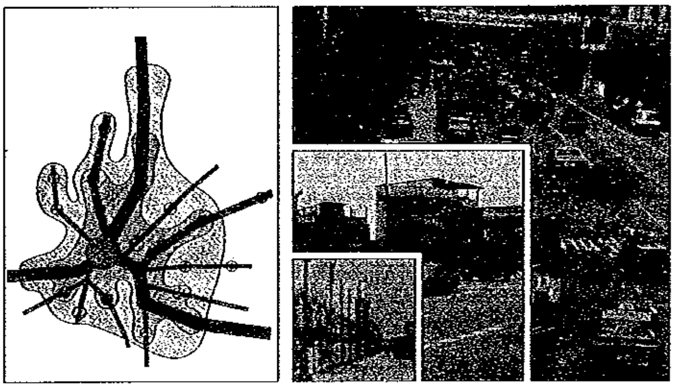
社会開発調査部報告書

THE STUDY ON MEDIUM TO LONG TERM IMPROVEMENT/MANAGEMENT PLAN OF ROAD AND ROAD TRANSPORT IN BANGKOK IN THE KINGDOM OF THAILAND

EXECUTIVE SUMMARY



MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Japanese Government decided to conduct a study on the Study on Medium to Long-term Improvement/Management Plan of Road and Road Transport in Bangkok and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Dr. Juro Kodera, and comprising of members from Yachiyo Engineering Co., Ltd., International Engineering Consultants Association and Almec Corporation from November, 1988 to March, 1989 and from May, 1989 to January, 1990.

The team held discussions with concerned officials of the Government of Thailand, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the realization of the project and the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

March, 1990

Kensuke Yanagiya
President
Japan International Cooperation Agency

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INTRODUCTION

1. Purpose and Background

The Bangkok Metropolitan Area has been suffering from traffic problems for a long time. Due to the rapid growth of population and vehicles during the high economic growth period in the latter part of the 1980's, the problems have became serious more than ever. Traffic jams are a daily occurrence in Bangkok and have reached a point where they obstruct the urban life and economic activity of the capital.

The Bangkok Metropolitan Administration (BMA) has given a top priority to the solution of traffic problems in the Metropolitan area. BMA has decided to formulate plans regarding short-term measures for the traffic control and medium- and long-term measures for the improvement of roads. In response to a request by the Government of Thailand to carry out a study regarding these measures, the Japanese Government through the Japan International Cooperation Agency (JICA), in conjunction with BMA and other related agencies, has been conducting the study since November 1988 with the following objectives:

a. To develop an medium- and long-term plan for the improvement of roads and road transportation .

b. To conduct a feasibility study regarding the introduction of an area traffic control (ATC) system.

c. To conduct a preliminary study regarding the need and practicability of common utility duct (CUD) system in the Bangkok Metropolitan Area.

d. To transfer technology related to the above points to the Thai side.

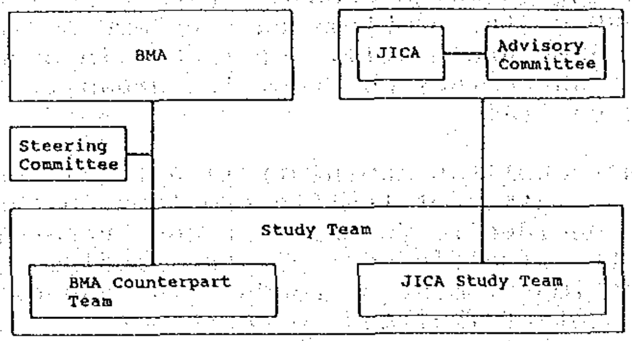
2. The Study Framework

The study consists of three main components: the medium- and long-term road plan, the ATC system, and the CUD system as outlined in the following Table.

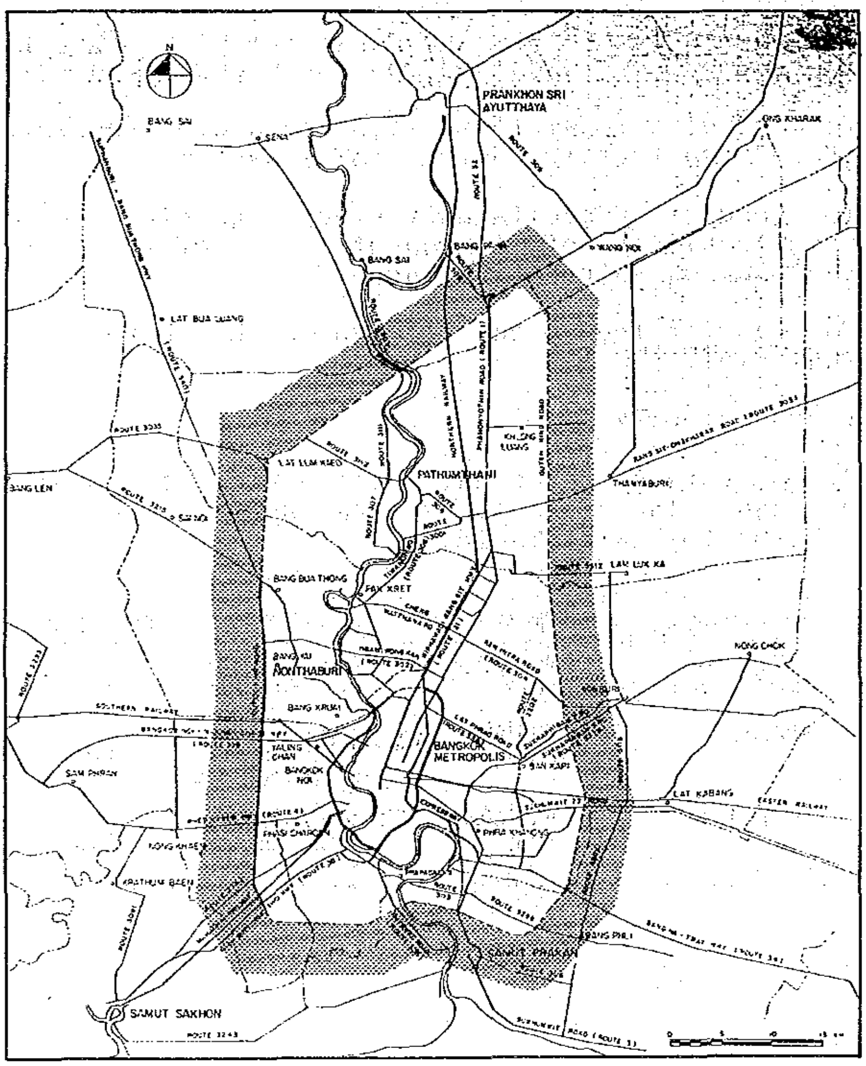
Study Component	Type of study	Area of study	Target year
Medium- and long-term road plan	Masterplan study	Area within the Outer Ring Road	2006
ATC project	Feasibility study	Area within the Middle Ring Road and adjacent areas	1992
CUD project	Preliminary study	Area within the Middle Ring Road	1993

3 The Study Organization

The Study was carried out by the Japan International Cooperation Agency in conjunction with the Bangkok Metropolitan Administration. The organization for the study is as follows:



4 The Study Area



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Mr. Akio Miyachi	System Planning
Mr. Setsuo Ninomiya	Common Utility Duct Planning

LIST OF ABBREVIATIONS

ROAD PLAN

BB	Budget Bureau
BCD	Building Control Division
BMA	Bangkok Metropolitan Administraion
BMR	Bangkok Metropolitan Region
BMTA	Bangkok Mass Transit Authority
BTS	Bangkok Transportation Study in 1975
BTSS	Bangkok Transit System Study in 1986
B/C	Benefit Cost Ratio
CAB	Cabinet
CCSD	Construction Control and Supervision Division
CMD	Construction and Maintenance Division
CMRT	Committee for the Manegement of Road Traffic
CPD	City Planning Division
DD	Design Division
DLT	Department of Land Transport
DOH	Department of Highway
DPP	Department of Policy and Planning
DPW	Department of Public Works
DTCP	Department of Town and Country Planning
ETA	Expressway and Rapid Transit Authority of Thailand
ETO	Express Transportation Organization of Thailand
FSE	First Stage Expressway
GDP	Gross Domestic Product
GRP	Gross Regional Product
HD	Harbor Department
HRT	Heavy Rail Transit
KSS	Elevated Toll Road above Klong Saen Saep
LRT	Light Rail Transit
LTCB	Land Transport Control Board
LTPC	Land Transport Polocy Committee
MOC	Ministry of Communication
MOF	MInistry of Finance
MOI	Ministry of Interior
MPB	Metropolitan Plice Bureau
MSTE	Ministry of Science, Technology and Energy
NESDB	National Economic and Social Development Board
NPV	Net Present Value
NSC	National Safety Council
OCMRT	Office of the Committee for the Management for Road Traffic
OFP	Office of Fiscal Policy
ONEB	Office of the National Environmental Board
OPM	Office of the Prime Minister
OPP	Office of the Policy and Planning
OPS	Office of the Permanent Secretary (BMA)
PCU	Passenger Car Unit
PD	Police Department
PT	Person Trip
PWD	Public Works Department
RWLD	Right of Way and Land Acquisition Division
SRT	State Railway of Thailand
SSE	Second Stage Expressway
STTR	Bangkok Metropolitan Short Term Transport Review
TD	Treasury Department
TED	Traffic Engineering Division
TPD	Traffic Police Division
TSES	Third Stage Expressway System
TTC	Travel Time Cost
VOC	Vehicle Operationg Cost

ATC SYSTEM

ATC	Area Traffic Control
BMA	Bangkok Metropolitan Administration
CCU	communication Control Unit
DET	Vehicle Detector
ETA	Expressway and Rapid Transit Authority of Thailand
FHWA	Federal Highway Administration
FSR	Frequency Shift Keying
GRM	Synchrinous Response Mode
MDF	Main Distribution Frame
MEA	Metropolitan Electricity Authority
OCMRT	Office of the Committee for the Management for Road Traffic
PCM	Pulse Code Modulation
PP	Pre-Processor of Vehicle Detector
PSK	Phase Shift Keying
SCAT	Sydney Highway Administration
TOT	Telephone Organization of Thailand
TTC	Travel Time Cost
TTR	Terminal Transmitter-Receiver
UTCS	Urban Traffic Control System
VA	Vehicle-Actualed
VOC	Vehicle Operating Cost

CUD SYSTEM

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standard Code for Pressure Piping
BMA	Bangkok Metropolitan Administration
CAB	Cable Box
CAT	Communication Authority of Thailand
CBD	Central Business District
CMD	Cubic Meter per Day
CUD	Common Utility Duct System
DDS	Department of Drainage and Sewerage, BMA
EGAT	Electricity Generating Authority of Thailand
ETA	Expressway and Rapid Transit Authority of Thailand
KV	Kilovolt
MEA	Metropolitan Electricity Authority
MTS	Mass Transit System
MVA	Megea-Volt Ampere
MWA	Metropolitan Water Works Authority
NESDB	National Economic and Social Development Board
PTT	Ptroleum Authority of Thailand
PVC	Polyvinylchloride
SRT	State Railway of Thailand
TOT	Telephone Organization of Thailand

PART 1

MEDIUM TO LONG TERM ROAD IMPROVEMENT PLAN

Part 1 Medium to Long Term Road Improvement Plan

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1. PRESENT CONDITIONS OF BANGKOK URBAN TRANSPORTATION

1.1 General

In Bangkok, continuous population growth associated with sharp increase in income and economic activities has led to an extraordinary rise in the number of vehicles. Among the many causes of Bangkok's chronic traffic congestion are too many vehicles using too few roads. The road system has been poorly developed; it lacks structural coherence and serves traffic needs inefficinely. Traffic congestion takes place not only during rush hours but also during off-peak hours in many locations. People travelling by vehicles (either private or public transport) not only have to spend a long time but also must be prepared for uncertainty in travel time. Oversaturated situation spoils the effectiveness of many existing traffic measures such as bus-lanes, one-way streets, etc. Traffic-caused environmental problems are becoming serious and threatening to the safety and amenity of Bangkok residents. While the worsening traffic situation is further aggravated due to the economic growth and urban development pressures, many projects face implementation difficulties.

There are various organizations related to urban transportation in Bangkok, comprising government agencies, statutory committees, ad-hoc inter-agency committees, and transportation associations. Among official agencies responsible for various aspects of planning, evaluation, approval, implementation, operation, maintenance or control of urban transport in Bangkok, functions of the major ones at different stages of activities are summarized in Table 1.1.

The value of transportation investments and expenditures made by various agencies in the past was approximately 2.4 billion Baht per year during 1977 and 1981, and 3.2 billion Baht per year during 1980 and 1984. The latter figure is roughly equivalent to 4.6 billion baht at 1989 prices.

1.2 Road Network

Bangkok is served by roads, river lanes and railways. However, the roads are practically the only urban transportation mode. Railways are largely for intercity transportation, and the once extensively developed water transport system has deteriorated except for Chao Phraya River. (See Figure 1.1)

The road network of Bangkok is composed of several major radial roads, a circumferential road surrounding the city centre, and minor roads and 'soi' providing access to the major roads. The First Stage Expressway system (27 Km) is also in service, connecting the three major intercity transport corridors together and with the port. Characteristics of the road network in the study area are as follows:

(a) The network is coarse and poor in both quantity and quality. Although the study area is served with about 980 Km of major roads and 2,800 Km of sois, the road availability (road area/area) is only 10.7% and 2.7% inside and outside the Middle Ring Road, respectively.

(b) Hierarchical structure of roads is inadequate and not clear. In particular, the deficiencies in secondary and distributor roads are critical. There are many "missing links" in the network.

(c) Absolute lack of roads outside the Middle Ring Road adversely affects the quality of transportation service and urban development to a large extent.

The major roads and bridges in the study area are currently constructed and managed mainly by BMA, DOH, ETA, and PWD. At present, there are no official design standards commonly applicable to the roads in the study area.

Table 1.1 Functions of Urban Transportation Agencies

Agency \ Function			Planning					Implementation									
									Roads								
			National Plan	Strategic Plan	General Plan	Specific Plan	Regulation	Bridge	National	Provincial	BMA/Municipal	Expressway	Rail Mass Transit	Railway	Bus	Bus Terminal	Land Acquisition
Central Government	OPM	NESDB	★	★													
Central Government	MOI	DTCP		★	★	★											★
Central Government	MOI	OCMRT		★	★	★											
Central Government	MOI	PWD					★	★		★							★
Central Government	MOC	DLT														★	
Central Government	MOC	DOH							★								★
State Enterprise	ETA (MOI)											★	★				★
State Enterprise	SRT (MOC)													★			★
State Enterprise	BMTA (MOC)														★		
Local Authority	BMA					★	★	★			★						★
Local Authority	Municipality					★	★				★						★
Private Sector	Private Company								★			★	★		★	★	

Statutory Committees
1. Land Transport Policy Committee (LTPC)
2. Committee for the Management of Road Traffic (CMRT)
3. Land Transport Control Board (LTCB)

Ad-hoc Committees
1. Bangkok Metropolitan Region Development Committee
2. Traffic Solving and Illegal Vehicles Management Committee
3. Rattanakosin Island Committee
4. Special Task Committee to Consider the Construction of Elevated Road above the Canals and Public Lands

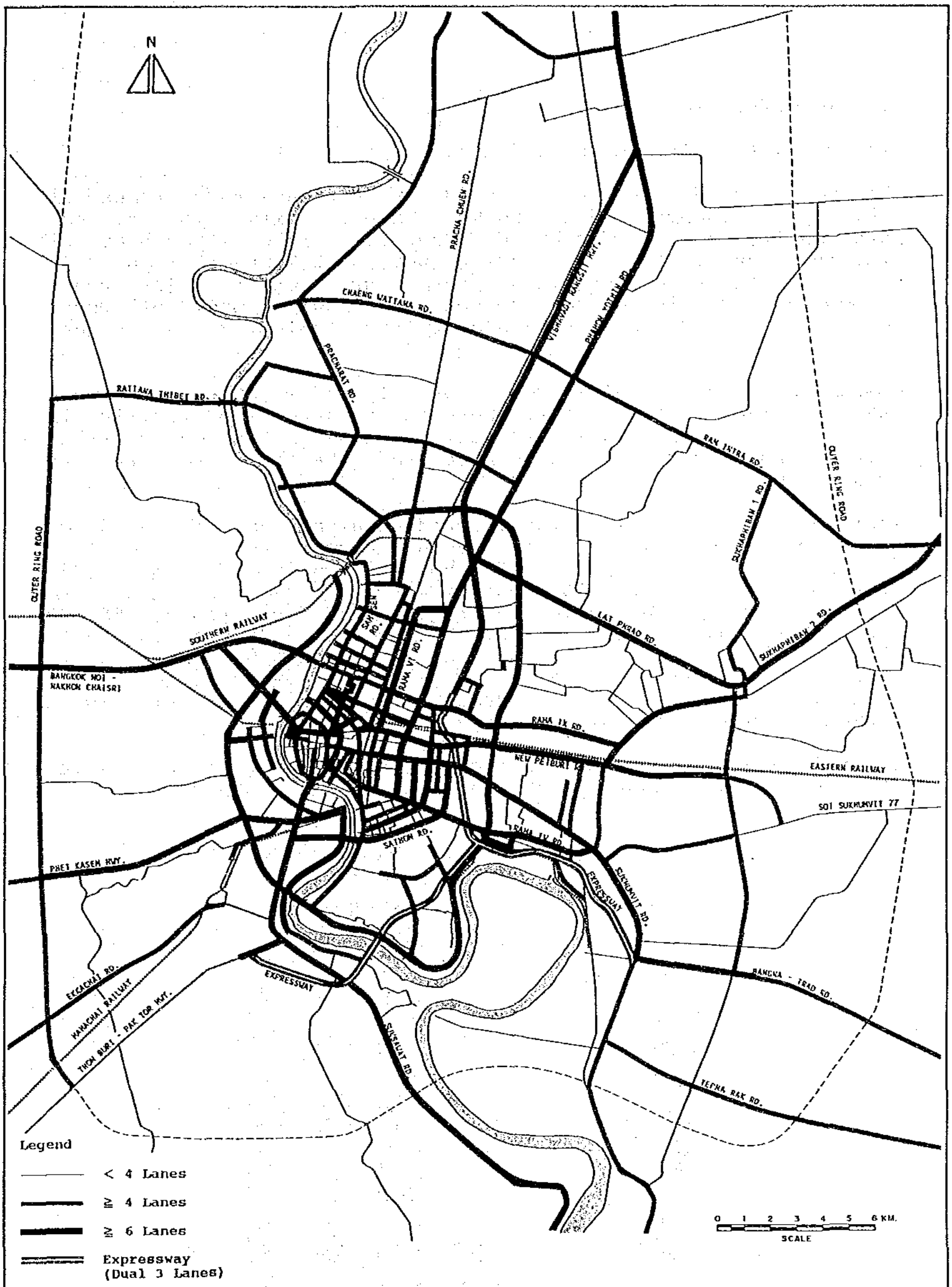


Figure 1.1 Road Network in Study Area

1.3 Road Traffic

1) Overall Traffic Level and Growth

The major roads are heavily used by various road transport vehicles; passenger cars, trucks, buses, taxis, motorcycles, paratransit, etc. Vibahavadi Rangsit carries the heaviest traffic, approximately 120 thousand pcu in 12 hours (7-19 hr) or 9 to 12 thousand pcu in a peak hour. Other major roads accommodate 30 to 80 thousand pcu in 12 hours. Many of these roads are already heavily saturated. (See Table 1.2 and Figure 1.2)

Comparison of road traffic volume on selected major roads between 1985 and 1989 indicates that there is no increase of traffic in the city centre but a significant increase in the outer area, around and outside the Middle Ring Road. The congested traffic area has been expanding.

Traffic crossing most of the 11 bridges along Chao Phraya River is also heavy. Total traffic volume across the screen line (along the Chao Phraya) is 480 thousand pcu in 12 hours (389 thousand vehicles and 170 thousand motorcycles). Bridges with relatively heavy traffic volume are Phra Pin Klao bridge (85,000 pcu), Phra Pok Klao Bridge (68,000) and Taksin Bridge (69,000). The increase of the screen line traffic between 1985 and 1989 is about 17% in pcu (or 18% in vehicular traffic and 36% in motorcycles). The sharp increase in motorcycle traffic is a common feature in the study area.

The volume of cordon line traffic defined as the traffic crossing the study area boundary is 397 thousand pcu in 12 hours.

