7.5 Trip Distribution

Table 7.5.1 is the origin-destination trip table for the year 2006 aggregated to 24 zones (80 zone O-D table is shown in Appendix C). Figure 7.5.1 illustrates the desire lines for inter-zonal trips in 1989 and 2006.

Table 7.5.1 Integrated Origin/Destination Table for Year 2006 (All Purpose, All MOde)

Zone	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Phranakhon-Pomprap	2817	615	527	730	371	496	269	405	1003	783	473	475	462
2 Dusit	620	4059	876	551	220	461	366	729	461	589	544	577	408
3 Phaya Thai	529	870	3622	733	318	719	666	686	517	437	616	712	580
4 Pathum Wan-Bang Rak	726	546	730	3123	602	827	383	451	858	446	530	589	615
5 Yanava	371	217	319	604	2043	486	148	180	518	201	189	274	310
6 Sukhumvit	501	458	721	831	484	5325	573	513	514	327	518	939	1354
7 Huai Khwang	273	366	668	389	150	575	2566	504	236	196	342	658	357
8 Chatu Chak	402	726	681	449	181	512	497	4741	325	306	1027	1018	434
9 Thon Buri	1011	462	523	870	530	517	236	330	4778	686	367	442	432
10 Bangkok Noi	787	586	436	448	201	326	195	306	681	2995	325	347	291
11 Bang Khen	474	547	618	532	195	523	344	1036	370	329	6056	1104	497
12 Bang Kapi	481	579	718	599	278	945	661	1021	445	351	1093	6941	1201
13 Phra Khanong	466	411	583	620	313	1360	358	438	431	294	492	1199	5638
14 Ratburana	603	366	476	616	344	495	200	283	715	407	282	430	424
15 Taling Chun	430	278	304	372	171	272	127	196	492	363	203	264	231
16 Muang Samut Prakan	320	248	337	421	346	618	186	246	361	216	287	454	980
17 Bang Kruai	253	283	243	217	75	163	96	186	186	255	180	189	122
18 Muang Nontha Buri	299	476	375	313	139	314	210	621	264	265	929	507	315
19 Pathum Thani	249	286	287	275	102	268	148	337	211	186	753	443	265
20 Minburi-L.Krabang-N.Chok	22	15	123	29	18	61	51	174	7	1	348	663	124
21 Bang Khun Thian-S.Sakhon	157	73	55	62	62	90	12	73	373	156	36	37	69
22 Bang Pli-Bang Bo	86	110	72	94	81	460	101	56	124	32	75	253	879
23 Bang Bua Thong	145	74	57	53	29	44	17	62	113	133	84	48	38
24 Thanyaburi-Lam Luk Ka	176	47	103	45	38	44	27	32	45	35	231	164	80
Total	12198	12698	13454	12976	7291	15901	8437	13606	14028	9989	15980	18727	16106

Zone	14	15	16	17	18	19	20	21	22	23	24	Total
1 Phranakhon-Pomprap	602	431	316	251	300	249	32	160	86	175	75	12103
2 Dusit	364	280	245	282	474	280	17	83	87	70	44	12687
3 Phaya Thai	474	307	335	239	378	280	113	45	85	56	79	13396
4 Pathum Wan-Bang Rak	615	373	414	214	309	268	25	69	130	51	51	12945
5 Yanava	340	169	342	71	137	100	13	81	89	40	21	7263
6 Sukhumvit	490	274	611	157	314	262	46	56	517	37	44	15866
7 Huai Khwang	200	129	186	94	213	146	49	23	89	14	25	8448
8 Chatu Chak	280	198	242	186	614	334	111	37	76	39	82	13498
9 Thon Buri	717	491	365	183	268	206	8	423	105	84	32	14066
10 Bangkok Noi	404	360	212	254	267	183	4	173	34	281	40	10136
11 Bang Khen	283	207	289	182	935	753	232	36	59	69	155	15825
12 Bang Kapi	426	267	455	187	514	440	546	33	167	48	99	18495
13 Phra Khanong	423	231	980	118	317	258	115	53	771	27	56	15952
14 Ratburana	3796	812	522	129	267	187	9	689	75	97	34	12258
15 Taling Chun	812	2766	217	135	208	143	49	496	44	157	28	8758
16 Muang Samut Prakan	524	222	3290	93	199	170	17	394	800	43	77	10849
17 Bang Kruai	128	137	97	1184	294	108	3	14	23	155	40	4631
18 Muang Nontha Buri	266	209	195	293	3184	461	7	30	28	232	84	10016
19 Pathum Thani	189	141	174	109	464	2930	22	35	62	262	556	8754
20 Minburi-L.Krabang-N.Chok	3	31	16	4	7	23	208	20	29	17	24	2018
21 Bang Khun Thian-S.Sakhon	648	411	433	19	42	20	20	167	86	51	47	3199
22 Bang Pli-Bang Bo	105	31	705	20	28	72	28	77	492	44	60	4085
23 Bang Bua Thong	113	198	85	159	216	255	18	55	50	164	60	2270
24 Thanyaburi-Lam Luk Ka	49	40	57	32	63	741	25	59	47	50	220	2450
Total	12251	8715	10783	4595	10012	8869	1717	3308	4031	2263	2033	239968

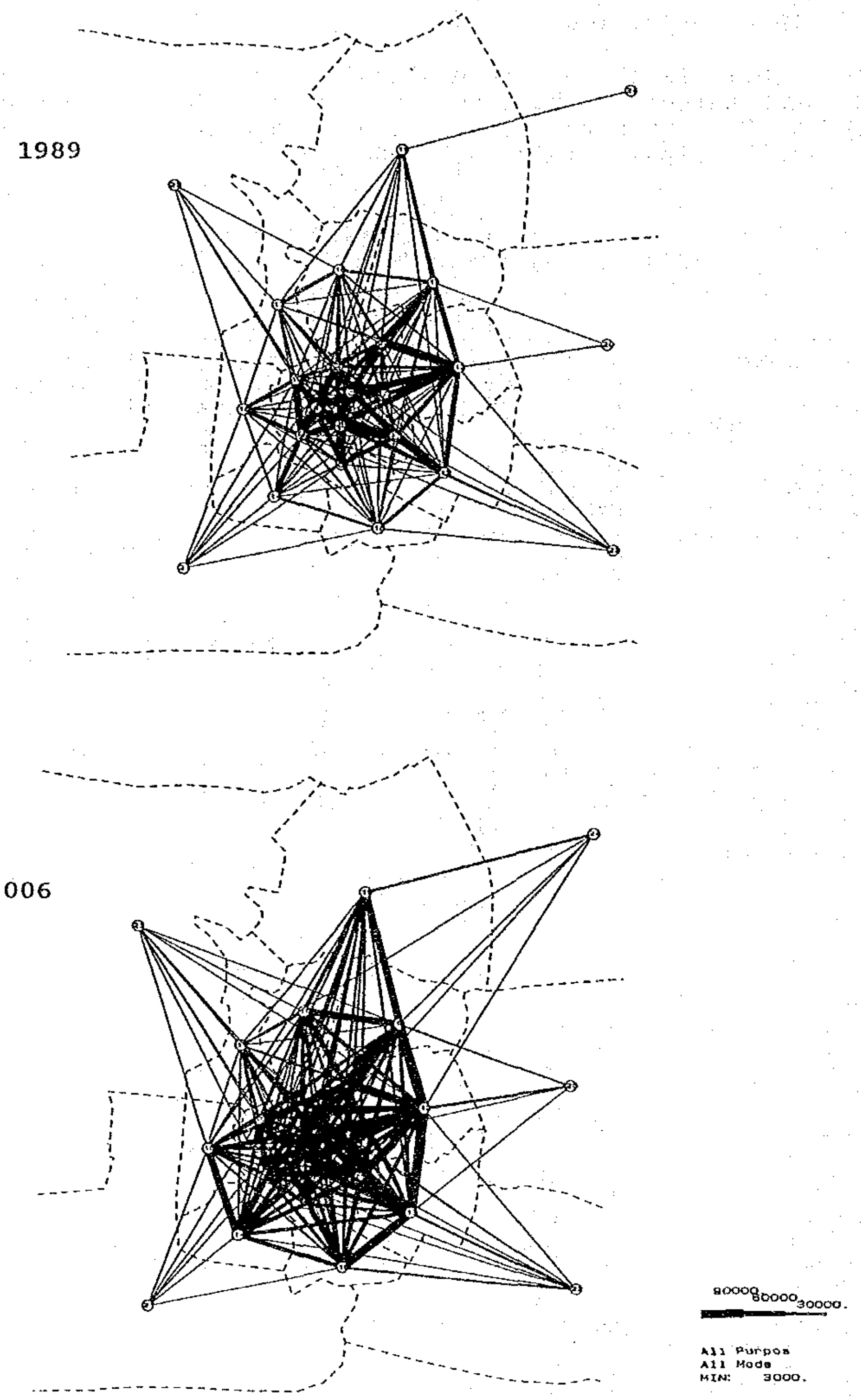


Figure 7.5.1 Person Trip Distribution in 1989 and 2006

Intra-zonal trips (diagonal elements in the O-D table) in the year 2006 will total 7.3 million trips per day, 30.4% of the total. Since the ratio was 32.2% in 1989, the nature of self-sufficiency of the study area zones will slightly weaken in terms of transportation demand.

Future inter-zonal trips will show a tendency to increase further in such zone pairs that already stand out as having a significantly high volume of O-D trips. Inter-zonal trips of more than 200,000 will be seen in the following eight zone pairs in the year 2006.

(1)	Sukhumvit (6)-Phra Khanong (13)	271,400 Trips/day
(2)	Bang Kapi (12)-Phra Khanong (13)	240,000
(3)	Bang Khen (11)-Bang Kapi (12)	219,700
(4)	Phranakhon-Pomprap (1) -Patum Wan-Bang Rak (4)	215,000
(5)	Chatu Chak (8)-Bang Khen (11)	206,300
(6)	Pathum Wan-Bang Rak (4)-Sukhumvit (6)	205,400
(7)	Chatu Chak (8)-Bang Kapi (12)	203,900
(8)	Phranakhon-Pomprap (1)-Thon Buri (9)	201,400

Figure 7.5.1 shows that the O-D trip distribution pattern will not change much in the planning period. Linkages between central zones (integrated zones 1 to 4) and peripheral zones will continue to be conspicuously strong also in the future. In addition, trips between peripheral zones adjacent to each other will significantly increase.

The structure of O-D trip distribution becomes clearer when the O-D trips are assigned to the spider network which is a hypothetical network connecting zone centroids adjacent to each other with straight lines. When comparing the two figures for 1989 and 2006, (Figure 7.5.2) the drastic changes between the two are very impressive.

In the former figure, at present heavy trip flows are observed only inside the triangle of Nonthabri, Thon Buri and Prakhanong. However, in the year 2006, almost all the connections except those in the western and south-eastern peripherals will have large number of trips.

In addition to the existing three major flows, from central area to the north, to the southeast and to the southwest, new demand axes along Lat Phrao-Bang Kapi-Prakhanong and Nonthaburi-Bangkok Noi- Bangkok Yai will be created.

Further integration of traffic zones into blocks, Figure 7.5.3, shows the future trip increases in the inner BMA area (integrated zones 1 to 10) and by radial directions from there. Trips with both ends inside the inner BMA area will increase by 1.4 times while in almost all the radial directions, trips will more than double. However, although the trips in the radial direction show higher increase rates than the internal trips in the inner BMA, the latter are significant in absolute number, exceeding 10 million trips per day.

The future expansion of urban area will increase the trip length in the future. Figure 7.5.4 compares the present and future trip length distribution. Currently, more than half of all trips are less than six kilometers in length and the average is 6.6 km. In the year 2006, the average trip length will be 10.4 km and more than ten percent of total trips will be longer than 20 km. This tendency will be one of the factors that will contribute to making the future traffic burden heavier.

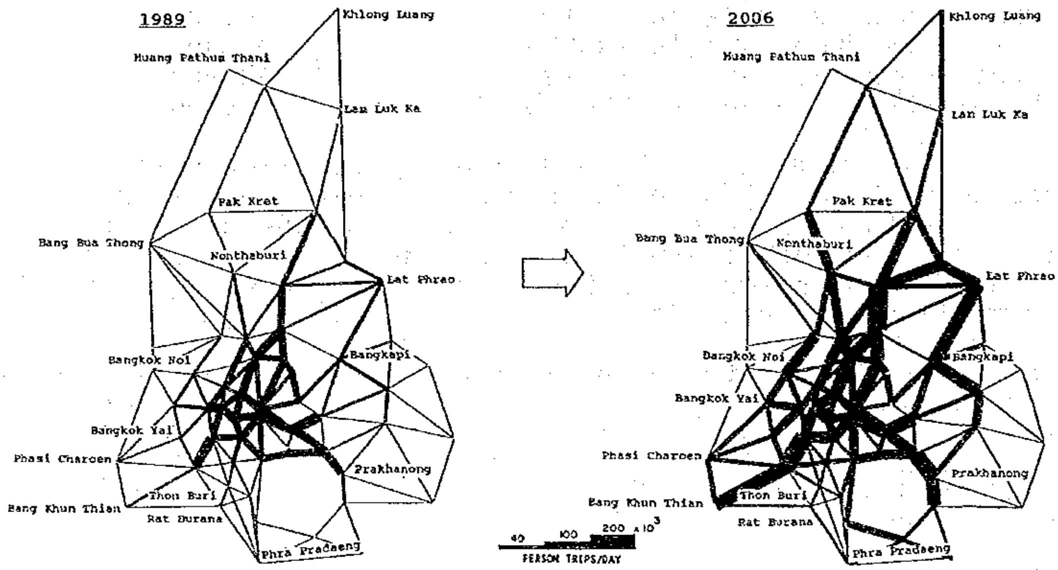


Figure 7.5.2 Trip Demand Assigned to Spider Network in 2006

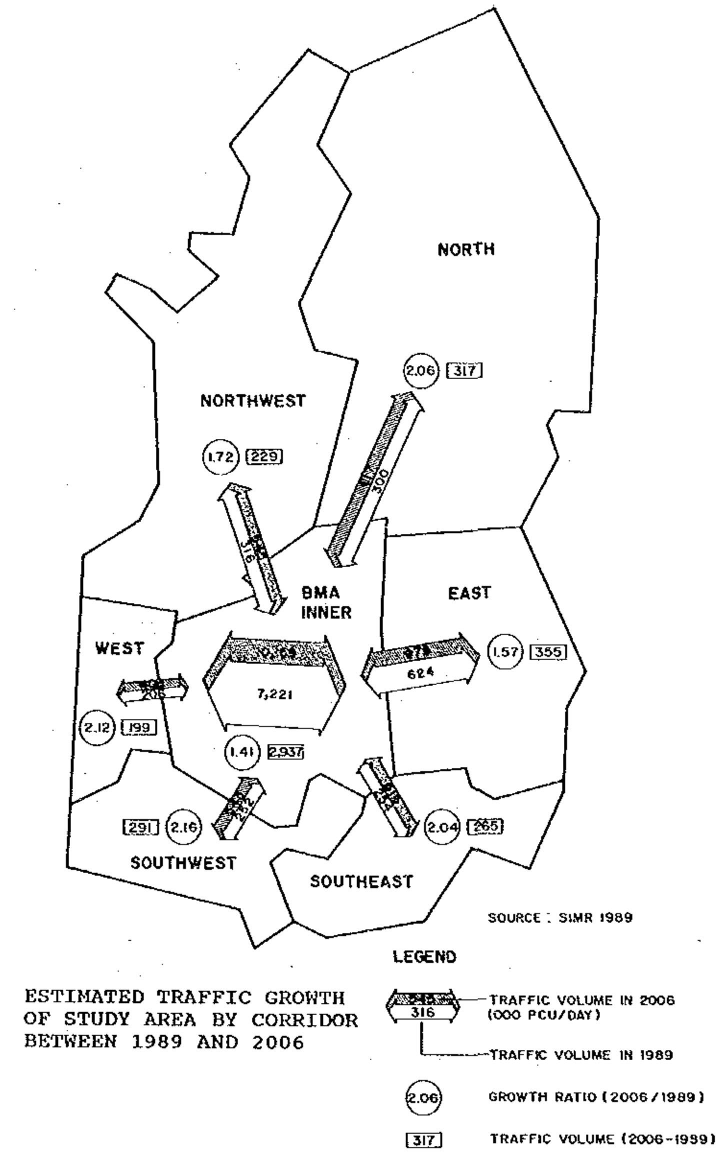


Figure 7.5.3 Trip Increase by Direction

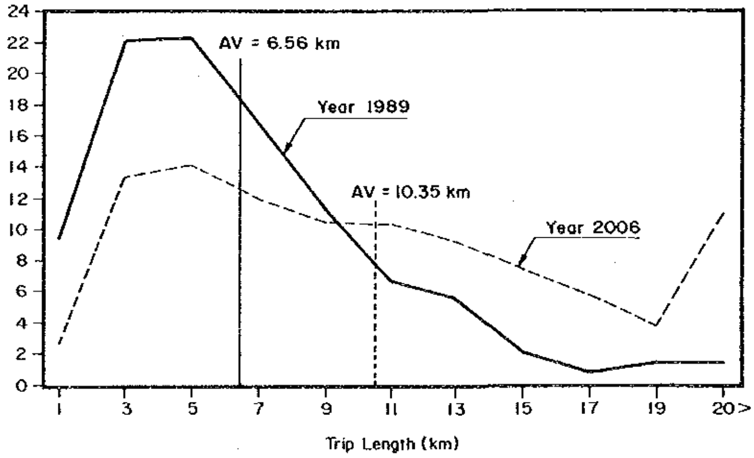


Figure 7.5.4 Trip Distribution by Length

CHAPTER 8

FUTURE TRANSPORTATION NETWORK

8. FUTURE TRANSPORTATION NETWORK

This Chapter aims at working out a transportation network to be developed by the year 2006, based on the existing plans, future urban structure, and future transportation demand described in the previous Chapters. The main purpose of this study is to develop a future road plan, and planning of rail transit system is not included in its scope. However, conditions of the future railway network and its service would strongly affect the road plan. Therefore, railway system will also be studied in this Chapter as a part of the future network and the result will be regarded as a precondition for the road plan in the next Chapter.

8.1 Planning Policy and Approach

1) Basic Planning Policy

To guide the development of the road masterplan in the long-term perspective, the following policies are set up:

(1) To establish a realizable plan

While it may be necessary to be moderately ambitious in order to create an attractive master plan, the plan must not be merely a dream. From this viewpoint, every effort was made to develop a realistic or realizable plan, especially in the following two points: Firstly, the financial scale of the plan should be in the reasonable range in light of the past investment trend and future economic growth. Secondly, large scale demolition of existing structures and buildings are to be minimized, not only to avoid social friction, but also to raise investment efficiency.

(2) To support the future urban development

Transportation network should be consistent with the future urban development pattern. The network should be arranged so as to support the urban growth, and at times guide the growth in the desirable directions. In this study, the network configuration highlighted the formation of urban corridors (aces) and connecting them together.

(3) To meet the future transport demand

Although it is undoubtedly not an easy task, to cope with the future transport demand which will grow more than double in sixteen years, the master plan network should guarantee the provision of an acceptable level of service. This study considered that level of service to be at least the same as the present level.

(4) To put emphasis on economic viability

Limited fund for urban transportation sector should be invested in the most effective way. In this sense, higher priority will be given to a project with higher economic feasibility, in principle. financial feasibility is also an important factor in order to attract capital fund from the private sector.

(5) To be consistent with existing plans and projects

As reviewed in Chapter 5, many projects have been already studied, designed and decided, and some of them are waiting for implementation. The masterplan should be well coordinated with those projects. Highly mature projects are to be preconditions to this study.

2) Planning Approach

The masterplan transportation network will be developed following the procedure shown in Figure 8.1.1, which is composed of three steps.

(1) Step 1: To quantify development requirement

Network planning shall begin by assigning the future traffic demand in the form of O-D trip to a network, in order to check the demand-supply balance. When the network is the present one, this analysis is called "Do nothing" analysis. In this study, another analysis is made by using a network which has all the existing projects listed up in Chapter 5, in addition to the present network. This case is referred to as "Do something" analysis. Through these analyses, it will become clearer how many roads or railways will be needed to maintain the targeted service level.

In this step, the projects to be treated as preconditions in this study will be identified, through hearings on the progress of each project with the related organization. The network with the precondition projects added to the present network is called "Do minimum" network in this study.

(2) Step 2: To plan "Maximum-size" network and project ranking

For the first trail, a large-scale network which can meet the future demand is planned based on the information of the previous step. In this case, every idea will be studied from the viewpoint of composing a well-balanced network, without much consideration about financial constraints. This network is called "Maximum-size" network in this study.

The maximum-size network consists of at-grade road, expressway, bus-way, and railway (LRT and HRT) projects. As every one of them, other than at-grade roads, will require a huge amount of investment to develop its infrastructure, the projects are ranked according to their future demand. The demand forecast is done through the analysis of the "Single mode oriented" network.

(3) Step 3: To establish the network for 2006

A possible investment amount in the planning period is estimated based on the past trend, and also taking into account the future economic growth. This amount will provide the financial framework for the future network.

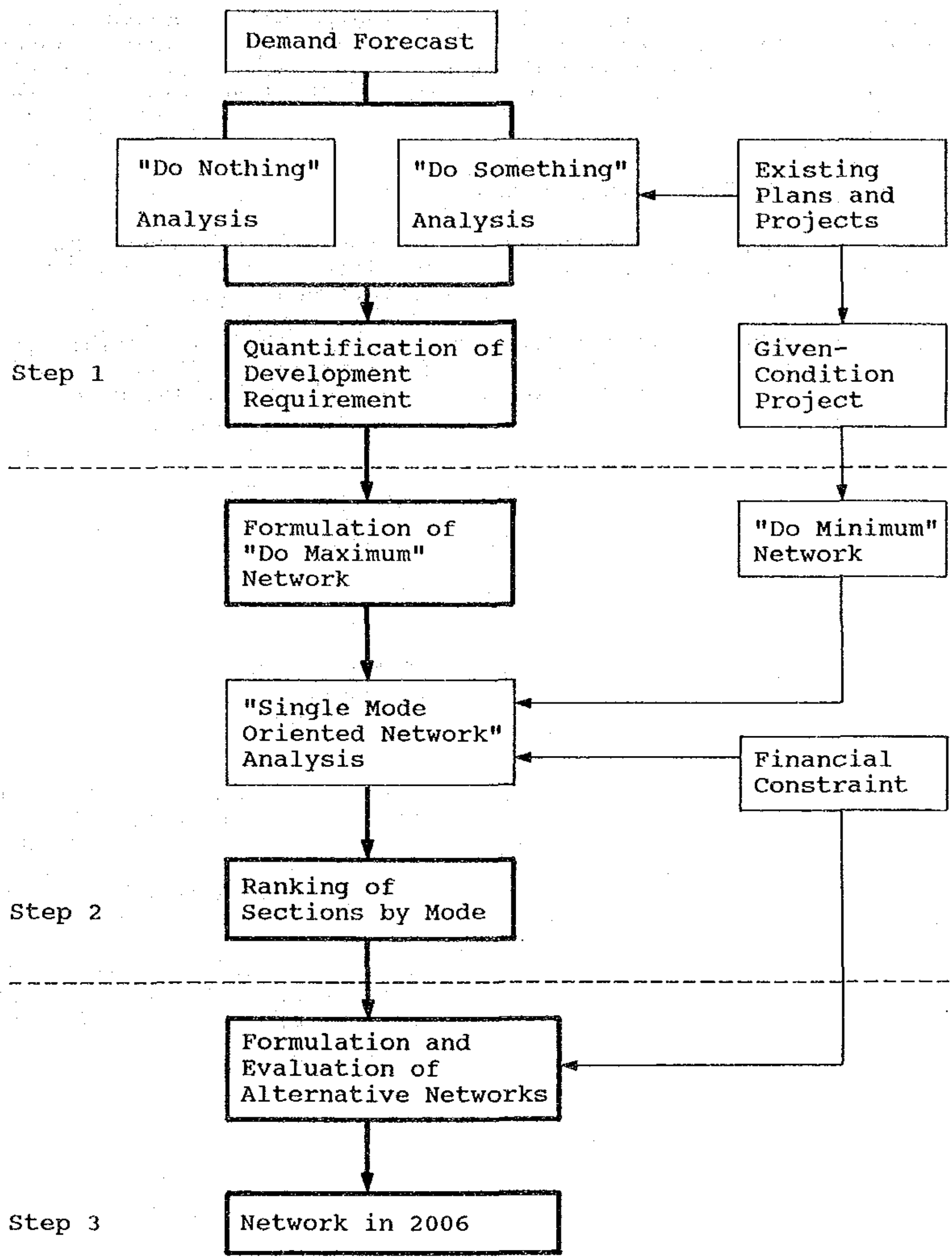


Figure 8.1.1 Planning Procedure for 2006 Transportation Network

Within the financial framework, several alternative networks are formulated by combination of the different modes' high ranked projects. After evaluating the alternatives, the best one is selected and further refined to form the final network for the year 2006.

8.2 Analysis on "Do Nothing" Case

What will happen in the future should the present transportation network remain unchanged with no new investment? The analysis on this problem is called the "do nothing" analysis.

The ratio of the traffic volume to road capacity (Q/C ratio) can be used to quickly evaluate a network or project. The Q/C ratio is an indicator of congestion degree and closely relates to the running speed as shown in Table 8.2.1.

Table 8.2.1 Q/C Ratio and Travel Speed

Q/C Ratio	Travel Speed (km/hr)	Remarks
0.5	30-50	Good
1.0	15-25	Fair
1.2	8-12	Bad
1.5	3- 5	Serious

As shown in Figure 8.2.1, Q/C ratios (the ratio of traffic volume to road capacity of a road section, an indicator showing congestion degree of the section) in 1989 have already exceeded 1.0 in most of the major roads in the central and northern parts of the city. However, sections where the ratio exceeded 1.5 are few. The average Q/C ratio of the network as a whole is 0.90.

If the present network remains unchanged in 2006, most road sections will be fully saturated with their Q/C ratio higher than 1.5 where running speed would fall below 5 km/hour. The average ratio is estimated at 2.2.

