water Corner	12	Injection PumpTest Room		

Equipments

No.	Descriptions
1	Crankshaft Grinder
2	Bench Drill
3	Bench Grinder
4	Lathe Machine
5	Arc Welder
6	High Speed Cut Off Machine
7	Spot Welder
8	Gas Welder Set
9	Universal Sawing Machine
10	Back Sawing Machine
11	Air Compressor
12	Air Reciver Tank
13	Work Bench
14	Overhead Crane 3ton
15	Hydraulic Press
16	Parts Cleaner
17	Pit Lift
18	Jib Crane 2ton
19	Jib Crane 1ton
20	Injection Pump Tester
21	Turning Radius Gauge
22	Sideslip Tester
23	Brake Tester
24	Head Light Tester
25	Alternator Tester
26	Engine Dynamometer
27	Mono-rail Hoist 1ton
28	Valve Refacer
29	Brake Lining Rivetter
30	Brake Drum Lathe
31	Tire Changer
32	Wheel Balancer
33	Boring & Surface Grinder
34	Tire Inflator
35	Concentrate Lubrication
36	Water Purifier
37	Wire Winding Machine
38	Exhaust Gas Collective
39	Steam Cleaner

Fig. 12-7-1 Bus Maintenance Shop

CHAPTER 13 RAILWAY PLAN

13.1 Railway Planning Policy

To handle the expansion in land-use and growth in population, economic activities and urbanization, the shift from road transport to rail transport is the most economical and practical solution to handle the resulting transport demand and to solve the traffic problems. The failure to develop a mass railway transit system in the early stages of socioeconomic development will result in an inadequate traffic conditions such as these in many Asian capitals where the road transport is almost the most dominant transport sector. The introduction of railway commuter systems to solve urban transport problems provides the following benefits:

- Better Road Traffic Conditions: The urban railway systems are generally operated on elevated or underground sections, they are separated from road traffic with no possibility to cause traffic interruptions or accidents. The high capacity of such systems would handle high transport demand which will result in decreasing the share handled by the road network.
- Lower Land Acquisition Cost: Compared with road projects in urban areas, there is a minimum need for land acquisition schemes for such elevated or underground railway systems at stations or for some viaduct piers.
- Environment Preservation: With the electrically-powered systems, there is no air pollution. In addition, advanced railway vehicles are designed to minimize the noise and vibration impact.
- Savings in Energy Consumption: The energy consumption per passenger in a high-capacity railway systems is much lower than in any other public transport system.
- Savings in Vehicle Operating Cost (VOC): With the high efficiency and capacity of railway systems and low running cost, they provide significant savings compared with the alternative road transport modes.
- Higher Transport Speed: The railway system, with no intersection or friction with the road transport system, provides a high transport speed resulting in savings in the travel time for passengers.
- Punctualability: The railway systems are normally the most reliable transport modes which provide a high punctualability rate with its good impact either economically or socially.

To formulate an efficient plan for a mass railway transport system in Hanoi, the capabilities of the existing railway facilities were assessed first and a tentative network was established to include different types of civil infrastructure and rolling stock as a preliminary comparative study of one line to assist in formulating the basic plan.

13.2 Comparative Study of Railway System

13.2.1 Lines to be Studies

(1) Hanoi Railway Network

The national railway network of Hanoi has a total length of about 90 km in which about 7 km passes through the urban area with several at-grade intersections with the street network. To assess the network from the urban transport point of view, the central north-south line can be utilized as it passes through heavy populated areas. The second outer line to the west of the city can not be utilized at this stage as it passes through unpopulated areas far away from urban and suburban Hanoi.

The network is mostly composed of single-track lines with low frequency of trains and does not at present serve any significant urban transport demand taking into consideration that daytime trains are banned from entering the city built-up areas as they interrupt the road traffic.

The present condition of the Hanoi railway network does not provide an efficient mass transport mode which can handle the future transport demand of the city. However, it can be partially utilized to decrease the cost of introducing new systems to the city. In this case, major improvement works are required to be integrated as a part of an urban railway transit system.

(2) Network Planning Concept

In establishing the Mass Railway Transit (MRT) network, and considering the characteristics and requirements of the city, especially its ancient quarter and central areas, the planning concept was established based on the following criteria:

- To connect the existing central area with the proposed new CBD [Central Business District] in Xuan La area.
- To handle the heaviest existing and future traffic demand and to pass through high density zones with high trip generation
- To utilize available space over wide streets or water areas for elevated sections and to minimize the adoption of the high-cost tunnel sections
- To connect any new lines with existing railway lines and facilities to economically extend the network
- To cover commercial and business centers as well as cultural and tourist areas

(3) Tentative MRT Network

To achieve the targets and objectives of the plan and considering the present transport pattern and heavy traffic movements in urban Hanoi, based on the results of the traffic surveys and analysis and the future forecast for the transport demand, a tentative plan of the MRT network, shown in Fig. 13-2-1, is composed of the following three lines:

A Ha Dong - Hoan Kiem - Thang Long Line

B Van Dien - Giap Bat - Gia Lam - Yen Vien Line
C Giap Bat - Phu Dien - Noi Bai Line

The first line is to handle the existing heavy transport demand between the town of Ha Dong and the central area of Hanoi in one direction and to connect the New CBD west of the West Lake with the existing central area of Hanoi. The line will support the development plan by handling the future transport demand generated by the socio-economic development activities of the New CBD in the near future. As the line passes through the existing central, commercial and recreational areas of the city, it will attract a high share of private-mode users which will result the improvement of traffic conditions in the city.

The second line is proposed to replace the existing railway line passing through the central area of the city by an elevated double-track line to eliminate the at-grade crossings with the roads. In addition to its inter-city transport function, the grade-separated line will be mainly utilized for the commuter transit movement between the northeastern and southern areas and crossing the Red River to Gia Lam District.

The third line is proposed to support the development of the western suburban areas of the city including the outskirts of the New CBD, and to provide a commuting line connecting the city with the Noi Bai International Airport. This line is planned to partially utilize the existing facilities of the VNR including the Thang Long bridge. Although Ring Road 2 is handling high traffic volumes at present, the alignment is proposed to run along the planned new third ring road of the city which will better support the extension of urbanization out of the existing built-up area.

13.2.2 Rail Passenger Demand

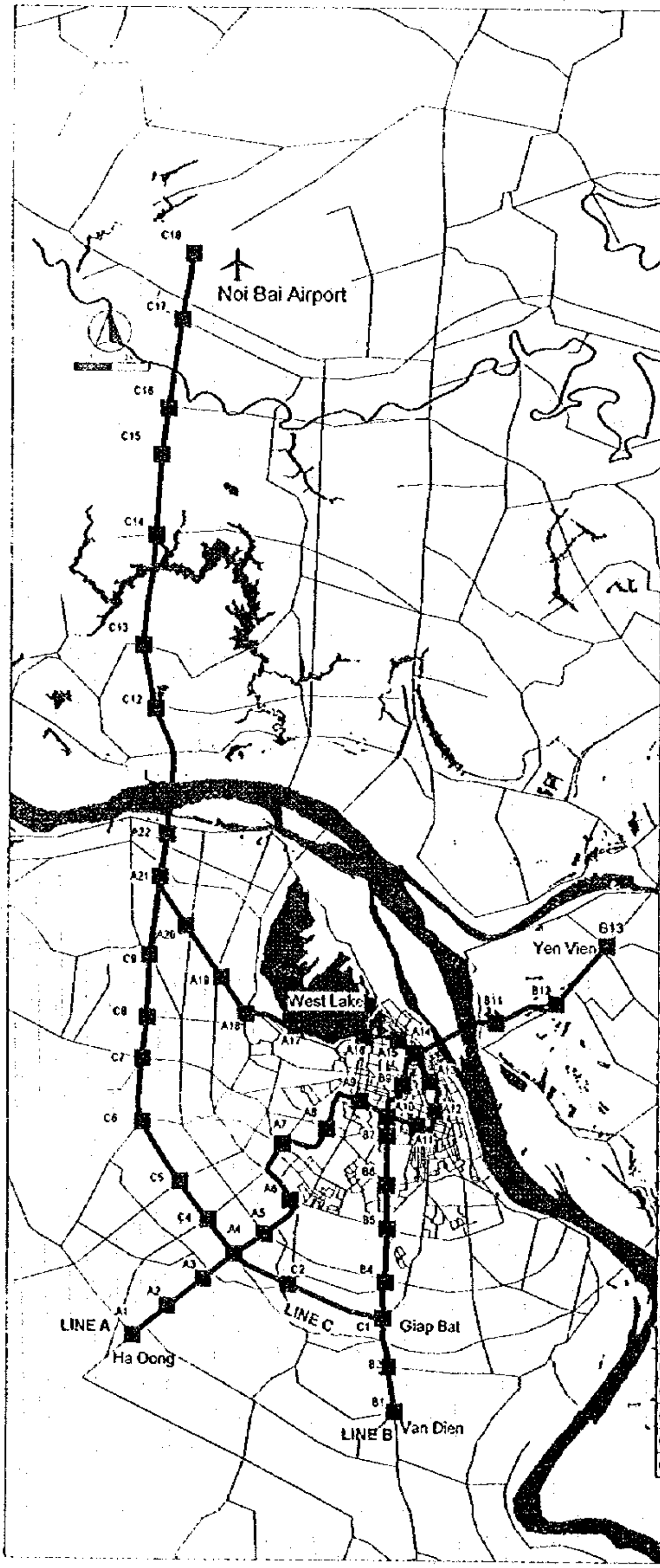
To estimate the tentative network demand the following procedure was applied. As the information on the modal choice of public transport passengers between buses and rail transport is not available in Hanoi, a modal split model developed in Cairo by JICA in 1989 was applied to estimate the potential demand of rail transit in Hanoi.

The time value of a non car own public passenger in Cairo was estimated at 0.178 USD/hr, which is equivalent to about 500 USD per annum and is almost the same level in urban Hanoi in 2015. The formula is;

$$P = 1.0 / (1.0 + EXP(0.127 - 0.041 \times DT - 0.06 \times DC))$$

where; P: Rail Passenger Share in Public Transport Demand
DT: Travel time deference in min.
DC: Travel cost deference in 1/100 Egyptian Pound
(1.00 USD = 2.3 Egyptian Pound = 11,000 VND)

The bus fare was fixed as the same level as the present 1,000 VND per ride and the rail fares were assumed to be 1,000 VND - 3,000 VND to check sensitivity and to obtain the maximum revenue level. Fig. 13-2-2 shows the relationship between rail fare level and the total daily revenue.



MRT Stations

A	B
LINE A	Ha Dong-Thang Long Line
A1	Ha Dong
A2	Ha Tay Bus Terminal
A3	Thanh Xuan Nam
A4	Thanh Xuan Bac
A5	Thanh Xuan
A6	Nga Tu So
A7	Thai Ha
A8	La Thanh
A9	Cat Linh
A10	Ha Noi
A11	Tran Hung Dao
A12	Hang Bai
A13	Hoan Kiem
A14	Dong Xuan
A15	Hang Dau
A16	Ho Tay
A17	Thuy Khe
A18	Buoi
A19	Nghia Tan
A20	Xuan Dinh Nam
A21	Xuan Dinh Bac
A22	Thang Long
LINE B	Van Dien-Yen Vien Line
B1	Van Dien
B2	Phap Van
B3/C1	Giap Bat
B4	Phuong Liet
B5	Vong
B6	Kim Lien
B7	Kham Thien
B8/A10	Ha Noi
B9	Phung Hung
B10/A14	Dong Xuan
B11	Gia Lam
B12	Duc Giang
B13	Yen Vien
Line C	Giap Bat-Noi Bai Line
C1	Giap Bat
C2	Kim Giang
C3/A4	Thanh Xuan Bac
C4	Trung Van
C5	Me Tri
C6	Yen Hoa
C7	Mai dich
C8	Nghia Do
C9	Xuan La
C10/A21	Xuan Dinh Bac
C11/A22	Thang Long
C12	Kim Chung Nam
C13	Kim Chung Bac
C14	Nam Hong Nam
C15	Nam Hong Bac
C16	Phu Cuong Nam
C17	Phu Cuong Bac
C18	Noi Bai

Fig. 13-2-1 Tentative MRT Network

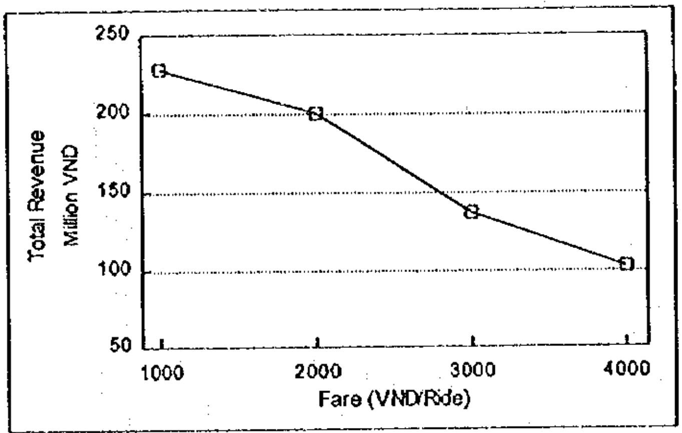


Fig. 13-2-2 Rail Fare and Revenue

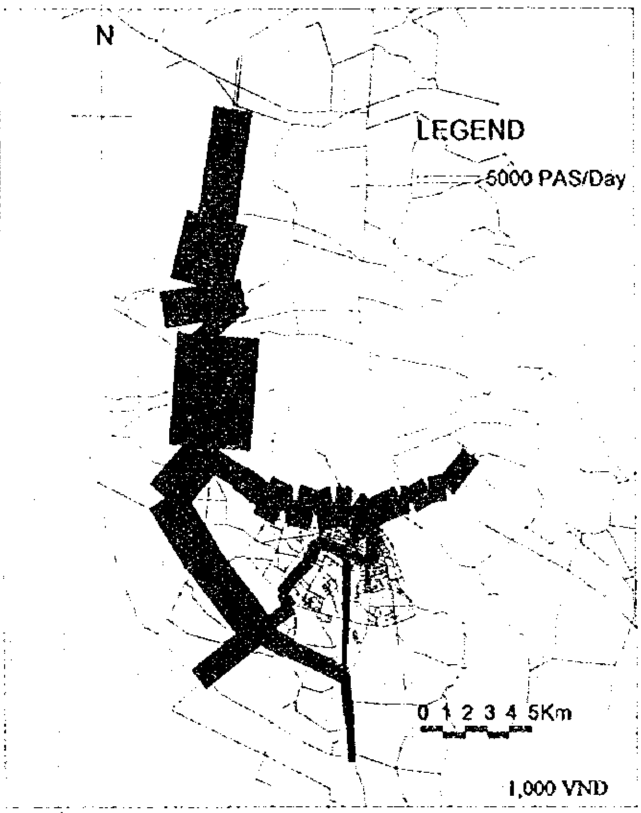
The highest revenue will be obtained when the same fare as the present bus system is applied to the rail system. Fig. 13-2-3 shows the passenger demand along the proposed MRT lines in 2015 using the fares of 1,000 / 2,000 / 3,000 and 4,000 VND per ride.