Table 1.2 Traffic Volume on Major Roads, 1989

Road Name	PCU for both directions	
	12 Hour	Peak Hour
Vibahavadi Rangsit	116,300 - 126,300	9,300 - 12,000
Petburi	23,400 - 81,600	2,200 - 7,200
Rama IV	43,600 - 80,900	3,900 - 6,800
Sukhumvit	38,500 - 79,100	3,200 - 7,700
Din Daeng	53,900 - 73,700	4,800 - 7,700
Phaya Thai	41,300 - 72,800	3,000 - 7,000
Ratchadamnoen Klang	70,300	6,700
Sathon	65,500	4,600
Ratchadaphisek	49,200 - 60,500	2,900 - 3,900
Phahon Yothin	40,700 - 57,100	2,900 - 4,700
Somdet Phra Chao Taksin	54,500	4,700
Rama VI	37,900 - 54,000	3,200 - 4,100
Suksawat	55,000	4,900
Charan Sanitwongse	52,000	6,600
Ratchaprarop	42,400 - 50,200	3,300 - 3,700
Witthayu	32,000 - 49,500	2,400 - 4,600
Sukhumvit 21	31,700 - 48,200	2,400 - 3,200
Ratchawithi	31,400 - 43,200	2,600 - 3,300
Lat Phrao	42,900	3,300
Henri Dunant	33,900 - 38,900	3,000 - 3,100
Rama V	29,900	2,500

Source : SIMR

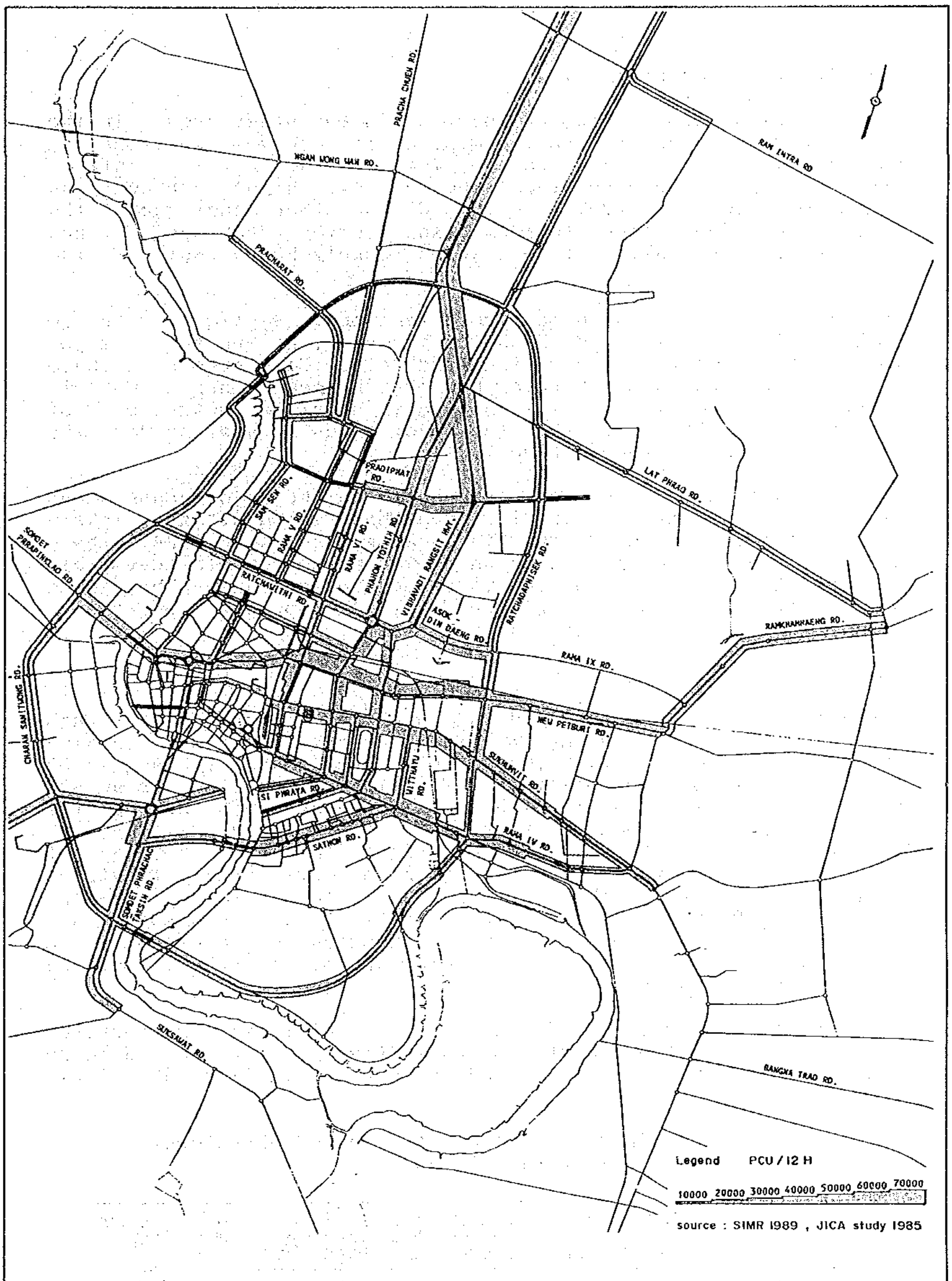


Figure 1.2 Vehicular Traffic Flow on Major Roads, 1989

2) Traffic Characteristics

Vehicle composition varies by location in the study area. In the city centre, passenger cars and motorcycles are dominant, sharing roughly 40 to 50% and 25 to 40% of the total traffic, respectively. The percentages increase even higher during peak hours to almost 85 to 90% by both. On the other hand around the study area boundaries (cordon line survey stations), truck traffic becomes significant sharing roughly 50 to 60% of the total.

Travel speeds are low in many road sections. Sections with 10 Km/hr or less are located in the city centre, at and around major intersections of the Middle Ring Road, etc. Congestions in these areas occur both in the morning and evening peak hours. Chronic congestions result in insignificant hourly fluctuation of vehicular traffic on most of the major roads in and around the Middle Ring Road. (See Figure 1.3)

Traffic accidents occur more frequently on the major roads such as Rama IV, Sukhumvit, Petburi, Phaya Thai, Sri Ayutthaya, Taksin etc., especially inside the Middle Ring Road. In 1988, there were 31 thousand accidents of which 76% were vehicle-to-vehicle (including motorcycle) and 20% involved predestrians. The causes were attributed to driving speed (47%), improper overtaking (27%) and improper turning (24%).

3) Parking

Parking situation was surveyed in a 9 Km^2 area surrounded by Chao Phraya River and Krung Kasem. The area has on-street parking space for approximately 32,000 cars. Parking density ranges 30 to 60% in most of the locations. The highest location has an 80% density. Hourly distribution does not vary much during the daytime, though the density is relatively high around midday due to business activities. One significant feature is the use of road space as garage by many residents and commuters. Off-street parking capacity of the surveyed area is 18,850 lots. Of the total, 12,100 lots (64%) and 6,750 lots (36%) are open space and parking buildings, respectively. Parking charges are collected for only 23% of the available parking space, and the remaining space is utilized free of charge.

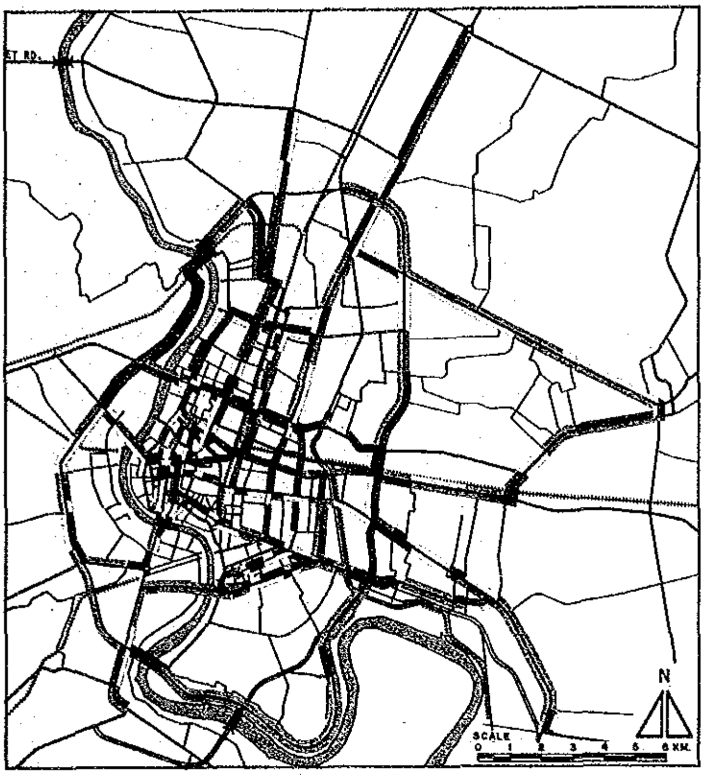
Utilization patterns of off-road parking facilities were surveyed at Central Chidlom Department, Wall Street Tower and Sathorn Thani. They vary by location and building use. (See Table 1.3)

Table 1.3 Characteristics of Selected Off-street Parking Facilities

	Capacity (No. of Lots)	No. of Cars Parked: Day	No. of Cars Parked: Peak Hour	% of Peak Hour	Ave. Parking Duration by Purpose 1/ (min)	Ave. Turn-over	Operating Hours
1) Central Chidlom Department Store	1500	6,023	1,067(15-16)	13.0	S= 85	4.0	10-20
2) Sathon Thani	750	2,085	502(10-11)	12.2	W=265, B= 66 R= 42, O=317	2.3	7-19
3) Wall Street Tower	500	1,156	272(9-10)	9.1	W=277, B=116 R=109, O=110	2.8	7-2

Source: SIMR parking survey 1/ W=to work, B=business, S=shopping, R=dining out, O=others

Morning Peak Hour



Evening Peak Hour

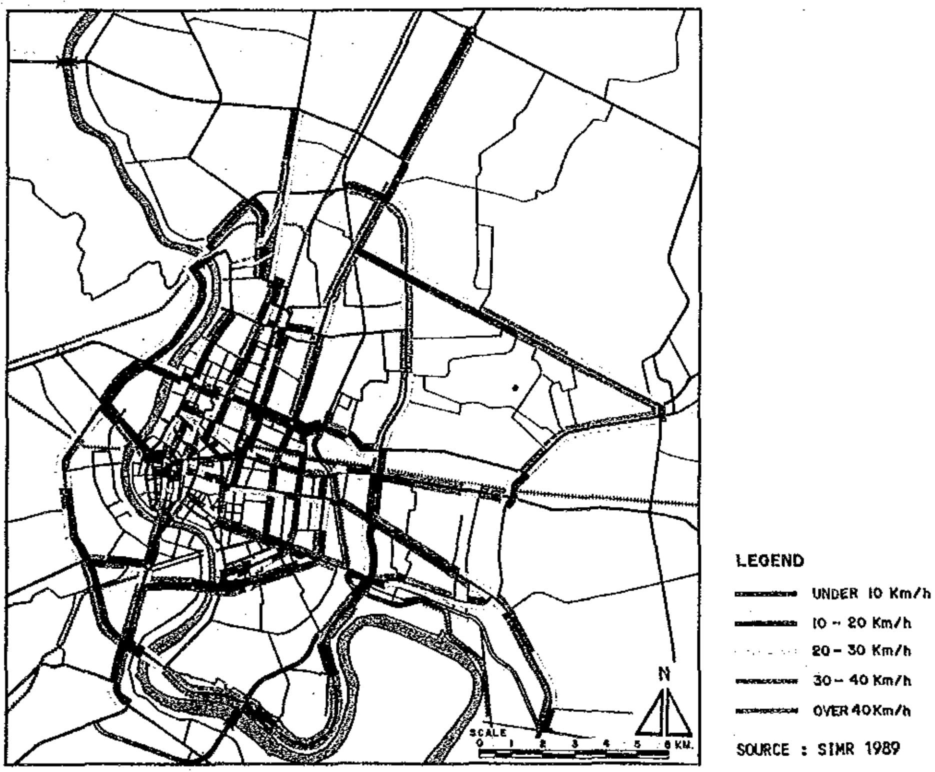


Figure 1.3 Average Travel Speed

1.4 Road Traffic Control and Management

The traffic control and management measures currently practised in the study area are briefly described as follows.

1) Signalization of Intersections

Most of the major intersections in Bangkok are signalized. Of the total 200 signalized intersections, 47 in the old city area are computer controlled with ATC system. Nearly all the signals are manually controlled at site by traffic policemen, who tend to operate at 2.5 to 8 minute cycles. Manual operations are based on assessments of the local conditions. Visibility of traffic lights is generally poor due to low location of the lights and small lenses.

2) Traffic Control Regulations

The major traffic control regulations are as follows:

One-way Traffic Regulations: There are many one-way roads. Major ones are Sukhumvit, Ratcha Prarop and Bamrung Muang. One-way circulation is clockwise and operated together with contra-flow bus lane, reversible lanes, and fixed unbalanced flow on arterial roads. However, it is observed that the coarse network density of the one-way roads causes excessive detour and resultant traffic congestions.

Unbalanced Lane Regulation: Main unbalanced lanes are practised on major roads in the congested areas. It seems they cannot meet the existing situation of frequently changing traffic demand.

Bus Lane Regulation: Usually, bus lanes are designed in contra-flow. Although they are strictly enforced by policemen, especially during peak hours, many of them are used by other vehicles.

Curb-side Parking Restriction: Parking is restricted on most of the major roads except for those in the old city. There are three types; whole day prohibition, prohibition during certain hours, and prohibition on certain days. Strict enforcement by policemen contributes to the reduction of violation.

Large Vehicle Prohibition Regulation: Four to six wheeled large vehicles are banned during 6:30-9:00 and 16:30-19:00, Monday through Friday. Large vehicles with 10 or more wheels are banned during 6:00-10:00 and 15:00-21:00, except for some roads. Heavy-long trucks are banned during 6:00-21:00, Monday through Friday.

1.5 Public Transportation

1) General

The public transportation system of Bangkok is dominated by road-based public transportation modes which consist of various types of buses (regular bus, air-conditioned bus and minibus), taxi and samlor, silor-lek and hired motorcycle. Buses are the most widely used mode. They are, however, supplemented greatly by other modes, especially hired motorcycle and silor-lek which provide important access services to the buses. River transport cannot be ignored in the area along Chao Phraya River. On the other hand, the railway's contribution to urban transportation is minimum.

Table 1.4 The Outline of Public Transport in Bangkok

Mode		Operator	Capacity (Person)	Service Area	No. of Routes & Units	Passenger (Thousand Pass./Day)	Fare (Baht)
Bus	Regular Bus	BMTA/Private	80	Main Road	Route= 144 Unit= 5348	4683	*2 2.0
	Air-Con. Bus	BMTA/Private	38	Main Road	Route= 19 Unit= 683	290	*3 5.0
	Minibus	Private	30	Main Road	Route= 60 Unit= 2151	1120	*4 2.0
	Total	BMTA/Private		Main Road	Route= 223 Unit= 8182*1	6093	
Taxi		Private	4	Main Road/Soi	Unit= 13493	466 *2	*6 18.0
Silor-lek		Private 7 Associations	6	Main Road/Soi	Unit= 7874	351 *2	*6 7.0
Samlor		Private 4 Associations	3	Soi	Unit= 7406	323 *2	*6 10.0
Hired Motorcycle		Private	1	Service for 829 Soi	Unit= 16588	577 *2	*6 6.5
Railroad		SRT			Route= 4 Station= 16	19	*7 2.0
Ship/Boat		Private		Chao Phraya River/Khlong		262	*8 0.5

Note: *1 Excluding Song Theao (No. of units = 3.016)
*2 Based on the survey result. (Taxi=34.5 Pass./Unit/Day, Silor=44.6, Samlor=43.6, Hired Motorcycle=34.8)
*3 Flat fare of blue regular bus
*4 Fare of air-conditioned bus within first 8 kms
*5 Flat fare of minibus
*6 Based on the survey result (Fare/Person/Trip)
*7 Fare of first 10 kms
*8 Fare of Chao Phraya Ferry

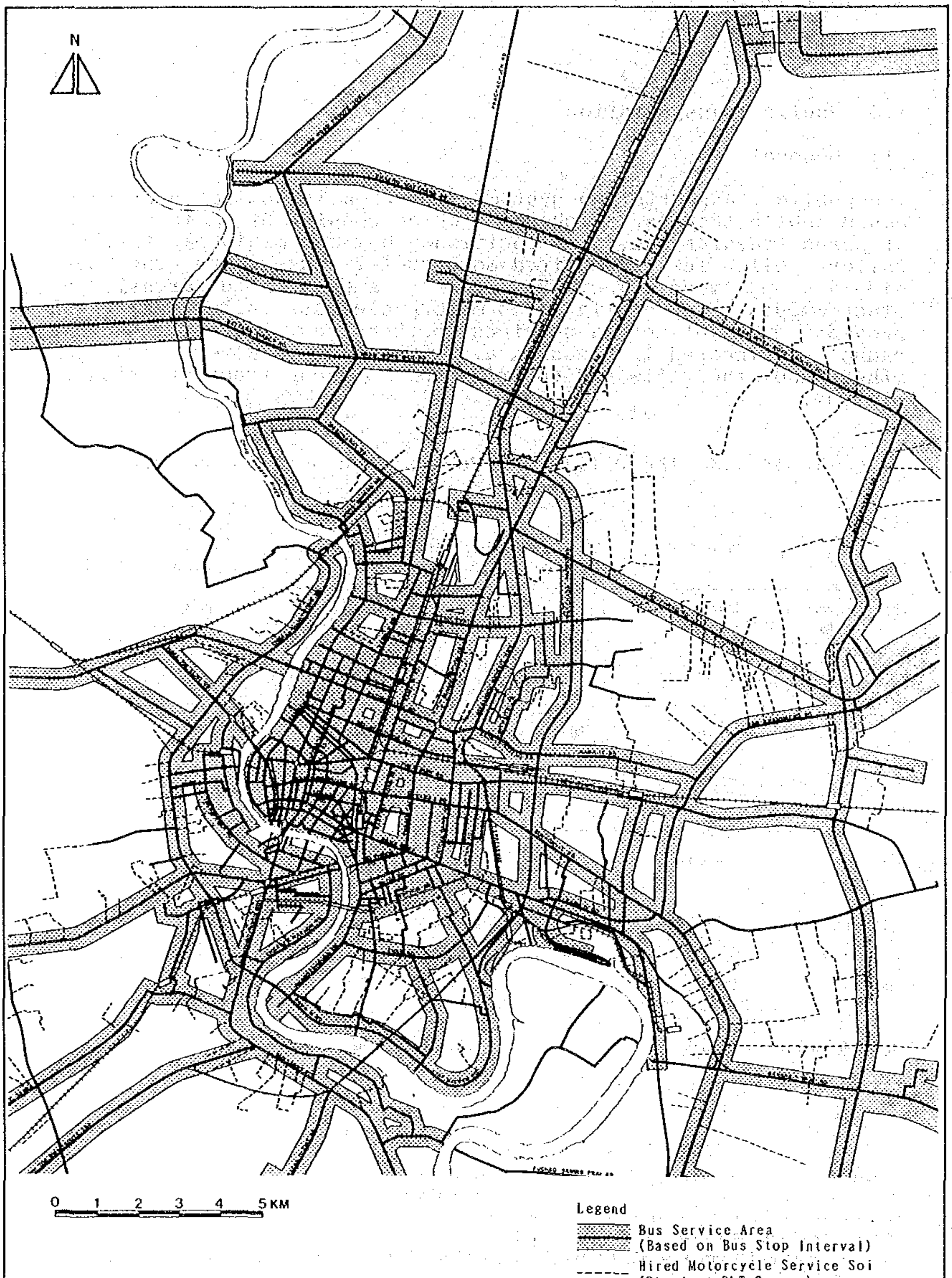


Figure 1.4 Coverage of Public Transport in Bangkok

2) Bus and Minibus

Of the total public transportation passenger demand of approximately 8.1 million a day in 1989, bus serves 6.1 million passengers or 76% of the total. Bus is composed of regular bus, air-conditioned bus and minibus. Regular bus and air-conditioned bus are operated both by a state-owned enterprise, BMTA, and a number of private companies, while minibus is entirely operated by the latter.

BMTA carries 3.8 million passengers or 62% of the bus demand with 4,220 regular buses and 420 air-conditioned buses. Although the buses provide basic public transportation services, it seems there is still much room for improvement to meet the ever increasing demand of the public in terms of quantity and quality. The main features of the existing bus services in Bangkok are as follows:

(a) Coverage of Bus Service: Due to the lack of adequate roads and road network for bus operation, large areas especially outside the Middle Ring Road are left without bus services. Inadequate road system also makes it difficult to configurate bus routes in such a way to meet travel demand pattern more effectively.

(b) Shortage of Bus Fleet: The fleet cannot be properly expanded, largely due to the financial difficulties of BMTA, which also contribute to the old and poor conditions of the fleet.

(c) Lack of Bus Measures: Although there is a number of bus priority measures including bus lanes, it seems they are not sufficient to meet existing demand. Capabilities of bus lanes alone are often lacking to accommodate the bus traffic demand. Unless more drastic measures are introduced, the gap between public transport and private transport services would further widen.

(d) Assessment of Bus Services by Residents: According to the questionnaire survey conducted in the study, the existing bus services (waiting condition, frequency, operation hours, fare, transfer, riding comfort, safety, noise etc.) are assessed by users as being generally acceptable except for strong dissatisfaction with noise, temperature in bus, safety and riding comfort of regular bus, and insufficient peak hour frequency and short operating hours of air-conditioned bus.