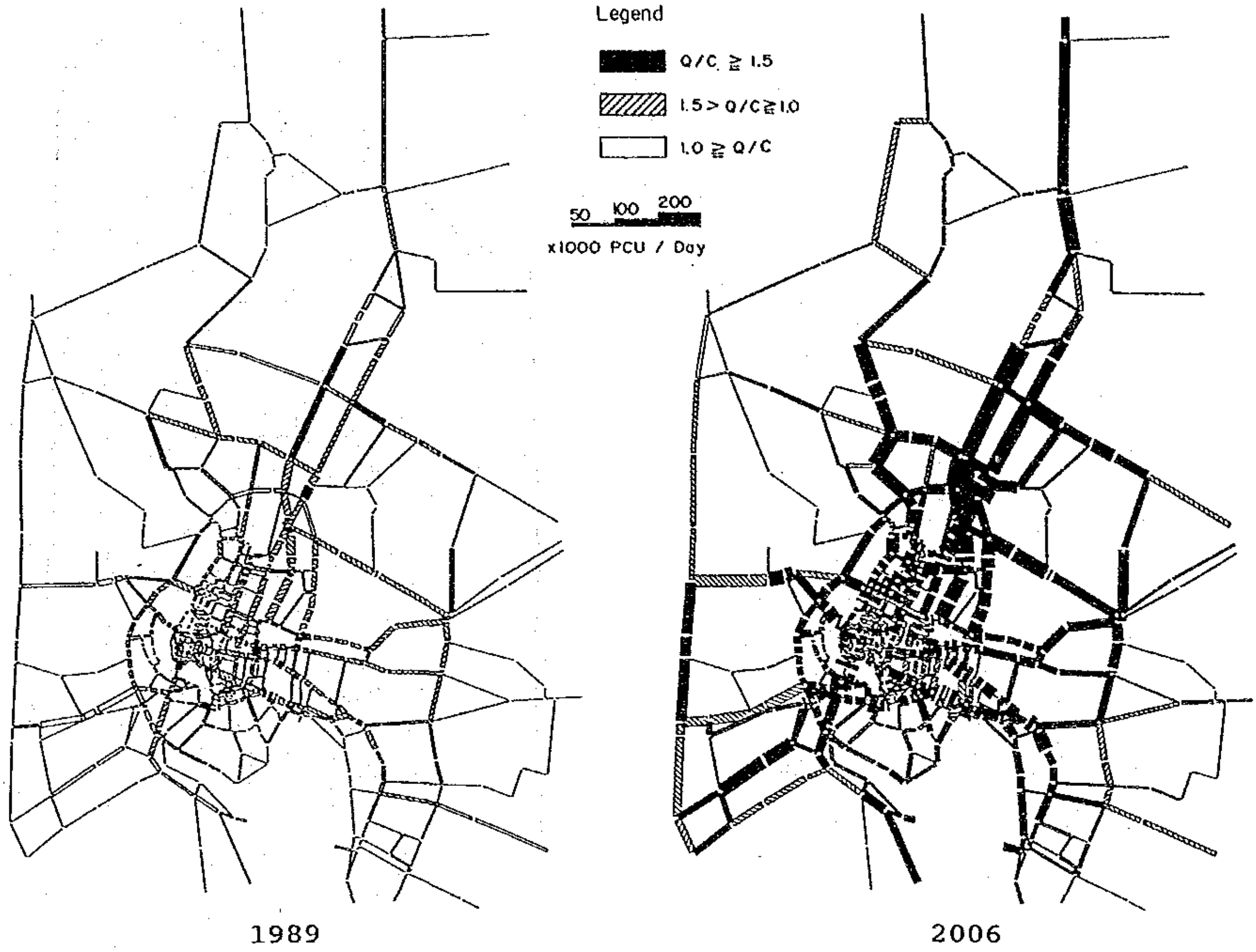
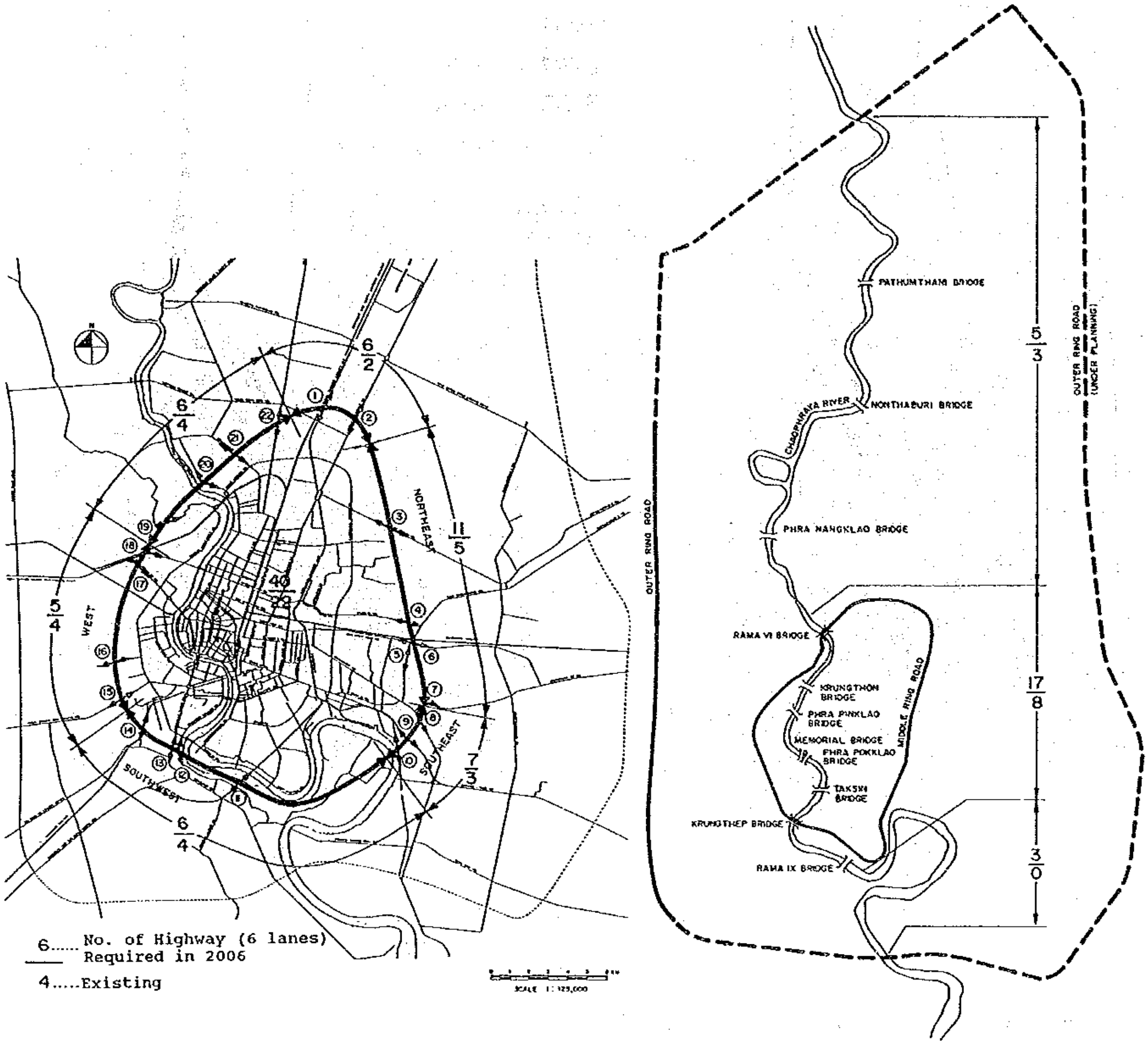


Figure 8.2.1 Assigned Traffic in "Do Nothing" Case

8.3 Network Development Requirement

Based on the future O-D table, an analysis was made on traffic demand increase by direction and necessary road quantity to meet the demand. At present 22 main roads intersect the cordon line drawn just outside the Middle Ring Road, having a total capacity of 1,640,000 in terms of passenger car unit (pcu) per day.

In the year 2006, Traffic crossing the cordon will increase to 3,319,000 pcu/day and thereby an additional 19 six-lane roads will be necessary just to maintain the present congestion levels. The road network especially needs to be strengthened in the north, east and south-east directions.
There are 11 bridges over the Chao Praya river having a total capacity of 714,000 pcu/day. In 2006, 25 bridges will be needed to meet the forecast 1,788,000 pcu/day demand in river crossing. Thus, 14 new bridges will be required.



(1) Inner Cordon Line (2) Screen Line

Figure 8.3.1 Network Development Requirement by 2006

8.4 Maximum-size Network

As the first step of future network formulation, a large-scale network was planned, encompassing plans and ideas to the maximum extent. (This network is called the "maximum-size" network). In this step, physical possibility of a project was the main factor and little attention was paid to financial constraint.

Basic policies for preparing the maximum-size network are:

a. The network consists of four types of facilities; expressway, at-grade main road, busway and rail transit.
b. All the existing plans and projects are taken in, and of which highly mature ones are regarded as given conditions to this study.
c. Public spaces such as canal, road and railway are to be effectively utilized and large-scale demolition of existing buildings shall be avoided.
d. The network is to be shaped in a radial and ring pattern so as to meet the urban development pattern.

Figure 8.4.1 shows the maximum-size network. The Expressway network is composed of two ring roads and eight radial roads in addition to the Second Stage expressways and Ekami-Ramintra line. The at- grade road network contains 42 new road construction and improvement project of total length 420 km.

Rail transit system is classified into Light-rail Transit (LRT) and Heavy-rail Transit (HRT). The former network consist of three lines already planned as the Stage I lines and their extensions in six directions to the suburban areas where rapid urbanization is expected in the future. An X-shaped network is planned for HRT, by connecting the SRT Northern line with Samut Sakhorn line and the Southern line with the Eastern line.

Table 8.4.1 Extension of Transport Facilities in Maximum-size Network

Facility Type	Length (Km)			Construction Cost (million Baht)
	Existing	Planned	Total	
Expressway	24.4	262.1	286.5	97,414.7
At-grade Main Road	922.1	420.7	1,342.8	38,925.1
Busway	-	194.3	194.3	24,234.0
Light Rail Transit	-	121.5	121.5	117,200.4
Heavy Rail Transit	-*	101.5	101.5	65,815.9

Note: * Heavy Rail Transit (SRT) is not functioning as urban transit, transporting a negligible small volume of 20,000 passengers per day.

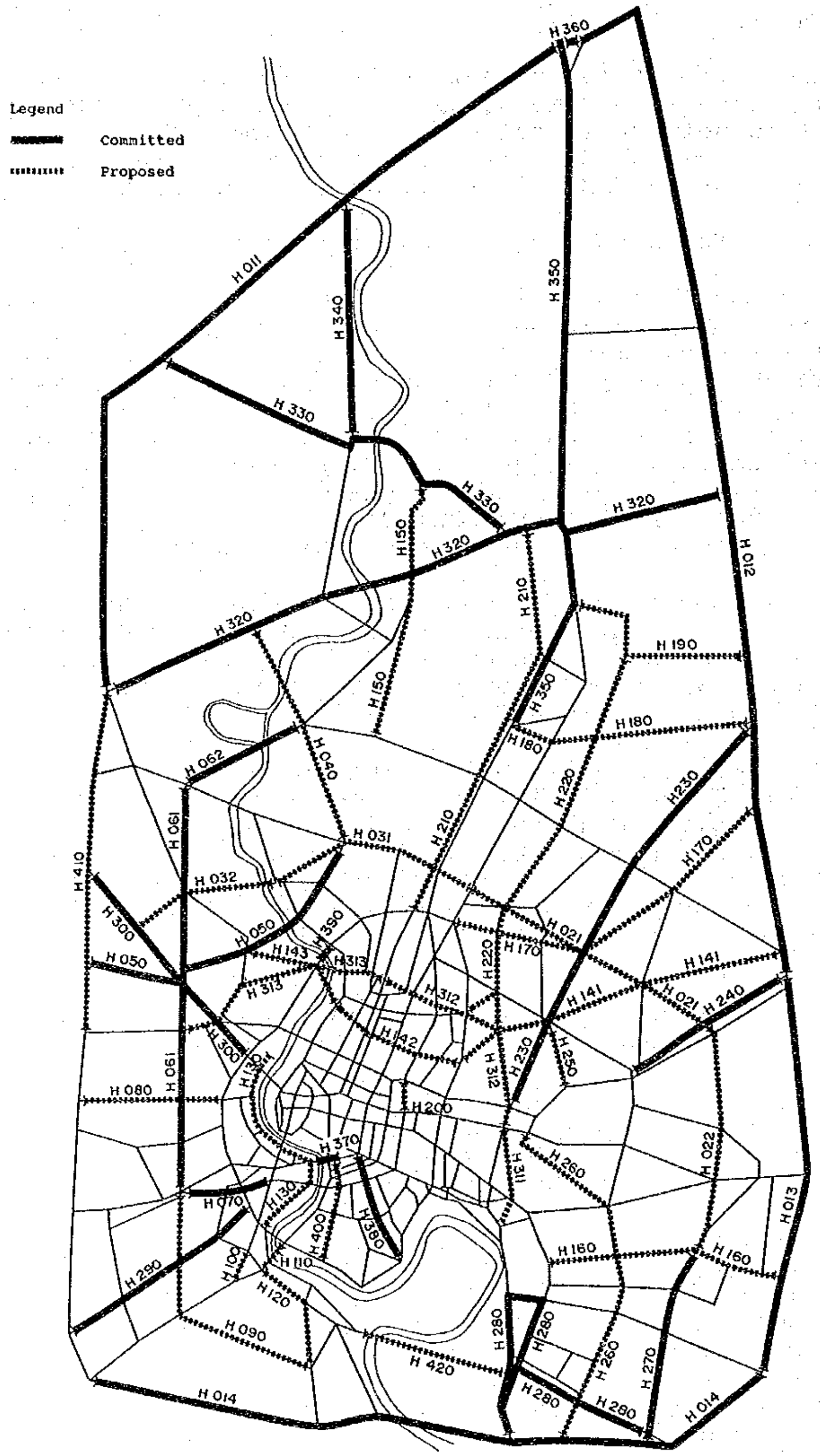
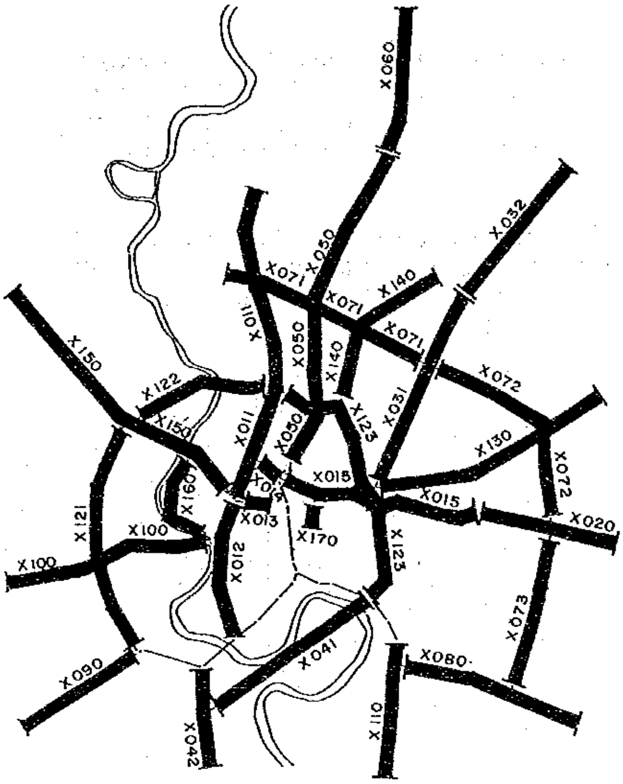
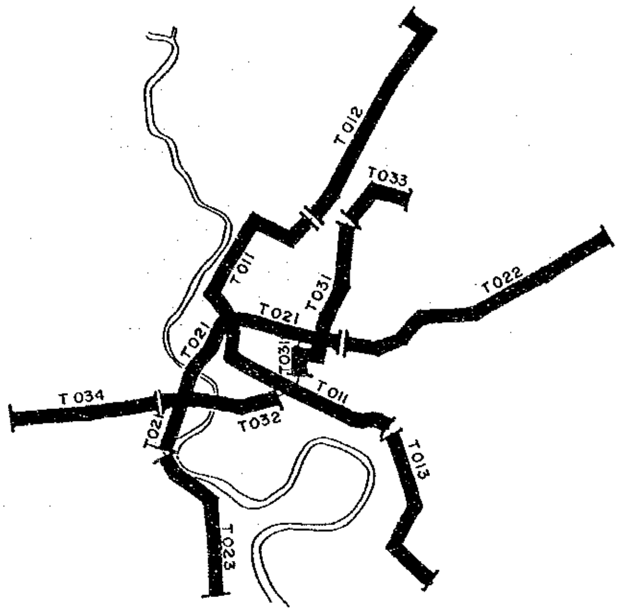


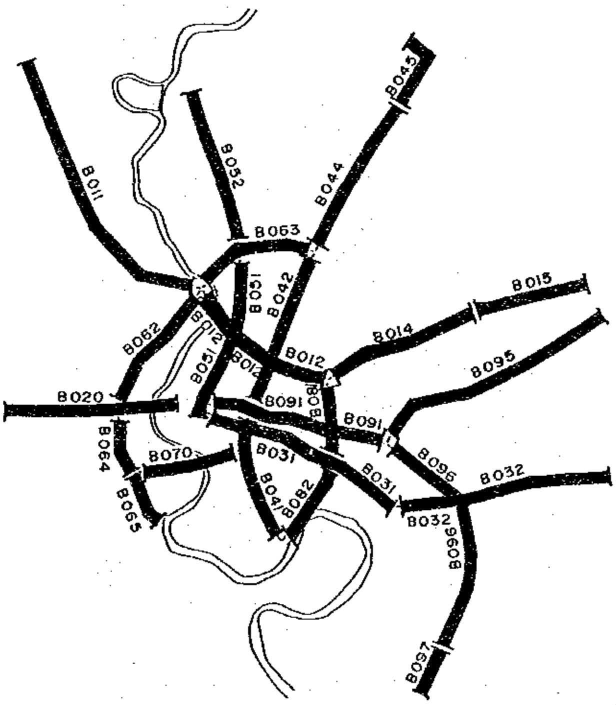
Figure 8.4.1(1) Maximum-size Network (At-grade Main Road)



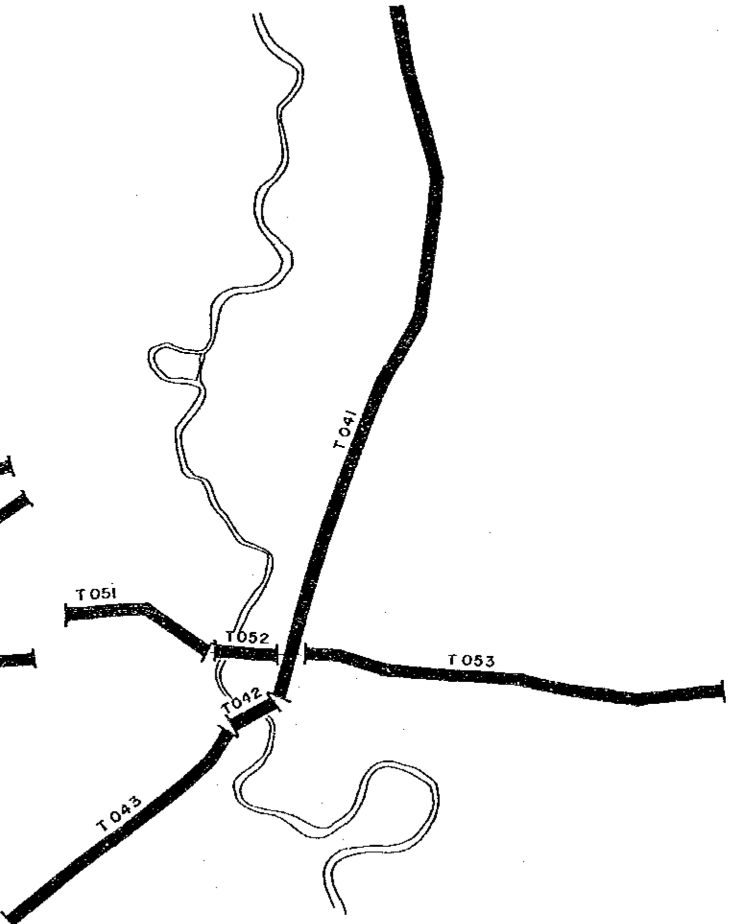
Expressway



Light Rail Transit



Busway



Heavy Rail Transit

Figure 8.4.1(2) Maximum-size Network

Figure 8.4.2 illustrates the assignment result of traffic demand in the year 2006 to the maximum-size network. All the road sections will have Q/C ratios below 1.5 and the average ratio is 0.81, which means that traffic conditions will be better than at present.

According to the traffic assignment results, average travel speed will fall from 8.1 km/hour in 1989 down to 4.8 km/hour in 2006 under the "Do nothing" case, while it will recover up to 8.2 km/hour if maximum-size network is developed.

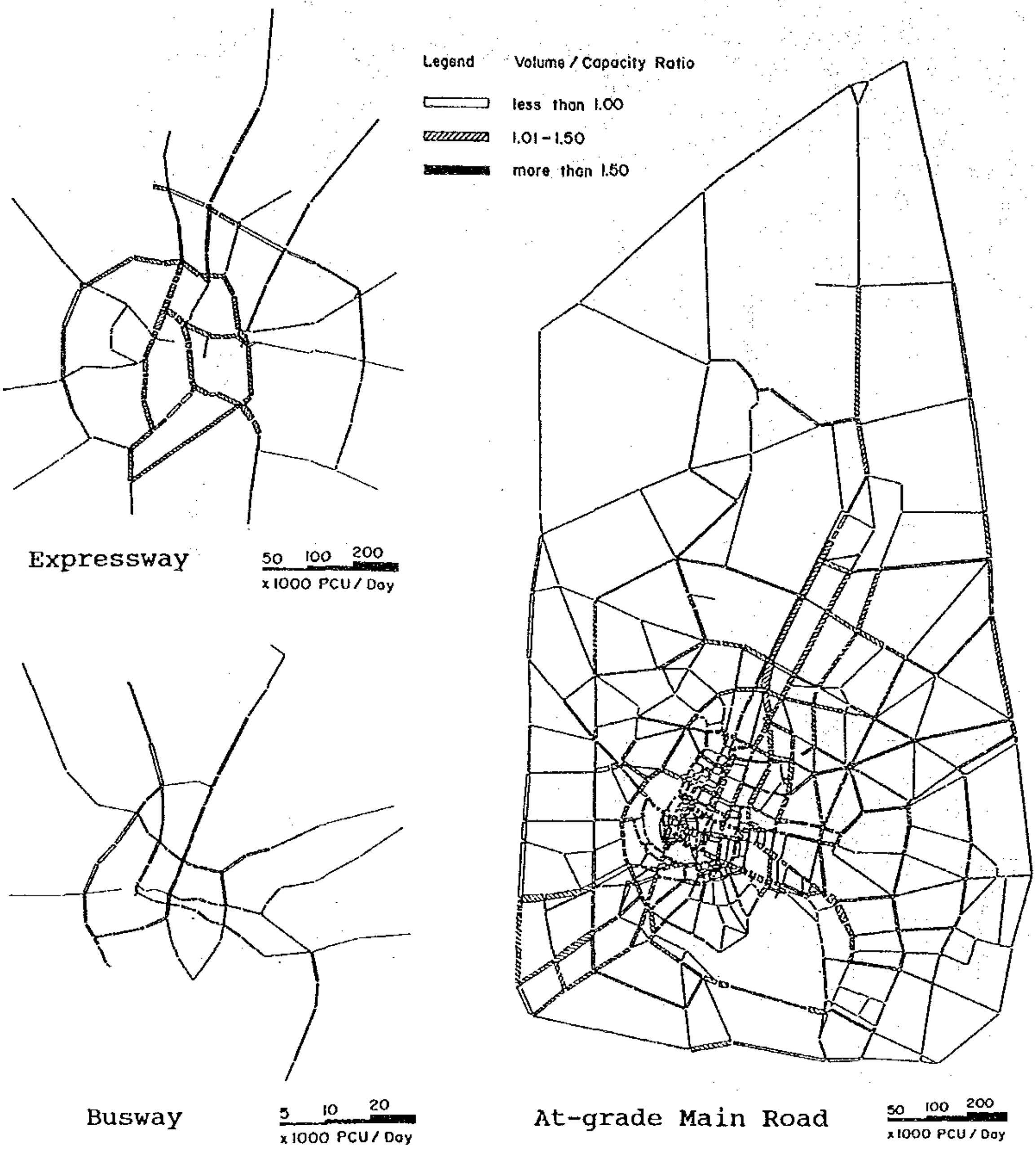


Figure 8.4.2 Assiged Traffic Demand in 2006 to the Maximum-size Network

8.5 Priority Ranking of Project Component

The projects composing the maximum-size network, other than at-grade road projects are further sub-divided when necessary and are ranked according to their priority. Firstly, 9 expressway projects and 4 LRT projects are selected as given condition projects based on a series of discussions with relevant authorities (Table 4.2).

Next, a base network is prepared adding all the given condition projects and at-grade road projects to the present network. Then four single-mode oriented networks are formulated by adding to the base network, each of expressway, busway, LRT and HRT projects. BY examining traffic assignment, every project is ranked into priority category A to E, according to its demand. At this stage inter-modal interaction or trade-off is not yet accounted for.

In Figure 8.5.1, the assigned traffic and the rank of project components in each "single mode oriented" network are shown side by side for the convenience of comparison.

Summing up the project costs by rank, the given condition projects account for 93.7 million Baht, 31% of the total, 304.7 million Baht. Rank A projects account for 25%, B for 12%, C for 11%, D for 13% and E for 7%, respectively.

Table 8.5.1 Ranking of Project Component

Rank	Expressway	LRT	HRT	Busway
Given Condition	X011,X012,X013, X015,X031,X050,	T011,T021, T031,T032	-	-
A	X121,X12,X123, X041,X071	T012	T041	B041,B042,B062,
B	X032,X042,X072	T013,T034	T042	B063,B064,B065,
C	X073,X100,X140	T023	T043	B012
D	X110,X130,X170	T022	T052,T053	B013,B095,B096, B097
E	X020,X150,X160	T033	T051	B011,B020,B032

Table 8.5.2 Project Costs by Rank

Rank	Expressway	LRT	HRT	Busway	Total
Given Condition	40261.6	53450.9	-	-	93712.5
A	25709.6	16603.0	27243.6	6700.2	76256.4
B	7267.6	17954.3	7125.0	4237.0	36583.9
C	9338.0	8293.7	8671.4	8515.5	34818.6
D	6507.5	14624.1	16828.5	2736.2	40696.3
E	8330.4	6274.4	5947.4	2046.1	22598.3
Total	97414.7	117200.4	65815.9	24235.0	304666.0

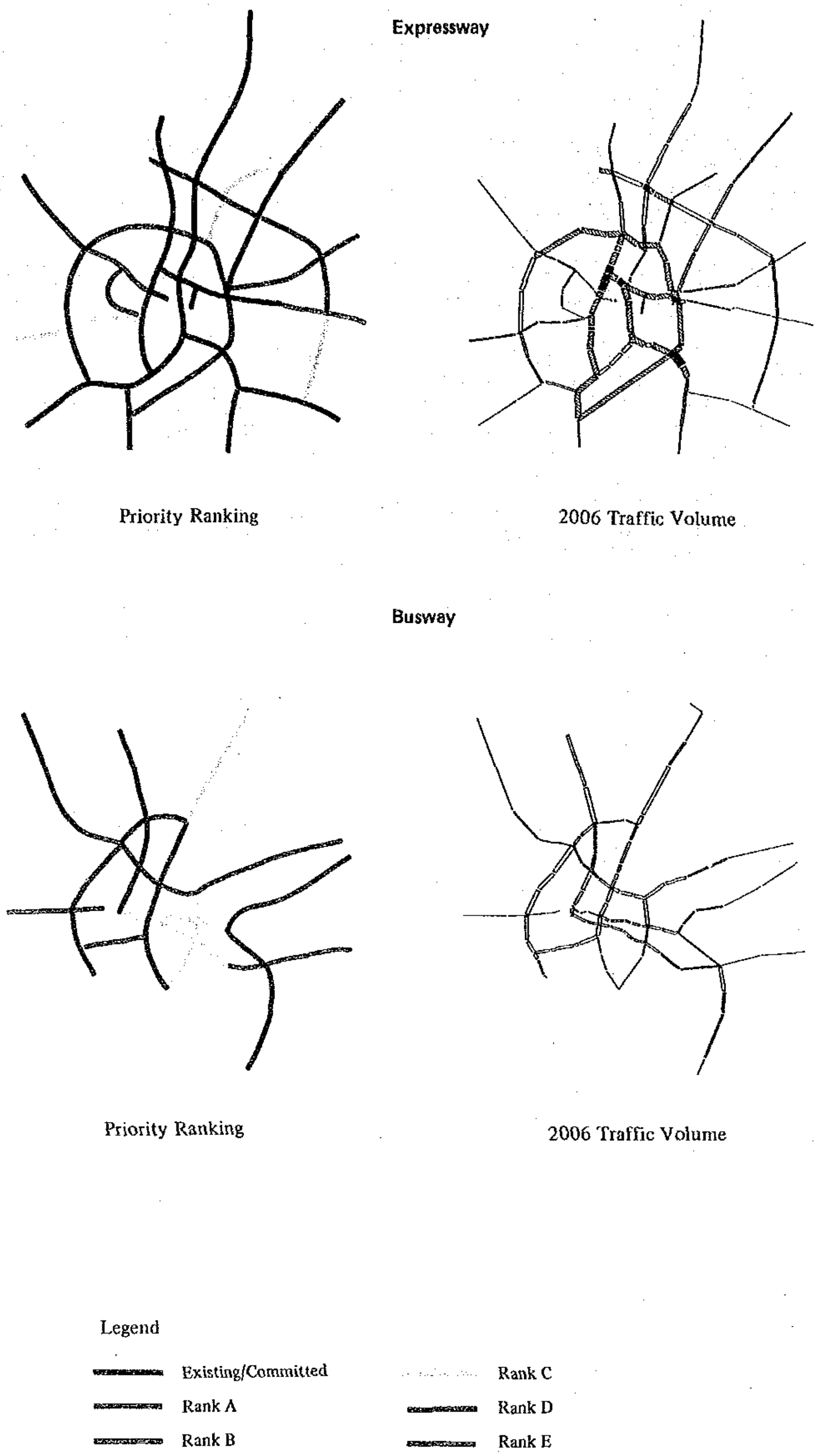
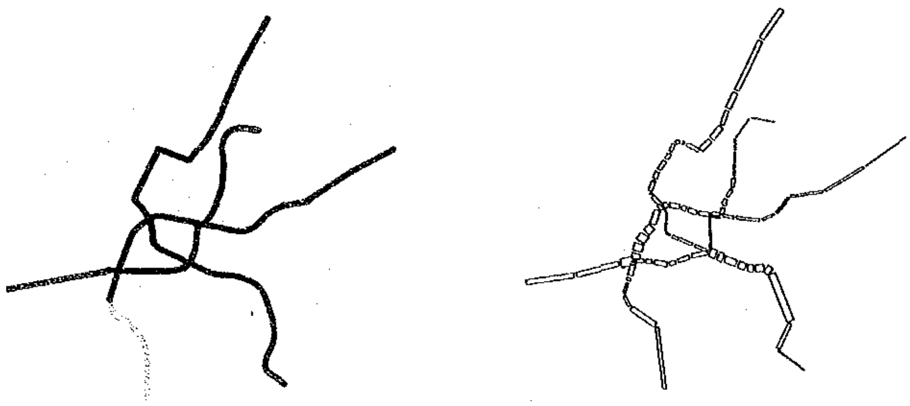
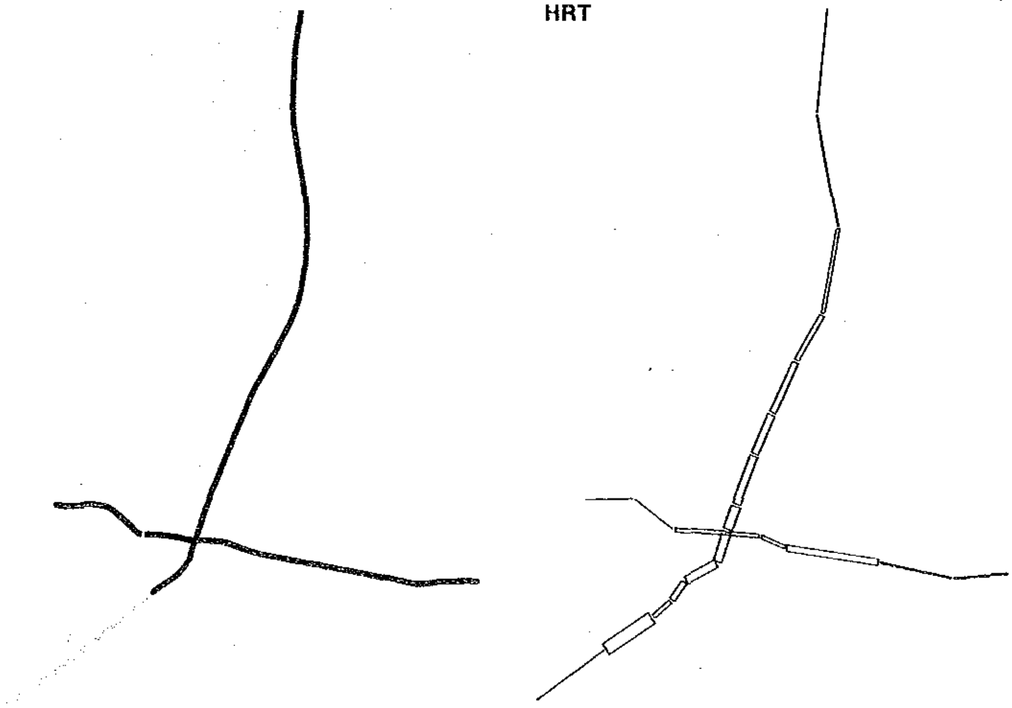


Figure 8.5.1(1) Demand and Ranking of Project Component

LRT



HRT



Legend

Existing/Committed	Rank C
Rank A	Rank D
Rank B	Rank E

Figure 8.5.1(2) Demand and Ranking of Project Component

8.6 Alternative Network

Alternative networks are developed by combining transport projects of different modes, other than at-grade highway projects. Possible investment to the Metropolitan transport sector is estimated at 230 to 250 billion Baht at 1989 prices until the year 2006. Since at-grade main road and distributor road projects would require about 50 billion Baht, each alternative should be prepared in the range of 180 to 200 billion Baht.