Based on the estimated demand for the required public transport network in Hanoi, the selected MRT line between Ha Dong and Thang Long in the new CBD is expected to handle a future capacity of about 29,000 passengers per day on its heaviest demand section in Central Hanoi in 2015 for the fare of 1,000 VND per ride. This demand gives a uni-directional peak-hour number of passengers of 2,500 when applying the directional factor of 67% and peak hour factor of 12.8% which are the average values estimated from the traffic survey results.

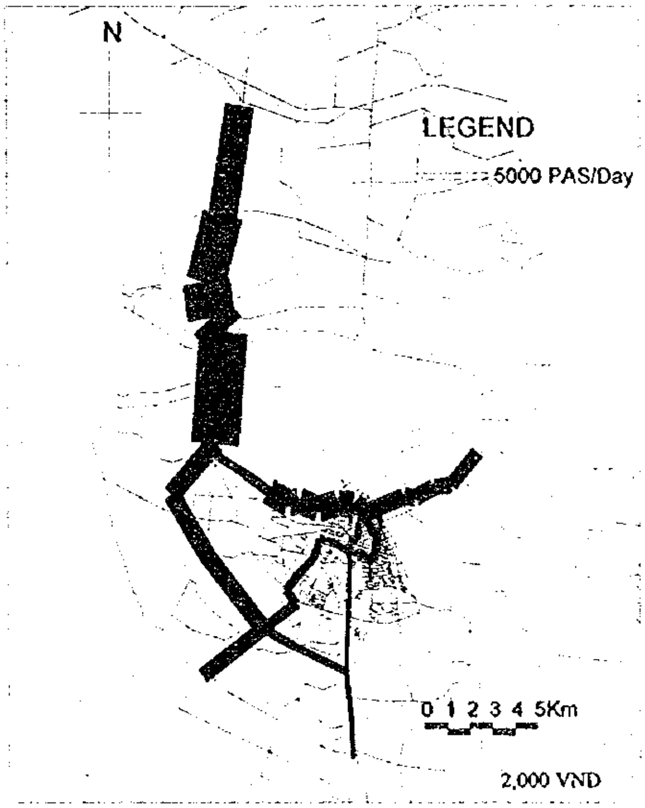
13.2.3 Selection of a Priority Study Line

Out of the three planned MRT lines, the Ha Dong - Hoan Kiem - Thang Long Line was selected for more comprehensive study for the following reasons:

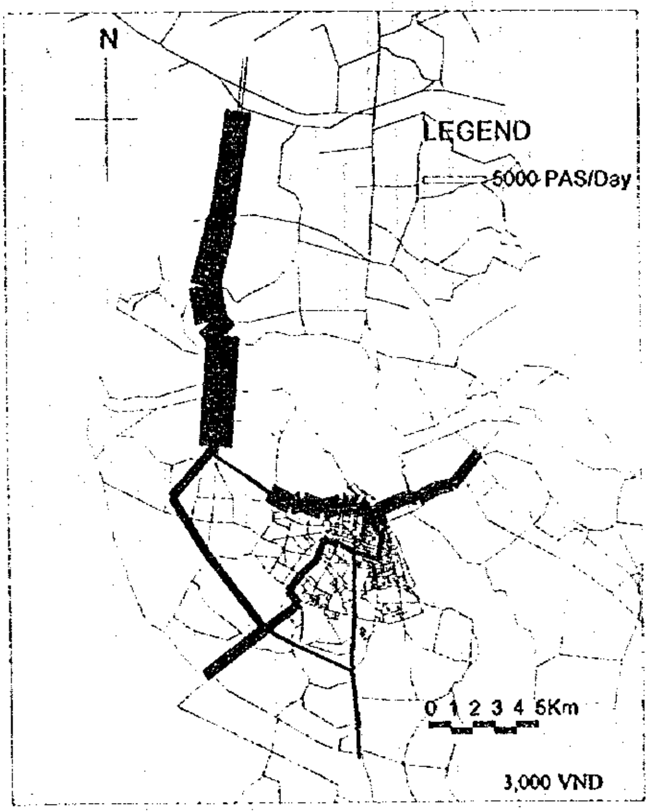
A. The line will connect the existing central area with the new CBD west of Hanoi which is planned to accommodate the future socioeconomic activities of the city.
B. The line is required to handle the heaviest transport demand existing at present in the corridor between Ha Dong and Hanoi central areas.
C. The line can be implemented independently under the HPC jurisdiction and new management and operating systems can be introduced without strong connections with other existing organizations.
D. The line is planned based on a new and independent alignment and will not interfere with or depend on other projects proposed for other railway lines by utilizing or upgrading existing facilities.
E. The line alignment has various characteristics including elevated and underground sections which will demonstrate and provide different new technologies and construction techniques.
F. The line can utilize any of the different types of MRT rolling stock because of its independent concept. It can be implemented either as suspended monorail, mounted monorail, dual-rail LRT (Light Railway Transit), HSST (High Speed Surface Transit) or linear motor system, and the five systems are subject to a comprehensive comparative analysis in this study.



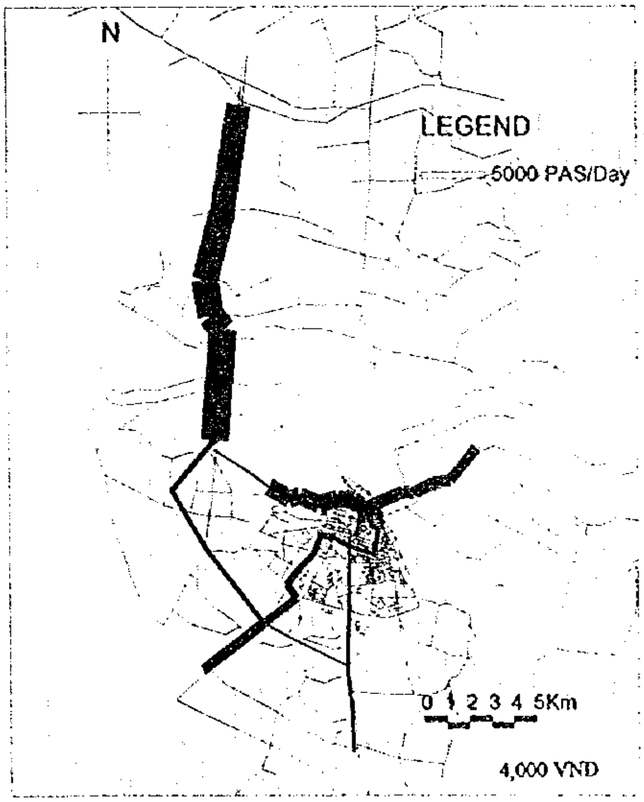
1,000 VND



2,000 VND



3,000 VND



4,000 VND

Fig. 13-2-3 MRT Passenger Demand

13.2.4 Line Alignment

The line was basically considered to be elevated where possible to minimize the cost of any required high-cost underground sections in the central areas of Hanoi, where the basic concept is to preserve these areas from any elevated structures on the roads which may affect the nature and environment of the city. The main control points which were considered in the conceptual alignment of this line covers the most important locations in Hanoi are as follows:

- Ha Dong: which has the highest population in the surrounding area of Hanoi
- Hanoi Station: to connect the urban line with the existing railway network
- Hoan Kiem Lake: which represents an important commercial and tourism area
- Ancient Quarter: which is the commercial and tourism center of Hanoi
- West Lake: which is one of the most important cultural and tourism areas
- New CBD: to support the urbanization development of the New CBD
- Thang Long: to connect the line with Noi Bai International Airport

The total length of the line extends to about 24 Km within which several alternatives were established for three sections along the alignment in the built-up area of Hanoi. The alignment of the line is roughly divided into three segments as follows:

Segment I: Ha Dong - Hanoi
This segment is planned to be completely elevated and tentatively starts near the center of Ha Dong and extends over the national highway No. 6 up to the To Lich River just before the intersection with RR-2. The line turns to the left over the To Lich River then to the right to enter the built-up area of Hanoi.

Segment II: Hanoi Built-up Area
The segment starts from the To Lich River and extends to pass the control points of Hanoi Station, Hoan Kiem Lake, the Ancient Quarter and the West Lake. The middle section of the segment goes underground at the central area of the city under Cat Linh street, Hanoi Railway Station and Tran Hung Dao street. It turns left under Hang Bai street to Hoan Kiem Lake commercial area. The line extends under Hang Dao street and turns left under Quan Thanh street.

Segment III: New CBD Area
This segment to the west of the West Lake goes to the new CBD and is planned to be elevated at the middle of the newly planned South Thang Long Road up to the Noi Bai Expressway. Then it goes parallel to the existing railway on the west side to the end of the line at the depot with a transfer station with the railway line going north to the Noi Bai International Airport.

As the second segment forms the most critical part of the alignment task, because it passes through the built-up area of the city, it was divided into the three sections A, B and C. A comparative analysis was carried out between the three alternatives for each of the three sections, as shown in Fig. 13-2-4, in order to identify the best alignment for the segment. The economic factor was basically the main issue in the analysis for the B and C alternatives based on a broad estimation for the construction cost as presented in Table

13-2-1. Of the A alternatives, A-2 was adopted due to other construction-related factors as it provides enough space to accommodate the a construction yard for the tunnel components.

Table 13-2-1 Cost of Alternatives

Alternative	Length (km)	Tunnel	Elevated	Cost (b VND)*
A - 1	3.85	1.00	2.85	1,011
A - 2 **	4.07	0.90	3.17	1,026
A - 3	3.40	0.90	2.50	898
B - 1 **	2.92	2.92	0.00	1,355
B - 2	3.45	3.45	0.00	1,601
B - 3	3.70	3.70	0.00	1,717
C - 1 **	2.93	0.45	2.48	685
C - 2	3.05	3.05	0.00	1,415
C - 3	3.22	0.45	2.77	741

* Direct construction cost excluding stations

** Selected Alternatives for the basic alignment

The selected alignment of the line is summarized in Table 13-2-2 and presented in Fig. 13-2-5, while the alignment profile is shown in Fig. 13-2-6.

Table 13-2-2 Summary of Alignment of Ha Dong - Thang Long Line

Item	Unit
Total Length	24.000 km
Viaduct	14.293 km
Tunnel [including approach]	8.170 km
Semi-Viaduct	2.000 km
Minimum Curvature	
Tunnel	300 m
Viaduct	200 m
Steepest Gradient	3.5 %
Number of Stations	22 Stations
Tunnel [including 2 transfer stations]	7 Stations
Viaduct [including 2 transfer stations]	15 Stations
Average Distance [Station to Station]	
Tunnel	1.000 km
Viaduct	1.300 km
Area of Depot	60,000 m^2