3) Other Road-based Modes

Taxi, Samlor, Silor and Hired Motorcycles have been playing important roles in Bangkok urban transportation system. In 1988, there were 13,500 taxis, 7,400 samlor, 7,900 silor and 16,000 hired motorcycles. Those modes carried approximately 1.7 million passengers a day and served 21% of the total public transportation demand. The current Government policy, however, places a ceiling on the number of these modes; 13,500 for taxi, 7,500 for samlor, and 8,000 for silor. This means the no more expansion of these modes can be expected unless the DLT policy is changed.

4) Railway

The existing SRT network is built for intercity transportation, and at the same time, it serves the area within 30 Km radius providing commuter service to a limited extent. Although it is planned to strengthen the railway's intra-city transport services, the capacity cannot be expanded significantly, unless the heavy road traffic at the existing 14 level crossings is properly managed. Elevation of the tracks is one of the measures to be examined.

5) River Transport

This once popular urban transportation mode has rapidly deteriorated and been largely replaced by road transportation. However, it is still important to the people who live along Chao Phraya River and in Thonburi. Of the total number of passengers of 313 thousand, 83% use ferry to cross Chao Phraya River, 4% use express boat along the river and 13% use long-tail boat inside the Klongs. It should also be noted that the travel time between Nonthaburi and Bangkok by express boat is shorter than that of bus.

2. FUTURE POPULATION GROWTH AND URBAN EXPANSION

2.1 Socio-economic Perspective of BMR

The recent high growth of the Thai economy will be maintained during the 6th Plan period. And the average annual growth rate of GDP in 1989-1996 is assumed to be at least 7%.

The BMR will continue to lead the national economy. Its GRP is expected to grow at a rate of 11.8% per year on average through 1996, which is the same level as in 1987.

In the long term, however, the economic growth will gradually slow down to a level of 5% per annum at the beginning of the 21st century.

The future population increase of the BMR will be greatly affected by the migration from provinces to the region. The above-mentioned rapid economic growth expected in the coming several years will attract many migrants from all over the country. The rate of population increase is assumed to be as high as 3.95% in 1989-1996 and gradually decline thereafter corresponding to the slowdown of the regional economy.

As shown in Table 2.2, the population of the BMR will increase from 8.5 million in 1989 to 14.1 million in 2006.

For the estimation of employment by sector, the following assumptions are made:

1) Agriculture

In spite of a considerably-high growth in recent years, particularly during the period 1985 through 1987, the long-term trend of growth will slow down due to decreasing farm land corresponding to urbanization.

The labor productivity will increase at an annual rate of 5 percent.

2) Manufacturing, Services and Others

The high growth rates of these sectors, achieved since 1986 and deemed to represent an economic boom, are to be sustained through the sixth plan period. Through this plan period the high growth rates experienced in 1986 and 1987 are applied to these sectors. After this period, the growth rates will return to the normal level experienced before the current industrial expansion.

About half of the growth of these sectorial products comes from the gain in labor productivity and the rest comes from the expansion of employment. Employment in these sectors will grow at half of the growth of the industrial product.

Table 2.1 Forecast of GRP Growth Rate, 1989-2006

(%)

	1989-1996	1996-2001	2001-2006
BMR	11.8	6.8	5.0
Whole Kingdom	7.0	6.0	5.0

Table 2.2 Forecast of BMR Population

(thousand, %)

	1989		1996		2001		2006
Population	8,513		11,164		12,631		14,083
Increase Rate		3.95		2.5		2.2	

Table 2.3 Forecast of Employment by Sector

(thousand)

Sector	1989	1996	2001	2006
Secondary	811	1,642	1,901	2,164
Tertiary	2,195	3,241	3,797	4,366
Total	3,206	5,049	5,850	6,658

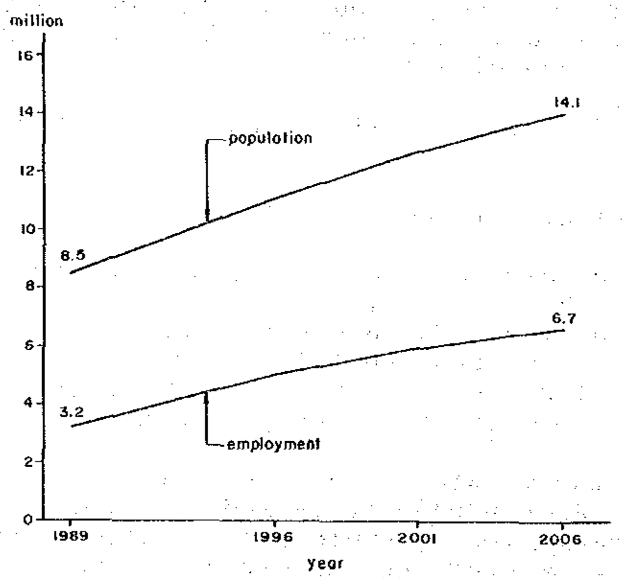


Figure 2.1 Forecast of Population and Employment

2.2 Urban Expansion

At present a chaotic mixture of various disordered urbanization movements are observed in the BMR.

The land use plans for 4 general planning areas in the study area are prepared by DTCP as shown integratedly in Figure 2.2. An area of 104,600 ha, accounting for 64% of the total study area of 164,000 ha, is designated as the urban land use area.

The location pattern of land use designation indicates low-density residential area all over the eastern area and medium-density residential area and non-residential use area along the trunk roads. This plan is based on the assumption that the population of BMA will be 7.6 million in 2001.

To form a perspective of future development in BMR, the following three typical urban development patterns are examined.

1) Corridor Development Pattern

Allowing the formation of ribbon-type urban area, appropriate communication facilities and other infrastructure will be constructed for more efficient and effective development of the urban corridor.

2) Concentric Pattern

Urban activities will be contained generally within the 30 km range. In order to build a high-density urban area, this pattern requires effective land use regulations and the building of an intensive and efficient urban infrastructure.

3) Polycentric Pattern

This will organize dispersed development operations into an organic system and build up the infrastructure required to promote the evolution of sub-centers.

Of these three, the concentric and polycentric patterns require substantial socio-economic and urban-planning efforts for their materialization. Compared with these two, the corridor pattern is basically in line with the trend of urbanization and requires less, though substantial, efforts for the building of good urban areas and for the appropriate setting and evolution of urban activities.

Development patterns provide a basis for the forecast of future population and employment by zone as described later. The population and employment of each zone will be a premise for the forecast of its traffic demand. Since the purpose of this study is to establish a transportation plan, it is questionable to base such a plan on premises heavily dependent on administrative actions. In view of this, this study will adopt the concept of corridor-type development for the assumption of the socio-economic framework.

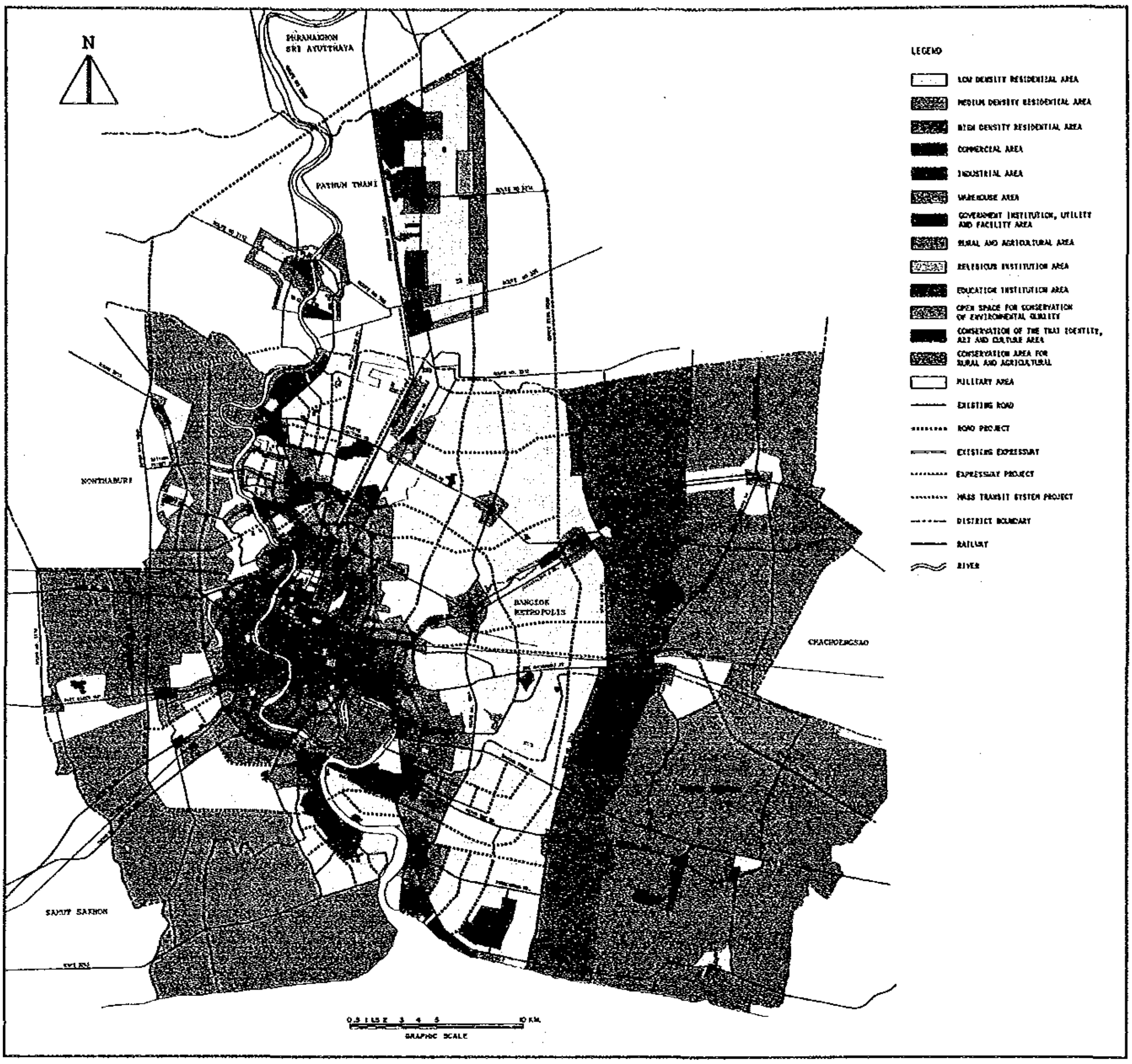


Figure 2.2 Land Use Plan based on General Plans

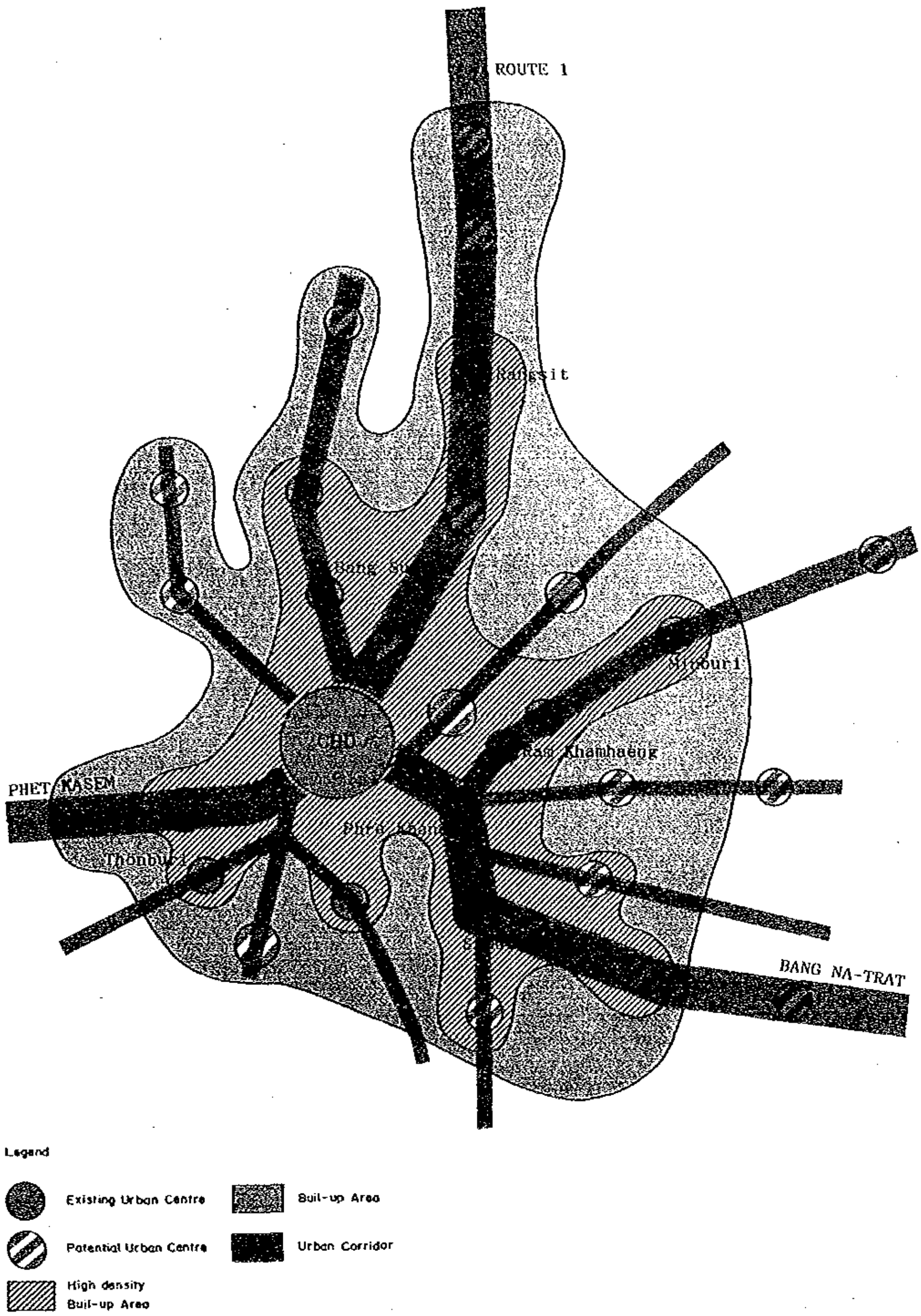


Figure 2.3 Urban Development Pattern

2.3 Demographic Framework of the Study Area

Based on the general plans and the future urban development pattern, the future population and employment in 2006 is forecast by zone in the study area.

1) Population

The population of the study area in 1989 is 6,357,000, accounting for 75% of the total BMR population of 8,513,000. The population of the study area in 2006, when the total BMR population will reach 14,083,000, is forecast based on the following conditions:

1. The rate of population increase in areas other than the study area is virtually equal to the rate of population increase in the total BMR in the 1980's.

2. Planned population by zone for the year 2001 provided in the general plan for BMA is regarded as a basis.

3. Population is distributed as heavily as possible in zones located along major trunk roads.

4. Referring to the general plans for BMA and others, a maximum limit of accommodation (or minimum limits for population decreasing zones) is computed for each zone to distribute population within the limit.

2) Employment

For the zone distribution of employment, the provincial trend of growth in each industrial sector is taken into consideration.

Next, the distribution to each zone will be made by working out sectorial location models.

Table 2.4 Summary of Population by Zone, 1989 and 2006

(in thousand)

	1989	2006	2006/1989
BMA	5,365	9,101	1.70
Inner	3,707	4,773	1.29
East	1,182	2,957	2.50
West	476	1,371	2.88
Samut Prakan	321	547	1.70
Nonthaburi	454	692	1.52
Pathum Thani	216	512	2.37
Study Area	6,357	10,852	1.71

Table 2.5 Summary of Employment by Sector and Zone, 1989 and 2006

(in thousand)

	1989				2006			
	Primary	Secondary	Tertiary	Total	Primary	Secondary	Tertiary	Total
BMA	18	487	1,724	2,229	11	1,206	3,319	4,535
Inner	11	331	1,346	1,688	7	683	2,350	3,039
East	3	103	282	388	2	331	695	1,028
West	4	53	96	153	2	192	274	468
Samut Prakan	2	47	70	118	1	132	175	308
Nonthaburi	15	35	102	152	7	95	231	333
Pathum Thani	7	40	43	90	3	121	106	230
Study Area	42	609	1,939	2,590	22	1,553	3,831	5,406

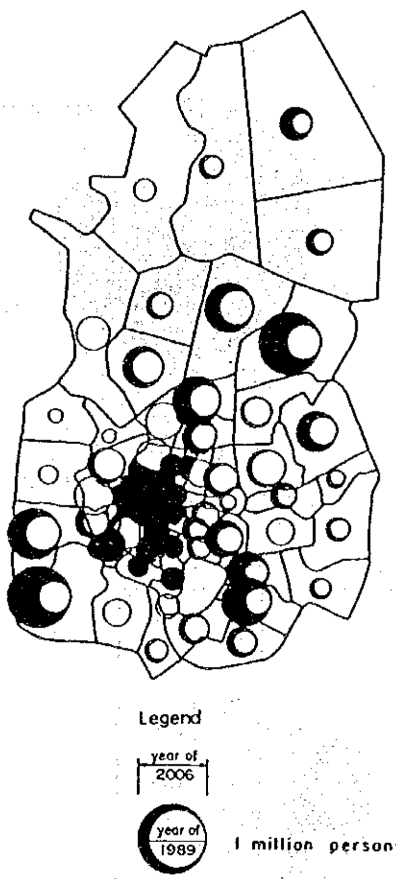


Figure 2.4 Population Growth by Zone

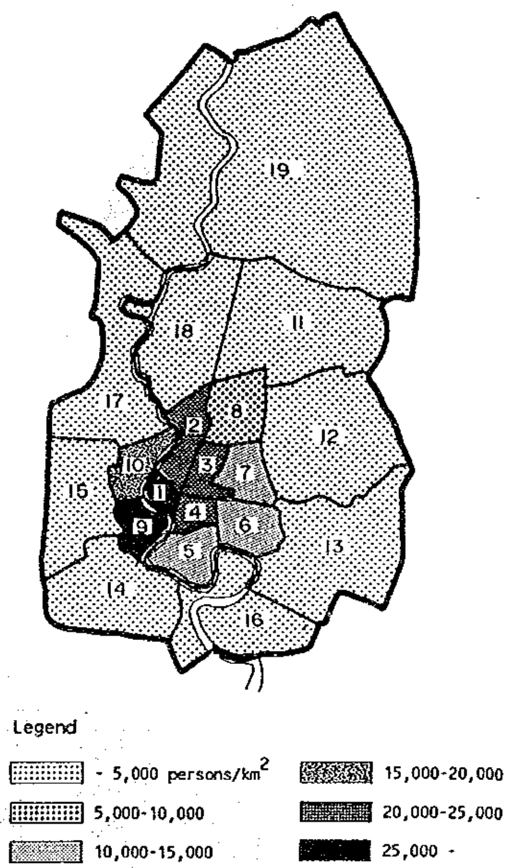


Figure 2.5 Population Density by Zone

3. TRANSPORTATION DEMAND INCREASE

3.1 Trip Production Rate in 1989

Currently, the study area population aged over five of 5.6 million, produces 12.5 million trips daily using motorized vehicles. The trip composition by purpose and by mode is shown in Figures 3.1 and 3.2, respectively.

Of 100 persons 82 go out daily and the others stay at home. Each person going out makes 2.70 trips per day in average. Thus, the gross trip production rate is 2.22 (2.70 x 0.82).

This trip rate varies considerably by vehicle-ownership. The rate is 3.21 for household members owning both car and motorcycle, while it is 1.57 for non-vehicle-owning household members (Figure 3.3). Vehicle-ownership raises people's mobility. In this study, these trip rates are regarded to remain unchanged in the future, in the estimation of the future transport demand.

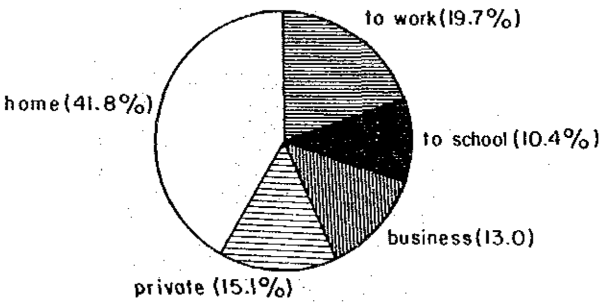


Figure 3.1
Trip Purpose Composition

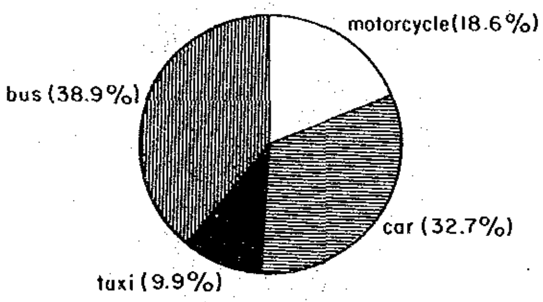


Figure 3.2
Trip Mode Composition

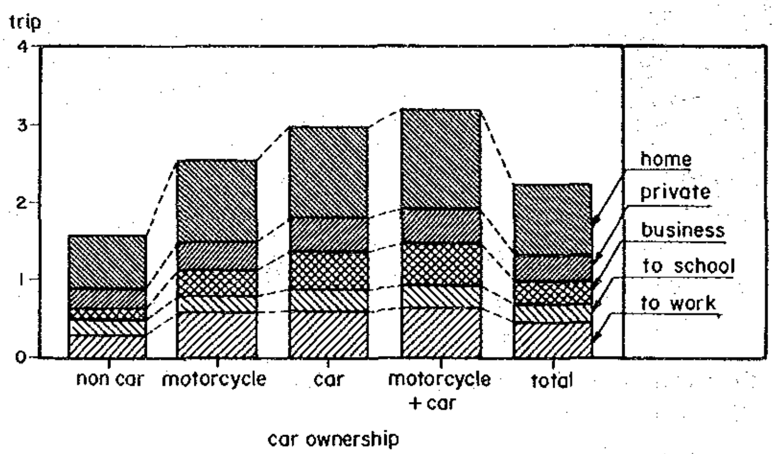


Figure 3.3 Trip Production Rate by Car Ownership

3.2 Future Car Ownership

To make a projection on vehicle-ownership based on the relationship between the ownership and household income, the motorcycle-owning household ratio will grow from the current 23.8% to 27.8%, and the car-owning household ratio from 30.7% to 36.2%, in the year 2006 (Table 3.1).