Basically, there are three kinds of alternatives from the viewpoint of the mode to be highlighted; Expressway-oriented, LRT-oriented, and Railway (LRT and HRT)-oriented alternatives. For each, three cases are considered by quantity of bus-way; (1) No bus-way, (2) Rank A and B bus-way, and (3) Ranks A to D bus-way. Thus, nine alternative networks are developed (Figure 8.6.1).

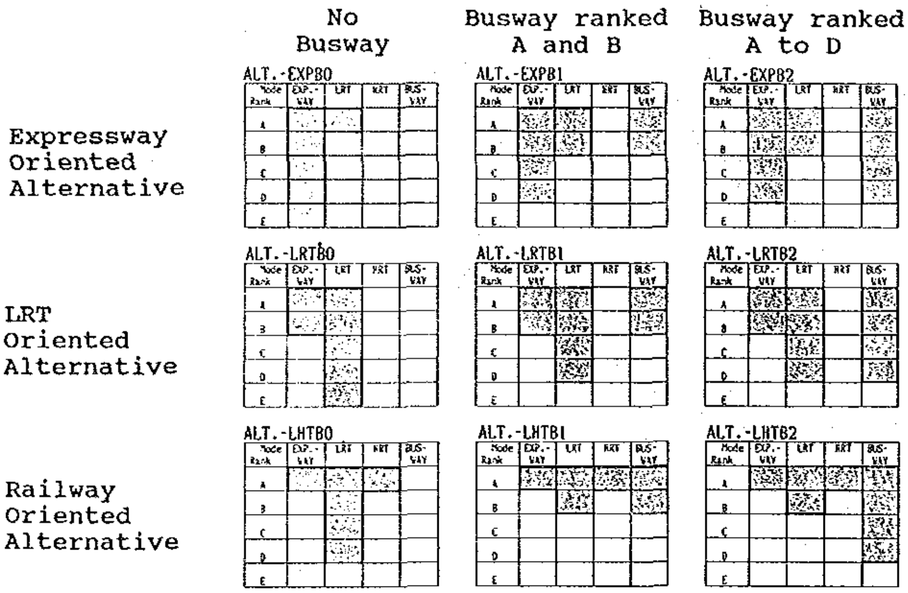


Figure 8.6.1 Project Combination for Alternative Networks

Table 8.6.1 Cost of Alternative by Facility Type

Alter-native	Cost (billion Baht)					Composition (%)				
	Expwy	LRT	HRT	Busway	Total	Expwy	LRT	HRT	Busway	Total
EXPB0	97.4	88.0	0.0	0.0	185.4	52.5	47.5	0.0	0.0	100.0
EXPB1	89.1	88.0	0.0	10.9	188.0	47.4	46.8	0.0	5.8	100.0
EXPB2	89.1	88.0	0.0	22.2	199.3	44.7	44.2	0.0	11.1	100.0
LRTB0	73.2	117.2	0.0	0.0	190.4	38.5	61.5	0.0	0.0	100.0
LRTB1	73.2	110.9	0.0	10.9	195.1	37.5	56.9	0.0	5.6	100.0
LRTB2	73.2	110.9	0.0	22.2	206.4	35.5	53.8	0.0	10.8	100.0
LHRB0	66.0	110.9	27.2	0.0	204.1	32.3	54.3	13.3	0.0	100.0
LHRB1	66.0	88.0	27.2	10.9	192.2	34.3	45.8	14.2	5.7	100.0
LHRB2	66.0	88.0	27.2	22.2	203.4	32.4	43.3	13.4	10.9	100.0

Based on the traffic assignment, alternative networks are evaluated as shown in Table 4.5. Here, economic benefit is defined as the annual saving in vehicle and railway operating cost in 2006 (difference of operating costs under "Do nothing" case and alternative network), while investment cost is estimated under the general conditions of 25 years of project life and 12% of interest rate.

Every evaluation indicator shows that all the alternatives are highly economically feasible and above all, the expressway-oriented alternatives are most favorable, followed by the LRT-oriented alternatives. The more bus-ways are added, the better results are expected.

Table 8.6.2 Evaluation of Alternative Networks

(Billion Baht at 1989 price)

Alter-native	Total Cost	Annual Cost	Benefit	B/C	Av.Q/C Ratio	Section of Q/C >2.0 (km)	Pax*Hour (million per day)
EXPB0	152.8	13.4	55.1	2.84	0.89	45	36,195
EXPB1	155.2	19.7	55.7	2.83	0.89	44	35,897
EXPB2	165.7	21.0	64.9	3.09	0.85	42	33,124
LRTB0	150.4	19.1	46.1	2.42	0.96	54	39,032
LRTB1	156.5	19.9	50.0	2.52	0.94	52	37,653
LRTB2	167.0	21.2	57.7	2.72	0.89	41	35,410
LHRB0	156.2	19.8	48.8	2.42	0.99	47	38,442
LHRB1	150.2	19.0	48.9	2.57	0.96	48	38,667
LHRB2	160.7	20.4	53.2	2.61	0.91	46	37,671

Cost of each alternative is shown in terms of economic cost, excluding all taxes and re-evaluating land cost.

8.7 Network for the Year 2006

Alternative network EXPB2, the most favorable one, is further refined towards the proposed network for the year 2006. Refinement is carried out mainly from the following points of view:

1) to make the network well-balanced and consistent, avoiding duplicated investment,
2) to coordinate the network with the expected urban growth directions, and
3) to change elevated facilities to at-grade facilities in the suburban areas reduce investment costs, in respect to their demand.

1) Expressway

The network for 2006 is formulated by eliminating from the maximum-size network, comparatively low demand sections such as the eight radial routes (X110, X020, X030, X032, X040, X142, X150, X160) and an eastern part of the outer ring route (x072, x073). This will allow for a well-balanced radial and ring expressway system. Total extension is 213 km including the existing 24 km.

In the year 2006, 1,240,000 pcu/day are expected to use the expressway. In particular there will be a large demand along the ring route, as well as the Second Stage lines and Ekamai-Ramintra line.

2) At-grade Main Road

In order to effectively utilize the rapid transport system such as expressway, bus-way and rail transit, a network of at-grade roads must be properly developed, to support such rapid system. Otherwise, the rapid system advantages will be off-set by congestion in access and egress trips.

All the at-grade road projects in the study area are highly evaluated from the economic viewpoint , while their construction cost is rather low comparing to other transport infrastructure. Therefore, all the 44 projects planned in the maximum-size network are to be completed by the year 2006. The present 922 km road network should be expanded to 1,342 km, covering the study area with main roads located at 2 to 3 km intervals.

3) Bus-way

Of the 194km bus-ways in the maximum-size network, 126km sections are recommended for the 2006 network, eliminating low demand route to the west (B020) and to the north-west (B011), and also the Sukhumvit line which will have a sizable demand but be competitive to the Saen Saep canal line. In 2006, 656,000 passengers can be expected to use the bus-way system.

Bus-way is a new type urban transport infrastructure which will offer rapid service in a cost saving way and will be promising in the Bangkok Metropolitan area where available space is limited. It is worthwhile to examine the engineering and financial feasibility of the bus-way.

4) Rail Transit System

It is proposed to develop by 2006, the three lines of the First Stage and the Rama line extension to the Don Muang international airport along Pahong Yothin street in the north and to Samut Prakan in the south. The Central line is also to be extended as far as the Outer Ring Road in the west. By these extensions, more passengers can be expected and at the same time, it will become easier to locate the car depots.

Although the connection of the SRT North line with the Samut

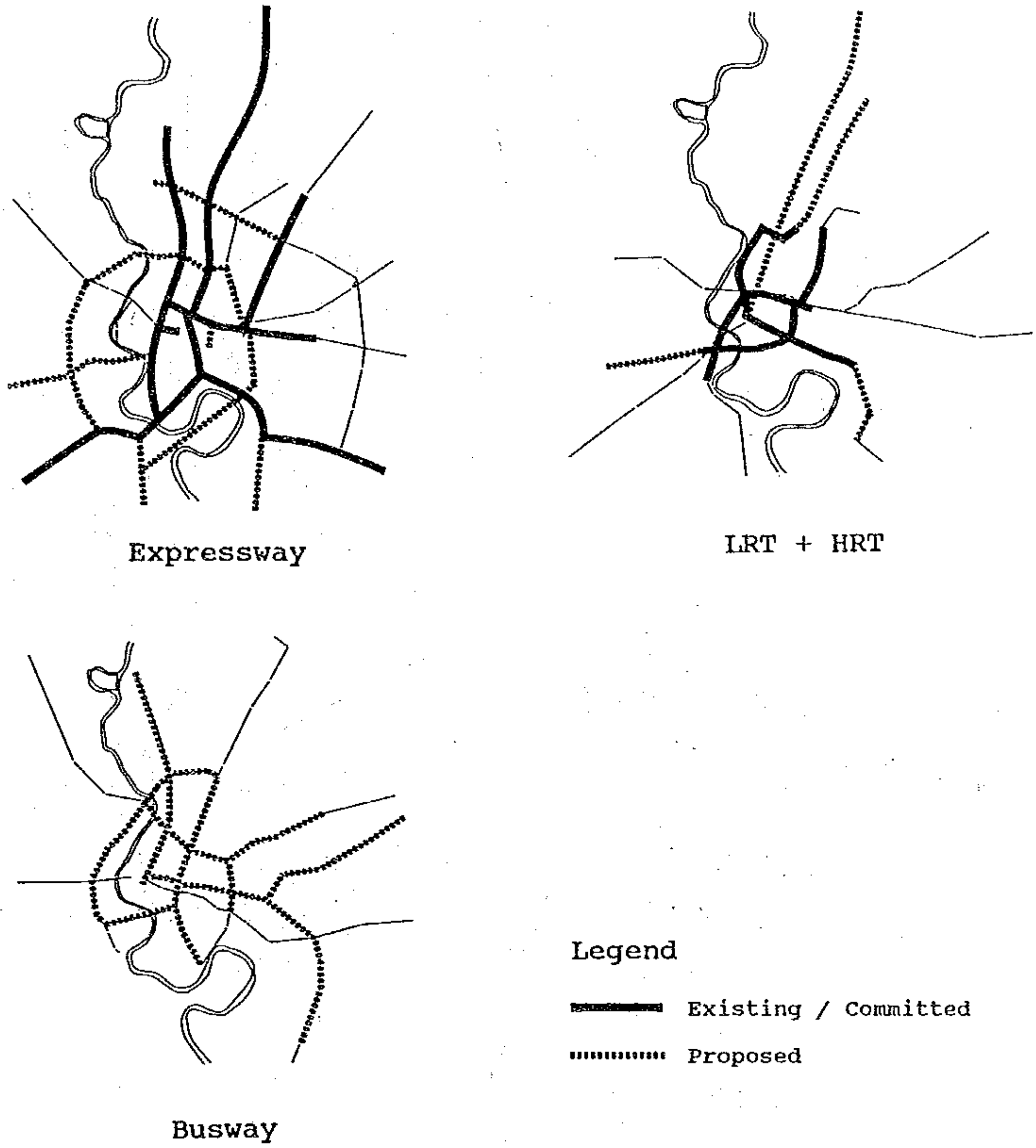


Figure 8.7.1 Selected Sections for Year 2006 Network

Sakhon line will serve a large demand, huge investment is needed for the river crossing. Therefore this project shall be postponed beyond 2006, and only the up-grading project of the North line between the Hua Lamphong terminal and Chiang Lak is proposed.

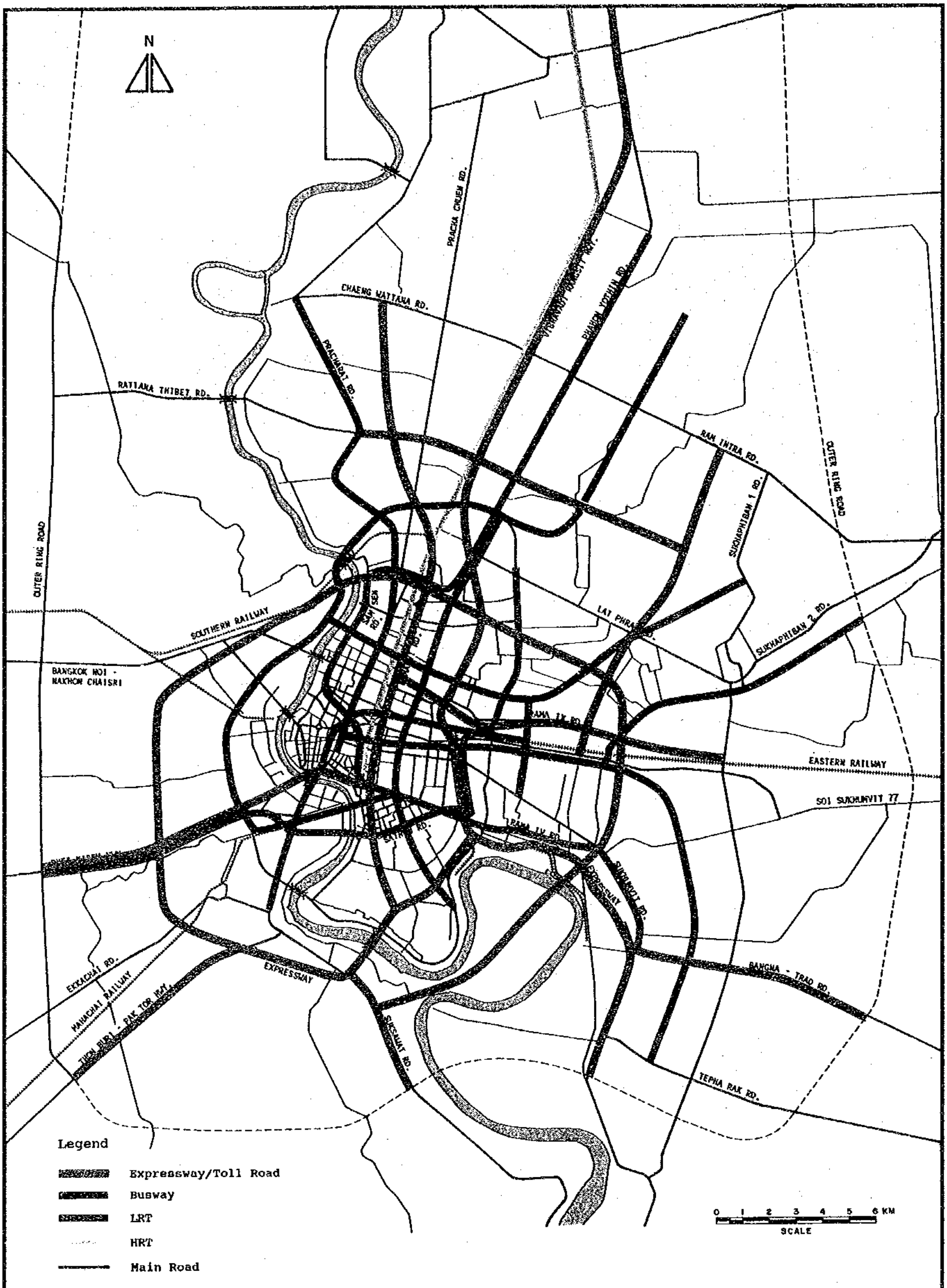


Figure 8.7.2 Proposed Transportation Network for 2006

5) Traffic in the year 2006 Network

The result of traffic assignment to the Network for 2006 is shown in Figure 4.8 and Table 4.6. The total cost to develop the maximum-size network, 343.6 billion Baht including at-grade road cost of 38.9 billion Baht, is reduced to 240.3 billion Baht in the network proposed for 2006, without much loss in effectiveness. Road congestion will be kept in the same level as at present.

Table 8.7.1 Summary of Traffic Assignment Result

	1989	2006		
		"Do Nothing"	Max-size Net.	2006 Net.
Av. Q/C ratio	0.90	2.24	0.81	0.90
Av. Speed: (km/hr)				
At-grade rd.	8.1	4.8	8.2	7.6
Expressway	11.4	5.1	18.2	11.6
VOC (bt.billion/year)	58.4	221.4	153.9	165.1
TTC (bt.billion/year)	98.4	871.3	436.2	496.3

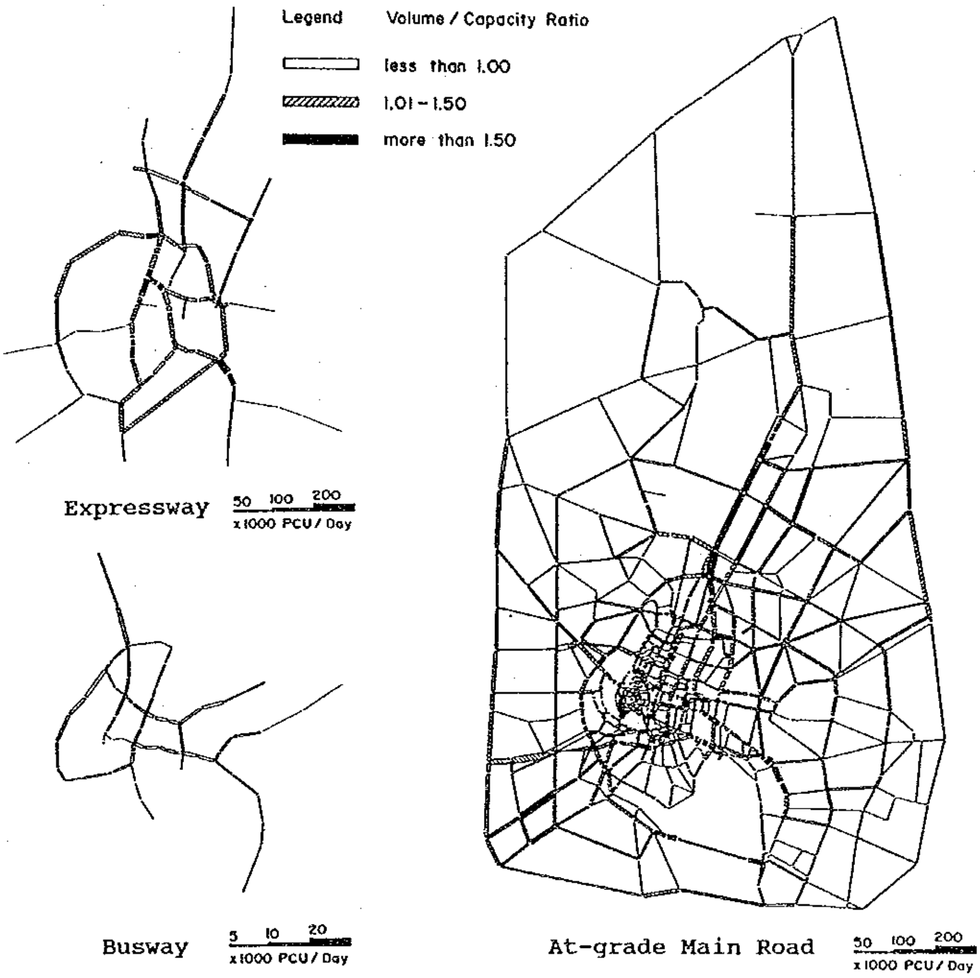


Figure 8.7.3 Assigned Traffic to Network in 2006

CHAPTER 9

ROAD NETWORK PLAN

9. ROAD NETWORK PLAN

9.1 Description of the Network

1) Planning Considerations

Metropolitan Bangkok depends almost entirely on road and road transportation, especially in intra-urban movement. The present SRT hardly contributes to urban transportation though the current plan is intended to strengthen its capabilities. Water transportation has ceased to exist except along Chao Phraya River and does not have any more capability to form a part of the main urban transport network.

Therefore, roads are practically the only means of transport at present and will continue to be the major mode long in the future. Nevertheless, the road and road transport development pace has been slow and faces difficulties. The main deficiencies in road development administration are;

- While the development of roads in suburban area and elevated expressways have shown fair progress, the implementation of at-grade roads in the inner area has been considerably delayed due to increased difficulties in land acquisition and compensation.

- There is no effective planning/development method with proper institutional support, creating a situation where neither systematic nor effective development of road network can be assured.

- Lack of public funds for infrastructure development tends to create a number of major projects under concession or BOT scheme. Implications among these projects have not necessarily been fully assessed.

The existing bottlenecks in urban transportation in Bangkok can be summarized as follows:

(a) <u>Network Deficiency</u>: This includes absolute lack of roads particularly in suburban areas, inadequate hierarchical structure of the network, and obvious mismatch between the capacities of the expressway and adjacent street system.

(b) <u>The Poor State of Public Transportation System</u>: This includes delayed improvement of BMTA bus operation, delayed implementation of Skytrain, and the undetermined improvement plan of SRT. Various para-transit modes, which are expected to supplement the existing transit system, are not properly managed.

(c) <u>Central Area Congestion</u>: The present situation will likely continue in the future even with the increase of road capacities, unless drastic demand restraint measures are enforced properly. Although a number of traffic management measures are effective to lessen the congestion, the critical factor is how to balance the total traffic capacity and traffic demand in the area.

(d) Insufficient Highway Capacity along Main Corridors: Since urban development has been expanding towards the outskirts along main corridors, it is anticipated that road transport capacities will be lacking in almost all directions, especially in the north where the southern section of Vibahavadi Rangsit Highway carries already on the order of 180,000 vehicles per day and in the east when the Eastern Seaboard becomes fully operational. Capacity deficiencies along the corridors are seen in almost all directions.

(e) Lack of Suburban Infrastructure: Many suburban areas are growing very rapidly, but urbanization patterns are often inefficient due to lack of planning, institutionalization and enforcement and poor investment coordination. "Ribbon development" along the corridors leads to long travel distances, and lack of distributor roads often leaves land parcels undeveloped due to lack of access. It is very important to develop inways to harness private sector participation in the rational development of suburban areas according to acceptable planning and design standards. More important is that the Government must be equipped with effective planning and institutional arms.

It is predicted that the future urban development pressure and traffic demand would aggravate the problems in a much more serious manner unless more fundamental and drastic measures are effectively taken. The main issues to be incorporated in the road network planning are fourfold:

(a) Strengthening of hierarchical structure of road network with clearer functional split among primary, secondary, and distributor roads.

(b) Development of bus-ways in parallel with the development of Skytrain and SRT to organize an effective public transportation system.

(c) Development of roads which can better lead urban development and facilitate control of land use.

(d) Formulation of effective methods for road development with particular regard to land acquisition, construction method, relieving financial burden, etc.

2) Overall 2006 Road Network

The overall road network plan has been prepared in compliance with the predicted urban development in the study area and considering functional split between rail transit and road transport. The factors taken into account in the road network planning are more specifically as follows:

(a) Development of elevated/access controlled primary road system: Many at-grade primary roads in Bangkok do not function as primary system due to ineffective land use control and lack of hierarchical road structure. Upon completion of a road, the areas alongside the road are instantly built up, while large pocket areas are left undeveloped behind the roads. Considering that the future car traffic demand will remain strong and financial viability of expressways is relatively high, a network of expressways and toll roads will be a practical way of securing a primary road system in Bangkok.

(b) Development of elevated/segregated bus-ways: It is unlikely the planned rail-transit system alone would effectively meet the future public transport demand. The rail transit system would still have to be supported by extensive bus system in the future. As many at-grade roads have physical and management constraints, it would be more practical and effective to provide a network of elevated and segregated (on at-grade roads) bus-ways with an effective integration of conventional bus system.

(c) Strengthening of radial/circumferential network configuration: Further urban development along transport corridors is the predicted pattern in Bangkok. In order to encourage proper urban growth with the development of new urban centres, it is considered that radial/circumferential network needs to be strengthened. It is also noted that the main road system is planned in such a way that the concept can further be extended beyond 2006.

(d) Expansion of at-grade main roads: It seems the construction of at-grade roads in the study area, especially in the inner area is considerably difficult. However, proper at-grade road system is a must, whether or not elevated primary system exists. Priority should be given to those roads such as missing links, the roads which will supplement the former elevated/segregated primary system, and roads on which elevated system is planned.

(e) Development of distributor roads: In order to complete the hierarchical structure of an effective road system, development of distributor roads is an inevitable component of the project. Government should find out the way to accelerate the development of distributor as well as access roads through strengthening financial, management and institutional measures.

Accordingly, the proposed road network is composed of expressways including toll roads, bus-ways, at-grade main (primary and secondary) roads and distributors which are explained in more detail in the following sections.