Fig. 13-2-4 Alignment Alternatives

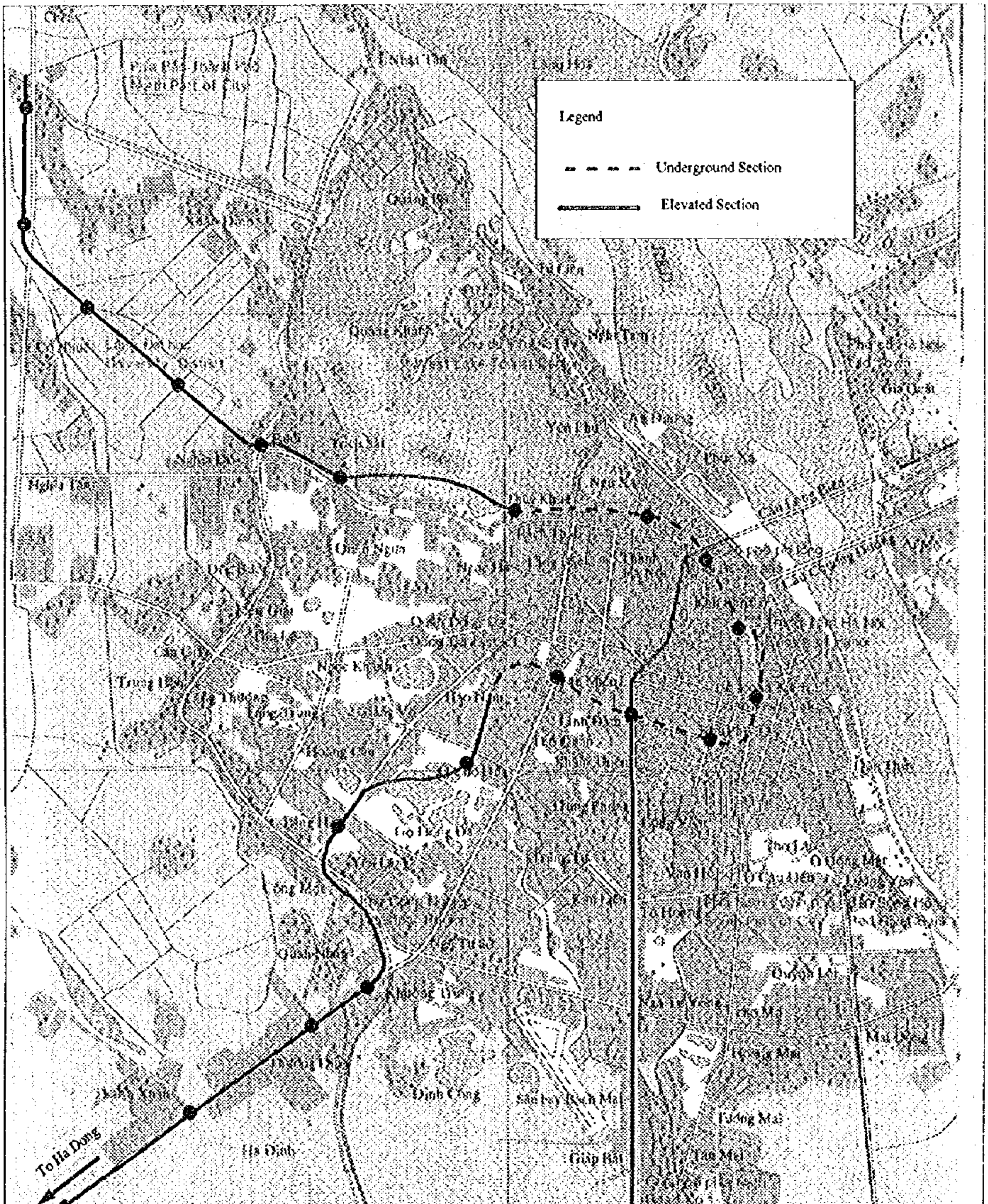


Fig. 13-2-5 Line Alignment

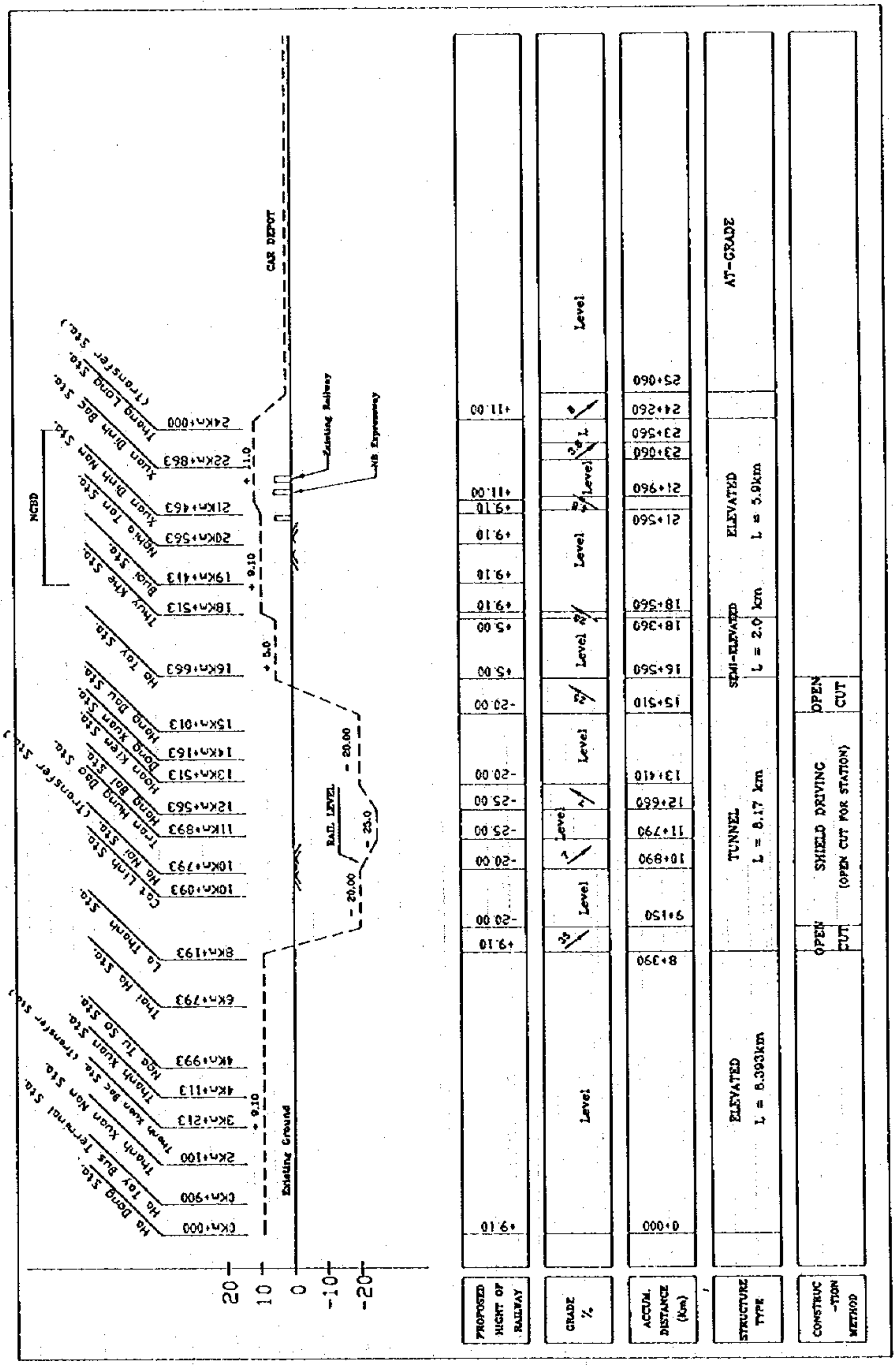


Fig. 13-2-6 Line Profile

13.2.5 Stations

The line has a total number of 22 stations based on an average interval of about 800m in the urban areas and 1,200m in the suburban areas taking into consideration the high generation/attraction areas which are either residential or commercial areas. In preparing the line basic plan and the preliminary estimation of the total cost, stations were classified into three ranks according to their function and expected demand as follows:

Large-size Station: To serve in the future two MRT lines and it has the additional function of handling the transfer of passengers.
Medium-size Station: To serve only one MRT line in a high density area .
Small-size Station: To serve only one MRT line in a low density area.

All platforms are planned to be long enough to accommodate longer train formation in the future. Rankings, dimensions and proposed area-based-names for the twenty two stations of the line are presented in Table 13-2-3, while Fig. 13-2-7 shows a general layout of an MRT station.

Table 13-2-3 Line Stations

Type	Rank	No. of Stations	Area (m2)		Name of Station
			Platform	Concourse	
Elevated Station	Large	2	1,040	2,100	Thanh Xuan Bac Xuan Dinh Bac
	Medium	6	800	1,440	Buoi Nghia Tan Xuan Dinh Nam Thang Long Nga Tu So Ha Dong
	Small	7	480	1,200	Thanh Xuan Thai Ha La Thanh Ho Tay Ha Tay Thanh Xuan Nam Thuy Khue
Subtotal		15			
Tunnel Station	Large	2	960	2,000	Ha Noi Dong Xuan
	Medium	2	640	1,280	Hoan Kiem Hang Bai
	Small	3	480	1,200	Cat Linh Tran Hung Dao Hang Dao
Subtotal		7			
Total		22			

13.2.6 Depot

In the basic plan, the site selected to accommodate the required depot and vehicle shed for the rolling stock of the MRT line is located near its terminal station south of the Thang Long Bridge. With an average of about 500 m^2 per vehicle, the selected area of about

60,000 m² can accommodate up to 120 vehicles for future expansion plans. The depot layout is shown in Fig. 13-2-8. The area provides the nearest location to the line terminal station to decrease the cost of extending the elevated section and tracks for a long distance. The depot would be used for regular, periodical maintenance works as well as for the daily service of washing and cleaning the vehicles as it would be equipped with a self-moving vehicle washing machine.

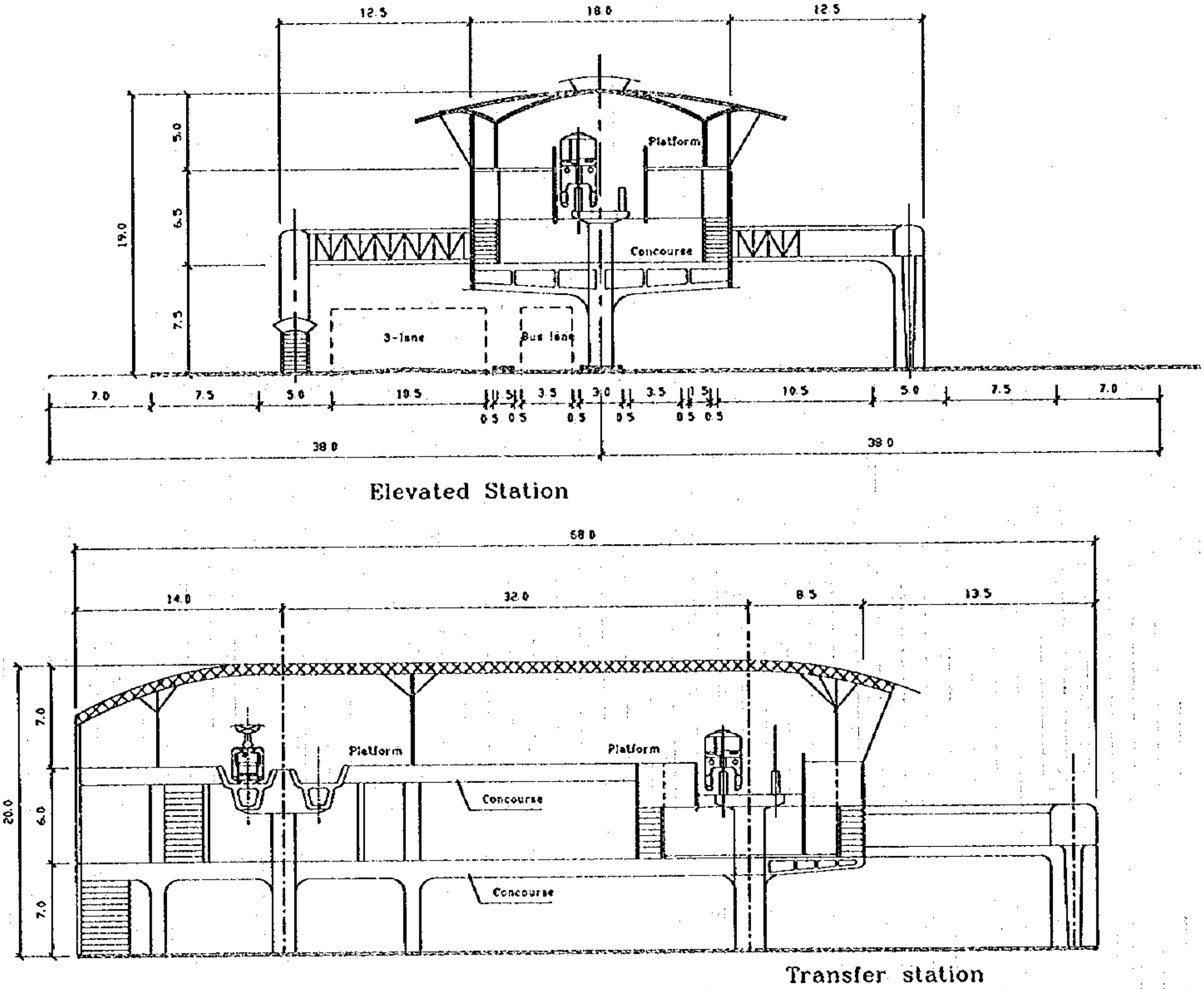


Fig. 13-2-7 Elevated MRT Station

13.2.7 Rolling Stock

Based on the demand forecast for the MRT line, the following five types of rolling stock, which cover the required capacity, were subject to a comparative analysis. The main operational features of these electrically-operated vehicles are summarized in Table 13-2-4 while Fig. 13-2-9 shows the different rolling stock vehicles.

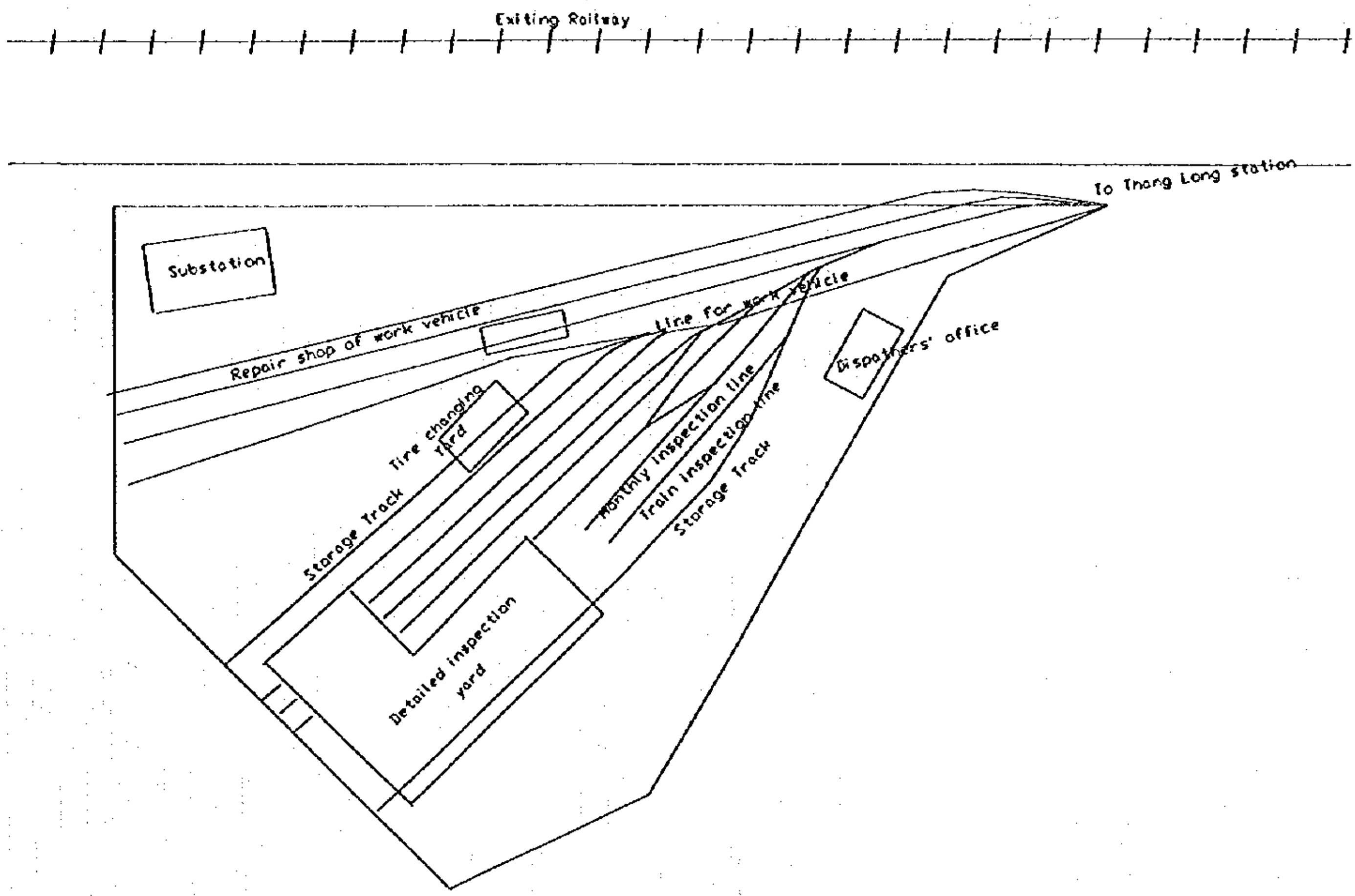


Fig. 13-2-8 Plan of Depot

(1) Mounted Monorail [ALWEG Type]

The mounted or straddle monorail is the standard type of the monorail in which the train vehicles are supported by rubber tyre driving wheels, two of which are fitted to one driving axle. The monorail vehicle is provided with solid rubber auxiliary wheels to back-up the driving wheels, to cope with tyre punctures, together with a flat-tyre detecting device. Two pairs of guiding wheels composed of pneumatic rubber tyre with nylon cord and combined with the auxiliary wheels are fitted to the bogie truck. The vehicles are guided by this set of rubber tyre guide wheels which hold both sides of the monorail. In addition, a pair of stabilizing wheels are also fitted to the bogie truck.