Table 3.1 Projection of Household by Car-ownership (1,000 households)

Ownership	1989 households (%)	2006 households (%)
Motorcycle	326.0 (19.0)	646.3 (22.1)
Car	443.4 (25.9)	891.6 (30.5)
M/C and Car	83.1 (4.8)	167.1 (5.7)
Non-owning	862.1 (50.3)	1,221.2 (41.7)
Total	1,714.7(100.0)	2,926.4(100.0)

Table 3.2 Projection of Vehickes (1,000 vehicles)

Vehicle Type	1989	1996	2006
Motorcycle	821.5	1,087.0	1,627.9
Car/Pick-up	972.1	1,353.2	2,170.5
Total	1,793.6	2,440.2	3,798.4

Note: including vehicles owned by governmental agencies and private companies.

By zone, in the central part of the city the vehicle-ownership will remain at the same level or decrease, reflecting the trend of population decrease, while a sharp increase is observed in the zone between the Middle Ring Road and the Outer Ring Road (Figure 3.4).

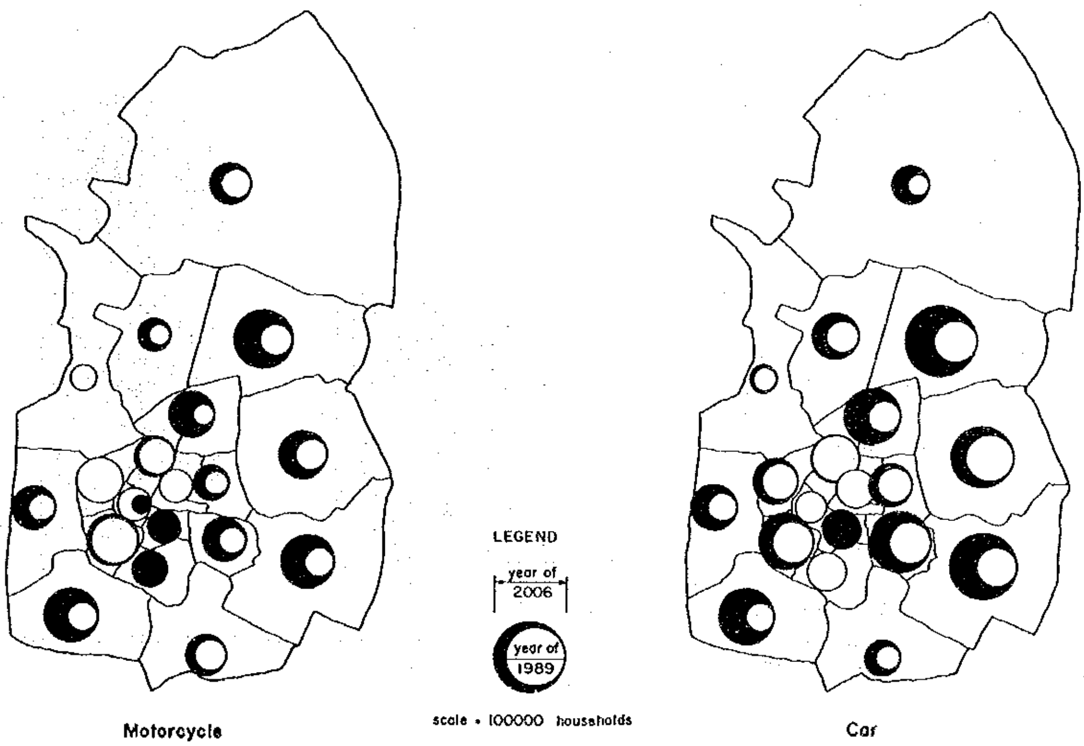


Figure 3.4 Vehicle-Owning-Household by Zone in 2006

3.3 Increase of Total Trip

Trips originating and ending in the study area will increase from 11.5 million per day in 1989 to 21.5 million in 2006. At the same time, trips originating or ending outside the study area and through trips will increase by 1.9 times and 2.0 times respectively (Figure 3.5).

By trip purpose, the largest share of internal trips in the year 2006 will be accounted for by returning-home trips, 46% of the total which remains almost at the same level as at present. The trip composition by purpose other than "returning home" is shown in Figure 3.6

The share of "commuting-to-work" trips is the second largest, 20% of the total, followed by "private (social, leisure, shopping and other purposes)" trips (13.3%), business trips (12.7%) and "commuting-to-school" trips (8.1%). The order will thus remain the same as in 1989, but a significant change will be the rise in the share of commuting-to work trips from 18.6% to 20.0%. These trips will occur mostly during peak hours and constitute the most critical element in transportation planning. It should be noted that the increased share of such trips in the future will create a major burden on the transport network.

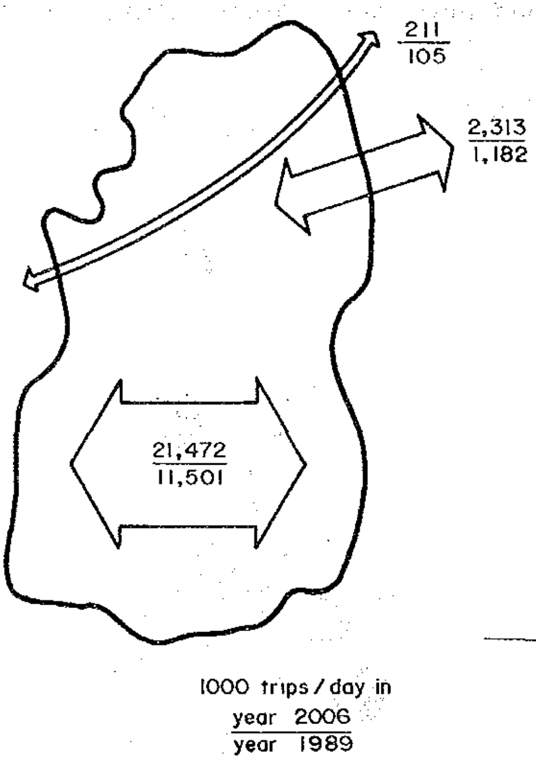


Figure 3.5 Total Trip in 1989 and 2006

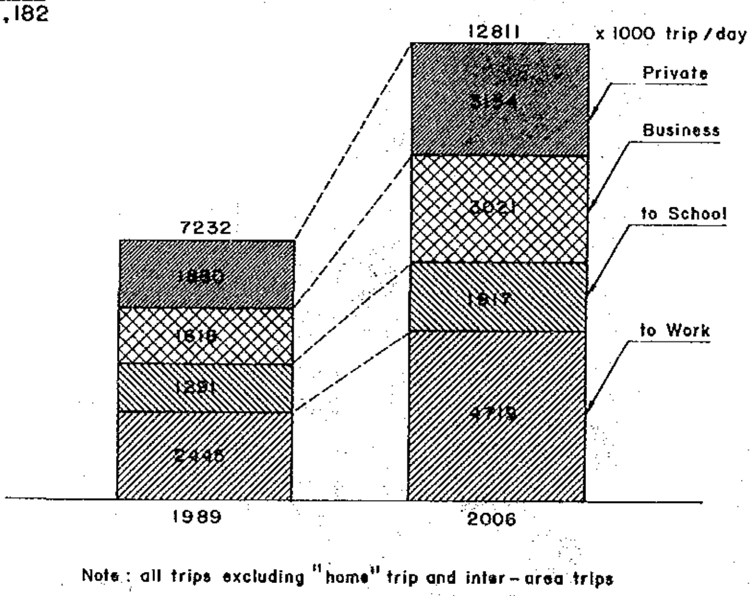


Figure 3.6 Trip increase by Purpose in 1989 and 2006

3.4 Trip Generation and Attraction

Since overall trip generation in a zone is more or less proportionate to the zone's population, those zones where a sharp increase in population is forecast, also expect to see a sharp increase in the number of trips generated.

Zones where generated trips will increase by more than two times in the year 2006 are: Ratburana (3.51 times), Taling Chun (2.82), Pathum Thani (2.76), Phra Khanong (2.70), Chatu Chak (2.61), Bang Khen (2.51), Muang Samut Prakan (2.13), and Muang Nontha Buri (2.09). All these zones are located in the suburban areas. Conversely, zones located in the central part of the city where resident population will decrease or remain unchanged will have a comparatively moderate increase in trip generation by 1.0 to 1.2 times.

Trip attraction will show a large increase in zones with a steep rise in population, zones where a new urban core will be established and zones where industrial development is planned. Zones where trip attraction will increase by more than two times are: Ratburana (3.33 times), Taling Chun (3.26), Bang Kruai (3.15), Phra Khanong (2.78), Muang Nontha Buri (2.42), and Muang Samut Prakang (2.19).

The ratio of trip attraction to trip generation is defined as the trip satisfaction rate within a zone. In 1989, 6 out of 19 integrated zones in the study area had a trip satisfaction rate of over 1.0. All these zones contain commercial, business or industrial centers. They are Phranakhon-Pomprap, Phaya Thai, Phathum Wan-Bang Rak, Sukhumvit, Chat Chak, and Bang Kapi. In the year 2006, in addition to the above 6 zones, the following 4 zones will have a trip satisfaction rate of over 1.0: Dusit, Thong Buri, Bangkok Noi, and Muang Nontha Buri.

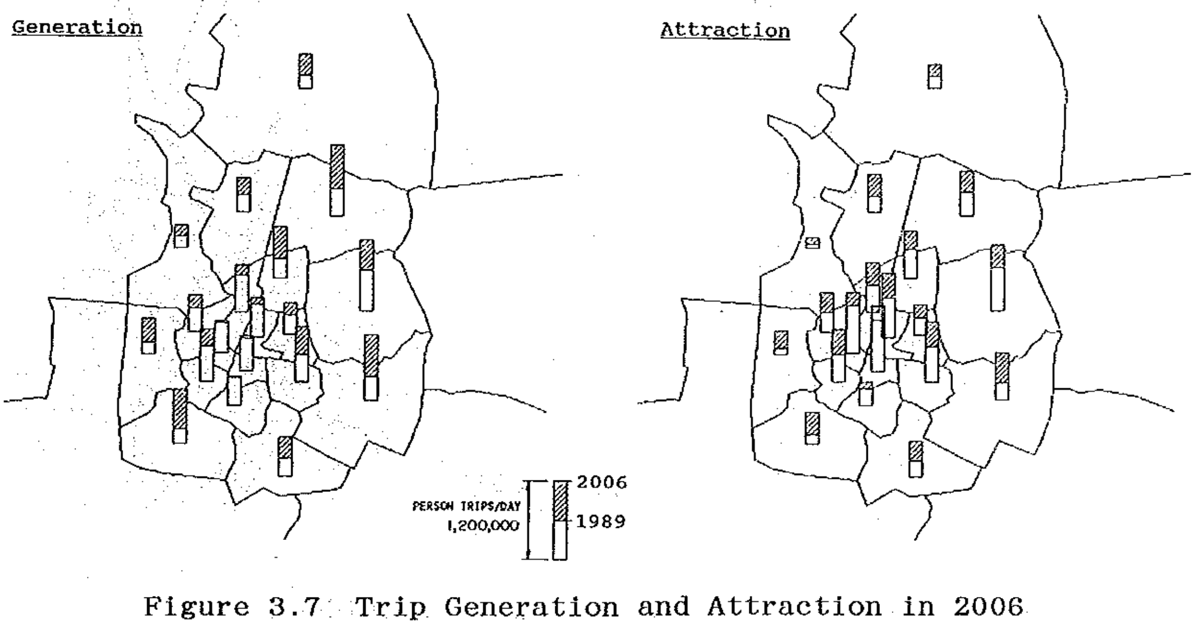


Figure 3.7 Trip Generation and Attraction in 2006

3.5 Trip Distribution

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. Zone pairs with especially large trip volume in the year 2006 are: Sukhumvit-Phra Khanong (271,400 trips/day), Bang Kapi-Phra Khanong (240,000), Bang Khen-Bang Kapi (219,000), and Phranakhon/Pomprap-Pathum Wan/Bang Rak (215,000).

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 spider network figures for 1989 and 2006, the drastic changes forecast to occur are very impressive. In the former figure, 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.

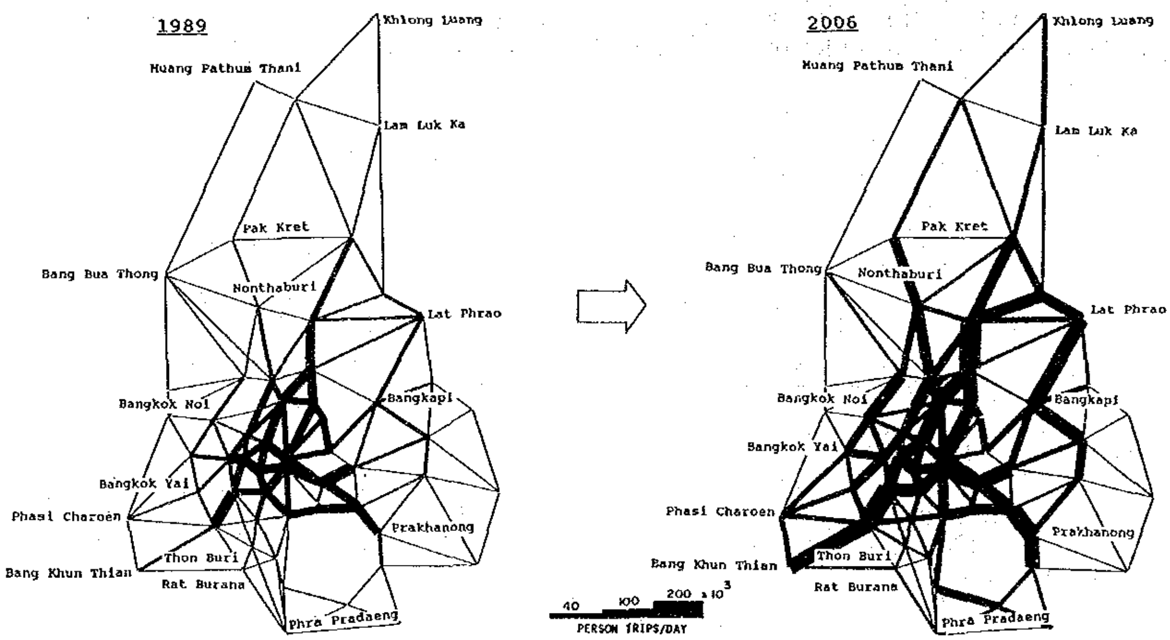


Figure 3.8 Trip Demand Assigned to Spider Network

Observing the future trip increases in the inner BMA area and in radial directions from there (Figure 3.9), trips inside the inner BMA area will increase by 1.4 times while in almost all the radial directions, trips will more than double. However, in absolute number internal trips are significant, exceeding 10 million trips per day.

3.6 Trip Length

The future expansion of the urban area will increase the trip length in the future. 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.

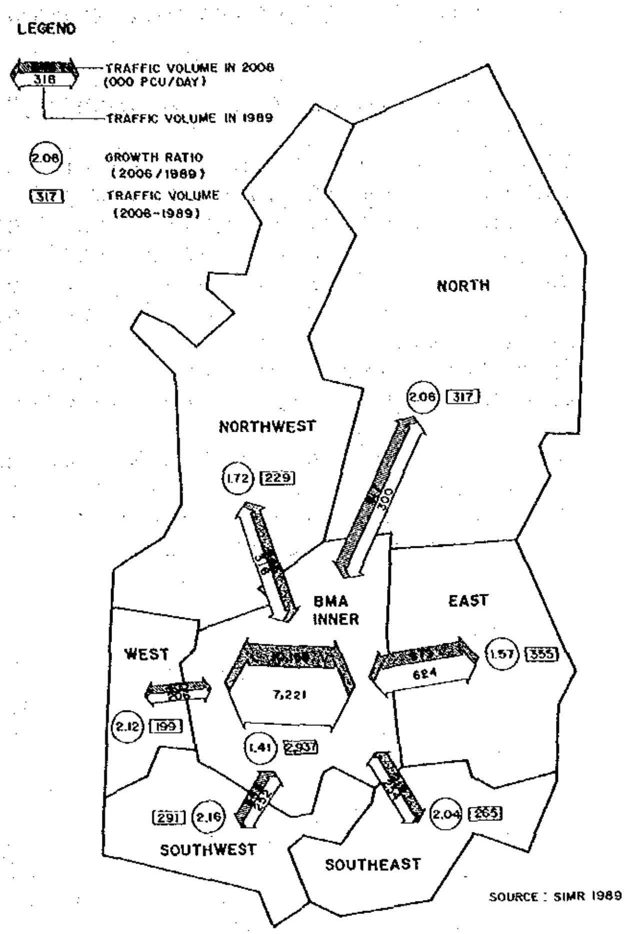


Figure 3.9 Trip Increase by Direction

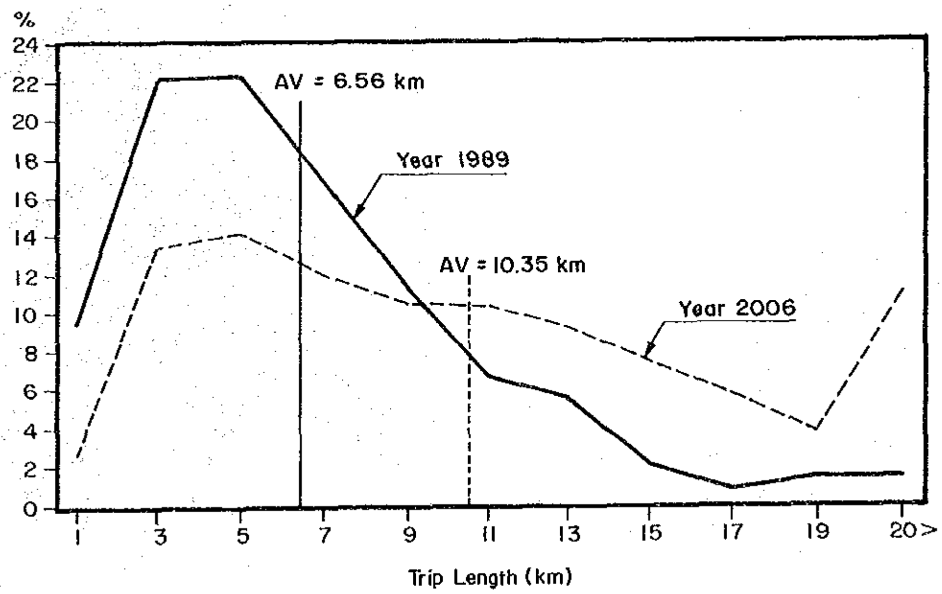


Figure 3.10 Trip Distribution by Length

4. FUTURE TRANSPORTATION NETWORK

4.1 Analysis on the "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. As shown in Figure 4.1, 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 and running speed would fall below 5 km/hour. The average ratio is estimated at 2.2.