Table 9.1.1 Summary of Road Network Plan, 2006

Classification	No. of Projects	Road Length (kms)					
		Existing		Proposed		Total	
		At Grade	Elevated	At Grade	Elevated	At Grade	Elevated
A. Main Road System 1/							
1) Expressways/ Toll Roads	12	-	27	18	166	18	193
2) At-grade Main Roads	44	800	-	599	-	1,399	-
TOTAL		800	27	617	166	1,417	193
B. Bus-ways 1/	7	-	-	34	87	34	87
C. Distributors	-	500	-	2,055	-	2,555	-

1/ including bridges

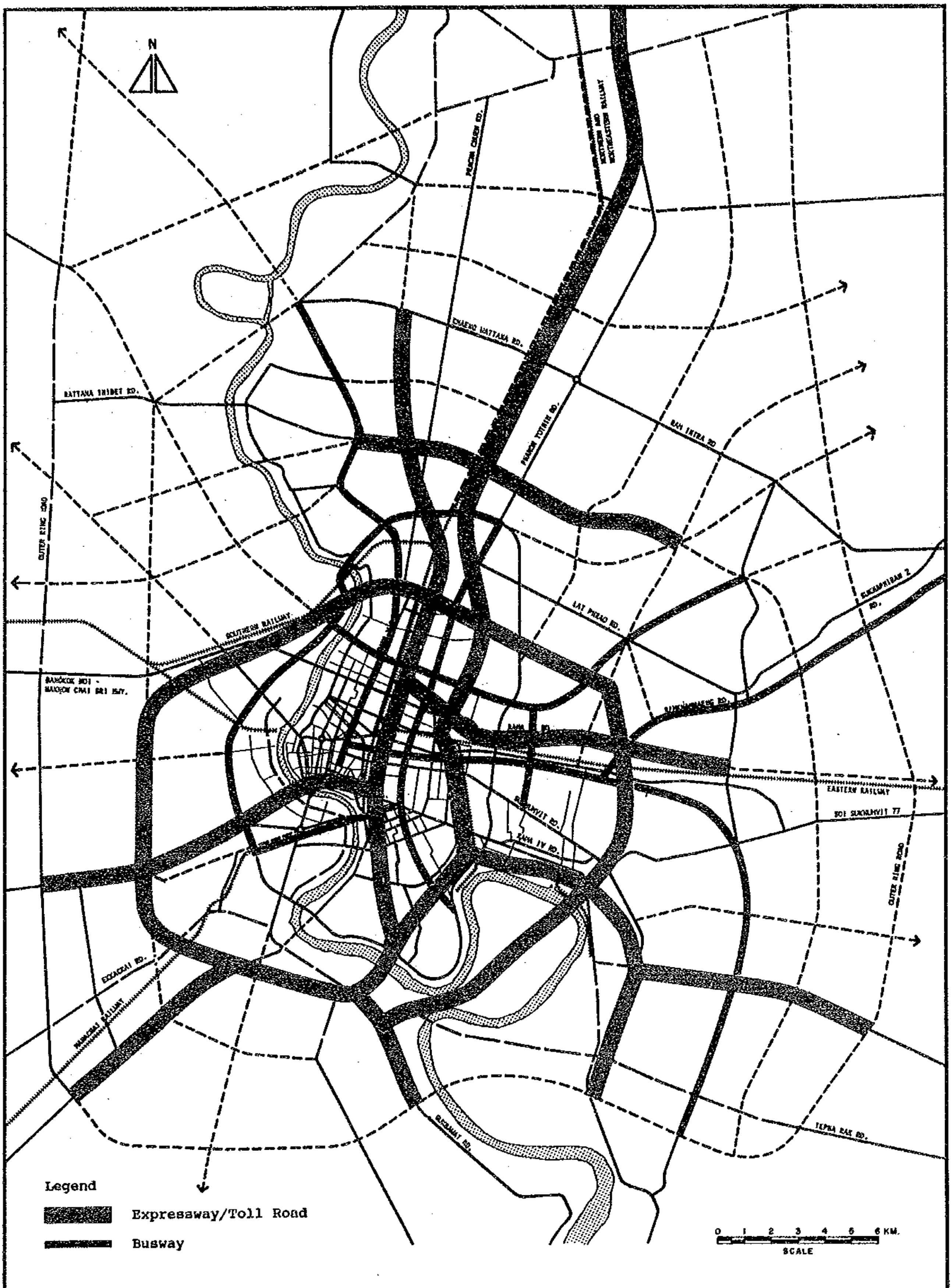


Figure 9.1.1 Overall Road Network Plan, 2006

9.2 Main Roads

Main roads include access controlled expressways which are mostly elevated, and at-grade primary and secondary roads. The former is shown in Figure 9.2.1, while the latter in Figure 9.2.2. The characteristics are as follows:

1) Expressways

The proposed system comprises the committed expressways and toll roads by ETA and DOH, and a number of proposed projects. The former include the following:

(a) ETA 2nd Stage Expressway System consisting of five sectors with a total length of 37.63 km, all of which are elevated dual 3-lane. The construction will commence in 1990 and is scheduled to be completed by 1992. The project is under BOT scheme.

(b) DOH FES-Don Muan Toll Road with 10.2 km dual 3 lane. The project is under BOT scheme.

(c) DOH Bang Na-Trad Toll Road, dual two lane at-grade road with toll free frontage roads, and Thonburi-Pak Tho Toll Road with the same standards: The projects are implemented directly by DOH.

(d) ETA Ekamai-Ram Intra Expressway between New Petburi and Ram Intra with 9.3 km of elevated dual 3 lane. This project is supposed to be implemented under BOT scheme.

Among the latter proposed projects, major ones are as follows:

(a) Expressway linking Thonburi-Bang Su and Ramkhamhaeng with elevated dual 3 lane: The project intends to provide east-west link and eventually form most of the second major circumferential expressway.

(b) Expressway linking Phet Kasem and SSE with elevated dual 3 lane across Chao Phraya River: This intends to provide direct expressway link between the CBD and western part of the city.

(c) Expressway linking Nonthaburi and Bang Kapi with elevated dual 3 lane: This intends to strengthen east-west connection.

2) At-grade Main Roads

At-grade primary and secondary roads are planned with due consideration of the following:

(a) The committed projects by relevant agencies such as DOH, PWD, BMA and those specified in DTCP general plan will be mostly included as given projects in this study. However, necessary modifications were made when it was considered

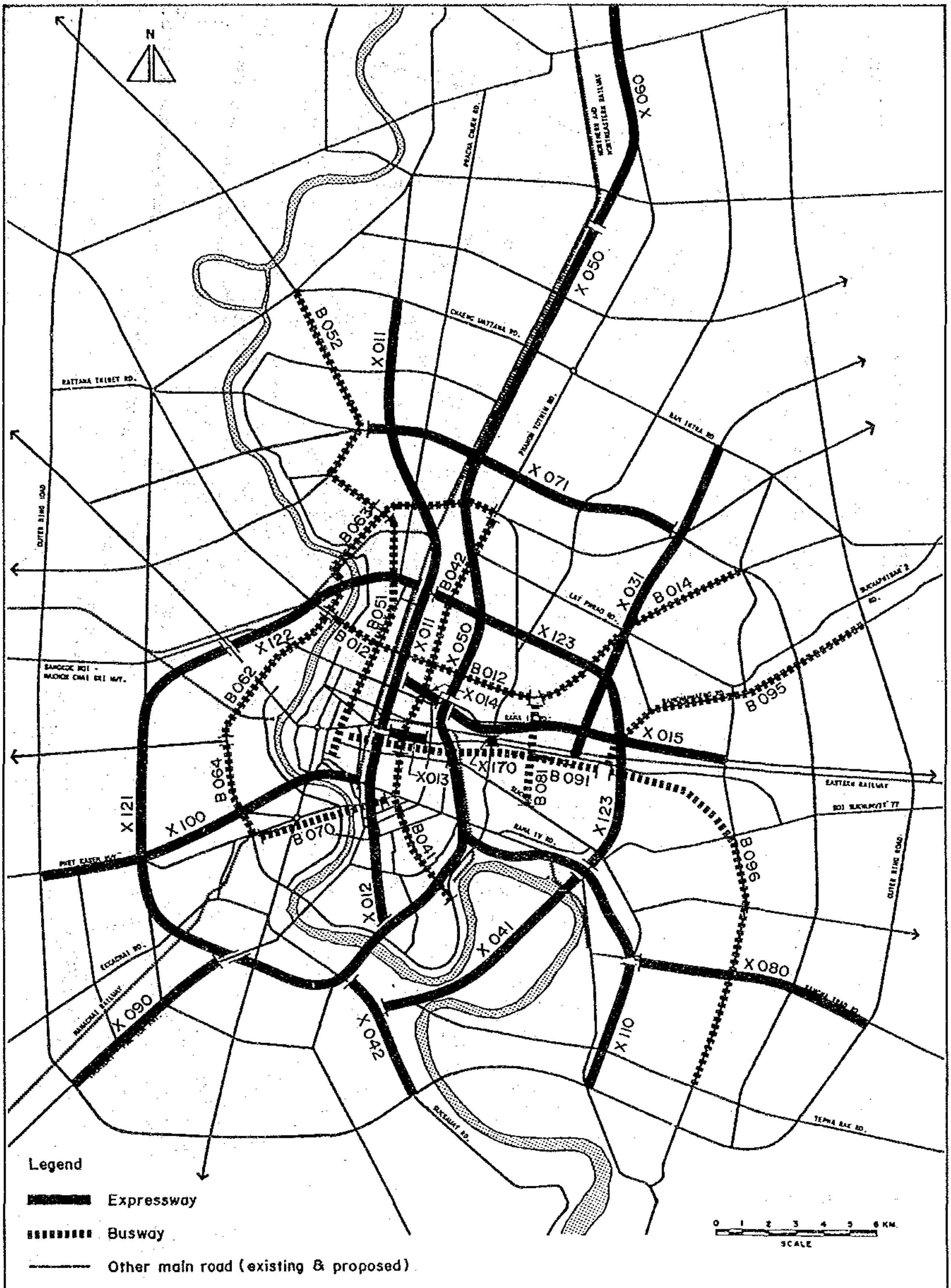


Figure 9.2.1 2006 Main Road Network in the Study Area (Expressways and Busways)

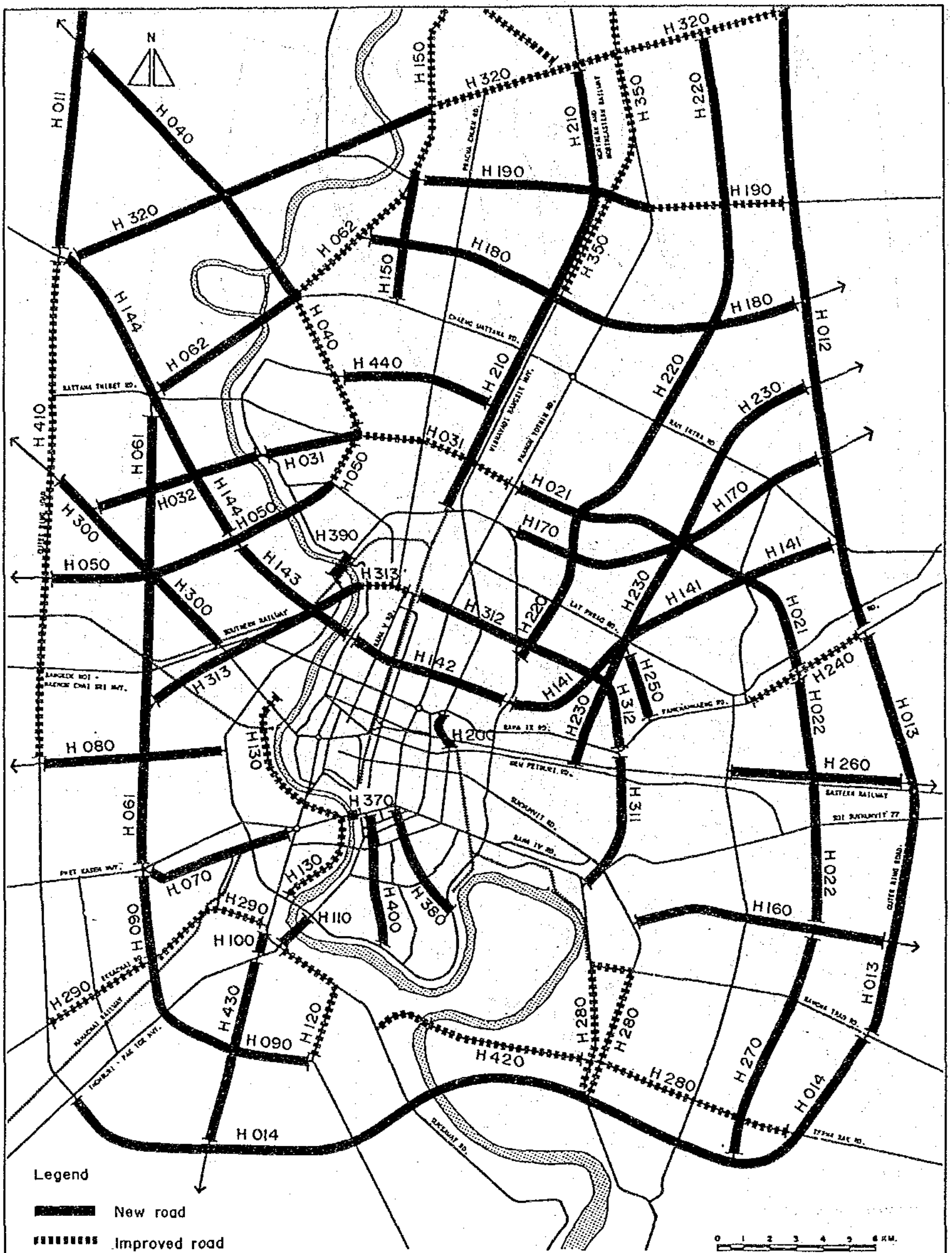


Figure 9.2.2 2006 Main Road Network in the Study Area
(At-Grade Main Roads)

that the projects can form a better network by doing do. Most of the projects are included in this category.

(b) Ground level of the proposed elevated expressways will be simultaneously developed as secondary or distributor roads depending upon the local conditions to make use of the acquired space to a maximum extent.

(c) At-grade main roads are structured in such a way that they serve future urban areas with appropriate network density, regardless of the elevated systems such as expressways, bus-ways and rail transit systems. Therefore, the proposed projects are more densely found in the areas where existing primary and secondary network density is low and accelerated future developments are anticipated.

(d) The network basically has a radial and circumferential pattern which also enables the strengthening of the east-west connections in the north considerably.

9.3 Bus-ways

1) Network Characteristics

Although segregated bus-ways have been proposed in the past studies including STTR, no definite actions were undertaken. However, in the light of the pressing needs of public transport improvement which can hardly be expected only from the improvement of at-grade operation, it is considered that the implementation of bus-ways (segregated bus operation) is the most practical solution to meet the policy objective. Extensive proposal on the bus-ways in this study intends to provide exclusive public transportation network together with the proposed rail transit systems (LRT and SRT) at relatively low investment costs. Following are the characteristics of the bus-way network;

(a) The bus-ways are segregated from other road traffic. In the built-up areas, they are elevated but are constructed at-grade with exclusive carriageway in the suburban areas.

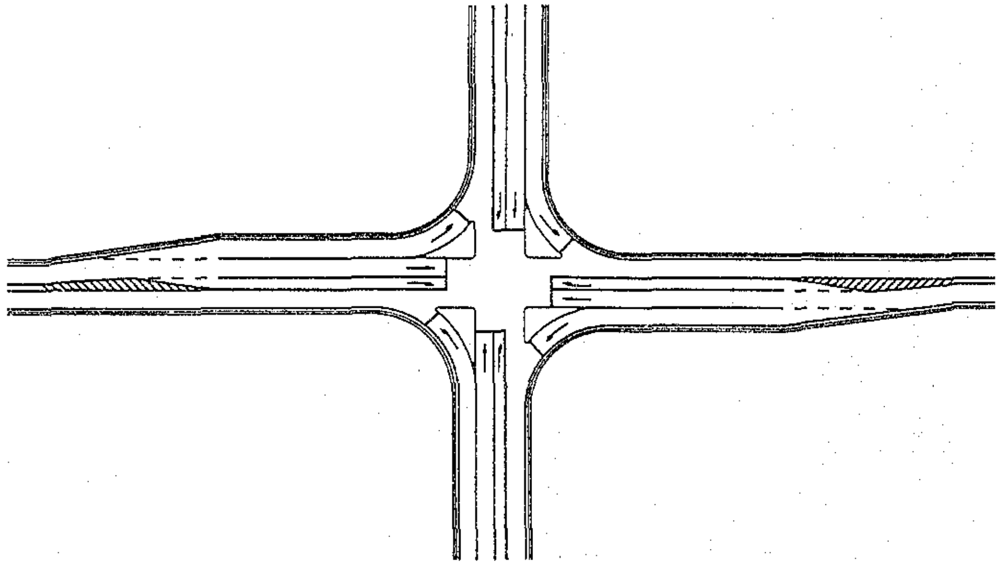
(b) The bus-ways are planned using the space of canals, existing roads, and the planned at-grade major roads.

(c) The network is basically in radial form which can further be extended along the corridors as the urban development takes place. However, some of the bus-ways are planned to meet the east-west and circumferential movements in the inner area.

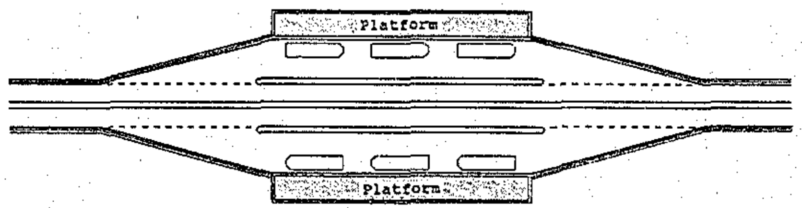
2) Concept of the Structure

There are not many cases of elevated bus-way development in the city centre in other countries. However, there are no significant reasons for not pursuing such development. In many cities, the authorities tend to introduce rail systems as a mass transit mode before the capabilities of buses are fully tapped.

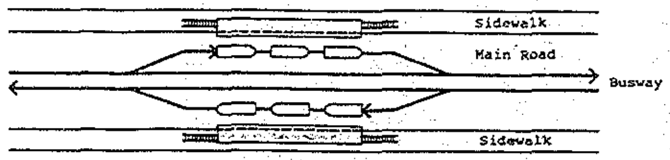
Concept of bus facilities is shown in Figure 9.3.1.



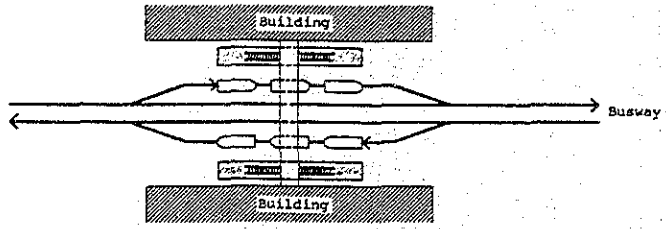
Plan for Intersection of Busway



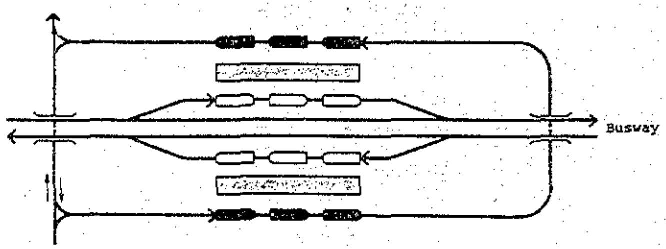
Plan for Bus Stop of Busway



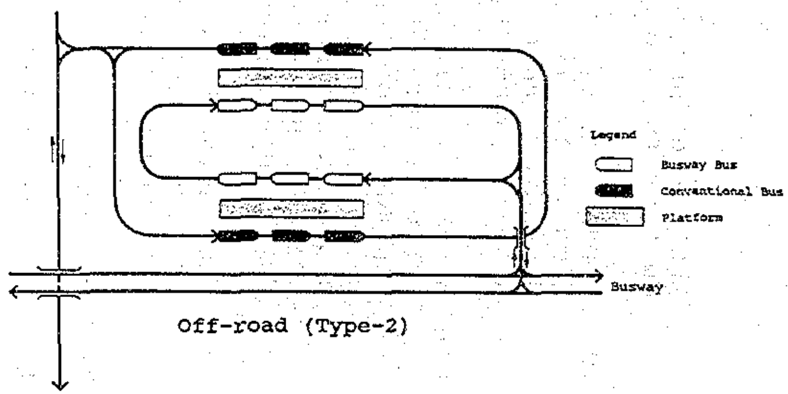
On the Main Road



Between Super Block (Commercial Complex)



Off-road (Type-1)



Off-road (Type-2)

Figure 9.3.1 Concept of Busway Facilities

9.4 Distributors

1) Planning Direction

Proper development of distributors is probably the most effective solution to Bangkok transportation problems both from traffic and economic viewpoints. It is also noted that the lack of coherence in road network affects rather adversely the efficient urban development. It is difficult to encourage the integration of community and to provide the community with necessary social and administrative infrastructures and services.

The requirement of distributors depends on the size of the block surrounded by primary/secondary roads and the level of vehicular traffic generation of the block. However, there is no readily available planning guideline applicable to the Bangkok situation. On the bases of the review of a guideline available in Japan and an exercise made in STTR, it is proposed to provide a block with distributors approximately every 1 to 1.5 km.

Distributors are planned in this study at two different planning levels. For the inner area around the Middle Ring Road, projects were identified based on the examination of available information including field reconnaissance, while for the remaining areas of the study area, an estimation was made based on various references.

2) Distributor Projects

As shown in Figure 9.4.1, 27 distributors with a total length of 51.9 km were specifically identified in the selected super-size blocks around the Middle Ring Road. They are listed in Table 9.4.1. The projects were identified with due consideration to the following factors:

a) To utilize existing public space, such as roads, canals, and publicly-owned land, to a maximum extent.

b) To meet planning guidelines discussed in the previous section so that the identified distributors can contribute to the strengthening of local road network.

c) To provide a supplemental function for the heavily congested primary/secondary network.

For the distributors, a number of standard cross sections were prepared as shown in Figure 11.2.1 of Chapter 11. The distributors are provided with sufficient sidewalks and parking lanes.

Figure 9.4.1 Proposed Distributor Projects for Identified Super-size Blocks

Table 9.4.1 List of Distributor Projects Identified for Selected Super-size Blocks

Project No.	Project Description 1/
R010	Pracha Rat - Vibahavadi Rangsit: This extends Lat Phrao to provide E-W link using SRT property and Golf club, crossing Klong Prapa and Klong Prem Prachakon. (4.9 km, 4 lane - Type 20)
R020	Phahon Yothin -Sutthisan: Using the road at the back of bus terminal, crossing Klong Bansu, the road reaches Sutthisan. (1.9 km, 4 lane - Type B and 2 lane - Type 19)
R030	Phahon Yothin - MRR: This provides a link to connect Yan Phahon Yothin with MRR via Phahon Yothin 18, new link, Ruam Siri Mit and Chok Chai Ruam Mit. (2.5 km, 2 lane - Type 19)
R040	Lat Phrao - Din Daeng: This road starts from Lat Phrao, utilizes a branch of Klong Ban Su, reaching Sutthisan Winitchai. Vacant space along Khlong will be used between Pracharat Bamphen and Pracha Sangkhro. Road facing Phot Siam Cinema and Yot Khman market will be widened. Passing Kop Wittaya school, the road connects with Metta and extends south along Khlong. (5.1 km, 4 lane - Type 20)
R050	Vibahavadi Rangsit - MRR: This road comprises Pracharat Bamoen and new road. (1.7 km, 2 lane - Type 19)
R060	Chan Road Extension: This road starts from Mit Maitri in the north and reaches Asok Din Daeng using Procha Sonkhrao. Khlong Sam Sen Nai and its reservoir will be crossed to reach Phetburi via Makkasan yard. Sukhumvit 3 and 4 will be widened. The road ends at R120 proposed distributor. The road further passes between Poli Club and Police Station and will be linked with Chan Road via Rama IV, Ngam Du Phli, Atthakan Prasit, and Yen Akat. (10.1 km, 4 lane - Type 20)
R070	Sukhumvit - MRR: New road will be constructed between Rama IX and Phetburi on the extension of BMA planned road. The road will cross Khlong Sam Sen Nai and intersect with SRT eastern line at-grade. Sukhumvit 39 will be used with minor improvement of alignment. (4.4 km, 4 lane - Type B and 2 lane - Type 19)
R080	Sukhumvit (Soi 39) - Sukhumvit (Soi 63): This road is composed of ThongLoll, Charoen Suk, and new link to be constructed between Samiti Wet Hospital and Distsaya Salih school. The hospital will be slightly affected. (1.8 km, 2 lane - Type 19)
R090	Sukhumvit - New Phetburi along Soi 55: The 22 meter wide Sukhumvit Soi 55 will be extended to link Phetburi and Rama IX. Khlong Saen Saep will be crossed, new link constructed across SRT to link with Sun Wichai 4. (2.4 km, 4 lane - Type 20)
R100	Sukhumvit - New Phetburi along Soi 63: Sukhumvit 63 will extend towards north with widening of Sun Wichai 4. (1.0 km, 6 lane - Type 10)
R110	Sukhumvit Soi 55 - Phrakanong Klong Ton: This road connects Charoen Suk, Sukhumvit 63 and 71. Charoen Chai will be widened. Klong will be used about 400 meters from Sukhumvit 63. (1.1 km, 2 lane - Type 19)
R120	Wittayu - MRR: Reservoir and Klong in the tobacco factory will be used. An underpass has been planned at the crossing with Expressway due to the existence of high voltage line. (1.2 km, 4 lane - Type 20)
R130	Rama IV - Sukhumvit Soi 22: Soi 22 will be widened. (1.6 km, 2 lane - Type 19)

Project No.	Project Description 1/
R140	Rama IV - Sukhumvit Soi 26: Soi 26 will be widened. Bending portion will not be touched. (1.3 km, 2 lane - Type 19)
R150	Rama IV - Sukhumvit Soi 40: The 7 meter wide Klong runs along Soi 40. The road will be widened, leaving Klong open. Som Pratthana school is affected slightly. (1.1 km, 2 lane - Type 19)
R160	Rama IV - Sukhumvit Soi 42: Soi 42 will be widened. Eastern bus terminal site will be used to smooth the connection with R100. (0.7 km, 4 lane - Type 20)
R170	Sathon - MRR (East): Suan Phlu and Nang Linchi will be improved. (2.7 km, 4 lane - Type 20)
R180	Sathu Pradit - MRR: This area is swampy and not densely inhabited. (1.8 km, 2 lane - Type 19)
R190	Chan Road - MRR: Northern portion of Saint Louis 3 will be widened. Bending portion will be cut short to smooth the alignment. (1.9 km, 4 lane - Type 20)
R200	Sathon - Chan Road: The 20 meter wide Sathu Pradit will be used. (1.5 km, 4 lane - Type 20)
R210	Charoen Krung - Expressway: Charoen Krung 91 will be widened and a new road will be constructed along Klong Khwang to link side road of Expressway. Area along Klong Khwang is not densely inhabited. (2.6 km, 2 lane - Type 19)
R220	Taksin - Charoen Nakhon: Road will be constructed along the north of Klong located parallel to Chamroen. (1.4 km, 2 lane - Type 19)
R230	Thoet Thai - Taksin: Road will be constructed along Klong Samre where, however, houses are densely located. (1.3 km, 2 lane - Type 19)
R240	Inthraphithak - Itsaraphap: Phet Kasem 4 and Wat Sang Krachai will be widened including betterment of alignment of bending portion around Phet Kasem. Wat Ratchasittharam school is slightly affected. (1.1 km, 4 lane - Type 20)
R250	MRR - Wang Doem: Wat Mai Phiren will be widened and a new road will be constructed along Wat Di Duat. (1.2 km, 4 lane - Type 20)
R260	MRR - Itsaraphap: Wat Amphama and Charan Samit Wong 22 will be widened. (1.0 km, 2 lane - Type 20)
R270	Phrapinklao - Ratchawithi: New link will be constructed from the end of existing 400 meter section branching from Phrapinklao by avoiding Wat and school. Klong Bang Chak will be crossed. (1.8 km, 6 lane - Type 10)

1/ For cross section type 10, 19 and 20, refer to Figure 11.2.1 of Chapter 11

For areas other than those where distributor projects were specifically identified, an exercise was made to estimate the approximate requirements of distributor roads based on a guideline practiced by Governmental agencies in Japan. In addition to the overall considerations and criteria on distributor roads planning, the guideline gives a following formula to assess the needs of distributors in the area:

$$L = \frac{Q}{4,000} \sqrt{\frac{A}{\pi}}$$

where;

L = road length (Km)
Q = generation/attraction traffic (pcu/day)
A = area (Km^2)

Based on the above, it is roughly estimated that the total requirements of distributors in the study area are approximately 2,500 Km. However, the distributor needs are different depending upon the size and traffic demands of the area. The northeast area where future traffic demand is relatively high, requires the most. Considering the already existing distributors which are estimated to be roughly 500 Km, the total requirements in the area outside the Middle Ring Road is about 2,000 Km.

Table 9.4.2 Estimated Demand of Distributor Roads

Area Outside Middle Ring Road	Area (sq km)	Traffic (000 PCU/day) 2006	Estimated Requirements (Km): Total	Per Km^2
North West	403	1,146	560	1.4
North East	585	2,702	1,320	2.3
South East	213	820	400	1.9
South West	189	459	220	1.2
Total	1,390	5,127	2,500	1.8

3) Assessment of Distributor Projects

The projects were assessed from traffic, economic, cost effectiveness expressed in terms of traffic volume/construction cost, and network aspects. Most of them were found feasible and favorable. The entire projects were economically assessed as a package by comparing the annual project cost and the estimated benefit. The results show that the vehicle operating cost saving alone generates significantly high B/C ratio of 19.2. The projects were further assessed as shown in Table 9.4.3 and categorized into three groups of investment packages as shown in Table 9.4.4.