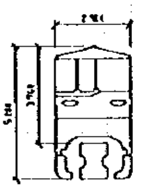
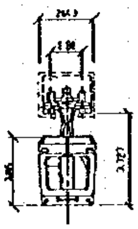
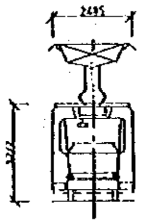
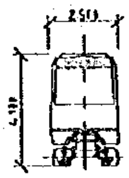
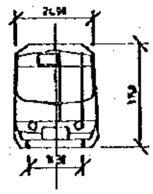
(2) Suspended Monorail [SAFEGE Type]

In this type, the monorail vehicles, suspended by a suspension link connected to rubber tyre running wheels, move on a resin-mortared running plate installed inside a box-type track. The vehicle is also guided by rubber-tyred wheels.

(3) Dual-rail LRT [Light Rapid Transit]

This system provides a light and rapid railway transit of conventional train vehicles in which the vehicles run on two rails. As an urban transport mode for commuting purposes, it is operated by electric power supply and utilizes small vehicles whose size can be selected to fit the required capacity to decrease the construction costs.

Table 13-2-4 Operational Features of MRT Systems

Type of vehicle		Monorail		LRT (Light Rail Transit)	HSST	Linear Motor
		Mounted	Suspended			
Section of rolling stock						
Length of car (car formation) (m)		15.5 31.0	15.4 (30.8)	11.145+11.45 (22.29)	14.1 (28.2)	16.5 (33.0)
Max. Speed (km/h)		80	65	60	90	70
Tare weight (ton)		27.8	21.5	41.0	15.0	25.0
Loaded weight (ton)		44	35	78	25	37
Axle load (ton)		11	9	10	2 ton/m	9
Train make-up		2-Mc	2-Mc	2-Mc	2-Mc	2-Mc
Capacity (for formation)	Seats	80	84	62	74	72
	Standing	120	74	107	103	108
	Total	200	158	169	177	180
	Max. Passingers	338	267	279	242	246
	Full passingers	496	401	410	363	369
Steepest gradient (‰)		40	53	35	70	50
Max.curve radius (m)		80	50	160	50	50
Formation for passingers carried		14	9.4	9.0	10.3	10.2
Train enterval (minute)		8:10	6:20	6:40	5:50	6:00
Number of rolling stock		28	40	36	36	36
Area for depot (m^2)		50,000	60,000	60,000	50,000	60,000
Remarks		- Rubber tire - PC Concrete rail - Rotary motor	- Rubber tire - Steel box rail - Rotary Motor	- Iron wheel - Iron rail - Rotary Motor - Gage D=1435mm	- Maglev - Maglev rail - Liner Motor	- Iron wheel - Iron rail - Liner Motor - Gage D=1435mm

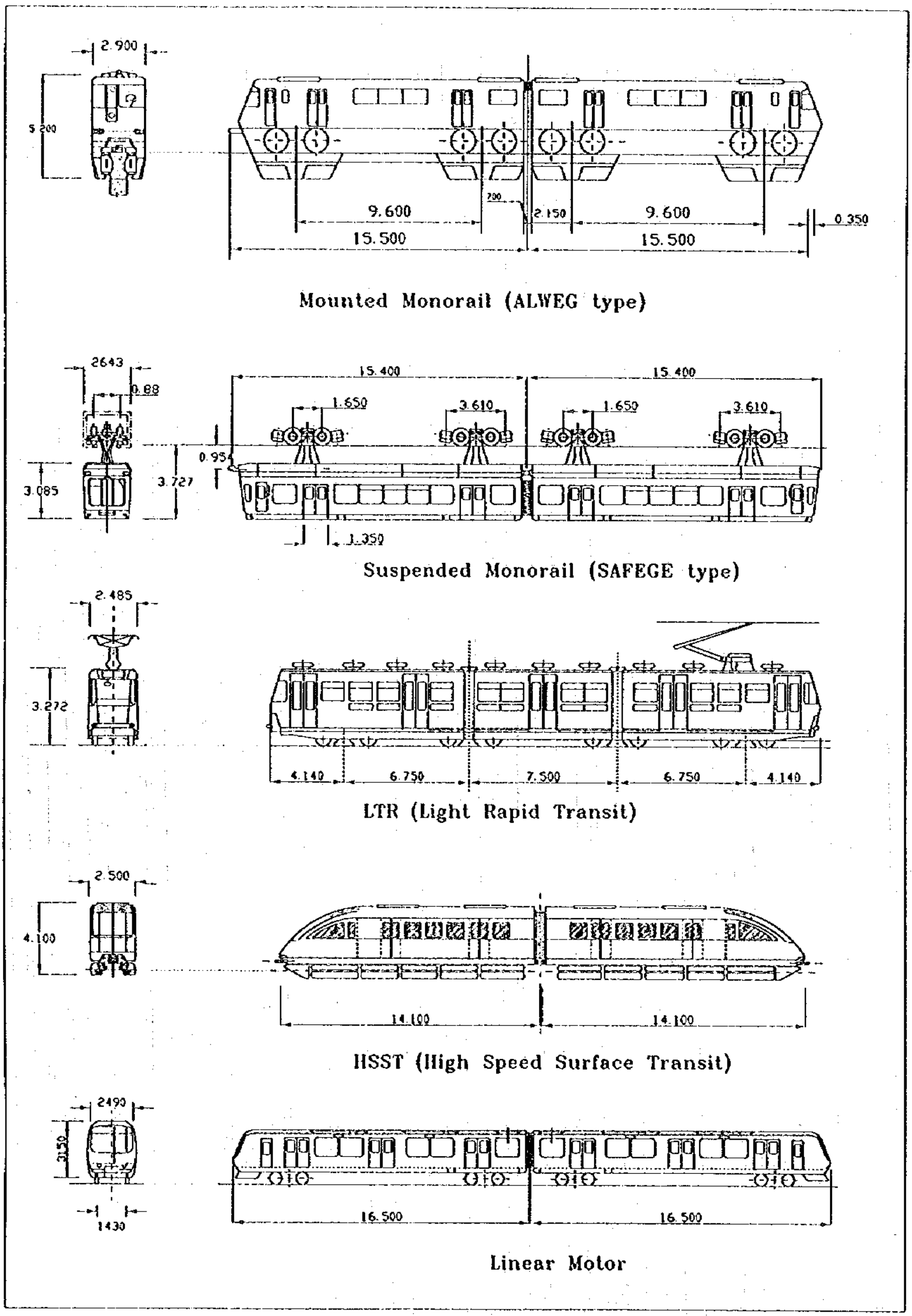


Fig. 13-2-9 Rolling Stock Vehicles

(4) HSST [High Speed Surface Transit]

This system is based on the new technology of magnetic levitation which gives a fast, safe and comfortable ride and provides protection to the environment. The system utilizes levitation by means of electromagnetic attraction and employs linear motors as a power source to propel the vehicles.

When electric current flows through the electromagnetic coil, magnetic attraction toward the rail is produced and the vehicle's body is held in a floating position. The clearance between the electromagnet and the rail is constantly monitored by sensors to maintain a fixed distance. When compared with other conventional rolling stock, the system can handle steeper slopes and sharper curves and provides higher speed and time saving benefits. The system also utilizes lighter structures and smaller tunnels which will result in a lower construction cost. Due to its levitating design, there are no friction parts which gives low levels of noise, vibration and maintenance costs.

(5) Linear Motor System

In this system, linear motors are utilized to move the steel wheels of the vehicles over guided conventional rails. The objective of developing this system is to decrease the construction costs of the underground sections due to the small-size cross-section used by the vehicles.

13.2.8 Civil Engineering Infrastructure

The three main elements of the MRT civil engineering infrastructure, which are the track girders, piers and tunnels, can be designed and implemented as different types and by utilizing different materials, such as concrete or steel depending on the adopted MRT system. The following sections present the characteristics and proposed cross-section of the three elements for the five MRT systems under study.

(1) Track Girder

The track beam of the ALWEG monorail can be implemented as pre-stressed concrete (PC) or steel cross section depending on the required span length and implementation schedule. The higher cost steel beams provide a longer span length with less piers when compared with the PC beams, and they can also be erected in a shorter time. The SAFEGE monorail utilizes steel beams while the PC track girders are used for the HSST system. For the LRT and Linear Motor systems, a PC viaduct is required to accommodate the rails which are laid on the girder. Table 13-2-5 presents the general characteristics of each of the girders used.

(2) Pier

Piers to support the track girders have a different design dependent on the MRT system used. The widely used piers for the five MRT systems are presented in Table 13.4.6. For any of the MRT systems, piers can be constructed either as PC or steel, except in the case of the SAFEGE monorail system which utilizes only steel piers and track girders to accommodate the wheels of the suspended vehicles.

(3) Tunnel

Table 13-2-7 presents different types of tunnels which can be used for any of the MRT systems while Table 13-2-8 shows a comparison between the dimensions and cost for the single-track tunnel of each system.

13.2.9 Operation Plan

Based on the characteristics of the line, specifications were established for its operation plan for the different systems based on the estimated demand of 29,000 passengers/day on the highest demand section of the line in Central Hanoi.

Applying a peak hour factor of 12.8% and directional factor of 67%, derived from the traffic survey, the peak-hour one-direction demand of 2,500 passengers was estimated for a fare of 1,000 VND per ride. The system specifications and estimated number of required cars are presented in Table 13-2-9.

Table 13-2-9 Specifications of Train Operation

Item		ALWEG	SAFEGE	LRT	HSST	Linear M
Max. Speed - km/hr		80	65	60	90	70
Normal Speed - km/hr		60	50	55	65	58
Acceleration to N. S.	Time - sec	58	48	60	40	58
	Dist. - km	0.700	0.450	0.550	0.350	0.700
Deceleration from N. S.	Time - sec	21	18	20	19	21
	Dist. - km	0.179	0.125	0.150	0.195	0.179
Normal Running	Time - sec	8	31	20	14	8
	Dist. - km	0.121	0.425	0.300	0.455	0.121
Station Stoppage-time - sec		30	30	30	30	30
Total Time - sec		117	127	130	103	117
Scheduled Speed - km/hr		31	28	28	35	31
Train Formation - cars		2	2	2	2	2
No. of Passengers		338	267	279	242	246
No. of Trains / hr		7.4	9.4	9.0	10.4	10.2
Headway - min.		8:10	6:20	6:40	5:50	6:00
Target Travel Time - min.		47	52	52	41	47
No. of Trains Required		12	18	16	16	16
No. of Reserve Trains		2	2	2	2	2
Total No. of Trains		14	20	18	18	18
Total No. of Cars		28	40	36	36	36

The ALWEG monorail has a high capacity which result in the lowest number of cars and the SAFEGE monorail has the highest number of cars while the other three types require the same number of cars. The train operation diagram for the different systems is presented in Fig. 13-2-10.

Table 13-2-5 Track Girders of MRT Systems

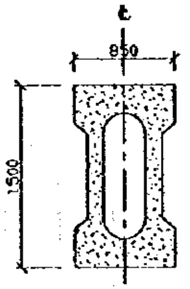
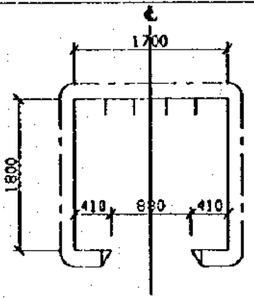
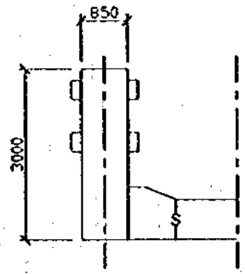
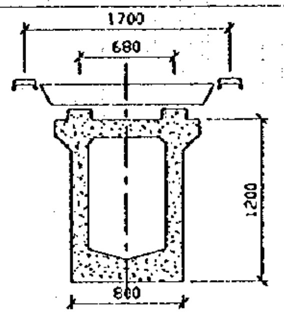
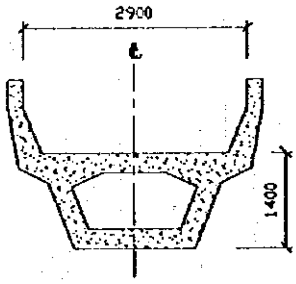
	Cross Section of Truck	Span Length (m)	Weight of Beam (ton/km)	Quantity (m^3/km)	Cost (per km)	Remarks
PC-truck beam		$L=20^{m}$	2.3 ton/m	Concrete volume Y=910 m^3/km	29.8	Monorail track of ALWEG type
Steel truck beam of suspended type		$L=30^{m}$	1.1 ton/m	Steel Weight W=1100 ton/km	41.5	Monorail track of SAFEGE type
Steel Truck beams		$L=40^{m}$	1.2 ton/m	Steel weight W=1200 ton/km	45.2	Monorail track of steel for ALWEG type
PC-Truck beam For HSST vehicle		$L=20^{m}$	1.3 ton/m	Concrete volume Y=510 m^3/km	21.3	Truck girder of HSST
Ginder for LRT/Liner motor		$L=30^{m}$ ~ 60^{m} (steel girder)	5.8 ton/m	Concrete volume Y=2305 m^3/km	96.8	Rail were laid on the girder