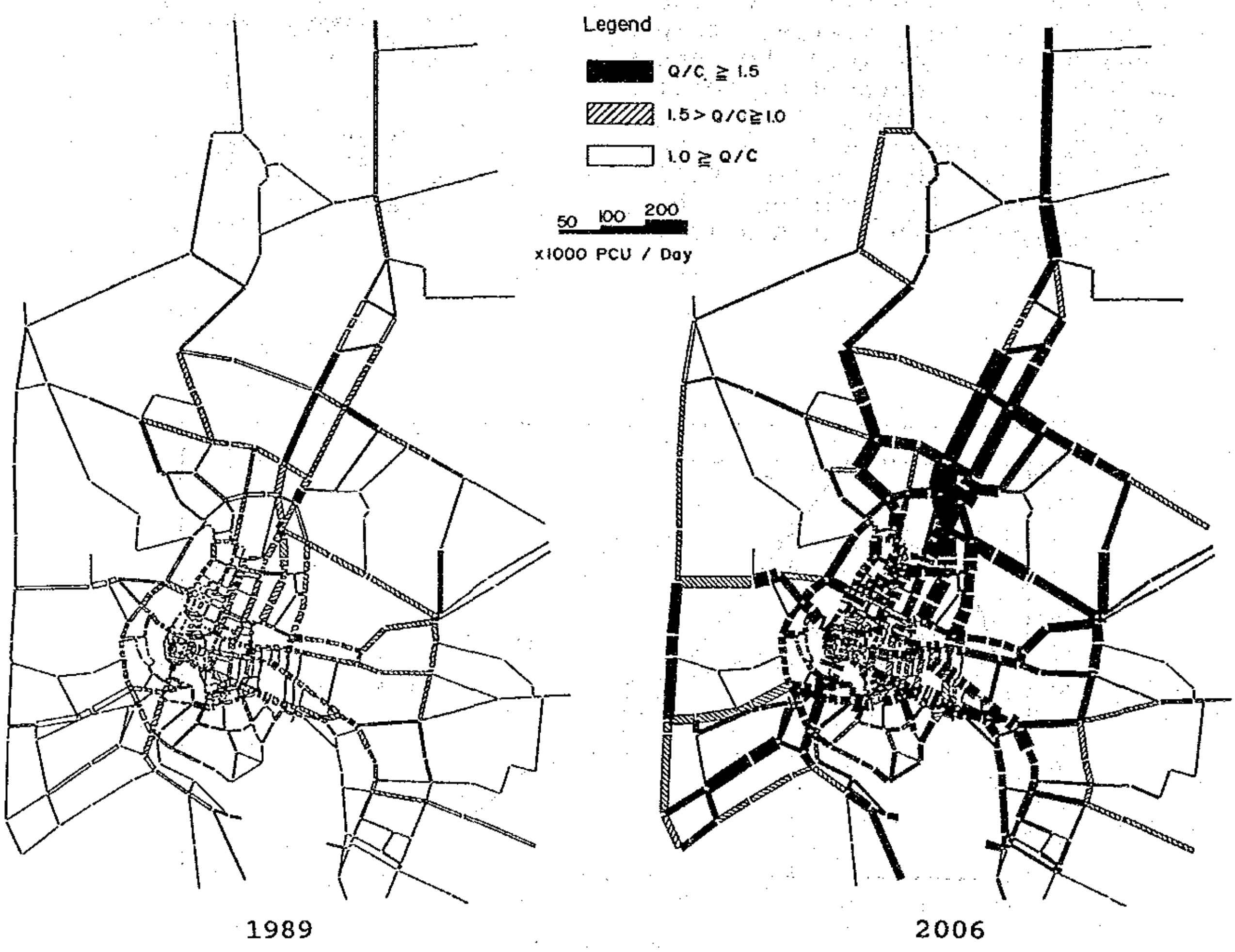


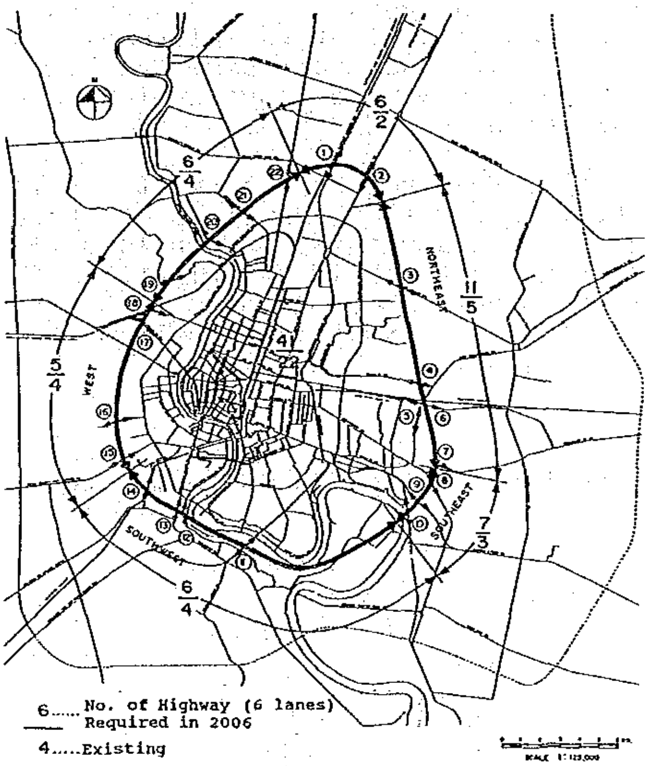
Figure 4.1 Assigned Traffic in "Do Nothing" Case

4.2 Network Development Requirement

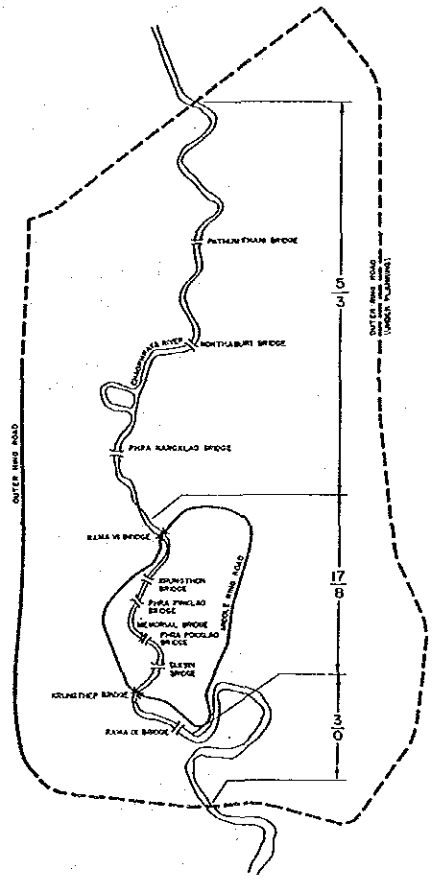
Based on the future O-D table, an analysis was made on traffic demand increase by direction and necessary road quantity to meet that demand. At present 22 main roads intersect the cordon line drawn just outside the Middle Ring Road, having a total capacity of 1,640,000 in terms of passenger car unit (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 4.2 Network Development Requirement by 2006

4.3 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 constraints.

Basic policies for preparing the maximum-size network are:

a. The network consists of four types of facilities; expressway, at-grade main road, bus-way and rail transit.
b. All the existing plans and projects are considered, and the 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 4.3 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 projects of total extension 420 km.

Rail transit system is classified into Light Rail Transit (LRT) and Heav Rail Transit (HRT). The former network consists of three lines already planned as 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 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.

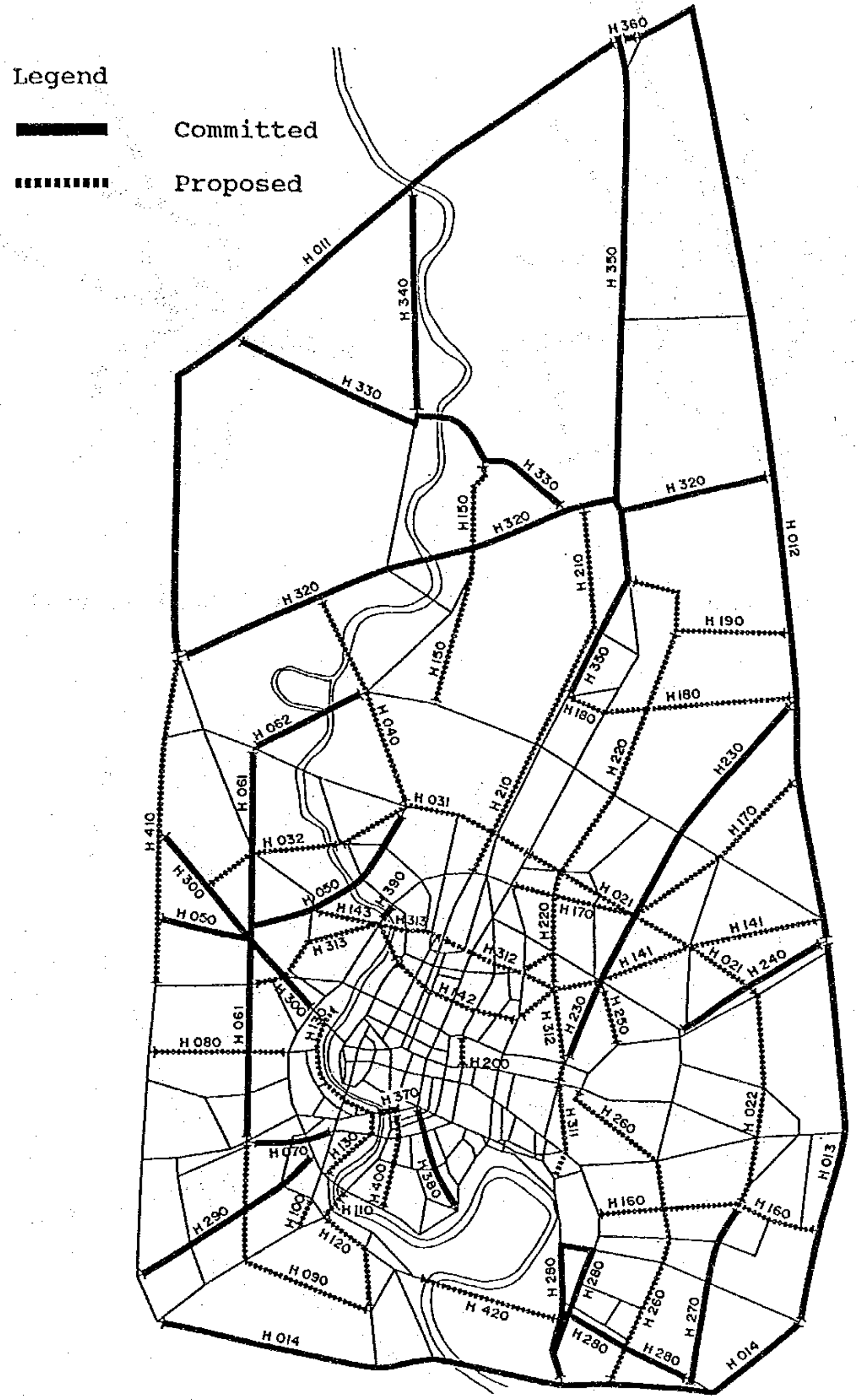


Figure 4.3(1) Maximum-size Network (At-grade Main Road)

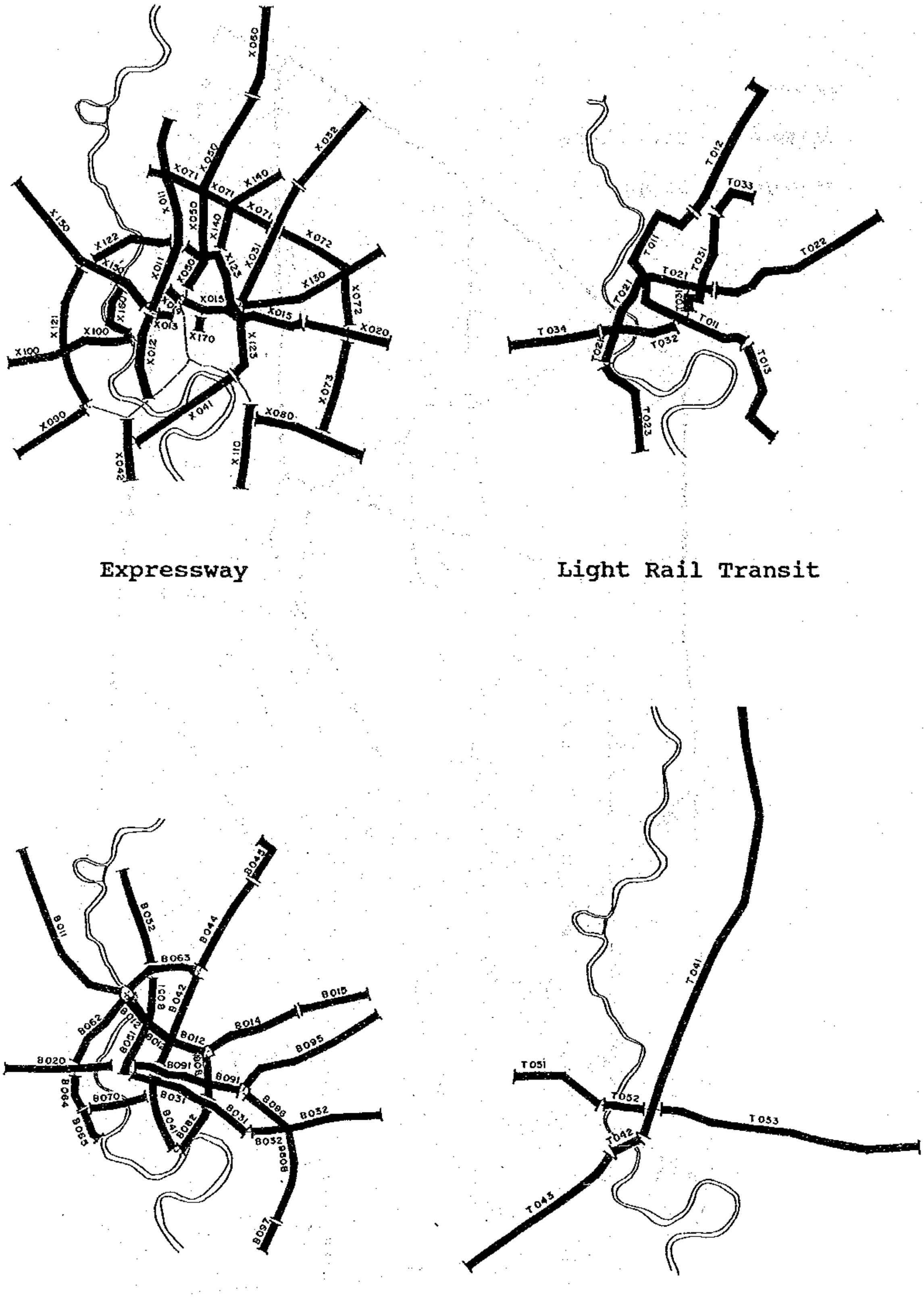


Figure 4.3(2) Maximum-size Network

Figure 4.4 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.

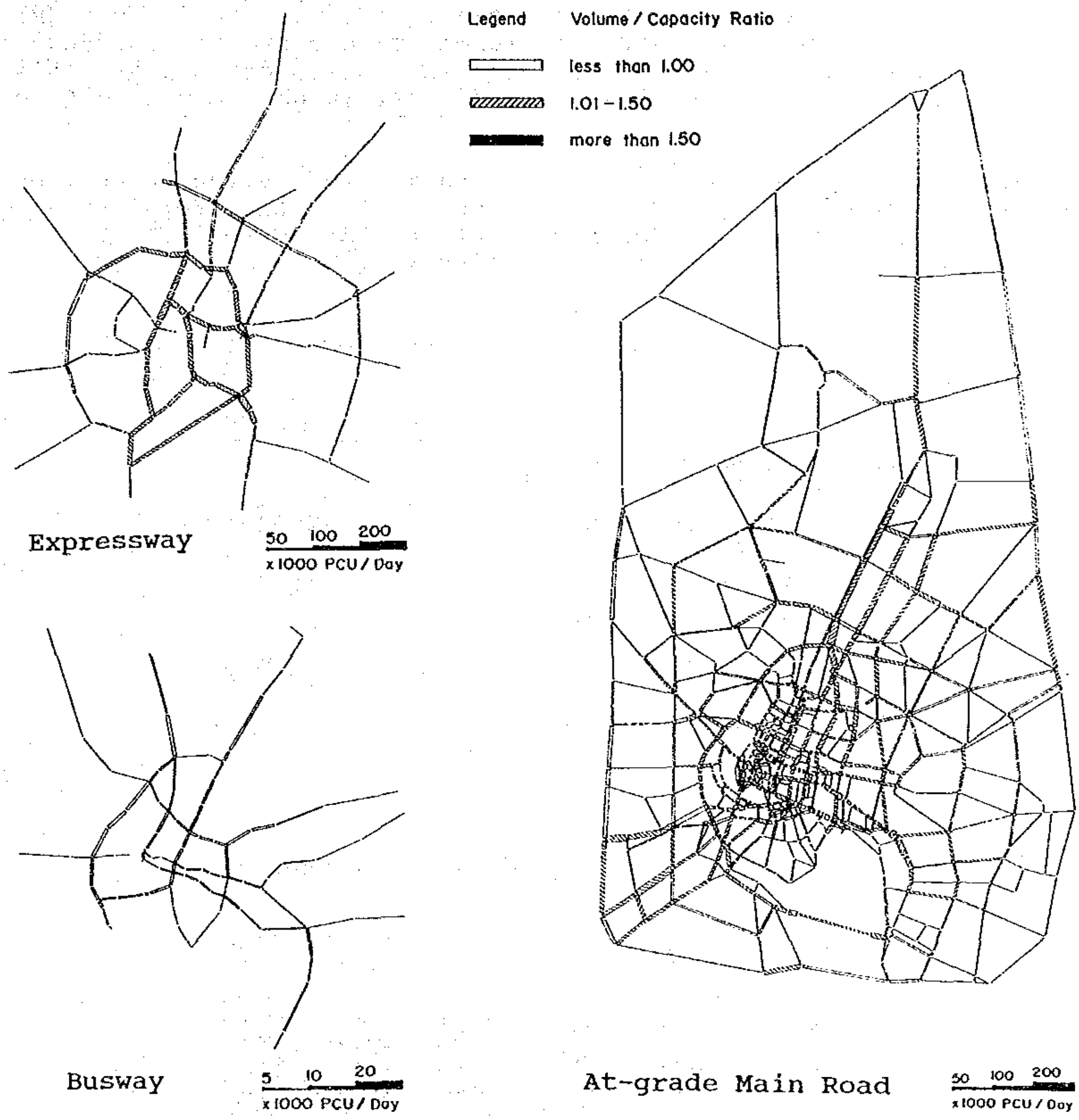


Figure 4.4 Assinged Traffic Demand in 2006 to the Maximum-size Network

4.4 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, bus-way, LRT and HRT projects. By examining traffic assignment, each 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.

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 4.2 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 4.3 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

4.5 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-oriented (LRT and HRT) 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 4.5).

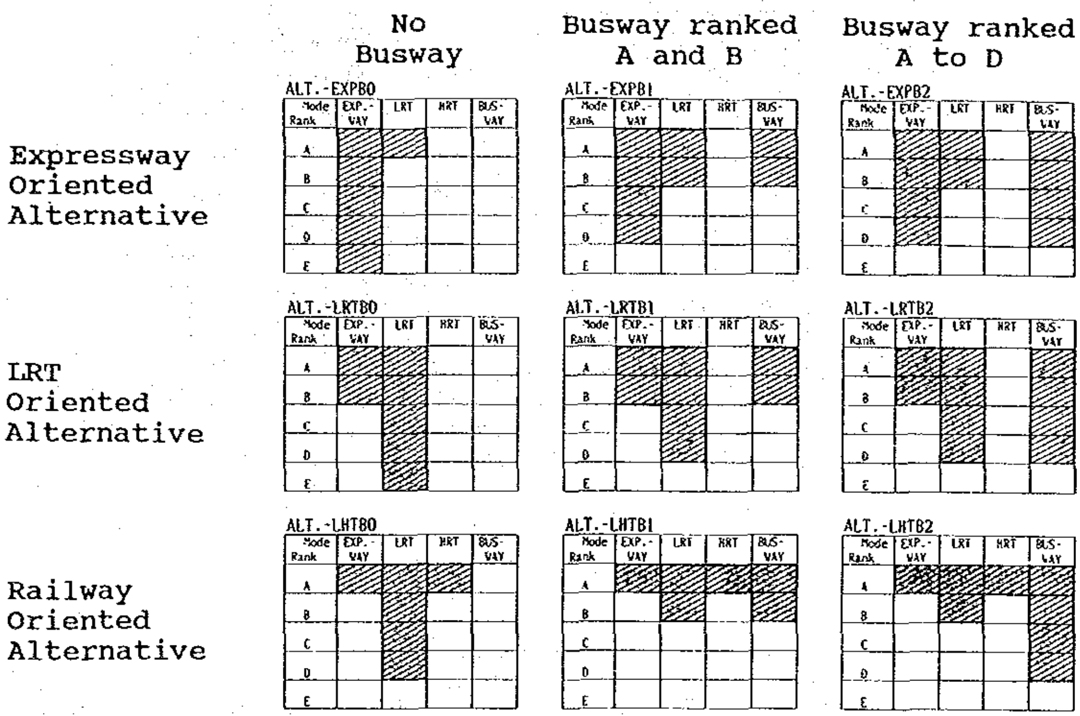


Figure 4.5 Project Combination for Alternative Networks

Table 4.4 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% interest rate.

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

Table 4.5 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.

4.6 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 viewpoints:

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 to decrease 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 systems. Otherwise, the advantages of the rapid systems 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 194 km bus-ways in the maximum-size network, 126 km 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.