Table 9.4.3 Assessment of Distributor Projects

Project No.	Length (Km)	Cost (B mil)	Estimated Traffic (Average) 1989 000 Veh/day	1989 V/C Ratio	2006 000 Veh/day	2006 V/C Ratio	Traffic/Cost (B 000) 1989	Traffic/Cost (B 000) 2006	Assessment 1/ Traffic	Cost Effect-iveness	Network Configu-ration	Overall Assess-ment
R 010	4.9	190.3	57.7	(0.7)	79.9	(1.0)	2.4	3.3	B	A	AA	A
R 020	1.9	99.3	31.0	(0.7)	32.7	(0.9)	2.4	2.6	B	A	B	A
R 030	2.5	181.8	35.5	(1.2)	30.4	(0.9)	1.5	1.3	A	B	AA	AAA
R 040	5.1	425.0	51.4	(1.1)	58.9	(1.2)	0.9	1.1	AA	B	AA	AAA
R 050	1.7	119.1	34.7	(1.8)	50.2	(2.1)	2.3	3.3	AA	A	AA	AAA
R 060	10.1	615.8	41.9	(0.9)	44.3	(0.9)	0.5	0.5	A	D	A	AA
R 070	4.4	286.6	41.5	(1.6)	41.7	(1.4)	1.1	1.1	AA	B	AA	AAA
R 080	1.8	127.0	61.5	(3.0)	36.7	(1.8)	3.8	2.3	AA	A	AA	AAA
R 090	2.4	90.5	37.8	(0.8)	87.4	(1.9)	3.3	7.6	A	AA	A	AA
R 100	1.0	77.2	26.1	(0.5)	72.8	(1.1)	2.7	7.4	C	AA	A	A
R 110	1.1	75.8	26.8	(1.3)	23.2	(1.1)	2.8	2.4	AA	A	A	AAA
R 120	1.2	83.0	61.5	(1.3)	65.6	(1.4)	5.8	6.2	AA	AA	AA	AAA
R 130	1.6	70.2	16.8	(0.8)	39.2	(1.9)	1.9	4.4	A	A	A	AA
R 140	1.3	55.3	35.7	(1.8)	36.7	(1.8)	5.0	5.2	AA	AA	AA	AAA
R 150	1.1	46.1	16.5	(0.8)	30.0	(1.5)	2.8	5.1	A	AA	A	AA
R 180	1.8	43.3	8.4	(0.5)	12.3	(0.8)	1.5	2.2	C	A	B	A
R 200	1.5	47.2	37.6	(0.8)	47.8	(1.0)	6.3	8.0	A	AA	A	AA
R 210	2.6	85.3	10.0	(0.5)	17.8	(0.9)	0.9	1.6	C	B	A	A
R 220	1.4	66.9	20.7	(1.0)	23.5	(1.2)	2.4	2.8	AA	A	AA	AAA
R 230	1.3	64.4	0	(0)	1.5	(0.1)	-	0.2	D	D	A	A
R 240	1.1	57.3	29.1	(0.6)	59.4	(1.2)	4.0	8.1	B	AA	A	AA
R 250	1.2	96.8	0	(0)	27.7	(0.6)	-	2.3	D	A	A	A
R 260	1.0	47.5	27.5	(1.4)	21.9	(1.1)	4.5	3.6	AA	AA	A	AAA
R 270	1.8	207.9	25.8	(0.4)	68.2	(0.9)	1.0	2.6	C	B	A	A

1/ assessment criteria is as follows:

Traffic (V/C Ratio)
- AA : more than 1.0 in 1989 and 2006
- A : 1.0 or more in 1989 and 2006
- B : 1.0 or less in 1989 or 2006
- C : considerably less than 1.0 in 1989 and 2006
- D : extremely low

Cost Effectiveness (No of Veh/B 1000):
- AA : more than 4
- A : 2-4
- B : 1-2
- C : less than 1

Network Configuration
- AA : Highly necessary
- A : Necessary

Overall Assessment
- AAA : Recommended (Urgent)
- AA : Recommended (Medium-term)
- A : Recommended (Long-term)

Table 9.4.4 Investment Package of Selected Distributors

Priority	Projects Included	Estimated Project Cost (B million)
AAA : Recommended for Immediate Implementation	R030, R040, R050 R070, R080, R110 R120, R140, R220 R260	1,468.0
AA : Recommended for Medium-term Implementation	R060, R090, R130 R150, R200, R240	927.1
A : Recommended for Long-term Implementation	R010, R020, R100 R180, R210, R230 R250, R270	864.5
TOTAL		3,259.6

9.5 List of the Road Projects

The proposed projects are listed in Tables 9.5.1, 9.5.2 and 9.5.3 for expressway, bus-way, and at-grade main roads respectively.

Table 9.5.1 Project List - Expressway

Code	Project Description	Cost (Million B)
X010	ETA 2nd Stage Expressway (SSE): 37.6 km elevated dual 3 lane.	19838
	X011 Sector A: Khlong Saen Saepto Ngam Wong Wan, 17.6 km.	(9758)
	X012 Sector B: FSE to Khlong Saen Saep, 5.3 km.	(3542)
	X013 Sector B Saen Saep Access: along Khlong up to Rachaprarop, 2.1 km.	(797)
	X014 Sector C1: FSE to X011 along Khlong Sam Saen, 2.7 km	(1784)
	X015 Sector D: FSE to Srinakhalin, 10.0 km.	(3957)
(X030)	X031 Ekamai - Ram Intra : New Petburi to Ram Intra 13.3 km elevated dual 3 lane	5141
X040	FSE-Suk Sawat Expressway: 14.30 km elevated dual 3 lane	
	X041 FSE to X042 over Phrapadaeng preserved area: 9.3 km including a 2.4 km new bridge and approach.	(5834)
	X042 FSE-ORR (South) along Suk Sawat: 5.0 km	(1692)
X050	FSE-Don Muan Toll Road: 18.7 km elevated dual 3 lane over Vibahavadi Rangsit	7227
X060	Don Muan - Rangsit Toll Road: 10.2 km elevated dual 3 lane.	2956
(X070)	X071 Nonthaburi - Bang Kapi Expressway: 12.3 km elevated dual 3 lane, Pracha Rat to Ekamai/Ram Intra (X031)	4759
X080	Bang Na - Trad Toll Road: FSE to ORR (East), 9.2 km at-grade dual 3 lane.	410
X090	Thonburi - Pak Tho Toll Road: 8.4 km at-grade dual 3 lane.	374
X100	Phet Kasem Expressway: 13.1 km elevated dual 3 lane,including a 0.4 km new bridge	3948
X110	Bang Na - Samut Phrakan Expressway: FSE to ORR (South),6.8 km dual 3 lane	2631
X120	Thonburi - Bang Sue - Ramkhamhaeng Expressway: 37.4 km elevated dual 3 lane	15117
	X121 Thonburi - Talingchan: 14.3 km	(5935)
	X122 Talingchan - SSE: 7.4 km including a 0.5 km new brige.	(3070)
	X123 SSE - FSE via Huai khwang: 15.8 km.	(6113)
X170	Soi Asok Flyover: 2.3 km elevated dual 3 lane from Sukhumvit to Rama IX	664

Table 9.5.2 Project List - Bus-way

Code	Project Description	Cost (Million B)
B010	Bang Phlat - Lat Phrao Busway: 18.5 km east-west transversal to link with B062.	1904
	B012 Bang Phlat - Huwai Kwang: 8.6 km elevated including a 0.5 km new busway bridge.	(1540)
	B014 Huwai Kwang - Lat Phrao: 9.9 km at-grade including a flyover at Lat Phrao	(364)
B040	Don Muang - Yanawa Busway: 19 km elevated north-south radial to link with B070, B091, B012 and B063.	2748
	B041 Yanawa - Khlong Saen Saep (B091): 6.9 km.	(1178)
	B042 Khlong Saen Saep (B091): 12.1 km.	(1570)
B050	Pak Kret - Pomprap Busway: 19.7 km northwest-CBD radial along Khlong Prein Prachakong to link with B091, B012 and B063.	1921
	B051 Pak Kret - MRR (North): 9.6 km elevated·	(1638)
	B052 MRR (North) - Nonthaburi: 10.1 km at-grade	(283)
B060	MRR (West) Busway: 18.8 Km elevated along MRR.	3294
	B062 Bangkok Noi - Bang Phlat (B012): 6.0 km	(1024)
	B063 Bang Phlat (B012) to Pahon Yothin (B042): 8.9 km including a 0.5 km new busway bridge.	(1579)
	B064 Bangkok Noi - Wong Wien Yai: 3.9 km to link with B070	(691)
B070	Wong Wien Yai - Bangrak Busway: 5.7 km elevated along Si Phraya and Charoen Rat including a 0.4 km new bridge to link B064 and B041	1008
(B080)	B081 Huwai Kwang (B010) - Sukhumvit Busway: 4.3 km elevated to link with B012 and B091	725
B090	Pomprap - Klongton - Samut Prakan - Bankapi Busways: 35.2 km to link CBD with the east and southeast connecting with B051,B041 and B081	4017
	B091 Pomprap - Klongton: 9.9 km elevated above Khlong Saen Saep.	(1681)
	B095 Klongton - Bankapi: 11.7 km elevated above Khlong Saen Saep.	(1997)
	B096 Klongton - Samut Phrakan (Route 3268): 13.6 km at-grade	(339)

Table 9.5.3 Project List - At-grade Main Road (1)

Code	Project Description	Cost (Million B)
H010	Outer Ring Road: New portion of Outer Ring Road, 138.9 km with 6 lanes.	8157
	H011 ORR Northwest section: Route 340 to Route 1, 38.3 km including a 0.7 km new bridge at Photaeng	(1468)
	H012 ORR Northeast section: Route 1 to Sukhaphiban 3, 48.7 km	(1269)
	H013 ORR East section: Sukhaphiban 3 to Bang Na-Trad, 18.6 km	(484)
	H014 ORR South section: Bang Na-Trad to Thon Buri-Pak Tho, 33.4 km including a 2.8 km new bridge at Phra Pradaeng	(4936)
H020	Phahon Yothin - Sukhumvit 101: 21.0 km new road with 4 lanes to form a new circumferential route outside MRR.	756
	H021 Phahon Yothin - Ram Khamhaeng: 12.6 km	(452)
	H022 Ram Khamhaeng - Sukhumvit 101: 8.5 km	(304)
H030	Phahon Yothin - Route 340: Extension of H020 towards the west.	1093
	H031 Phahon Yothin - Route 3099: widening from 2 to 4 lanes, 6.1 km	(266)
	H032 Route 3099 - Route 340: 10.2 km new road, including a 0.7 km new bridge.	(827)
H040	Rattana Thibet - ORR (Northwest): 12.4 km 4-lane new road including a 0.65 km new bridge. A radial to link with the northwest.	668
H050	Rattana Thibet - ORR (West): Widening of 2.2 km from 2 to 4 lanes and 10.7 km new 4-lane road including a new 0.65 km bridge. A link to connect the east and west across the River in Nonthaburi.	712
H060	Nonthaburi - Thonburi: 24.6 km 4-lane new road parallel to ORR from H190 to Phet Kasem (Route 4) to provide a north-south link in the west forming a part of circumferencial route as well.	1221
	H061 Rattana Thibet - Phet Kasem: 18.2 km	(658)
	H062 H190 - Rattana Thibet: 6.4 km including a 0.7 km new bridge.	(563)
H070	Phet Kasem Bypass: New 4.6 km 8-lane bypass of Phet Kasem Highway between H061 and Taksin.	311
H080	MRR - ORR (West): 6.7 km 2-lane new developmental road in the west.	143
H090	Phet Kasem - Pracha Uthit: 9.0 km 4-lane new road in the southwest and link with H061.	392
H100	Thon Buri - Pak Tho (Route 35) Shortcut: 1.1 km 4-lane new shortcut of Thon Buri - Pak Tho to link with Taksin directly.	58
H110	New Bridge (Suksawat - MRR): 0.78 km 6-lane new bridge and approach; widening of 0.5 km from 2 to 6 lanes, and new 0.5 km 6-lane road.	2408
H120	Suksawat - Pracha Uthit: 2.2 km 4-lane new road in the south.	76
H130	Phrapin Klao - Arun Amarin - MRR: 0.9 km 4-lane and 0.8 km 6-lane new roads parallel to the Chao Phraya River.	103
H140	ORR (Northwest) - Phaya Thai - ORR (Northeast): 25.6 km 4-lane new road to link the northwest, and the east via northern part of the Inner Area.	1668
	H141 ORR (Northeast) - MRR (East): 13.3 km	(457)
	H142 MRR (East) - Bang Kurabua: 5.5 km	(225)
	H143 Bang Kurabua - Bangkok Noi: 6.8 km including a 0.7 km new bridge.	(623)
	H144 Bangkok Noi - ORR (Northwest): 13.0 km	(363)
H150	Chaeng Watthana (Route 304) - Route 306: 4.0 km widening from 2 to 4 lanes and new 8.5 km 4-lane road to link with SSE.	429
H160	Sukhumvit - ORR (East): 7.1 km 4-lane new road along Sukhumvit Soi 101 to serve the southeast.	276
H170	MRR (North) - ORR (Norhteast): 12.4 km 4-lane new road to provide direct link to the northeast from MRR.	424
H180	Route 306 - Don Muang - ORR (Northeast): 16.6 km 4-lane new road to provide eastwest link in the north.	540
H190	Route 306 - ORR(East): 10.0 km vindening of Route 3312 from 2 to 4 lanes and new 6.9 km 4-lane road to provide eastwest link in the north.	489
H200	Din Daeng - Phet Buri Shortcut: 1.2 km 4-lane new road under the 1st Stage Expressway.	30
H210	MRR (North) - Route 306: Widening of 1.6 km from 2 to 6 lanes and new 20.3 km 6-lane and new 20.3 km 6-lane road along SRT to strengthen north-south link.	738
H220	Huwai Khwang - Route 305: Widening of 4.6 km from 2 to 4 lanes and new 22.8 km 4-lane road parallel to Phahon Yothin, to strengthen north-south link and provide access to Phahon Yothin,to strengthen north-south link and provide access to the northeast	1246

Table 9.5.3 Project List - At-grade Main Road (2)

Code	Project Description	Cost (Million B)
H230	Ekamai - Ram Intra: New 13.3 km 6-lane at grade road along Ekamai-Ram Intra Expressway and its 5.5 km 4-lane extension to ORR (northeast).	1032
H240	Sukhapiban 2 Improvement: 6.8 km widening of Sukhapiban 2 from 2 to 4 lanes between Srinakarin and ORR (East).	201
H250	Ram Khamhaeng - Lat Phrao: 3.5 km 4-lane new shortcut to link Ram Khamhaeng at Lat Phrao directly.	169
H260	Bangkok-Chonburi: New 6.0 km 4-lane road from SSE to ORR (East) parallel to SRT.	610
H270	Sukhumvit 101 - ORR (South): 9.8 km 4-lane new road to serve the southeast and link with H022 to form circumferential route.	353
H280	Samut Phrakan Roads Improvement: A total of 18.2 km widening of Samut Phrakan Roads from 2 to 4-lane to serve the southeast.	542
H290	Ekachai (Route 3242) Improvement:5.5 km widening from 2 to 4 lanes and new 2.1 km road to strengthen the southwest radial link.	280
H300	Bangkok Noi - Nontha Buri: 9.1 km 4-lane new road to provide northwest radial link, extension of Phrapin Klao Tatmai.	328
H310	Thon Buri - Bang Sue - At Narong: Widening from 2 to 4 lanes, and new 6-lane road including a new bridge under the proposed expressway, 22.9 km	1383
	H311 At Narong - Phet Buri: new 3.7 km 4-lane and 1.0 km 6-lane roads under X123	(287)
	H312 Phet Buri - Rama VI: 9.7 km 4-lane new road, under X123.	(534)
	H313 Rama VI -H061: 1.5 km widening from 2 to 4 lanes, and 8.2 km 4-lane new road including a 0.68 km new bridge, under X121 and X122	(562)
H320	Ban Bua Thong - Rangsit - Thanya Buri: 19.7 km widening from 2 to 4 lanes, and 10.1 km 4 -lane new road including a 0.8 km new bridge to provide east-west link in the north and connect ORR together	1446
H330	Route 306 and Route 3112 Improvement: 16 km widening from 2 to 4 lanes to serve the north.	476
H340	Route 3111 Improvement: 12.6 km widening from 2 to 4 lanes to serve the north.	375
H350	Route 1 Improvement: 29.9 km widening from 4 to 6 lanes from Don Muang to ORR (North) to strengthen the north-south link.	1296
H360	ORR/Route 1 Interchange: New interchange construction at ORR/Route 1	3355
H370	New Si Phraya Bridge and Access: A 0.6 km 6-lane new bridge over the Chao Phraya River including 0.2 km access	404
H380	Si Phraya (East) - MRR (South): 5.3 km 8-lane new road.	353
H390	New Rama VI Bridge and Access: A 0.7 km 6-lane new bridge including 0.5 km access	405
H400	Si Phraya (West) - MRR (South): New 0.5 km 4-lane and 3.8 km 6-lane roads	285
H410	ORR (West) Improvement: 16.7 km widening of Outer Ring Road from 4 to 6 lanes between Route 338 and route 340.	366
H420	Na Krom - Suksawat: 5.7 km widening from 2 to 4 lanes, including a 2.6 km new bridge	2674
H430	Taksin Extension: 6.7 km new 4-lane road to provide access to the south by extending Taksin Road.	206
H440	H040 - H210: 7.0 km new 4-lane road to provide secondary road in the north	202
GRAND TOTAL		38925

CHAPTER 10

THE TRAFFIC MANAGEMENT AND PUBLIC TRANSPORTATION OPTIONS

10. THE TRAFFIC MANAGEMENT AND PUBLIC TRANSPORTATION OPTIONS

The road network plan discussed in the two previous chapters can be considered ambitious, especially when the investment amount necessary for the plan is compared to amounts actually invested in the past. In spite of that, however, on the basis of the traffic demand forecast for the year 2006, the planned network will only make it possible to maintain the present level of service. It will not be sufficient to resolve the various traffic issues.

Plans and measures for the maximum utilization of available traffic facilities, therefore, will become even more important in the future. When the infrastructure becomes unable to cope with the increased traffic volume, other measures will become necessary. These measures include those that would encourage greater use of public transportation systems, which transport commuters at a higher rate and are more effective than private modes of transportation, or those that would encourage coommuting during off-peak hours. In this chapter, various measures for more effective use of traffic facilities are discussed.

10.1 Traffic Signal Installation and ATC Area Expansion

1) Traffic Signals Installation

With the construction of the planned road network, in the future there will be a great increase in the number of intersections where traffic signal will be necessary. The number of signals additionally needed is estimated on the basis of projections regarding the volume of traffic in the year 2006.

In the case of urban roads, traffic signals will need to be installed at intersections where the main road has a width more than 10 m and where the amount of traffic surpasses the standard amount as shown in Table 10.1.1. When the traffic volumes in peak hour in the year 2006 are compared to the figures in the Table, there will be approximetely 140 intersections that need to be equipped with traffic signals (Figure 10.1.2). If signals already in operation are also considered, this would mean a total of about 400 signals within the study area. The number of new signals needed was estimated only for intersections that involve only main roads. The number of signals needed to be installed at intersections between main roads and distributors ones (soi) should also prove to be very high.

2) Expansion of ATC Area

Regarding the ATC project in this study, with 1993 as the target year, the introduction of an ATC system that would cover 235 intersections located inside the Ring Road and their adjacent areas was proposed. In the long run, however, it will be necessary to Cexpand the system even further. Areas, where the peak hour volume of traffic in the future would exceed 2500 PCU/hour are shown in Figure 10.1.2. It is desirable that the ATC system be expanded to cover these areas as well by the year 2006.

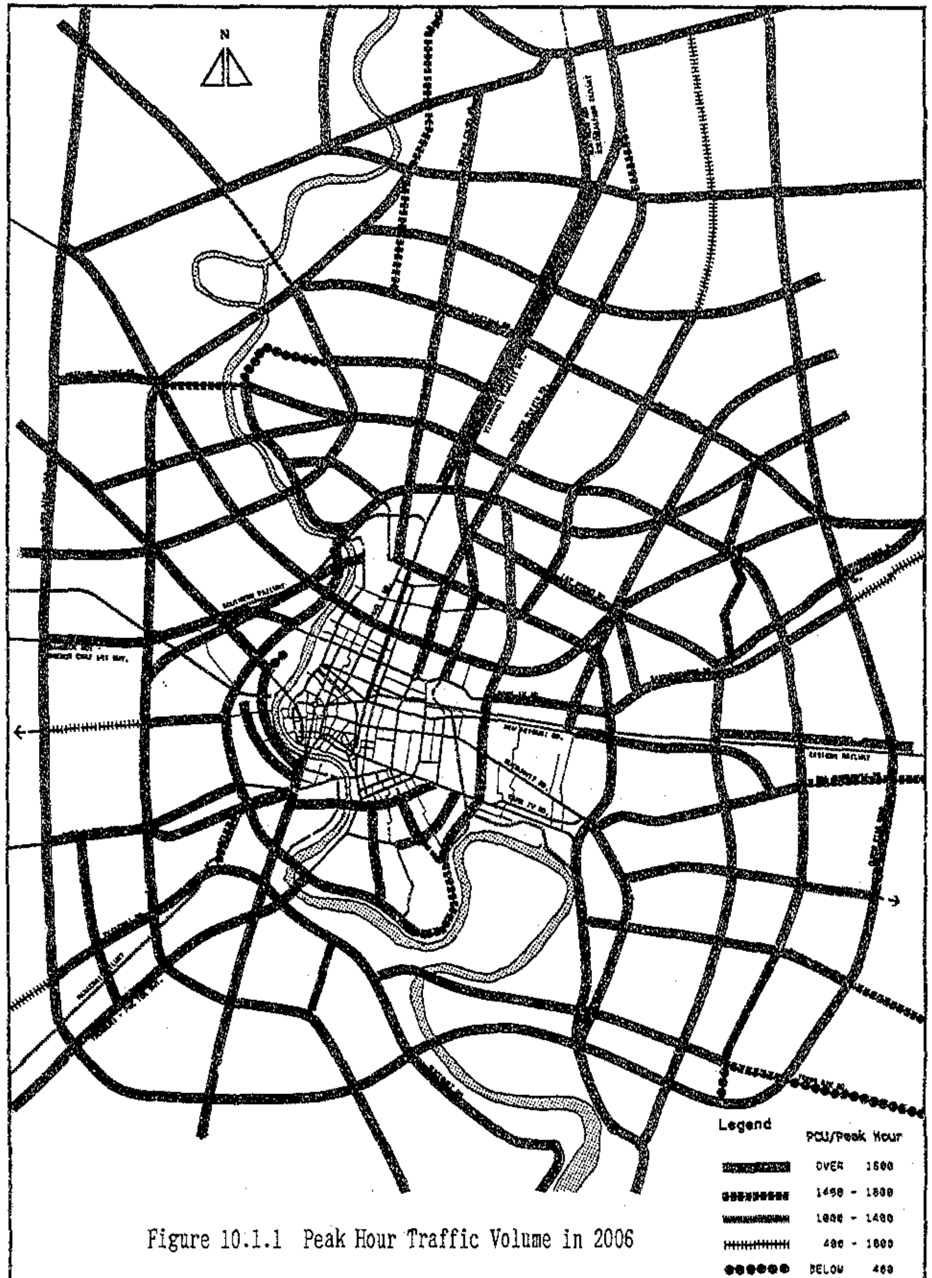


Figure 10.1.1 Peak Hour Traffic Volume in 2006

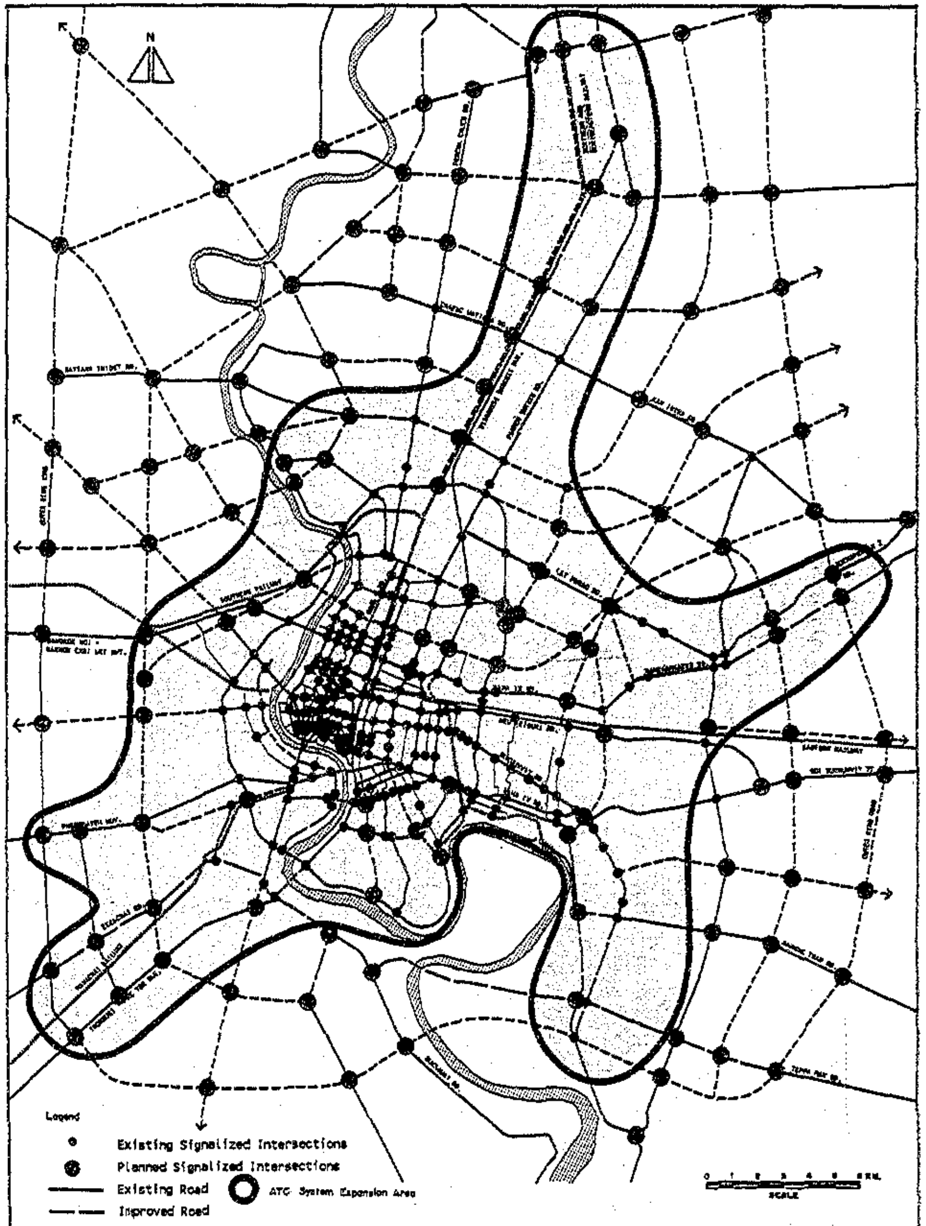


Figure 10.1.2 Signalied Intersection in 2006

Table 10.1.1 Criteria of Traffic Volume for Signal Installation

		Two-way Traffic Volume on Major Road		Heaviest Traffic Volume on Minor Approach	
Major Rd	Minor Rd	12 Hours	Peak Hour	12 Hours	Peak Hour
10m & Above	Under 10m	10,000	900	3,800	350
		12,000	1,000	3,100	270
		15,000	1,400	2,000	190
		20,000	1,800	1,450	140
10m & Above	10m & Above	10,000	900	4,500	420
		12,000	1,000	3,500	320
		15,000	1,400	2,500	220
		20,000	1,800	1,700	160

With the expansion of areas served by the ATC system, it will be necessary to improve the capacity and speed of the CPU of the host computer at the control center. A larger number of front-end processors will also have to be installed. Although the construction of sub-centers, when the system covers only 400 intersections, is not absolutely necessary, line concentrators reduce usage fees for the telephone circuit (Figure 10.1.3).

In order to disperse traffic, supplying drivers with traffic information through the use of radio broadcasts, variable information display boards, route guidance systems and such, may also be considered as part of the duties of a control center in the future.