Table 13-2-6 Piers of MRT Systems

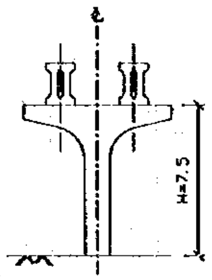
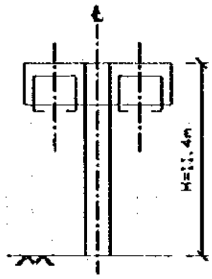
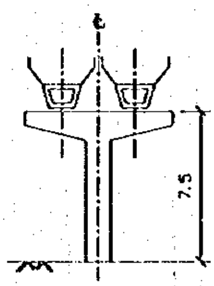
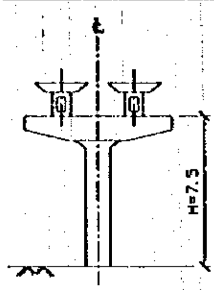
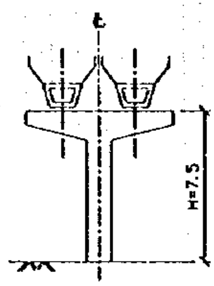
	Cross Section of Pier		Span Length (m)	Size of Pier (m)	Quantity	Cost (B.VND/km)	Foundation
Monorail (ALWEG)		RC	L = 20	1.8x1.8		35.1	6 pile L=13 m
		Steel	L = 30	1.5x1.5	1070 ton/km	47.1	6 pile L=13 m
Monorail (SAFEGE)		RC	———	———	———	———	Not make from RC
		Steel	L = 30	ϕ1.5	1350 ton/km	34.2	6 pile L=13 m
LRT		RC	L = 30	1.8x1.8		28.7	6 pile L=13 m
		Steel	L = 40	1.5x1.5	800 ton/km	35.2	6 pile L=13 m
HSST		RC	L = 20	ϕ1.8		33.2	6 pile L=13 m
		Steel	L = 40	ϕ1.4	520 ton/km	22.9	4 pile L=13 m
Linear Motor		RC	L = 30	1.7x1.7		25.9	6 pile L=13 m
		Steel	L = 40	ϕ1.5	720 ton/km	33.2	6 pile L=13 m

Table 13-2-7 Tunnel Types for MRT Systems

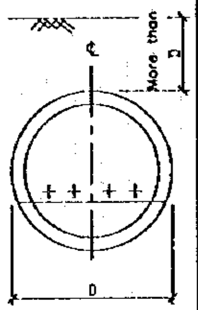
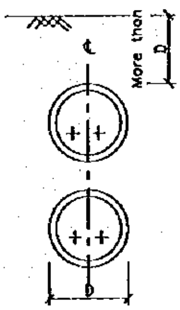
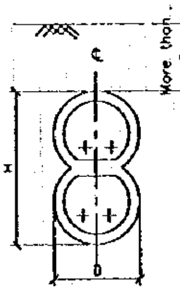
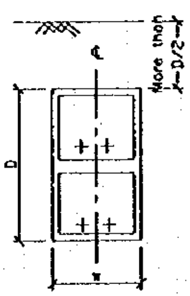
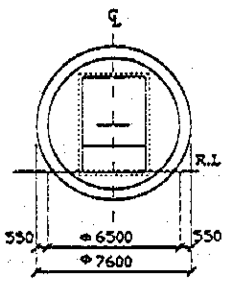
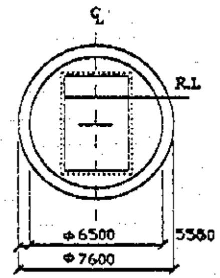
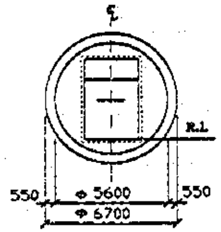
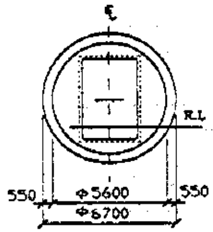
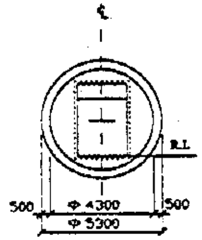
Type		Tunnel Section	Item of Comparative	Rolling Stocks				
				ALWEG	SAFEGE	LRT	HSST	Linear Motor
Single shield tunnel	Dual-truck		Diameter of tunnel	9.2^{m}	9.2^{m}	8.0^{m}	7.0^{m}	6.8^{m}
			Area of Tunnel section	66.5 m^2	66.5	50.3	38.5	36.3
			Volume of segment	20,090 m^3/km	20,090	17,629	15,230	15,230
			Cost (per Km)	573 (bil VND)	573	503.4	433.0	393.4
	Single-truck		Diameter of tunnel	6.5^{m}	6.5	5.6	5.0	4.3
			Area of Tunnel section	2x33.2 m^2	2x33.2	2x24.6	2x19.6	2x14.5
			Volume of segment	14,600 m^3	14,600	12,800	12,800	9,300
			Cost (per Km)	576 (bil VND)	576	445	437	288
Multi-face shield			Dimension of tunnel	Ø6.5 m x14.8	Ø6.5 x14.8	Ø5.6 x12.8	Ø5.6 x12.8	Ø4.3 x9.8
			Area of Tunnel section	59.9	59.9	45.3	45.3	32.7
			Volume of segment	13870	13870	12200	12200	8800
			Cost (per Km)	598.0	885.8	478.2	411.0	373.7
Open-cut tunnel			Dimension of tunnel	5.7x15.2	5.3x15.2	5.4x13.4	5.4x13.4	5.3x12.8
			Area of Tunnel section	2x37.1	2x37.1	2x30.2	2x28.6	2x22.8
			Concreat volume	30780	30780	27960	27960	27020
			Cost (per Km)	300.0	300.0	239.0	187.0	187.0

Table 13-2-8 Tunneling Comparison

Item \ Type	MONORAIL		LRT	HSST	Liner Motor
	ALWEG	SAFEGE			
Tunnel Section (Single Truck)					
Section Area (m2)	33.2	33.2	24.6	24.6	14.5
Section Area for Excavation (m2)	47.8	47.8	34.7	34.7	23.8
%	100	100	78	78	50
Volume of Excavation (m3)	382,400	382,400	299,200	299,200	190,400
Volume of Segment (m3)	116,800	116,800	102,400	102,400	74,400
Cost per Km (αx2)B.VND	628.6	628.6	483.0	483.0	314.3
Length of Tunnel (Km)	7*2	7*2	7*2	7*2	7*2

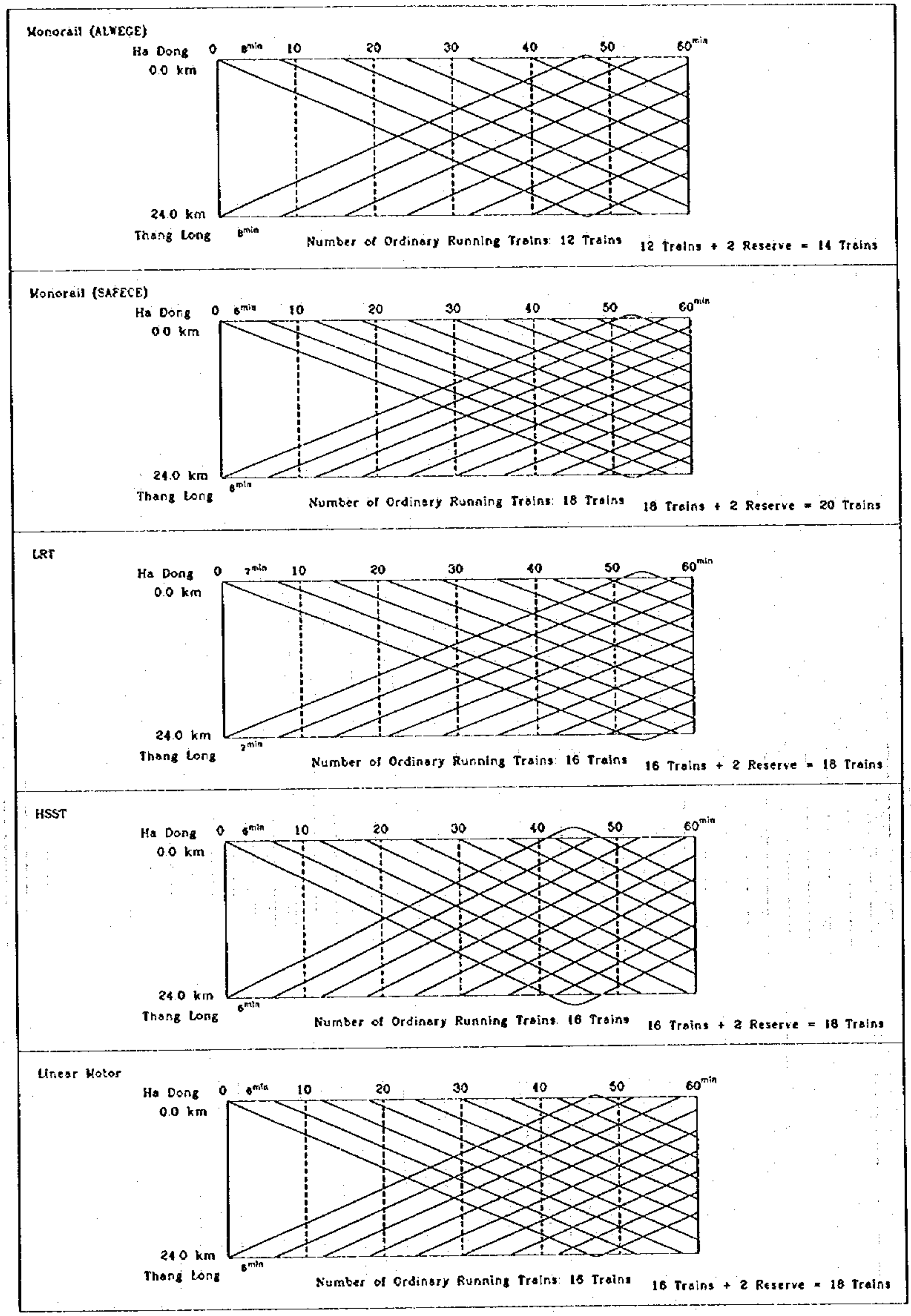


Fig. 13-2-10 Train Operation Diagram

13.2.10 Cost Estimate

(1) Civil Engineering Capital Costs

Direct civil engineering costs were calculated based on cost data for similar rail transit systems which have been constructed in Japan and the Philippines. These costs were subdivided basically into the route section categories of: Shield Tunnel; Open Cut; Elevated; and Station.

An average of 20% was added as indirect cost and the engineering and supervision costs were estimated at 12% of the sum of the direct and indirect costs. These costs set out for each system in Table 13-2-10. Total civil engineering costs for each system in VND at 1996 prices are as follows:

ALWEG Monorail	10,948 Billion VND
SAFEGE Monorail	12,264 Billion VND
LRT	10,306 Billion VND
HSST	8,201 Billion VND
Linear Motor	6,823 Billion VND

The two Monorail systems are the most expensive because their large track soffit to top of vehicle height requires a larger tunnel cross-section that for the other systems. The LRT system also requires a relatively large tunnel cross-section due to the space required for the power pickup pantagraph. The Linear Motor system requires the smallest tunnel cross-section and is therefore the cheapest. Foreign and local percentages were calculated for each cost item based on the Consultants experience.

(2) System Capital Costs

Direct system costs were calculated based on cost data for similar systems which have been constructed in Japan and the Philippines. These costs were subdivided as follows:

- Rolling Stock;
- Power Feeding Equipment;
- Power Line to Energize Trains;
- Signaling and Train Control Systems;
- Telecommunication Systems;
- Station Facilities;
- Maintenance Depot Facilities; and
- Track or Guidance Systems.

Indirect cost and engineering and supervision costs were estimated at 12% of the direct cost, except for the rolling stock cost which is inclusive of these costs. The costs for each system are presented in Table 13-2-10. Total system costs for each system in VND at 1996 prices are as follows:

ALWEG Monorail	4,924	Billion VND
SAFEGE Monorail	5,213	Billion VND

LRT	5,024	Billion VND
HSST	5,516	Billion VND
Linear Motor	5,497	Billion VND

The HSST and Linear Motor systems are significantly more expensive because their rolling stock, maintenance depot and track costs are higher than for the other systems.

Table 13-2-10 Capital Cost Estimate (1)

[B. VND - 1996 Prices]

Description		Cost Breakdown						
		Direct	Indirect	Const-ruction	Engin-eering	Foreign % age	Local % age	Total Cost
ALWEG Monorail								
1	Shield Tunnel	4,400	880	5,280	634	80%	20%	5,914
2	Open Cut	210	42	252	30	30%	70%	282
3	Elevated	2,864	573	3,437	412	10%	90%	3,849
4	Station	672	134	806	97	0%	100%	903
1 to 4	Total Civils	8,146	1,629	9,775	1,173	48%	52%	10,948
5	Rolling Stock	588	0	588	0	100%	0%	588
6	Power Feed	581	70	651	70	50%	50%	720
7	Power Line	1,408	169	1,577	169	50%	50%	1,746
8	Signaling	752	90	842	90	80%	20%	932
9	Telecoms	102	12	114	12	50%	50%	126
10	Station Facilities	170	20	190	20	50%	50%	211
11	Maintenance Depot	442	53	495	53	50%	50%	548
12	Track	42	5	47	5	30%	70%	52
5 to 12	Total Non Civils	4,085	420	4,505	420	61%	39%	4,924
13	Land	3	0	3	0	0%	100%	3
1 to 13	Total All Costs	12,234	2,049	14,283	1,593	52%	48%	15,876
SAFEGE Monorail								
1	Shield Tunnel	4,400	880	5,280	634	80%	20%	5,914
2	Open Cut	210	42	252	30	30%	70%	282
3	Elevated	4,010	802	4,812	577	20%	80%	5,389
4	Station	505	101	606	73	0%	100%	679
1 to 4	Total Civils	9,125	1825	10,950	1,314	48%	52%	12,264
5	Rolling Stock	588	0	588	0	100%	0%	588
6	Power Feed	581	70	651	70	50%	50%	720
7	Power Line	1,408	169	1,577	169	50%	50%	1,746
8	Signaling	752	90	842	90	80%	20%	932
9	Telecoms	102	12	114	12	50%	50%	126
10	Station Facilities	170	20	190	20	50%	50%	211
11	Maintenance Depot	560	67	627	67	50%	50%	694
12	Track	157	19	176	19	30%	70%	195
5 to 12	Total Non Civils	4,318	448	4,766	448	60%	40%	5,213
13	Land	3	0	3	0	0%	100%	3
1 to 13	Total All Costs	13,446	2,273	15,719	1,762	52%	48%	17,480
LRT								
1	Shield Tunnel	3,447	689	4,136	496	80%	20%	4,633
2	Open Cut	113	23	136	16	30%	70%	152
3	Elevated	3,436	687	4,123	495	10%	90%	4,618
4	Station	672	134	806	97	0%	100%	903
1 to 4	Total Civils	7,668	1,534	9,202	1,104	41%	59%	10,306
5	Rolling Stock	605	0	605	0	100%	0%	605
6	Power Feed	581	70	651	70	50%	50%	720
7	Power Line	1,408	169	1,577	169	50%	50%	1,746
8	Signaling	752	90	842	90	80%	20%	932
9	Telecoms	102	12	114	12	50%	50%	126
10	Station Facilities	170	20	190	20	50%	50%	211
11	Maintenance Depot	413	50	463	50	50%	50%	512