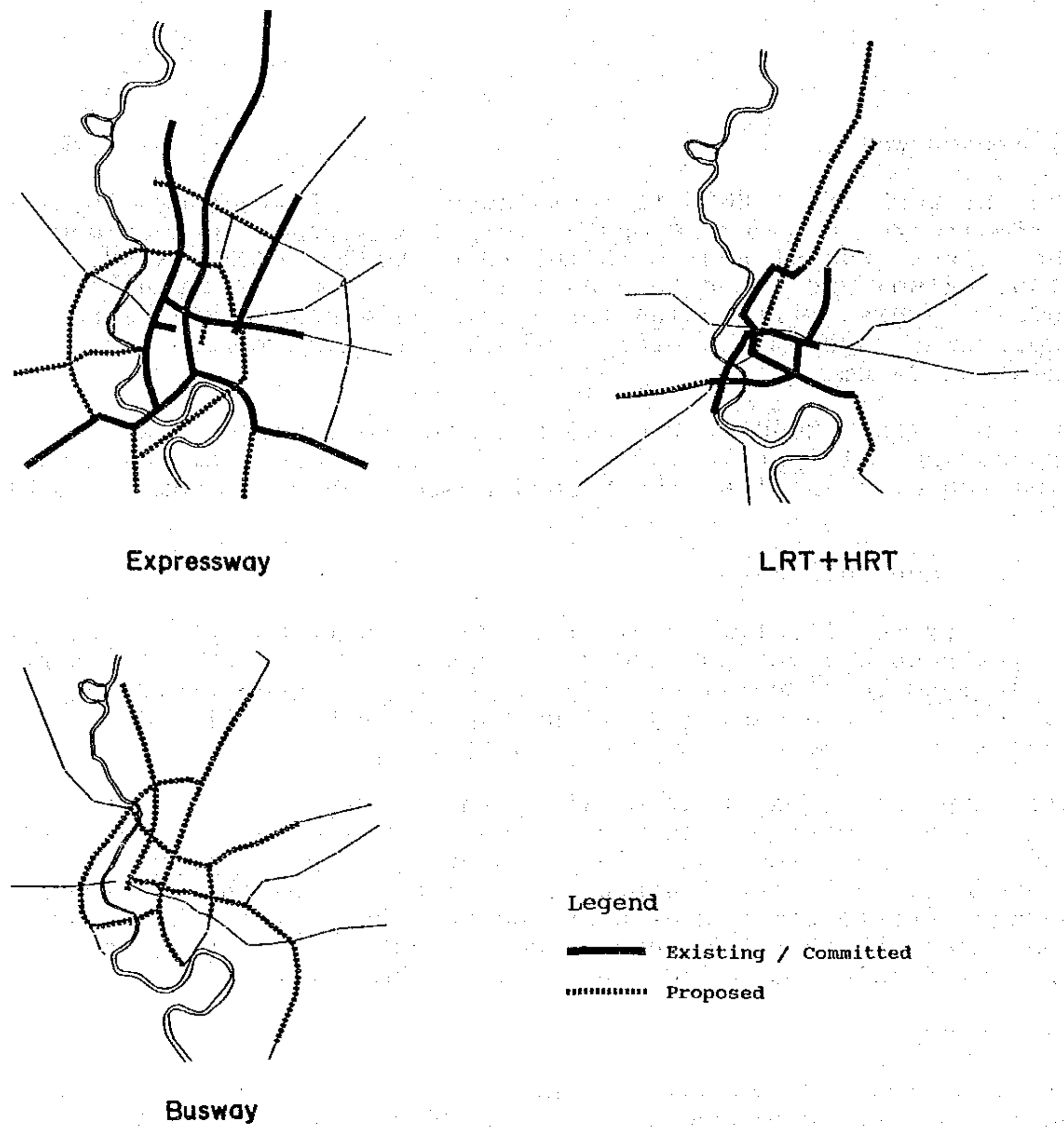


Figure 4.6 Selected Sections for Year 2006 Network

Although the connection of the SRT North line with the Samut 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.

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 at the same level as present.

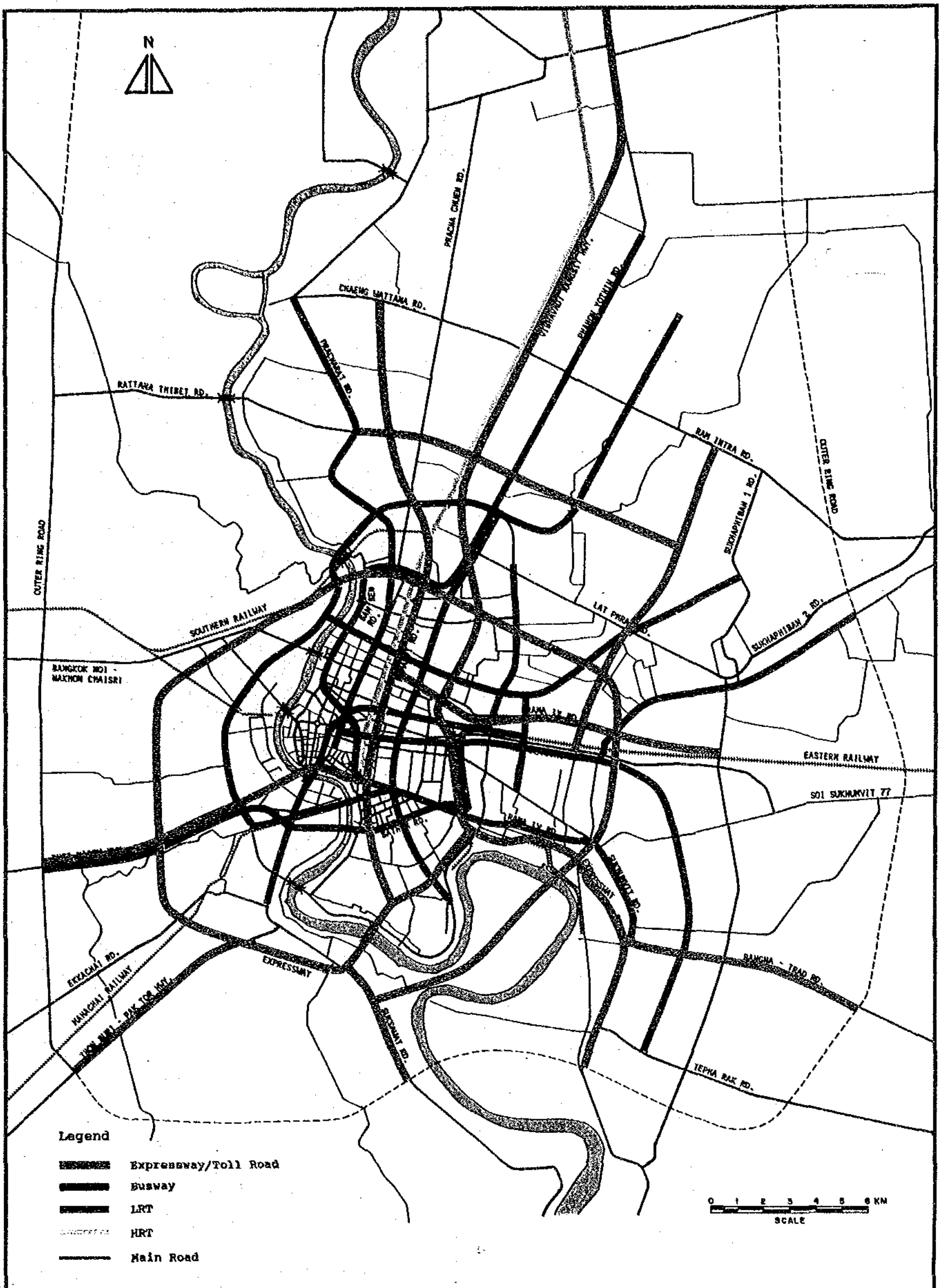


Figure 4.7 Proposed Transport Network for 2006

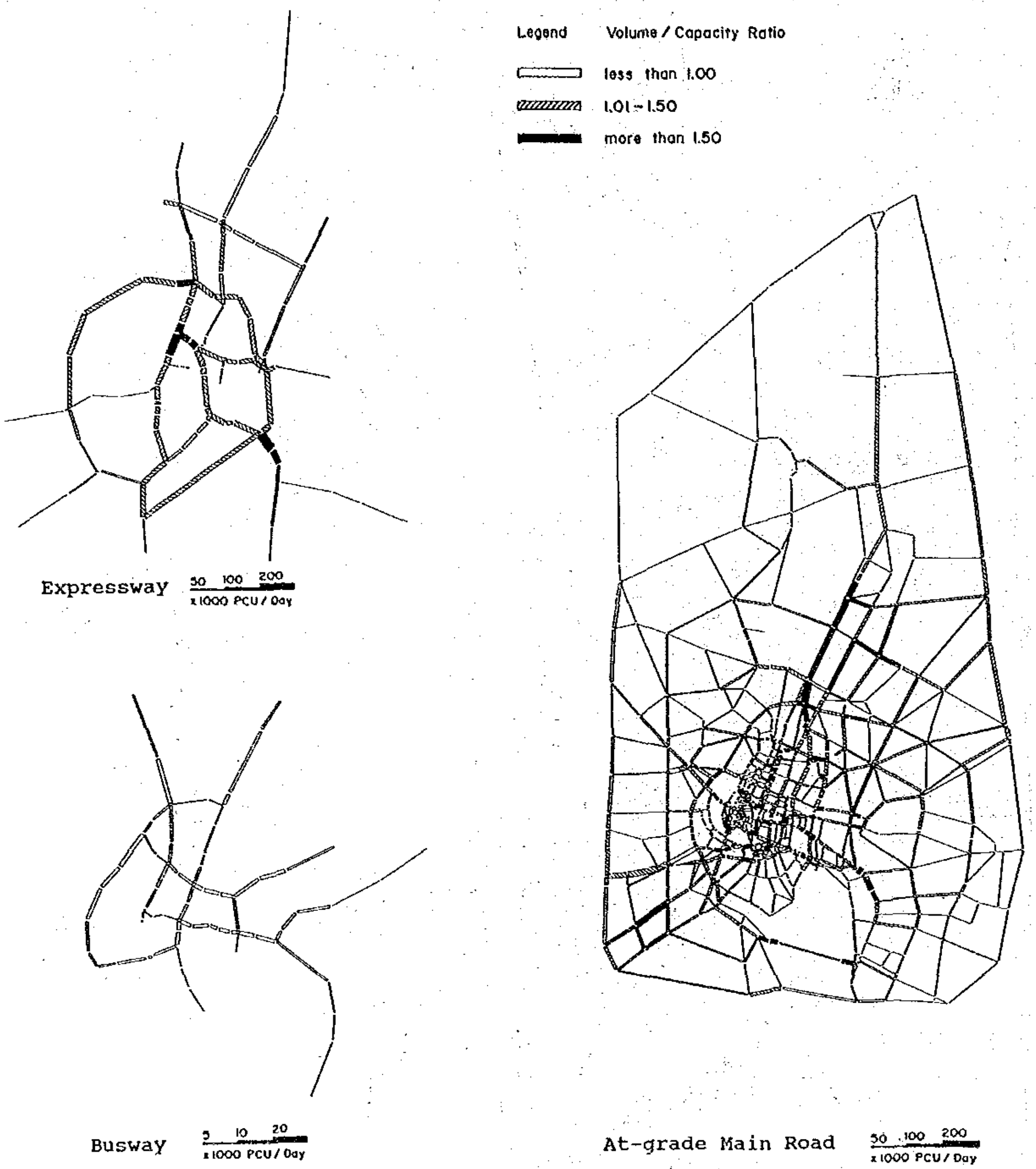


Figure 4.8 Assigned Traffic to Network in 2006

Table 4.6 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

5. ROAD NETWORK DEVELOPMENT PLAN

5.1 Overall Road Network Plan

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:

1) 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 are instantly built up, while large pocket areas are left undeveloped behind the roads. Considering that future car traffic demand will remain strong and financial viability of expressways is relatively high, development of expressways and toll roads network will be a practical way of securing a primary road system in Bangkok.

2) Development of elevated/segregated bus-ways

It is unlikely that the planned rail-transit system alone will effectively meet the future public transport demand. The rail transit system will 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, and the planned rail transit systems.

3) Strengthening of radial/circumferential network configuration

Further urban development along transport corridors is the pattern predicted in Bangkok. In order to encourage proper urban growth with the development of new urban centres, it is considered that the 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.

4) Expansion of at-grade main roads

The construction of at-grade roads in the study area, especially in the inner area appears to be 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, roads which will supplement the elevated/segregated primary system, and roads on which elevated system is planned.

5) 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. The Government should determine the means to accelerate the development of distributor as well as access roads through strengthening financial, management and institutional measures.

5.2 Main Roads and Bus-ways

The proposed road network is composed of expressways/toll roads, bus-ways, at-grade main (primary and secondary) roads and distributors. Figures 5.1 and 5.2 show the road network plan for year 2006, while Table 5.1 the summary of road network development. The list of all identified projects is shown in Table 5.2. Main characteristics are as follows:

1) Main Roads

Main roads comprise access controlled expressways which are mostly elevated and at-grade primary and secondary roads.

(1) Expressways

The proposed system includes the ongoing/committed projects of ETA and DOH and the projects proposed in this study. The former include Second Stage Expressway System and Ekamai-Ram Intra of ETA and FSE-Don Muang Toll Road, Bang Na-Trad Toll Road and Thonburi-Pak Tho Toll Road of DOH. Major roads in the latter category are;

a. Expressway linking Thonburi - Bang Su - Ramkhamhaeng which intends to provide east-west link and eventually form most of the second major circumferential expressway system.

b. Expressway linking Phet Kasem and SSE which intends to provide direct expressway link between the CBD and western part of the city.

c. Expressway linking Nonthaburi and Bang Kapi which intends to strengthen further the east-west connection in the northern part of the study area.

(2) At-grade Main Roads

AT-grade main roads are planned with consideration of the following:

a. The committed projects of relevant agencies such as DOH, PWD and BMA and those specified in DTCP general plan will be implemented by 2006. Modifications were made when and where necessary.

b. Ground level of the proposed elevated expressways and bus-ways will basically be developed as secondary or distributor roads depending upon local conditions. Frontage roads along at-grade bus-ways were also considered.

c. Basic network of at-grade main road system will be constructed particularly in an integral manner with expressways to cover the entire study area at proper density.

2) Bus-ways

Bus-ways were planned in such a manner as to be integrated with the LRT system, but at the same time, they can also provide a relatively independent network. They serve major radial transport corridors to/from the inner areas. They are connected with each other so that varied bus route configuration can be made possible. The proposed bus-ways will be elevated in the built-up areas, while they will be at-grade in the suburban areas but segregated from other traffic and elevated only at the major intersections.

Table 5.1 Summary of Road Network Plan

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	17	-	29	-	255	-	284
2) At-grade Main Roads	42	800	-	606	-	1,406	-
TOTAL		800	29	606	255	1,406	284
B. Bus-ways 1/	9	-	-	66	126	66	126
C. Distributors	-	500	-	2,690	-	3,190	-

1/ including bridges

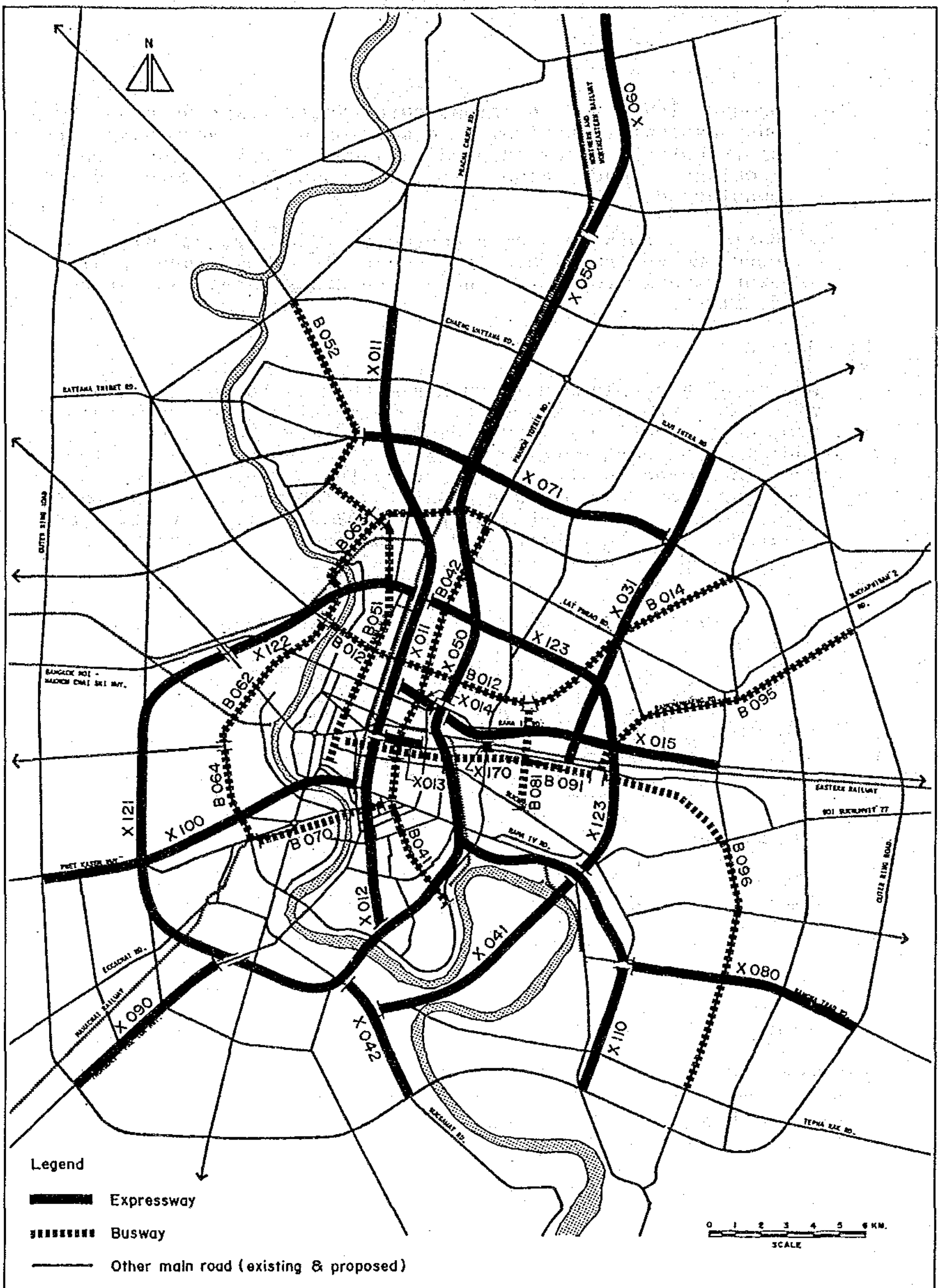


Figure 5.1 2006 Main Road Network of Study Area (Expressways and Bus-ways)

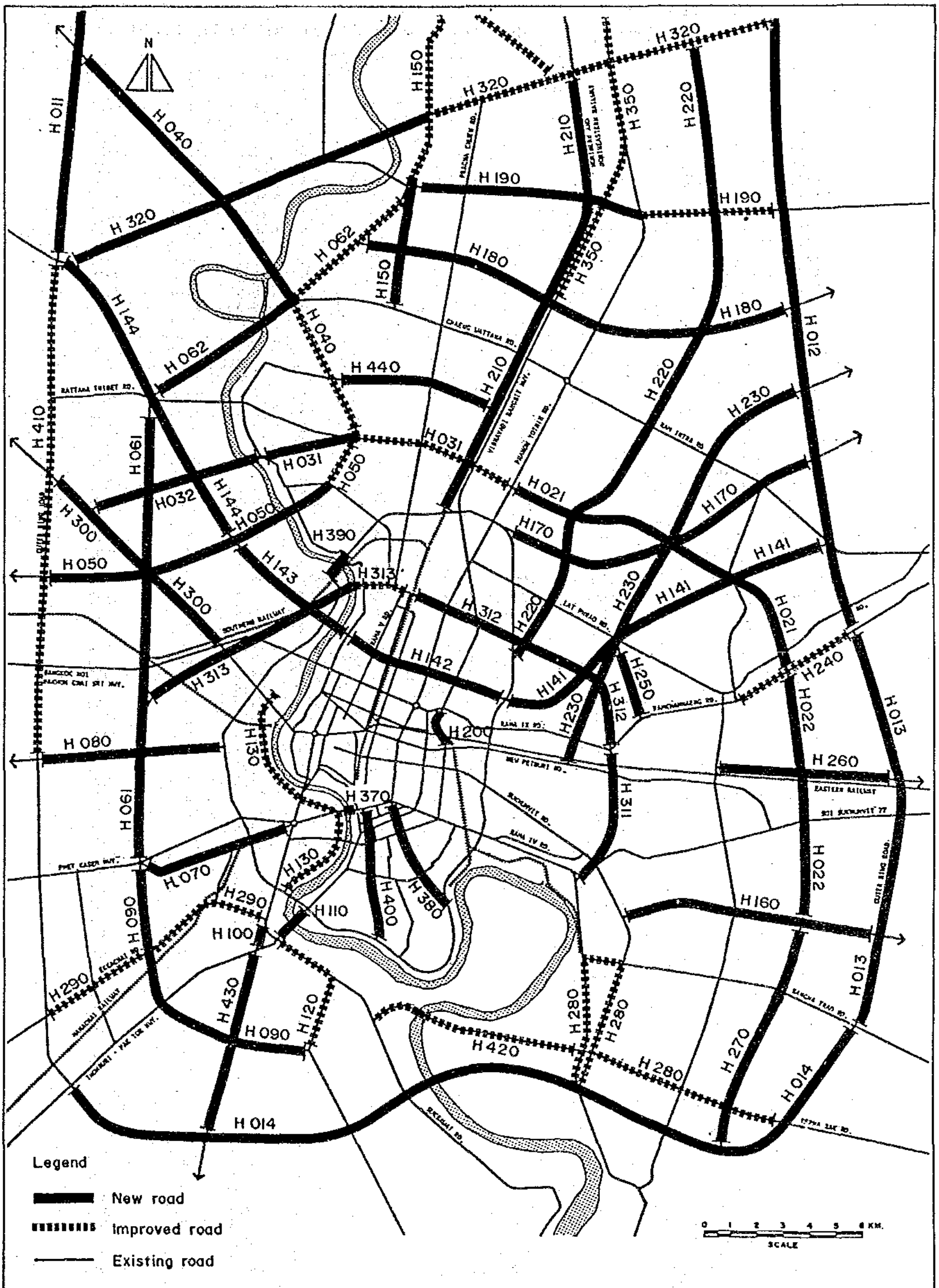


Figure 5.2 2006 Main Road Network of Study Area
(At-grade Main Roads)