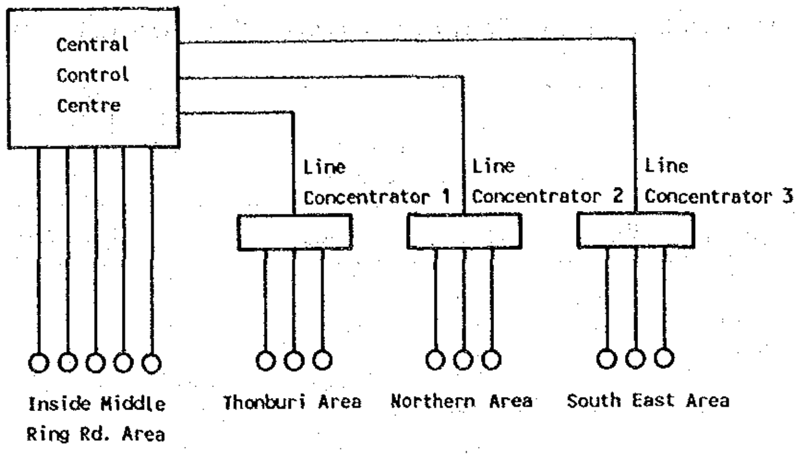


Figure 10.1.3 Outline of Line Concentrator

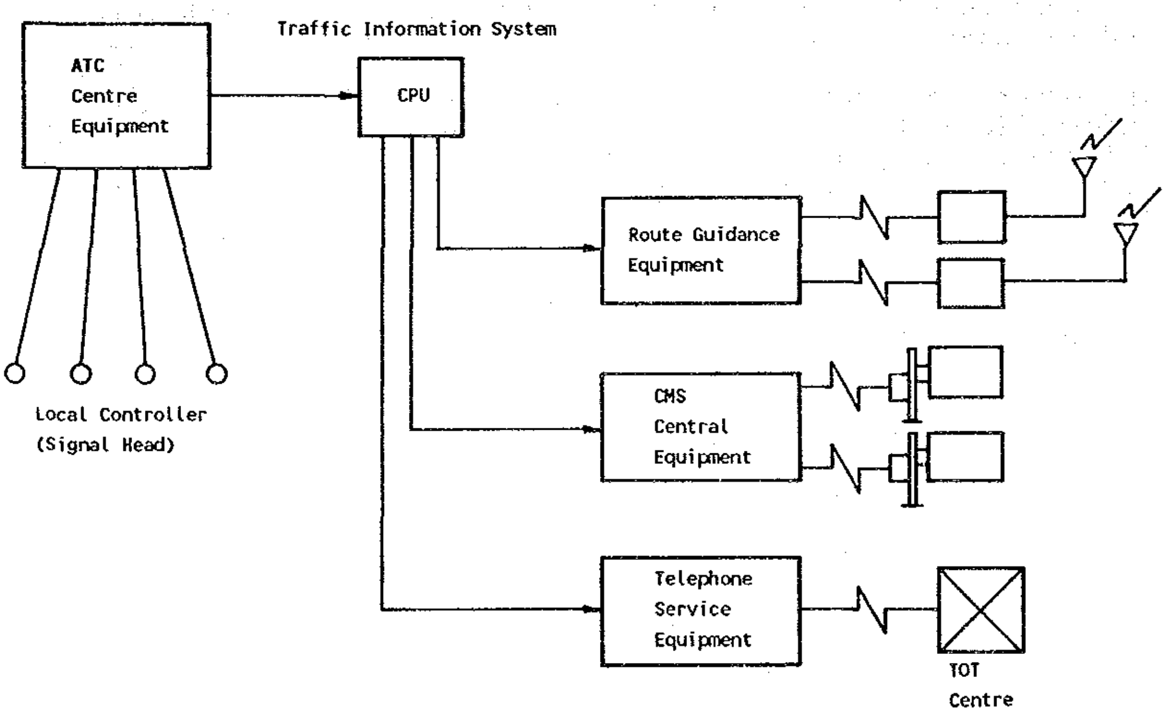


Figure 10.1.4 Outline of Traffic Information System

10.2 Controlling parking space demand in downtown areas

Even at present, there are areas downtown, where parking conditions have deteriorated. In the future, however, due to a greater inflow of traffic into downtown, the lack of parking spaces will become a much greater problem. Designating 5 zones (1, 2, 10, 11 and 12) from among the PT Survey zones as the CBD area, the future parking demand was estimated as follows.

At present, about 1,430,000 trips are made into this area (not including those returning to their homes). About 443,000 or 31% of these, are by car. Since the average number of passengers per car is 2.1, it is estimated that about 211,000 cars daily will require parking spaces within the CBD.

Almost half of these, 103,000, cars have zones 1 and 2 as their destination. According to the parking space survey discussed in Chapter 3, however, the parking capacity of the two zones is for 32,000 (lots) spaces on-street road and 19,000 off-street a total of 51,000 cars. The average turnover rate is estimated at 2.0.

By the year 2006, the number of trips to the CBD using cars is estimated to be 1.34 times the present level, that is, 594,000 trips. That would mean 283,000 cars per day in the CBD. If the turnover rate remains constant, then the amount of parking space needed will also be 1.34 times the present level. Thus, a total of 141,000 lots will be needed. After subtracting the estimated present capacity for 106,000 cars it can be concluded that in the future the construction of an additional 35,000 lots will become necessary. If, in order to increase the capacity of the road, tougher regulations regarding on-street parking are to be introduced, the need for the construction of additional parking space will be even greater.

A greater part of the demand for additional parking space in the CBD area, will be, henceforth, satisfied by the private sector such as office buildings and large stores. However, to continuosly construct more than 2,000 lots in the CBD every year for the next 16 years is clearly a difficult task.

Furthermore, as will be discussed in the next section, from the point of view of the necessity for measures to control demand, the vigorous construction of parking space in the CBD area would be counterproductive. Such construction will also encourage commuting by car and is not desirable.

Therefore, the construction of parking spaces using public funds should be avoided, and regulations should be enacted to control the construction of public parking spaces by the private sector.

On the other hand, a severe shortage of parking space to accomodate short term business and commercial trips, would harm the economic activities in the city center. Large commercial and office buildings mostly have their own parking places, but there tends to be a shortage of such space where medium- and small-size buildings are concerned. In such cases, it will probably be necessary to strengthen regulations, which would require that parking spaces be made available.

10.3 Demand Control Impact

Assuming traffic demand controls for the future traffic volume and through a study of the traffic management, the impact to the traffic flow will be analyzed. The assmued traffic demand control measures are shown hereafter. The traffic impact by each system was reviewed through comparison between the cases of "with" and "without" such demand controls.

1) Staggered Office/School Hours Control
2) Car Ownership Control by Car Tax
3) Car Ownership Control by Gasoline Price
4) Restrictive Use of Passenger Car
5) Area License Control
6) Restriction of Private Car Use for School

1) Staggered Office and School Hour Control

The road network facility is not sufficient to accomodate the peak time demand, and traffic congestion is generated. Under these circumstances, the staggered commuting hour system can lower the maximum demand volume by altering the position of the peak time.

The measure can be easily implemented by the governmental bodies. Staggering government commuting hours will also have a positive effect for enterprises and private sector bodies.

Setting PT zones 1, 2, 10, 11, and 12 as the CBD area, the effect of staggered commuting hours was forecast for going to work and school trips in 2006. According to the forecast, out of approximately 114,010 PCU during the peak time (7:00-8:00), staggered commuting is recommended for about 42%, or 47,870 PCU, before or after the peak time. Table 10.3.1 shows the decrease achieved by staggered office and school hour control in the CBD area.

Figure 10.3.1 shows the hourly attraction fluctuation of incoming volume of current office and school traffic in the CBD area. The peak hour of traffic volume is from 6 to 9 o'clock in the morning, during which the volume is approximately 198,420 PCU. From this, an average trip frequency per hour of 66,140 PCU/hour is calculated, and excess of the peak time PCU is to be assigned for differentiated commuting hours.

Table 10.3.1 Traffic Decrease by Staggered Office/School Hour Control

CBD Attraction			Object Attraction for Control	Decrease Rate of Peak Hour Attraction
6:00-9:00	Average Hourly Volume	7:00-8:00		
198,420	66,140	114,010	47,870	42%

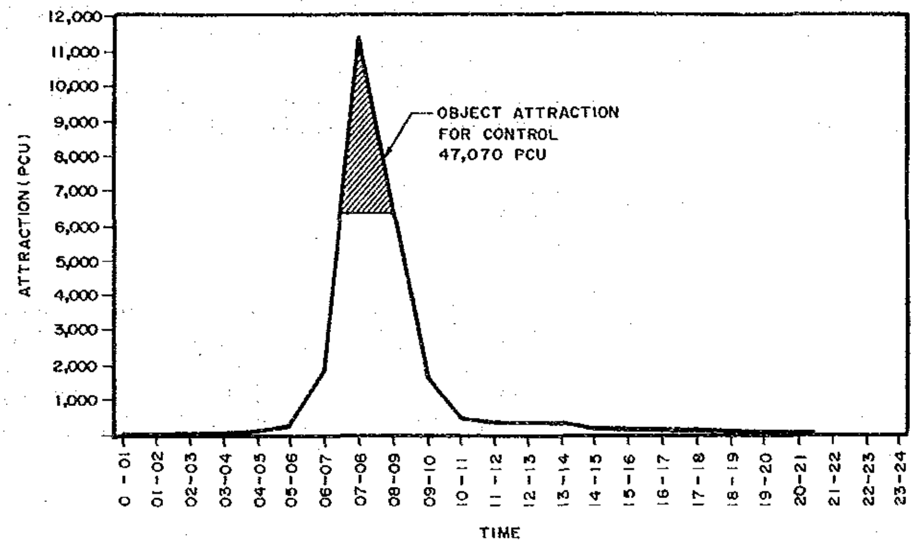


Figure 10.3.1 Hourly Attraction Fluctuation for Work/School Purpose in CBD

2) Car Ownership Control by Car Tax

This system is presumed to control passenger car ownership rate by raising the car tax.

The market sales price of a passenger car (Toyota Corona 1600 as a typical car) is 500,000 Baht. Of this amounts, 267,000 Baht (114%) is tax. If the tax rate is increased to 150% or 200%, the expected increase in amount to be paid shall be 81,750 or 198,100 Baht, respectively. Assuming an interest rate of 12% and 10 year deferred payment, the amount to by paid per month is as follows:

150% : 1,206 Baht
200% : 2,922 Baht

The number of passenger cars (n) owned by ordinary households is calculated by the following formula.

$$n = N x \Sigma_i \{f(i) \Sigma_k g_k(i)\}$$

where:

- N : Number of households
- f(i) : Percentage of households of income level i
- $g_k(i)$: k-unit owing ratio of households of income level i

If the household income would decrease by m Baht/month due to the increased tax, the decrease in number of cars (n) is calculated by the following formula.

$$\Delta n = N x \Sigma_i \{f(i) \Sigma_k k(g_k(i) - g_k(i-m))\}$$

Currently there are about 972,000 passenger cars (including pick-up vans) in the study area (inside of the Outer Ring Road). Out of this figure, 708,000 cars are owned by ordinary households. This is expected to increase to 1,445,000 in 2006 under the current tax rate, but it is forecast that the figure will decrease as shown below under an increased tax rate.

114% : 1,445,000 cars
150% : 1,329,000 cars (8.7% decrease)
200% : 1,161,000 cars (20.2% decrease)

As a result of distributing the traffic volume to the future road network under this condition, the traffic impact is shown in Table 10.3.2. Increased car tax is effective in all respects. The road congestion rate is lowered by 5%. Public transportation is increased by 10% in the modal share. VOC and TTC costs are lowered by 8 to 14%.

Table 10.3.2 Car Ownership Control by Car Tax

	Road Congestion		Modal Share		Traffic	Cost	
Car Tax Increase	Study Area	Inside MRR	Car/M.C	Public	PCU km (x1000)	VOC (x1,000,000 B/Year)	TTC
Without Tax Increase	0.90	1.09	56	33	108,700	165,100	496,300
With Tax Increase	0.85	1.04	53	36	102,200	149,500	428,700

3) Car Use Control by Gasoline Tax

Presuming that the gasoline price is increased by 1.5 to 2.0 times the current rate, the vehicle ownership rate shall be controlled. The traffic volume assignment was made to the future road network, and the VOC, TTC, PC.km, and Q/C ratio were calculated, and the impacts on them assessed as shown in Table 10.3.3.

The measure of increased gasoline price is more effective than that of increased car tax. If the gasoline tax increases by 150%, the Q/C ratio shall decrease by 10%. In the modal share, the public transportation share increases by 12%. The VOC and TTC costs decrease by 15 to 20%. On the other hand, a 200% increase of the gasoline tax is about twice as effective as the 150% increase.

Table 10.3.3 Car Ownership Control by Gasoline Tax Increase

Gasoline Tax Increase		Road Congestion		Modal Share		Traffic	Cost	
		Study Area	Inside MRR	Car/M.C	Public	PCU km (x 1000)	VOC (x 1,000,000 B/Year)	TTC
Without Tax Increase		0.90	1.09	56	33	108,900	165,100	496,300
With Tax Increase	150%	0.81	1.01	53	37	98,000	140,400	398,400
	200%	0.74	0.91	49	42	88,300	123,100	336,000

4) Restrictive Use of Passenger Car

This measure restricts the use of passenger cars in the congested areas of the city every other day depending on even and odd number license plates. This system is applied to a limited area and is effective in such a City as Bangkok. However, in order to maintain this control system, it is necessary to have many policemen monitor the traffic. It may be expected that some people would attempt to acquire two different license plates for one car or modify plates, making it difficult to continue the system for a long time.

Setting PT zones 1, 2, 10, 11, and 12 in the CBD area for applying this measure, in the year 2006, 565,700 PCU including passenger cars and motorcycles out of 1,785,850 attracted PCU traffic in the CBD area can be decreased (this is equivalent to 32% of CBD OD). Such decrease will be replaced by public transportation media such as buses. Table 10.3.4 shows the traffic volume decrease by means of this control measure in the CBD area.

Table 10.3.4 Traffic Decrease by Restricting Use of Passenger Cars in CBD

Attraction/Generation (PCU)			Traffic Decrease by Restriction (PCU)
All Mode	Passenger Car	Motorcycle	
1,785,850	942,107	189,341	565,700

5) Area License Control

In the CBD area where the traffic is very heavy and congested, all vehicles except public transport entering this area are presumed to be cherged an entrance fee. The main contents are as described below in accordance with STTR. Charges are classified by type of vehicle, but a constant charge of 30 Baht is adopted for the traffic flow impact calculation. Public bus is free of charge, and traffic assignment is made to the future road network.

This system has been implemented in Singapore. The restriction time applied there is 7:30 - 10:15, Monday - Friday to a 4.8 km^2 area including the center of the city.

The total income from the system is approximately 500 million US dollars per month, which is put into the national treasury. The number of passenger cars entering the restricted zone after introducing this system has decreased by 75%. In the case of all vehicles, a 49% decrease is reported.

Suggested application to the Bangkok CBD recommended by STTR is as follows.

(1) Toll zones

The area surrounded by Sri Ayuthaya Road, Wittayu Road, Sathon Road, and Chao Phraya River. (See Figure 10.3.2)

(2) Toll points

There shall be 20 points in all, for incoming traffic. (See Figure 10.3.2)

(3) Type of ticket

One-day ticket, 1-week ticket (7-day ticket), and 1-month ticket will be made available and sold at shops, parking lots, post offices, etc.

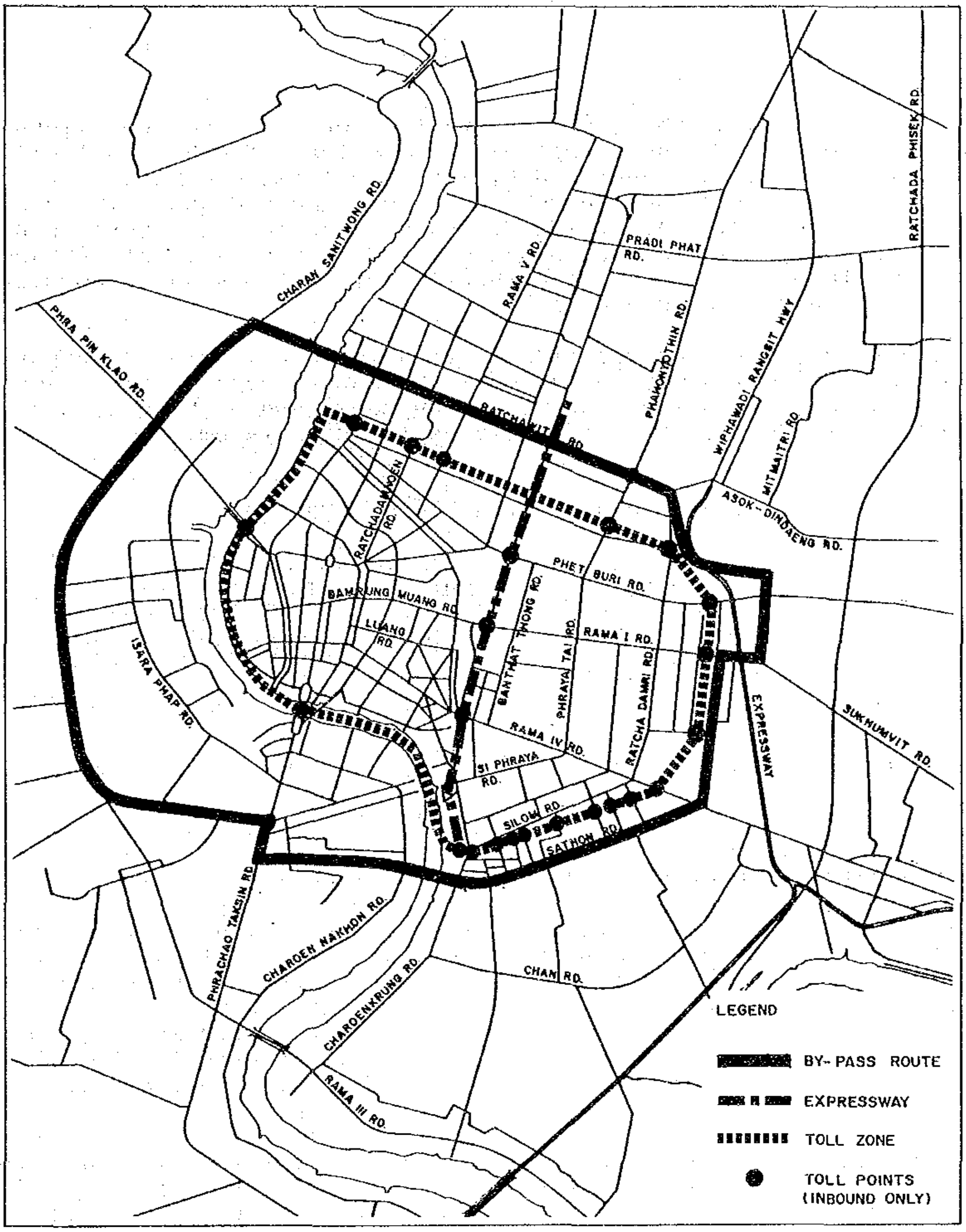


Figure 10.3.2 Area License Control

(4) Charge

Based on the 30 Baht charge set for general passenger cars, the charge value for each type of vehicle is determined as follows: Passenger car (30 B), taxi (30 B), minibus, bus, and truck (private cars) (40 B) and Motorcycle (10 B).

Table 10.3.5 shows the expected traffic impact. The area license system demonstrates an effect similar to that of other policies. The Q/C ratio has decreased by 10%. In terms of modal share, public transportation increased by 10%, and VOC and TTC costs decreased by 13%. According to the STTR estimates, there would be a 20% decrease in the volume of traffic, in terms of PCUxkm, inflow into the area. The results of this study, however, indicate only a 13% decrease.

These figures are much smaller that those observed in Singapore. Remarkable results were obtained in Singapore because improvement was made in the public transportation media and parking lots were added to the application of the area license system.

Table 10.3.5 Area License Control

	Road Congestion		Modal Share		Traffic	Cost	
Restriction	Study Area	Inside MRR	Car/M.C	Public	PCU km (x 1000)	VOC (x 1,000,000	TTC B/Year)
Without Tax Increase	0.90	1.09	56	33	108,700	165,100	496,300
With Tax Increase	0.83	0.98	54	36	95,000	146,000	430,200

6) Restriction of Private Car Use for School

This system is presumed to ease traffic congestion by prohibiting the use of passenger cars and motorcycles for attending school and going home. It is possible to recommend this system to schools in Bangkok. This system is effective when many cars are used for attending school and going home, but these make up only 4% of the total passenger cars and motorcycles used in the whole zone in the City of Bangkok. Thus, no drastic effect can be expected.

Table 10.3.6 shows the traffic volume decrease through the prohibition of passenger cars for school purposes. The decrease is about 656,300 PCU from the approximately 16.56 million PCU of generation/attraction volume of all purposes and vehicles. (This is about 4% of the generation/attraction volume in the study area.)

Table 10.3.6 Restriction of Private Car Use for School

Attraction/Generation (PCU)			Traffic Decrease by Restriction (PCU)
All Purpose All Mode	School Passenger Car	School Motorcycle	
16,560,800	53,070	275,080	656,300

10.4 Public Transportation Options

The study clearly indicates that bus is the most popular form of public transport and is expected to occupy 75% of the total public transportation demand, even after the completion of LRT and SRT in 2006. Measures to further strengthen and improve bus service in the study area include, but not limited to, the following

1) Expansion of Bus Fleet

Based on the results of traffic assignments, it is estimated that bus passenger demand, in terms of passenger.km will double over the next 17 years (1989-2006), of which 16% will be met by buses to be operated on the proposed bus-ways, as shown in Table 10.4.1.

Table 10.4.1 Bus Passenger Demand in 1989 and 2006

Year	Item	Bus	Bus-way
1989	Vehicle.Km (x 1000)	2,027	-
	Passenger.Km (x1000)	42,562	-
2006	Vehicle.Km (x 1000)	3,435	551
	Passenger.Km (x1000)	72,129	11,565

The current bus system in Bangkok carries approximately 6.1 million passengers/day by 8,182 bus units, operated mainly by BMTA.

Table 10.4.2 Buses in Operation in 1989

Item	Regular Bus		Air-conditioned Bus		Minibus	Total
	BMTA	Private	BMTA	Private	Private	
Bus in Operation	4,216 (51.5%)	1,132 (13.9%)	444 (5.4%)	239 (2.9%)	2,151 (23.6%)	8,182 (100.0%)
Bus Passenger (x1000)	3,613 (59.3%)	1,070 (17.6%)	192 (3.1%)	99 (1.6%)	6,093 (18.4%)	(100.0%)

Based on the present operational performance, it is estimated that the required number of conventional bus units for the year 2006 will be approximately 13,900.
Assuming that the current shares by bus types, and operators remain unchanged, as well the current vehicle life of 10-12 years for an ordinary bus and 5-9 years for a minibus, the number of bus units (whether purchased or leased) that will be required in 2006 is shown in Figure 10.4.1.

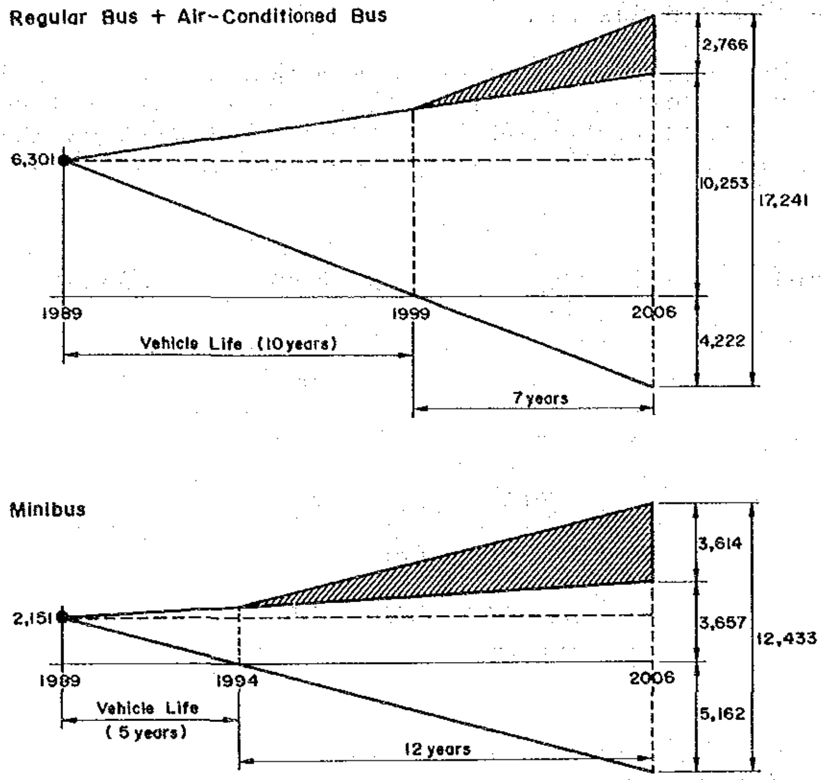


Figure 10.4.1 Number of bus units required (leased or purchased) in Bangkok in 2006

It can be deduced from the figure that it will be necessary to lease or purchase approximately 30,000 units over the next 17 years. BMTA's share of this figure will be approximately 17,000, or 59% of the total requirement, meaning that they will have to acquire buses at the rate of approximately 1,000 a year.

On the other hand, the required number of bus units to be operated on the bus-ways is estimated to be approximately 2,600, based on improved performance such as higher occupancy and travel speed, as shown below.

656,000	x	0.18	÷	45	≒	2,600 (= 2,624)
↑		↑		↑		
Daily Passengers in 2006		Peak Hour Ratio		Occupacy (persons/unit)		

2) Strengthening the taxi system

At present DLT has set a limit of 29,000 units on the number of taxis, inclusive of samlor and silor, that can be registered because of the serious traffic congestion in Bangkok, among other factors.

However, considering the forecast increase in demand in the future, as shown in Table 10.4.3, it is necessary to strengthen the taxi system, as in the case of the bus fleet.

Table 10.4.3 Future Increase in Taxi Demand

Year	Item	Taxi
1989	Vehicle.Km (x1000)	9,798
	Passenger.Km (x1000)	11,856
2006	Vehicle.Km (x1000)	24,138
	Passenger.Km (x1000)	29,207
2006/ 1989	Vehicle.Km, Passenger.Km	2.46

Assuming that the operational performance of taxi remains at the current level, it is estimated that the number of taxis required in 2006 will be approximately 71,400, as shown in Table 10.4.4.

Table 10.4.4 Taxis required in 2006

Item	Registered Number of Units in 1989	Growth Rate	Required Number of Units in 2006
Taxi	13,500	2.46	33,200
Samlor	7,500		18,500
Silor	8,000		19,700
Total	29,000		71,400

3) Restructuring the Bus Routes

The present bus route network forms a radial pattern with the CBD inner area in the center, as shown in Figure 10.4.2, and is structured relatively unevenly due to the lack of main roads and proper hierarchy.

The future public transportation demand will increase significantly, not only radially, but also circumferentially as well, as shown in Figures 10.4.3 and 10.4.4. The proposed plan shall be introduced to cope with the circumferential demand as well as improve the existing radial bus network. Bus mode is the most basic form of public transportation for the residents, and the buses should be rerouted taking into account the following.