Table 13-2-10 Capital Cost Estimate (2)

[B. VND - 1996 Prices]

Description		Cost Breakdown						
		Direct	Indirect	Const-ruction	Engin-eering	Foreign % age	Local % age	Total Cost
12	Track	138	17	155	17	70%	30%	171
5 to 12	Total Non Civils	4,169	428	4,597	428	62%	38%	5,024
13	Land	3	0	3	0	0%	100%	3
1 to 13	Total All Costs	11,840	1,961	13,801	1,532	48%	52%	15,333
HSST								
1	Shield Tunnel	3,381	676	4,057	487	80%	20%	4,544
2	Open Cut	113	23	136	16	30%	70%	152
3	Elevated	1,936	387	2,323	279	20%	80%	2,602
4	Station	672	134	806	97	0%	100%	903
1 to 4	Total Civils	6,102	1,220	7,322	879	51%	49%	8,201
5	Rolling Stock	792	0	792	0	100%	0%	792
6	Power Feed	550	66	616	66	50%	50%	682
7	Power Line	1,274	153	1,427	153	50%	50%	1,580
8	Signaling	648	78	726	78	80%	20%	804
9	Telecoms	102	12	114	12	50%	50%	126
10	Station Facilities	170	20	190	20	50%	50%	211
11	Maintenance Depot	604	72	676	72	50%	50%	749
12	Track	462	55	517	55	70%	30%	573
5 to 12	Total Non Civils	4,602	457	5,059	457	64%	36%	5,516
13	Land	3	0	3	0	0%	100%	3
1 to 13	Total All Costs	10,707	1,678	12,385	1,336	56%	44%	13,720
Linear Motor								
1	Shield Tunnel	2,200	440	2,640	317	80%	20%	2,957
2	Open Cut	105	21	126	15	30%	70%	141
3	Elevated	2,100	420	2,520	302	10%	90%	2,822
4	Station	672	134	806	97	0%	100%	903
1 to 4	Total Civils	5,077	1015	6,092	731	39%	61%	6,823
5	Rolling Stock	756	0	756	0	100%	0%	756
6	Power Feed	581	70	651	70	50%	50%	720
7	Power Line	1,408	169	1,577	169	50%	50%	1,746
8	Signaling	752	90	842	90	80%	20%	932
9	Telecoms	102	12	114	12	50%	50%	126
10	Station Facilities	170	20	190	20	50%	50%	211
11	Maintenance Depot	579	69	648	69	50%	50%	718
12	Track	231	28	259	28	70%	30%	286
5 to 12	Total Non Civils	4,579	459	5,038	459	63%	37%	5,497
13	Land	3	0	3	0	0%	100%	3
1 to 13	Total All Costs	9,659	1474	11,133	1,190	50%	50%	12,323

Notes:
Indirect Cost Civil: 20% of Construction Cost
Indirect Cost Others: 12% of Construction Cost
Engineering Cost Civil: 12% of Construction Cost
Engineering Cost Others: 12% of Direct Cost

(3) Land Costs

Land cost estimates were based on the official land prices in Hanoi for urban and suburban areas. This cost is 3 B.VND at 1996 prices for all options.

(4) Total Capital Costs

Civil engineering, system and land costs were added to give the following total capital costs for each system at 1996 prices:

ALWEG Monorail 15,876 Billion VND [129% of the cheapest]

SAFEGE Monorail	17,480 Billion VND	[142%	"	]
LRT	15,333 Billion VND	[124%	"	]
HSST	13,720 Billion VND	[111%	"	]
Linear Motor	12,323 Billion VND	[100%	"	]

The SAFEGE Monorail system is the most expensive while the Linear Motor system is the cheapest.

13.2.11 Comparative Analysis

(1) Project Cost

As five MRT systems were investigated in this study, a summary of the direct capital cost for the main items is presented in Table 13-2-11 for comparative purposes. Fig. 13-2-11 gives a graphical presentation for the direct cost per kilometer for each item.

Table 13-2-11 Summary of System Cost

[B. VND]

No.	Item	ALWEG	SAFEGE	LRT	HSST	Linear M
1	Shield Tunnel [7km]	4,400	4,400	3,447	3,381	2,200
2	Open-cut [1km]	210	210	113	113	105
3	Elevated [15km]	2,864	4,010	3,436	1,936	2,100
4	Station [22 sta]	672	505	672	672	672
5	Sub-total [1 ~ 4]	8,146	9,125	7,667	6,102	5,077
6	Rolling Stock	588	588	605	792	756
7	Line Facilities	3,470	3,730	3,564	3,810	3,823
8	Sub-total [6 ~ 7]	4,085	4,318	4,169	4,602	4,579
	Total Direct Cost	12,231	13,441	11,836	10,704	9,656
	Total D. Cost / km	510	560	493	446	402
	Financial Cost	15,876	17,480	15,333	13,720	12,323
	Financial Cost / km	662	728	639	572	513
	Oper. & Maint. Cost	420	562	499	642	556

The results of the direct capital and financial costs estimation show that the highest cost system is the SAFEGE monorail which requires steel structures of girders and piers in addition to the large size tunnel in the underground section. It is followed by the ALWEG monorail and the LRT systems. The lowest value for the annual operation and maintenance cost, estimated based on rates in Japan after adjustment to local conditions is for the ALWEG monorail system as it utilizes fewer large-sized cars compared with other systems.

The MRT system of Hanoi City should not be adopted based only on a monetary comparison. Other qualitative and environmental aspects related to the five systems are presented in Table 13-2-12 for comparison purposes. The comparative evaluation here is limited to the comparison between the five systems, which means it is not an absolute comparative analysis.

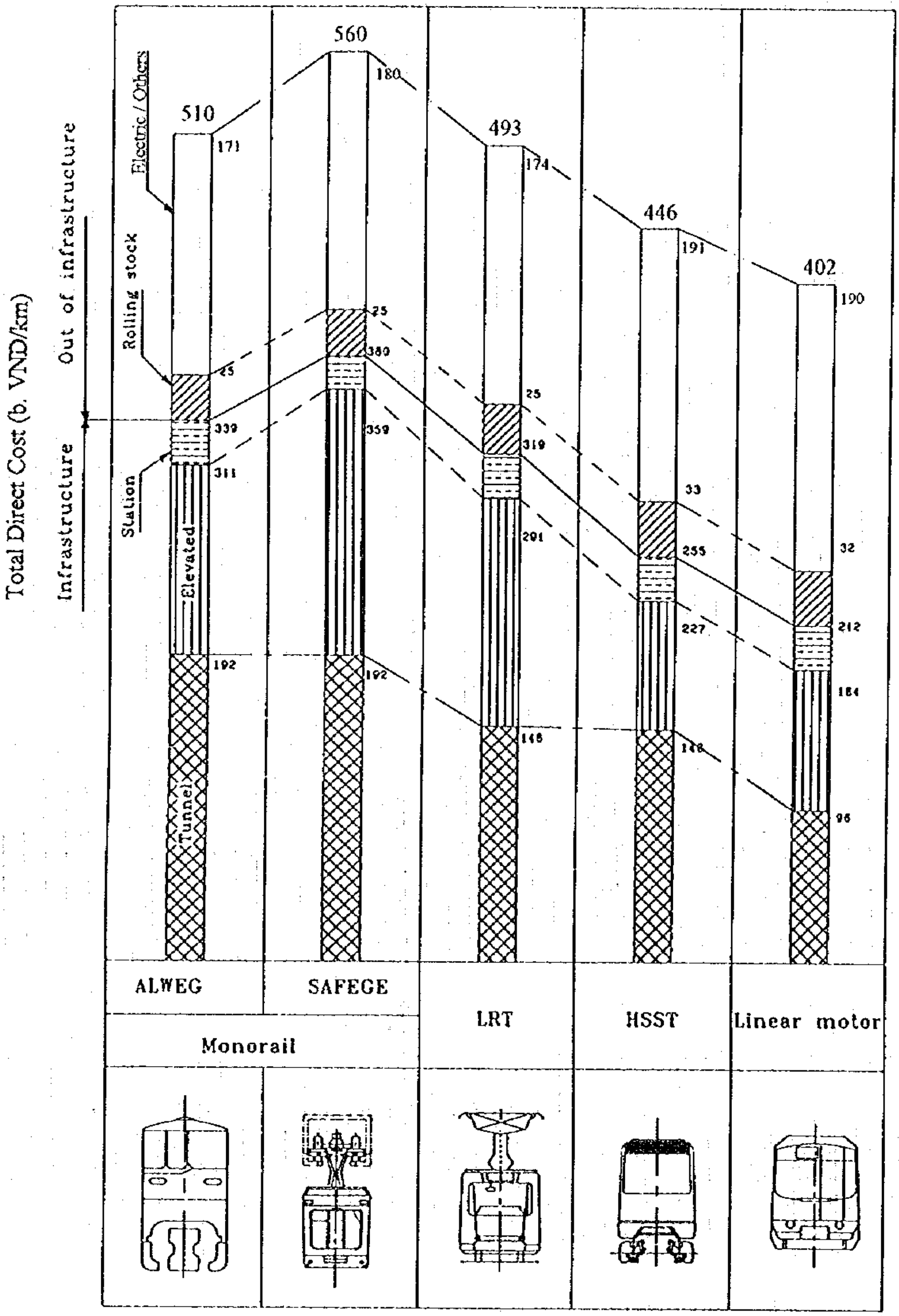


Fig. 13-2-11 Average Construction Cost of MRT Systems

Table 13-2-12 Qualitative Aspects of MRT Systems

Item	ALWEG	SAFEGE	LRT	HSST	Linear M
Concentrated Load [ton]	11	9	10	7	9
Tunnel Section	Large	Large	Medium	Medium	Small
Elevated Structure	Medium	Medium	Heavy	Light	Medium
Track Girder	Heavy Beam	Medium Beam	Girder & Slab	Light Beam	Girder & Slab
Noise	Low	Low	High	None	Medium
Vibration	Low	Low	High	None	Medium
Maintenance Parts [year]	Tyres [1 y]	Tyres [1 y]	Wheel & Rail [2 y]	Aluminum Plate [2 y]	Wheel & Rail [2 y]
View and Landscape	High Harmony	High Harmony	Medium Harmony	High Harmony	Medium Harmony
Grade & Curvature Maneuverability	Medium	High	Low	High	Medium
Construction Period	Medium	Medium	Long	Short	Long
Technology	Medium	Medium	Old	New	New
Usability of Existing Rail Facilities	None	None	High	None	Medium

The results of the qualitative comparison show that the HSST system is the most environmentally-friendly system with low negative impact with its light structure and advanced technology. The LRT system is based on the conventional railway technology and it seems to be the least technological system when compared with the others.

When considering the usability of existing facilities to extend the line length, the LRT has the advantage as it can run over the existing rails of the same gauge. The linear motor vehicles can also be used with the installation of additional rails for the linear motor part. The three other vehicles can not use any existing rail facilities as they require a completely independent system.

13.2.12 System Assessment

Based on the information provided in this study, which does not cover all the aspects of the MRT systems in full detail, the selection of a basic, or optimum, system for Hanoi can not be finalized at this stage. In general, the system cost is considered very high for the available demand at this stage. The high cost is mainly due to the tunnel section and the electrification facilities of the line.

An MRT network without tunnel sections and utilizing the existing railway lines and facilities with non-electrified system of diesel vehicles can at first provide a cheaper option for the forecast demand.

13.3 Basic Plan

The basic plan is based on the concept of minimizing the construction cost of an MRT system by avoiding the tunnel sections and utilizing the existing railway lines and facilities. Diesel rolling stock is planned to be used in the early stages, and to be electrified later as an LRT system, to save the high cost of electrification systems.

13.3.1 Network Components

Planning the network has basically the same concept of connecting the central area of Hanoi to the New CBD and to Ha Dong as well as utilizing existing railway facilities. Four lines compose the network, which is presented in Fig. 13-3-1, as follows:

(1) Hanoi - Noi Bai Line
(2) Van Dien - Yen Vien Line
(3) Ha Dong - Kim Ma Line
(4) Giap Bat - Thang Long Line

The first line starts from Hanoi Station and proceeds west as an elevated line over Kim Ma Street to cross the To Lich River toward the New CBD. In the newly planned area, the line would run elevated in the middle of South Thang Long Road where separated lanes are planned to be used by bus services at first before the railway line is operated. The line is to be connected next to existing double-track railway line crossing the Red River over the Thang Long Bridge to Dong Anh District where several development projects and industrial estates are planned. The end of the existing double-track section is at Bac Hong Station where the first stage of implementing the line will end. In the future, the line will be extended in its second stage to Noi Bai International Airport to directly connect it with central Hanoi.

The second line is planned to support the Hanoi Urban Development Corridor [HUDC] by running in the middle of RR-3 from Giap Bat to the New CBD south of Thang Long Bridge. Implementing this line depends mainly on the development of the corridor along RR-3. The operation of this line is expected to increase the number of passengers on the first line

The third line is to connect Ha Dong with central Hanoi as this route provides the highest traffic volumes on the road network at present. Buses on this route would also handle a high volume of about 27,000 passenger/day between Hanoi and Ha Dong. This line is completely elevated over the NH-6 from Ha Dong to RR-2 and then over Lang Ha Street to meet the first line at Kim Ma Street. The line is expected to be implemented after the operation of the second line and development of the HUDC.

The fourth line has the same concept as in the tentative plan to replace the existing at-grade single-track railway by an elevated double-track viaduct to be used by VNR trains as well as commuter trains. Several alternatives were studied to improve the existing at-grade line by providing passing loops at stations so it can be used for commuter trains on a single-track basis. The interruption of east-west road traffic at the at-grade intersections in central Hanoi will create a more complicated and unresolved traffic crisis.