Table 5.2 List of Road Projects (Expressways, Bus-ways and At-grade Main Roads)

Project Code	Name	No.of Lanes	Width (m)	Length (km)	Estd. Cost (Mil.B)
Expressway					
X010	ETA 2nd Stage Expressway (SSE)	6	28.5	37.6	19838
X031	Ekamai - Ram Intra	6	28.5	13.3	5142
X040	FSE - Suk Sawat Expressway	6	28.5	14.3	7526
X050	FSE - Don Muang Toll Road	6	28.5	18.7	7227
X060	Don Muang - Rangsit Toll Road	4	21.5	10.2	2956
X071	Nonthaburi - Bang Kapi Expressway	6	28.5	12.3	4759
X080	Bang Na - Trad Toll Road	4	21.5	9.2	410
X090	Thonburi - Pak Tho Toll Road	4	21.5	8.4	374
X100	Phet Kasem Expressway	4	21.5	13.0	3948
X110	Bang Na - Samut Prakan Expressway	6	28.5	6.8	2631
X120	Thonburi - Bang Sue - Ramkhamhaeng Expressway	6	28.5	37.5	15117
X170	Soi Asok Flyover	4	21.5	2.3	664
Total				183.6	70589
At-grade Main Roads					
H010	Outer Ring Road	6	36.5	138.9	8157
H020	Phahon Yothin - Sukhumvit 101	4	24.5	21.0	756
H030	Phahon Yothin - Route 340	6	32.5	16.3	1093
H040	Rattana Thibet - ORR (Northwest)	4	22.5	5.4	668
H050	Rattana Thibet - ORR (West)	4	22.5	12.8	712
H060	Nonthaburi - Thonburi	4	22.5	24.6	1221
H070	Phet Kasem Bypass	8	37.5	4.6	311
H080	MRR - ORR (West)	2	14.5	6.7	143
H090	Phet Kasem - Pracha Uthit	4	22.5	9.0	392
H100	Thon Buri - Pak Tho (Route 35) Shortcut	4	22.5	1.1	58
H110	New Bridge (Suksawat - MRR)	6	30.5	3.2	2408
H120	Suksawat - Pracha Uthit	4	22.5	2.2	76
H130	Phrapin Klao - Arun Amarin - MRR	6	30.5	1.6	103
H140	ORR (Northwest) - Phaya Thai - ORR (Northeast)	4	22.5	25.6	1667
H150	Chaeng Wattana (Route 304) - Route 306	4	22.5	12.5	429
H160	Sukhumvit - ORR (East)	4	22.5	7.1	276
H170	MRR(North) - ORR (Northeast)	4	22.5	12.4	424
H180	Route 306 - Don Muang - ORR (Northeast)	4	22.5	9.3	540
H190	Route 306 - ORR (East)	4	22.5	10.0	489
H200	Din Daeng - Phet Buri Shortcut	4	24.5	1.2	30
H210	MRR (North) - Route 306	6	28.0	22.0	738
H220	Huwai Khwang - Route 305	4	22.5	20.6	1495
H230	Ekamai - Ram Intra	6	32.5	18.8	1032
H240	Sukhapiban 2 Improvement	4	22.5	6.8	201
H250	Ram Khamhaeng - Lat Phrao	4	22.5	3.2	169
H260	Bangkok - Chonburi	4	24.5	10.4	610
H270	Sukhumvit 101 - ORR (South)	4	24.5	9.8	353
H280	Samut Phrakan Roads Improvement	4	22.5	18.2	542
H290	Ekachai (Route 3242) Improvement	4	22.5	7.6	280
H300	Bangkok Noi - Nontha Buri	4	24.5	9.1	328
H310	Thon Buri - Bang Sue - At Narong	4	20.5	19.9	1383
H320	Ban Bua Thong - Rangsit - Thanya Buri	4	22.5	30.6	1446
H330	Route 306 and Route 3112 Improvement	4	22.5	16.0	476
H340	Route 3111 Improvement	4	22.5	12.6	375
H350	Route 1 Improvement	6	32.5	29.9	1296
H360	ORR/Route 1 Interchange	-	-	1.0	3355
H370	New Si Phraya Bridge and Access	6	28.5	0.8	404
H380	Si Phraya (East) - MRR (South)	8	37.5	5.3	353
H390	New Rama VI Bridge and Access	6	28.5	1.2	405
H400	Si Phraya (West) - MRR (South)	6	27.0	4.3	285
H410	ORR (West) Improvement	6	36.5	16.7	366
H420	Na Krom - Suksawat	4	22.5	8.3	2674
H430	Taksin Extension	4	22.5	6.7	206
H440	H040 - H210	4	22.5	7.0	202
Total				598.6	38925
Busway					
B012	Bang Phlat - Huwai Kwang	2	9.5	8.6	1540
B014	Huwai Kwang - Lat Phrao	2	9.5	9.9	364
B041	Yanawa - Klong Saen Saep (B091)	2	9.5	6.9	1178
B042	Klong Saen Saep(B091)	2	9.5	12.1	1570
B050	Pak Kret - Pomprap Busway	2	9.5	19.7	1921
B062	Bangkok Noi(B020) - Bang Plat(B010)	2	9.5	6.0	1024
B063	Bang Plat(B010) - Phahon Yothin(B040)	2	9.5	8.9	1579
B064	Bangkok Noi - Wong Wian Yai	2	9.5	4.1	691
B070	Wong Wian Yai(B060) -Bangrak Busway	2	9.5	5.7	1008
B081	Huai Khwang (B010) - Sukhumvit Busway	2	9.5	4.3	725
B091	Pomprap - Klongton	2	9.5	9.9	1681
B095	Klongton - Bangkapi	2	9.5	11.7	1997
B096	Klongton - Samut Prakan(Route 3268)	2	9.5	13.6	339
Total				121.2	15616

5.3 Distributors

1) Planning Direction

Proper development of distributors is one of the most effective solution to Bangkok transport problems both from traffic economics and urban development viewpoints. Without proper distributors, it is difficult to strengthen roads as a system, and to encourage the integration of community and provision of necessary social and administrative infrastructures and services. Requirement of distributor depends on the size of the block bounded by primary/secondary roads and level of vehicular traffic generation of the block. However, there is no readily available planning guideline which is applicable to the Bangkok situation. On the basis 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 one to 1.5 kilometer in general, in the areas outside the Middle Ring Road.

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 a formula prepared in the study.

2) Distributor Project

Twenty-seven distributors were specifically identified in the selected superblocks (large block areas with no internal streets connecting the surrounding major roads from one side to the opposite) around the Middle Ring Road as shown in Figure 5.3. They are listed in Table 5.2. Following factors are considered in the study:

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 and thus the identified distributors can contribute to the strengthening of local road network.

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

For the distributors, a number of standard cross sections were prepared. The distributors are provided with sufficient sidewalk and parking lanes. The identified projects were assessed from traffic, economic, and network aspects. Most of them were found feasible and favorable. Even vehicle operating cost saving alone will generate very high B/C ratio of 19.2 for the entire package of 24 projects with a total length of 55.8 km which requires an estimated construction cost of 3.3 billion Baht.

The estimated requirement of distributors in the areas outside

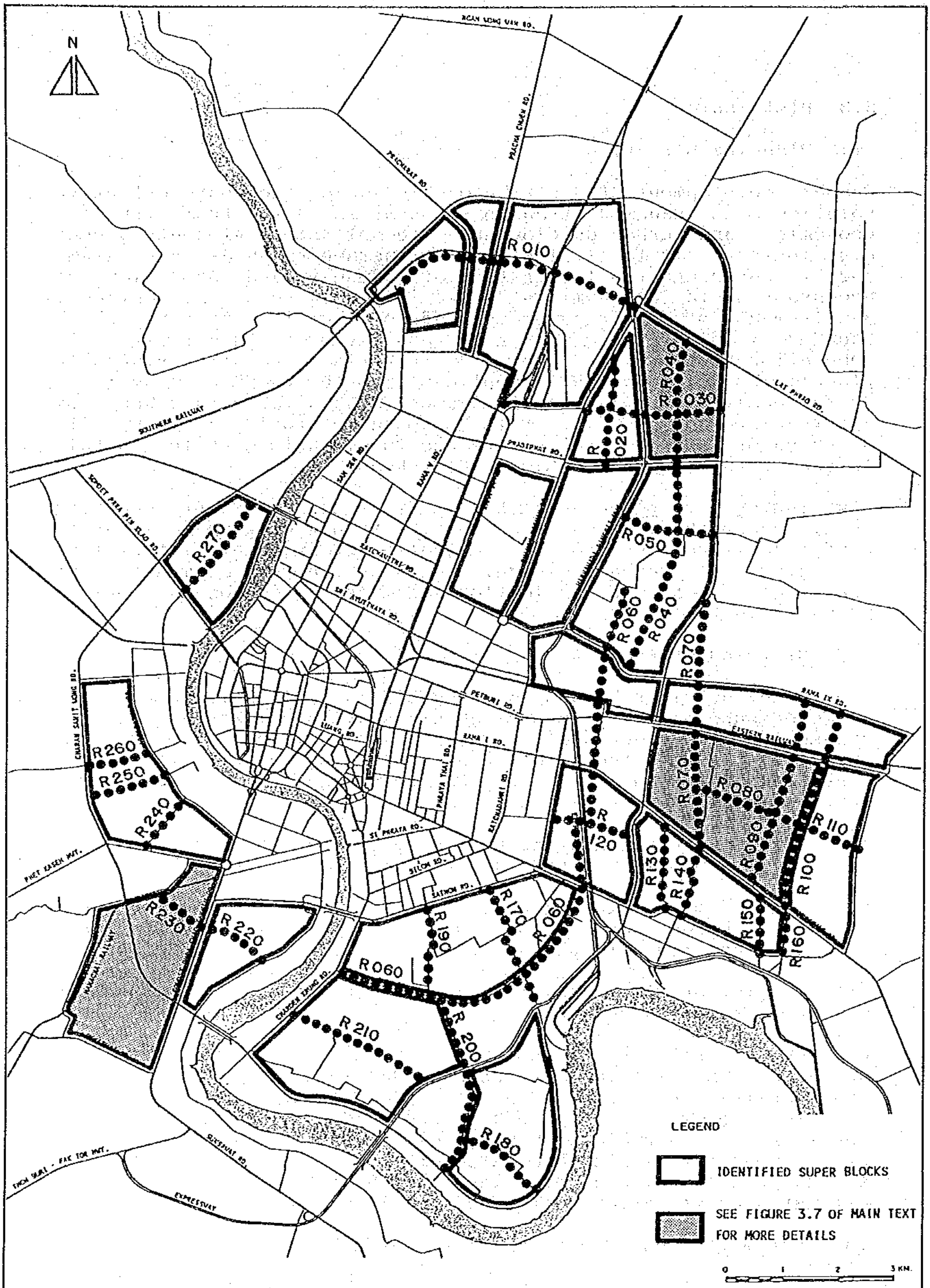


Figure 5.3 Proposed Distributor Projects for Identified Super-size Blocks

the Middle Ring Road is approximately a total of 2,000 km by year 2006.

Table 5.3 List of Distributor Projects

Code	Name	No.of Lanes	Length (km)	Estd. Cost (B.million)
R010	Pracha Rat - Vibahavadi Rangsit	4	4.9	190.3
R020	Phahon Yothin - Sutthisan	4	1.9	99.3
R030	Phahon Yothin - MRR	2	2.5	181.8
R040	Lat Phrao - Din Daeng	4	5.1	425.0
R050	Vibahavadi Rangsit - MRR	2	1.7	119.1
R060	Chan Road Extension	4	10.1	615.8
R070	Sukhumvit - MRR	4	4.4	286.6
R080	Sukhumvit (Soi 39) - Sukhumvit (Soi 63)	2	1.8	127.0
R090	Sukhumvit - New Phetburi along Soi 55	4	2.4	90.5
R100	Sukhumvit - New Phetburi along Soi 63	6	1.0	77.2
R110	Sukhumvit Soi 55 - Phrakanong Klong Ton	2	1.1	75.8
R120	Wittayu - MRR	4	1.2	83.0
R130	Rama IV - Sukhumvit Soi 22	2	1.6	70.2
R140	Rama IV - Sukhumvit Soi 26	2	1.3	55.3
R150	Rama IV - Sukhumvit Soi 40	2	1.1	46.1
R180	Sathu Pradit - MRR	2	1.8	43.3
R200	Sathon - Chan Road	4	1.5	47.2
R210	Charoen Krung - Expressway	2	2.6	85.3
R220	Taksin - Charoen Nakhon	2	1.4	66.9
R230	Thoet Thai - Taksin	2	1.3	64.4
R240	Inthraphithak - Itsaraphap	4	1.1	57.3
R250	MRR - Wang Doem	4	1.2	96.8
R260	MRR - Itsaraphap	2	1.0	47.5
R270	Phrapinklao - Ratchawithi	6	1.8	207.9
TOTAL			55.8	3259.6

5.4 Design Standards and Cost Estimate

1) Typical Cross Sections of Project Roads and Bridges

On the basis of review of 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 5.4 and outlined as follows:

a. Expressway : Types 1, 2 and 3 will be applied. Elevated section will have dual-2 to dual-3 lanes, while at-grade section dual-2 lanes with a lane width of 3.5 m and proper shoulders. Total road width is 21.5 m for dual-2 lane and 28.5 m for dual-3 lanes.

b. At-grade Main Roads : 17 types (Type 4 through Type 18) were prepared for 4, 6 and 8 lane roads including dual-2, dual-3 and dual-4 lane roads. A Lane width is 3.25 m for four/dual-2 lane roads, and 3.5 m for six/dual-3 lane and eight/dual-4 lane roads. The roads where other elevated structures such as expressways, bus-ways and LRT are to be constructed, 3.5 m of central median is provided to facilitate the construction of the substructures. Separate carriageway as shown in Type 16 was prepared for Outer Ring Roads. Road width is between 19 m and 37.5 m.

c. Distributors : Two lane and four lane undivided roads with respective carriageway width of 3 m and 3.25 m are proposed for distributors as shown in Type 19 and Type 20. Total road width is 15 m and 22 m.

d. Bus-ways : Two types of cross sections were prepared for at-grade section and elevated section. Both will have two lanes with a lane width of 3.25 m. Total road width is 14.5 m and 9.5 m, respectively.

e. Bridges : Bridge types are broadly classified into two; those to be constructed north and those south of the existing Krung Thep Bridge. The former ones will have navigation clearance of 10 m and three continuous box girders with central span length of 120 m. For the latter ones, structures will become significantly large due to the existence of a number of port facilities and navigation of large vessels. Navigation clearance will be 40 to 50 m, and more than 350 m is necessary for central span length.

2) Estimate of Project Cost and Implementation Period

Project cost was estimated by cost component such as direct cost, overhead, design/supervision cost, contingency and land acquisition and compensation cost. The direct cost is composed of labor, machine/equipment and construction materials costs. The costs were estimated both in financial and economic terms. The costs were also brokendown into foreign and local portions. Assumed exchange rate of foreign currency is US$1.0 = B25.0.

It is noted that the land acquisition/compensation costs will be the major portion of the construction costs. The costs were estimated by project based on the results of land price study, relevant feasibility study reports and the estimate of land acquisition/compensation requirements of each project.

Project implementation period of each project was estimated based on the experience and plans of relevant implementing agencies for different types of projects, land acquisition and construction size and ease.

The estimated construction costs and construction periods are shown in Table 5.4.

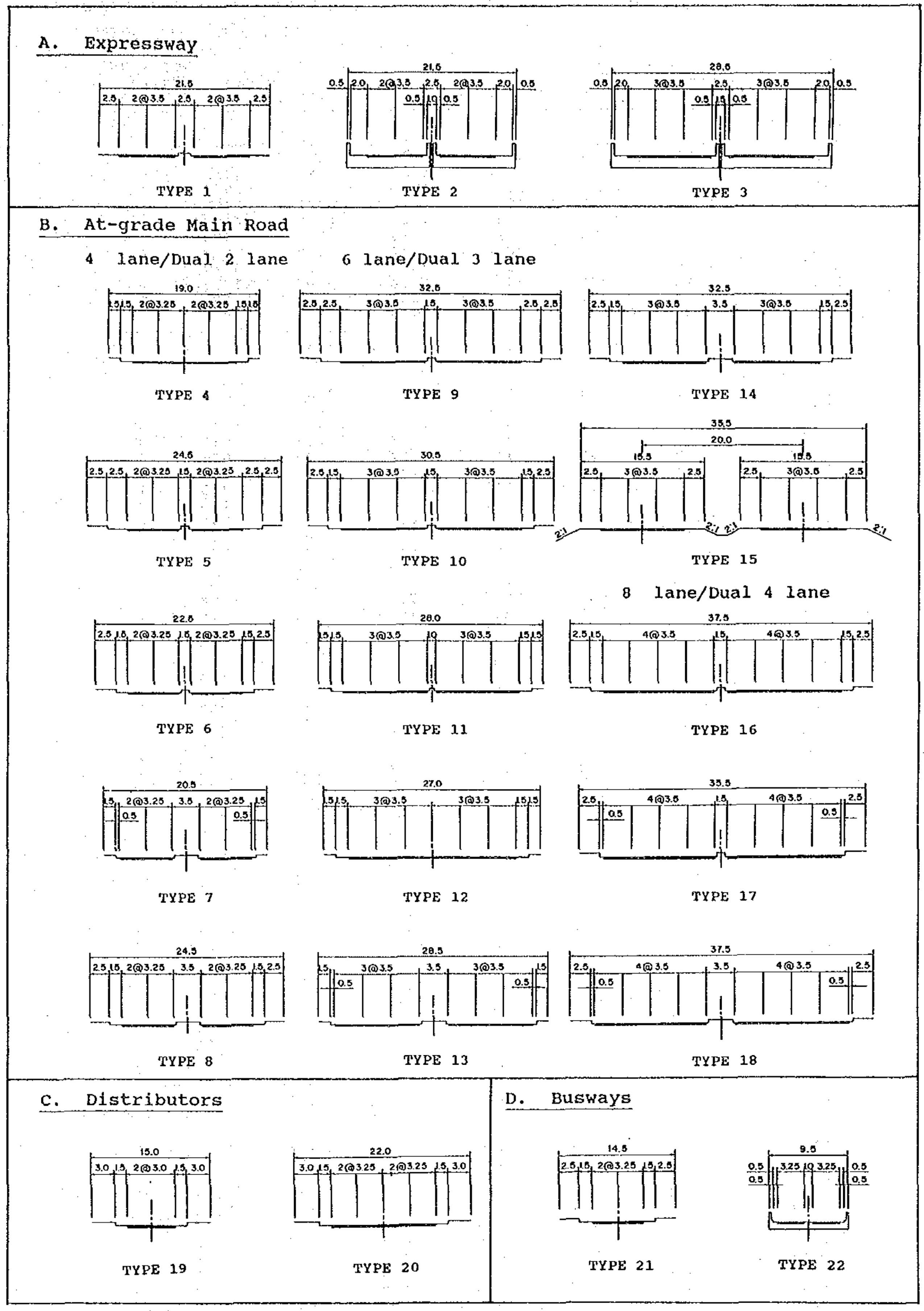


Figure 5.4 Typical Cross Sections for Roads

Table 5.4 Estimated Costs and Construction Period of the Projects

(Million Baht at 1989 price)