(a) Integration with the rail transit services
(b) Maximum use of the proposed bus-ways
(c) Coordination with paratransit modes especially with minibus and hired motorcycle modes
(d) Assurance of services in areas where public transportation is poor, such as the suburban areas, where development is progressing, however demand is scattered in a wide area

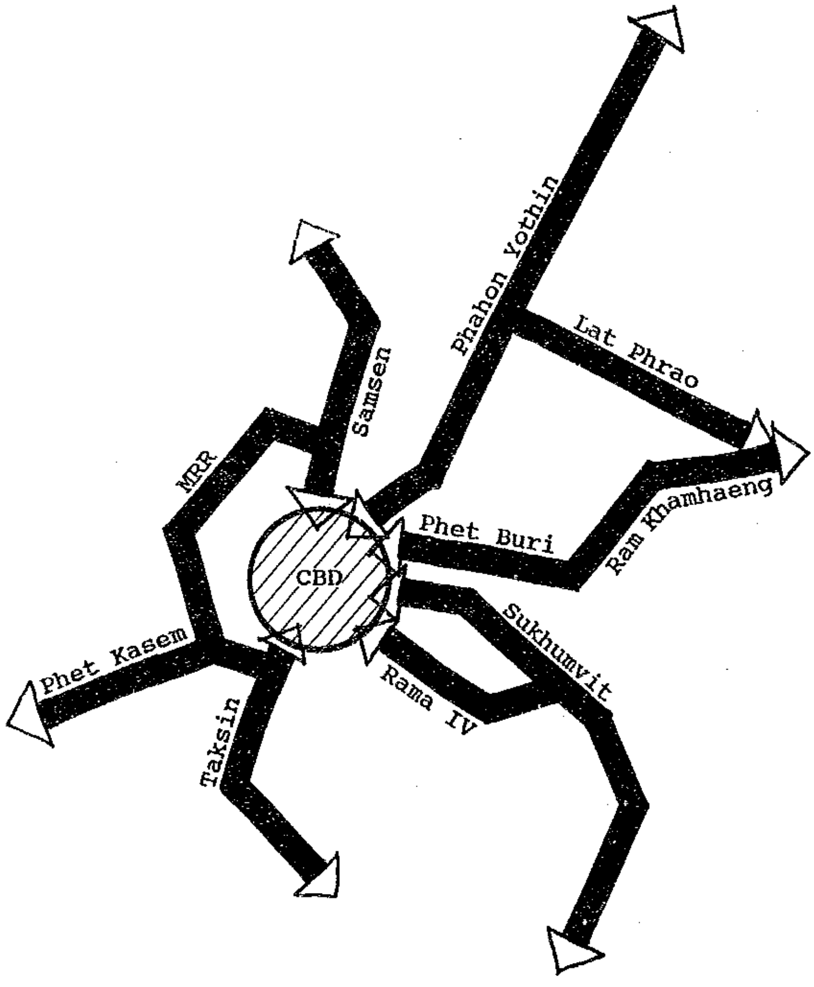


Figure 10.4.2 Present Bus Route Network Pattern

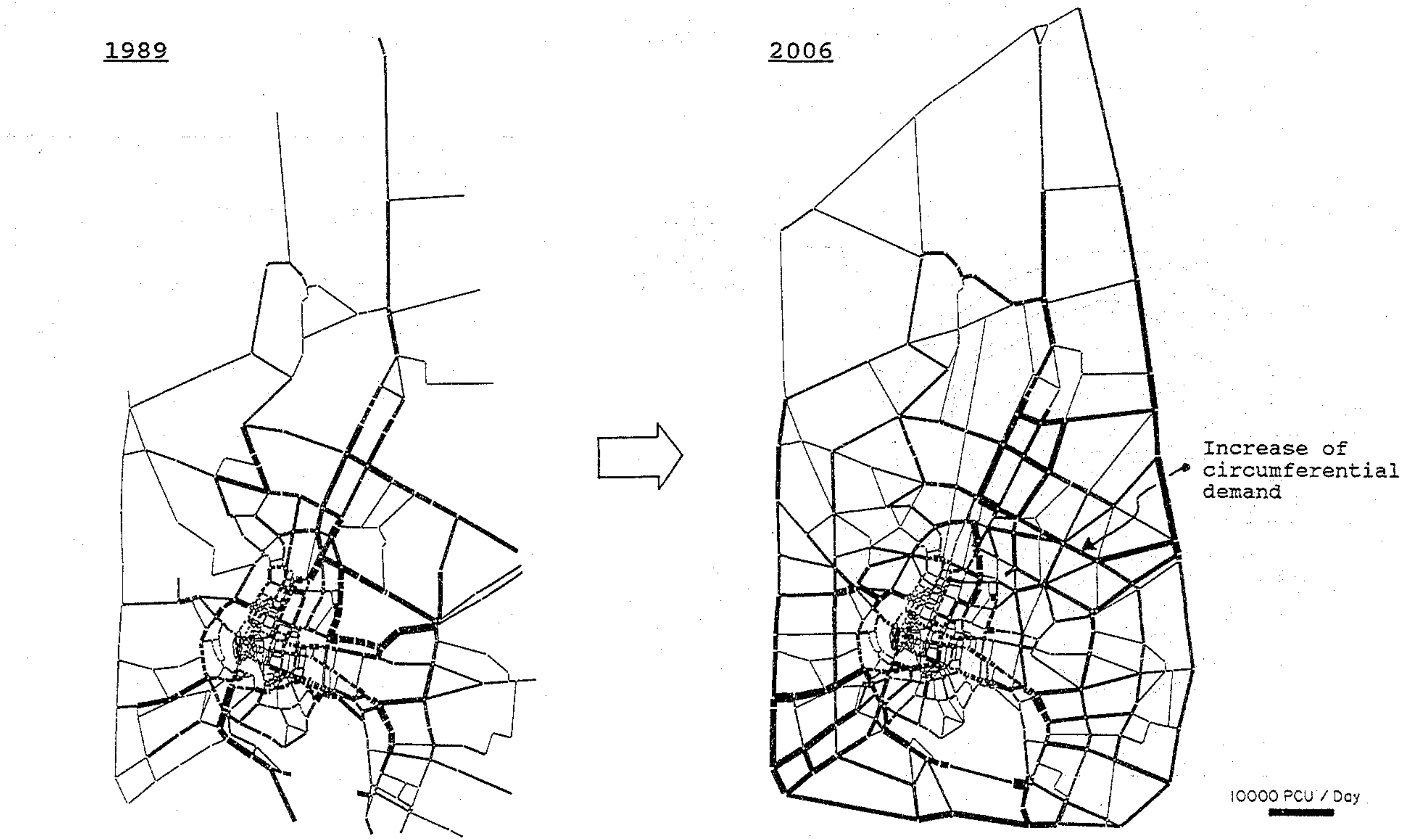


Figure 10.4.3 Traffic Assignment of Public Transportation (1989 and 2006)

DIRECTION	MODE	CAPACITY	TRAFFIC VOLUME		CAPACITY -VOLUME
			BUS	TOTAL	
NORTH	ROAD	451,200	44,418	685,860	-234660 (0)
	BUSWAY	14,400	10,241		4,159
	LRT	50,000	15,671		34,329
	SRT	50,000	16,728		33,272
	TOTAL	565,600	87,058	685,860	71,760
NORTHEAST	ROAD	480,000	35,093	518,320	-38320 (0)
	BUSWAY	43,200	28,631		14,569
	TOTAL	523,200	63,724	518,320	14,569
SOUTHEAST	ROAD	102,000	21,595	228,410	-126410 (0)
	LRT	50,000	21,754		28,246
	TOTAL	152,000	43,349	228,410	28,246
SOUTHWEST	ROAD	399,600	39,627	449,638	-50038 (0)
	LRT	50,000	4,468		45,532
	TOTAL	449,600	44,095	449,638	45,532
WEST	ROAD	777,600	54,549	745,534	32,066
	LRT	50,000	13,125		36,875
	TOTAL	827,600	67,674	745,534	68,941
NORTHWEST	ROAD	192,000	7,730	115,606	76,394
	BUSWAY	11,440	11,258		182
	TOTAL	203,440	18,988	115,606	76,576

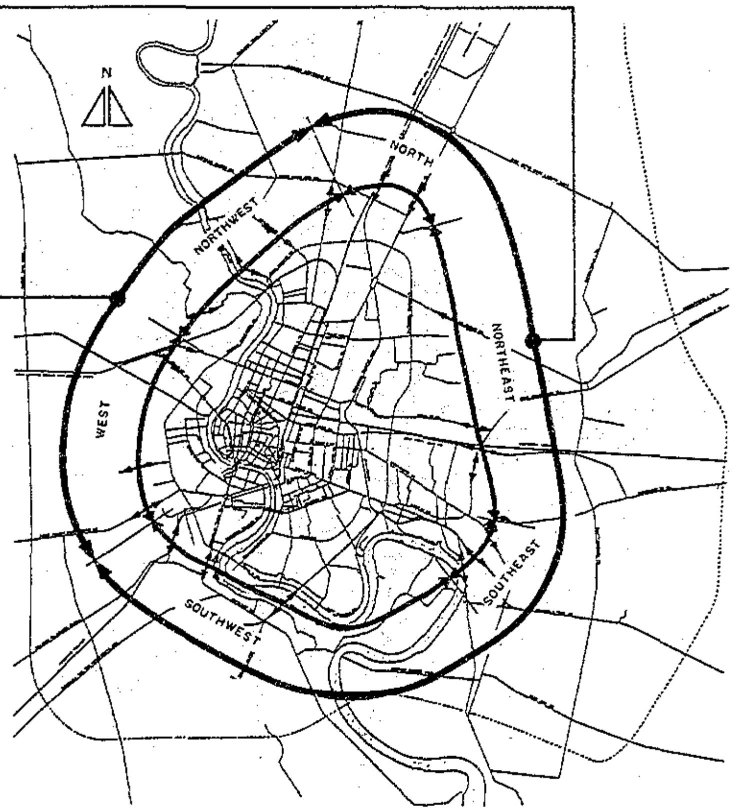


Figure 10.4.4 Demand and Supply of Public Transportation by Direction, 2006

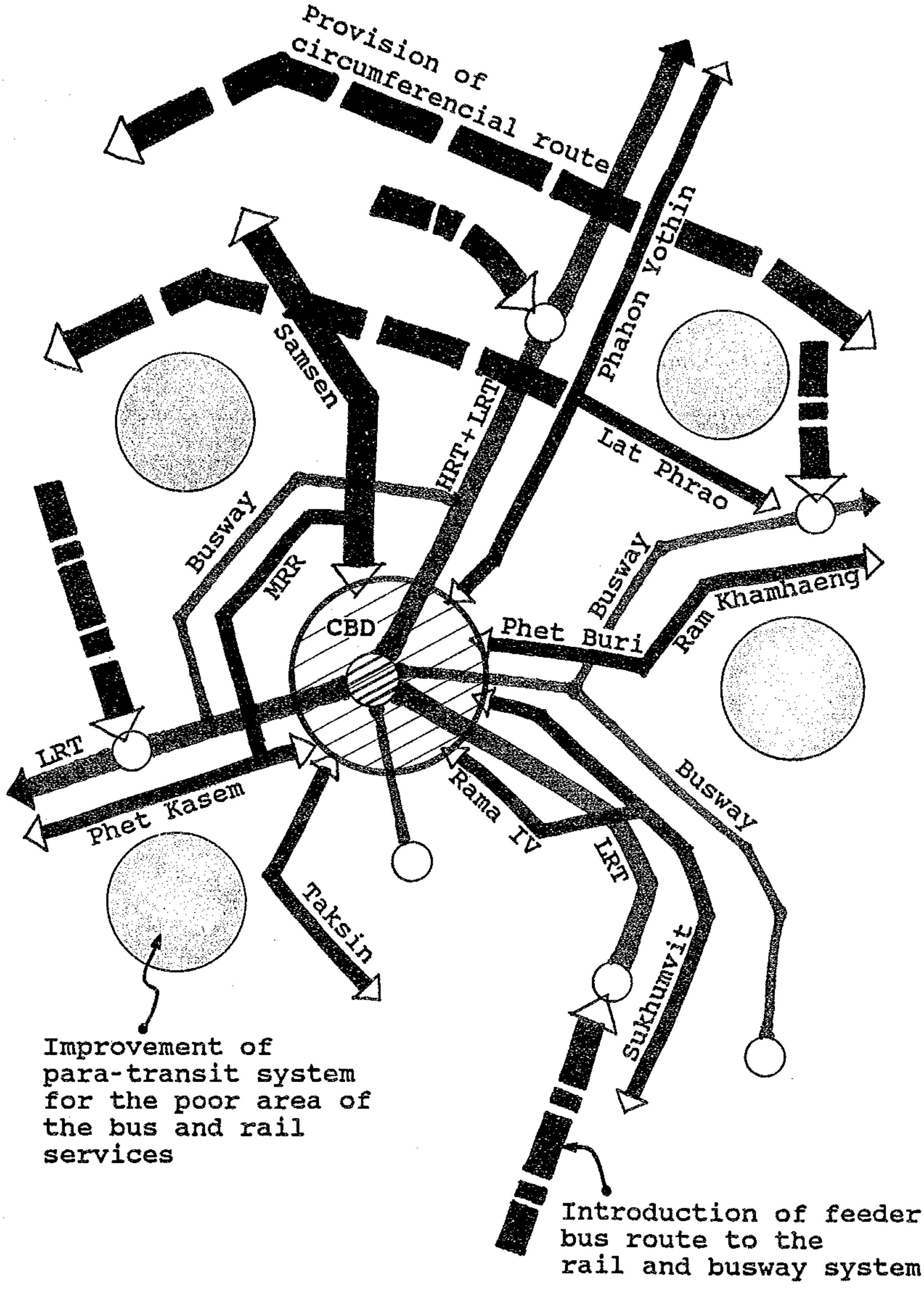


Figure 10.4.5 Restructuring of Bus Routes

4) Development of Mode Interchange Facilities

With the increased variety of transportation modes in the future, such as rail transit systems, it is important to develop adequate facilities at the major terminals and transfer points.

Based on the rail transit and bus-way network, as well as the traffic flow/volume of transferring passengers, the transportation terminal areas, where the mode interchange function has been targetted for strengthening have been selected, and are shown in Figure 10.4.6, and the characteristics and facility requirements of each area are summarized in Table 10.4.5

Table 10.4.5 Characteristics and Estimated Facility Requirement

Name of Terminal	Mode Interchange Pattern	B/A Passenger <a>	Transferring Passengers <b>	Facility Requirements <c> (m^2)
1. Rangsit	HRT ←→ Bus	78,300	59,800	9,000
2. Don Muang	LRT ←→ BUS	155,700	141,100	11,100
3. Nontha Buri	Busway ←→ Bus	81,600	35,500	6,000
4. MRR East	LRT ←→ Bus	54,900	16,400	5,200
5. *Hua Lamphong*	*HRT ←→ Bus*	*97,500*		
	LRT ←→ Bus	18,200		
	Total	115,700	82,900	11,500
6. Ekachai	LRT ←→ Bus	130,700	100,200	9,900
7. Sukhumvit	Busway ←→ Bus	37,500	28,800	2,900
8. Phrakanong	LRT ←→ Bus	145,100	111,000	10,600
9. Phratunam	Busway ←→ Bus	64,700	50,800	4,900

Note: Basic considerations in estimating facility requirements are as follows:

HRT = Based on the Japanese formula for facility requirements for station plazas

$a > 73{,}000$ $C = 0.0259 \times a + 25.09 \times (a)^{(1/2)}$

$a < 73{,}000$ $C = 0.1190 \times a$

LRT = Space requirements are 80% of those for HRT due to the limited land area alongside the trunk roads where the facilities are mainly located.

Bus-way = Space requirements are 80% of those for LRT as the facilities can be used by both conventional buses and those running on the bus-ways.

Type of Mode Interchange

Area	Mode Interchange Pattern				Impact on Urban Development
	Bus	Busway	LRT	HRT	
1. Rangsit	O			O	O
2. Don Muang	O		O		
3. Nontha Buri	O	O			O
4. MRR East	O		O		O
5. Hua Lamphong	O		O	O	
6. Ekachai	O		O		
7. Sukhumvit	O	O			O
8. Phrakanong	O		O		
9. Phratunam	O	O			O

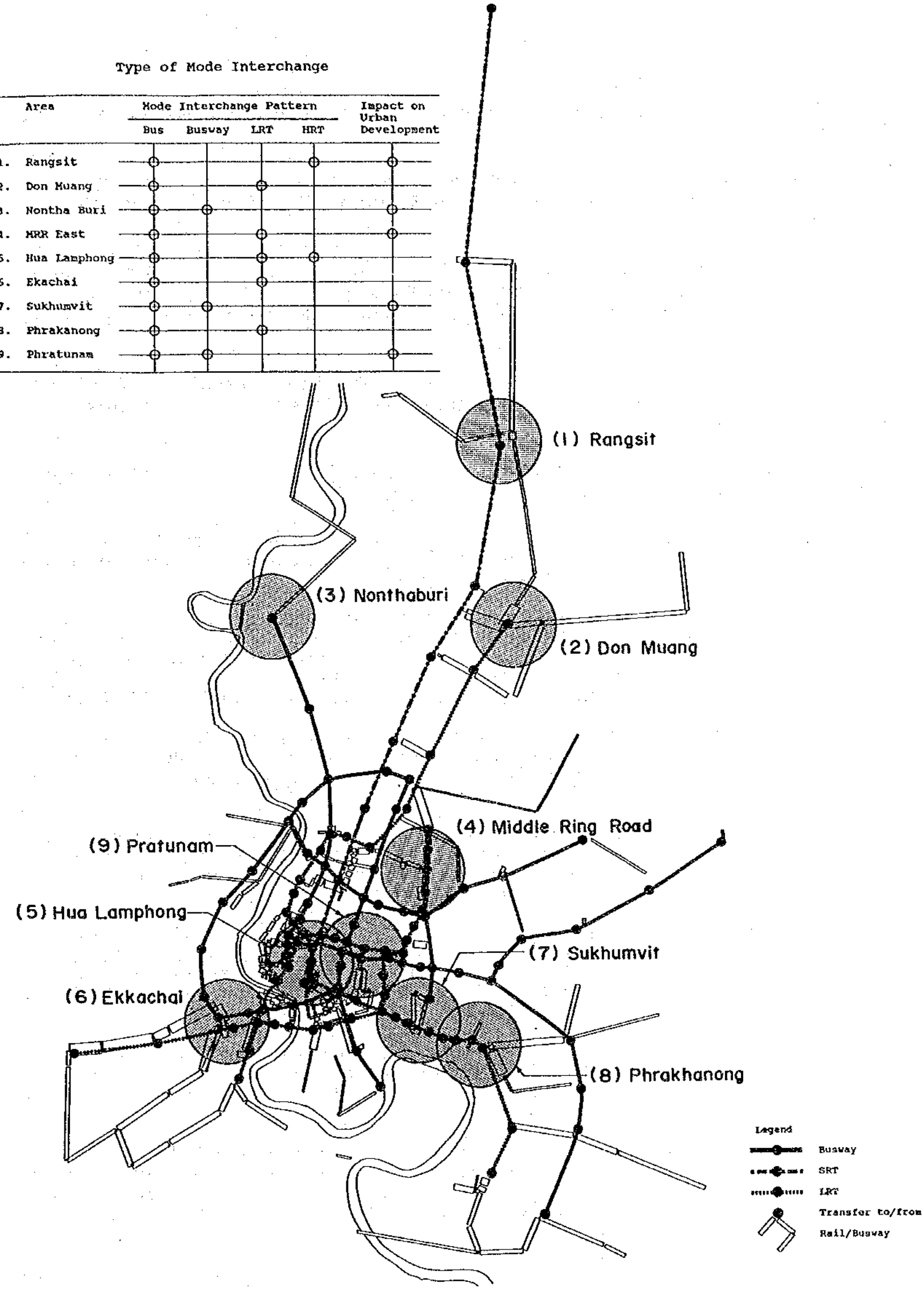


Figure 10.4.6 Major Mode Interchange Areas in the Future

The importance of mode transfer facilities stems from the following two reasons:

- As a result of the limited coverage provided by the railway network, patronage is considerably affected by feeder services.

- The terminals/major transfer points tend to attract large numbers of passengers, and therefore proper traffic management facilities including the provision of proper pedestrian facilities are required.

It should also be noted that properly designed mode interchange areas, when suitably located will create new urban space for Bangkok residents.

The characteristics and planning directions of the nine mode interchange areas are described below:

1. Rangsit : Upgrading the Rangsit HRT station plaza together with the introduction of bus terminal facilities ($9,000m^2$)

2. Don Muang : Location is the LRT Don Muang Airport station on the Phahon Yothin Road, the heaviest bus corridor in Bangkok. Provision not only of a bus transfer system but also of a reliable transfer system for air passengers ($11,100m^2$)

3. Nonthaburi : One of the major transport terminals in the northern suburban area. Strengthening of the bus feeder function at the end of the busway ($6,000m^2$)

4. MRR East : LRT station at the future commercial/institutional core along the Middle Ring Road. Strengthening the transfer function between LRT and bus ($5,200m^2$)

5. Hua Lamphong: Upgrading of this facility, the largest existing HRT terminal, as well as expanding of the existing station plaza together with the introduction of a transfer function between HRT and LRT ($11,500m^2$)

6. Ekachai : LRT station at one of the major transport terminal in the southwestern area. Provision of a smooth transfer system between LRT and bus ($9,900m^2$)

7. Sukhumvit : Transport terminal at the end of the bus-way in the commercial area of the new CBD. Provision not only of mode interchange facilities, but also of new urban amenities ($2,900m^2$)

8. Phrakanong : LRT station at one of the major transport terminals in the southeastern area. Strengthening the bus feeder system ($10,600m^2$)

9. Phratunam : A new type of transport terminal at the intersection of the proposed bus-way on the Klong Saen Saep Canal and the Rachaprarop Rd., a major urban transport corridor. Introduction of mode interchange facilities along with convenient pedestrian facilities for the public transport passengers in the area (4,900m²)

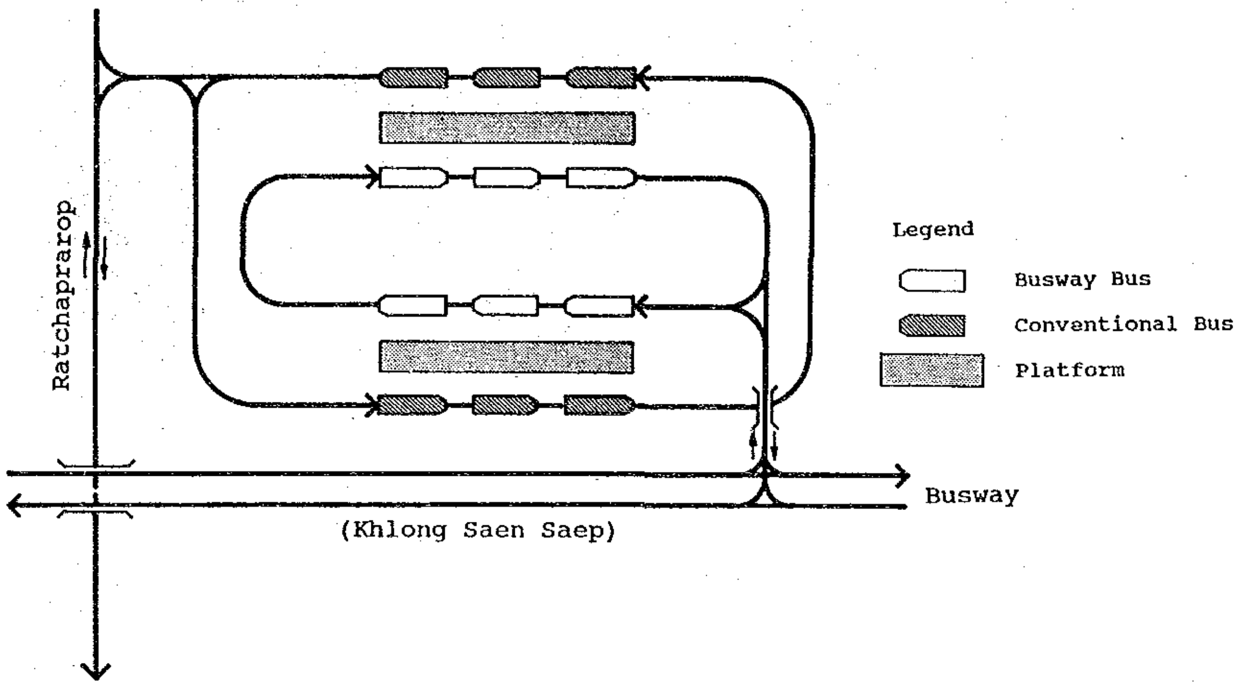


Figure 10.4.7 Concept of Mode Interchange Area

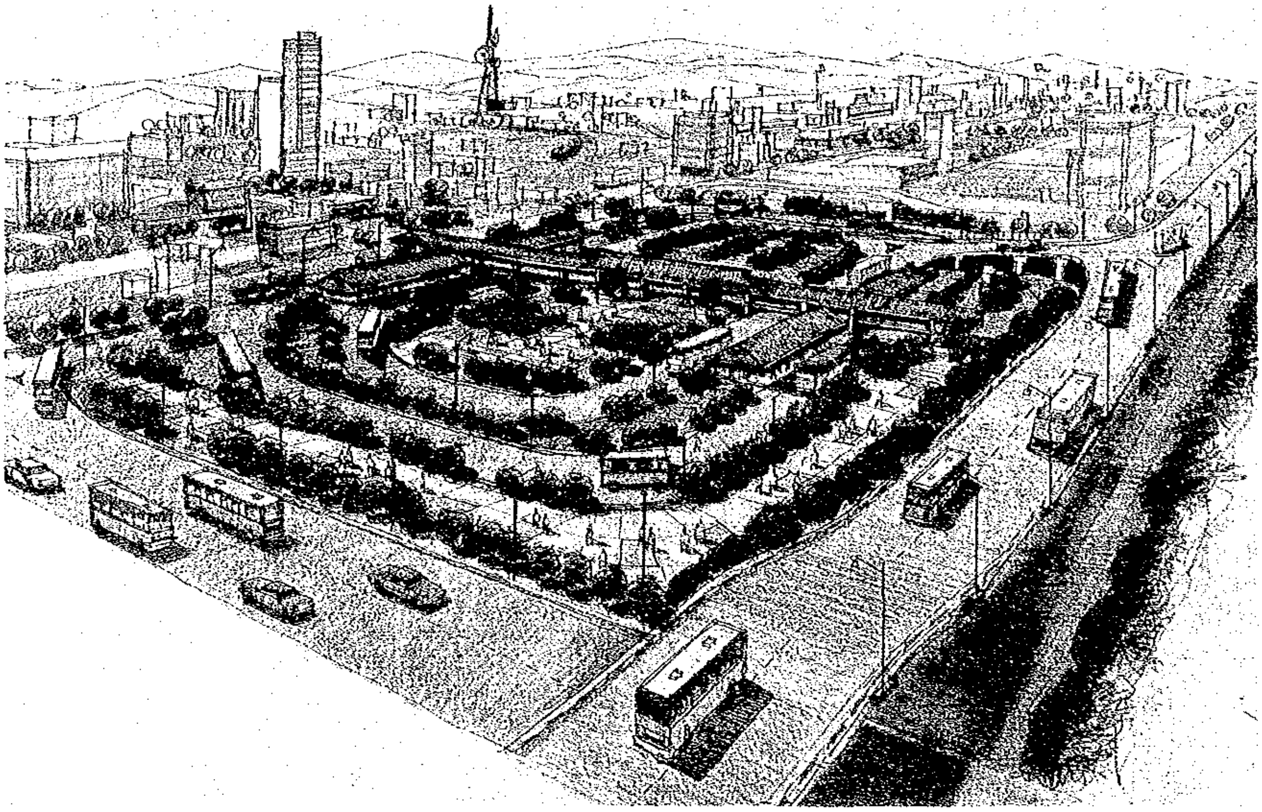
5) Others

(1) Expansion of Improved Bus Services

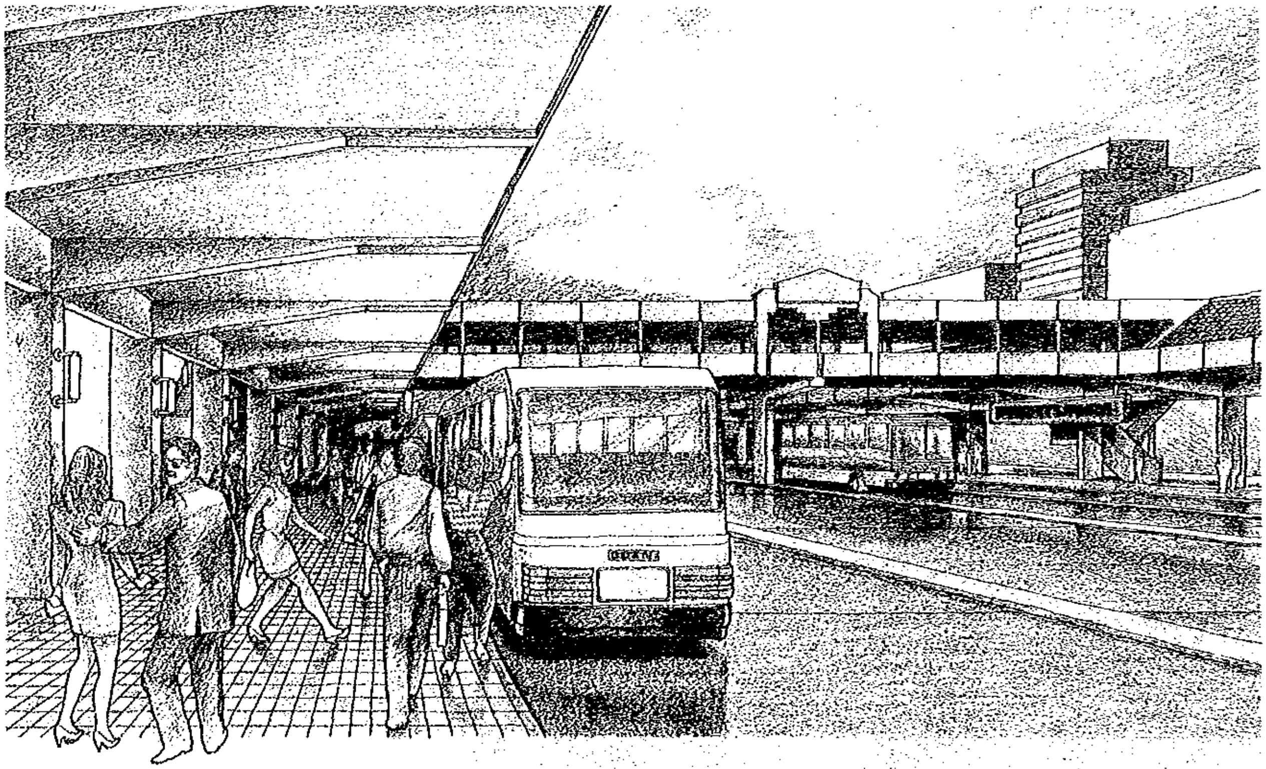
The proposed extensive bus-way network will make possible the introduction and expansion of new bus services. This would encourage the use of public transportation, hopefully diverting people away from private cars and motorcycles. Examples of such services are; air conditioned express buses, articulated bus along bus-ways, low bed buses, buses which can be easily used by the aged, the disabled and infants, community buses, upgraded school/company buses, and so on.

(2) Adjustment of the Fare System

In order to attain proper functional splits among various public transportation modes and make them more attractive to public transport users and operators, the existing fare system should be reviewed and adjusted.