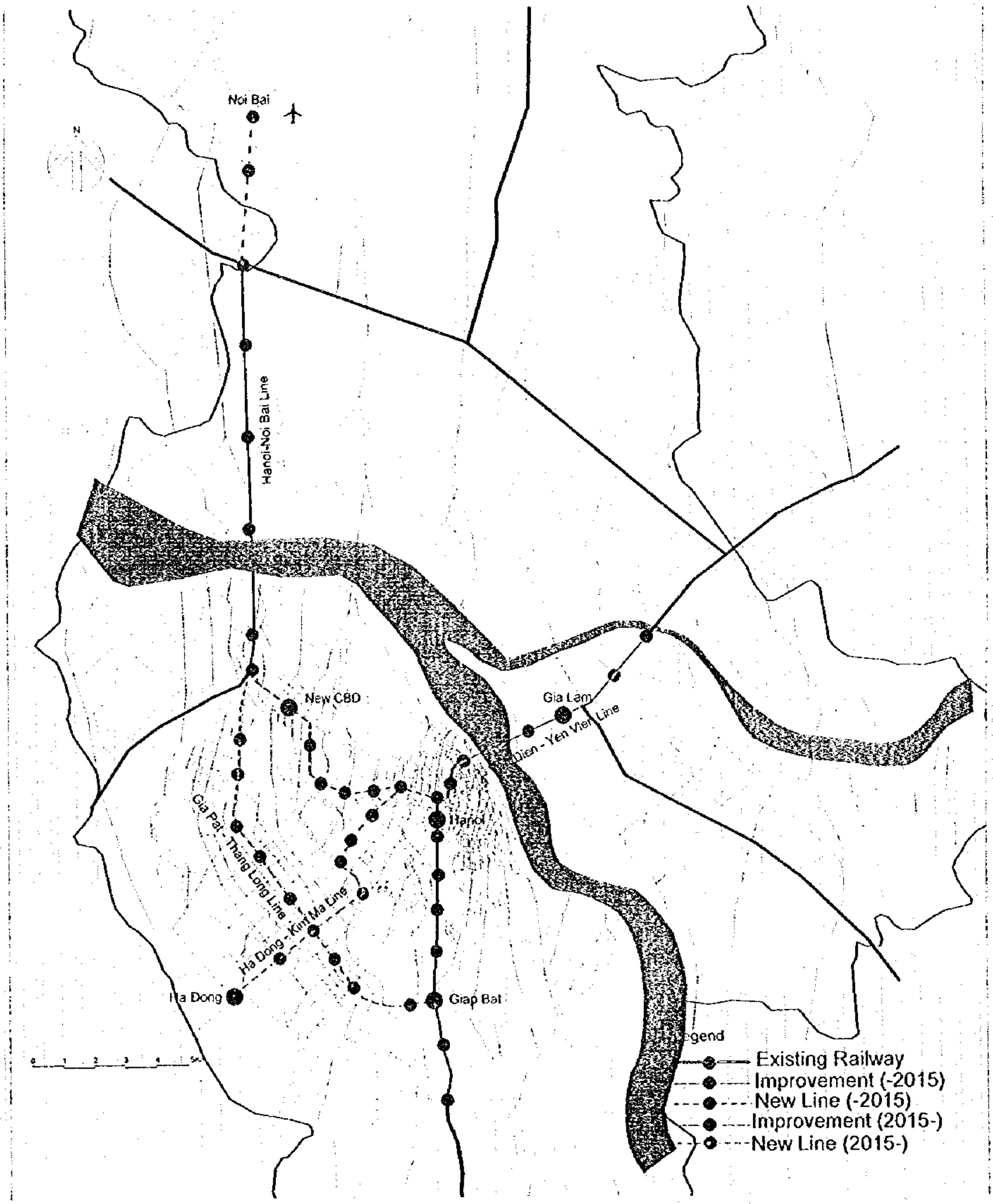


Fig. 13-3-1 Railway Basic Plan

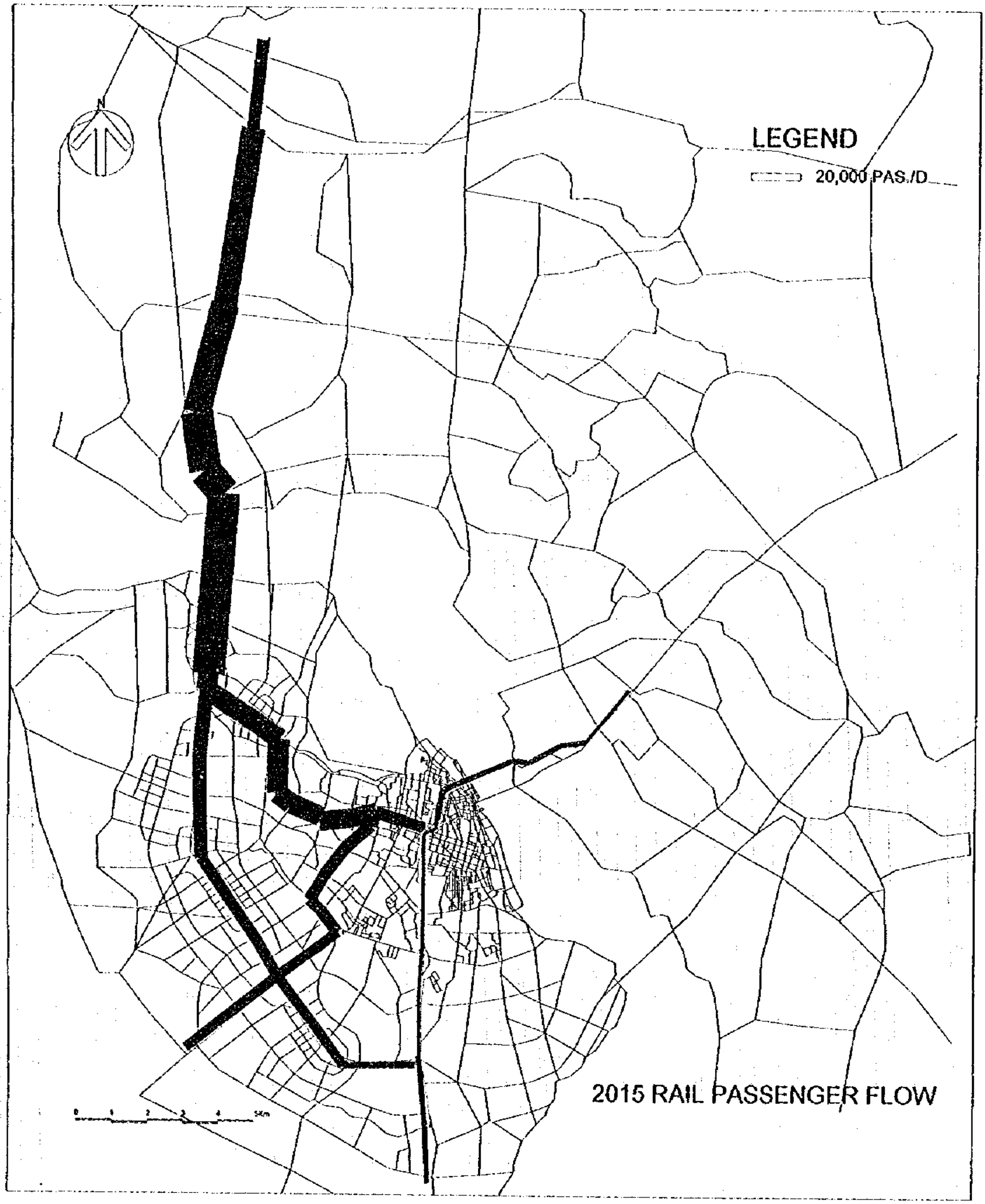


Fig. 13-3-2 Basic Plan Demand

In addition, the existing condition of the Long Bien Bridge northern of Hanoi Station over the Red River which does not allow a speed more than 10 km/hr will limit the service headway to 50 minutes for the single-track line between Gia Lam and Hanoi. To the south, the concentration of many socioeconomic activities close to the line is composing a very serious safety problem especially with the frequent operation of the line. To use this line for commuter trains, the alternative of providing an elevated double-track line requires vast investment to construct the viaduct and a new bridge over the Red River. The economic and financial viability of the project should be investigated especially with its low demand forecast compared with other lines. Implementing the elevated line, however, will provide additional indirect benefits such as easing the east-west road traffic and utilizing the space under the viaduct as for commercial activities.

13.3.2 Network Demand

As shown in Fig. 13-3-2, there is a heavy demand on the western sections of the network due to the high potential of urban development with several industrial estates. The New CBD south of the Red River will generate much of this demand, together with North Thang Long City and Noi Bai EPZ. Other southern and eastern sections of the network have a lower demand forecast as their socioeconomic activities have limited potential especially south of Hanoi.

Based on the high forecast railway demand for the first line, which gives it the viability to be constructed in the mid-stages of the masterplan period, and considering the priority of implementing the New CBD of Hanoi which is, to a large extent, supported by this line, the line is subject to more detailed study in the following sections.

13.3.3 Selection of Priority Line

Out of the four lines of the planned network, Hanoi - Noi Bai Line has been selected for further studies due to its highest transport demand and to support the development of the New CBD. In addition, it extends to the north of the Red River where there is high growth of population and employment. The line is planned to be implemented, dividing into two stages as follows:

Stage I: From Hanoi Station to Bac Hong Station [Length: 17.4 km]

This stage will connect Hanoi Station with Thang Long station in the New CBD. It will be a new alignment on an elevated viaduct over Kim Ma Street constructing after the implementation the road scheme to widen the road to 21m. The line crosses the Red River using the existing railway facilities to Bac Hong Station at the end of the existing double-track railway. To provide an integrated transport system, a bus terminal is planned at Hanoi Station to serve the railway services to different destinations in the central areas of the city. Regarding the construction items of this stage, the line is generally divided into the following two segments:

Segment 1: From Hanoi Station to Thang Long Station [Length: 9.0 km]
Construction Item: New construction of an elevated line

Segment 2: From Thang Long Station to Bac Hong Station [Length: 8.4 km]
Construction Item: Upgrading the existing double-track line.

Stage II: From Bac Hong Station to Noi Bai International Airport [Length: 8 km]

This stage is planned to be implemented in the future as a new at-grade line in order to support the development of urbanization and new industrial centers in Soc Son District and to handle the increasing demand of the international airport and connect it directly with Hanoi Station and other central areas.

13.3.4 Line Demand

Fig. 13-3-3 presents the relationship between the level of fare and the number of passengers and revenue for the line. The fare of 1,000 VND, applied at present for the bus service, gives a high demand of about 85,000 passenger/day for the two directions. To establish the optimum fare, financial analysis procedure is applied in later sections.

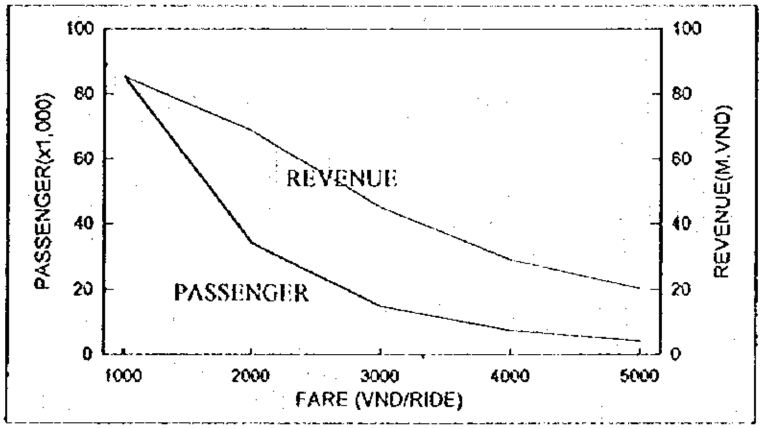


Fig. 13-3-3 Line Demand and Revenue

13.3.5 Line Alignment

The first segment will be a completely new viaduct, with a 9.0 Km length, starting from Hanoi Station to the north and turning west to Nguyen Thai Hoc Street then Kim Ma Street. The line will utilize the new road from South Thang Long - Buoi, which is currently under construction, to cross the To Lich River and turn north to the core of the New CBD.

In the New CBD, there is a reserved space in the middle of South Thang Long Road, to be utilized by bus services at first, to accommodate the elevated structure. At its connection with the existing national railway line, the new station of Thang Long will be constructed to function as a transfer station.

From that point the second segment, of 8.4 Km length, utilizes the existing line double-track which will be upgraded to serve the frequent service of commuter trains. The line crosses the Red River over the Thang Long Bridge to the new urbanized areas and extends to Bac Hong at the end of the double track segment. The alignment of the line is shown in Fig. 13-3-4.

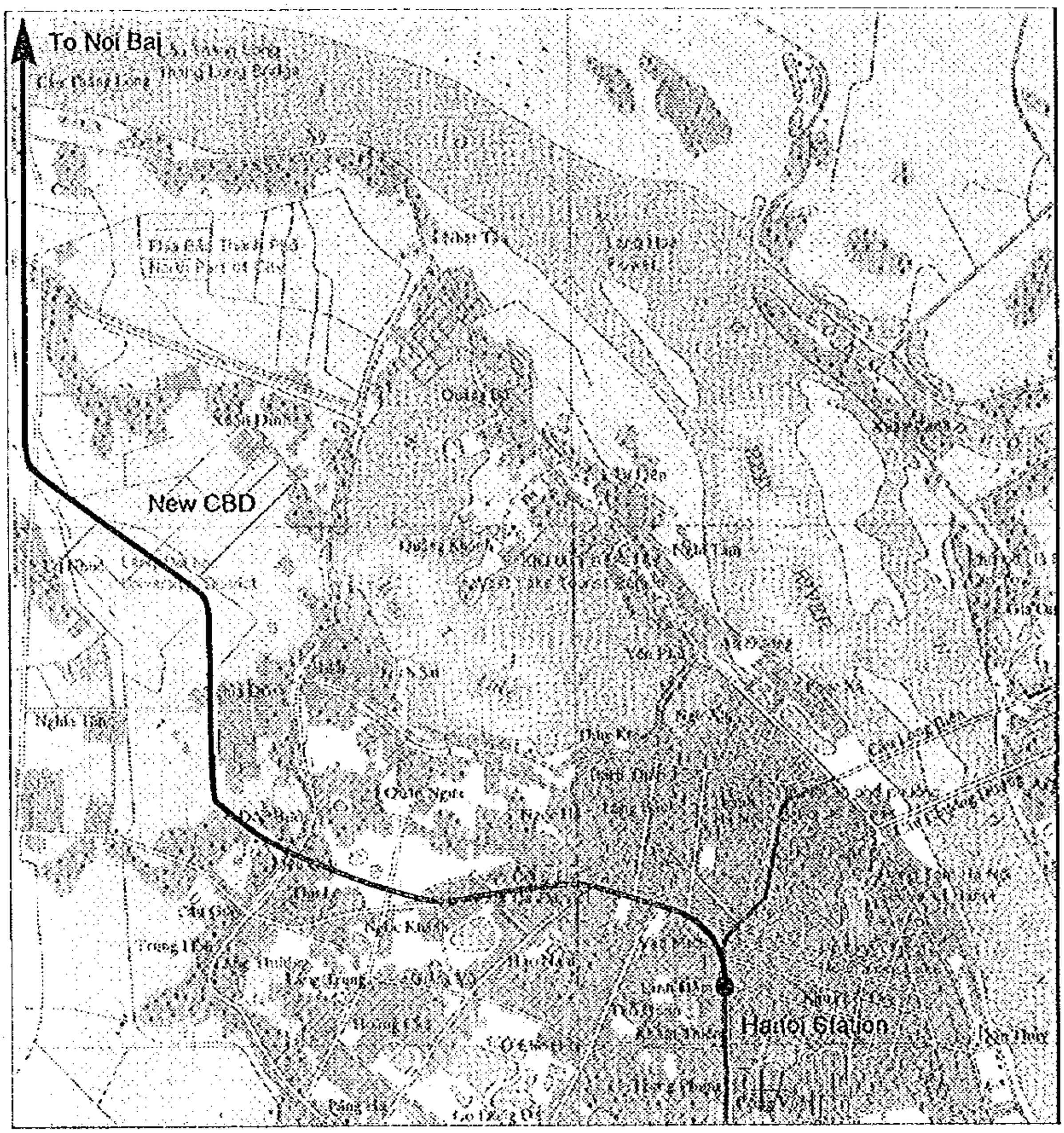


Fig. 13-3-4 Hanoi - Noi Bai Line Alignment

13.3.6 Stations and Depot

A total of 15 stations are planned to cover the requirements Stage I of the line with an average distance of about 1.0 km between stations in urban areas and 1.5 km in rural areas. The stations are categorized into three sizes according to their function and ridership. Large-size stations would be used as transfer or interchange stations between three lines. Medium-size stations would be for two lines or single line in high density area and small-size stations would serve single lines in low density areas. Table 13-3-1 presents a list of the main stations and their category and area. Cross sections of elevated stations and transfer stations are shown in Fig. 13-2-7.