Project Code	Financial Cost Foreign Portion	Financial Cost Local Portion	Financial Cost Total Cost	Economic Cost Foreign Portion	Economic Cost Local Portion	Economic Cost Total Cost	Construct. Period (Years)
Expressway							
X010	9586	10252	19838	9614	9179	18793	5
X031	3377	1765	5142	3377	1382	4759	3
X040	4620	2905	7526	4624	2226	6851	5
X050	4747	2480	7227	4747	1942	6689	3
X060	1944	1012	2956	1944	795	2739	2
X071	3125	1633	4759	3125	1279	4404	2
X080	216	194	410	216	177	393	2
X090	197	177	374	197	162	358	2
X100	2566	1383	3948	2566	1081	3647	3
X110	1728	903	2631	1728	707	2435	2
X120	9656	5461	15117	9658	4340	13999	5
X170	436	227	664	436	179	615	2
Total	42198	28391	70589	42233	23448	65680	
At-grade Main Roads							
H010	4713	3444	8157	4720	2593	7313	6
H020	287	469	756	288	443	731	4
H030	525	568	1093	526	494	1020	4
H040	345	323	668	345	272	617	3
H050	352	360	712	352	308	661	3
H060	544	677	1221	545	599	1144	6
H070	111	201	311	111	192	303	1
H080	55	89	143	55	83	138	2
H090	123	268	392	124	258	381	2
H100	16	42	58	16	41	57	1
H110	1543	865	2408	1544	533	2077	3
H120	29	46	76	29	44	73	1
H130	28	75	103	28	73	101	1
H140	731	936	1667	736	917	1653	6
H150	166	263	429	166	249	415	2
H160	96	181	276	96	172	268	2
H170	164	260	424	164	246	410	2
H180	219	321	540	219	302	521	3
H190	220	269	489	220	250	470	3
H200	15	15	30	21	119	139	1
H210	390	348	738	390	318	709	3
H220	541	954	1495	542	909	1451	3
H230	341	691	1032	342	663	1005	2
H240	88	113	201	88	105	193	2
H250	45	123	169	45	120	165	1
H260	225	385	610	226	365	590	2
H270	134	219	353	134	207	341	2
H280	238	304	542	238	283	521	3
H290	102	178	280	102	170	272	2
H300	124	203	328	169	1074	1243	2
H310	460	923	1383	467	957	1424	4
H320	705	741	1446	706	633	1339	4
H330	209	267	476	209	249	458	2
H340	165	210	375	165	196	361	2
H350	574	722	1296	574	675	1249	4
H360	1528	1828	3355	1376	1676	3053	3
H370	223	181	404	223	139	362	3
H380	124	229	353	124	219	343	2
H390	235	170	405	235	120	354	3
H400	80	205	285	80	200	280	2
H410	211	155	366	211	125	336	2
H420	1697	977	2674	1697	674	2371	4
H430	88	118	206	88	110	198	2
H440	91	111	202	91	103	194	2
Total	18899	20027	38925	18827	18476	37303	
Busway							
B012	995	545	1540	995	422	1417	2
B014	139	277	364	139	161	267	2
B041	773	404	1178	773	316	1090	2
B042	1031	539	1570	1031	422	1453	2
B050	1184	737	1921	1184	605	1788	4
B062	673	351	1024	673	275	948	2
B063	1028	551	1579	1028	424	1452	3
B064	454	237	691	454	186	640	1
B070	653	356	1008	653	277	930	3
B081	476	249	725	476	195	671	3
B091	1104	577	1681	1104	452	1556	2
B095	1311	685	1997	1311	537	1848	2
B096	143	196	339	143	182	325	3
Total	9964	5704	15616	9964	4452	14383	

6. TRAFFIC MANAGEMENT AND PUBLIC TRANSPORTATION OPTIONS

6.1 Traffic Signal Installation and ATC Area Expansion

In the case of urban road network, traffic signals need to be installed at intersections where the main road has a width of more than 10 m, and where the traffic volume during peak hours would be higher than the standard amount set to determine traffic signals installation requirement. On the basis of the traffic demand projection in the year 2006, there are 140 crossings that will have to be additionally equipped with signals in the future (Figure 6.1). If signals already in operation are also taken into account, 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 crossings between main roads and distributors (soi) should also prove to be very high.

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 middle Ring Road and its surrounding areas was proposed. In the long run, however, it will be necessary to expand the system even further. Areas, where the peak hour volume of traffic in the future would exceed 2500 PCU/hour are shown in Figure 6.1. It is desirable that the ATC system be expanded to cover these areas as well by the year 2006.

With the expansion of areas that will be equipped with 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 crossings, is not absolutely necessary, line concentrators should be installed to reduce usage fees for the telephon circuit.

In order to disperse traffic adequately, 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.

6.2 Control of Parking Facility Development

Even at present, there are areas downtown where parking conditions have deteriorated. In the future, however, due to a greater inflow of traffic into the midtown areas, the lack of parking spaces will become a much greater problem. Designating 5 PT Survey zones (1, 2, 10, 11 and 12) as the CBD area, the estimation of the future demand for parking spaces at 141,000 cars confirms that the demand in the year 2006 will be 1.34 times the present level. Since the present level of demand is for 106,000 cars, new parking spaces for a total of 35,000 cars will have to be made available.

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 continuously construct more than 2000 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. The construction of parking spaces where drivers can park their cars all day, serves to 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.

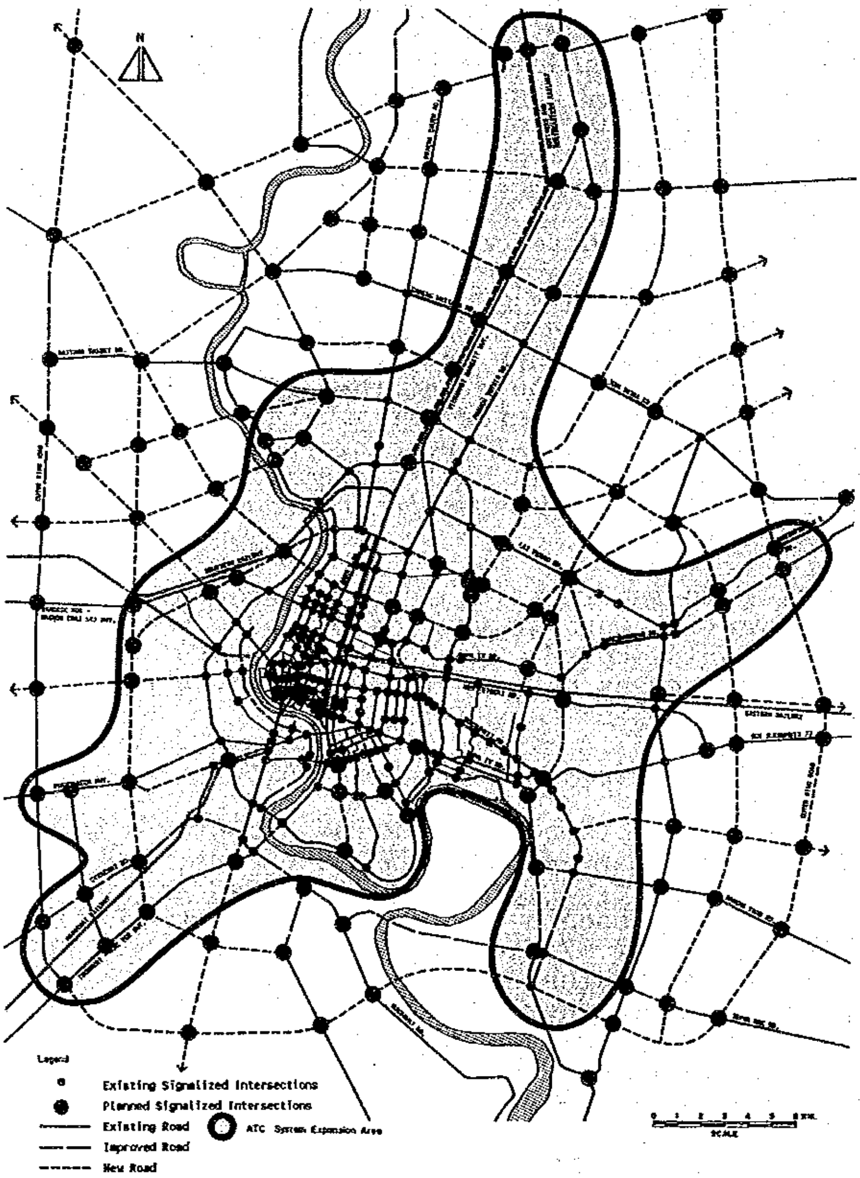


Figure 6.1 Signalized Intersections in 2006

On the other hand, a severe shortage of parking space to accomodate short term business and commercial trip , 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.

6.3 Demand Control Measures

Among various demand control measures, seven were selected for impact analysis. The results are summarised in Table 6.1, and outlined as follows:

1) Staggered Time for Commuter and To School Traffic

If this traffic to/from the city centre (defined by zones 1, 2, 10, 11 and 12) is shifted from the peak hour period (7-8:00 am), approximately 42% or 48,000 pcu of attracted traffic during the peak hour will be reduced.

2) Increase in Vehicle Tax

If vehicle tax is increased by 10% to discourage vehicle ownership, road congestion will be slightly improved and the encouragement of conversion from car to public transport made shall be accomplished.

3) Increase in Gasoline Tax

If gasoline price is increased by 1.5 times to discourage vehicle use, traffic congestion will decrease by 8 to 10%, public transport use increase by 12%, and vehicle operating cost decrease by 15 to 20%. This measure has more significant effects than the vehicle tax increase measure.

4) Vehicle Use Restriction

If entrance to the city centre is alternately restricted for odd and even number plates, generated and attracted traffic will be reduced by 32% or 566,000 pcu/day.

5) Area License Control

If all traffic except public transport is charged 30 Baht upon entering the city centre to encourage made conversion from car to public transport, overall effects similar to the gasoline tax increase measure can be expected. The impact is significant in the inner area.

6) Car Ban for Going to School

If all to/from school trips including those of escorted students are banned from using cars and motorcycles, this will reduce the total generated/attracted traffic by about 4% or 656,000 pcu/day.

6.4 Public Transportation Options

The study clearly identifies bus as the most popular and important public transportation mode. It is estimated that in the year 2006 the bus mode will share 75% of the total public transportation demand, even after the completion of LRT and SRT. Measures to further strengthen and improve bus services in the study area include, but are not limited to, the following:

1) Expansion of Bus Fleet

Based on the result of traffic assignments, it is estimated that bus passenger demand in terms of passenger.km will be doubled in the next 17 years (1989-2006), of which 16% will be met by buses to be operated on the proposed bus-ways. Based on the present operational performance, it is estimated that the required number of conventional bus units for the year 2006 is approximately 13,900. The required number of bus units on the bus-way system shall to be approximately 2,600, based on the improved performance such as higher occupancy and travel speed.

Assuming that the present conditions of share by type of bus, and by operator and life of 10-12 years for ordinary bus, and 5-9 years for minibus remain unchanged, it shall be necessary to purchase or lease approximately 30,000 units in the next 17 years. BMTA's share is approximately 17,000 units, or 59% of the total requirement. Therefore BMTA should acquire approximately 1,000 buses a year.

2) Restructuring of Bus Routes

The present bus route network is relatively coarsely structured largely due to the lack of main roads without proper hierarchy, and the proposed plan will significantly improve this situation. Since bus is considered the most basic public transportation mode for the residents, bus rerouting should be made by taking into account the following:

a. Integration with the rail transit services
b. Maximum use of bus-ways
c. Coordination with paratransit modes especially with minibus and hired motorcycle services
d. Assurance of services in the public transportation poor areas such as the suburban areas where development is taking place but demand is scattered over a large area.

3) Expansion of Improved Bus Services

With the proposed extensive bus-way network it shall be possible to introduce/expand new types of bus services, which would encourage the use of public transportation and possible conversion from private cars and motorcycles. Examples of new bus service types are air conditioned express bus, articulated bus along bus-ways, low bed bus, bus which can be easily used by aged, infants, and disabled, community bus, upgraded school/company bus, and the like.

4) Development of Mode Interchange Facilities

With a variety of public transportation modes including the rail transit systems incorporated in the future plan, it is very important to develop adequate facilities at the major terminals/transfer points among different modes. This is particularly the case for the rail transit systems. The importance of the mode interchange facilities for the rail transit systems is two-fold:

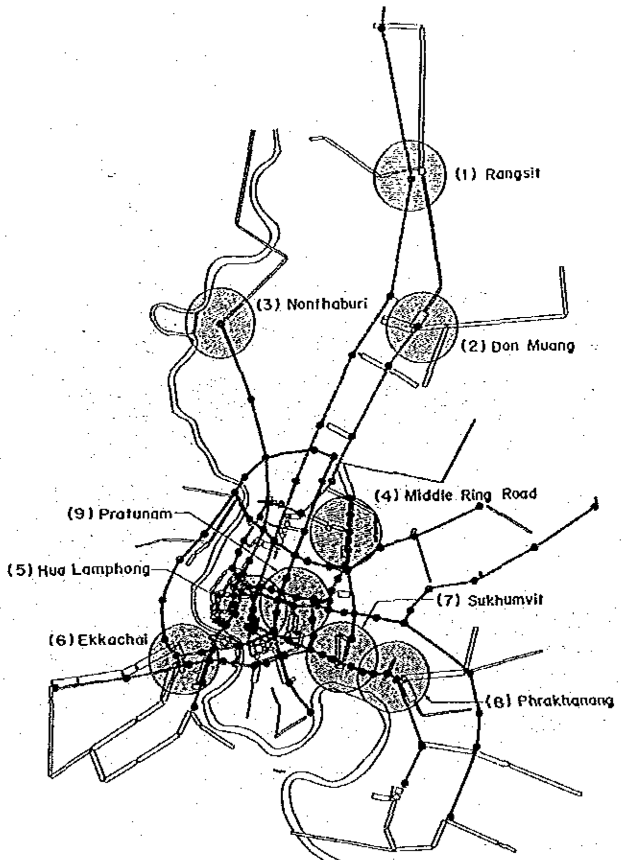
a. As the coverage of the rail services is limited, patronage is considerably affected by feeder services.

b. The terminals/major transfer points attract a large number of passengers, and require proper traffic management facilities including the provision of proper pedestrian facilities.

It is to be noted that strategically locating properly designed mode interchange points will create new urban space for the Bangkok residents.

5) Adjustment of 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.



Type of Mode Interchange

Area	Mode Interchange Pattern				Impact on Urban Development
	Bus	Busway	LRT	MRT	
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

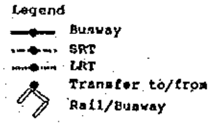
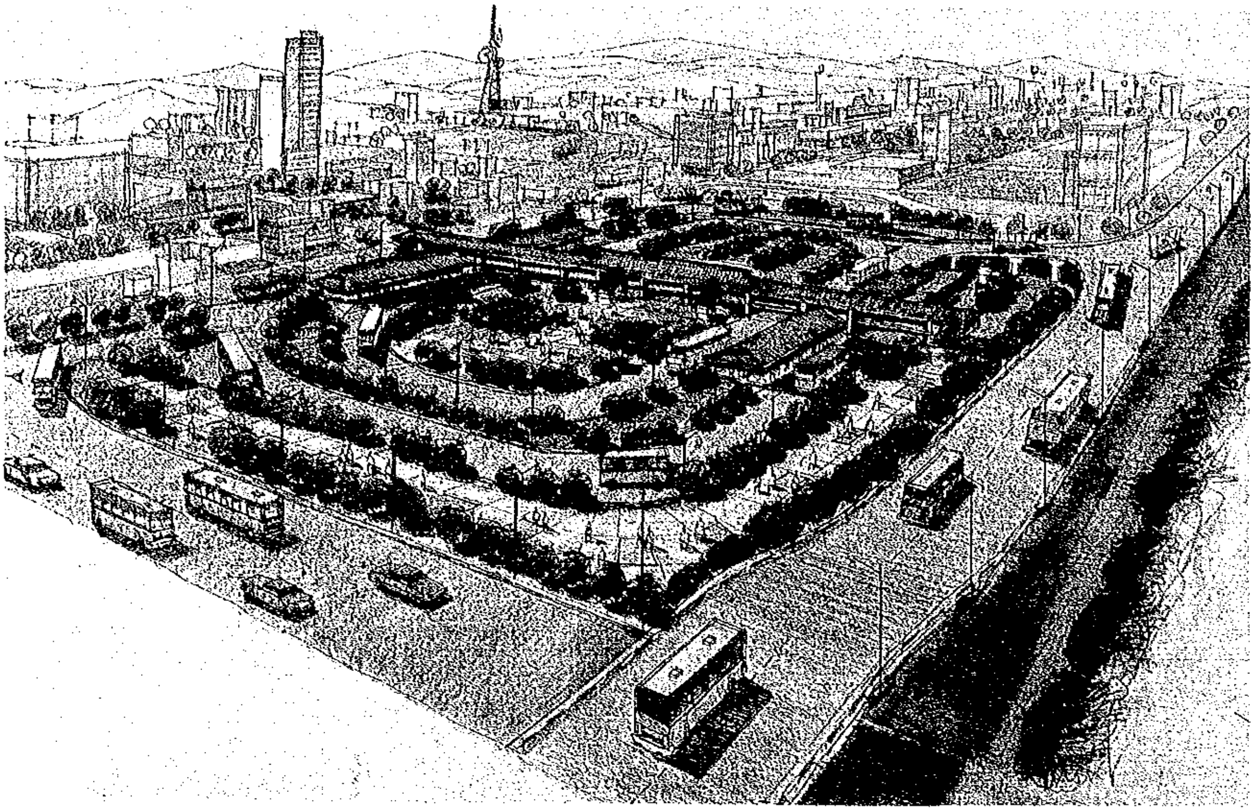
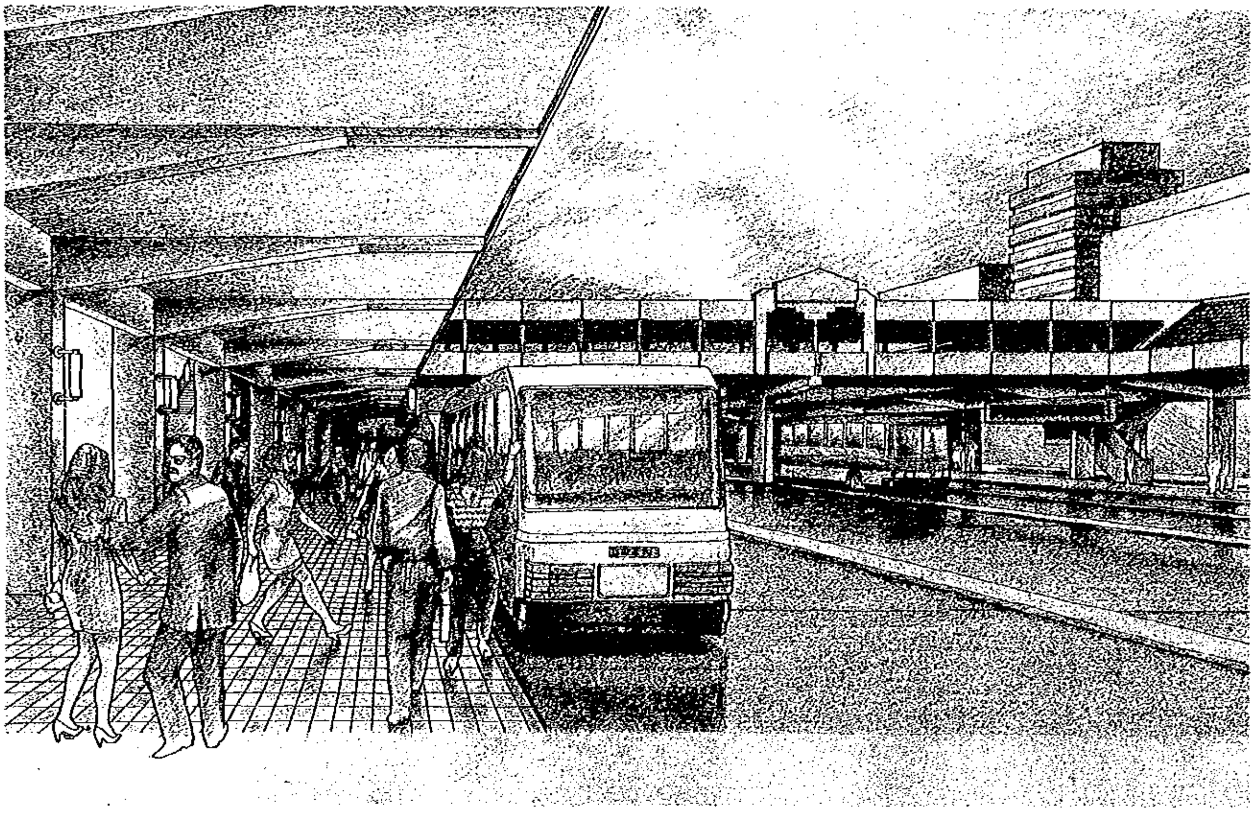


Figure 6.2
Concept of Mode Interchange Facilities



Busway Terminal



Bus Stop of Elevated Busway