Busway Terminal



Bus Stop of Elevated Busway

CHAPTER 11

DESIGN STANDARDS AND COST ESTIMATE

11. DESIGN STANDARDS AND COST ESTIMATE

11.1 General

This Chapter explains the engineering basis of the study with particular regard to design standards and cost estimate of the projects. At present, there are no authorized design standards in Bangkok, though AASHTO standards are often referred to. Design standards vary by agency. DOH has its own standards prepared based on AASHTO, while BMA does not, using available standards of other sources including technical guidelines formulated by the JICA study titled "Study on Road Improvement, Rehabilitation and Traffic Safety in Bangkok, March 1987". ETA and PWD (MOI) do not have their own standards for structure design but principally rely on AASHTO and BS, respectively.

The existing roads in the study area are classified by administrative agency but not by function. Differences in the standards followed by the various agencies makes it also difficult to determine the hierarchy of roads. Since the urban areas have been and will continue to expand significantly, that expansion should be associated with proper roads development, and it is necessary to prepare consistent design guidelines/standards applicable to, and to be applied in the urban area of Bangkok.

The cost estimate of the projects identified in this study is made on the basis of the data available from various implementing agencies and relevant study reports.

11.2 Design Standards

1) Typical Cross Sections of Roads

After reviewing the existing standards, related study reports and expected changes in land use in the study area, various types of cross sections were prepared for expressways, at-grade main roads, distributors and bus-ways. They are shown in Figure 11.2.1 and outlined as follows:

(1) Expressways

Three cross section types were prepared. Elevated section will have dual 2 to dual 3 lanes depending upon the traffic volume, with shoulders and a lane width of 3.5 meter (Type 2 and Type 3). A cross section having dual 2 lanes with shoulders was prepared for at-grade sections (Type 1).

(2) At-grade Main Roads

Fifteen types were prepared; 5 for four/dual 2 lane roads (Types 4, 5, 6, 7, and 8), 7 for six/dual 3 lane roads (Types 9, 10, 11, 12, 13, 14, and 15), and 3 for eight/dual 4 lane roads (Types 16, 17, and 18). For the four lane/dual 2 lane roads, lane width is 3.25 meter, while it is 3.5 meter for the other roads. For roads

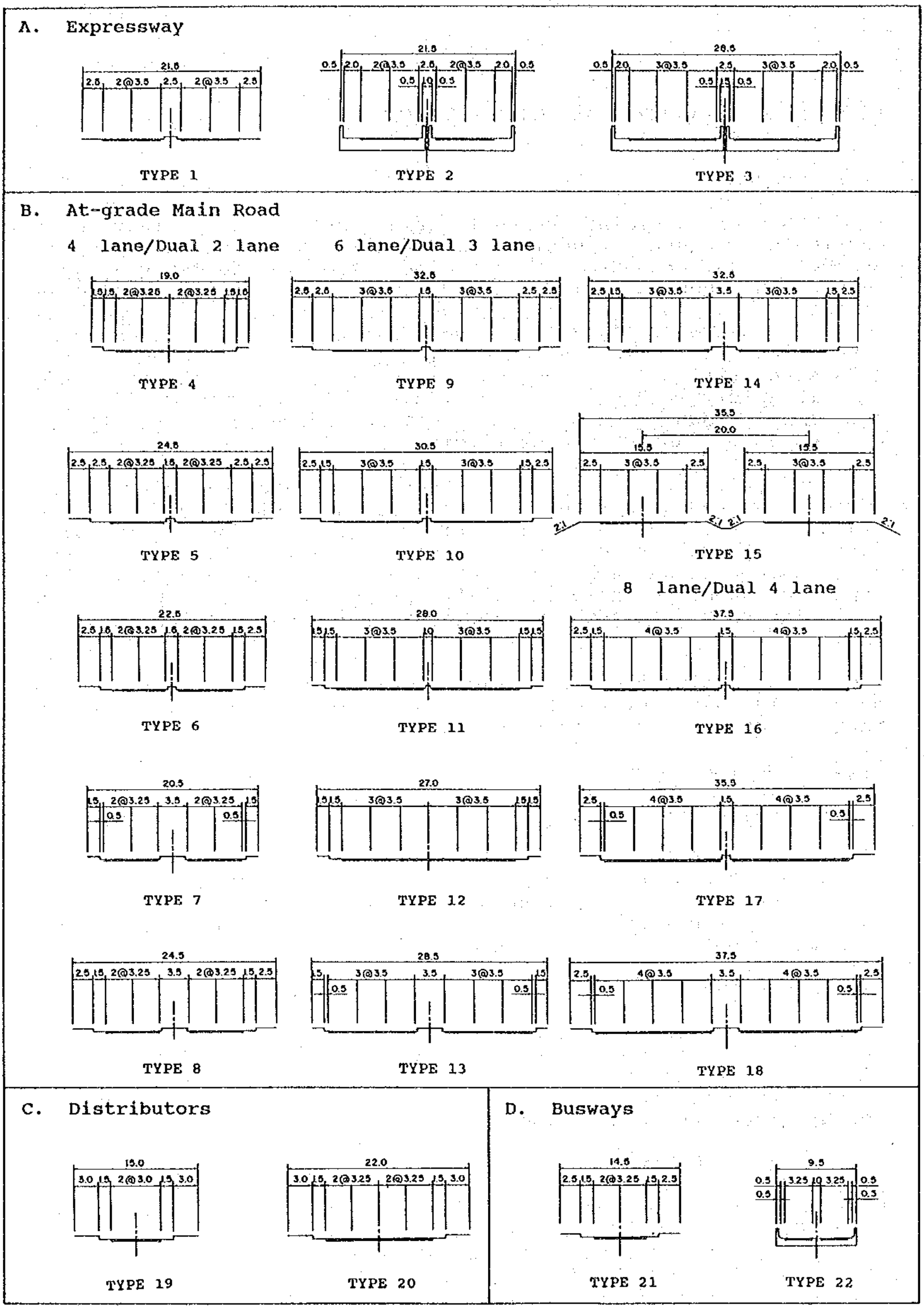


Figure 11.2.1 Typical Cross Sections for Roads

where other elevated structures such as expressways, bus-ways and LRT are constructed, 3.5 meter of central medium is provided to enable the construction of the substructures. Separate carriageways were prepared for Outer Ring Roads as shown in Type 15. Since these roads will form the primary and secondary system in the urban areas 1.5 to 2.5 meter wide sidewalks are provided on both sides of the carriageway. Total road width is 19 to 24.5 meter for four/dual 2 lane roads, 27 to 32.5 meter for six/dual 3 lane roads, and 31 to 37.5 meter for eight/dual 4 lane roads.

(3) Distributors

Two cross section types were prepared for two lane and four lane roads (Types 19 and 20). They are provided with 3 meter wide sidewalks on both sides of the carriageway because pedestrian traffic is considered to be fairly large. Total road widths are 15 and 22 meter, respectively.

(4) Bus-ways

Two types were prepared; one for at-grade section (Type 21), and the other for elevated section (Type 22). Both are provided with two lanes with carriageway width of 3.25 meter. For the at-grade section, 1.5 meter wide shoulders and 2.5 meter wide sidewalk are provided on both sides.

2) Elevated Structures

(1) Elevated Road Sections

PC composite girder type was assumed for the elevated sections of the project roads. This type is also used for both the First Stage Expressway and the Second Stage Expressway. Typical sections are shown in Figure 11.2.2.

(2) Bridges

Types of bridge across Chaophraya River are broadly classified into two; those to be constructed north and those south of the existing Krung Thep Bridge. The former ones will have a navigation clearance of 10 meter and PC 3-span continuous box girders with 120 meter central span, as shown in Figure 11.2.3.

On the downstream side of the bridge, there are many harbor facilities and large ship navigation. Therefore, the necessary navigation clearance is 41 meter up to the Rama IX Bridge, and it is 50 meter on the downstream side. Although the river width may vary depending on the bridge construction site, a bridge with 350 meter or longer span will be necessary, considering the waterway width limit. The following four bridge types can be considered for the bridges with a 350 meter span:

- Cable stayed steel bridge : Maximum span of 465 meter
- Cable stayed PC bridge : Maximum span of 440 meter
- Suspension bridge : Maximum span of 1,410 meter
- Arch bridge : Maximum span of 518 meter

Since Bangkok is founded on weak alluvium along Chao Phraya River, 25 - 40 m long, foundation piles are used for major bridges and buildings in the city. Therefore, instead of suspension bridges and arch bridges which require large anchors cable stayed steel bridges are employed, as shown in Figure 11.2.4.

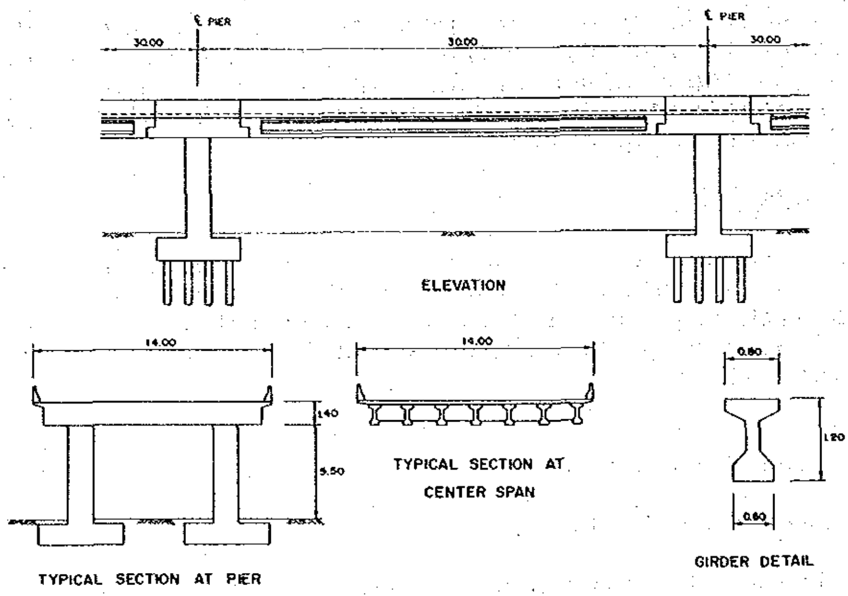


Figure 11.2.2 Typical Sections of Elevated Sections of Project Roads

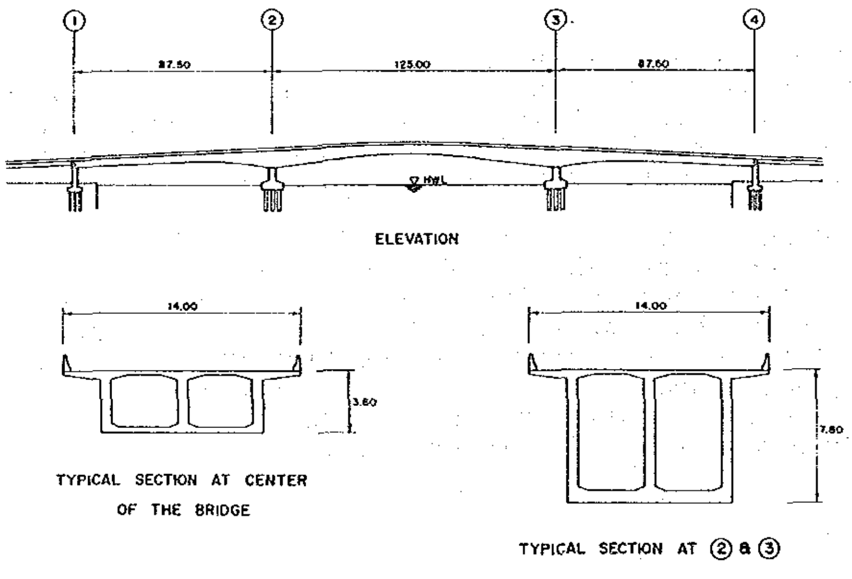


Figure 11.2.3 Typical Sections of PC 3-Span Continuous Box Girder Type Bridge

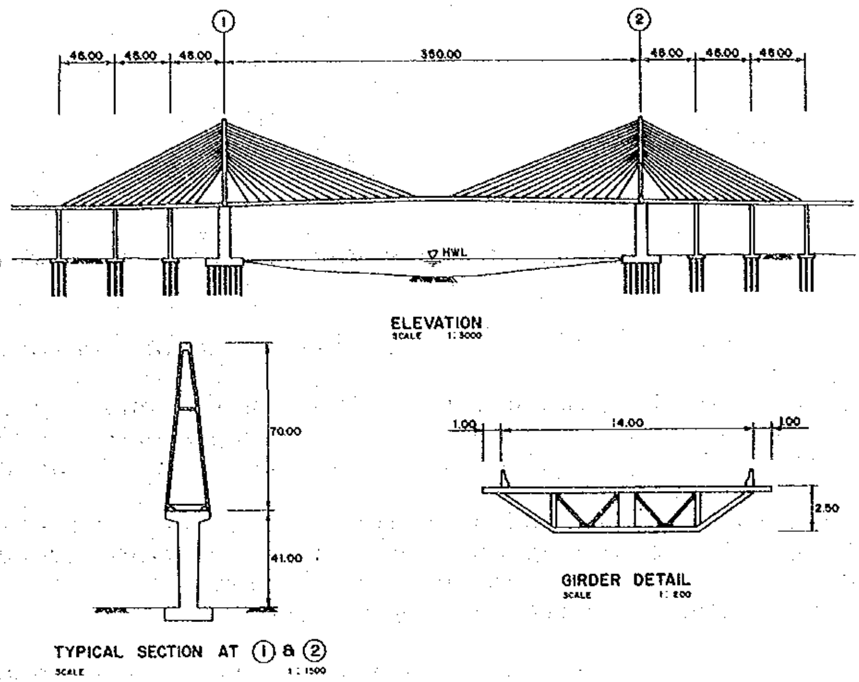


Figure 11.2.4 Typical Section of Cable Stayed Steel Wire Bridges

3) Rail Transit Systems

For the purpose of cost estimates of LRT (Light Rail Transit) and SRT, typical sections and elevations were assumed as shown in Figure 11.2.5.

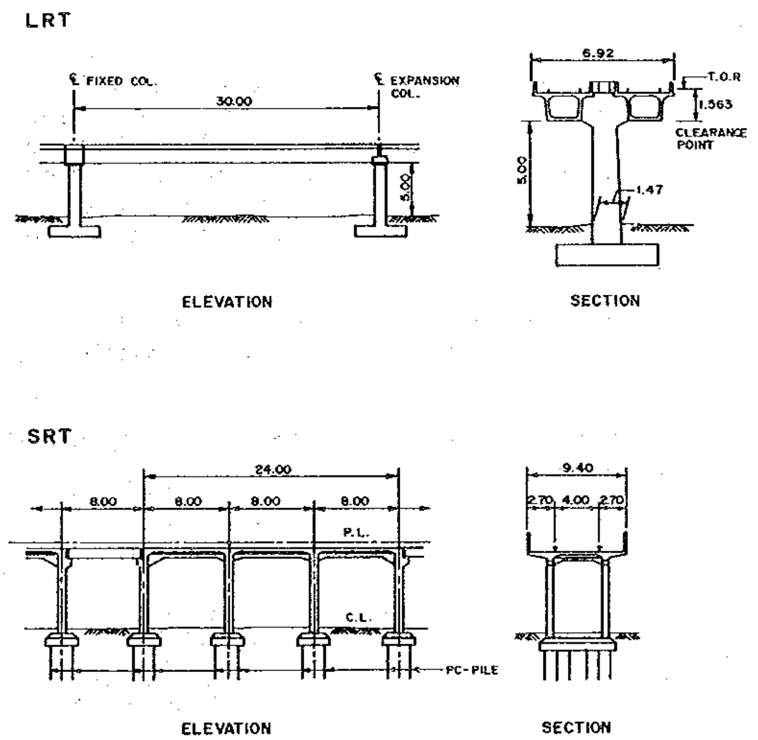


Figure 11.2.5 Assumed Typical Sections of Rail Transit Systems

11.3 Cost Estimate

1) Methodology and Assumptions

Project cost was estimated considering the following cost component;

(a) Direct construction cost comprising labor, materials and equipment costs.
(b) Indirect cost including temporary and preparatory work, measures needed for environmental protection, administration of site office and portion of head office administration.
(c) Engineering cost including detail design and supervision.
(d) Contingencies covering physical and price contingencies.
(e) Land acquisition and compensation costs.
(g) All costs are estimated at 1989 price.

The details concerning the basis upon which the above cost components were estimated, are described in the respective sections. The project costs were estimated both in terms of financial and economic costs. The financial cost was broken down into local currency and foreign currency portions wherein the latter was converted in Baht at the exchange rate of 25 Baht per 1 US$. The economic cost was estimated by subtracting all transfer costs such as import duties, sales taxes, etc. from the materials cost.

2) Estimate of Direct Construction Cost

(1) Labor Cost

To obtain the labor cost per hours, (Table 11.3.2), annual labor cost is first calculated from the unit cost per hour or monthly wages and allowance (social insurance and welfare cost), and it is divided by the number of annual working hours, which are estimated to be 2,543 hours considering that there are about 96 non-working days including holidays, festivals, holidays with pay, and non-working days due to bad weather, as well as 55 overtime hours/month, as shown in Table 11.3.1. The above costs are added to the basic wages to calculate the labor cost as shown in Table 11.3.2. Unskilled workers are classified as part-time workers.

Table 11.3.1 Number of Annual Non-working Days

Item	No. of Days/Year
1. Sundays	53
2. Holiday	13
3. Paid vacation	10
4. Interruption due to bad weather	20
Total	96

Table 11.3.2 Labor Cost per Hour

Type of Labor	Unit wage: Baht/Hour
a. Driver	28
b. Foreman	38
c. Operator	31
d. Skilled labor	28
e. Unskilled labor	13

(2) Machine Cost

The heavy machines cost per hour is calculated based on the depreciation expenses and repair cost. The depreciation cost is based on the fixed rate method with 10% residual value. Major heavy machine costs are shown in Table 11.3.3.

Table 11.3.3 Estimated Machine Cost by Equipment

Equipment Name	Basic Price (US$)	Operational Life (years) 1)	Annual Operated Hours	Maintenance Rate (%) 2)	Management Rate (%) 3)	Power/Fuel Consumption 4): Diessel Oil (l/h)	Power/Fuel Consumption 4): Electricity (kw/h)	Cost per Hour: Foreign (US$) Financial	Cost per Hour (Baht): Financial	Cost per Hour (Baht): Economic
Agg. Spreader 2.3m	1500	3	530	40	5	0.48	-	1	5	2
All Casing Excavator	327900	5	900	70	7	-	-	132	255	0
Apron Feeder 30t	44600	9	1000	45	5	0.53	-	9	15	2
Asphalt Plant 60t	308200	8	1500	50	7	-	201.00	86	2213	1621
Asp. Finisher 3m	117950	7	550	50	7	3.26	-	55	100	15
Batching Plant	480000	7	950	60	7	20.80	78.00	139	521	246
Belt Con. 0.35*10m	1500	2	600	55	5	1.37	-	2	13	6
Belt Con. 0.6*15m	19600	4	600	55	5	1.50	-	13	33	7
Bulldozer 11t	108000	7	1500	65	7	8.50	-	21	94	39
Bulldozer 21t	220900	7	1500	65	7	15.70	-	42	181	72
Compressor 4.6m3	33200	5	1000	50	5	6.00	-	11	60	28
Compressor 9.6m3	42810	5	1000	50	5	10.17	-	15	94	47
Conc. Cutter 0.3m	6000	3	680	25	5	0.48	-	4	7	2
Conc. Breaker 30kg	4000	2	960	20	5	-	-	2	2	0
Conc. Bucket	1800	5	560	55	5	-	-	1	2	0
Conc. Finisher 5.5m	103000	7	530	35	7	3.10	-	47	71	14
Conc. Spreader 2.3m	124000	7	530	35	7	2.30	-	56	75	11
Cravlor Crane 35t	261000	7	1000	70	7	6.50	-	74	177	30
Diesel Hammer 1.25t	44000	5	800	60	7	9.40	-	20	101	43
Diesel Hammer 2.5t	65000	5	800	60	7	15.00	-	30	157	69
Distributer 4kl	25000	6	530	40	7	0.67	-	13	21	3
Dump Truck 11t	92000	4	1550	60	10	6.30	-	27	90	29
Dump Truck 2t	23000	4	1550	55	10	6.36	-	7	56	29
Dump Truck 6t	62000	4	1550	60	10	5.00	-	18	66	23
Earth Oager 0.45	50000	4	950	35	7	2.11	-	19	38	10
Engine Pump 4in	1730	6	740	110	5	0.70	-	1	7	3
Grout Mixer	3400	6	600	55	7	-	4.40	2	11	8
Grout Pump	4000	6	600	55	7	-	3.20	2	9	6
Hand Hammer 1.1m3	1200	2	1280	20	5	-	-	1	0	0
Hydro-Shovel 0.6m3	155000	7	1200	60	7	4.10	-	35	85	19
Line Marker 90kg	4600	4	850	30	5	3.88	-	2	30	18
Mac.Roller 12t	50000	7	750	50	7	5.40	-	18	63	25
Melting Tank	13100	4	850	50	10	0.28	-	7	12	-1
Motor Grader 3.7m	119870	7	850	50	7	7.80	-	37	106	36
PC Jack	10500	5	2000	75	10	0.00	-	2	4	0
Road Sweeper 1.8m	171000	5	950	50	7	8.70	-	61	153	40
Soil Compacter 0.05t	1800	3	800	45	5	0.30	-	1	4	1
Soil Compacter 0.2t	2900	2	800	45	5	0.48	-	3	8	2
Soil Mixing Plant 15	157000	6	1200	50	7	0.00	43.00	38	132	78
Spray Gun	25500	5	1440	85	7	0.96	-	7	22	4
Sprayer 0.3kl	2200	3	1360	25	5	0.34	-	1	3	2
Surf. Vibrater 1.5*0	1800	4	530	65	5	0.43	-	1	6	2
Tandem Roller 10t	48000	7	650	45	7	5.57	0.30	19	64	26
Tire Roller 15t	56000	7	750	50	7	5.58	-	20	67	26
Truck 5t	26000	4	1250	55	10	4.50	-	10	47	21
Truck 8t	39000	4	1400	55	10	6.00	-	13	62	28
Truck Crane 11t	140700	7	900	35	7	3.00	-	38	61	14
Truck Crane 16t	159500	7	1000	35	7	5.00	-	39	76	23
Truck Crane 40t	365600	7	1100	35	7	6.17	-	80	127	28
Truck Crane 5t	67000	7	900	35	7	2.30	-	18	35	11
Truck Crane 70t	577500	7	1100	35	7	10.80	-	127	209	50
Truck Crane 90t	718800	7	1100	35	7	13.80	-	158	263	63
Truck Mixer 3m3	47000	5	950	45	7	8.40	-	17	83	39
Vibrater	960	3	1280	35	5	-	0.30	0	1	1
Vibro Hammer	43200	4	800	35	7	-	6.70	20	36	12
Vib-Roller 3.5t	70535	5	600	45	7	1.70	-	38	65	8
Watering Cart 5.5kl	40000	5	1000	50	7	5.00	-	14	56	23
Wheel Loader 1.4m3	83540	7	1200	60	7	8.45	-	20	1819	479

1) residual value is 10% of the Basic Price at the end of operation life
2) maintenance rate is assumed to be 10% of the basic price for total life year period
3) management rate is assumed in percentage to the basic price for every year
4) lubricant cost is assumed to be 30% of the power/fuel consumption costs

(3) Material Cost

Most construction material can be locally procured. However, the cost of some local material is partly regarded as foreign currency portion because in the course of production, some of row material, fuel and production plant and equipment would have been imported. The composition of foreign and local currency portion of main local material is shown in Figure 12.2.4. The costs of imported material are estimated based on the CIF price adding port charges and cargo handling charges. Table 11.3.4 shows foreign cost ratios and units of locally procurable materials. Prices of imported materials are converted into local prices after adding duty and margins to CIF prices.

Table 11.3.4 Unit Price of Major Materials by Currency Component

Material	Unit	Price (Baht)	Composition		Price	
			Foreign	Local	US$	Baht
a. Cement	ton	1,400	50	50	28.0	700
b. Sand	cum	170	50	50	3.4	85
c. Crusher run	cum	250	50	50	5.0	125
d. Reinforcement	ton	15,000	80	20	480.0	3,000
e. Hard wood	cum	13,350	40	60	213.6	8,010
f. Soft wood	cum	5,826	40	60	93.2	3,496

(4) Direct Construction Cost

Direct construction cost was estimated by multiplying unit construction cost per meter for roads with the length. In the case of rail transit system, the construction cost estimated in the "Lavarin Project" report of 1984 for the LRT and "JICA Report" of 1983 for the SRT were updated to the current price level. Unit cost per meter for each type is shown in Table 11.3.5.

Table 11.3.5 Estimated Unit Direct Construction Cost per Meter for Each Project Type

Type	Kind	Discription		Financial Cost			Economic Cost		
				Foreign US$	Local Baht	Total Baht	Foreign US$	Local Baht	Total Baht
1	Expressway	at grade 4 lanes	W=21.5	370.69	8,065	17,332	370.68	7,389	16,656
2		elevated 4 lanes	W=21.5	5,037.59	65,849	191,789	5,037.60	51,552	177,492
3		elevated 6 lanes	W=28.5	6,716.78	87,799	255,718	6,716.80	68,736	236,656
4	Main Road	at grade 4 lanes	W=19.0	315.85	7,073	14,969	315.84	6,452	14,348
5		at grade 4 lanes	W=24.5	379.94	8,922	18,421	379.96	8,118	17,617
6		at grade 4 lanes	W=22.5	342.90	8,152	16,725	313.28	8,152	15,984
7		at grade 4 lanes	W=20.5	302.38	7,331	14,891	302.40	6,672	14,232
8		at grade 4 lanes	W=24.5	352.44	8,709	17,520	352.44	7,912	16,723
9		at grade 6 lanes	W=32.5	528.10	12,002	25,205	528.12	10,944	24,147
10		at grade 6 lanes	W=30.5	491.06	11,232	23,509	491.08	10,238	22,515
11		at grade 6 lanes	W=28.0	475.65	10,485	22,376	475.64	9,580	21,471
12		at grade 6 lanes	W=27.0	464.01	10,153	21,753	464.00	9,278	20,878
13		at grade 6 lanes	W=28.5	450.55	10,411	21,675	450.56	9,498	20,762
14		at grade 6 lanes	W=32.5	500.60	11,789	24,304	500.60	10,738	23,253
15		at grade 6 lanes	W=35.5	330.84	4,403	12,674	330.84	3,231	11,502
16		at grade 8 lanes	W=37.5	620.70	13,927	29,445	620.72	12,711	28,229
17		at grade 8 lanes	W=35.5	583.66	13,157	27,749	583.68	12,004	26,596
18		at grade 8 lanes	W=37.5	593.20	13,714	28,544	593.20	12,504	27,334
19	Distributers	at grade 2 lanes	W=15.0	205.73	5,290	10,433	205.72	4,778	9,921
20		at grade 4 lanes	W=22.0	335.37	7,985	16,369	335.36	7,251	15,635
21	Busways	at grade 2 lanes	W=14.5	208.48	5,179	10,391	208.48	4,688	9,900
22		elevated 2 lanes	W=9.50	2,278.91	29,789	86,762	2,278.92	23,321	80,294
23	LRT	elevated	W=6.92	11,606.40	177,840	468,000	10,003.56	153,280	403,369
24	SRT	at grade	W=9.40	1,280.00	32,000	64,000	1,103.23	27,581	55,162
25		elevated	W=9.40	8,000.00	200,000	400,000	6,895.20	172,380	344,760

3) Indirect Cost

The temporary construction cost included in the indirect cost covers expenses of transport, installation, and removal of heavy machines and various plants, electric equipment, etc., those required for environmental protection and maintenance regarding noise and groundwater, those for site administration including safety measures, water, light and fuels, personnel and site administrative facilities. The general administrative cost includes expenses at the head office.

The indirect cost, unlike the direct cost, may vary greatly depending the contractor appointed for the actual construction work. As an accurate estimate is difficult, 25% of the direct cost is assumed with reference to other construction work in Bangkok. The foreign and local component ratio in the indirect cost is estimated to be 50%.

4) Engineering Cost

The design and supervision cost is calculated based on the assumption that there will be international bidding. Based on the available cases in Bangkok, it is estimated that the engineering cost is 10% of the total direct and indirect costs. Foreign and local components are assumed to be 50% of the total, respectively.

5) Contingency

This is composed of physical and price contingencies. The former is reserved for unexpected obstacles or incidents which may suspend the construction work. The latter is reserved for unexpected cost escalation during the construction period. This study only considers the former because the cost escalation is separately dealt with in the financial analysis.

Bearing in mind that there are many uncertain factors involved in the implementation of projects in urban area, 10% of the total direct and indirect construction costs and engineering cost are considered as physical contingency, which is the current practice in Bangkok.

6) Land Acquisition and Compensation Costs

Referring to the land value survey result of the "TISCO Real Estate Study, 1986/1987" and the estimated land costs in Ekamai Highway Feasibility Study Report, the percentage of land cost to the total road construction cost is computed as a basis for the estimation of land cost. The estimate procedure is more specifically as follows:

(a) Based on the result of the TISCO Real Estate Study, the land price of the study area is classified into five levels as shown in Figure 11.3.1.