Table 13-3-1 Line Stations

Type	Rank	No. of Stations	Area (m^2)		Station Name
			Platform	Concourse	
Elevated	Large	1	1,040	2,100	Hanoi
	Medium	2	800	1,440	Kim Ma Thang Long
	Small	12	480	1,200	
Total		15			

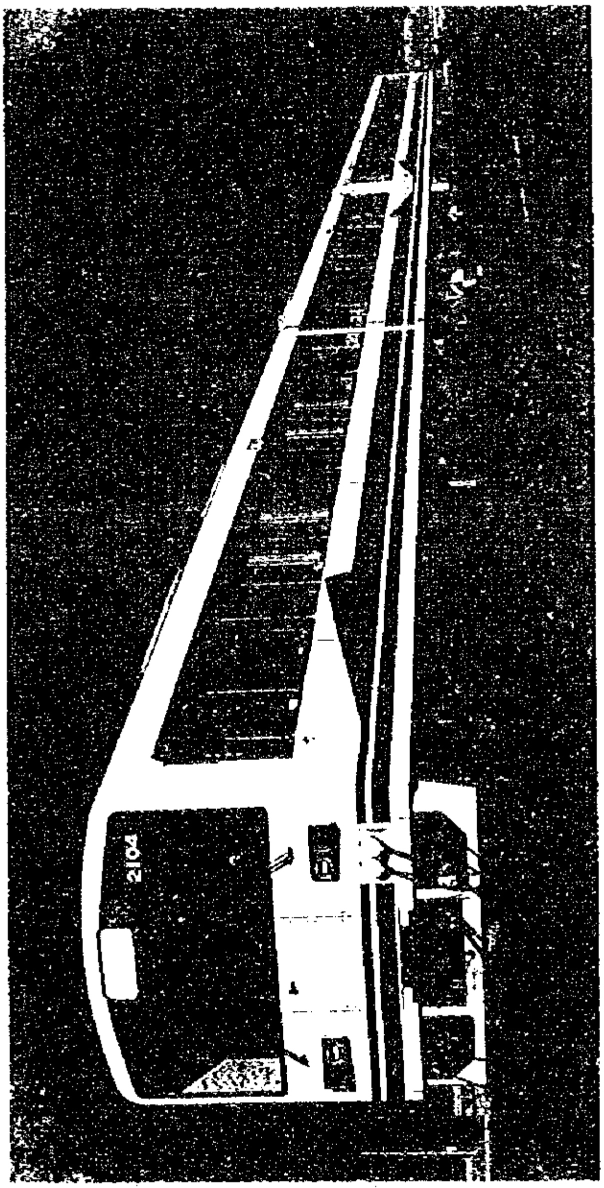
A depot, or vehicle shed, for the regular and periodical maintenance works as well as daily service of washing and cleaning the diesel vehicles is planned to be north of the Red River near the Bac Hong Station where the land is not yet developed. A plan of the rolling stock depot is presented in Fig. 13-2-8.

13.3.7 Rolling Stock

To minimize the system cost in the early implementation stage, it is recommended that diesel vehicles are used to save the high capital cost of electrification systems. Fuel for such vehicles is not expensive and their operation and maintenance cost is relatively lower when compared with some electrified systems. Standard diesel vehicles would have, in general, the specifications presented in Table 13.6.2, while Fig. 13-3-5 presents a general view of a diesel train which can be utilized as the rolling stock for this line.

Table 13-3-2 Operational Features of Diesel Trains

Item		Specifications
Length	m	19.5
Max. Speed	km/hr	95
Normal Speed	km/hr	55
Empty weight	ton	31.5
Loaded Weight	ton	48
Axle Load	ton	12
Steepest Gradient	%	35
Max. Curve Radius	m	160
No. of Seats		52
Standing Passengers		92
Normal Capacity	passenger	144
Max. Capacity	passenger	230



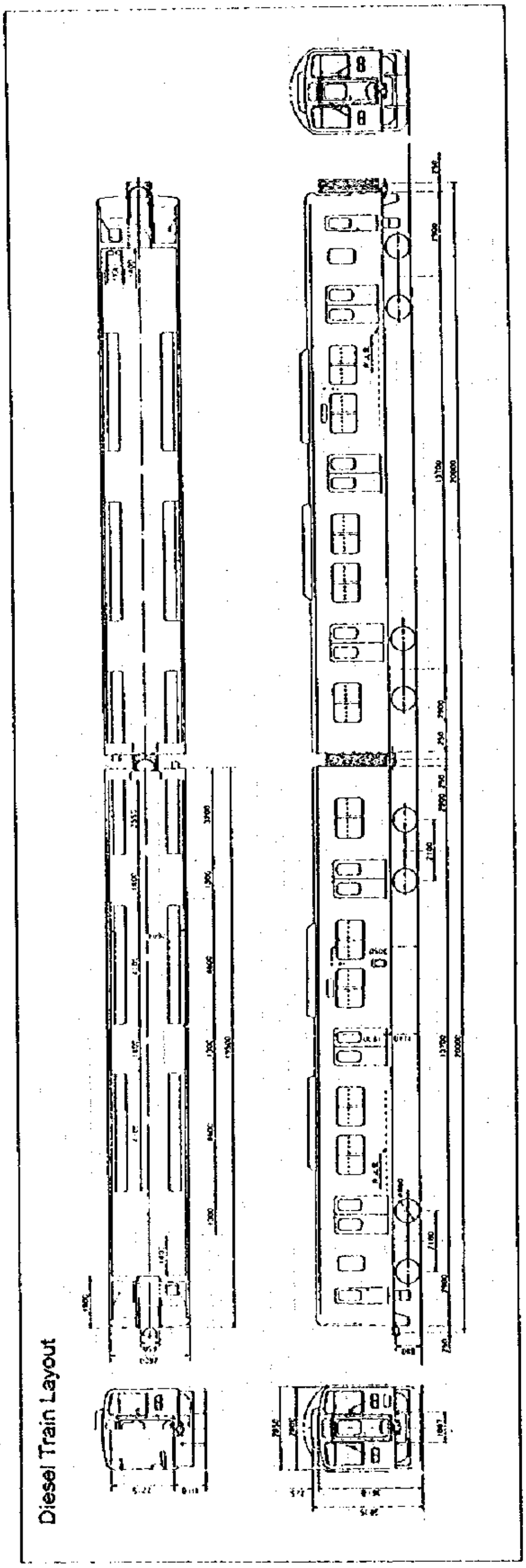


Fig. 13-3-5 Diesel Train

13.3.8 Civil Engineering Infrastructure

13.3.8 Civil Engineering Infrastructure

The main elements of the civil engineering infrastructure used for such elevated system are the piers and girders of the viaduct. In Section 13.2.8, several types of these elements were studied before for different rolling stock systems and the concrete elements were found to be the most suitable for the LRT system which is similar to the vehicles used here. Piers can be placed at intervals of about 30m, which give an appropriate length for the girders. The PC viaduct will accommodate the rails of the system. The general characteristics of these elements are presented in Tables 13-2-5 and 13-2-6.

13.3.9 Operation Plan

The highest demand between two stations by operating only that line and applying a fare of similar to the bus service, was estimated as 40,600 passenger/day in 2015. This demand was converted to peak-hour demand by applying the average peak-hour factor of 12.8% and directional factor of 67%, as derived from the traffic surveys. Based on this demand as well as the characteristics of the line and diesel trains, specifications were established for the operation plan of the line as presented in Table 13-3-3.

Table 13-3-3 Specifications of Diesel Train Operation

Item		Diesel Train Operation
Max. Speed - km/hr		95
Normal Speed - km/hr		55
Acceleration	Time - sec	72
to Normal Speed	Dist. - km	0.700
Deceleration	Time - sec	20
from Normal Speed	Dist. - km	0.150
Normal	Time - sec	10
Running	Dist. - km	0.15
Station Stoppage-time - sec		30
Total Time - sec		132
Scheduled Speed - km/hr		27
Train Formation - cars		2
No. of Passengers / car		230
No. of Trains / hr		7.5
Headway - min.		8
Target Travel Time - min.		36
No. of Trains Required		10
No. of Reserve Trains		2
Total No. of Trains		12
Total No. of Cars		24

The above operational plan is based on train combinations of two cars which gives a headway of 8 minutes. To decrease this headway, one car can only used to give a 4 minute headway which means higher service level for passengers with shorter waiting time. In such a case, all cars should be equipped with driver seats on both sides so the car runs on a single-car basis in both directions.

13.3.10 Cost Estimate

(1) System Capital Costs

The total capital cost is estimated to be about 3,000 B.VND for the entire Stage I of the line with a length of 17.4 Km. The rolling stock cost is about 10 % of the total cost while the share of the 9.0 Km viaduct is about 60 %. A breakdown of the economic and financial cost is presented in Table 13-3-4.

Table 13-3-4 Capital Cost Estimate

Description		Unit Cost b. VND	Quantity	Unit	Direct Cost	Indirect Cost	Constru-tion	Engine-ering	Foreign %	Local %	Total Cost
Upgrading Existing Track Bed [km]		8.2	8.4	km	57.4	11.5	68.9	8 3	0	100	77.1
New Construction of Viaduct [km]		180	9.0	km	1,350.0	270.0	1,620.0	194.4	10	90	1814.4
Track Rail [L=52.8 km, W=2,640 t]		0.0105	2,640	ton	23.1	4.6	27.7	3.3	90	10	31.0
Laydown of Rail		5	26.4	km	110.0	22.0	132.0	15.8	0	100	147.8
Train Depot		0.00688	20,000	m2	114.7	22.9	137.6	16.5	50	50	154.1
Station	Large	0.00248	1,200	m2	2 5	0.5	3.0	0.4	0	100	3.3
	Medium	0.002	2,000	m2	3 3	0.7	4.0	0.5	0	100	4.5
	Small	0.00165	9,600	m2	13 2	2.6	15.8	1.9	0	100	17.7
Station Facility	Large	3.4	1	Sta.	2.8	0.6	3.4	0.4	50	50	3.8
	Medium	3	2	Sta.	5.0	1.0	6.0	0.7	50	50	6.7
	Small	2.8	12	Sta.	28 0	5.6	33.6	4.0	50	50	37.6
Rolling Stock *		13.6	24	car	326.4	0.0	326.4	0.0	100	0	326.4
Signaling *		21	17.5	km	367.5	0.0	367.5	0.0	80	20	367.5
Telecommunication *		3.1	17.5	km	54.3	0.0	54.3	0.0	50	50	54.3
Total					2,458 2		2,800.2				3,046.4

* Cost is Inclusive of Indirect and Engineering Costs
Indirect Cost = 20% of Direct Cost
Engineering Cost = 12% of Construction Cost

The capital cost of the system is planned to be covered by the profits of the land development schemes in the New CBD of Hanoi as the railway system is an essential factor to support the development projects. On the other hand, the revenue of the system should cover its running cost for the operation and management of the system as well as the depreciation cost to keep the system in an efficient operating condition.

(2) Operation and Management Cost

The annual cost required to operate and maintain the system is estimated based on similar systems operated in Japan, taking into consideration the local conditions. This cost does not include the depreciation cost of the system. Table 13-3-5 presents the breakdown of the operation and management cost.

Table 13-3-5 Operation and Management Cost

Description	Cost [M. VND]
Track	8,810
Electric Line	1,720
Car	5,170
Operation (including fuel)	5,300
Other Direct Cost	6,130
Administration	3,640
Total	30,650

The break even point to cover the operation and maintenance cost through the revenue, a fare of 2,070 VND/ride should be applied. In order to also cover the depreciation cost of the rolling stocks, assuming a life span of 20 years, the fare should be 3,070 VND/ride.

13.3.11 Project Justification and Recommendation

The implementation of the railway system for Hanoi City is concluded as follows:

(1) The initial cost cannot be covered by the fare revenue, however the operation and maintenance cost can be covered by the fare revenue of 2 -3 times higher than the present bus system.
(2) With the high cost of implementing a railway system, recycling of the value capture from development along the railway can be considered as a main financial resource in which the amount of the benefit from the development may be utilized to partially cover the project capital cost and to maintain a rational fare policy, to convince people to switch from private to public transport modes.
(3) To avoid future land acquisition, the space to accommodate railway system should be reserved in the development area, and for this purpose, the more detailed plan for the priority line should be established.

To implement the commuter railway system for Hanoi, many issues should be carefully considered, including the following:

(1) Although the project cost is an important factor in selecting the system, the special environment of Hanoi requires the consideration of other social, amenity, landscape and aesthetic aspects.
(2) The adopted system should be efficient and attractive, with smooth and convenient connections to other transport modes.